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The mission of the IJISPM - International Journal of Information Systems and Project Management - is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

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Editorial

It is our great pleasure to bring you the third number of the third volume of IJISPM - International Journal of Information Systems and Project Management. The mission of the IJISPM is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

In this issue readers will find important contributions on IT consumerization risks, IS/IT project evaluation, and business intelligence.

The first article, "Addressing consumerization of IT risks with nudging", addresses the main issues of IT consumerization that are related to security risks, and vulnerabilities of devices used within Bring Your Own Device (BYOD) strategy in particular. The authors Iryna Yevseyeva, James Turland, Charles Morisset, Lynne Coventry, Thomas Groß, Christopher Laing, and Aad van Moorsel, propose a 'soft' mitigation strategy for user actions based on nudging, widely applied to health and social behavior influence. In particular, they propose a complementary, less strict, more flexible Information Security policies, based on risk assessment of device vulnerabilities and threats to corporate data and devices, combined with a strategy of influencing security behavior by nudging. The authors argue that nudging, by taking into account the context of the decision-making environment, and the fact that the employee may be in better position to make a more appropriate decision, may be more suitable than strict policies in situations of uncertainty of security-related decisions. Several examples of nudging are considered for different tested and potential scenarios in security context.

The second article, "Development and assessment of an instrument to measure equivocal situation and its causes in IS/IT project evaluation", is authored by Arviansyah, Ton Spil and Jos van Hillegersberg. Project evaluations are vital for organizations to manage and balance the costs and benefits of their IS/IT investment. Despite the importance of project evaluations, equivocal situation may limit the effectiveness of an evaluation and hinder decision-makers in generating purposeful resolutions. According to the authors there is a dearth of empirical studies with regard to equivocal situation, which this study addresses by developing and measuring a construct of an equivocal situation and its causes. The equivocal situation construct is derived from the notion of equivocality and its causes are extracted from the extant literature. The developed constructs are subjected to empirical validation through Partial Least Squares (PLS) analysis by employing the data collected from knowledge professionals in IS/IT project management. The developed instrument provides a foundation for future studies of equivocality in IS/IT project evaluation.

Viktor Dmitriyev, Tariq Mahmoud, and Pablo Michel Marín-Ortega, in their article "SOA enabled ELTA: approach in designing business intelligence solutions in Era of Big Data", present a new approach for designing business intelligence solutions. In the Era of Big Data, former and robust analytical concepts and utilities need to adapt themselves to the changed market circumstances. The main focus of the article is to address the acceleration of building process of a "data-centric" Business Intelligence (BI) solution, besides preparing BI solutions for Big Data utilization. This research addresses the following goals: reducing the time spent during business intelligence solution's design phase; achieving flexibility of BI solution by adding new data sources; and preparing BI solution for utilizing Big Data concepts. The research proposes an extension of the existing Extract, Load and Transform (ELT) approach to the new one Extract, Load, Transform and Analyze (ELTA) supported by service-orientation concept. Additionally, the proposed model incorporates Service-Oriented Architecture concept as a mediator for the transformation phase. On one side, such incorporation brings flexibility to the BI solution and on the other side; it reduces the complexity of the whole system by moving some responsibilities to external authorities.

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We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

João Varajão

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João Varajão is currently professor of information systems and project management at the *University of Minho*. He is also a researcher of the *Centro Algoritmi* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997) and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are in Information Systems Management and Information Systems Project Management. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 50 Masters and Doctoral dissertations in the Information Systems field. He has published over 250 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served in numerous committees of international conferences and workshops. He is co-founder of CENTERIS – Conference on ENTERprise Information Systems and of ProjMAN – International Conference on Project MANagement.

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Addressing consumerization of IT risks with nudging

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Addressing consumerization of IT risks with nudging

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Abstract:
In this work we address the main issues of Information Technology (IT) consumerization that are related to security risks, and vulnerabilities of devices used within Bring Your Own Device (BYOD) strategy in particular. We propose a 'soft' mitigation strategy for user actions based on nudging, widely applied to health and social behavior influence. In particular, we propose a complementary, less strict, more flexible Information Security policies, based on risk assessment of device vulnerabilities and threats to corporate data and devices, combined with a strategy of influencing security behavior by nudging. We argue that nudging, by taking into account the context of the decision-making environment, and the fact that the employee may be in better position to make a more appropriate decision, may be more suitable than strict policies in situations of uncertainty of security-related decisions. Several examples of nudging are considered for different tested and potential scenarios in security context.

