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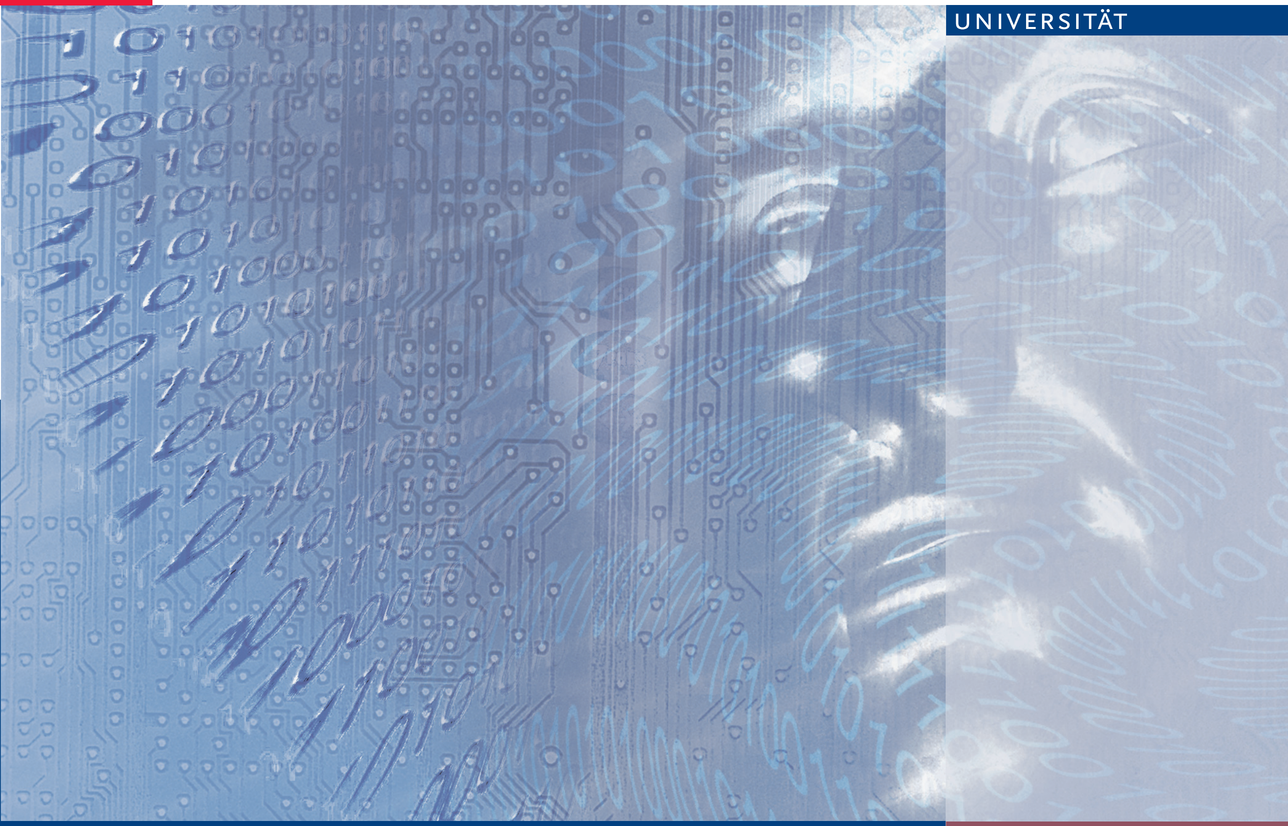

SCHRIFTENREIHE INFORMATIK

48

DOUCEK PETR ■ CHROUST GERHARD ■
OŠKRDAL VÁCLAV (EDITORS)

IDIMT-2019

Innovation and Transformation in a Digital World

27th Interdisciplinary Information Management Talks

Sept. 4–6, 2019

Kutná Hora, Czech Republic

JOHANNES KEPLER UNIVERSITÄT LINZ

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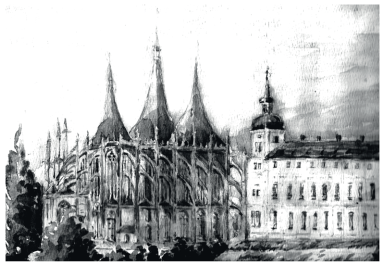
Kutná Hora, St. Barbara Cathedral

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Impressum

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(Editors)
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Innovation and Transformation in a Digital World
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This publication was partially supported by the Česká spořitelna, a.s. and University of Economics, Prague – project IGA 409039

The Conference IDIMT-2019 took place September 4–6, 2019 in Kutná Hora, Czech Republic

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Herstellung: Kern:
Johannes-Kepler-Universität Linz,
4040 Linz, Österreich/Austria

Herstellung: Umschlag:
TRAUNER Druck GmbH & Co KG,
4020 Linz, Köglstraße 14,
Österreich/Austria

ISBN 978-3-99062-590-3
www.trauner.at

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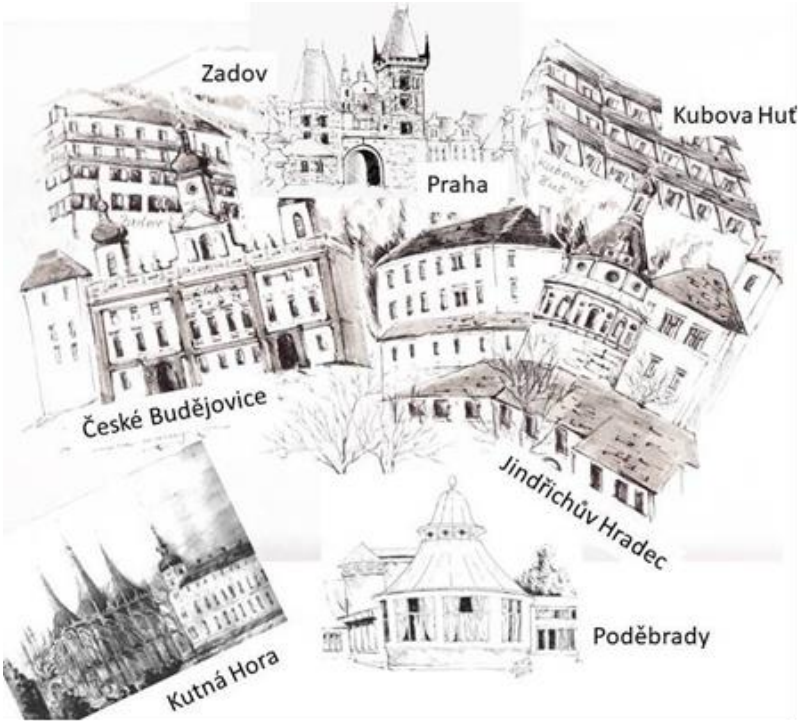


The 7 locations of IDIMT (1993 – 2019)

A hearty welcome to the 27th IDIMT Conference!

Through the years, the IDIMT Conferences have taken to the tradition of rotating between different historically relevant villages/cities of Southern Bohemia. 2019 we stay again in Kutná Hora, the 7th location hosting the IDIMT Conference. Again we can enjoy an old historical and picturesque city, in addition to discussing scientific issues of information management, interdisciplinarity and digitalization.

Kutná Hora, as its name suggests, was originally a thriving silver miners' town (kutání in Czech means mining). In 1142 the first Cistercian monastery in the Czech lands was established in the nearby village of Sedlec and at the end of the 13th century the original mining settlement of Cuthna antiqua – Old Kutna - was founded. The city lay on high deposits of silver ore and was a successful mining town. It was the the strongly fortified 'treasury' of the Bohemian kings. As a consequence it became Bohemia's political and economic center between the 14th and 15th century and once was one of the richest cities of Bohemia. The Barbara's Cathedral was founded ('privately'!) by one rich mine owner (!) in 1388. Today the silver mines are depleted, but still can be visited.

It is quite remarkable to follow the development and growth of the IDIMT Conferences from a small meeting in 1993 in Kubova Hut[1] until today. In 1993 we began with 13 speakers and participants. Since then we have made continuous improvements and our conferences have consequently grown as documented in a book published in 2017[2]. In 2019 we received 53 submitted

[1]Chroust, G. and Doucek, P., editors (1993). *Information Management Workshop 93, Kubova Hut, Czech Republic*. Univ. of Economics Prague & J. Kepler University Linz, Austria 1993, ISBN 3-902457-06-6

[2] G. Chroust, P. Doucek, L. Nedomová: 25 Years of IDIMT:A History of Continuity and Change, Books on Demand, Norderstedt, Germany, 2017 (hard copy and e-book).

papers from a total of approx. 100 co-authors. Employing a two-step submission procedure and a blind review process we have accepted 43 of the submitted papers plus 11 invited papers. The authors have come from 7 different countries: Austria, Czech Republic, Kazakhstan, Romania, Russia, Slovakia and Ukraine. The programme will run in two parallel streams. In the conference we expect approximately 90 participants.

The overall orientation of our conferences varies slightly from year to year. The topics of the individual sessions and the number of accepted papers reflect the current interest of authors and participants and can thus be taken as a regional indicator for the future. When you look at the program, well organized by Antonin Pavlíček and Lea Nedomová, you will notice only minor changes in comparison to 2018 and you will find the names of many people who loyally return year after year. We are a big family!

This year topics are:

- ICT Future Scenarios - Visions and Challenges
- Digital Economy and Industry 4.0
- Digital Transformation in Crisis Management
- Digital Single Market Innovation
- Cyber Security in a Digital World
- Innovation, New Business Models and Strategies
- Social Media and On-line Privacy
- Society Beyond Industry 4.0: Smart Systems as Enablers
- Innovative Models of IT Systems Delivery
- Performance Management

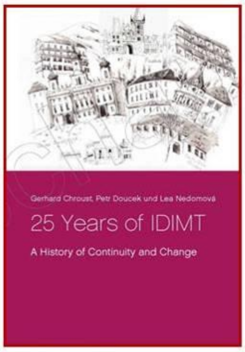
Compared to 2018 we notice a growth in 'Digital Economy' and 'Social Media' and a continuing interest in 'Innovation and Business Models', while 'Digital Market' and 'Innovative Models found less support. The Conference title 'Innovation and Transformation in a Digital World' reflects these changes.

A new feature is the workshop on Friday which provides a hands-on demonstration of a platform of solutions for disaster management developed under an EU-project..

Since 2000 Christian Loesch has always offered a special contribution: an overviews of global technical, economic and/or business developments. This year he will discuss 'ICT Future Scenarios - Visions and Challenges', covering ICT economy, Artifiial Intelligence, Quantum Computing, and lateral ICT developments.

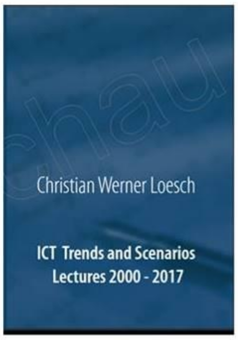
Each session is organized by a Session Chairperson and traditionally starts with a keynote, followed by papers providing additional points of view. At the end of each session there is a 20 minute, often heated, discussion. This extensive interdisciplinary exchange of thoughts is one of the unique features of the IDIMT-Conferences.

On the occasion of IDIMT's 25th anniversary in 2017 the details of IDIMT's impressive history have been separately published as a hard cover book and as e-book[3]. Additionally we have collected Christian Loesch's 18 presentations (2000--2017!) and republished them in a separate book[4].



25year IDIMT Conferences (1993 – 2017)

Memorial Publications



G. Chroust, P. Doucek, L. Nedomová: 25 Years of IDIMT: A History of Continuity and Change

C. Loesch and G. Chroust (eds.): ICT Trends and Scenarios - Lectures 2000 – 2017

Books on Demand, Norderstedt, Germany, 2017

60 pages, hard-copy 14 €, e-book 4,50 € ISBN 978-3-74480-9573

244 pages, hard-copy 15 €, e-book 8 € ISBN 978-3-74489-4265

Order information:
BoD Buchshop https://www.bod.de/buchshop/
and in international bookshops like Amazon.

Another traditional highlight is the afternoon/evening excursion, excellently organized by Petr Doucek and his team. It has always offered a visit to various culturally impressive sights followed by a hearty and very plentiful dinner in a typical Czech inn. This year Kutná Hora itself provides the cultural background and gives the participants the chance to appreciate the historical importance of this city.

The preparation and realization of IDIMT 2018 would not have been possible without the support of many organizations and persons. Therefore we would like to express our thanks to:

- the University of Economics Prague for the project IGA 409039,
- the Faculty of Informatics and Statistics of the University of Economics, Prague, and
- the Johannes Kepler University Linz.

Our further thanks go to:

- Petr Doucek for chairing the Organizing Committee, for arranging the conference location, the hotels and the greatly appreciated evening event,
- Antonín Pavlíček and Lea Nedomová, for organizing the program, the reviews, keeping contact with all involved speakers, and reminding forgetful authors and session chairs,
- Václav Oškrdal for arranging and assembling the selected papers for the proceedings,
- Lea Nedomová, for her support in performing the necessary administrative tasks,

[3] G. Chroust, P.Doucek, L. Nedomová: 25 Years of IDIMT: A History of Continuity and Change, Books on Demand, Norderstedt, Germany, 2017 (hard copy and e-book).

[4] C. Loesch and G. Chroust (eds.): ICT Trends and Scenarios – Lectures 2000 – 2017, Books on Demand, Norderstedt, Germany, 2017 (hard copy and e-book).

- all Keynote Speakers, speakers and contributors of papers,
- all members of the Programme committee and the Session Chairpersons for soliciting contributors and creating an interesting and compact program,
- all reviewers providing critical remarks for improving the papers,
- the Trauner Verlag for acting as the publisher of our conference, and
- all other unnamed persons contributing to the success of this conference.
- Looking forward to a successful and interesting conference!

Gerhard Chroust July 2019 Petr Doucek

Previous locations of IDIMT Conferences

- 1993, 1994: Kubova Huť
- 1995 – 2002: Zadov
- 2003 – 2007: České Budějovice
- 2008 – 2012: Jindřichův Hradec
- 2013: Praha
- 2014 – 2017: Poděbrady
- 2018: Kutná Hora

List of Reviewers

We want to express our special thanks to the reviewers of the IDIMT 2017 Conference:

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INVITED CONTRIBUTION

ICT FUTURE SCENARIOS: VISIONS AND CHALLENGES

Christian W. Loesch

IBM ret.

CWL001@gmx.net

Keywords:

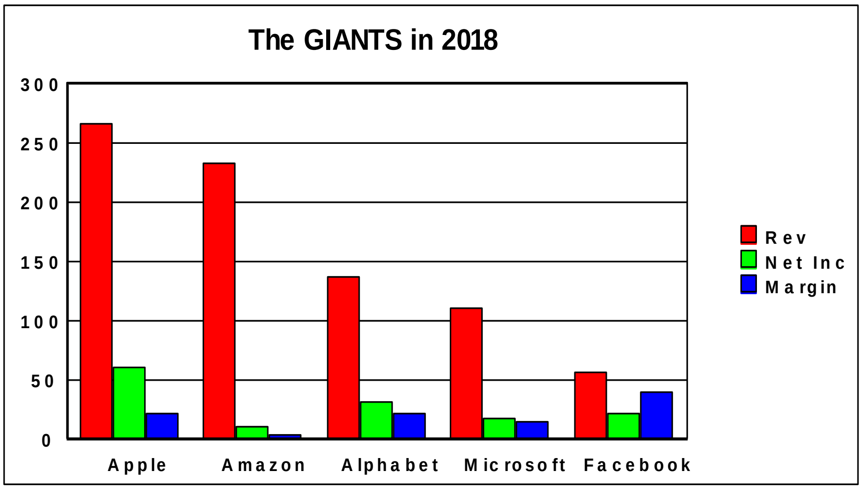
ICT economy, future of technology, applications, AI, QC, supercomputing, communication, and lateral ICT developments.

Abstract:

We will try by selected topics to cover of the present and future scenarios in ICT analyzing critically the economic and technological perspective as well as special topics as applications, AI, QC as well as well as supercomputing, communication and important lateral developments. It will be realistic review showing not only the achievements but also the challenges ahead.

1. Economy

In the last few years the ICT Industry has changed dramatically, to illustrate this lets have a look at the economic developments of some key players of the ICT Industry.



How do the “Big Five” accomplish their successes?

Apple: Phone 63%, Services 14% Mac 10%

Alphabet: Despite a wider umbrella name, ad revenue (via Google, YouTube, Google Maps, Google Ads, etc.) still drives 85% of revenue for the company

Facebook: Generates almost all revenue (98.5%) from ads, remarkably, as a free service the company generated more revenue per user than Netflix pay services.

Microsoft: Most diversified revenue, office products, server products, cloud, and Windows each around 20 %

The worldwide market for chips has reached in 2017 the impressive volume of 412 b$ representing a rise of 21,6% and is still continuing as shown by the table below.

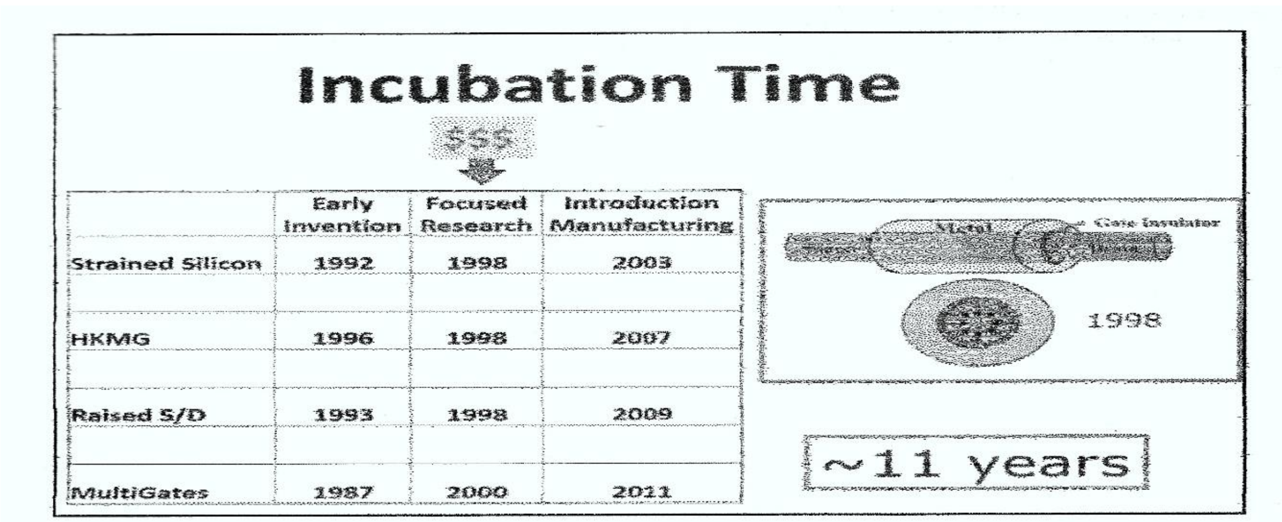
The main players in the new IC technology industry structure are

2018 Rank	2017 Rank	Vendor	2018 Revenue	2018 Market Share (%)	2017 Revenue	2017-2018 Growth (%)
1	1	Samsung Electronics	75,854	15.9	59,875	26.7
2	2	Intel	65,862	13.8	58,725	12.2
3	3	SK hynix	36,433	7.6	26,370	38.2
4	4	Micron Technology	30,641	6.4	22,895	33.8
5	6	Broadcom	16,544	3.5	15,405	7.4

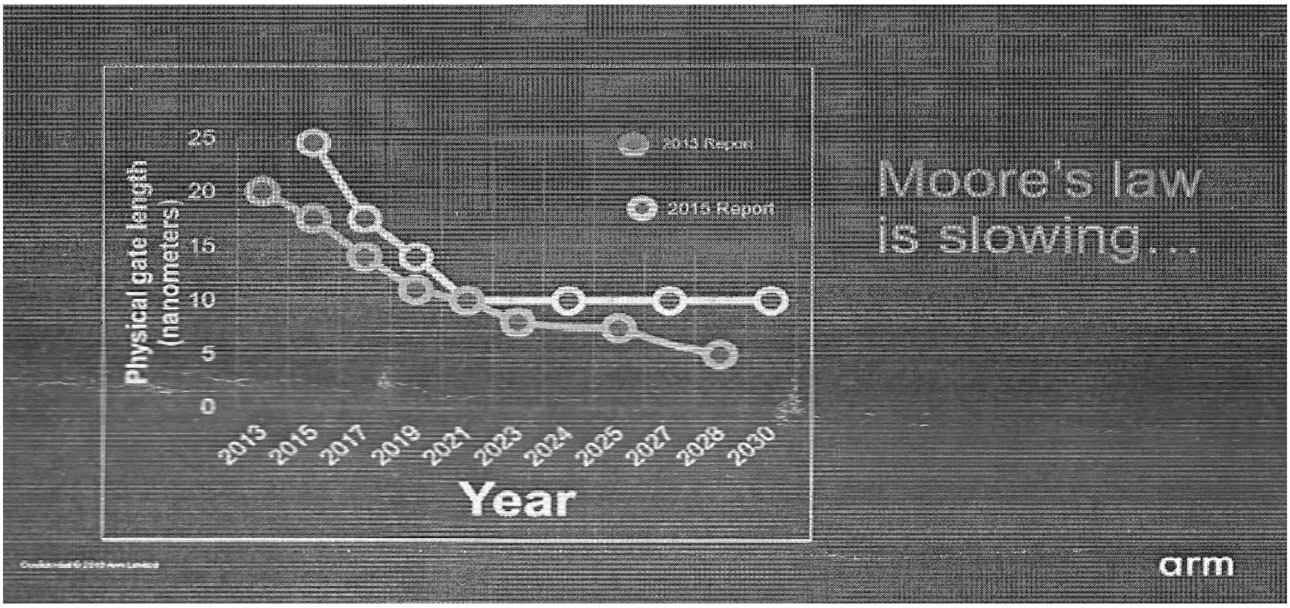
Parallel to this a concentration process has reduced the number of leading edge chip manufacturing companies from twenty-eight in 2001 to five in 2018.

2. Technology

Bipolar transistors (faster than MOS devices) were reaching the power limit by mid 90s, as reaction the CMOS technology was pushed by industry both for logic and memory devices. Again, power limits were reached at the middle of the last decade. No longer faster processors trigger the design of a new PC but the design of a new smartphone generates the requirements for ICs and components. This indicates the end of 2D topology and end of scaling as in history. The ICT Industry recognized very early in 1998 the need to restructure the MOS transistor and new worldwide approach to restructuring the transistor was 'equivalent scaling'. The goal of this program consisted in reducing the historical time of ~25years between major transistor innovations to less than half to save the semiconductor industry from reaching a major crisis.



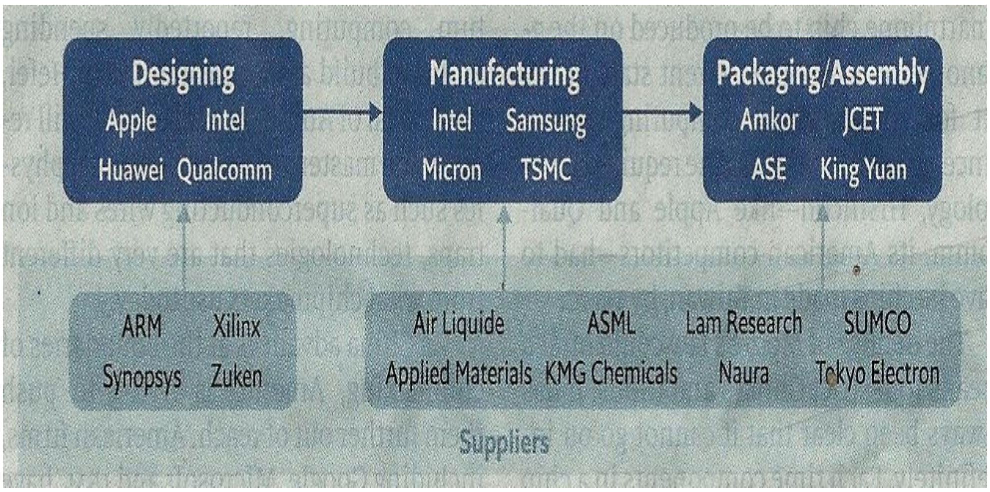
Strained silicon, high-κ/metal gate, finFET and the use of other semiconductor materials (e.g., Germanium) represented the main features of this scaling approach. All these new process modules were successfully introduced into high volume manufacturing. Additionally the industry itself underwent an unparalled restructuring process, during the last decennium. Several developments revolutionized the ICT industry the way business is done. The advent and success of the combination of fabless design houses and foundries revolutionized the way in which business was done and heralded the coming of the new semiconductor industry.



The restructuring of the ICT Industry, the Advent of fabless design houses and foundries as

- Fabless Advanced Micro Devices and Apple Inc.
- Memory Micron Technology and Samsung Electronics
- Foundries Global Foundries and TSMC

TSMC has plans has reaching out for even a 3nm or 2nm technology and supplies Intel as well as for IBMs (7LPP,Power110 and Z15 chips) who is contracting out as well to Samsung



2.1. Future technology challenges

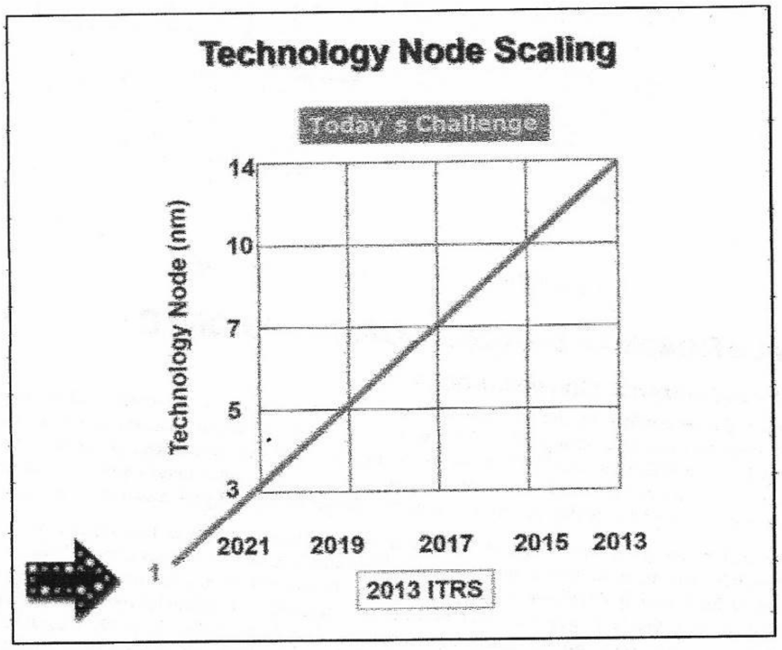
The next steps will be the integration of processor and memory, improving the bottleneck data in and out of the processor and is expected to enable improvements of 10-100 times.

Memory products have always been the leaders in transistor density (smallest feature pitch) and so it is not been surprising to realize that the solution to this problem came first from companies producing Flash memories. Flash products have been the technology leaders in pitch scaling since the mid-70's and they have already overcome the 2D limitations by aggressively implementing 3D memory cell strictures even 72-96 layers of Flash memory-cells have been demonstrated. It is anticipated that logic technologies will follow this transition.

Since the DRAM storage capacitor gets physically smaller with scaling, it is necessary to scale down significantly to maintain adequate storage capacitance thid means that dielectric materials with high relative dielectric constant (κ) will be needed. This material evolution and improvement will continue until 20 nm high-performance and ultra-high-κ (as Perovskite κ> 50-100) materials are realized.

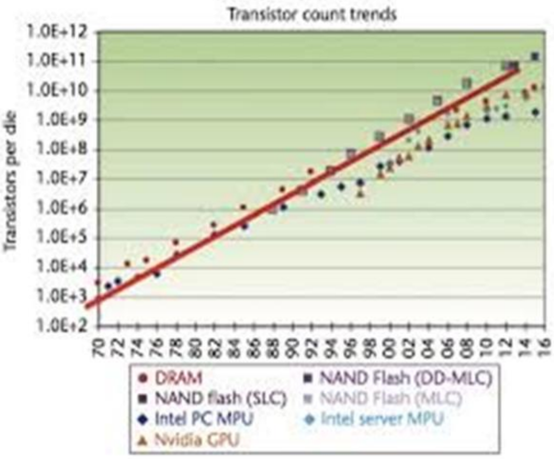
These technological solutions will assure continuation of Moore's Law for additional 10−15 years!

While new creative 3D transistors memory cells aso. are revolutionizing the way ICs are produced, comes an old problem again.



Nevertheless, just shrinking devices can result in unacceptable electrical performance. In addition, the necessity to use as many as 4-mask exposures to pattern a single layer is driving manufacturing costs towards levels no longer affordable. These considerations have driven the industry towards major innovations in device design as Flash memory products were becoming unreliable, because the physical size of the gate, where the bits were stored, was becoming too small (only few electrons could be stored). The industry is moving to three-dimensional (3D) flash memory to enable improved bit density on chips. Packaging is an additionally limiting factor in cost and performance for electronic systems.

To make ICs operating under "normal" thermal conditions the choice between frequency or number of transistors had to be made: Frequency was the looser and has stalled at few GHz since.



Processor performance does not have a first-order significance anymore. Future-range gains in processing performance may rather come from improvements in algorithms, memory, architecture, and interconnections.

We also have now reached many of the limits of human perception, so increases in requirements on display resolution and similar parameters will be limited in the future based on multimedia needs.

An emerging perspective in dealing with novel materials as III-V (GaN, InP, InGaP, etc.) or nano materials is the impact of their utilization. The utilization challenge as materials efficiency of incoming fab materials is <2%, or the treatment and abatement solutions will have to meet future regulatory requirements as well as increasing costs and restrictions on recycling, repurposing, and reuse.

Emerging research materials

As many novel materials are needed to satisfy in the long term the requirements for extending or even replacing CMOS, there still are substantial challenges for the development and integration of these alternative materials in the fields:

3D monolithic and vertical integration of high mobility and steep subthreshold transistors (III-V, Ge, 2D, carbon nanotube, complex metal oxides, etc.) for extending or replacing CMOS will be required.

We might see the emerging of non-charge-based memories and select devices (ferromagnetic, multiferroic, complex oxides, etc.) to replace present technologies and interconnects with improved reliability and electromagnetic performance at nanoscale as (CNT, novel interlayer dielectrics, metal organic framework and carbon organic framework) to replace copper, and integration on CMOS platforms, with flexible electronics or biocompatible functional materials will be required.

Beyond CMOS

The beyond CMOS era requests major research efforts. Nanoscale volatile and nonvolatile memory technologies to replace traditional SRAM, DRAM and FLASH in appropriate applications are necessary, for instance new types of resistive memories PCRAM (phase-change RAM), ReRAM (ResistiveRAM) or MRAM (magneticRAM).

Beyond MOORE

The scaling of information processing technology substantially beyond the ultimately scaled CMOS will oblige the search for of new ways of computing out of a plethora of options ranging from neuromorphic, approximating computing Graphene, CATOMs-(programmable matter, able to change physical properties between semiconductor and discrete molecules), molecular transistors (rotaxanes or Bencentenenthiole), Quantum dot, optical, QC computing to “Wet electronics” as DNA computing. Emerging is additionlly a new kind of computing using charges or even alternative state or hybrid state variables as spin, magnon, phonon, photon, or combination as electron-phonon, photon-superconducting qubit, photon-magnon.

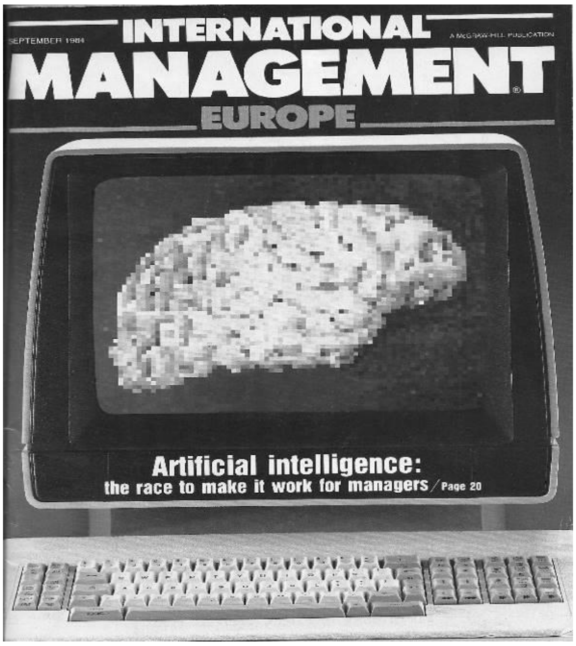
This will be accompanied by the growing importance of packaging, due to the necessity to develop reliable interconnects, and substrates for wearable electronics (bendable, washable), bio compatible systems for miniaturized implants, efficient integration of electronic and optical components; and integration of cooling systems for quantum computing.

The end of Moore is not a dead-end but could rather can be the beginning of a golden age of architecture, software, and materials.

3. Applications

3.1. Artificial Intelligence

In 1956, first academic gathering on AI took place and thirty years later in Sept.1984, it made it already to the front-page front page of journals.



Sept.1984

The main difference enabling was the exponential development of hardware and storage cost and possibilities. While earlier generations of AI and Expert systems, were fed by human expertise, the new generation with algorithms starts ignorant at beginning, learns, consuming huge amounts of data, to function autonomously.

AI is an omnibus term for a salad bowl of different segment and disciplines reaching from robotics, computer vision, to identify persons to self-driving car technology.

AI is may have a greater impact than anything since the arrival of computers and Internet. Therefore it is supported by intense economic interests.

3.2. Robotics

Since this subject will be covered in a special session let us refrain to some notes:

Robotics has made tremendous progress in the last years, with impact mainly in developed economies and driven by demographic fact of aging skilled population (esp. in Japan), increasing salary levels and last but not least its military potential. (NZZ 14.11. 2018)

3.3. Nano Medicine (Applications on the horizon)

Medical Applications, one of the most desirable developments could be products as "smart pill" for e.g. coloscopy

- Trailing of bacteria (magnetic)
- Medical care by automated diagnosis of common ailments
- Bathrooms (toilets as health indicators).
- Cancer detection by blowing on a mirror
- Small MR machines

The tradeoff is giving data of your intimate life for the price of a reduction of your life or health insurance may lead to the question "what is the cost limit for your therapy"?

3.4. HR (Human Resources)

The application range from screening candidates, determine pay, when to give a salary based on performance etc.

Companies like Transparenca, US, offer programs to monitor that there is no discrimination in HR. Humanyze provides people analytics to track employees by "enhanced" badges (micros, MEMS, accelerometer, data from calendars, email contacts to other persons differentiated by sex and analyzing the duration of speaking vs. listening. Hitachi has a similar product (officially developed against "karishi" = overwork). It means that your company may know more about you than you and your family. "

Amazon, Google and Microsoft already offer pre-trained models that corporate clients can use to build AI enabled systems.

The future may extend the technology to Mind reading fMRI. AI makes workplaces more efficient and much creepier.

3.5. Retail and Logistic

Another attractive field of application of AI and RFID is retail automation. Promising no waiting at the checkout, but also automated 3D of customer tracking, instantaneous discounting if customer not sure to buy, data of customer, less personnel, and profiling every single customer form eating habits to diabetes or pregnancy are evaluated features. However it is presently still an expensive investment,, but Amazon, Google or Alibaba and Baidu would not be so successful without AI. Targeting advertising forecasting demand, guiding robots through warehouses, optimize packaging and delivery (Amazon). Another example is preventive maintenance combined with IoT Inventory optimizations (2015 cost to companies more than 1000b$), including appliations as smart placement boosting efficiency by 20% (IHL Group research firm).

3.6. Privacy and AI

Think of examples as China with 600 mio. cameras, social evaluation system of e.g. your visits to your old parents or pedestrian behavior, speed of bicycle. It records not just facts of your past life but affects your future behavior.

Another example is the US Home land security system AVATAR (Automated virtual agent for truth assessment in real time). Avatar monitoring pupils dilation, and other uncontrollable reactions, or the "Consensus eye detector" which achieves an accuracy of today 86% with a future target of 90%. This is raising "dystopian" fears.

3.7. Some developments to think about:

About 85% of companies think AI will offer a competitive advantage, (but presently only 1 in 20 are using it actively). Most are more interested in the potential labor and cost savings than in more complex opportunities, whereas non-tech companies get worried and buy promising young firms.

AI will effect competition in business giving big companies an advantage through lower costs and prices, but at the same time put small companies at the edge of business.

All algorithms are discriminating. The proliferation of dystopian applications is much easier than for weapons of mass destruction.

There are AI no regulatory standards neither an up to date antitrust law up to now, but we may witness the first attempts by the DoJ in the US in the impending Facebook case.

3.8. Digital Dementia

Every activity changes brain the structure of brain, as the permanent use of navigation systems deteriorates the sense of orientation, the overuse of Internet verbal communication capabilities as the development of speech, the use of mobile phones calculators the mental arithmetic a.s.o.. The use of an average of 3,75 h per day mobile phone and other media might show long range paraphernalia as well as an increasing "multitasking epidemics". Digital media per se is not the problem but adequate use. (M. Spitzer, and Chr. Egger). The time frame is still too short evaluate the effects.

That Janus duality characterizes AI, devastating and exhilarating at the same time.

Until now, there is no great political answer, knowing that in history transition have been very bumpy! These developments underline the necessity for regulations to navigate through the Janus headed scenario, and to develop algorithms to make life better, richer, and more interesting (Max Ridley Oxford Univ.).

The synthesis with other technologies as IoT & IoE has opened an additional dimension with promising perspectives. The advent of foundries, fabless companies can now cover all the aspects of IoE. It would be a mistake to assume that the semiconductor industry is by now a mature industry, the new fabless/foundry ecosystem has opened the door to a flow of innovation available at very reasonable and affordable costs. The advent of the third phase of device integration plus the new capabilities associated with the introduction of revolutionary materials in the semiconductor industry will revolutionize how computers are built.

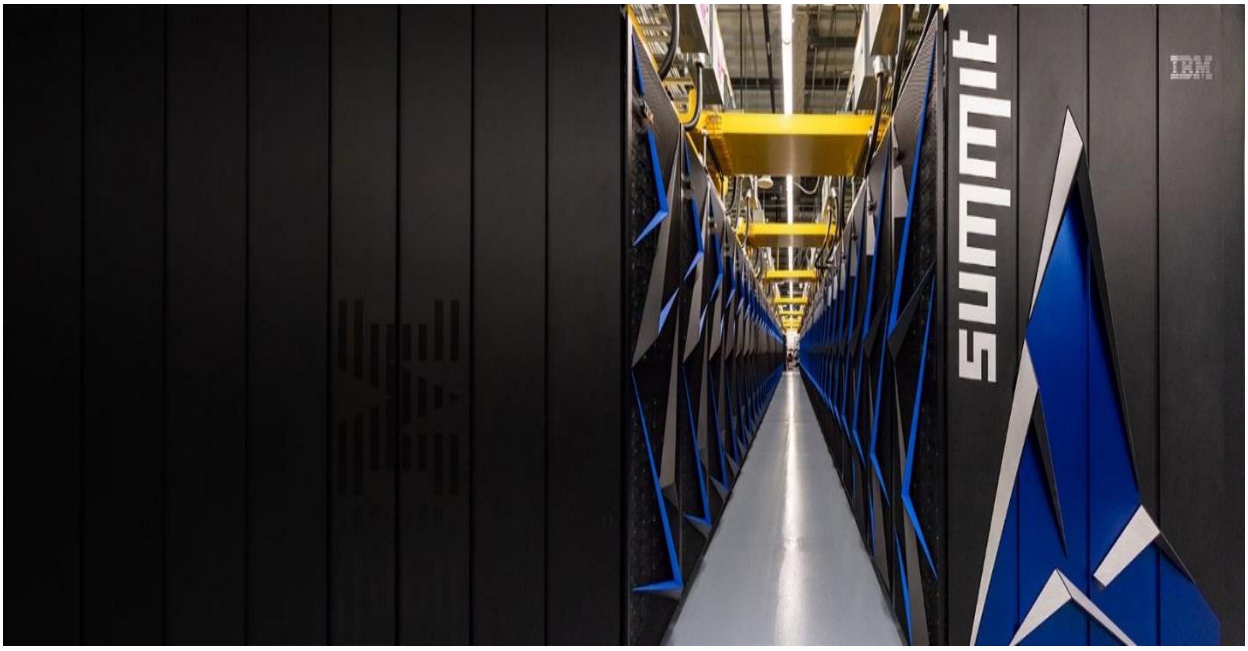
4. IoT

IoT is one of the most important developments supported by high anticipations. Since an IDIMT session will be devoted to this subject, we will restrain us to few comments.

The development of IoT also faces significant long-term challenges as improvements in the areas as cost-efficient energy harvesting using multiple sources to develop autonomous systems, energy storage and management, low power sensing, computing and communication, automatic network configuration, and security.

Supercomputer (Summit The IBM Supercomputer)

The reputation of supercomputing stems not only from their prestige and military application potential but also because it shows new developments and features that will triple down. Today US Department of Energy´s IBM supercomputer (143,5 petaflops) followed by another IBM supercomputer and two Chinese contesters is the fastest on earth (potential nonmilitary uses range from research on fusion energy, material science, AI, to weather forecast.)



IBM's Watson "The Debater"

A new feature of IBM's Watson is the "The Debate." It addresses the question: Can a computer with access to large bodies of information digest and reason on that information and understand the context and present it in natural language, with no human intervention?

In a public demonstration The Debater, speaking in nearly perfect English, replied on topics as shown.

To put things into proportion, we should remember that the human brain has 100 trillion synapses, 100billion neurons, 20W in comparison with the lowest power supercomputer in the world 1,5 M processors it is 1500 times slower while using 8MW (Livermore Labs simulation).

5. QC

The idea of quantum computing appeared in 1980, when the Russian Yuri Manin, first put the notion forward. The concept really got on the map, the following year, when Richard Feynman independently proposed it, but it did not attract much attention until 1994, when Peter Shor proposed an algorithm that would allow very large numbers to be factored much faster than could be done on a conventional computer (QC threatening many crypto protocols as SSL, HTTPS, AES, DSA, RSA etc. This theoretical result and the temptation of computers one billion times faster than today's fastest supercomputer triggered an explosion of interest in quantum computing. Thousands of research papers, mostly theoretical, have since been and continue to be published on the subject, at an amazing rate.

We have reviewed the basics of quantum physics in IDIMT 2000 and 2014, so let's in this session only recap some of the phenomena as the famous two slit experiment, Superposition or Entanglement, which cannot be understood applying classical logic

Experts estimate that the number of qubits needed for a useful quantum computer, one that could compete with your laptop in solving certain kinds of interesting problems, is between 1,000 and 100,000. Thus the number of continuous parameters describing the state of such a useful quantum computer at must be at least 21,000, which is to say about 10300. That's a number, much greater than the number of subatomic particles in the observable universe.

Error correction is still a practical unresolved challenge. Yet quantum-computing theorists are claiming that this is feasible, that the threshold theorem proves it can be done. They point out that once the error per qubit per quantum gate is below a certain value, indefinitely long quantum computation becomes possible, at a cost of substantially increasing the number of qubits needed.

The huge amount of scholarly literature generated about quantum computing is notably light on experimental studies describing actual hardware. The relatively few experiments that have been reported were extremely difficult to conduct, but command respect and admiration for the physicist involved. There is a tremendous gap between the rudimentary but very difficult experiments that have been carried out with a few qubits and the extremely developed quantum-computing theory. That gap is not likely to be closed soon.

QC has become a kind of self-perpetuating arms race, with many organizations seemingly staying in the race to avoid being left behind. Some of the world's top technical talent, at places like Google, IBM, and Microsoft are working with lavish resources in state-of-the-art laboratories, to realize their vision of a quantum-computing future.

Many people overlook that top researches have been working decades on QC without any practical results and that various scientific and journalistic publications feel obliged to relate or justify their work by claiming some relation with QC.

The famous question remains unanswered: When will useful quantum computers be constructed? The most optimistic experts estimate it will take 5 to 10 years. Ones that are more cautious predict 20 to 30 years. Similar predictions have been voiced, for the last 20 years, but they have been moving targets.

6. Communications

We take it as granted that communication technology will provide the infrastructure as the horse pulling the chariot we are all sitting on for future developments. One of the pending implementations is 5G, so a short overview could be useful.

Pros are:

- Data rates up to 20 Gbps (about 100 times 4G).
- Latency below 1msec (30-70 msec at 4G).
- About 90% lower power consumption, so some IoT devices (one button cell for years).

Cons:

- Electromagnetic waves in the frequency range of 5G are more strongly absorbed by the atmosphere and have lower penetration, therefore, the network cells are smaller than at 4G which means many more stations are needed (about every 100 meters), making a nationwide coverage very expensive.
- There is also skepticism and ambiguity from an environmental and medical perspective, calling 5G the most serious intervention in nature in human history and the 5G risk greater than climate change. WHO classifies the cancer risk of cell phones as 2B (limited evidence of carcinogenicity,) whereas CDC, FDA, FC, NIH see no health risk from cell phone use.

The expected market of 33 B$ in 2026 is luring companies into this huge investment. (Leaders guide Oct 2018). Especially for applications as Industry 4.0, IoT, Factory Automation, Virtual / Augmented Reality, Autonomous Cars, Smart Homes, Smart Cities, Digital Healthcare, etc. the improved latency is essential.

The attitude of government is ambiguous. Some are pushing 5G not to fall back in the technology race. In June 2019 Germany has auctioned the frequencies 2GHz and 3GHz for 6,5B€ with a planned implementation in 2021 and 2026. In contrast, Australia twice banned Huawei's 5G, Brussels (city) and Geneva the expansion of 5G in April 2019. US bans Huawei to avoid dependence on a Chinese infrastructure network mainly for espionage exposure concerns.

While we discuss 5G, 6G is already in discussion at international congresses

7. Further "Lateral" Challenges

We may face substantial environmental, safety, health and sustainability challenges because of a possible impact on health and environment by emerging materials (III-V materials, perfluorooctanoic acid (PFOA). Driving green chemistry and engineering concepts considering their impact on sustainability can become a criteria for future technologies, and future regulations.

An international comparison of education and human resources shows future challenges heightened by increasing East-West competition. Points arising were:

Shortage of "hard core" students esp. in mathematics, physics (MINT) in Western countries. Other issues are days in school 178 vs 251, or Silicon Valley's universities having 50% foreign born students on H1B visa, and 50% of PhD students or at the East coast especially Univ. of NY up to 100%.

US is better in design and production of high-end chips, but China has launched an incentive program to attract top people from Taiwan.

What can the West offer to meet that challenge? Proposals reach from an improved education system that promotes excellence, the "appetite" for creativity to the famous "Ingenieurkunst" of Germany even missing in Silicon Valley.

8. Summary And Outlook

From the users perspective the outlook is very promising as he can expect continued progress for the next 5 to 10 years. However, intensive R&D activity behind the scene will be necessary to maintain more Moore and constitutes a big effort from the ICT industry.

In spite of the fact that a dependable weather forecast for three weeks is already impossible, we have tried to enumerate some of the emerging trends for the coming years:

- Continuing industry restructure
- New materials
- "Golden" age of architecture and software
- 3D technologies from chip to printer, production and medicine
- Interconnection and Communication improving dramatically
- First driverless cars (US)
- First city w/o traffic lights
- Robotic pharmacist or equivalent applications
- One trillion sensors
- Supercomputer in the pocket
- IoT pervasive into daily life
- 80% of population will have digital presence
- Start of brain wave communication

All this in the challenging scenario of:

- Population growth, predominantly in low education level areas, concurrent with increasingly difficult productivity increases in rich countries and a shortage of experts.
- Increasing influencibility by technology and impact on the political system
- Speed of adoption may be too fast for regulation and education system
- Protection of private sphere disappearing
- Cloud, AI and 5G/6G among the most important technologies
- No fundamentally new technology ready for mass production in sight
- A time window of 10-15 years of more Moore and beyond Moore full of improvement for the user implementing more scaling and parallelism.

We can look forward to fascinating but challenging times.

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DIGITAL ECONOMY AND INDUSTRY 4.0

DIGITAL ECONOMY AND INDUSTRY 4.0

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Keywords

Digital economy, industry 4.0, Internet of Things, cyber security, cyber security risks

Abstract

The development and penetration of information technologies (IT) into our everyday life changes the paradigm of entire society. The impact of IT integration on our life is reflected both in how we use information technologies and in society's ethics. However, expected positive effects, such as higher labor productivity, the elimination of routine work, better control, etc., come with limitations and risks. This article points out some aspects of the security of devices that constitute an integral part of the Industry 4.0 concept. Security gaps are especially in remote access to such devices, the use of communication protocols with lower security and the way passwords in text form are stored.

1. Introduction

The development of information and communication technologies (ICT) significantly impacts the further development of our globalized society. The bigger the impact and influence on entire human society is, the more information technologies become its integral part (Teplý, Kvapilíková, 2017). Some thoughts about the inseparability of information technologies from human society have already been presented e.g. in Carr's elaboration (2004) where the author compares the use of ICT in organizations' utilities and the overall impact of ICT on the economy to the industrial revolution's phases – steam in the 19th century, electricity in the 20th century (Kelly, 1998). ICT become a necessity for modern, dynamic activities of society that finds itself at a stage of major changes. When looking at the development of the past 20 years, it is obvious that the economy's dynamics fluctuate and that high expectations are put on ICT that are supposed to resolve, or at least considerably help to resolve, society's problems (Basl, Sasiadek, 2017).

The current transformation caused by a massive onset of digitalization includes practically all areas of the economy and social life (Basl, 2017). The main approaches and trends concerning industrial production and its links are available e.g. in (Basl, Doucek, 2019). Research on the impact of information technologies on the development of net production and thus on the environment and the concept of permanently sustainable development or sustainable development is another important trend (Bruntlandová, 1991). This trend is connected to the social responsibility of both organizations and individuals. In the current closed system of finite resources of a globalized society, organizations contribute, by being socially responsible, to sustainable development, [5] to a

[5] The first definition of sustainable development from the Report for the UN World Commission on Environment and Development (WCED) called "*Our Common Future*" and presented in 1987 by former Norwegian Prime Minister Gro

balance between three basic interconnected areas of life and to sustainable development (Figure 1), thus jointly representing a certain model as well as a vision of society's development.

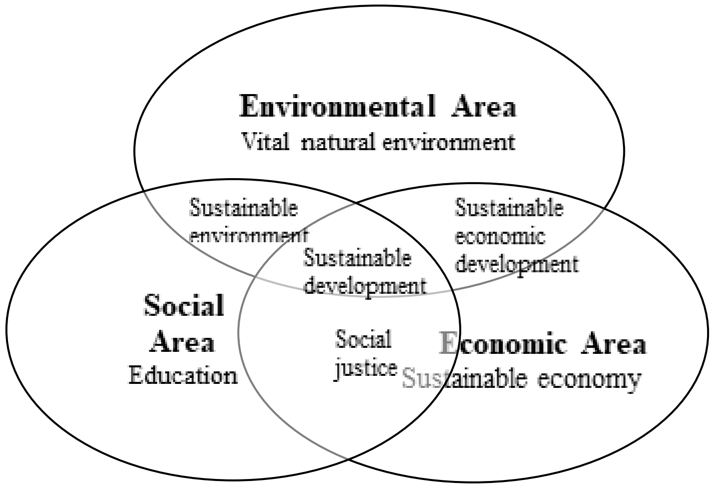

Figure 1: The intersection of the basic pillars of Corporate Social Responsibility and Sustainable Development (Moon, 2010)

The basic pillars of social responsibility and sustainable development are as follows:

- **Economic growth** – businesses should be transparent and have a positive relationship to investors, customers, suppliers and other business partners, and the impact on the regional, national and global economy should be monitored (Maryska, 2009, Maryska, Novotny 2013), including employment development and the fight against corruption;
- **Environment** (a sustainable natural balance) – organizations realize their impact on the environment and its ecosystems (water, land, air) and their activities will thus burden the environment as little as possible;
- **Social area** (social progress) – this includes an approach to own employees in terms of living standard, health, safety, education, cultural development and regional development support in these areas.

This trend, nowadays reflected by attempts to influence the environmental development and to galvanize society to protect the environment, represents a space and opportunity for applying information technologies.

Potential threats and limitations of used and implemented information technologies lie in the functioning of information systems. We all can surely imagine a failure of the systems that concern our everyday life – from banking systems, to local, long-distance and transcontinental transport control systems all the way to strategic and air defense systems. We have been bedazzled by ICT possibilities for some time now, but let's look at real ICT threats and limitations. The areas presented below are very closely connected. The first one concerns the maturity of people operating information systems – their ethics. (Sigmund, 2014, 2015) Security is another area.

Harlem Brundtland says: "Permanently" sustainable development is such development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland, 1991).

In this article, we would like to also present the risks of a blanket use of information technologies, e.g. in the form of Internet of Things.

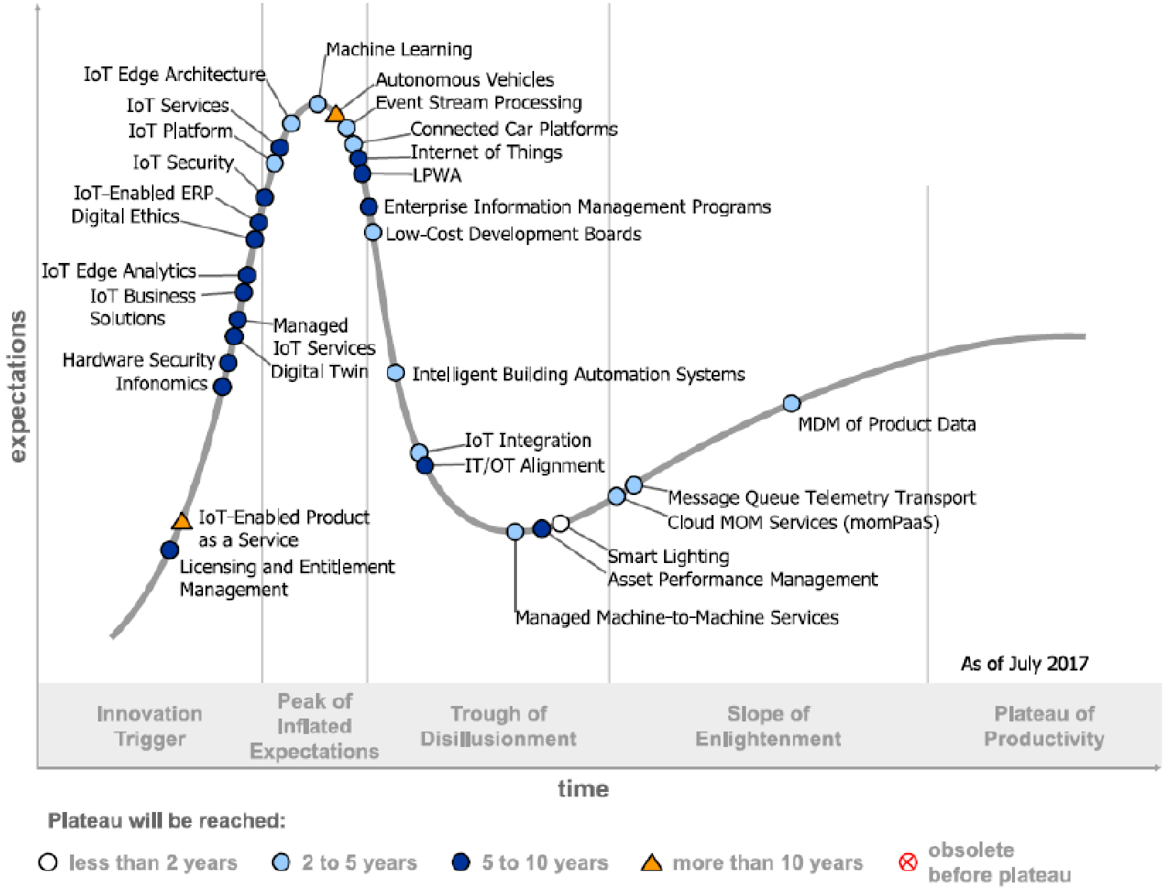

Figure 2: Hype Curve for Internet of Things 2016 (Source: Gartner, 2016)

Mařík describes the concept of security of Industry 4.0 applications (2016): "The safety and reliability of Industry 4.0 systems must be understood in a comprehensively systematic way — from data and communication security at the lowest level, on through infrastructure reliability and security, on out to global system security at the level of manufacturing plants or chains of them, including the upholding of individuals' information privacy and of intellectual property rights."

Such defined cyber risks represent a new challenge but also new limitations with which we will have to deal in the future when implementing ICT. The most common risks that we usually deal with concern information technologies – the time of their operation, reliability – i.e. their technological aspect.

This is also proven by the fact that security risks of Industry 4.0 are often discussed. These risks usually stem from the wireless transmission of data between production and monitoring devices and their sensors that implement the idea of Industrial Internet of Things (IIoT). This usually concerns the hacking of this type of connection or device or a potential interference due to the operation of other electronic and electric devices. A rather important aspect of processed data is the complexity of their security (Marik, 2016). This is about ensuring the integrity of transmitted and processed data. This fact considerably affects the reliability and completeness of provided data collected through sensors and stored in data warehouses or lakes. Providers try to ensure full data integrity that cannot be compromised in any way during data transmission. The limit here is set up in a way that if we receive data that are somehow distorted (a defective sensor, a wrong temperature measurement – e.g. the sensor sensitivity is lower than required, the sensor is worn out due to the environment or measurements are wrong due to a low battery voltage), the automated control system with fixed required values then directs the controlled system in the wrong direction. This factor may lead to false (inaccurate, detached from reality) virtual reality – a digital image of the controlled system where information flows will not display actual material or energy flows. Control based only on data from sensors may lead to loss of confidence in information systems that monitor real phenomena through censors as well as in the data stored in these systems. The use of artificial intelligence elements without effective control by man may destroy the entire controlled system. As an example, we could mention two fatal Boeing plane crashes.

According to Mařík (2016), a more comprehensive concept of security in Industry 4.0 is based on taxonomy as mentioned in Lezzi's Lezzi, Lazoi, Corallo, elaboration (2018). Here, cybersecurity with respect to Industry 4.0 is considered a unity of systematic vulnerability, cyber threats, from which arise risks and measures adopted to protect company assets. Another matter that organizations must deal with in connection to security in cyberspace is the cybersecurity management system. They must apply best practices in the form of guidelines for implementing cybersecurity reference models (Doucek, Novák, 2018) and propose and implement countermeasures in the form of security projects (Novák, Doucek, 2017).

Another and completely different security dimension includes comprehensive protection of a company information system as a whole and company assets through the functions of the information security management system (ISMS). It still holds true that the security of the entire information system of a company is as strong or weak as its weakest link.

2. Methodology

The fundamental approach to collecting data used in this article is that of studying subject literature and comparing the founded facts, both among each other and with our mental models in the area of security in Industry 4.0 and digital economy, the circular economy included. Added value of this article is that it does not promote the information technology but it also presents the dark sides of it in business and every day´s life.

The results of our research could fill up many pages, but in this article, we would like to focus only on the risks of IoT implementation in small and medium-sized businesses (van Kranenburg, 2018). According to Flatt, Schriegel, Jasperneite, Trsek, Adamczyk (2016) typical threats for cyberattacks are:

- Direct attacks on external accesses;
- Indirect attacks on the IT systems of the service provider for which the external access has been granted;
- Unknown attack vectors without detection capabilities enabled by unknown vulnerabilities (or zero-day exploits);
- Non-targeted malicious software which infects components and impairs in their functionality;
- Intrusion into neighbouring networks or network segments (for instance, the existing office network).

In our article we will focus on potential direct external attacks on select devices. According to McAfee (Wineberg, 2015) the number of attacks on IoT devices will go up considerably. It is because the number of these devices will increase, they will be less secured and, last but not least, the data generated on such devices will be important.

3. Results

Why are we focusing on SMEs? Large and transnational companies have large teams of specialists in information technologies, communication, security, system architecture, network elements, administration aspects, data storing and processing and many other matters. Small and medium-sized businesses, especially micro firms, cannot hire highly specialized professionals mainly for financial reasons and thus the risk of increased and potent cyber threats due to the implementation of IoT elements in their information systems is much higher and will have a much more important impact on these systems.

One of the main technology-oriented results concerning IoT security is the identification of threats that may impact the functionality of company information systems through the integration of sensors and data that are recorded and transmitted by these sensors. These company information systems typically include different types of internet cameras, thermostats or sensors on production lines. The method of transmission of data from standard commercial devices is often attacked by hackers.

What are IoT, automation and smart devices: Electronic devices designed to perform specific tasks and operate within other devices or management systems with scope multiple technology fields from automation on assembly lines to the smart sensors and devices for home use. Current challenges of IoT devices are mainly:

- Power consumption is one of the concerns when deploying variety of electronic device within enterprise or at home.
- Low power consumption system on chip (SOC) requirements define computational and processing resources of small CPUs unites, that are not capable electively handle processing overhead introduced with strong end-to-end encryption and authentication schemes.

The most common IoT implemented devices are different types of sensors, smart cameras, thermostats big data, etc. Primary security concern on the default IoT use case, smart sensors or data generating device, smart IP cameras included are meant to be available 24/7 sending data either to on-premise server, but primarily to vendor cloud environments. In order to connect to the cloud environment, the internet access is required, very often are smart IoT devices exposed directly to internet on public IP address space that translates to condition where the device security relies on proper configuration and firmware security. Smart devices may hold more then one network interface let it be, Ethernet and Wi-Fi or Broadband 3G / 4G mobile internet connectivity. **Network exposure is a critical element to the IoT security from perspective of entry point the technology solution which smart devices are part of**. Exposed configuration / management web portals, ssh or even telnet services or exposed communication bus interfaces, Onboard Data Port – car hacking.

The following text will focus on a potential direct attack.

SMEs very often use internet cameras and thermostats (Wineberg, 2015). Their connection to a computer network comes with the following risks in particular. The main identified risk in the case of cameras is:

- The backup of information about login passwords in text form;
- The use of the protocol http and not https for communication; the use of this protocol in some devices is optional;
- The use of User Datagram Protocol for communication with users.

Identified weaknesses in the case of thermostats are very similar:

- The use of the protocol http and https or only the protocol http for communication.
- Open wifi for initial pairing.
- No certified pinning.

4. Conclusion

The Industry 4.0 concept and the follow-up concept of digital economy and the massive implementation of artificial intelligence in business models (Maryška, Doucek, Sládek, Nedomova, 2019) and thus in everyday life changes the paradigm of society's functioning. Up until now we did not fully understand the growing dependency of people from Western society on information technologies (Teplý, Klinger, 2018). However, this dependency will become critical for our civilization after the implementation of data-collecting sensors and follow-up structures of data stored in cloud technologies and distributed in the computer networks practically of the entire planet. This dependency will be critical not only in terms of technologies but also in terms of ethics – who will have the right to monitor practically anything about people and to evaluate and make decisions based on these data – morality and the system of civil and life values.

The Industry 4.0 concept and follow-up innovations do not only change the level of implementation of information technologies but also society as a whole, including its fundamental values. Only an integral development of technologies and human values is able to ensure a harmonious society in the future.

5. Acknowledgement

Paper was processed with contribution of the Czech Science Foundation project GAČR 17-02509S and with support from institutional-support fund for long-term conceptual development of science and research at the Faculty of Informatics and Statistics of the University of Economics, Prague (IP400040).

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THE PREMISES FOR THE DEVELOPMENT OF THE DIGITAL ECONOMY IN THE CZECH REPUBLIC

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Keywords

Digital economy, ICT professionals, ICT technicians, ICT specialists, ICT risks

Abstract

Concepts of Industry 4.0 and digital economy require higher skills and knowledge in information technology (IT). Building up of the new information technology based economy without qualified set of employees in IT is not feasible. Our contribution maps the development of number of ICT professionals in the Czech economy in the period 2014 – 2017. It compares collected data about the Czech reality mainly with data of V4 countries (Czech, Republic, Hungary, Poland and Slovak Republic) and also with leading and the most lagging countries in the European space. Lack of IT qualified people represents a risk for further development of the information society and the digital economy as well. Results present that the number of ICT professionals is increasing in the Czech economy, but in the comparison to leading countries in Europe shows that this trend is not sufficient. Gender analysis of ICT professionals shows that share of women in ICT Professionals is permanently decreasing.

1. Introduction

According to politicians, economists and captains of large corporations, we are now in the first phase of a digital transformation of the economy, which is the implementation of a new concept of production – so-called Industry 4.0 (Basl, & Doucek, 2018). The implementation of Industry 4.0 includes another change - the application of artificial intelligence. This trend in the economy of a globalized society is expected to continue. The readiness of Czech society for this new trend, even in comparison to the world trend, is shown e.g. in (Basl, Doucek, 2019). This article outlines the trends in the further development of societal digitalization and points out some risks of a blanket application of information technologies in the economy. It mainly concerns security risks (Maryska et al., 2019) and insufficient ethical principles of people who will use and especially manage these technologies. The ethical and moral dimension of information technologies, in particular the understanding and implementation of this dimension, rather lags behind the technological and economic dimension (Sigmund, 2015; Smutný, 2016). We can see the potential of technologies in terms of higher labor productivity (Lin, & Chiang, 2011; Ballesteros-Carrasco, 2013; Hanclová et al, 2014; Manďák, J., & Nedomova, L., 2014) and an overall higher production volume, yet we continue to underestimate their impact on the environment, on the meaningfulness and fulfillment of human life (will the Industry 4.0-based economy need less, but more qualified, workers?) and especially on the education system. Although it may seem unimportant right now, we cannot continue with a digital transformation of the economy without workers educated in information technologies. If we become mere users of applications, the purpose and functionality of which we understand only from a user's point of view, and resign on our active role in the development of information systems and applications for the digitalization of the economy, we will no longer be active creators of a new society and will become mere passive, easily manipulated elements that have no influence over its further development. A lack of qualified IT professionals represents a distinct potential risk for our entire Central European society (Rippel, & Teplý, 2011). Only a society that will have a very good IT education, which is focused not only on the technocratic aspect of these technologies but also on their ethical dimension, has a chance to create a well-balanced, harmonious society with minimal social conflicts and consequent crises that the widening of the social gap causes also due to the implementation of information technologies.

2. Methodology and Data Collection

The basic point of departure and the source of data for this article were data from public sources, mainly data from the Czech Statistical Office, and sometimes also data from Eurostat, World Bank and OECD databases. To classify the professions of ICT Professionals, we used the CZ ISCO classification without any transformations and modifications because the data presented in this article are from 2014 and on. The methodology of the classification of ICT professions was valid for 2014 and the following years. If we wanted to present results from previous years, i.e. in particular results from before 2010, we would have to use data convertors between the KZAM-R classification and the CZ ISCO classification. We analyzed the following profession categories (ISPV, 2019):

- **ICT Specialists** (CZ-ISCO 25) who research, plan, design, write, test, provide consultations and improve IT, hardware and software systems and related concepts for specific applications; prepare related documentation, including principles, policies and procedures; design, develop, supervise, maintain and support databases and other information systems in order to ensure optimal performance and data integrity and security. The professions in this class are subdivided into the following groups:
    - Software and Computer Application Analysts and Developers (CZ-ISCO 251).
    - Database and Computer Network Specialists (CZ-ISCO 252).

ICT Technicians are another group that represents a major percentage of the number of ICT workers.

- **ICT Technicians** (CZ-ISCO 35) who support the regular operation of computer and communication systems and networks and perform technical tasks related to telecommunications, the transmission of image, sound and other types of telecommunications signals on land, on the sea or in the air. The professions in this class are subdivided into the following groups:
    - ICT Operation and User Support Technicians and Related Workers (CZ-ISCO 351).
    - Telecommunications and Transmission Technicians (CZ-ISCO 352).

Both these groups of professions are analyzed in this article as the category of ICT Professionals. For the purposes of this article, we purposely excluded from the number of ICT Professionals the category CZ ISCO 133 – ICT Managers – because we want to analyze a change in the number of executing IT workers and not an increase in administration and administrative structures.

We analyzed our data, using MS Excel tools and statistical functions. We estimated trends, using linear extrapolation of identified functions.

Our analysis results are presented mainly for the years 2014 – 2017 due to the following three reasons:

- We have already presented the analysis of previous years in articles (Doucek, Nedomova, & Maryska, 2015), on which we follow up;
- Data from 2018 have not yet been entirely processed, and therefore some analyzed indicators are not yet available;
- The classification of job positions in the Czech Republic changed at the beginning of 2011 and the KZAM-R methodology was replaced with the CZ-ISCO methodology. Therefore, a comparison of values by profession over a longer period of time could be incorrect and misleading.

3. Results

3.1. ICT Professionals in the Czech economy and as compared to Europe

Total number of ICT Professionals

The Czech economy has already joined developed economies, even though it has not yet quite dealt with the heritage of the past. Some of the typical characteristics of the development of society in Europe in particular include a share on international exchange of goods and services as well as an increase of labor in the area of intangible assets – i.e. labor in the area of information technologies. The Czech Republic participates in cooperation with other countries in the area of information technologies with a wide variety of offered services as well as with the number of ICT Professionals (Maryska, Wagner, 2015). The number of ICT Professionals in the Czech Republic keeps growing. The analysis of the years 1993 – 2013 is provided in (Doucek, Nedomova, & Maryska, 2015). The analysis of the years 2014 – 2017 also confirms this trend – Figure 1.

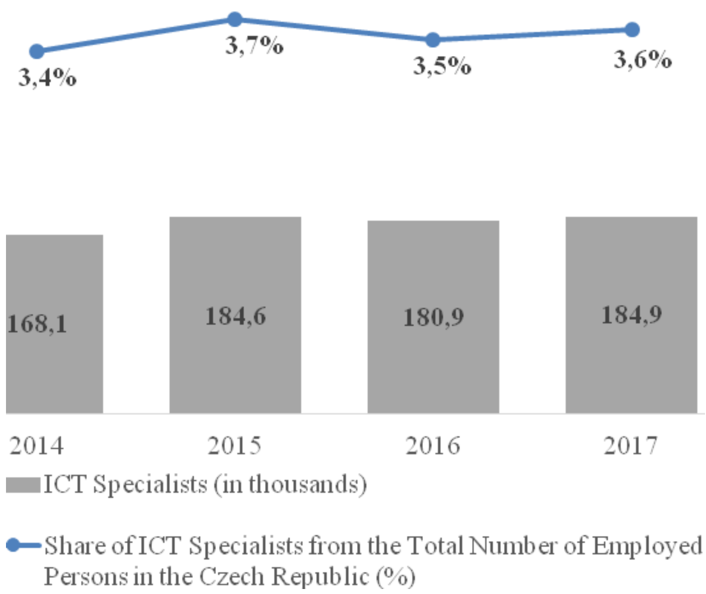

Figure 1. The percentage of ICT Professionals from the total number of employees in the Czech Republic (Data Eurostat, 2019; authors)

In 2017, there were 184,900 active ICT Professionals, of which 17,200 were women and 167,700 men. These ICT Professionals worked in all economic sectors. It is interesting that while in 1993 – 2013 this trend had been approximated with the straight line y = 4.1506x + 42; with the coefficient of determination $R^2 = 0.8792$, i.e. almost 87.9% (the trend line was significantly affected by a drop in the number of ICT Professionals in 2004), we approximated the same trend in the years 2014 – 2017 (see Figure 1) with the straight line y = 4.67x + 167.95; with the coefficient of determination $R^2 = 0{,}583$, i.e. 58.3 %. The trend in the compared periods is very similar. The years 2014 – 2017 show a slightly faster trend in the number of ICT Professionals in the Czech economy than that in the previous period. The slowdown of this faster trend had a negative impact on the number of ICT Professionals in 2017 that shows a drop by 3,700 ICT Professionals as compared to 2016. The trend in the number of female ICT Professionals in the Czech Republic can be estimated as y = 0.17x + 17.8; i.e. the growth trend is practically zero; with the coefficient of determination $R^2 = 0.0249$, i.e. 2.5 %. The low coefficient of determination of the future trend is a result of a drop in the number of female ICT Professionals in 2016. The values oscillate during the analyzed period and this is why the trend line is not conclusive.

Comparison with Europe

Let's see how the Czech Republic is doing as compared to other European countries. For this comparison, we mainly chose the Visegrad Four (Czech, Republic, Hungary, Poland and Slovak Republic) and also included two countries with the highest percentage of ICT Professionals in the economy and (Finland and Sweden) two countries with the lowest percentage of ICT Professionals (Greece and Romania). The comparison of the number of ICT Professionals in select countries is provided in Table 1.

Table 1: Number of ICT Professionals in the economies of select countries (in thousands)

Country	**2014**		**2015**		**2016**		**2017**	
	Females	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**
Finland	33,7	122,6	35,3	122,4	35,6	126,7	36,6	131,6
Sweden	53,0	223,9	55,6	238,2	64,7	246,1	69,6	263,2
EU28	1 193,7	6 286,0	1 250,0	6 487,0	1 372,0	6 853,0	1 445,1	6 940,7
Czech Republic	17,3	150,8	18,2	166,4	20,2	160,7	17,2	167,7
Hungary	16,8	127,4	18,1	134,5	20,7	137,4	14,1	143,6
Poland	57,2	355,9	57,3	366,4	62,6	369,2	67,1	384,9
Slovakia	7,8	57,5	7,8	60,3	6,8	66,4	9,7	60,9
Greece	7,9	38,2	5,8	37,9	6,5	44,7	6,6	53,9
Romania	30,1	109,8	43,8	117,0	44,1	123,6	47,7	137,7

(Eurostat, 2019)

Here we can see the trend in the number of ICT Professionals in Visegrad Four countries and compare it with that in other select European countries.

Table 2 shows the trend in the number of male and female ICT Professionals during the years 2014 – 2017.

Table 2: The trend in the number of male and female ICT Professionals in select EU States and V4 countries

Country	Trend Approximation	
	Females	Males
Finland	y = 0,9x + 33,05 R^2 = 0,9332	y = 3,13x + 118 R^2 = 0,8709
Sweden	y = 5,89x + 46 R^2 = 0,961	y = 12,58x + 211,4 R^2 = 0,9825
Czech Republic	y = 0,17x + 17,8 R^2 = 0,0249	y = 4,5x + 150,15 R^2 = 0,5703
Hungary	y = -0,5 5x + 18,8 R^2 = 0,0668	y = 5,15x + 122,85 R^2 = 0,9778
Poland	y = 3,5x + 52,3 R^2 = 0,9022	y = 8,98x + 346,65 R^2 = 0,9351
Slovakia	y = 0,47x + 6,85 R^2 = 0,2506	y = 1,63x + 57,2 R^2 = 0,3193
Greece	y = -0,32x + 7,5 R^2 = 0,2226	y = 5,39x + 30,2 R^2 = 0,8599
Romania	y = 5,31x + 28,15 R^2 = 0,7814	y = 9,03x + 99,45 R^2 = 0,9641
EU 28	y = 0,8762x + 1096,2 R^2 = 0,9814	y = 2,33x + 6059,2 R^2 = 0,9542

(Data Eurostat, 2019; authors)

The comparison of V4 countries shows that Poland has the highest increase in the number of ICT Professionals. The coefficient of determination is also one of the highest (95.5%). Therefore, we can conclude that thanks to the increase in the number of ICT Professionals, Poland is creating good conditions for improving the informatization of society. When looking at the table, we can see that Sweden - as one of the European superpowers in the informatization of society - has the highest increase in the number of ICT Professionals. Sweden and Finland belong among the countries with the highest penetration of ICT into their citizen's common life and economy. The trend in Finland is rather conservative, without any big increase in the number of ICT Professionals in the economy. As mentioned above, Poland shows the highest increase in the number of ICT Professionals among V4 countries. The Czech Republic and Hungary show a similar trend, but the number of ICT Professionals in Hungary is higher than that in the Czech Republic. The increase in the number of ICT Professionals in Slovakia is the lowest; however, what is positive is the increase in the number of female ICT Professionals during the analyzed period. The number of ICT Professionals in Romania shows a very positive trend. It is one of the ways of building an information society and a digital economy.

In terms of gender, no major revolution in Europe is happening or coming. The number of female ICT Professionals is permanently lower than that of male ICT Professionals. The number of women in the economy of Hungary and Greece went down during the analyzed period. The trend estimates were considerably affected by the lower number of female ICT Professionals in Hungary in 2017 as compared to 2016. A drop in the number of female ICT Professionals in 2015 as compared to 2014 was affected by the identified trend in Greece. Since the coefficient of determination in Hungary is only 6.68%, it seems that the permanently growing trend during the years 2014 – 2016 turned into a drop in the number of female ICT Professionals. Sweden, Romania and Poland show the highest increase in the number of female ICT Professionals. However, this trend did not surpass the trend in the increase of male ICT Professionals in these countries.

Another indicator in terms of a digital economy and the implementation of Industry 4.0 principles in entire society that is worth mentioning is the relative share of ICT Professionals on the total number of employees in the economy. These data for the years 2014 – 2017 are provided in Figure 2.

The statistical data in Figure 2 compare the number of employees in the economy and the number of ICT Professionals. Therefore, the drop in the share of ICT Professionals does not have to be an immediate negative thing since as the economy grows, there is mostly a focus on professions other than ICT Professionals.

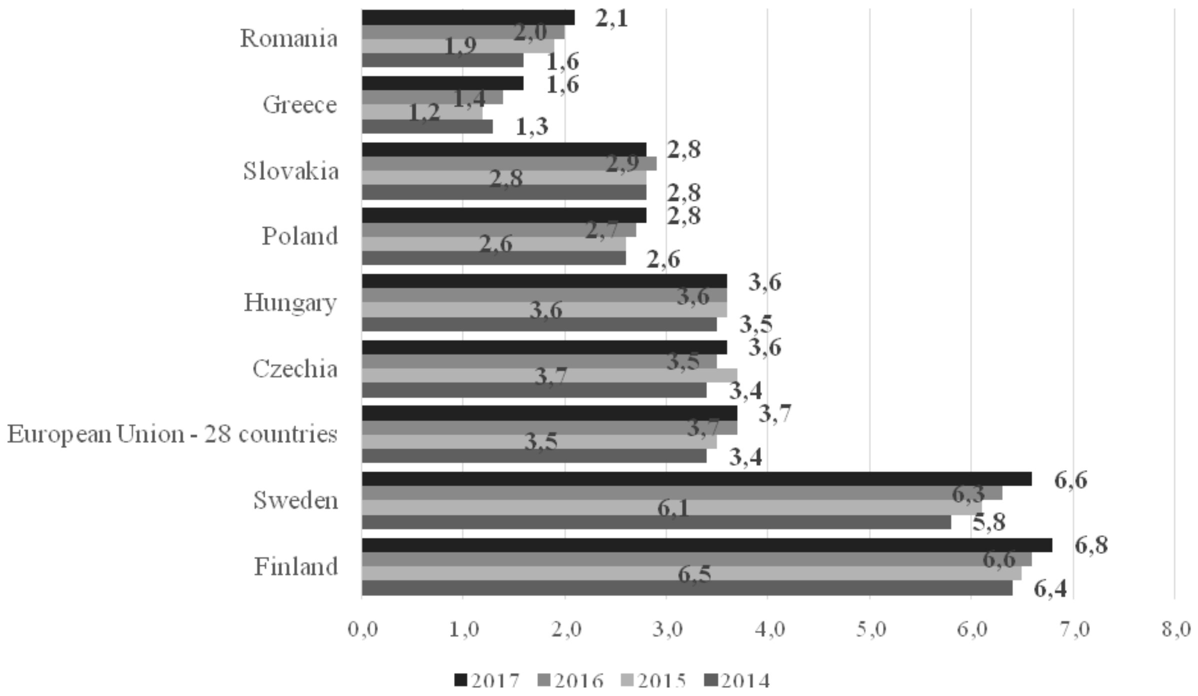

Figure 2. The percentage of ICT Professionals from the total number of employees in select European countries (Data Eurostat, 2019; authors)

It is typical that the percentage of ICT Professionals in Finland and Sweden, which are leading European countries in penetration of ICT into the economy and have a strong ICT industry, is over 6.5% of the total number of all employees and that this percentage kept going up during the analyzed period. As to V4 countries, the number of ICT Professionals in Hungary and the Czech Republic approaches the average in the EU. Slovakia and Poland with their 2.8% share in 2017 lagged behind these countries by 1.2 percentage point. The number of ICT Professionals in Romania and Greece is considerably below the average of the European Union. The dynamics in Romania during the analyzed period (Table 2) assure the development of a digital economy in this country.

3.2. ICT Specialists and Technicians in the Czech Economy

A permanent and harmonious growth of the economy and ICT services requires a balance between ICT Specialists (CZ-ISCO 25) and ICT Technicians (CZ-ISCO 35). It is a balance between ICT development and services and the support and communication backup of these services.

ICT Specialists CZ-ISCO 25

As their job description implies, ICT Specialists analyze processes, develop software and ensure the operation of databases and computer networks. The trend in their number (in thousands) in the Czech economy is shown in Table 3.

Table 3: Trend in the number of ICT Specialists

	2014	2015	2016	2017
ICT Specialists (CZ-ISCO 25) total	63,4	66,6	71,9	71,9
Software and Computer Application Analysts and Developers	45,0	45,2	46,7	47,8
Database and Network Specialists	18,4	21,4	25,2	24,0
ICT Managers, Engineers and other Specialists	20,3	19,7	16,7	16,5

(CZSO, 2019)

Table 3 shows an increase in the number of ICT Specialists during the years 2014 – 2016. Their number stagnated in 2017 as compared to 2016. This stagnation is mainly a result of a drop in the number of workers in the category CZ ISCO 252 Database and Network Specialists. The number of workers in CZ ISCO 251 Software and Computer Application Analysts and Developers went up. This trend is positive because:

- It shows an increased need for Computer Application Developers;
- The lower number of Database and Network Specialists may be a result of the concentration of these services in large companies or centers outside the Czech Republic.

Moreover, Table 3 also includes data about a drop in the number of ICT Managers during the analyzed period by approximately 20%. This fact also indicates a higher concentration of ICT services and development in the Czech Republic during the analyzed period.

ICT Technicians CZ-ISCO 35

ICT Technicians mostly ensure and support the processes of user support ICT – CZ ISCO 351 and communication – CZ ISCO 352. The trend in the number of these workers (in thousands) in the Czech economy is shown in Table 4.

Table 4: Trend in the number of ICT Technicians

	2014	2015	2016	2017
ICT Technicians (CZ-ISCO 35) total	68,9	61,5	65,7	70,0
ICT User Support and Operation Technicians	52,5	48,6	51,9	56,2
Telecommunications and Transmission Technicians	16,4	12,9	13,9	13,8

(CZSO, 2019)

The data identified and provided in Table 4 also show a concentration in telecommunications and transmission in particular (i.e. a drop in the number of these technicians in the economy), which corresponds to the current trend not only in Europe but also in the USA. The overall increase in CZ ISCO 351 technicians in 2017 in particular is a positive trend. We will see whether or not this positive trend will be confirmed in the future as well.

4. Conclusions

The number of ICT Professionals during the years 2014 – 2017 keeps growing, which is a positive fact for the development of the Czech economy that strives to implement the Industry 4.0 principle and a digital economy. However, what is less positive is the speed of this trend. The trend in the number of ICT Professionals in the Czech Republic corresponds to the trend in the entire European Union but not to the trend in the ICT economies of Scandinavian countries where the penetration of ICT into national economies is very high up (Kuncova, Doucek, & Novotný, 2018). Hungary and the Czech Republic are slightly ahead of the other V4 countries; the percentage of ICT Professionals from the total number of workers in their economies is almost as high as the European average, but the trend in Poland during the analyzed period shows that Poland makes maximum efforts to remedy this handicap and to join the countries able to build a digital economy. Slovakia keeps lagging behind in terms of the number of ICT Professionals in the economy.

The gender aspect is a different matter. ICT Professionals have been mostly men for a long time. In the Czech Republic, they represent approximately 90% of all ICT Professionals. The data that we discovered and analyzed do not indicate any increase in the percentage of female ICT Professionals. In every analyzed economy, an increase in the percentage of female ICT Professionals is lower than that of male ICT Professionals. Based on this fact, we can assume that the percentage of female ICT Professionals will continue to drop.

The insufficient number of ICT Professionals, both ICT Specialists and ICT Technicians, in national economies may hold the Czech Republic back in joining the countries that will create an international concept of a digital economy.

5. Aknowledgement

Paper was processed with contribution of the Czech Science Foundation project GAČR 17-02509S and with support from institutional-support fund for long-term conceptual development of science and research at the Faculty of Informatics and Statistics of the University of Economics, Prague (IP400040).

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DETERMINANTS OF ORGANIZATIONAL CULTURE IN RELATION WITH THE IMPLEMENTATION OF INDUSTRY 4.0

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Keywords

Industry 4.0, Organizational culture, Size of organization

Abstract

The Industry 4.0 has been very well studied and there are plenty of readiness and maturity models available from the technological point of view. However, the organizational culture dimension of Industry 4.0 has received little to no attention. The aim of this paper is to find out whether or not the size of an organization affects the innovative culture and consequently the readiness of the organization for implementing industry 4.0. Results show that the innovative organizational culture according to the index of organizational culture does NOT depend on the size of an organization.

1. Introduction

Industry 4.0 is considered as the essence of the fourth Industrial revolution, and it is being used in manufacturing recently through utilizing cyber-physical systems (CPS) so as to reach high levels of automation (Ziaei Nafchi & Mohelská, 2018). The Cyber-Physical System (CPS) is the groundwork for smart factories and it makes it possible to interconnect sensors, machines and IT systems within the value chain throughout enterprise boundaries (Kopp & Basl, 2017).

The Industry 4.0 has been very well studied from the point of view of information technology, and there are plenty of readiness and maturity models available in this regard. However, the organizational culture dimension of Industry 4.0 has received little to no attention.

Between the three types of organizational culture explained by Wallach (1983), the innovative culture stands out as the type of culture that is better for implementation of Industry 4.0. In other words, Organizations that have more innovative culture are more ready and will have better transition when it comes to implementing Industry 4.0. Considering this as assumption, the aim of this study is to find out whether or not the size of an organization affects the innovative culture and consequently the readiness of the organization for implementing industry 4.0.

2. Theoretical background

2.1. Industry 4.0

According to Kopp & Basl (2017) "*Industry 4.0 concept can be characterized as a transformation of production as separate automated factories into fully automated and optimized manufacturing environments. Production processes are linked vertically and horizontally within enterprise systems*".

Because of Industry 4.0, producing things that are unique regarding the excellent quality has become possible and with a price corresponding the price of mass-produced goods (Nowotarski & Paslawski, 2017).

In Theory, implementing Industry 4.0 and digital transformation concepts is increasingly significant for manufacturing companies that are performing in such markets that are considered as dynamic and competitive. However in practice, there are some challenges for organizations when implementing such concepts since Industry 4.0 is more a concept than a ready-to-implement solution; Additionally the complexity of Industry 4.0 causes delays to the successful implementation of Industry 4.0 systems in such a way that they incorporate all organizational features and levels accurately (Issa et al., 2018).

Adequate resources, skilled and competent employees and well-organized processes, that are suitably flexible and innovative, are considered as necessities while implementing the Smart concept (Odważny et al., 2018).

Lak & Rezaeenour (2018) denote: "*Maturity models can be considered as a structured collection of elements in which certain aspects of the capability maturity in an organization are described.*" Maturity models are typically used as an instrument to conceptualize and measure maturity of an organization or a process regarding certain target state (Schumacher et al., 2016).

According to Colli et al. (2018) "*The transformation of the manufacturing sector towards Industry 4.0 is setting the scene for a major industrial change. Currently, the need for assisting companies in this transformation is covered by a number of maturity models that assess their digital maturity and provide indications accordingly.* "

To achieve success in an uncertain environment like Industry 4.0, training, learning, and innovation capability play significant roles. Organizational training, learning, and innovations are strongly reliant on the role of employees in the organization and because of that organizations have to prepare their strategies conferring to what they expect from their employees (Shamim et al., 2017). On the other hand, transparency is important to be considered as it plays an important role in rationality, decent governance, and better progress (Ziaei Nafchi et al. 2018).

2.2. Organizational Culture

According to Armstrong (2006) "*Organizational or corporate culture is the pattern of values, norms, beliefs, attitudes and assumptions that may not have been articulated but that shape the ways in which people in organizations behave and things get done. It can be expressed through the medium of a prevailing management style in the organization.*"

Organizational culture is the mutual beliefs, principles, standards, and assumptions that form behavior by building commitment, giving direction, generating a collective identity, and building a community. An organizational culture is believed to be effective when it is in alignment with the organization's environment, resources, values, and goals (Okatan & Alankus, 2017).

Verdu-Jover et al. (2017) state that organizational culture is defined and used largely as a properly stable set of values, beliefs, assumptions, and symbols distributed in the organization and according to this formation, researchers have developed studies concerning the relationship among several types of cultures and innovation results.

Organizational culture is considered as a leading enabler in building a positive knowledge transfer environment. Supplementary studies about this matter came to the conclusions that organizational cultural elements such as trust, communication, reward system, and organizational structure are able to influence knowledge sharing in organizations in a positive way (Rahman et al., 2018).

2.3. Wallach’s Model

Ellen J. Wallach has categorized organizational culture into three dimensions: bureaucratic, supportive, and innovative. Bureaucratic culture is believed to be a prominent hierarchical organization that is very much organized on the basis of a clear definition of authority. The focus of the supportive culture is on interpersonal relationships and it is founded on mutual trust, encouragement and co-operation. Innovative culture on the other hand is dynamic and it supports creative work, faces new challenges and inspires risky behavior (Wallach, 1983).

Wallach’s Questionnaire (1983) also known as The Organizational Culture Index (OCI), is commonly recognized, the questionnaire is arranged in a way to analyze the organizational culture level and because the individual questions of the questionnaire are very simple, social and technological development has no significant effects on it. Because of the simplicity of Wallach´s Questionnaire and because it allows comparing the results internationally scholars are still using this method today. Revising of scientific sources such as “Scopus” and “Web of Science” proves the validation of this model, as it is evident in impact factor journals that researchers are still using this method.

3. Methodology and Objectives

The main goal of this paper is to find out if the innovative culture, which is a very important pre-condition for implementing Industry 4.0, varies in organizations of different sizes. Therefore the following hypothesis was formulated:

H_0: The innovative organizational culture according to the index of organizational culture depends on the size of the organization.

The Organizational Culture Index (OCI) questionnaire was used as the main method for the purpose of this study as well as methods of analysis and synthesis, induction and deduction, abstraction and concretization were used.

Data was collected from 1500 copies of the Wallach’s questionnaire (translated to Czech language) that were printed and distributed among part-time students of university of Hradec Kralove, studying at the faculty of Informatics and Management in the years 2013, 2015, and 2017.

To test and analyze the obtained data, ANOVA, Kruskal-Wallis, Brown-Forsythe, and Cronbach’s alpha were used.

4. Results and Analysis

The organizations were divided into three groups according to their size, organizations with up to 50 employees, between 51 to 250 employees, and more than 251 employees. Results show that there is a statistically significant difference in bureaucratic culture between first and second groups, first and third groups, and second and third groups as we can see in table 1. In supportive culture, a statistically significant difference amongst the first with the other two groups is present.

Table 1: Results of Statistical analyses of dependence of the culture indexes on the size of company

	Bureaucratic	Innovative	Supportive
ANOVA	<0.001*	0.358*	<0.001*
Kruskal-Wallis	<0.001	0.137	<0.001
Differences	1-2,1-3,2-3		1-2,1-3

* Brown-Forsythe test used for non-homogeneity of scattering

In innovative culture however, there is no significant difference between organizations of different sizes. Generally large organizations have higher bureaucratic culture, and small organizations have a significantly higher supportive culture than the other organizations.

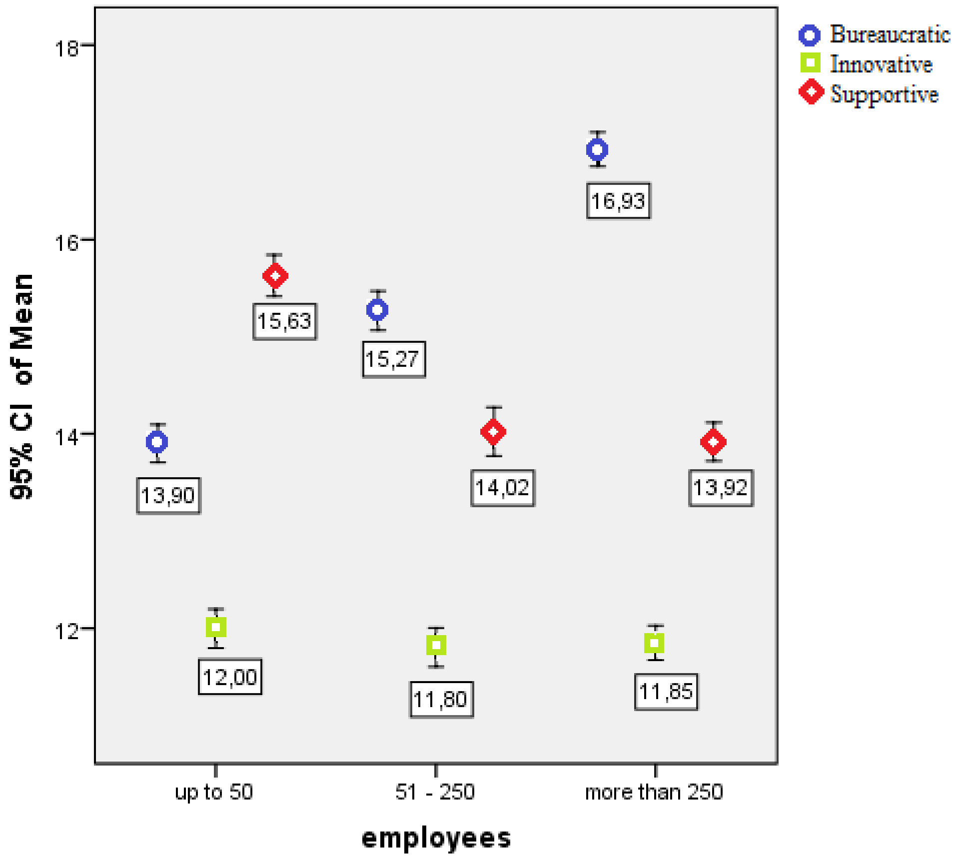

Figure 1: Dependence on the size of the organization

As it is evident in figure 1, as organizations get larger, bureaucratic culture gets noticeably stronger. Instead, the larger organizations get the less supportive culture they have. Innovative culture however, doesn't change much.

Cronbach's alpha was calculated for Wallach's questionnaire based on the dimensions they were associated with in order to check the internal consistency of the questionnaire. The internal consistency of the bureaucratic culture and the innovative culture are considered to be acceptable and the internal consistency of the supportive culture is good.

5. Discussion and Conclusions

According to the results of this study, there is a statistically significant difference in bureaucratic culture concerning all group sizes. This is due to the fact that larger organizations relay heavily on strict rules and a chain of command in order to be able to manage larger groups of people. It turns out that strategic corporate governance is a very important determinant for organizational culture. For example Gerlitz (2016) suggests how small enterprises within the Industry 4.0 domain can accelerate their growth targets and become more innovative, innovation being the move towards sustainable competitiveness and smart growth.

In supportive culture, a statistically significant difference between the first group with all the other groups is present as shown in figure 1, meaning the larger the organization gets the less supportive its culture becomes. This is considered to be valid since the supportive culture generally relying on the interpersonal relationships and it is heavily dependent on mutual trust, encouragement and co-operation (Wallach 1983), which is harder to have as the organizations get larger.

Nevertheless, there was no significant difference found in the innovative culture between the different size groups. This could be due to the fact that smaller organizations are typically relaying on being innovative but the larger organizations are seeking after innovative solutions rather than being innovative.

Statistical analyses provide enough evidence to conclude that the innovative organizational culture according to the index of organizational culture does NOT depend on the size of an organization. Therefore, the null hypothesis H_0 is rejected.

6. Acknowledgement

The paper was written with the support of the specific project 2106/2019 grant "Determinants of Cognitive Processes Impacting the Work Performance" granted by the University of Hradec Králové, Czech Republic.

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APPLICATION OF INTERNET OF THINGS

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Keywords

Internet of Things; Technologies; Application; Sigfox; LoRaWan; NB-IoT; Parameters; Czech Republic

Abstract

The article focuses on the phenomenon of the Internet of Things, especially the technologies that can be employed in the implementation of a specific project. Due to the strategic importance of information and communication technologies and considerable costs related to them, appropriate selection is seen as one of the most important decisions. Special attention is paid to technologies belonging to the Low Power Wide Area Network in the context of the Czech Republic. In particular, Sigfox, LoRaWan and NB-IoT technologies are considered. Key criteria such as battery life, Quality of Service, range, downlink capacity, latency and susceptibility to jammability are discussed. Parameters are then used to compare mentioned technologies and methods suitable for multicriteria selection are also recommended. In the conclusion part, the most suitable technology for implementing solutions within the Czech Republic is selected and the recommendation is given.

1. General

IoT can be perceived as an evolution of Internet which is characterized by the integration of not only mobile devices but also other things like sensors connected to cars, home appliances, different objects into one interconnected mesh (Perera, 2014). IEEE defines (Minerva, 2015) Internet of Things as a: "*network of objects with embedded sensors connected to the Internet. Connectivity is one of the basic pillars of IoT*".

Smart things integrated in IoT context are characterized by three principal features (Miorandi, 2012):

- Communication, the ability to establish usually wireless communication between the elements and set up ad-hoc networks of interconnected objects
- Identification with a digital name, relationships between things can take place in the digital domain while physical interconnection does not have to exist
- Interaction with the local environment due to detection and action capabilities, if this behavior is possible and required

The amount of IoT devices connected into IoT network and its importance of IoT topic is increasing every day and above-mentioned basic tasks are extended to another functions (proactive monitoring and information etc.). The growing importance of IoT is possible to demonstrate through results gathered by investigation realized by Gartner, Cisco and others. The study (Bradley, 2013) predicts that the number of things connected in the year 2020 will reach 50 billion devices.

This number was reduced to 30 billion devices in 2020 (Statista, 2019) with value of 457 billion USD and with expectation of 75 billion devices in 2025 and yearly growth by 28% (Columbus, 2017). The reduced number for 2020 is closer to the expectation presented by IDC, which estimates approx. 37 billion devices for 2020 (Kalal, 2016; Sladek, 2017). Above mentioned 457 billion USD will be generated mainly by the B2B segment, which should generate about 300 billion USD (Columbus, 2017). 70% of IoT devices will be based on cellular technology in 2022.

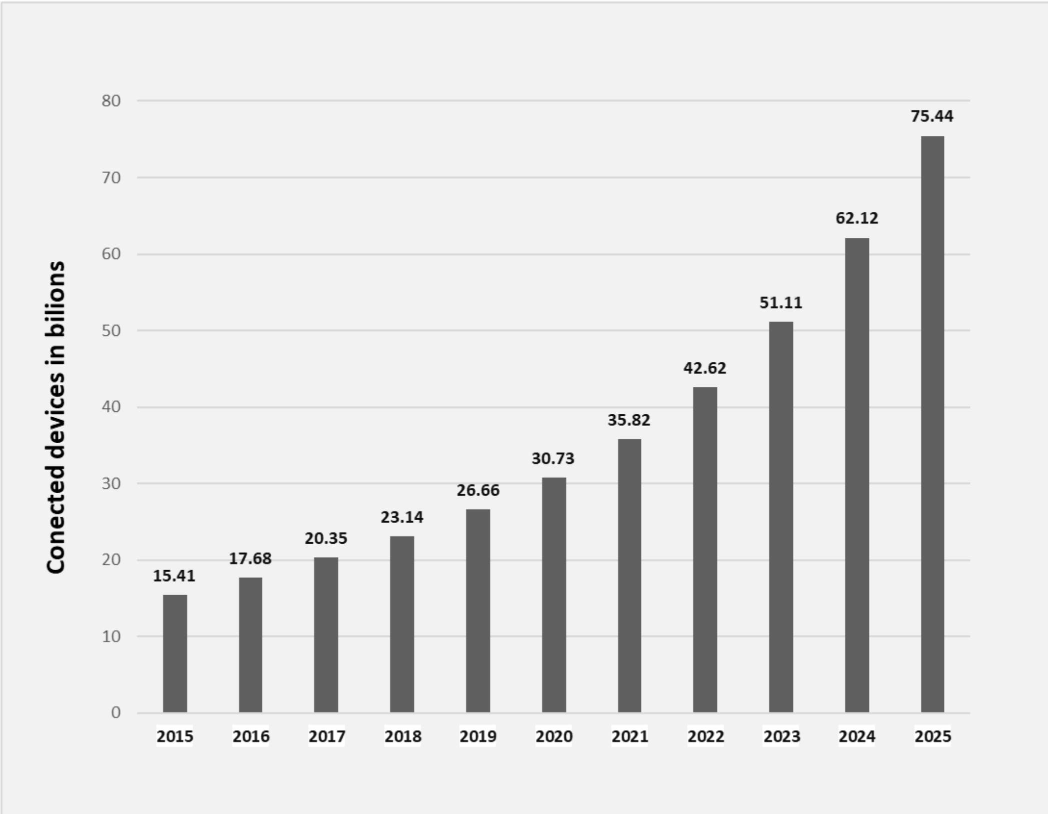

Figure 1: Connected IoT Devices (Statista, 2019)

It is obvious that the vision of future is a world in which objects maintain mutual communication resulting in smart behavior. This smart world will be represented by interconnecting smart devices, which will result in qualitatively new services. As mentioned above, the Internet of Things plays key role in this situation (Stankovic, 2014). Based on the research in (Kalal, 2016) for most of global companies (56%) the Internet of Things represents a strategic activity. The motivation for implementation of Internet of Things based on this research consist in increasing productivity (24%), decreasing time to market (22.5%) and improving process automation (21.7%). The Vodafone IoT Barometer 2016 survey identified, that 63% of businesses will have launched Internet of Things projects in the next year and 76% of businesses say, that Internet of Things will be "critical" for their future success. (Vodafone, 2018; Sladek, 2017)

Technologies suitable for transferring data among IoT devices can be divided into 8 groups. Each group can be specified mainly by distance range they provide and energy consumption. Detailed description of each type of network can be found in (Sakovich, 2018) and names and order of networks is shown in the following figure. This paper is devoted to LPWAN (Low Power Wide Area Network) technology that belongs to WAN segment.

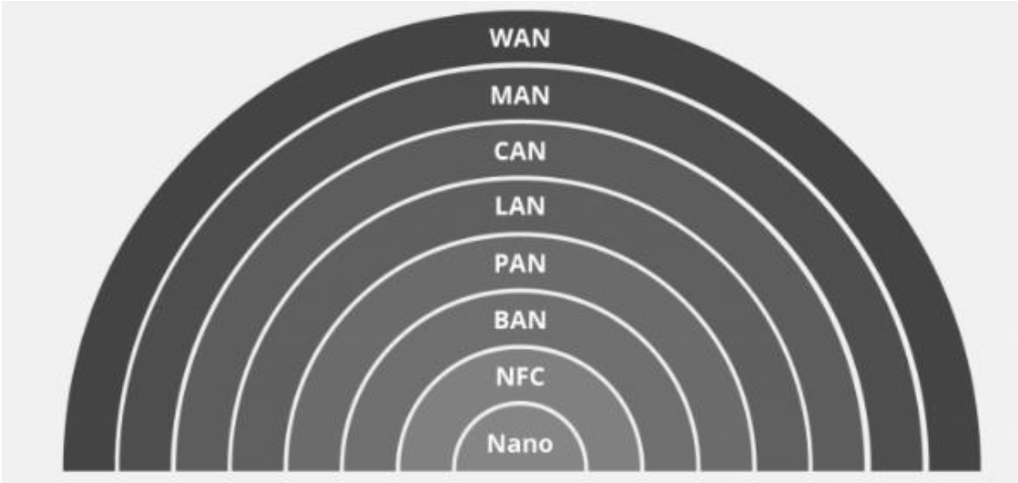

Figure 2: Type of Network (Sakovich, 2018)

IoT applications can be classified into four application areas (Gubbi, 2013): personnel and home, business, utilities and mobile. These domains provide a general classification of possible uses of IoT, but the actual business environment generally transcends mentioned domains and take everything as IoT and does not make almost any difference among application areas.

All recent IoT technologies and expectations coming from implementation of these technologies are related to difficulties and complications. The biggest challenge is not how to implement them, but to be able to reason their installation and evaluate what new values generate for the organization. The user expects that the new technology will be more efficient, that it will be easy to use, that the necessary conditions exist, and that the new technology will make sense to use (Venkatesh, 2003; Maryska, 2013).

The ability of companies to implement the IoT concept, reasoning the advantage of IoT technologies and take advantage of new possibilities can be crucial to obtaining a competitive advantage in the future. The reality of current organization is a fact, that organizations struggle with accelerated technological innovation. This acceleration influences the way they deal with their employees, customers and partners. To survive and thrive in the digital economy, enterprise architects and leaders in technological innovation have to collaborate with their CIOs and business leaders to look for emerging technologies that can help create a competitive advantage, generate value, overcome legal and regulatory obstacles, reduce operating costs, and support transformational business models (Walker, 2017; Maryska, 2013; Maryska, 2008).

2. Problem Formulation

The diversity in the area of Internet of Things is highly extensive and the lack of standardization is notable. The deployment of one of available technology confirms higher requirements when choosing suitable technologies and protocols. The choice of one of available IoT technologies must be based on carefully defined set of properly chosen key criteria. The second very important part is adequately defined evaluation process, which helps companies to select the most appropriate IoT technology which satisfies their needs

The best way to select proper technology is using the multiple-criteria approach, since the multiple-criteria decision allows taking into consideration smore attributes and allows setting different weights according to attribute importance. Multiple-criteria decision methods are usually user friendly and very understandable.

The main contribution of present article consists in description of selected technologies and offers crucial evaluation criteria which can help user to select the best variant without omitting any of the important key factor.

3. Materials and Methods

This paper presents analysis of parameters which are suitable for selection of technologies which are applicable for implementation of complex IoT solutions and validated on the situation in the Czech Republic. Special attention is paid to the field of Low Power Wide Area Network technologies (LPWAN).

First, we identified a lot of different technologies and then three selected technologies are described in detail. The specification and description of selected IoT solutions is based on the official documentation and another information gathered from already published journal and conference papers which are dealing with IoT topic. Core part and main outcome of this research is the definition of the most important factors, which should be considered during their evaluation. For each attribute we are providing reasons why it was defined and selected as a key attribute/parameter.

Due the fact that every solution is unique and focus on different attributes we recommend the use of the multicriteria-decision making method, which is based on the pairwise comparison. As the best one is proposed method with the use of the so-called Fuller's triangle for the evaluation because allows the assignment of different weights to individual criteria and can reflect varied requirements of heterogenous solutions (Agarski. 2012) .

4. Results

There is a lot of different technologies which can be used for transmission of data generated by IoT devices. This chapter identifies key technologies, which are suitable for usage of IoT, describe some of them and analyze their key attributes.

This paper focus on technologies referred as The Low Power Wide Area Network (LPWAN). LPWAN is defined as a network with high communication range (at least 500 meters of signal range) and low energy requirements which are demanded from the connected devices. These networks can be divided into licensed (LTE, NB-IoT etc.) and unlicensed (SigFox, LoRaWan, etc.) networks. Negative side of LPWAN technologies is the early stage of deployment (the much-discussed NB-IoT was presented only in 2016), and its full potential and disadvantages will not become clear until the networks have been implemented at a greater scale. Furthermore, only 20% of the global population is covered by an LPWAN network, however the availability is growing rapidly, and by 2022 LPWAN technologies are expected to provide coverage for 100% of the world population (Makarevich, 2018).

4.1. Key Attributes of IoT Technologies Important for Comparison

We can identify a lot of different attributes/factors, which affects selection of the best IoT technology. Based on our research we identified more than 18 attributes. Those were assessed mainly form usability and applicability dimension and the following attributes are the most important from our point of view for selection of suitable IoT Technology.

- Energy consumption, battery endurance and lifetime: the replacement of batteries is not easy. devices must be highly efficient in energy consumption and they must be able to stay in operating mode for more than 5 years.
- Range: densely / sparsely populated areas will have different coverage. The sparsely populated area usually lead to lower infrastructure investments and smaller coverage. The technology should be able to manage this issue.
- Geographic coverage: geographic coverage cannot limit deployment of selected technology.
- Frequency band: the radio frequency spectrum is divided among ranges from very low frequencies to extremely high frequencies. Each band has defined upper and lower frequency limit
- Common operation latency: express the time usually needed to transmit the data from the point of origin to the destination point.
- SLA / Quality of Service (QoS): defines guaranteed data transmission parameters. In case of higher requirements on QoS usually costs are increasing.
- Uplink capacity / Downlink capacity / speed: the data transmission is a factor, which influence ratio between the range and the energy power needed.
- Device jamming resistance: device jamming occurs when any device blocks, jams or interferes connection / signal among other devices. The technology should have mechanism to prevent jamming or be able to cope with it.
- Data encryption + security: translates data into different form (or code) to prevent others to allow them to read it, in other words it allows to read it only by people with access to a secret key (decryption key) or password that allows to read it.
- Number of messages sent per day/ hour/ minute: defines number of messages that can be sent in certain time interval.

Prerequisites for comparison of communication technologies is defining basal and ideal variants and transformation of attributes to numeric representation. Example of transformation is mentioned in the following table:

Table 1- Transformation of parameters to values

Parameter	Criteria	Variant 1	Points 1	Variant 2	Points 2	Variant 3	Points 3
Battery endurance	Years	below 5 years	0	between 5 and 10 years	1	over 10 years	2
SLA/QoS for message delivery	Yes/No/ Partial	No	0	Partial	1	No	2
Common operation latency	Milli-seconds	over 7000 ms	0	between 4000 and 7000 ms	1	below 4000 ms	2
Device jammability resistance	Yes/No/ Partial	No	0	Partial	1	No	2

We already know, that exist number of different technologies which we can be used for implementation of IoT projects (see list of 12 technologies mentioned below). For the purpose of this paper, we narrow them down to three variants, however these technologies are the most widespread.

4.2. Technologies Suitable for Usage of IoT

There is a lot of different technologies, which can be used as a technical platform for transferring data from sensors into cloud or any other data store, where can be data processed, analyzed and used. All technologies mentioned below are based on wireless data transfer and allow long range communication, what is the main requirement demanded from the LPWAN.

The most important technologies are (Makarevich, 2018; Sakovich, 2018; PostCapes, 2019; SOS electronics, 2017a, 2017b):

- GSM (Global System for Mobile Communications)
- GPRS (General Packet Radio Service)
- 3G (third generation of wireless mobile telecommunications technology)
- LTE (Long-Term Evolution is a standard for high-speed wireless communication for mobile devices)
- Wi-Fi (wireless local area networking)
- Bluetooth (a wireless technology standard for exchanging data over short distances)
- **NB-IoT** (Narrowband Internet of Things)
- Ingenu (wireless networks)
- **Sigfox** (wireless networks to connect low-power objects)
- **LoRaWAN** (digital wireless data communication technology)
- Telensa
- Weightless

These technologies are expected to be not demanding in power consumption, because the devices should be able to stay in operation mode for up to several years without replacing a power source, which is often impossible. Also, due to the character of IoT projects, it is important to evaluate the ability to manage thousands of devices at low economic costs. Finally, it is necessary to consider the type of band used for transmission. Both licensed and unlicensed has pros and contras and have important impact on the features of the IoT solutions.

In the next sub-chapters, we are describing chosen Low Powered Wide Area Networks in detail. We selected NB-IoT, SIGFOX and LoRaWAN, which were identified in (SOS Electronic, 2017a, 2017b; PostCapes, 2019) as leading technologies for usage in transferring of data from IoT devices.

4.2.1. Sigfox

The Sigfox network uses a non-licensed ISM (industrial, scientific and medical) band, it operates on 868 MHz (Sigfox, 2017). This range is not charged, however we must to mentioned, that there is no guarantee of free-interference ambient. The communication is the Ultra Narrow Band type. This type of communication transmit power to a very narrow frequency range and allows transmission at long distances with low transmit power. Message from IoT device is transmitted at a rate of 100 or 600 bits per second. The transmitted rate is depending on the region (Sigfox, 2017). Size range for message is a maximum of 12 bytes (Sigfox, 2017). Devices are usually activated only at uplink time and repeat the transmission three times for a greater chance of capture. The network operates on a cooperative principle.

4.2.2. LoRaWAN

LoRaWAN uses the non-licensed ISM bands. This ISM Bands is free of charge. The ISM Bands is using 868 MHz and 433 MHz in European Union (Lora Alliance, 2015).

Data bandwidth values are between 290 bps and 50 Kbps (Lora Alliance, 2015). The width of the channel is not fixed. The width is determined by the device and its capabilities. Important effect of this approach are:

- maximization of the lifetime of the power source
- optimization of the transmission capacities.

We must to mention, that messages cannot be bigger than 255 bytes.

4.2.3. NB-IoT

NB-IoT is mobile technology suitable for the usage in the area of Machine-Type Services. This technology is heavily developed already since year 2005 (5G, 2017).

NB-IoT uses the licensed ISM band (GSM, LTE) for the uplink and downlink bandwidth of 180 Khz, which corresponds to one LTE block. The protocols themselves share the basics with the LTE suite, however, they are lightweight versions and area adapted to transmit small data volumes. Really important attribute of this technology is a fact, that this technology does not require encapsulation in IP datagrams (5G, 2017).