Keywords:
consumerization; security; risks; mitigation strategies; nudging.

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1. Introduction to the consumerization of IT

Globalization and the worldwide availability of the Internet (for both stationary and mobile devices) has led to the reduction of spatial restrictions within traditional working environments, and thereby enabling the working environment to be highly mobile. Increasingly, people work not from a single office, but from multiple offices, on customer sites, when traveling, at home and in public places. At the same time, the technology markets fuel and adapt to such dynamic environments by regularly supplying a variety of new mobile devices to meet different business requirements and purposes.

The rapid development of Information Technology (IT) products and their constantly reducing costs make the best 'high-tech' technologies available not only to large companies, but also to the general public for personal usage. Data interchange between devices is also increasing. Storing data on individual devices not only becomes impractical, but also insufficient for its distributed usage. Cloud-based solutions are therefore of high demand for both private and work-related usage by employees.

This orientation of products and services towards users is known as *consumerization of IT*. Here, a user (an employee of a company) is also a consumer of devices and services, both owned by the company (the user's employer) and privately purchased by the user. The use of such products and services via the Internet for personal activities (e.g. social networks and other web tools) pushes companies to adapt business technologies and practices to allow employees access for personal purposes. At the same time, companies expect an employee to be productive and responsive at anytime from anywhere, thus removing the boundary between an employee's personal life and work. In turn, companies that keep pace with new technologies and take full advantage of them have more opportunities to improve their business and achieve both short- and long-term returns [1].

Under the conditions of a fast growing economy and improved technologies, such "mobilization" of businesses will continue. To stay competitive in such a dynamic market, companies need to quickly adapt to these trends and provide their employees with ways of working in such mobile environments, for instance by providing them with up-to-date mobile phones, laptops and/or tablets. However, frequently updating the equipment of employees is costly for companies and the pace of upgrades may not keep up with their expectations.

In such circumstances, a recent trend is for companies, large firms and *small to medium enterprises* (SMEs) alike, to allow their employees to work with their own devices. This strategy, known as *bring your own device* (BYOD), introduces flexibility for employees and affords the opportunity for the companies to satisfy the wishes of their employees to work with their preferred devices without increasing equipment budgets.

Many practitioners consider further IT consumerization inevitable. Trend Micro Inc. performed a survey confirming that 74% of IT enterprises were allowing BYOD for their employees. However, they emphasized that consumerization of IT carries strategic and operational challenges and *'creates security risk, financial exposure and a management nightmare for IT*' if not properly managed [2].

In addition to opportunities, consumerization of IT also introduces some severe security risks. These risks include: weak control over employees private devices (e.g., old or absent anti-virus software); possible weakness of protection measures of services used to transfer or store company data; potentially unsecured environments, in which employees may use their mobile devices (e.g., public places or foreign countries).

In addition to preoccupations related to technical security aspects, human factors are of high importance in the context of global consumerization. When using personal devices for work (or company devices for personal purposes), the boundary between personal and company data becomes blurred. However, attempts from companies to take control over personal devices for their better protection may meet opposition from employees, and disturb their ownership perception associated with their devices and privacy intrusion sentiments. Therefore, companies must consider these facts when developing their security policies.

In this work we consider how changes in the employees working context (from the office to public places or home) and in the ownership of the devices (from corporate to personal) introduce uncertainty in security decisions. We suggest a 'soft' strategy to assist in security decision-making under uncertainty, based on nudging. This approach has been used to create health [3] and social solutions [4] and recently studied in the context of security and privacy decision-making [5]-[12]. In particular, we consider when nudging may be beneficial to both the company and employee and, consequently, lead to a more secure and productive society in general.

In Section 2, we discuss practical approaches to risk assessment and mitigation of consumerization risks from the literature. In Section 3 we analyze in more detail the uncertainty that consumerization of IT brings to security decisions. In Section 4 we discuss risks that the BYOD strategy introduces and different levels of controls for managing those risks. We provide an approach to influencing the behavior of users to make more secure or more productive choices based on nudging techniques widely applied in marketing in Section 5. Finally, we conclude this work and outline directions for future research in Section 6.

2. Approaches to consumerization risk management

Different organizations may have different risk assessment strategies and may include in their security policy only risks specific to their activity. The European Network and Information Security Agency (ENISA), which develops security recommendations for EU countries, delivered a report that may serve as a good guideline for SMEs to perform a risk assessment [13]. According to this report, a company should identify its risk profile depending on the: size of the company; yearly revenue; data type a company is dealing with (e.g. critical personal data, such as medical information, customer data or employees data); loss of reputation and loss of customers' confidence resulting from unavailability of service. The critical assets should be identified among systems (server, laptops, workstations storage, archiving and backups), networks (routers, cabling, gateways wireless access points, network segments, etc.), people (HR, R&D, Sales and Marketing, Contractors and Third Party, Operations and Technology) and applications (ERP, Logistics, e-commerce, financial control, logistics) categories. In particular, for each asset the security requirements related to confidentiality, integrity and availability should be identified.

Depending on the company risk profile and critical assets, ENISA suggests selecting a number of organizational and asset-based controls that will become a part of a security requirements list, implemented within either physical security, system and network management, system administration tools, monitoring and auditing IT security, authentication and authorization, vulnerability management, encryption, security architecture, incident management or general staff practices [13]. The identified key security areas of the company help to shape its security efforts, in particular (i) defining and selecting requirements to be implemented within company's security policy; (ii) specifying key technical and management controls for preventing disasters and incidents; (iii) developing recovery plans and educational programs needed for staff training.

In addition to standard risk assessments, e.g. based on ENISA proposed scheme [13] or ISO/IEC 27005:2011 [14], when assessing the BYOD strategy of a company, opportunities should be considered. ENISA analyzed IT consumerization considering related costs and opportunities [15], and suggested various mitigation strategies to reduce the risks in the areas of governance, legal and regulatory issues and technical issues [16], which are related to potential losses and gains that a company may have with respect to confidentiality, integrity or availability of its assets when introducing IT consumerization. These mitigation strategies correlate with concerns related to consumerization reported by several Chief Information Security Officers (CISOs) of large enterprises interviewed by Microsoft [17], such as governance related to monitoring of personal devices, e-discovery associated with legal issues of business data stored on personal devices, and general security and control of data for privately owned devices.

MWR Security published a detailed report on mobile devices security, including BYOD strategies for companies, in cooperation with the Centre for the Protection of National Infrastructure (CPNI) [18]. According to this report, companies developing a security policy including mobile devices and BYOD strategy should consider the following challenges: (i) fast developing IT technologies in general and the constantly emerging variety of mobile devices in

particular; (ii) different risk profiles within variety of vendors of the same type of device (for instance, iPhone-based and Android-based mobile phones risk profiles are different, moreover, risks vary between devices using different versions of the same Operating System (OS)); (iii) assets that a company possesses and tries to protect; (iv) possible assets vulnerabilities (which are assets weaknesses that can be used for security breaches); (v) threats (against what the protection efforts are directed) and risks specific to the activities of the company and its employees; (vi) variety of working locations, both public (cafes, parks, hospitals, organizations) and private (home, other companies); (vii) organizational structure, whether it is an SME (with mainly 3rd party vendors/suppliers taking care of security) or a large company (with a CISO dedicated to maintaining company security).

In addition to technical challenges, attention should be paid to users' awareness of risks, their education and the provision of recommendations to users whenever possible [18]. Employers may consider different educational tools to communicate the requirements of the security policy, reasons for these requirements, benefits of compliance, and consequences of non-compliance and thus promote a security culture. However, these long-terms approaches require time and involve user awareness and conscious decision-making. While users may be aware and intend to behave securely, these intentions do not always translate into actual behavior. Therefore a complementary alternative approach would be to try to influence the behavior of the decision makers directly at the moment of the decision-making.

Influencing users behavior rather than forcing it appears to be an attractive option when security decisions are made in situations of uncertainty, when users may be required to balance competing requirements (e.g. security versus productivity), and/or when dealing with mobile devices, which employees use, but which are not fully controlled by the company-employer.

3. BYOD Vulnerabilities

Vulnerability can be seen as 'the intersection of three elements: a system susceptibility or flaw, attacker access to the flaw, and attacker capability to exploit the flaw' [30]. For the purpose of this paper we shall reflect explicitly on the first two elements assuming a 'worst case scenario' in the latter (data theft, financial loss, etc.). With this paradigm, we present an environment where there are numerous intervention methods to reduce risk and conversely several exploitations with respect to the BYOD trend. It is necessary to discuss each in light of users' behaviors.