4.3. Comparison of Selected Technologies

For this paper we have selected five key attributes. List of these attributes and their values are given in the table 2 below. The importance of each attribute was described in previous chapter 4.1. The values classified in this way allow us to apply the approach of quantitative assessment, which was also presented in the chapter 4.1. Depending on the requisites demanded by concrete project we can assign different number to reflect the impact of the concrete attribute, furthermore, as we stated in the chapter 3, it is possible to combine the qualitative assessment with the association of different weights.

Table 2: Information on the assessed technologies and on their parameters

Parameter	**NB-IoT (LTE)**	**SIGFOX**	**LoRaWAN**
Battery life	Years	Years (>10 years)	years (>10 years)
SLA/QoS guaranteeing	Y	N	N
Range (km) country/rural	15/6	50/3	20/2
Uplink capacity	20-250 kbps	100 or 600 bps	0.3–50 kbps
Latency	within 100 ms	7 s	7 s
Device jammability	Easy	Extremely	Easy

Since we are not looking for a concrete solution for a specific IoT project, selected attributes are discussed at general level in the next chapter.

5. Discussion

Each solution is unique due to the specific requirements and situations in which it is deployed. Based on this fact we cannot unequivocally stated, that one of the presented IoT technologies is the best one for all projects, hence the discussion is hold at general level.

It seems that SigFox has a comparative advantage in range, although this attribute is not the key one thanks to the geographical scope of the Czech Republic (CR). All operators, which are providing services of IoT, declare more than 90% coverage of the territory. The quality of service and possibility of bi-directional communication could be more crucial, SigFox and LoRaWan offer mechanisms to maximize the success of data transfer, however only NB-IoT can guarantee QoS LoRaWan and NB-IoT acquire advantage if full bidirectional communication is required, SigFox supports bidirectional communication only in certain scenarios. Decisive attribute could be the lifetime of the energy source, because the replacement of batteries is often impossible or generates extra costs. Also, the security issues must be considered, LoRaWAN and NB-IoT provide encryption at the MAC (Media Access Control) layer, while SigFox not and uses additional mechanisms to assure credibility of the message.

The costs of the devices and costs related to the operations are important factors, which are from our point of view one of the most important factors, however it is hard to evaluate this attribute, because of the lack of clearly defined pricelist. In case of the Czech Republic, all 3 described IoT solutions are most likely applicable in majority of IoT solutions and it is necessary to make decision regarding the needs of the concrete project. Although it is difficult to make unambiguous recommendation, we have reached the conclusion that Sigfox and LoRaWan are the most suitable choice for implementations in which the range and battery life are crucial attributes, while the quality of service and transmission rate are not decisive. NB-IoT is the only option in projects that require stable and guaranteed connectivity with low latency, while the range and battery life are not of vital importance.

6. Conclusions

The Internet of Things is a phenomenon gaining strength and importance. The companies must consider the incorporation of new technologies to their existing infrastructure to acquire competitive advantage or at least maintain their actual position. Hence, they are obligated to select a proper technology to support their business model which can be problematic due to heterogeneity of existing possibilities. That is why we have enumerated the most widespread technologies usable for IoT solutions, although for a more detailed analysis, representatives of the Low Power Wide Area Network family were chosen, special attention was paid to Sigfox, LoRaWan and NB-IoT. For mentioned technologies, we have also provided a list of key criteria to evaluate them and for each parameter, reasons were given for its inclusion in the list. We have as well mentioned two technics suitable for multicriteria evaluation. Afterwards, we have compared all three technologies using 6 selected parameters relevant to the context of The Czech Republic and in the discussion, advantages and disadvantages were presented. Finally, we reached the conclusion that Sigfox and LoRaWan should be suitable for projects in which the quality of service is not of vital importance, while NB-IoT is recommendable for solutions demanding guaranteed and stable connection without limits in volume of transmitted messages.

7. Acknowledgements

Paper was processed with contribution of long term support of scientific work on Faculty of Informatics and Statistics, University of Economics, Prague (IP 400040).

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RADICAL CHANGE IN MACHINERY MAINTENANCE – A MATURITY MODEL OF MAINTENANCE USING ELEMENTS OF INDUSTRY 4.0

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Keywords

Industry 4.0, predictive maintenance, maintenance, maturity model

Abstract

The main goal of the article it to present a maintenance maturity model, incorporating radical change with implementation of predictive maintenance (Industry 4.0) into existing maturity models. In first part there is a theoretical review of industrial maintenance, citing most important definitions and approaches. Consequently, different kinds of maintenance with relation to historical development are mentioned. Then, a maintenance maturity model is based on all types proposed. In the final part of the article the predictive maintenance with relation to Industry 4.0 and its technologies is presented.

1. Machinery maintenance definitions

In global terms, business need to synergically develop all areas, processes and systems that have been implemented. Machines and equipment (machinery) have a central position in each enterprise from point of view of needs and prosperity of operational practice. For maximum efficiency it is necessary that manufacturing equipment and systems operate and are managed in a reliable manner. That why, problems of machinery and equipment maintenance appear to be important from the point of effectivity, especially in times of financial crisis and reduced turnover, rising costs of energy, raw materials and labor. Nowadays, over € 1,500 billion a year is spent on maintenance, repair and renovation (MRO) only in the EU and over € 7,000 billion globally. More than 50 million jobs are directly linked to the MRO and 150 million indirectly. Sustainable level of maintenance is an essential requirement for long-term survival of all factories. Surveys show that for maximum efficiency it is necessary that manufacturing equipment and systems operate and are managed in a reliable manner. Maintenance is one of the essential elements of a comprehensive production system. Machinery maintenance is defined by International Organization for Standardization as set of activities performed during the operating life of a structure to ensure it is fit-for-purpose (International Organization for Standardization, 2013). But the most “basic” definition is by Swedish standard SS-EN 13306 (SIS Förlag AB, 2001), who defines it as a "combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function". Maintenance management here means covering actions including mostly inspection, adjustments, cleaning, lubrication, testing, and replacement of expendable parts, as necessary to maintain the serviceability of the equipment (Maintenance Terminology, 2001). According to (Bagadia, 2006) maintenance is defined as "measures that help to preserve and re-create the required state of machinery and equipment." This means not only to monitor the state of the equipment, but in case of failure to bring the equipment to desired (fully operational) state, where all equipment functions are restored in the required quality. There are many point of views, by which maintenance can be divided. Several approaches to maintenance can be distinguished, based on that whether it is performed before or after failure. We also differentiate between proactive maintenance (dependent on device status) and preventative one (performed independently of the state of the device). After-fault maintenance serves mainly to return the machine to a state in which it can continue to perform the required functions. We also differentiate this kind of maintenance to be moved (moved according to the maintenance rules) and immediate (performed immediately after the failure is detected).

2. Methodology of maintenance maturity model

2.1. Principles of maintenance maturity model

The fundamental methodology used in this article is inspecting various models of machinery maintenance, based on its historical development. Results obtained from the analysis of models (Basl, 2017) were transformed into a creation of a maturity model, which can be seen in Table 1. Their article is dealing with an overview of readiness indexes and maturity models for evaluating enterprises readiness for Industry 4.0. Based on 22 maturity models they are trying to measure the achieved level of maturity in various areas. Their model has 7 levels overall, starting with "Society 4.0" and "Industry 4.0." on levels 1 and 2, continuing to lower levels (up to level 7) through sectors, enterprises to sub-dimensions within an individual dimension of an area of an enterprise. This model is mostly dealing with levels 1 and 2, thatswhy it was necessary to create a model solely dealing with maintenance.

Based on (Basl & Doucek, 2018) evaluating analyzed maintenance approaches columns in (Table 1) represent 5 different "attributes" of each maintenance approach.

- functionality (maintenance planning and integration into company core processes),
- decision support (which type of data do maintenance personnel have, when making decisions),
- business processes (how digitization and automation can ease them),
- users (what kind of personnel does the maintenance, how they do it and how they are motivated) and
- technologies help provide or support maintenance.

Table rows represent these different approaches to maintenance based on historical and technological level of the equipment (Poór, Ženíšek, Basl, 2019)

- (-1) Degradation,
- (0) Regeneration,

- (1) Ad-hoc.
- (2) Reactive approach
- (3) Proactive approach
- (4) Proactive approach with evolution,
- (5) Radical change or Maintenance 4.0 (using elements of Industry 4.0)

Degrees of machinery maintenance are described in details in part 2.2., but we can say that there is a growing trend between the development of maintenance and technologies used. The more sophisticated machinery maintenance, the more sophisticated technologies and skilled personnel needed for its operation. This is maybe not so crucial for the early stages of maintenance, when the "most advanced technologies" were pen and paper, but dealing with TPM, RCM or upcoming Predictive Maintenance 4.0, technologies play a crucial role.

Table 1 Maturity model – Predictive Maintenance using elements of Industry 4.0 based on works (Basl & Doucek,2018) (Basl,2018)

	Maintenance type	**Functionality (planning + integration)**	**Decision Support (data)**	**Business processes (digitization + automation)**	**Users (motivation)**	**Technologies**
-1	**Degeneration** (Machine is not maintained nor cared about at all. Once broken, it is replaced)	Lost functionality. No plans, no care.	No data.	No process. No maintenance.	No training, no skills, no knowledge sharing.	No technology
0	**Regeneration** (Basic maintenance tasks - lubrication and cleaning) (Similar to autonomous maintenance)	Elementary care, no plans. The basic operational conditions are followed.	Basic documentation how to operate the machine.	Basic operational tasks to keep the machine operating.	Basic training and knowledge sharing concerning operational tasks.	Operational documentation (paper)
1	**Ad hoc** (Break down maintenance, on green field (no plans and standards used)	Once machine breaks, it is repaired. No plans, information or data are known or registered.	Basic documentation how to operate the machine.	No maintenance processes. Basic operational tasks to keep the machine operating.	Staff with training but little or no experience.	Operational documentation and machine characteristics documentation. (Paper)
2	**Reactive approach** (Break down maintenance, where plans and standards for corrective actions are	There are contingency plans what to do once machine is broken. Machines data, their	Simple sheets with evidence of failures.	Standard maintenance processes in case of failure. Basic operational tasks to keep the machine operating. Spare	Staff trained for standard repairs. Occasionally dedicated repairman.	Paper sheets, excel tables.

	known (brown field))	characteristics and failures are collected.		parts management.		
3	**Proactive approach** (Maintenance is done in order to prevent failures – forms – Preventive (based on Performance/Time/Condition, perhaps also predictive maintenance)	Failures are predicted and prevented at any cost. Functionality is the priority. Data is collected; excel sheets or basic form of CMMS. Lots of plans. (Broum & Kleinova)	Monitoring, excel sheets, basic CMMS.	Preventive maintenance processes focused on functionality. Spare parts management. Standard maintenance processes in case of failure. Basic operational tasks to keep the machine operating.	Dedicate maintenance and operation staff with knowledge and skills.	Automation of Failure Reporting Scheduling, Parts Management CMMS.
4	**Proactive approach with evolution** (More complex maintenance optimising costs, quality and performance. TPM and RCM. Requires advanced CMMS)	Functionality optimised towards the costs on the best currently possible level. Data is collected into CMMS.	CMMS calculations, dashboards.	Well-defined and optimised maintenance processes organised by CMMS.	Operators closely cooperating with dedicated maintenance. Operators have basic knowledge of work with evidence of failures and downtimes.	Automated failure reporting, scheduling, parts management. CMMS, connected to other departments.
5	**Radical change** (Maintenance using elements of Industry 4.0)	Functionality is optimised based on on-line data analysis. Sensors follow data.	Artificial Intelligence (AI) On-line sensors, dashboards, etc.	Processes are fully automated and digitalized.	Operators are fully involved in CMMS and network.	Intelligent maintenance systems, Remote monitoring Augmented reality for MRO digital twins, etc.

2.2. Degrees of machinery maintenance

From historical point of view, maintenance is already associated with the time when people began to make tools. Of course, we are not talking about serious mechanical maintenance up to World War II. Till that time operators did not place any emphasis on maintenance. After some part (or the whole equipment) broke, it was replaced partially, or, when the degradation was total a new machine was placed. All possible failures were handled operatively until they occurred. There were no maintenance plans, no specific company processes were dealing with maintenance. There were also no maintenance squads, specific departments or people with repair/maintenance training. From this "user" point of view, there was no further information sharing. Of course, with no qualified personnel there were no technologies connected to maintenance monitoring. Until the end of the 1940s we are talking about the 1st generation, characterized by so-called after-maintenance failure or reactive maintenance (we talk about machinery degeneration – "letting the device work until it goes wrong").

From machines *degeneration*, which was of course very ineffective, machine operators stared to do basic maintenance tasks such as basic lubrication and cleaning. We can call this type of maintenance as "*regeneration*" and it is very similar to autonomous maintenance. There was still no maintenance planning, but at least elementary machinery care was done. Also, basic operational conditions were followed. Also, basic documentation how to operate the machine are given. These basic operational tasks had one primary purpose – to keep the machine operating. As an example can be used the Ford Manual from 1919 (Ford Motor Company, 1919). Basic "maintenance tasks" involved frequent inspections of running gear, visual inspections of blockings in either front or rear wheels and that all bolts and nuts are tight, preparing and practicing of taking care of every repair or adjustment as soon as its necessity is discovered." (Ford Motor Company, 1919) All these actions were serving as a prevention to avoid delay or possible accidents on the road. What is also different from the previous maintenance model, maintenance personnel begun to share basic training and knowledge. This also concerned operational tasks and documentation, mostly in physical form of papers, notes...

The strategy of "once the machine breaks, it is repaired" was related in the period up to 1945, and partly up to the 50s, with problem of data collection and evaluation. Maintenance work was aimed at repairing damaged parts and simple activities such as cleaning and lubrication. No plans, information or data on machinery repair are known or registered. As in earlier maintenance model, there is some basic documentation how to operate the machine. Maintenance staff receives some training but has little or no experience (Poór, 2016). Operational documentation and machine characteristics exist, still in form of papers. In our metamodel, we called this type of maintenance as *ad-hoc* (break down maintenance), where plans and standards are created "on green field" (very rarely or not used at all)

Further approach in the model is *reactive* maintenance. It can be considered as the first targeted strategy of maintenance management. Reactive maintenance therefore only responds to machine and its lifecycle- it works, and when a fault occurs, the maintenance department and removes (repair or change of machine part) it. There are contingency plans on what to do once the machine is broken. But data about machines, their characteristics and failures are collected. According to (Mobley, 2002) reactive maintenance represents the largest (over 55%) percentage. 31% of companies use preventative maintenance, 12% predictive maintenance and 2% use other type. Using this type of maintenance, plans and standards for corrective actions are known ("brown field") and simple sheets with evidence of failures are kept. Standard maintenance processes are used in case of failure. Operators are learnt basic operational tasks to keep the machine operating. Also, spare parts management is introduced. Maintenance staff is trained for standard repairs; in terms of improvement some workers are occasionally dedicated to their jobs. No special technologies are used, only paper sheets. But there is an improvement – using computerization (excel tables).

With increasing effort to prevent unexpected failures and optimize maintenance costs following two types of maintenance were developed, proactive and predictive maintenance (Dhillon, 2002). Using *proactive* approach counts on maintenance done in order to prevent failures (based on Performance/Time/Condition) maintenance is the key here. Preventive maintenance processes are focused on functionality. With more complex machinery, their operation became more and more complicated and expensive. A new type of maintenance was developed (*preventive*) with regular inspections and repairs. Their frequency was expressed by their time to failure, or specified by the manufacturer. This also needed good spare parts management. Failures are predicted and prevented at any cost. During this kind of maintenance, functionality is the priority. Also, a lot of data is collected; in excel sheets or basic form of CMMS (computerized machinery maintenance software) are being created. Also, maintenance plans are created. Basic perceptions such as hearing, sight and touch are used, where operators can guess from experience that there is something wrong with the machine. They are also taught basic operational tasks to keep the machine operating. They are motivated to improve their knowledge and skills.

The last "classic" approach to machinery maintenance we called *proactive approach with evolution*. This type of maintenance is even more complex that the previous ones, dealing (apart from the "classic" maintenance tasks) also with optimising costs, quality and performance. New types of maintenance like TPM and RCM are introduced, which require advanced forms of CMMS.

Productive Maintenance combines Corrective Maintenance and Preventive Maintenance techniques, but a widely analytical approach is used. (Aziz, 2012). Using data analysis (sometimes real-time monitoring) that can lead to breakdowns are identified in first place. It also brings longer equipment lifespan, decreased downtime over spare parts inventory and is more cost-effective.

Reliability-centred maintenance (RCM) according to (Moubray, 1997) is "a procedure to establish maintenance requirements for any physical asset in its operational context." Not all equipment in an enterprise has the same importance(value) and different equipment is more likely to cause a fault for different reasons. Also, financial and personnel resources are limited and need to be identified and optimized. RCM is characterized by specialized standards (Society for Automotive Engineers., 1999). RCM also deals with the assessment of possible causes of device failures and that why it needs tools to identify risks. Most used are: FMEA (Failure Mode and Effect Analysis), Analysis of the ways and consequences of faults, Analysis of causes and consequences and Risk analysis.

Total Productive Maintenance (TPM) - is a set of maintenance activities performed throughout the lifetime - the existence of machines in order to improve their accuracy, reliability, performance and efficiency as well as reducing all possible losses. It is part of the company's production philosophy, it includes all the departments of the company and represents the interconnection of maintenance and production with the technical security of the construction and technology (Sullivan, Melendez, & Pugh, 2004) The most important factor here are the employees. TPM must be managed by factory employees and is supported by process and maintenance partners so that they work together and are equal partners. The TPM includes every employee from the executive to the top manager. The TPM includes a process of continuous improvement of equipment and overall quality. It is based on the support of product maintenance by small group activities (production teams). Mostly in the last type (TPM) we see that operators closely cooperate. Also, they have basic knowledge of work with evidence of failures and downtimes. Using complex CMMS solutions (Chovancova, a další, 2017) enables other developed technologies as automated failure reporting, scheduling, complex parts management.

3. Radical change- Maintenance using elements of Industry 4.0

The last row in our metamodel is represented by Predictive maintenance or Maintenance using elements of Industry 4.0. Concept of relatively new (Marešová, 2018) Industry 4.0 fully used (Vrchota, Volek, & Novotná, 2019) the advantage of cyber systems, cloud storage or Internet of Things resulting in the most advanced form of maintenance "Predictive Maintenance" (PdM 4.0). It is the most advanced form of maintenance as of today. Predictive maintenance is an analytical approach (Pietrikova & Chodarev, 2015) that allows you to predict when production equipment fails by analysing production data to identify patterns and predict issues before they happen. Functionality is optimised based on on-line data analysis. To achieve this, you need to use big data analytics with combination of artificial intelligence (Chodarev, Pietrikova, & Kollar, 2015) in order to create insights and detect patterns and anomalies. Another technique used are continuous real-time monitoring, external data (for example from the environment) usage and alerts based on predictive techniques (regression analysis). Also, artificial Intelligence (AI) and on-line sensors, dashboards, etc. are here for supporting major decisions. The basic components of predictive maintenance in context of Industry 4.0 are: internal data sources from internal data sources from sensors (Pietrikova A. , 2001), control units, CMMS systems, maintenance reports, warehouse management or ERP. Another technology used are Cyber-Physical Systems, Internet of Things, Big Data, Cloud computing, Networks and Artificial Intelligence, Mobile networks and WIFI. Also, the job of maintenance operators changed. Instead of craftsmen and inspectors, reliability engineers, IT specialists and data scientists are in need.

4. Conclusions

With the ongoing 4th Industrial revolution changes are to every aspect of production process. As mentioned in the article, production equipment has central position in each enterprise. Machinery maintenance is needed not only to "not let the device work until it goes wrong", but with more and more sophisticated machinery and automation, predicting equipment degradation. In the article we tried to summarize types of machinery maintenance (from machines degradation and no maintenance, to modern types of maintenance using a trained personnel and CMMS). We are also presenting a new (radical) change - predictive maintenance using elements of Industry 4.0, whose functionality is optimized on on-line data analysis (provided mostly by sensors). Maintenance processes are fully automated and digitalized (M., a další, 2018). Operators (software engineers) are fully involved in CMMS and company network. Also, intelligent maintenance systems are used, remote monitoring and production control. For MRO, also augmented reality can be used, as other advanced technologies as cyber-physical systems, digital twins, automated guided vehicles, additive manufacturing and many others (Puškár, 2017). Creating this maturity model for predictive maintenance implementation into existing maintenance system is only the beginning of our research. Predictive maintenance definitely fits into Industry 4.0 and done in a correct way can be one of its main driving forces.

5. Acknowledgements

This research was supported by the project SGS-2018-031 Optimizing the parameters of a sustainable production system

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DIGITAL LITERACY AND DIGITAL EXCLUSION OF POOR, UNEMPLOYED, UNEDUCATED AND PENSIONERS: WHO IS THE MOST THREATENED?

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Keywords

Digital literacy, Digital Technologies, Education, Internet access

Abstract

The digital economy becomes essential as other skills like reading, writing and computing. That is why the Czech Ministry of Labour and Social Affairs introduced the Strategy of the Digital Literacy that focuses on the usage of the digital technologies for citizens' long-life personal development and increasing their quality of life. This paper aims to describe the development of digital literacy in the Czech Republic. Moreover, the paper seeks to compare the digital literacy of the specific group of people threatened by digital exclusion and to evaluate the realisation of the Strategy partially. For fulfilment these goals, we employ the assessment of several selected indicators.

1. Introduction

According to several scenarios, digital literacy becomes as important as the reading, writing and computing skills. Following this hypothesis, the Czech Ministry of Labour and Social Affairs (MoLSA) has prepared the Strategy of Digital Literacy in the Czech Republic for years 2015-2020[6] (from now on: "the Strategy"). The Strategy focuses on the development of Czech citizens. The Strategy aims to allow the Czech citizens to use the potential of digital technologies for their long-life personal growth and for increasing their quality of life.

The Strategy reflects societal changes. These changes are related to the increasing importance of information and knowledge as well as on the reaction on the implications of related societal processes (globalisation of ICT; productivity increase in the area of production, processing and transfer of information; increase of share of employment in tertiary and quaternary sector; rise of importance of knowledge). According to the Strategy, efficient connectivity to ICT is considered as one of the critical factors of participation in societal life. Furthermore, the usefulness of ICT is crucially based on the human abilities to perceive the benefits of ICT, operate ICT and utilise ICT. The Strategy warns about the growing digital division[7] (the gap between people who serves and utilise ICT and which do not). The Strategy points out the impact of the digital literacy development on the economic issues (employment, competitiveness), political issues (public

[6] Strategy of digital literacy in the Czech Republic for 2015-2020. June 2015. Author unknown.

[7] Van Dijk, J. and Hacker, K. (2003).

administration, development of education and training system) and societal-cultural issues (social inclusion, support of families).

The concept of digital literacy is based on the general concept of literacy. The literacy "enables individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society"[8]. According to Justenhoven (2017), Gilster (1997) introduced the concept of digital literacy. Currently, digital literacy is defined as "the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills."[9] By another definition, digital literacy is "the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action"[10].

Many authors stress the impact of digital literacy. Lynch (2017) points out the term "digital citizenship" and considers digital literacy as the most critical tool for lifelong learning. Antonio and Tuffley (2015) emphasise the need for developing pedagogical strategies to teach digital literacy skills to older adults and point out those who live in rural and remote areas. Reynolds and Leeder (2018) analyse the relationship between digital literacy and democratic participation, life and livelihood outcomes.

This paper aims to describe the development of digital literacy in the Czech Republic, to compare the digital literacy of the specific group of people threatened by the digital exclusion (poor, unemployed, uneducated and pensioners) and to partially evaluate realisation of the Strategy using the assessment of several selected indicators.

The paper consists of four parts. In the first part, we present data and methodology. Secondly, we assess the development of the digital literacy of individuals and employees. Thirdly, we focus on education in the area of digital technologies. Finally, we describe the development of the access of poor household to digital technologies. Using this analysis, we propose some suggestions for further development.

2. Data and Methodology

For our paper, we use data from the sample survey on utilisation of information and communication technologies in households and between individuals. This survey is operated by the Czech Statistical Office since 2003 and harmonised by the Eurostat. The survey consisted of 7,639 persons who provided complete data to the questioner (the response rate was slightly above 70%).[11] The cited publication includes detailed methodological explanatory notes.

From the results of this survey, we select indicators and descriptive statistics which we consider as the most important for fulfilment the goals of our paper.

[8] UNESCO (2004), p. 13.

[9] Bailey (2018).

[10] Koltay et al. (2016).

[11] CSO (2018).

3. Digital Literacy of Individuals and Employees

The Strategy strongly prefers the portable digital competences contrary to the specific digital competencies. The portable digital competencies consist of "the ability to use knowledge and skills which are not directly connected to the particular job, qualification or task but they are widely used across fields and in the private life as well; these competencies allow the individual to use the digital technologies in the common practice and to react to changes in a flexible way"[12].

Following this starting point, one of the arrangements consists of support of private education of employed and unemployed persons in the area of portable digital competencies. According to the Strategy, this should be measured by the indicator which outlines the development of digital literacy in the Czech Republic in comparison with the growth in other countries.

One of the essential tasks consists of the measurement issue. How to measure digital literacy? How to measure portable digital competencies? As we see the definition stated above, the portable digital competencies are widely and generally defined. It implies that it is impossible to measure them directly – it is not possible to include the following questions into the survey: "What is your level of portable digital competencies?"; "Do you perceive the benefits of ICT?"; “Do ICT help you to react on changes in a flexible way?”. This issue is a part of the so-called adequation gap[13] between social and economic processes on the one hand and the statistical indicators, on the other side. For the description of the development of portable digital competencies, we select three indicators from the publication of the Czech Statistical Office[14]: (i) communication on the internet, (ii) searching the information on the internet, (iii) using the internet for entertainment.

It would be possible to use other indicators (using the internet for activities related to healthcare and travelling, using online financial services, using the internet for purchasing and for communication with the administration) but these indicators include not just digital literacy (portable digital competencies) but also the development of particular areas (e-health, e-banking, e-government). We also neglect indicators related to using social networks (we, as the authors of this paper, evaluate ourselves as the persons with a high level of digital literacy but use the social networks at a marginal level) and the indicators describing pure using of the internet (which measures competencies and availability as well).

74.7% of the Czech population use the Internet for sending e-mails, with significant differences by education (primary education – 30.2%, secondary without GCE – 62.6%, secondary with GCE – 82.0% and tertiary – 94.4%) and economic activity (e. g. employed – 89.9%, unemployed – 69.9%, retired – 33.1%, disabled – 58.0%). The Czech Statistical Office also publishes adjusted data – the share of the people who use the Internet for sending e-mails on the people who have used the Internet during the last three months. In our opinion, these adjusted data better describe the competencies as they improve measured skills from availability. 92.6% of the people who have used the internet during the last three months also sent e-mails (data ranged from 81.9% for primary education to 98.5% for tertiary education). The difference is for pensioners: 81.0% for the retired and 86.7% for the disabled.[15]

In table 1, we describe the digital literacy of employees. Digital competencies differ between males and females (women often use office and specific software, while men usually program). Except for

[12] The Strategy, p. 9.

[13] Hindls, R. and Hronová, S. (2014).

[14] CSO (2018).

[15] CSO (2018), p. 46.

programming, there are no age differences. However, there are significant differences across the education level.

Table 1 Digital literacy of employees, 2018, %

	Using office software (Word, Excel)	Using specific software	Programming
Total (aged 16+)	**48.6**	**36.7**	**5.0**
Total (aged 16-74)	48.6	36.7	5.0
Sex			
Males (aged 16+)	45.9	33.7	7.4
Females (aged 16+)	51.9	40.4	2.1
Age group (years)			
16-34	46.8	37.2	7.6
35-54	49.8	36.2	4.3
55+	47.6	37.6	3.4
Education attainment (aged 25+)			
Primary	6.3	8.8	0.0
Secondary without A-level exam	19.7	15.2	0.7
Secondary with A-level exam	60.2	44.6	4.8
Tertiary	80.5	59.7	12.6

as a percentage of all persons employed* in a given socio-demographic group;

*** persons employed category includes employees and self-employed persons**

Source: CZSO (2019).

Education in Digital Technologies

This chapter focuses on another indicator which measures the development of portable digital competencies. According to the Strategy, "the number of employed and unemployed persons who have developed their portable digital competencies in the last year should increase"[16].

Figure 2 shows the share of the persons who attain the process of education in digital technologies. We can see that the average level of attendance is near 28% with significant differences by the age (presence decreases with age) and by the education level (highly-educated people more often the life-long learning in digital technologies). There is a low share at the unemployed, females on maternity leave, and at the disabled; the lowest percentage is at the retired.

[16] The Strategy, p. 33.

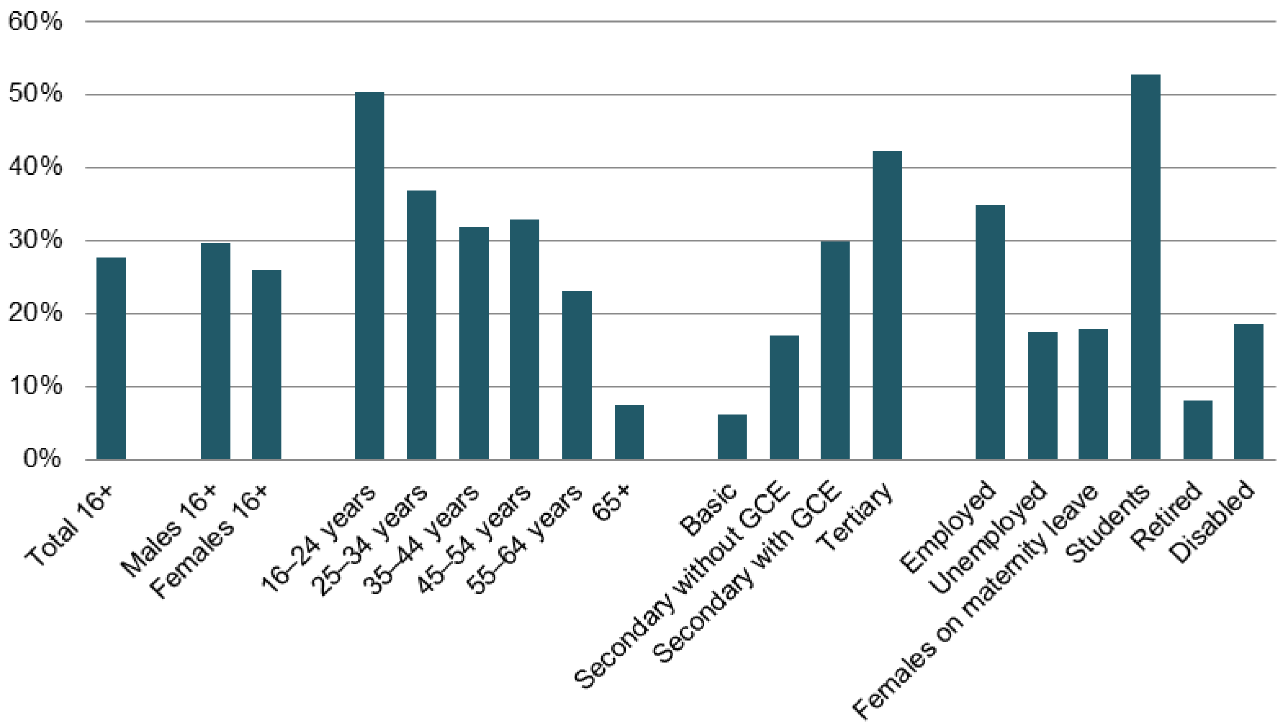

Figure 1 Education in digital technologies, 2018, % Source: CZSO (2018), p. 80.

4. Access of the Poor Households to the Digital Technologies

The last chapter focuses on another arrangement of the Strategy. The aim of this arrangement consists “to connect education and motivation activities of the strategic goal Employment with the activities supporting physical access to digital technologies; contribute to increasing of employment and the access to information related to the labour market"[17].

We can measure this arrangement by three indicators:

- Increasing share of poor households/individuals with access to digital technologies (mainly internet access),
- An increasing number of the points of physical access to digital technologies for individuals threatened by social exclusion,
- Improvement of the infrastructure of public libraries which is necessary for access to the digital content.[18]

We focus on the first indicator, using the data from the Czech Statistical Office (CSO, 2018). The number of households with internet access increased from 73.1% in 2015 to 80.5% in 2018. The differences between types of households and by the income group remain. However, the share of households of person 65+ has increased by 50 % during the three years (from 24.2% to 37.4%). Similarly, there is a significant increase in households under the median income (from 33.8% to 47.1% in the lowest income group and from 57.2% to 78.8% in the second quartile income group).

[17] The Strategy, p. 34.

[18] Ibid.

Table 2 Households with internet access in the Czech Republic, 2015-2018, %

	2015	2017	2018
Total	**73.1**	**77.2**	**80.5**
Total (with at least one member younger than 75)	79.0	83.2	86.4
Type of household (HH)			
Households with no children, total	65.2	70.5	73.8
HHs of persons aged up to 40 years	94.7	96.8	97.7
HHs of persons aged 65+ years	24.2	31.1	37.4
Households with children	93.6	95.9	97.8
Household income group			
The lowest income group (first quartile)	33.8	42.6	47.1
Second quartile income group	57.2	70.7	78.8
Third quartile income group	85.8	93.9	96.5
The highest income group (fourth quartile)	96.8	99.3	99.5

as a percentage of all households of a given type

Source: CZSO (2019).

In figure 2, we can see the comparison of the households from the lowest income group between the Czech Republic and the EU average. Although the access of low-income households to the Internet is getting better in the Czech Republic, the gap between the Czech Republic and the rest of the EU remains.

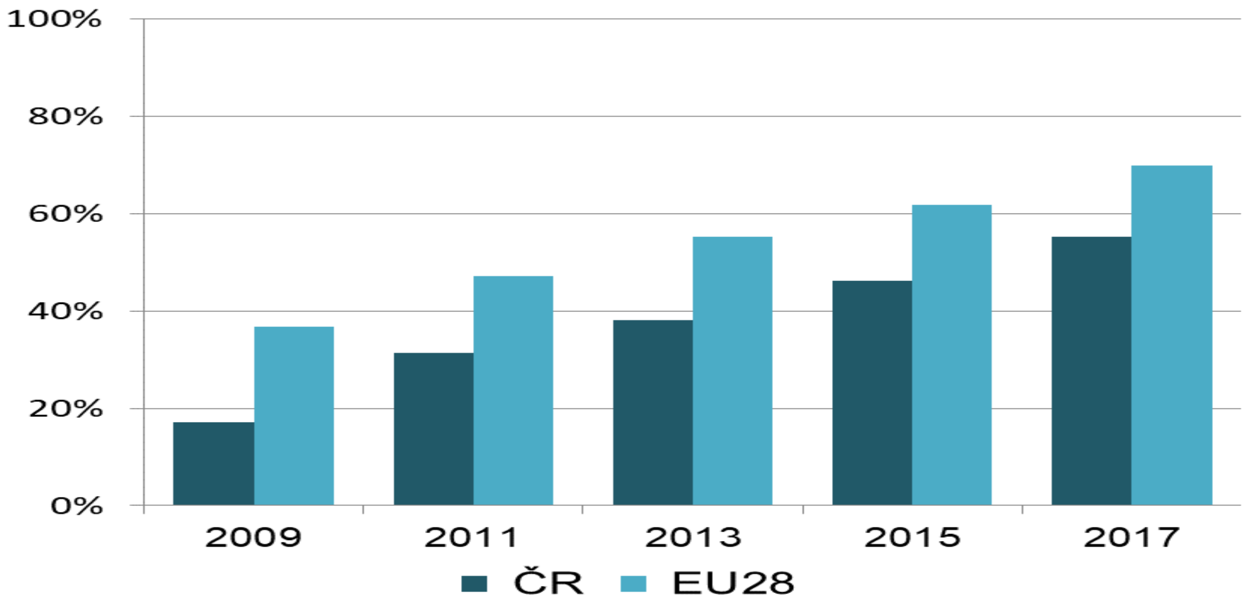

Figure 2 Households with internet access, the lowest income group, 2009-2017, % Source: CZSO (2018)

The last figure focuses on the usability of the Internet in households. The most important is the gap in using the internet measured by the share of the individuals who have access to the Internet but which do not use it. We estimate this phenomenon for the old-age people (10% of 55-64 year-olds and 16% of 65+ year-olds), people with just primary education (18%) and the retired and the disabled (16 % and 13 %, respectively). In this case, there is no issue with the physical access to the Internet but with poor digital literacy.

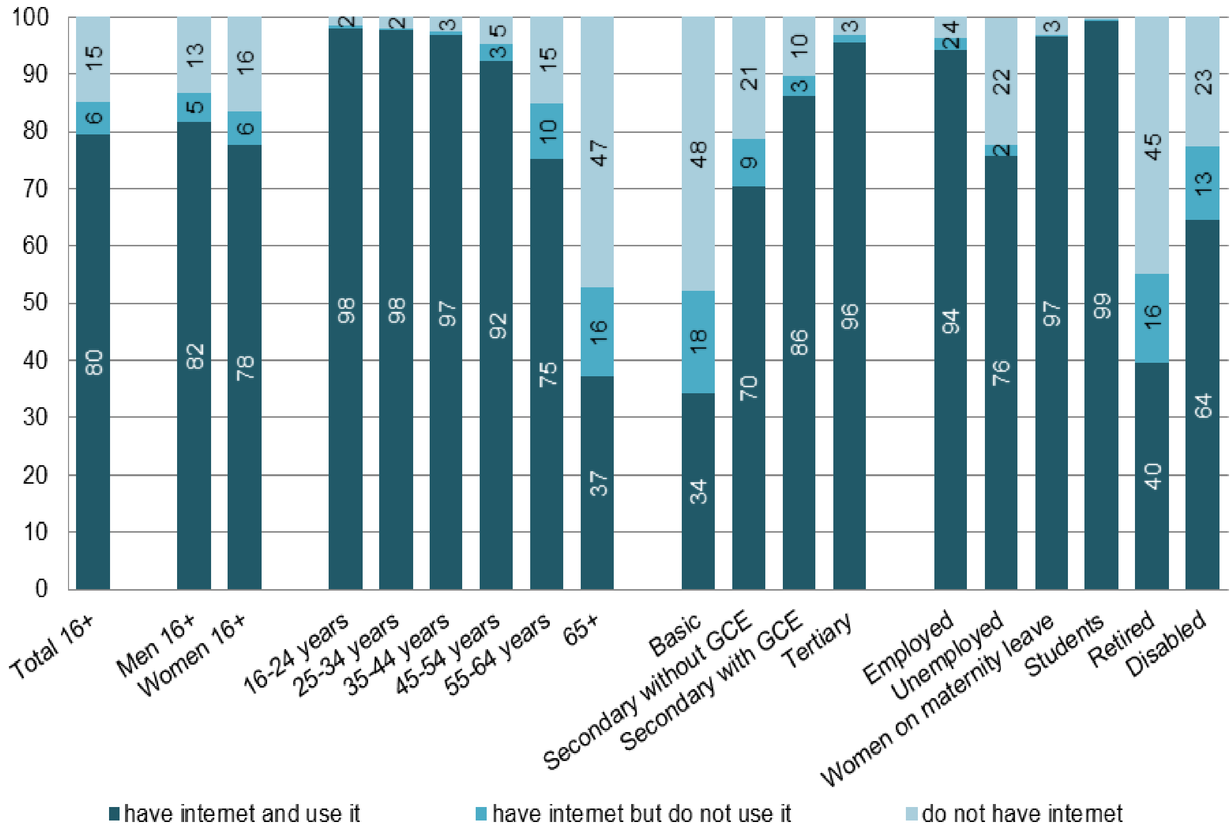

Figure 3 Individuals with the internet at households, 2018, % Source: CZSO (2018), p. 25.

5. Conclusion

Our paper aims at the digital literacy of individuals, both employed and unemployed. We focus on the analysis of the indicators mentioned by the Strategy of the development of digital literacy in the Czech Republic in the years 2015-2020. We discussed these indicators by the point of view of the adequation gap as these indicators are hard to be measured in a statistical sense.

Portable digital competencies primarily measure digital literacy. Despite the improvement made in the last years, some groups are still threatened by digital exclusion (retired, disabled, unemployed, less educated). In all these groups, there is a significantly lower share of the people who make everyday activities using digital technologies. The gap in digital exclusion between low-income households in the Czech Republic and EU28 also remains.

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FORMATION AND DEVELOPMENT OF THE DIGITAL ECONOMY IN MODERN CONDITIONS - DEVELOPMENT WITHIN THE FRAMEWORK OF INDUSTRY 4.0

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Keywords

Digital economy, information society, globalization, digital technologies, national economy, quality of life.

Abstract

The formation and development of the digital economy is associated with the transformation of leading technologies that provide human life. The leading idea of the program "Digital Economy of the Russian Federation" (2017) is to create a certain set of conditions for ensuring the digitalization of all economic processes in Russia. The main infrastructure component of the new way of life should be the digital environment.

The adopted direction of the development of the digital economy in the Russian Federation does not contradict the policy of the state both as a whole and in relation to each of the spheres of social life. It is important to note that the system must develop in a holistic and complex manner, because the bias in the development of its individual parts can be equated to a complete lack of improvement. Creation of the digital platforms for managing the economy is a strategically important task, the solution of which can not only restore a material production and lay the foundation for the introduction of future innovations, but also provide the priority development of the Russian Federation, which is now only catching up with advanced western countries.

The authors note in the article that the digital economy is becoming the driving force of economic growth in Russia. The analysis of the state of the main indicators of the digital economy is carried out. It is concluded that the further digitalization of the economy is inevitable for Russia. The ways for the improvement of the digital economy development are suggested in the article.

1. Introduction

In July 2017, the federal program "Digital Economy of the Russian Federation" was adopted, within the framework of which the transfer from the digital technologies' implementation to the integrated formation of the digital ecosystem takes place throughout the country. The realities of the present time dictate a communication through digital technologies and the Internet to the state, society, enterprises, organizations, factories and cities. The concepts of Industry 4.0, the Fourth Industrial Revolution, digitalization, digital technologies are picking up steam; they are no longer just the words, they represent real projects that are the part of our life. The concept of the Fourth Industrial Revolution was formulated in 2011 by Klaus Schwab, President of the World Economic Forum in Davos. Klaus Schwab saw the global changes of humanity in the Fourth Industrial Revolution; not the products will change anymore, but the people themselves and, accordingly, the whole world in this Revolution.

In the Russian Federation, digitalization is becoming a major factor in economic growth, both for business and for the state. In order to introduce the digital economy in Russia, a number of regulatory acts have been approved by the executive bodies of the state power.

2. Methods

The concept of digital economy is disclosed in the first section "Strategies for the development of the information society in the Russian Federation for 2017-2030", approved in May 2017 , and is defined as an economic activity, in which the key factor of production is digital data processing of large volumes and the use of the results of the analysis, which, compared with traditional forms of management, can significantly improve the efficiency of various types of production, technology, equipment, storage, sales, delivery of goods and services.

In order to manage the Program, five basic directions for the development of the digital economy in Russia for the period up to 2024 have been defined, namely: regulation, personnel and education, a formation of research competencies and technical reserves, information infrastructure and information security. According to the plan, a full range of standards of the digital economy planned will be formed by 2020, and digital infrastructure - by 2024. Digitalization of finance and the creation of a single financial market are expected by 2025. The changes in the field of energy are expected earlier. So, by 2019, it is planned to create a single electricity market, and by 2024 - a single gas market.

3. Analysis

Let`s analyze the data on the use of information and communication technologies (ICT) by the population and in business; the development of an electronic state in Russia and in foreign countries; indicators characterizing the digital economy cadres; the telecommunications market; the activity of the ICT sector (information computer technologies). For this purpose, we consider the main indicators of digital economy development in the Russian Federation for the period of 2010-2017.

According to Table 1, countrywide for the period 2010-2017, there is an increase mainly of all indicators (Abdrakhmanova, G. I., Gokhberg, L. M., Demyanov, A. V. and other, 2018, p.89). The situation in the use of modern information technologies is improving at a slow pace, the use of which is the most important feature of the development of a modern economy based on knowledge and the use of artificial intelligence technologies, which minimizes the influence of the human factor.

Artificial intelligence, the blockchain, the Internet of things etc. play an essential role for all areas of the Digital Economy of the Russian Federation Program. Mobile Networks and Artificial Intelligence worthily occupy the first and second places in any research, being basic technologies that provide the current wave of digitalization, and E-commerce is characterized by high investment activity and a large number of transactions segment.

Table 1 - The main indicators of the development of the digital economy in the Russian Federation for the period of 2010-2017

Indicators	2010	2012	2013	2014	2015	2016	2017
Domestic costs for research and development in the priority direction "Information and telecommunication systems" in percentage of the total domestic costs for research and development	7,3	8,9	8,0	8,3	8,2	8,3	-
Publications of Russian authors in the field of Information and Communication Technologies (ICT) in editions indexed in the Web of Science database; in total, units	1197	1175	1529	2593	3678	3927	4036
In percentage of the global number of ICT publications	0,76	0,71	0,82	1,27	1,62	1,70	2,10
Patent applications for ICT inventions filed by Russian applicants; in total, units	1239	1583	1772	1763	1898	1532	-
In percentage of the global number of ICT patent applications	0,43	0,49	0,50	0,44	0,45	0,35	-
Gross value added of the ICT sector in percentage of GDP*	-	-	-	-	2,7	2,6	2,7
Subscribers of fixed broadband Internet access per 100 people population, units	-	14,4	16,5	17,0	18,3	18,6	20,9
Subscribers of wireless broadband Internet access per 100 people population, units	-	52,7	59,9	65,2	69,1	72,4	80,5

There are researches in the Table 2 based on the researches data of the National Research University Higher School of Economics (HSE), cloud services use is observed in 30% of the population and 18% in organizations. The following ratio has been determined among Internet users: population 81%; public administration 95%; financial sector 92%; processing industries

96%; trade 93%; transport 80%; social sphere 89%; households 75%. (Abdrakhmanova, G. I., Gokhberg, L. M., Caves, M. A. and other, 2017, p.20)

According to the Digital Economy of the Russian Federation Program, by 2025, 97% of Russian households will have broadband Internet access, ten digital platforms will be introduced for the main sectors of the economy and universities will produce more than 100 thousand IT specialists a year.

According to the international company McKinsey, working in the field of management consulting, the digitalization of the Russian economy will be the source of long-term economic growth. The potential effect on GDP from the digitization of the economy by 2025 is estimated at 4.1–8.9 trillion rubles, which will be 19–34% of the total increase of GDP.

Today, international experts refer Russia to the group of leading countries in terms of the development of the digital economy. In 2011, The Boston Consulting Group (hereinafter referred to as BCG) estimated the contribution of the digital economy to Russia's GDP at 1.6%. According to the study of "Economics Runet", conducted by the Russian Association of Electronic Communications (RAEC), the digital economy in 2016 was 2.8% of Russia's GDP or $ 75 billion, while in 2015 it accounted for 2.3% GDP (Annual analytical report, 2017, p.6). According to BCG, the share of the digital economy in the GDP of developed countries is 5.5%, and the developing ones 4.9%.

In 2016, one of the main reports of the World Bank (Annual analytical report, 2017, p.2) was devoted to the development of the digital economy. The reasons for this are simple. According to the Huawei’s Global Connectivity Index (GCI) rating, which measures the progress of 50 major states on the path of digital transformation, it is obvious that there is a clear correlation between digitalization and sustainable economic growth. If a country rises by at least one point in the ranking, it is accompanied by an increase of 2.1% in competitiveness, 2.2% in innovation and 2.3% in labor productivity (Annual analytical report, 2017, p.5).

Table 2 - The dynamics of the structure of indicators characterizing the digital economy in the Russian Federation for the period of 2010-2017

Indicators	2010	2012	2013	2014	2015	2016	2017
Percentage of households with Internet access in the total number of households	48,4	60,3	67,2	9,9	72,1	4,8	6,3
Including broadband	-	-	56,5	64,1	66,8	70,7	72,6
The share of population using the Internet to receive state and municipal services in electronic form in the population aged 15–72 years who received state and municipal services in the last 12 months, %	-	-	30,8	35,2	39,6	51,3	64,3
The share of population using the Internet to order goods and services over the past 12 months in the total population aged 15–74 years, %	-	-	15,3	17,8	19,6	23,1	29,1
The share of organizations of the business sector using broadband Internet, in the total, in %	63,8	79,3	80,8	81,4	78,9	80,5	-
The share of organizations in the business sector using "cloud" services, in the total, %	-	-	11,0	13,8	18,4	20,5	-

The share of organizations in the business sector using electronic data exchange between their own and external information systems, in the total, %	-	23,1	24,1	53,1	59,2	1,6	-- -
The share of organizations in the business sector using the Internet to interact with customers, in the total, in %							
With suppliers	69,4	70,1	70,7	69,2	67,4	68,6	-
With consumers	54,8	57,1	57,1	55,6	54,4	55,6	-
The share of social organizations using broadband Internet, in the total, %							
Healthcare and social services	58,0	84,6	87,8	89,1	88,4	89,9	-
Higher education	84,3	94,2	94,7	94,6	92,5	93,9	-
Activities of libraries, archives, club-type institutions	25,2	49,4	55,5	62,6	64,2	67,0	-
Museum activities and the preservation of historical sites and buildings	38,0	68,9	75,4	80,6	81,3	84,1	-

4. Conclusion

Based on the above-mentioned, further digitization of the economy is inevitable for the Russian Federation. For the accelerated and effective development of the digital economy of the Russian Federation, it is necessary to assist in the development of ICT, which contains the major part of the staff required by the digital economy; it is also necessary to stimulate large-scale innovation and technological transformation in fields, especially in industry. The technological development of enterprises will be based on the development of global industrial networks and compliance with the requirements of Industry 4.0; the government needs to support society on the path to digital adoption.

In modern conditions, the introduction of Industry 4.0 leads to an increase in the quality of life, in turn, leads to an increase in human capital, as it is one of its components. Thus, one can talk about the development of the socio-economic triad “quality economy - development of human capital - quality of life” as the basis for creating a new quality of the country's economy that meets the needs of the individual, that is, improving the quality of life (Annual analytical report, 2017, p.5). But, on the other hand, the development of electronic servers leads to a reduction in jobs in the same banks or stores, since they are no longer needed. That is the increase in unemployment, which inevitably leads to a decrease in the quality of life. Currently, the leading countries are at the stage of the fifth technological order, which is characterized by the massive use of nuclear energy, the rapid development of electronics and microelectronics, information technology, genetic engineering, and the exploration of outer space. However, the most developed countries are ready to move on to the sixth technological order, developing combinations of intelligent production technologies with the latest high-quality information and communication technologies, i.e. cybernetic systems are being introduced to digitize the manufacturing industry. In other words, the production process will be controlled jointly by robots and humans, intelligent machines will coordinate the product life cycle, and transport will be carried out by drones. In addition, digitalization reduces the time required for design and production, provides a significant increase in labor productivity and increases the number of new products and technological systems. That`s why considerable attention is paid today to the development of the digital economy in the world. Therefore, today not only developed, but also developing countries consider the development of the digital economy as one of their priorities.

However, in comparison with the leading countries in this area, the Russian Federation is five to eight years behind. And there is a serious danger of stay behind forever, that`s why one cannot hesitate. So, today our country must do everything to remain a leading technological power and not lose its advantages during the new scientific and technological revolution.

The transformation of the technological basis of the economy is so significant that it is necessary to adapt a person in the diversity of his functions to the new realities of the digital environment. This environment is new conditions for the realization of the economic interests of citizens, enterprises and the state on the basis of "digital" competitive advantages. Many people associate such advantages with the level of development of digital skills, by which they understand the skills of applying digital technologies to solve daily and professional problems in the modern economy. The Fourth Industrial Revolution leads to the full automation of most production processes. Many operations in the industry and household have already moved to the online environment, and this process is gaining momentum. Digital transformation helps not only to follow the trend but also to save time, money, resources, i.e. to remain competitive.

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The federal target program "Digital Economy of the Russian Federation Program" was adopted by the Resolution of the Government of the Russian Federation on July 2017.

MULTI-CRITERIA SPANNING TREE FOR SENSOR NETWORK OPTIMIZATION

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Keywords

Sensor networks, graph theory, spanning tree, multiple criteria, constraints

Abstract

Sensor networks play an important role in the progress of modern society. Sensor network efficiency depends heavily on its topology, so designers are trying to design networks to maximize functionality and minimize sensor overhead. Since the topology of such networks may be described by "partially mesh" topology, we have turned to network graphs for assistance. Usually, only the location of the node is taken into account when creating a network, but the paths between nodes are not taken into account. This problem is describable by a network graph and can be optimized by searching for a spanning tree. There are several specific algorithms for finding the minimum spanning tree, such as Prim's algorithm or Kruskal's algorithm. The disadvantage of these algorithms is that they take into consideration only one optimization criterion and do not take into account limitations on weights of the edges. In this paper, we try to outline a solution how to calculate an optimal way of interconnecting sensors in a sensor network by applying several criteria at once.

1. Introduction

Computer networks play an important role in the progress of today's information society. However, sensor networks are of no less importance, and their development is parallel to the development of computer networks for over 40 years. While in the early days, sensor networks were exclusively a military domain, nowadays they are applied almost in all areas of our lives. Initially, they were very simple sensors that only recorded some physical quantity. The evaluation of the measured values required complex technologies and considerable financial resources. The idea of sensor networks at the time of the Cold War was a progressive, but still utopian idea. The growth of the Internet, miniaturization of semiconductor elements, the introduction of IPv6 and the overall accelerated development in the field of informatics and communications have created conditions for the emergence of sensor networks beyond military technology. It appears that well-designed sensor networks can be very useful and can protect life and property. Sensor network efficiency depends heavily on its topology and that is why designers are trying to design networks with maximizing functionality and minimizing sensor overhead. Since the topology of such networks can be described by "partially mesh" topology, which can be modelled as an incomplete network graph, it is usually only the location of the node that is considered when creating these networks, but paths between nodes are not taken into account. This problem can be described by a network graph and optimized by searching for a spanning tree. Current sensor networks are very heterogeneous in terms of their use, size, communication capabilities, lifetime, etc. There are sensor networks in which more than 100 sensors are implemented per m^3 and there are also those in which the distances between the sensors can be measured in kilometres. Sensor network nodes are in most cases randomly distributed in the selected area and form a so-called sensor array. Each node has the ability to capture data from its surroundings and process it locally. The data is then transmitted over the network to a special node called a sink by hops. The sink communicates with the outside world via Internet or satellite to which the user is connected via a task node. The communication architecture may vary depending on which application the network is used for. However, the basic principles remain the same. The sensor network design is further influenced by several factors that must be taken into consideration when designing routing algorithms and protocols. They are based on metrics for determining the quality and efficiency of these algorithms. The most important of these factors are:

- Cost of production - with a large number of nodes, there are also large financial costs for networking. Therefore, it is important to select nodes with a sufficiently low price.
- Hardware restrictions - The sensor node consists of four main parts: computing unit, sensor unit, power unit and transmitter with receiver. Data sensing is provided by a sensor unit consisting of sensors and converters of analogue signals to digital ones (ADCs). After data processing by a processor that usually has some memory, the node connects to the network by means of a transmitter/receiver and interacts with other nodes that the processor is in charge of. In addition to these components, the node can contain other important parts. Most routing algorithms need to know the position of nodes in the network for their operation, which is achieved algorithmically, or by adding a positioning device. One of the most important parts of the node is an energy unit that supplies all components with energy.
- Network topology may change during network lifetime. Once deployed in the sensor array, the individual nodes have to identify their neighbours with whom they will communicate. This information has to be kept up-to-date either because of node outages or because of deployment of new nodes due to low network connectivity or changes of requirements placed on it.
- Scalability - Sensor networks can contain hundreds, thousands, and in some cases, millions of nodes. This fact is related also to the density of the network, which significantly affects the efficiency of communication algorithms. In addition, number and density of nodes in the network change dynamically.
- Failure tolerance - due to a limited power source, hostile activity, physical damage, or environmental interference, network node failures occur. The network should reckon with it and keep its functionality.
- Environment - the use of sensor networks envisages a wide variety of environments, and the design should be adapted to it. A network for forest fire detection has its own safety requirements, and a network monitoring motion on enemy territory does it as well. Similarly, there is a distinction between environmental disturbances in built-up areas and undeveloped ones.
- Broadcasting media - largely influences network design and media choice for communication. The most common options are: radio communication, infrared communication or optical media.
- Energy consumption - one of the most specific features of sensor networks is the non-renewability of energy resources and thus their limited lifetime.

2. The minimum spanning tree problem

The problem of finding a way to interconnect a set of nodes on a network graph with a set of edges in such a way that there are no cycles and none of the nodes are isolated, is called a spanning tree problem. According to Levitin (2007):"A spanning tree of a connected graph is its connected acyclic subgraph (i.e. a tree) that contains all the vertices (i.e. nodes) of the graph". We can also add some numeric values to the edges of the network graph, which typically represent the mutual distances between two nodes or relevant costs that are involved in creating connections between these nodes. Such a network graph is called a weighted network graph. If this graph is connected (i.e. it does not contain any isolated nodes), then it is possible to find a spanning tree with the minimum sum of weight for all included edges. This type of spanning tree of a network diagram is called its minimum spanning tree. Levitin defines a minimum spanning tree of a weighted connected graph as "its spanning tree of the smallest weight, where the weight of a tree is defined as the sum of the weights on all its edges" (Levitin 2007).

There are a few algorithms that are suitable for solving the minimum spanning tree problem. According to Graham and Hell (1985): "It is standard practice among authors discussing the minimum spanning tree problem to refer to Kruskal (1956) and Prim (1957) as the sources of the problem and its first efficient solutions, even though both of their papers refer to Borůvka (1926)." Borůvka's algorithm was the first algorithm for spanning trees; however, it is only applicable under the special condition that every edge of a network graph has a unique weight. If there are two or more edges with the same weight in the network graph, it is not possible to find its minimum spanning tree using Borůvka's algorithm. In sensor networks it is very hard to fulfill this condition and therefore we consider this algorithm to be inappropriate for the development of sensor networks.

A better algorithm for searching for the minimum spanning tree of a connected network graph is Kruskal's algorithm because it always yields an optimal solution. Kruskal's algorithm looks at minimum spanning tree for a weighted connected graph $G = (V, E)$, where V is a set of vertices (i.e. nodes) and E is a set of edges, as an acyclic subgraph with $|V| - 1$ edges for which the sum of the weights of the edges is the smallest. The algorithm constructs a spanning tree as an expanding sequence of subgraphs, which are always acyclic, but are not necessarily connected during the intermediate stages of the algorithm (Levitin 2007).

Initially, the algorithm sorts the graph's edges in a non-descending order according to their weight. Then starting with an empty subgraph it scans the sorted list of edges and at every iteration it adds the next edge on the list to the current subgraph, if such an inclusion does not create a cycle. If it would lead to creation of a cycle, then the algorithm simply skips the current edge and goes to the next iteration in which it considers the inclusion of the next edge on the list.

Kruskal's algorithm consists of a sequence of following steps:

1. Edges of graph G = (V, E) are sorted in a non-descending order according to their weight;
2. $E_T \leftarrow \emptyset$ (E_T is a set of edges that were already included in the generated spanning tree);
3. *ecounter* $\leftarrow 0$ (*ecounter* is a variable indicating the number of edges in E_T);
4. k $\leftarrow$ 0 (k is a variable representing an index of an edge on the sorted list that is currently considered to be or not to be included in the constructed spanning tree during the algorithm);
5. Until (*ecounter* $< |V| - 1$) {

   $k \leftarrow k + 1$;

if $E_T \cup \{e_k\}$ is acyclic, then

(e_k is a considered edge on the list of sorted edges and k represents the order of this edge on this list)

{

$E_T \leftarrow E_T \cup \{e_k\}$;

ecounter ← ecounter + 1;

} };

6. The output is E_T

3. A multi-criteria spanning tree taking into account the importance ratio of individual criteria and constraints on the weights of the edges

In this chapter we present our algorithm for finding a multi-criteria spanning tree taking into account the importance ratio of individual criteria and constraints on the weights of the edges. We think that a sensor network interconnection optimization using only one criterion is not sufficient anymore and there should be also some constraints on the weights of the edges taken into account, for example the transmission capacity of any edge or a subset of edges should be higher or equal than a required constant or the necessary costs involved to create a direct connection between two vertices should be lower than a specific constant.

In our opinion, the most meaningful criteria that should be considered during the design and development of a sensor network is the minimization of creation costs, maximization of transmission capacities and maximization of reliability of the individual edges; however, other criteria may be considered as well. These criteria should correspond to the needs of a business or an organization for which the sensor network is being constructed. For example, some organizations prefer transmission capacities over creation costs in a 2:1 ratio, while other organizations prefer creation costs over transmission capacities in a 3:1 ratio.

Besides the criteria and their importance ratio, it is also necessary to know the evaluation matrices of the individual edges in terms of the individual criteria. These matrices contain the weights of the edges corresponding to individual criteria. The number of matrices is equal to the number of the criteria. For example, if an organization wishes to consider three different criteria, then it is necessary to have three different evaluation matrices, because each of them is devoted to only one criterion.

All these evaluation matrices are square matrices, i.e. the number of their rows is equal to the number of their columns and that is equal to the number of nodes (i.e. $|V|$) of the graph $G = (V, E)$. For example, if $|V| = 10$, then each matrix will have 10 rows and 10 columns. At the crossing points of the rows and the columns of a matrix there are numeric values representing the weights of the individual edges corresponding to a selected criterion. These values are given in specific measurement units. For example, appropriate measurement units for creation costs are EUR or USD and appropriate units for measuring transmission capacities are bits per second (i.e. bps), kilobits per second (i.e. kbps), etc. Regarding measurement units, reliability of the edges is an interesting criterion. The weights of the edges in terms of reliability can be determined by a group of experts using their expert estimations. For example, experts can assign a certain number of points from 0 to 5 to the individual edges as their judgments of their reliability. On this scale, 0 means a very low or zero reliability of an edge, while 5 means a very high or maximum reliability. Experts can evaluate, for example, the appropriateness of the edges in terms of their resistance to mechanical damage, electromagnetic radiation, resistance to heat, personal safety, fire protection, flood protection, etc. The final weights of the individual edges in terms of their reliability can be calculated as an arithmetic average of individual evaluations of all experts within an expert group.

On the main diagonal of these matrices there are no numeric values because it is not logical to connect a node of a sensor network to itself. Another important characteristic is that the matrices are symmetrical alongside their main diagonal. This is because an edge $e = (u, v)$ is the same edge as (v, u), where u and v are vertices from the set V of G's vertices. For example, the edge in the second row and the third column of a matrix is the same edge as the edge in its third row and its second column and that's why the weights on both of these crossing points are the same.

As we mentioned earlier, the multi-criteria spanning tree problem can be extended by specific constraints (i.e. limitations) on the edges of the constructed spanning tree. There are a few kinds of constraints that come into play, for example "greater or at least equal in comparison to a required constant" (i.e. some of the edges or all of them must have a greater or at least equal weight corresponding to a specific criterion in comparison to a required constant), "lesser or at most equal in comparison to a required constant", interval constraints (i.e. some of the edges or all of them must have a greater or at least equal weight corresponding to a specific criterion in comparison to a constant and a lesser or at most equal weight corresponding to this criterion in comparison to another constant at the same time), etc. The interval constraint makes sense mostly in conjunction with transmission capacities because of an effort to achieve a balanced network. It is possible to apply multiple constraints on a single criterion, because one of these constraints can be applied on a specific set of edges (i.e. edges that connect specific nodes in the network) and other constraints can be applied on other sets of edges. In this case, there are multiple constraints set for the same criterion, although they are set for different segments of the spanning tree.

If some constraints are established, then it is necessary to identify any edges that do not meet any of these constraints for any criterion. After the identification of all inappropriate edges a subgraph of graph $G = (V, E)$ is created, which can be denoted as $G' = (V', E')$. This subgraph must contain only the edges of G that meet all constraints. After the creation of the subgraph G' it is necessary to verify if it is still possible to construct the required multi-criteria spanning tree of G using the edges in E'. If there is no acceptable spanning tree meeting all the required constraints, then there is no optimal solution for the task. Verification of the existence of at least one feasible solution can be done through an analysis of the subgraph G'. If this subgraph contains all the vertices of the graph G and it is connected at the same time, then it is possible to find at least one feasible spanning tree of G for sure. These two conditions must be met at the same time. A spanning tree of G' is a connected acyclic subgraph of G' containing all its vertices and it is logical that it is not possible to find a connected subgraph of G' containing all its vertices if G' itself is not connected. It is also obvious that if the subgraph G' doesn't contain all the vertices of G, then it is not possible to create a feasible spanning tree of G using the edges of G'.

The verification of the connectivity of the sub-graph G' can be done as follows. If G' is really connected it must be true that if we select any vertex of G', it is possible to reach this vertex from any of the other vertices of G' using the edges in E'. For example, if the subgraph G' contains vertices v_1, v_2, v_3 and v_4 (i.e. $V = \{v_1, v_2, v_3, v_4,\}$) and we select vertex v_1 for the verification of the connectedness of G', then it must be possible to identify a path connecting vertex v_1 to vertex v_2, a path connecting v_1 to v_3 and, finally, a path connecting v_1 to v_4 using only the edges in E'. If this is true, then vertex v_1 is reachable from all the other vertices of G' and therefore it means that G' is a connected graph.

After the verification that the subgraph G' is connected and it contains all the vertices of the original graph G, we can proceed to find the optimal solution. The next problem that should be solved is the mutual incomparability of the evaluation matrices due to different measurement units used in each matrix. For example, if the first optimization criterion is the minimization of creation costs and the second criterion is the maximization of transmission capacities, then the weights in the first evaluation matrix can be measured in EUR or USD and the weights in the second matrix can be measured in kbps. Due to different measurement units, it is not possible to mutually compare these matrices. However, this problem can be solved by normalization of the matrices.

Normalization can annul the relation of the matrices to specific measurement units and it can make them mutually comparable. Normalization of a matrix $\mathbf{C} = \{c_{ij}\}$, where $i = 1,\ldots, |V|$ and $j = 1,\ldots, |V|$ can be made using the following formula: $c'_{ij} = \frac{c_{ij} - \min\{c_{ij}\}}{\max\{c_{ij}\} - \min\{c_{ij}\}}$

With the help of this formula we can calculate a normalized matrix $\mathbf{C'} = \{c'_{ij}\}$, where $i = 1,\ldots, |V|$ and $j = 1,\ldots, |V|$ and the original values of the matrix $\mathbf{C}$ can be transformed into dimensionless numbers at a closed interval [0;1] of the matrix $\mathbf{C'}$.

If some of the criteria that are set for the multi-criteria spanning tree are maximization criteria, then it is necessary to convert all these maximization criteria into an opposite form intended for minimization. Of course, we still want to preserve the original type of a required extreme of a specific criterion (i.e. maximization), so that the conversion of a maximization criterion into an opposite form intended for minimization is done only from a computational point of view. For example, if we have two edges, edge *a* and edge *b*, so that the normalized weight of edge *a* corresponding to a maximization criterion is equal to 0.4 and the normalized weight of edge *b* corresponding to the same criterion is equal to 0.6; then in terms of this criterion we prefer edge *b* because it has a higher normalized weight. The maximization of normalized weight corresponding to a maximization criterion is equivalent to the minimization of the absolute difference between the normalized weight and the maximum normalized weight. The maximum normalized weight using the formula above is always equal to 1 and it corresponds to the best edge in terms of the selected maximization criterion because after the normalization of any matrix all of its values are at the closed interval [0;1]. The absolute difference between the normalized weight of edge *a* and the best possible weight is equal to 1 – 0.4 = 0.6 and for edge *b* this absolute difference is equal to 1 – 0.4 = 0.6. Thus, if we are looking for an edge that has the lowest absolute difference between the normalized weight and the best possible weight, we again prefer the edge *b*. This means that we have transformed the selected maximization criterion to a form intended for minimization from the computational point of view only and we still have preference for the same edges that we would prefer without this transformation.

The conversion of a normalized matrix $\mathbf{C'} = \{c'_{ij}\}$, where $i = 1,\ldots, |V|$ and $j = 1,\ldots, |V|$ to a normalized matrix $\mathbf{C''} = \{c''_{ij}\}$, where $i = 1,\ldots, |V|$ and $j = 1,\ldots, |V|$ corresponding to the opposite type of extreme can be performed using the following formula: $c''_{ij} = 1 - c'_{ij}$

After the normalization of all matrices and the conversion of all matrices corresponding to a maximization criterion to an opposite form intended for minimization we can proceed to the creation of a final matrix $\mathbf{K} = \{k_{ij}\}$, where $i = 1,\ldots, |V|$ and $j = 1,\ldots, |V|$, which we intend to use to find the final spanning tree of G taking into account the importance ratio of the required criteria. The elements of this matrix represent a weighted sum of corresponding elements in all the normalized matrices (regarding minimization criteria) and the transformed matrices (regarding maximization criteria) taking into account the importance ratio of all criteria. Thus, if there are, for example, three optimization criteria, then the matrix $\mathbf{K}$ is calculated using three evaluation matrices and the importance ratio of these criteria. If two of them are minimization criteria and one of them is a maximization criterion, then it is needed to transform the normalized matrix corresponding to the maximization criterion in an opposite form intended for minimization and we can calculate the values of the matrix $\mathbf{K}$ using the two normalized matrices corresponding to the minimization criteria and the transformed matrix corresponding to the maximization criterion. The elements of the matrix **K** can be calculated using the following formula:

$k_{ij} = v_1 * k_{1ij} + v_2 * k_{2ij} + \ldots + v_k * k_{kij}$

where v_1, v_2, ... ,v_k are the weights representing the importance ratio of required criteria. For example, if we take three criteria into account – the minimization of creation costs, the maximization of transmission capacities and the maximization of interconnection reliability – and their importance ratio is 3:2:2, then it means that $v_1 = 3$, $v_2 = 2$ and $v_3 = 2$. k_{1ij}, k_{2ij}, ..., k_{kij} for $i = 1, \ldots, |V|$ and $j = 1, \ldots, |V|$ represent the normalized evaluation matrices (regarding minimization criteria) or the transformed evaluation matrices (regarding maximization criteria) and their elements at the crossing points of their rows and columns.

After the creation of matrix **K** it is possible to proceed using standard algorithms for the minimum spanning tree problem, for example Kruskal's algorithm or Prim's algorithm. Thus, the aim of the whole procedure described above is to convert a multi-criteria optimization task with constraints on the weights of the edges into a standard one-criterion optimization task without any constraints. However, for the purpose of interpreting the final result it is necessary to use the original weights of all edges regarding all required criteria, not the normalized or the transformed weights.

The whole algorithm described above consists of the following steps:

1. Identify all edges that do not encounter any constraints;
2. Create G' = (V', E') – a subgraph of the original network graph G consisting of all the edges that meet all the required constraints;
3. ET ← ∅ (ET is a set of edges that were already included in the constructed spanning tree);
4. If G' doesn't contain all the edges of G, then

the output is E_T (the optimal solution of the task doesn't exist);

else

if *G'* is not a connected graph (i.e. if we select an arbitrary vertex of *G'* and it is not possible to reach this vertex from all of the other vertices of *G'* using the edges in *E'*), then

the output is E_T (the optimal solution of the task doesn't exist);

else

go to step 5;

5. For every evaluation matrix C = {cij}, where i = 1,…, |V| and j = 1,…, |V| create a normalized evaluation matrix C' = {c'ij}, where i = 1,…, |V| and j = 1,…, |V| using the following formula:

   $c'_{ij} = \frac{c_{ij} - \min\{c_{ij}\}}{\max\{c_{ij}\} - \min\{c_{ij}\}}$;

6. For every normalized matrix C' that corresponds to a maximization criterion, create a transformed matrix C'' = {c''ij}, where i = 1,…, |V| and j = 1,…, |V| representing a transformation of the maximization criterion into an opposite form intended for minimization using the following formula:

   $c''_{ij} = 1 - c'_{ij}$;

7. Create a matrix K = {kij}, where i = 1,…, |V| and j = 1,…, |V| that aggregates all the normalized matrices (for all minimization criteria) and all the transformed matrices (for all maximization criteria) using the following formula:

$k_{ij} = v_1*k_{1ij} + v_2*k_{2ij} + \ldots + v_k*k_{kij}$ (i.e. $\mathbf{K} = v_1 * \mathbf{K_1} + v_2 * \mathbf{K_2} + \ldots + v_k * \mathbf{K_k}$),

where $v_1, v_2, \ldots, v_k$ are the weights representing the importance ratio of the required criteria and $k_{1ij}, k_{2ij}, \ldots, k_{kij}$ represent the elements of the matrices necessary to calculate the elements the matrix **K** (i.e. for each of the criteria: if it is a minimization criterion we use the normalized matrix regarding this criterion for the creation of the matrix **K** and if it is a maximization criterion we use the transformed matrix);

8. Calculate the minimum spanning tree of G' using the edge weights in matrix K with the help of Kruskal's algorithm or Prim's algorithm. If we select Kruskal's algorithm, then the following steps are required:
   a. Sort the edges in *E'* in a non-descending order according to their weight in matrix **K**;
   b. *ecounter* ← 0 (*ecounter* is a variable indicating the number of edges in E_T);
   c. k ← 0 (k is a variable representing an index of an edge on the sorted list that is currently considered to be or not to be included in the constructed spanning tree);
   d. Until (*ecounter* < $|V|$ - 1) {

      $k \leftarrow k + 1$;

      if $E_T \cup \{e_k\}$ is acyclic, then

      (e_k is an edge on the list of sorted edges and k is the order of this edge on this list)

      {

      $E_T \leftarrow E_T \cup \{e_k\}$;

      ecounter ← ecounter + 1;

      } };
   e. The output is E_T;

4. Conclusion

The problem of finding a minimum spanning tree of a network graph can be solved using specific algorithms such as Prim's algorithm and Kruskal's algorithm. The drawback of these algorithms is that they take into account only one optimization criterion and they are not adequate for dealing with constraints on the weights of the edges. In our opinion this is no longer sufficient and because of this we present our own algorithm for finding a spanning tree of a network graph taking into account multiple criteria at the same time and also constraints on the weights of the edges. According to our view, the most meaningful criteria related to the edges that should be considered in design and creation of a sensor network are the minimization of creation costs, the maximization of transmission capacities and the maximization of reliability of the individual edges; of course, other criteria may be considered as well. Let us believe that this algorithm can be helpful for the designers of sensor networks in the process of sensor network optimization.

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STUDY OF SELECTED SERVICE PROVIDERS IN THE CZECH REPUBLIC WITHIN SOCIETY 4.0

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Keywords

Sharing Economy, Providers of Digital Content, Online Communities

Abstract

The paper discusses the topic of sharing of digital content as part of a sharing economy. The phenomenon of last decade is the sharing economy. Originally, the sharing in offline communities was replaced by the sharing in online communities. The most famous are areas such as accommodation services or transport services. One of the area of the sharing economy is the sharing of digital content (especially movies, music, electronic books etc.). This area interferes with the lives of almost every one of us, especially the digitally literate people of the younger generation. The described research shows the extreme involvement of the young generation (secondary and primary school pupils) in sharing digital content. Other analyses also show key players on the Czech market. Research has shown that, although a perfectly competitive environment could be expected, it is not. Although there are no formal barriers to entry, digital content sharing is characterized by a monopoly or oligopolistic position. A specific problem area is the issue of the legality of the sharing digital content, especially these days when the new EU directive came into force and EU Member States should implement it in national legislation.

1. The sharing of digital content as a part of the sharing economy

Principles of sharing have been known since time immemorial, but during last decade the term sharing and the sharing economy has received new dimension. Frenken and Schor (2017, pp.4-5) defined sharing economy as “consumers granting each other temporary access to underutilized assets, possibly for money”. Growing attention has two main causes: (1) the sharing economy has potential to support more sustainable lifestyle (Vaskelainen & Piscicelli, 2018, p. 1); (2) an increasing connectivity leads to development of virtual (online) communities (Huarng & Yu, 2018).

The specific area is the sharing of digital content. Hargittai & Walejko (2008) discuss it. We can recognize two forms: (1) the author of the (digital) content shares its content with others; (2) someone other than the author of the digital content shares it (and typically, this digital content could be downloaded elsewhere then the origin content).

In connection with this phenomenon is necessary to mention the problem of legality of some services of the sharing economy. The most famous cases are Airbnb as a provider of accommodation services (see more e.g. Ključnikov, Krajčík & Vincúrová, Z., 2018) or Uber as a provider of taxi services (see more e.g. Švecová & Veber, 2017). Pirate Bay is a typical world-known digital content representative. Pirate Bay is a website that indexes torrents. It is the world's largest torrent database and the 93rd most popular website by Alexa.com. Site traffic is funded mainly through ads appearing during searches that are on the site, through the extraction of Bitcoin, Bitcoin cash, Litecoin and Monero (Švecová et all, 2018, p. 51). Many countries have banned it (for example Netherland) and Court of Justice of the European Union issued a fundamental verdict that Pirate Bay violates copyright and may be blocked (CJEU, 2017).

2. The sharing of digital content in Czech Republic

In 2018, research on digital content providers in the Czech Republic was conducted. As part of this research, the providers were divided into these groups:

(Group #1) **Hosting services with content search by public**; they allow sharing digital content, but they renounce of responsibility for the content (the responsibility is up to the uploaders of the content).

(Group #2) **Audio-visual services providers based on request and e-book sellers and online libraries**; they usually purchase the copyrights to digital content and their profits are from reselling the digital content.

(Group #3) **Web portals**; they are typically signposts and refer to multiple digital content servers (mostly from group (1).

(Group #4) **Hosting services without content search by public**; there are storages (not primarily aimed at sharing digital content such as movies or music, but for sharing private content between registered persons).

(Group #5) **Web portals for digital content obtained through BitTorrent** (more about chapter 1). BitTorrent providers are basically tracker servers that offers torrent files. The service works by providing files to multiple users, and the client then downloads small parts from multiple sources. At the same time, the download is already offered to other users at the time of downloading.

(Group #6) **Social networks** (specialized or generic) can be used to share digital content too.

3. Research conducted and methodology

Overall analysis during research was delivered through several specific analyses:

(Analysis #1) **Pupils' questionnaire survey**.

Overall, relevant data from 1,069 primary and secondary school pupils (age group 13 and 18) were collected during June 2018. The target was chosen for these reasons:

1. Pupils has a high level of ICT knowledge and skills, esp. in the area of Internet search (Rambousek, Stipek & Wildova, 2015). Changing level of their skills are well described in Bombelli, Jirkovska, Sawyer et all. (2016).
2. Pupils does not have enough money for paying for digital content, participation of their parents is necessary.

3. The class environment is perfect for learning from each other in ICT (collective approach). There we can find connection between offline and online communities; see more about types of communities Vaskelainen & Piscicelli (2018).
4. Current pupils will be the one to continue using these services in the future.
5. Higher truthfulness of the answers was expected than, for example, for a group of university students or adults, who are also aware of the legal aspects of sharing digital content.

The questionnaire has only four questions (except demographic information). For every question, it was possible to check more options and for every option, it was necessary to specify frequency of use. The question was:

1. Check which of the following public cloud storage services you know of or use to store or/and share data, and how often.
2. Check which of the following services you know of or use to access music, movies, e-books, etc. on the Internet, and how often.
3. Check which social networks you use to store and share data, and how often.
4. Check which of the following non-media content providers (such as e-books) you know of or use, and how often.

The data was processed using descriptive statistics (absolute and relative frequency, cumulative frequency analysis, histograms), and chi-squared test for independence.

(Analysis #2) **Public information analysis** of hosting services providers focused on availability of content and price policy. The aim of this investigation was to confirm the hypothesis that costs are one of the primary motives for choosing digital content download servers. For the purposes of this analysis, 16 servers offering digital content have been identified. In addition, the following groups of digital content (77 items in total) were selected: (1) new movies in cinemas; (2) new series or episodes (foreign); (3) new DVD and BlueRay movies; (4) Top 20 most popular movies; (5) selected Czech movies (by popularity, user ratings, etc.); and (6) Top 10 most popular series (foreign).

(Analysis #3) **Transmitted data analysis** in cooperation with CESNET. IP ranges for selected providers (from group #1) were identified by the research team. IP address ranges have been derived from test traffic to selected services. The capture of the communication was through WireShark. These IP ranges were subsequently verified in several steps and then passed to CESNET. Fortunately, dynamic address assignment do not occurs in this situation. Sites with described content have static IP addresses and dedicated IP address ranges. Dynamic address assignment occurs only on client side, e.g. customer computer connected through ISP. The monitoring of transferred data was in the period 20 July 2018 to 15 August 2018.

(Analysis #4) **Technical content analysis**. In order to find out what data is available on the providers, a simple Python software tool was created by the research team, which regularly searched for the specified content on the servers. Python was chosen because of the availability of suitable libraries and documentation. Attention was focused on movies and series. The reason is that they are the most in demand and best found. The movie files are also the largest, so it is to be expected that movies or episodes of the series will be the largest part of data traffic. These films (136 titles in total) were searched for: (1) Top 100 IMDb; (2) new movies; (3) new series, resp. episodes; (4) new movies on DVD and Blue-Ray. After this initial analysis, which was done manually using the Developer Tools in Google Chrome, software tools for the selected servers were created.

The scan was run automatically once a day for each of the data sets at different times of the day. Also, the query-specific search was randomly paused after each query. The results were recorded in a file which was then further processed manually. Names of files and their sizes would be difficult to analyse by machine, it was necessary to find out which data is relevant and which data is for example a trailer.

(Analysis #5) **ČNS IFPI analysis**. ČNS IFPI (Czech National Group of the International Federation of Music Industry) has developed its own software through which it searches public storages and detects files whose names match their search terms (i.e. multimedia content with copyright).

4. Research Results

4.1. Hosting services with content search by public

As a rule, this category of providers has its business conditions based on the principle that it charges services for comfortable access to its content to its clients.

These players were identified on the Czech market (alphanumerically): *datoid.cz*, *eDisk.cz*, *fastshare.cz*, *hellshare.cz*, *hellspy.cz*, *sdilej.cz* and *uloz.to*.

According to the search for the same string (for example, a movie), it was found that players in this category contain similar or even the same content (the same file). Digital content uploaders likely upload content to multiple web sites. Their aim may be (among other things): (1) to get funds from downloading a file by other users, (2) to get the possibility to download the digital content for more advantageous conditions (according to the server).

Based on above stated analysis (see chapter 3) it could be concluded that: Server *uloz.to* has dominant position in this category. Other providers in total are not reaching 20% of *uloz.to* position.

Server *uloz.to* reaches more than 90 % of transmitted data from CESNET (see Figure 1). Transmitted data to CESNET from *uloz.to* reaches 87 % and it was more than 63 TB during monitored period.

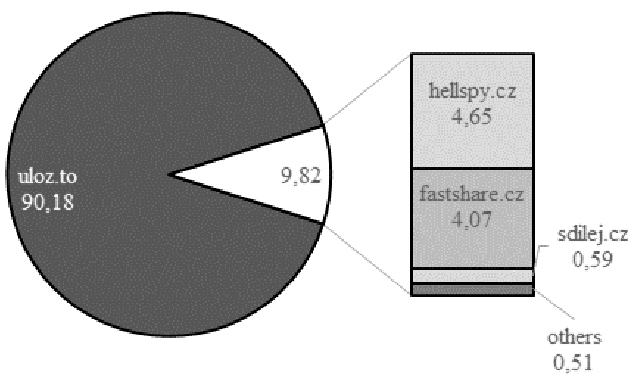

Figure 1: Transmitted data from CESNET Source: own research

The questionnaire survey showed that 98% of the surveyed pupils know the server *uloz.to* and more than 60 % use them (see table 1). The results are gender different. Boys know (and use) more providers, girls "are usually more loyal" to one. For example, 67% of girls used for the sharing of the digital content the server *uloz.to* and only 56 % of boys do it same, but the knowledge of the server *uloz.to* is the same for both group. Analogically, 81% of girls and 60% of boys used for the access to multimedia this server. Overall, 67% of girls and 78% of boys used three and more servers for the access to multimedia; however, 47% of girls and 63% of boys used four or more servers. The possible causes of this fact may be in the lower orientation of the girls in ICT services and their reliance on verified sources.

Table 1: A usage of selected providers for the sharing of the digital content

	Known	Used	Used occasionally	Used regularly	Used daily
Uloz.to	98%	59%	40%	15%	4%
Dropbox.com	67%	13%	10%	2%	1%
OneDrive	79%	26%	14%	8%	4%
GoogleDrive	83%	46%	22%	14%	10%
Hellshare.cz	43%	4%	3%	1%	0%
Hellspy.cz	54%	9%	6%	2%	1%
iCloud	76%	25%	9%	5%	11%
Mega.cz	44%	36%	32%	3%	1%

Source: own research

When comparing content of data, all of the storages were comparable except eDisk.cz (96 % of monitored content for *uloz.to*), but the prices (for download speed) were significantly higher for *uloz.to* than for most competitors, except *hellspy.cz*/*hellshare.cz* (see table 2).

Table 2: Average download prices of 1.5 GB of data (in CZK) and offered tracked content (in %)

	The best purchase	Purchase for 100 CZK	Offered content
Uloz.to	4.41	6.25	96%
Hellspy.cz/Hellshare.cz	6.24	10.61	95%
Datoid.cz	1.20	2.85	95%
Fastshare.cz	2.10	3.00	96%
eDisk.cz	1.21	4.30	87%
Sdilej.cz	0.50	1.00	95%

Source: own research

4.2. Audio-visual services providers based on request and e-book sellers and online libraries

This group provides on-demand audio-visual services or includes electronic retailers or content renters. Google Play, followed by Spotify and Netflix have the most important position in this category. There is no dominant player in “e-book sellers and online libraries” category.

The analyses show that these servers cannot compete with providers from category (1) described in chapter 4.1, in terms of the range of offered content. Their offer is very limited. ITunes has the widest range of offerings (with less than one third of the monitored content), GooglePlay offers only one quarter of the monitored content. Domestic TV servers offer only time-based content according to their broadcast schedule, which is variable. Netlix and HBO are only marginally usable for the needs of Czech audience. New movies and series do not offer these servers (they do not have copyrights). The strength of them is the good quality of the offered content. In terms of prices, they are substantially uncompetitive. Their prices are at least tenfold than providers from category (1). Price competitiveness is also debatable in relation to alternative cinemas that feature older movies too.

4.3. Web portals

There are intermediate servers in this category. These are signposts that typically link to multiple digital content servers. Some are completely free; others allow customers to purchase credit, which is used to purchase services on the servers, which are linked. Revenues are usually generated as commission for advertising a "click". *Multishare.cz*, followed by *Sledujufilmy*.cz have the most important position in “web portals” category. There is minority position of all others.

4.4. Hosting services without content search by public

This category includes storage that is not primarily aimed at sharing digital content (movies or music) between anonymous entities, but for sharing private content between registered entities. *DriveGoogle.com*, followed by *Mega.nz* and *Onedrive.com* have the most important position in this category. Totally, 83 % of pupils know *DriveGoogle.com*, but only 46% use them (see Table 1). There is minority position of all others.

4.5. Web portals for digital content obtained through BitTorrent

Based on the survey, the use of torrent servers (tracker servers) was mentioned in a large group of respondents. Neither the analysis of transferred data in cooperation with CESNET nor the technical analysis of public information has been carried out (this is not possible from the nature of the service). Based on the analysis of selected content, it was found that most of the selected content for analysis (96%) was found on the servers, including new movies. Content quality varies, from recorded videos to cinema viewing to fullHD files. *Cztorrent.net* is the most important domestic player in this category. *Thepiratebay3.org*, *Rarbg.to*, *1337x* and *Torrentz2.to* are the most important foreign servers here.

4.6. Social networks

Social networks can be used to share digital content, either specialized or generic. Table 3 shows how many percentages of pupils use social networks for access to digital content. You can see, that *Facebook* is the most important players in this category. This conclusion is supported for example statements of Bene (2017). The second one is *YouTube.com*, as other analyses have confirmed.

Table 3: A usage of social networks for access to digital content

	Not used	Used	Used occasionally	Used regularly	Used daily
Facebook	10%	90%	16%	17%	57%
Instagram	20%	80%	12%	9%	59%
LinkedIn	84%	16%	14%	1%	1%
Google+	52%	48%	30%	8%	10%
Twitter	60%	40%	24%	7%	9%
MySpace	85%	15%	13%	1%	1%
SnapChat	48%	52%	22%	11%	19%
Flicker	87%	13%	12%	1%	1%

Source: own research

5. Conclusion

All analysis of the research (the survey, the content analysis, the technical analysis, the price analysis etc.) discovered, that the dominant player of this area is from the category of provides described as “Hosting services with content search by public”. It leads to interesting consequences. The providers from this category allow everybody to share digital content, but they are not responsible for this content. Typically is possible to find the digital content which violets the copyrights. The providers (servers) “wash their hands” and shift responsibility for the legality of digital content (movies, music, books) to uploaders. They do not guard the legality of the content, they only respond to stimuli from the surroundings. The Commission recommendation (EU) 2018/334 of 1st March 2018 on measures to effectively tackle illegal content online sets out new possible obligations in the area of providing hosting services for storage of information provided by various recipients of the service.

Another interesting finding is the fact that the dominant player has essentially a monopoly position. Although the sharing economy sector could be expected to be more competitive, it is not the case. A similar situation exists in the accommodation services sector (Airbnb) or individual transport (Uber). For further research, it would be interesting to analyse the market positions of other entities in other areas of the sharing economy.

6. Acknowledgment

The survey was conducted within the project for Technology Agency of the Czech Republic named “Study of Selected Service Providers in the Czech Republic within Society 4.0”. This topic is developed in the project “Preparing the Commercialization of New Education Methods for the Needs of the Digital Economy and Industry 4.0” financed by Operational Programme Prague – Growth Pole of the Czech Republic.

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INNOVATION, NEW BUSINESS MODELS AND STRATEGIES

TOWARDS CYBERSECURITY-QUALIFIED WORKFORCE

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Keywords

Cybersecurity, curriculum, qualification, qualifications framework, lifelong learning, vocational education and training

Abstract

Currently, we see a plethora of coordinated or independent activities leading to establishment of national and international frameworks oriented to identify and describe cybersecurity qualification and/or provide mapping between professional roles, their tasks, knowledge and skills needed to fulfill the respective qualifications and appropriate education leading to achieve them. The goal of the project National Cybersecurity Qualifications Framework is to define a cybersecurity qualifications framework that is based on established standards, is compatible with European frameworks and can be implemented for Czechia. The purpose of this paper is to summarize recent activities and frameworks that should serve as a base for the Czech National Framework.

1. Introduction

The structure of the paper is as follows. Section 2 gives a brief overview of present cybersecurity education context – the main challenges in industry, infrastructures, and society, namely critical infrastructures and Industry 4.0 including IoT being the most critical and pervasive technology where the cybersecurity was underestimated in the past. Section 3 outlines existing cybersecurity qualifications frameworks and also general reference frameworks enabling mapping among national systems in Europe, namely European Qualifications Framework and e-Competency Framework. The Czech National Qualifications Framework is presented, too. Section 4 proposes foundation of a meta-model helping to understand the design of existing frameworks and allowing to compare their approach from a higher level in order to construct the *Czech National Cybersecurity Qualifications Framework*. Section 5 presents core ideas of this Framework. Section 6 concludes the paper and briefly outlines ideas worth attention in future research.

2. Cybersecurity Education Context

2.1. Critical Infrastructures

Critical infrastructures represent key systems and individual assets whose malfunctioning would endanger or seriously limit the society in its vital functions. The definition varies among legislation and (supra)national systems (Oliver & Haney, 2018). Nevertheless, due to the size, complexity, and interdependence, protecting critical infrastructure is a difficult problem. Moreover, the individual parts of subsystems are not solely owned or controlled by public sector but are owned and operated by either public or private organizations that must cooperate during its design, implementation, operation under normal circumstances but also co-work on their protection, maintenance, and during security-related incidents.

Therefore, there is a common need to educate experts in the field, with a mutually agreement upon a set of skills required to operate and protect critical infrastructure and produce a common body of knowledge (CBK) (Oliver & Haney, 2018). It does not only mean we need a commonly agreed set of skills forming complete professional qualifications with a 1:1 mapping to job positions. We must understand cybersecurity as a cross-cutting concern affecting many professional roles thus requiring general and/or specific skills to be capable to conduct professional activities responsibly with regards to cybersecurity interests.

Critical infrastructures only slowly establish themselves as a widely accepted formal field of study. Oliver & Haney (2018) argue this is because of complexity of the field and its multidisciplinary nature which does not fit easily into a graduate study program provided by a single academic department.

As a summary, we can derive the following findings:

- Cybersecurity can be a single discipline of study as well as a cross-cutting topic (or minor) within many other study fields.
- It is a multidisciplinary area encompassing elements form technical/IT disciplines as well as sociological-, psychological-, law- or business studies.
- It will always encompass public and private sphere and their overlapping interest that intersect in a common need for CI protection.
- There must be a shared terminology enabling basic common understanding of concepts among all actors which definitely include professionals, educators, administrators, decision and policy makers.
- Due to rising globalization and interconnection of critical infrastructures between national legislations, it has a strong international dimension, typically in telecommunication, banking, defense sector, power transmission, railway and air transport and many other fields.
- As the critical infrastructures are still strongly anchored in national legislation systems, international coordination in legal aspects including the roles of law enforcement is of utmost importance which involves also role of supranational bodies such as the European Union or NATO.

2.2. Industry 4.0

The nature of Industry 4.0 brings numerous inherent risks that must be avoided or mitigated in order to make the transition to Industry 4.0 viable. According to Thames and Schaefer (2017) *"Industry 4.0 will face traditional cybersecurity issues along with its very own unique security and privacy challenges. If these challenges are not appropriately addressed, the true potential of Industry 4.0 may never be achieved."* Nowadays, there are already many examples of the impact of cybersecurity issues in traditional industrial sectors (Moravec, 2017).

The main risks include:

- Risk of *cyber-espionage* of industrial intellectual property such as documentation for construction (CAD files), business process descriptions, or other business documents that cannot be kept in a safe but must be (partially) shared in the supply chain.

- Risks caused by *blurred security perimeter* in contrast to traditional environment with clear borders.
- *Big-data specific risks* including Internet of Things systems and privacy issues, see its impact e.g. in (Kozel et al, 2018).
- Risks arising from growing transition from on-premise to *cloud system operations* in the so-called cloud manufacturing including virtualization.

The significance of Industry 4.0 thus has a strong impact on cybersecurity qualification influencing composition and applicability of qualifications frameworks. We can summarize it as follows:

- High attention to *data security and privacy* to protect industrial intellectual property while allowing to share what needed.
- In-depth *security analysis of system perimeters* being blurred due to interconnection of production and supply-chain systems.
- Instruments for *analysis and design-phase security requirements* but also
- *security monitoring systems* enabling the enforcement of business and security rules during operation.
- Strong IT knowledge of *architectural and security aspects* of cloud and networking technologies that are key fundamentals to many present and future critical infrastructures.

3. Cybersecurity Qualifications Frameworks

3.1. NICE Qualifications Framework

The U.S. National Initiative for Cybersecurity Education (NICE) has developed a comprehensive cybersecurity qualifications framework called NICE being published by National Institute of Standards and Technology (NIST) under in NIST Special Publication 800-181. NICE is aimed at various audiences and purposes. Namely, the organizations and individuals should be able use the framework to (NIST, 2017):

- Map or assess their cybersecurity workforce and understand the strengths and gaps in *Knowledge, Skills,* and *Abilities (KSA)* and *Tasks* performed;
- Identify training and qualification requirements to develop critical KSA to perform cybersecurity Tasks;
- Improve position descriptions selecting relevant *KSAs and Tasks*, once work roles and tasks are identified;
- Identify the *work roles* and develop *career paths* to guide staff in gaining the requisite skills for those roles;
- Establish a shared terminology between hiring managers and *human resources* (HR) staff for the recruiting, retention, and training of a highly-specialized workforce;
- Provide a reference for *educators to develop curriculum*, certificate or degree programs, training programs, courses, seminars, and exercises or challenges that cover the KSAs and Tasks described;
- Allow a *technology provider* to identify the cybersecurity work roles and the KSAs and Tasks associated with hardware and software products and services they provide.

From the structure point of view, NICE divides the content into the following seven chapters closely related to job requirements for specific workforce:

- *Workforce Categories & Specialty Areas* [work areas]
- *Work Roles & Tasks* [work activities]
- *Knowledge- & Skills- & Ability-Descriptions* [content]

The subject of interest, i.e. jobs related to cybersecurity are described based on primary roles that can be one of: *Securely Provision, Operate and Maintain, Oversee and Govern, Protect and Defend, Analyze, Collect and Operate, Investigate*.

3.2. European Qualifications Framework (EQF)

On the contrary, the *European Qualifications Framework* (EQF) has a different primary goal. It is a very general instrument not related to cybersecurity nor ICT. It is a *translation tool* that helps communication and comparison between qualifications systems in Europe, namely the EU. The EQF is generally aimed at defining three categories for reference – *knowledge, skills and competences*. It should enable mapping and specify requirements for *mutual recognition* of qualifications among European countries. In order to achieve this, it defines eight common European reference levels that are described in terms of learning outcomes.

This allows any national qualifications systems, national qualifications frameworks (NQFs) and qualifications in Europe to relate to the EQF levels. *Learners, graduates, providers and employers* can use these levels to understand and compare qualifications awarded in different countries and by different education and training systems. The European Qualifications Framework (EQF) is a common European reference framework whose purpose is to make qualifications more readable and understandable across different countries and systems. Covering qualifications at all levels and in all sub-systems of education and training, the EQF provides a comprehensive overview over qualifications in the 39 European countries currently involved in its implementation. (Cedefop, 2008)

3.2.1. Occupation Profile, Qualification, and Assessment

In the sense of (not only) EQF, occupational profiles or standards are normally set outside the education and training system by labor market stakeholders. It is demand-driven bottom-up effort which may lead to the use of different terminology and conceptual framework by different stakeholders. Various study programs at potentially different EQF levels can lead to fulfillment of such needs. Occupational profiles or standards specify the main jobs that people do, describing the professional tasks and activities as well as the competences typical of an occupation.

- Therefore, *qualification profiles and standards* define the expected outcomes of the learning process, leading to the award of a full or partial qualification. In vocational education and training (VET), profiles or standards normally answer questions such as “what does the student need to learn to be effective in employment and what does the learner need to learn to become an active citizen, supporting basic human and democratic values?” (Cedefop, 2008).
- A *qualification standard* is not exclusively about promoting skills relevant to the labor market but must address a broader set of competences *relevant to life and society in general*. It might lead to conclusion that EQF is less pragmatic in direct connection with a concrete job but rather provides a broader background and complex view of a position in society, reflecting the dynamics of labor market and society. It emphasizes also transversal skills and

competences, such as communication, social skill and problem solving rather than a pure professional hard-skills.

- *Curricula* set the framework for planning learning experiences. Depending on the country, the type of education and training, and the institution, learning outcomes statements form an important part of curricula – namely, in university undergraduate and graduate programs, specifying learning outcomes in terms of knowledge, skills, and competences is a vital part of curriculum description which is equally important as listing content topics being covered by the curriculum. Curriculum should guide the teacher not only in content but also appropriate learning methods together with expected outcomes – and the same holds for the students.
- Similarly, *assessment specifications* identify the content, the methods and the criteria underpinning assessments in a measurable way. Such criteria are often typically given as threshold levels which have to be met by the candidate to pass, gaining e.g. "E-level" grade.

3.2.2. EQF level descriptors

The EQF level descriptors use three main elements: knowledge, skills, and responsibility/autonomy (KSRA):

- *knowledge* is described as: theoretical and/or factual;
- *skills* are described as: cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments);
- *responsibility and autonomy* are described as abilities of the learner to apply knowledge and skills autonomously and with responsibility.

3.3. European e-Competence Framework (e-CF)

The *European e-Competence Framework* (e-CF) provides a reference of *40 competences* as applied at the Information and Communication Technology (ICT) workplace, using a common language for competences, skills, knowledge and proficiency levels that can be understood across Europe. Since 2016, the e-CF is an official European standard published as the European Norm EN 16234-1. (CEN, 2016)

The e-CF fits for application by ICT service, user and supply organizations, multinationals and SMEs, for ICT managers, HR departments and individuals, educational institutions including higher education and private certification providers, social partners, market analysts, policy makers and other organizations in public and private sectors.

The e-CF gives clear definitions and sound orientation to support decision-making in relation to the selection and recruitment of candidates, as well as the qualification, training and assessment of ICT professionals. It enables the identification of skills and competences that may be required to successfully perform duties and fulfill responsibilities related to the ICT workplace. The widespread adoption of the e-CF by companies and organizations throughout Europe has started to increase the transparency, mobility and efficiency of ICT sector related human resources.

3.4. EU Agency for Network and Information Security (ENISA)

ENISA was established in 2004 to contribute to European Network and Information Security (NIS) policy, in order to support Member States and European Union stakeholders to support a response to large-scale cyber incidents that take place across borders in cases where two or more EU Member States have been affected. This work also contributes to the proper functioning of the Digital Single Market. Its role therefore encompasses also education, namely leading to improve capabilities, e.g. by organizing pan-European Cybersecurity Exercises.

ENISA is not (yet) focused on cybersecurity qualifications though it published Offering roadmap for education (ENISA, 2014) which foresees creation of roadmap for NIS programs in Europe with the goal to map available courses, programs, materials, databases, and educational information across the EU by:

- suggesting the creation of a *Europass for NIS skills* for the general public, very much in line with the model from CEDEFOP;
- deploying better *continuing education programs for teachers* for enhancing the multiplier role they have;
- European organizations and authorities should start developing NIS *MOOCs*;
- developing a NIS course for *health practitioners*;
- developing a Data Protection Officers (DPOs) course directed at *lawyers and digital security specialists*;
- development of an EU *information assurance training/education* solution for the working realities of SMEs;
- development of an EU-based academic recognition for continuing professional development in *digital forensics*.

3.5. ACM Cybersecurity Curricula

ACM Cybersecurity Curricula published in 2017 is a result of joint-effort of ACM, IEEE-CS, AIS SIGSEC, IFIP WG 11.8. as *Curriculum Guidelines for Post-Secondary Degree Programs in Cybersecurity*. It structures the cybersecurity discipline as a computing-based discipline involving technology, people, information, and processes to enable assured operations in the context of adversaries. It is an interdisciplinary course of study, including aspects of law, policy, human factors, ethics, and risk management. It offers flexible guidance based on a comprehensive view of the cybersecurity field and specific disciplinary demands. It supports the alignment of educational offerings (formal and informal) along the full K-12 – professional development continuum. It serves as the foundation for emerging cybersecurity accreditation efforts; and it provides a structure for linking cybersecurity curricula to workforce frameworks. (ACM et al, 2017)

3.6. Czech National Qualifications Framework

The Czech *National Qualifications Framework* (*Národní soustava kvalifikací*, CzNQF) means a publicly accessible register of all complete professional and professional qualifications confirmed, distinguished and recognized in the Czech Republic. It defines the qualification requirements for individual qualifications regardless of how they are acquired. It describes what is necessary to be able to perform the profession or their part, i.e. partial work activity. The NQF is a linking system framework for initial and in-service training, while allowing comparison of our national qualifications with those set out and described in other European countries.

The goal of CzNQF is to create a system environment that it will support:

- Comparability of *learning outcomes* achieved through different pathways, allowing recognition of actual knowledge and skills, regardless of how they are obtained;

- Comparability of *qualification levels* in the Czech Republic and within the EU;
- Transfer of *labor market requirements to education*;
- *Public awareness* of all nationally recognized qualifications.

CzNQF distinguishes in accordance with the legal regulation two categories of qualifications:

- Full professional qualification meaning ability to practice a particular (complete) profession;
- Professional qualification which means ability to carry out a particular occupational activity or a coherent set of work activities applicable to the labor market. Selected professional qualifications may be a compulsory part of a complete professional qualification.

Currently, the Czech NQF does not define any complete nor partial professional qualification in ICT neither cybersecurity. CzNQF, however, plans to define several (partial) professional qualifications including cybersecurity in future, namely:

- *Cybersecurity Manager* (EQF Level 7)
- *Cybersecurity Architect* (EQF Level 6)
- *Cybersecurity Auditor* (EQF Level 6)
- *Cybersecurity Analyst* (EQF Level 5)
- *Cybersecurity Worker* (EQF Level 5)
- *Security Operation Center Worker* (EQF Level 5)

4. Common Meta-Framework for Cybersecurity Qualifications

We could see from the previous sections, cybersecurity qualifications frameworks have many commonalities but also differences including different purpose, audience, and structures. A common meta-framework should therefore be developed to map the frameworks, find commonalities, and be able to adopt frameworks to specific needs or target groups. We propose such a meta-framework with the following components.

4.1. Main purpose and goals

It identifies and describes the main purpose of the respective qualifications framework.

4.2. Audience and target groups

It identifies and describes the main target groups and audience of the respective qualifications framework, such as cybersecurity professionals, educators, human resources (HR) staff, policy makers, technology providers, or CI operators.

4.3. Legislative background

It identifies and describes relevant legislation or mandates that apply (if any) to the respective framework, whether the framework is anchored in national legislation, industry or association standard, or endorsed by some significant independent (business) players in the field.

4.4. Conceptual model

It identifies and describes the main concepts the respective framework defines and operates upon.

Table 1 Cybersecurity Qualifications: A Comparison of Frameworks

Framework	**Purpose and goals**	**Audience and target groups**	**Legislative background**	**Conceptual model**
NICE	Cybersecurity workforce profiles	HR, educators, workers, technology providers	Federal Information Security Modernization Act (FISMA) of 2014, non-binding non-superseding other regulations, may be used for non-government	Categories+Specialty Areas, Work Roles+Tasks, Knowledge, Skill, Ability
EQF	Reference between country systems	EU and national policy makers, learners and workers	adopted by the EP and the Council on 23 April 2008, a revised and strengthened Recommendation on the EQF was adopted 2017 by the Education, Youth, Culture and Sport Council	Occupation Profile, Qualification, and Assessment, Knowledge, Skill, Competences, Level, Qualification Standard, Curriculum
e-CF	common language to describe competences, skills and knowledge requirements of ICT professionals at 5 levels	ICT service, user and supply organizations, industry, ICT managers, HR, and individuals, educational institutions, certification providers, policy makers	European Norm EN 16234:2016 by Technical Committee CEN/TC 428 “Digital competences and ICT Professionalism”	5 e-Competence areas, 40 reference e-Competences, Proficiency levels of each one
ENISA (no framework)	Specific education scenarios	Professors and trainers	Information purposes only	Mapping Resources, Programs, Scenarios
ACM CSec	Vision of proficiency in cybersecurity, alignment of academic programs with industry needs	Faculty members in computing-based disciplines at academic institutions	Recommendations	CS Curricular Framework, Knowledge area, Topic, Cross-cutting concept, Learning outcome
CzNQF	Professional qualifications	Organizations providing or recognizing education and assessment, workforce	Act on Recognition of Further Education Results 179/2006 Coll.	National Qualifications System, Assessment criteria

5. Czech National Cybersecurity Qualifications Framework

The *Czech National Cybersecurity Qualifications Framework* (CZ-NCQF) is to be developed within the project having the following phases:

1. Creating a *Taxonomy of Qualifications* - analysis of existing solutions and research results abroad, investigation of needs within the security forces in the Czech Republic and identification of the character and structure of relevant entities in the Czech Republic. The necessary qualifications in both technical and non-technical fields at the level of both private organizations and the state will be offered in a structured manner.
2. Design of a *Competency Model* - professional competencies will be assigned to the individual roles / qualifications – those should be concerned as prerequisite for performing the appropriate role in cybersecurity.
3. *Cybersecurity Qualifications Framework* - the Qualifications Framework will include proposed taxonomy and competencies of individual qualifications, extended in the manner to identify the required training capacities based on the existing demand for qualifications.
4. Analysis of *available education* in the Czech Republic – based on surveys and questionnaires, the current offer of available educational programs, courses and exercises in the field of cybersecurity will be identified, which can be used to build the necessary capacities described in the framework.
5. *Gap analysis* – the training requirements described in the framework with the existing offer will be compared. Based on this comparison quantitative and qualitative gaps in terms of available cybersecurity education should be identified.
6. *Action plan on building educational capacities* – in order to effectively implement the results of the project, the aim will also be to develop an action plan to inform users and target groups about the practical application of research results at the level of support and development of cybersecurity training, recruitment and evaluation.
7. *Interactive Database for Qualifications Framework* - in order to effectively implement the Qualifications Framework, an interactive software tool will be created to provide knowledge databasis.
8. In all phases, a close collaboration with industry (Pucihar et al, 2017) and government is foreseen.

6. Conclusion

The project *National Cybersecurity Qualifications Framework* has the ambitions to create a comprehensive framework with the potential to be implemented in Czechia while being fully compatible with European and international activities. It should facilitate increase of capacity in cybersecurity education and help to precisely define requirements for specific positions and identify gaps in education offers at all levels and forms including lifelong and vocational education and training.

7. Acknowledgement

This research was supported by the Security Research Program of the Czech Republic 2015-2022 (BV III/1-VS) granted by the Ministry of the Interior of the Czech Republic under No.

VI20192022161 – *National Cybersecurity Qualifications Framework*. Finally, we thank our colleagues for their helpful comments and suggestions.

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INNOVATION OF DISPATCHING INFORMATION SYSTEM IN UNDERGROUND GAS STORAGE TŘANOVICE INCLUDING INVOLVEMENT OF STUDENTS IN SOLVING PARTIAL PROBLEMS

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Keywords

Dispatching information system, gas flow balance, SCADA, underground gas storage (UGS), Visual Basic 6 to Visual Basic .NET conversion

Abstract

The article describes the innovation of the dispatching information system operated in the underground gas storage Třanovice, Innogy. The primary objectives of the system are to monitor gas flow, monitor the status of gas reserves in the underground storage and calculate and present balance sheets. In 2009-2012, technologies of underground gas storage were modernized, which also caused changes in the information system. This eventually led to the need to upgrade the information system - updating operating documentation and solving obsolete technical and software resources. The solution of the innovation was successfully joined by students who dealt with partial tasks in the form of diploma theses.

1. Introduction

In 2003-2005, a Dispatching Information System for monitoring the Underground Gas Storage (UGS) was put into operation in the locality Třanovice (near Český Těšín, North Moravia). Třanovice UGS, operated by Innogy (formerly company RWE), currently has two basic functions: as underground gas storage and as a transfer station. As is stated in (Mokhatab, Poe and Mak, 2015), during the summer, when gas consumption is low, the overflow between gas imported and consumed amount is stored in underground storage – this storage operating mode is so called “injection”. In winter, on the contrary, gas consumption exceeds the supply from abroad and the difference match by gas from storage – a mode which is call "extraction". If gas taken from a high-pressure gas pipeline from Russia is directly supplied to the gas distribution companies, it is operating mode called "transfer”.

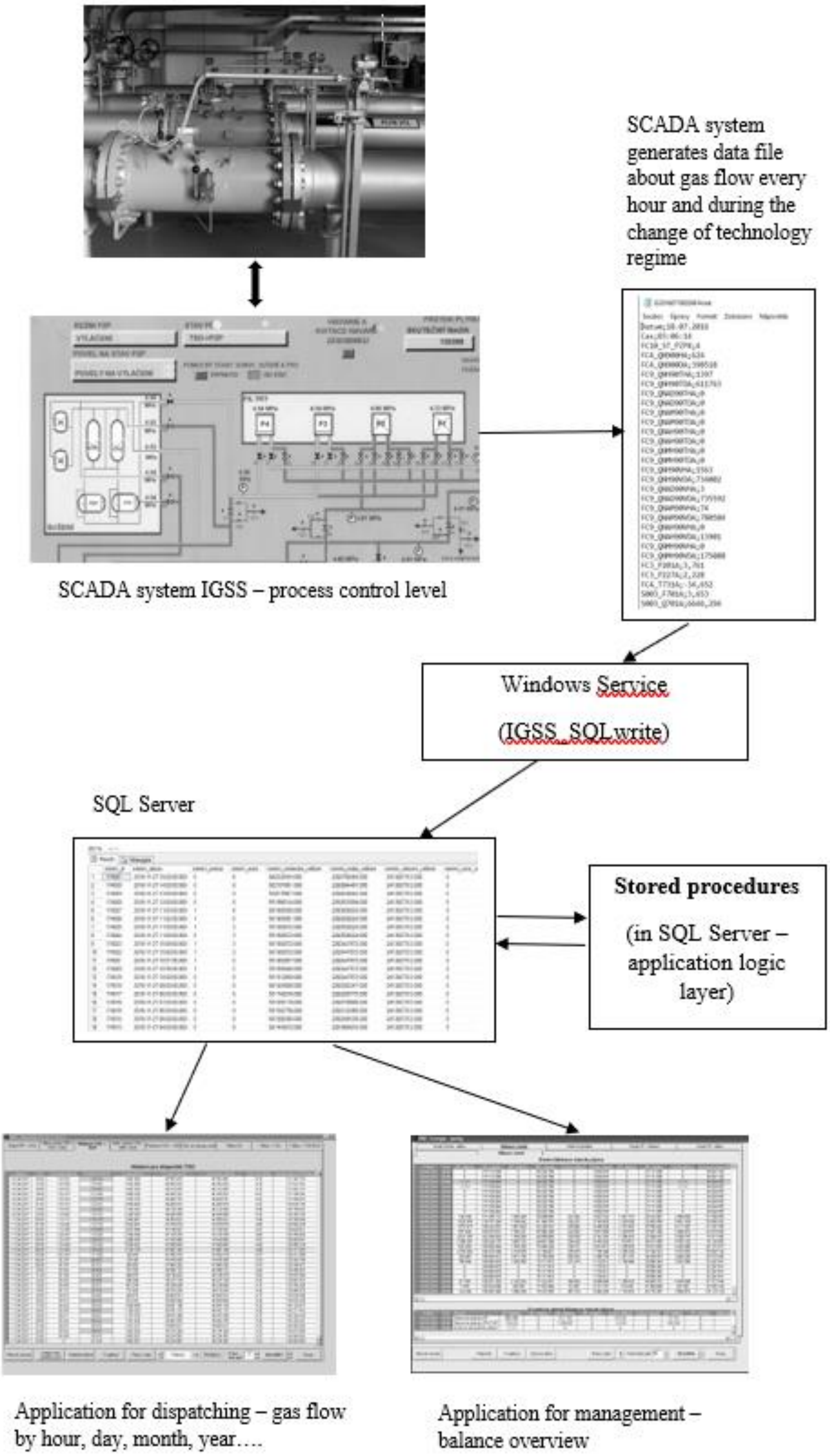

Figure 1. Schema of Innogy balance information system

The structure of the gas flow balance monitoring system is shown in Figure 1. Direct control of technological process in Třanovice is implemented by multilevel distributed SCADA control system IGSS of Danish company Seven Technologies (now Schneider Electric) with applications created by UniControls a. s. IGSS system export the data file containing all measured information by every hour or immediately after the dispatcher control intervention or after change the operating mode of the storage. Data files are then processed by Windows service (IGSS_SQLwrite) that evaluates, transfer and write down data into relational database (Microsoft SQL Server). Data stored into database are further processed by storage procedures, which count the averages, aggregate and progressive values.