3.1 A system susceptibility or flaw

With the introduction of unknown devices into the network the likelihood of a susceptibility or flaw increases. Unknown devices are typically self-monitored and (specifically in this case) are mobile. This is highly problematic as the unknown software, mobile nature and the method in which the device is used present a real security threat. The phrase, 'a system is only as strong as its weakest link' is highly appropriate when such devices will be configured and managed manually with numerous issues associated with this.

Within many companies employees' computers are centrally managed under a specific data security policy. These machines are static often with a single user per machine and are homogenous throughout the company (with possible exceptions in policy related to specific roles within the company – i.e. installation rights, administrator access etc.). This allows for a robust, secure (albeit policy dependent) environment where risk can be mitigated by rigid control mechanisms. Installation of software can be blocked, operating system, virus scanner, firewalls and software patches can be automatically deployed and attachments to peripheral devices can be denied or monitored to name but a few.

With BYOD, however, the above level of central control is lost. Self-managed devices are typically not used in the same manner and often fulfill a multitude of roles. For example, an employee owned laptop would be used in both an office environment for work and a home environment for non-work activities. This duality of use, stronger sense of ownership, lack of knowledge, lack of prioritization of security by users and lack of central control, may lead to security features being omitted or simply not configured correctly, particularly if the security feature is perceived as inconvenient or hindering productivity. Activities that would either be impossible or forbidden by policy are now

available and this presents a conflict for users related to what they are and are not allowed to do. For instance, a given website or software may be forbidden and inaccessible on a work machine. Does this, however, mean that it is forbidden on an employees' own machines outside of work?

Unsafe practices on a personal device outside of the working environment are problematic when re-introducing a device to the work environment. The device has transformed from a personal device back to a work device but has, in the process, been exposed to numerous policy breaching activities. It is highly likely that the device has (from a company perspective) connected to unknown networks, with unknown traffic, attached to unknown physical devices (a highly relevant problem with recent documentation on USB stick firmware exploits – 'BadUSB' [31]). This presents a major threat to the company's infrastructure and data security if not carefully managed (e.g. via separate networks for personal devices).

3.2 Attacker access to the flaw

Attacks generally fall into three categories [32]: persistent targeted; single targeted; or random (chance). The adoption of BYOD is vulnerable to all of these and presents an attractive avenue for attack. One could further argue that BYOD introduces an additional 'physical' attack relating to device theft that is exacerbated by the mobile nature of the device (particularly problematic if the device is not encrypted).

Targeting such a device can be beneficial to an attacker for many reasons. Firstly, it enables personal targeted attacks (i.e. targeting the CEO), which allows attackers to be much more focused. As cyber-attacks are often financially motivated (with time being a key factor) identifying such a device optimizes the attack by enabling bespoke (either physical or device specific) methods to be devised. The attacks are likely to be more successful due to the susceptibilities noted in 3.1 and the availability of the device to be attacked (predominantly in a more unsecured environment).

To understand such an attack and how BYOD may create new threat vectors, it is necessary to work through a practical example. A Man-in-the-Middle [33] attack exploits a network connection by intercepting traffic sent and received. The most successful Man-in-the-Middle attacks aim to remain anonymous by having a negligible (particularly unnoticeable by humans) impact on users' activities. Data is intercepted and subsequently analyzed in an effort to exploit a particular vulnerability (e.g. stealing Facebook login details via FireSheep FireFox plugin [34], [35]). Following the example demonstrated in [8] we see a typical BYOD scenario where attackers can exploit users' behaviors. When in a public environment the user accesses a public Wi-Fi network, the device is placed under threat. Open Wi-Fi networks present an unknown threat environment, where it is impossible to verify other users and identify malicious activity. This infrastructure provides a relatively simple platform to intercept and steal data as in the above Facebook example [34], [35] if connections are not encrypted (which is typical for small-medium enterprises and general public use). Unencrypted connections on such networks are simple to intercept enabling specifically targeted attacks to be highly successful.

Exploiting users' behaviors via phishing is also a common approach. This attack plays on users' vulnerabilities and attempts to deceive users into carrying out an action (such as clicking on a link). This is a non-technical attack, which targets users, not physical hardware or software. Phishing is a problem since permissions are often granted erroneously by users, who are fooled into believing that the task they are presented with is genuine. By providing authorization, the attacker can then gain sensitive information (often usernames and passwords) allowing them to masquerade as a genuine user. It is then extremely difficult for the system (moreover the system administrator) to determine whether or not a user is who they say they are.