Stored procedures prepare data for the presentation layer of the system, made up of applications written in Visual Basic 6. In addition to immediate monitoring of production such as hourly gas flows depending on the operating modes (extraction, injection, transfer to the distributor or combined mode), the information system also provides gas flow balance, status of total gas reserves and progress value of flow. The application at the dispatch center monitors the progress of the daily gas flow, which is reported to the superior dispatching center (Innogy central dispatching in Prague) at 6 am. Dispatching personnel also have continuous monthly and annual gas flow rates in each mode, gas pressure and dew point information, and current total gas deposit.

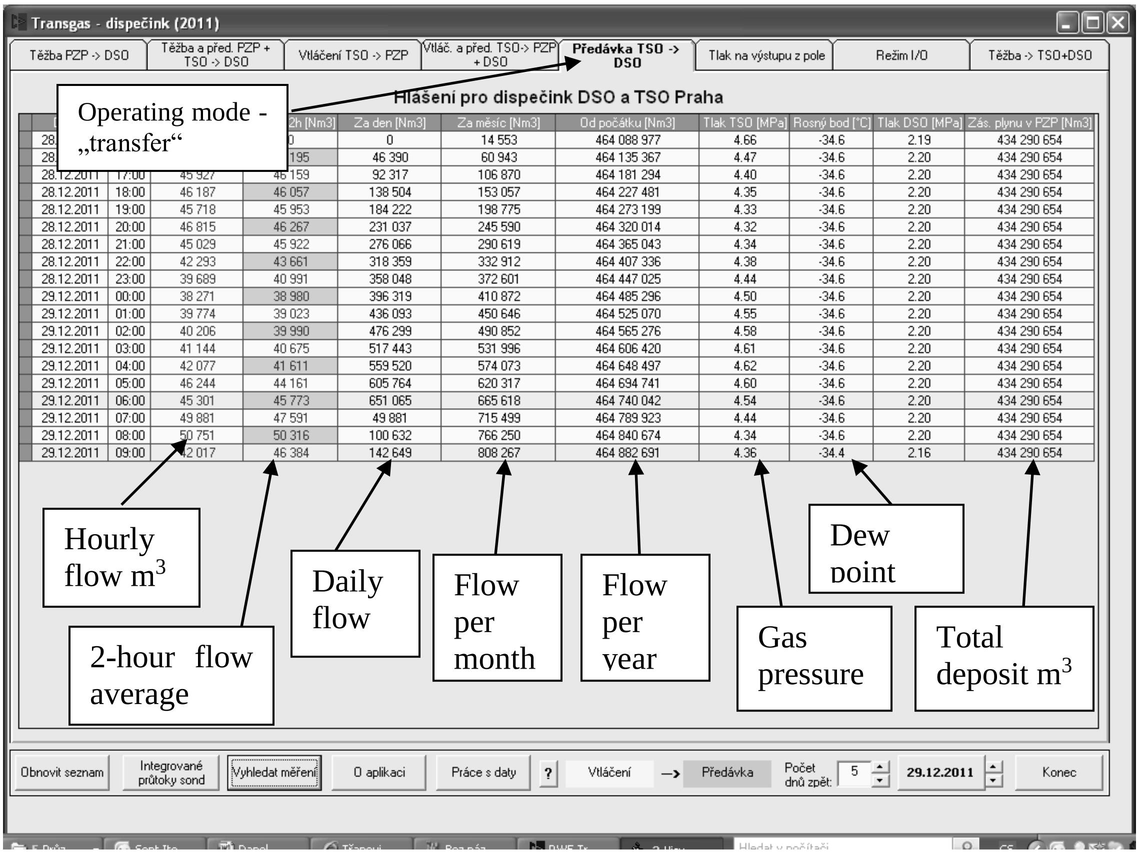

Figure 2. The application at the dispatch center written in Visual Basic 6. Monitoring of the gas flow.

The second application was programmed for geologist and management of the UGS Třanovice. Application shows detailed value from the probes (28 wells, an hourly flow, an integration value and a gas pressure). System counts flow values from probes and gives basic data for reporting. Also, there is a reporting about the status of gas reserves at every of four separated areas and total reserves based on information from probes. The sum of the flow rates from the probes must be the same as the gas flow measured at the entry into the UGS (when injecting gas into the reservoir from the gas pipeline from Russia) or from the UGS output (during gas extraction from the reservoir to the distribution network). The system thus checks for gas technological losses.

The UGS Třanovice underwent a major reconstruction of the technology between 2009 and 2012 (Mikoláš et al, 2015), which was also reflected in the need to redesign the information system, database structures and reprogrammed application logic in stored procedures. A more detailed description of the storage technology and the balance information system is given in (Danel & col., 2012).

2. Problems in Dispatching Information System

After ten years of operation, a number of problems have been identified in the Dispatching Information System that have to be solved. We can divide the problems into three groups:

- Obsolete hardware and software server architecture (operating system Windows Server 2000 and database system Microsoft SQL Server 2000)
- Discrepancy between system documentation and actual system status, especially at the level of application logic in SQL Server (stored procedures), due to gradual updates (especially in connection with the reconstruction of technology in 2011 - 2012. The system was further expanded according to users' requirements (e.g. data exports to Excel, new functions, sensor changes)
- The visual interface of the system, created in an already unsupported Visual Basic 6 programming environment, whose maintenance and expansion has become problematic.

Within the cooperation with the academic sphere, some tasks in solving the problems above were realized in the form of student diploma theses.

3. Innovation of server layer of Dispatching information system

During 2016, the on-premise solution with server Compaq Proliant ML 370 (Windows Server 2000, SQL Server 2000) was replaced by a virtual server running Windows Server 2012 and Microsoft SQL Server 2014. Moving data from the original storage in Microsoft Server 2000 was quite complicated because the difference between the four generations of the SQL Server database system did not allow to use of original data files directly. The data had to be exported as a backup first, then restored in the SQL Server 2005 database system, then re-exported and the data thus prepared could be imported into SQL Server 2014. Stored procedures that are part of the database were fully functional after export without any changes. The use of virtualization then enabled remote access to the system and also to the database, which making system maintenance easier.

4. Updates database architecture and stored procedures documentation

In 2017 the thesis (Staňková, 2017) was solved, the output of which was, among others, inventory and documentation of current status of the dispatching information system. The main task was a review of stored procedures in SQL Server. Two key stored procedures (procedure for calculation of hourly gas flow and balance values and procedure for flow calculation by individual probes) were processed to a graphical form using a flowchart for visualization of the solution algorithm. The author of the thesis further analyzed and documented the sequence of function and procedure calls when writing data into database. The partial aim of the thesis was to test the new functionality - the possibility of entering corrections of gas inventory level in the underground storage (evidence of operational gas losses performed by an authorized employee). Calculation errors were detected during testing of writing the correction of inventory into database (for a particular combination of underground storage mode - injection/extraction depending on time of write). Test results were submitted to the authors of dispatching information system for further processing.

5. Analysis the possibility of converting applications written in Visual Basic 6 to Visual Basic .NET

In 2018, a study of the possibility of converting applications written in Visual Basic 6 to the .NET platform was solved as a diploma a thesis (Angelovič, 2018). Architecture .NET is not compatible with applications created in Visual Studio 6 (and earlier versions). Microsoft's official support for Visual Basic 6 (the latest version is from 2004) ended in 2008 and only Visual Basic Runtime is further supported. Microsoft is still issued and will issue security updates for Visual Basic Runtime, at least until the end of Windows 10 support (Microsoft, 2017). However, it is clear from operational experience that some Visual Basic 6 applications can no longer run on Windows 8 operating system (data type issues and missing support for some components OCX). The aim of this thesis was to analyze the possibilities of transferring applications between these architectures, especially evaluating whether one of the existing conversion tools can be used.

When converting Visual Basic 6 (VB6) applications to VB .NET it is necessary to solve the following:

- Controls
- Compatibility with other technologies
- Data types of variables
- Runtime for running programs

The .NET platform has introduced a different compilation method (JIT), the namespace concept and the platform's languages are fully object-oriented (Hančlová et al, 2015).

There are three situations when you convert controls:

- The equivalent of the original element among .NET elements exists and is compatible
- The equivalent of the original element among .NET elements exists but does not have the same properties
- The equivalent of the original element among .NET elements does not exist

The compatibility with the following technologies has not been maintained in VB.NET:

- Dynamic Data Exchange (DDE) – DDE was only supported in VB6 for backward compatibility and is not supported at all in VB.NET.
- Object Linking and Embedding – in VB6, you can use an OLE container to insert or attach a document of OLE compatible application (such as Word or Excel). This functionality is not supported in .NET.
- Data Access - in VB6, DAO, RDO, and ADO were generally used to access data. The last one has been replaced by ADO.NET, others are not supported, with no replacement.
- Drag & Drop – VB6 distinguished two types of "drag and drop" operations: Within the form and off the form. In VB.NET, access has been unified and everything related to drag & drop has to be completely rewritten.
- Win32 API – due to the transition from the Type data type to Structure and the absence of fixed-length string support, some Win32 API calls in VB.NET may need to be modified.
- Fonts – in VB6 you can use raster fonts, True Type or Open Type fonts. Raster fonts cannot be used in VB.NET.

- COM (ActiveX) – in VB.NET, the CLR must use Runtime Callable Wrapper (RCW) as an intermediary between COM component and VB.NET applications (Angelovič, 2018).

Possible conversion issues:

- Late binding - the type of the variable (or object) is determined only when the program is running (it concerns to setting of some elements at the time of their initialization) - not supported in VB.NET
- Soft binding - Form and Control data types refer to the elements of their instances (e.g. with referencing the label in the form – it is assumed that this element exists) - this behaviour is not supported in .NET
- Default properties issues - Unlike VB6, VB.NET does not support default properties
- Data Bindings - VB.NET only supports ADO data binding, DAO and RDO are not supported
- Interoperability between COM (and ActiveX controls) and .NET. The problem may be especially with third-party objects (Huňka & Ministr, 2013). You can use:
    - Runtime Callable Wrapper utility with central COM component storage (so called interop assembly)
    - For ActiveX components encapsulation using Windows Form Wrapper - enables the original properties and methods of the object and adds new, common for .NET architecture.
    - To import a COM component using references (only suitable when a COM object is used in a single application).

During solving the thesis, tools for conversion of VB6 to VB .NET listed in Table 1 were analyzed and tested.

Table 1 Tools for converting app from VB6 do VB.NET

Tool	**Source**	**Notes**
VBto Converter	http://vbto.net/	$ 599; the trial version is limited to 800 rows per file
Project Analyzer for Visual Basic	http://www.aivosto.com/project/vbnet.html	$ 990, conversion is possible only in Enterprise version, demo version is limited to 10 files
Migration & Modernization Toolkit 2017	http://www.ispirer.com/application-conversion/visual-basic-to-net-migration	Trial version limited to 300 lines of code
VB Migration Partner	http://www.vbmigration.com/	30-day trial, limit to 10,000 lines of code; 1,500 EUR
gmStudio	https://www.greatmigrations.com/	10000 USD; least ergonomic interface
VB Upgrade Companion Enterprise Edition - VBUC	https://www.mobilize.net/solution/vb-upgrade-companion	Trial version - 10,000 lines of code, unlimited version for MSDN subscribers; $ 6,200 license for 1 year
Visual Basic Upgrade Wizard	SW by Artinsoft, part of Visual Studio 2008	Free for Visual Studio 2008 owners

When testing applications from the Třanovice UGS dispatching system, the use of some third-party ActiveX elements (OCX) and the fact that the applications use OLE Automation to export data to Excel has proven to be problematic. None of the tools tested was able to convert these features automatically. From the conversion tools listed in Table 1, the VBUC provided the best results, but the license is somewhat expensive.

To test the conversion tools, the author of the thesis received the source codes of two applications from the Třanovice dispatching information system - none of these conversion tools were able to fully convert these applications. As a result of conversion tools testing, it is not recommended to buy any conversion tools. We recommend re-write these applications in Visual Studio .NET programming languages (Visual Basic .NET or C#) and not just convert existing codes.

6. Conclusion

In the paper we have described examples of successful involvement of System Engineering students in solving specific problems from the practice and functioning of university staff in applied research. Several tasks were solved in the form of student diploma theses. The SQL Server stored procedures were reviewed and documented. The algorithms for calculating gas flow balances were tested. During testing, a calculation error was detected when inserting inventory correction. Students also analyzed and tested tools for automatically converting Visual Basic 6 applications to VB.NET. As a result of these tests, the application's recommendation is not to convert, but to write it again. Data to Excel conversion functions have proved to be the biggest problem for Visual Basic conversion tools.

Cooperation with the Innogy Třanovice UGS is an example of how commercial and academic spheres can be connected to the benefit of both parties.

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RECIPROCAL TRANSACTION MODELING

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Keywords

DEMO, Co-creation Co-production, DEMO enterprise ontology (DEO), reciprocal transactions

Abstract

Reciprocal transactions, in general, denote two groups of transactions, in which performing one group of transactions is in consideration of performing the other group of transactions. Seemingly simple situation is more complex because it covers reciprocal commitments and reciprocal fulfilment and can be also accompanied by quarrels and disputes between partaking parties during fulfilment of reciprocal transactions. The objective of the paper is to find and apply better methodology and its model that would provide better mechanism for handling reciprocal transactions and in this way better economic information systems. The DEMO Co-creation Co-production (CC-CP) model, which has its foundation in DEMO (Design Engineering Methodology for Organization) methodology is presented and applied on a simple example of a pizza shop. This simple application demonstrates possibilities and achievements of the reciprocal transaction modeling in the form of the CC-CP model.

1. Introduction

What seems to be simple and obvious at first sight, such as buying a pizza and paying for it, turns out to be very complex and abstract phenomenon when studied in more detailed and formal way. Reciprocal transactions are sometimes called business or economic transaction. Closer observation reveals that there is often an exchange of some product, service or money, closely related and balanced in some way to another exchange of some product, service or money (Hruby, 2006). The situation where there is just one exchange of some product, service or money also occurs but less frequently.

Another observation is that the exchange of products, services and money is driven by communication in natural language. Capturing natural language in a formal way has been a very difficult subject for philosophers and linguists. However, in recent years progress has been made (Dietz, 2015). We must capture that communication in natural language in a formal way, in order to derive the formal representation provided by a target information system. For example, an invoice and a bank statement are formal representations of "things", expressed in (semi) natural language.

A transaction, in an economic or business sense, is inevitably composed of two parts. It is a commitment part, in which partaking actors (parties) make an agreement of reciprocal exchange of product, service or money, and a fulfilment part, in which the actors (parties) fulfil their mutual obligations. Most important phenomenon for modeling is to identify and reflect all process of reciprocal transactions in the form of precisely defined states and state transitions.

The notion of intersubjective commitments using natural language between human actors belongs to the fundamental notions in the social systems, in which human beings are the core participants (van Kervel, 2012A). In general, human beings plan and achieve their goals through conversation (coordination). Human beings, who are involved in conversation concerning commitments, are performer (anyone who exposes intention) and addressee (somebody, to which the intention is addressed). A commitment being made now demands that some action has to be taken somewhere in the future, where the state of the world of interest will then be changed. Such a commitment has a strong legal character, it is binding. Close observation of economic transactions reveals that essentially contracts are devised, signed and executed. In practice we observe that these contracts can be challenged and disputed in many ways.

Commitments are, in this way, also regarded as atomic parts of contracts and a set of commitments are always part of some contract. In the simplest form there are two reciprocal kinds of 'commitments' and two reciprocal kinds of ‘fulfilments’ forming an exchange process (Hanclova, 2013).

Communication with commitments is described in many papers (Dietz, 2006; Hunka, 2017). However, in many of these articles, commitments are described as a static entity having relationships with two different kinds of actors and possibly relationships with exchanged resources or services. In some of these papers there were also relationships with real event when transfer or reciprocal transfer occurs (Hanclova, 2015). However, only one methodology introduces rigorous formalization of the human’s conversation in the form of state and state transitions. It is done in the DEMO methodology and its transaction pattern is a general pattern around which not only human’s conversation occurs, but it can be used as a pattern for workflows (van Kervel, 2012B).

The structure of the paper is as follows. Section 2 is focused on the main features of the DEMO methodology. The DEMO CC-CP model is introduced and clarified in Section 3. A pizza shop example covering a traditional solution and reciprocal transaction solution in the form of the DEMO CC-CP model is depicted in Section 4. Section 5 discusses achieved results and aims of the future research and Section 6 concludes the paper.

2. DEMO Main Features

DEMO is an engineering methodology to derive conceptual models of enterprises, based on an ontological theory, DEMO enterprise ontology (DEO) (Dietz, 2006). According to DEMO (Design & Engineering Methodology for Organizations) methodology (Dietz, 2006), an organization is composed of people (social individuals) that perform two kinds of acts, *production* acts and *coordination* acts. The result of successfully performing a production act is a *production fact*. An example of a production fact may be that the payment has been paid *and accepted*, or the offered service has been accepted. All realization-specific details are fully abstracted out. Only the acts and facts as such are relevant, not how they are achieved. The result of successfully performing a *communication act* is a *communication fact*. Examples of coordination acts are *requesting* and *promising* a production fact, which essentially constitutes a mutually binding contract. The subsequent communication acts and facts *state* and *accept* of the production constitute the fulfilment of that contract, agreed by both actors.

A *fact* is a proposition that can be either false or true, to be validated by empirical observation. A fact may encompass a single object, or may encompass more objects. Depending on the number of objects that are involved in a fact, we speak of unary, binary, ternary, etc., facts. An example of unary fact is that *Vendor is a Person*. Another example of binary fact is that a *Customer receives a Pizza*.

In DEMO modeling enterprises are represented by discrete deterministic systems that may exist in a set of precisely defined allowed states. For each state there is a set of allowed transitions to another state, so-called the state transition space. All other state transitions are forbidden and cannot occur. In general, a state is determined by the set of facts that exist at that moment. A state change or state transition consists of one or more facts starting or ending to exist. The occurrence of a transition at some moment is called an event.

Events are widely defined as "things that happen in the real world", and that cause some effects. In DEMO there exist only i) *communication facts,* that are brought about by actor's communication, following the transaction pattern; ii) *production facts* that describe the production of a specific actor; and iii) *facts*, that are caused by acts in the real world that may become true or false. Example i): the pizza has been requested by the customer and promised by the pizza baker, a contract has come into existence. Example ii): the production *fact* of the pizza baker is a pizza margarita. Example iii): the exchange rate between the US dollar and the EURO is 1.234. By empirical observation of the real world this fact is either true or false.

3. The Co-creation and Co-production Model

Many highly specialized enterprises 'Contractors' do not have a well-defined portfolio of products with fixed prices but offer their capabilities to meet the specific requirements of their 'Principals'. We define: co-creation captures the principal and the contractor(s) working together on the engineering of an acceptable artifact; co-production captures the shared production of the engineering artifact by both principal and contractor(s), including matching financial transactions, see (Hunka, 2017; Hunka 2018). The co-creation co-production model is composed of three phases, each of which contains two generic transactions. The Structure of the CC-CP Construction Model, which is based on reality observation, is shown in Fig. 1.

3.1. The Co-Creation Phase

Transaction T01 represents a production fact the definition of what the product to be delivered by the Contractor must be. Typically, product specifications with quality criteria, materials used, testing procedures to be followed. The initiator of T01 is the Principal who issues T01.Request to the executor, Contractor, to provide appropriate product specifications. Each transaction instance represents a product specification. If T01 is Stated and Accepted then there is a shared agreement, without any ambiguity, between Principal and Contractor about what the co-production must be.

Transaction T02 represents a production fact the definition of the price, including specific payment terms and conditions, etc. precisely applied to the product defined by the transaction result of T01. The Principal is the initiator who issues a T02.Request to the Contractor for a price for the production defined in T01. This implies the condition that T01.Accepted must be true before T02.Request can be issued by the Principal. T02.Accepted means that the two actors agree that there is a well-defined price for the product. It does not mean yet that the two actors have decided to commit to a delivery and payment.

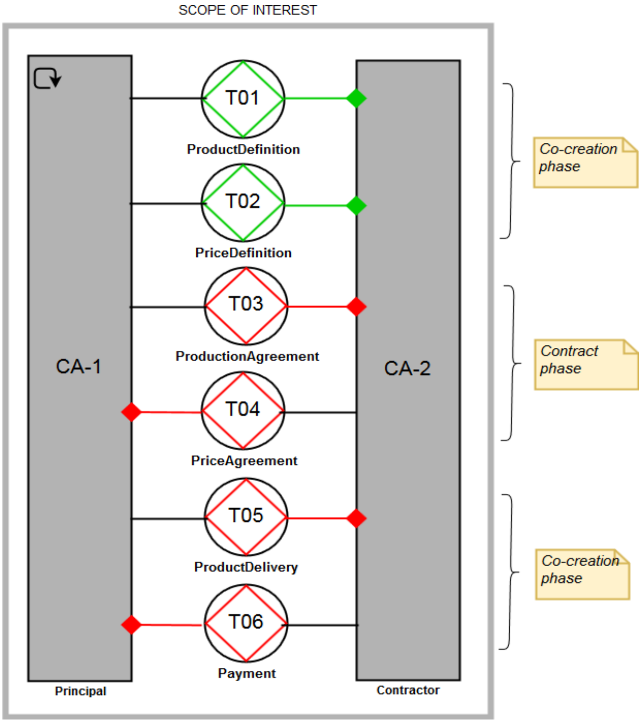

Figure 1 The DEMO CC-CP Construction Model Source (Hunka, 2017)

3.2. The Contract Phase

At this stage, with *T01.Accepted and T02.Accepted*, represent the situation that there is a well-defined but yet unsigned contract on the table. The contract is composed of two directly related mutually binding obligations; defined by the two transaction results of T01 and T02. The Principal requests the Contractor a commitment to deliver the production, T03, by issuing *T03.Request*. The Contractor requests the Principal a commitment to pay the price, T04, by issuing *T04.Request*. The two signatures on the contract are represented by *T03.Promised and T04.Promised*. Transaction T03 represents the commitment, an *obligation* that the production has to be delivered by the Contractor, executor, to the Principal, initiator. At some moment the Contractor may issue *T03.State*, meaning that the Contractor thinks that the contractual agreement to deliver the product has been fulfilled.

If the Principal agrees then the Contractor may issue T03.Accept, the contractual obligation for the production has been fulfilled. Similarly, transaction T04 represents the obligation to pay the price to be paid by the Principal, executor, to the Contractor, initiator. If both actors agree, they will issue *T04.State* and *T04.Accept*, the contractual obligation to pay the correct price has been fulfilled. Contract disputes are very common and may involve either the payment, or the production or both. Parties may reach agreement that the contract has been fulfilled partially. All these specific cases are dealt with the Complete DEMO Transaction Pattern which includes revoking and cancellation operations as underlying operations.

3.3. The Co-production Phase

The actual co-production is captured by one or more instances of transaction T05 and T06. Since the Contractor signed the contract, he has the obligation to issue *T05.Promise* for multiple deliveries of productions, as long as the *T05.Request* fits within the contract. The co-production phase encompasses also multiple payments, instances of T06. Often an instance of T06 is directly related to an instance of T05, as stipulated in the contract. The co-production phase ends when the

Principal and the Contractor have fulfilled their obligations defined in T03 and T04. The fulfilment of the obligation of goods/services delivered by instances of T05 will result in T03 being Stated and Accepted. Similarly, the fulfilment of the obligation of PricePaid delivered by instances of T06 will result in T04 being Stated and Accepted. The contract has been fulfilled by both parties.

The versatileness of the CC-CP model is enabled by the fact that all these ontological transactions are *independent* transactions with only *horizontal dependencies* between them (Hunka 2018; Skotnica 2016). These dependencies enable to set ordering between individual transactions more precisely in respect of reciprocal transaction needs. There is no *parent-child* relationship between transactions.

4. A Pizza Store Example

Customers announce themselves at the counter of pizzeria or make a telephone call. In both cases their requirements are written down. The customer is informed about the price and the expected time when the order is ready. As soon as the order is completed pizzas are slid into boxes and the customer is expected to pay. If it is necessary, the order to be delivered to the customer it is done by the delivery service.

4.1. Traditional Solution

The construction model requires identification of the actor roles, transaction kinds and product kinds. The Construction Model is illustrated in Fig. 2. In terms of actor roles there are elementary actor roles A01 completer, A02 baker and possibly A04 deliverer, see (Dietz, 2006). External or composite actor roles are formed by CA01 customer. The actor roles of A01, A02 and A04 represent employees of the pizzeria.

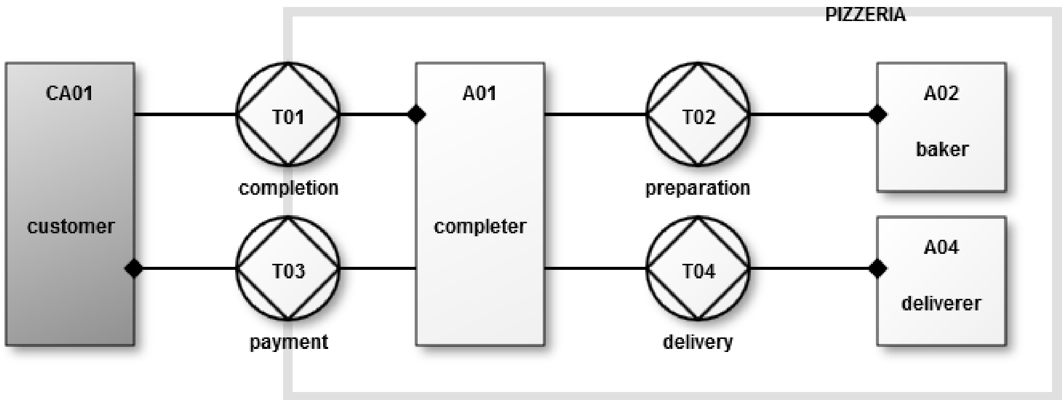

Figure 2 The Construction Mode of Pizza Store   Source (Dietz, 2006)

There are four essential transaction kinds. T01 completion transaction is the root (parent) transaction and all other transactions are ‘child’ transactions in respect to T01. The notion of a parent and a child transaction represents the relationship between transactions, see Fig. 3. T02 preparation transaction stands for own pizza cooking and baking. T03 payment transaction corresponds to its name. The customer is requested to pay for pizzas. T04 delivery transaction is an optional transaction. If the customer ordered delivery then the pizzas are delivered to the site of the customer. In case the customer comes to the counter there is no delivery transaction.

The Construction Model depicts actor roles and transaction kinds. T01 and T03 are transaction kinds on the interface; T02 and T04 are transaction kinds within the pizza store (system). The black dots on the actor role boxes indicate that the actor role is the executor of the transaction kind. A01 actor role is an executor of T01 transaction kind. Similarly, A04 actor role is an executor of T04 transaction kinds. The detailed workflow is captured in the Process Model.

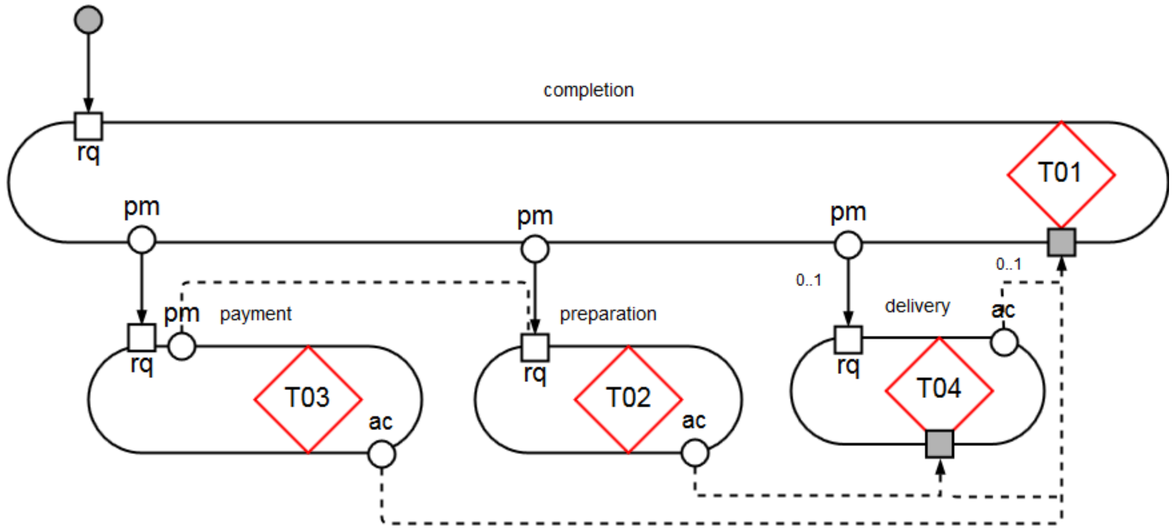

Figure 3 The Process Model of the Pizza Store Source (Dietz, 2006)

The Process Model indicates a tree structure of transaction kinds. T01transaction is a parent transaction and T02, T03, and T04 transactions are child transactions, see Fig. 4. The dotted line indicates 'wait condition', which means: when payment is promised the preparation is requested; the *T01.Execute* has to wait for *T03.Accept* and *T02.Accept* and possibly for *T04.Accept.*

The cardinality '0..1' at T04 transaction indicates that the delivery may or may not be performed in one diagram. It depends on the customer whether he/she takes pizzas personally or he/she has pizzas delivered.

4.2. Reciprocal Transaction Model Utilizing the CC-CP Model

The previous example followed traditional systemic modeling approach, in which there is a system indicated by a box called 'pizzeria' – Fig. 3 and environment represented by the customer. The mutual relationships between transactions are dealt with causal and conditional relationships. In the reciprocal transaction model there can be two different views on the same issue. The first view can prefer a 'pizzeria' as a system and a client as a pizzerias environment. The second view can give preference to the customer and see him/her as a system and perceives the pizzeria as its environment. In the final result, there are actually two systems that have to be counted on. This situation is depicted in Fig. 4.

The reciprocal transaction model follows the above mentioned CC-CP model. The co-creation phase is stipulated to define pizza kinds and price for pizza kinds. Each pizza kind corresponds to one T01 transaction, and the price is in accordance with T02 transaction. Successful agreement is done by the production facts "*pizza kind was defined*" and "*price for pizza kind was defined*". Character of T01 and T02 transaction kinds is informative, which is indicated by a green color in the construction model. All T01 and T02 transactions represent mutual agreement, which is formally concluded in the contract phase. In a case of pizza purchase the informal agreement is done tacitly by e.g. nodding a head. However, formal expression of the agreement is done by *T03.Promise and T04.Promise*. It is a composite coordination fact composed of two elementary coordination facts.

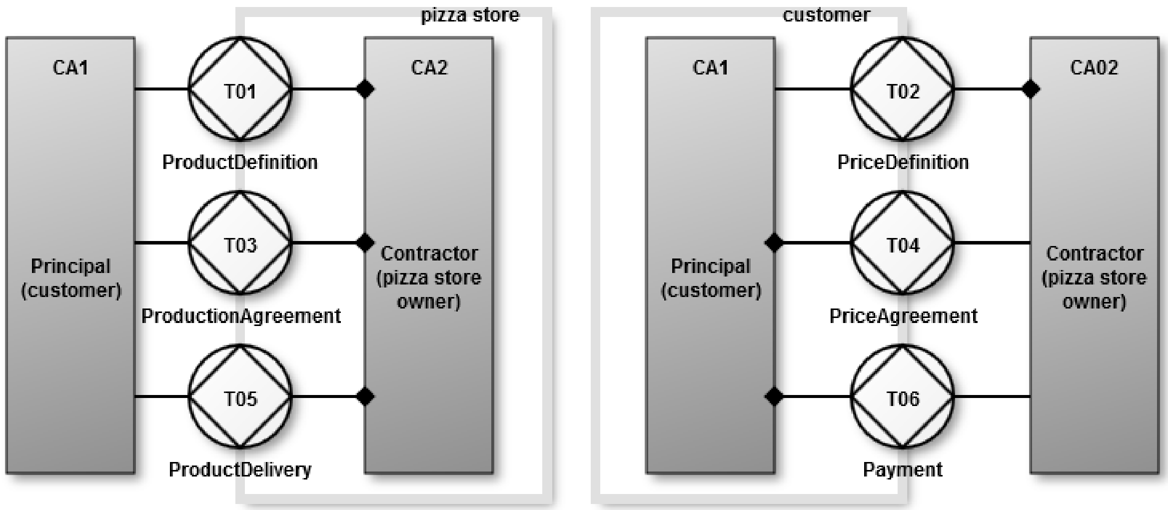

Figure 4 The Reciprocal Transaction Model utilizing the CC-CP model

The co-production phase deals with pizza kind deliveries and payments for pizza kinds. Different T05 transactions represent a different pizza kinds delivery. In terms of T06 payment transaction in this simple case it is obvious that the owed amount of money was paid in one payment. On the other hand, there can be more payments.

5. Discussion

Traditional solution of a pizza store strictly corresponds to the DEMO methodology utilizing parent-child relationships and causal and conditional relationships between transaction kinds. It corresponds to systemic theory with one system and one environment. It also covers preparation of pizza which belongs to the inner transaction kinds in the pizza store. This model is very effective but unsuitable for reciprocal transactions modeling.

The reciprocal transaction model focuses on 'exchange' process and perceives the whole application as two systems. This model has more transaction kinds but covers a mechanism in which reciprocal transactions are driven by a contract. The model itself focuses on the exchange itself and doesn't include any inner transaction kinds. The CC-CP model distinguishes three phases and complete contract phase (model) is represented as a state machine with precisely defined states and state transitions. A couple of T03 and T04 transaction kinds model the contract. The dynamic feature of the model is given by the DEMO transactions with explicitly specified states and state transitions. At one hand it is more complex but on the other hand it realizes reciprocal transaction modeling and thus better reflects business or economic transactions.

6. Conclusion

The paper explains and depicts the Co-creation and Co-production model and applied this model on a simple example of a pizza store. Utilizing the DEMO CC-CP model can be mainly beneficial when the contract conditions are more complex and require detailed specification. Secondly, when the exchange between parties covers more product kinds. Finally, when there are partial deliveries of the products or partial payment for delivered products. Utilizing the DEMO methodology enables to capture all modelled phenomena with a good empirical evidence. In addition, the whole model implementing reciprocal transactions is built up as a state machine. Actor roles can't deviate the states and state transitions. In spite of promising results which were achieved, future research is needed to validate and extend the DEMO CC-CP model to be more robust. The future research in this area will also include linking this approach and its outcomes to the Service Science theory and concepts of value co-creation.

7. Acknowledgements

This paper was supported by the grant provided by Ministry of Education, Youth and Sports Czech Republic, reference number SGS06/PRF/2019.

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INNOVATION OF COMMUNICATION SYSTEMS WITH THIRD PARTY SYSTEMS

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Keywords

NSESSS – national standard for electronic systems of file services, eSSL – electronic system of file service, ISSD – information system for document administration, standardization

Abstract

Frequent and recurring software integration tasks bring issues concerning interfacing with third part systems and their services. Different approaches and ways of implementation are used. Potential issues continuously increase in time and the costs for integrating parties rise and more complex service management is required to serve each customer separately. As this problem is frequent, standardization should be applied. This guarantees the same access conditions for all as well as the quality provided by the service. Decrease in the cost and difficulty of individual integration, which is also often, can get rid of unnecessary redundancy. The paper deals with one of such standards, namely the National Standard for Electronic Records Systems services (NSESSS), from the perspective of integrating third party systems. It outlines a short analysis of the Czech National Standard and implementation integration layer into a framework of an implementing organization.

1. Introduction

Definition of National Standard of Electronic Records Management service, terms and other legislation is given by the National Standard of Electronic Records Management (NSESSS) issued by the Ministry of Interior the Czech Republic on the basis of § 70 of Act no. 499/2004 Coll., About Archives and Archive Services. The objective of this standard is to specify the individual rules that electronic record (filing) systems must fulfill. It therefore lays down essential requirements for the functions of these systems, thereby creating uniform parameters for filing services in relation to digital documents. NSESSS is divided into 11 chapters that follow each other. It is about:

- Basic concepts
- Receiving and recording of documents
- File plan and organization of files
- Referencing between entities
- Search, selection, representation and design
- Saving and discarding of documents
- Control and security
- Managerial functions
- Interface to connect the information system which managing documents
- Documentation of eSSL live cycle
- Metadata

Records management systems can cover overall records and document management, preservation of their digital form as well as mediation of the electronic shredding process. To this end, they are interconnected with other systems and agendas providing the necessary functionality. The National Standard introduces the term *information system documents administration* (ISSD) to designate such a linked system (Triada, 2018). The National Standard thus describes the interface and mandatory functionality between eSSL and ISSD. It is a replacement for the original "Best Practices", which is found in Chapter 9 of the current fourth version.

2. Communication between eSSL and ISSD

Communication between eSSL and ISSD is based on web services which have their synchronous and asynchronous parts. These two methods are mostly implemented simultaneously and are used together over the same data (Rozehnal & Novak, 2017). However, the use of synchronous communication is minimized because of the need for online availability of both participating systems, while asynchronous calls work on the basis of sending and processing individual batch tasks.

Asynchronous communication allows incremental data creation at the sender and subsequently being sent for processing within agreed time periods. The receiving system checks data for validity and saves the request but does not process it immediately.

On the other hand, synchronous communication uses atomic processing requests in real time with immediate sending of acknowledgement to the sender on successful or failed execution. Thus, the caller system receives the response and is able to react upon the situation that has occurred.

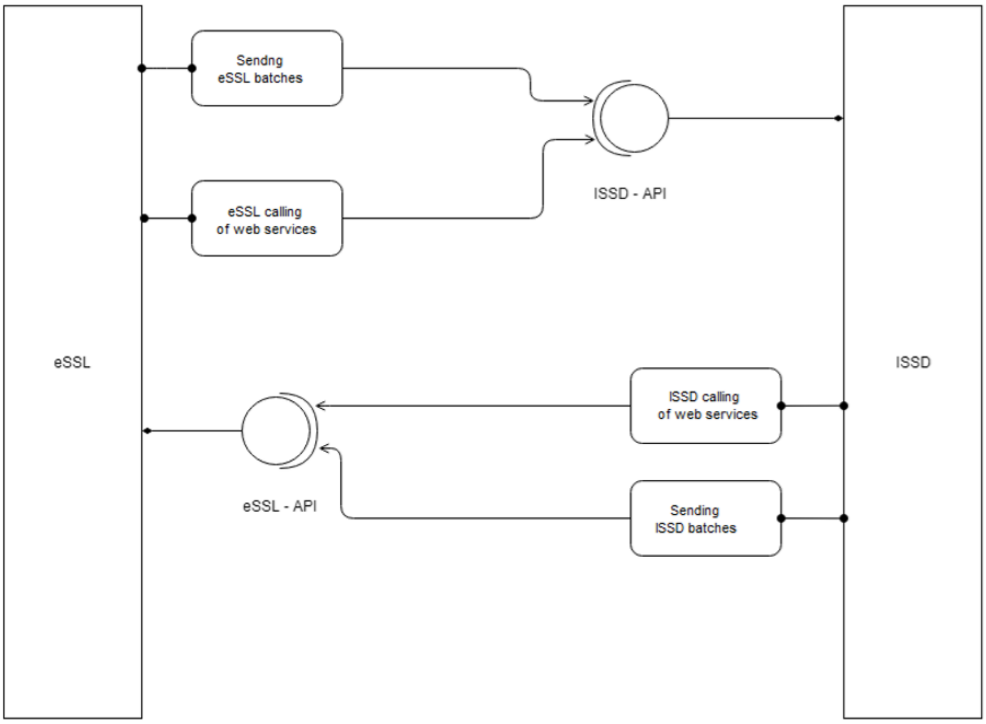

Figure 1 Asynchronous communication process eSSL ISSD, source: Tirala (2019)

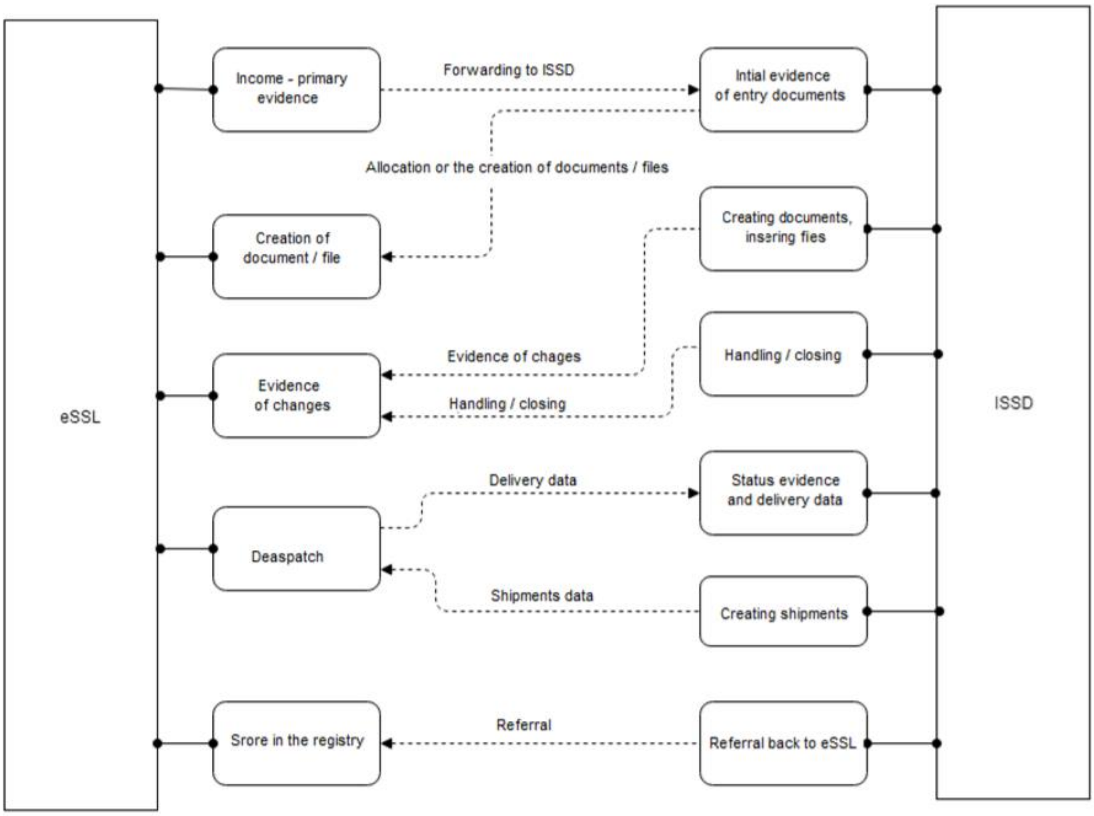

Figure 2 Synchronous communication process eSSL ISSD, source: Tirala (2019)

When systems communicate, it's important to define rules how both sides can manipulate data each time (Hunka & van Kervel, 2017). Systems may perform all authorized operations and subsequently transfer the data for operation to the other party in this way.

3. General communicating rules between eSSL and ISSD

Chapter 9 of the NSESSS contains 34 parts describing the mandatory requirements that a system must comply. It applies to eSSL but also the ISSD party during the mutual communication. Based on these rules, ISSDs clearly define the necessary calls and functionality. Thanks to that they can communicate with eSSL. Secure system communication and transaction preservation is also achieved when working with objects (Association for Information and Image Management International, 2018).

Initial rules for eSSL promote communication with multiple ISSDs, their unambiguous identification, atomicity of individual operations, immediate response at synchronous and return the same result for each recurrence calls without duplicating it.

The important section is 9.1.8 where it is possible to find description of synchronous interfaces that eSSL must issue for the ISSD. It is a basic functionality for creating, modifying, and retrieving file information documents and other underlying entities. Thanks to fact that this functionality is required and has predefined function names, the ISSD systems can integrate by calling specific SOAP[19] messages without complicated information about how to communicate with a particular eSSL implementation.

The synchronous part is followed by the general requirements for asynchronous communication that both systems have to comply with. It's a transfer additional information, the transaction processing with individual identification and dispatch. Sections 9.1.11 and 9.1.12 list events that eSSL and ISSD must implement in order to support asynchronous communication.

The conclusion of the chapter on communication requirements contains several points focused on safety and seamless communication. It's about using HTTP or HTTPS protocol adding electronic signatures ensuring data integrity, but also transferring exclusive rights to manipulate entities between individual systems.

4. Use case study

The Faculty of Informatics of Masaryk University has developed a framework within the framework of cooperation with start-up software companies that will create agenda-oriented information systems. This over-construction was created to optimize development, save time and maintain the necessary functionality in one place.

In order to support asynchronous data exchange between systems, necessary methods for this kind of communication are also implemented in the module. In addition to calling individual eSSL module functions, there are also mandatory ISSD requirements.

“Agenda” in this case is understood as a file of records that consist of attributes, whether of basic or complex types. For example, it is a record of *projects*, *announcements* or *events*. Except for the basic support, the framework also includes a number of integrations on third party systems that are as configurable as possible.

[19] SOAP – Simple Object Access Protocol for message Exchange based on XML

4.1. Architecture of the communication framework

The communication framework is divided on two main parts that communicate with each other through REST[20] and API[21].

- Framework for backend programming
- Framework for frontend programming

A third-party file management system communication module is integrated and implemented in the backend part (Ministerstvo vnitra České republiky, 2018).

The framework backend implements, supports, and uses various technologies that other framework-based projects subsequently share (Hunka & Ministr, 2013). Thus, they may not be implemented by each project and configure them from scratch separately. The main technologies are (Tirala, 2019):

- Java
- Spring Boot
- Apache Tomcat
- JBoss Hibernate
- Apache velocity
- ElasticSearch
- QueryDSL
- Liquidbase

4.2. Integration of WSDL[22] (Web Services Description Language)

Implementation of integration layer for communication with systems is specified by WSDL files (Refsnes Data, 2018) issued by the Ministry of Interior of the Czech Republic. Communication Implementation interface according to these files ensures standardized functionality (Hunka, 2015).

The Ministry has issued six WSDL appendices to the inside to define a required web interface provided by record management services and systems communicating with them (Brandall, (2018). According to these attachments also included integration of the communication module into the framework (Danel & Neustupa, 2016).

Communication between eSSL module and record service systems it is done by sending requests and their subsequent SOAP processing. They are XML structured objects used for swapping more complex and comprehensive information. The structure of these messages is the defined by the WSDL described templates (Refsnes Data, 2019).

[20] REST – Representational state transfer is a simple way of data access by HTTP

[21] API – Application Programming Interface is a group of functions that programmers can to use from other applications

[22] WSDL - Web Services Description Language that is used for definition of functions which are served by web services

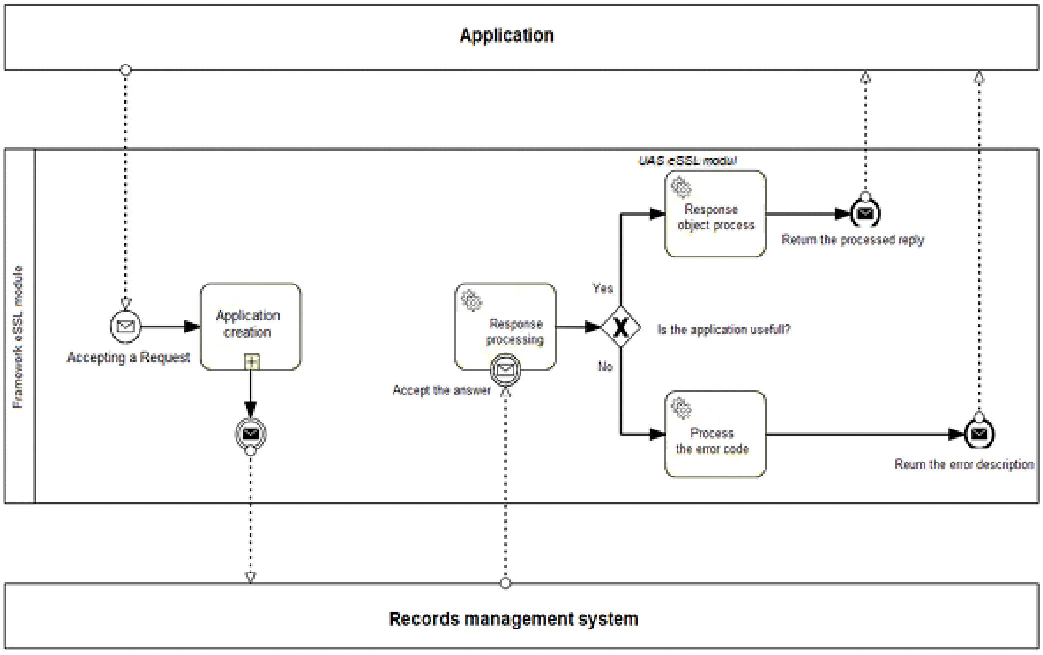

Figure 3 Communication between application and Record management system through Framework eSSL module, source: Tirala (2019)

4.3. Implementation of the module

First, it was necessary to create individual classes together with their attributes to define the names and attributes of the main synchronous and asynchronous methods (Danel et al, 2015). Individual objects were created from bottom-up, what means that simpler classes have been created first containing only primitive or general attributes followed by more complex classes that use them.

After creating the classes, it was possible to gradually define the structure of the most important methods for the main synchronous and asynchronous service classes. Only the basic functions offered by the standardized were created WDDL definitions that were used in other applications during the implementation period. National standard definition itself offers a number of additional functionalities. Individual defined functions were created sequentially as needed.

5. Conclusion

The goal of the contribution was to get familiar with the latest specification of the National Standard of the Ministry of Interior of the Czech Republic for record services and communication with them. As a result, it was possible to design the communication module into the platform of an industrial partner who can mediate synchronous and asynchronous communication between company applications and record services systems provided by third parties.

The final result is a new integration of a module in a company platform that can be used by all applications built on this framework (Tirala, 2019). The module is built according to the latest specifications and thus provides a standardized interface by the Ministry requirements. Industrial partner benefits from the cooperation by increased standardization efficiency and reduction of the costs.

The module can further be extended due to its service-oriented architecture allowing customization when changes are required.

6. Acknowledgement

This paper was supported within Operational Programme Education for Competitiveness - Project No. CZ.1.07/2.3.00/20.0296.

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FORMATION AND DEVELOPMENT OF SKILLS IN THE LEARNING PROCESS OF THE DIGITAL AGE

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Abstract

The article presents the analysis of new approaches to teaching that make sure students acquire the most complex skills necessary for cooperation and communication in the digital age. The authors also present the analysis of readiness among the teaching staff of the Perm National Research Polytechnic University when it comes to using the models of competences' formation. Stemming from this analysis, the authors detect the barriers hindering the introduction of such models and also offer their own recommendations on how to overcome these barriers.

Keywords

Digital age; digitalization of education; universal skills; models of the universal skills' formation; flipped classroom model.

1. Introduction

In today's world, technological changes take place with an ever-increasing rate and are often unpredictable. In order to describe these changes VUCA model is frequently applied. In it, V stands for volatile, U - for uncertain, C - for complex, and finally, A stands for ambiguous. As applied to the education system this means that we cannot really know whether our graduates will be in demand and even whether their future professions will remain valid in the future. For this very reason, all universities must answer the following serious questions:

- What should be taught in the world of freely accessible loads of information?
- Which professions will be most needed tomorrow and the day after tomorrow?

Finding answers to these questions is not easy at all, however, looking at them we can already formulate at least one conclusion: it is vitally important to teach students be flexible, be able to learn independently all life long and be ready to develop their skills continuously.

The share of workers the labor of which is based solely on knowledge is actively growing in both developed and developing countries. Most of competitive advantages fall on those sectors and companies that are already using the latest and the most advanced achievements in the knowledge field.

Experts often mention the following common features of the workers whose performance is based on knowledge (Bates, 2015, p. 17).

Having own business. Quite frequently these workers have a business of their own or work in small companies (less than 10 people). For both these reasons, knowledge-oriented workers tend to perform several different roles at the same time (marketer, designer, sales manager etc.).

Active presence of digital technologies. The key component of their work is digital technology. Once market and technological innovations are introduced, the very nature of work changes. For this very reason, all workers are expected to learn constantly and be ready to manage this process of learning on their own.

The growth in volume of knowledge-based work influences further on the process of new job places' creation. Workers of the knowledge sector tend to create and maintain their own job places. Moreover, they create their own companies providing new products and/or services that never existed before. Today, even manual workers (plumbers, car mechanics, welders and so on) are expected not only maintain their own job places and take managerial decision but also use the most advanced information technologies and devices.

Another important effect from the growth in knowledge-based work volume is the increased demand for highly qualified workers. Consequently, types of knowledge and skills the university and college graduates are expected to have are also changing. Thus, the very course of teaching is supposed to provide future graduates with the skills necessary to respond to the challenges of tomorrow.

Today we are actively using information and communication technologies and devices that we could have never imagined 30 years ago. Therefore, our set of mandatory competences and vitally necessary skills is also changing. Since we need new skills every once in a while, there arises an obvious necessity to improve own qualifications. This, in turn, means that the very system of higher and postgraduate education needs to expand so that to satisfy the growing demand for knowledge and for higher levels of qualification.

According to the data by the Boston Consulting Group (2017, p. 8), in the Russian Federation only 17% of all job places can be attributed to the knowledge sector. One of the key reasons for such situation is that the education system itself does not prepare sufficient number of workers for the knowledge economy development. According to the same research (Ibid, p. 38), higher education in the country has become massively accessible but in parallel to that it has lost its quality. Majority of employers note that university graduates often lack practical skills for the job. The research carried out by the Institute for Demography of the Higher School of Economics has shown that nearly 30% of all employed with university degrees state there no relation between the profession they used to study at a university and their actual job (Varshavskaya, 2017).

2. Research aim

The aim of this research study is to determine the barriers hindering the introduction of new teaching models to be used for the formation of universal competences among the university students of the digital age.

3. Recent research publications' analysis

Within the knowledge society, the set of most necessary skills is changing all the time, however, we can outline the following broad categories of skills vital for today (Bates, 2015, p. 21):

Communication skills - apart from the traditional skills of reading, writing and speaking, these also include the skills of communication in social networks. The new generation of communication skills include: the ability to create a short presentation video for oneself; the skill of addressing wider Internet audience with the presentation of own ideas; the ability to receive feedback and respond to it in an adequate manner.

The skill of independent learning. This skill means, in the first place, taking the responsibility for updating own knowledge base. The knowledge base is expanding all the time, thus, knowledge update must be a continuous, life-long process. And this knowledge update means renewing not only academic knowledge but also studying newer equipment, mastering new technologies and so on.

Cooperation. Despite the fact that most of the knowledge sector workers perform their activities independently or in small companies, they are still very much dependent upon cooperation, knowledge exchange and overall communication with the companies of the adjoining sectors. This skill also means the ability to work together with colleagues, clients and partners, moreover, together but virtually at the same time.

Thinking skills. This group of skills is probably the most important one for the knowledge-based society. All businesses are increasingly dependent upon the creation of new products and introduction of new processes, both aimed at decreasing costs and increasing competitiveness at the same time. For this reason, problem-solving skills, creativity, originality and strategy development skill become the most relevant ones.

Digital skills. Absolute majority of the knowledge-based types of activity are directly dependent upon various technologies. The key problem at this is how to integrate the related skills into the corresponding sphere of activity. For example, real estate agents are expected to be ready to use various information systems so that to reveal the current trends in sales, fluctuations of prices in various districts etc.; welders are expected to be able to use robots in construction and repairing works; doctors are expected to be able to analyze the results of MRI tests and so on.

Knowledge management. This skill is also of vital importance for the knowledge-based society. Knowledge does not only rapidly change due to newer research and various inventions, but the sources of knowledge are also becoming more versatile, even though this automatically means more versatility in the levels of their credibility and trustworthiness.

In the course of competences' formation universities should pay enough attention to the development of cognitive skills: self-development, critical thinking, initiative, teamwork, the ability to organize own work, the ability to work under uncertainty and the like. Development of such skills has already become top priority for the leading universities in many developed countries worldwide.

The Sberbank charitable foundation "Contribution into the future" has also initiated an international project called "Key competences and new literacy: from declarations to reality" (2017). This initial report has been prepared by the team consisting of Russian scientists, representatives of the OECD and UNESCO as well as staff members of the leading research and higher education institutions from the UK and Canada. Within the frameworks of this project the researchers have prepared an analytical overview of how competences are being formed in various countries of the world.

Canada

A brand new approach to definition and measurement of universal competences of the 21st century has been approved in Canada in 2014. The Canadian model covers 6 groups of key competences: critical thinking; creativity (innovativeness and entrepreneurship); communication and cooperation. To these key competences the authors of this approach also add "character upbringing" (persistence, flexibility, value of personal growth) and also "civil literacy" which is understood as the ability to do the right thing under various ambiguous circumstances. As of today, all these groups of competences are already integrated into all aspects of the learning process, starting with the stage of teaching planning and finishing with the instruments of assessment.

Finland

Finnish state mandatory programme of basic education was updated back in 2014. All interested stakeholders were involved in the process of its renewal: education institutions, parents and students too.

The key feature of the Finnish model of education is its emphasis on the interdisciplinary project types of activities and development of universal competences integrated across all subjects. These universal competences include: the ability to learn; social and civil literacy; initiative and entrepreneurship skill and also digital literacy.

China

The education system of China is developing as rapidly as its economy. Its development started back in the 1980s with the key task being to eliminate illiteracy, today its key task is development of the 21st century competences. In Chinese language the very notion "literacy" does not mean just being able to read and write. This is a much more complex category, it manifests the development of individuality as a whole and also the level of individual's "quality". In Chinese interpretation, the model of comprehensively developed human being covers six universal competences grouped into three broader categories - self-development, social engagement and cultural basis.

Mastering universal competences in Chinese system of education is built into the general context of learning which also includes other key elements such as knowledge on specific subjects, character development and establishment of own mindset.

South Korea

Education in the Republic of Korea has been frequently criticized for its overwhelming intensity and severe competition between the students. Thus, there has been a necessity for education reform in this country not only because of the changed competences of the 21st century but also so that to ease the load on the students as well as to change the attitude to the education system in general. The reform started back in 2012, and it is still ongoing.

The new national programme of general education has been based on the reduced volume of teaching specific subjects and less frequency of test tasks. Another important feature is improvement in the results' assessment methodologies and introduction of the six key all-inclusive competences.

The key competences, according to the Korea model, include: self-management; the skill of working with knowledge and information; creative thinking; aesthetics and emotionality; communication and civil literacy.

Russia

Russian model of education is defined according to the Federal state standard of higher education (FSSHO, 2017). This standard covers general cultural, professional and universal competences. Mastering the universal competences is built into the teaching programmes of the Russian education system (see table below). These universal competences include development of critical thinking, self-organization, cross-cultural interaction. One of the key competences mentioned in the teaching programmes is cooperation (or the skill of working in teams in the course of project implementation).

Table 1. Universal competences within Russian system of education

System and critical thinking	The ability to search for information, critically analyze and synthesize it; the ability to apply the system approach while performing various tasks
Development and implementation of projects	The ability to determine the tasks to be carried out so that to achieve a certain aim; the ability to choose the optimal means and methods stemming from the current legal norms, available resources and acting limitations
Teamwork and leadership	The ability to perform social interaction and perform own role in a team
Communication	The ability to get engaged in business communication in its oral and written forms using the state language of the Russian Federation and also foreign language(s)
Cross-cultural interaction	The ability to perceive cross-cultural variety in the society in the sociohistorical, ethical and philosophical contexts
Self-organization and self-development (including personal healthcare)	The ability to manage own time, plan and implement self-development basing on the principles of life-long learning. The ability to maintain an appropriate level of physical readiness for full-fledged social and professional activity
Personal safety	The ability to create and maintain safe enough conditions for own life and activities, including those that might take place during the emergency situations

As of today, many Russian universities are actively introducing cognitive skills' component into their education systems and programmes, with the aim to partially substitute the traditional "knowledge upload". One of the central universal competences, as it is noted in the programmes of many education centers, is self-development which is understood as the ability to find necessary information, analyze it, apply it in teamwork and later use in the decision-making process while preparing and implementing various projects.

4. New models for the formation of universal competencies

Digital environment is constantly experiencing the emergence of new models and instruments to be used for formation of universal skills and competences, and first of all - information exchange, efficient communication and joint work on various projects. As of today, the most efficient models to be used for universal competences' formation are the BYOD model and also the so-called Flipped Classroom model.

The BYOD (Bring Your Own Device) model allows creating nearly perfect models for blended learning. And the Flipped Classroom model is actually part of a wider teaching approach which also includes blended learning, problem-oriented teaching and some other methods and means of teaching, all being much more flexible as compared to traditional teaching and all focused on students' fuller engagement and more activeness in class. Implementation of this model assumes active use and creation of video clips, availability of own teaching platform, presence of various practical tasks, business cases and so on.

Active use of such new models means that the teacher's role is changing: moving from traditional presentation of the materials on a specific subject, today the teacher is expected to set the direction for further independent studies, search and analysis of information, all to be carried by students themselves. The teacher is not just presenting a new topic - he/she is supposed to organize the student audience in such a way so that it will solve a problem, implement a project and discuss it afterwards. Implementation of this approach is possible on the basis of an online platform where the teacher can publish various materials on the topic (in different formats, not just text), organize the process of communication and control over the exchange of information between students themselves and with the teacher.

Russian universities are actively discussing the opportunities provided by such models, however, their actual implementation, unfortunately, is not yet that mass-scale. For this very reason, attitudes of Russian universities' staff to the use of such models in the teaching process still require special attention and research.

The experience of our colleagues from other Russian universities show that the use of such newer models guarantees much wider engagement of students into the teaching process. In their opinion, the most important features of newer approaches are individualized teaching and extra flexibility in assessment of students' successes (Kvashnina and Azhel, 2016, pp. 108-112; Tikhonova, 2018, pp. 74-78).

5. Research methodology

The study used data from a survey of teachers in 10 departments of the Faculty of Humanities of the Perm National Research Polytechnic University (PNRPU). The research sample included all faculty members.

6. Research results

Own experience of working in universities has allowed the authors of this article analyze the readiness of the university and its staff to use newer models of teaching in the course of universal competences' formation.

Our university has already created its own electronic informational environment for education which is represented by several sites, corporate email server, online library, various teaching platforms and also several online directories. Taken all together, this digital environment provides all the opportunities to form and develop the competences of new generation. At the same time, these opportunities, unfortunately, are not always used to their fullest capacity.

The following factors have their impact on the formation and development of universal competences:

- Equipment of the learning space;
- Applying blended learning methods;
- Using newer models of teaching in the education process.

Equipment of the learning space. Application of the new-generation technologies and new forms of teaching based on them require new planning of the learning space. Classrooms today must be arrange in such a way to provide students' interaction during projects' implementation. This includes the use of various mobile devices and telecommunications within teams. At Perm National Research Polytechnic University, the absolute majority of classrooms are already equipped with wireless Internet connection, online projectors, large screens etc. This guarantees there are enough opportunities to apply new model of teaching in the education process. Also, there is specifically dedicated space where students' research groups may work together. Even hallway spaces at the university have been reorganized for better communication and more productive student work. All hallways are also covered by the wireless Internet connection.

Applying blended learning methods. Perm National Research Polytechnic University has already accumulated enough successful experience in the field of blended learning implementation, namely, on the basis of the online teaching platform of the Humanities faculty (http://platform-hsb.pstu.ru). During the ten years of this platform functioning our staff has created and updated the complete database of the e-courses, while faculty staff has been gaining sufficient experience in using online technologies in the teaching process. The focus has been always on maintaining and supporting the independent work of the students. However, we need to admit here that not all the teachers are using the technical capacity of the platform to its fullest, some of them limit the use to publishing their teaching materials only, and nothing else.

Using newer models of teaching in the learning process. Students of our faculty are mostly using mobile devices when downloading and uploading materials from/to the platform, same applies to communication with all the teachers and department coordinators. For further promotion of the BYOD model use we need to modernize the IT infrastructure of the university so that to guarantee higher network security and confidentiality of data at all stages (Petrenko, 2016, pp. 385-389). The use of mobile devices in the learning process is not a purely technical problem, it is directly related to the issue of understanding the needs of both students and teachers. Unfortunately, not all teachers of our faculty are ready to realize the need for closer integration of the BYOD model into the learning process. The Flipped Classroom model is also used only but a few teachers at our faculty (Akhmetova, Esaulova, 2015, p. 361-363; Akhmetova, Nevskaya, 2018, pp. 62-69).

In order to boost the digital awareness at the faculty back in 2017 the university organized trainings for all academic staff so that to teach them how to use the platform resources and technical capacities more wisely and in the context of new teaching models. Once these trainings were over, all academic staff was surveyed so that to reveal the actual reasons why the platform was not used as actively as desired. The results of this survey revealed that one of the key reasons for non-using the platform was academic overload; other important reason was lack of the IT skills. Also, 40 representatives of the surveyed staff stated that they think traditional teaching technologies are sufficiently enough for their work (see Figure below for more details on the answers).

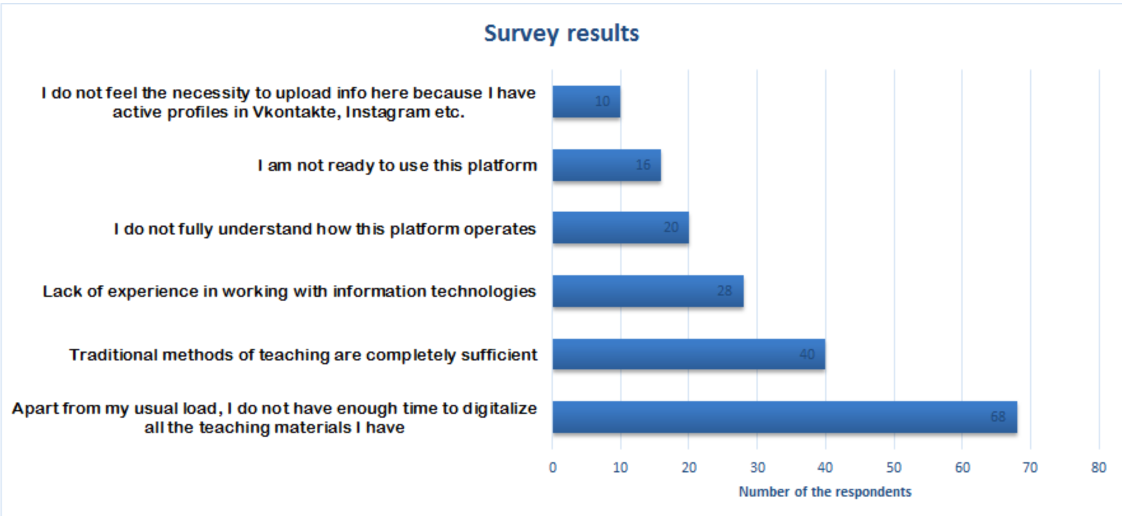

Figure 1. Results of the teachers' survey

A serious hindrance to introducing new models of teaching is significant increase of the load per one teacher which is not supported financially, neither stimulated by other means. The teacher is expected to completely rebuild own teaching materials and divide them in such a way so that to publish one part on the platform (as short videos, presentations, lists of links to various other online resources), while the second part is supposed to remain for the classroom use. A significant part of work in this regard falls on the development of a separate system for assessment of students' independent work and also their teamwork in the classroom.

Another problem is related to low level of students' readiness to use the materials published online as the latter are not always good in terms of quality due to low level of teachers' technical preparedness to produce digital materials.

7. Conclusion

To sum up, today's digital environment opens up new opportunities for using new models of teaching and formation of universal competences among students. At this, the education process must be first of all directed at the development of student's personality. For this, it is first and foremost necessary to:

- increase teachers' qualifications in the field of digital technologies overall and new models of teaching in particular;
- reconsider all teaching plans along with the systems of students' assessment;
- develop a new system of teacher incentives for those members of academic staff who are actually using new methods and means of teaching;
- guarantee sufficient technical support for implementation of new teaching models by those teachers who are directly involved in development of online course and teaching materials for them.

Despite all the mentioned and other problems that are hindering the use of newer models in our university, the development prospects seem to be still rather optimistic: we have already accumulated enough experience of working with new-generation technologies, also, all technical preconditions have been created by the university for their further use and spread. Today more and more teachers at our university become aware about the necessity for transition to the new technologies and means of student education.

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THE APPLICATION OF ADDITIVE MODEL IN PREDICTING THE RISK OF BANKRUPTCY

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Keywords

Bankruptcy, Data Envelopment Analysis, model, prediction

Abstract

In this paper the following research problem was addressed: Is DEA (Data Envelopment Analysis) method a suitable alternative to prediction models in predicting the risk of bankruptcy? In relation to research problem the aim of the paper was formulated: To use DEA method in predicting the risk of bankruptcy and compare its results with the results of selected prediction models. The research was carried out on a sample of 343 businesses operating in Slovak heat industry. To fulfil the aim we applied additive DEA model. We chose this model because of negative values of financial indicators. We compared the results of additive DEA model with the results of Altman model, Virag-Hajdu logit model and Zmijewski probit model. We found out that according to prediction models, 161 businesses from the analyzed sample are threatened with bankruptcy. The important conclusion of this paper is that additive model allows us to classify businesses into larger amount of scales than prediction models and therefore the classification is more precise.

1. Introduction

The diagnostics of the financial health of a company, as well as the prediction of its bankruptcy, is currently a highly discussed topic. In order to maintain prosperity and competitiveness, it is extremely important for a company to know what financial situation it is in. Adequate management decisions cannot be made without detailed analyses. An important prerequisite for effective decision-making of business owners is a high-quality, comprehensive and timely diagnosis supported by a detailed analysis of adverse phenomena threatening the company's operations. By taking early trade remedy measures, companies can prevent adverse future events (Gundová 2015). To date, empirical studies have found that inefficiency, high corporate indebtedness, and solvency problems (Altman 1968) are prerequisites for bankruptcy. Higher efficiency can enable the company to perform strategic activities better/ cheaper than its competitors, and this will in turn lead to a competitive advantage (Kočišová 2012, p. 169). Thus, efficiency measuring and search for the causes of potential inefficiency are a necessity for a success of a company. In scientific studies, particular attention is paid to the use of various tools for the design of diagnostic models. However, the need to meet several statistical assumptions as to whether the relatively stringent size of the data set of these traditional tools has become an incentive to develop new approaches (Mendelová a Bieliková 2017, p. 26). Jablonský, Dlouhý (2015) consider evaluating and analyzing the efficiency and performance of a set of production units to be a task that is widely used in many areas of the economy. The aim of such a task is not only to rank or classify the evaluated units within a given set, but also to carry out more in-depth analysis to answer the question of the company's inefficiency, how to improve the performance of the units under assessment, how to improve competitiveness compared to others. There is now a wide range of methods and procedures to measure the efficiency and financial health of businesses. Each of these methods has its ups and downs. Currently, the most used tools are discriminatory analysis (DA), logistic regression (LR), decision trees (DT) and various types of neural networks (NN). The leader among the methods is the method we know under the name "data envelopment analysis" (Kliestik, 2009, p. 133 - 134). One of the advantages of this method is its possible application not only in the evaluation of company's performance, but also in the area of bankruptcy prediction. Premachandra et al. (2009) addressed the aforementioned in their research. They used the DEA method to evaluate and predict bankruptcy. They pointed out that DEA is a very fast and easy-to-use tool for exposing an impending bankruptcy. This is the direction in which we explored DEA is in our paper, too.

In line with the above-mentioned text, we identified the following research problem: Is DEA (Data Envelopment Analysis) method a suitable alternative to prediction models in predicting the risk of bankruptcy? The aim of the paper is: To use DEA method in predicting the risk of bankruptcy and compare its results with the results of selected prediction models.

2. Literature review

DEA is one of the most important management tools. Compared to statistical and other methods, the DEA is a relatively new and non-parametric method, representing one of the possible approaches to assessing the efficiency, performance, productivity and financial health of homogeneous production units of companies. The DEA theory originated in the 1970s, and it is based on the idea of "Measuring efficiency of decision-making units" published by Farrel in 1957. His work was based on the works of Debreu (1951) and Koopmans (1951).

There are two approaches to creating DEA models. The first is multiplicative and the second is dual. Dual model is an additional task to the multiplicative model. The basis for DEA models is inputs or outputs. By evaluating the efficiency of a given production unit, we basically evaluate its efficiency in transforming inputs into outputs. Some of the basic models are input-oriented and some are output-oriented. The input-oriented models minimize inputs, while output values remain unchanged, and the output-oriented models maximize outputs at non-increased input values. Another criterion for possible model classification is the nature of scale revenues: constant returns to scale (CRS) - CCR models (Charnes, Cooper and Rhodes 1978), variable returns to scale (VRS) - BCC models (Banker, Charnes and Cooper 1984), FDH models (Free Disponsable Hull) and Free Replicability Hull (FRH) models, which are not limited by the a priori assumptions about the nature of scale revenues. Jablonský and Dlouhý (2015, s. 116) describe the FDH model as follows: "The basic idea of the FDH model, which was first formulated by Deprins, Simar and Tulkens (1984), is the non-convexity of a set of production possibilities. This means that the unit can only be evaluated relative to other, actually existing units, not to their convex combinations." DEA models can further be divided into radial and non-radial models. Radial models provide a measure of efficiency that points to a proportional reduction in inputs or expansion of outputs so that the production unit becomes effective. Radial models include CCR, BCC and super-efficiency calculation models. Non-radial models address the potential for disproportionate changes in inputs and outputs to achieve efficiency. These models include the additive model of Charnes et al. (1985) and the SBM (Slack Based Measure) model by Tone (2001). In previous models, an input-oriented and an output-oriented model are to be distinguished. The additive model combines both of them. The additive models are able to take into account all sources of inefficiency but do not directly provide the degree of efficiency. The degree of efficiency needs to be additionally defined.

Over time, the DEA method started to be used to predict bankruptcy. The use of the DEA model in this area has been the subject of research by many authors, many of whom have compared the results of the DEA model with other models. According to the Mousavi, Ouenniche, Xu (2015) in 1997, Simak compared the results of Altman's Z-score with the DEA results for the first time. He pointed out that the DEA could also be a very suitable method to predict bankruptcy. In 2002, the authors Pille and Paradi (2002) tried to uncover the reasons for the decline of Canadian financial institutions Credit Unions. They used the modified CCR and BCC models with variable returns to scale which they compared with the equity / asset indicators and the modified Z-score model. Other authors who dealt with the subject matter included Cielen, Peeters, Vanhoof (2004). Cielen et al. used the DEA radial model to predict bankruptcy and compared the results with DA methods. In 2009, Premachandra, Bhabra and Sueyoshi published an article dealing with the bankruptcy prediction using the DEA additive model with variable returns to scale model and compared it with the results of logistic regression. The additive model was used because the CCR DEA model is not able to work with negative financial indicators. The conclusion was that logistic regression is better at identifying healthy companies. In identifying companies at risk of bankruptcy, logistic regression has reached a maximum of 64% success rate. That means that the additive DEA model is much more appropriate for predicting bankruptcy. Premachandra et al. (2009) also suggested a way to construct a business failure frontier. In 2012, Janova, Vavřina and Hampel used the additive DEA model with variable returns to scale applied to identify bankruptcy in industrial companies. After applying the DEA model, the resulting probability of correct identification of a bankrupt company reached up to 94%, a healthy company 73% and the overall accuracy of the prediction reached 75%. The fewer healthy companies in each sample, the more successful the model proved to be. It turned out that the additive DEA model is very good at identifying bankrupt industrial companies, but at the same time slightly weaker in identifying healthy companies. The findings of Premachandra et al. were used by Mendelová, Stachová (2016), who compared the results of the additive DEA model with the results of logistic regression when predicting financial distress. They arrived to a conclusion that none of the applied methods is better or worse, what matters is data used, its amount and suitability for the method (Mendelová, Stachová, 2016). Shetty, Pakkala, Mallikarjunappa (2012) also applied Data envelopment analysis (DEA) to predict the bankruptcy of the sample of companies. The solution to their model was to place inefficient companies to the inefficient frontier. The result of their study was the summary of indicators that are suitable to be applied as predictors of bankruptcy.

In the work of some authors, the bankruptcy prediction DEA model was used in conjunction with the Logit, Probit and Tobit regression models. Araghi and Makvandi (2013) wanted to find out whether DEA models could predict bankruptcy better than Logit and Probit statistical models or multidimensional discriminatory analysis. They used an additive super-efficient DEA model and data on 55 bankrupt and 134 healthy industrial companies. The results showed that Logit and Probit models were somewhat better, the additive DEA model and the discriminatory analysis were just a bit worse. The authors proposed to use the BCC and CCR models or to incorporate inflation into testing. In their paper, Ahmad, Ishtiaq, Hamid, Khurram, Nawaz (2017), applied the DEA model and the Tobit model for assessing business efficiency with respect to working capital management.

3. Data and methodology

The input database for analyzing the bankruptcy risk determinants was created from 2016 data obtained from 343 companies active in the heat industry. These are companies whose territorial scope is limited and therefore their market share is also limited. These companies are mostly local but few of them have a monopoly position in a given geographical area. We assessed bankruptcy of the selected sample of businesses with the use of eight financial variables, six inputs and two outputs. These financial ratios were used by Premachandra et al. (2009) and are considered to be the most efficient ones by Altman (1968): CFTA – Cash flow/ Total assets, NITA – Net income/ Total Assets, WCTA – Working Capital/ Total assets, CATA – Current assets/ Total asserts, EBTA – Earnings before interest and taxes/ Total assets, EBIE – Earnings before interest and taxes/interest expenses, ED – Equity/Debt, TDTA – Total debt/Total Assets, CLTA – Current liability/Total assets.

It might happen that the efficiency analysis based on the DEA models lacks the required input data. The biggest problem is that the input values of the model are negative. To solve these problems, we need a model that is invariant to some changes in input data. Invariance is the ability of a model to keep the value of a purpose-built function unchanged, while still being able to divide businesses into efficient and inefficient, with some input / output transformation.

Such a model is the additive DEA model. The additive model is one of the non-oriented models. It was first formulated in 1985 by Charnes et al. In order to determine the effectiveness of DMUs using the additive model in variable returns to scale we need to solve the linear programming task:

$$\max_{\lambda,s^x s^y} A_o = (e_m^T s^x + e_s^T s^y)$$

$$\text{s.t.} \quad \sum_{j=1}^{n} x_j\lambda_j + s^x = x_o, \qquad s^x \geq 0,$$

$$\sum_{j=1}^{n} y_j\lambda_j - s^y = y_o, \qquad s^y \geq 0$$

$$\sum_{1}^{n} \lambda_j = 1, \qquad \lambda_j \geq 0,$$

where e_m, e_s, are unit vectors of the appropriate length and s^x, s^y are additional variables, the so-called slacks. The DMU_o is effective when s^{*x}=0, $s^{*y} = 0$. In other words, when the purpose function equals zero. Otherwise DMU_o is not effective.

Since we did not address the efficiency of the analyzed sample of companies but rather their risk of bankruptcy, the input vectors x_o, were replaced by output vectors y_o. The conditions of effectiveness in this case were the conditions for the anticipated bankruptcy of the company.

We compared the results of the DEA additive model with the results of the prediction models. With this comparison, we wanted to confirm the ability of the additive model to predict bankruptcy. In doing so, we chose the Altman model from 1983. The model took the following formula:

$$Z' = 0.717 * x_1 + 0.847 * x_2 + 3.10 * x_3 + 0.420 * x_4 +,$$

where x_1 is Working capital/Total assets, x_2 is Retained earnings/Total assets, x_3 is Earnings before interest and taxes/Total assets, x_4 is Equity/Total debt, x_5 is Sales/Total assets.

Zones of discrimination are as follows: Z′ > 2.9 → safe zone; Z′ ∈ < 1.23; 2.9 > → grey zone; Z′ < 1.23 → distress zone

We then chose logit and probit models for comparison. Logit and probit models are included in classification models and predict the probability of a failure of a business. The unpretentious clarification of the results and the absence of evaluation and classification scales to interpret these results are their common strengths. These models are modified by the regression analysis, i.e. logistic regression, which is a sought-after modeling technique. Logistic regression has several advantages. e.g. unnecessary normal distribution of independent variables, unnecessary testing of the importance of individual variables prior to the analysis, as well as non-equality of variance-covariance matrices (Gundová, 2015).

Virag-Hajdu logit model uses the cumulative logistic function for bankruptcy prediction with the help of the following formula (Virág, Kristóf, 2005):

$$PR(solvent) = \frac{e^{Z}}{1+e^{Z}} = \frac{e^{\beta_{0}+\Sigma(\beta_j x_j)}}{1+e^{\beta_0+\Sigma(\beta_j x_j)}},$$

where β_j are regression parameters; X_j are independent variables (financial ratios); $j = 1,..,m$ where m is the number of financial ratios, We applied these financial ratios: x_1 = *Quick liquidity ratio*,
x_2 = *Return on sales*, x_3 = *Cash flow / Total debts*, x_4 = *Current assets / Total assets*, x_5 = *Accounts receivable / Accounts payable.* Regression parameters were as follows: $\beta_0 = 3.432, \beta_1 = -10.320, \beta_2 = 0.01439, \beta_3 = -4.438, \beta_4 = -0.02992, \beta_5 = 8.170.$ The cut-point value in this model is 0.525. Companies which achieve higher value of *PR* are classified as insolvent.

As another model we chose the Zmijewski's model - the probit model. It looks as follows (Gundová 2015):

$$Zm = -4{,}336 - 4{,}513*x_1 + 5{,}679*x_2 + 0{,}004*x_3,,$$

where: x_1 = *EAT / assets*, x_2 = *Debt / Assets*, x_3 = *Current assets / Short-term liabilities.* If the probability of failure $1/(1+e^{-zm})$ reaches a value higher than 0.5 (50%), we can talk about a business threatened with bankruptcy.

4. Results and discussion

Based on the comparison of the results of analyzed models we can conclude that businesses operating in Slovak heat industry have problems with their financial health and the vast majority of these businesses is threatened with bankruptcy. This can also be seen in the results of descriptive statistics of selected models (see Table 1). The average value of the Altman model is 1.275, with a median of only 0.659. It means that average value as well as median are below the value of the possible bankruptcy defined by this model. 35 businesses achieved negative values of Altman model. There were only 43 businesses which achieved the value of Altman model 2.9 and above. 255 businesses did not reach the value 1.23 which represents possible bankruptcy frontier.

Table 1: Descriptive statistics of bankruptcy models

Variable	Valid N	Mean	Median	Minimum	Maximum	Std. Dev.
Altman model	343	1.257	0.659	-1.50	24.01	2.103
Virag-Hajdu model	343	0.737	0.999	0.00	1.00	0.419
Zmijewski model	343	0.53	0.582	0.00	1.00	0.279

Source: own processing in Statistica

We applied also logit model. 256 businesses achieved the value of this model above 0.525. 215 businesses reached the same results as in the Altman model. The last prediction model which we used was the Zmijewski probit model. Results of the model reached minimum value 0 and maximum value 1. The average value and median of this model are approximately at the same level. However, their value indicates problems and possible threats to the analyzed sample of businesses. According to this model, 208 businesses from the analyzed sample are threatened with bankruptcy. 161 businesses achieved the same results as in the previous models. Based on the above-mentioned we can say that 161 businesses from the analyzed sample are threatened with bankruptcy. 17 businesses achieved good rating in all applied models. Grey zone is only in the case of the results of Altman model. 45 businesses from the analyzed sample located in this zone. In the case of these businesses we are not able to say if they are threatened with bankruptcy or not. Table 2 shows the comparison of the results of selected models.

Table 2: Comparison of the results of bankruptcy according to selected models

Model		Altman	Virag-Hajdu	Zmijewski
		Number of businesses which are threatened with bankruptcy		
Altman	Bankrupt	255	215	188
Virag-Hajdu		215	256	167
Zmijewski		188	167	208

Source: authors

Applied prediction models have good estimation accuracy of bankrupt companies. However, their estimation accuracy of financially healthy companies is lower. The most businesses threatened with bankruptcy were identified by Virag-Hajdu model, the least businesses were identified by Zmijewski model. This may also be due to the fact that in Zmijewski model are applied only 3 indicators (liquidity, capital structure, profitability). Virag-Hajdu model is composed of 5 indicators, it means that its approach and scope of evaluation is greater. The highest match in the prediction of business bankruptcy occurred between Altman and Virag-Hajdu models.

Additive DEA model identified 13 businesses which are located on bankruptcy frontier. After excluding these companies from the sample and resolving the model, we identified another 22 businesses that met the bankruptcy assumptions. Based on the above-mentioned we can conclude that when predicting business bankruptcy, additive model allows us to classify businesses into larger amount of scales. We used the same efficiency intervals for the classification of businesses into DEA levels as Ševčovič et al. (2001).

Table 3: Results of DEA model

DEA level	Frontier	1	2	3	4	5	6	7
Efficiency interval (%)	0	0-20	21-35	35-50	51-65	66-80	81-90	91-100
Number of businesses	13	35	14	23	45	63	65	98
% of equally identified businesses	54%	49%	57%	74%	80%	57%	32%	28%

Source: own processing in EMS (Efficiency Measurement System)

Table 3 shows estimation accuracy of the DEA model compared to the above-mentioned prediction models. We can see that DEA model identified 13 businesses which lie on financial distress frontier. By comparing this result with the results of above-mentioned models, a 54% match was achieved in the area of bankruptcy prediction. The highest match of 80% was achieved at 4th level.

The lowest match was achieved at 7th level in which financially healthy businesses dominate. None of the analysed businesses achieved efficiency score of 100%.

5. Conclusion

In our research, we focused on comparing the results of selected prediction models with the results of the additive DEA model. We have applied this model because it has the property of translation invariance (Cielen et al. 2004). This feature of the model is important when there are negative values of selected financial ratios which enter the model. Additive model was applied by many authors (Premachandra et al., 2009; Cheng et al., 2006; Ravi et al., 2008, Mendelová and Stachová, 2016), so when solving the problem we were inspired by their results. Another reason for applying this model is the fact that the selection of input-output characteristics to be used in the additive model DEA is based on analyst's experience, application of various economic theories and is similar to the regression analysis (Premachandra et al., 2009). The evaluation of the results of this model is easier than in the case of radial models, since the determination of efficiency, in our case bankruptcy, is only given by the value of the slacks. In the case of radial models, the efficiency score is also required.

6. Acknowledgement

This paper was prepared within the grant scheme VEGA no. 1/0887/17 - Increasing the competitiveness of Slovakia within the EU by improving efficiency and performance of production systems.

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ANALYSIS OF COBIT FRAMEWORK INPUTS

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Keywords

COBIT, framework, inputs, analysis, process

Abstract

COBIT is an IT Governance framework. It is a set of processes that should enable the strategic goals of the organization to be achieved through the efficient use of available resources and minimization of IT risks. In addition, to describe these processes and their interdependencies, COBIT also includes the table of alignment goals to governance and management objectives and their mapping to processes that serve to meet these goals. Thus, the IT manager knows which processes are immediately needed to satisfy the desired alignment goal but does not see directly which processes must precede those required processes. COBIT only defines inputs from other processes as direct predecessors. The aim of this paper is to find and analyze the predecessor processes in several generations. These processes (their outputs) are not directly required by a given alignment goal but they should be considered due to the interconnections of individual processes. Information about links between processes and their predecessors could be useful for the selection of processes when implementing the governance concept. These links represent inputs to the processes selected for implementation. In conclusion, the results of the analysis are interpreted.

1. General

The transformation of enterprises towards the use of digital technologies as well as the massive use of data brings a need for comprehensive management. Information technologies create a dynamic environment full of possibilities and challenges. On the other hand, such environment presents higher demands for continuous innovation and readiness for change. As far as information technology is concerned, it is still more important to achieve IT/business alignment in organizations (Mikko, 2011, Avison et al, 2004, Chan & Reich, 2007, Schlosser et al, 2012).

COBIT is worldwide known framework for information technology (IT) and business alignment. It is available in new version COBIT 2019 (ISACA, 2019c; ISACA, 2019d) now. Compared to previous version, COBIT 2019 introduces several changes. However, the main purpose and general approach remains the same. It is still process oriented, although there are changes in terminology. In COBIT 5 and its previous versions, the term *process* is used for definition of an area covering a specific management field (ISACA, 2019d). In COBIT 2019, the term *objective* is used instead, which relates to one process with the same purpose and serves as an umbrella for process and its related activities definition as well as other components (previously *enablers*), which are important to achieve the objective. In this paper, term *process* is used.

Whichever term is used, the philosophy of the framework remains the same. There are management areas (processes – objectives) that have to be managed. The framework describes activities that should be done, assigns roles, inputs and outputs, metrics and other components. The process is an elementary artefact of process management and plays an important role in life of organization. It should be aligned with other processes. The process management approach expects knowledge of all important processes. For the process description we use different details according to levels of abstraction (Řepa &Svatoš, 2016). If it is used with activities details, inputs and outputs, metrics etc., it should be beneficial to know how processes relate to each other. Moreover, the information about inputs gives us a set of predecessors for chosen process, while information about outputs gives us a set of successors.

COBIT approach organizes knowledge between business objectives and IT objectives. In other words, what we want to achieve through IT in business (ISACA, 2019c, figure 4.16). The value creation is a basis challenge for management activities. However, there is not a process map to describe interconnections of processes. There are 1) links between business objective and IT processes (as noted above) and 2) information about inputs and outputs for each process. Each input is generally represented by an information (document, rule, policy etc.) that should be forwarded to target process. It is not possible to see overview of mutual position of processes, the flow of processes, their consequences and other potentially useful information.

The aim of this paper is to analyze inputs and outputs of COBIT 2019 processes and present basic results of this analysis. Although we are aware of limitations of such approach (especially as it is only quantitative analysis) we believe that it is possible to show the internal complexity of interconnections in COBIT and provide a basis for furthermore in-depth analysis.

In this study, we want to answer the following research question: “Is it reasonable to assume that other processes such as input producers may be important enough to implement a set of processes within alignment goal?”

We do not try to develop new theories, but rather to make an empirical contribution to governance and management discipline. COBIT is well established framework but it is still possible and necessary to support its implementation. The most significant change in the new version of framework is in the area of deployment. The framework supports design phase and supports how to better tailored enterprise governance system for IT by so called design factors and focus area which are discussed in new version (ISACA, 2019a).

2. Research design

The analysis of processes interdependency is based on information about process inputs and outputs. Each COBIT process contains inputs and outputs relevant to the process. It should be mentioned that some outputs of given process will also serve as inputs for other processes. By chaining the inputs of individual processes, it is possible to obtain information about the interconnections of processes.

2.1. Data transformation phase

During the first phase, data concerning COBIT process inputs were transformed. A relational database-based solution was chosen to model the traceability of individual processes. The traceability analysis is based on two fundamental parts of the COBIT framework:

- a list of processes and their predecessors (ISACA, 2019d),

- mapping table of alignment goals (AG) to governance and management objectives and processes that serve these goals (ISACA, 2019a, Appendix C).

Note: There are no “internal” inputs/outputs that are shared between practices in the same process and multiple inputs/outputs listed in Cobit (2019d, p. 23). Internal inputs/outputs does not influence predecessor or follower. Multiple inputs/outputs on the other hand affect a lot of processes and this effects should be assessed individually.

To model the traceability of individual processes in several generations, the following database tables had to be created:

- code list of all processes,
- code list of all alignment goals to governance and management objectives,
- process traceability table containing two columns: process and its predecessor (also process),
- table mapping alignment goals to individual processes.

Based on the self-join operation on the traceability table of individual processes, tracing of processes through a given number of generations (nesting levels) was found. According to the desired nesting level, the self-join operation had to be repeated a number of times equal to generation number. Processes that were necessary to achieve alignment goals, were excluded from each generation. In this way, only processes that serve as predecessors to those processes were left. In addition, processes occurring outside COBIT (e.g. other frameworks) and serving as predecessors for multiple processes (e.g. ISACA, 2019d, Fig. 3.8) were excluded as well.

Finally, frequency of occurrence was calculated for processes. This frequency was calculated for each individual AG and corresponding generation. For this calculation, Excel PivotTables were used. Results were obtained in a matrix form.

2.2. Data evaluation phase

COBIT framework is often viewed as an umbrella for other IT frameworks due it its comprehensive approach and focus area. The comprehensive, holistic framework for governance area implies challenges in the implementation phase. It is practically impossible to implement COBIT as a whole. Basically, it's not even the goal. Its deployment thus leads to the question of which processes are the most important for the company in the given situation.

Great attention is paid to adapting framework to a specific of the enterprise. Moreover, the primary goal of governance system is to align business and IT. These challenges are supported by goals cascading and by selection of important processes according to the company specifics (ISACA, 2019c, chapter 7). In short, as a result of designing we can have a set of primary and secondary recommended processes that serve as the best support for the initial intentions (we use a mapping table in (ISACA, 2019a, Appendix C)). COBIT operates with AG representing an area in IT which is typically supported by a set of IT processes. Such approach expects that we do not pay attention to other processes. In other words, we reduce the holistic approach of the solution. This feature of COBIT framework is discussed by Ministr and Pitner (2017) on example of information system security issues. It is important to consider processes that relate to main goal as well.

In this paper, we analyze process inputs in following way. First, business process is selected and its predecessors are identified. For these processes, we analyze their predecessors up to fourth generation (it should be noted, that those direct predecessors to selected business process are considered first generation, therefore we focus on processes present at second, third and fourth generation). While some business process may contain even more generations of predecessors, we decided to limit our analysis to fourth generation for practical reasons. In this way, we obtained process map for each selected business process (i.e. all predecessors of the selected process). We know all processes that create input for process we need to implement (see Figure 1). Thus, we have an information which processes are potentially important for currently implemented process. This approach has its limits: it is not possible to automatically evaluate importance of these processes by qualitative analysis. This must be done manually. However, quantitative analysis may yield information which processes may be considered vital. Individual evaluation based on a spevific situation is an integral part of Cobit methodology.

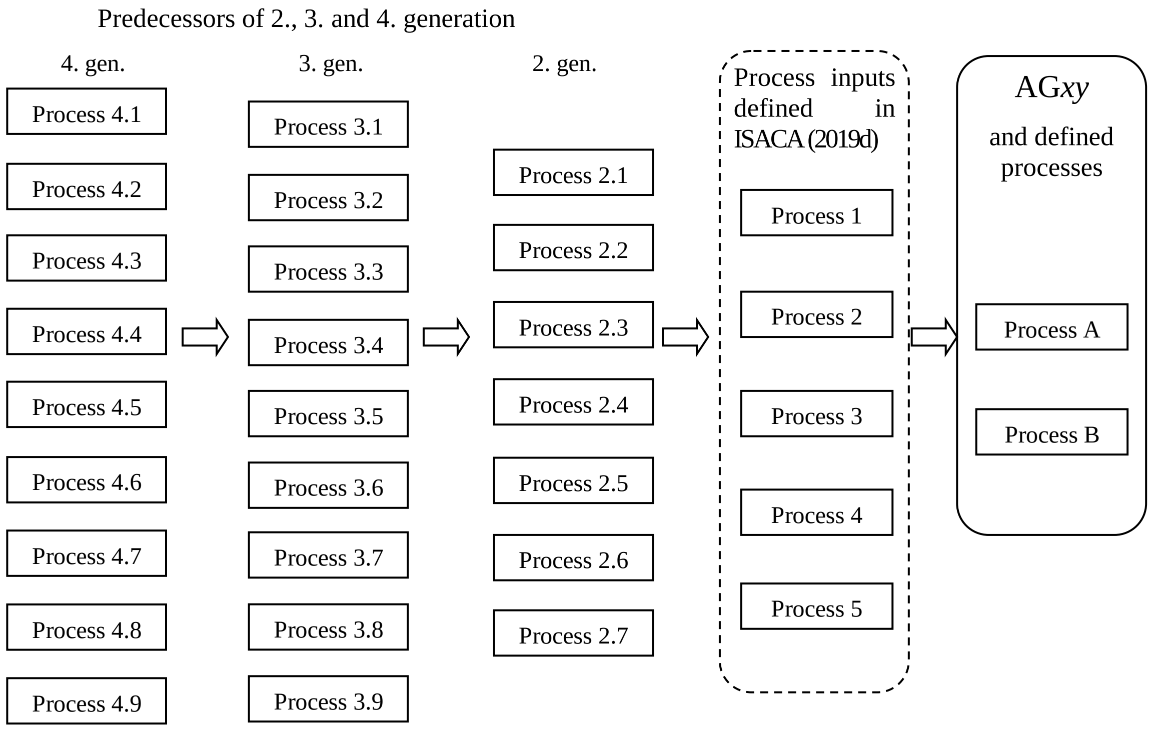

Figure 1 Cascading inputs in generations

In our approach, the importance of the process (predecessor) is given by the frequency of its occurrence among predecessors. If a predecessor is repeatedly used as an input for a set of processes in a given AG, its higher importance could be expected.

3. Research findings

Table 1 shows occurrence frequency for second generation of predecessors. The results are transformed from pivot table for second generation of predecessors. Frequencies were divided into three categories and number of processes falling into these categories was then counted, resulting in distribution shown at the bottom of Tab.1. To improve lucidity of the table, individual frequencies were colored using differing shades of gray. We may see that for each AG there is at least one process – predecessor that is used more than 9 times.

Furthermore, the results show that for the realization of any AG, respectively its group of processes inputs that are produced by other processes are required. In category of occurrences of nine or more (>9), there is always at least one process, for most AG more than one process. In the occurrence category 5 to 8 (5-8), the number of input processes increases (in average 5,7; median 6). The highest number is in occurrence category 2 to 4 (2-4) the number of inputs processes is in average

9; median 8. If only one process produces inputs, we evaluate it as an unimportant for realization. Of course, this is only quantitative interpretation. In fact, such input may be very important although it is used only once.

E.g. for process AG01 it is necessary to focus on process APO05 (outside its own set of recommended processes), as it serves as an input process nine times for processes implemented for AG01. Similarly, other (though less) relevant processes for AG01 are EDM02, EDM04, APO09, APO11, APO12 and BAI01.

From the numbers of predecessors, it is possible to see which processes are rather closed, without the need to follow other processes (with a limited number of inputs). AG05 typically.

Table 1 The predecessors of the second generation

	AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
APO01				9		6						6	3
APO02	4			1			1		10	3	4		
APO03	3	6		2					8	6	3	5	1
APO04	3	4		1	4		7		3	3	2		
APO05	9	4		8			5			16	9	18	19
APO06	2	5				2	7	2			2		4
APO07	1			3		1	1	1		4	1		
APO08	1	1					1			1	1		
APO09	5	7	2	6		2	3		7	10	4	3	4
APO10	3		3				3	3		1	3	2	5
APO11	5	10				6	10	8			4	13	9
APO12	5		7	4	3	6		8	3	4	2	2	2
APO13			3	1				1	2	2		2	3
APO14			9		3	3		2	12		10	5	3
BAI01	5	4		4	4		4			7	3	4	8
BAI02	2	4		1			14			1	2		7
BAI03	3	8					8			2	5	6	11
BAI04	2	4		1		1		2		1	1	1	1
BAI05	3	4		8			4			9	3		11
BAI06	1		2						1	1	1	1	2
BAI07	1			2	12			1		3	1	7	8
BAI08	2	2		2			2			2			
BAI09	1	6	11		1	5	6	7	8		1		
BAI10	1	3	3	1		1		2	1	1	1	1	4
BAI11	2	2		2			2	3		3	1		
DSS01	2	4	2	2		1	1		1	2	1	1	1
DSS02	6	4		2		13		9	11	6	7	10	10
DSS03	6	7		6		5		9	12	9	6	4	4
DSS04	4	3		1		7		7	6	3	3	1	1
DSS05			7	1		5		6	6	3		4	4
DSS06			1						2	1		1	1
EDM01				1		5	1			1		1	1
EDM02	7	4		2			5		9	7	5	7	
EDM03			15	3	19	4		7	7	6		4	4
EDM04	6	6		1			8			5	3		8
EDM05		5	2		2		2	3					
MEA01							2						
MEA03					6		6		6	6			
MEA04			1						2				
2 - 4	13	13	7	11	5	4	8	7	5	12	13	8	11
5 - 8	8	8	2	4	1	8	8	6	7	7	4	6	5
>9	1	1	3	1	2	1	2	2	5	4	2	3	5

Table 2 lists process occurrences frequencies for all analyzed generations (second, third, and fourth). Following the results, it can be expected that the number of predecessor processes does not increase with each further generation. While at start it may seem that the number of first and second generation predecessors is increasing, this trend does not apply to further generations. Also, tree hierarchy of the process map does not expand any further as well, indicating that the predecessors come from limited set of processes that are used for IT management purposes. In the next generations, the same processes appear to be re-used, resulting in an increase in the number of occurrences in the frequency group 9 and above (=> 9) and the decrease in the frequency group 2-4 (2-4). However, further analysis is needed for these conclusions.

Table 2 Inputs for AG for 2,3 and 4 generations

		AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
G2	2 - 4	13	13	7	11	5	4	8	7	5	12	13	8	11
	5 - 8	8	8	2	4	1	8	8	6	7	7	4	6	5
	> 9	1	1	3	1	2	1	2	2	5	4	2	3	5
G3	2 - 4	8	8	3	13	3	6	7	1	3	9	7	8	7
	5 - 8	6	4	1	6	0	2	4	2	2	4	8	4	6
	> 9	11	7	2	5	1	3	9	3	9	13	11	10	12
G4	2 - 4	2	4	3	9	0	6	3	4	2	5	3	8	4
	5 - 8	4	4	3	4	0	1	3	3	1	3	4	3	1
	> 9	21	17	1	14	1	6	15	4	13	21	22	15	20

4. Conclusion and directions for future

Although extensive documentation is available for COBIT, we have not found a suggestion or discussion about the COBIT process model that deals with the interconnection of COBIT-defined processes. It is obvious, that the implementation of COBIT approach to the organizations does not require a process model but the possibility of deeper inputs analysis would be beneficial for implementation process. COBIT defines direct predecessors and successors for each process in the form of inputs and outputs. Thus, the information about sequence of processes is limited but it exists.

In the paper, we describe the use of inputs and outputs to link processes to each other to identify the predecessors of each process.

Although we presented only quantitative approach, the results show that COBIT is a complex framework based on a holistic concept of organization. The range of inputs and outputs of each process entails the need to perceive their implementation in the context of other processes, whether they are implemented in the organization or not.

With regard to our research question, the results show that there are potentially important processes (predecessors) for each AG respectively its processes. COBIT 2019 works with so called design factors which are important in design phase to improve decision which processes should be realized to implement governance system within the organization. Inputs (or outputs) analysis of COBIT processes has a potential to be another design factor and to show links between these processes to support design phase of COBIT concept implementation.

We have presented the first results of our analysis in this paper. Nevertheless, there it is great scope for further research. The challenges for further research are as follows.

Our results only originate from quantitative analysis. Subsequent qualitative assessment would improve the perception of the real importance of inputs (processes) for practical use. It is important to note that COBIT is the best practice framework and qualitative (although subjective) assessment is a part of design phase. COBIT does not represent exactly defined methodology but rather recommendations. In this context, analysis of inputs may be further source of information about analyzed processes.

The presented analysis results are aggregated to the level of the whole process (APO02) although the inputs are described for more detailed level of so-called governance practice (APO02.01;

APO02.02 etc.). A more detailed analysis would provide more accurate information about practices (i.e. subprocesses) that are key to input generation.

Processes providing outputs to multiple processes are not included in the current model. Including the processes of predecessors that produce outputs for multiple processes would result in an increase in the number of links in the model, and it is a question of further research whether it would produce positive or negative consequences for the interpretation of the consequences and its explanatory power. The predecessors of these processes (their input processes) are the same and as a consequence, the same patterns of interconnected processes would be repeatedly implemented in the model. It is necessary to verify the effect of this group of processes exactly.

Each alignment goal defines processes that are specified as primary and secondary for a given area of interest. In our research, we did not distinguish between these more and less important processes. In other analyzes, it would be appropriate to study the effect of taking this breakdown into account.

The benefit could be visualization of the sequence of processes. It is clear from the results so far that with regard to the number of links and their complexity, it is not possible to visualize all processes beyond the entire framework at the level of governance practice (APO02.01; APO02.02; APO02.03). Even one process with all governance practices represents high amount of connections would lead to a model, which will be extremely difficult to navigate through. In such model, only a few selected groups of processes could be viewed at a time. However, limiting the display of a selected group of processes and their context could improve the concept of the framework.

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UNIVERSITIES SUPPORT OF STUDENTS ENTREPRENEURIAL ACTIVITIES

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Key Words

Start-up, business, entrepreneurial activities at universities, innovation, triple helix, innovation ecosystem

Abstract

The goal of this article is to examine the university activities supporting the innovation and entrepreneurial skills of their students. In the new innovation strategy (until 2030) of the Czech government entitled "Czech Republic, The Country for The Future" the support of science is crucial; research and innovation have an absolute priority. The authors of the article realized the analysis of the innovation centres in the Czech regions. This analysis and the results of long-term research of entrepreneurial spirit of students indicate that almost one - third of the students are very active and keen to start their business after graduation and the universities play the key role in this process.

1. Introduction

How to encourage students to be active, how to teach innovation management? All these questions are important in universities and also in companies (just instead of students the employees should be educated). When we compare innovation activities with other countries, the Czech Republic is still catching up with the development of start-ups, spin-offs and innovative ecosystems in regions. Geographically, the biggest European start-up hubs have been established in London, Berlin, Paris, Copenhagen and Lisbon (startupmonitor.eu, 2018). On the other hand, there is no European central register of start-up businesses and national registries do not consider the degree of innovativeness, the aim to grow, or the sources of financing during the business creation. This makes it difficult to find data on these specific types of businesses. In fact, all start-ups are Small Medium Enterprises (SMEs), but not all SMEs are start-ups, due to their differences in set-up and vision.

In this article, the authors would like to share their experience with encouraging the students who want to be active and want to try to do something different and innovative. Therefore the Student business club has been established in Faculty of Economics Technical University of Liberec. From 5 years' experience, we can see that still there are many students who would like to change somehow the future in their lives and to improve something in their environment or society. They are bringing more and more very interesting ideas about the new styles of life (for instance recycling of clothing, health food, saving energy, help the differences and not understanding of generations, improve the living environment, saving energy of some products or manufacturing etc.). We have some success stories about the realization of their dreams (see http://sbc-tul.cz).

Czech government published a new innovation strategy for future (2019–2030) based on nine ambitious goals consistent with the international requirements of a number of innovative Scoreboards (http://mpo.cz):

- Funding and Evaluation of R&D
- Polytechnic Education
- National Start-up and Spin-off Environment
- Digital State, Manufacturing and Services
- Innovation and Research Centres
- Smart Investment
- Intellectual Property Protection
- Mobility and Construction Environment
- Smart Marketing

2. Literature review

The universities play a very important role for innovations as knowledge - producing and dissemination in society. Another key factor is the government responsible for taxes politics and business climate; the third part of the innovation process belongs to the companies. These three institutional spheres public, private and academic are described as Triple Helix System. The concept of the Triple Helix of University-Industry-Government relationships was developed in the 1990s by Etzkowitz (1993) and Etzkowitz and Leydesdorff (1995). The role of the universities is inevitable – the students bring their ideas, fantasy and new "wind" in stereotypes, the companies have a role as experience part, funds and resources; the government brings a synergy of these three parts. From the perspective of systems theory, we can see this model as a set of Carlsson and Stankiewicz, 1991; Carlsson et al. 2002; Edquist 2005; Bergek et al. 2005:

- Components: the institutional spheres of University, Industry and Government, each encompassing a wide-ranging set of actors;
- Relationships between components: collaboration and conflict moderation, collaborative leadership, substitution and networking;
- Functions: described as a set of activities specific to the "Triple Helix Spaces": the Knowledge, Innovation and Consensus Spaces.

European Community is supporting innovation activities of their countries building of efficient relationships between academic institutions and the business sector through RIS3 (Strategy for Smart Specialization). Smart Specialization Strategy and their effective target fund (in all levels European, national, regional, and private) support activities that lead to strengthening the research and innovation capacity in promising areas. These areas have been singled out as priorities in order to fully utilize the knowledge potential to promote the reduction of unemployment and strengthen the competitiveness of the economy.

For their implementation, the status of the innovation ecosystem in the regions is important. The term ecosystem is used in the area of the environment, where it is defined in the Czech Republic Act no. 114/1992 Coll. on nature and landscape protection (see Ministry of Industry and Trade, MPO.cz, 2019): "Ecosystem is a functional system of living and inanimate components of the environment that are interconnected by substance exchange, energy flow, and information transfer, and interact and develop in space and time”. The concept began to be used also in the context of knowledge ecosystem, which, like the natural ecosystem individual organisms disappear and arise, or are replaced, as well as knowledge evolves and is replaced, the example is Silicon Valley (Bahrami, 2005). The innovative ecosystem introduced by Pitra in 2006 (2006, 2007) is perceived as a business model that enables the risk of the innovation process to be spread (i.e. the successful commercialization of innovative internal and external stimuli). As Pitra points out, it will allow spreading the innovation risks to an acceptable level among the various components of the business ecosystem, among potential investors, supporting researchers to implement science or similar research results. Furthermore, the innovation ecosystem integrates the unique skills, knowledge, competencies and raises the level and value of the intellectual capital of the entire ecosystem. What can be defined below a given term, e.g., South Moravian Innovation Centre (Czech acronym JIC, 2018). It presents an innovative ecosystem such as: “We are South Moravian innovation ecosystem, i.e. modern public administration, universities, research centres, technology firms, creative residents and many other active subjects, and we need to attract international talented students, technology workers to the region scientists and investors.".

3. Data and methodology

In order to fulfil the objective of the article, the monitoring and evaluation of the innovation ecosystem was carried out with a focus on the support of business activities of institutions implementing R&D in selected regions of the Czech Republic. The analysis focused on cities that are centres for a given region in terms of civic amenities, the existence of major employers, cities providing not only secondary but also higher education, i.e. cities that fulfil the basic parameters of the innovation ecosystem. Another selection factor was whether the university in the city was interested in participating in a global research project on student entrepreneurship (acronym GUESSS) in 2016 and/or at the end of 2018.

The authors of this article became members of the research team mapping the students’ entrepreneurial intentions and activities (acronym of this survey is GUESSS), including the topic of family firms, from 2016. The survey is organised by the University of St. Gallen and the University of Bern (both from Switzerland) since 2003. Table 1 brings the list of the universities involved in the GUESSS survey for the Czech Republic.

Table 1 Czech universities involved in the GUESSS survey

GUEUSSS Czech Universities (2016)	GUEUSSS Czech Universities (2018)
Charles University (Prague)	Technical University of Liberec
Masaryk University Brno	Technical University of Ostrava
Silesian University in Opava	Tomas Bata University in Zlin
Skoda Auto University	University of Economics in Prague
Technical University of Liberec	University of Hradec Kralove
Technical University of Ostrava	University of West Bohemia (Plzen)
University of Economics in Prague	Silesian University in Opava
University of Hradec Kralove	Masaryk University Brno
University of Pardubice	
University of West Bohemia (Plzen)	

3.1. Innovation centres in selected regions of the Czech Republic

Next table (table 2) displays a short list of different approaches towards the innovation centres in the Czech Republic from Triple Helix point of view (mentioned above). In some cases, the organiser of these activities is a statutory town or the district where universities are established or in some cases, the centres are parts of universities.

Table 2 Characteristics of innovation centres in selected regions

University Towns in CR	**Selected university**	**Role of government (organiser)**	**Short information**
Brno	- Masaryk University (MUNI) - Brno University of Technology - Mendl university in Brno - University of veterinary and Pharmaceutical Science in Brno	JIC – network of 4 universities, the city of Brno and South Moravia County	One of the most successful (since 2001) centre in the South Moravia County, this model is inspiration of other districts (www.jic.cz).
Hradec Kralove	University Hradec Kralove	City of Hradec Kralove established the Technologic Centre in 2006	Very strong cooperation between the University Hospital Hradec Kralove and Faculty of Military Health Sciences, has Centre for Transfer of Biomedical Technologies, founded in 2012.
Karvina and Opava	Silesian University in Opava	City of Karvina and university: Coworking centrum Business Gate	The students have possibility to work on real company's tasks (through Program Academy), so the companies will get wholly different point of view, a number of impulses and ideas.
Olomouc	Palacký university Olomouc	Science and Technology Park of the Palacky University is part of the university	University founded this park with help of the European union project and Ministry of Industry and Trade.
Ostrava	Technical University of Ostrava	Moravian-Silesian Innovation Centre was founded by and Technical University of Ostrava and city of Ostrava	Moravian-Silesian Innovation Centre Ostrava began its activity in 2017 by transforming the Scientific and Technological Park Ostrava.
Pardubice	University Pardubice	P-PINK started by the cooperation of city of Pardubice university and Pardubice district (in 2018).	Since 2017 the cooperation between Regional Development agency and university help to P-Pink.
Plzen	West Bohemian University	Pilsen's Science and Technology Park was initiated by the City of Pilsen and West Bohemian University.	Centre of Business is part of the Faculty of Economic.

Prague	- Charles University - University of Economics, Prague - CVUT	- Centre for Knowledge and Technology Transfer (the Centre is part of the university) - X-port is a part of the university - InovaJET since 2016	- The Centre is "the third role" of Charles University; - X-port is also part of some teaching activities in university; - InovaJet is part of the university. In Prague: Each university has own system supporting transfer of knowledge.
Zlin	Tomas Bata University of Zlin	Faculty of Multimedia Communication established UPPER	UPPER is start – up incubator.
Liberec	Technical University of Liberec (acronym TUL)	Lipo.Ink (cooperation of Liberec County and Technical University) has started 2017 SBC TUL until 2014	LipoInk is start – up incubator; SBC – Student business Club TUL.

Prague was not included in the next evaluation of the regions. In assessing the region's approach to supporting and initiating innovation activities, it is, in terms of content, the following:

- Activities linked to technology and knowledge transfer. There is more often initiation by the university, often linked to the career centre of the university (Ostrava, Zlin, Olomouc,etc.). Mostly, activities are also offered outside the university, for example towards high schools. The actual incubation of companies is either part of, or it is subsequently left (in collaboration) on an incubator or science and technology park in the city. In this context, the ensuing efforts to establish university-wide business education across the university are evident.
- Activities primarily linked to encouraging entrepreneurship towards innovation (science parks, incubators). The university is part of the system as a partner. More often, the regional authority, the city administration, or jointly (Karvina, Pardubice, Plzen, etc.) are the initiators of activities.
- An example of a comprehensive concept of the innovation ecosystem in the Czech Republic is the South Moravian Region with its centre in Brno. When the JIC Brno was established, the concept was first created and then it was fulfilled. Furthermore, it is possible to say that the Zlin and Ostrava regions are trying to achieve a comprehensive concept. Here is the "what works" effort to build an innovation ecosystem framework.

3.2. A survey of interest in entrepreneurship of the Czech university students

Focus on entrepreneurship in universities deals with Global University Entrepreneurial Spirit Student' (Survey GUESSS acronym). As mentioned, the Czech Republic joined the GUESSS survey in 2016, the survey takes place in two-year cycles (see guessssurvey.org). The survey deals with career choice intentions; about the university environment in relation to entrepreneurial activities, skills of students, their family background, society, their own business, about start-up, about parents´ business.

The survey (2018) in the Czech Republic had 1255 respondents from eight universities. The list of Czech institutions with a significant number of completed questionnaires is in figure 1. Here we can see the proportion of the students who gave a positive answer to the question: “Are you currently trying to start your own business/to become self-employed?" The questionnaire in 2018 had ten sections (together 15 pages), about the university environment, motivations and goals of students' entrepreneurship and their lives, the society where the students live and parents' businesses. The same questionnaire was distributed in 54 countries and 208 636 respondents took part in the survey. Next figure (number 2) represents selected question in relation to the article of the topic if the students would like to start their own business. The same question was in the year 2016 where the participation in the project was accepted by the 50 countries, more than 1000 universities, and 122 509 students who completed responses (see figure 3). When we compare these two questions and the results, we can see little progress.

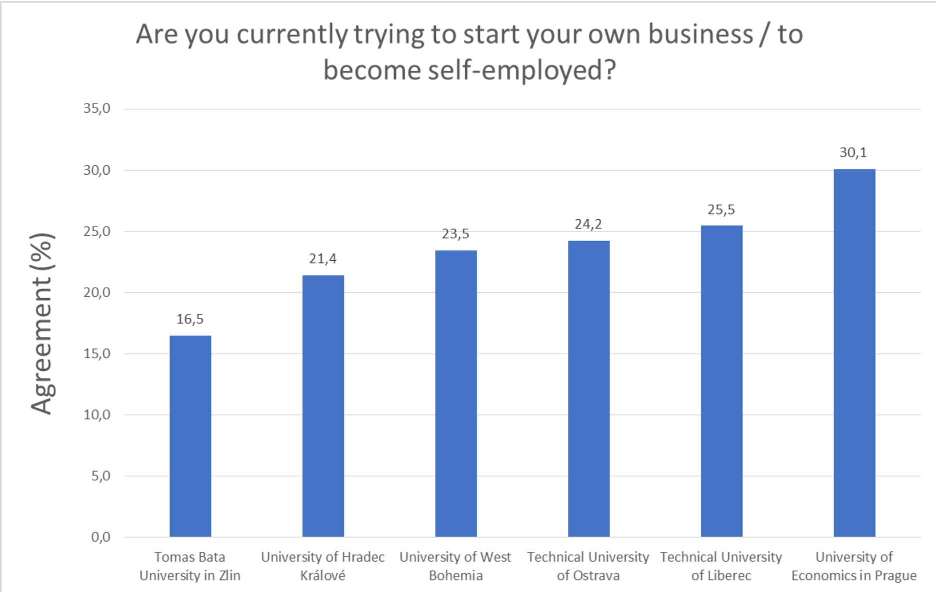

Figure 1 – Czech students from survey 2018

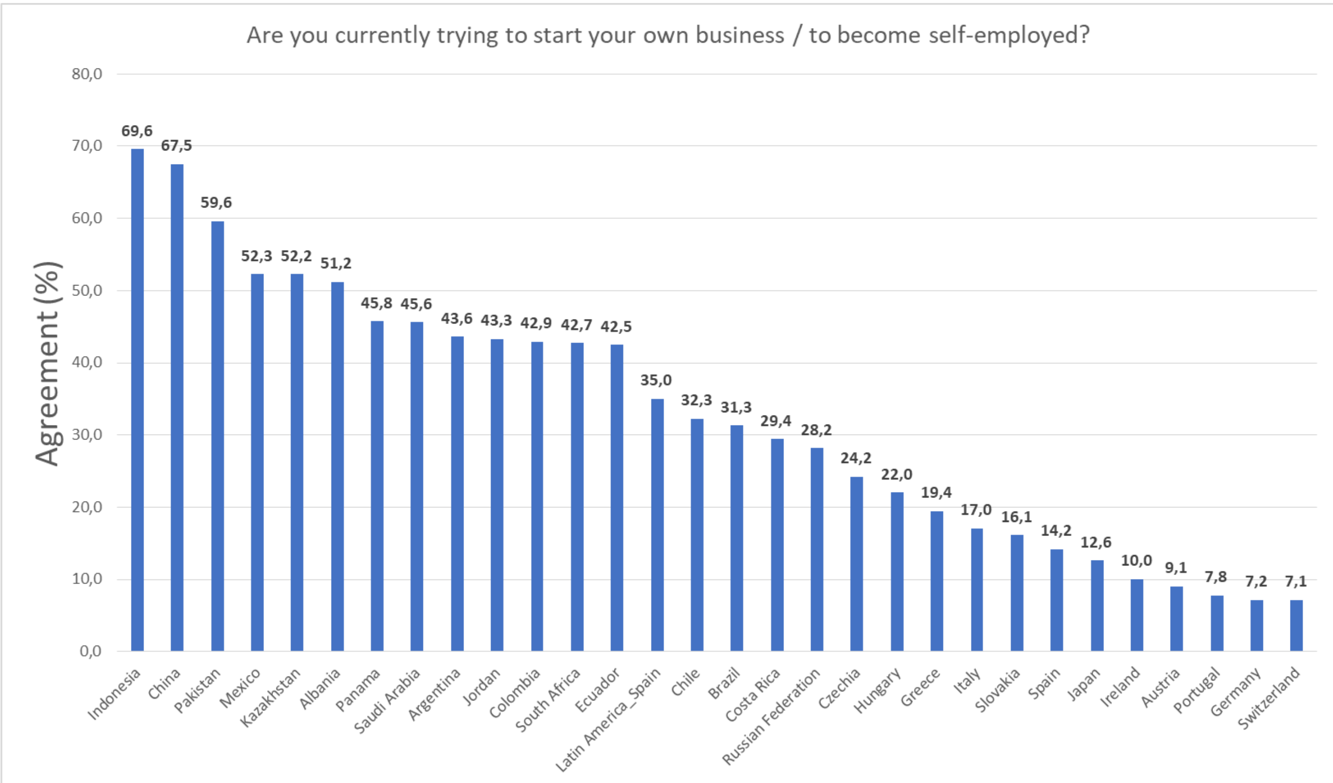

Figure 2 Results from the survey 2018

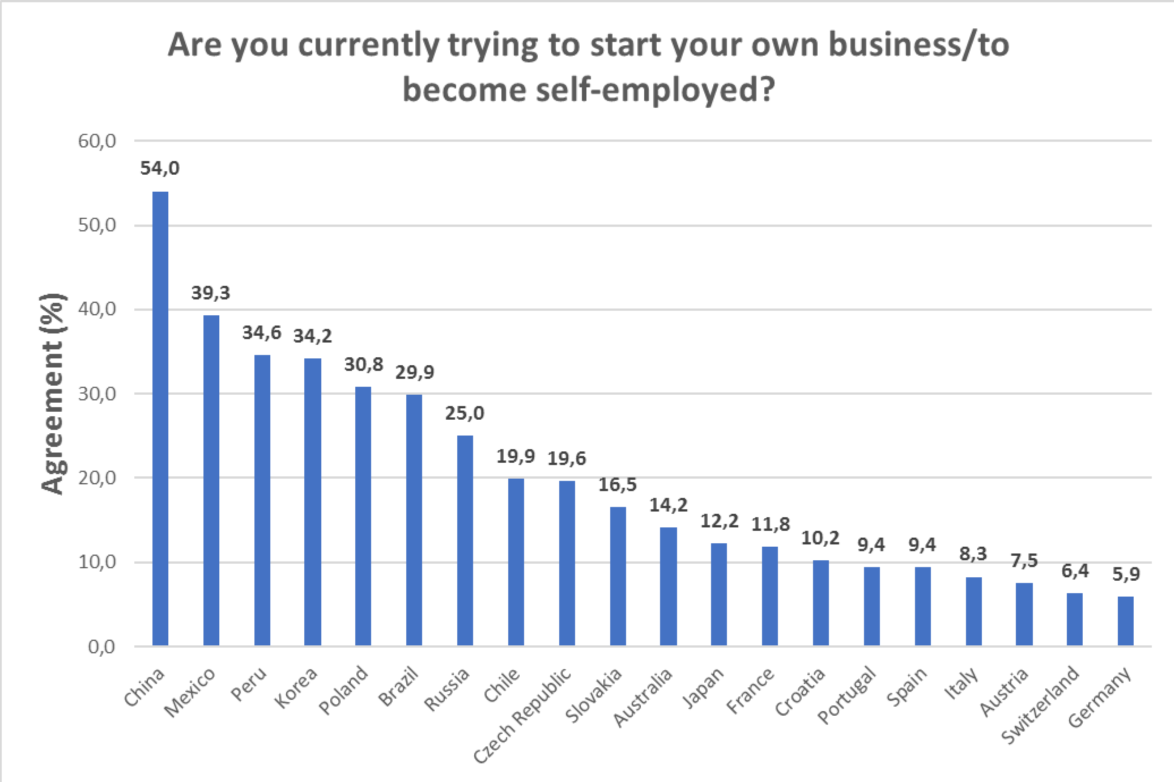

Figure 3 Results from survey 2016

A summary report of the research survey carried out from September to December 2018 will be published on the web portal GUESSS in autumn 2019.

4. Discussion and conclusion

The student's spirit to start their own business is slightly growing in all countries involved in the survey from last year. When we look at the situation in the Czech Republic, we can see that especially in Prague, where start-up activities are concentrated because of many entrepreneurial hubs, it is very similar to other countries. Therefore the universities should support and seek alliances with other organizations. Various industrial companies and government entities must help to create new opportunities and an innovative ecosystem for students. Students should understand that the university's network is also their network. By encouraging students to experience and collaborate inside and outside of academia during their university experience, it will help them to develop confidence and improve the future.

For each of the regional centres, authors prepared to summarize information and the specified link to the university in the city (in the form of direct quotations from that source). The analysis was carried out in terms of the role of universities in a given environment, interest/attitude of self-government (municipality, region), the existence of science and technology parks, incubators, etc. Also, the state of the entrepreneurship education at selected universities (GUESSS 2016, 2018) was examined. In future, the authors would like to deep analyze the results from their long-term survey and to find there some other dependencies in family background, living environment etc.

5. Acknowledgement:

This study was supported by Technology Agency of the Czech Republic, in the framework of the project “Family business – solutions to social and economic disparities of municipalities”; reg. number TD03000035 and institutional support Faculty of Economics, Technical University of Liberec, Students ´Attitude to Entrepreneurship.

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DIGITAL TRANSFORMATION IN CRISIS MANAGEMENT

THE PROCESS OF DIGITALIZATION IN EMERGENCY AND DISASTER MANAGEMENT: OVERVIEW ON DEVELOPMENT, INTEGRATION, RESEARCH GAPS, AND PERSPECTIVES.

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Keywords

Digitalization, information management, crisis management, disaster management, integration of data sources, measurement categories, implementation of new data, data management

Abstract

Emergency and disaster management is a highly complex and above all a highly critical field regarding data and information management. The retrieval, preparation, processing and digestion, and above all regarding the condensation, visualization and sharing of data and information are of vital importance but do not fully take advantage of the benefits of the developments in digitalization. Besides the issues of a sensible selection of the relevant data formats, the question of the integration of digital data and the transformation into potentially pre-selected information and lastly towards situational awareness is key for timely, efficient, and effective interventions.

This paper will show an overview of the development of the process of digitalization of data and information use. Basing on selected examples, potential solutions and tool implementations will be shown and the specifics and challenges of the integration and processing of relevant data and information leading to innovative perspectives of efficient disaster management in the future will be outlined.

1. Introduction

While in the face of growing complexity and globalization of incidents and their effects, the “past and future objectives remain the same in crises, providing relevant communities collaborative knowledge systems to exchange information" (Turoff 2002[23], 29). Thus, the relevance and sensibility of using digital data and information transfer and integration between involved management agencies becomes obvious to tackle increasing scales and interconnectedness of emergencies and disaster. However, despite the fact of the widespread digitalization in everyday life, disaster management is still in wide parts working with insulated solutions of data gathering, implementation and information processing. Moreover, on a broad range, the financial and organizational means for the integration of digital tools and integrated information management are still rudimentary or at least insulated singularities (see Hristidis et al. 2010). Traditional, reliable but highly limited "pen and paper"-solutions are still the overall common practice (Schwarz 2016).

Relief organizations depending on the reliability and stability of data are trying to integrate additional sets and sources of novel data and work on interoperability issues influencing data and information exchange to facilitate a better and more efficient intervention practice. However, until now, current digital solutions already state of the art in economy (Cavanillas et al. 2016) are due to several factors not incepted in disaster management. Projects and most times small scale case studies currently try to tackle the challenges that were identified in research in the past decades on the process of data integration, processing and information gathering.

2. From Data towards Information: Digitalization in the context of integrated crisis and disaster management – definition, parameter, and boundaries

A concise, common operational picture basing on reliable, timely, and dynamic data without unnecessary information is a key factor for efficient and effective emergency and disaster management (Horita et al. 2016). While selected, traditional data seems to be available en masse in specific regions of the high-tech world via bots, online data bases (see also De Albuquerque et al 2015), and other open data sources (Fertier et al. 2016), the integration of this multitude of data and of the emerging, relevant information is crucial but questionable for the broad practice. Hristidis et al. (2010) have nearly a decade ago already discussed the optimum data flow in emergency and disaster management and outlined potential solutions and tools set up in case study:

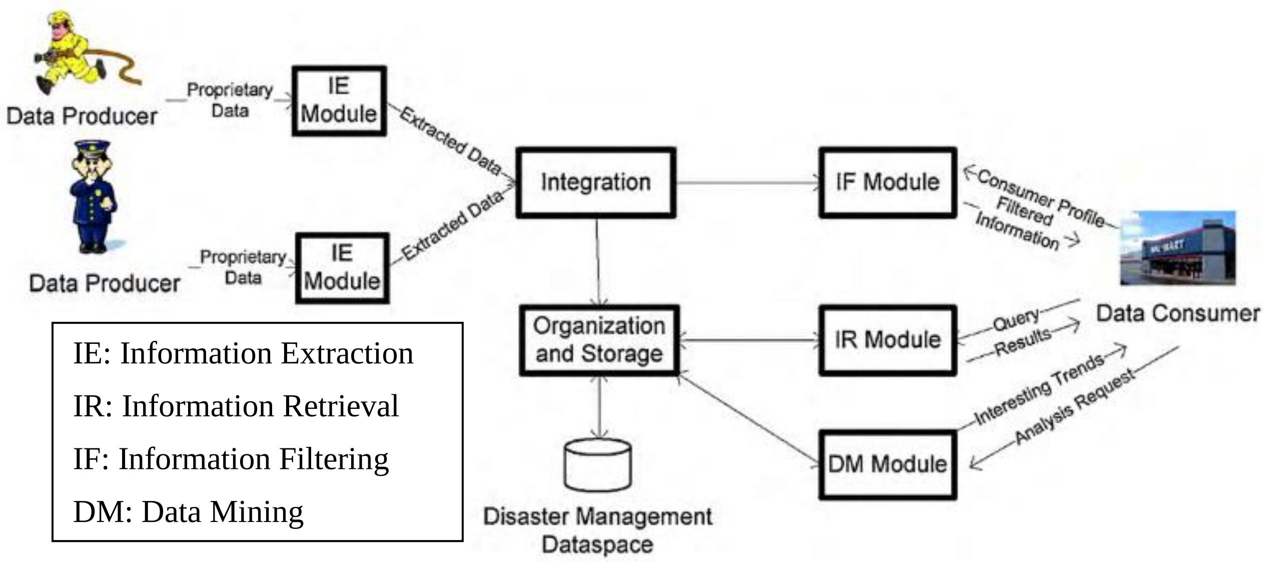

Figure 1: Optimum data stream model in disaster management (modified Hristidis 2010)

[23] Turoffs diagnosis dating nearly 20 years ago is still valid, his projection of a thorough integration of digitalized data and information for the creation of a holistic situation awareness of emergency or disaster situations was too optimistic.

To understand the challenges and also the reasons for the still existing gap between the requirements for pertinent information, the difference between data and information has to be clarified in this specific context. Useful data can or could be retrieved under certain circumstances and prerequisites via multiple channels (see Rainer et al. 2015) and with different properties – to be shown by different examples in a following section of this paper. While in current research "big data" and open source intelligence is a popular and widely discussed area, the integration of spatiotemporal data like GPS, participatory information via social media or the data collection via small satellites and UAVs, commonly known as drones, or wireless sensor data is promising but not widely spread. Specific challenges regarding the technologic feasibility and reliability of (big) data collection are key factors for this gap between existing data and its potential and their everyday application. Additionally, the analysis of this data mass and their stability as well as their selection and the integration of derived information are still core challenges for the use in emergency and disaster management (Yu et al. 2018).

Thus, applicable and innovate information according to Ciriello et al. (2018) has to be extracted and processed on basis of this underlying raw material. According to the model of evolving complexity and at the same time growing usefulness of the retrieved and transformed data, knowledge and understanding as well as the application and decision support are generated in the best case for the use of a frictionless and efficient emergency management (see Figure 2).

From initially small scale expert assessment including face to face meetings and analyses to broader, Delphi Method application and the installation of first computerized data processing in the 1970s, emergency and disaster planning basically was driven by role definitions and action templates (Turoff 2002, 30). The requirement to match arising intervention needs with given or accessible resources has not changed over the last decades while the scale and complexity of emergencies visibly grew, as Okuyama et al. (2009) show. In the last 20 years alone, as CRED, the Centre for Research on the Epidemiology of Disasters, in cooperation with UNISDR, the United Nations Office for Disaster Risk Reduction, jointly published (2017), a culmination of high impact disasters regarding economic losses and fatalities was evident.

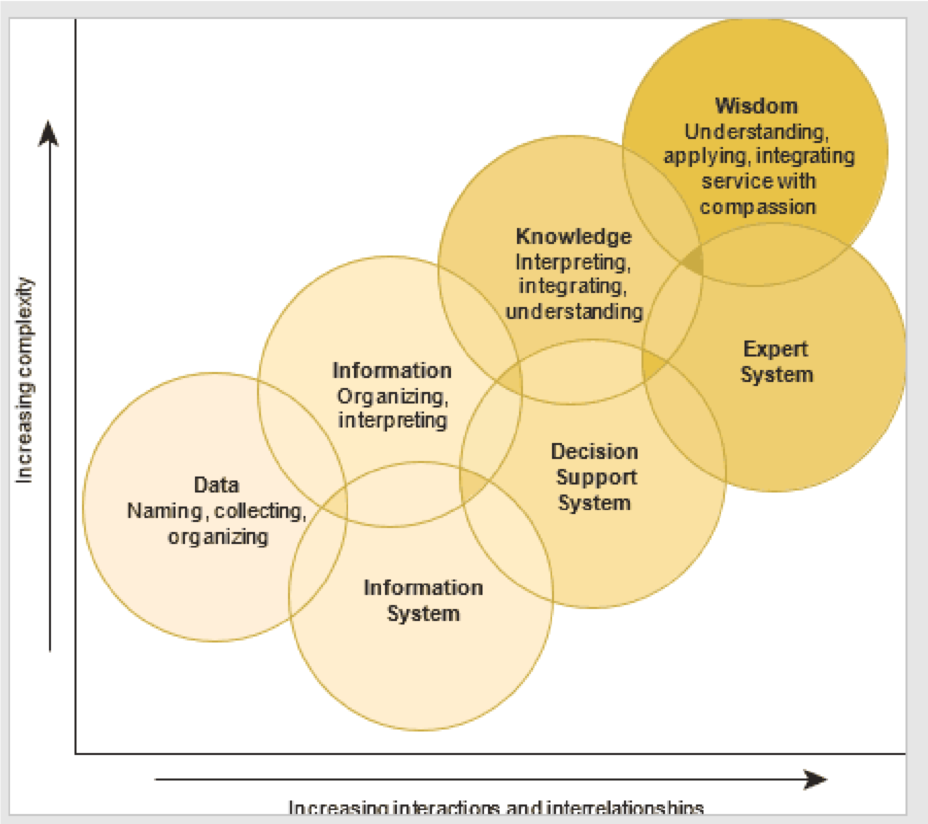

Figure 2: Relationship of Data, Information, Knowledge, and Wisdom and Automated Systems: version 2. (Nelson 2018)

Also, the overall quantity of disasters rose together with other factors like damage costs (see Figure 3), internally displaced persons, and socio-economic effects, whereas the annual death rate/deaths from natural disasters decreased in the past century (EMDAT 2017). Even if the methodology of EMDAT and the background of the data collection is highly complex and should not be used unquestioned and only with great delicacy, the graphics below show an impressive tendency of the development of the last five decades:

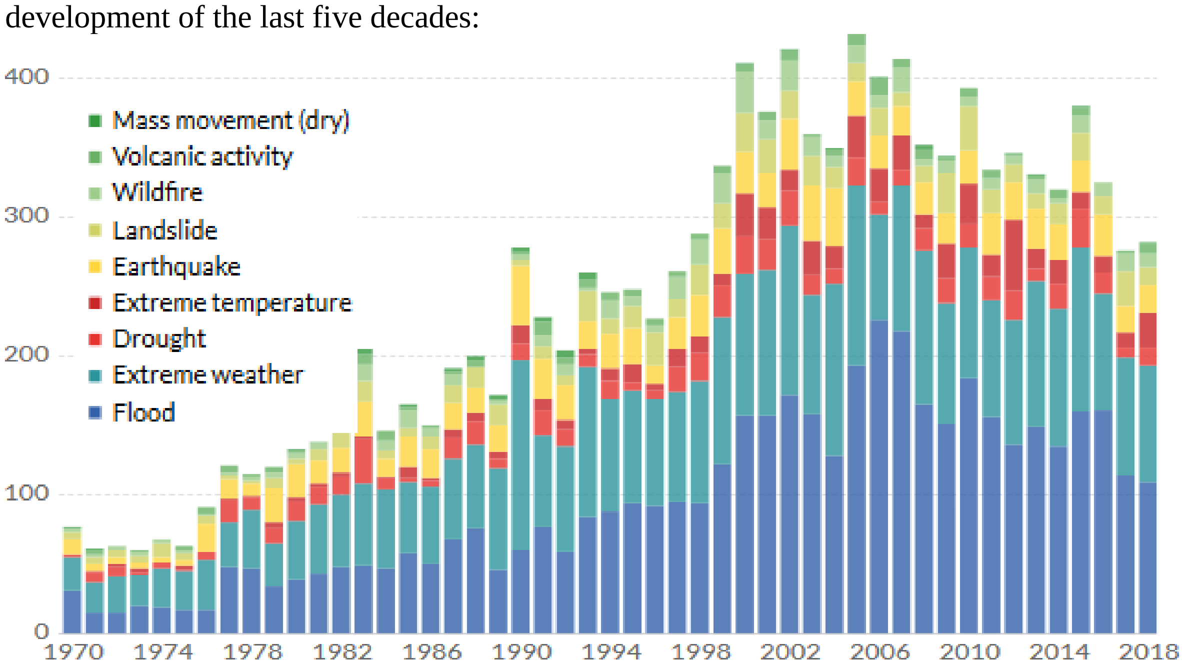

Figure 3: Global reported natural disaster by type from 1970-2018 (adaptation of EMDAT 2017)

On the other hand, the possibility of assessing the most pressing needs of tackling this growing number of large-scale, complex events via a holistic operational picture became possible due to digital data availability. The potential of access to supportive background data and resulting information has explosively developed due to the expansion of digitalization, the spread of the internet and Web 2.0 and 3.0 applications (Schulz et al. 2012).

However, a relevant understanding of the underlying basis for the creation of such an intentionally focused overview is not available or in broad scale implemented in national emergency management organizations. Regarding the relevant parameters of emergency situations and the intended interventions, only insulated and organization specific use of data/information is common practice (Rainer et al. 2016). This gap between available data and the processed and used information or even guidance in the form of (semi-/automatic) decision support is still evident and a big challenge for the evolving demands of our current globalized and complex environment.

3. From Information towards Situation Awareness: Integration of exemplary digitalization approaches in specific projects and organizations

3.1. Procedural tools for digitalization in crisis management

A challenging example in the area of crisis management are large-scale forest fires. In general, dramatic increases of forest fires in Europe as well as worldwide in can be observed. Therefore, technical developments to support large-scale forest firefighting strategies and management solutions are an international issue in the quest to protect human lives and resources as well as to reduce the negative environmental impact. The EU has initiated international cooperation and initiatives to provide interoperable systems and information in order to support prevention and fire-fighting efforts. For example, the European Forest Fire Information System (EFFIS http://forest.jrc.ec.europa.eu/effis/) has become a central reference system for the relevant national fire services (Almer et al. 2017).

Technologies which can be used to realize an efficient support in forest fire management strategies have to be distinguished in general according to time critical and non-time critical tasks. The type data source will be differentiated as satellite and airborne (planes, helicopters, UAVs) based as well as terrestrial sources. In order to support the event phase of a forest fire situation, a real-time data acquisition and a near real-time generation of a common operational picture is an essential prerequisite.

Figure 4 gives an overview of the operation layers and different types of resources that are involved in recent forest firefighting situations. In this concept, the third level represents the airborne surveillance level operating in 800-1000m above ground level (AGL), which acquires optical and thermal images on demand to enable an efficient support of the management processes based on a near real-time common operational picture which allows an optimal control of ground and airborne firefighting operations. For an efficient support of time critical tasks and decision processes an innovative concept was created, from data acquisition to role-oriented information distribution (see Figure 5).

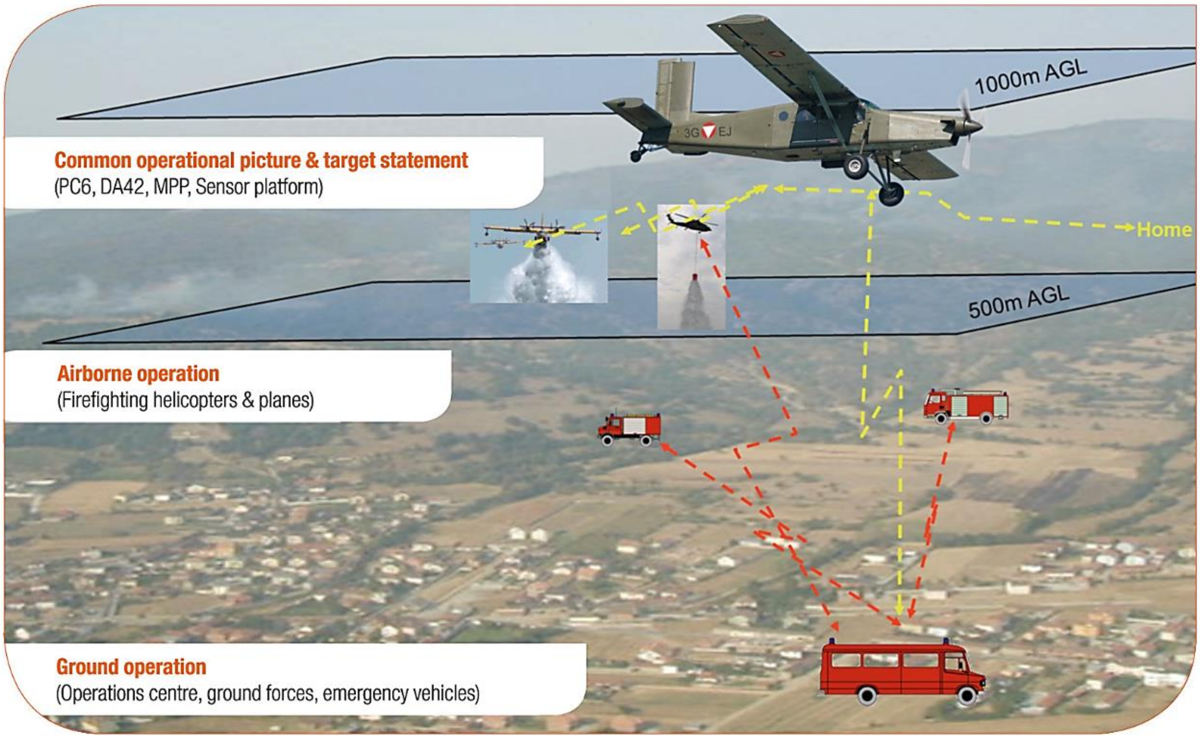

Figure 4: Multi-level-management concept from data acquisition, real-time data communication, data processing and information distribution in forest fire situations (graphic: JOANNEUM RESEARCH)

Figure 5: General concept of data acquisition, line of sight (LoS) real-time data communication, data processing and information distribution to support time critical decision processes in forest fire situations (graphic: JOANNEUM RESEARCH)

3.2. Technological and systemic integration of IT tools and methods of crisis and disaster management organizations

A consequence of digitalization in crisis and disaster management in the recent years was the introduction of IT tools supporting practitioners and other stakeholders in executing their processes. Such tools are used to assist in very different ways, encompassing main functionalities such as information exchange, resource management, modelling as well as acquisition and management of sensor data. A major challenge arises due to the need of cooperation between different stakeholders. In particular, in the response phase of the management of a crisis, but also in other phases of the crisis management cycle fast and reliable exchange of information is key for successful management of a specific event.

In this light not only optimized crisis management tools, but also optimized platforms allowing cooperation between them became imperative assets. There are several models describing the different layers of interoperability, two examples are given in Figure 6.

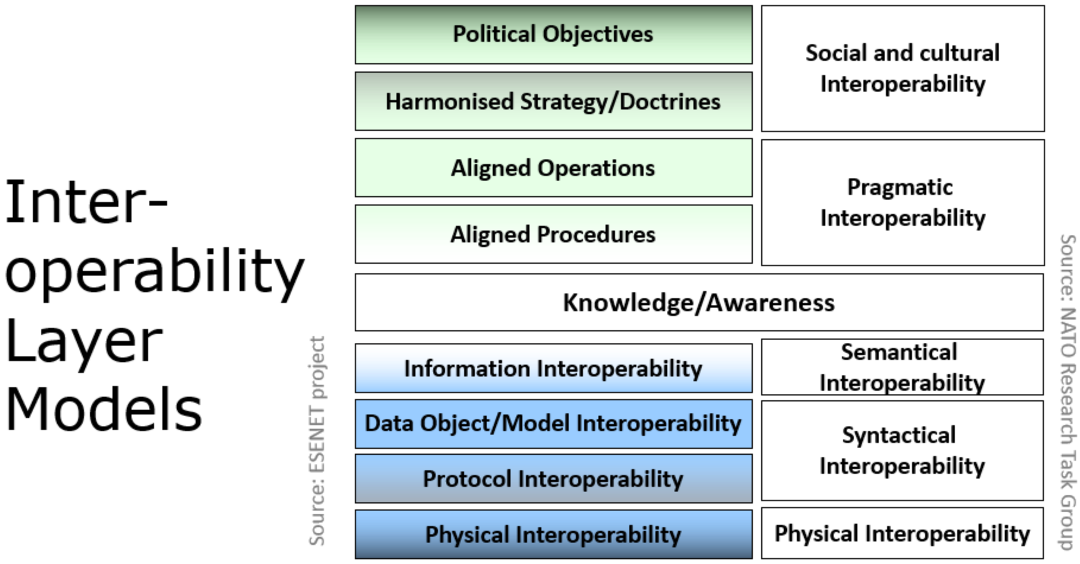

Figure 6: Layers of Interoperability according to the ESENET project (left side) and the NATO Research Task Group (right side)

Multiple approaches exist describing the meaning of different levels of interoperability, e.g. Neiva et al 2016. Here we give a pragmatic description based on the model of the NATO research task group (see also EPISECC Deliverable 2.1, 2014).

- Physical interoperability: This level focusses on physical communication infrastructure used to exchange data with the tool examined. Basically, the communication infrastructure can be categorized as public (e.g. GSM, UMTS, public IP-networks, etc.), dedicated (e.g. TETRA, TETRA-POL, dedicated IP-networks, etc.), or both.
- Syntactical interoperability: This level deals with exchange of data allowing automatic processing by another tool. This can be realized by data exchange standards such as EDXL (Emergency Data Exchange Language), CAP (Common Alerting Protocol), EDXL-SITREP (Emergency Data Exchange Language Situational Reporting), OGC (Open Geospatial Consortium) standards for geo-data (KML (Keyhole Markup Language), WMS (Web Map Service), WFS (Web Feature Service) etc.) and OGC standards for sensor data (SWE (Sensor Web Enablement)).
- Semantical interoperability: Interoperability on this level means that identical interpretation of information exchanged between tools is made possible. This includes the outcomes of the CEN workshop agreement summarized in 2018 (CEN 2018).
- Pragmatic interoperability: Interoperability on this level means that exchanged information is interpreted identically and common actions can be deduced. Systems on this level realize a shared situational awareness.
- Social/cultural interoperability: This level of interoperability deals with social and cultural aspects and assures coherent cooperation of all participating actors.

Social and cultural interoperability (reflecting also political co-operations) is a pre-requirement to make cooperation on a technical level meaningful possible. It may be established on a legal, contractual basis describing the strategic will of cooperation between organizations as well as regions or states. Such an agreement is imperative to ensure cooperation. Pragmatic interoperability is reached when cooperating entities are aware of the processes and procedures that are applied by the other entities. Moreover, a minimum level of adaptation of the processes and methods might be necessary to reach interoperability.

4. Opportunities, limitations, and perspectives of expanding digitalization

Holistic data management including the implementation of novel data sources and sets as well as their proper processing with up-to-date digital means are highly relevant in regard to the mitigation of emergency and disaster effects on all levels of their impact on society (see Soden 2017). The paper outlined the historical development of data/information gathering and processing, the current standing practice in disaster management organizations. Additionally, innovative interoperability models and data gathering, integration, and processing approaches facilitated by research projects and prototypes were shown. This contrast illustrates the gap between the still established tradition and digital tools and solutions that allow and encourage interoperability and exchange of data, information, and knowledge for a more efficient and resource-sensitive emergency management in all phases of the disaster management cycle.

Digital data and the derived information has to be of high quality and reliability for a highly complex and dynamic area as emergency handling – above all under the pressure of minimizing fatalities and economic loss in a short range of time and with only limited resources available. The implementation of new data sources and the request for interoperability and digital data/information sharing between disaster management organizations presents big benefits regarding efficiency and at the same time a high range of hurdles. Besides the technological questions of data retrieval and management, security, quality and stability, economic barriers, but also human and ethical factors like legal aspects and organizational reservations have to be considered.

Thus, the sheer availability of digital data for emergency management alone has to be considered as only one link in a potentially strong chain leading via data procession, information extraction and filtering towards decision support systems, interoperability and exchange and finally towards a timely, cutting-edge, and holistic implementation of digitalization benefits for disaster management. To provide a stable and at the same time agile management of processes in disaster management, it will be necessary to include further sources of data as well as underlying models and benefits of the digitalization age. An unrestricted view on possibilities created by semi-automated tools as well as new models of interoperability is necessary under the prerequisite of affordable and per se resilient and robust solutions to keep disaster management working under evolving challenges of a globalized world and complex incidents.

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MULTI-LEVEL INFORMATION STRATEGY TO SUPPORT DISASTER MANAGEMENT PROCESSES

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Keywords

Forest fire/wildfire management; airborne operations; multi sensor imaging; near real-time processing; impact assessment; early fire detection; post-fire monitoring; information management concept; integration of data sources; management strategies

Abstract

Dramatic increases in forest fires in Europe as well as worldwide can be observed. Therefore, technical developments to support large scale forest firefighting strategies and management solutions are an international issue in the quest to protect human lives and resources as well as to reduce the negative environmental impact. This article describes an airborne based concept to enable an efficient management of airborne operation forces as well as ground forces in frame of a forest fire / wildfire event situation. The concept is based on a multi sensor airborne platform and includes the development of a multi-level information management system. The aim is to support tasks and time-critical decision processes in disaster situations by near real-time processing chains and end user oriented management solutions. Further, a simulation based decision support and impact evaluation module is developed in frame of the national funded research project 3F-MS.

1. Introduction

Nowadays, dramatic increases in forest fires can be observed worldwide, even in countries in northern and central Europe where large forest fires have hardly occurred in the past (e.g. Sweden 2014 and 2018; see URL1). In order to improve the protection of human lives and resources it is mandatory to support large scale forest firefighting strategies and management solutions with innovative technical developments. The EU has initiated international co-operations and initiatives to provide interoperable systems and information in order to support prevention and firefighting efforts to protect human lives and resources and to reduce the negative environmental impact of these fires to a minimum. For this reason the Joint Research Centre works closely with European countries and other relevant EC services to monitor forest fires through the European Forest Fire Information System (EFFIS; see URL2).

An important complement to the existing EU-wide initiatives is the development of an optimized technical solution for various phases of a forest fire management concept leading into an immediate support of fire brigades and other involved organizations. In this context, a major national initiative is the KIRAS project "3F-MS" (URL3) which focuses on an optimized assistance in time critical tasks during a forest fire. The key issues to support time critical tasks comprise firstly the realization of a demand driven data acquisition procedure, secondly a near real-time processing and analyses environment as well as an end user oriented data and resource management application. To guarantee an efficient deployment and management of firefighting teams, it is a prerequisite to deliver a common operational picture (COP) and to enable a powerful scenario-related management solution very quickly. These proposed solutions will ensure that resources, such as mobile firefighting and rescue teams, vehicles/equipment on the ground as well as planes and helicopters, can be deployed efficiently based on a solid and reliable data base (Almer et al., 2017).

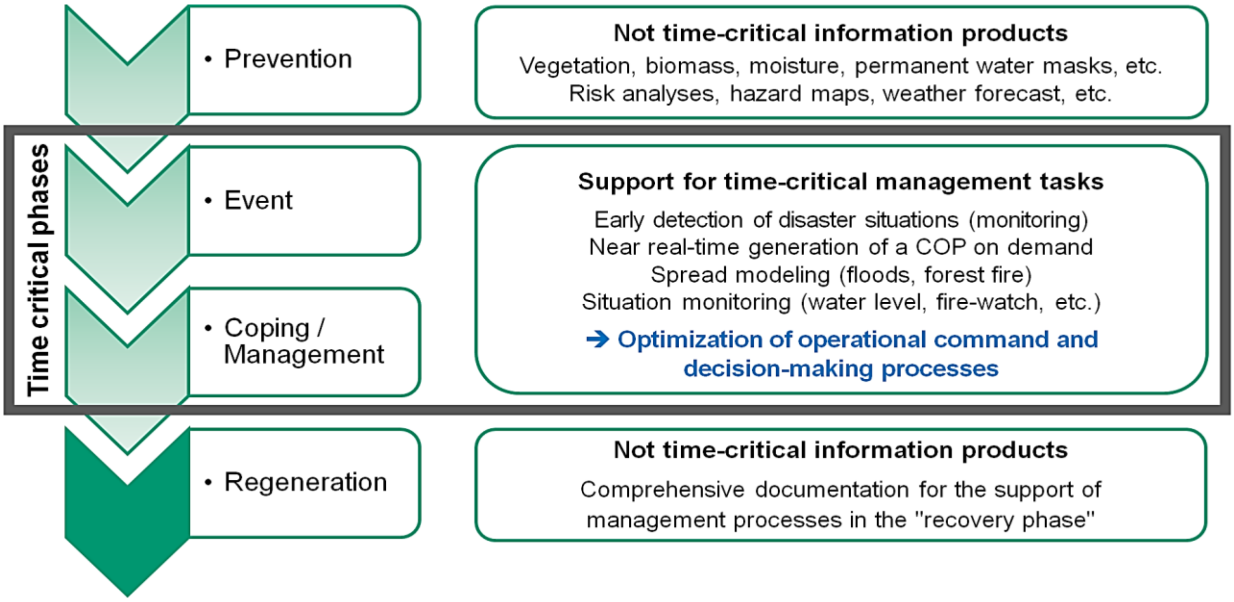

Figure 1: Overview of forest fire/wildfire disaster management phases and time-critical processes

2. General multi-level management strategy

Figure 1 gives an overview of time critical and non-time critical tasks which occur in a forest fire disaster management cycle (San-Miguel-Ayanz et al. 2012). Therefore, technologies which can be used to realize an efficient support in management strategies have to consider the following main criteria: (a) quality of information (temporal/spatial resolution; thematic and geometric accuracy), (b) access and availability of data and information, (c) required time for observing / monitoring areas and (d) costs, organizational, legal and administrative efforts.

In general, the type data source will be differentiated as satellite and airborne (planes, helicopters, UAVs) based as well as terrestrial sources. These are capable of providing different performance levels of support for individual tasks depicted in Figure 1. Satellite based solutions mainly focus on covering large areas but they are limited in the temporal and spatial resolution. Satellite cycles are in general too long and the image resolution is inadequate for detecting fires when they are small and developing (Allison et al. 2016). However, satellite data appeared to be very useful to activate early detection systems. Moreover, the launch of a new generation of high-resolution satellites seems promising (Kolaric et al. 2008). Terrestrial solutions (e.g. watchtowers) are adapted to specific requirements and have to be carefully placed related to the topographic situation (visibility, etc.) to enable a permanent monitoring operation (early detection and post fire monitoring). They offer only a limited management support during a forest fire event.

Principally, forest firefighting operations are very dangerous and complex. Regarding the involvement of comprehensive human resources as well an extensive use of ground-, aerial vehicles and equipment, the event management is crucial to protect human lives and to optimize resources deployed in the field. Area-wide geo-oriented information as well as specifically monitoring flights and ground-based activities (continuous impact control) are important requirements for an optimized operational management. It must be taken into account that firefighting measures differ substantially depending on the type of forest fire. Ground fires, crown fires and large-scale surface fires require different control strategies, which need to be taken into account in the management solution. Apart from the optimal deployment of emergency teams during the forest fire, it is also necessary to monitor the affected area for at least 36 hours after the fire has been extinguished in order to detect any hot spots that may rekindle the fire (Almer et al. 2015).

Figure 2 gives an overview of the operation layers and different types of resources which are involved in recent forest firefighting situations. In this concept the third level ("airborne surveillance") acquires optical as well as thermal (TIR) imagery on demand to enable an efficient and precise management of ground and airborne firefighting operations.

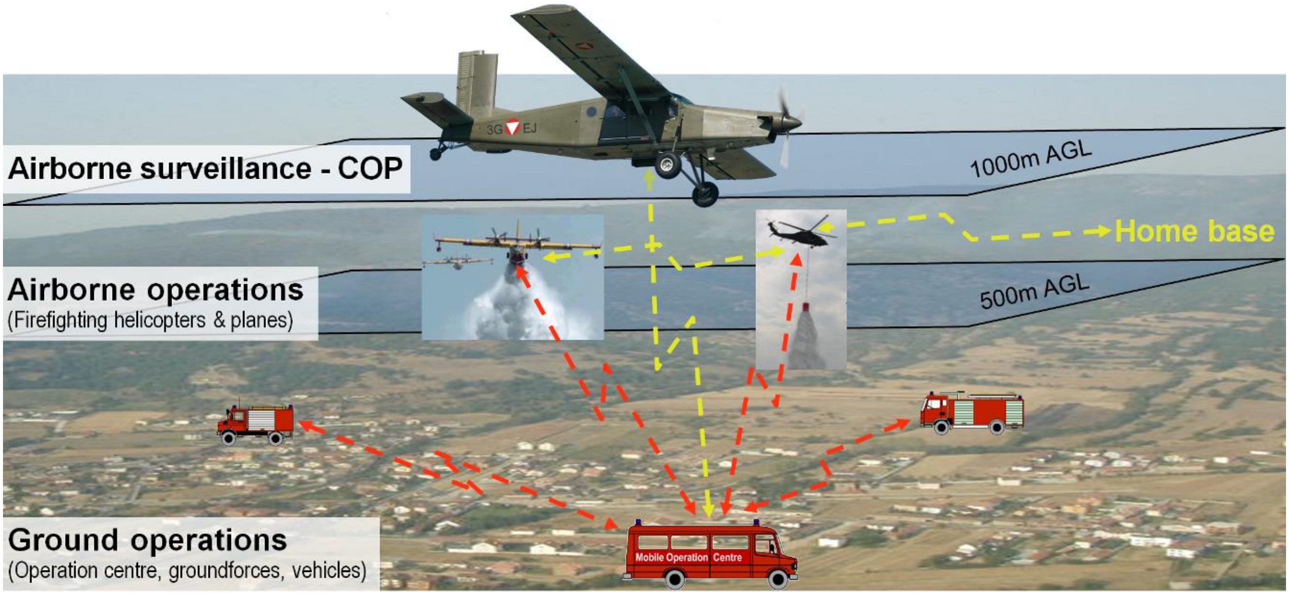

Figure 2: Overview of a multi-layer forest fire management strategy.

3. Overview of system components and information flow

The developments within the project 3F-MS are based on the system "ARGUS" which was developed as part of the KIRAS project AIRWATCH (URL4) and enables near real-time monitoring of natural disasters using optical (RGB) and thermal infrared (TIR) images. It meets fundamental requirements of customers and end users to support time critical management processes. In comparison to other existing systems and ongoing research projects 3F-MS focuses on system requirements which enable a wide area monitoring of threatened forest surfaces (up to 150 km2 per hour) using small and cost-effective planes (e.g. Pilatus Porter PC 6; Diamond Aircraft DA 42 MPP) and a tailored bi-directional line-of-sight communication for RGB and TIR images as well as meta information to realize demand oriented automated image processing procedures. An important factor for the applicability is the modular, easily transportable multi-sensor data acquisition platform and the efficient integration of the platform into different airplanes. Figure 3Figure shows the system containing the airborne, the real-time communication and the ground segment (Almer et al., 2015). In frame of the project 3F-MS, the components of the ARGUS system are significantly expanded to enable an efficient support of disaster management processes. The following tasks will be covered by the ARGUS functionalities: (a) wide area monitoring of threatened forest surfaces based on risk analyses from an early detection service, (b) extension and optimization of command and control functionalities regarding requirements of forest fire situations, (c) Monitoring support application for the pilot and on board operator, (d) near real-time situation picture (NRT COP), (e) Automated analysis of thermal data for evaluating different fire types as input for a NRT COP, (f) management for ground and aerial forces as well as human resources during the operation, (g) communication and coordination of operational units including wearable systems, (h) impact analysis of used firefighting resources, (i) simulation of resources usage as well as comparison of the simulated and real impact, (j) monitoring of doused areas for min. 24-36 hours to detect re-blazing fire sources very early and to manage targeted counter measures, (k) comprehensive documentation to support management processes in the “recovery phase“ and (l) interfaces to existing expert systems for risk forecasts and fire propagation.

Figure 3: System overview and general concept of data/information flow in a forest fire event situation.

4. Airborne Segment

The airborne segment is a multi-sensor imaging platform including RGB, near (NIR) and thermal (TIR) infrared range sensors for the acquisition of images as well as high-precision GPS/IMU sensors to enable a near real-time ortho-rectification of image data. Especially TIR images enable important information extraction which is an essential data source for the generation of a NRT COP in forest firefighting operations. The information about measuring temperature differences and detecting drenching ground and seeds of fire are included in the TIR. The airborne segment is controlled by a support application for the on-board operator and pilot guidance. In Almer et al. 2015 further information on the usage of the image data covered from the ARGUS airborne segment is given.

5. Real-time Communication

The Real-time data transfer from the plane to the ground station is established by using a line-of-sight (LoS) connection. The LoS system is designed for a bandwidth of 8Mbit/s at the required operational range of 50 km using a tracking antenna. Actual benefits like high carrier frequency agility and single carrier operation with flexible up and downlink bandwidth configuration are further extended with features of adaptive range and bandwidth extension. This allows higher downlink data rates of up to 20Mbit/s at short distances as well as dynamic data rate adaptation without interruptions for distances of up to 100km. The bi-directional LoS data transfer is an essential system module to enable an efficient and targeted support of forest firefighting scenarios.

6. Ground segment functionalities

The development priorities for the ground segment modules were driven by the requirements of the national and international forest fire experts (URL5). In general these modules enable an efficient data processing as well as the definition of different processing chains aligned to user requirements.

The data processing and analysis module offers automated processing chains for a direct geo-referencing approach for RGB and TIR images. Enhanced mapping and mosaicking functionalities provide results for the management modules which provide a user focused visualization of geo-referenced results as well as support the interactive work of the operator. Automatically geocoded aerial images using a direct geo-referencing, enhanced mapping or precise mapping approach result in different geo-location accuracies. The results are analyzed by means of computer vision techniques. Data acquisition using TIR cameras differs to the usage of optical cameras, which has to be considered for further analysis. First, it has to be taken into account that a TIR camera that is not cooled cannot take calibrated temperature measurements over time. Second, different materials have varying emissivity that changes the temperature measurement. Thus, e.g. metallic objects lead to wrong temperature measurements, which make a basic classification of the targets necessary. Figure 2 shows a test setup to train the classification algorithm using an artificial laid fire. TIR data of multiple overflights was analyzed. In particular a local region of 30x30 pixels, i.e. 7.5x7.5m, holding the fire is shown over time in Figure 5 with a peak temperature of 255°C.

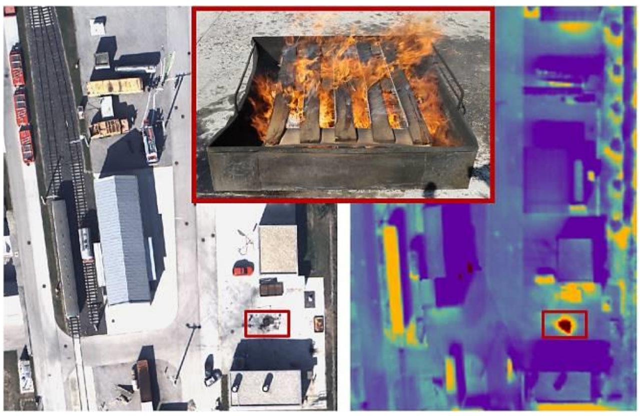

Figure 4: Setup of a fire exercise. RGB (left) and TIR (right) airborne images and the fireplace (middle)

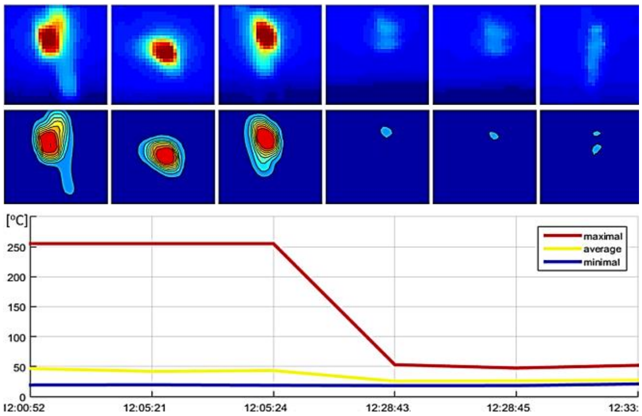

Figure 5: Local temperature (top), temperature zone classification (middle) and statistics over time (bottom).

The geo-oriented management module offers a set of features for the use in forest firefighting situations. These include the following functionalities: (a) data acquisition planning and real-time mission control, (b) situation monitoring based on images of the affected areas, (c) temporal/spatial search functions, (d) trigger semi-/automatic data analysis processes and visualization the results, (e) visualization of available geo-data and positions of deployed operational units, (f) creation of value added products (e.g. mosaics, hotspot maps, 3D reconstruction), (g) thermal image analysis and target spotting, (h) data interfaces to forest fire management components. Figure 6 (left) shows examples of the geo-oriented data visualization within the remote sensing management module.

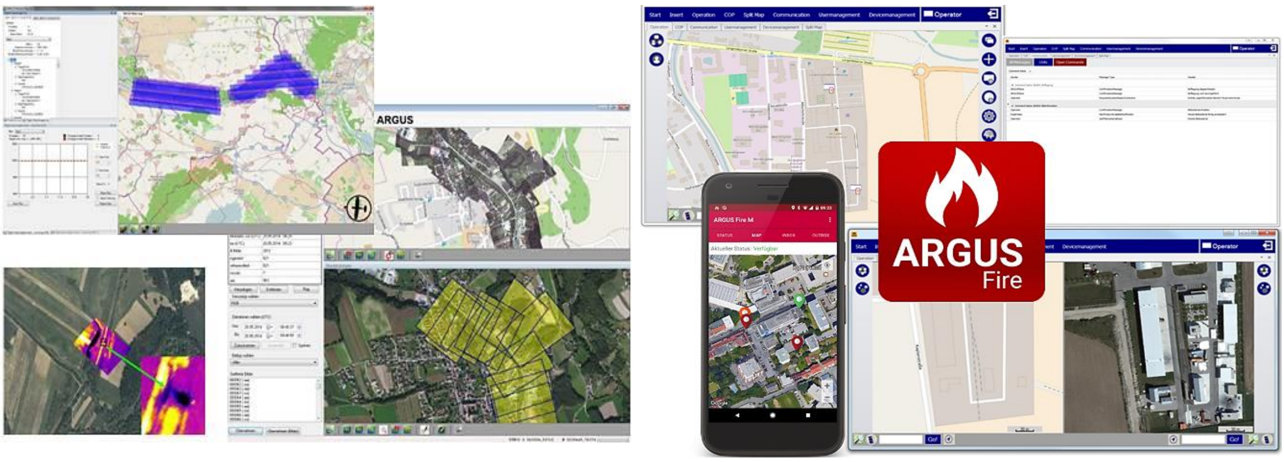

Figure 6: Data (left) and resource management module (right).

To support the command, control and management of units as well as resources in the described concept of multi-layer management for forest fire situations, ARGUS Fire (Figure 6 - right) is used. It is a module which supports an operator during the whole forest firefighting operation by providing resource and decision support features. The features of ARGUS Fire are: (a) comparison of historical and current images for assessing changes, (b) presenting a common operational picture (COP), (c) text based communication with the on-board operator, (d) communication with connected operational units, (e) administration of the allocation and affinity of resources and (f) protocol communication and task allocations during the mission (Lukas et al. 2017).

ARGUS Fire is connected to the data management module via a communication service to exchange information. Geo-referenced image data from the data management module can be sent to ARGUS Fire and there visualized for the decision support. The communication service also serves as the communication interface to mobile units on the ground and on aerial vehicles. The software component ARGUS Fire can be split up into two applications.

The first is the desktop application. It collects data from the whole forest firefighting operation and visualizes them on the screen to support decision processes of the operator. The decision process is supported by a split screen feature, which enables the comparison of images with different timestamps, different map layers (OSM, satellite and aerial images, etc.) and different image type material like thermal images and multispectral images. Another support function is offered by the COP module. This provides an actual image of the situation on the fire side and the overall situation of the operation. The most important point of this picture is its actuality. If it provides an outdated representation of the situation to the operator, the possibility of wrong decisions is raising and leads to a high risk for the forces at the fire site. The messaging function module in ARGUS Fire handles the communication between operation units in the air and on the ground by using the communication service. The module aims at giving orders and getting optimized feedback from currently performed tasks by the different involved parties. Therefore it requires a communication channel to the unit (forest fire engines, control units as well as support units and airborne units). For basic information, the best approach is by using Terrestrial Trunked Radio (TETRA – see URL6) which allows using a small bandwidth to exchange command and control messages. For solutions with higher bandwidth requirements (e.g. in-situ images, situation reports, etc.) the systems supports commercial solutions like WLAN, LTE and TETRA over LTE as well as using bi-directional data exchange links between the control point and vehicles and operational units in the field. The biggest advantage of TETRA compared to LTE and WLAN is the reliability during crisis situations and the fact, that it is a standard technology used by first responder organizations and law enforcement agencies.

The second part of the ARGUS Fire application is the mobile application ARGUS Fire Mobile, which enables communication and data exchange between firefighting units on the ground and in the air (e.g. plane, helicopter, field forces). The mobile application is an add-on to ARGUS Fire, enriching the operational picture by real time positions and status reports from mobile units. During the development process a strong focus was set on the usability design. It was important to keep the application handling simple and use procedures which the fire fighters are conversant with. To realize this task, procedures from different digital radio devices were explored to design a graphical user interface for the mobile application. Further data which are sent using the communication module include information about water tank, availability, location, wind, etc. which is used to extend the operational picture and allows an efficient usage of available resources.

Large forest fire scenarios usually require a coordinated deployment of several fire brigade groups and different emergency and rescue organizations which have different management systems in use. Interoperability with existing systems is also a key requirement and therefore the generated information products are available in standardized data formats to allow an easy exchange with other, existing geo-information and management systems (local/regional GIS systems, etc.). Also, the results of the data processing and analysis processes can be distributed offline via standard file transfer as well as online via ftp or OGC standard compliant interfaces like WMS. This means that staff experts always have access to relevant up-to-date data on site and are able to use their existing command and control system. Import interfaces allow using available local raster data like risk maps, basic data products and data services like Copernicus EMS. In addition, results can be displayed using a web presentation including basic data from Open Street Maps (OSM) or Google Maps / Bing Maps and are available on different platforms – web, desktop, mobile devices.

7. Conclusion and outlook

There is a dramatic increase in forest fires and wildfires worldwide. Europe alone suffers about 65,000 fires annually, which in total destroy more than a half million hectares of forest (JRC, 2010). The risks for human lives and also environmental and infrastructure damages are becoming larger and reached a very critical level in some regions of Europe. To reduce the negative impact of wildfire and forest fire situations it will be very important to realize extensive research activities and innovative technological solutions to enable a comprehensive support of the full forest fire and wildlandfire disaster management cycle.

To manage disaster events it is a fundamental requirement to offer timely and holistic information products to allow the support of time critical decision processes of the involved organisations and persons. This paper presented a multi-functional airborne management system which allows to support crisis management tasks of emergency teams and armed forces in disaster situations based on the generation of a near real-time situation map and a powerful role and scenario-focused management solution.

In general, a very important question for future activities will be to bring together the already existing effective solutions to offer an entire service regarding the issues of forest fires for the national civil protection organizations. From this point of view, existing solutions such as terrestrial sensor networks and UAS (unmanned aerial system) solutions must be included. These solutions provide important information to support the disaster management phases as shown in Figure 1.

For the use of UAS solutions in the context of forest fire situations the legal framework conditions nationally are very different. Further, the flight and sensor performance parameters of the carrier platform have to be considered for an efficient integration in existing disaster processes. Both aspects have very concrete effects on the deployment strategy in the context of forest fire situations.

8. Acknowledgments

The presented research activities were embedded into a project worked out within the Austrian Security Research Programme KIRAS and funded by the Austrian Research Promotion Agency (FFG). The project 3F-MS was carried out in close cooperation with the Austrian Federal Ministry for National Defence as well as the Ministry of the Interior

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Online access - links

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EFFIS - European Forest Fire Information System (accessed April 2019):

URL2: http://effis.jrc.ec.europa.eu

KIRAS research project 3F-MS (accessed April 2019):

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URL6: http://www.etsi.org/technologies-clusters/technologies/tetra

THE PORTFOLIO OF SOLUTIONS

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Keywords

Portfolio of solutions, crisis management, disaster management, practitioners, trial

Abstract

In national as well international crisis and disaster management it is imperative that practitioners address detrimental events in the best possible way. For this purpose, the Portfolio of Solutions (PoS) (Pos.driver-project.eu, 2019) was developed in the frame of the DRIVER+ project (DRIVER+, 2019). The PoS supports two core functionalities: Firstly, it assists practitioners and other stakeholders in discovering innovative solutions that are described in the PoS's database. Secondly, the PoS supports solution providers in advertising their solutions. For this purpose, it provides pre-defined templates supported by the Crisis Management (CM) functions taxonomy for the classification of solutions. This taxonomy is designed to assure common understanding between practitioners and the solution owners. The CM functions taxonomy is used by the PoS to match the capabilities of the advertised CM solutions with the needs of the practitioners and thus help them to manage the crises more efficiently.

1. Introduction

In crisis and disaster management, practitioners, first responders, authorities and other stakeholders must execute a multitude of processes to ensure the provision of adequate responses in all phases of the crisis management cycle. Such processes can be supported by different crisis management solutions. In the context of this paper a CM solution is defined as a combination of a process and one or more tools that are designed to support practitioners in the execution of their tasks. A multitude of such solutions with varying levels of maturity is provided by different solution providers such as industry, SMEs, standardization or research organizations.

Examples are solutions that might provide a common operational picture (COP) or allow to exchange information, model natural events such as mass movements or enable volunteer management. Figure 1 includes a possible core structure to sort crisis and disaster management solutions.

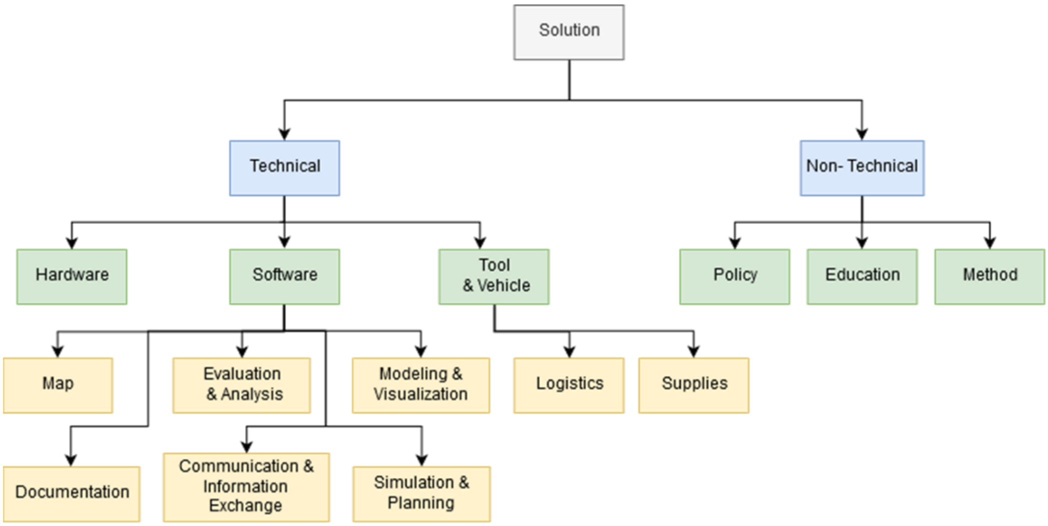

Figure 1: Exemplary levels of a crisis and disaster management structure of solutions

It is imperative for practitioners to identify the best suitable solution for their specific needs. For this purpose, it is very helpful to describe the needs of practitioners in a systematic way and to match these needs with the features of the solutions.

The European project DRIVER+ addresses the above described requirements. The DRIVER+ team has developed a pragmatic step by step method for systematic testing of CM solutions through “trials”, which are defined as “events for systematically assessing solutions for current and emerging needs in such a way that practitioners can do this following a pragmatic and systematic approach”. It is central to the DRIVER+ approach that the same taxonomy of Crisis Management Functions is used to describe both the gaps practitioners experience and the features of the solutions on the other. This way requirements of practitioners (formulated as “gaps”) and offers of solutions can be matched. This matching is performed automatically by the DRIVER+ Portfolio of Solutions web site, which allows to:

- Describe CM solutions and link them with relevant CM functions (solution owners).
- Express own crisis management needs as “gaps” and link them with relevant CM functions (practitioners).

Share user experiences with solutions in DRIVER+ trials and other trial-like setups to ease the successful implementation and use by other practitioners.

The PoS site has been pre-filled with gaps, trials and solutions that are pertinent to the DRIVER+ project before opening it to the early adopters outside consortium. Currently, the site is open for all solution owners and practitioners.

In the next chapter the architecture and the implementation of the DRIVER+ Portfolio of Solutions is presented.

2. The concept and architecture of the PoS

The Portfolio of Solutions (POS 2019) is an online knowledge management system that stores information on CM gaps, solutions and experiences in using these solutions and makes this information available to the end-users through a web interface. This assures that all information about the innovative solutions in the crisis and disaster management is easily available to anyone that has access to the Internet, which bridges the gap of having interested communities geographically dispersed across Europe. For solution owners, the Portfolio of Solution provides a platform for advertising their offers in an efficient way, for the practitioners an efficient way to discover the relevant solutions. Thanks to the use of an online platform, the information about solutions can be easily updated. Furthermore, the platform also facilitates the communication between interested parties by mean of the contact forms, thus allowing faster information flow without exposing the e-mail addresses of participants to potential spammers.

Figure 2 illustrates the structure of the PoS, which is realized inside of a common database, where all authenticated users can store information about their solutions and relate other entities. The core entity is “Solution” which stores the general information and description and other entities are related to it as show in figure 2. In order to better understand the term “Solution” in this context, a comparison to a software tool can be made, where one would describe what is the purpose of it, which programming language was used to build it, what the expected inputs and outputs are and so on. Furthermore, specific use cases would be described to define interactions between external actors and the tool to attain specific “business” goals, and supportive documentation would be made available.

2.1. Functionalities of the Portfolio of Solutions (PoS)

The Portfolio of Solutions is designed to provide two main functionalities. Firstly, it gives the possibility of describing a solution in a standardized way. The solution provider has the possibility to state in which innovation stage the solution is currently in, what readiness level it has, which crisis cycle management phase is targeting, and which crisis size it covers. It also gives the opportunity to provide information on which standards are supported by the solution, and to upload and store all documentation regarding the solution, such as manuals, installation/ configuration guides, etc. Solution providers can also describe use cases and relate them to the CM functions taxonomy. Other than that, the platform allows adding references to both PoS-internal and external descriptions of the real-life experiences and trials involving this solution.

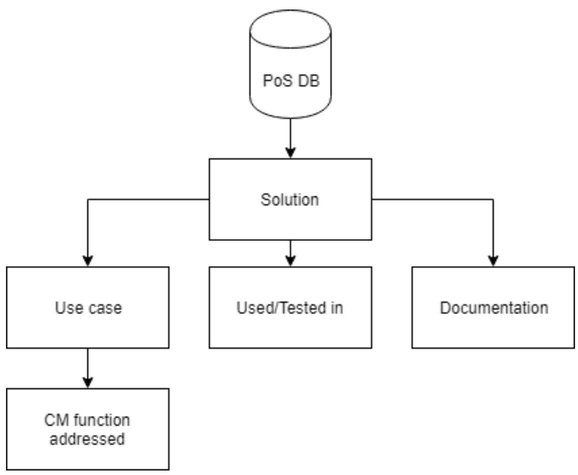

Figure 2: PoS structure diagram

Practitioners and other stakeholders, using the PoS's search function can discover relevant solutions by filtering on all information provided by the solution provider and by clearly stating which CM functions are being addressed. The solution overview page of the PoS implements deep search algorithms that allow searching relevant terms through all components of the described solution allowing fast, user-specified search. The PoS also implements a PDF export function to allow easy information extraction for further usage. This functionality can be combined with the filtering function that the PoS offers to generate PDFs containing user specified information, that being a description of a single solution, or for example, the description of all solutions that address the same CM functions. Alternatively, they can also define own gaps and the site will automatically suggest a list of presumably relevant solutions. This matching is based on the overlap between CM functions that are advertised by the solution and those that are requested by the gap.

An integrated help functionality is designed to help both solution providers in describing their solution in the best possible way and to help practitioners and other stakeholders in selecting relevant solutions to be assessed.

Figure 3 illustrates a typical PoS's use case for the described functionality, in which a solution provider stores all information about his solution into the PoS database, and a practitioner or other stakeholder accesses the database to find this information.

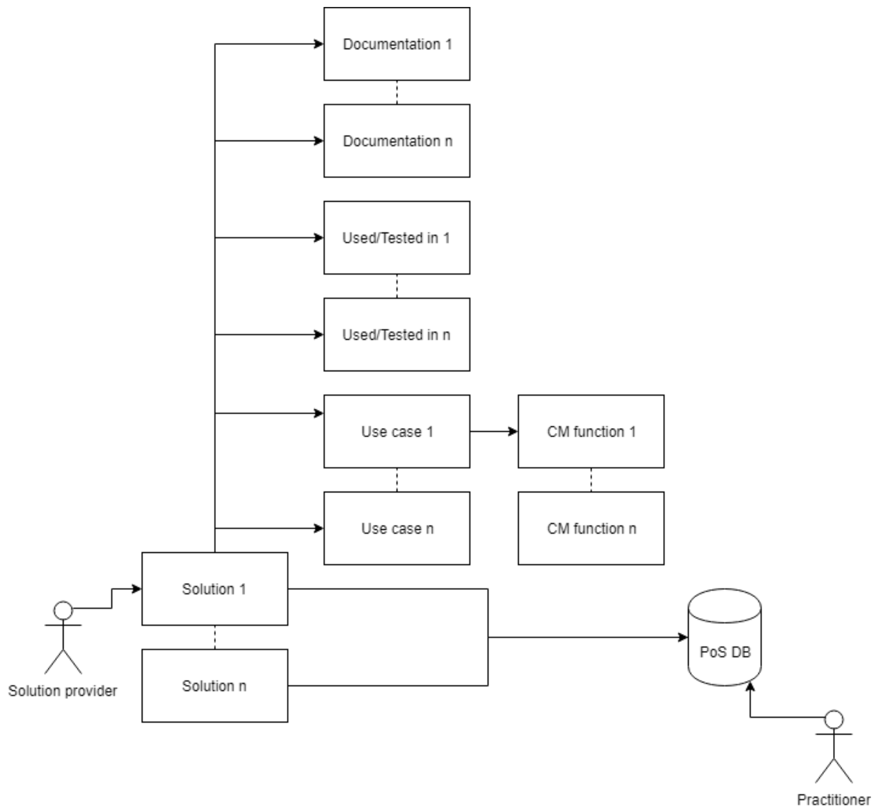

Figure 3: PoS use case

3. Implementation of the PoS

This section attempts to provide a concise summary of the implementation process of the PoS and is divided into two parts, one describing the development approach taken and the other one describing the implementation steps.

3.1. Development approach

For the development of the PoS platform a mixture of two software development approaches was used:

1. Agile approach (Scrum.org, 2019),
2. Prototyping approach (En.wikipedia.org, 2019).

The first approach was chosen because it resonated well with the needs of the project, with the emphasis on the team development rather than following predefined structured development process. It encouraged cooperation and team work between partners, while maintaining contact with end users allowing quick responses to changing specifications. Two environments were set, one being a development environment and the other a production environment. A monthly sprint was chosen, and new features were developed during the course of one month in the development environment. At the beginning of each month, also in this case of each sprint, these features were migrated to the production environment, to be immediately used by relevant stakeholders.

The second approach was chosen to improve end user participation, where smaller scale models of desired functionalities were introduced and demonstrated, to ensure that they meet the user's needs.

3.2. Implementation steps

The implementation of the PoS is based on Drupal 8 (Drupal.org, 2019) – an open-source, content management framework written mainly in PHP, which offers a wide variety of contributed modules used to further extend the core functionality, while also allowing development of custom modules to adjust to the specific needs of the project. The implementation steps can be divided into two groups, one being the steps that are required for visual elements and the other being the steps that are required for the functional elements of the PoS.

The first group has been implemented by developing custom visual elements using the Hypertext Markup Language (HTML) (En.wikipedia.org, 2019) and Extensible Markup Language (XML) (En.wikipedia.org, 2019), supported by Cascading Style Sheets (CSS) (En.wikipedia.org, 2019) language to describe how elements should be rendered on the screen. The project required development of a custom theme for the website, as well as all other visual elements to portray the visual identity of the project. In order to make the website more attractive and user-friendly, displaying of the content was also adjusted using the mentioned languages and graphical design techniques.

The second group was implemented based on the functional requirements for the PoS by using the mixture of functionalities that the Drupal framework, together with community developed modules offers, and of functionalities that were custom-developed during the project. In order to satisfy the requirements for different permissions, where each solution provider together with his team could add, edit, remove solution description(s) as well as perform the same operations on related entities on the website, a contributed "Group" module was implemented and configured to match the needs. In the implementation of the PoS a solution description is designed as the main entity with three additional entities related to it, namely "Use cases", "Used/tested in" and "Documentation", as shown in the Figure 2. They have been implemented by using and configuring the contributed "Group node" module. The "Use case" entity was extended with a "CM functions" taxonomy vocabulary which was then used to implement the search and matching function on one hand, and on the other hand to achieve one of the main goals of the project – to assure that all innovative solutions that exist in the PoS are classified and discovered based on a common taxonomy across Europe. Individual fields for each entity have been implemented by using the existing functionality provided by the chosen framework and its community.

In order to allow an easy discovery of the solutions, the PoS implemented advanced search algorithms that are mainly based on the Drupal's core "Search API" module but are also changed and fine-tuned according to the specific requirements of the project. In addition, a custom matching functionality was developed to further improve the discovery of solutions by matching them based on the CM functions they address. In order to provide assistance to solution providers in describing their solutions in a systematic and standardized way, two custom functionalities were developed and implemented - namely "contextual help" and "validation". The first one aims to provide contextual help to the user in each part of the website, by determining the user's location on the website from the URL and displaying the relevant helping information. The second one aims to automatically validate input and warn the user if the solution description does not meet the defined criteria.

Figure 4 illustrates a part of the solutions overview page within the PoS, containing the search, filter and export functionalities.

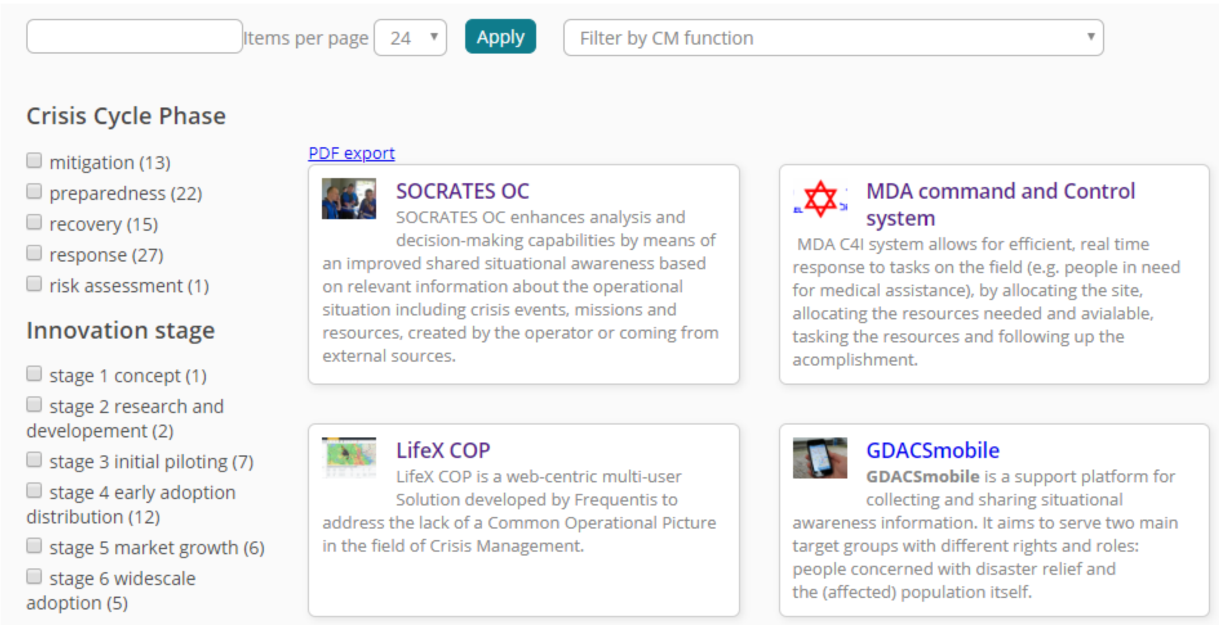

Figure 4: PoS solutions overview page

To conclude, based on the evaluation of results gathered by interviewing relevant stakeholders, all the mentioned functionalities, as well as many other that have been implemented, have resulted in achieving the two main goals of the PoS: by using it, innovative solutions in the field of crisis management can be described and categorized in a systematic way that is common across the Europe. Additionally, they can easily be discovered by practitioners or other relevant stakeholders. Further information can be found in the publicly available documentation on the PoS ("DRIVER+ Project Public Reports | DRIVER+", 2019).

3.3. Related work

Even though research in crisis and disaster management field is wide, not many similar platforms have been developed so far. One example of similar application in this field is the DRMKC's (Drmkc.jrc.ec.europa.eu, 2019) project explorer which provides an overview of the relevant research and operational projects and their results. It has a similar purpose as the PoS platform, to improve understanding of disaster risks, to strengthen the resilience across EU member states, but of course with different type of information stored in it. Further research has not implied the existence of other platforms matching supply and demand on solutions in the domain of crisis and disaster management.

Several services exist for other domains that provide context on products and offer some labelling features. One example is DEKRA (Dekra.com, 2019) dealing with several domains such as automotive, cyber security and loss assessment after catastrophes, or the Fire Equipment and Safety Center of Japan (Anon, 2019). Partnership building is another feature several platforms are providing. An example to illustrate this approach is given by the European Agency for SMEs (EASME - European Commission, 2019) that provides several partner search tools such as NCPs CaRE and the Enterprise Europe Network cooperation database. Other approaches are E-CAM (E-cam2020.eu, 2019), a European HPC Center of Excellence that supports Software, Training and Consultancy in Simulation and Modeling or EoCoE (EoCoE, 2019), the energy- oriented Centre of Excellence in computing applications. In this context it is worthy to mention the Centre of Excellence in Production Informatics and Control (EPIC) ("Centre of Excellence in Production Informatics and Control", 2019).

4. Conclusion and Outlook

Within this paper insight is given on the methodology on how to develop a repository of crisis and disaster management solutions. The platform allows not only to describe solutions in a systematic way and making them therefore comparable, but it goes beyond that and describe on how the solution performed in real life conditions. Such an approach has the advantage to mitigate the fragmentation of the Crisis and Disaster Management domain. Available solutions become visible to a larger, cross-border acting community of practitioners, authorities and other stakeholders. It must be pointed out that the PoS requests an adequate number of solutions in order to give practitioners a complete set of options for their decisions. However, the visibility of a large portfolio of solutions helps to address the needs of the stakeholders in a more focussed way, enhancing the likelihood of the availability of better suitable solutions and enhancing therefore the resilience of the European civil societies.

5. Acknowledgment

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement n°607798.

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SIMILARITY OF DEFINITIONS CHALLENGES OF COMPARISON

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Keywords

Disaster management, crisis management, definition, similarity, measurement, feature

Abstract

Mutual understanding is a key requirement of the crisis and disaster management domain but it is definitively not limited to this domain. A divergent understanding of concepts, methods, and objects exists in the domain of crisis and disaster management due to the specific purpose and cultural or organizational context. Precise and clear communication, however, based on definitions across language barriers and organizational differences are a key to speedy and effective help.

In this paper concepts of feature-based semantic analysis and comparison of definitions and quantifi- cation of their similarity are presented together with an overview of a complete comparison process.

1. Motivation

"When I use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean - neither more nor less." Lewis Carroll (1832-1898).

Mutual understanding is a key requirement of many areas such as the crisis and disaster management domain. Precise and clear communication across language barriers and organizational boundaries provides a key to fast and effective help. Different understanding of concepts, methods, and objects exist, . depending on the specific purpose and context. The assumption of the future use of a single terminology to deal with the whole crisis and disaster management domain beyond organizational, structural, political and cultural borders does not seem to be realistic, and can certainly in any case not be expected in the short term. Under this assumption the provision of thesauri including vocabularies and taxonomies such as the ones from ISO 22300:2018 (ISO, 2018) or UNISDR 2015 are expected to be quite helpful and are therefore intended to be provided by initiatives such as the FP7 project DRIVER+ (Consortium, 2019).

A methodology for comparing definitions of terms as well providing a quantification of the degree of similarity has been developed in the CERN Workshop Agreement, "CWA" (CEN/TC (ed.), 2018). In this paper concepts for semantic analysis and comparisons of approaches to the quantification of similarity are investigated in order to establish a basis for examination and further development of the methodologies of the CWA.

The paper is structured as follows: Chapter 2 discusses definitions as a basis for understanding, leading up to the feature-oriented, taxonomy-based representation of definitions in Chapter 3. In chapter 4 the different notions and measurements of similarity are discussed together with the feature-oriented comparison of one single aspect of a definition, resulting in a similarity score. Chapter 5 focusses on the aggregation of similarity scores for complete definitions and for higher aggregates. In chapter 6 a complete comparison process is presented

2. Using definitions as a means of description

Definitions help users to quickly comprehend terms and concepts. A ’concept is understood as units of thought or ideas, meanings, or (categories of) objects and events (EPISECC, 2017). Robinson (1950) defines seven forms of definitions, including the ’ostensive method’ ("showing *it*").

In our case, when comparing definitions, it is necessary to identify definitional sentences - sentences that interpret terms and concepts - in a given text, e.g. a standards document. It is necessary to identify included definitions even if they are not in the standard form ("X is defined as . . .") but appear in other forms. Jin et al. (2013) discusses semi-automatic identification of definitions in texts. For the purpose of our research only natural language definitions of the form "Term = ’textual description’" will be considered. It turns out that it is also necessary to recognize and record the scope and context in which a definition is found. For crisis and disaster management (and for similar domains) we are mainly interested as to whether two terms define the same object or concept.

3. The feature-oriented description

3.1. Basic concept

While natural language definitions are the most flexible and an obvious method to define concepts, is difficult to extract their semantics in a systematic way. As a result the comparison of definitions has to rely on human effort.

The alternative approach is a feature-based description of definitions. In the last couple of years this method of specifying semantic contents has been very successful, especially in biomedical research. Comparing large sets of definitional texts (Jin et al., 2013; Garla and Brandt, 2012) becomes imprac- tical for natural language definitions and the resulting human effort.

The basic idea is to characterize a term not by its definition in textual form but by its ’essentials’, the so-called ’features set’ (Tversky, 1977; Khan and Mustafa, 2016): a subset of pre-established set of properties (’features’) used to characterize the term. For each domain (or discipline) experts define for the concepts, methods, tools and objects of the domain the relevant and essential feature, obviously the chosen set of features must contain all relevant and distinguishing features. It provides the so-called (limited!) ’world view’ of the domain. The features are supposed to express all necessary aspects of the definitions. Bateson (1997, p. 452) speaks of "the difference that makes a difference".

Comparing definitions is based on the match/mismatch of their associated features. For disaster management this approach seems to be very promising, especially in view of comparison of the similarity of definitions. For each definition it is necessary to map its natural language definition plus further pieces of information (e.g. from the encompassing document) onto the set of features (’mark-up’). This has to be done only once!

We have to be aware that in order to evaluate the similarity of two definitions we must reduce it to the question of similarity of two feature sets associated with the different definitions in question (fig. 1).This can only be an approximation no matter how well-worked-out and sophisticated the features sets are. It can only cover some aspects of similarity.

3.2. Structuring the pre-defined feature sets

Several organizational principles offer themselves for the feature sets. The most promising one is a taxonomy. This allows showing certain basic relationships between the individual features: synonyms and the hierarchical structure (Hyponym/Hypernym relationship, i.e., is-a relationship). Fig. 2 shows a section of the three-tiered taxonomy used by CWA (CEN/TC (ed.), 2018): each aspect is associated to a feature set. Aspects are aggregated into categories, categories are collected in category types. A simpler approach is using just a bag-of-words, i.e. an unstructured list of words. The disadvantage is that some essential relationships between the words cannot be expressed (e.g. synonymity) (Clinchant and Perronnin, 2013; Passalis and Tefas, 2018).

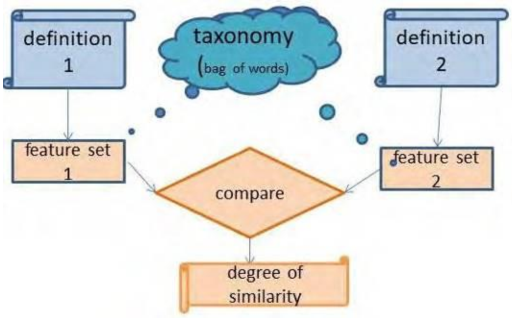

Figure 1: Basic comparison approach

More expressiveness could be provided by employing an *ontology*, e.g. expressing neighborhood of terms. It is questionable as to whether the added effort really pays off.

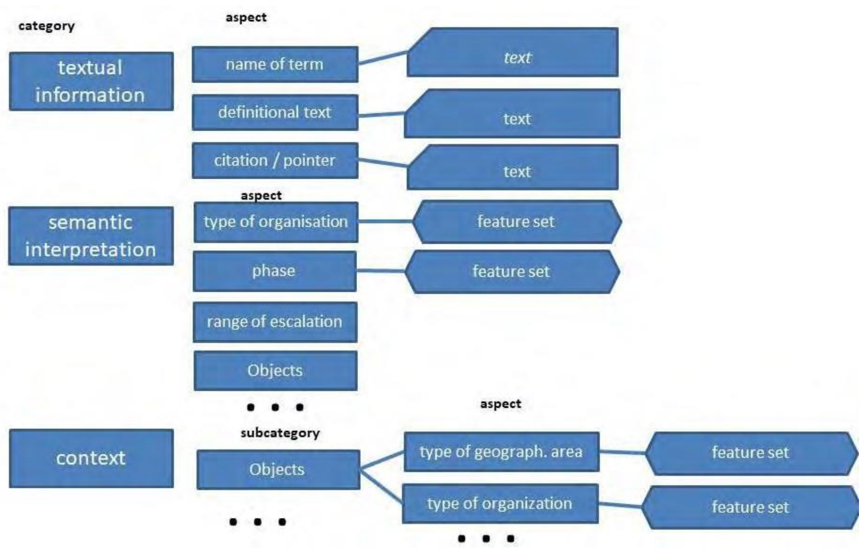

Figure 2: Example of a Taxonomy scheme (CEN/TC (ed.), 2018, Annex A)

The multitude and diversity of features makes it necessary to structure the taxonomy (see fig. 2)

- On the lowest level an 'aspect' collects features of similar type. Features are assigned to an aspect in order to characterize the term, e.g. type of disaster, type of organization. Assigning features to the aspects is a largely human activity, since the assignment is not unambiguous. Some pieces of information must be deduced from the meta-information or the environment. Obviously the key to success for this approach is the quality of the aspect/feature selection.
- On the next higher level aspects are collected in 'categories' or 'subcategories': see fig. 2, e.g. who created a definition, for whom etc. The structure is strongly influenced by usage and intuitive understanding.

For each aspect a pre-defined set of 'features' is created by board(s) of experts. The names of these features act as keywords. They are to be valid for a specific aspect and do not depend on the specific definition in which they are used. The totality of all features provided for all aspects and descriptors is assumed to model the complete domain. Obviously there must also be provisions for later expanding or even changing the set of features.

For example to the aspect of 'objects' either 'concept' or 'equipment' or even both ought to be assigned! For 'type of organization' it could be 'government', 'NGO', 'standards institute', etc. (see (CEN/TC (ed.), 2018, section A.5). An example, based on (CEN/TC (ed.), 2018, Table 2) is shown in fig. 3.

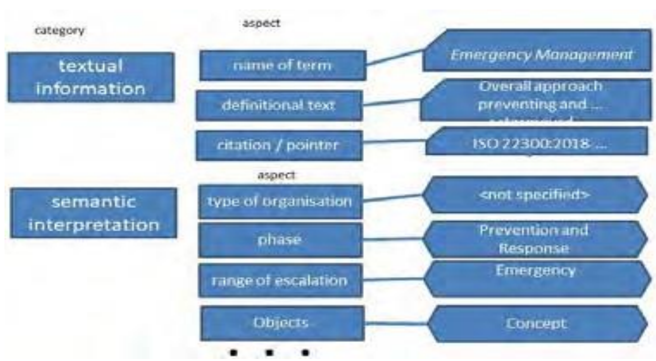

Figure 3: Example of an Taxonomy (see (CEN/TC (ed.), 2018, Table 2))

One of the key advantages of this approach is that one has to assign features to definitions only once. The further steps do not need to refer back to the textual definition. The comparison of definitions becomes the largely mechanical process of comparing sets of features (Apel et al., 2014; Chroust, 2014; Formica, 2009; Garla and Brandt, 2012; Kang et al., 1990; Tversky, 1977).

4. Similarity

4.1. What does similarity mean?

Similarity is a very elusive notion. It strongly depends on the type of concepts to be compared and on the purpose of the comparison: which of the properties ("features"!) of the compared concepts are of importance for the current test of similarity, thus *"Similarity is in the eye of the beholder"*.

While for works of literature similarity considers questions of style, wording, phrasing, originality, potential of plagiary, etc., similarity of technical concepts, as in crisis and disaster management, concern only the semantics of the underlying concepts, ideas etc. Therefore a comparison of the natural language texts is not successful, while feature sets (if selected carefully and completely) tend to describe the 'essence' of each definition.

4.2. Comparing definitions for similarity

Similarity between the definitions will be based on the comparison of the sets of features associated to the comparands. We must understand, however, that this comparison is only based on the comparison of sets of features and therefore provides only a limited world view which can be expressed by the (pre-established) features (fig 1).

4.3. Similarity vector

The similarity vector is the starting point in order to measuring similarity. Given 2 features sets, one can derive a *similarity vector* consisting of 3 sets of features (Lin, 1998): Let *A* and *B* be the feature sets of two definitions A and B then the similarity vector is defined as $<L , M , R>$ with

- L : features ('left') only in A , i.e. $(A \setminus B)$
- M : features ('middle') in A and B, $(A \cap B)$
- R: features ('right') only in B, i.e. $(B \setminus A)$

For the aspect 'phase' in CEN/TC (ed.) (2018, sect A.5.2): Let A = <Prevention, Response, Recovery>

and B= <Preparedness, Response, Recovery> then the basic similarity vector $<L , M , R>$, will be <<Prevention>, <Recovery, Response >, <Preparedness>>.

4.4. Size of a feature set: fsize

To derive a *numerical similarity score* we need to 'count' the number of features in a feature set. We define a function *fsize* which can be chosen differently according to variations in the purpose of measuring similarity. The simplest choice is the number of the elements, but there are also other useful measurements, e.g. forcing a ceiling for the count of features (e.g. CEN/TC (ed.) (2018) uses a limit of 3), or under- or overproportional counting. Even using different functions for computing *fsize* of *L* and *R* can be meaningful (Rodriguez and Egenhofer, 2003).

4.5. The similarity score

A *similarity scores* converts the *fsize* of the 3 sets into a single number. It will be different depending on the type of similarity which is of interest.

Basically a similarity score is defined for the comparison of 2 sets of features and thus of 2 definitions only. In section 5 we will aggregate the similarity scores to higher aggregates (components of definition, complete definitions, standards, etc.).

The *Jaccard* similarity measure is most widely used and seems to be a generally accepted measure for similarity. It relates the number of features common in both sets to the number of all features used in the comparison (Gupta, 2018; Lin, 1998). Therefore similarity-score

$jac\,c = fsize(M) / \mathrm{fsize}(L \cup M \cup R)$.

The first and third set of features (L and R) represent the dissimilarities of the two compared definitions, the 'middle' one (M) the commonality. It is possible to use different functions for *fsize*. For the example in section 4.3 the sizes of the the similarity vector would be $< 1, 2, 1>$ and therefore the similarity score would be 2/4 = 0,5

4.6. Compliance / Extension

Another important question (especially for laws, rules, procedures, ...) is: *"Is the definition of term B compliant with the definition of term A?"* Compliance means that term B fulfils all features of term A but might have some additional ones, while A does not have any extra features. Compliance is not commutative, since B is a superset (or an extension) of A. It is characterized by L as being the empty set.

5. Aggregating Similarity scores

In the previous sections a similarity score has been derived for a single aspect. To be useful the individual similarity scores have to be combined for a complete definition and also for the collection of definitions, e.g standards documents.

5.1. A Similarity Score for a complete definition complete definition :

The combination process for individual similarity scores has to take into account the structure of the definition and the importance of the different aspects, which are usually different. This has to be reflected in the choice of a weight vector (see section 5.2). For level i+1 the similarity score will be similarity-score $i+1 = \Sigma(\, j = 1..n)$ similarity-score i, j * weight i, j, where similarity-score i, j is the similarity score of the j-th feature-set on level i.

Comparing complete documents:

Usually definitions are not stand-alone, but are collected in comprehensive documents. For comparing documents of this kind the following observations have to be made:

- It is of interest which definitions are common to the various documents and which ones not.
- For the computation of the similarity score for two or more documents a weight function could be applied, but in most cases an average will do, since the importance of different documents is not easily decided upon.
- For judging compliance attention has to be paid to the non-commutativity of compliance.

Only if all documents have the same compliance behavior, then the result is meaningful.

5.2. Weight vector for definitions

The weight vector expresses the difference in importance (including none) of the contributing similarity score of the individual aspects. Some standard weight vectors are (but depending on individual interests users might supply their own):

average : All aspects have the same weight (this is used in CWA (CEN/TC (ed.), 2018)): the resulting similarity score is the average.

expert opinion : Experts judge the importance of the individual similarity scores and define the weight vector(s).

size of the aspect's feature set in the total taxonomy : The more features an aspect has in the relevant taxonomy, the more weight is given to that similarity score. It could be proportional to the number of features.

scarcity : Aspects which are seldom specified in a definition, could receive a higher weight. The rational is that they might carry distinguishing information.

subset selection : Sometime only part of the definition is of interest, e.g. the meta-information with respect to the source organization or the target organization (see fig. 2).

6. A complete comparison process

The complete comparison can be divided into 7 tasks, some of which were not discussed.

Task 1: Create a Reference Taxonomy *(once per domain)* The Reference Taxonomy must contain all relevant features and relevant relationship between features, especially synonyms and hierarchical dependencies between features.

Task 2: Define the Interpretation Model(s) *(once per domain)* It defines the 'admissible similarity questions', especially the required feature size functions (*fsize*, see section 4.4) and weight vectors (see section 5.2).

Task 3: Mining of Definition *(once per definition)* This task finds, extracts, and potentially edits definitions found in the supplied documents.

Task 4: Mark-up of Definitions *(once per definition)* To each identified definition experts/specialists assign the appropriate features from the taxonomy on a per aspect basis.

Task 5: Raw Comparison and Normalization (for each single aspect) *(once per comparison)* Create the similarity vector and compute the appropriate similarity score, taking inter-feature relationships into consideration.

Task 6: Aggregate similarity scores of aspects into similarity scores of a definition *(once per comparison of 2 definitions)* Compute the similarity score of the definition (using the weight vector, see Task 2).

Task 7: Aggregate similarity scores of definitions in different documents *(once per set of documents)*. Aggregate the similarity score of all definitions in a document or set of documents, using a weight function (often an average).

7. Conclusion

It is evident that mutual common understanding of the multiple actors in crisis and disaster management is essential for the success of crisis management activities. Federal and local authorities as well as the different first responders, e.g. fire brigades and ambulances, have diverse mandates, different histories and culture and consequently different processes. As a consequence they use different vocabularies or taxonomies. For the short terms it can not be expected that the involved actors will agree on using only a single vocabulary, despite its high potential. A crisis and disaster management thesaurus, however, showing variants of definitions in parallel, comparing them and measuring their semantic similarity has a high potential of acceptance. Such an approach can support crisis and disaster management actors and improve information exchange on the semantic level. It would help to identify the best possible definitions of terms for a specific situations.

8. Acknowledgment

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No.607798

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SOCIAL MEDIA AND ON-LINE PRIVACY

SOCIAL MEDIA AS A DATA SOURCE FOR HUMAN RESOURCES

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Keywords

Social networks, HR, Recruiting, Facebook, Twitter, LinkedIn, Data mining

Abstract

The paper analyzes means for collecting and analyzing data from social networking sites for HR purposes, mainly recruiting. We have determined available types of information and whether said information has value for HR purposes.

1. Introduction

Social media as an online interacting communities are the fastest growing communication platforms all around the word with. According to Global Web Index Slideshare annual research the social media market had increased by 17% last year with Asia – Pacific area as a growth drivers. (Chaffey, 2016) This way China can serve as an example because it is the world's most socially engaged market with 84% of Internet users uploading video, sharing photos and chatting at least once a month. They are followed by Russia, Brazil, and India. (Isaacson, Peacey, 2012).

When talking about the common use in corporate governance and business, social media (SM) are well-established tool to work with customer audience and increasingly, SM are also being mentioned as an innovative solution for employer brand building strategies. As the time goes on, SM are becoming an integral part of modern lifestyle. Millennials – people born between 1980 and 1995 – are getting engaged more intensively. In 2014 it was expected, 47% of working population should had been composed of millennials, who were raised up playing video games and living online. These people (X as well as the Y generation) are used to work without contact in person. That is also the reason why ways people are searching for job and getting information about their employer to be, are changing dramatically, because e.g. 41 % of university graduating students in 2011 searched for their first job on SM. The searchenginejournal.com released, in 2012 even 80% of companies used social media for recruitment and 95% of them used LinkedIn. KPMG added the information that 76% of American companies used LinkedIn and searched threw 100 million registered users when recruiting. Which is connected and maybe even based on the situation that more than 84% of job seekers have a Facebook profile, and 48% of them did at least once job-hunting activity on Facebook during last year. (Isaacson, Peacey; 2012)

This work is focused on the data available for HR offices and agencies, because according to Human resource management journal “employers are increasingly using SM as a mechanism to screen potential job candidates.” (Curran, Draus, Schrager, Zappala; 2014)

This leads us to the deeper look at the most job related social network – LinkedIn, and the most popular SM platform worldwide – Facebook. Furthermore it can be expected that the impact of social media content created and shared by potential job candidate will have higher importance in recruitment practices and even less frequent social media channels will be monitored.

1.1. LinkedIn

LinkedIn is a social network with more than 400 million members from over the 200 countries. (LinkedIn, 2019)

It was founded in 2003 with the aim to connect professionals all over the world and to create a place full of job opportunities and information. The data from 2014 says that every two seconds there is a new user registered to the network and LinkedIn is the 13th most visited website on the Internet. (Kadlec; 2014)

The whole hiring process is changing. Unemployment rate is usually declining and people do not feel the necessity of changing their jobs. According to the latest research there are about 80 % of users on LinkedIn currently not looking actively for a new job. In this case we are talking about passive candidates. We divide them into three types: Tiptoers (thinking about changing work), Explorers (they are not looking for a job but they stay open to change) and Super Passive (they are satisfied with their current work and they do not consider changing that). (Kadlec; 2014)

Our question is: „How can we use this particular social network and its data for HR purposes? “. As it is with almost everything, LinkedIn offers two versions of platforms for companies: paid (called Talent Finder) and unpaid (basic version). The difference consists in following business solutions:

Recruiter – it works closely with InMail communication on LinkedIn and offers a specific filters to get very precise results when searching for candidates. It includes a possibility of saving applicants to keep a shortlist of talents for future use. Mobile app allows recruiters to work on the go. (LinkedIn, 2019)

Job Slots – LinkedIn automatically delivers job offers to selected members. It is based on skills and expertise. Therefore the HR gets in touch with more relevant applicants. It also includes a tool called “Suggested Professionals” that screens qualified people even if they haven’t applied. It represents a great option to attract passive candidates, to review and filter them. It offers a distribution via Job Search App. (LinkedIn, 2019)

Career Pages – is a great possibility to present company’s values and mission. The content of a page can be dynamic in order to show different information in relation with viewer’s profile (location, industry, current position etc.). (LinkedIn, 2019)

Work With Us Ads – aims on top passive candidates. It works with new connections – when anyone connects to one of the employees from a particular company, LinkedIn is going to show them personalized job advertisement based on viewer’s profile. According to the data from company itself, their “recruitment ads dramatically outperform typical banner ads with up to 50 times higher clickthrough rate, driving interested professionals to your jobs, Career Page, and other destinations”. (LinkedIn, 2019)

Referrals – employees are able to create a wider network of connections related to their current and previous position and – also to look for connections in relation with their future job. All that information might be very useful for potential recruiter. (LinkedIn, 2019)

If LinkedIn is primary tool for hiring, then company should consider the possibility of an upgrade. But opting for an unpaid version also gives possibility to find and hire talented people. For an illustration there is a list of visible information in free version:

Basic data: Picture, Name, Sex, Age, Marital status, Location, Segment

Education: University, Courses and Certificates, Languages

Working Experience: Skills, Current Position, Reference/Recommendation, Rich media – presentations and projects.

Additional information: Volunteering, Interests

Participation on LinkedIn: Connections, Groups, Activity, Similar profiles

As LinkedIn expert Petr Kadlec says: “Access to LinkedIn by itself does not mean an advantage. Everyone has it.” (Kadlec, 2014) The only factor dividing us from being successful in recruiting is the knowledge of how to use it. Recruiter with an unpaid version has a possibility of sending 3000 invitations. In order to get the most of this tool is crucial to consider who we are going to turn in a new connection.

I would like to focus on using the data from previous table to recruit effectively. The most important things from basic data are location and segment. In case of Czech Republic there is no need to specify the location. The only effect would be increase of possibility that we might lose a good candidate because of its incorrectly filled profile. Recruitment segment is for example IT, banking etc. Our knowledge of that particular segment is the key. Then we are able to use the right key words in relation with the position we are hiring for. Another helpful recommendation consists in connecting with people from one segment in order to build recruiter’s specialization.

Data from education are useful when we look for a candidate with specific language skills or skills that need to be supported by a certificate. Sometimes it is convenient to search by universities, especially if we are interested in graduate student. In case of a senior position we would be much more interested in working experience. LinkedIn offers a wide range of information in this area. Besides skills and previous positions candidates can show their work in more interesting way using rich media (presentations, picture gallery or simple link to web page). Certain point of view can be created by several recommendations from people who cooperate with candidate on both sides – as co-workers, clients etc. I find this to be very useful tool. Additional information and data about candidate’s activity complete the full picture of him as a possible employee.

According to all the information mentioned above, I see a big potential in on-line recruiting, especially through this particular network. Candidate’s profile has much more to show in comparison to a regular CV send via e-mail. Many of the tools can also replace motivation letter. The done works speaks for itself. Companies will have better opinion of candidate’s qualities without long lasting and complex interviews.

1.2. Facebook

Facebook is the most often used social media platform worldwide. (Chaffrey, 2016) That is fascinating database of information connected with active users and provided by themselves personally. That is the reason why it can be really interesting data source for HR management, does not mind if they need to screen candidates, and try to disqualify those who are not appropriate or attract possible candidates.

Even though a sizeable majority of HR specialist, according to Gibbs, MacDonald and MacKay (2015) never uses subscription-based services for heavy users such as Facebook Marketplace (or LinkedIn Talent Advantage) Facebook allows its users to mine wide range of interesting user data through Facebook for developers Social Graph API. „From a social web mining standpoint, the wealth of data that Facebook stores about individuals, groups and products, is quite exciting, because Facebook´s clean API presents incredible opportunities to synthesize it into information (the world´s most precious commodity), and glean valuable insights.“ (Russell, 2014) The great responsibility goes with the great power, thus Facebook has one of the most sophisticated set of online privacy controls in order to protect its users from exploit.

Facebook (in contrast to e.g. Twitter) has a symmetric friendship model, which requires agreement between users to allow them the following activities and interactions of each other's. „As a Facebook social web miner, the only way that you can access a Facebook user's account data is by registering an application and using that application as entry point into the Facebook developer platform. Moreover, the only data that is available to an application is whether the user has explicitly authorized it to access“ (Russell,2014)

Facebook provides the full list of Graph API Root Nodes which can be minded via Social API, all of them are listed below.

Table 1. Facebook official API roots nodes list (Facebook, 2019)

Achievement	Represents a person gaining a game achievement
Achievement Type	A games achievement type
Album	A photo album
App Link Host	An individual app link host created by an app
App Request	An individual app request received by someone, sent by an app or another person
Application	A Facebook app
Application Context	Access to available social context edges for app
Comment	A single comment
Conversation	A Facebook Messages conversation between a person and a Facebook Page
Credit Card	Payment created by the payer.
Debug Token	Debug token endpoint docs
Doc	A Document
Domain	A web domain claimed within Facebook Insights
Education Experience	The person's education history
Event	An event
Friend List	This represents a user's friend list on Facebook
Group	A Facebook group
Group Doc	A document in a Facebook group
Life Event	Page milestone information
Link	A link shared on Facebook
Mailing Address	A mailing address object
Message	A single message in Facebook Messenger
Milestone	A milestone for a Facebook Page
Notification	An individual unread Facebook notification
Object Comments	Comments on an object

Object Insights	Insights and metrics for an object
Object Likes	Likes for an object
Object Shared posts	Shares of this object
Offer	An offer published by a Facebook Page
Open Gr. Act. Type	An Open Graph action type
Open Graph Context	Social context
Open Gr. Obj. Type	An Open Graph object type
Page	A Facebook page
Page Call To Action	Page's call-to-action
Page Status Card	The page status card displayed on a page when a user completes a CTA flow.
Payment	A single payment
Photo	This represents a Photo on Facebook
Place	A place
Place Tag	A Place Tag
Place Topic	The category of a place Page
Post	Special syntax for the link field.
Profile	A profile - a user, page, group or event
Promotion Info	A promotional info for the post.
Request	An app request received by a person. A request can be sent by an app or another person
Status	A status message in a profile's feed
Test User	A test user associated with a Facebook app.
Thread	A messages thread in Facebook Messenger
URL	Shares, app links, and Open Graph objects URL
User	Returns a single user node
User Context	Social context for a person
Video	A Video
Video List	A playlist for videos
Work Experience	Information about a user's work

When analyzing opportunities for HR management to mine useful information though the API, we should mostly be focused on Education Experience, Life event, Open graph context, User context and Work experience roots, furthermore we each or rather to say most of the roots can bring back interesting answers but basic is the question, HR specialist wants to ask. What kind of information provided by this Facebook could be suitable for the situation depends on type of work position, responsibilities of employees, specialization of the company, type of the marketplace, and many others.

2. Collecting information

This section will cover some of the available options for social media data extraction, which can be suitable for use in human resources departments. The general purpose of many of these options varies widely, therefore this chapter will be divided into parts based on the group of alternatives discussed within each part.

2.1. Apps for recruiters

As was mentioned above, the tools which can be used for data extraction come in various forms, the first of which, and probably the simplest is mobile/smartphone applications. Smartphones and tablets are becoming more and more available thus creating space for apps of all kinds. It comes as no surprise that there exist specialized standalone apps built exclusively for recruiting purposes.

LinkedIn has consistently been among the top 10 social networks rated by the market share of visits according to Dreamgrow (Dreamgrow, 2016) and it is also widely recognized as the primary place to find talent online. (Medved, 2015) Since LinkedIn operates as a professional social network the use of data shared through this network is pretty straightforward in regards to recruiting and HR. In its Source of Hire report (a yearly analysis of where some of the world's largest companies have been finding talent) CarrierXRoads state that LinkedIn is becoming more and more of a staple in recruiting. (Crispin, 2014)

As if the use of LinkedIn in HR wasn't simple as it is, a standalone app for recruiters called ***LinkedIn Recruiter*** is available for both Android and iOs makes things even easier. It allows recruiters to search and review profiles, manage job postings, save and add notes to candidate profiles on-the-go. (LinkedIn, 2019)

Among the other popular online employment solution is a company named ***Monster***. The company has been around for about 20 years and was once the top-dog in online recruiting along with Carreerbuilder.com. (Crispin, 2014) The company has expanded from a "job board" to a global provider of a full array of job seeking, career management, recruitment and talent management products and services. (Monster, 2016)

As expected of one of LinkedIn's contenders, Monster also has a free app for recruiters that can be used not only to post new jobs, but shortlist applicants, search resumes, contact candidates etc. (Monster, 2016)

2.2. Facebook apps

Work4 Labs is a global player in terms of social recruiting. This app makes it possible for companies to directly target the most suitable candidates, based on criteria such as their location, education or work history and using this information they can post job ads, events and company news on the selected individual's news feeds. Another key feature of Work4 is a careers tab, appearing on the navigation bar of a company's Facebook page. Current job openings can be listed here, allowing candidates to apply with a simple 1-click application system, using information that they have previously entered.

An upgraded version of the app, called Work4 Recruiter Solution, is also available and works similarly to LinkedIn, functioning as a database of potential talent and users have access to source from any one of Facebook's 1.23 billion users. The solution adapts Facebook's Graph Search for recruiting, by syncing it to any applicant tracking system and adding automated search, referrals and tracking so recruiters can easily find and contact exactly the right talent for their jobs. Alongside the simple design, with the ability to share and 'Like' jobs as well as applying, Work4 Labs offer 'detailed metrics' of the recruiter's progress – including number of views, applicants and likes for each posting – an interesting element which may help discover which is the most popular job. (Deering, 2015)

The ***Jobcast*** app is sold on the basis that not everyone are on job boards, but they are on Facebook and therefore opens up their reach to passive candidates, which are highly regarded by a lot of recruiters. The application is one of the most popular available, used by the likes of Samsung and Pizza Hut and enables companies to transform their Facebook page into a career site, by posting job listings directly to their Facebook timeline, also making it possible for users to like, comment on and share job listings.

Jobcast also makes it even quicker and easier to broadcast jobs on multiple platforms with its automated sharing feature, which will broadcast your jobs across Facebook, Twitter and LinkedIn, saving the time and effort of having to create separate listings. Additionally notes about candidates can be added for sharing with team members, tracking hires, and rating applicants. The free version allows recruiters to post an unlimited amount of jobs, with additional options, such as the publish duration and all the standards fields including an applicant routing option – whether the recruiter wants the application to actively collect all the applications, or redirect applicants to an external site to apply. The upgraded versions offer Jobcast branding removal, a customized banner, an embeddable YouTube option, a brandable colour scheme and the more expensive plan being the only one to offer automatic job synchronization with the recruiter's career site. (Deering, 2015)

2.3. Twitter apps

TweetMyJobs holds two options for recruiters – the small business, free option (less than 25 jobs per year) and the enterprise (more than 25 jobs per year) option. Some big clients (such as Intercontinental Hotels Group) use the Enterprise option, where the company receives its own 'branded [job] Twitter channel', however both options receive post distribution on Facebook and Twitter.

According to statistics from the @TweetMyJobs_EU feed, the website tweets well over 1,000,000 jobs a month, and around 60,000 or more a day – so your post may become lost if you use the free option, however it has received a lot of positive feedback. (Hebberd, 2012)

TwitJobSearch is a simple search engine for jobs. There are three options – either TJS can pick up a job tweet, recruiters can have an XML file of jobs tweeted by TJS, or recruiters can manually add their jobs to the search engine (linked via their Twitter account). The website is extremely simple to use and there is no charges for posting jobs. (Hebberd, 2012)

2.4. Universal apps

Jobvite offer two Facebook apps, 'Work With Us' and 'Jobvite Facebook Application'. Much like Work4, the 'Work With Us' app enables users to add a Jobs tab to any Facebook page. The tab can be used to display current job listings directly within the company Facebook page, allowing users to search the listings and apply for jobs through Facebook. Alternatively, they can send 'jobvites' to other users who may be interested in the ad, working as job referrals. This activity is all tracked, making it possible for the recruiter to monitor the progress and interest in all job openings. (Deering, 2015)

The 'Jobvite Facebook Application' app creates a large network of all of their Facebook friend's connections, enabling recruiters or employees to easily search for potential matches to available jobs, using the app's matching technology. Users are then free to privately invite matches to apply for jobs using Facebook and when employees refer a connection, they'll be awarded with credit as an incentive.

Both apps also have 'Twitter channel feeds', which promise automatic distribution of jobs with shortened and trackable URLs and hashtags, as well as automatic posting on Facebook, Twitter and

LinkedIn feeds. Jobvite also release a 'Social Recruiting Survey' each year, so have a lot of knowledge in their field. (Hebberd, 2012)

There are many other apps that specialize in providing useful tools for recruiters, but the main objective here is to prove their significance and usage rather than name them all. Among others that are worth noting are Hootsuite (Twitter app which can post tweets and job posts) SmartRecruiters or Talent Xray to name just a few. (Russel, 2014)

2.5. Data mining tools

Moving on to more complex forms of data extraction, data mining tools come into play. These tools can perform various tasks ranging from data preprocessing, visualization, predictive analytics and statistical modelling. Their use is not limited to social networking sites and it also important to keep in mind that many of these tools require specific skills in order to fully utilize their potential. Despite the immense capabilities of these tools one does not need to spend a fortune in obtaining one, there are dozens of free data mining tools out there and their quality matches that of paid tools. Because of this, there is really no reason to look into the paid tools since their use in HR will be limited and paying for a service you are not going to fully utilize is nonsense. Below is a description of five of the best free data mining tools. (Goopta, 2014)

RapidMiner is the number one open source predictive analytics platform. It is written in Java and offers advanced analytics through template-based frameworks. Its customization options are limited since it's distributed under the AGPL open source license and one of its advantages is that users don't need to write much code to use it. In addition to data mining, RapidMiner also provides functionality like data preprocessing and visualization, predictive analytics and statistical modeling, evaluation, and deployment not to mention the its use in analyzing Big Data thanks to the recent addition of Hadoop support. RapidMiner also provides learning schemes, models and algorithms from Weka and R scripts, which will be mentioned later. (RapidMiner, 2019)

Orange is a data mining and machine learning software written in Python. It's suitable for both novices and experts and offers data visualization and analysis through either visual programming or Python scripting. Along with machine learning, the suite has add-ons for bioinformatics and text mining. Rich in features for visualizations (bar charts, trees, heatmaps and networks) and data analytics, Orange also remembers choices that were made and suggests most frequently used combinations to intelligently choose the channels for its widgets. Despite its advantages, Orange seems unable to download data from the internet and needs to be fed an actual data file to work with rather than being able to get data by itself. (Orange, 2019)

Knime or the Konstanz Information Miner is a user friendly and comprehensive data analytics framework whose features cover the entire analysis process from data access, pre-processing to predictive analytics, visualization, and integration as well as reporting. Written in Java and based on Eclipse, it has a lot of potential for extension and adding plugins is easy. The basic software is free but there a number of commercial extensions. A big part of why Knime is mentioned here is its ability extract, transform and load data by itself, or the ability to cover data preprocessing which was explained earlier in this text. (Knime, 2019)

Weka is a sophisticated Java based tool for visualization, data analysis and predictive modeling. Distributed under the GNU General Public License means it's free and users can customize it however they want, which gives it an advantage over non-customizable tools like RapidMiner for example. Weka is a collection of machine learning algorithms for data mining tasks. The algorithms can either be applied directly to a dataset or called from a Java code. Weka contains tools for data preprocessing (this means it can get its own data), classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes. It can also access SQL databases and process query results, however it is not capable of multi-relational data mining without use of a separate software for converting a collection of linked database tables into a single one. (Weka, 2019)

The last data mining tool mentioned here is ***R*** (commonly referred to as R-project or the R language. R is a language and environment for statistical computing and graphics. It is a GNU project which provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, etc.) and graphical techniques, and is highly extensible. (R, 2019)

R is an integrated suite of software facilities for data manipulation, calculation and graphical display. It includes

- an effective data handling and storage facility,
- a suite of operators for calculations on arrays, in particular matrices,
- a large, coherent, integrated collection of intermediate tools for data analysis,
- graphical facilities for data analysis and display either on-screen or on hardcopy,
- a well-developed, simple and effective programming language which includes conditionals, loops, user-defined recursive functions and input and output facilities (R, 2019)

2.6. Power Query

Power Query (or Get & Transform in Excel 2016) is an MS Excel add-on which serves as a self-service Business Intelligence platform. It allows extracting/downloading, combining, and refining data across a wide variety of sources, such as Web page (even Facebook), Folder or Excel/CSV/XML/Text file, Databases from (SQL Server, Microsoft Azure SQL, Access, IBM DB2, MySQL, …), OData feed, Microsoft Azure Marketplace, HDInsight and Table Storage, Hadoop File (HDFS), Active Directory, Microsoft Exchange.

3. Conclusion

The article described various social media and the data found on them from the point of view of human resources. It has been proven that social media data is now commonly used for the HR purposes and there are a number of applications and programs that can be utilized. The second part of this article provides an overview of selected best apps. The current issues of privacy and security on social media are thus very topical and should not be overlooked.

4. Acknowledgment

Paper was processed with contribution of grant IGS 27/2019 from the Faculty of Informatics and Statistics, University of Economics, Prague.

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RECENT ANOMALY DETECTION APPROACHES IN COMPUTER NETWORKS

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Keywords

Anomaly detection, machine learning, computer networks

Abstract

In this paper a global overview of the recent and the most prominent anomaly detection algorithms and techniques is presented. These techniques are divided into two main categories – supervised and unsupervised, although some methods can use both approaches. These approaches are considered in computer networks environment. The results show the best possible methods which can be used nowadays to detect anomalies in such environment.

1. Introduction

We live in a complex world where personal data are getting more and more valuable. The value of personal data from two complementary perspectives: the value of personal data for companies and the value of personal data for individuals (Lieshout, 2015). Both of these groups show steady increase of importance, which obviously attracts attackers. In recent years, there have been substantial increasement of attacks directed towards computer networks. In virtue of these attacks, the need for security protection is increasing noticeably (Chio et al., 2018). Many basic attacks can be prevented quite simply, for example by blocking certain scripts, restricting access from unsecured networks or analyzing system log messages. Modern attacks can be very sophisticated with possible chance to avoid most of the basic protection mechanisms. In order to prevent these attacks from being successful, there is a need for more advanced protection mechanisms (Bhuyan et al., 2017). These mechanisms are usually based on log analysis, which involves combining several different log sources together, cleaning them and finding coherence between individual events. This deeper analysis could find very valuable information and potentially prevent harmful breach.

One of the ways to do so is using anomaly detection methods (Dunning et al., 2014), which can analyze network traffic and observe user behavior. If there is an unusual behavior detected, it can alert system administrator and he can react to it accordingly. These methods can result in a lot of false errors notification, so it’s very important to choose these algorithms wisely and validate them on real data, especially in non-standard area such as is university environment (Stamp, 2018).

There are two possible approaches to detect intrusion in the system – signature-based detection and anomaly detection. Signature based detection, also known as misuse detection-based approach, identifies attacks in form of a signature or pattern and compare system interaction to them. That means it can only detect known attacks, i.e. attacks which have been documented and their patterns are coded into the algorithm. Although they usually work very well in preventing such attacks, the huge disadvantage is the fact that it fails in identifying unknown threats and attacks. In contract, anomaly detection methods are designed to detect mainly unknown threats or unusual behavior.

2. Anomaly Detection Definition

Anomaly in general is a value or action that deviates from what is standard, normal or expected. They are divided into three categories: point, contextual and collective anomalies. Point anomalies are defined as a single instance of data is anomalous if it's too far off from the rest. Contextual anomalies are defined when the abnormality is context specific. This type of anomaly is common in time-series data. Collective anomalies are a set of data instances collectively helping in detecting anomalies.

Anomaly detection is similar to — but not entirely the same as — noise removal and novelty detection. Novelty detection is concerned with identifying an unobserved pattern in new observations not included in training data. Noise removal (NR) is the process of immunizing analysis from the occurrence of unwanted observations; in other words, removing noise from an otherwise meaningful signal (Oracle, 2018).

3. Anomaly Detection Algorithms and Techniques Overview

Anomaly detection approaches use machine learning techniques and are divided into two main categories – supervised and unsupervised learning algorithms (Bhattacharyya et al., 2013). Both of these groups contain specific methods and can be useful for different purposes. Some of them are much better for large sum of data or complex data. Others are more suitable for smaller sample sizes or more simple data. Several methods can belong both into supervised and unsupervised category, depending on its setting. Machine learning techniques are not useful only in anomaly detection algorithms but can be widely successful in other fields as well (Sladek et al., 2018), for example in a traffic safety (Lamr et al., 2017).

3.1. Supervised Learning

Supervised learning techniques have a wide range of possible applications in data mining industry or anomaly detection. As its name implies, these techniques need to be supervised. There is a teacher who tags data with right answer – labels them. Algorithms based on supervised learning use a well-known training dataset to model a function to make future predictions. Supervised learning techniques can be divided into two categories – regression and classification. Regression techniques are used for continuous output variables. Classification techniques can be used for simpler data, such as numbers and categories. Some more complex algorithms combine all of the approaches described above.

K-nearest neighbor (k-NN) is considered as one of the simplest classification algorithms. It stores the labeled training data and classifies new data based on similarities in distance metrics. To classify them it uses density-based anomaly detection methods – either Euclidean distance (continuous data) or Hamming distance (discrete data). Due to these facts, it works very well for dynamic environment with frequent updates and non-standard data types. Tsigkritis and his coworkers implemented k-NN algorithm in a log database system in PCCW Global using actual network traffic from backbone network. It was used to generate early notifications regarding suspicious IPs that although no security information was available, they were observed with similar traffic behavior with IPs that have been involved in network security incidents in given time context (Tsigkritis et al., 2018).

Hidden Markov Anomaly Detection (HMAD) is based on Hidden Markov Model (HMM). Görnitz and his coworkers extended the regular one-class support vector machine and optimized the approach, which is non-convex, via a DC (difference of convex functions) algorithm and showed that the parameter "ν" can be conveniently used to control the number of outliers in the model. It combines ideas from structured output learning and kernel-based anomaly detection. The results showed that the proposed HMAD significantly outperformed the original one-class SVM on real output sequence data (Görnitz et al., 2015).

One class Naive Bayes classifier for payload-based anomaly detection (OCPAD) is based on Multinomial Naive Bayes, which assumes that the attributes are conditionally independent and tries to estimate class-conditional probability. It requires only one scan of training data for classification, which makes it quite easy and fast. It provides good results where simpler relations exist. Swarnkar and his coworkers proposed this approach for detecting HTTP attacks. Their experiments with a large dataset of 1 million HTTP packets collected from an academic network revealed OCPAD has a high Detection Rate (up to 100%) compared to previous methods and acceptable rate of False Positives (less than 0.6%) (Swarknar et al., 2016).

Isolation Forest (iForest) builds an ensemble of iTrees for a given data set, then anomalies are those instances which have short average path lengths on the iTrees. There are only two variables in this method: the number of trees to build and the sub-sampling size. iForest's detection performance converges quickly with a very small number of trees, and it only requires a small sub-sampling size to achieve high detection performance with high efficiency. Anomaly detection using iForest is a two-stage process. The first (training) stage builds isolation trees using subsamples of the training set. The second (testing) stage passes the test instances through isolation trees to obtain an anomaly score for each instance. As a result, iForest has a linear time complexity with a low constant and a low memory requirement which is ideal for high volume data sets. Essentially, Isolation Forest is an accurate and efficient anomaly detector especially for large databases. Its capacity in handling high volume databases is highly desirable for real life applications (Liu et al., 2008)

Robust Random Cut Forest Based Anomaly Detection is based on Random Forest. If the data is recorded in the correct scale, distance is crucially important to preserve for computations, and not just anomaly detection. They adopted a model-based definition of an anomaly that captures the differential effect of adding/removing a point on the size of the sketch. Experiments suggested that the algorithm holds great promise for fighting alarm fatigue as well as catching more missed alarms. They tested the algorithm in New York City taxi ridership and compared it's results to Isolation Forest algorithm. According to the researchers it caught more anomalies and also caught them significantly faster (reduction from 11 hours to 7 hours compared to Isolation Forest) (Guha et al., 2016).

Stochastic Gradient Boosting Average Precision (SGBAP) is focused on areas with very sparse positive examples. They instantiate the loss function in two different ways: first, they introduced a differentiable version of AP using the sigmoid function. Then, in order to reduce the algorithmic complexity, they suggested to use a rough approximation based on the exponential function. They showed that this second strategy allowed them not only to drastically reduce the complexity but also, to get similar or even better results than the sigmoid-based loss. (Frery et al., 2017).

One-Class Kernel Fisher Criterion is based on Fisher linear discriminant and improves it. Dufrenois and his coworkers proposed a one class Fisher's linear discriminant to isolate normal data from outliers. Originally on the basis of an iterative optimization process, alternating between subspace selection and clustering, they showed there that their criterion has an upper bound making these two problems independent. In particular, the estimation of the label vector was formulated as an unconstrained binary linear problem (UBLP) which can be solved using an iterative perturbation method. Once the label vector is estimated, an optimal projection subspace is obtained by solving a generalized eigenvalue problem (Dufrenois, 2015).

3.2. Unsupervised Learning

Unsupervised learning techniques work without human interference, that means there is no need for labels. They sort information according to similarities and don't need any training data to detect an anomaly. Unsupervised learning techniques can be divided into two categories – clustering and association. Clustering techniques assigns objects to subsets – clusters, where the object have similar characteristics. Association techniques use association rules to find association amongst data. They tend to discover relationship between variables in large dataset. Some more complex algorithms combine both approaches.

K-means is simple and very popular clustering algorithms. It pairs objects with similar parameters into cluster groups. It supports only numerical data and needs equally distributed observation of each cluster to work properly. Although it's considered as unsupervised learning technique, it could be considered semi-supervised in case of adequate human interference. K-means algorithm is good to be used in cooperation with other methods like ID3 decision tree learning (Gaddam et al., 2007). Shekhar and his coworkers were able to pair these two methods in order to first partition the training instances into clusters and then use ID3 to build a decision tree above each cluster. Decision trees are built to obtain a final decision on classification in order to reach high accuracy and low false-positive rate. By using testing data that contained network anomalies, duffing equation data and mechanical system data, Shekhar´s team was able to reach 85,38 % anomaly detection accuracy with data from different sources.

Local Outlier Factor (LOF) uses a concept of local density. It determines areas of similar density and detects objects that have a significantly lower density that their neighbors – these are tagged as anomalies. Although it belongs to nearest neighbor techniques, it is called a density-based algorithm (Breunig et al., 2000). LOF had been used for example in order to create detection model of malicious network behavior generated by smartphone users (Hu et al., 2018), which was adopted in ADMDM model for dynamic behavior analysis. By using local outlier factor method authors were able to reach good results in unknown anomaly detection environment.

Connectivity-based Outlier Factor (COF) is based on local outlier factor but tries to solve some of its issues. It assigns degree of outlier to each data point. An improved Incremental Connectivity-based outlier factor algorithm had been developed (Pokrajac et al., 2008) in order to improve computation efficiency. Proposed Incremental COF algorithm computes COF value for each data record inserted into data set and instantly determines whether inserted data record is an outlier. Experimental results from synthetic data show that detection performance has same accuracy rates as static COF algorithm, but with higher computation efficiency.

Local Outlier Probability (LoOP) algorithm defines a score for data objects in range from 0 to 1, which means that it contains the probability of data object to be an anomaly. These scores are comparable within a data set or even between different data sets. This method is focused on answering the question how to interpret outlier factor in order to decide if the data object is an outlier. Outputs generated by this algorithm are meant to give directly interpretable results as a probability of a data object for being an outlier (Kriegel et al., 2009).

Local Correlation Integral (LOCI) is density-based approach for outlier analysis. It uses only nearby data points in terms of distance to compute density of a point. LOCI is highly effective for detecting outliers and groups of outliers (a.k.a.micro-clusters) (Papadimitriou et al., 2003).

Subspace Outlier Degree (SOD) explores outliers in subspaces of the original feature space by combining the task of outlier detection and relevant subspace finding (Kriegel et al., 2009). SOD was used by Liangwei Zhang and his team in industrial environment with an application to industrial fault detection. By default, an industrial fault can be classified as an anomaly in high-dimensional reliability data. Experiment demonstrated on industrial dataset showed promising results (Zhang et al., 2015).

Link-based outlier and anomaly detection in evolving data sets (LOADED) is designed to work well with mixed attribute data sets under a variety of constraints, such as minimizing the time to respond, and adapting to the data influx rate. LOADED is one-pass algorithm for outlier detection in evolving data sets containing both continuous and categorical attributes (Ghoting et al., 2004)

Table 1 - Anomaly Detection Techniques Overview

Method	**Type**	**Primary category**	**Researcher**
Connectivity-based Outlier Factor	Unsupervised	Clustering	Pokrajac et al., 2008
Hidden Markov Anomaly Detection	Supervised	Classification	Görnitz et al., 2015
Isolation Forest	Supervised	Classification	Liu et al., 2008
K-nearest neighbor	Supervised	Classification	Tsigkritis et al., 2018
K-means	Unsupervised	Clustering	Gaddam et al., 2007
Link-based outlier and anomaly detection in evolving data sets	Unsupervised	Clustering	Ghoting et al., 2004
Local Correlation Integral	Unsupervised	Clustering	Papadimitriou et al., 2003
Local Outlier Factor	Unsupervised	Clustering	Breunig et al., 2000
Local Outlier Probability	Unsupervised	Clustering	Kriegel et al., 2009
One-Class Kernel Fisher Criterion	Supervised	Classification	Dufrenois, 2015
One class Naive Bayes classifier for payload-based anomaly detection	Supervised	Classification	Swarknar et al., 2016
Robust Random Cut Forest Based Anomaly Detection	Supervised	Classification	Guha et al., 2016
Stochastic Gradient Boosting Average Precision	Supervised	Regression	Frery et al., 2017
Subspace Outlier Degree	Unsupervised	Clustering	Kriegel et al., 2009

4. Conclusion and future work

We prepared a complete overview of the most recent and prominent approaches for anomaly detection techniques in computer networks, both supervised and unsupervised. According to performed research we also prepared a subjective ranking of the most appropriate methods for anomaly detection in computer networks sorted by potential effectiveness (the most promising ones). We evaluated all of the methods mentioned above mostly theoretically and considered the results in papers which they were used in computer networks environment.

Table 2 – Ranking of The Best Anomaly Detection Techniques

Ranking of Potential Effectiveness	Method	Justification
1.	Hidden Markov Anomaly Detection	Precise detection and ability to detect new and unknown intrusions well, real-time data processing
2.	Isolation Forest	Accurate and efficient especially for large databases
3.	Robust Random Cut Forest Based Anomaly	Similar to Isolation Forrest, but potentially faster, although it needs to be set more precisely
4.	K-means	Ease of implementation, very popular

Hidden Markov Anomaly Detection, Isolation Forest, Robust Random Cut Forest Based Anomaly and K-means algorithms performed generally well with most promising results, although in most cases, they needed to be adapted for specific environment. That will be part of our subsequent research, which will be focused on benchmarking the mentioned algorithms within environment of university information system. University environment is different to usual business company environment. Users of university systems are very variable as every year new students are coming, while some others are leaving. There is also a high number of external experts who cooperate with university but not in same way as casual employees. In such conditions there can be defined a specific user behavior that's very different to user behavior that can be observed in business environment. As research suggests, some students use the system in a non-intended way, exhibit long periods of off task behavior, try gaming the system, seek help of parents or peers, etc. Such usage patterns will manifest themselves in sequences of activity that do not represent student abilities and will result in student modelling anomalies causing subsequent suboptimal adaptive interventions from the system (Sosnovsky, 2018). We need to consider these differences and modify existing approaches for them.

So far, we are in process of polishing data from university information system log from last several years, where every action of every user is stored. We structured the data to be ready for running anomaly detection algorithms and already tested few of the simple ones to verify that data are prepared for more advanced algorithms which we will run in the future. We would focus mainly on anomaly detection techniques we considered the best in our subjective ranking list mentioned above. Final artifact of our following research will be proposing a modification to one of the methods described in this paper which will perform the best in computer networks in university environment.

5. Acknowledgment

This paper has been financially supported by Internal Grant Agency of University of Economics, Prague by a project F4/12/2019.

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STUDY OF ANONYMIZATION TECHNIQUES FOR LOGGING DATA FROM UNIVERSITY INFORMATION SYSTEM

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Keywords

Data anonymization, privacy-preserving, anomaly detection

Abstract

Sensitive personal data are collected in various domains. If such information becomes publically available, it can be misused by a malicious adversary. Thus various anonymization techniques are currently being adopted to protect such data. The paper focuses on the data privacy techniques related to data mining tasks, particularly to anomaly detection. The motivation is an ongoing research project in the area of computer attacks in the university information system. We provide an introduction to data privacy, enumerate the types of privacy attacks, describe selected techniques to protect sensitive data and propose an approach how to anonymize such data.

1. Introduction

Sensitive personal data are collected in various domains, medicine, banks, and insurance companies or e-shops being typical examples. If such information is publically available, it can be misused by a malicious adversary. There has been a tendency to regulate the conditions for handling of privacy information in the past by governments or professional committees. Recently, the GDPR directive has been implemented in the EU countries including the Czech Republic. Thus the anonymization techniques, i.e. techniques of changing the data in a way that prevents the *identification* of sensitive information (mostly a person), are currently being adopted in the commercial sector and further research is supported.

We are focusing on the data privacy techniques related to data mining tasks, particularly to anomaly detection. The motivation of our anonymization study is an ongoing research project in the area of computer attacks in the university information system. Here we use the term “attack” in two different contexts; attack on the information system itself and attack on someone’s privacy when any dataset is published. We provide an introduction to data privacy, enumerate the types of privacy attacks and describe selected techniques to protect such sensitive data. For the anonymization, we focus on the models which mathematically guarantee some level of protection of the sanitized dataset (i.e. a dataset, where sensitive information has been made safe so that it can be published, it is more general term than data anonymization). The techniques simply perturbing or masking the data are not included in the paper. We further discuss some algorithms and open-source tools available for anonymization. We also describe the structure of the university information system log data and present an approach on how to anonymize our data in future experiments.

2. Privacy-preserving Data Mining

Privacy-preserving techniques deal differently with a substantial problem, how to guarantee that sensitive information cannot be reconstructed or revealed during and after data mining. They also use different procedures on how to process or modify sensitive data. There are two contradictory requirements on the dataset. One is having high data utility and second is having little sensitive information at the same time. It is always a tradeoff and hence it is important to choose a convenient technique for the data mining use case one wants to perform.

According to Qi and Zong, (2012) there are five aspects which researchers consider during the definition of the privacy protection methods: *data distribution* (physical location of the data sources), *data distortion* (how to modify data, e.g. perturbation, blocking, aggregation or merging, swapping and sampling), *data mining algorithm* (using of data mining algorithm for privacy protection), *data or rules hiding* (hiding of output model rules, classifier downgrading, etc.), *privacy protection* (proposed privacy model which maintains sufficient data utility).

When dealing with privacy information a researcher works with a dataset which can have different recipients based on the case of the data mining task. Different types of information which need to be protected represent also different risks: *identity disclosure* (an individual is revealed, named re-identification) and *attribute disclosure* (sensitive information about an individual is revealed). Different recipients then can represent different risks of re-identification. Based on the type of information and the recipient, different privacy attacks need to be considered. The recipient of nonpublic data is a qualified investigator, whereas the recipient of public data can by any person. The attack scenarios on public data include *prosecutor scenario* (target a specific person in the dataset which is known to the adversary, this increases the risk), *journalist scenario* (target at least one person, they are not known to the adversary, the goal is often to embarrass or discredit) and *marketer scenario* (adversary tries to re-identify as many persons as possible) (Emam, 2013).

3. Privacy Models

Data anonymization is the process of changing the data in a way that prevents the *identification* of sensitive information. There is extensive research on different privacy models describing how to ensure anonymization and measure its level. We focus on selected techniques which could be convenient for the type of data generated by the university information system.

Samarati and Sweeney (1998) propose a formal foundation for the anonymity problem against linking and for the application of generalization and suppression towards its solution. They define *quasi-identifiers* (attributes which can be used for linking attack, *QI*) and *k-anonymity* (degree of protection of data with respect to inference by linking). The transformations proposed to achieve such anonymized dataset are *generalization* and *suppression*. The definition of k-anonymity requirement says that each release of data must be such that every combination of values of *QI* can be indistinctly matched to at least k individuals. The proposed algorithm to achieve k-anonymity uses vector distance metrics to measure the level of generalization. It is calculated as a length in the domain generalization hierarchy (*DGH*) for each attribute of two tuples (from the original and anonymized set). The algorithm searches for minimal possible generalization which satisfies k-anonymity condition. The second transformation is the suppression, which means to remove complete tuple. This is used to eliminate outliers to prevent over-generalization. The minimal required suppression is searched, maximal suppression is a user-defined parameter and suppression is preferred over generalization.

A new version named *k^m-Anonymity* was designed for transaction data (data having variable length, high dimensionality and the same domain for all the values) to avoid the association of specific transactions to a particular person (Terrovitis, Mamoulis, & Kalnis, 2008). The maximum knowledge of an adversary is *m* items in a specific transaction. For any set of *m* or fewer items, there should be at least *k* transactions in the published dataset.

The k-anonymity model is prone to many kinds of attack, especially if an adversary has some background knowledge. Authors of the *ℓ-Diversity* model present two attacks on a k-anonymous dataset, the *homogeneity attack*, and the *background knowledge* attack (Machanavajjhala, Gehrke, Kifer, & Venkitasubramaniam, 2007). Homogeneity attack can be performed on the k-anonymous group, which has no diversity in a sensitive attribute (has the same value). If adversary predicts which group belongs an individual to, he/she knows the sensitive information as well. Background knowledge attack can be performed when the adversary has some knowledge that helps to choose one sensitive value (i.e. *positive disclosure*) from more possible values in the k-anonymous group or to eliminate some possible values (i.e. *negative disclosure*). The k-anonymity model protects individuals from being identified but does not provide any method of protecting the sensitive values within a group of k individuals. The ℓ-diversity model introduces the concept of the diversity of sensitive values within a q-block. Q*-block is a set of tuples whose non-sensitive attribute values generalize to q* (* means suppressed value). According to the definition of ℓ-diversity principle, a q*-block is ℓ-diverse if contains at least ℓ well-represented values for the sensitive attribute. A table is ℓ-diverse if every q*-block is ℓ-diverse. The larger the value of ℓ, the more information is needed to rule out possible values of the sensitive attribute. It is possible to use the same algorithm as proposed for k-anonymity with the modification of checking the ℓ-diversity condition instead of k-anonymity.

t-Closeness model enhances ℓ-diversity model in such way, that it requires the distribution of a sensitive attribute in any equivalence class to be close to the distribution of the attribute in the overall table (Li, Li, Venkatasubramanian, & Labs, 2007). It also overcomes the limitation other methods have – the assumption that all sensitive attributes are categorical and the attacker either learns something sensitive or not. But if attributes are numerical, being close to the value is often good enough. ℓ-diversity requirement ensures diversity of sensitive values but does not take into account the semantic closeness of these values. If the values are semantically close within the group, such information disclosure also reveals sensitive information. Such case is described by the authors as *similarity attack*. The distribution of the sensitive attribute in the overall population is assumed to be public information, therefore the distribution for the same attribute in the equivalence class should be similar (smaller than a threshold *t*).

According to Dwork (2006), differential privacy *(DP)* means that risk to someone's privacy should not increase as a result of participating in a statistical database. The author defines a randomized function, which gives *ε-differential privacy* if the probability for each possible randomized (output) dataset changes at most by a multiplicative factor of exp(ε) for any single element changed in the input dataset (considering the probability of randomized function). This represents the privacy risk of someone participating in the database. Such a randomized function is achieved by adding appropriately chosen random noise to the data. Sensitivity is then defined as a maximal difference in the randomized datasets, when original datasets are differentiating in at the most single element. Sensitivity is a property of the function and the goal is that the noise is small. The privacy mechanism adds symmetric exponential noise to each instance.

ρ-Uncertainty anonymization model, designed for transaction data, protects against mining sensitive inferences (Cao et al., 2010). The objective of the method is to prevent an adversary from disclosing sensitive transaction items from knowing other non-sensitive items. Authors define the sensitive association rule (SAR) as a rule which antecedent represents the items known to the attacker and consequent has at least one sensitive item. The transaction dataset satisfies ρ-uncertainty, if for any subset of any transaction (χ) and any sensitive item (α), the confidence of SAR for $\chi \rightarrow \alpha$ is less than a value ρ. Information loss for the generalized item is defined as the ratio between the number of the leaves of the generalized item and the total number of items. For a suppressed item, the information loss is 1. The proposed algorithm generating an anonymized dataset with the confidence lower than ρ and minimized information loss is based on top-down global generalization and an iterative greedy heuristic for suppression.

4. Algorithms, Tools and Quality Metrics for the Anonymization

We selected several algorithms which we consider to be used with the university data.

Datafly was proposed by the author of the k-anonymity model prior to the release of the k-anonymity model (Sweeney, 1997). Datafly automatically generalizes, substitutes and removes some information in the data without losing too much detail. The algorithm requires an user-specified parameter *anonymity level* in the range [0, 1] according to which the minimum size of the bin (the number of occurrences of every value in each field) is defined. For a public release of the data, the level should be 1 for all sensitive fields.

Incognito is designed to achieve k-anonymity in an optimal way (Kristen LeFevre, DeWitt, & Ramakrishnan, 2005). The algorithm performs a bottom-up breadth-first search and generates the set of all possible k-anonymous full-domain generalizations. It uses *DGH* for the individual attributes and combined for multiple attributes to a multi-attribute generalization matrix (when the *QI* consists of more attributes). It optionally uses a maximum suppression threshold.

Mondrian is one of the approximation models (K. LeFevre, DeWitt, & Ramakrishnan, 2006). It is a multidimensional recoding model and a simple greedy approximation algorithm. The time complexity of the greedy algorithm is much smaller than that of the optimal single-dimension algorithm. This model partitions the values of *QI* attributes into regions according to multiple dimensions. Recoding functions are constructed then using some summary statistics from each region. As a quality measure, discernibility metric and normalized average equivalence class size metric are used.

FLEX is the name of the randomizing function for ϵ-differential privacy model implemented to SQL query in an open-source project in collaboration by Uber and researchers at the University of California, Berkeley (Johnson, Near, & Song, 2018). PINQ (Privacy Integrated Queries) is another implementation of the ϵ-differential privacy model by McSherry (McSherry, 2010).

Evaluation of the anonymization level can be done by measuring the utility and privacy. For group-based anonymizations, level of privacy has a direct relationship with the sizes of the homogenous groups (how many instances are indistinguishable from each other). One of such metrics is the *Discernibility Metric* (penalty for each tuple based on the number of records which are indistinguishable from each other, each suppressed tuple gets a penalty equal to the total number of records). Another used metric is the *Average Group Size*. For the *DP* model, it is possible to measure the *error* introduced by *DP* on each query against the population size of that query (absolute, relative, variance). For small datasets, the error would be higher than for large ones.

There are several open-source tools available for the anonymization. *Anonymization ToolBox* (http://cs.utdallas.edu/dspl/cgi-bin/toolbox/) developed at the University of Texas at Dallas supports the following algorithms: Datafly, Mondrian Multidimensional k-Anonymity, Incognito, Incognito with l-diversity, Incognito with t-closeness and Anatomy. Another comprehensive tool with a graphical user interface that uses its own Flash algorithm and supports several privacy models is *ARX* (https://github.com/arx-deidentifier/arx). For *DP*, the *Uber* implementation is available on GitHub (https://github.com/uber/sql-differential-privacy). McSherry's implementation *PINQ* is available at Microsoft research website (https://www.microsoft.com/en-us/research/project/privacy-integrated-queries-pinq/).

5. Comparison

We selected the privacy models in such a way, that they represent more research directions. Table 1 provides a basic comparison of the models. First four models are based on the same concept, grouping the instances in the equivalence classes, each is derived from original k-anonymity. K-anonymity was designed for a relational data, where each row in a table represents a person, and primarily for categorical attributes (used with *DGH*). Its objective is to protect the identity from linking the data with some other public data. Main methods applied to achieve k-anonymity are generalization and suppression, where global means that the generalization or suppression is applied to all the rows which match the criteria whereas local means applied only to one or several rows. Both ℓ-diversity and t-closeness take into account the sensitive attribute values appearing within the equivalence class. They deal with an issue when the equivalence class can be guessed and the sensitive values are not well represented within the group. They ensure thus a higher level of protection and should be used when the published dataset contains such sensitive attributes. T-closeness provides a little higher protection than ℓ-diversity because it considers the distribution of the sensitive attribute in the whole dataset and in the groups. Another advantage is that it can be used when the sensitive attribute is numeric. K^m-anonymity provides an extension to k-anonymity for set-valued data (transactions with a variable number of values from the same domain, e.g. market basket) and focuses on the protection of the identities when an adversary knows several transaction items (they have the same concept as *QI* attributes). The difference from k-anonymity is the type of data which it was designed for. Group-based anonymizations are the most developed and researched so far. Researchers designed several algorithms on how to achieve k-anonymity (Table 2Table) in addition to the original algorithm. Full-domain generalization method here means that all the values within the domain are generalized to the same level in *DGH*. This can also lead to over-generalization, unlike local generalization where each group of values could be generalized only to the minimum required level. Currently, Mondrian is the most developed and is designed mainly for numeric data in contrast with the previous algorithms. It applies multidimensional global recoding, meaning all the values within the domain are recoded according to the same rule. It also provides the fastest performance, the second fastest is the Datafly since it uses heuristic and the slowest is Incognito. The reason is that it searches for optimal anonymization and it's been proven it is an NP-hard problem, for larger datasets with more *QI* attributes optimal algorithm becomes unusable.

P-uncertainty is designed for transaction data, but on a different concept than k^m-anonymity. It generalizes and suppresses the attributes as long as the mined association rules (having sensitive consequent) maintain confidence higher than some threshold. Thus the adversary can infer the sensitive value only with the confidence lower than the threshold. This approach is suitable for categorical data. Last research direction is represented by differential privacy. It's based on a completely different concept than the previous models. The interactive mechanism (query to the database and a result) is currently being researched significantly. *DP* is considered a very strong requirement, it makes no assumptions about the knowledge or the semantics. Its constraint is that it is principally designed for statistical databases and aggregate queries (to support data analysis). It randomizes the result in such a way that the result is not sensitive for having any person in or out of the database. Count and histogram are the most common aggregations. Non-interactive mechanism fulfilling *DP* has not been published yet, generally, *DP* is not intended to address this problem. However a study and indication that Mondrian algorithm could be used are described in (Chen et al., 2011), so more research will be needed.

Table 1 Comparison of the anonymization techniques

Model	**Usage**	**Original Alg.**	**Method**	**Protection**
k-anonymity	Relational data	Deterministic	Generalization and suppression	Identity disclosure
km-anonymity	Transaction data	Deterministic or greedy heuristic	Generalization	Identity disclosure
ℓ-diversity	Relational data	Deterministic	Generalization and suppression	Identity and attribute disclosure (extension to k-anonymity)
t-closeness	Relational data	Deterministic	Generalization	Stronger attribute disclosure, but often used with k-anonymity
ε-differential privacy	Statistical databas e (query/result)	Randomizing	Perturbation (adding noise to the answer)	Identity and attribute disclosure independent of adversary's background knowledge
ρ-uncertainty	Transaction data	Deterministic for generalization and greedy heuristic for suppression	Global generalization and global suppression	Sensitive item disclosure, against mining sensitive inferences (sensitive association rules)

Table 2 Comparison of selected anonymization algorithms

Name	**Algorithm type**	**Method**	**Criteria**	**Suitable data**
Datafly	Greedy heuristic	Full-domain generalization	Bin size (k-anonymity)	Categorical
Incognito	Hierarchy-based / Optimal search	Full-domain generalization	k-anonymity	Categorical
Mondrian	Partitioning / Approximation	Multidimensional recoding	k-anonymity	Numerical
FLEX	Randomizing function	Smooth sensitivity and Laplace noise	(ϵ, δ)-differential privacy (a relaxation of ϵ-DP)	Numerical
PINQ	Randomizing function	Laplace noise	ϵ-differential privacy	Numerical

6. Anonymization Approach for the University Information System Log Data

Table 3 describes the structure of the activity log together with example values. The data contains records of all the activities performed in the university information system. The nature of this data is not purely transactional (all the values from one domain), so we don't consider k^m-anonymity and ρ-uncertainty suitable. Group-based anonymization models require to divide the attributes into identifiable, *QI* and sensitive ones, but the distinction is not straightforward when applied to a real dataset. L-diversity and t-closeness models work to protect sensitive information if the sensitive attribute has a fixed set of values and the set is rather small. We don't have such attribute to protect, so we don't apply either of these models.

We started pre-processing by removing *SessionID* and *ParentID* because they are not used properly. *ParameterString* has an infinite number of values in the domain and contains any data supplied by a user, it is related to the type of action performed by a user. It is a combination of the identifiable and sensitive attribute. We have removed it because it can directly disclose sensitive information about an individual. *URLString* has a fixed set of values in the domain when an identifiable part is removed (*QI* part here is represented by an identification of the document which can be encoded in the URL). We consider *UserID* and *SourceIP* as *QI* attributes. They can lead to the identification of the persons when linking to some additional data. Another *QI* could be *DateTime*. There are some indications that the identity could be revealed when discovering user behavior. The example in the table records a logging request of an unauthenticated user (*UserID* = 0) under "user1" username.

Finally, we decided to extract the identities table from the data and thus create relational data. This table consists of *UserID* and *SourceIP* attributes. The aim is to have all the users with all their originating IP addresses. The relationship between the attributes is many-to-many, meaning that each user can use more IP addresses and also each IP address can be used by more users. Each tuple occurs only once in the table, they don't repeat. We further removed all tuples where the user is anonymous (unauthenticated) and the associated IP address occurs also in another tuple, associated with an authenticated user. The idea behind is that mostly the user is the same and hence there is no need to duplicate identity in the table. Such pre-processed data can be used then for achieving k-anonymity by Datafly, Incognito and Mondrian algorithms. Differential privacy as described in the previous chapter is generally designed for aggregate queries, so it can be used to perturb any summary statistics which needs to be published during the research project for anomaly detection.

Table 3 Data model for the activity log table

Attribute	**Domain**	**Description**	**Example**
TransactionID	Number	Non-sensitive TRN identification	1054406944
UserID	Number	Numeric user identification (QI)	0
DateTime	Date	Time of TRN (possibly sensitive)	2016-01-01 14:09:19
URLString	String	Type of action (fixed set of values)	/system/login.pl
SourceIP	String	User's IP address (QI)	78.45.111.222
ParentID	Number	Link to parent TRN identification	0
ParameterString	String	User data in HTTP request (sensitive + identifiable)	destination=/auth/;credential_0=user1;login=Login;credential_2=123000
SessionID	Number	Numeric session identification	0

7. Conclusions and future work

We have performed a theoretical background review of the privacy preservation techniques and provided a comparison. The reviewed anonymization techniques and tools have been chosen according to three criteria. The first criterion was the suitability of the privacy model for the data from the university information system. The second criterion was the availability of the appropriate open-source tool and the third was the intended anomaly detection task to be run on the sanitized dataset. We identified a common misconception in the anonymization for anomaly detection, which is based on a concept of hiding individual information while still remaining aggregate information. Anomaly detection requires to find outliers (or anomalies). Attributes then need to be properly selected not to lose important information, tuples suppression might need to be avoided at all.

Compared to the studies where researchers design privacy models on the same dataset (i.e. Adult available at https://archive.ics.uci.edu/ml/datasets/adult), application to raw data requires a lot of pre-processing and it is not so straightforward. Finally, we were able to present an approach on how to do basic pre-processing for experiments with k-anonymity, we discovered limitations of the privacy models and eliminated some of them. We described possible usage of *DP* however its main advantage is when the data needs to be made available to the data analyst who runs aggregate queries frequently. In our future work, we will focus on the experiments with the anonymization where we described the approach, evaluate also the possibility of perturbing the user behavior pattern. Subsequent experiments with anomaly detection will also be evaluated.

8. Acknowledgment

The work reported in this paper is carried out with the support of the IGA F4/12/2019 project of the University of Economics, Prague.

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VIDEO ADVERTISEMENTS ON FACEBOOK: ARE THEY REALLY THAT EFFECTIVE?

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Keywords

Social commerce, social media, e-commerce, online advertising, sponsored posts, facebook ads manager, online marketing, social network sites

Abstract

The social network, Facebook, has struggled with content over-saturation in recent years. The volume of posts that are created every day is growing. This puts business page owners in an unfortunate position, because display algorithms decrease the reach of their posts. This means that business page administrators are increasingly being faced with the question of how to attract the attention of existing fans while continuing to expand their number. However, generating user interest is getting more and more difficult with each passing year. Strong competition means that content consumers have become more demanding in terms of the visual aspects of posts. Often times, even excellent graphics will not help increase the reach of posts, and page administrators are thus being pushed to publish video posts. The question, however, remains: Are video advertisements as effective as they are claimed to be? When and for whom are video advertisements actually effective? This article answers these questions based on a comparative analysis of data from a paid promotional campaign.

1. Introduction

The importance of the social network, Facebook, is undeniable. According to statistics as of the end of March 2019, Facebook traffic amounts to 1.56 billion active users per day. More than 2.38 billion people use this social network at least once a month (“Company Info”, 2019). This means that Facebook holds the position of being the most frequently-visited social network site.

With the increasing number of Facebook users, this social network has become a popular medium for business entities that are trying to attract attention to their products/services (Novotová, 2018). Facebook has thus become a communication tool and a means for making money.

The main reason why users visit social networks, however, remains mutual interaction. Facebook is well aware of this, which is why it limits corporate content in newsfeeds and on homepages (“Bringing People Closer Together“, 2018). Display algorithms, therefore, do not show new page posts to all fans, but filter them based on relevance and popularity (DeVito, 2017). For this reason, business pages are forced to use tools for paid content display (i.e. Facebook Ads Manager or Business Manager).

Business page owners, however, are still faced with an important question: how can they attract the interest of users so that they react to the sponsored post? This is because price-per-click is dependent upon users engagement rate (Tikno, 2017).

Research conducted in Indonesia showed that one way to spark greater attention in users is through video posts (Tikno, 2017).

The goal of this article is to verify the validity of the Indonesian study, primarily in terms of smaller business entities that manage their Facebook profiles themselves. Are video advertisements really that effective?

2. Theoretical framework

Facebook has held the position of the most frequently-visited social network for over seven years (Hsu et al, 2012; Bogaert et al, 2016, "Company Info", 2019). And the price of Facebook advertisements has grown alongside the popularity of this social network. Previous research has shown that the exact same advertisements that ran in 2017 and 2018 were 34.83% more expensive in 2018 (Ládrová, 2018).

The basic principle of Facebook advertisements is very simple. As stated previously, the amount per price-per-click unit depends on the engagement rate. This means that if users have positive reactions to the post, Facebook algorithms will display them to a wider group of fans (Meire et al., 2016). In other words: if it's a good post, more users can be reached for the same overall cost.

Users can express their interest in the post in three ways (Kim, Yang, 2017): (1) passive consumption (likes), (2) active engagement (comments) and (3) dissemination of content (sharing). In terms of advertisement display algorithms, every type of reaction carries a different weight. However, neither the users nor the Facebook page administrators know the precise coefficients. This is because the rule for display algorithms is that they are non-transparent (Powers, 2017).

2.1. The principle of Facebook advertisement display

Picture the Facebook ad as a funnel. The display algorithms will show the ad to a large number of people. A much smaller percentage of people, however, will click on the post, and an even smaller section of users will carry out the final action. This principle can be seen in a study by American researchers (Schwinn et al., 2016) who showed an ad to over 2 million users belonging to a selected target group. Approximately 68,000 people clicked on the ad, which determined that the click-through rate equalled 3.0%. Only 797 users, i.e. 0.03% of the original 2 million users addressed, completed the final action.

The advantage of Facebook ads is the wide range of parameters for the most precise campaign settings and targeting possible. Defining the demographic attributes and interest of target users is one of the fundamental settings. A helpful tool in increasing the effectiveness of paid promotion is selecting the type of ad placement, i.e. where the user may encounter the ad. In respect to this, two most commonly used ad types can be singled out: (1) Facebook stream ads and (2) ads in the right-hand column. Both of these placements were examined in an article by Belgian researchers (Broeck et al., 2018) in respect to negative attitudes toward advertisement and the level of advertising blindness. The conclusions confirmed that if ads are shown to users who have higher product involvement, advertising blindness does not occur as often. In such cases, ads in the Facebook stream are more effective than ads in the right-hand column.

Other ways to make Facebook ads more effective are so-called personalised ads, also called retargeted Facebook-ads (Tran, 2017; Zarouali et al., 2017). This type of advertisement is based on previous interest in a product, and invites users to renewed attention.

All of the above-mentioned Facebook ad options can be applied both to advertisements containing an image and to ads with video content.

3. Data collection and methodology

The aim of this study is to verify the effectiveness of video advertising on the social network, Facebook. As stated previously, the term “effective” in terms of Facebook ads is understood to mean sponsored posts that, for the same cost, reach more users. This formed the basis of the first hypothesis.

H1: Video advertisements are more effective than ads containing images, i.e. static elements.

Another objective of this study was to take into account the effectiveness of video ads from the perspective of smaller business entities. These are typified by the fact that they do not have a specialised marketing department. Often times, the administrator of the Facebook profile is an assigned individual who has a different primary job, and therefore cannot dedicate themselves fully to marketing activities.

H2: Video advertisements are not effective for small businesses due to the high cost of video production.

3.1. Data collection

All of the data used for this study comes from the Facebook administrator application: Facebook Ads Manager.

Two ad sets were used for the study, of which each contained two posts. The ads were designed so that they promoted a single specific product of a selected Facebook page with an invitation to receive a free sample. Adding an invitation to action allowed for more detailed monitoring of user behaviour and reactions.

The first ad set contained two posts with video (V1 and V2). Both of these posts were identical, with the only difference being the ad target. One post was shown to new users, and the other solely to existing fans of the page.

The second ad set met the same criteria as the first, with the sole exception that it did not contain any posts with videos, but contained only static images (P1 and P2).

This raises the question of why each ad set contained two identical posts differing only in the target group. Both types of advertisement promoted the same product with an invitation to receive the same free sample. This, however, raised the assumption that fans who already follow the Facebook page will have a greater interest in the product and the opportunity to try it.

H3: Advertisements for existing fans have a greater conversion rate regardless of whether the ad contains a static image or a video.

In view of previous research (Broeck et al., 2018), this study chose ads displayed in the main Facebook stream for promotion.

3.2. Methodology

In order to confirm or disprove the established hypotheses, this study utilised comparative analysis. For the sake of comprehensiveness, the following methodological principles were used for collecting data:

1. The video posts and posts containing static images being compared differed solely in whether they contained a video or a supplementary image. The post text and targeting were identical.
2. Comparison equality was also preserved in terms of the cost of promotion for the individual posts. This means that $C_{V1} = C_{V2} = C_{P1} = C_{P2}$ (± 5%)[24].
3. The primary success indicator was the reach of the post and the price-per-click, which is closely related to the reach.
4. The posts were designed so that, in addition to the conventional options of expressing interest (like, comment, share), they also invited users to complete a specific action. The number of completed actions therefore were another monitored indicator of the effectiveness of the campaign.

4. Results

In total, all four sponsored posts reached 13,834 users. A total of 1,601 users expressed interest in the promotional posts. The individual results are presented in the following tables.

Table 1 shows the primary comparison of the individual posts. As you can see, the price-per-click and reach of the posts are better for both video posts than for the posts with static images.

Table 1 – A comparison of the posts in regard to price per click and reach[25]

Name	Cost	Reach	Impressions	Engagement	Price per click
V1 (Fans)	$10.02	1696	4926	337	$0.030
V2 (Others)	$10.00	7852	9614	1020	$0.010
P1 (Fans)	$10.08	1651	3289	125	$0.081
P2 (Others)	$10.05	2635	3287	119	$0.085

Table 2 adds a view of the campaign in terms of the number of completed actions. As one can see, the video posts were once again more effective in both cases, and contributed a higher number of completed actions. Table 2, however, offers an additional view: the cost per single action taking into account the creation cost of the post. The cost of creating the video amounted to $357.99 while the cost of creating static graphics amounted to only $44.75. The cost per action with additional costs were calculated in the following manner:½ of the cost of creating the video/image (because these costs were divided between the two posts) + the cost of the campaign, all divided by the number of completed actions.

After factoring in the additional costs for creating the videos/images, the tables suddenly turn, showing that the posts with the static images were more effective.

[24] The 5% accuracy level is set because Facebook Ads Manager does not allow to set the final price exactly to the cent.

[25] Advertising costs were charged in CZK. The conversion to US dollars is based on the CNB exchange rate (January 7, 2019). 1 USD = 22.347 CZK.

Table 2 – A comparison of the posts in regard to cost per action

Name	Cost	Actions	Cost per action	Cost per action with additional costs
V1 (Fans)	$10.02	39	0.257	$4.85
V2 (Others)	$10.00	34	0.294	$5.56
P1 (Fans)	$10.08	35	0.288	$0.93
P2 (Others)	$10.05	24	0.419	$1.35

In chapter 3, an effective advertisement was defined as a sponsored post that reaches more users for the same cost. In this regard, therefore—even despite the unfavourable amount of the cost per action with additional costs—it can be said that H1 has been confirmed.

From the data in Table 2, we can conclude that advertisements reaching existing fans have a higher number of requested actions in both cases. This confirms the veracity of H3, which is thus upheld.

Let us now take a closer look at the cost per action after factoring in the costs of creating the videos/images. Doubt may be cast on this indicator because the advertisements did not run long enough for the fixed cost of creating a video to be returned. However, Table 3 offers a view of the data from a different angle, and shows the daily increase in the number of completed actions.

Table 3 – Daily increase in number of completed actions

Name	T=24h	T=48h	T=72h	T=96h	T=120h	T=144h
V1 (Fans)	17	9	6	3	4	0
V2 (Others)	4	7	11	5	4	3
P1 (Fans)	11	12	3	3	3	3
P2 (Others)	9	3	4	2	2	4

In the cases where the ad was shown to the smaller group of fans, a significant decrease in effectiveness can be observed. Even in the data in Table 1, it is evident that the small target group is saturated sooner and the post is shown repeatedly to people who have already seen it before and did not react to it. For this reason, the effectiveness of the ad decreases quickly, and the sponsored post may become displeasing or even annoying.

A similar phenomenon can be expected after a specific period for ads targeted at other users. Based on the current set of data, however, when this decrease will occur cannot be definitively defined. For this reason, we also cannot determine whether the fixed cost of creating a video would have the ability to spread out over time so that the video post becomes more effective. Hypothesis H2, therefore, was neither confirmed nor disproved, and offers room for further study in the future.

5. Conclusions and limitations

This study confirmed that video advertisements attract more interest among users and have greater influence, even in terms of the level of conversion. Despite this fact, however, the results in respect to a short-term campaign met with a certain barrier, i.e. the cost of creating video material. The effectiveness of video did not prove to be high enough to cover both the cost of the ad itself as well as the cost of creating the video in a short-term campaign.

Based on these findings, it can be said that video advertisements can be a more effective promotional medium for mid- to long-term campaigns. Still, the research encountered some pitfalls here as well. The results showed that the effectiveness of an ad decreases significantly after a certain point. When this point occurs depends on the size of the target group that is exposed to the sponsored post. In the case of small target groups, the advertisement begins to be shown to the same users after a certain period, and can thus even incite a negative response. The aim of future research will therefore be to determine how large the target group needs to be in order for video advertisements to actually be profitable.

6. Acknowledgements

Research presented in this paper was supported by the funds from the project SGS-2019-1075 (EF-3320-21300): Efficiency of paid advertising on the social network Facebook.

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WHY DON'T YOU CHECK YOUR SOURCES? THE NON-EVIDENCE-BASED APPROACH OF YOUTUBE INFLUENCERS

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Keywords

Influencers, YouTubers, content makers, evidence-based practice, information sources

Abstract

Youtube influencers are in high regard in our society, and their numbers and numbers of their followers grow exponentially. But are the information they share evidence-based? How do YouTubers handle validation of their sources and is it important to them at all? These are some of the questions that were asked to 15 well-known YouTubers that claim to be working with scientifically proven information. One-on-one semi-structured interviews in person or via Skype were conducted to find out. The results are enthralling as they show that none of the 15 well-known YouTubers understands the difference between experts´ view and systematic literature review or importance of checking if other studies confirmed a finding of one presented research. This approach could have an enormous impact on our society in the coming decades as children that were born to the age of the internet are becoming young adults and will start making important decisions about their lives or, in managerial positions, about the lives of others.

1. Introduction

The purpose of this research is to find out how content makers work with information sources when creating YouTube videos on scientific topics. This platform counts 1.58 billion of users in 2018 ("Global social media ranking 2019 Statistic"). For several years it has been in the Top 3 of the most visited websites in the world ("Youtube.com Traffic, Demographics and Competitors - Alexa"). Additionally, YouTube is considered nowadays as a learning and educational tool for the engagement of Web 2.0 generation (Burke and Snyder, 2008). However, the platform has no regulations regarding the validity or quality of content. According to YouTube "Terms of Service", as a YouTube account holder, you should "understand and agree that you are solely responsible for your own Content and the consequences of posting or publishing it" ("Terms of Service - YouTube"). Therefore, the responsibility for incorrect and misleading information is held solely by content makers. The need for the project is highly important nowadays as YouTube becomes more popular as a new platform of knowledge (Glavas, Mathews, & Russell-Bennett, 2019). Moreover, Burke and Snyder (2008) conducted the research and found out that college professors attempt to engage students with YouTube videos more and more, therefore, it is important to understand how properly "scientific" YouTubers work with information sources.

2. Theoretical Background

Social media research is a relatively new field of study that has emerged in conjunction with the development of social media technologies and the upsurge in their use (Duggan et al., 2015). Furthermore, social media trends in the selection of research design, data collection techniques, and analytic approaches are not well known (Snelson, 2016). Hence, the data quality used for content creation cannot be assured. Therefore, this research focuses on identifying how scientific YouTubers work with information sources, also meaning the extent of trust and level of credibility people should have towards the platform. Ten out of fifty scientific articles were selected for review, where eight were medical related articles. Thus, theoretical review is prevailed by medicine topic, considering that in creating medical videos, an influencer would not dare to leave the reliable sources of information unchecked before making suggestions to their followers. Should followers rely on information from YouTube? The research on Parkinson (Al-Busaidi, Anderson, & Alamri, 2017) shows that the quality of information on the topic is mediocre. 15% of Parkinson disease videos were found to be somewhat valid and only 4% were evaluated as delivering very useful information. The similar results are shown in knee arthroplasty and osteoarthritis research (Wong et al., 2018), where only 1.8% of videos on the related topic were found as good educational quality. The research about type 2 diabetes (Leong et al., 2018) shows that the quality of videos was variable, and deceptive videos were popular. 32.4% of research results were misleading. Moreover, food allergy study (Reddy et al., 2018) states that frequently recommended information on this topic on YouTube has controversial diagnostics. The research on the dental implants (Abukaraky, Hamdan, Ameera, Nasief, & Hassona, 2018) states the low quality of videos, showing that the mean usefulness score of videos is poor (6.02 ± 4.7) in the range of 0-21, and misleading content was common (30.1% of videos). In addition (Keelan, Pavri-Garcia, Tomlinson, & Wilson, 2007) in their study about vaccination and immunization could be an example of the danger of unreliable information sources. According to the results, videos that advocated against vaccination were more popular, compared to those representing immunization positively. However, 45% of content within the negative category of the main message contained information with unsubstantiated or contradicted reference standards. Although, all the positive videos were substantiated. On the other hand, there were some positive findings. 58,3% of videos on kidney stone disease were viewed and classified by two independent physicians as useful, 18,1% contained misleading information. Same diabetes type 2 research shows that 63.4% of results were rated as useful (Leong et al., 2018; Sood, Sarangi, Pandey, & Murugiah, 2011). Moreover, ankylosing spondylitis research outcomes show that 48.2% of results were of high quality. The research on heart transplantation presents that 62.8% of results has useful information about specialized knowledge, and 19% has relevant information about heart transplantation (Kocyigit, Nacitarhan, Koca, & Berk, 2019; Chen et al., 2013). It should be mentioned that videos from university's channels contributed the most in terms of scientifically correct content. All videos with unproven information were either made by medical advertisement or independent users. All observed articles are showing the 3rd party point of view; either a viewer's opinion or an expert's assessment. The perspective of the content creator on YouTube is absent. And it is crucial in this research since it is the creators who make the videos, therefore they are the ultimate guarrantors over the information quality. Thus, the research gap is the absence of point of view of YouTubers on the topic.

Consequently, the research aims to answer the following research question: How do scientific YouTubers work with information sources?

The emphasis is put on the side of content makers (YouTubers) to fill in the research gap.

2.1. Research Methods

In order to fill the research gap, the interview method has been selected as a tool for gathering the required information in depth. Overall, the interviewing procedure has a clear purpose, it assumes preliminary planning of information gathering actions and the processing of the results obtained. The interviewing method was chosen because it has a number of advantages. First of all, it enables to get missing information directly from the knowledge and experience of content makers. For instance, McNamara (1999) stated that interviews are particularly useful for getting the story behind a participant's experiences and that it can pursue in-depth information around the topic. Secondly, the interviewing situation, which is close to the usual form of conversation, contributes to the emergence of a comfortable atmosphere of communication and increases the sincerity of the answers. Silverman (2004) claimed that interviews are most appropriate for exploring sensitive topics. It is expected that influencers will need this setting for talking about omitting to look for reliable sources of information. And finally, the verbal communication eliminates the problem of misperception of the questions, because it is always possible to repeat and explain the question deeper to the person to get a clear answer. As noted by Navarro Sada & Maldonado (2007), interviewing is "a valuable method for exploring the construction and negotiation of meanings in a natural setting". Furthermore, Berg (2007) argued that the value of interviewing is not only because it builds a holistic snapshot, analyses words, reports detailed views of informants; but also because it enables interviewees to "speak in their own voice and express their own thoughts and feelings".

Semi-structured interviews were conducted as the purpose of it is to use discussion, conversation, as well as questions to get an insight on the research topic. According to Bernard (1988), a semi-structured interview is the best tool when there will not be any other chance to interview someone again. The choice of respondents was based on the following criterias: type of content, knowledge of English or Czech, number of followers (more than 10 000).

To respect the criteria "type of content", the content of YouTube videos should have been qualified as "educational" or "instructional" meaning, proving an instruction on how, what to do in a certain situation. Interviews were conducted personaly or via Skype. All interviews were recorded (audio for personal interviews, video for Skype interviews.

To analyze the outcome of interviews the software MaxQDA PRO was used. The interviews were transcripted, coded and categorized.

2.2. Research Sample

10 respondents were interviewed for the research. They were recruited through random sampling via search on YouTube. Following keywords were used to select channels: "scientific YouTubers", "scientific channels", "medical YouTubers", "medical channels", "educational channels".

All respondents are English/Czech speaking YouTubers from different parts of the world. The content of their channels has an educational purpose. During the selection process channels with top video views and high activity in comments were considered in order to assure the human touch and relevance within the audience.

3. Pilot Study - Data Analysis and Results

After conducting a series of interviews, we used coding to analyse outcomes. In order to find out the way YouTubers work with information sources, we figured out the main categories - topics to be analysed in depth. Three main categories and 8 sub-categories were defined: background of a content maker, the process of working on videos and information source itself.

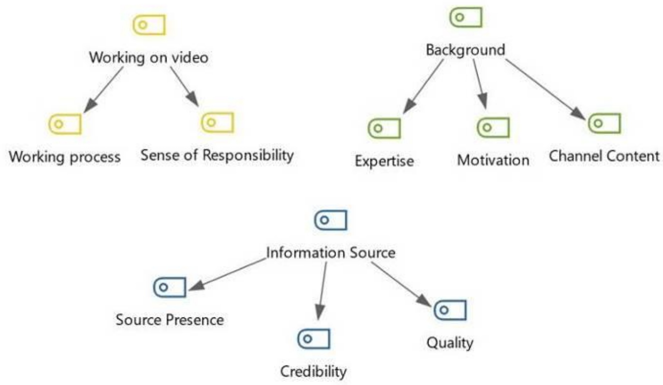

Figure 1 - Themes

The background of YouTuber, including his/her motivation, expertise and channel content provided an overall picture of the influencers and the context of their work. The working process clarified the methods and approaches used for the creation of the video. The theme - information source revealed the presence of the sources itself, allowing to assess the YouTubers attitude towards it; the level of credibility and quality of sources used and the videos themselves.

For this research it is considered the conventional source as any formal written source one can refer to, e.g. a book or a scientific paper. As an unconventional source, it is considered intact sources of knowledge as working and personal experience, reference to the colleagues and respected opinions.

3.1. Findings and Discussion

It has been found out that all the topics discussed in the videos require the usage of conventional information sources. Depending on the field, the necessity of information source may differ. In some fields, mathematics, for instance, references are not deemed applicable at all.

“......I'm introducing matrices. Sure, there are books I could point to that also talk about matrices, but they're just part of the standard language in math at this point, and unless the way I'm writing about them draws from a specific mother source, it doesn't really make sense to artificially insert one for the sake of legitimacy.”.... If you have a proof, you know it's a valid proof without external validation. ….it's not the same as it would be for some other sciences.” Grant Sanders

“....it depends how cutting-edge the content is. If you’re making a video on Newton’s Laws you don’t really need to cite someone—anyone can go on Wikipedia and see what you’re talking about.” Tim Blais

Also, some other topics like motivation or depression, which are discussed by Kamil Wawrzyszko on his channel, do not require references as it mainly relies on the personal experience and perception. Thus, Youtubers do not always see a point of using not only conventional sources but any source at all. In case they use unconventional sources they tend to rely on their working and educational experience.

A very interesting point is that respondents themselves do not consider YouTube as a reliable source of information.

“We don't really rely on YouTube as real source for researching our own videos.” Lewis Potter

“...I don't think people should be in the habit of trusting YouTube channels too much...” Grant Sanders

As for the quality of videos and information sources, the results were very different. Each respondent had their own sense of “credible source”. For instance, some respondents uses Wikipedia as a source.

“My source was a BBC article linked from a Wikipedia page....” Tim Blais

Other respondents considered other people as a high-quality information source e.g. colleagues.

“So our resources are generally sort of a medical school expects as a part of their curriculum and also specialists in the particular area relevant to the clinical skill…. essentially we use medical school curriculum and specialist's input.” But for each video, we do involve specialists.Lewis Potter

“I think well-established textbooks are a pretty safe bet. Peer-reviewed articles are usually fine in the physical sciences.” Tim Blais

It is also important to point out the sense of responsibility that the respondents have to their viewers. One of the questions was: do you feel responsible for what you are saying in your videos?

“So yes, absolutely that is always a concern that someone does something based on the video where there is an issue, an error. And we do make a lot of steps to make sure that information is high quality” Lewis Potter

“I take responsibility for what I say, so I will not tell anyone something that I do not believe that it is true, not that I am not sure about basically.” Kamil Wawrzyszko

“Of course yes. That’s why I always check info if I am not sure. It’s the best way to show respect to the followers.” Grant Sanders

Hence, YouTubers themselves might be motivated to deliver high quality and helpful information to the audience and feel responsible for provided information.

3.2. Interconnection of categories

The analysis with MaxQDA software enables to use the intersection of codes in a segment of the interview to identify the correlation of categories and its mutual influence.

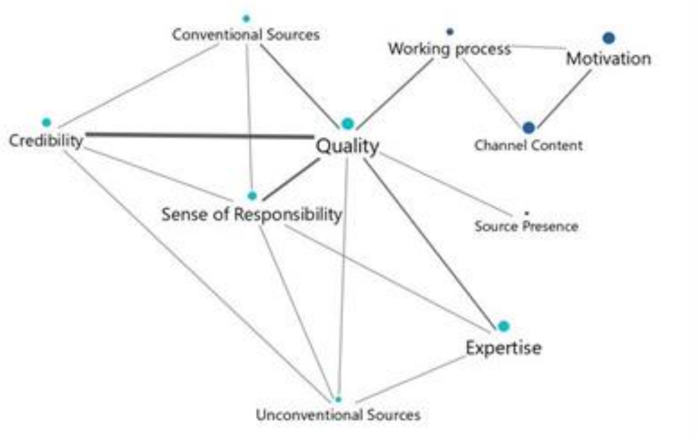

Figure 2 Themes Interconnection

Hence, it was identified as main tendencies. On the picture, it can be seen that three main categories have strong interconnection. The analysis shows that the quality strongly depends on the sense of responsibility and the level of credibility. It can be also seen the less obvious connection of quality and presence of conventional sources and expertise on the field. Thus, it can be further studied if the video can be considered of high quality when the YouTuber used either conventional sources or his personal expertise on a matter. In addition, the sense of responsibility for the information that

YouTubers transmit to their public enhance the level of trust and credibility towards them and information sources.

4. Conclusion

The present study analysed the process of working with information sources from the perspective of content makers themselves. The results support the findings from literature review, in particular that the data quality is hard to access as YouTube channels in most cases do not provide reliable references. However, it can be observed that quality of information might play an important role for scientific YouTubers, as they talk about feeling deep responsibility about what they provide for their viewers. Nevertheless, there is a contradiction that was found during the data analysis. Despite the fact, YouTubers want to assure the quality of their videos and reliability of their sources, they do not have full trust to the platform when it comes to them to use it as a source of knowledge.

It can be related to the fact of subjectivity of the information. The results show that some of the YouTubers use as an information source their own experience and expertise. That means that basically communicate the information through the prism of their own opinion.

Taking into account channels with medical topic, the quality of information provided and consequently the resources used are treated more carefully. The reason is that the main target audience of those channels are medical students who rely on it as a source of knowledge and can apply it in practice. Moreover, YouTubers who talk about medicine, in most cases have higher medical education, however, tend to quote their anecdotal evidence rather than relying on the more reliable sources of information. Youtubers that focus at vaccination tend not to know the mainstream facts about the major studies. Youtubers that focus on critical thinking do not know the basic theories or even most of the cognitive biases that are at the core of the topic.

The main limitation was the accessibility to YouTubers as it was quite complicated to get the responses from them. In addition, a lot of them don't have a written email on their channel. From 102 YouTubers which were contacted, only 46 of them responded, from which 15 reacted positively and were interviewed.

Participative observation could be adviced as a follow-up research. Scientific videos on YouTube channels can be checked for references under videos that can be coded. The main strength of the observation method is that it gives direct facts on whether some conditions are fulfilled or not. In addition, due to the stated above limitations, study in depth of one scientific field could show the similarities and differences in using valid and reliable sources of information and testing possible correlations. The wider study that would confirm these preliminary findings should follow.

Possible hypotheses to be tested:

- H1: Scientific youtubers do not check the state-of-the-art knowledge in the subject they cover.
- H2: Scientific youtubers do not trust the facts stated by other youtubers
- H3: Scientific youtubers believe that their experience is enough to make generalizing statements on the subject they cover.

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QUALITATIVE STUDY OF SOCIAL MEDIA USE BY SMALL ENTERPRISES AS ILLUSTRATED ON THE CZECH-GERMAN BORDER

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Keywords

Social media, Small business enterprise, Facebook, Activity

Abstract

The aim of this article is to present by a qualitative methods study how small businesses near the Czech-German border (Usti Region and Free State of Saxon) use social media and web pages to promote their products and services. A sample of twelve companies was selected based on search engine results. Then their Internet presence was evaluated according to chosen criteria. The findings are that there are differences between the use of social media on the Czech and German sides of the border. The presence on Facebook (number of posts, profile quality, etc.) is industry dependent. The best-kept pages were found in Ústí nad Labem, where all three evaluated Cafeterias had well-kept Facebook profiles, as well as Instagram accounts. Cafeteria companies were most active from all of the evaluated industries. Hairdressing companies had the best profiles in Zwickau, where all three companies posted more than 20 posts on average per one month and reacted to their customers.

1. Introduction

Small and medium enterprises (SME) are facing constant challenges. In the Czech Republic it is possible to find problems with staffing because of the low unemployment rate (around 3% at the end of 2018), high administrative cost and taxation, electronic evidence of incomes, etc. They face competition from both, other SME and large companies.

The purpose of this article is to compare chosen companies in the close range of the Czech-German border according to their Internet presence, i.e. web page, Facebook and Instagram accounts.

The first chapter of this paper deals with an introduction to the topic. The second chapter is focused on literature review. The third chapter describes methodology. The forth chapter contains results. The fifth chapter contains discussion and recommendations. The final chapter is the conclusion.

2. Literature review

The importance of the interaction between a customer and a brand is emphasized by Arriaga et al. (2017). In this article the interaction between fashion brands and consumers on social network pages (the low-cost fashion company Primark) was analyzed. The conclusion is that there is some engagement between Facebook users and Primark. However, on the profile page there were no reactions to customers' posts. Therefore, the company is missing an important opportunity to improve their engagement.

Lisnik and Diacikova (2016) sum up basic approaches to social media in marketing. In this qualitative study questionnaires were used. The main findings conclude the general opinion, that Facebook is the major player in the field of social media and networks. The company (Beer industry) could improve their information, e.g., events, festivals, etc. In addition, a mix of social networks presence is recommended.

The success or failure of any company on a social media page could be expressed as the number of interactions (comments, "likes", shares, etc.). Pechrova and Lohr (2016) in their introduction mentioned specific metrics. The first one of them is the organic reach of posts and the number of engaged users. This metric indicates how many people could be reached for free on a social media page. The engaged users' measures are the number of the users that took action on the page or with its content. They have found that the average reach of the posts is higher in the case of a smaller Facebook page. This could be an advantage for small business with a limited marketing budget.

A study of Pesonen (2011) focused among others on 270 SME companies from rural areas of Finland. The evaluated pages that were in this study were: Wall, Info, Video, Photos, Links, Notes, Events, Discussions, Reviews and company generated custom pages. The results showed that only 40 from 270 SME companies had Facebook pages. The average number of fans or followers was 116 (most of the profiles had less than 50 fans; on the other hand there were profiles with several hundreds of fans).

Danis et al. (2011) was able to support the hypothesis that the relationship between associational activity and new business activity will be stronger in emerging rather than in developed economies.

3. Methodology

To find small business, we have simulated one possible use case as to how a customer will search for a service. Two pairs of cities from both regions were selected by the following criteria:

- Number of citizens in the city
- Location from Czech-German border

Following cities were selected, see Table 1.

Table 1: Selected cities with number of citizens.

Country	City	Number of citizens in thousands
Czech republic	Ústí nad Labem	93
	Děčín	49
Germany	Zwickau	90
	Freiberg	41

Then a search by Google search engine was used for the identification of the following providers of services:

- Gardening
- Hairdressing
- Cafeteria
- Restaurant

Therefore, Google search has been used to find, with the first results, a list of possible candidates for evaluation.

After the companies were identified (three from each city for each service), additional information about each of them was found. The first evaluated criteria were for the presence of a web page, Facebook page, Instagram and the existence of a way to contact the company online.

After this evaluation, the online presence of the selected business was evaluated. Criteria were based on (Pesonen, 2011) and slightly altered. Table 2 shows this criteria and their description.

Table 2: List of used criteria's and their description.

Criteria name	Values	Description
Web presence	Yes/No	Does a company have a web page (Is it possible to find it)?
Web quality	1 to 5 where 5 is the best	If there was a page, the page was visited and evaluated by authors according to design and information content (e.g. contacts, reservations, map, parking options, etc.).
Facebook page	Yes/No	Does a company have a Facebook page (Is it possible to find it)?
Review score	1 to 5 where 5 is the best	If a Facebook page was found, the review score from users was found.
Contacts	1 to 5 where 5 is the best	The contact information on Facebook page was evaluated.
Pictures	1 to 5 where 5 is the best	Presence of pictures in the Facebook profile was checked as well as quality.
Videos	1 to 5 where 5 is the best	Presence of videos in the Facebook profile was checked as well as quality.
Number of posts	0 to n	Number of posts in March 2019.
Reactions	Yes/No	Were there reactions to questions, complaints, etc. about company?
Instagram	Yes/No	Does a company have an Instagram profile (Is it possible to find it)?
Instagram activity	Yes/No	There is at least one post in March 2019.

4. Results

According to the described methodology and criteria that were evaluated on small businesses in regions of Usti Region (Czech Republic) and Free State of Saxony (Germany), the results showed that there is a difference between industries as well as between regions.

All evaluations were added into a table. An example of one of the tables is shown as Table 3.

Table 3: Example of evaluated gardening companies in Czech and German area.

Country	Czech	Czech	Czech	Germany	Germany	Germany
City	Ústí nad Labem	Ústí nad Labem	Ústí nad Labem	Zwickau	Zwickau	Zwickau
Field	Gardening	Gardening	Gardening	Gardening	Gardening	Gardening
Company	EZS, s.r.o.	NATURBAD, s.r.o.	MAAX GARD s.r.o.	Gärtnerei Ziegengeist	Gärtnerei Pechmann	Blumen Fiedler
Web presence	Yes	Yes	No	Yes	No	Yes
Web quality	5	3		4		4
Facebook page	Yes	No	Yes	No	Yes	Yes
Review score	5		5		5	5
Contacts	5		3		5	5
Pictures	5		3		4	4
Videos	5		3		3	0
Number of posts	11		0		4	0
Reactions	Yes		No		No	No
Instagram	No	No	No	No	No	No
Instagram activity						

4.1. Gardening

Companies based in Děčín and Freiberg had the best web presence. All of the evaluated web pages were easy to use, with up to date information. Figure 1 shows a screenshot of a small business in Děčín. The page is easy to navigate, all of the necessary information is available.

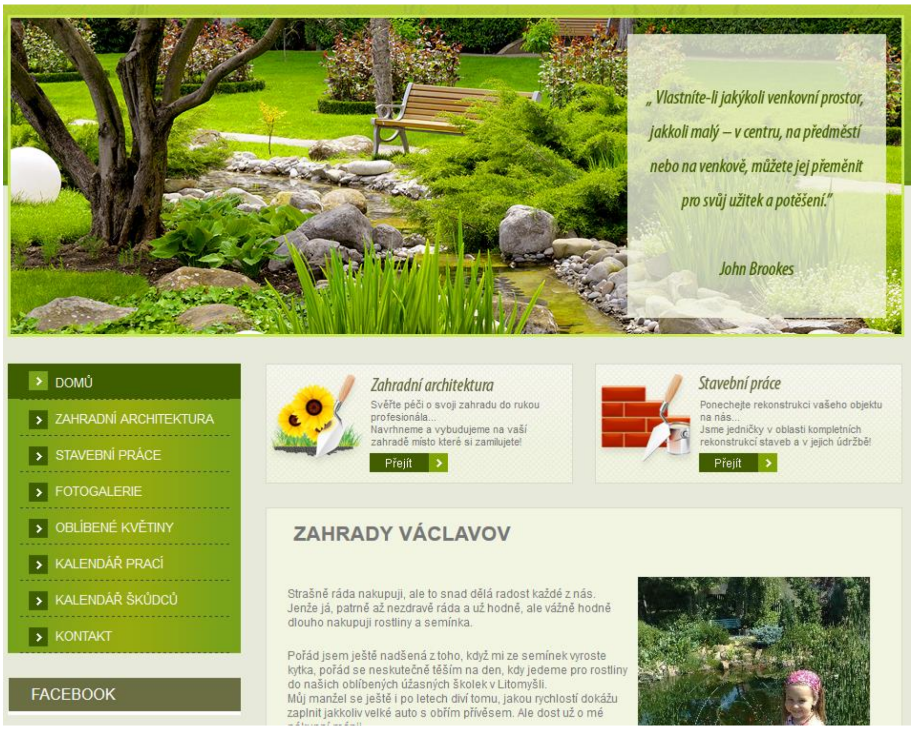

Figure 1: Web page of one evaluated company (Zahrady Václavov) Source: ("Zahrady Václavov - Zahrady Václavov", n.d.)

From the evaluated (12 in total) businesses 9 of them had Facebook profiles. Only two had active profiles in the Czech Republic (one in Ústí nad Labem and Děčín). Only one business in Děčín had an Instagram account. In Germany there were two active companies in Zwickau.

4.2. Hairdressing

The situation in the field of hairdressing is completely different from gardening. From 12 evaluated business (three from each city), all of them had a web page with contacts, pictures, etc., and Facebook pages. Five out of six Facebook pages in Germany were active. From the study of the activity of profiles, it was concluded that all Facebook pages from business based in Zwickau were active (24, 24, and 19 posts in one month). They used this activity to advertise the results of their work as well as to promote upcoming events. The businesses also reacted to customers comments. On the other hand, only one active Facebook page was identified in Ústí nad Labem and its activity consisted of only four posts in one month. The situation in comparison with Děčín and Freiberg is also in favor of Germany. In Freiberg all three evaluated Facebook pages were active (4, 3 and 1 post in one month) in comparison with Děčín, where there was no such activity on the Facebook pages.

The situation is even worse from an Instagram point of view for Czech Republic. None of the evaluated Czech business were active on Instagram and only one business had an Instagram account. On the other hand, all businesses in Zwickau had active Instagram accounts. In the Czech Republic there was not any identified evaluated business with an active Instagram account.

4.3. Cafeterias

The overall activity in Děčín is the best from all of the evaluated cities. All cafeterias have their web pages up to date and they actively use Facebook pages (around 19 posts in one month in Děčín). Furthermore, their accounts were active on Instagram. The largest number of posts was held by Café Max in Ústí nad Labem (45 posts in March 2019). Figure 2 shows the web page of Café Max in Ústí nad Labem. The page content is rather limited. This could be explained by the preference of activity on Facebook.

Figure 2: Web page of Café Max Source: (Café Max, 2019)

In Zwickau no active Facebook pages within the evaluated businesses were identified. The smaller of the two German cities (Freiberg) had two out of three businesses active on Facebook. However, they had not responded to the questions and comments of their customers. The opposite examples are with Czech businesses as they responded to them right away.

4.4. Restaurants

The situation in the field of restaurants is completely different in the Czech Republic and Germany. In the Czech Republic only one of the six examined restaurant does not have a web presence, but in Germany three of the six examined restaurants have a web presence. In the case that the restaurant has the web presence, then it has a very high quality in both countries, i.e. it has a 4 or 5 number for web quality criteria (see Table 2). All examined restaurants have a Facebook page. There is a big difference in Zwickau and Ústí nad Labem, in the number of posts in March 2019, because all German restaurants don’t have any posts in a one month period, but for Ústí nad Labem there are (7, 5 and 5 posts in one month). The situation with posts on a Facebook page is better for smaller cities of both countries, i.e. Děčín (14, 2 and 17 post in one month) and Freiberg (9, 0 and 6 post in one month).

The situation is not so bad for Instagram in view of the Czech Republic. In Ústí nad Labem only one restaurant was active on Instagram and in Zwickau none were active. In Děčín, none were active and Freiberg had only one active restaurant on Instagram.

5. Discussion and recommendations

Both for locals and tourists, online presence of a company is important. In the well-connected world of the Internet, it is quite unexpected, that is has been found that there were companies without sufficient web presentation, as well as in quite competitive fields. Tussyadiah (2012) recommends several strategies as to how to use social networks/media (location based) for a business advantage. It is quite unexpected that most of the evaluated companies were using close to none of them.

To improve loyalty behavior, it is recommended to use discounts for newcomers or rewards for recommendations. Also, the organization of a competition with rewards for the most active or best evaluated participant/contribution could help to spread word about the business. Trusov et al. (2009) recommends the use of a promotion by Word-of-Mouth. Overall costs were lower than generated income and profit made by these promotional activities.

The main recommendations should be, for every business, to create or update/maintain its business websites. They should provide up-to-date information, also there should be a maintained and regularly updated Facebook profile with examples of products/services, reactions to customers' questions, requests and reviews. Also a way as to how to easily contact the company should be provided.

6. Conclusion

Based on this qualitative study, it can be concluded that there are differences between the uses of social media across the border at chosen services of SME. The use of Facebook depends on the number of citizens as well as industry.

In the case of gardening, there is competition in smaller cities, where web pages are well kept. However, Facebook pages and Instagram are not as important. German companies rarely use Facebook.

In the case of hairdressing, the importance and use of Facebook is different across the border. In Germany (mainly in Zwickau) Facebook pages are used much more frequently to keep businesses in touch with current and potential customers. In Ústí nad Labem only one active account out of three was identified. Instagram is actively used in Zwickau in all three evaluated companies.

The overall results confirm the findings of Pesonen (2011) that active use of Facebook is problematic for small companies.

Just a minor portion of small companies actively use Instagram (mainly hairdressers). Facebook is preferred by cafeterias in the Usti region as well as in the Free State of Saxon. The combination of Facebook and Instagram is preferred by Cafeterias.

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USAGE OF THE INTERNET AND THE ELECTRONIC REGISTRATION OF THE BENEFICIAL OWNER TO THE BUSINESS REGISTER

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Keywords

Beneficial owner, Company, Electronic Communication, Internet

Abstract

The topic is related to the current obligation for representatives of Slovak companies to record information under the act on protection against legalization of proceeds of crime, builds on a series of requirements of the decision sphere institutions - to communicate effectively with entrepreneurs by using the Internet. The aim of the article is to create a competences profile of Slovak companies to record beneficial owner to the Business Register. The results of the investigation are intended to provide stakeholders with view on the conditions of the electronic communication and the entrepreneurs digital competency.

1. Introduction

As A. V. Bataev (2017) claims, lately the development of information and communication technologies has led to the creation of a new type of economy, called information economy, based on the introduction of the latest advances in computer technology. The innovative economy expansion requires new advanced approaches in all areas of development.

The last decade of business environment development is, besides many other features, characterized by intense electronization, the Internet, the introduction of new technologies, etc. (Zimermanová, 2018).

Besides higher profits the main expectations could be achieving higher flexibility, increasing the availability of products and services, further reducing costs, lower resource consumption or lower impact on environment, etc. Achieving these goals is often linked to finding out what "maturity level" the business is today and what further steps could be done due to the 4.0 development. (Basl, Doucek, 2018)

Electronization is the application of principles based on physico-electrical properties of a substance, on the flow of electrons, etc. in the most diverse fields of technology. The system is a set of elements, phenomena, etc. having a certain arrangement and is bound by mutual relationships (Šaling, 1997).

From the point of view of formalization of relations in the system, we distinguish mainly formal and informal information system. A formal information system is composed of people, organizational and technical elements, it is the basis of every company information system (Jenčo, 2011).

By Chadwick and May we identify three forms of e-government models in interaction state and citizens:

- managerial Model: using ICTs is communication faster, is in the form of "service delivery" from the government to citizens,
- consultative Model: is quite the opposite of the managerial model, where ICTs are used to improve the administration and to provide better policies,
- participatory Model: solutions are based on agreements between the state and the citizens and all relevant data must be publically available.

By Araujo and Tejedo-Romero there is a higher demand from society to access public information because of corruption, government's abuse of power, theft and fraud, favoritism, abuse of discretion, embezzlement, nepotism, and clientelism. In order to respond to this growing demand, governments have to be more transparent conducting their activities (Nafchi, M. Z. et al., 2018).

The issue of recording the beneficial owner (BO) is governed in particular by these legal standards (Accace, 2019):

- Directive 2015/849 of the European Parliament and of the Council of 20 May 2015 on the prevention of the use of the financial system for the purpose of money laundering or terrorist financing,
- Act No. 52/2018 Coll., amending Act No. 297/2008 Coll. on anti-money laundering measures and protection against terrorist financing,
- Decree No. 178/2018 Coll., laying down the specimen forms for submitting applications for entry in the Business Register and a list of documents to be attached to the application for registration,
- Act No. 530/2003 Coll. on the Business Register,
- Act No. 373/2018 Coll., amending Act No. 371/2014 Coll. on financial market crisis management.

European directive has been governed in the article 3, paragraph 6 a term „beneficial owner" like any natural person(s) who ultimately owns or controls the customer and/or the natural person(s) on whose behalf a transaction or activity is being conducted and includes at least.

According to the act in the Slovak Republic (SR), after November 1, 2018, all companies incorporated in the Business Register, that aren´t a public administration entity or issuer of securities, must enter data (name and surname, birth number or date of birth, address, nationality, ID card Nr., etc.) about its BOs: bank, accountant, lawyer, auditor and all entities related to the business, as well as a silent companion like a investor in the business.

2. Objective, methodology and methods of exploration

The survey results determine the competence, readiness of business representatives to use the Internet as an effective tool for electronic communication, by the recording of beneficial owner (BO) in the Business Register in the SR. It is a formal information system, consultative model of e-communication between government (state authorities) and companies.

The survey was conducted in November 2018 and in the first quarter of 2019. The formalized, structured questionnaire was the survey technique, communicated personally with representatives of Slovak enterprises (respondents) in the Prešov region. In particular were used explorers personal contacts. A total of 100 respondents were approached and 72 correctly completed questionnaires were used.

The evaluation determines the mode - the most numerous value of the statistical character and their order. The relationships between interdependence between the values of the selected characters were investigated: the type of subject of e-communication and the state of fulfillment of the obligation to register the BO; the contents truthfulness of the BO registration and knowledge of the registration conditions under the law; causes of the transfer of responsibilities from representative to other entities and sources of process information. Statistical function Correl in Excel has been used to determine dependency between characters. The correlation coefficient has been determining the relationship of the degree of dependence, which is high if the result is close to 1.

The questionnaire had 10 questions. First, the identifying features of the company were investigated: the type of company (personal, capital); business´s age (according to the law, all businesses established before November 2018 have this duty); a silent companion; the status of the company in the register of public sector partners (these aren´t obliged to register the BO).

Followed by a set of questions about the competence of companies representatives to reach their legal obligation.

3. Results of the analysis

The results are based on the number of correctly completed 72 questionnaires from companies: 8 personal (11%) and 64 capital (89%); 24 companies were established before 2013 (33%), 35 companies (48%) in 2013 - 2017, 13 companies (18%) were established in 2018. In 18 companies are silent companions (25%); 19 companies (26%) are registered in the Register of public sector partners yet. Companies are referred to as micro and small enterprises by trait number of employees.

In chart 1 is the structure of e-communicators in the companies. In its own name - by owner or executive - communicate only 15 representatives (21%). Instead of an company owner is an e-communicator with the state authorities especially: company accountant (27; 38%); external specialized company - outsourcing (19; 26%); another employee (11; 15%).

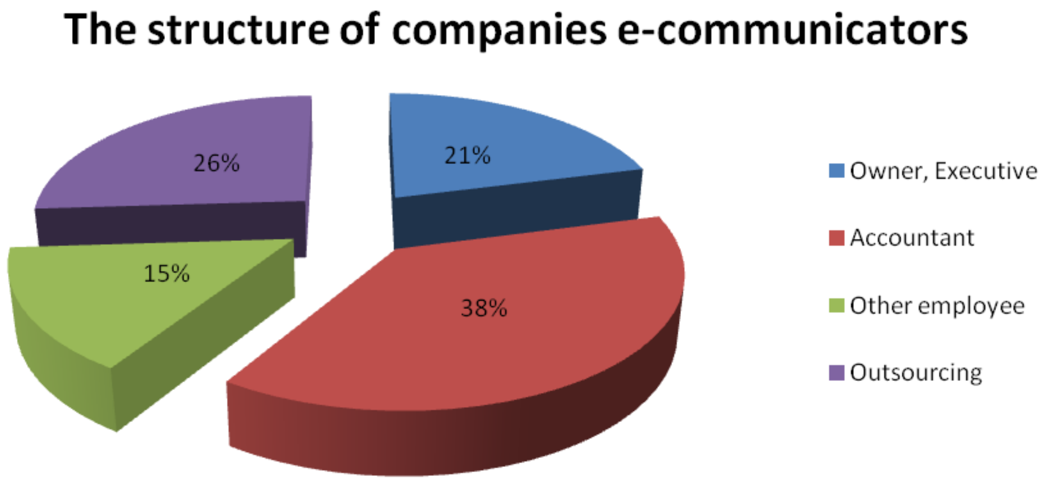

Chart 1 The structure of companies e-communicators with the state´s authorities

Respondents who don´t communicate personally with the state authorities (57; 79%) said the following reasons: I don´t know work on computer - software (18; 32%); I don´t know how to communicate electronically respectively I don´t have skills (15; 26%); I don't have time respectively I´m busy (11; 19%); I don't have the Internet (8; 14%); other (5; 1%). Results views chart 2.

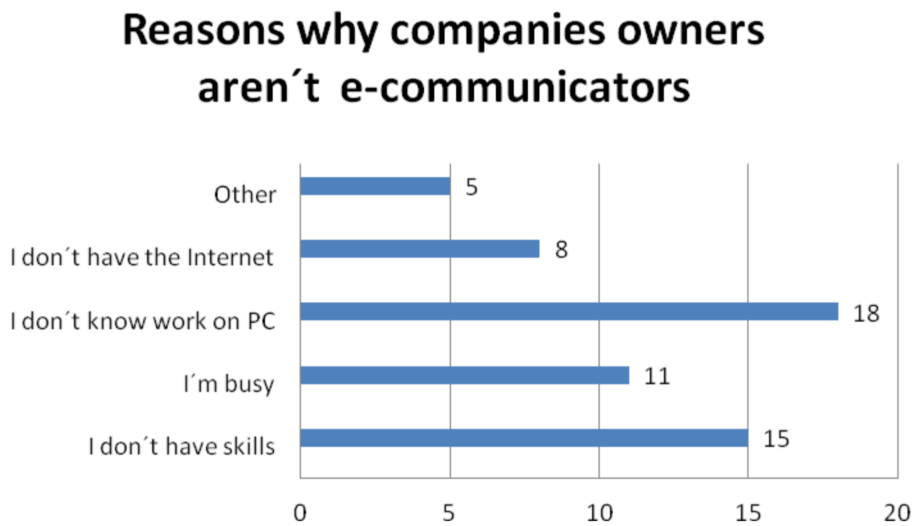

Chart 2 Type of reason for delegating the obligation from company owner to another entities

28 respondents (39%) have sufficient knowledge of the obligation to record a proposal for a BO in the Business Register, 44 (61%) respondents have heard or heard something for the first time. Those who are aware of this obligation have received information mainly from: communication with other entrepreneurs and accountants (32%), Internet (29%), media (25%), training (14%).

33 respondents (46%) know, who is their BO, 39 don´t know (54%). During the survey, 23 companies have declared. that they have fulfil an obligation (32%), while others (49; 68%) didn´t have do it yet. They plan to do it: in electronically 26 (53%); in paper form 23 (47%). Only 9 out of 49 respondents know, how to make this entry in the Business Register, while only 7 of them are planning to do it personally. Up to 40 (82%) of the 49 respondents don´t know the enrollment

process at all and therefore 20 of them (41%) entrust this task to another company through outsourcing, in 16 companies do it by an accountant (33%), other employee of enterprise (6; 12%). 27 out of 49 respondents (55%) searched the internet for information about the offer and price of these services (outsourcing), 49% of them are willing to pay up to 30 €; 31% from 31 to 50 €; 6% from 51 to 100 €;14% over 100 €.

Out of the 72 respondents, 35 would to learn to communicate electronically with the state authorities this year yet (49%), but 37 of them didn´t consider of it and want to communicate through others (51%).

The last question had the background of moral choices in accordance with the principle of common good, and we found that 19 respondents (26%) assume that they either didn´t state or couldn´t indicate the correct data of BO for various reasons, especially from ignorance and fear of harm. Up to 53 respondents (74%) will truthly to record all BOs.

The results of examining the interdependence between selected features - the current state of fulfillment of the obligation to record the BO in the Business Register and the type of e-communication entity - the result 1 expresses an absolute direct linear dependence. Among the selected features - the cause of the transfer of duties from the owners to other entities and the choice of the source of information about the enrollment process - a direct linear dependence without strong binding was found from the 0.296 correlation result. Between the characters: the truthfulness of the content of the BO registration and the knowledge of the registration conditions under the law - is no dependence there according to the result of the correlation in the value -1.

4. Discussion, conclusion

The information gathered and the results of the survey gave rise to several ideas for discussion:

- the silent companion status of the company has been protected under the Commercial Code, its personal data have been anonymous. According to new Act on Protection against Legalization of Proceeds of Crime, the entry of BO in the Business Register, especially in paper form, will limit the anonymity of the silent companion. Electronic registration is preferable. Although the data will still be placed in a non-public part of the registry, it may be misused. It is anticipated that there will be increasing pressure to publish this data in the future and they will be available to crowd. This can to trigger the lack of interest from potential silent companions to invest in the business and later, the overall decline in private business investments and the increase of gray economy;
- representatives don´t have sufficient time to fulfill their obligations, they need a transitional. The requirement for the establishment of the BO register doesn´t come from entrepreneurs. Small business representatives didn´t have sufficient information about the purpose of the obligation to register a BO - 61% of respondents didn´t know about this obligation and 54% didn´t know, who is a BO - so they may perceive it like annoying or increasing check of their business;
- if representatives of small companies don´t have skills to work with the Business Register information system, if they are unable to communicate, so their spending on outsourcing of this service or on their own education will to grow;
- the introduction of an obligation may cause panic in the company, lack of interest in certain jobs or the provision of false information, which results in high fines if detected.

From the survey results was determined the competences´ profile of Slovak entrepreneurs for entering the BO in the Business Register:

- it is a micro enterprise, capital´s trading company, the establishment before year 2017, isn´t in the public sector partners´ register, it doesn´t officially have a silent companion;
- in the e-communication with the state authorities have been using the company representative other entities (accountant, outsourcing, etc.), the cause is: the inability to work with the computer, lack of experience, incompetence to work with the e-communication system;
- the Internet is an essential source of information in fulfilling e-communication obligations with the authorities and in finding information;
- is willing to pay an average of € 50 for outsourcing of this service.

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DIGITAL SINGLE MARKET INNOVATION

PERCEPTION OF TRUST BUILDING MECHANISMS IN EU COUNTRIES

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Keywords

Public administration, Trust, DSM, EU, Digital single market strategy

Abstract

The paper analyses how citizens of EU countries, perceive the role of trust building mechanisms. The research tries to determine whether trust building mechanisms are recognize by citizens as significant driver of use of digital technology in comparison to other tools of Digital single market (DSM) strategy. Other part of research analyses strength of the relationship between citizens' support of DSM tool and level of agreement with positive impact of digital technologies on the economy, society and quality of life.

1. Introduction

The term e-service encompass various different types of transactions and interactions between service users and service providers over the electronic networks. (Mou et al., 2017) Although the concept of e-service is often adopt, it has various context in different fields. (Jansen and Ølnes, 2016) Whether the e-services are used in commercial (B2B, B2C) and non-commercial sectors (e-government and e-health) the lack of physical interaction, distance between providers and consumers, relying on electronic environment provided by service provider (or third party) etc. increase the uncertainty, opportunism, information asymmetry and chance of information misuse, (that is presented also in non-online interaction and transaction), to a whole new level. (Mou et al., 2017) On the other hand, it should be noted that very same e-services provide perfect environment for design and adoption of mechanisms which can reduce these externalities, both for online and non-online interactions and transactions. Examples of such mechanisms are reputation mechanisms, references, third party certification, online dispute support, standardization activities, and contract execution support and escrow services. These mechanisms are known as trust building mechanisms (TBM). because trust is known as key element in reducing impact of these negative aspects of interactions and transactions. Although, there are maybe as many definitions of trust as there are definitions of services (Sütőová, 2018), from trust building mechanisms' point of view, it is worth to mention the concept that 33 year ago introduced Zucker (1986). He specified three types of trust: Characteristic-based, Process-based and Institutional-based. Characteristic-based trust is determined by personal preferences which are formed based upon personal background, age, sex and ethnicity. According to Chang et al. (2013) this kind of trust is very ineffective to build in online environment. Trust acquired from previous and foreseen interactions is known as Process-based trust. This kind of trust can be gained from previous experience or indirectly based on word of mouth, reputation, references, branding etc. The last type of trust, the Institutional-based trust, can be divided into two group. First is connected to societal institutions such as "membership of an association, or third-party certification". (Chang et al., 2013) The second type of Institutional-based trust is associated with intermediary mechanisms, such as insurance, escrow, or legal rules (Chang et al., 2013) According to Delina (2015) most European studies are covering technical aspect of trust in e-services such as security, privacy (see e.g. Pavlicek et. al, 2019), or environment setting (see e.g. Delina a Grof, 2019). On the other hand, importance of trust building mechanisms was recognized by European Commission (2016). In one of their communication regarding collaborative economy European Commission states "Trustbuilding mechanisms such as online rating and review systems and quality labels can be an essential tool to overcome the lack of information about individual service providers." In other part of the report is stated "rating and reputational systems or other mechanisms to discourage harmful behaviour by market participants may in some cases reduce risks for consumers stemming from information asymmetries. This can contribute to higher quality services and potentially reduce the need for certain elements of regulation, provided adequate trust can be placed in the quality of the reviews and ratings." Although European Commission recognized added value of trust building mechanisms, as Mou, (2017) claims consumer acceptance and engagement in the use of e-services are parameter characterized by high variability. The aim of this paper is understand how EU citizens perceive trust building mechanisms that improve trust and reputation. Whether they see these mechanisms as a drivers to improve use of digital technologies.

2. Methodology of the research

The aim of this paper is to measure citizens' perception of trust building mechanisms within EU. The research in this paper is mainly based on results of 11 questions from Special Eurobarometer 460 (EB 87.1): *Attitudes towards the impact of digitisation and automation on daily life* study. This study was chosen because, to the best knowledge of the authors, it is first study of European countries, where trust and reputation (QD 2.1) is clearly distinguished from security (QD 2.3). To identify more factors which influence the perception of EU citizens towards trust building mechanisms, we selected other 8 trust and TBM orientated questions from all Eurobarometer and Flashbarometer, Specialbarometer studies conducted within the years 2017-2018. The overview of the questions is presented in Table 1. However, these questions have different answers and came from several studies, the methodology of the questionnaire was similar for every study. Therefore we were able to collect the same parameter for every question presented in the table. The parameter represents: percentage of asked citizens of particular EU country that supports the predetermined answer to the question. Because currently 28 member states in EU, size of the sample for every questions was 28.

Table 1: Overview of the questions used in the research

Study	Questions	Answer*
EB 87.1	QD1.1 In your view, what impact do the most recent digital technologies currently have on: The economy	Positive
EB 87.1	QD1.2 In your view, what impact do the most recent digital technologies currently have on: The society	Positive
EB 87.1	QD1.3 In your view, what impact do the most recent digital technologies currently have on: Your quality of life	Positive
EB 87.1	QD2.1 Would each of the following encourage you or not to make more use of the most recent digital technologies? More widespread use of tools that improve trust and reputation (e.g. rating systems and certified standards)	Yes
EB 87.1	QD2.2 Would each of the following encourage you or not to make more use of the most recent digital technologies? Faster and more reliable internet connection	Yes
EB 87.1	QD2.3 Would each of the following encourage you or not to make more use of the most recent digital technologies? More widespread use of technologies to secure online services (e.g. encrypted information or fingerprint recognition)	Yes
EB 87.1	QD2.4 Would each of the following encourage you or not to make more use of the most recent digital technologies? More public services online (e.g. online medical prescriptions)	Yes
EB 87.1	QD3 In your opinion, which of the following actors is best placed to take effective actions to address the impacts of these most recent digital technologies?	The public authorities
EB 87.1	QD3a In your opinion, which of the following actors is best placed to take effective actions to address the impacts of these most recent digital technologies?	Companies
EB 88.3	QA8a.4 I would like to ask you a question about how much trust you have in certain media and institutions. The Internet	Tend to trust
EB 88.3	QA8a.5 I would like to ask you a question about how much trust you have in certain media and institutions. Online social networks	Tend to trust
EB 88.3	QA8a.10 I would like to ask you a question about how much trust you have in certain media and institutions. Public administration in (OUR COUNTRY)	Tend to trust
EB 88.3	QA8a.11 I would like to ask you a question about how much trust you have in certain media and institutions. Regional or local public authorities	Tend to trust
FB 464	Q1.2 How much do you trust or not the news and information you access through Online newspapers and news magazines	Trust
FB 464	Q1.3 How much do you trust or not the news and information you access through… Online social networks and messaging apps Trust	Trust
EB 89.1	QA10.13 Could you please tell me for each of the following, whether the term brings to mind something very positive, fairly positive, fairly negative or very negative? Public service	Positive
EB 87.3	QA16.8 What is your opinion on each of the following statements? Please tell me for each statement, whether you are for it or against it. A digital single market within the EU	For
EB 87.1	QD4.4 To what extent do you agree or disagree with the following statements regarding your	Agree

	skills in the use of digital technologies: You consider yourself to be sufficiently skilled in the use of digital technologies to use online public services, such as filing a tax declaration or applying for a visa online	
EB 87.1	QD4.5 To what extent do you agree or disagree with the following statements regarding your skills in the use of digital technologies: You consider yourself to be sufficiently skilled in the use of digital technologies to benefit from digital and online learning opportunities	Agree
*We measure percentage of citizens who answer to question accordingly. EB- Eurobarometer, FB- Flashbarometer		

Source: EUROPEAN COMMISSION a,b,c,d,e (2019)

3. The results of the research

The first part of the research tries to analyze attitudes of EU citizens towards impact of digital technologies in general. Motivation for such analysis is to determine whether EU citizens recognize positive impact of digital technologies on the economy, society or quality of their life. The boxplot analysis presented in Figure 1 shows distribution of percentage of EU countries' citizens, which agree that recent digital technologies have currently positive impact on economy (first boxplot), society (second boxplot) or quality of life (third boxplot).

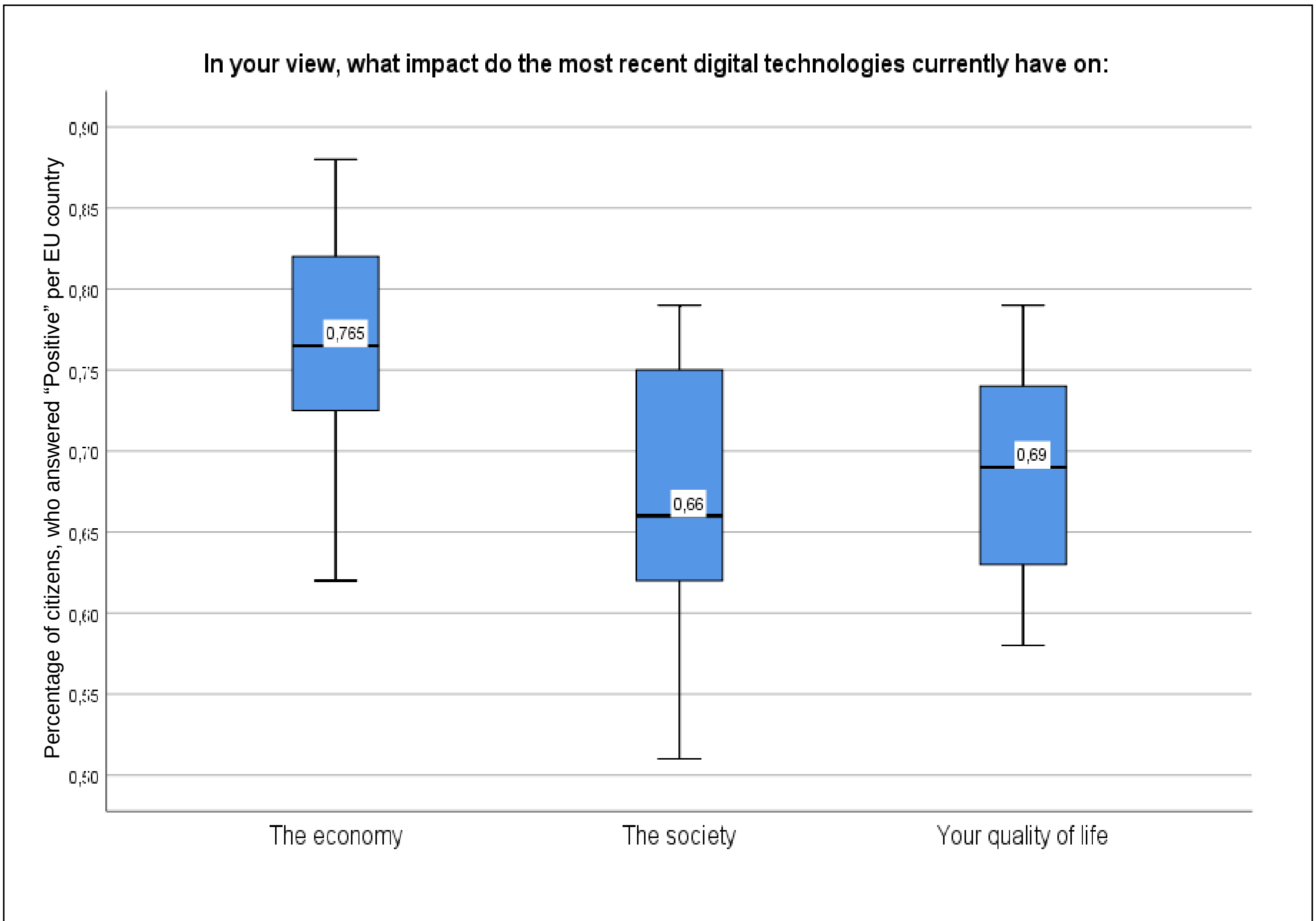

Figure 1: Box plot analysis of the attitudes of EU citizens towards impact of digital technologies Source: Author

As can be seen in Figure 1, the first boxplot is the highest and also has a smallest interquartile range. This mean, that EU citizens perceive positive impact of digital technologies mainly on the economy. The smallest interquartile range shows little variability in percentage of citizen with positive attitude between EU countries. The second boxplot has on the other hand the lowest position in the graph and the widest interquartile range. Such results suggest that comparing positive impact of digital technology on economy, society and quality of the life, the impact of lastly mentioned area has a weakest recognition between citizens. On the other hand the wide interquartile range of second boxplot suggests, that there are quite differences between level of recognition of positive impact of digital technologies on society between countries. Slightly better results are presented in the third boxplot, where positive impact of digital technologies on quality of life is measured.

In the next part of the research, we tried to determine how particular areas of Digital single market strategy encourage citizens to use digital technologies. Results are presented in Figure 2.

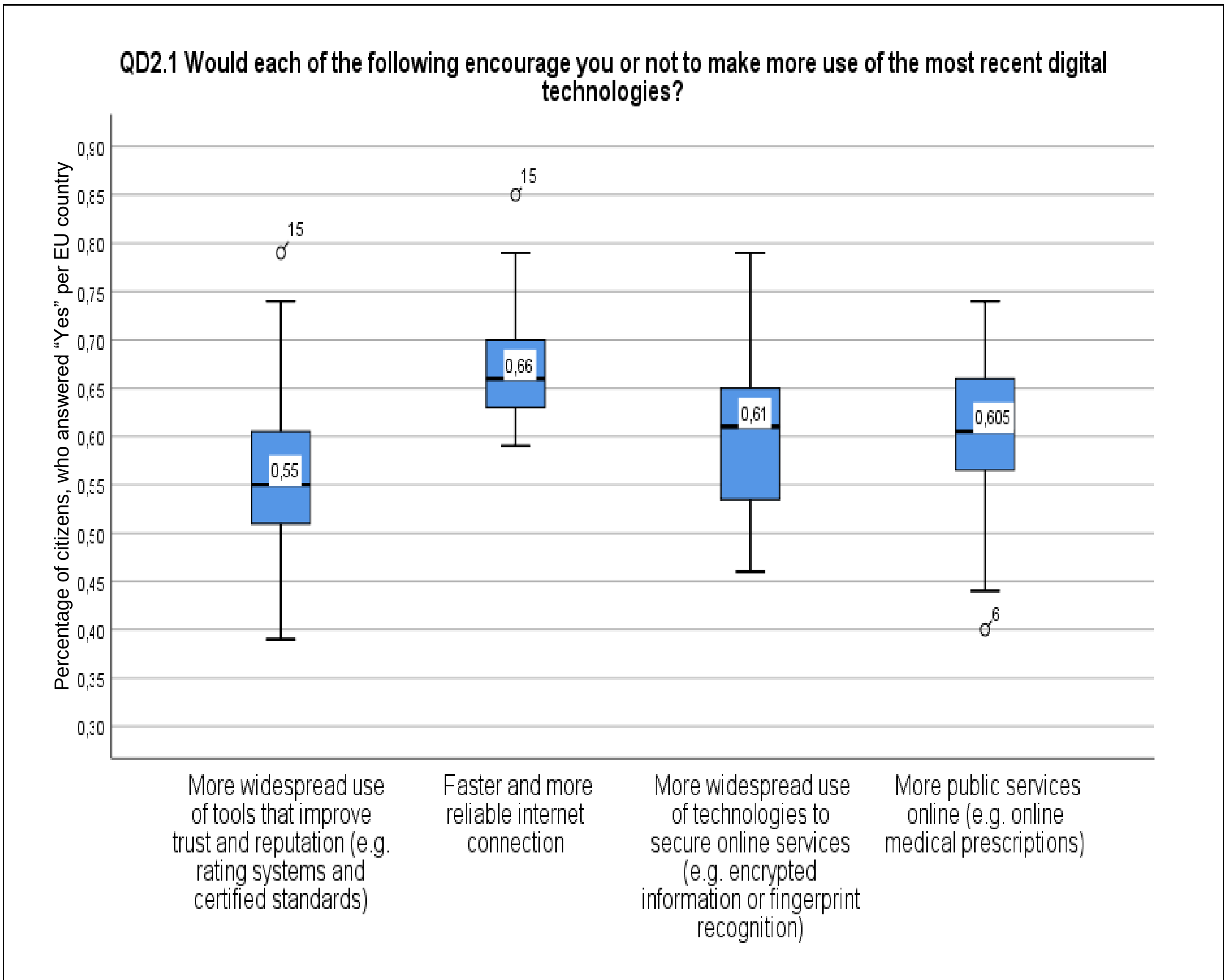

Figure 2 Boxplot analysis of EU citizens' perceptions of Digital single market strategy areas Source: Author

The Figure 2 shows that across all EU countries the highest percentage of citizens are encouraged to use digital technologies because of faster and more reliable internet connection. The security electronic services are in the second place and more public services online are in the third place. The results suggest that trust building mechanisms motivate citizens less likely to use digital technologies than any other of mentioned Digital single market strategy tools.

In the third part of research we conducted correlation analysis. We tried to determine how citizens' support of particular digital single market strategy tools influence the perception of positive impact of digital technologies on the economy, society and quality of life. The results of correlation analysis are presented in Table 2.

Table 2: Correlation analysis of impact of Digital single market strategy areas

Correlations

			Would each of the following encourage you or not to make more use of the most recent digital technologies?			
			QD2.1 More widespread use of tools that improve trust and reputation	QD2.2 Faster and more reliable internet connection	QD2.3 More widespread use of technologies to secure online services	QD2.4 More public services online
In your view, what impact do the most recent digital technologies currently have on:	QD1.1 The economy	Corr. Coef.	0,097	0,363	0,236	0,190
		p-value	0,624	0,058	0,227	0,332
	QD1.2 The society	Corr. Coef.	,476*	0,219	,407*	**,590****
		p-value	0,010	0,262	0,032	0,001
	QD1.3 Your quality of life	Corr. Coef.	**,567****	,411*	**,535****	**,565****
		p-value	0,002	0,030	0,003	0,002

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author

The correlation matrix presented in Table 2 shows that p-value is lower than significance level α=0,05 only in seven instances. For these seven cases is correlation coefficient valid measure. Only four of them have correlation coefficient higher 0,5. Highest correlation coefficient (0,59) was found when comparing QD 2.4 with QD 1.2. Such result implies that countries with higher percentage of citizen which are encouraged by more public services online to use digital technologies are also a countries where higher percentage of citizens recognize positive impact of digital technologies on society. Second biggest correlation coefficient was found by comparing QD 2.1 with QD 1.3. Such result implies that countries with higher percentage of citizen which are encouraged by trust building mechanisms to use digital technologies are also a countries where higher percentage of citizens recognize positive impact of digital technologies on quality of their lives. The effect of security services on positive perception of digital technologies on quality of life is represented by third biggest correlation coefficient.

Based on the results of previous analyses, we tried to identify factors which influence EU countries' percentage of citizens encouraged by trust building mechanism to use digital technologies. Motivation for such research was to find factors which differentiate countries with higher percentage of encouraged citizens apart from countries with lower percentage of encouraged citizens. To identify these factors we extend the dataset and used also a questions from other studies. The description of all used questions is in the methodological part of the paper. We use classification tree algorithm CHAID to identify the main factors which influence distribution of QD 2.1. The results of the analysis presented in Figure 3.

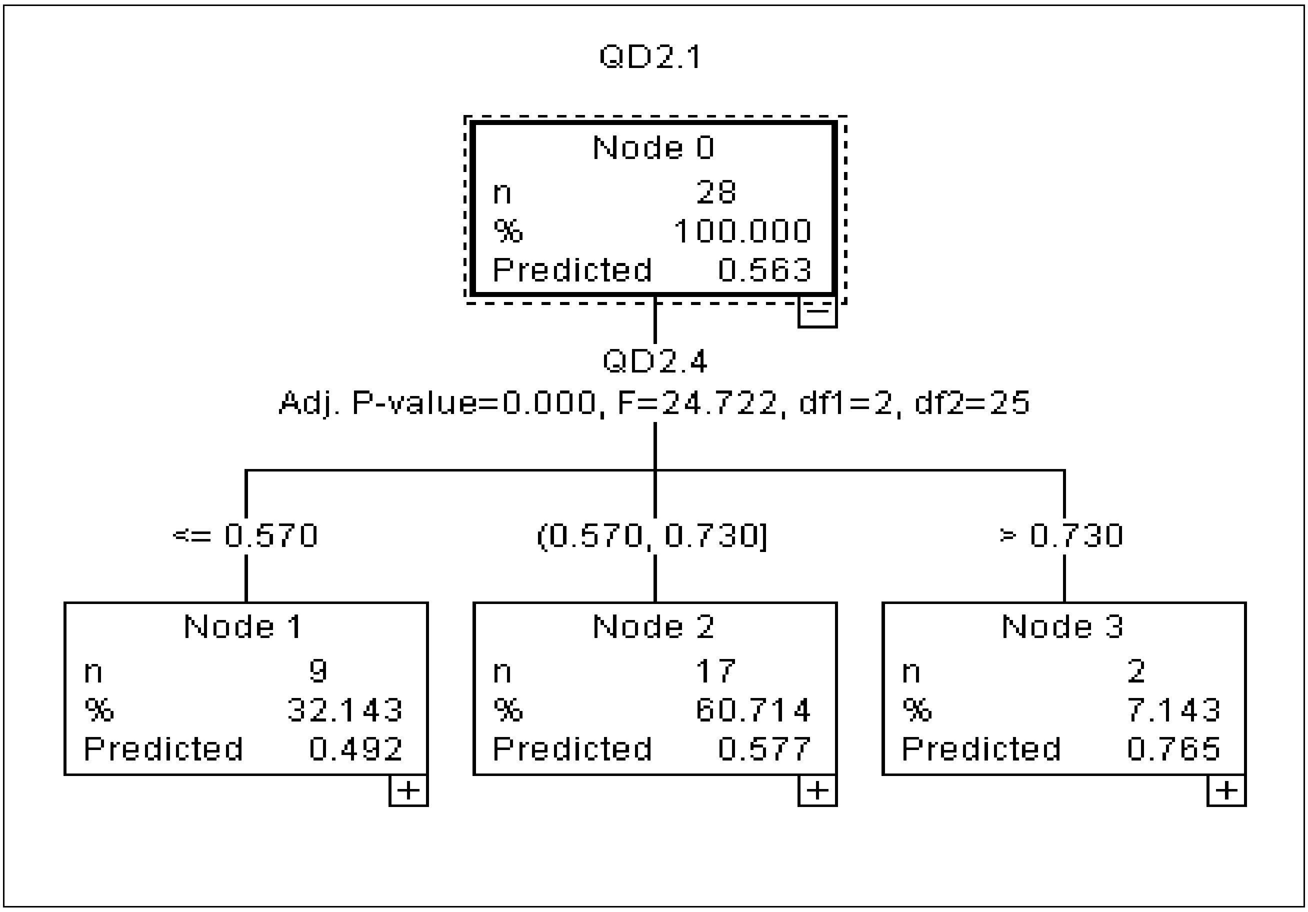

Figure 3: Classification tree describing factors influencing support of trust building mechanisms within EU countries. Source: Author

The classification tree presented in the Figure 3, showed that support of trust building mechanisms is strongly influenced by support of more public services online. The tree implies that in the countries, where fewer (57%) people are motivated to use digital technologies because of more public services online, there is even a lesser motivation to use digital technologies because of trust building mechanisms (49,2%). On the other hand in the countries, where high number of people (73%) are motivated to use digital technologies because of more public services online, there is also a higher motivation to use digital technologies because of trust building mechanisms (76,5%).

4. The conclusion

This paper focuses on perception of trust building mechanisms within EU countries. The aim of this paper was to measure how trust building mechanisms are perceived by EU citizens in comparison with other areas of Digital single market strategy. The results shows that support of trust building mechanisms as driver of use of digital technology is the lowest in comparison with other tools of Digital single market strategy. Another part of the research tries to identify main factors which influence recognition of trust building mechanisms as motivational tools for use of digital technologies. The research starts with analysis of attitudes towards digital technologies. We compare how the positive impact of digital technologies on the economy, society and quality of life is recognized in EU countries. Results showed that in most of the EU countries citizens recognized that digital technology has highest positive impact on the economy sector. In average, the percentage of citizens within EU countries, who support positive impact of digital technology on the economy is 75%. The positive impact of digital technologies on society and quality of life is substantially less recognized by citizens within EU countries. This lead to a question how to improve the impact of digital technology on society and quality of life that is perceived by citizens. There we tries to determine how use of certain Digital single market strategy tools as motivational tools for use of the digital technologies is linked to recognized positive impact of digital technology on society and quality of life. The results showed that in countries where high percentage of citizens recognize that more public services online and more trust building mechanisms encourage them to use digital technologies also high percentage of citizens recognize positive impact of digital technologies on society and quality of life and vice versa. Further study also shows how perception of public services online is closely linked with recognition of trust building mechanisms. In countries, where high percentage of citizens recognize that more public services online encourage them to use digital technologies we observed that higher percentage of citizens recognized also trust building mechanisms as motivational tools to use digital technologies. And vice versa, in countries, where low percentage of citizens recognize that more public services online encourage them to use digital technologies we observe even lower percentage of citizens that recognized trust building mechanism as motivational tools to use digital technologies. This led to assumption that the role of trust building mechanisms by citizens is magnified by the role that online public services plays in the country.

5. Acknowledgement

This work was supported by Scientific Grant Agency VEGA of Slovak Republic within the grant No. 1/0736/19 “Application of methods of artificial intelligence for European bond market modelling.”

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INNOVATIVE APPROACHES TO THE REPUTATION MANAGEMENT IN THE TOURISM SECTOR

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Keywords

Reputation management, marketing, corporate reputation, tourism, Adriatic Coast.

Abstract

The paper discusses the issue of innovative approaches to reputation management of the best Adriatic Coast Hotels, operating on the global market in the time of hyper-competition. The main aim of paper itself is to present the available ways and methods of measuring the marketing phenomenon of reputation, especially online reputation, as the modern challenge for responsible and sustainable development of perceived image of subjects, as their very fragile intangible assets. A thorough standardized multifactor analysis of reputation in the virtual world of the Internet was conducted on a specific sample of entities - best Adriatic Coast Hotels selected by British experts for The Daily Telegraph Journal. Taking into account all the relevant factors, all online ratings are normalized and then compared against the offline ratings provided by main players on the selected market. Using a careful statistical testing, relationships between factors are then examined in order to identify and describe basic facts affecting offline and online reputation of selected entities in the hyper-competitive market environment of the Internet.

1. Introduction

The problem of building and subsequent maintenance of a good reputation is hundreds of years old. In the eighteenth century, Benjamin Franklin, a wise man, nowadays mostly known only as the face of the one-hundred-dollar bill, or an inventor of the lightning rod, described the process of building of a positive reputation as an extremely fragile system. He used to say that it takes many good deeds to build a good reputation, but only one bad one and the good reputation is immediately lost. Today, his words are more up to date than ever before (Pollák 2015). As already mentioned, the problem of building a positive reputation in the traditional "brick and mortar" world has been known for centuries, we know how to build a good image, or more precisely how to help in building of a good image. Even if we are a target of various half-truths and slander, we are aware that if that are only spoken words, their durability over time is quickly fleeting. However, written text is different from spoken words, its life durability over time is much longer. In our paper, we bring the overview of what happens if we must suddenly face the problem of building and maintaining a good reputation in both, traditional and the virtual world. Sustainable development of corporate reputation has never been that complex. From the point of view of our prime motivation for assembling of this study, we would like to state, that we have been studying reputation issues for more than half a decade, as part of a grand assignment in which we examine various aspects of marketing, we have decided to explore this specific area through the presented empirical study. The area of tourism marketing has a number of specifics, among other things the high sensitivity of customer perception. Therefore, the field of tourism seems more than adequate for a thorough examination. The market location was chosen because in the Adriatic coast, there is a relatively small but highly turbulent and competitive market, it was possible to test all significant entities in the form of a whole set of most prestigious Hotels selected by prestigious British journal, subsequently identifying significant findings and connections valid also for other entities operating on a specific market. We believe that regardless of market location, the findings can be applied to any developed market globally.

2. Literature Review

Reputation is a concept commonly used in marketing management and it generally means an overall presence on the market. From the point of view of the Internet, we can compare it to leaving footprints. All activities are inter-connected and complement one another (Janouch 2011). Each institution has a reputation or online reputation, whether they want it, or not; the reputation does exist (Marsden 2013). If entrepreneurs are running their own businesses (or managing institutions), they should not leave their reputation to chance. It is their ultimate responsibility. Company's reputation is considered to be a very valuable asset (Zgodavova, Slimak 2008). As George Washington once said: "With a reputation you can do anything, without one, nothing" (Haywood, 2002). However, if we consider corporate reputation, its definition is a bit complicated (Griffin 2008, Balmer,Greyser 2003), characterize corporate reputation as such which is created over time, based on what the organization did and how it behaved (Zgodavova, Hudec, Palfy 2017). Company's or corporate reputation only reflects relative standing of the company, both internally with its employees and externally with other stakeholders, in both its competitive and institutional environments (Litavcova, Bucki, Stefko, et al. 2015). Helm defines corporate reputation as a global, stable over time, evaluative judgement about a company that is shared by multiple constituencies (Helm 2011). It is a pure reaction of customers, investors, employees and other stakeholders. It is a collective judgement of individual impressions (Gottschalk 2011). The Internet has changed the way we are thinking about reputation (Štefko, Fedorko, Bačík, 2016). What was once private is now public. What was once happening on the local level is now discussed on the global level. What was once ephemeral is now permanent. What was once trusted is now unreliable (Delina, Drab 2010). These changes happen because the Internet has modified our interaction with reputation (Pollák, Nastišin, Kakalejčík 2015). Understanding the unique relationship between technology and online culture is a key to understand how to manage online reputation (Loayza 2013). Those who apply off-line techniques on their Internet reputation or use off-line assumptions to solve online problems are doomed to failure. Instead, the user must be capable to understand the cultural and technical differences between the Internet and off-line world to effectively protect and improve his online reputation (Delina 2014). Walter (2013) argues that reputation is a cornerstone of one's life and business. This means that reputation is very fragile, and one mistake can sometimes cause irreparable damage. This is especially true in the digital world ruled by radical transparency and high standards of customers (Soviar 2011). Entities must be able to learn to communicate on social networks, follow the "chatter" on social media and effectively respond to such impulses without harming their reputation in line with expectations of their customers. Chernatony et al. in Siano et al. (2011) argues that when the Internet allows consumers to share information about businesses and brands, entities have the opportunity to control information published about them. Negative comments on the Internet can quickly and severely damage image and reputation of the brand.

3. Materials and Methods

The main aim of paper itself is to present the available ways and methods of measuring the marketing phenomenon of reputation, especially online reputation, as the modern challenge for responsible and sustainable development of perceived image of subjects, as their very fragile intangible assets. Using the multi-factor analysis of the reputation in the online Internet environment, we tested specific subjects, namely 15 best Adriatic Coast Hotels selected by experts of The Daily Telegraph (2018). Within the testing, we considered the entire spectrum of perceiving their reputation since we compared the whole specter of relevant virtual factors and connections measured by us against significant and relevant ranking of the mortar world provided by British experts for The Daily Telegraph. From the point of view of the subjects, these subjects as a lighthouse of perceived quality guarantee the relevance for identified connections, and findings and recommendations drawn from them directed to the other players operating in the analysed market. As already mentioned, within our research, we used the methodology of multi-factor analysis of online reputation, namely its modified version we would like to present as a priority possibility to measure the entire power of online reputation of a subject in the Internet environment. The TOR (, Pollák, 2015, Pollák et al 2016) methodology, presented by us, brings the entire spectrum of possible applications from the point of view of the scope of activity of selected subjects as well as more accurate forms of measurements and subsequent comparison of the findings across the analysed subjects than the usually used methodology presented by Sasko (2015). It also brings quantification of the overall power of online reputation of a subject expressed in percentage compared to its possible maximum value. From the point of view of the number of variables, the TOR methodology presented by us is n-factor which only increases its versatility and usability.

4. Results and discussion

4.1. Overview table of partial score

Using Advanced Sentiment Analysis (ASA), we calculated the power of subjects' online reputation determined by the nature of the top ten search results via Google. However, search engines are just one of the ways by which users get what they want. Based on previous research in the given issue (Pollák et al 2016, Dorčák, Markovič, Pollák, 2017, Pollák et al. 2017), we identified other determinants of reputation, that is in other words reputators for the field of tourism, in particular:

Facebook (reviews on the scale 1-5), Google (reviews on the scale 1-5), Trip Advisor (reviews on the scale 1-5), Booking (score 0-10, converted to percentage).

Three of four reputators has a 5-point system of quantification of the perceived online reputation, namely the evaluations in the form of stars. These were converted into percentages. Booking use its own system, where providing score from 0 to 10, this score was converted to percentage. Before we present our own interpretations, we consider necessary to present partial evaluations of the subjects as well as all relevant indicators in one summary table. Table 1 presents both individual ranking of the mortar world and a partial score obtained by quantification of individual reputators and last but not least it shows the overall level of online reputation represented by the TOR indicator:

Table 1: Overall (Total) online reputation

Subject/ Result	ASA score (%)	FB rating (%)	Google rating (%)	Trip Advisor (%)	Booking rating (%)	Number of pages indexed by Google	TOR score (%)	Reference expert rating (%)
Villa Dubrovnik	73.42	94.00	96.00	100.00	95.00	11 500 00	91.68	90.00
Hotel Navis Opatija	92.09	96.00	92.00	90.00	91.00	36 100	92.22	90.00
Hotel Monte Mulini Rovninj	73.74	92.00	96.00	100.00	95.00	160 000	91.35	90.00
Aman Sveti Stefan	93.38	96.00	88.00	90.00	-	202 000	91.85	90.00
Regent Porto Montenegro	88.55	98.00	94.00	100.00	95.00	540 00	95.11	90.00
Borgo Egnazia Fasano	93.38	98.00	94.00	90.00	94.00	137 000	93.88	90.00
Hotel Excelsior Dubrovnik	92.09	92.00	94.00	90.00	93.00	416 000	92.22	80.00
Sun Gardens Dubrovnik	65.37	94.00	94.00	90.00	89.00	972 000	86.47	80.00
Little Green Bay Hvar	56.99	100.00	96.00	80.00	92.00	496 000	85.00	80.00
Hotel Liburna Korcula	65.69	94.00	88.00	80.00	90.00	252 000	83.54	80.00
Radisson Blu Resort Split	75.35	88.00	90.00	80.00	85.00	635 00	83,67	80.00
Hotel Splendid Budva	85.97	96.00	94.00	90.00	90.00	204 000	91.19	80.00
Don Ferrante Monopoli	88.87	94.00	94.00	90.00	92.00	97 500	91.77	80.00
Belmond Hotel Cipriani Venice	96.60	96.00	94.00	90.00	92.00	617 000	93.92	80.00
Kempinski Palace Portorož	83.40	94.00	94.00	90.00	92.00	617 000	90.68	80.00

Firstly, we focused on analysing the virtual reputation of the subjects using an Advanced Sentiment Analysis ASA. With regard to each subject, we analysed the first 10 results of the Google search. Searching by specifying the first parameter, the subject’s own name, we recorded the subjects’ own sites predominantly at the first positions in searching. This came out as not a surprising fact since the situation is almost the same for all sectors of business. It was expected that the following nine search results will be of a neutral character, however, this was not confirmed in any cases. Neutral search results are mostly various sub-pages of the homepage or various formal references found on pages related to the subject. Although they do not damage the reputation of the subject, they definitely do not add to its value with respect to the virtual "attractiveness". Positive search results related to the searched subject are from the point of view of Internet users more interesting, especially if the users have no direct experience with any of those. The perception of the subject is thus established on very subjective – virtual experience. In this case, the positive sentiment regarding the studied subject was generally associated with the presence of the subject on Wikipedia or its profile on Facebook or other social media showing up in the first ten search results. The reviews of the studied subject appearing in the first ten search results after typing in the name of the studied subject were also considered as positive sentiment. Then we repeated the measurements using only one parameter, the full name of the subject. This time, we focused on the results found in the tab "News". Based on the results, we can state that the subjects are almost perfect in mastering media communication. Except for few cases, the subject has recorded positive sentiments almost on all position in their search results. Especially Hotel Excelsior Dubrovnik recorded (as one of four hotels from sample) positive sentiment in all positions in google tab News. This phenomenon was connected with another phenomenon, namely Game of Thrones, referring to place when all mail stars were accommodated. We need to mention, then newer before we recorded full positive sentiment score in any field of our research. Superstar Hotel was followed with trinity of top hotels, namely Hotel Navis in Opatija, Aman Sveti Stefan and Borgo Egnazia Fasano. Those Hotels gained their unbelievable score by their exclusive location or services (or both). Firs from “normal” subjects were Hotel Splendid in Budva with approx. 92% of possible positive sentiment score in google tab News, especially because of reference on James Bond Movie called Casino Royal. The analysis showed relatively close relations between offline and online factors, based on previous researches, we consider this finding very interesting. In the second step, we analysed reputation of the analysed subjects calculating their reputation using the following: reviews on Facebook, Google, Trop Advisor and Booking. We appreciate the fact that all of the analyzed subjects got such positive reviews. This shows that they have penetrated into the market. Since these are the best Hotels in their field, this is not surprising at all. In the third step of the analysis, we calculated the overall reputation. The clear winner in both brick and virtual world is the Regent Porto Montenegro, the rating of which exceeded 95% of the total value of positive online reputation. The Borgo Egnazia Fasano was followed by the Belmond Hotel Cipriani Venice. Then we have the Hotel Liburna Korcula Radisson Blu Resort Split with approx. 83 % rating. Interestingly enough, that being in competition fight with the best, providing great work is not enough, you need to be just perfect.

4.2. Interesting outcomes of the analysis

The following figures and Tables point out some interesting outcomes of the analysis:

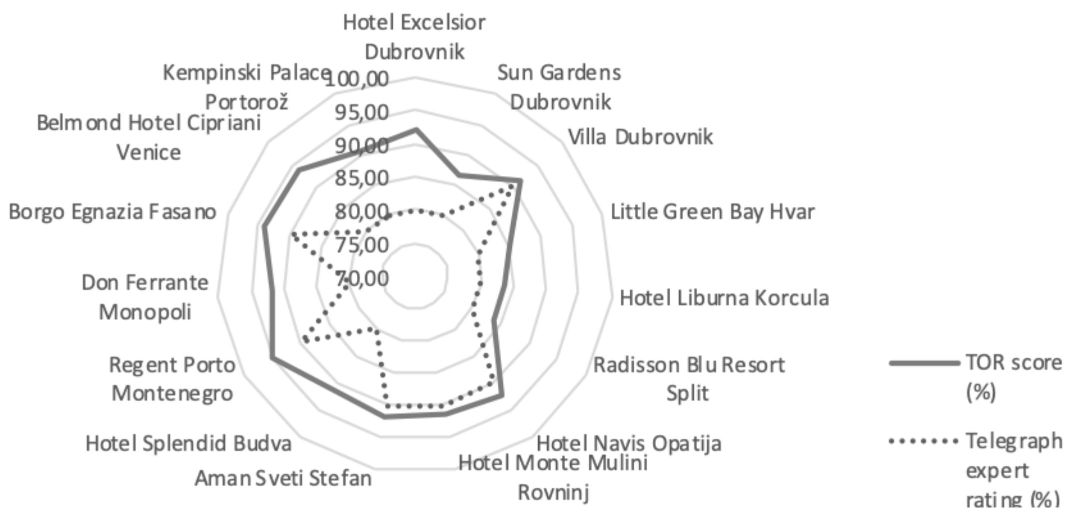

Figure 1: Offline vs. Online ratings

In comparison with the results of the The Daily Telegraph, the score of the analysed subjects with regard to their online reputation was almost same. It points to fact, that both worlds are connected.

As we can see in Table 2, the correlation coefficient describing relationship between Telegraph rating and the level of overall virtual reputation is statistically significant because at the chosen significance level of 5%, the p-value is sharply lower than 0.05. Based on the value of correlation coefficient, that is relatively substantial, we cannot refuse existence of statistically significant correlation between brick and virtual ratings.

Table 2: Offline vs. Online ratings

Variables	Valid N	Kendall Tau	Z	P-level
TOR & Telegraph	15	0.440	2.288	0.022

For the purpose of better interpretation of the findings, we tested the differences between variables is shown in Figure 2, values obtained by selected reputators and values measured by analysing Goole search results (ASA) exhibit a high degree of similarity. In only one subject we recorded deviation, namely Aman Sveti Stefan, who did not have a profile on Booking, logically, no profile means no booking rating. We can see the graphic interpretation of the tested variables in Figure 2:

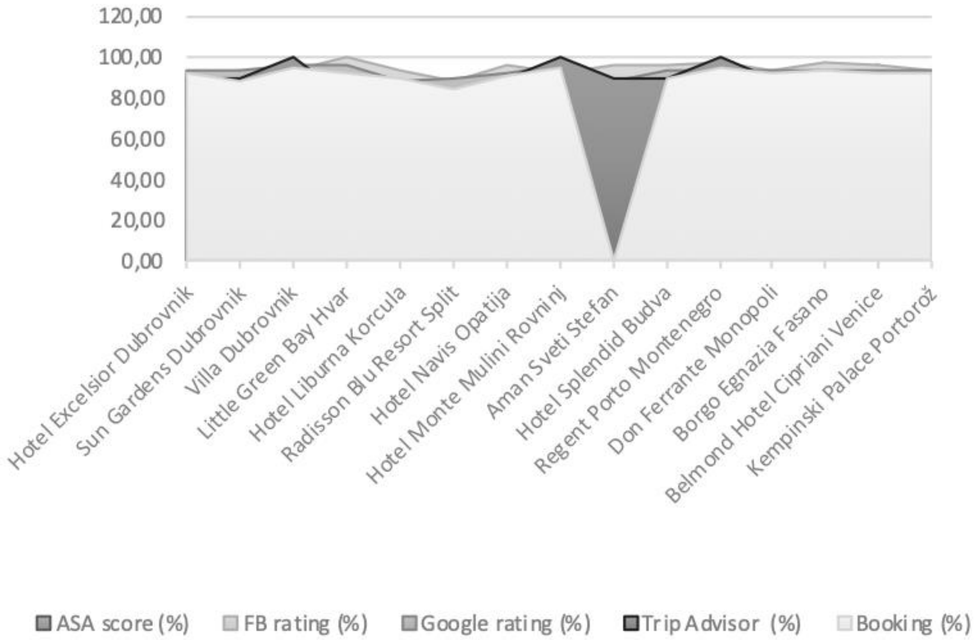

Figure 2: Dependencies between variables

Is there any connection between offline and online ratings? Based on findings presented in Figure 1 and Table 2, we can state, Yes. There is connection, strong connection between ratings indicate necessity of combine online and offline approaches to obtain sustainable development of reputation of tested subjects.

5. Conclusions

In the online world, the Hotels from the top places of the ranking have undoubtedly a notable advantage from the point of view of online reputation for general public from the ranks of the Internet users. If a user is searching for relevant information and at the same time does not have his/her own experience with a particular subject, in the absence of positive reputators, his/her perceptions of the particular subject can be significantly deformed despite the enormous endeavor and physical demonstration of the perfection of the subject in the traditional world. By eliminating negative publicity while maximizing positive media outputs in opinion-forming Internet media, and the displacement of neutral or negative search results to irrelevant positions presented by the second to n-th side of Google search results. Responsible and sustainable is the multiplatform approach to the reputation management. Strategic alliances of major players will help to more effective optimization of search engines, improving the availability of preferred results on relevant positions in searching. However, Google is not the only platform that needs to be considered. Integration of the main platforms presented by virtual social networks and media will ensure active feedback, as well as active content control. This largely eliminates the possibility of spreading half-truths and incomplete or untrue information. Finally, it is important to pay attention to the construction of consumer tribes, without any developed and motivated user base, it is not possible to predict any significant results for any of the activities described.

The offline world represented by traditional players largely affects the reputation of selected entities, especially among professionals. Given the specificities of the time (and the number of other research and analyses), we would like to state that the general public, generations X and Y, is affected by those traditional players in terms of reputation shaping to a limited extent. The center of their information world is the Internet. Another trend of the times, the move away from mainstream information sources to alternative media and community portals makes it harder to control one’s reputation. Search results on Google in the form of links to fan pages, community forums, catalog portals or local media can reveal even the smallest imperfections in marketing communication. In combination with Facebook and Google ratings in the form of stars, or traditional virtual reviews by Booking ore Tri Advisor a single person can destroy reputation of a company. The strength of that person’s "marketing" message is enforced through authenticity that this message carries and making it look legit. Our research synthesizes all mentioned viewpoints and offers a clear comparison of reputations of the analyzed subjects across both worlds (online and offline). The results bring interesting findings worthy of greater consideration. From the point of view of future research, authors will aim their effort to improving presented methodology by the completion of TOR in its complex formula, with described and measured weights of individual reputators for more accurate use in academic research and practice.

6. Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-15-0511.

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RESPONSIBLE DEVELOPMENT OF CORPORATE REPUTATION

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Keywords

Corporate reputation, reputation management, competitiveness, healthcare, United States, America.

Abstract

The paper discusses the issue of responsible development of corporate reputation, specifically the issue of traditional and innovative approaches to reputation management. The main objective of our study is to present the accessible ways and approaches of measuring the reputation, especially online reputation, as the current challenge for responsible and maintainable development of perceived image of subjects, as their very fragile intangible assets. For the analysis itself, significant rankings, specifically for offline and online environment were used, then thorough primary analysis was carried out by our own methodology. The control measurements were performed within the analysis with an aim to identify and describe relevant connections and variables for a subsequent proposal and presentation of an affordable and useful tool to measure online reputation in a turbulent environment of the Internet.

1. Introduction

The rapid onset of mass-media communication in the second half of the 20th century has fundamentally changed the established principles of corporate practice in many areas. Prior to the advent of the media era, the reputation of business entities, or even individuals, was hard to build, but also well-guarded. Procedures on how to build a good reputation have been honed for hundreds of years. However, times have changed, and the flow of information has accelerated (Zgodavova, Lengyel, Golemanov, 2008). What was once private is now public. The availability of information in combination with the interactivity of the environment offers innumerable possibilities for influencing the reputation; of course, it is not just about influencing it in a positive sense. Based on knowledge of management practice, as well as on the basis of professional literature, it may seem that the way to achieve a positive result is the effort to maximize transparency, maximum correctness and a positive approach to entrepreneurship (Zgodavova, Slimak, 2008, Delina, Tkáč, 2010, Zgodavova, Hudec, Palfy 2017). If we lived in an ideal and rational world, it would surely be a guaranteed step towards the desired goal. Businesses as well as individuals would be able to plan a sequence of steps to build the dreamed-of target. However, we live in a real world full of real people. Warren Buffett would certainly be able to talk about that. Mr. Buffett came face-to-face with the limits of the real world in 1987, when his company Berkshire Hathaway made its biggest acquisition until that time, buying Solomon Inc. for 9 billion dollars. Despite the famous Oracle of Omaha building up an excellent reputation over dozens of years, it was soon necessary to tangle with an existential threat in the form of negative publicity associated with the activities of Solomon. Mr. Buffett had it easier in the period before the onset of the Internet. The audiences that he and his team had to manage in the process of fixing their reputation were largely clearly defined. With the advent of the Internet, the flow of information has accelerated tremendously, one could say that a few mouse clicks are enough to destroy a good reputation today. There are many entities who are deliberately attempting to destroy corporate reputation, whether they are fierce competitors or dissatisfied employees or clients. It is enough to mention the name of Jeff Jarvis and his blog Dell Hell from the year 2005. The Internet gives users the ability to permanently interfere with the online reputation of a business in real-time. Google has become the ideal tool to build or destroy a reputation. The unregulated nature of the site provided a platform for the unregulated dissemination of information. The positive side is, of course, the access to up-to-date and uncensored information, while the downside is a severe lack of authenticity and false or modified information. In our paper, we bring the overview of what happens if we must suddenly face the problem of building and maintaining a good reputation in both, traditional and the virtual world. Responsible development of corporate reputation has never been that complex.

2. Literature Review

Many authors (Janouch, 2011, Jones, Temperley, Lima, 2009, Spišák, 2016, Litavcova, Bucki, Stefko, et al. 2015) describe online reputation as the overall presence of a particular subject on the Internet. At present, from a layman's point of view, presence on the Internet is equal to presence on social media, and from a professional point of view, this view is to a large extent limited. Reputation is not only the domain of social platforms, it is created primarily by users sharing their attitudes and following their interactions through a wide range of tools such as search engines, catalogues, forums, blogs, and so on (Williams, Schanke, Fredenberger, 2005, Weber, 2007). Due to the instrumental variety of marketing in the Internet environment, it is recommended that the subjects use the largest possible number of these sub-tools as part of their marketing communications. There is pressure on active marketing communication to eliminate potential threats caused by content moderation or the complete passivity of the subject. The contrast of "one" negative mention in the context of dozens of positive messages will greatly reduce the risk of a long-term damage to the reputation of the subject. According Pollak et al. (2017) Concept of online reputation covers a wide range of aspects of the business presentation in the Internet environment. Online reputation is therefore a direct consequence of the enterprise's action on the Internet. It includes the actual performance of the company, but also the interaction of the company with potential as well as actual customers. Submitting a question about the importance of online reputation for business itself has long been inappropriate. It is more than desirable for businesses to actively manage their virtual reputation without delay. The author also presents three essential points in which he unambiguously and clearly describes the circumstances underlying the need to actively seek to manage corporate reputation on the Internet environment, namely:

- the continuous increase of Internet users, the perception of the advantages of the Internet in the process of making decisions about purchasing or purchase itself by users,
- perceptions of the Internet, as a sort of "lightning rod" of business activities, a high degree of secondary transparency,
- the need to not lose control of your own brand.

The very structure of the Internet multiplies the effort necessary for the active management of a company's reputation. Technologies with user-driven content of a varying nature, caused by various motivators, are not able to "judge" this content themselves. From the viewpoint of the tools, these are simple data, numerical series of ones and zeros. The technology itself distinguishes the character of the message, distinguishes true information from false and separates private information from public. Based on its principle, technology is already beyond generally accepted moral principles; the cool logic of machine code allows users to disclose whatever they deem appropriate (Loayza, 2013). Once a message is published, it is generally accessible via the Internet without geographical or time limitations. Enterprises must be aware of the fact that any interaction between them and the users is public and official at every turn, so it is necessary to approach it with the appropriate weight. Otherwise, the effort spent to remedy the undesirable situation may be highly counterproductive (Spišák, 2016). It is possible to conclude that the Internet has radically affected the dynamics of corporate reputation management. With the growing consumer and media focus, businesses are finding it increasingly difficult to reach target markets in a way that generates the desired interactions. In a decentralized Internet environment, the voice of an individual can be the power of a large organization, the user is given the opportunity to present his/her opinions or attitudes. At any time, they can present their attitudes in the form of reviews, blogs, discussion posts, and so on, from the position of a "journalist" of “their own media”. They thus have the ability to judge the brand or the company itself. New communication channels have greatly affected the balance of power. As a result, the reputation of businesses is often no longer defined by their behavior and performance, but by how they are perceived by the Internet community and its reactions and interactions towards the organization. Classical approaches to public relations are far too inefficient in the Internet environment as well as top-down communication (Bunting, Lipski, (2000).

3. Materials and Methods

The main objective of our study is to present the accessible ways and approaches of measuring the reputation, especially online reputation, as the current challenge for responsible and maintainable development of perceived image of subjects, as their very fragile intangible assets. Selected methods of quantification and subsequent measurement of reputation were presented, for the purposes of this study. For the research itself, we used significant rankings, specifically for offline and online reputation, then thorough primary analysis was carried out by our own methodology. The control measurements were performed within the analysis with an aim to identify and describe relevant connections and variables for a subsequent proposal and presentation of an affordable and useful tool to measure online reputation in a turbulent environment of the Internet. The research sample was represented by the top 10 hospitals operating in the U.S. market, selected from a whole set with more than 4,500 hospitals on the basis of 2018-19 Best Hospitals Honor Roll (U.S. News & World Report, 2018) These entities act as flagships of positive corporate reputation, operating in a highly competitive market, the connections identified on this significant sample form the basis for formulating accurate and relevant findings and thus providing an overall and full glance on the matter of the responsible development of corporate reputation in the field of health care providers. Considering competitive character created by the market itself, all selected subjects’ approach actively to the management of their reputation in an online or virtual as well as traditional brick & mortar or offline world. Describing the key connections and determinants influencing the reputation of these subjects will certainly help to better understand this, from our point of view, extremely important issue. Using multifactor analysis of the reputation in the virtual Internet environment (Pollák, 2015), we tested specific subjects. Within the testing, we considered the entire spectrum of perceiving their reputation since we compared the connections measured by us against available significant, and relevant rankings of offline and online world. Primarily against the offline world ranking of U.S. News & World Report, one of the main players in the field of ranking of Healthcare providers in a chosen market unified for percentages, secondarily against the selected significant online world rankings as Google reviews and Facebooks reviews, our own TOR ranking, and last but not least to ranking of The Cybermetrics Lab, called Webometrics in its last updated version elaborated, based on more than 16 500 Hospitals worldwide (The Cybermetrics Lab, 2015). Considering their size and scope, these ratings guarantee the relevance for the identified connections for both offline and online worlds, and findings and recommendations drawn from them directed to the other players operating in the analyzed market. Within our research, we used our own methodology of multifactor analysis of online reputation TOR, which we would like to present as a priority possibility to measure the entire power of Online Reputation of a subject in the Internet environment. The measurement of TOR itself takes place in three steps, in the first step, it is necessary to analyze the sentiments of the first ten keyword search results, namely own or established name for each of the particular subject from selected sample through Google search engine (Pollak, et al., 2017). In the second step, we identify the relevant determinants of online reputation. For this case, we used the evaluations of one of the most important online players Google and Facebook assessments of the subjects in the forms of users/customers reviews in stars which we subsequently converted into percentages. In the third step, we can proceed to the actual calculation of the overall power of online reputation of a specific subject which then serves as a starting point for complex comparison of overall power of reputation across all analyzed subjects. The standard equation for TOR calculation, presented in our previous studies (Pollák, 2015), predicts the occurrence of the factor and its weight, the primary reputator is here the overall score of the analysis of sentiment (step one), for the purposes of interpretation marked as ASA, the equation then allows the possibility to consider n of additional reputators. This score appears in the presented methodology as a marker called TOR. The connections identified on this significant sample form the basis for formulating accurate and relevant findings and thus providing an overall and full glance on the matter of the responsible development of corporate reputation in the field of health care providers.

4. Results and discussion

4.1. Overview table of partial score

Using Advanced Sentiment Analysis (ASA), we calculated the power of subjects' online reputation determined by the nature of the top ten search results via Google. However, search engines are just one of the ways by which users get what they want.

Based on previous research in the given issue (Pollák, 2015), we identified other determinants of reputation, that is in other words reputators for the field of healthcare, in particular:

- Google reviews (scale on the basis of stars, range 1-5),
- Facebook reviews (scale on the basis of stars, range 1-5),

Each reputator has a 5-point system of quantification of the perceived online reputation, namely the evaluations in the form of stars. These were converted into percentages. Before we present our own interpretations, we consider necessary to present partial evaluations of the subjects as well as all relevant indicators in one summary table. Table No. 1 presents both individual ranking of the offline and online ranking as well as partial score obtained by quantification of individual reputators subsequently forming the overall level of online reputation represented by the TOR indicator:

Table 1: Overall (Total) online reputation

No.	Subject/ Result sentiment	ASA score (%)	FB rating (%)	Google rating (%)	Number of pages indexed by Google	Reference Online rating (rank)	Reference Offline rating (%)	TOR score (%)
1	Mayo Clinic, Rochester	48.16	92.00	84.00	1,130,000	4	86.25	74.72
2	Cleveland Clinic	42.57	88.00	86.00	7,770,000	1	80.20	72.19
3	Johns Hopkins Hospital	48.38	92.00	72.00	2,130,000	3	73.95	70.79
4	Massachusetts General Hospital	78.26	90.00	86.00	5,580,000	7	73.75	84.75
5	Michigan Medicine	48.38	92.00	70.00	528,000	174	67.50	70.13
6	UCSF Medical Center	89.01	92.00	78.00	1,130,000	398	61.66	86.34
7	UCLA Medical Center	84.93	92.00	84.00	1,350,000	75	55.62	86.98
8	Cedars-Sinai Medical Center	79.12	88.00	80.00	2,650,000	116	52.50	82.37
9	Stanford Hospital	59.56	88.00	84.00	334,000	590	52.08	77.19
10	New York Presbyterian Hospital	51.82	86.00	72.00	1,930,000	10	50,41	69,94

4.2. Interesting outcomes of the analysis

Within this chapter, we will try to bring together the most interesting findings from the more in-depth analyses carried out, the measured results and the identified contexts. The first step in explaining the differences between the online and offline world as well as between the different reputational determinants is to illustrate the findings through combined graphs, then we will proceed to present the findings resulting from thorough statistical reputation testing and the overall order of reference ratings. Let us look at the visualization of our findings in the way as they are shown in Figure no.1.:

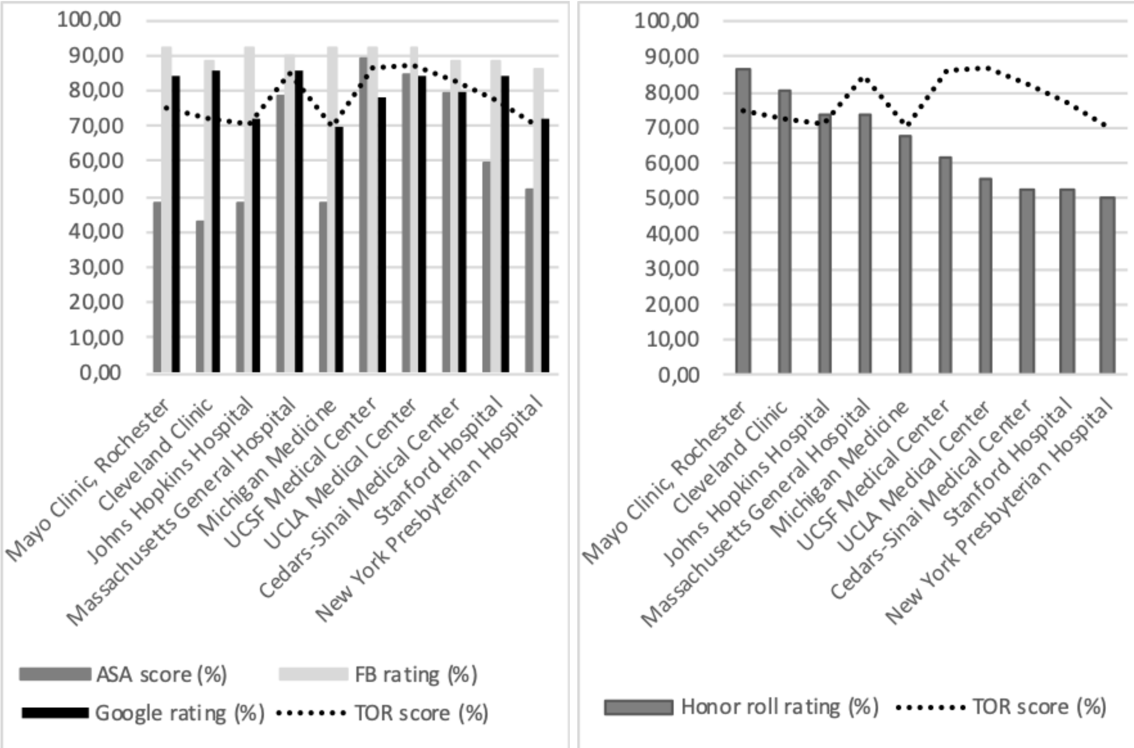

Figure 1: Online ratings vs. TOR (a), Offline vs. Online ratings (b)

The first part of the visualization (a) shows the connections between the reputators of the online world and the total strength of these reputators expressed through the TOR. As mentioned before, the relatively high coefficients and the overall indicator reflect the relevance and market dominance of the research sample. The second part of the visualization (b) deals with the connection between standardized ratings from the offline world and the total strength of the online reputation expressed by the TOR. To draw out the relevant findings, we have carried out a thorough statistical analysis of the measured data, which is shown in the following Table no.2:

Table 2: Dependencies between variables

Variables	Valid N	Kendall Tau	Z	P-level
ASA & FB rating	10	0.0839	0.3380	0.7353
ASA & Google rating	10	-0.0238	-0.0959	0.9235
ASA & No. of Google pages	10	-0.1590	-0.6403	0.5219
ASA & Honor roll rating (Offline)	10	-0.3595	-1.4472	0.1478
Google rating & Honor roll rating (Offline)	10	-0.1590	-0.6403	0.5219
FB rating & Honor roll rating (Offline)	10	0.3598	1.4484	0.1474
TOR & No. of Google pages	10	0.0449	0.1809	0.8564

As is apparent from the table, at the selected level of significance for all tested variables the p-value is significantly larger than the selected α-value at the level of 0.05. Therefore, we can say that at the chosen level of significance we cannot confirm the statistically significant differences between the variables tested by us. This leads us to assume the independence of individual reputators. From the point of view of reputation management, it is therefore necessary to devote individual attention in terms of time, finance or overall effort to each of the reputators. After examining the differences between reputators, we went through the Wilcoxon matched pair test to test the overall ranking of our own and reference rankings. Table No.3 presents the results of our testing:

Table 3: Dependencies between variables

Variables	Valid N	T	Z	P-level
Honor roll rating (Offline) & TOR	10	10.000	1.7837	0.0744
Webometrics & Honor roll rating (Offline)	10	24.000	0.3567	0.7212
Webometrics & TOR	10	26.000	0.1528	0.8784

As is evident from the table, at all tested ranges, the p-value is much larger than the selected α-value at the level of 0.05. Again, we cannot confirm a statistically significant differences between the rankings. However, if we were to reduce the significance level by 5 percentage points to a level of 90%, meaning α-value at 0.1 level, we cannot reject the statistically significant differences between the rankings achieved in the renowned offline world ranking and the online ranking of the TOR.

5. Conclusions

The traditional world in our research, also referred to as the offline environment, has a dominant role in the process of building the reputation of the subjects as such. Renowned institutions focusing on the evaluation of different target groups developed effective approaches to measure reputation bound to objective data and objective factors, such as demonstrable outputs, technologies, certifications, and so on. On the other hand, factors affecting reputation in the virtual world are predominantly subjective. Therefore, a gap between objective and subjective reality occurs. The problem of objective reality is that it requires enormous resources in the form of finances, time, effort, and so on. Subjective reality, on the other hand, is based on the opinions of anonymous individuals. This results in the immense fragility of reputation as an intangible asset, as on one side, there is a tremendous effort, and on the other side, a disproportionate variability and uncertainty. We share the opinion of the authors Kanika (2016) and Štefko, Fedorko, Bačík (2016) who consider the effort not to give up the control over the brand as one of the key preconditions when moving from offline to online reputation management. Responsibility in terms of building a corporate reputation is, in our opinion, continuation of investing in a traditional environment while actively monitoring the virtual environment. Only by considering all variables, the organization can minimize threats and maximize opportunities on the increasingly turbulent 21st century market. Our research synthesizes all mentioned points of view, offers a clear comparison of the reputations of the examined subjects across both worlds (virtual and brick & mortar). The presented results, especially after their visualization, bring interesting findings worthy of greater consideration. Despite the fact that literature offers a wide range of approaches to measure reputation, the presented methodology offers a relatively simple and fairly accurate form for active reputation management, thus providing an effective tool for increasing the competitiveness for a wide range of subjects trying to seek strategic alliances to achieve responsible development of their corporate reputation and maximize their market advantages against their competitors.

6. Acknowledgement

This article is one of the partial outputs of the currently solved research grant VEGA no. 1/0807/19.

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BUSINESS DATA SHARING FUTURE APPROACHES FOR SOURCING

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Keywords

Data economy, Business data sharing, Transparency, Supplier selection

Abstract

The first pillar of the EU strategy 2020 is to create the digital single market that would contribute to the development of innovation, economic and inclusive growth and trust in the economic environment accomplishing by greater transparency in the online environment, interoperability, and standards for e-business and business systems and the development of "data economy". A significant role in a supply chain plays market transparency in the field of business information like price, ability to deliver a product with specific parameters, stability in the market and other trusts related information. Sharing business information can be a systemic approach to more effective network activities and market behavior. The objective of the paper is to identify how the companies perceive data sharing and change in their behavior with a lowering of the transparency level of the data. The analyses show that companies are in general more willing to share categorical data instead of original data but their attitude depends on the size of the company and the attitude to share in general.

1. Introduction and literature review

To face the major challenges of the society EU created the Europe 2020 Strategy that explains five key areas of interest: employment, education, research and innovation, social inclusion, poverty reduction, and climate/energy. The creation of the digital single market in the EU is the first pillar of the EU strategy, which factors of development are connected with a number of initiatives (Digital Agenda, Innovation Union, Integrated Industrial Policy and the Agenda for new skills). Specifics of the digital market should, according to the EC, contribute to the development of innovation, economic and inclusive growth and the general growth of trust in the economic environment and its bodies (European Commision, 2010).

Based on the Digital single market (DSM) strategy and the European Parliament and the Council Directive (EU) No. 910 / 2014 from July 23rd 2014 on electronic identification and trusted services for electronic transactions in the internal market, European Commission stresses the needs of achievement and development of trust accomplishing by greater transparency in the online environment, interoperability, and standards for e-business and business systems and the development of "data economy" which are crucial for development of next-generation supply chains (European Parliament and Council, 2014). Network activities on the electronic market relate to interoperability, standardization, and transparency. In this area, some scientific studies have examined the network effects and diffusion theory of innovation and impact on the group of market participants and their innovation absorption capacity. A significant role within network activities, as a crucial factor of supply chain management, plays market transparency in the field of business information like price, ability to deliver a specific product with parameters, supplier's stability in the market and other trusts related information. Sharing business information can be a systemic approach to more effective network activities and market behavior. Weitzel, Wendt, & König, (2003) emphasize that understanding the networking environment and transparency is highly important because without a proper understanding of what happens, promoting networking can be dangerous. Some specifics in this area are now starting to appear in world studies. E.g. Turnes & Ernst (2015) claim in their article that in the near future there will be a huge increase in standardized business processes that will be determined by the need for an enormous increase of interoperability between systems and reviewing of impact on the environment. Now is the time to merge two dimensions of researches: studies in supplier selection criteria and technological trends in data sharing providing new opportunities for supplier selection criteria management.

Purchasing and outsourcing literature reviews in vendor selection reflect a variety in the evaluation criteria (Weber, Current, & Benton, 1991) as well as in the systemic approaches for selection (Ho, Xu, & Dey, 2010). With the complexity increase, it was realized that not all evaluation criteria could be quantitative and qualitative, and furthermore, some of them may have tangible or even intangible form (Çebi & Bayraktar, 2003)(Saen, 2007). For instance, there exist evaluation criteria like technical capability, skill level of staff, educational level of personnel and design capability which represent the capabilities of the human resources available for the vendor within its organization (Kar, 2009) (Pani & Kar, 2011) (Pani & Kar, 2011) (Kar, 2012). The sourcing process can be improved by making the supplier qualification process more efficient, drafting an effective workflow process by understanding demand and various market dynamics with a large amount of data that is generated by procurement process and can be successfully mined to provide keen insights, trend data and more for successful procurement strategy implementation. Furthermore, the use of analytics in the sourcing process can illuminate the vagaries in pricing or vendor efficiency.(statXO, 2019)

Understanding the impact of IT and technological solutions on various changes in the transparency of processes, services, and data in the digital society and understanding of the impact of this changes on the stability and evolution of the market as a whole is one of the most sensitive and most critical factors of development of the digital society. It is necessary to fully understand the behavioral aspects of the deployment of a specific innovation, adoption of which can significantly alter patterns of behavior of market participants, their preferences for the implementation of these innovations and the actual impact on individual subjects as well as the market as a whole.The main task when developing effective innovation to meet the needs of the fulfillment of the EU strategy and action plan for the development of global supply chains 4.0 concern is how to apply technological developments for standardization, interoperability and esp. data sharing approaches for sourcing processes. The search for a suitable approach on how to motivate to share and process business data for a new generation of e-sourcing services is the key mission of this research paper.

2. Methodology

The first step to identify a suitable approach for motivation and also the research question of this study is how the companies perceive data sharing and how their behavior changes with a lowering of the transparency level. The research was based on the questionnaires completed by the representatives of 43 different Slovak companies competent to the company´s top policy decision making. Answers were collected at the beginning of the year 2019 and companies were selected randomly. This sample was used as a test sample in order to identify the weak spots in a questionnaire as well as the main trends in the perception of data sharing. The questionnaire is focused on the willingness of the companies to share their business documents information. The analyses were based on these specific questions:

1. Demographic questions (number of employees and average turnover per year)
2. Business documents data sharing (Answers on the scale 0-10, min. 0, max. 10, to indicate the willingness to share. Each subpart contains two levels of transparency.)
    a. Identification of the business partner (specific business name/ anonymized categorization)
    b. Item or product descriptions in the business documents and catalogs (specific items/ catalog)
        i. Types of the catalogs used by the company
    c. Price (specific as in original business document/ anonymized price)

We studied willingness to share and shifts in the attitudes from sharing raw data to categorical data based on two parameters of the size of the company: average turnover per year and number of employees. Size structure in a sample depicts Table 1.

Table 1 Size structure in a sample

Number of employees		Average turnover per year	
< 10	74.42%	< 2 M	86.05%
11-50	13.95%	< 10 M	9.30%
51-250	6.98%	< 50 M	2.33%
> 250	4.65%	> 50 M	2.33%

The term "raw data" represents the data in the exact same form as they occurred in business documents without a change. Categorical data are raw data that are transformed into groups, intervals or other similar pseudo-anonymized form and are shared just after the transformation, so it represents lowering the transparency level. In order to show the effect of lowering the transparency on the willingness to share, we calculated the parameter of change between raw and categorical data as a simple difference.

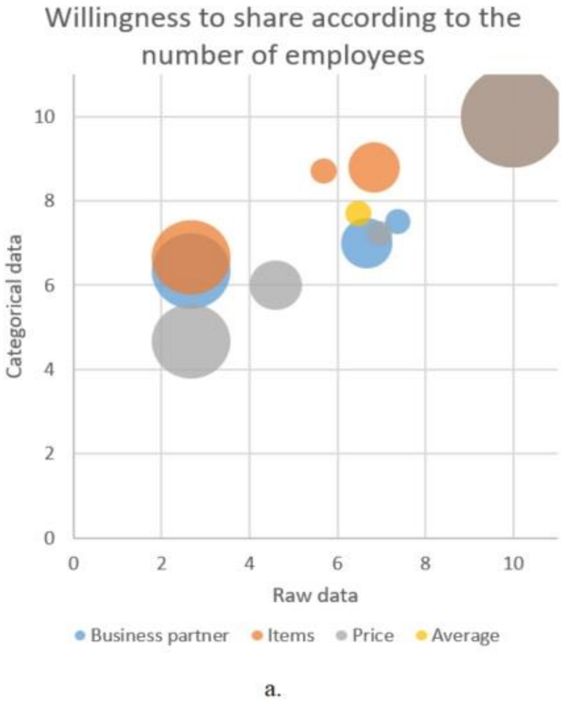
$$Change = Categorical\ data - Raw\ data$$

Finally, we performed Spearman's rho correlation analysis to detect similar movements between variables.

3. Results and discussion

To answer the research question we first created the bubble graph of the dependence between raw data and categorical data. Figure 1 consists of two bubble graphs in order to provide a comparison of the different size metrics applied to the data. Both show the company´s willingness to share data in three areas: business partner identification data, price, and item descriptions. On the x-axis is the attitude to share raw data and on the y-axis is the attitude to share categorical data. The size of the bubbles indicates the size of the company by a number of employees in graph a. and average turnover per year in the graph b. The average value represents order pair of the average willingness to share [6.5; 7.7], which means that on average companies scored a willingness to share raw data to 6.5 from 10, but categorical data up to 7.7 out of 10. Both numbers are above level 5 which indicates overall optimism to share data in both levels of transparency. Noticeable is a positive shift from a willingness to share data by lowering the transparency level. The difference in attitudes of the companies with different sizes emerged in both metrics.

According to the number of the employees in a company (graph a.), micro companies (with less than 10 employees) are the least willing to share raw data about items (5.7) but much more willing to share the catalog (8.7). Sharing price in any form reaches similar values around 7 and business partner details follow the same trend around value 7.5. So these companies do not consider lowering the transparency as an important factor in price and business partner details sharing. Small companies (with 11 to 50 employees) are the least willing to share information about the price where the raw price has value 4 and categorical 6. This indicates an aversion sharing any form of the price. On the other hand, sharing item and business partner details have similar value in raw data sharing, but sharing the catalog is more favorable than sharing categories of the business partners.



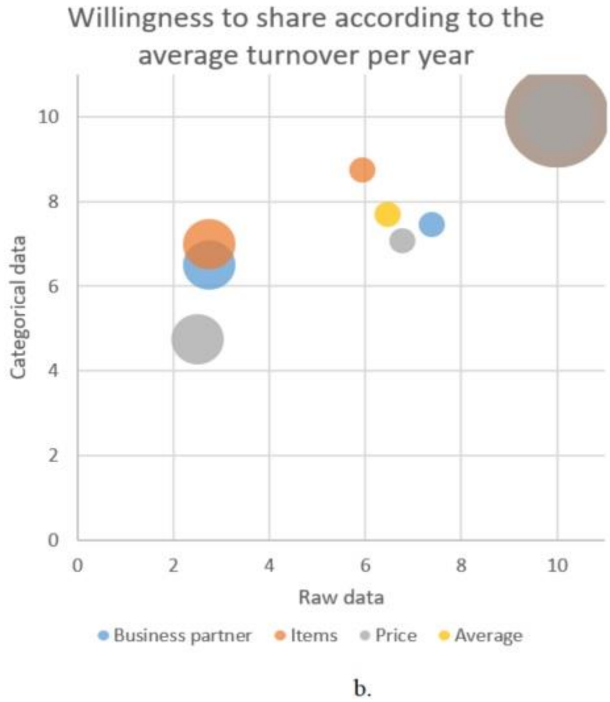


Figure 1 Attitude toward sharing business data

Medium companies (with 51 to 250 employees) are the only group below the average in all three variables and their willingness to share almost triples in shifting from raw to categorical data with the highest difference in item description transformation to catalog sharing. Big companies (more than 250 employees) expressed the largest willingness to share with all parameters at the value of 10. Generally, points are mostly above the equality line (0-0), which means that in the business environment is more favorable to share categorical data than raw data, lowering the level of the transparency would inspire more companies to join the sharing platform. Graph b. in Figure 1 represents an attitude to share according to the average turnover per year. Micro companies (with turnover less than 2M) answers are located around the average value and are behaving similarly as in a number of employee metrics. Small companies (with turnover less than 10M) are located below average and the biggest shift from raw to categorical data is in the item descriptions. These companies are the least willing to share the price in any form. Companies with a turnover larger than 10M are the most willing to share data whether raw or categorical.

The effect of lowering the transparency on the perception of sharing is depicted in more detail in Figure 2. It shows positive and negative shifts from the raw to the categorical form of business partner details (graph a.) and price (graph b.). Item descriptions and catalogs are not considered as different levels of transparency because catalogs generally contain more information than just the item description. Due to this fact the graph c. depicts relation between item and catalog willingness to share. Business partner details categorization was able to convince companies to change their

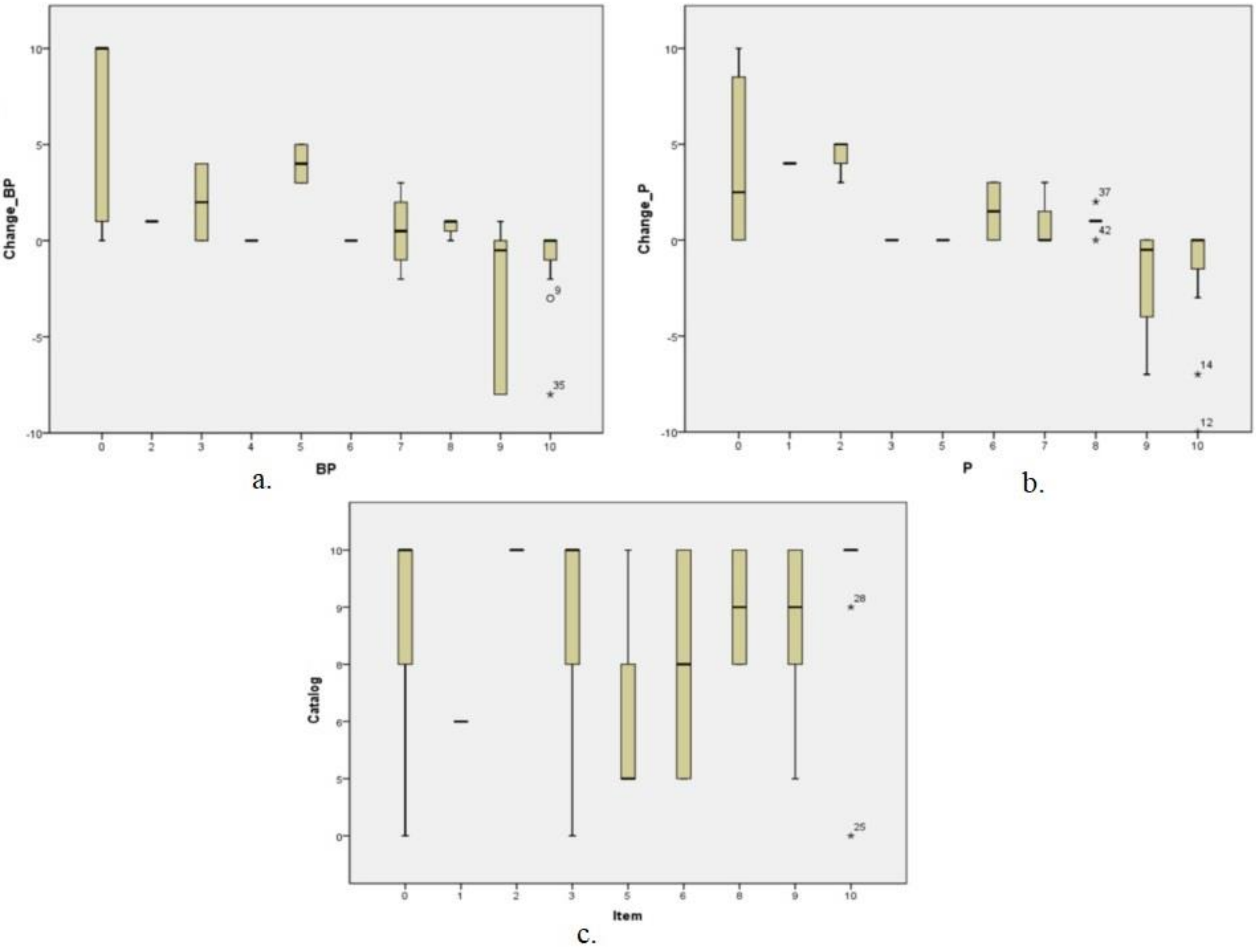


Figure 2 Changes of the attitude to share with lowering of the transparency

will from 0 to 10 with an average change of 10). Although value 9 has an average change of 0, negative changes largest in value 9, indicates that some companies are highly willing to share raw data, but they lose interest in sharing a categorical form of this parameter. The parameter price contains the highest changes also at value 0. However, the shift from 0 to 10 achieve a lower average value than BP on the value 3, which indicates the lowering of transparency level motivates the sharing of price but with less power. Price reaches less negative changes than BP so with lowering of the transparency parameter price is more favorable to share for companies than BP. Graph c. in Figure 2 reflects that companies with different willingness to share item descriptions are highly willing to share a catalog of their products. Lower willingness to share catalogs can be in some cases explained by the fact whether the company uses the catalogs or not. Companies that are not using catalogs are more willing to share Item descriptions. On the contrary, sharing the catalogs is more favorable for companies that are using catalogs.

Table 2 Usage of the catalogs in the companies

Catalog usage	Percentage in a sample	Average value of Item details sharing	Average value of Catalog sharing
Do not use	51.16%	6.45	7.90
Use	48.84%	5.15	9.40

The last step of the analysis was the performance of Spearman’s rho correlation analysis. (Table 3). Correlation between raw and corresponding categorical variable are significantly weakly positively correlated only in parameter price. Raw variables indicate a significant weak or moderate positive correlation.

Table 3 Spearman’s rho correlation analysis

			BP	BPCat	Item	Catalog	Price	PriceCat
Spearman’s rho	**BP**	Correlation.Coeff	1.000	.141	.455**	.176	.643**	.189
		Sig.(2-tailed)	.	.367	.002	.259	.000	.226
	BPCat	Correlation.Coeff		1.000	.310*	.511**	.294	.491**
		Sig.(2-tailed)		.	.043	.000	.055	.001
	Item	Correlation.Coeff			1.000	.145	.409**	.491**
		Sig.(2-tailed)			.	.355	.006	.001
	Catalog	Correlation.Coeff				1.000	.376*	.325*
		Sig.(2-tailed)				.	.013	.033
	Price	Correlation.Coeff					1.000	.473**
		Sig.(2-tailed)					.	.001
	PriceCat	Correlation.Coeff						1.000
		Sig.(2-tailed)						.

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

4. Conclusion and discussion

The research paper was the first step in identifying a suitable approach for motivation to share and process business data. Previous research in a perception of data sharing was mostly focused on B2C relations as f.e. sharing data by customers to the retailer in order to improve the product (McKinsey&Company, 2016), by patients to improve the medical treatment (Kim, Sankar, Wilson, & Haynes, 2017), by customers to advertising company for personalizing the advertisement (Leon et al., 2013). The research in B2B supply chain environment is focused mostly on types of information to share (Lotfi, Mukhtar, Sahran, & Zadeh, 2013), why the sharing is important and value of the information (Rached, Bahroun, & Campagne, 2015), but the willingness of sharing information is not sufficiently researched in previous works.

The analyzes focused on the attitude of the companies to share business information and monitor the changes in perception to share information with lowering of their transparency level. Sharing business data will lead to new generation of organization’s management and management quality (Zgodavova, Kisela & Sutoova, 2016). Willingness to share is positively changing by the transition from raw to categorical data and is influenced by the size of the company. Companies that are not willing to share business partner details are more motivated to share categorical form. In price, the most motivated are companies that were willing to share price at a minimum level, but after categorization, the willingness rises to the highest possible. In general, companies want to share their catalogs regardless of their willingness to share item descriptions from the invoice. The only exceptions are the companies that are not using the catalogs in their practice. Those companies have a higher willingness to share item descriptions, but sharing catalogs is not so significantly important than for the companies with the catalogs in use. Between the variable price and its corresponding shift was found a significant weak positive correlation. Variables between each other have weak or moderate positive correlation which means that attitude to sharing any variable is influenced by the company´s attitude to sharing in general. The limitation of this work is a relatively small sample of companies. We identified specific behavior during lowering transparency that we would like the companies to explain. We would like to overcome these limitations in further research. Together, we would like to encourage innovation enhancement in this field within different researches and education in innovation engineering and strategic management fields to change current business thinking (Zgodavova, Lengyel & Golemanov, 2008; Zgodavova, Horvath, 2015).

5. Acknowledgment

This contribution was supported by the Slovak Research and Development Agency within the project APVV-16-0368 “Determinants of Digital Single Market development and implementation in the field of global supply chains and in relation to changes of behavior of participants on the market”

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CYBER SECURITY IN A DIGITAL WORLD

THE END OF THE BLOCKCHAIN

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Keywords

Blockchain, security, evidence

Abstract

Blockchains are propagated as "secure evidence" and to record data unchangeably for a later point in time. And while these promises might be true for a "living" blockchain, where many parties contribute to its further existence e.g. through mining or performing some other (mathematical) work, at some point in time a blockchain might "die off". I.e., there are no further contributors, but the chain itself as data continues to exit on some (or many) storage mediums. What the scenarios for a blockchain to end and the consequences of this are, is discussed in this paper. It also provides ideas how a blockchain could prepare for its end or be "transferred" to another blockchain. In essence, how can the content of a blockchain remain secure, even if it has stopped growing, or under what circumstances can which attacks be avoided? While blockchains already did die in the past, this was typically of no consequence, as they were of little importance and all interest in them was lost since then. But if it would be used for instance to document land ownership or the financial history of persons/companies like a bank account, the content will be of interest much later and must exist and remain unchanged. Should e.g. bitcoin cease growing at some point, tax authorities might be interested in it for many years; and courts might investigate the content for decades, e.g. as evidence for money laundering or spending illegally obtained money.

1. Introduction

To start a public blockchain is easy and trivial (once the mathematical problems are solved and the "continuity function" is decided: an initial block is generated, and from this all further blocks propagate through calculating hashes or proof-of-work. But how does/can/should a blockchain end? This might be because it is no longer useful, or because a better (but incompatible) version was developed. Therefore it is necessary to investigate this topic. This is similar to life: many people expect to live eternally - or at least decline to think about their death. And medicine does all it can to extend and prolong life. But it is necessary to prepare, because at some point in time the end comes to all. This needs preparation for the end itself (e.g. palliative care or for blockchains perhaps some "end marker") as well as what happens after (with the body - who is responsible for archiving the blockchain; or the legacy - what happens to the content of the blockchain, e.g. spending remaining tokens or the legal effects of previous/uncompleted transactions). For example, there exists a current trend to move land registries to blockchains, see e.g. Hamilton (2019) or Exonum NAPR - these will have to remain valid for practically eternity, as such data will typically never be deleted. Similar considerations apply to supply chains as described by Deloitte (2017). And while bitcoin is not dead, support is dwindling, see e.g. Ruggieri (2019) and Karlo (2018).

This article investigates public blockchains, i.e. distributed ledgers. Private blockchains, which more closely resemble "several persons create signatures on data" are left out here.

1.1. Termination models

A blockchain can end in several ways. The first one, which is however unlikely, is sudden abandonment: all those contributing to the blockchain (typically: miners) continue working on it until block X, but nobody even starts working on block X+1. As a result, anyone who would like to continue now controls 100% of all computing power related to this blockchain - and can therefore continue it immediately (=without any pause) in any way he/she sees fit. This might be detectable because the "next" block takes an inordinate amount of time. A more probably termination scenario is however, that the number of contributors continuously, but slowly (i.e. over many blocks), declines. As an effect, attacks become more easier the longer you can wait, and it is hard to point at a specific block as the definitive end.

There is one important consequence to these two scenarios: many blockchains contain some sort of difficulty setting to ensure that blocks are created in roughly regular intervals independent of the number/computing power of contributors. In the first scenario the difficulty does not change until the end and an attacker would have to surmount this high obstacle alone. As this would probably take a long time (or he could have taken over the blockchain already while it was active!), the difficulty would then fall precipitously. While this can perhaps be avoided by falsifying time information, this will only change the stored time in the blockchain, but not the real time blocks are actually produced. So either the difficulty suddenly decreases enormously, or the time difference between a block appearing and its internal timestamp is large. While the previous cannot be hidden, the second might: calculating two new blocks for a year and only then using them publicly while claiming that they already existed for almost a year. If nobody regularly checked (the chain was abandoned after all!), this cannot be verified from the blockchain itself alone. So the second scenario is much easier for attackers, as the difficulty is actually being continuously reduced, so when the blockchain ends and an attacker tries to change it, it is already low (meaning they must expend less resources) and does not change strongly or has changed like this several times before (effectively allowing better hiding).

Another aspect of termination is, who decides upon it, i.e. declares it to be dead. In both models above there is no explicit declaration at all, just a cessation of continuity. If an explicit end is desired, either one person can do this, with the problem of how that person is selected (much easier in private blockchains!), or can be decided upon by consensus, i.e. more than 50 % of the (remaining at that point in time!) contributors. In the first model, while the chain is living nobody except the designated person(s) can terminate it unilaterally, but this is not true for the second one.

1.2. Attack models

An attacker could pursue several strategies relating to the end of a blockchain: first, the blockchain could be extended after its "official" end, i.e. attaching further blocks. A variant of this is, that not the official end needs to be the starting point, but sometimes earlier. A "resurrection" would be when only an "end/termination" block was removed and replaced by a new chain fragment. Note that variants, also called forks, are a natural element of blockchains and are typically solved via the length: whichever chain is longer is the "real" one. As by definition no one is working on the original chain after its end anymore, it would be easy for an attacker to create a longer fragment.

But the same could also happen in reverse: a living chain might be attacked by creating a "fake" termination block, if such a thing exists. Distinguishing this from the previous scenario would be impossible. Note that such an "earlier end" might be produced even at a much later point in time.

A third kind of attack would be to change the content at some previous point in time and then recalculate the chain from then on with the same content (except the one/several transactions of interest) and end the chain at the same block, in effect creating two forks of exactly the same length.

For bitcoin as an example these attacks are limited to a certain degree, as one rule for block acceptance is, that the timestamp must be later than the median time of the last 11 blocks ([Bitcoin protocol rules] "block" messages rule 13). This limits forks to approx. 6 blocks in length. However, even if this rule is violated and two forks of e.g. 10 blocks exist, it remains impossible to determine which of the two forks is the one not conforming to the rules.

It should also be noted that timestamps are usually unsigned, i.e. merely a statement of the "current" time by the entity creating the message or data structure. While this is fine for a living blockchain, where everyone verifies that these are "close enough" to their own current time, this is useless in a historic perspective. They can be verified for a living blockchain, as e.g. every block should have a certain "age" compared to the next one, and the last needs to be "current". But after the end such an anchor in the current time, allowing verification back, no longer exists.

1.3. Intermediate result

As intermediate result we can determine that after a "normal" public blockchain has ended, various attacks are possible, and many will be even easy, i.e. with little resources required to perform. It is therefore necessary to either abandon a blockchain after its end completely (which cannot be guaranteed for public blockchains!), or somehow produce an "official end". Abandonment means to completely disregard its content forever - it might have been valid once, but now we cannot say anything about it with certainty. These were past cases, but might not be good enough for the future. One example for an official end would be to obtain a copy of the blockchain from a trusted source, which guarantees that the chain was fully verified at the time each block was created, that it has not been changed since, and that only "acceptable" (as defined by that source!) contributors were/are allowed to submit new blocks. This outcome could be reduced slightly and roughly according to the following estimate:

- The blockchain was known to be living at the time *t*. This knowledge must come from an independent and reliable source. Note that this time is not necessarily the end of the blockchain but can also be earlier.
- At the point in time *t* the then current end of the blockchain was a specific block *b* which is known (its signature as well as some identifying information - either the full block or some kind of block serial number). This must again originate from a trusted source.
- Since the time *t* a timespan *s* has elapsed. This can trivially be calculated.
- The computing power *p* of the attacker(s) can be estimated (or is set as a limit for security check purposes).

Based on the computing power and the timespan *s*, it can be checked whether it would have been possible to start at block *b*, and with the computing power *p* available to the attacker, calculate a variant blockchain up to the end, i.e. of at least the same length. When calculating the potentially faked blockchain length, the difficulty needs to be taken into account: whatever the blockchain says, as this is the actual need for any falsification (if such took place). Note that any decreases in difficulty renders this chain longer for a constant time - and this is up to the attacker.

If the result is “no”, then the existing blockchain is valid, as (with the probability of not being extremely lucky in completing the proof of work/hashing) it is longer than anything the attackers could have created in the time available to them. But it must be considered that the attackers could have started the modification much later, and therefore have computed only a much short chain. This guarantee therefore only fully applies to block *b+1*. As effect, “recently deceased” blockchains can be verified fully for a short time, but those longer dead allow at least their ends to be modified. Or calculated in reverse: if the attacker can produce blocks at a rate of *r* blocks per time unit, elapsed timespan *s* multiplied by *r* blocks could have been falsified. This number of blocks from the end backwards must be seen as suspicious, only the blocks “not reached” can be relied upon. Note that this approach of working backwards is impossible for attackers, as they cannot calculate the chain backwards: they must select a starting point and from there on work forward.

However, if the answer to the question is “yes”, then we cannot make any assumptions anymore: the starting point *b* might be correct, but whatever comes after could have been faked. Note that this result will always be the outcome at some (future) point in time - it is merely a question of the duration since the termination of the blockchain and the capabilities of the attacker. Therefore an explicit “end” is necessary if it should remain valid for an indeterminate time.

2. Securely terminating a blockchain

Several approaches can be devised to terminate a blockchain. These are described and discussed with their (dis-)advantages in the following subsections.

2.1. Secure archive

The simplest option is, that when a blockchain ends, it is securely archived with a trusted party. This entity should guarantee the following elements:

1. The blockchain was verified up to the very end and was valid at the moment it ended
2. The moment of end has been securely recorded
3. The whole blockchain is available for inspection
4. Its definition of when the chain is considered to be “terminated” is made public

Technically this can be performed through a secure archive combined with an (external to the block) secure timestamp on the last block. But this approach suffers from one very serious shortcoming: this agency has to decide when a blockchain is dead, and this must be determined immediately. Otherwise anyone could always claim that the blockchain did continue, and was later “cut short” through the later-added timestamp. The only defence against this is, that this is a “trusted” party, i.e. it would not do this, or to obtain the timestamp from yet another party (which again must be trusted). While such a party might be seen as trusted by many people, this does not guarantee that everyone trusts it. Also note, that multiple such parties might exists, which are all trusted by a significant number of people, but still have different opinions on the end (both based on different termination scenario requirements and different assessments of the facts!).

So if a general consensus exists that a blockchain should be terminated at a certain point in time, e.g. because of replacement, this is an option - for those part of the consensus. It is therefore better suited to the first termination case described above, but not the latter, where participation continuously declines. Still the third requirement, a trustworthy archive of the blockchain, is needed even in all further approaches (but need not be at a single institution - this is merely the minimum).

A typical case for his would be, when a blockchain is used for official business, i.e. a company or a state employs this blockchain and now stops this (when switching to another chain/technology see below). So even when lots of people contribute and no centralized approval exists during its life, there exists some authority which can declare it "dead". Persons can of course continue the blockchain on a technical level, but for any official use or as evidence this termination would be final.

2.2. Integration into another blockchain

Based on the previous is the next approach: someone (but not necessarily a *trusted* party!) has to archive the blockchain and keep it available. The timestamp of its "death" however is recorded in another blockchain in some way. If that second blockchain is still in active existence at the time of checking, it provides the equivalent of the timestamp above. However, this approach suffers from some problems too: anybody could integrate such data from any blockchain whenever they want, effectively declaring another blockchain dead. Additionally, this would not necessarily be noticeable immediately to users of the second blockchain (and users of the "terminated" one might not even know about the second one!), so even only a long time later this fact could be revealed. This approach is therefore not useful, as anybody could at any time declare the end of a blockchain - which also means that anybody can claim that the actual and real ending notice was such a fake. So the only solution for this is, that a trusted authority (see problems above) declares the end and includes this declaration in the second blockchain - with the addition that the identity of the entity must be derivable from the blockchain entry (and is trusted by the verifying person).

2.3. Termination block

A blockchain could also define a "termination block" in advance - a special block that ends the chain. This requires that during the operation of the chain contributors refuse to create such a block, but at the death moment lift this restriction and do add it. This block would be detectable as such from its content. The advantage of this approach is, that it follows the general model of blockchains: a consensus must be reached. As an effect, a single miner might always propose to prematurely end a blockchain, but cannot enforce this as the others would not accept such a block and rather continue creating normal blocks, outpacing the attacker. However, this also has problems: at a later point in time such a block could be mined retroactively, therefore cutting off the end of the blockchain. The same is true while the blockchain still lives: if someone has a significant computing power, (say 40%) he could create such a block before this fork dies off. Moreover, even if the chain should have ended there, attackers could continue the chain from the previous block and claim to be the correct fork. Again, this is (given enough time has passed) undecidable.

To improve this solution, the end block could be externally signed with a trusted timestamp (inside the block is useless, as the timestamp then cannot attest to the block itself!). This timestamp would have to be applied before the next block were to be expected (i.e. immediately after the block was confirmed). In this way alternative forks could still be constructed afterwards, but because this is a valid block before the next block appeared, it is very likely to have been generated by the consensus (=at least 51%) and not an attacker (who would require more time), thereby invalidating the fork, even though it might be longer. This approach can be further improved to reduce the probability by chaining several such blocks, e.g. until the consensus rules specify that this is the "real" chain (e.g. 5/6 blocks for bitcoin; see above). Care should be taken that this is not performed with a change in difficulty to a lower level (see above) - the same or higher difficulty for all these blocks should be required. The timestamps could be included in the next blocks, with a final additional termination block without timestamp for itself at the end, obviating the need for external timestamps or other confirmations.

This would solve the following problems:

- Resurrecting a “dead” blockchain is impossible, as at the time of dying the blockchain was still valid, which can be verified by the timestamps. I.e. attacks would require getting a timestamp at the correct time for some random data, and later constructing a valid block hashing to exactly this pre-determined data (impossible with a secure hash function, but potentially possible at a much later point in time after the algorithm has been broken!). With multiple blocks this would have to be repeated several times.
- Maliciously terminating a live blockchain is impossible, as this would require taking over the complete blockchain, i.e. being able to calculate multiple blocks faster than the rest of the contributors together until this fork is the dominant one (51% attack, so a problem for public blockchains anyway).
- Alternative ends are impossible, as they also would require generating blocks for pre-retrieved timestamps. Intermediate modifications before the termination blocks would require creating hash collisions.

From a technical point of view, a weakness of this scheme is that the hash algorithm must remain secure even after the end - as soon as collisions can be created in reasonable time, the security of the whole chain fails. Note that for a living chain this is also a problem - the past could then be modified. But there switching to a better algorithm, creating a (new algorithm) hash over the whole (!) past (not only the last block as typical), and inserting it into the blockchain would solve the problem. Note that a Merkle tree hash in the blockchain would not solve the problem: this is advantageous, but also provides any guarantees only for a secure hash algorithm. So even then the whole data of the blockchain needs to be re-hashed once. For a dead chain this is not possible, unless a secure archive or a secure signature over the whole chain are added before the insecurity begins (see first solution).

From an organizational point of view, someone must initialize the creation of the termination blocks. Merely proposing them as a technical block and distributing it is probably not going to work, so some communication and off-chain consensus building will be necessary. Another issue is, that the security depends on the trustworthiness of the timestamps: if the issuing party is untrusted (or trusted no longer at some later point in time!), the scheme falls apart.

2.4. Termination blocks and integration into another blockchain

Combining the two former approaches results in multiple termination blocks, calculated through consensus, and inserted into another blockchain. In this way no actual (third-party) timestamps are needed, as they are obtained through the position (and the timestamps) in the second blockchain. In this way no central instance is required at all. But even in this solution one difficulty remains: the problem is not actually solved, it is “merely” moved to another blockchain. As long as this blockchain remains active, the former blockchain is secure too. This means organizationally that only “important” blockchains should be considered for such inclusion and that these should itself contain provisions for their secure termination. This problem cannot be fully solved but at least reduced by including the termination information into multiple blockchains - as long as one survives, the “original” remains secure. Note that additional hash values might be required if the algorithm used is rendered weak (see above). Even if one of these blockchains can be attacked successfully, then this only means that one piece of evidence is lost. As the termination blocks were created on the original blockchain, no artificial false termination blocks can be generated on the broken chain they were included into, merely false evidence about termination not having taken place.

3. Conclusions

While proponents of blockchains extol the advantages of blockchains it should be clear, that not every blockchain is going to survive indefinitely. Especially when regarding the continuous improvement of quantum computers and that even very good hash algorithms might be broken at some time in the future, and even when ignoring all kinds of organizational and economic issues that might arise. It is therefore necessary to also consider, how blockchains might end, and how their content is kept secure against later changes. These issues were discussed and several possible solutions presented: from central ones (e.g. organized by a state, like the tax authority) to completely distributed ones, where not only the decision on the end but also the preservation remains distributed. All however require that someone archives the blockchain and keeps it accessible - the schemes "merely" retain the unchangeability of this copy. So in the design of future blockchains some thoughts should be given to this aspect too. And while contemplating the end/failure of a project right at the beginning is not very "sexy" for developers and e.g. start-ups, from a business point of view, especially when considering this for some "official" content of durable evidentiary value it is a necessity and should be asked for and required from the initiators.

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STATE OF CONNECTION SECURITY TO WEBSITES OF EDUCATIONAL INSTITUTIONS IN CZECH REPUBLIC

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Keywords

HTTPS, certificate, security, education, websites

Abstract

Although educational institutions use websites as one of their main online communication channels, their implementation can be outdated or poorly implemented and therefore potentially vulnerable. This contribution focuses on the use of HTTPS on websites of Czech educational institutions and analyses security of HTTPS implementations, including used SSL/TLS protocols, cyphers and certificates and comparison to the alternative solution provided by ČŠI. The analysis shows that although HTTPS is present on 89.4 % of studied websites, only 35.5 % of websites implement HTTPS in a way which could be considered errorless. However, further analysis of HTTPS implementations reveals that only 16.63 % of all websites do not use deprecated protocols and weak cyphers. An alternative solution from ČŠI provides an average level of security; nevertheless, it could improve the security of 64.04 % websites.

1. Introduction

Internet in its core was not designed with security in mind because at the time nobody could imagine how it is going to be used. Soon a substantial part of communication involved internet and privacy became a necessity. Therefore, new security measures had to be developed to ensure that communication is private and safe. This fact was recognised by The Internet Architecture Board (IAB) and Internet Engineering Steering Group (IESG) 23 years ago (IAB and IESG, 1996) and yet we have seen widespread development in this area only in recent years. One of protocols which have been widely adopted in recent years on the World Wide Web is Hypertext Transfer Protocol Secure (HTTPS), a protocol which uses Transport Layer Security (TLS) and makes sure that one's communication is encrypted and that the identity of the other side is verified with Extended Validation (EV) Certificates. To strengthen the security and to prevent threats documented in RFC 3833 (Atkins and Austein, 2004) it is also possible to use DNSSEC which secures the domain name to IP address translation.

Almost every educational institution in the Czech Republic uses the web to communicate information to and get from its customers, students, and their parents. According to Czech School Inspectorate (ČŠI), 99 % of elementary schools with more than 150 students and 93.9 % with less than 150 students use a website to communicate with students and parents (Ševců, 2017). Schools on their websites do not only provide simple textual information but also offer services to their students and parents. Example of such a service is web access to a school email box or a grading system. Both examples store sensitive data which can become a target of various malicious attacks.

Although most educational institutions in the Czech Republic are financed by the government, there are no guidelines for web, specifying how sensitive data should be made available, and which security measures are necessary to implement. The only applicable rules are general ones regarding GDPR. The problem is the same for all educational institutions, yet each institution must solve it on its own. Each of the thousands of institutions must solve their website on its own, which makes this area of website implementations in public institutions unique. Another important aspect which makes this security problem different from other institutions is the user base, consisting mainly of parents and students.

Main benefits of HTTPS are:

1. *Privacy thanks to encryption.* According to RFC 7258 (Farrell and Tschofenig, 2014), even eavesdropping is a cybernetic attack. HTTPS uses TLS to encrypt communication between user and server, but information about which user connects to which server is still unencrypted.
2. *Unchanged content.* End-to-end encryption also guarantees that the end user gets content provided by the server unchanged. This includes targeted severe attacks but also prevents changing content by the internet service provider, for example, by adding ad banners on free Wi-Fi hotspots.
3. *Authentication of a server.* TLS only provides a secure channel for communication without authentication of the other side. This is possible when the server provides an EV Certificate. This way, the user can be sure the communication is not only secure but also with the right partner.
4. *All communication is treated the same.* With correctly implemented HTTPS, there are no differences in communication. Because all communication is encrypted, it is not necessary to treat sensitive information differently. This is especially helpful in the context of GDPR. For this to work correctly, it is crucial that the website does not contain “mixed-content”, content provided over an unsecured channel.

In this paper, the security of the connection to websites of educational institutions will be assessed regardless of the actual content on the site, and alternative solution provided by ČŠI will be used for comparison. This alternative to a website owned and managed by the school is provided as a service on InspIS PORTÁL where schools can create and design their website. However, the created website is not published on their domain, but on www.webskoly.cz/X, where X is chosen identification name of the school.

2. Method and data

Analysed domains were sourced from an aggregation of data from Ministry of Education, Youth and Sports (MŠMT) database stistko (Výběr z adresáře škol a školských zařízení, 2019) and database of ČŠI (Vyhledávání školy | Portál ČŠI, 2019). There are 9922 institutions registered under MŠMT. Webpages of some institutions were not available in these databases, and some institutions are not present on the internet. Therefore, the total of 7666 domains was analysed, out of which 221 were not available. Our list of domains accounts for approximately 77 % of institutions registered under MŠMT. In the further text, the focus is on levels 0 — nursery schools, 1 & 2 — both levels of elementary schools and 3 — high schools by ISCED 2011 classification.

These account for approximately 92 % of all domains analysed. If an institution provides two or more levels of education, it is included in statistics for all levels.

To scan websites, various open source tools have been used. DNSViz v0.8.2 was used for DNSSEC detection (Deccio, 2019). Program testssl.sh Version 3.0 rc4 was used for a detailed analysis of HTTPS implementation. This Bash script provides valuable information about available protocols, vulnerabilities, and certificates (Wetter, 2019).

Firstly, domains were scanned to determine their existence. Then it was determined if the web supports redirection from or to http:// and http://www. Websites which did have HTTPS were separated from those which did not. The ones which had an unsevered trust chain and valid, trustworthy certificate have been separated from the rest. These websites are considered to have functional HTTPS implementation. Those which did not fulfil this requirement were objected to further analysis which determined reasons of the failure such as trust issues regarding the certificate.

Websites which correctly implemented HTTPS were further analysed from the point of view of available SSL/TLS protocols, offered cyphers and used certificates.

3. Results

DNSSEC is not used by 4051 or 54.12 % of all 7485 accessible domains. Approximately 30.92 % of domains implement HTTP/2, but only 47.88 % of these also has functional HTTPS implementation. Only 88 does not have redirection from WWW, and 280 does not have redirection to WWW. This may cause an issue for users because the website appears not available. Even though not using WWW might be common, the solution is straightforward, and there is no actual reason for not fixing it. 10.6 % of websites do not respond on port 443, which means that HTTPS is not implemented.

Table 1: Main categorisation of webpages

Category	Type of school			All tested n=7445
	Nursery n=3687	Elementary n=3693	High n=1308	
HTTPS not implemented	10 %	10.9 %	10.4 %	10.6 %
Poor HTTPS implementation	58.7 %	53.8 %	43.3 %	53.9 %
Good enough HTTPS implementation	31.3 %	35.3 %	46.4 %	35.5 %

Out of 6648 websites which have HTTPS implemented, only 4031 (60.63 %) implements it in a way which makes it not usable, and we define it as poor implementation. This means that their certificate either does not include domain with WWW or includes only the WWW variant which renders their certificate not trustworthy when redirection is not in place. 69.9 % does not have a trustworthy certificate; this also includes 517 cases of self-signed certificate or 1567 cases of the broken chain of trust. More can be seen in table 2.

Table 2: Causes and main issues of poor HTTPS implementations (n = 4031)

Issue	Type of school			All tested n=4031
	Nursery n=2101	Elementary n=1946	High n=559	
Without redirection from www	1.5 %	1.2 %	0.2 %	1.2 %
Without redirection to www	2.5 %	4.1 %	6.6 %	3.7 %
Certificate without www	23.7 %	18.3 %	10.4 %	18.8 %
Certificate with www only	3.8 %	5 %	7.6 %	4.7 %
Self-signed certificate[26]	11 %	12.8 %	11.4 %	12.8 %
Broken chain of trust[26]	35.7 %	38.6 %	42.4 %	38.9 %
Untrusted certificate	67.8 %	70.6 %	67.6 %	69.9 %

Only 35.5 % of all domains which are used by educational institutions implement HTTPS in a way which does not cause major visible issues when opened in the browser. These might be considered good enough implementations. Although these do not cause disturbing warnings in the browser, they are by no means perfect implementations and therefore are a subject of further analysis. Main categories are enumerated in table 1. Considering how these types of institutions significantly differ from each other, the differences in implementation of HTTPS are not as substantial as might have been expected.

As figure 1 shows, the use of weak SSL/TLS protocol is not uncommon. Few institutions still use protocols SSL 2.0 prohibited by RFC 6176 (Turner and Polk, 2011) and SSL 3.0 deprecated by RFC 7568 (Barnes *et al.*, 2015) and quite a substantial number uses TLS 1.0 (might be vulnerable to CVE-2014-8730 (*NVD — CVE-2014-8730*, 2017)) and 1.1. Adoption of the newest TLS 1.3 is still very low.

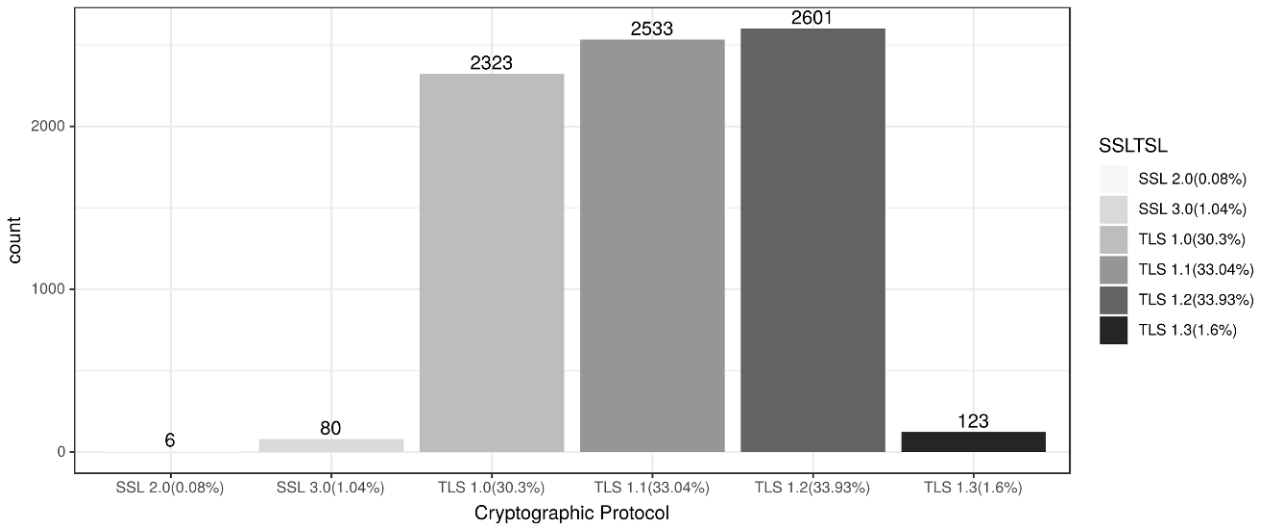

Figure 1: Use of SSL/TLS, n=2657

Scan of offered cyphers reveals that in 5 cases the server allows HTTPS communication without any authentication, in 3 cases "export" cyphers are offered, in 173 cases 64-bit cyphers with DES or

[26] Also part of Untrusted certificate

RC2/4 and in 1319 cases 3DES which was deprecated by SP 800-131A Rev. 2 (Barker and Roginsky, 2019) is available or IDEA which was deprecated for TLS 1.2 and newer (Eronen, 2009). All websites support current safe-enough cyphers, and only 67 does not offer strong AEAD cyphers. Cypher ordering supports 91.98 % of websites with good enough HTTPS implementation. If all websites using deprecated SSL protocols and cyphers are eliminated, and cypher ordering is considered mandatory, the set of remaining the includes 1245 domains which are only 16.63 % of all working websites.

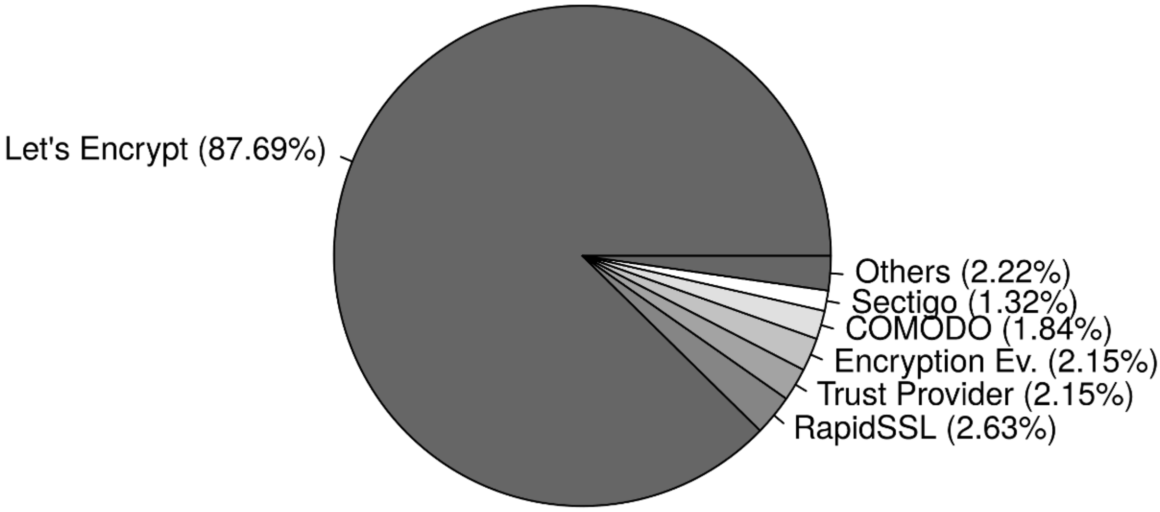

Figure 2: Most common CAs, n=2657

Certificate analysis shows that the most commonly used Certificate Authority (CA) is Let's Encrypt with 87.69 % share, as shown in figure 2. All certificates use 32-bit SHA265 hashing algorithm. The most common signing algorithm for server key is RSA with either 2048-bit key, 1797 cases, or 4096-bit key, 822 cases, as shown in figure 3. Only 15 certificates do not support Certificate Transparency (CT) (Laurie, Langley and Kasper, 2013). CT is now enforced by Google (The Chromium Project, 2019) and Apple (*Apple's Certificate Transparency policy*, 2019). Only 22.65 % of websites with good enough implementation support OCSP stapling (Myers et al., 1999).

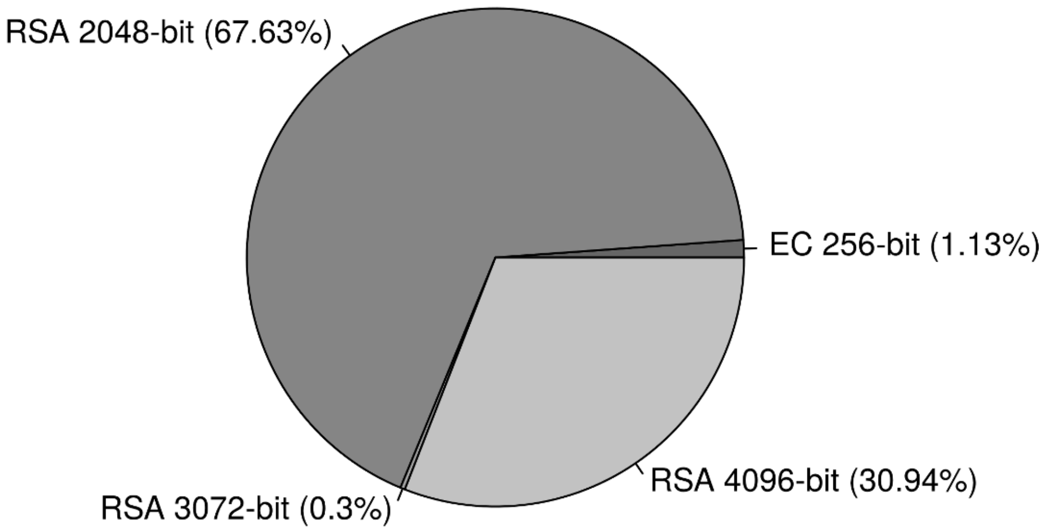

Figure 3: Certificate signing algorithms, n=2657

Website on domain www.webskoly.cz does offer an average level of security in terms of HTTPS implementation. The server correctly redirects to www subdomain, and although service does not offer deprecated SSL 2.0 and SSL 3.0 protocols, it still uses 64-bit cyphers, DES and RC2/4, and Triple DES and IDEA. Nevertheless, this means that use of this service can improve the security of 4910 or 64.04 % websites which have none or lower level of security than this service of ČŠI. No server offers HTTP Strict Transport Security (HSTS), or HTTP Public Key Pinning (HPKP).

4. Discussion

The use of TLS 1.0 and 1.1 is unnecessary as according to statistics of Google Chrome browser (Benjamin, 2018) they represent only around 0.5 % of all HTTPS connections and 0.72 % in case of Microsoft Edge (Pflug, 2018). These versions are going to be deprecated by Apple, Google, Microsoft or Mozilla in the first quarter of 2020, approximately one year after this research was conducted (Thomson, 2018; Wood, 2018). Only 68 websites offer TLS 1.2 and newer exclusively. When those who implement weak cyphers are eliminated, just 58 or 0.77 % remains. Only those would be considered trustworthy after the mentioned date.

Regarding the security headers, implementation of HSTS would be beneficial as it enforces HTTPS connection and protects against downgrade attacks. HPKP, on the other hand, might be dangerous in case of missing keys (HPKP suicide), especially when high max-age is set which can render domain not accessible; moreover, this security measure can be abused for the RansomPKP attack (Lester, 2019). Google also deprecated it in Chrome browser version 67. Therefore, it is better to implement Expect-C header (Stark, 2018; Medley, 2019).

Connection security and correct implementation of HTTPS is a major concern as users can be exposed to numerous possible exploits and attacks. Solution provided by ČŠI is not perfect but would improve the security of many institutions and remove the burden of maintenance and responsibility for websites.

Users of websites are free to update their web browser and operating system. Therefore there is no reason to maintain compatibility with old clients, and therefore, there is no restriction in the implementation of cyphers and newer protocols which are supported in current releases of mentioned software.

Higher tendency to overlook warnings in their browsers while visiting their websites can be expected because schools are public institutions; therefore, users usually trust them. That increases the risk from the lousy implementation of HTTPS.

From our previous research (Svoboda and Georgiev, 2019) follows that only a small portion of the Czech educational institutions have their own IT department, and they mostly rely on outsourcing and self-made solutions. For smaller dealing with ICT can be cumbersome and financially exhausting, but lousy ICT solutions should not be considered normality or standard in the area of educational institutions.

The list of requirements for safe enough website could be standardized as an ordinance of MŠMT. This would help in the specification of requirements for a website when school is putting together contract with an IT company providing web hosting.

It is necessary to point out that MŠMT does not use HTTPS on the main webpage of their website.

5. Conclusion

Because educational institutions are not excluded from the ever-increasing demand for modern communication technology and presentation, they are starting to use the internet as a communication channel with students and parents and provide more and more ICT services. Because the focus of these institutions is education and not an implementation of the latest whims of the technological world, they tend to forget about updates and maintenance. This is undoubtedly a case of website presentations of Czech educational institutions because around 10 % of institutions do not have any implementation of HTTPS on their websites, and around 55 % have significant flaws in their implementation.

We, as a society, care about the physical security of our children in schools. This area is visible and readily comprehensible to a broad public whose pressure produces necessary actions of government (Fidrmuc, 2015). Details of online communication are not a distinct topic, but its importance should not be omitted. The government should issue the best practices and guidelines to keep people who oversee ICT in educational institutions informed and ready to make the right choices. This might improve the current situation. Future research should focus on other possible vulnerabilities, for example, those of content management systems and installed plugins.

Further inspection of website content and identification of available services would also be valuable. Another possible angle might be an attempt to identify the reasons behind the current status quo, whether it is lack of knowledge, lack of finances or other reasons.

6. Acknowledgements

This paper has been partially supported by the IGA grant VŠE IGS F4/60/2018.

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TOWARDS ESTABLISHING THE LINK BETWEEN A PERSON'S REAL-WORLD INTERACTIONS AND THEIR DECENTRALIZED, SELF-MANAGED DIGITAL IDENTITY IN THE DIGIDOW ARCHITECTURE

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Keywords

IDIMT, Digidow, digital identity, biometrics

Abstract

The Digidow architecture is envisioned to tie digital identities to physical interactions using biometric information without the need for a central collection of biometric templates. A key component of the architecture is the distributed service discovery, for establishing a secure and private connection between a prover, a verifier and a sensor, if none of them knows the others ahead of time. In this paper we analyze the requirements of the service discovery with regard to functionality and privacy. Based on typical use-cases we evaluate the advantages and disadvantages of letting each of the actors be the initiator of the discovery process. Finally, we outline existing technologies could be leveraged to achieve our requirements.

1. Digidow vision

Digital identity will be a central requirement for many future applications. There is ample research under many different aspects on how to create, assign, and verify an individual person in a digital world based on interactions in the physical world. The Digidow project (Institute of Networks and Security, 2019) envisions a trustworthy infrastructure enabling biometric authentication without central databases. Such an infrastructure would provide two new capabilities:

- Individuals should no longer need to carry a physical token to prove a digital identity. Providing their biometric attributes to a sensor should be sufficient.
- Individuals should remain in full control of their personal information, the data should remain decentralized and offer extended privacy guarantees.

Of course, these new capabilities must not compromise the security of the infrastructure. Otherwise, it would no longer be useful for critical applications, like i.e. passport checks.

1.1. Security Benefit

Digidow's decentralized approach provides an important security improvement over current implementations. Passports provide a very nice example:

Currently, passports contain a chip with the biometric information of their holders. This information can be used to verify the identity of a person by comparing the measured biometric values with the data stored on the passport's chip. But that also creates a security issue because it means that biometric information could be extracted from stolen passports and used for identity theft (Vijayakrishnan, 2008). With Digidow there is neither a physical token that could be lost, nor a centralized database, which would be hacked, as seen in countries like India (Khaira, 2019). The important biometric information remains under full control of the owner at all times. This also has another advantage over current biometric passport implementations: If a foreign government wants to read out a passport, they will be able to do so, in Digidow the individual user still has the power to prevent that (or at least notice it happening).

1.2. Envisioned architecture

The Digidow architecture is illustrated by Figure 1. The communication always flows between three actors. The personal agent is a piece of software under full control of an individual person and manages all personal information. Verifiers can be operated by everyone who wants to use the Digidow infrastructure to interact with the digital identity of people. The most common scenario will probably be matching an individual with his/her identity. That identity will usually come from a nation state, but of course a personal agent could be linked to other identities as well.

Sensors can be operated by everyone and are responsible for collecting and providing biometric information to personal agents. They must be available in every location where a verifier wants to interact with a personal agent. But that does not imply that sensor and verifier have to be operated by the same entity.

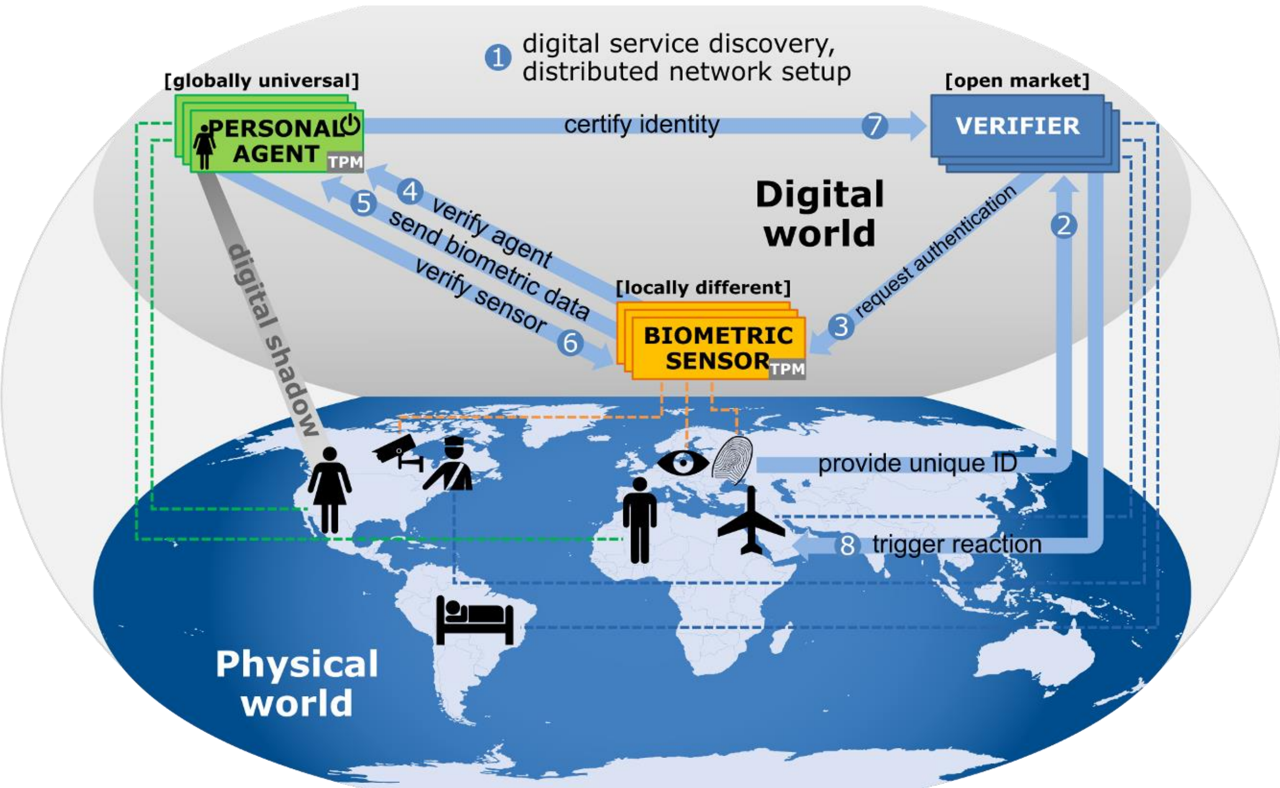

Figure 1: Overview of Digidow Architecture (INS, 2019)

2. Service discovery requirements

Figure 1 has a rather inconspicuous step one called ``digital service discovery". The main objective of this step is the identification and localization of all parties required for the transaction. A set of functional and privacy requirements has been identified for this initial step.

2.1. Functional requirements

- Working on a global scale: In the digital world there should be no need to restrict a distributed system to a specific reason. Therefore, the service discovery should function equally, independent of the location of the parties involved in the transaction.
- Latency: In order to be practical, the entire process of verifying an ID should take no longer than alternative authentication procedures. The first step must therefore be as time efficient as possible. It is hard to pin down exact timings, but transit fare providers for example have historically required transaction times below 500~ms (Smartcard alliance, 2011). We believe that the generic and decentralized approach of Digidow justifies longer transaction times, but use the 500~ms as a goal for now. More research has to be done on acceptable average and maximum transaction times for Digidow in the future.

2.2. Privacy requirements

- A global listening adversary should not be able to correlate which personal agent is talking to which verifiers. We assume that this meta information could be used to infer the individual behind a personal agent without permission.
- A verifier should not receive any information about the user identity until the personal agent decides to actually reveal it. Otherwise the user would not retain full control over his personal information.

3. Use-cases

In order to identify the challenges presented by this project, two possible Digidow use cases have been selected, which will be used to identify requirements in more detail. For every use case there is a set of questions to be asked:

- Who will be operating the verifier?
- Who will be operating the sensor?
- Who should initiate the transaction?
- Which information is available at sensor, verifier and agent?
- Which additional information must be provided?

3.1. Digital passport

The digital passport would enable citizens to legally prove their identity without a physical identification token (the classical passport). This means that the personal agent needs to be confirmed by the issuing country of the passport. This will most likely work with technologies and procedures similar to the ones currently in place for the European E-ID (European Parliament, 2014).

Fortunately the implementation details are not relevant to the question, which should be answered here. Passports can be used in multiple different scenarios, but the by far most common one is providing identification when traveling in foreign countries. Passport verification usually happens at borders or airports. In both cases the verifiers would be operated by the border guard of a nation. Assuming that the digital passport should allow for the passport check to work as before, it is a fair assumption that the sensors will also be operated by the border guard. In this arrangement the verifier wants to identify one specific individual at a time based on the biometric data provided. It would make sense to expect the verifier to initiate the transaction by trying to find the responsible personal agent.

3.2. Ticketing for public transport

Ticketing is an area where a smooth transition between the digital and the physical world could provide significant benefits. The general trend towards mobile payment (European Parliament, 2017) also applies to the purchase of tickets for public transportation. More current trends try to remove the need for purchasing tickets in advance entirely. Instead users just have to identify themselves when entering (for example public transport) and leaving (Rhein-Main-Verkehrsverbund, 2019). The selection of the ideal ticket as well as the actual payment can be handled automatically in the digital world. A good example for such an approach would be GPS ticketing using smart phones (FairTiq, 2019).

Such a system could also be based on the Digidow architecture. It would allow users to board simply by interacting with a sensor, without any need for physical devices or special applications. Furthermore, it would no longer be necessary to fully track users via GPS in order to select the ticket. Instead only personal agents would be tracked, without any knowledge about the person in the physical world running the personal agent.

4. Open questions

The goal of this research is to identify all criteria the service discovery step needs to satisfy and provide a potential implementation. A core issue is how the entire service discovery process should be structured.

4.1. Who initializes the service discovery?

4.1.1. The sensor

The currently suggested infrastructure requires a human interacting with a sensor in order to work. Considering that most users would not interact with a biometric sensor, unless they wish to authenticate themselves, this event makes for a good starting point for the digital service discovery. At this point the system has very little information available. The sensor only knows the biometric information it has collected and may reasonably assume that there is a personal agent somewhere on the network, which feels responsible for the individual with the collected biometric features. Detecting a personal agent with only that information without compromising privacy and security is a currently unanswered question.

Most likely the sensor would have to provide an additional interface enabling users to provide a specific ID unique to their personal agent (and maybe a second one for the verifier). This idea is reflected in the current Digidow architecture shown in figure 1 where the verifier receives a unique ID from the user.

A problem to keep in mind here is that there are also biometric measurements, which can easily be extracted without consent. Face recognition using surveillance cameras would be the prime example. If the sensor acts as the starting point for service discovery and no additional user input is required, measures must be taken to prevent abuse of the Digidow infrastructure to track users against their will.

4.1.2. The personal agent

An alternative approach towards service discovery might be to start the process earlier. If we assume that a personal agent has extensive information about every real-life interaction of its owner, it might be able to predict necessary interactions even before the user interacts with a sensor. Imagine a scenario where you leave your house, activating the alarm system via your personal agent. Your personal agent now knows your location and can make reasonable assumptions about your next actions. Most likely you will go to your own car, call a taxi (or self-driving car in the future) or use public transport. So the personal agent could proactively contact the very limited set of likely sensors the user might interact with and establish multiple probable connections.

Such a system would be nice while it works, but it would need a backup mechanism where the user can manually tell the personal agent to prepare a connection to a sensor in order to ensure availability. And that in turn would require a physical device, which would not be an issue due to the widespread use of smart phones, but it would compromise on Digidow's goal to work without physical tokens.

4.1.3. The verifier

The last idea would be to split the responsibility for service discovery. What would be the case if the sensor was only responsible for detecting the verifier (which it will often be paired with anyway) and leave the remaining work there?

If the personal agent has already been linked with the verifier, this approach would work very reliably. In the case of passports that might have happened during the visa application process or in other scenarios during an account creation process. If the biometric information of everyone with a valid visa is available to the verifier along with a unique ID of their personal agents, the verifier could easily take care of service discovery.

Again this approach has the disadvantage that it does not work for the initial identification procedure and gives the verifier access to sensor data, which it would not need otherwise.

4.2. Link personal agent to sensor data

The most critical piece of information within the system is the biometric data collected by the sensor. An ideal goal would be to discover the responsible personal agent only based on the measured biometric information, without revealing that information to anyone but the corresponding agent. If that is not possible, which additional information must be provided by the user in order to enable that detection? The classic approach of assigning a unique identifier to a service available on the internet is insufficient, because that would either require a central name service or reveal the names of the personal agents, a sensor is communicating with, to a passive attacker.

5. Potential directions

5.1. Lessons from OAuth

The OAuth framework provides a similar functionality as Digidow. It also defines communication between three parties: A client, an authorization server and a resource holder. The client is verified by the authorization server and receives a token to make requests to the resource holder (Hardt, 2012). A personal agent acts like an authorization server, verifiers are just another word for resource holders and sensors are only the tool a client uses for interactions. For the relevant research question the functionality itself is not too important, but the data exchanged between the parties and the experiences made in the real world will be able to provide valuable input.

5.2. TOR Hidden Services

TOR (The Tor Project, 2019) is a project to enable safe and private routing of traffic on the internet. One of the capabilities of TOR lies in running hidden services. They are designed in a way that their public IP address remains hidden. The only way to access them is via their unique hostname. That improves privacy by making schemes like IP localization impossible, but the individual personal agent can still be tracked reliably.

The protocols of the Digidow project should work independent of TOR, but the service discovery process has to be aware of the additional indirection steps required to reach a hidden service. Can service discovery reliably detect personal agents within the defined performance requirements without compromising the privacy offered by the TOR network? Can the privacy of personal agents improved by replacing the static unique hostname with a temporary one? Otherwise a global passive attacker could still track connections based on who accesses which hidden service when.

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CLOUD SECURITY AWARENESS IN CZECH ORGANIZATIONS

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Keywords

Cloud computing, cloud services, security, survey, awareness

Abstract

Cloud security is a current subject matter in the IT security area as organizations are continuously migrating to the cloud computing technology. Since cloud security brings new approaches and requirements in comparison to the security of traditional on-premise systems, appropriate security controls and measures must be set with the cloud service adoption. Otherwise, a huge risk of security breach threatens. Managers and IT specialists need to be aware of these specifics to assure that the IT environment of organizations is well secured. This article presents selected results of the survey that was performed among managers of Czech public and private organizations and focused on the area of cloud security.

1. Introduction

Overlooking cloud security might have critical consequences for all organizations that adopted any cloud service into their IT infrastructure. The reason is that organizations might tend to manage cloud security in the same way as they manage any other component of IT infrastructure that is hosted locally (on-premise). However, the organizations need to realize certain specifics of cloud architecture and approach to managing cloud services that split responsibilities between both a cloud service customer (organizations that use and pay for the cloud services) and a cloud service provider.

The importance of appropriate handling of cloud security is rising with every year. The first reason is that many new technologies and areas (trends) of cloud services are being developed constantly. The examples are rising usage of serverless and micro-services (Ludvík, 2019), hybrid and multi-cloud solutions, cloud backup and disaster recovery technologies and artificial intelligence platforms (Babu, 2019). The second reason corresponds to the information that is annually published in reports focusing on the use of cloud services – organizations are continuously migrating from a traditional on-premise solution to cloud services. The exemplary reports are *RightScale – State of Cloud Report™* (RightScale, 2018), *Cloud Security Report 2018* (Crowd Research Partners, 2018), *State of Cloud Security 2018* (Cloud Security Alliance, 2018) and *Cisco 2018 – Annual Cyber Security Report* (Cisco, 2018). As a result, both the new approaches to cloud services and the rising usage of them push the requirements on cloud security straight forward.

This article presents the results of the survey focusing on awareness of Czech organizations in the area of cloud security. The objective of the article is not to present all available results but to provide the evaluation of the hypotheses defined prior to data gathering.

1.1. Research objectives

The survey was named *Cloud security in the private and public sectors* and its main objective was to analyze how the organizations are aware of security risks and benefits of cloud services. Among the other goals of the survey belong e.g. discovering level of cloud services usage, implemented controls and security standards focusing on cloud computing.

A lot of information was obtained by the questionnaire that could give a clue to many conclusions. In this contribution, three main research questions are asked and evaluated.

1. Persons employed on positions in management (TOP, middle of first-line) consider cloud services less risky from the security point of view than persons employed on IT security position.
2. Organizations and firms, that are not aware of security threats associated with the use of cloud services, do not have sufficient controls implemented in this field.
3. Organizations and firms, that use cloud services in greater extent are aware of security threats and limitations associated with the use of cloud services more than the ones that prefer traditional systems.

2. Theoretical background

National Institute of Standards and Technology (NIST) defines the cloud computing (Mell & Grance, 2011) as: *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."* Further, the NIST publication includes two models of cloud services:

- Deployment model: Private cloud, Public cloud, Community cloud, Hybrid cloud
- Service model: Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS)

The cloud security approach includes many differences in comparison to traditional on-premise infrastructure security. The paragraphs below contain an introduction to a few of these differences that people who manage the security of cloud services need to be aware of.

The main consideration related to managing cloud security is the fact that cloud computing is based on the shared responsibility model (Cloud Security Alliance, 2017). It means that the first part of the responsibilities lay at the cloud service provider (SCP) side and the second part at the cloud service customer (CSC) side. The ratio of responsibilities always depends on the particular case; but in general, it corresponds to the service model whether the cloud service is IaaS, PaaS or SaaS. With IaaS solution, CSP maintains the infrastructure and everything implemented on it (e.g. operating system, applications, and configuration) is under the control of CSC. On the second side, with SaaS solution, CSP bares merely all responsibilities and CSC almost only cares about correct configuration. Such setup implies that CSC does not control all aspects of cloud service security, sometimes even only the minimum of them. Consequently, CSC has to trust with all security aspects to the CSP. The contract with CSP is the main governance tool on the side of CSC. The contract defines the distribution of all responsibilities and anything that is not in the contract may not be expected. Service Level Agreement (SLA) is one part of the contract and assures the required level of service. (Cloud Security Alliance, 2017).

Compliance is another large area that is relevant to the security of cloud services. Regarding cloud service compliance, A. Rosso described the importance of this issue as below (Rosse, 2013): *"Make sure in your contracts with cloud providers to consider all the obligations to the provider and address the risks you would have to address in your own organization. Cloud providers that manage your applications and data may need to be compliant with the same rules and regulations you follow."* Cloud compliance covers security standards (e.g. specialized on cloud computing – ISO/IEC 27017, 27018), regulations (e.g. Healthcare Insurance Portability and Accountability Act – HIPPA, Payment Card Industry Data Security Standard – PCI DSS), internal policies and others (Yimam & Fernandez, 2016). For having the complete conception of the level of CSP's security and compliance, CSC would need to perform own assessment of the CSP's environment. However, this option is usually not possible as CSP does not want to allow the external party (CSP in this case) to have access to its complete environment. As a result, CSC needs to trust CSP that it has a sufficient level of security and compliance. Sometimes, CSP is attested by some third party organization for a certain level, e.g. a family of security standards ISO/IEC 27000 (Cloud Security Alliance, 2017).

In comparison to traditional on-premise infrastructure, risk management of cloud services differs mainly in specific risks related to this technology and used countermeasures/controls minimizing the risks. The examples of specific risks are isolation failure, loss of governance, compliance risks, management interface compromise, insecure data deletion or malicious insider (Catteddu & Hogben, 2009).

The cloud computing approach further influences many other areas that are not described in this article due to its limited length. The examples are business continuity, information and data security, identity and access management, management plane and virtualization.

3. Methodology

The survey was performed thank to the support of organizations *PricewaterhouseCoopers Czech Republic* and *Tate International*. The data was gathered on three events – *Academy of ICT Management* (registered participants – accessible for anybody) and *Letní Soirée* (invited participants) organized by TATE International and *Business Continuity Forum* (registered participants - accessible for anybody) organized by PricewaterhouseCoopers. The set of respondents was composed of representatives of Czech private and public organizations. They worked mostly on managerial (54,5 %) positions; the others operated mainly in IT security departments or on specialized/referential positions. Figure 1 refers to the detailed division of the working positions of the questioned. For the evaluation of the results, responds of all working positions had the same weight. The total number of respondents was 102.

The survey was in the form of a questionnaire that included 27 questions. The precise content of the questionnaire is accessible at the link *https://bit.ly/2WlNJqJ*. Three types of questions were contained in the questionnaire. The first type included closed questions where respondents were choosing between *Yes* and *No* (event. *Do not know*). The second type was in the form of closed questions where the respondents might have chosen multiple answers; plus, in majority questions, they had an opportunity to write their own answers (not limiting to the offered ones). The last type contained answers in the form of a Likert scale. From the content point of view, the questions were from the areas of governance, security, security risks, security controls and measures, compliance and National cloud computing.

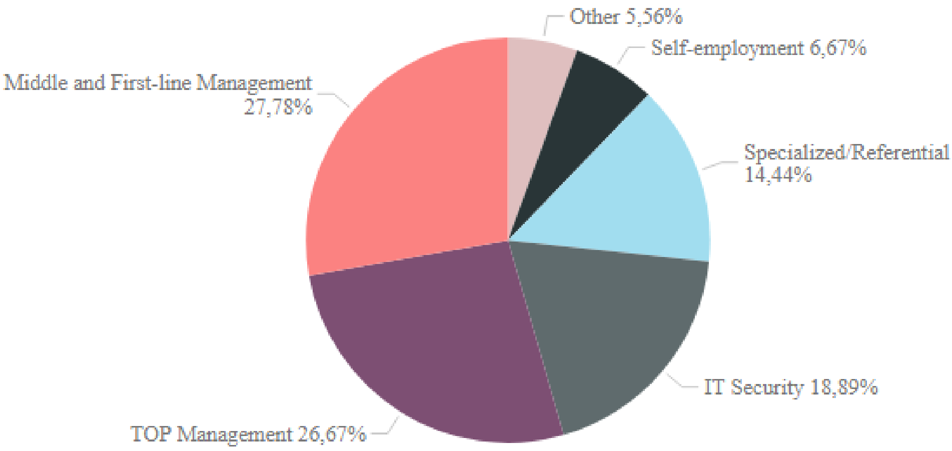

Figure 1: Division of job positions of the questioned

4. Research

This chapter focuses on the three hypotheses that were mentioned in Section 1.1. Prior to that, general information about the usage of cloud services within the researched organization is introduced.

The research showed that the most frequent service model of cloud services was the private cloud (47 %). Then, both the public and the hybrid cloud were used in 27 % of organizations. Further, only 6 % of organizations used the community cloud. Besides, 6 % percent of respondents answered that they do not exactly know. From the perspective of delivery model of cloud services, the most organizations (54 %) had implemented Software-as-a-Service. Further, 38 % of organizations selected Infrastructure-as-a-Service. Platform-as-a-Service was selected in 35 %. Nevertheless, 14 % of respondents were not sure with the delivery model and answered as “Do not know”.

Respondents were also asked to compare the use of cloud services and traditional on-premise infrastructure in their organizations. The results are shown in Figure 2. The average value is 4,1 and it indicates that the organization still use rather traditional on-premise solution.

The fact that the questionnaire was answered by employees working at various positions has to be taken into the account during the analysis of the answers. Not all these employees might have detailed information about technologies and services used in IT departments and some questions might reflect rather their opinion than the facts.

The first hypothesis is based on the assumption that IT specialists have deeper knowledge and overview of offered services in the IT field than the member of all levels of management. Figure 2 confirms this idea. The respondents expressed their opinion about the level of security of cloud service. The original questions included a Likert scale with values from one to ten where one represented that security risks are significantly more related to traditional on-premise solution and ten to cloud services. The responses were transformed into *Yes/No* answers for graphical elaboration. *No* stays for the opinion that cloud services are not more risky than traditional infrastructure (values from one to five), *Yes* on the contrary (values from six to ten). Even if the awareness of the members of management was high, IT specialists performed much better in the knowledge of riskiness of cloud services. Nearly 60% of the IT specialists know about the problematics of the kind compared to less than 40% of the management members. To evaluate whether this difference is statistically significant, logistic regression was employed. The working position of the respondents was used as the dependent variable. Since the dataset was restricted only on the management positions and IT specialists, the dependent variable has binomial character and logit model is the correct choice analytical tool. The theoretical details are explained in (Wooldridge, 2016).

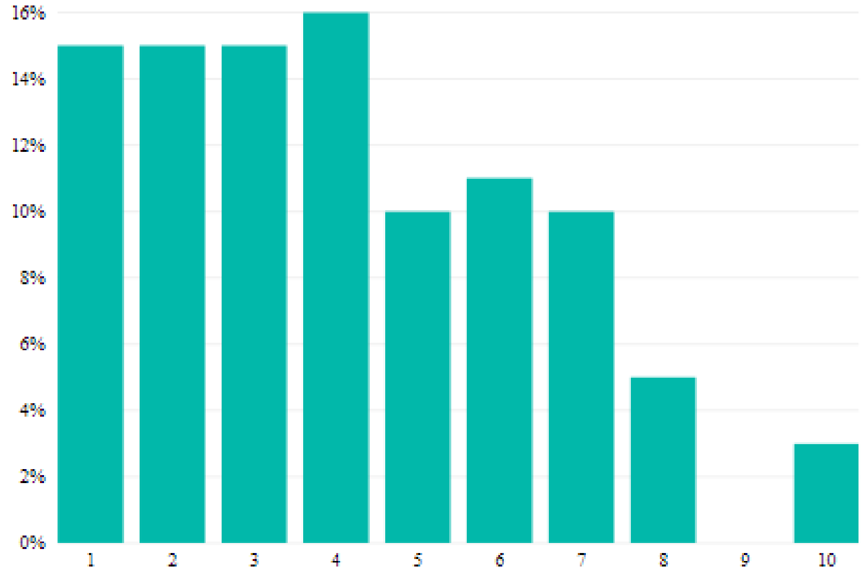

Figure 2: Comparison between the usage of cloud services and traditional on-premise infrastructure in organizations (1 - on-premise solution, 2 - cloud solution).

Based on the estimated coefficients, the hypothesis can be confirmed: IT specialists know significantly more about the riskiness of the cloud services security and members of management consider the cloud services less risky from the security point of view.

Figure 3: Do management and IT specialists consider cloud services more risky than traditional the on-premise solution from the security point of view?

The second hypothesis says that those who do not see cloud services as a security threat do not have sufficient controls in their IT security system. Figure 3 shows a summary of questions regarding the sufficiency of the current security system and the misgiving of cloud services. The questioned answered whether they think that their current security system is sufficient or insufficient (Likert scale with values from one that indicates complete insufficiency to ten that indicates complete sufficiency). Again, values from one to five were transformed into “insufficient” state and values from six to ten to “sufficient” state. The second relevant question was about how they judge the security of cloud services according to their opinion. Values on the scale from one to ten were chosen: one represents that the questioned evaluates the traditional approach as the most dangerous and prefers the cloud services as more secure way. Based on Figure 3, one cannot clearly see if the assumption was correct or not. The answers seem balanced.

For this case, the security level is used as the endogenous variable. It has the character of the ordinal variable and ordinal logistic regression could be the ideal solution for this problem. On the other hand, the obtained estimates are not easily interpretable. To simplify this task, security levels on the scale from one to ten are concerned as a continuous variable and classical linear regression model can be employed.

According to the results, employees from organizations with an insufficient security system tend to judge cloud services as more secure than the traditional structure. These obtained estimates do not meet our expectation but also they do not appear statistically significant and it cannot be decided whether the hypothesis is rejectable.

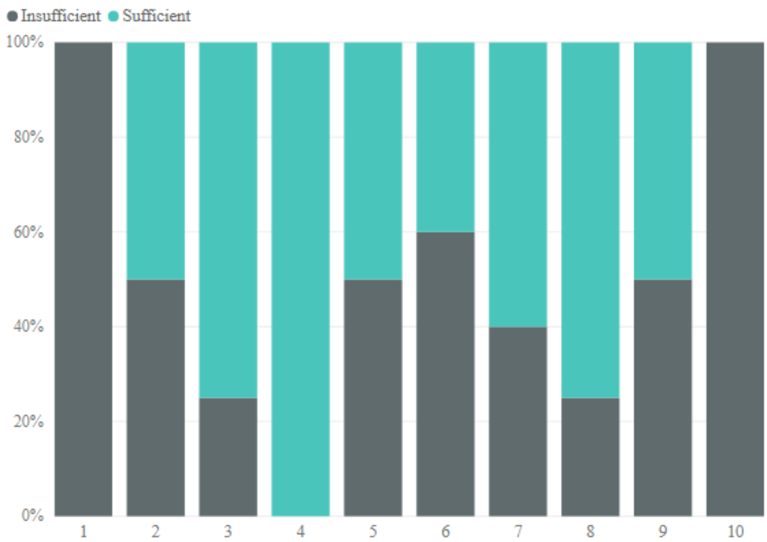

Figure 4: Security risk (1 - traditional structure, 10 – cloud services) according to the sufficiency of the current security system

The third main hypothesis assumes that the organizations that know more about security threats and limitations of cloud services currently use the cloud services more than the ones who judge traditional structure as the more secure solution. This assumption cannot be clearly confirmed according to Figure 4 which shows assumed security risk level on axis X and current use of cloud services as the average from the gathered answers on axis Y. The current use of cloud services was measured on the scale from one to ten where one represented the situation where organizations use only traditional on-premise solutions and ten represented only cloud services usage.

For an analytical model, again we use the simplification for continuous variable. The result met our expectations that the ones who currently use more cloud service see more security danger in cloud services structures than the ones who are not experienced with them and use traditional structure. The obtained estimates appear statistically significant.

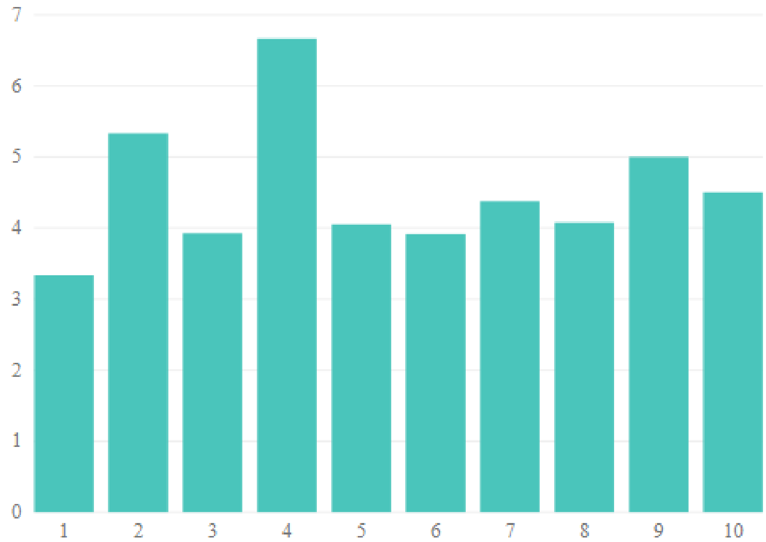

Figure 5: Security risk (1 - traditional structure, 10 – cloud services) according to the current use of cloud services

The whole analysis was performed in the freeware statistical software R.

5. Conclusion

This contribution introduced the topic of awareness about cloud services and dataset gathered during the survey that was focused on relevant public and private organizations. The main hypotheses that wanted to be confirmed based on this survey were formulated and relevant analytical tools as linear and logistic regression were employed for evaluation. Unfortunately, some of the results met our expectations but did not appear statistically significant. With certainty, the assumption about significantly better awareness of IT specialists can be confirmed.

The results of the survey indicated that the respondents oriented themselves in the area of cloud service security. Further, the organizations obviously are aware that they need to pay special attention to the security of their cloud environment besides the security of the traditional on-premise infrastructure. However, the organizations still prefer the on-premise infrastructure rather than cloud services. Nevertheless, the research also showed that organizations plan to transfer the majority of their IT environment to the cloud. For that reason, it is important for the organizations to fully understand the specifics of cloud security and get the detailed knowledge of it. One of the possible solution for the organizations to align with cloud security is to implement the standard ISO/IEC 27017 that focuses on cloud security.

The results of the survey were already presented and discussed in the two-part article (Zbořil, 2018) and (Zbořil & Wojnar, 2019). These articles introduced general results without any detail correlations and relations between the answers. The future research is focused especially on this advanced relations among the answers to discover further interesting findings.

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PERFORMANCE MANAGEMENT

BUDGETING PRACTICES IN CZECH MANUFACTURING COMPANIES: AN EMPIRICAL STUDY

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Key words

Budgeting, Performance management, Czech Republic, Questionnaire

Abstract

Though academics and professionals may disagree, budgets play a key role in business performance management and management control. Due to the lack of empirical evidence concerning budgeting practice in Central and Eastern Europe, an empirical questionnaire-based survey on budgeting in the Czech Republic was conducted. This paper analyzes and discusses the responses of 222 Czech manufacturing companies and delivers results on (a) the extent of budget use, (b) the purposes of budgets in management control, (c) the impact of budgeting on the behavior of managers and employees, and (d) satisfaction with the role of budgeting. The findings show that budgets still play an important role in Czech manufacturing companies, especially in planning, controlling, and performance assessment. The highest intensity of the usage of budgets was found to be for cost control and corporate performance assessment. In general, respondents expressed their satisfaction with budgetary control systems, especially with budgets as a performance management tool at the corporate level and at the level of organizational units. The respondents emphasize the enabling, rather than coercive, use of budgets and do not perceive the negative effects of budgeting on behavior as of high significance.

1. Introduction

Budgeting belongs to a traditional, although quite debatable aspect of performance management and the management control agenda. Atrill and McLaney (2009) characterizes budgeting as a business plan for the short term. Drury (2018) summarizes that budgets serve a number of useful purposes such as planning operations, coordinating activities in an organization, communicating plans to responsibility center managers, motivating people to achieve organizational goals, controlling activities and the performance of managers.

The debate over the last two decades concerned the efficiency of budgeting, especially due to the unintended effects on manager and employee behavior. Hope and Fraser (2003), who initiated the beyond budgeting round table (BBRT), argue that annual budgeting processes are time-consuming, add little value and prevent managers from responding quickly to changes in today's business environment and state that traditional budgeting's focus on fixed targets and performance incentives often leads to dysfunctional, even unethical, management behavior. As an alternative, they propose, beyond budgeting, an approach enabling more adaptive management processing and a radically decentralized organization.

Despite this, budgeting is still esteemed as a vital process in many organizations. For example, Libby and Lindsay (2010, p. 67), on the basis of large-scale empirical research in American and Canadian companies, state that "budgeting systems continue to play a key role in firms' control systems and that most companies have no plans to abandon this practice, although many are planning to take steps to improve their budgeting systems to overcome some of the common criticisms".

Empirical research on budgeting in the Czech Republic is quite rare (Popesko, Dokulil, & Hrabec, 2017; Popesko, Novák, Papadaki, & Hrabec, 2015). For this reason, we decided to realize a large-scale empirical study on budgeting practice in Czech manufacturing companies. The paper aims to describe and discuss important facets of budget implementation. We formulated the following research questions: (a) To what extent do companies prepare budgets?; (b) For which purposes do companies use budgets in management control systems?; (c) What are the implications of budgeting on manager and employee behavior; and (d) How do budgets contribute to efficient performance management?

This paper contributes to budgeting research as it explores budgeting practices in the Czech business environment and discusses the findings in the context of previous studies realized in other countries.

2. Methodology

2.1. Sample

The sample of companies comprises Czech business organizations categorized as industrial companies (group "C" – Manufacturing according to the NACE Rev. 2) with more than 50 employees and turnover of more than 256 million CZK (i.e., 10 million EUR). These companies were selected as they are of sufficient size and feature an ample structure of activities where budgeting plays an important role in the context of management control systems. The sample base was obtained from the Albertina CZ Gold Edition database.

The sample included 1,326 companies of which 188 companies were not contacted due to a lack of a phone number (5 companies), unsuccessful phone calls (172 companies), or lack of a valid e-mail address (11 companies). Another 287 companies refused to provide an email address to participate in the survey. Ultimately, the on-line questionnaire was successfully e-mailed to 851 companies. Seeking to increase the number of responses, attempts to contact respondents by phone a second time were made approximately 14 days after the first email. As 112 companies replied dismissively and 517 did not provide any feedback, 222 usable questionnaires were obtained. The response rate was 16.74 percent.

Tab. 1 shows the structure of the sample according to size measured by average number of full-time employees (n = 222).

Table 1 - Structure of the sample according to size

Average number of FTEs	Number of companies	
50 - 249	107	48%
250 - 499	65	29%
500 - 999	32	14%
1,000 – 1,999	15	7%
2,000 -	3	1%
Min = 51, Max = 2,747, Mean = 406, Median = 254		

2.2. Questionnaire

Data were collected via a questionnaire survey which was pilot tested with three executives and two academics which led to some minor changes after their comments and suggestions were taken into consideration. To increase the response rate, we first contacted companies by phone enabling us to obtain an email address of targeted senior executives (such as a CFO, Controller or Financial Manager).

The survey questionnaire was originally designed in English since we used some measures that were operationalized in previous English-written studies. All questions and scales were translated into Czech with some minor adjustments with regard to Czech stylistics and terminology. We used a back-translation method to ensure validity.

A five-point Likert scale was used for almost all questions except for descriptive statistics questions.

The survey was conducted as an on-line survey using LimeSurvey Professional.

3. Results and discussion

The presentation and analysis of the results follow our research questions. First, we focus on the budget extent; second, we analyze the intensity of budget use in management control systems; third, we consider the implications of budgeting on manager and employee behavior and, finally, we show the satisfaction of companies with the role of budgeting in the context of performance management.

3.1. Budget extent

We expected that a majority of our respondents prepare budgeted income statements as profit is a key measure of business performance. The results confirmed our expectation as only four companies (1.8 % of the sample) did not prepare budgeted income statements.

However, the intensity and time scope of the use of budgeted income statements differ as shown in Figure 1. It shows that a yearly budget is used most intensively followed by monthly budget and quarterly budget. A weekly budget is not used extensively. Such a result is not surprising considering the usual operating cycle of manufacturing companies in contrast to trading companies.

In addition to short-term budgets, companies were asked if they prepare long-term profit budgets. We found that 36 percent of companies always or frequently use these budgets, 23 percent do so sometimes, and 43 percent rarely or never do.

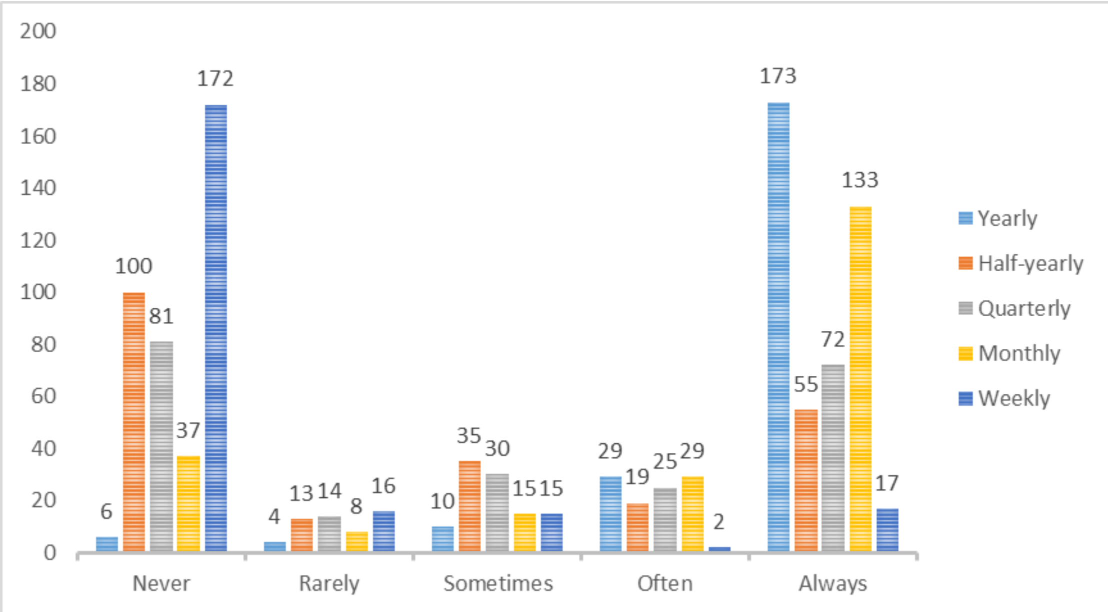

Figure 1 - Budgeted income statement – intensity and time scope of use

Even though profit is the key point of budgeting, companies also prepare and use budgets for economic measures of financial position and changes in financial position. Figure 2 shows how intensively these measures are used. A high frequency of respondents report the usage of budgets for cash flow and fixed assets with around 69 percent of companies answering they use them often or always. The lower score for working capital is somewhat surprising as working capital management has a strong impact on changes in cash flow. A quite low use of long-term capital budgets indicates that the key competencies in financing issues are usually in the hands of owners, i.e., those competences not delegated to corporate management.

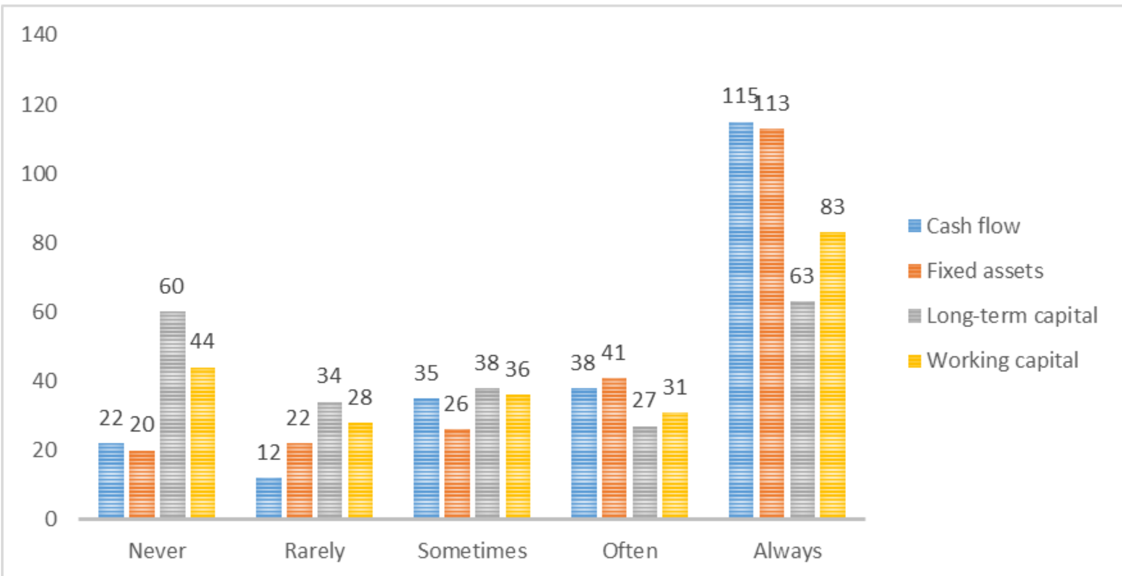

Figure 2 – Use of budget for measures of financial position

3.2. Budget use in management control systems

Based on numerous studies (especially Sponem & Lambert, 2016; Hansen & Van der Stede, 2004; Bhimani, Sivabalan, & Soonawalla, 2018), an extensive list of thirteen budgeting functions was prepared and respondents were asked how systematically their companies use budgets in management control systems. The results are presented in Tab. 2.

Table 2 – Use of budgets

Function of budgets (1 = not used at all, 5 = systematic use)	**Mean**	**SD**	**Min**	**Median**	**Max**
Cost control	4.67	0.695	1	5.0	5
Corporate performance assessment	4.43	1.062	1	5.0	5
Forecasting of financial needs	4.14	1.025	1	4.0	5
Approval of expenditures	4.13	1.101	1	4.0	5
Setting of selling prices	3.97	1.325	1	5.0	5
Performance assessment of responsibility centers	3.80	1.420	1	4.0	5
Allocation of resources	3.72	1.247	1	4.0	5
Remuneration of managers	3.68	1.507	1	4.0	5
Setting of responsibilities and tasks	3.63	1.349	1	4.0	5
Communication with external stakeholders	3.59	1.420	1	4.0	5
Transformation of strategy in management control	3.34	1.342	1	3.0	5
Coordination of activities, processes and departments	3.33	1.361	1	3.0	5
Communication between managers at all levels	3.30	1.434	1	3.5	5

The results confirm the importance of budgets in management control systems as the average values are higher than or equal to 3. Primarily, budgets are utilized for planning, controlling, and performance measurement and rewarding functions. It corresponds to Becker, Mahlendorf, Schäffer, & Thaten's (2016, p. 1509) findings which, on the basis of a literature review, identified "three stable macro-functions that can be interpreted as budgeting for (1) planning, (2) resource allocation, and (3) performance evaluation".

The highest-ranking factor was the application of budgets for cost control (mean = 4.67 and standard variance 0.695). Specifically, 74 percent of companies use budgets for cost control systematically and 13 percent very often. These results support the finding of Sivabalan, Booth, Malmi, and Brown (2009) in a sample of 331 Australian companies in which control of costs also had the highest mean (5.87 of 7) in the list of 10 budget reasons.

The highest standard deviation for "remuneration of managers" shows the variability of budget use for the compensation of managers. We can formulate a hypothesis that the larger the company, the greater the need to apply a formalized approach to remuneration. However, the Pearson correlation coefficient for two variables – size of company measured by average number of FTE and usage of budgets for remuneration of managers – is positive but very low (0.057) and is not statistically significant. We can also formulate a hypothesis that there is a relationship between the usage of budgets for performance assessment of responsibility centers and usage for remuneration of managers. The results of the correlation analysis confirm a significant positive relationship, $r = 0.51$, $p < 0.001$.

3.3. Implications of budgeting on manager and employee behavior

Behavioral implications of budgeting play a key role in the implementation of budgets in management control process. These effects can be either intended, i.e., bringing a positive contribution to management control process, or unintended, i.e., the ensuing pitfalls of budgeting implementation.

Hartmann and Maas (2011) distinguished two potential roles of budgetary control systems – a coercive use and an enabling use which were linked with the role of the controller in the company acting as a policeman or business partner. The list of items was tailored slightly and the results are presented in Tab. 3. The results show that companies prefer the enabling use of the budgetary control system.

Table 3 – Coercive and enabling use of budgetary control systems

Frequency of responses	**Strongly disagree**	**Disagree**	**Un-decided**	**Agree**	**Strongly agree**
Coercive use					
The budgeting process is used as an instrument to limit managers' decision-making authority.	9%	62%	16%	13%	0%
The budgeting process is used to communicate to managers what is, and what is not, allowed.	4%	48%	18%	29%	1%
The budgeting process clearly limits managerial freedom of action.	6%	58%	16%	19%	1%
Enabling use					
The budgeting process provides a structure to discuss the decisions and actions of managers.	1%	11%	18%	65%	5%
Budgeting is a continuous process that requires attention from all managers on a day-to-day basis.	2%	35%	19%	39%	4%
The budgeting process is used by managers and employees to discuss the effects of organizational and environmental changes.	3%	14%	20%	56%	7%

Sponem and Lambert (2016) distinguished four factors that serve as major sources of criticism of budgeting implementation: (1) the adverse effects of budgeting, (2) constraint of budget when it is inappropriate to the environment, (3) ritual aspects of budgeting, and (4) the short-termist focus of budgets. In our analysis, we focused on all of these factors save for "ritual aspects of budgeting" upon consideration of the specifics of the Czech Republic. Given that the Czech business environment has been a transitional economy the past three decades, it is not stable enough for ritual aspects to be rooted in management control processes.

Table 4 – Negative effects of budgeting implementation

Factors of criticism (1 = strongly disagree to 5 = strongly agree)	**Mean**	**SD**	**Min**	**Median**	**Max**
Factor 1 – Adverse effects					
The budget elicits opportunistic behaviors.	2.36	0.86	1	2	5
The budget elicits conservative behaviors.	2.52	0.96	1	2	5
The budget deters cooperation.	2.09	0.64	1	2	5
Factor 2 – Inappropriate to environment					
The budget is no longer suitable in an environment that has become too uncertain.	2.18	0.90	1	2	5
The budget introduces rigidity into the organization.	2.14	0.81	1	2	5
The budget imposes a culture of control rather than a	2.63	1.04	1	2	5

culture of engagement.					
The budget impedes innovation.	2.06	0.83	1	2	5
Factor 4 – Short-termist focus					
The budget translates the predominance of short-term profitability to the detriment of long-term value creation.	2.39	0.97	1	2	5
Budget is separated from strategy creation.	2.21	0.87	1	2	5

Tab. 4 shows that, in general, Czech companies do not consider the negative effects of budgeting implementation to be of high importance. For all questions, the median is 2 (i.e., disagree with the statement) and means range from 2.06 to 2.63. It corresponds with Sponem and Lambert's (2016) findings on 269 French companies that "the overall level of criticism is fairly low".

The highest means, together with high levels of standard deviation, were received for the statements "The budget elicits conservative behaviors." and "The budget imposes a culture of control rather than a culture of engagement." A correlation analysis shows that there is a positive significant relationship between the level of agreement on these two statements ($r = 0.34$, $p < 0.001$).

We assume that the importance of negative effects can differ according to the type of organizational strategy. Based on the approach of Miles, Snow, Meyer, & Coleman (1978) and in congruence with Bedford, Malmi, & Sandelin (2016), we distinguished companies in four categories according to the type of their strategy – defenders, analyzers, prospectors and reactors. An unlabeled description of the strategic type was provided to the respondent, requiring them to select the paragraph that best describes their firm. Tab. 5 shows a somewhat surprising finding where the defenders perceive these effects of budgeting implementation as more important than those of other types of strategies. We speculate that defenders understand some of these effects as supporting the execution of their strategy rather than as negative facets of budgeting.

Table 5 – Effects of budgeting according to type of strategy

Factors of criticism (1 = strongly disagree to 5 = strongly agree)	**Defenders** (18 companies)		**Analyzers** (152 comp.)		**Prospectors** (47 comp.)		**Reactors** (5 comp.)	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Factor 1 – Adverse effects								
The budget elicits opportunistic behaviors.	2.61	0.83	2.29	0.86	2.40	0.87	2.46	0.87
The budget elicits conservative behaviors.	2.72	1.04	2.50	0.92	2.53	1.05	2.52	1.01
The budget deters cooperation.	2.33	0.94	2.05	0.59	2.09	0.65	2.10	0.63
Factor 2 – Inappropriate to environment								
The budget is no longer suitable in an environment that has become too uncertain.	2.61	1.01	2.16	0.85	2.04	0.87	2.10	0.95
The budget introduces rigidity into the organization.	2.28	0.87	2.14	0.81	2.09	0.79	2.10	0.77
The budget imposes culture of control rather than culture of engagement.	3.28	0.99	2.56	1.00	2.57	1.14	2.60	1.11
The budget impedes innovation.	2.28	0.99	2.06	0.80	2.00	0.83	1.98	0.82
Factor 4 – Short-termist focus								

The budget translates the predominance of short-term profitability to the detriment of long-term value creation.	2.89	1.10	2.36	0.94	2.28	0.89	2.33	0.93
Budget is separated from strategy creation.	2.50	0.76	2.13	0.87	2.30	0.85	2.33	0.85
Index of all questions	2.61		2.25		2.26		2.28	

3.4. Satisfaction with budgeting

Satisfaction with budgeting shall be the primary outcome of the budgeting use. Tailoring the Hansen and Van der Stede (2004) concept, we asked three questions in this regard: Q1 – How satisfied are you with the budgets as an aid to transform the strategy to management control?; Q2 – How satisfied are you with the budgets as a performance management tool at the corporate level?; Q3 – How satisfied are you with the budgets as a performance management tool at the level of organizational units? The results are presented in Figure 3 and show that the highest satisfaction is with the role of budgets as a performance management tool at the corporate level as 70 percent of respondents declare they are satisfied or very satisfied. In second place is satisfaction with budgets at the level of organizational units.

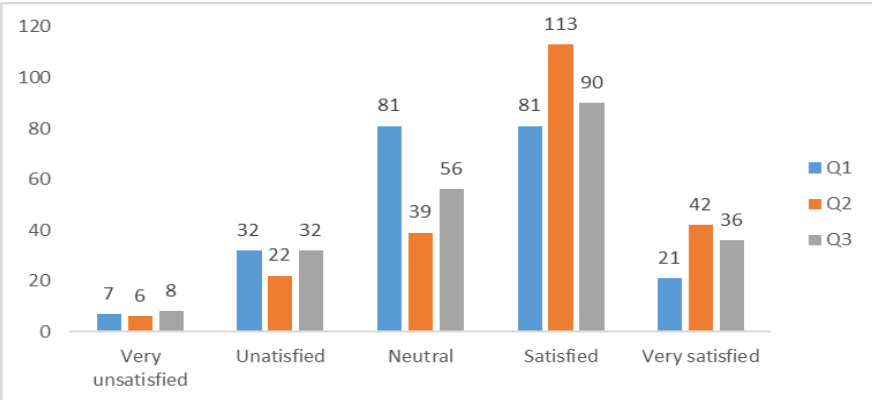

Figure 3 – Satisfaction with budgeting

4. Conclusion

Our research study proved that budgets play a vital role in performance management and management control of Czech manufacturing companies. The most widespread usage of budgeted costs, revenues and profit manifests itself in annual and monthly budgets. In addition to the income statement, the budgeting of economic measures indicating the financial position of a company is in use in the majority of cases in the sample.

The budgets of the Czech companies studied meet the traditional functions as described in management accounting literature. Cost control is ranked highest followed by corporate performance assessment, the forecasting of financial needs and approval of expenditures. We also found a positive significant correlation between the usage of budgets for performance assessment of responsibility centers and its usage for remuneration of managers. In general, it corresponds with the practical implications of goal-setting theory.

Indeed, budgeting impacts the behavior of managers and employees. Following the Hartmann and Maas (2011) framework, we found that companies prefer the enabling use of budgetary control systems rather than the coercive form. Although the negative effects of budget implementation have been widely discussed in the last two decades, Czech managers do not perceive them as a substantial drawback. Surprisingly, companies employing the defender's strategy showcase the pitfalls of budgeting implementation more than others.

Overall, managers' satisfaction with budgeting is quite high. Though we should bear in mind that the participation of companies in the sample was on a voluntary basis and some companies with a negative budgeting experience may have decided to forsake participating. In particular, we note the satisfaction with the role of the budgets as a performance management tool at the corporate level as more than 70 percent of respondents declare they are satisfied or very satisfied.

5. Acknowledgment

This paper is one of the research outputs of the project GA 17-13518S/P403 "Determinants of budgeting and performance measurement systems design and impact of these systems on organizational behavior and organizational performance" registered at Czech Science Foundation.

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THE INVOLVEMENT OF MANAGEMENT ACCOUNTANTS IN STRATEGIC DECISION-MAKING

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Keywords

Strategic management accounting; role of controller; role of management accountant; perceived environmental uncertainty; strategy; market orientation; contingency theory; Czech Republic

Abstract

The purpose of this paper is to reduce the existing research gap in the knowledge of the involvement of management accountants in strategic decision-making processes. Methodologically, the data were collected via a questionnaire survey, then statistically analysed. The results of this study support the hypothesis that management accountants are intensively involved in strategic decision-making activities. A statistically significant and positive correlation was found between the involvement of controllers and the utilization of strategic management accounting techniques, as well as company market orientation. This supports the view that companies with strong market orientation need to engage their management accountants in strategic decision-making.

1. Introduction

A turbulent and competitive business environment increases the requirements on the proper management of a company (Kaplan & Anderson, 2004; Kaplan & Cooper, 1998) and forces companies to raise their market orientation and strategic focus (Grinstein, 2008; Adams, Bodas Freitas, & Fontana, 2019).

The above-mentioned issues influence not only information support, but also the entire management control system (Chenhall, 2003; Ax & Greve, 2017) together with the required skills, professional training, experience and ethics of financial managers, management accountants and controllers (the terms “management accountant” and “controller” are used interchangeably in this paper).

Grandlund and Lukka (1998) see the role of a management accountant not only as a provider of information support, but rather as a manager’s partner. The perception of the management accountant as a manager's partner in the process of formulating and implementing strategies is gaining weight in the literature (Steinke, Schulze, Berlin, Stehle, & Georg, 2014), although particular requirements, their position in the organizational structure and the perception of a management accountant’s tasks may vary between companies and countries (Heinzelmann, 2016; Richardson, 2017).

Changes in the content of management accountants' work have altered the requirements for their professional competences. Management accountants should be able to justify, interpret and present the results of the company and its parts, to provide quality information support to the decision-making process and to strengthen synergies based on the relations they develop (Byrne & Pierce, 2018; Hopper, 1980; Horváth, 2006).

Management accounting change in the Czech Republic and its institutional and contingency factors are not sufficiently discussed in the literature (Wagner, 2018). Our paper aims to reduce this research gap by providing an analysis of original empirical data obtained from 90 medium and large companies domiciled in the Czech Republic through a questionnaire survey conducted at the end of 2018. Specifically, this paper provides descriptive statistics related to a management accountant's role in strategic decision-making. Correlations of this role with selected factors (contingent variables) are analysed. The factors include the degree of strategic management accounting (hereinafter abbreviated SMA) use, company size, perceived environmental uncertainty, company strategy and market orientation.

2. Literature review and hypotheses development

2.1. Operationalization of constructs

The ***involvement of a controller*** (management accountant) in strategic decision-making may be operationalized in various ways, therefore, we adopted operationalization typical for the field of our study, i.e., SMA. Specifically, we utilized the approach of Cadez and Guilding (2008) and investigated the involvement of the controller in the following five activities (measured on a scale from 1 = not at all involved to 5 = fully involved):

- identifying problems and proposing objectives (hereinafter abbreviated "A1"),
- generating options (hereinafter abbreviated "A2"),
- evaluating options (hereinafter abbreviated "A3"),
- developing details about options (hereinafter abbreviated "A3"),
- taking the necessary actions to put changes into effect (hereinafter abbreviated "A4").

A "controller_involvement" index, computed as an arithmetic mean of the values of all five above-mentioned activities, was also constructed for each respondent.

Regarding the ***degree of use of various SMA techniques***, a measurement instrument featuring 11 strategic management techniques selected from the relevant literature (Cadez & Guilding, 2008; Cinquini & Tenucci, 2010) was used. For each technique, our respondents were asked to specify to what degree a given technique was used (measured on a scale from 1 = not at all to 5 = very intensively). We also investigated the expected degree of use of each of these techniques in the future (after three years).

Specifically, we addressed the following techniques: quality costing; target costing; strategic planning and budgeting; strategic costing (strategic cost management); activity-based costing; benchmarking; integrated PMS; competitor accounting; customer accounting; strategic pricing; life-cycle costing.

For each respondent we constructed the indices "SMAU_now" and "SMAU_future" which were computed as arithmetic means of the values of all 11 SMA techniques at present and for usage after three years. An SMAU_change ratio (SMAU_future/SMAU_now) was also computed.

According to previous research, there are several contingent variables which impact the role of the controller in the company. The following contingency factors were investigated in this article: company size, perceived environmental uncertainty, strategy, and company market orientation.

Company size is considered an important contingent variable in numerous studies. Within management accounting research, size is usually measured as a unidimensional construct (e.g., total turnover, total assets, number of full-time employees). In this paper we use total turnover as a proxy for company size because this measure was used in key strategic management accounting studies (e.g., Cadez & Guilding, 2008). Moreover, numerous previous studies have discovered statistically significant positive correlations between total turnover, full-time employees and total assets. The total turnover was found in the annual financial reports of the respondents.

Otley (2016) highlighted the importance of ***environmental uncertainty*** as a contingent variable. In this paper this construct is measured in accordance with King, Clarkson, and Wallace (2010) who distinguished two types of uncertainty: dynamism and hostility (an approach suggested by Gordon and Narayanan, 1984). Dynamism is associated with the need for broader, more externally-focused, and timelier information, and hostility (competition) is connected with a greater emphasis on budgets. Specifically, we asked our respondents the following six questions: (1) How stable or dynamic is your company's economic external environment (on a scale from 1 = stable to 5 = dynamic)? (2) How stable or dynamic is your company's economic external environment (on a scale from 1 = stable to 5 = dynamic)? (3) How would you characterize the market activities of your competitors (on a scale from 1 = very predictable to 5 = very difficult to predict)? (4) How intense is the competition in the market for materials and services in your industry (on a scale from 1 = not at all intense to 5 = very intense)? (5) How intense is the competition in the market for workforce in your industry (on a scale from 1 = not at all intense to 5 = very intense)? (6) How intense is the competition in the outputs market in your industry (on a scale from 1 = not at all intense to 5 = very intense)?

A "PEU" index, computed as an arithmetic mean of the values of all the answers to six questions related to perceived environmental uncertainty, was constructed for each respondent.

Strategy is often used as a contingency variable in management accounting research and, in this paper, we adopted a simplified typology of Porter (1980) distinguishing between the strategy of cost leadership and the strategy of differentiation. Specifically, we asked our respondents the following set of questions (all answered on a scale from 1 = not important, low cost and price are crucial to 5 = important): (1) How would you best describe your practice's strategic emphasis regarding the quality of products and services? (2) How would you best describe your practice's strategic emphasis regarding customer support? (3) How would you best describe your practice's strategic emphasis regarding the unique properties of products/services?

A "Strategy" index, computed as an arithmetic mean of the values of all the answers to the three questions related to strategy, was constructed for each respondent.

Market orientation was measured by an instrument developed by Guilding and McManus (2002) (all questions are answered on a scale from 1 = strongly disagree to 5 = strongly agree): (1) Our company has a strong understanding of the needs of our customers. (2) The functions in our company work closely together to create high-quality products and services for our customers. (3) Our managers think in terms of serving the needs and wants of well-defined markets chosen for their long-term growth and profit potential for the company. (4) Our company has a strong market orientation.

A "Market_orientation" index, computed as an arithmetic mean of values of all the answers to the three questions related to market orientation, was constructed for each respondent.

2.2. Development of hypotheses

As the literature (e.g., Grandlund & Lukka, 1998) advocates that a management accountant (controller) serves not only as a provider of information, but as a partner of management, we propose the following hypothesis:

H1: The controllers are significantly involved in decision-making processes.

As increasing competition requires a well-developed strategy and implementation, we advocate that strategic management accounting techniques should be used more in the future. Therefore, the following hypothesis was formulated:

H2 The expected use of SMA techniques after three years will be higher than the utilization of SMA techniques at present.

The intense utilization of SMA techniques should be logically connected with greater involvement of a controller (management accountant) in strategic decision-making, therefore we hypothesize:

H3 There is a positive correlation between involvement of controller in strategic decision-making (measured by the index "Controller_involvement) and SMA usage (measured by the index "SMAU_now").

According to numerous studies (e.g., Guenther & Heinicke, 2019), company size is a significant contextual factor. Larger companies need more sophisticated management control systems than smaller companies and we, therefore, hypothesize:

H4: There is a strong positive correlation between involvement of controller in strategic decision-making processes (measured by the index "Controller_involvement") and company size (measured by total revenues).

Regarding perceived environmental uncertainty, the majority of previous research advocates that higher environmental uncertainty requires companies to implement more sophisticated management control systems and it is possible to hypothesize:

H5: Perceived environmental uncertainty (measured by the index "PEU") is positively related to involvement of controller in strategic decision-making processes (measured by the index "Controller_involvement").

Regarding market orientation, we expect that higher degree of market orientation leads to higher involvement of controller in strategic decision-making, i.e.:

H6: Market orientation (measured by the index "Market_orientation") is positively related to involvement of controller in strategic decision-making (measured by the index "Controller_involvement").

Finally, we hypothesize that companies pursuing a strategy of differentiation need more SMA information in all areas (including costs, because knowledge of costs is important even if low costs are not the primary objective of the company). Our hypothesis is, thus, framed as follows:

H7: The role of the controller in strategic decision-making activities is positively associated with the strategy of differentiation than in companies pursuing a cost leadership strategy.

3. Data gathering, sample

The data were collected via a questionnaire survey developed in the first half of 2018 and discussed over several months. Ultimately, the survey was tested on three executives (managerial accountants) and three academics, and the relevant feedback was incorporated into the questionnaire.

The questionnaire consisted of eight sections exploring various areas of strategic management accounting (including the role of management accountant). The majority of questions were answered on a five-point Likert scale.

The sample of companies for our research was sourced from the Albertina CZ Gold Edition database. The companies selected were domiciled in the Czech Republic, had more than 50 employees, and boasted a turnover above 256 million CZK. Our research was cross-industrial, but the following industries were excluded (according to NACE ver. 2) 'O – Public administration and defence', 'P – Education', 'Q – Human health and social work activities', 'S – Other service activities', 'T – Activities of households as employers', and 'U – Activities of extraterritorial organisations and bodies'. Consequently, we randomly selected 1,000 companies matching these criteria.

To increase the response rate, these companies were contacted by phone and, if they agreed to participate in our research, we sent them an e-mail with a link to the web-based questionnaire. A reminder was also sent to those who did not react to our first email. During telephone calls we asked for contacts to respondents in senior finance positions to ensure a high quality of response.

The data were gathered from September 2018 to December 2018 and we obtained, in total, 90 responses.

4. Results and discussion

Descriptive statistics related to controller's involvement can be found in Table 1.

Table 1 – Descriptive statistics of controller's involvement (n=90)

Activity (abbreviation)	**A1**	**A2**	**A3**	**A4**	**A5**
Mean	3.36	3.27	3.44	3.39	3.32
Median	4	4	4	3.5	4
Mode	4	4	4	4	4
Std. deviation	1.115	1.149	1.082	1.067	1.120
Skewness	-0.448	-0.316	-0.425	-0.327	-0.572
Kurtosis	-0.727	-0.888	-0.735	-0.522	-0.564

It is possible to summarize that our research confirmed strong involvement of controller in strategic decision-making activities (for an explanation of the abbreviations used, see chapter 2.1). According to basic statistical measures, the role of the controller is above the mean value for all activities. We can confirm hypothesis H1 that controllers are significantly involved in decision-making processes.

Our computations also confirmed hypothesis H2 concerning the expected increase of SMA usage. But the mean value of SMAU_change (the ratio of expected SMA use after three years and present SMA use) is only about 1,12, i.e., the increase is not significant. Approximately 5.6% of companies expected a decrease of SMA usage, 27.8% of companies expected an increase of SMA usage, and 66.7% of companies expected the same usage of SMA within the next three years.

Descriptive statistics of the analysed indices can be found in Table 2 and the correlation between the analysed variables is depicted in Table 3.

Table 2 – Descriptive statistics of indices (n=90)

Index	Controller_involvement (I1)	SMAU_now (I2)	PEU (I3)	Strategy (I4)	Market_orientation (I5)
Mean	3.3556	2.9101	3.2648	4.1741	3.9667
Median	3.4000	2.9091	3.3333	4.3333	4.0000
Mode	4.00	2.64a	3.50	4.33	3.75
Std. deviation	0.93510	0.67791	0.51500	0.67823	0.50168
Skewness	-0.526	-0.140	-0.690	-0.896	-0.120
Kurtosis	0.074	-0.159	1.488	0.711	0.143

Table 3 – Pearson correlations between variables (n=90)

	I1	I2	I3	I4	I5	Turnover
I1	1	0.477**	-0.021	0.179	0.307**	-0.51
I2		1	-0.078	0.385**	0.456**	-0.060
I3			1	-0.205	-0.114	0.152
I4				1	0.496**	-0.065
I5					1	-0.052
** Correlation is significant at the 0.01 level (2-tailed).						

It is possible to conclude that there is a positive and statistically significant (at the 0.01 level) correlation between the index of controller involvement in strategic decision-making and the index of present SMA use. This result is in accordance with H3.

A positive and statistically significant (at the 0.01 level) correlation was also found between the index of controller involvement in strategic decision-making and the index of market orientation. This result is in accordance with H6.

The index of present SMA utilization is positively, and statistically significantly (at the 0.01 level), correlated with the index of strategy (companies pursuing differentiation use of SMA techniques more than companies pursuing the cost leadership strategy). The same is true for the relationship between the index of present SMA utilization and the index of market orientation. Finally, there is also a positive, and statistically significant (at the 0.01 level), correlation between the index of strategy and the index of market orientation (companies pursuing a strategy of differentiation). Nevertheless, we did not formulate any hypothesis regarding these relationships.

5. Conclusion

Our paper uses data from an original empirical survey research conducted in the Czech Republic at the end of 2018. The role of the management accountant in strategic decision-making has been primarily investigated. Information concerning the involvement of a management accountant, in key activities associated with strategic decision-making, is provided and hypotheses related to the correlations of this role with various variables are tested. The degree to which selected companies use strategic management accounting techniques at present is also examined and the status quo is compared with the expected degree of use (as expressed by our respondents) after three years.

We found that controllers are intensively involved in strategic decision-making activities. The utilization of strategic management techniques is expected to rise, but not significantly, and a majority of companies indicated that they will use the techniques at the same level as now after three years.

We found that the index of controller involvement in strategic decision-making is positively, and statistically significantly (at the 0.01 level), correlated with the index of present SMA use (hypothesis 3 was confirmed), as well as with the index of market orientation (hypothesis 6 was confirmed).

Hypotheses regarding the correlation of the index of controller involvement in strategic decision-making and other indices (perceived environmental uncertainty, company size and strategy) were rejected because these correlations were not statistically significant. This result is surprising and future research is needed. We propose that the correlation with company size may be insignificant because we did not include small companies in our sample and the differences in company size may be small.

6. Acknowledgement

This paper is an outcome of the "Effect of remuneration system and performance measurement system on employee motivation and behavior" project supported by Grant No. F1/25/2018 – Internal Grant Agency of the University of Economics, Prague.

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INFORMATION-TECHNOLOGICAL SUPPORT OF PERFORMANCE MANAGEMENT IN HOSPITALS – RESULTS OF SURVEY

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Keywords

Performance management, information technology, hospital management, Czech Republic

Abstract

The intra-organizational performance represents the vital information required by the management to support its decision-making activity. The relevance and reliability of this information are crucial and more so in the case of hospital management where the impacts of the decision-making activity reach beyond the economic dimension. While the proper use of information technology in performance management should facilitate the process of obtaining and evaluating the necessary information, the final form of its implementation may yield various outcome. This paper examines the results of a survey focusing on the capabilities of currently existing information technology to support performance management in the hospital. The results suggest that the hospital managers incline towards an agreement with information systems for reporting and performance analysis providing enough support for the performance management, but less so in the case of systems for planning and forecasting. The final part then contemplates about the possibilities of further enhancement of the information value of obtained results by follow-up research.

1. Introduction

Technological advance in recent decades has led to the introduction of sophisticated information technology (IT) across different industries and thus opened the possibility of doing things with increased efficiency. The IT has enabled to produce, transfer, and store the information with higher speed and more efficiency, making it more accessible when needed. For example, the introduction of computers in healthcare allowed the hospitals to develop internal health information technology (HIT) systems containing large amounts of various data (e.g., patients, diagnoses, treatments, bed occupancies) and made them accessible on demand, but if the management aspires to achieve an improvement in performance, it is more about the relevance of available information than its quantity.

To adequately support its performance related decision-making activity, the management requires timely delivery of relevant information from reliable sources represented by the performance measurement system. However, the information itself would not be beneficial to managers without the existence of an efficient control mechanism, allowing them to influence the intra-organizational activity towards higher performance. Regarding this subject, this paper examines the current state of IT, which supports performance measurement in the environment of healthcare in the Czech

Republic. More specifically, its primary goal is to answer the question of whether the hospital managers find enough support in these technologies for their performance related decision-making activity as the answer to this question provides the basis for further research.

2. Briefly on IT in performance measurement in healthcare

Regardless of the specific variation of the national healthcare system, the performance measurement in healthcare is a challenging task, mainly due to the complex nature of the healthcare environment (Cylus et al., 2016). As Cylus et al. (2016) note about the healthcare system, there exist a seemingly infinite set of interlinked processes that could be evaluated independently, and while their indicators might give a glimpse of certain aspects of inefficiency, they rarely offer a comprehensive overview. To be economical and effective in such complex environment, the performance measures must focus on the assessment of the right things from the user´s point of view (Halachmi, 2000), and while exploiting benefits of IT in this context might prove a difficult task, as Halachmi (2000) suggests, if advances in IT facilitate the performance measurement, organizations should use it. However, the evidence provided by literature examining this issue suggests this relationship is not being entirely straightforward.

In their study analyzing the impact of HIT on the quality of healthcare delivery and the operating expenses, Bardhan & Thouin (2013) provided the evidence of a positive association between the usage of financial management systems and lower hospital expenses through better planning and resource utilization. While this study contemplated about IT enabling further performance management capabilities, implementation of IT does not bring the improvement in performance if the information they provide is not efficiently utilized (Yunis et al., 2018; Limburg et al., 2017; Mapoma, 2017; Devaraj & Kohli, 2003). Devaraj & Kohli (2003) in their longitudinal study analyzing the relationship between IT and performance in healthcare provided the evidence on actual usage of IT being essential factor mediating the relationship between the hospital performance and investments in technology. Similar findings were obtained by Yunis et al. (2018) for companies outside the healthcare industry. While the adoption of innovative IT contributes to improvement in organizational performance, they pointed out that the innovative usage of IT is the key factor leading to substantial competitive advantage (Yunis et al., 2018). Besides the usage of IT, the level of IT integration also appears to be the influencing factor.

Angst et al. (2011) provided empirical evidence on the integration of various IT into centralized information systems positively influencing performance. They also contemplate that accurate information from different standalone information systems complete each other and enhance themselves by further context, to which the integrated IT solutions highly contribute (Angst et al., 2011). The sound IT infrastructure and the manager´s knowledge how to use it is then vital for proper decision-making (Mujtaba & McFarlane, 2011). Similarly, Peters et al. (2016) conclude that investments in business intelligence infrastructure integration and functionality are associated with an increased competitive advantage, and these effects occur through performance measurement capabilities.

Although healthcare organizations acknowledge the importance of performance management, the design of the performance measurement system is often practically omitted (Mettler & Rohner, 2009). The results of research done by Mettler & Rohmer (2009) further suggest that the market dynamics and the regulation are the key drivers for the adoption of performance management. Furthermore, the different market dynamics might also be the cause of the gap between the potential for productivity gains from IT adoption in developing countries and developed economies (Rajnoha et al., 2017). As Rajnoha et al. (2017) pointed out in their study of the impact of application of enterprise resource planning (ERP) and business intelligence (BI) information systems on the organizational performance of various Slovak companies, while the impact is generally beneficial its significance is generally lower in transition economies due to the difficulties resulting from the existing organizational conditions.

Aligning these findings next to each other, they may be distilled into few conclusions about IT and performance measurement in healthcare. Firstly, the introduction of IT into performance measurement extends its information capability which is further enhanced by the integration of information from standalone information systems (Peters et al., 2016; Bardhand & Thouin, 2013; Angst et al., 2011). Secondly, the actual usage of information provided by performance measurement mediates the influence of advancement in IT on hospital performance (Yunis et al., 2018; Mapoma, 2017; Devaraj & Kohli, 2003). Lastly, the market dynamics and the regulations stimulate the managers to use the performance measurement in order to manage the organizational performance (Mettler & Rohmer, 2009).

Acknowledging these conclusions, it may be postulated that if IT provides enough support for performance measurement and managers are stimulated to use it, adoption of IT solutions in performance measurement should have a positive influence on organizational performance. Motivated by this postulate, a survey has been conducted in summer 2018 to examine the capabilities of currently adopted information systems in their relation to the performance management from the hospital managers point of view. As this topic has been to date only scarcely examined in the healthcare environment, the obtained results should aid in filling out the existing research gap and provide greater insight into this matter.

3. Data and methodology

Regarding the target population for the survey, the segment of public hospitals directly governed by the public sector was selected as these institutions represent the core healthcare providers of the healthcare system in the Czech Republic and are more likely expected to utilize the sophisticated IT in their performance management practice in comparison to local practitioners for example. Inspired by research done by Mettler & Rohner (2009), the respondents were selected to represent the expert knowledge in order to provide the most relevant view of the current state of IT supporting the performance management in the hospital. In this spirit, each institution from the target population was reached by a phone call in order to identify the qualified respondents for the survey. These respondents, generally hospital managers operating the analytical software providing support for performance management (e.g., chief performance analysts), were asked to participate in a survey by completing a brief online questionnaire. This approach resulted in 40 fully completed questionnaires representing the 56% response rate within the target population.

Within the questionnaire, the respondents were asked to evaluate on the scale from -3 to 3 (-3 = absolute disagreement, 0 = ambivalence, 3 = absolute agreement) how they perceive the various characteristics of the enterprise information system used for planning and forecasting and of the enterprise information system used for reporting and performance analysis. This scaling approach was chosen for its ability to capture the subjective nature of the respondent's perception of the statements (Kaptein et al., 2010) with the negative and positive points of the scale being explicitly differentiated to limit the possible positive response bias (Trevin et al., 2015)

Both information systems were presented separately due to their different time orientation and scope of activities as the enterprise information system for planning and forecasting serves for ex-ante determination of goals and targets while the enterprise information system for reporting and performance analysis serves for the ex-post identification of actual results and their evaluation. Each of the examined characteristics was presented in the form of the standalone statement following an introductory sentence assigning it to the examined information system as is demonstrated in the following table (table 1).

Table 1: The statements about IT supporting the performance management presented in the questionnaire

ID	Statement
1	Enterprise information system for planning and forecasting…
1.1	…allows to quickly create and update budgets/forecasts
1.2	…allows to implement sophisticated planning models (incl. variant scenarios)
1.3	…contains large quantity of functions facilitating planning (e.g., compared to MS Excel)
1.4	…quickly adds actual data to perform variance analysis
1.5	…is fully integrated solution instead of a set of standalone spreadsheets (e.g., MS Excel)
1.6	…works with data from a single integrated source (e.g., data warehouse, data marketplace)
1.7	… has a fully automatic connection to all relevant transaction systems for tactical and operational management (e.g., Enterprise Resource Planning systems)
2	Enterprise information system for reporting and performance analysis…
2.1	…contains sophisticated tools for data visualization and time series analysis
2.2	…allows interactive reporting (e.g., ad hoc user customization of reports)
2.3	…offers the user immediate detailed information (contains drill-down tool)
2.4	…has a fast response time
2.5	…is a fully integrated solution (typically topped by the Business Intelligence application)
2.6	…obtains data from a single integrated source (e.g., data warehouse, data marketplace)

While the nature of each statement is self-explanatory, they represent the general functionalities of examined systems (statements from 1.1 to 1.4 and 2.1 to 2.4) and the aspects of IT integration (statements 1.5 to 1.7 and 2.5 to 2.6). The responses for the statements were analyzed using the descriptive statistics as the evaluation of each examined characteristic should reflect the respondents´ perception of how IT supports their performance related decision-making activity. The relationship between the statements was further analyzed using the correlation coefficients for the responses for each combination of statements. These coefficients were then tested for significance using a chi-squared test under the assumption of equidistance between the scale points. This test was performed at the significance level of 5% for the null hypothesis of no significant relationship existing between the tested pairs of statements.

4. Results and discussion

As may be seen in the table containing the descriptive statistics for examined statements (table 2), the values of mean and median for the statements related to information systems for planning and forecasting are different from the values of mean and median for the statements related to information systems for reporting and performance analysis. This difference between the descriptive statistics suggests that managers generally find the information systems for reporting and performance analysis more capable of supporting their decision-making activity than systems for planning and forecasting. The leading cause of this difference appears to be the general functionalities of information systems for reporting and performance analysis that better meet the requirements of the respondents.

From the point of IT integration, the results suggest the existence of a slight difference between both systems. The information system for planning and forecasting appears to operate with data from a more integrated source than it is in the case of the information system for reporting and performance analysis. The respondents were also more inclining to the information systems for planning and forecasting not being automatically connected with the relevant transactional systems (1.7), which suggest the manual load of data into these information systems. Similar ambivalence was observed in the case of the information system for reporting and performance analysis having a single integrated source (2.6).

Table 2: Descriptive characteristics for the examined statements

ID	Mean	St.Dev.	Median		ID	Mean	St.Dev.	Median
1.1	0.875	1.667	1		2.1	1.625	1.628	2
1.2	0.075	1.927	0		2.2	1.600	1.751	2
1.3	0.475	2.050	0		2.3	1.750	1.645	2
1.4	0.525	1.826	0		2.4	1.125	1.682	1
1.5	0.525	2.148	1		2.5	0.950	1.894	1
1.6	0.950	1.999	1		2.6	-0.125	2.255	0
1.7	-0.425	2.024	0					

Furthermore, these results also suggest the IT supporting the performance management system being more developed from the perspective of ex-post performance evaluation, thus more supporting reactive than proactive management style. High values of standard deviation for both groups of statements represent the great diversity amongst the respondents. Whether this is due to different capabilities of IT between the institutions represented by respondents or due to the different requirements of hospital managers remains to be explored. Regarding the absolute span of the given scores, both the minimum of -3 and the maximum of +3 was reached for all the statements, thus presenting the evidence of diversity between the institution in the sample the respondents have represented.

In conclusion, the respondents´ perception of the capabilities of both systems appears to be slightly biased towards an agreement in the case of information systems for planning and forecasting and highly biased towards an agreement in the case of reporting and performance analysis. These results are similar to the results of Mettler & Rohmer (2009) of information technology supporting rather operational activities than strategic perspective. The results for IT integration in both cases suggest the existence of the potential of further development as is usually the case with the companies in the developing countries according to the literature (Mapoma, 2017; Rajnoha et al., 2017).

The correlation matrix (table 3) presents the results for the relationship between the answers for various combinations of the statements. These results pointed out the existence of high to strong correlation between the responses related to the statements for the information system for planning and forecasting (1.1-1.7) with the most of these relationships (16/21) proving to be of significance as the hypothesis of their independence has been rejected. The lowest coefficients in this group are for the relationship between the responses for automatic connection with relevant transaction systems for tactical and operational management (1.7) and the rest of the statements related to this system.

Table 3: Correlation matrix for examined statements (*the null hypothesis rejected at alpha = 5%)

ID	1.1	1.2	1.3	1.4	1.5	1.6	1.7	2.1	2.2	2.3	2.4	2.5
1.1	1.00											
1.2	0.79*	1.00										
1.3	0.82*	0.76*	1.00									
1.4	0.77*	0.74*	0.71*	1.00								
1.5	0.86*	0.80*	0.85*	0.76*	1.00							
1.6	0.78*	0.58	0.63*	0.73*	0.77*	1.00						
1.7	0.58	0.65*	0.77*	0.49	0.64	0.39	1.00					
2.1	0.46	0.54	0.44	0.53	0.64	0.57	0.46	1.00				
2.2	0.19	0.30	0.28	0.18	0.32	0.30	0.33	0.83*	1.00			
2.3	0.47	0.46	0.33*	0.30	0.52	0.54	0.35	0.77*	0.77*	1.00		
2.4	0.31	0.52	0.26*	0.30*	0.31*	0.22*	0.46	0.66*	0.76*	0.77*	1.00	
2.5	0.58*	0.52*	0.52*	0.41*	0.52*	0.59*	0.40	0.57*	0.64*	0.75*	0.65*	1.00
2.6	0.45*	0.39	0.59	0.30	0.53	0.39	0.72	0.46	0.37	0.47	0.36	0.46*

Further results suggest high to strong correlation between the scores given to statements for the information system for reporting and performance analysis (2.1-2.6). As was in the case of the previous group, the most of correlation coefficients for the statements in this group (11/15) have proven to be significant since the null hypothesis of independence was rejected in these cases. The lowest coefficients were observed for the relationships between the responses for the information system for reporting and performance analysis obtaining data from a single data source (2.6) and the responses for other statements in this group.

The results for relationships between the responses for statements related to different systems pointed out weak to moderate correlation at the significant level for a smaller number of the coefficients (12/42) compared to the previous case of the statements related to each of the systems. Regarding this outcome in the context of descriptive statistics for each group of the statements, these results verify the aspect of diversity as some respondents may perceive the difference between the capabilities of each information system as high while the other respondents evaluate these capabilities being on a similar level. However, whether this is due to the difference in the perception of individual hospital managers or the capabilities of information systems remains unclear.

5. Conclusion

In alignment with its aim, this paper focused on the information technology used in public hospitals for performance management and analyzed the results of a questionnaire investigating the level of support the information technology provides to the hospital management. This issue was examined separately for the information systems supporting the future-oriented activities such as planning or forecasting and separately for the information systems supporting the monitoring activities such as reporting and performance analysis. The evidence suggests that the hospital management inclines towards an agreement with the information systems for reporting and performance analysis providing enough support and the respondents were rather ambivalent about the support provided by the information system for planning and forecasting.

Nonetheless, this conclusion is drawn in the context of limitations resulting from the exploratory nature of the research. Despite the rather simple design of the questionnaire and the superficial level of data analysis, the results provided the means to answer the question presented in the introduction of the paper. However, the proper understanding of the role of information technology in the performance management in the healthcare environment requires more sophisticated research approach of a follow-up study. Another limitation is the scarcity of actual literature with a comparable research focus, as most of the reviewed literature was either of less actual date or not entirely related to the focus of this paper. While this state makes any comparison of the research results difficult, it also presents an interesting research opportunity.

While the survey covered mainly the general functionalities of examined systems, it would be beneficial to examine the hospital management requirements regarding the technology supporting the performance management as it would shed more light on the causes of the current state. Including the organizational performance into such follow-up research would further enhance these results as it would establish a complete set of evidence making it possible to contemplate about the technological requirements of hospital management regarding the performance management, the fulfillment of these requirements by the capabilities of available technology and its impact on the performance of the hospital. Such research would complete the whole picture about the role of information technology for performance management in this environment and allow further practical implications.

6. Acknowledgment

This paper was supported by the project “Effect of remuneration system and performance measurement system on employee motivation and behavior” supported by the Internal Grant Agency of University of Economics, Prague, No. IG107018.

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INFORMATION SYSTEM ARCHITECTURE FOR COMPETENCY MODEL

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Keywords

Information system, competency, management, nursing

Abstract

The Faculty of Health Studies cooperates on a long-term basis with five hospitals in the East Bohemia region, which are joined into one joint-stock company. One of the topics of mutual cooperation is focus on nursing competency management. The Lenburg COPA model of nursing competency appeals as suitable model. The success of model implementation requires an information system architecture that meets the main criteria for safe operation. This article brings a proposal information system architecture for competency model implementation.

1. Introduction

This article introduces software support for an integrated competence management system to be implemented in five hospitals in the Pardubice Region. The article summarizes one of the principal parts of the project supported by the Technology Agency of the Czech Republic: Competent Nurse of the 21st Century, in creating software for supporting the competence management – competence model.

The competences and activities of nurses are defined by Decree No. 55/2011 Coll., based on the activities of healthcare professionals and other professional workers, (Česko, 2011). Another important legislative standard that the performance of these professions is based on is Act No. 96/2004 Coll. which concerns the conditions for obtaining and proving the competence in general health professions and for carrying out activities related to the provision of health care. The laws came into force in 2004, when the Czech Republic became part of the European Union and it had to take a number of measures concerning nursing (Sehnalová, 2015). Act No. 96/2004 Coll. has changed the nursing education system to recognize their qualifications within the EU. According to this law, nurses become fully qualified after a three-year bachelor programme at a university or a three-year course at a tertiary professional school. The law also requires nurses to be continuously educated throughout their active careers (Česko, 2004). This legislation implies competencies in the context of the professional competence that nurses receive through their education.

The current system has caused that there are nurses with different levels of education in the Czech nursing practice - secondary, higher professional and university (bachelor and master). In fact, if they meet the registration requirements, all of these categories are equal in terms of their competences and salary conditions. The Czech Republic, like many other European countries has recently suffered from a lack of general nurses, especially in acute care hospitals in inpatient wards. A more effective setting of competencies for nurses could lead to better utilization of their work capacity, solving nurse and doctor shortages in the Czech healthcare system (Rodriguez, 2015). At present, however, there is no guiding competency model available in the Czech Republic, which would cover nurse competencies, all regulated by legislative standards (including the acquisition of specialized and special expertise) and the competences assigned and required by the organization (administrative, organizational, managerial, mentoring, etc.).

Thus, the competency model that is being developed must be based on current legislation regulating the professional competence of non-medical workers, more precisely general nurses, and the results of the research concerning the fulfilment of these competences in the performance of the profession. The competency model will be based on three basic areas: legislative standards, gaining professional specialization, and competencies allocated by the organization (administrative, organizational, managerial, mentoring, etc.).

The competency model will be a model for more effective use of the working capacity of general nurses, subsequently to increase the efficiency of the education, training, development and performance of nursing professions, especially in competencies that are not based on legislative standards (administrative, organizational, managerial, mentoring, etc.).

2. Model design

In order to create competences and manage their life cycle (competence management), it is necessary to define a competence as a requirement of an employer (educator) and put it into a conceptual framework supporting its life cycle.

Competence (it is also possible to translate in as “qualification” or “ability”) most often means the assumptions or ability to perform an activity, a situation or a profession. Competence therefore means the ability to manage a particular job, to be able to do it, to be qualified in the relevant area, to have the necessary knowledge and skills.

Competence can also mean a requirement to manage a particular job previously mastered by the bearer in the process of learning and to bring it into practice, where he/she continues to develop it and to fulfil it. Competence in some assumptions emphasizes the inner quality of a man, which is the result of their development, more or less independent of the outside world, which allows them to provide a certain (required, standard) performance (Hekelova2015).

According to Hronik (2006), a competence is defined as a cluster of knowledge, skills and experience that supports the achievement of the goal. This complexity shows in the behaviour, the actions of the individual in an organization. Therefore, competence models are used to connect the service standard requirements as a link element to integrate "work for the organization" – it applies consistently to all business sectors, especially services. Kubeš et al. (2004) adds that such a person can then work in any position because his behaviour can be anticipated. On the other hand, Tureckiová (2004) states that it is necessary to take into account the personality characteristics of the profession bearer as well as the "hard" skills, focusing on acquaintance and knowledge (e.g. cognitive competence, technical competence).

From an organizational point of view, the requirements of workers‘ competencies are one of the basic needs - every job performed within the profession has certain requirements for the qualification of the employee and their personality characteristics, while a competency gains its importance as a commission to perform specific tasks.

When creating a competency model, it is about determining priorities for providing nursing care. It is the arrangement of the required competencies that creates "intellectual capital" ensuring the required quality of care. For the purposes of the project, the expert group has defined the concept of competences as follows: A competence means the ability to manage a certain job position, to be able to perform it, to be qualified in the relevant area, to have the necessary knowledge and skills. The competence of nurses involves professional eligibility but also the commission to perform such eligibility.

For the creation of competences and management of their life cycle (competence management), support is necessary to create a conceptual framework that supports methods of acquiring and evaluating and enhancing competences following education, remuneration and career management.

Especially in the field of evaluation, there are still far more subjective and inconsistent methods, more focused on immediate results, which reduce the significance of evaluation as an important management tool. These procedures do not allow the development of specific practical competencies that are needed in practice. It is therefore necessary to integrate individual components into a coherent system following the concept of employee development according to the needs of the organization.

The design of the application should ensure the integration of individual implementation concepts of competence management throughout their life cycle from acquisition through re-evaluation, training to increase or to loss.

It is necessary to take into account not only the definition of the competence entity, but also its variability in many dimensions, which are determined by three basic factors in the hospital environment:

- bearer (experience, skills, knowledge, motivation, attitudes, qualifications, education),
- organization (employer), working conditions and objectives,
- external factors such as technological advances, demographic development and the related demands on nursing care, health and education

The basic problems associated with the development and implementation of competency management programs may be associated with insufficient emphasis on nurse preparation. Therefore, it is necessary to consider all the requirements associated with the subsequent operation at the design stage.

Preparation and subsequent implementation represent a wide range of issues and concerns for those currently involved in the allocation and evaluation of competences. An expert group consisting of 11 top and middle nursing management representatives is therefore working together to develop the model including determining its content, its distribution, the methods of education to be used, and finding ways to objectively and correctly assess the results of fulfilling the required competencies. Everything is complicated by the variability of demographic, socio-economic and political circumstances and their effects on education and health systems.

2.1. Proposed information system architecture

The development of a software tool for competence management was based on a defined need for effective management of competency lifecycle for non-medical healthcare professionals. The architecture of the developed information system was designed based on a set of requirements that were elaborated in the initial phase of project implementation according to the "Software requirements specification IEEE 830" (IEEE, 1997) standard. Requirements for the final form of software support have been developed and revised by a professional working group in which architects of competency model, software analysts, HR managers, and future software users were represented. The requirements were based on the proposed processes of the newly conceived competency model and the generally applicable standards used in the development of information systems. The key system requirements were:

- full audit trail of records
- managing records ownership;
- sharing / portability of records between entities;
- a decentralized modular information system;
- support for versioning of application modules
- encrypt all communication between entities.

Figure 1 shows the communication scheme of the proposed information system, which consists of: "Manager of Competence" (CA, CB, CC), provider identity (IP CA, IP CB), user data storage, and tracker.

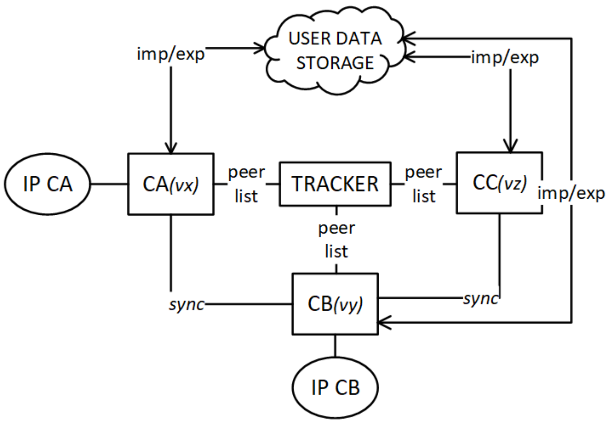

Figure 1: High level communication schema

Individual elements of the communication scheme communicate with each other only through an encrypted channel. Only qualified certificates are required for communication.

2.1.1. Manager of Competency

Competency Manager is a software application for managing competencies of non-medical professionals in a company (e.g. hospital). The design of the system allows for each company to implement its own internal structure of the competency model, which corresponds to the type and size of the company. The application enabled the introduction of any number of workplaces in the company, including the creation of their hierarchy. The system allows human resources to be linked to these workplaces, including the registered positions. Specifically, this system is designed to track complete professional history for every human resource, from the beginning of employment within the company. This professional history includes evidence of educational achievement, job placement, assigned competencies, review of competencies, plans and reports on adaptation processes, periodic assessment by senior staff and training plans (seminar, training, vocational training, internship, etc.). All competencies linked to a particular human resource can be reviewed, suspended, or withdrawn over time.

The key requirements for the entire information system were the decentralization of the system and the provision of information sharing / portability between companies that use the competence management system. In order to achieve this decentralization, it was necessary to design the application as an individual application instance, which can be run without any central control. In order to ensure the sharing of information between application instances, it was necessary to provide a communication interface to share this information between instances. In order to maintain decentralization, the client-client communication model was implemented.

Figure 1 gives an example of how to communicate between three application instances (CA, CB, CC). Instances communicate directly with each other (sync binding). As shown, communication between instances is optional. In this example, only CA applications communicate with CB and CB application communicate with CC. The information system allows you to define the scope of communication for each company individually. What data can be shared between companies is determined by company access and applicable legislation.

2.1.2. Identity provider

User data storage is a cloud application where users of the system can temporarily store their data. The application can be used if the user terminates his / her employment in the company and joins the next employment with another company. If there is a time gap between the two employments, the user data may no longer be available in the original employer application at the start of the second employment. The cloud application serves only for data storage, data cannot be edited in the application in any way.

2.1.3. User data storage

User data storage is a cloud application where users of the system can temporarily store their data. The application can be used if the user terminates his / her employment in the company and joins the next employment with another company. If there is a time gap between the two employments, the user data may no longer be available in the original employer application at the start of the second employment. The cloud application serves only for data storage, data cannot be edited in the application in any way.

2.1.4. Tracker

Tracker is a small server application that was created to support data sharing between application instances. The tracker itself does not provide application data sharing, or does not act as an intermediary to exchange data between instances; the tracker only maintains a list of access points for each instance of the application. Therefore, if an application wants to share data with another instance, it can automatically ask the tracker for the access point address. Also, if an application instance changes the location of its access point, it only reports to the tracker.

2.2. Sharing information between companies

Sharing information between companies was one of the key requirements for the information system. Data sharing is limited to human resource data and competencies. Unfortunately, the extent of data sharing is a very sensitive issue, as the legislation in force determines the possibilities of data sharing and is mostly defined by internal company guidelines. For a range of data, the employee's consent is also required to be shared. An example of this may be the obligation arising from the General Data Protection Regulation (EU, 2016), which, in the case of a request, sets out the obligation to erase all personal data after termination of employment, from primary systems and also from their backups.

However, data sharing has a number of added values for companies and employees. For the company, sharing data means a higher level of awareness of human resource competence that they can use to more efficiently develop and route human resources within the organization. For employees, the added value is the possibility of transferring work history information in the event that a person passes from one employer to another. Alternatively, if an employee is simultaneously working with two employers, the employee can only create and edit personal and professional data at one employer, and then share that data with other employers.

Unfortunately, the decentralized architectural model creates a number of barriers that do not allow easy implementation of sharing records between application instances, because each company has different master data. This data cannot be automatically linked to each other.

The basic link that had to be ensured in the information system was the link between employees who have their own user account in more than one instance of the application, and where from global perspective, they are two different entities. The birth number was not used to create a link of identities, which should be unique for the citizens of the Czech Republic, because foreign nationals are not assigned this number. For this reason, within the implementation of the application, a system of artificial keys, that are generated for each identity in the application, has been accessed. The user can attach this artificial key to his account from another employer's application instance, linking both accounts together.

As part of data sharing, it was also necessary to address the issue of authorship and data ownership. In the information system being developed, the entity that created the record is always the author of the record. However, this does not specify the owner of the record. Determining the owner of the record is required for data sharing control. Only the data owner can determine how data can be shared between companies.

Figure 2 below illustrates the Entity Relations model that expresses the implementation of record management in the Manager of Competency application.

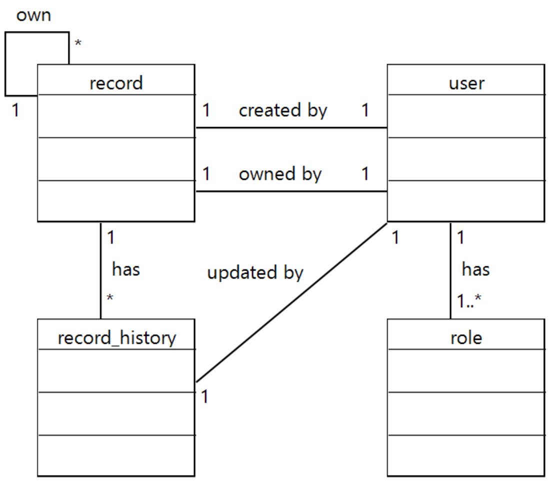

Figure 2: Entity relations model of record

The authorship of a record is unchangeable and non-transferable in time, while the ownership of a record is transferable over time. Such an example is where certificate is issued by a third-party authority to an employee who uploads that certificate to their account. When uploading a document, the employee can decide who will own the record; either him/her or the company. In the event that an employee assigns ownership of a company record, it transfers the right to use the document to the company as needed. So, this document can be shared among other companies. Otherwise, sharing the document would be fully within the competence of the employee.

2.2.1. Audit Trail

Another key application requirement is to provide a full audit trail, meaning unambiguous identification of the source recording system and retention of all record modifications over time. The implementation of the audit trail in the developed information system was implemented at the database level of the system, where each record is provided with six not null attributes:

- r_valid (NUMBER (1)) - record validity (0 - valid record, 1 - invalid record)
- r_parent (NUMBER (10)) - identification of parent record
- i_date (DATE) - creation date of the record
- i_author (VARCHAR (256)) - the author of the record
- u_date (DATE) - date of invalidation of the record
- u_author (VARCHAR (256)) - author of the invalidation of the record.

If a new record is created in the application, a unique identifier is generated and assigned to it. This identifier is also stored in the r_parent attribute for the new record. The i_date attribute specifies the record creation date, as the value and the i_author attribute is the record's authoring key. In the case of a new record, the same values are given analogously to the attributes with the prefix u_. In the case of modification of the record, the source record identifier is specified in the r_parent attribute and the i_author and u_author attribute values are updated for the source record. Therefore, the last valid record can be uniquely identified by the i_date and u_date attribute values being identical. If a record is removed, the r_valid attribute value is changed to 0 for the record.

In order to achieve a full audit trail, data is not allowed to be deleted from the database. For this reason, permission is set for individual tables to prevent DELETE operations. The only exception is a special account that can permanently erase data for legal reasons. Further, for UPDATE operations, the permission to change values is set only for r_valid, u_date, and u_author. In other words, every change in the system record is projected on the data level as a new record.

3. Conclusion

The proposed architecture of the model appears to be sufficiently friendly and practical for the implementation of the COPA model of Lenburg (1999), which supports the competency outputs and assessment needed for nursing practice. It is an example of competency management from their creation, adoption and adaptation to goal-oriented in the clinical and academic environment, and is specifically focused on health care. This Competency Outcomes and Performance Assessment (COPA) involves connecting education to clinical practice and emphasizing the need for process support. Despite its qualities, the proposed model cannot guarantee its effective use and projection into the organization's activities. It is up to the organization's management to work with the creators to find answers to Lenburg's basic questions (1999).

- What are the basic competences and outcomes necessary for today’s practice?
- What are the accessible criteria for defining these necessary competencies?
- What will be the most effective ways to learn or expand new competences?

To create an “ideal” competency model, we can use a combination of Kubeš's possible approaches (2004): adopting an existing or already created one, adapted to the specifics of the organization and the field for which it is created, and creating a new one according to the organization's mapping and preferences. When designing the model, it is necessary to take into account the legislative standards and requirements of the organization for the performance of the profession as well as the existing set processes in personnel management. When designing a new model, the purpose for which the model should serve and the goal it should pursue must not be forgotten. Therefore, in-depth analysis is a necessary part of the proposal, leading to the model not only taking into account the core skills, but also being sufficiently specific, tied directly to a defined job and serving the worker's development and assessment as well as generic organization of a generally required competence within one job (e.g. doctors, nurses).

The software design takes into account not only the key requirements for the operation of the software application, but also the fulfilment of the main goals associated with its creation. However, its successful implementation depends on the management of the hospitals.

4. Acknowledgements

This paper was created within the project The Competent Nurse for the 21st Century: The Analysis and Design of the Optimization of Nursing Education and Professional Practice supported by Technology Agency of the Czech Republic TL01000094.

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PREDICTIVE MODELS OF DIGITALIZATION EFFECTS AND INDICATORS: TECHNOLOGICAL SYSTEM EXAMPLE

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Keywords

Digital Economy, Digitalization, Information Technology, Information Society, effectiveness, efficiency, productivity, Proceedings, guidelines

Abstract

The article outlines the conceptual and corresponding formal models of the formation of digitalization effects on the example of modern information (digital) operations use in technological systems. Such models can be used, for example, to estimate the usage performance, efficiency, and effectiveness indicators of digital technology on the basis of predictive mathematical models of such usage. As well, such models could be used for the estimation of dynamic capability and indicators of system potential as a result of technological systems digitalization. Technological system is such system which functioning is fully described by operations in its documentation. The estimation of mentioned operational properties of digitalization is obtained by plotting the dependences of predicted values of operational properties of the use of information technology as a result of digitalization against the variables and options of the problems to be solved. To develop this type of models, we analyzed the use of information operations during system functioning. Basic concepts, principles, assumptions, and models are provided. Examples of models constructed for the estimation of system potential indicators regarding the use of information operations are given. An example of the estimation of system potential indicators is considered.

1. Introduction

The research on the use of information technologies traditionally (Ashimov, 2018) implemented based on the operational properties of such use. The operational properties of the objects under study are an extensive class of properties of various objects, such that these properties characterize the results of the activity with these objects. Therefore, the operational properties form the basis of the quality of objects under research (Teece, 1997). These properties are manifested at the boundary of the object in which the activity is implemented and in the environment. Operational properties are characterized by the effects (main results) of activity at the boundary, and then – by these effects compliance with the requirements of the environment. Activity is always implemented using certain information operations (Geyda, 2019). Information operations are elements of activity whose objectives are to obtain information, not to exchange matter and energy. Information operations are implemented in accordance with certain information technology whose objective is to describe the use of information operations. However, the mechanisms of the formation of activity effects and the subsequent formation of operational properties, taking into account the use of information operations, including modern (digital) information technologies (IT), have not been studied in sufficient detail in order to predict the effects of activity with mathematical models, depending on the selected characteristics of the information operations used, as mathematical problems of evaluation, analysis, and synthesis. This is primarily because there are no suitable models and methods for analytically describing the effects of information operations and the operational properties (Taticci, 2010). This, in turn, is related to the absence of a universally accepted concept of the manifestation of the effects of information operations, particularly for non-information (material) effects that are obtained by non-information (material) operations, which depend on the information operations under study (Mikalef, 2017). The non-information effects of such operations vary with the implementation of the dependencies between environmental changes, further information, and subsequently non-information operations.

Since information operations lead to changes in non-information operations but do not directly lead to non-information effects, it is necessary to develop the concept of information and non-information action dependencies and the concept of effect manifestation as a result of such dependencies. It is the development of the concept of such dependencies that causes conceptual difficulties. Therefore, further research is directed to the description of the dependencies between information and non-information actions and between information and non-information effects, but first an analytical description using mathematical models is required. The results presented in this study are aimed at bridging the gap between the need to solve research problems of operational properties based on mathematical models and methods and the lack of the necessary concepts and methodology for solving usage problems of information operations in the sense of formalizing them as mathematical problems of estimation, analysis, and planning by operational properties indicators. The results can be used in solving such diverse problems as dynamic capabilities research (Teece, 2007, Wang, 2007), strategic management problems (Hybertson, 2009), business process management problems (Taylor, 2011, Debevoise, 2014). Their common feature is the need to solve these problems based on mathematical models (Henderson-Sellers, 2012) of the functioning of complex systems. For these purpose indicators of system functioning, the quality shall be measured analytically (Ashimov, 2018). Such indicators shall reflect the effects of information technology (Geyda, 2019) during system functioning. For this purpose, the models and methods of research on the effectiveness of system functioning shall be adapted to reflect the use of information operations. Article structured as follows: conceptual model presented in brief at section 2, modelling method described at section 3, formal model fragment example shown at section 4. Results obtained and future research directions discussed at conclusion.

2. Conceptualizing the use of information technologies: basic concepts, principles, assumptions and models

The use of IT is illustrated in such complex systems that the operation of these systems (and hence the use of IT) is technological. We will say that the operation is technological if it is specified by technological operation modes, i.e. descriptions of technological operations in the technical documentation for a complex technological system (hereinafter CTS). This assumption further allows us to assert that the states of the beginning of CTS operations, the modes of the implementation of technological operations, and the possible resulting states of such operations are described in the technical documentation. The essence of changes in non-information operations as a result of the use of information operations is that different states of the system and the environment (because of the changing environment) can be implemented and different requirements can be accommodated. These states and requirements can lead to different information operations and their results, i.e. lead to changes in information operations and subsequently to changes in other operations. It is assumed that the number of such changes in operations is finite and can be described by modes of operations. Such modes based on the initial states allow specifying the possible transitions and the corresponding possible final states of the operations. The modes of technological operations are specified in the technical documentation of a CTS, so this feature can be represented as a feature of the technical documentation, consisting of an exhaustive description of the possible initial states, transitions, final states, and the finiteness of such states and transitions. Accordingly, knowing the possible changes in the environment and their impacts on the CTS, we can build a model of the possible CTS states as a result of the chains of environmental impacts and information operations. These chains, in turn, can lead to different states of the beginning of non-information operations and, consequently, to different modes of the implementation of non-information (or material) operations. Furthermore, various modes of such material operations can lead to effects that will meet the differential effect requirements of the changing environment. Information operations in the CTS, thereby, can allow carrying out material actions in the changing conditions of the environment with modes of operations that are better adapted to these changing environmental conditions. If we make certain assumptions about the technological nature of CTS operations (of all types) and the limited number of possible environmental states, we can further assert that the possible chains of ways of implementing information, and dependent on them the modes of implementation of non-information operations, can be modeled. To model the use of information operations and therefore the use of IT describing these operations, it is necessary to perform conceptual modeling of possible sequences of environmental states and information and non-information operations. In these sequences, the states and operations are in causal relationships, and there can be alternative relationships and states. It is further assumed that such alternatives are known and that a measure for the possibility of such alternatives can be constructed. To model possible sequences of relations between states, information and non-information actions, and their subsequent formalization, a method of modeling research problems based on possible sequences of states and operations is proposed.

3. Formalising use of information technologies: modelling method

The method of formalization consists of assigning the main concepts and relations of set-theoretic forms and linking these forms with the use of relations, expressed as graph-theoretical objects. To implement such a set-theoretic formalization, the graph-theoretic model of explication of the main set-theoretic forms of the problem is used. For such an explication, it is proposed to describe the set-theoretic forms so that they correspond to the elements of graph-theoretic models, connected by the explicated relations. This makes it then possible to go to the parametric models by parameterization of the graph-theoretic model and to the functional models by specifying and explicating the functional dependencies between the explicated parameters and variables. As a result, the main set-theoretic forms are connected by relations so that by traversing the graph corresponding to the specified forms and performing functional transformations when performing the traversal, the results required for solving the problems of evaluation, analysis, and synthesis by operational properties, mainly system potential indicators, would be obtained. The feasibility of such model construction is based on the given assumptions and the formalization assumption that causal relations between states can be formalized as sequences of functional relations on graphs. So, the formalization of the dynamic capability or system potential research problem can be represented as a regular construction of graphs based on already constructed graphs (extension). Such a construction of graphs can be, for example, in the form of a graph-theoretic model construction based on a conceptual model Next, graphs are constructed that describe algebraic graph-theoretic models of the formation of effects during functioning in a changing environment Following that, the graphs are labeled by variables and parameters of models of algebraic graphs. Then, parameterized graph-theoretic models are created. Finally, graph theoretical models are built in which functional dependency labels are assigned to its elements, with functional dependency labels explicated using regular expressions and programming language. The graph-theoretic models created differ in that they are functionally consistent with the local graph-theoretic structure. This property of the models is further described because such a property, which enables computations according to the type of model and which is associated with edges and vertices, can be ordered as a linear sequence of operations for a given graph structure (and then further linearized). This linearization refers to a property of models that for the calculation of the functional dependencies of the models, there should always be enough parameters, variables, and functional dependencies associated with the elements of adjacent graph-theoretic models (edges, arcs, hyper arcs). These elements are associated with the functional dependency labels, which are mathematical objects that describe the calculation of effects. Models with such a property are possible to construct because of the formalization assumptions and the graph traversal properties. In this case, the graph-theoretic model graph must be connected without loops so that it can be traversed to calculate all the required expressions based on the mathematical objects specified at the labels. As a result, the calculations can be performed by traversing the graph (in depth, in width) with the calculation of the functional relations specified. Based on such linearized graph-theoretic functional models, it is possible to generate a functional model that describes a finite sequence of functional expressions for the calculation of the system's potential indicators depending on the variables of the problems (estimation, analysis, planning) to be solved. The models obtained can be further described using, for example, computational expressions in the programming language, so such a graph-theoretic formalization can be regarded as a kind of domain-specific programming method.

4. Technological system functioning with IT use: formal model example

An algebraic structural model of the CTS describes the elements and structure of the workplaces (WP): $e_{jk} - k -$th element on $j -$th WP, according to the technical documentation; $e_{jk} \in E_j$, where $E_j -$workplace $j = \overline{1,J}$; Realizations of states and WP in appropriate sets fulfilled according to the created concept model. At a given moment t, part or all the WP are functioning; that is, those WP where technological operations (TlOp) are implemented. TlOp, implemented on the WP according to one of the possible modes, can begin only if the specified state of the WP is reached. Such TlOp can lead to different states as a result of TlOp implementation, depending on the environmental conditions and IT used. The set of states of $E_j -$th WP at each moment forms a state of the CTS: $Q(t) = \bigcup_{j=\overline{1,J}} Q_{E_j}(t)$.

System states $Q(t)$ at moment t are manifested and checked at the boundary of the system (CTS) and its environment. A mathematical model of states at the CTS boundary is built in the form of an algebraic model of sequences of CTS states on the boundary of the CTS and transitions of such states. It is assumed that the number of checked states on the boundary is limited. The algebraic model can be represented as a geometric graph. Then, from the constructed algebraic model, a functional model of correspondence between the states of the CTS and its environment is generated on their boundary. The peculiarity of this model is that it unites the model of CTS, the model of states at the boundary of the CTS, the model of states on the boundary of the CTS environment, and the model of the environment. It is the last model that needs to obtain the functional relations for the calculation of the CTS potential indicators. We assume that both the number of states at the boundary of the CTS and its environment and the possible number of transitions between such states are finite. States at the boundary are checked with special information operations. The results of these information operations are a measure of the CTS and the correspondence of the environmental states. Thus, the sequence of such information operations on the border is finite, and this sequence shall be used to determine the CTS potential indicators, according to its definition.

As a result of the research, the main types of relations between states were identified. These types of model relations are arc, hyper arc, and nested graph at the tree of states. Transitions are a special case of relations that are associated with the mode of operations in this tree. In particular, relations belong to two main classes: relations of possible joint realizations of states (simultaneity relation) and relations of possible transitions between states. The first class arises from the possible implementation of TlOp on several WP at the same time. The second class of relations emerges by the completion of TlOp and, consequently, the transition to the state of TlOp termination. Some relations require input (initial) and output (final) states of different types (information, non-information) during the transition. Each of the possible finite sequences of states and relations (transitions) checked on the boundary of the CTS and the environment is part of a particular branch of the tree. It is assumed that the number of such sequences (tree branches) can be L; that is, the set of possible sequences of CTS states has L power: C^{CTC}: $|C^{CTC}| = L$.

The sequence of states is assumed to be such that for different initial states before testing, states on the boundary correspond to different modes of implementing technological non-information operations (TIO). The mode of TIO execution functionally depends on the state before the start of the TIO, on the IT used, and the plan of operations. If the state before the start of the TIO, the information technology, and the plan of operations are known, then the mode of TIO will be known as well. The mode to execute the TIO of checked states on the border of the environment, in turn, may correspond to the mode of environmental state changes if the environmental state changes are modeled accordingly. It is assumed that the modes of environmental operations are not known for sure, but the resulting state sequences, their relations (transitions), and the measure of the possibility of implemented transitions are known. Therefore, as a result of a sequence of environmental state transitions and a sequence of modes of implementation of the CTS operations, we can get a pair of states on the border whose correspondence can be measured and whose possibility of actualization can be measured as well. In the sequences of C^{CTC} states, each pair of states on the boundary corresponds to different branches of the tree of environmental states and the tree of CTS states. Let's fix the sequence of environmental states and transitions. To do this, assume that the actions and states of the environment do not depend on the operation modes and the states in the CTS, but the CTS states, of course, depend on the sequence of environmental states. Then the specified sequences of the environmental states can be presented without taking into account their connections with CTS functioning. As a result, the sequences of environmental states can be presented in the form of a tree of possible sequences of environmental states before a tree of CTS states is constructed, which depends on these sequences. In this tree, the edges correspond to the transitions of environmental states that happen due to modes of actions in the environment (possibly unknown). The states correspond to the states of the environment on the border of the environment with the CTS. The number of sequences of the states of the environment is a result of some modes of action of the environment, M. Let's denote a set of possible sequences of environmental states as a result of some modes of environmental actions as C^{Cp}. Accordingly, $|C^{Cp}| = M$ and the elements $c_m^{Cp} \in C^{Cp}$ are associated with the branches of the tree of environmental states, $m = \overline{1,M}$. The functional model of the environment is first constructed by parameterization of the sequences $c_m^{Cp} \in C^{Cp}$, associated with the branches. This means a parameterization of states and their transition dependencies and then a parameterization of sequences of states, including a parameterization with the probabilities of states and transition actualizations. Subsequently, functional relations are assigned that connect the parameters, the measures of the probability of the states, and the transitions in the branches of the tree, as well as the dependent characteristics of the states of the environment.

A mathematical model of the environment under the assumption of independence of the activities of the environment from CTS operations is connected with a mathematical model of the compliance of CTS states with its environment on their boundary by relating states to the appropriate TIO of state checking on the boundary. These relations are specified between the nodes of the CTS states tree as a result of the CTS functioning and the nodes of the environmental state tree. Since the state of the CTS during its functioning depends on the states of the environment and such a dependency in the study of the potential cannot be neglected, each method of implementation of the checking TIO on the boundary of the CTS is related to (associated with) the branch of the tree of possible states of the environment. A complex model of the CTS and the compliance with environmental states can be constructed as a result. It allows measuring the CTS dynamic capability and potential.

In this regard, the set of branches of the CTS state tree is constructed under the condition that the branch $c_m^{Cp} \in C^{Cp}$ is given, that is $|C^{CTC}(c_m^{Cp})| = L_m$. Further, speaking of the branch $l \in \overline{1,L}$, we will assume that it is built for $c_m^{Cp} \in C^{Cp}$, i.e. $l_m \in \overline{1,L_m}$. This means that a relationship is defined between each branch $c_m^{Cp} \in C^{Cp}$ and the corresponding $C^{CTC}(c_m^{Cp})$. As a result, a new tree can be constructed that includes a branch $c_m^{Cp} \in C^{Cp}$ before the root of the $C^{CTC}(c_m^{Cp})$ tree. The resulting model, corresponding to all the branches, is used to create the functional model and then the terminal model to calculate the CTS potential. The number of states in the state tree branch $l \in \overline{1,L}$ is assumed to be variable because the number of operations that caused transitions and, accordingly, the number of resulting states could be different because of the impact of the environment. In addition, due to the same environmental impact, the duration of the state transitions and the duration of the sets of actions on different WP are different as well. As a result, the number of required state checks at the system and environment boundaries may vary. Let the number of such states be Q_l for a given branch $l \in \overline{1,L}$ of the tree. Each state check number on the CTS border $q_l \in \overline{1,Q_l}$ corresponds to the implementation of the checking TIO in the specified mode, and the only state corresponding to this mode is $q_l \in \overline{1,Q_l}$. Each of the states $\hat{S}_{l.q} =< \hat{y}_{1.l.q}....\hat{y}_{k.l.q}...\hat{y}_{K.l.q} >$ checked at the boundary of the CTS and its environment is fully described by the effects of functioning by the time the state check starts. This state is compared with the environmental state, which specifies the requirements $S_{l.q}^{\partial} =< y_{1.l.q}^{\partial}....y_{k.l.q}^{\partial}...y_{K.l.q}^{\partial} >$ values (these may be random, but for simplicity they are considered non-random). Then, a probability measure $P_{l.q}$ of the compliance of states $\hat{S}_{l.q}$ with the requirements of the environment $S_{l.q}^{\partial}$ can be defined:

$$P_{l.q} = P(\hat{A}_{l.q}) = P(< \hat{y}_{1.l.q} r_1 y_{1.l.q}^{\partial} ... \hat{y}_{k.l.q} r_k y_{k.l.q}^{\partial} ... \hat{y}_{K.l.q} r_K y_{K.l.q}^{\partial} >),$$

where r_k is the required relationship between the predicted values of the effect characteristics and their required values (e.g. <,>). The probability measure is calculated using a functional model for calculating the correspondence at the boundary of the CTS and the environment.

$P(\hat{A}_{l.q}) -$, the probability of an event consisting of the fact that when checking the state $\hat{S}_{l.q}$ for one of the possible branches of the tree, performing a single checking TIO by the defined mode is required by the environmental characteristics of the effects, will be achieved. This event means that the result of the checking TIO achieves the required intermediate goal of the CTS functioning. The measure of compliance for the implementation of the entire sequence of checking TIO for one branch $c_m^{Cp} \in C^{Cp}$, the corresponding measure for the whole (but one) branch of $C^{CTC}(c_m^{Cp})$ can be calculated as the probability of a complex event $\hat{A}_l$, which means all the intermediate goals are achieved in the given environmental circumstances. Event $\hat{A}_l$ probability is $P(\hat{A}_l) = P(\bigcup_{q \in \overline{1,Q_l}} \hat{A}_{l.q})$. If the probabilities of compliance for each of the checking TIO are conditionally independent in their sequence, then $P(\hat{A}_l) = \prod_{q \in \overline{1,Q_l}} \hat{A}_{l.q}$. Let the probability of an event $\hat{B}_{q,p}$, consisting of the fact that the transition $a_{q,p}$ will be executed $\hat{B}_{q,p} = (\hat{S}_{l.q}, \hat{S}_{l.\mathrm{p}}) : \exists a_{q,p} : q, p \in \overline{1,Q_l}$, be equal to $P_{q,p} = P(\hat{B}_{q,p}) \sim a_{q,p}$, i.e. the probability $P(\hat{B}_{q,p})$ is associated with the transition $a_{q,p}$. Then the probability of implementing a branch $v_l : l \in \overline{1,L}$ of the tree $C^{CTC}(c_m^{Cp})$ is $P_l = P(\bigcap_{a_{q,p} \in v_l} \hat{B}_{q,p})$. If these events of transition executions are conditionally independent, $P_l = \prod_{a_{q,p} \in v_l} P(\hat{B}_{q,p})$.

Then, as a scalar indicator of the CTS potential ψ or dynamic capability indicator under condition of given IT use, we can take the expected probability of the event that whatever branch $c_m^{Cp} \in C^{Cp}$ and corresponding branches of $C^{CTC}(c_m^{Cp})$ are implemented, there will be the right correspondence between the expected and required states as measured by the checking TIO.

This means that whatever changes in the environment happen, and whatever corresponding to them information and then, non-information (material) operations are conducted to fulfill the changing goals, the changing goals of the CTS will be achieved: $\bar{\psi} = P(\hat{C}) \approx \sum_{l \in \overline{1,L}} (P_l \cdot P(\hat{A}_l))$. In general, the probability $P(\hat{C})$ of a specified event can be represented as a random variable $\hat{\psi}$, not its expected value $\bar{\psi}$. $\hat{\psi}$ discrete distribution $f_{\hat{\psi}}(l)$ could be described by the vector of pairs: $f_{\hat{\psi}}(l) = (P_l, P(\hat{A}_l))$. This vector of pairs can be used as a vector function of the CTS potential: $\Psi = < f_{\hat{\psi}}(l), l = \overline{1,L} >$. These indicators make sense of the different characteristics of the complex probabilistic measure of compliance of the predicted effects with the requirements of them. With this compliance measured at the boundary of the CTS and its environment at different times, while taking in account the possible changes in the environment, the appropriate changes in the CTS that are caused by these environmental changes can be found. The mathematical model of such correspondence on the boundary is the basis of the mathematical model of the CTS potential and dynamic capability estimation task. To obtain a mathematical model of the tasks of potential estimation based on the specified model, it is necessary to construct models that reveal the values $< \hat{y}_{1.l.q} ... \hat{y}_{k.l.q} ... \hat{y}_{K.l.q} >$ and $< y^{\partial}_{1.l.q} ... y^{\partial}_{k.l.q} ... y^{\partial}_{K.l.q} >$ with the use of labeled (parametric and then functional) graph-theoretic models.

5. Conclusion

The results obtained enable the evaluation of the predicted values of the operational properties of systems depends IT used for system functioning changes due to changing conditions of environment. Corresponding IT-usage indicators, dynamic capabilities, or system potential indicators can be estimated as a result. Analytical estimation of such indicators becomes possible depending on the variables and options in the mathematical problems to be solved. This could lead to a solution to contemporary problems in research using predictive analytical mathematical models and mathematical methods.

Examples of such research problems are problems related to IT productivity and efficiency and the estimation, analysis, and synthesis of the dynamic capabilities of systems (Teece, 2007, Wang, 2007). Possible aspects include choosing the best information operations, choosing IT and TIO characteristics for the optimal implementation of new IT, choosing best digitalization scenarios (Lee, 2015). It makes it possible, as a result, to overcome the existing gap between the need to solve research problems in operational properties (especially regarding digitalization) based on mathematical models and methods and the lack of the necessary concepts and methodology for solving such problems.

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SOCIETY BEYOND INDUSTRY 4.0: SMART SYSTEMS AS ENABLERS

BEYOND SMART SYSTEMS – CREATING A SOCIETY OF THE FUTURE (5.0) RESOLVING DISRUPTIVE CHANGES AND SOCIAL CHALLENGES

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Keywords

Smart Systems, Autonomous Systems, Industry4.0, Systems of Systems, Cyber-physical systems, Internet of Things (IoT), Artificial Intelligence, Society 5.0, Ethical Aligned Design, Sharing Society, Sharing Economy.

Abstract

Smart Systems are today's drivers of innovation, in all industrial and social areas highly automated or autonomous intelligent systems are taking over tasks and services – and maybe, one day, control of our lives. The keynote will address technologies of the fourth industrial revolution in a holistic manner (e.g. IoT, Big Data, Artificial Intelligence, Connectivity, robots) enabling disruptive developments (evolutionary or revolutionary), but also discussing ways they could enable towards a creative, innovative and sustainable sharing society. It will focus on a few areas not covered by other topics of this year's IDIMT, particularly on highly automated systems in transport, smart farming, smart cities and homes, infrastructure, economic systems, and for "inclusion" of elderly or handicapped persons to facilitate longer independent living ("ageing well"). A short critical survey of the Japanese concept of "Society 5.0" will be provided. First approaches of international organizations, e.g. ICT standards organizations, some governments, the European parliament and the UN, are explained on how society and the technical community may meet the rising awareness and ethical concerns, human factors and the like, besides safety, security and resilience and their interplay.

1. Introduction and Overview – Smart Systems Everywhere

Smart things everywhere – an estimate of IDC (International Data Corporation), a worldwide active global provider of market intelligence and advisory services, expects by 2025 that every average person will interact each day many thousand times with a smart device. And smart devices are not just single devices – that would be the conventional way of some equipment used for a particular purpose in an isolated manner with only local intelligence based on some sensors or actors, no, they are connected with systems and systems-of-systems in your environment and to a certain extent even worldwide. The pretended purpose of this high degree of connectivity is to serve customers (peoples) needs for their benefit – but the impact is much higher. Challenges are not only on the technical and usability level, they are on the level of increased risks, threats and vulnerabilities of the systems concerning safety, security and privacy. Last but not least are we afraid of the "transparent citizen", the total surveillance ("Big Brother") like shown in a much simpler and less professional manner in the famous book "1984" by George Orwell; less professional because of lack of the technology that is easily available now.

This will impact considerably our lives and lifestyle, and, as a consequence, we will have to face the new challenges, opportunities and risks. The technological basis is laid by IoT (human – smart devices interaction and communication) and IIoT (IoT in industrial context, machine-to-machine communication) as infrastructure (connectivity), and CPS (Cyber-physical Systems) as "things" or "devices". However, "smart things everywhere" is not just IoT or IIoT, or mobile phones – it means intelligence, cognitive systems and technology, machine learning and artificial intelligence, security, big data and cloud connectivity, involving many domains of everyday life and digital transformation of our world. IDC expects, that AI will be a new standard element in virtually all enterprise and consumer apps and services, including home, health-care, industry and transport as well, and that AI capabilities being used today are only one-third of what will be available over the next five years.

Cognitive technologies for smart systems include particularly:

- Cognitive decision and self-organizing systems,
- Swarm intelligence
- Cognitive technologies to create applicable information from big data generated by massively deployed smart things,
- Embedded, distributed and resource-aware machine learning of IoT and IIoT devices and systems

With respect to safety, cybersecurity, privacy, and data sovereignty, these cognitive technologies are a severe concern for specialists, politicians and citizens, and raise severe ethical and societal concerns.

Smart Systems are digitalized – and part of the so-called "Digital Transformation". This covers all aspects of economy, industry and living, examples are (without prioritization):

- Smart Production/Manufacturing,
- Smart Health,
- Smart Mobility,
- Smart Farming,
- Smart Energy,
- Smart Critical Infrastructures
- Smart Cities/Homes/Buildings,
- Smart Construction (of buildings by smart machines and robots)
- Smart Living for Ageing Well,
- Smart Wearables (for health, comfort, security, particular services),
- Smart Water or Waste Management, etc.

2. Smart Systems Everywhere – Research and Standardization Efforts

In all technological and industrial advanced regions of our world, research and innovation in this field are considered essential and a lot of money is invested by governments and industry (and, not to forget, military). On European level, organizations like AIOTI [AIOTI], the Alliance for Internet of Things Innovation, which takes care of the IoT aspects in 13 Working Groups, or the industrial associations ARTEMIS [ARTEMIS] (Advanced Research and Technology on Embedded Intelligent Systems), EPoSS [EPoSS] (European Technology Platform for Smart systems Integration) and AENEAS (Association for European Nano-Electronics Activities), which are the private partners in the ECSEL Joint Undertaking, a European PPP within Horizon 2020 (Public-Private Partnership) with an industry-oriented Research Program, and other PPPs, take care of further development of research, standardization and promotion of these topics, together with the European Commission and national funding authorities. China is already keeping up with Europe, US and Japan, e.g. with its AI initiative and strategy.

The digital transformation of European business and society is a major goal of the EC. EC Growth, the DG (Directorate General) for Internal Market, Industry, Entrepreneurship and SMEs, considers digital transformation as a key element for European growth, because Europe can build on its strength in traditional sectors and can take up the potential and challenges of advanced digital technologies. Technologies considered in this context are IoT, big data, advanced manufacturing, robotics, 3D printing, blockchain technologies and artificial intelligence (see European Commission, 2018).

The initiative “Digitizing European Industry” targets to meet Europe’s needs to join forces under a common strategy that takes digitalization of the EU's economy forward in order to unlock the full potential of the 4th industrial revolution. The pillars of this initiative are:

Figure 1: Pillars of the European Initiative “Digitizing European Industry”

Source: https://ec.europa.eu/digital-single-market/en/pillars-digitising-european-industry-initiative

In the booklet “My agenda for Europe” of Ursula von der Leyen, the new President of the European Commission, is one chapter dedicated to “A Europe fit for the digital age”. It focuses on AI, IoT, 5G, and ethical and human implications of these technologies, empowering people through education and skills, and on protecting ourselves with respect to the risks of these technologies.

DG CONNECT, DG for Communications Networks, Content and Technology, has a strong focus on “Digitalization of European Industry”, with the pillars IoT (physical meets digital), Big Data (value from knowledge) and AI and Autonomous Systems (which is somehow a revival of AI in a new context and now considered as the “next digital revolution”). The links between technologies are shown in [European Commission, 2017b].

Additionally, DG Growth delivers an annual report on standardization, e.g. the “Rolling Plan on ICT Standardization”, which includes most of the relevant areas in this paper’s context and is a key pillar in Digitalization, and have started a Joint Initiative on Standardization (JIS) http://ec.europa.eu/growth/single-market/europeanstandards/notification-system_en, although they do primarily consider the European SDOs (Standardization Organizations, ESOs) CEN, CENELEC and ETSI.

On international level, the large standardization organizations ISO and IEC have joined forces in many respects. One the one hand, in the Joint Technical Committee 1 (ISO/IEC JTC1, Information Technology), starting several new or extending existing Subcommittees, e.g. JTC1 SC41 (Internet of things and related technologies, which covers also wearables and sensor networks), JTC1 SC42 (Artificial intelligence, which covers also Trustworthiness in AI, Bias in AI, Risk Management of AI, Big Data and Algorithms), JTC1 SC 38 (Cloud computing and distributed platforms), JTC1 SC 27 (Information security, cybersecurity and privacy protection), WG 11 (Smart Cities) or AG 6 (Autonomous and Data Rich Vehicles) and AG 11 (Digital Twin). On the other hand, they have installed coordination groups on several topics, e.g. Smart Manufacturing, Ethical considerations, or Focus Groups like CEN/ETSI/CENELEC on AI, or ITU/WHO (International Telecommunication Union/World Health Organization) on “AI for Health”. In some sectors, like ISO TC 22, Road vehicles, many standards are arising on automotive safety, cybersecurity engineering, extended Vehicle standards (connectivity, V2I, V2V), and a Roadmap towards “Automated Driving” is developed in coordination with various related ISO subcommittees and SAE (Society of Automotive Engineers, US) by an Ad-hoc Group AG1 (ADAG – Automated Driving Ad-hoc Group). In IEC TC 65 (Industrial-process measurement, control and automation), a new focus is on “Smart Manufacturing”, including Joint Working Groups with ISO TC 184 (Automation and Integration).

An overview over the rich landscape of standards and standardization organizations (SDOs) in an ordered manner (domains and generic/horizontal standards) is provided by Figure 2:

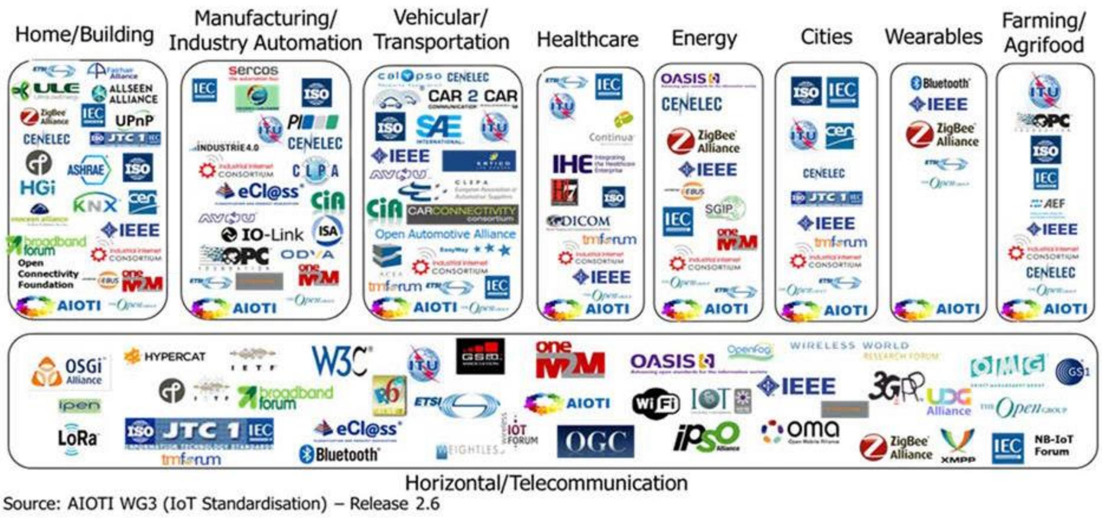

Figure 2: AIOTI Standardization landscape, ordered overview (Source: ETSI 2016a)

3. Autonomous Systems, CPS and IoT as Drivers for Digitalization

Highly automated or autonomous smart interacting systems are becoming the main driver for innovations and efficient services. The impact on society and economy as a whole is tremendous and will change our way of living and economy considerably - thus dependability (safety, reliability, availability, (cyber-)security, maintainability, but additionally resilience, robustness, sustainability, etc.) in a holistic manner becomes an important issue, despite emergent behaviors and critical interdependencies.

Social media have proven, that they are not only supporting people in emergency cases, connecting people, support learning and increase knowledge, but also cause the opposite: enable new crimes, make mobbing undefeatable, distribute wide spread rumors, “fake news”, undermine substantially the belief in objectivity and science, and influence even elections and referendums in a manner never foreseen before. Movies from YouTube are often informative or funny, but on the other hand anybody can upload nonsense, lies and conspiracy theories, which already without the seemingly plausibility of a movie were dangerous in the past (see Wikipedia https://en.wikipedia.org/wiki/Conspiracy_theory). There are studies [Primack, 2017], which detected, that young adults with high level of social media use feel more social isolation than those with lower social media use. The “Pisa tests” demonstrate that many abilities are lost because of the new media and new technologies, methods and tools. This has of course also happened in the past, but the influence on social behavior and the control of society was not so perfect as it will become now, and countermeasures are often impossible – “the net never forgets” (which is a basic property in Blockchain!), as Facebook has proven, although it was illegal according to European Privacy Laws not to delete completely contents everywhere if the generator wants to have deleted it. And anyway, you cannot delete illegal or fake contents that has been downloaded already by users.

Autonomous systems have a property that is new to ICT systems – they have to decide on basis of data provided to them based on algorithms (particularly neural networks, big data, and AI methods), where predictability of dependability properties (safety, security, resilience) is not possible today or difficult to prove. The dependability of results of such decisions is a major obstacle to implementation of fully autonomous systems without human control – and liability issues are difficult to handle in a fair manner. This raises severe ethical questions as well, additionally to all technical questions, – how to decide in a no-win situation? A few principles and recommendations will be discussed later under “Ethical considerations”.

A critical part of the AI game is “Machine Learning”. ISO/IEC JTC1 SC42 (“Artificial Intelligence”) has started a New Standardization Work Item (NP AWI 23053) “Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)”. This is a first approach to provide some structure to such systems; the resulting Specification or Standard should be the starting point for further work towards safety and security considerations of such systems, and include later on ethical considerations as well (WG 3 on “Trustworthiness of AI”).

Here again we have to take into account that existing standards and certification procedures do not fit. We have to “re-think” standardization and certification, and recent research projects in ECSEL JU (see acknowledgements) like the “lighthouse” projects Productive 4.0 (Industry4.E) and AutoDrive (Mobility.E) have set the goal to promote work in that direction. Related projects like SECREDAS, AMASS, AQUAS, and now iDev40 or even AfarCloud in the Smart farming sector, will be invited to participate in the “lighthouse initiatives” to provide synergies in a larger context to promote digitalization/digital transformation in these sectors.

Originally, communication and connectivity included always humans as one partner. With the ascent of machines talking to each other without human interaction, the age of “M2M” (Machine-to-Machine Communication) has begun, with first working groups and standards arising e.g. at ETSI, the European Telecommunications Standards Institute, one of the official ESO’s (European Standardization Organisations, the others are CEN and CENELEC).

AIOTI [3], the Alliance for Internet of Things Innovation, really aims at making Europe the leading region in the world to create and master sustainable innovative European IoT ecosystems in the global context to address the challenges of IoT technology and applications deployment including standardization, interoperability and policy issues, in order to accelerate sustainable economic development and growth in the new emerging European and global digital markets. One of the key findings of the recommendations was, that privacy, security and trust challenges are everywhere in the IoT – privacy and trust have to be built-in by design. There are already several known attacks on IoT-systems, e.g. a University was attacked by its own vending machines! One rather new attack-type are ransomware attacks encrypting the users disk and blackmailing the owner.

Another key issue are interoperability of protocols, data and semantic interoperability, and security – therefore the AIOTI Standardization WG issued several reports and is very active because of the importance of standardization for huge IoT systems with many interfaces and "things". Standardization as such is done via ETSI [ETSI] as supporting standardization organization (SDO). A view on the "Standardization Landscape" shows the heterogeneity of the landscape: horizontal, rather generic standards and domain specific standards, from many international and industrial standardization organizations. (see Figure 2).

4. Evolutions in Industry, Automated Driving - and Society

Europe has focused very much on the "Industry 4.0" aspect (somehow driven by Germany's "Industrie 4.0") in driving the Digitalization, and mainly from the economic/manufacturing/ competition point of view. The "generation aspect" can be observed in all contexts of evolutions (revolution is just a term describing when the evolution leads to a dramatic fast change of the situation with disruptive consequences for people, society and economy).

The stages of evolution from Industry 1.0 to Industry 4.0 over time are characterized by the means and processes typical for a longer period of time (see Figure 3):

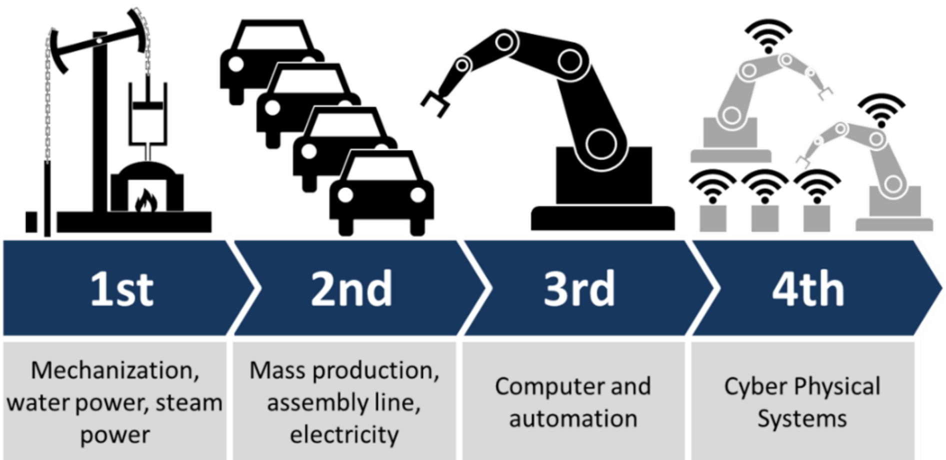

Figure 3: Industrial evolution over time: 18th-19th century (1), 19th-20th century (2), 1970+ (3), today (4)

Source: Christoph Roser at AllAboutLean.com, Creative Commons Attribution-Share Alike 4.0 International license

The change from one stage to the next higher stage was often accompanied by severe consequences for people and society – jobs were lost or changed dramatically, social instabilities, threats to people and environment followed, and in many cases the situation became disastrous for masses of citizens as "losers" of the changes. Only when social systems were introduced in time, the effects could be buffered to avoid catastrophic situations for the society.

Highly automated systems in a stable society under socially compliant conditions have a good chance to lead to benefits for all in the end – but politics has to be careful to avoid too much inequality of distribution of benefits from the opportunities achieved by automation. The threats of digitalization are not only in economic change – it may endanger our democracy, citizens independence and freedom we have fought for more than 200 years now!

Automated Driving is a particular result of the technology-driven evolution in our society: The goal of "Zero Accidents", as announced by the EC when introducing the automated driving programs, is only one side of the coin: besides clear benefits for health and environment, there may be a disruptive change in transport, affecting not only taxi drivers, but also public transport, vehicle sales, the whole vehicle market, etc. We have still some time to adapt – and large OEMs are already planning ahead towards a future where managing fleets of autonomous vehicles used on demand only may become a major business case. One key issue, that the autonomous vehicles should mainly be used for the "last mile" or remote country side, to reach the next more efficient and environmentally sustainable public transport means, e.g. high- speed trains, was not very often mentioned in the "green transport scenarios" or research projects.

From Horse Power to Driverless Vehicles: The Road to Automated Driving, Vienna Convention, 1968, Article 8:

- Every moving vehicle or combination of vehicles shall have a driver.
- Every driver shall at all times be able to control his vehicle or to guide his animals.

Remark: Horses find their home "autonomous" – nothing new, take-over from driver automatically!

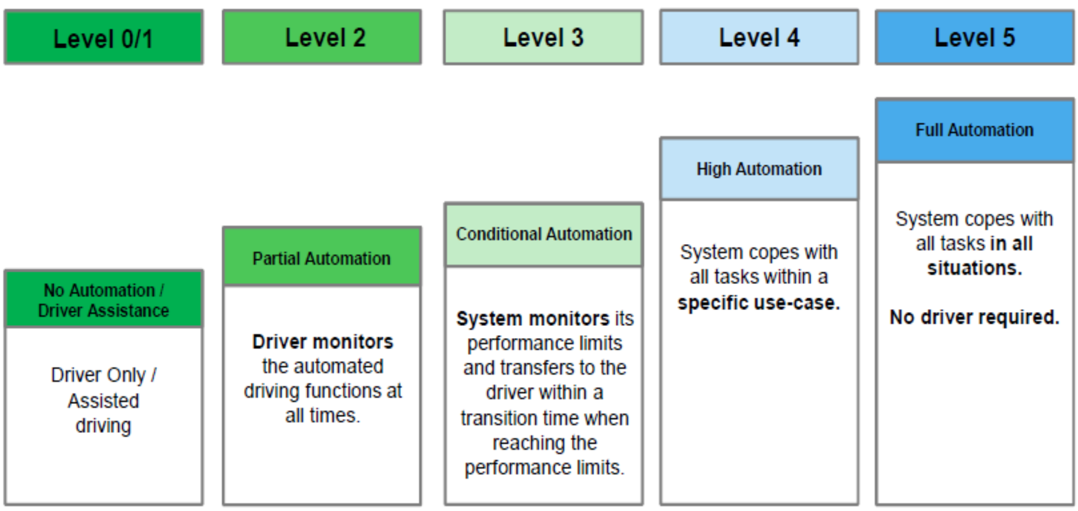

Figure 4: Source: SAE (Society of Automotive Engineers, USA) – Levels of Automation for Automated Driving

The best automation levels reached in practice are 2 -3 at the moment. Test vehicles claiming higher levels at least under certain conditions are at the moment not allowed to drive autonomously without a responsible, trained driver (see GOOGLE car accident and TESLA crash) as a fall-back solution. Especially critical is considered the "mixed mode" situation – non-automated and autonomous vehicles interfering, and additionally in urban environments VRUs sharing the road (cycles, pedestrians, …). Therefore, several organisations tried to establish rules on "Intelligent transport systems and automated driving" (e.g. UNECE ITS/AD).

But what about human society? – The Japanese Strategy Society 5.0

5. Society 5.0 – Aiming for a New Human-Centred Society

There are far reaching concepts implemented around us with the "Smart Systems Everywhere". On the other hand, all technologically and economically highly developed countries face chronic social challenges, which add up to the challenges and risks impacted by all the "4.0" revolutions to people and society.

The Japanese strategy "Society 5.0" envisions a so-called "Super-Smart Society". It should create a sustainable, inclusive socio-economic system, powered by the achievements of the fourth industrial revolution and the digital technologies. It leads far beyond Industry 4.0, it aims at benefitting the whole society by utilizing the integration of cyberspace and physical space [UNESCO 2019]. It is fully supported by government and industry to revitalize Japan, an extremely aging society with shrinking work force [Japan Business Federation, 2016, 2017] [Japanese Government, 2017, 2018].

Evolution of Human Society over time:

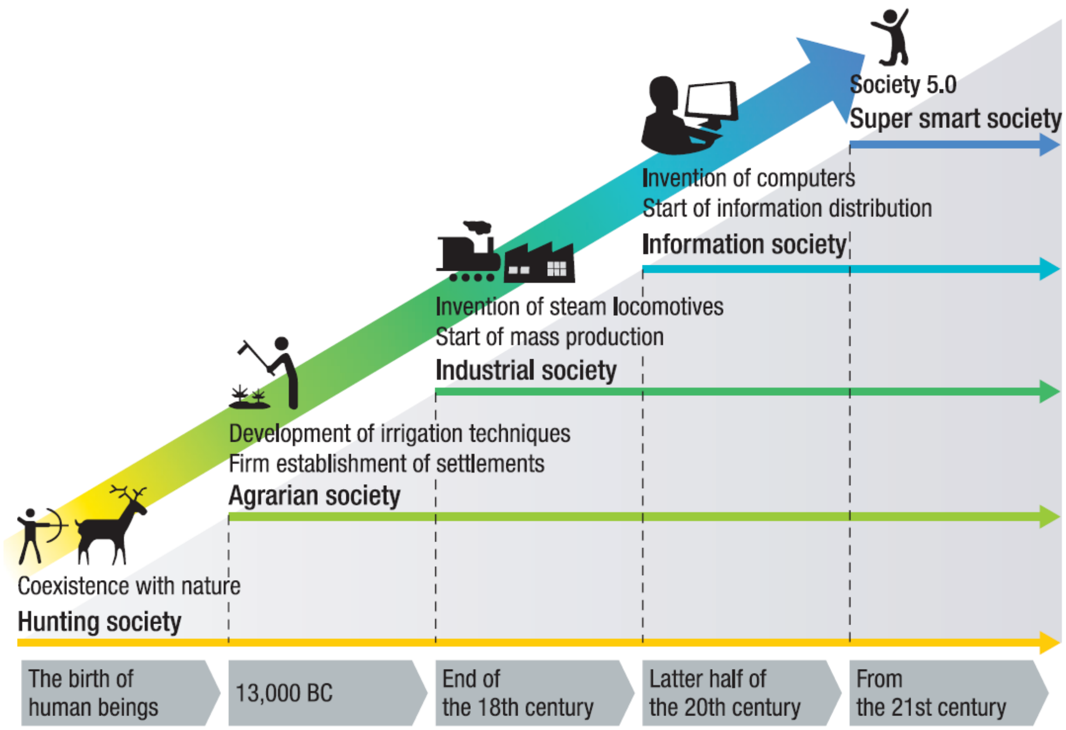

Figure 1: Evolution of Human Society towards Society 5.0 (Source: Mayumi Fukuyama (2018))

The documents on their vision say (citation from [Japanese Government, 2017])

"We aim at creating a society where we can resolve various social challenges by incorporating the innovations of the fourth industrial revolution (e.g. IoT, big data, artificial intelligence (AI), robot, and the sharing economy) into every industry and social life. By doing so the society of the future will be one in which new values and services are created continuously, making people's lives more conformable and sustainable.

This is Society 5.0, a super-smart society. Japan will take the lead to realize this ahead of the rest of the world."

The concept of "Society 5.0" was drafted in the 5th Science and Technology Basic Plan by the Council for Science, Technology and Innovation 2016.

Key issues of this plan are sustainability and social benefit for all citizen ("inclusion") by utilizing the advanced opportunities of Digital Transformation and Smart Technologies. Social reform (innovation) will achieve a forward-looking society that breaks the existing stagnation in societal and economic stagnation, forming a society of mutual respect, transcending the generations, and a active and enjoyable life for every person. This concept should also face challenges on a global scale, like depletion of natural resources, global warming, growing economic disparity, and even terrorism, by sharing knowledge and information, and cooperation.

From a moral and ethical point of view, this sounds extremely well. The question that arises if it fits to other kinds of societies and regions in the world, having different social and economic preconditions, and different long-standing cultures and mind sets. From experience in history we know, that the fantastic technologies and opportunities can be misused by some people, criminals or governments against citizens. Therefore, in Europe, which is by far not so homogeneous in culture and mutual influences of neighbours as Japan, and America, institutions of different type have tried to set up ethical guidelines in the field of automated systems, cognitive decision taking (AI), and governance of data and connectivity.

6. Ethics Guidelines

6.1. Ethics Commission for Automated Driving (German Federal Ministry of Transport and Digital Infrastructure)

Automotive is a real mass market, and the trend towards highly automated and autonomous driving is ongoing in research and development. On the one hand, it is rather simple compared to complex AI issues and cognitive decision in achieving transparency in self-learning systems in detail (which is not possible at the moment), but even high-level principles are interesting.

The German document (available in English) [German Federal Ministry, 2017], includes a punctuation of 20 ethical rules for automated and connected vehicular traffic (shortened):

- The primary purpose of partly and fully automated transport systems is to improve safety for all road users. Another purpose is to increase mobility opportunities and to make further benefits possible. Technological development obeys the principle of personal autonomy, which means that individuals enjoy freedom of action for which they themselves are responsible.
- The protection of individuals takes precedence over all other utilitarian considerations. The objective is to reduce the level of harm until it is completely prevented. The licensing of automated systems is not justifiable unless it promises to produce at least a diminution in harm compared with human driving, in other words a positive balance of risks.
- The public sector is responsible for guaranteeing the safety of the automated and connected systems introduced and licensed in the public street environment. Driving systems thus need official licensing and monitoring. The guiding principle is the avoidance of accidents, although technologically unavoidable residual risks do not militate against the introduction of automated driving if the balance of risks is fundamentally positive.
- The personal responsibility of individuals for taking decisions is an expression of a society centered on individual human beings, with their entitlement to personal development and their need for protection. The purpose of all governmental and political regulatory decisions is thus to promote the free development and the protection of individuals. In a free society, the way in which technology is statutorily fleshed out is such that a balance is struck

between maximum personal freedom of choice in a general regime of development and the freedom of others and their safety.

- Automated and connected technology should prevent accidents wherever this is practically possible. This includes dilemma situations, in other words a situation in which an automated vehicle has to "decide" which of two evils. In this context, the entire spectrum of technological options should be used and continuously evolved. The significant enhancement of road safety is the objective of development and regulation, starting with the design and programming of the vehicles such that they drive in a defensive and anticipatory manner, posing as little risk as possible to vulnerable road users.
- The introduction of more highly automated driving systems, especially with the option of automated collision prevention, may be socially and ethically mandated if it can unlock existing potential for damage limitation. Conversely, a statutorily imposed obligation to use fully automated transport systems or the causation of practical inescapabilty is ethically questionable.
- In hazardous situations that prove to be unavoidable, despite all technological precautions being taken, the protection of human life enjoys top priority in a balancing of legally protected interests. Thus, within the constraints of what is technologically feasible, the systems must be programmed to accept damage to animals or property in a conflict if this means that personal injury can be prevented.
- Genuine dilemmatic decisions, such as a decision between one human life and another, depend on the actual specific situation, incorporating "unpredictable" behavior by parties affected. They can thus not be clearly standardized, nor can they be programmed such that they are ethically unquestionable. It is true that a human driver would be acting unlawfully if he killed a person in an emergency to save the lives of one or more other persons, but he would not necessarily be acting culpably. It would be desirable for an independent public-sector agency (for instance a Federal Bureau for the Investigation of Accidents Involving Automated Transport Systems or a Federal Office for Safety in Automated and Connected Transport) to systematically process the lessons learned.
- In the event of unavoidable accident situations, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited. It is also prohibited to offset victims against one another. General programming to reduce the number of personal injuries may be justifiable. Those parties involved in the generation of mobility risks must not sacrifice non-involved parties.
- In the case of automated and connected driving systems, the accountability that was previously the sole preserve of the individual shifts from the motorist to the manufacturers and operators of the technological systems and to the bodies responsible for taking infrastructure, policy and legal decisions.
- Liability for damage caused by activated automated driving systems is governed by the same principles as in other product liability.
- The public is entitled to be informed about new technologies and their deployment in a sufficiently differentiated manner.
- The complete connectivity and central control of all motor vehicles within the context of a digital transport infrastructure is ethically questionable if, and to the extent that, it is unable to safely rule out the total surveillance of road users and manipulation of vehicle control.

- Automated driving is justifiable only to the extent to which conceivable attacks, e.g. manipulation of the IT system or innate system weaknesses, do not result in such harm as to lastingly shatter people's confidence in road transport.
- Permitted business models that avail themselves of the data that are generated by automated and connected driving and that are significant or insignificant to vehicle control come up against their limitations in the autonomy and data sovereignty of road users. It is the vehicle keepers and vehicle users who decide whether their vehicle data that are generated are to be forwarded and used.
- No abrupt handover of control to the driver ("emergency"): To enable efficient, reliable and secure human-machine communication and prevent overload, the systems must adapt more to human communicative behaviour rather than requiring humans to enhance their adaptive capabilities.
- It must be possible to clearly distinguish whether a driverless system is being used or whether a driver retains accountability with the option of overruling the system. The distribution of responsibilities (and thus of accountability), for instance with regard to the time and access arrangements, should be documented and stored. This applies especially to the human-to-technology handover procedures.
- In emergency situations, the vehicle must autonomously, i.e. without human assistance, enter into a "safe condition". Harmonization, especially of the definition of a safe condition or of the handover routines, is desirable (standardization).
- Learning systems that are self-learning in vehicle operation and their connection to central scenario databases may be ethically allowed if, and to the extent that, they generate safety gains. Self-learning systems must not be deployed unless they meet the safety requirements regarding functions relevant to vehicle control and do not undermine the rules established here. It would appear advisable to hand over relevant scenarios to a central scenario catalogue at a neutral body in order to develop appropriate universal standards, including any acceptance tests.
- The proper use of automated systems should form part of people's general digital education. The proper handling of automated driving systems should be taught in an appropriate manner during driving tuition and tested.

6.2. Trustworthy AI (Highly Automated systems in General)

Here is only a short overview on a few AI-related documents on "Trustworthy AI" and Ethical Guidelines for "Smart Systems' Decision Taking" provided:

- The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems (AI/AS) (April 2016)
  - Ethically Aligned Design: A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems (EAD V1 released)
  - Identification and recommendation of ideas for Standards Projects focused on prioritizing ethical considerations in AI/AS.
  - IEEE ECAIS "Ethics Certification for Autonomous and Intelligent Systems" (Industry Connections Activity Initiation Sept. 2018!).
- IEC/SMB Ad Hoc Group on autonomous systems and ethics (AHG 79) (ISO/TC299, June 20, 2018!!), scope commitment:

- SMB (Standardization Management Board) agreed to setup AHG 79, Autonomous Systems – Ethics, with the task of assessing the role of IEC and standards in addressing ethics, trust and values particularly in autonomous systems, and making recommendations. The review should consider the work of JTC 1/SC 42 (Artificial Intelligence), ACART (Advisory Committee on Applications of Robot Technology), ACOS (Advisory Committee on Safety), TC 59 (Performance of household and similar electrical appliances), TC 100 (Audio, video and multimedia systems and equipment), SyC AAL (Systems Committee on Active Assisted Living), SyC Smart Cities, IEEE, ISO and others.
- "When Computers Decide" – European Recommendations on Machine Learned Automated Decision Making (Informatics Europe & EUACM 2018) includes Technical, Ethical, Legal, Economic, Societal and Educational recommendations)
- EC: "Ethics Guidelines for Trustworthy AI" (Final report April 2019, HLEG AI) https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai
- ISO/IEC JTC1 SC42 (Artificial Intelligence): TECHNICAL MANAGEMENT BOARD RESOLUTION 53/2018: Approval of the inclusion of certain aspects of 'societal concerns' in the ISO/IEC JTC1/SC 42 programme of work.

7. Conclusions

The technologically oriented funding organizations and the EC have a very positive approach and high expectations concerning the benefits of digitisation of economy, industry and society. They highlight the fascinating opportunities for a better life for all, better and sustainable usage of resources, reduced environmental footprint, and of course economic competitiveness for European industry. The Japanese approach to "Society 5.0" even goes far beyond Industry 4.0, and the visionary declarations are of high ethical and moral value. Applications like military, espionage etc. are explicitly excluded in Research here. However, we should be aware that many of the achievements could be used against us as well (and some research projects consider this fact already) – drones help with precision farming, and building inspection and maintenance, but also as war drones. Robots can help in health (exoskeletons), ageing well, rescue and maintenance actions, etc. by saving peoples life or keeping people to live longer independently, but also serve as a robot army. Knowledge and information can build a better society, but also be used against you by criminals or organizations. This requires careful European and international legislation and control to avoid the worst outcomes of these new technologies, and requires high public awareness. Politics sometimes tend to use safety and security threats as argument for more surveillance and control of people, endangering freedom and democracy. A first approach is taken by several authorities and international or governmental organisations to provide guidelines and recommendations for an ethical approach to highly autonomous systems.

8. Acknowledgements

Part of the work received funding from the EC under grant agreement n° 645149 (CP-SETIS), from the EU ARTEMIS/ECSEL Joint Undertaking under grant agreement n° 692474 (AMASS), and from both, the EC ECSEL JU and the partners' national funding authorities (in Austria FFG (Austrian Research Promotion Agency) on behalf of BMVIT, The Federal Ministry of Transport, Innovation and Technology) - (Grant agreements n° 692455-2 (ENABLE-S3), n° 737475-2 (AQUAS), n° 737459-2 (Productive4.0) and n° 737469-2 (AutoDrive) and SECREDAS (783119), iDev40 (783163) and AfarCloud (783221)).

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Verizon RISK – 2017 Data Breach Digest Scenario

SMART INDUSTRIAL INDOOR FARMING – TECHNICAL AND SOCIETAL CHALLENGES

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Keywords

Smart indoor farming, reliability, security, STPA, SAHARA, FMVEA, industrial indoor farming

Abstract

Population growth and food development are two of the major challenges for society. While smart farming can help, available arable land is restricted. Smart industrial indoor farming has the potential to increase agricultural production while also reducing resources usage. To guarantee a reliable food supply, we need to ensure a dependable system, which protects not only the plants, but also the Intellectual property (IP). We give an overview about the challenges on agriculture, available indoor farming systems and standards for smart farming. We evaluate the standards for applicability towards indoor farming and present a use case for a smart industrial indoor farming system. To assure a dependable system, we present a methodology to analyze the system and achieve a trade-off between different dependability attributes.

1. Introduction

Based on the latest UN Reports the world population is projected to reach 9.8 billion in 2050, and 11.2 billion in 2100 (Department of Economic and Social Affairs, 2017). In 2017 around 1 in every 9 people in the world, 821 millions, are estimated to be undernourished (UNICEF, FAO, WFP, IFAD, & WHO, 2018). Currently we could solve this by a redistribution of food, considering that also more than 672 million are obese. Population growth, more complex, frequent and intense climate extremes challenge any solutions which relies on classical farming. The world resources institute predicts that we need a 69% increase in food calories to feed the population in 2050. If we redistribute all food produced, we would still be missing 974 calories per person per day by 2050 (Janet Ranganathan, 2013).

If we also consider classical farming, experts predict an increase of the arable land by around only 5% until 2050. Increasing the food production on the land which is already in use will only increase the environmental impacts like soil nutrient depletion, erosion, desertification, depletion of freshwater reserves, loss of tropical forest and biodiversity (Food and Agriculture Organization of the United Nations, 2009).

Based on this we face the challenge to increase the output and efficiency of food production, while reducing the needs in term of space and minimizing the environmental impact. Due to this reasons we see currently a trend towards smart farming. Smart farming enhances farming by applying technologies for data acquisition, data analysis and evaluation and precision application (Balafoutis et al., 2017). This allows to optimize the whole farming process and consider the needs of each individual plant, thereby reducing water, fertilizer and weed and vermin killers.

Smart farming has still the same requirements on land usage and vulnerabilities against climate extremes. Therefore, we propose smart indoor farming. Smart indoor farming takes the generic concept of smart farming and transfers the farm in a completely controlled environment. Smart indoor farming can use otherwise un-arable land in urban environments and even allow multiple “layers” of farms on top of each other. While currently indoor farming is mainly done for private use (Thomaier et al., 2015), we foresee an increasing industrialisation. Along with this there is a need for improved monitoring and control, to ensure food safety and security (Meharg, 2016).We start with a short overview about different technologies used for smart indoor farming and evaluate the existing standardization landscape on smart farming for their applicability toward smart indoor farming. Afterwards we will present a concept for a smart indoor farming use case and, based on the identified standards, identify the dependability needs of this use case. We will present a methodology to identify requirements based on the dependability needs and conclude with an outlook on the next steps and societal impact of smart indoor farming.

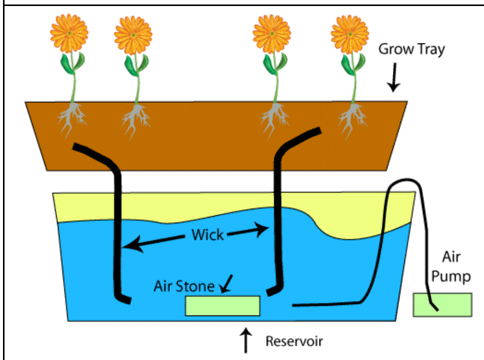
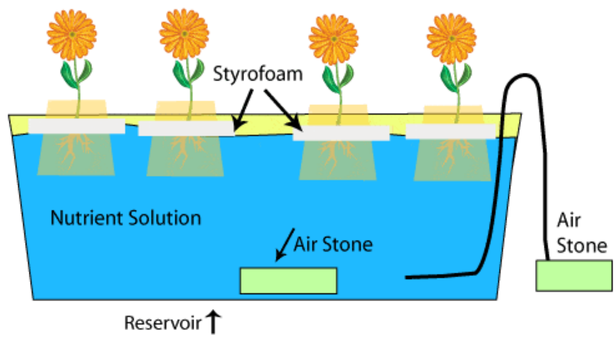
2. State of the Art

2.1. Types of industrial indoor farming systems

While (Thomaier et al., 2015) includes soil-based indoor farming, we consider this on the boundary towards a classical houseplant or “hobby” farming. In our understanding of smart industrial indoor farming we require a fine-granular control over the environment of the plants, which requires a growth medium that can be changed and where the amount of nutrients can be fine-tuned. This is one of the differentiations between indoor farming and smart industrial indoor farming.

Based on this we restrict ourselves to hydroponic indoor farming. The Oxford Dictionary defines hydroponics as “The process of growing plants in sand, gravel, or liquid, with added nutrients but without soil." In most cases this is done in an indoor environment and requires and allows therefore also a fine-tuned control of the lighting. Hydroponic systems can be mostly categorized into six different types of systems (Bruce Dunn, 2013).

Table 1: Overview about hydroponic systems (pictures from https://outdoorauthority.org/garden/hydroponics/hydroponic-systems/)

<table>
<tr><td>Wick System</td><td>Water Culture</td></tr>
<tr><td>
</td><td>
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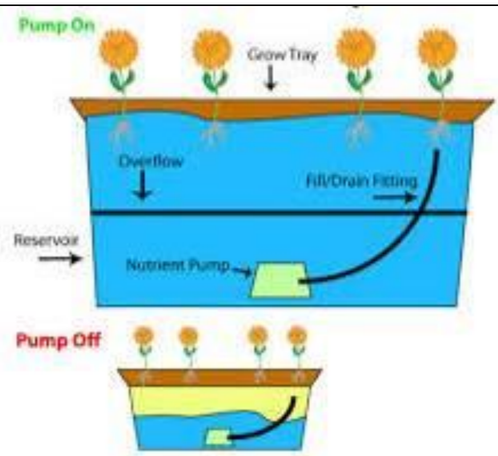
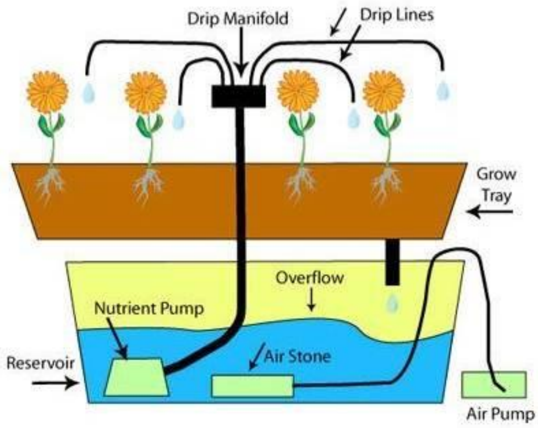
<tr><td>Ebb and Flow</td><td>Drip</td></tr>
<tr><td>
</td><td>
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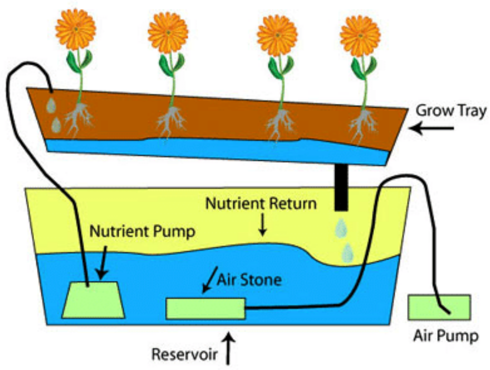
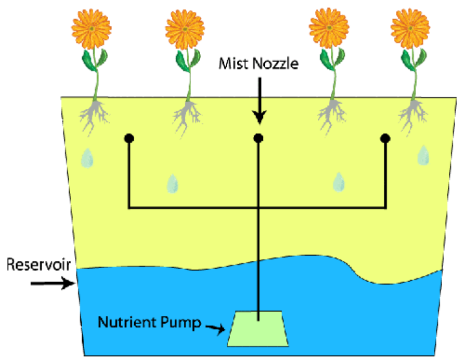
<tr><td>Nutrient Film Technique</td><td>Aeroponic</td></tr>
<tr><td>
</td><td>
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There are many variations and adaptions of these types, as example combining Water Culture with a fish farm leads to an Aquaponic system (Kyaw & Ng, 2017), where the fish provide water with nutrients for the plants. In general hydroponics for industrial indoor farming have the following advantages (Bruce Dunn, 2013):

- Usage of non-arable land
- Complete control over growing environment, including nutrient and lightning
- Lower water and nutrient usage
- Increased growth by optimizing environment and supplying roots with oxygen
- Elimination of soil related issues (vermin's and illnesses)
- Higher and more consistent yields
- No crop rotation, cultivation and transplantation from cultivation to grow environment

Existing disadvantages are (Bruce Dunn, 2013):

- Initial costs and operation costs are higher than soil culture
- Skill and knowledge are required to design, install and operate the system

We can divide the systems in active and passive systems. Passive systems rely on natural phenomena to supply the plants with nutrients (e.g. the wick system relying on capillary action). Active systems can control the nutrient supply fine granular but require a dependable operation because disruptions of the supply can inhibit or destroy harvest. Active systems have also the potential to produce increased and consistent phytochemical yields (Hayden, Yokelsen, Giacomelli, & Hoffmann, 2004). This means that a fine-tuned control strategy for lighting (times, composition from the electromagnetic spectrum) can greatly increase quantity and consistency of various biologically active compounds found in plants. This allows to use plants produced in such systems to be used in cosmetic and medical uses without concerns about pesticides contaminating the cosmetic or medical product. Development of such control strategies needs to be conducted for each plant and is a time and resource consuming activity.

2.2. Smart Farming standards

Since hydroponic farming and smart industrial indoor farming is a rather new topic, there are currently no specific standards for this field. Instead we need to look at the existing standard landscape for smart farming and identify topics not suitable or not covered. ISO published in their spotlight magazine an overview about the smart farming landscape (see Figure 1).

Evaluating these standards with a viewpoint on smart industrial indoor farming, the work of ISO/TC 190/SC 3 "Soil quality - Chemical and physical characterization" is not relevant. The focus on soil quality is irrelevant in an environment without soil. Depending on the degree the hydroponic system is interacting with the environment ISO/TC 207/SC 7 "Environmental Management - Greenhouse gas management and related activities" is partially relevant. Due to the high dependency on water and the ecological benefit of reusing water and nutrients in it, ISO/TC 282/SC 1 "Water reuse - Treated wastewater reuse for irrigation" is of high importance. Here especially ISO 16075 Part 1-3, "Reuse of irrigation water" and ISO 16075 Part 4, "Monitoring of reuse and irrigation" are relevant standards. Due to the high dependency on the technical system for all active hydroponic systems we need to ensure dependable operation of these systems. Here standards from ISO/TC 23/SC 19 "Tractors and machinery for agriculture and forestry - Agricultural electronics" on "Safety-related parts of control systems" (ISO 25119 Part 1-4) and "Resistance to environmental conditions for electrical and electronic equipment" (ISO 15003) should be considered. While we take here safety related standards into account, the focus is on achieving a high reliability. ISO/TC 34/SC 17, "Food products - Management systems for food safety" are relevant for all steps in the food production. ISO/TS 22002-3 "Prerequisite programmes on food safety -- Part 3: Farming" is the relevant standards from a food management side.

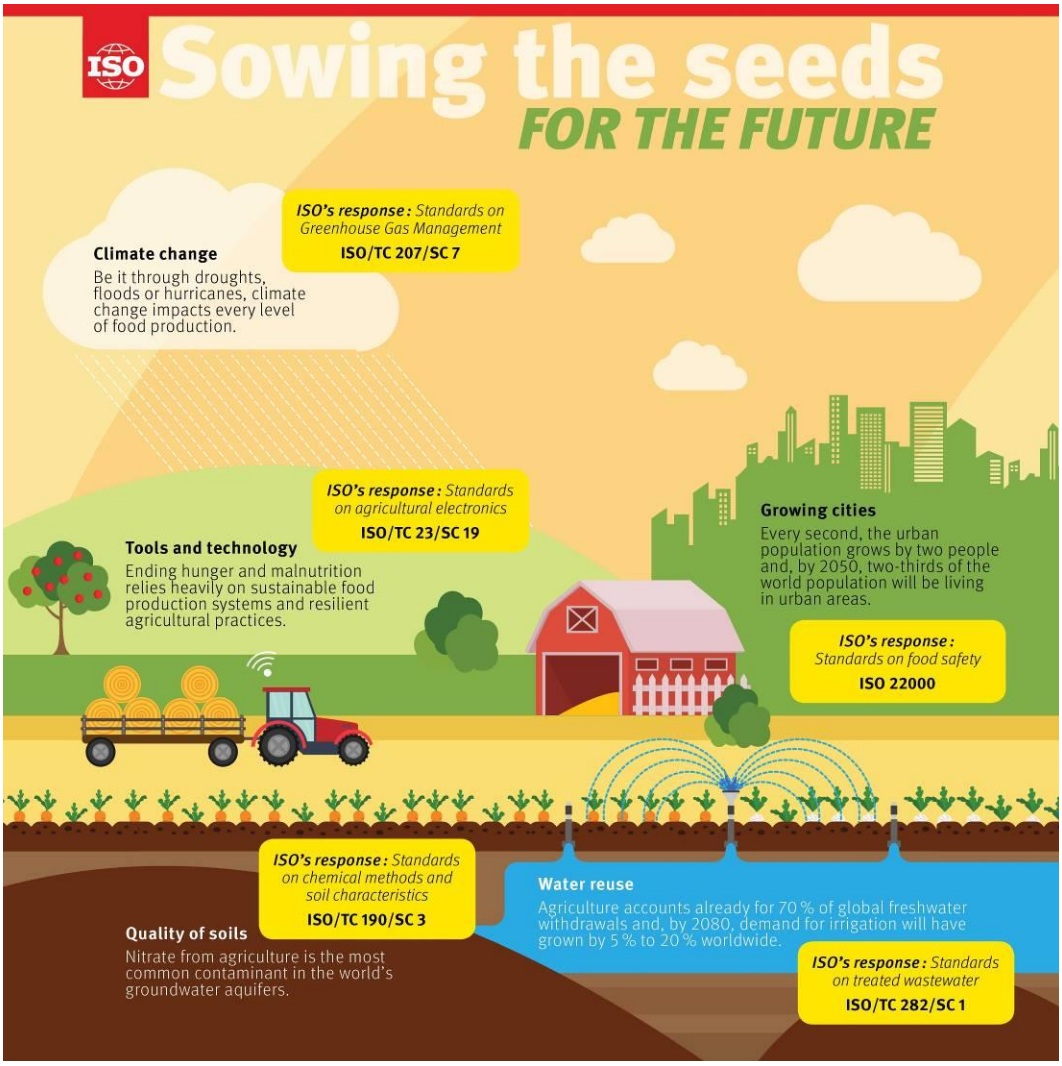

Figure 1: ISO Smart Farming standard overview from (ISO, n.d.)

3. Use Case

We consider here an industrial smart indoor farming system based on aeroponics. Due to the currently higher costs when we compare smart industrial indoor farming with classical farming it seems to be best suited for high-value crops where the higher yield and the more predictable phytochemical yields (Hayden, Yokelsen, Giacomelli, & Hoffmann, 2004) bring a clear benefit compared to classical farming. The consistent and optimized phytochemical yield depends on a very fine-tuned control of lighting and nutrients, down to the mixture of light based on different wavelengths.

This focus on high-value crops minimizes also the societal impact by avoiding direct competition with classical farming. Increased pressure on food supply which causes increased food prices, reduced costs for aeroponics systems by savings of mass productions and reduced availability of arable land could increase the set of interesting crops.

We envision a "as a service model" for industrial smart indoor farming. This allows to increase adoption by dividing between the required resources to build aeroponic systems and the required expertise to manage an aeroponic system.

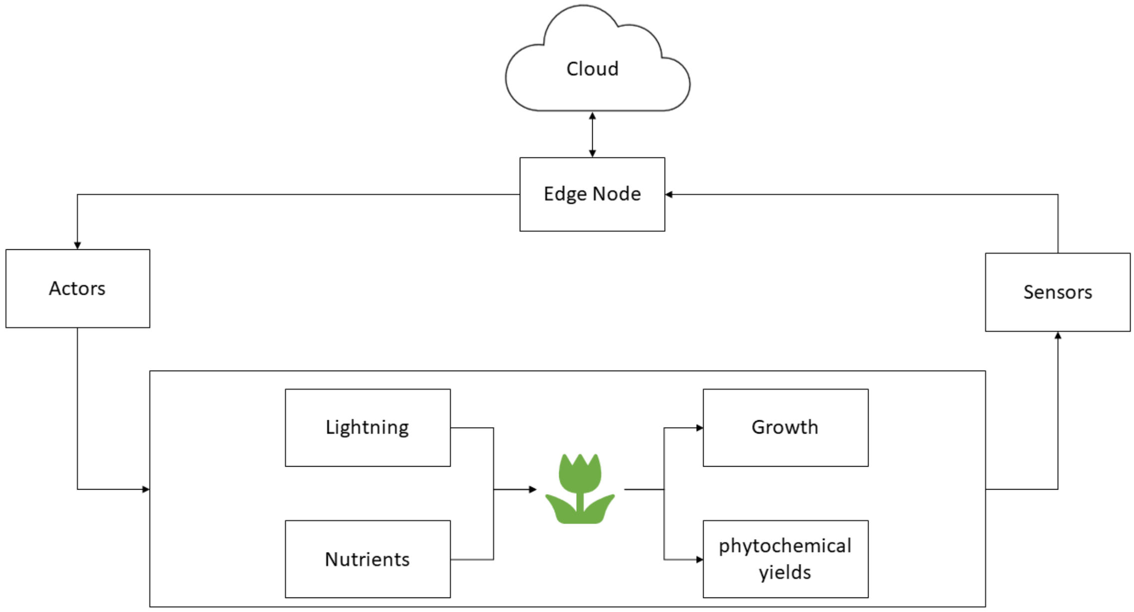

Figure 2: Use Case

To support a system analysis with Systems Theoretic Process Analysis (STPA) (Nancy Leveson, 2013) we model the whole system as a control loop. Plants are the controlled system which are indirectly monitored by sensors for light and moisture. Additional sensors for pressure and nutrient content in the water support the control process. A set of actors control the complete environment, illumination and nutrient mist. The short-term control is done on a local edge level and the long-term control is done in a cloud system. Figure 2 gives an overview about the system, modeled as a control loop.

From previous applications we see that the operation of the system and the design of components is complex and failures can have immediate effects (Margaret Chiipanthenga, 2012). Compared with other types of hydroponic systems, aeroponic has no buffer medium. A failure of the system producing the nutrient mist can cause lasting damage and production loss in a relative short time frame (Mateus-Rodriguez et al., 2013).

Besides that, the knowledge about process optimization, e.g. light phases and mixture and fertilizer are also one of the main intellectual properties (IP). Developing a recipe how the different wavelengths are mixed during the lifecycle of different types of plants to optimize the phytochemical yield requires multiple evaluation and growth cycles. Based on the effort required to develop them this is one of the most valuable IPs for indoor agriculture companies.

There are therefore multiple dependability (Avižienis, Laprie, & Randell, 2004) attributes which we need to consider.

- Reliability and Availability of the environmental control system
- Availability, Integrity and Confidentiality of the control communication

If we look at the standards evaluated, we see that standards on security are currently missing. For this use case we propose to apply suitable parts of IEC 62443 (International Electrotechnical Commission, n.d.) for the field and edge system and existing generic cloud and backend security standards for the cloud system.

4. Methodology

The methodology is based on Systems Theoretic Process Analysis (STPA) (Nancy Leveson, 2013). This approach was developed to analyze complex systems. The steps, adapted to our use case and considered dependability attributes, are:

1. Define the system under consideration
2. Identify undesirable outcomes
3. Identify control action (CA) leading to undesirable outcomes
4. Define requirements and constraints based on step 3
5. Analyze causes for potentially hazardous control actions

Step 4 and 5 can be repeated to get a complete set of constraints and requirements.

While there were some approaches to extend STPA towards security (Young & Leveson, 2014), the analysis was still looking at security for safety, e.g. security was only considered in step 4 and 5 as a cause for safety hazards (undesirable outcomes). In our case security needs to be considered from the beginning (Step 3), since security threats, e.g. losing the confidentiality of the control strategy is also an undesirable outcome. We need to identify unsafe and insecure control actions which lead to undesirable outcome. Similar we also need to look in step 5 at failures and threats.

We define "unsafe control action" as everything which could cause a production loss and "insecure control action" as everything which could allow an adversary to learn the control strategy.

The system is not able to harm humans. We adapt the ISO 26262-3 (International Organization for Standardization, 2018) scale of safety impact (severity) towards the plants (there is no danger to humans). We set S0 as no impact, S1 as minor impact on the yield, S2 major impact on yield or minor chance of complete yield loss and S3 is high chance of complete yield loss. To avoid misunderstandings, we define a Botanical Safety Integrity Level (BASIL) based on Severity (S), Exposure (E) and Controllability (C). The BASIL is derived by the same rules as the ASIL and structured from A (lowest) to D (highest) (International Organization for Standardization, 2018).

We extend the STPA guidewords in step 3 with the methodology from the Security Aware Hazard Analysis and Risk Assessment (SAHARA) (Macher, Harald Sporer, Reinhard Berlach, Eric Armengaud, & Christian Kreiner, 2015) and utilize Failure Mode, Vulnerabilities and Effect Analysis (FMVEA) to analyze causes in step 5 (Schmittner, Gruber, Puschner, & Schoitsch, 2014). Using SAHARA allows us to also prioritize risks already in 3 and optimize the overall risk management. We set T3 as everything which can cause a production loss. Table 2 gives an example of step 3 of the methodology for the control action "start spraying".

Table 2: SAHARA for Control Action "Start spraying"

Risk description			Security Risk classification				Safety Risk classification				Goal
Control Action	STRIDE / STPA	undesirable outcomes	Resources	Know-How	Threat Level	SecL	S	E	C	BASIL	
Start spraying	Information disclosure	Adversary learns about control strategy	2	1	2	1					Prevent disclosure of communication
	CA not provided	Production loss					3	4	2	C	Prevent outages of control communication

For the security situation we consider sniffing a communication where the attacker has access to the communication, which requires some resources (sniffing tools, Wireshark), basic Know-How and can cause some financial impact but not endanger the plants. For safety we have a high severity (death of plants) and a high exposure (spraying is required every few minutes) and a medium controllability, resulting in a Botanical Safety Integrity Level (BASIL) of C. We assumed for the initial step, e.g. using SAHARA and STPA to identify unsafe and insecure control actions, a system without any safety and security measures.

If we look at the potential causes, we can identify that for example wired communication would support the security goal since it is much harder to sniff from the outside. Since the system is in a rather harsh environment with high humidity and nutrients in the air, we would prefer wireless communication and battery driven systems. Looking at the SecL vs. the BASIL, the higher risk is on the safety side. A first design trade-off would use wireless communication but put a constraint on the communication to use state-of-the-art encryption.

Figure 3 shows the process based on STPA, SAHARA and FMVEA used to analyze and protect smart indoor farming systems.

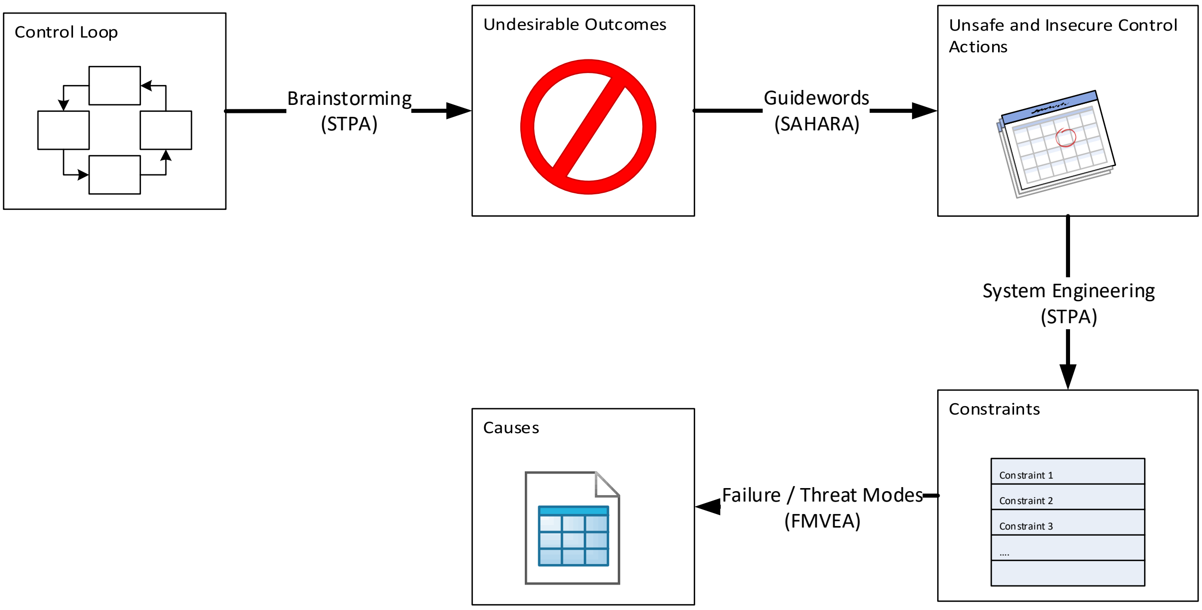

Figure 3: Adapted Process for smart indoor farming

5. Conclusion

Hydroponic and especially aeroponic systems show great promise in addressing agricultural challenges in the next years. Due to the costs and the high expertise required for operation we see currently mainly an application in high-value crops. Considering the inherent vulnerability against unsafe conditions and the high value of expertise and plants ensuring a dependable operation is of utmost importance. We showed here a potential approach to analyze a complex smart industrial indoor farming system for safety and security based on STPA, SAHARA and FMVEA.

With the current approach we foresee a net-benefit for the society. Smart industrial indoor farming allows to utilize non-arable areas and does also not compete with livable space. Producing high-value plants with a consistent phytochemical yield can enhance cosmetic and medical use cases and reduces transport costs for exotic plants which are difficult to grow.

6. Acknowledgment

This research was funded by Europäischer Fonds für regionale Entwicklung - IWB/EFRE Agri-Tec4.0 grant number FE06, Atmos-Code 1AABBA_00759

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TACKLING THE CHALLENGES OF IOT SECURITY TESTING USING ONTOLOGIES

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Keywords

IoT, Cybersecurity, Security Testing, and Ontology

Abstract

Cybersecurity needs to be an integral part of the development phases of the Internet of Things (IoT) technology. Heterogeneity of elements and diversity of the communication protocols generate new security issues which need to be addressed by proper security requirements. This work introduces an ontology-based security testing framework for IoT applications. The framework describes threats and related security requirements of an IoT application in ontologies form. These ontologies are used to validate and verify the security requirements against the threats to ensure that security requirements are fulfilled.

1. Introduction

Industry 4.0 comes as a new advancement concept of the industrial revolution, which introduces a full utilization of Internet technologies. That concept aims to integrate the physical and cyber worlds. This integration aims to migrate the typical industry scenarios into a smart one, managed and controlled by machines and intelligent components. Cyber-physical Systems (CPS) and their applications in the context of the industrial production are referred to as Cyber-Physical Production System (CPPS). The CPPS is one of the special forces to integrate and build a variety of existing technologies and components such as robotics, industrial automation and control, IoT, big data, and cloud computing (Ma, Hudic, Shaaban, & Plosz, 2017). IoT technology is a new evolution of the industrial domain, which allows different interconnected things to communicate together for performing specific tasks. Nowadays, security is a critical topic in IoT (Zhou & Chao, 2011). According to the growth of IoT technology, new security issues arise.

This work presents a newly ontology-based security testing model for IoT applications. This model uses Ontologies for validating and verifying the security requirements, for mitigating the overall risk of a system. The model creates an ontological representation as a comprehensive overview of all details of assets in a system, detected threats, and related security requirements. It manages the ontologies by using Ontology Security Testing Algorithm (OnSecta). OnSecta is a rule engine which performs logical rules from a set of asserted facts or axioms of threats and security requirements. The algorithm performs security verification and validation according to the current security status, and the actual security goal needs to be achieved. The Security Target (ST) is set during the concept phase to define a specific security goal. The security requirements are defined accordingly to mitigate the risk to an acceptable level. The resulting state is defined as Security Achieved (SA). The V&V process completes if only SA = ST; otherwise, OnSecta applies inference rules based on the values of SA and ST to the Ontology Outlook to finds additional security requirements that address threats. The security requirements are described in ontology form and are stored in an Ontology Knowledge Base (KB). The current version of the Ontology KB contains IEC 62443-4-2, the technical security requirements for Industrial Automation and Control Systems Components (IACS) (62443-4-2, 2017).

The structure of the paper is as follows; related works in IoT cybersecurity is discussed in Section 2. Section 3 discusses the main contribution of this work. A simple example of Automated Driving is demonstrated in Section 4. Section 5 presents the evaluation of the ontology-based model. The paper ends with outlook, discussion, and presents the plans for future work.

2. Related Works

Ontologies have been used in several cybersecurity topics. Defining security-related information in web services by using ontologies has been presented in (Denker, Kagal, Finin, Paolucci, & Sycara, 2003). In (Gyrard, Bonnet, & Boudaoud, 2014) the concept of the security ontologies which help the software designer to select security mechanisms in different IoT application domains were discussed. The article (Herzog, Shahmehri, & Duma, 2007) shows how the general and specific, machine-usable, and extensible ontology for the cybersecurity can be used. An ontology-based method to integrate the knowledge of threats and countermeasures is presented in (Ekelhart, Fenz, Klemen, & Weippl, 2006).

(Shaaban, Schmittner, et al., 2018) discusses current security standards that can be used in the IoT domains such as ISO 27000 and IEC 62443 for information and control system security respectively. The ISO/IEC 27000 is a substantial family of standards that helps organizations to keep information assets secure (ISO, 2013). The IEC 62443 series implements a standard methodology for building a secure infrastructure, which modifies the security requirements needed by IACS (Moregård & Vandikas, 2015).

The National Institute of Standards and Technology (NIST) classified the most common testing techniques into three groups (Scarfone, Souppaya, Cody, & Orebaugh, 2008):

1. **Target Vulnerability Validation Techniques:** These testing techniques are effective information security methods that corroborate the existence of vulnerabilities. They include password cracking, remote access testing, penetration testing, social engineering, and physical security testing.
2. **Target Identification and Analysis Techniques:** These testing techniques identify systems potential vulnerabilities in ports, services, and others. They include network discovery, network port, and service identification, vulnerability scanning, wireless scanning, and application security examination.
3. **Review Techniques:** These are examination techniques used to evaluate systems, applications, networks, policies, and procedures to discover vulnerabilities.

3. Ontology-Based Security Testing Model

The IoT cybersecurity management process helps to get a better understanding of different attack scenarios and defines suitable security requirements. The authors developed the Threat Management Tool (ThreatGet) to identify, describe, and understand several potential threats. The tool uses different source materials to ensure a range of threats is examined (AIT, 2019). ThreatGet performs a risk assessment of detected threats to define the risk severity. For example, the detected threats are classified according to different levels of risk severity (i.e., Extreme, High, Medium, or Low). In addition, as a part of the authors' contribution, they created a Model-based Security Requirement Management Tool (MORETO) for security requirements analysis, allocation, and management using modeling languages such as SysML/UML (Shaaban, Kris-ten, & Schmittner, 2018). MORETO is an Enterprise Architect (EA) plugin for managing the IEC 62443 security series. It is reliable and flexible to model security requirements suitable for different components and system architectures.

The ontology-based model comes to verify and validate a set of security requirements against specific potential threats. The ontology describes data (threats and security requirements) in expressions of well-defined terms, vocabularies, and relationships; and comprehends both data and knowledge to cope with the semantics itself (Schikuta, Magdy, & Mohamed, 2016) (Shaaban, Schmittner, et al., 2018). Figure 1 depicts, the structure of the ontology-based model. The model consists of three connected phases.

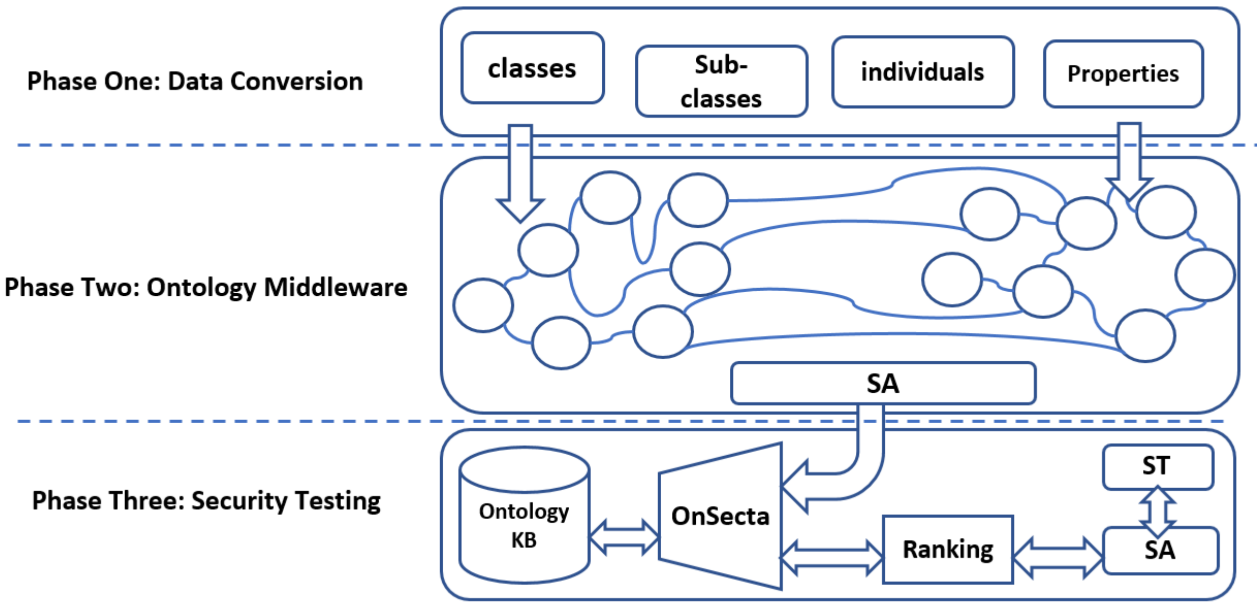

Figure 1 The structure of ontology-based security testing model

3.1. First Phase: Data Conversion

This phase collects data (threats and security requirements) of a specific IoT application, which are needed to be verified and validated. Then it converts these data into ontology entities such as classes, subclasses, individuals, and properties.

3.2. Second Phase: Ontology Middleware

This phase acts as an ontology middleware to create a domain knowledge of threats and security requirements. That knowledge is essential for identifying relationships between threats and related security requirements. The output of this phase is called "Ontology Outlook." The Ontology Outlook contains two ontological hierarchies that are mapped together. On the left-hand side is the ontological representation of threats, and on the right-hand side is the ontological representation of the related security requirements. The links between these two hierarchies represent the selected security requirements that can address one or more of the defined threats and determine the current security state (SA).

3.3. Third Phase: Security Testing

The OnSecta applies a set of queries and inference rules on the Ontology Outlook to check the validity of the security requirements against the threats based on the values of the SA and ST. If that process failed, OnSecta uses additional security requirements of the Ontology KB to achieve the actual ST, this process is repeated until the SA = ST.

The value of the ST is determined according to the security behavior for a particular IoT application. For example, the IoT applications in healthcare are dealing with a massive number of Personal Health Records (PHR), and any cybersecurity breaches could not be acceptable. Moreover, the threats analysis has to be applied to an IoT components structure to define the exact potential threats. Afterward, the risk assessment process is applied to the identified threats to determine the ST. The next Section shows a clear vision about the ST and the SA and how these values can be used in the security testing process.

4. Case-Study: Automated Driving

Automated driving is one of the IoT application areas which influence the complete traffic domain. As transportation is considered a significant part of human life, we expect that autonomous vehicles will replace the traditional means of transportation in the future. As mentioned in (Shaaban, Schmittner, et al., 2018), connected vehicles will have an essential role in reducing the rate of accidents and will improve traffic efficiency based on real-time traffic monitoring and control. To achieve that, it is essential in the development process to verify and validate the security mechanisms of autonomous vehicles. Furthermore, this case study shows how important it is to introduce the ontology model to manage a massive number of relationships, properties, characteristics between threats, and security requirements.

This Case-Study shows some of the interconnected units in a vehicle with road infrastructure as a simple example of automated driving, as illustrated in Figure 2. The Camera Unit is collecting data from the environment, the Vehicle Control Unit process the collected data to adapt the vehicle speed by controlling the Acceleration Unit. The vehicle receives traffic updates from the Traffic Updated Server through the V2X Gateway to accelerate or stop the vehicle according to the traffic status.

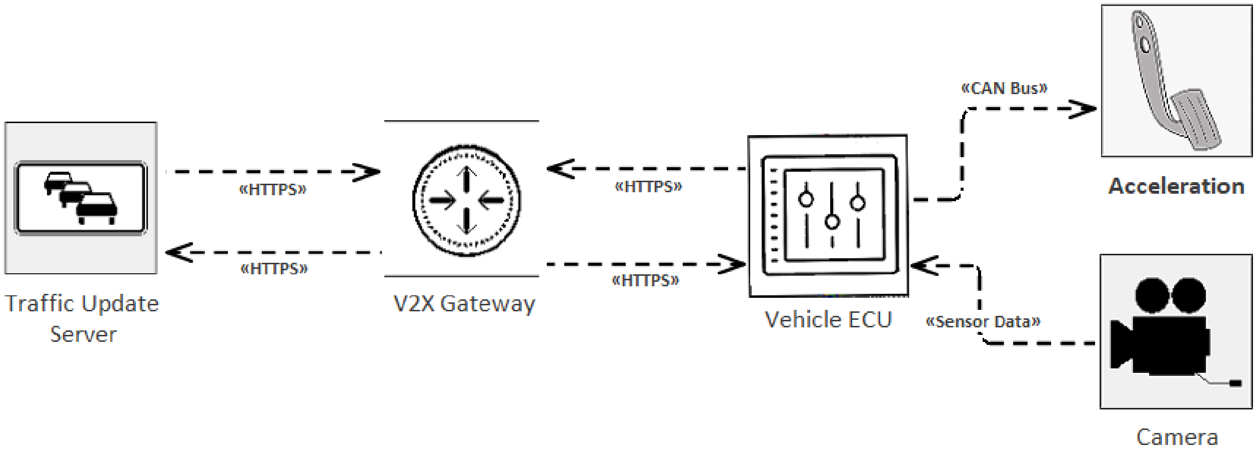

Figure 2 Automated Driving

ThreatGet and MORETO tools are applied to this example to find security threats and select the proper security requirements to address these threats. ThreatGet identifies 25 potential threats; these threats are classified according to the STRIDE model which divides threats into six main types (i.e., Spoofing, Tampering, Repudiation, Information disclosure, Denial of service (D.o.S.), and Elevation of privilege) (Sparx Services CE, 2019). Afterward, the tool evaluates the detected potential threats to calculate the risk severities. Table I shows the number of threats according to the risk severities.

Table 1The severity rates of the detected potential threats

Severity	Numbers
Extreme	5
High	4
Medium	7
Low	9

In addition, MORETO automatically generates a list of security requirements based on expert knowledge encoded in the tool itself and on the description contents of the IEC 62443 standard (COSMAN, 2017). The ontology model collects the results (threats and security requirements) and creates the Ontology Outlook, as depicts in Figure 3. Before start performing security testing activity, the values of SA and ST must be determined. This example focuses on the threats of Extreme level of severity, which must be addressed to mitigate the overall risk and to meet the actual ST. Furthermore, the value of ST = 5 according to the number of Extreme threats as defined in Table I. OnSecta performs a series of queries to the Ontology Outlook to check which of the applied security requirements are fulfilled and to define the current security state in this Case-Study. According to the IEC 62443 security standard, the algorithm finds that the selected security requirements address three out of the five Extreme threats. That means the SA = 3 (SA < ST), and OnSecta must select additional security requirements until SA = ST.

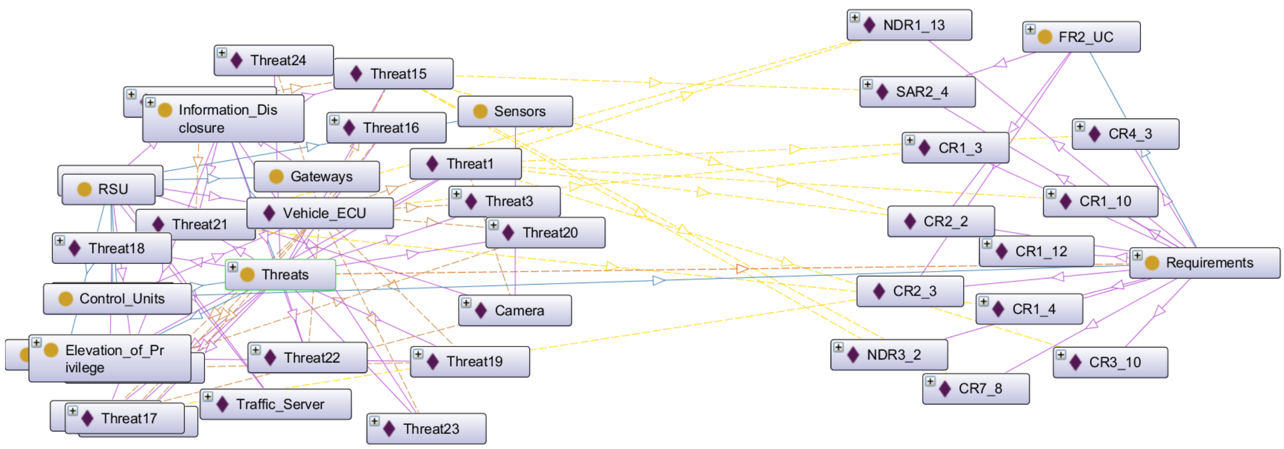

Figure 3 The ontologe outlook of the automated driving example

OnSecta applies a series on inference rules to select additional security requirements from the Ontology KB to address the security issues. The rules find other security requirements that can address the existing Extreme threats as described in Figure 4. The figure illustrates the number of selected security requirements before (left-side) and after (right-side) applying the inference rules. Afterward, the algorithm calculates the value of SA to guarantee the ST is achieved. In the case of SA < ST, OnSecta applies new inference rules to meet the actual ST.

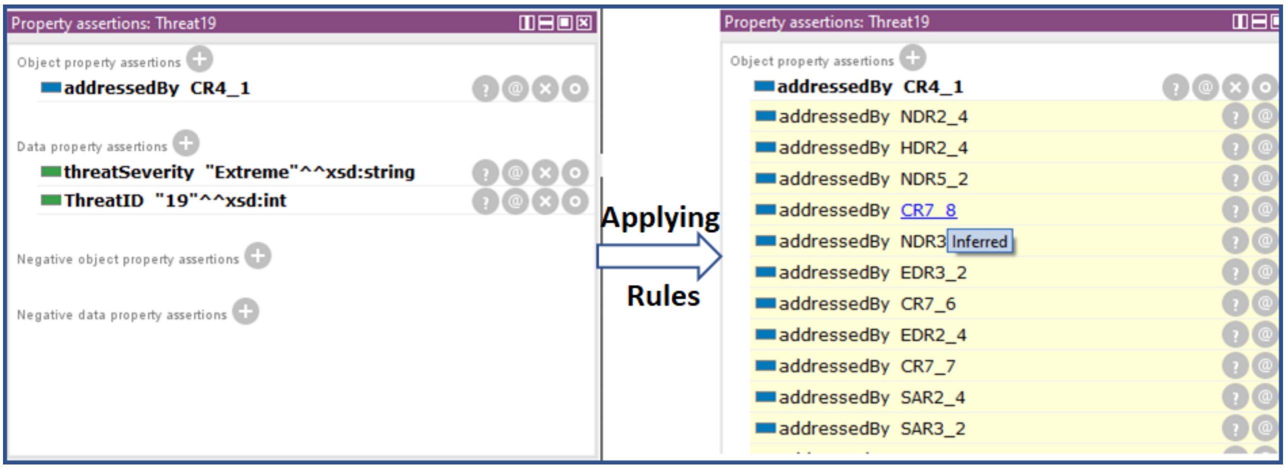

Figure 4 Additional security requirements are selected after applying inference rules

As depicted in Figure 4, Threat19 has been addressed by one security requirement. However, after the inference rules have been applied, a list of security requirements is selected to address that threat.

5. Model Evaluation

The ontology-based model demonstrates the power of ontology approach to tackling the complexity in IoT security testing process. The technical features of the ontology approach fit into IoT applications. The combinations of these features are unique compared to alternative approaches (Oberle, 2014). The OnSecta algorithm performs inference rules over ontologies to generate new relationships between threats and security requirements. These rules help to find additional security requirements that can address threats and meet the actual ST.

6. Outlook & Discussion

This contribution introduced a novel ontology-based security testing framework for IoT applications. The model builds the Ontology Outlook as a comprehensive overview of all threats and related selected security requirements. The OnSecta applies a series of queries and inference rules to the Ontology Outlook to validate and verify they are fulfilled. This model uses the IEC 62443 standard as the basis security standard. Future steps will include the following:

- Develop a ranking algorithm to filter the security requirements which are selected by the OnSecta to give the most optimum security requirements for different security issues.
- Add the rest of the IEC 62443 series to the Ontology KB, to benefit in a wide range of security requirements in various IoT applications.

7. Acknowledgment

This work has received funding from the AQUAS project, under grant agreement No 737475. The project is co-funded by grants from Austria, Germany, Italy, France, Portugal and ECSEL JU.

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INNOVATIVE MODELS OF IT SYSTEMS DELIVERY

IT SYSTEMS DELIVERY IN THE DIGITAL AGE: AGILE, DEVOPS AND BEYOND

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Keywords

Agile Development; DevOps; Digital Transformation; Multi-speed IT; Software development methods

Abstract

Today, we live in the digital age. However, the original plan-driven methods of IT and software systems delivery were proposed several decades ago, being coined in an entirely different context. In this position paper we review recent advancements in the IT and software systems delivery method space, and discuss and categorize concepts such as method tailoring, method hybridization, large-scale agile and multi-speed IT. From a method-centered perspective, we outline possible future directions towards making digital transformation happen.

1. Introduction

Many people believe that "software is eating the world" (Andreessen, 2011). This expression highlights the role of software in modern society, which has strongly been influenced by the enormous opportunities that innovative software solutions presently offer. Put differently, software is a major driving force behind digital transformation, a technology-driven continuous change process focused on companies and entire society. In general, digital transformation is about adopting disruptive technologies to increase productivity, value creation, and the social welfare (Ebert & Duarte, 2018). Although digital transformation is already underway, it has not been proceeding at the same pace everywhere. According to the McKinsey Global Institute's Industry Digitization Index (McKinsey, 2016), Europe is currently operating at 12% of its digital potential, whereas the USA at 18%.

CIOs and their IT teams are in a unique position to drive this transformation. However, many of these initiatives have fallen behind due to implementation challenges (Ismail, 2018). As confirmed by the long-standing results of the Standish Group's CHAOS Reports, only one third of all application development projects satisfy the criteria of successfulness (Standish Group, 2015).

While digital transformation does not necessarily require development of radically new software technologies, it has given rise to new software technology applications. As a consequence, complexity and scale of technological solutions have increased substantially along with placing time to market, quality, and affordability at the forefront (Ebert & Duarte, 2018). An effective software development management, reusability, and requirements engineering methods, techniques, and tools are needed to address these issues of IT systems delivery.

The aim of this position paper is to review current approaches to IT systems delivery, categorize them and outline possible future directions towards making digital transformation happen. In this paper, we examine the problem from a dual perspective. Firstly, we begin by categorizing modern software delivery methods in a generic sense. Then, we deal with the impact of these methods on the whole enterprise.

2. From Waterfall to Agile, Lean, DevOps and Hybrid Methods

2.1. Plan-driven Methods

Traditional plan-driven development approaches emphasize predictability and stability in a project (Boehm & Turner, 2003). These approaches are known as "Waterfall" as they use a downward-flowing stage model for developing software requiring substantial upfront design (Mahadevan, Ketinger, & Meservy, 2015). Feedback is limited between stages of the system development lifecycle (SDLC), including specifications, development, testing, and implementation (Boehm, 1988).

While the traditional plan-driven software development methods do not scale to the challenges brought by digital transformation, agile and lean approaches are a major step in that direction. Roots of these approaches as well as their main principles are outlined further.

2.2. Agile Methods

Agile methods have now become the mainstream for software development worldwide. Formally, they were introduced through a set of four core values and 12 principles laid out in the Agile Manifesto (Beck et al., 2001). At their inception, agile methods were coined by a group of "organizational anarchists", who strived to uncover "better ways of developing software". In essence, this group of people believed that software should be developed differently from the then mainstream norms of software engineering (Doležel, 2018). However, many people put much less emphasis on the ideological dimension of the problem nowadays, while prioritizing the pragmatic benefits of agile methods.

Looking at their pragmatic aspects, agile methods have been proposed as a way to avoid project failures (Dybå & Dingsøyr, 2008). The risk of project failure is reduced each time a software increment is delivered, since the highest priority requirements are selected for development during each increment and each increment is used to gather client and user feedback. The increments are delivered regularly and each comprises a carefully defined fragment of the overall development effort. This contrasts with the plan-driven methods in which risks progressively rise until the product is handed over at the end of the project. On these grounds, there is an evidence that agile methods can improve both software development productivity and product quality (Dybå & Dingsøyr, 2009).

2.3. Lean Methods

Lean software development has its roots in Lean manufacturing and Toyota Production System. Lean is about "doing more with less" by ideally producing "the right things, at the right time and in the right place", as stated in the book *The machine that changed the world* (Womack, Jones, & Roos, 1990). Lean software development dates to the early 1990s. At the beginning, Lean software development was predominantly considered as one of Agile methods (Dybå & Dingsøyr, 2008). Later, it has become a method of its own. However, there are several interpretations of Lean in software development, some of them are explained by Rodríguez et al. (2019). The main benefits of

Lean software development include: increased customer satisfaction; increased productivity; decreased lead and development times; improved progress transparency; identification of problems' root causes; identification of bottlenecks (Rodríguez et al., 2019). The most popular among Lean techniques is Kanban. In short, Kanban uses a board visualizing each activity in the development cycle in a column, and sticky notes representing user stories or tasks from the product backlog. The number of items associated with every activity is limited by establishing work in progress (WIP) limits. Importantly, there is a clear conceptual link between Lean software development, DevOps and scaled agile methods. When examining the role of Lean software development nowadays, one should therefore attempt to see beyond the strict limits of the individual methods. In that vein, combining different methods and approaches to software development seems to be a natural step today. More formally, this is often labeled as method tailoring.

2.4. Method Tailoring and Hybridization

It has been known for quite a long time that due to the differences in project characteristics, environmental contexts, and developer characteristics no particular software development method will ever be a "silver bullet" (Brooks, 1987). As a result, software development methods are rarely implemented in a "by book" manner (Dittrich, 2016). Instead of rigidly following the method prescriptions, selecting, adapting and combining software practices is a reality.

Commonly, the term "method tailoring" is used as an umbrella concept to label such strategies. Method tailoring comprises two main approaches, contingency-based method selection and method engineering (Bass, 2016). Contingency-based method selection is about selecting an appropriate software development method dependent on the project context. In contrast, using the method engineering approach, development teams construct a bespoke new process using method fragments (Fitzgerald, Hartnett, & Conboy, 2006).

Conceptually, the relationship between tailoring and hybrid software development methods should be clarified. In general, "A hybrid software development approach is any combination of agile and/or traditional (plan-driven or approaches that an organizational unit adopts and customizes to its own context needs)" (Marco Kuhrmann et al., 2018). However, we believe that two very different classes of hybridization efforts deserve one' attention: (i) hybridization occurring within the tents of the Agile camp (e.g. ScrumXP), and (ii) hybridization occurring across the Agile vs. Plan-driven divide (Doležel, 2018). These two classes of hybridization are described further.

2.4.1. Hybridization within the Agile Method Space

Although early agile adopters stated a very strict and orthodox approach to the method usage, at present some agile methodologists predominantly view the agile practices as a "toolkit" to be applied as needed in a variety of project environments (Tripp & Armstrong, 2014). A recent systematic literature review of empirical agile tailoring research papers suggests that the method engineering approach is more popular with project teams (Campanelli, Camilo, & Parreiras, 2015) and can be related to stakeholders, project life cycle, project organization and knowledge building (Kalus & Kuhrmann, 2013). According to the last State of Agile Development survey (VersionOne, 2018), combined agile methods together account for 28% of the total usage. One of the first combined agile methods was the union of Scrum and Extreme programming (XP), which makes use of the Scrum's focus on project management and XP's focus on software engineering (Fitzgerald et al., 2006). This combined method still keeps a relatively high share (6%) in method usage (VersionOne, 2018). Being another example, ScrumBan combines Scrum and Kanban with its share recently still increasing and reaching 8% (VersionOne, 2018). The examples of an agile method tailoring usage in practice can be found in (Conboy & Fitzgerald, 2010; Fitzgerald et al., 2006).

2.4.2. Hybridization among Agile and Plan-driven Methods

According to West (2011), hybrid agile and plan-driven methods are the reality in most agile implementations. Scrum adoption is limited to the development-team level, whereas compliance requirements are another factor driving hybrid approaches, as they call for strong governance processes before and after the development. The term “Water-Scrum-Fall” has been coined and West (2011) hypothesized that hybrid development methods would become the standard. Based on this idea, the HELENA study has been conducted aimed at determining the current state of practice in using and combining the multitude of available software development approaches - be it agile and traditional ones (Kuhrmann et al., 2017). The results of this study conducted in more than 55 countries confirmed that the combination of different software and system development approaches has become the reality and is found independently of the company size, the respective industry sector or the actual region (Kuhrmann et al., 2018).

2.5. DevOps

The software development methods described above represent only one dimension of the problem how IT systems are implemented within the industry. The remaining issue is how the systems are deployed, supported, monitored, and later decommissioned. An important trend in this domain is DevOps.

The concept of DevOps emerged about a decade ago, still attaining an increasing interest both from practitioners and researchers. DevOps is an abbreviation of Dev (development – software development) and Ops (operations – software operations). Many practitioners view DevOps as a logical and natural extension of agile software development ideas (Jabbari, Nauman, & Tanveer, 2016). In essence, DevOps promotes those practices that are making software development and operations closely integrated with each other, emphasizing a frequent feedback from both sides. In that sense, DevOps is commonly associated with a shift in work responsibilities and with a change in work patterns related to IT professionals working in the IT systems delivery domain.

Pragmatically speaking, DevOps can be viewed as “a development methodology aimed at bridging the gap between Development (Dev) and Operations, emphasizing communication and collaboration, continuous integration, quality assurance and delivery with automated deployment utilizing a set of development practices" (Jabbari et al., 2016). Taken more broadly, however, DevOps can also be associated with four basic elements, providing a sort of loose prescription on how DevOps principles can be put into reality. That is, by introducing specific Culture elements, Automation practices, Measurement principles, and by supporting information and knowledge Sharing (altogether abbreviated as CAMS). Taking such an approach, one is to build a foundation where modern software development and operations approaches can thrive alongside each other, supporting both current and future business needs. The above CAMS principles can then serve as a conceptual guideline in a sense of highlighting the foremost priorities for the DevOps implementation programs, whether they are focused on particular development teams or on the corporate level.

Being not always apparent, an important part of the DevOps efforts is building a specific DevOps culture. In that sense, Sánchez-Gordón & Colomo-Palacios (2018) remind that “beyond the tool chain, DevOps is [predominantly] a culture shift“. In addition, many practitioners call for making the business component in DevOps more explicit, which leads to promoting the term BizDevOps (Erich, Amrit, & Daneva, 2017). Others would like to see software testing and quality assurance at the same place, resulting in the idea of DevTestOps (Scheaffer, Ravichandran, & Martins, 2018).

3. Which Way to the Digital Age?

An illustrative overview of current approaches to IT systems delivery is pictured in Figure 1. The root paths of current approaches, e.g waterfall, agile and lean are depicted at the bottom. These methods are tailored in a way that results in a hybrid nature of the formerly autonomous methods; development is widened to operations, together forming DevOps. All these approaches are primarily followed at the IT organization level – within particular development teams.

Looking at Figure 1, the crucial question to ask is: Which direction should one take today? Nevertheless, we are hesitant to give a universal answer, because this would largely depend on the particular set of context-dependent factors of one’s enterprise. In any case, we can acknowledge the current trend, which seems to be to scale agile and lean approaches to larger projects (and to the whole enterprise). This type of scaling is described in the next section.

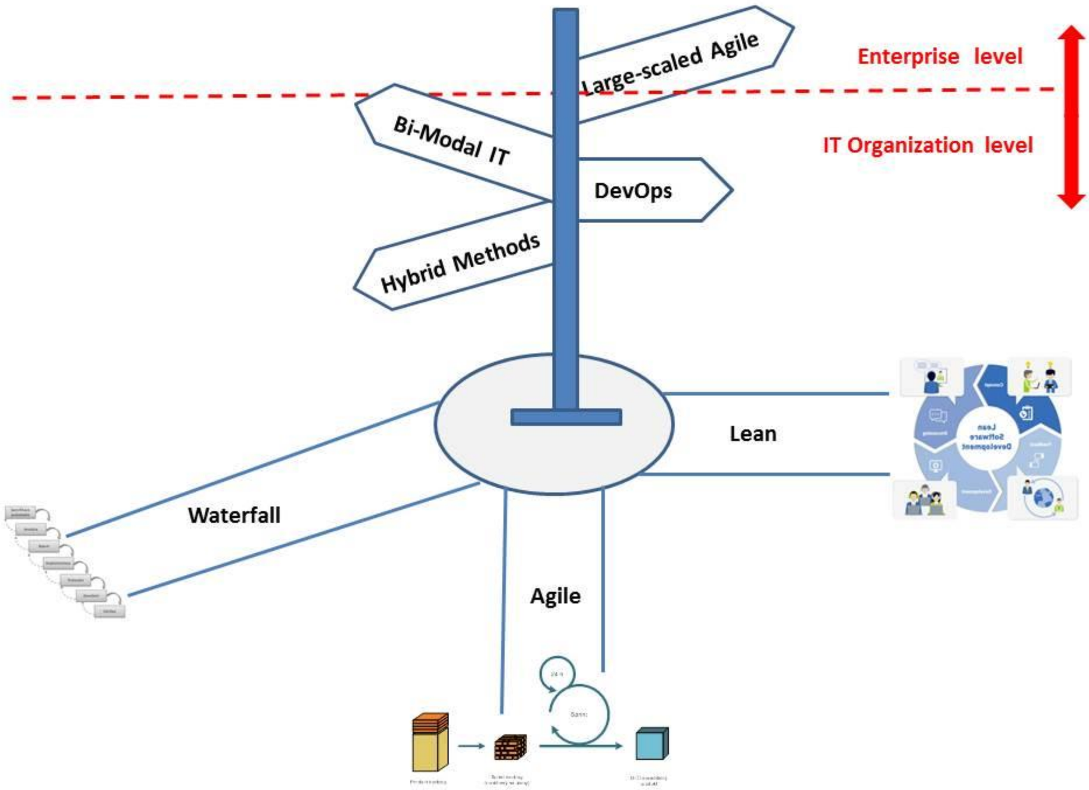

Figure 1. Overview of IT Systems Development Methods and Organizational Structures

4. Scaling Methods to Enterprise Level and New IT Organizational Structures

4.1. Large-scale Agile Methods

Although agile methods were originally designed to be used in small, single team projects (Boehm & Turner, 2005), their benefits have made them attractive also for larger projects and larger companies (Dikert, Paasivaara, & Lassenius, 2016). Compared to small projects, larger ones are characterized by the need for an additional coordination, which makes agile method implementation more difficult (Bick, Spohrer, Hoda, Scheerer, & Heinzl, 2018; Dybå & Dingsøyr, 2009). Large-scale agile involves additional concerns in handling an inter-team coordination and interfacing with other organizational units, such as human resources, marketing and sales, and product management. In addition, large scale may cause users and other stakeholders to become distant from the development teams (Dikert et al., 2016). Despite such known problems related to large-scale agile, there is an industry trend towards adopting agile methods in-the-large (Dingsøyr & Moe, 2014; VersionOne, 2018). A number of scaled agile methods and frameworks are in place like the Discipline Agile Delivery (DAD), Large-scale Scrum (LeSS), Scaled Agile Framework (SAFe), Scrum@Scale, and Nexus (Kalenda, Hyna, & Rossi, 2018).

4.2. Two-speed/multi-speed IT and New IT Organizational Structures

Given that "DevOps presents challenges for the existing IT function and organizational structure" (Wiedemann, Wiesche, Gewald, & Krcmar, 2018), it is important to understand how the DevOps principles can be combined with traditional IT organizations and departments. In fact, due to complex and rigid IT infrastructures and inflexible hierarchical organizational silos in business and IT, companies are often unable to achieve the level of agility and flexibility needed for conducting digital transformation. In some cases, digital transformation in traditional organizations results in two different modes of IT operations, i.e. "two-speed IT" or "bi-modal IT" (Haffke, Kalgovas, & Benlian, 2017). This model consists of two components, a fast customer-facing and slow business-oriented IT organization. The first IT component is established in order to react to rapidly changing customer needs. The goal of this mode is to explore new IT capabilities and to innovate. The second IT component is established to respond to the need of companies keeping or gradually decoupling the 'legacy IT' within the established IT infrastructure and IT organization. This part of the IT organization works in longer cycles (i.e. at a "lower speed"), as it commonly runs large legacy systems, which cannot be changed or turned into a new digital architecture easily. Alternatively, such a turn would pose a risk. Therefore, the goal of this latter mode is to provide stability for existing IT operations (Horlach, Drews, & Schirmer, 2016).

Apart from the different speed modes, both parts operate with different organizational structures and methods. Hence, many companies implement a "bimodal IT" organization with different governance mechanisms, processes and organizational structures to respond to this duopoly of speed (Horlach et al., 2016). Broadly speaking, there is an increasing interest in the changing nature of IT departments and IT organizations. Companies seem to transform their formally defined IT organizational entities into less formal and more pervasive ones, responding to the needs of digital transformation (Peppard, 2018). In so doing, however, companies also face the danger of losing control over their IT landscapes. Such an unwanted situation is commonly referred to as the problem of "Shadow IT" (Huber, Zimmermann, Rentrop, & Felden, 2017).

5. Conclusion

Today, we live in exciting times when IT-driven solutions transform our ways of living and working. Looking on the bright side of this trend primarily, we argue that IT and software professionals should be ready to accept their pivotal role in all these changes. To support digital transformation, a number of important concepts, tools and techniques have been introduced in the recent years. Their common denominator is the need to promptly respond to the changing business needs, fulfilling the vision of the world being "eaten" by modern software.

In this position paper, we covered mostly innovative software development methods and new organizational models of IT operations.

As the traditional methodologies do not scale to the challenges brought by digital transformation, agile methods have become the mainstream software development methods in the world. Thanks to their pragmatic benefits and ability to avoid project failures, they have become the innovative means of digital transformation in practice. Getting closer to the reality, a method tailoring approaches have emerged following the trend of adapting and combining software practices within the agile space, scaling agile methods or heading towards the traditional methods.

Responding to the other side of digital transformation, new organizational models of IT operations have emerged. The concept of DevOps bridges the gap between Development and Operations and makes the business component more explicit. Whereas the two-speed IT model makes it possible for a typically rigid company to react fast to rapidly changing customer needs and at the same time give the organization a possibility to preserve its stability and take time to carry out large digital transformation changes. Overall, companies head towards transforming their formally defined IT organizational entities into less formal ones, responding to the needs of digital transformation.

Clearly, there are many other important topics that are related to innovative models of software and systems delivery and were not discussed here. Among these we include, for example, the software development and operations specifics of SMACIT (social, mobile, analytics, cloud and Internet of things) (Moloney et al., 2017), the role that crowdsourcing starts to play in software development and testing, or the need to understand how successful engineering managers carry out their job duties in modern enterprises (Kalliamvakou et al., 2017). In our view, especially Internet of things has a potential to truly revolutionize a number of industry sectors. However, the need of selecting optimal technology from quite a diverse set (Maryska, Doucek, Nedomova, & Sladek, 2018) also clearly foresees the need of deploying "fitting" IT systems delivery models.

We conclude by reiterating the words of George Westerman from MIT: "When digital transformation is done right, it's like a caterpillar turning into a butterfly, but when done wrong, all you have is a really fast caterpillar" (MIT Sloan, 2014). Hence, it does matter whether and how we support the transformational processes by providing and managing innovative IT means.

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HOW TO IMPROVE THE CAPABILITY OF IT VENDOR MANAGEMENT

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Keywords

COBIT 2019, Czech Act on Public Procurement, performance management, vendor management, vendor selection, BSC for ERP procurement

Abstract

One of the most risky stage in the management of IT vendors is the selection of vendors. In the same time related guidance like ITIL v3, newly released version of COBIT or the Czech Act on Public Procurement provide only general recommendations focused mainly on recommended capability levels (COBIT 2019) or the rules for evaluation (Czech Act)). Any guidelines how to fulfil these general recommendations are missing. The article discusses the possibilities of BSC method usage in the process of Vendor Management which can help organizations to attain at least the second capability level and in the same time to be compliant with the Czech law. The example is based on practical experience with the selection of ERP systems providers.

1. Introduction

A lot of managers are often facing problems with the objective assessment of the proposals that are received as a reaction on their request of information (RFI) or proposals (RFP) on the delivery of IT services and/or products. In the same time the relevant regulations are very brief in this area mainly describing "what" to do without saying "how" to do that. The article discusses the possibilities of BSC method usage in the process of Vendor Management. The main research question of the article is: Can the application of BSC method improve the capability of the process Vendor Management in context of COBIT 2019 and the Czech legal regulation? The research methodology is based on DSRM[27] (Peffers, 2007) and covers its first three steps: problem identification and motivation (Chapter 2), definition of the objectives for a solution (Chapters 3), design and development (Chapter 4).

2. Examples of Regulations for IT Vendor Selection

To demonstrate that vendor selection is very important initial step within the lifecycle of vendor management together with the fact, that there is a limited knowledge how to manage the capability of this process, three relevant regulation were chosen.

[27] A Design Science Research Methodology for Information Systems Research

2.1. ITILv3

ITIL v3 and related ISO 20000-1 present this problem in the process Supplier Management of Service Design book. The impact is on supplier management of existing IT services. “Definition of new supplier and contract requirements” and “Evaluation of new supplier and contract management” are two activities within this process, but any mode detailed description is missing. The quality of the process can be measured against the process maturity framework (PMF). It can be used either as a framework to assess the maturity of each of the service management processes individually, or to measure the maturity of the service management process as a whole. The maturity levels are: level 1- Initial, level 2: Repeatable, level 3: Defined, level 4: Managed, level 5: Optimizing.

Each level requires a change of a combination of elements in order to be fully effective. Therefore a review of processes will require an assessment to be completed against the five areas of: Vision and steering, Process, People, Technology and Culture (TSO, 2011, p 339).

2.2. COBIT 2019

COBIT 2019 introduces core conceptual model, which is described in one of the publications called COBIT® 2019 Framework: Governance and Management Objectives. It describes 40 core governance and management objectives. Each objective relates to one process which represents one of the governance components applicable to that governance or management objective.

One from the 40 objectives of COBIT 2019 is APO 10 Managed Vendor. ISACAb (2018) describes its main purpose: “Optimize available I&T capabilities to support the I&T strategy and road map, minimize the risk associated with nonperforming or noncompliant vendors, and ensure competitive pricing.” (p.118). Process is divided into 5 management practices and each practice is described by the set of activities.

The process quality assessment of COBIT 2019 is based on COBIT Performance Management (CPM) model which is integrated into core conceptual model.

COBIT 2019 recognizes two levels of performance management:

- Process capability: The process within each governance and management objective can operate at various capability levels, ranging from 0 to 5. The capability level is a measure of how well a process is implemented and performing. The COBIT 2019 core model assigns capability levels to all process activities, enabling clear definition of the processes and required activities for achieving the different capability levels.
- Focus area maturity: represents higher level for expressing performance without the granularity applicable to individual process capability ratings. Maturity levels are associated with focus areas (i.e. a collection of governance and management objectives and underlying components) and a certain maturity level is achieved if all the processes contained in the focus area achieve that particular capability level.

These concepts and methods are compliant with ISO/IEC 33000 (which replaced the ISO/IEC 15504) and largely align to and extend CMMI® Development V2.0.The general characteristics of the capability levels are in Table 1.

Table 1: Capability levels for processes (ISACA, 2018, p.39)

Capability level	Description
0	Lack of any basic capability; incomplete approach to address governance and management purpose; may or may not be meeting the intent of any process practices
1	The process more or less achieves its purpose through the application of an incomplete set of activities that can be characterized as initial or intuitive – not very organized
2	The process achieves its purpose through the application of the a basic, yet complete set of activities that can be characterized as performed
3	The process achieves its purpose in a much more organized way using organizational assets. Processes typically are well defined
4	The process achieves its purpose, is well defined, and its performance is quantitatively measured
5	The process achieves its purpose, is well defined, its performance is measured to improve performance and continuous improvement is pursued

In case of our example of objective APO 10 Managed Vendor the related process is described by the help of next practices that follow vendor management lifecycle:

- APO10.01 Identify and evaluate vendor relationships and contracts
- APO10.02 Select vendors
- APO10.03 Manage vendor relationships and contracts
- APO10.04 Manage vendor risk
- APO10.05 Monitor vendor performance and compliance

Each practice is furthermore divided into activities. In context of our topic let us focus on the practice APO10.02 Select vendors.

Next Table 2 summarizes the activities relevant to capability levels as they were assigned in the chosen process practice description.

Table 2: APO 10.02 activities and assigned capability levels (ISACAb, 2018, p. 120)

Capability level	Relevant activities for practice APO 10.02 Select vendors
2	Review all requests for information (RFIs) and requests for proposals (RFPs) to ensure that they clearly define requirements Evaluate RFIs and RFPs in accordance with the approved evaluation process/criteria and maintain documentary evidence of the evaluations. Verify the references of candidate vendors. Select the vendor that best fits the RFP. Document and communicate the decision, and sign the contract.
3	In the specific case of software acquisition, include and enforce the rights and obligations of all parties in the contractual terms. In the specific case of acquisition of development resources, include and enforce the rights and obligations of all parties in the contractual terms. Obtain legal advice on resource development acquisition agreements regarding ownership and licensing of intellectual property (IP). In the specific case of acquisition of infrastructure, facilities and related services, include and enforce the rights and obligations of all parties in the contractual terms

From the table it is apparent, that activities of the practice APO10.02 Select vendors are core conditions for capability levels 2 and without their fully achievement it is not possible to attain next levels (3 up to 5). Looking in to the Table 2 one can see that the description of activities is very brief and there is no related guidance for this management practice.

2.3. Act 134/2016 Coll. on Public Procurement

This problem is particularly urgent for government contracting authorities that shall use the procurement procedure to award a public contract in compliance to 134/2016 Coll. Act of 19 April 2016 on Public Procurement. One of the main differences between this law and its predecessor 137/2006 Coll. on Public Contracts is the evaluation of the tenders. While in the old act the basic evaluation criterion for the award of a public contract were economic advantageousness of the tender, or the lowest tender price, at present, it is the contracting authority's obligation to state that the tenders will be evaluated according to the basis of their economic advantageousness as well, but in the same time it is specified that the economic advantageous should be the most advantageous price quality ratio, including the ratio between life cycle costing and quality (section 114). In cases where the law so permits, the contracting authority may determine the economic advantageousness only on the basis of the lowest tender price. However, the main emphasis is on the economic advantageousness as the best ratio between quality and price. Thus many stakeholders involved in procurement process must in the procurement documents lay down rules for the evaluation of tenders that shall include

- evaluation criteria based on the combination of the price and quality criteria,
- the method of evaluation of tenders under the individual criteria and,
- weighting or another mathematical relation among the criteria.

3. BSC as a Tool for Vendor Management Improvement

In order to demonstrate the advantages of BSC method application we will combine recommendations from two regulations: Czech Act 134/2016 Coll. on Public Procurement and COBIT 2019:

- Czech Act 134/2016 Coll. on Public Procurement explains the economic advantageousness of the tender as the best ratio between quality and price which means that there is need to balance quantitative and qualitative measures within the vendor selection.
- COBIT 2019 provides recommendations of what activities should be provided in order to improve the capability level of vendor management.

Authors of BSC Kaplan, Norton (1996) have introduced the balanced scorecard at the enterprise level. Their basic idea is that the evaluation of an organization should not be restricted to a traditional financial evaluation but should be supplemented with measures concerning customer satisfaction, internal processes and the ability to innovate. These additional measures should assure future financial results and drive the organization towards its strategic goals while keeping all four perspectives in balance.

They propose a three-layered structure for the four perspectives: mission (e.g., to become the customers' most preferred supplier), objectives (e.g., to provide the customers with new products) and measures (e.g., percentage of turnover generated by new products). Kapur (2010) explains briefly each of the original four perspectives as follows:

- The financial perspective is focused on ensuring that the execution of the strategy of an enterprise is contributing to bottom-line growth. Revenue growth, costs, profit margins, cash flow and net operating income are some illustrative metrics that are incorporated into the planning and evaluation of an enterprise's activities vis-a-vis this perspective.

- The customer perspective is focused on the value proposition (based on the appropriate mix of operational excellence, customer relationship management and product share) that the enterprise implements to generate greater sales by courting its customers.
- The internal business processes perspective focuses on the processes that create and deliver the product's value proposition for the customer. Included in these processes are those that deal with (but are not limited by) operations, regulation, compliance, innovation, and the discharge of social and corporate responsibility.
- The learning and growth perspective focuses on the foundation of any strategy: the intangible assets of an organization, which primarily comprise the internal skills and capabilities that are required to mentor and support the value-creating internal processes. Though investment in these assets usually decreases the short-term bottom line, it is necessary to realize long-term goals and success of an enterprise.

From the above information we can conclude, that BSC is widely used tool in cases, where there is need to prepare simple and transparent formal framework that takes in account different perspectives for object matter assessment and in the same time it provides base for communicating these objectives across different organizational entities and management layers. Specifically

- BSC provides structured way how to evaluate RFIs and RFPs in accordance with the approved evaluation process/criteria and maintain documentary evidence of the evaluations which is one of the core conditions for capability level 2 of the process of vendor management.
- BSC perspectives offer a good base for balancing the quantitative and qualitative measures and thus to be compliant with the Czech law.

The detailed description of how to apply BSC within the IT vendor management process is influenced by the particular IT product and/or service which is the subject of the tender. Next aspect influencing the usage of particular goals and measures is the type of enterprise strategy. E.g. Treacy, Wiersema (1995) came to conclusion that a successful organization always choose one dominant strategy from three possible strategies: operational excellence, product leadership and customer intimacy. An IT function supporting the operational excellence value discipline focuses on its cost-efficiency in delivering a limited number of standardized IT services. The IT function of the product leadership enterprise plays an important role to protect and secure critical company knowledge. Companies with a customer intimacy strategy select one or a few high-value customer niches and provide tailor-made products and services to their customers. That means that customer defines the IT service and accordingly, the IT function has to deal with a flexible and agile enterprise information systems.

4. Example of BSC Application

Table 3 shows the chosen objectives and measures that are mostly relevant for Enterprise Resource Planning systems (ERP systems) procurement.

Table 3: Example of BSC usage in ERP systems procurement (source author)

Corporate contribution Mission: To increase the enterprise value through effective delivery of IT products/services		
Sub-category	Objective	Examples of measures
Costs	Law project price	Licence costs Costs of implementation Fixed costs of maintenance for specific time period Costs of legacy systems operation and maintenance during the implementation and migration of existing data to the new system Services covered by fixed costs of maintenance Compliance with profitability strategy Costs of hardware Training costs
Benefits	High qualitative and quantitative benefits	Quantifiable direct and indirect benefits Month until benefits realized
Compliance	Compliance with the relevant regulations	Czech law regulations compliance (e.g. accounting act) EU regulations compliance (e.g. GDPR) Industry specific regulations (e.g. finance, health,..) Security compliance (e.g. ISO 27000)
Functionality	Support of the identified business processes and/or information needs	Percentage of the listed core business processes support within one software product Percentage of the listed basic information needs coverage Quality of the offered functionality beyond the requirements Percent of tailor-made development to cover needed functionality Level of compatibility with the existing enterprise software Possible future compatibility with competing system (when buying new modules from another company) The conditions for future customization (due to changes in legal legislation, company extension, etc.)
Dispute management	Clear understanding of the procedure and costs of disputes solution	Costs of arbitration procedure
Future orientation Mission: Acquire and maintain IT skills that respond to the importance of IT product/services delivery		
Training and documentation	To enable users to use and operate system	Number of training hours according to specific roles (key users, users, IT specialist, administrators,..) and phases of the project (initial, before the “going life”) Organizational support of training Regular ERP staff training Existence of separate clients for training, customization and product operation Responsibility for system and user documentation
Enterprise architecture adherence	New application must be implemented as a integral part of enterprise architecture in all its components (business, application, data, technological); changes a deviations must be identified and evaluated	Project adheres to the defined state of enterprise architecture Rate of business process engineering Adherence to the software architecture (integration with the existing applications is included) Adherence to data architecture (need to collect new data or level of existing data formats change) Adherence to technological architecture (level of exploitation of the existing hardware facilities)
Personnel skills	Ensure appropriate personnel	Number of employees assigned to the project from the side of

and experience	support for the project	provider Quality of the personnel (number of the certifications, number of completed projects) Number of employees needed to play roles within the project from the side of customer Number of third party providers
Customer orientation Mission: To offer hassle-free IT services at low costs		
Quality of software product	To choose the best fitted SW product	Number of implementations in companies from the selected market segment Number of years on the market Number of versions Level of Customization Level of Scalability Existence of different delivery models (cloud solution, hosted solution and on-premise solution) Quality of interface Level of support of the new trends (social network, mobile devices, in-memory computing, two-tier architecture, SOA architecture, IoT)
Quality of service provider	To choose the experienced implementation service provider	Solvency of the company The total number of employees Number of references from other companies from the selected market segment •
Implementation (delivery conditions)	To achieve the optimal conditions for IT product delivery Quality of legal documents (	Quality and integration of the legal contracts (licence agreement, SLA for implementation and reengineering, SLA for maintenance) Delivery period Delivery models Penalties
Project management	To implement SW product within the targeted time, quality, costs	Project budget Payment schedule (funds allocated, impact on operating costs) Quality of the project management methodology Description of the project goal, milestones, project outcomes Defined acceptance procedures Risk and change management procedures
Operational excellence Mission: To adapt the enterprise architecture to deliver timely and effective IT services at targeted service levels		
Infrastructure	Clear understanding of the infrastructure issues	Cost of infrastructure, facilities and related services Service levels, maintenance procedures Access controls, security, privacy, performance review, Basis for payment and arbitration procedures
Information security	Level of general and application controls must adhere to the enterprise security policy	Quality and scalability of: Application access controls Network access controls Database controls Number and types of tests Physical and logical controls Tools for continuous monitoring and continuous auditing Controls of remote access Data encryption
Maintenance	To assure sustainable system for sustainable business	Warranty, post-warranty and additional maintenance conditions Claiming a free or discounted update and upgrade Costs and availability of hot line and helpdesk Maintenance remote access management

In the BSC perspective Corporate Contribution main components of the project price are licence costs, cost of implementation, hardware costs, and the annual service fee. They represent the lifecycle costing of acquired system. Examples of measures in remaining three perspectives are mostly qualitative measures. At first glance, it may seem that there are no problems with project costs, but the opposite is true. Licence costs depend on the licence model and currently in context of cloud computing they represent one of the most risky measure. Similar situation can occur in case of implementation costs and annual service fee. As a consequence project costs are hardly comparable and many actions are needed to clarify these issues and get an objective scale for bid evaluation.

5. Conclusion

Currently COBIT 2019 and the Czech Act 134/2016 Coll. on Public Procurement are the most relevant regulations helping organization to select and manage their IT vendors. In the same time they only briefly describe how to do that. BSC is a traditional tool that can help managers to articulate and communicate objectives together with measures across the organization. In this context it seems to be useful to use BSC as a method for balancing different objectives and measures from different perspectives and thus to be compliant with the law and in the same time to provide good base for capability improvement of the vendor process management.

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ANNEX

Advertisement

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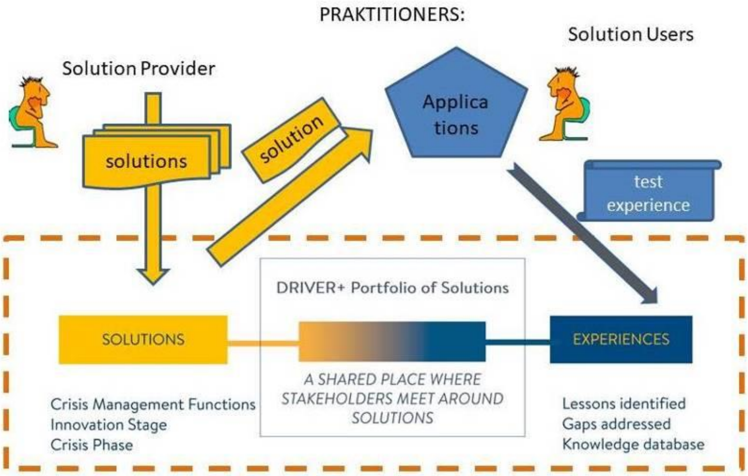

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- In this volume: Drazen Ignjatovic, Denis Havlik, Georg Neubauer: The Portfolio of Solutions.

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This project has received funding from the European Union's 7th Framework Programme for Research, Technological Development and Demonstration under Grant Agreement (GA) N° #607798.

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ISBN 978-3-99062-590-3
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