3.3 BYOD risks and controls

There is clearly significant impact of BYOD on a network's security infrastructure if not managed in a controlled manner. By enabling users to transport their devices between environments, new vulnerabilities and exploits are

presented that must be combatted. It is important this control is managed in a fashion that does not detract from the core attraction of BYOD, particularly mobility and productivity.

4. Assistance in risk assessment under uncertainty

We now propose an approach to risk assessment assistance in situations of uncertainty. The standard risk assessment procedure, for instance suggested in [13] or [14], is adjusted taking into account consumerization of IT adaptation, e.g. proposed in [16], and includes: the estimation of company activities profile; the corporate data and the evaluation of the vulnerabilities and threats of professional or personal devices; the security checks of services that employees use on a daily basis; and the analysis of potential human behavior vulnerabilities. Moreover, we consider the ownership of devices and data (private or corporate) as well as the context, in which the devices, services and data are used. Here, by context, we mean a dynamic environment, e.g. work, home or a public place, in which the mobile device users may utilize devices or data or services. Note that the context may include services that the employee is allowed to use including those owned by the company, bought by the employee or even freeware.

4.1 Risk assessment for consumerization of IT

The designer of a security policy for a company working with mobile devices should consider the properties given in Table 1. Together with important functionalities, they may expose security vulnerabilities of devices. Paradoxically, one of the greatest advantages of mobile devices, mobility, is also one of its greatest vulnerabilities. Some devices (laptop and tablet) have large screens, which makes them convenient for regular tasks (e.g., writing/reading emails, programming, watching video), but it also becomes easier to shoulder surf these devices and for data shown on large screens to be disclosed accidentally. In Table 1 '+' refers to a vulnerability being present, '-' means that a vulnerability is not present and '?' refers to the presence of a vulnerability being unpredictable.

Here, we refer to a private device as a mobile device bought by an employee and to a corporate device as a mobile device bought by a company for an employee to work on. Then, a mixed-usage device is a private or corporate device used for both personal and work purposes.

Table 2 presents an example of threats adapted from [18] to mixed-usage devices, taking into account vulnerabilities presented in Table 1 and considering possible scenarios in which an employee may happen to work.

Table 1. Vulnerabilities of devices

Property	Laptop	Tablet	Phone	USB Stick
Connectivity	+	+	+	+
Mobility	+	+	+	+
Applications	+	+	+	+
Lock	+	+	+	?
Remote Access	+	+	+	+
Out of date software/OS	+	+	+	+
Large screen	+	+	-	-
Admin access	+	?	?	-
Removable Media	?	+	+	-
Access to SIM card	?	?	+	-

On the one hand, many threats presented in Table 2 can be controlled with technical solutions, such as data loss/leakage prevention (DLP), if private devices are locked down in a similar way to corporate devices with some security policy and/or with mobile device management (MDM) programs that allows management of the assets (both devices and data). Security practitioners consider MDM as a necessary risk prevention tool [19], and highlight the urgent need for an MDM version for Android-based devices [20] for companies adopting IT consumerization. Companies with 'mobile' employees already appreciate the help of mobile Virtual Private Network (VPN), which extends a private network across a public network. Research in Motion (RIM) announced a multi-platform version of its BlackBerry Enterprise Server [20] for improving the security of mobile devices. Separation of private and corporate data with data segregation tools may help to differentiate data that should be monitored from that which is personal.

Table 2. Threats for devices and corporate data

Device compromised	**Device contaminated**	**Communication compromised**	**Data compromised**	**Data disclosed**	**Security/trust model weakened**
Device lost	Malicious application installed by user	Data interception in transit	Integrity (access via security breach)	Inappropriately stored / transferred data	Personal credentials shared
Device stolen	Device infected by malware / virus	Encryption key disclosed	Confidentiality (access via security breach)	Discloses data after being asked (social engineering)	Device jailbroken
Device decommissioned	Device contamination	Insecure unencrypted connection	Availability (denial of service)	Discloses data unintentionally (shoulder surfing/ duplication)	Security controls bypassed

On the other hand, many threats presented in Table 2 involve risk prone actions, which increase security breaches significantly. Hence, companies' security policy efforts are twofold: the identification of technical controls to apply (e.g. which anti-virus to buy, which software to install and how to control its updates, allowable ways to access corporate data and how to guarantee data protection) and the prevention of possible human errors. This should be via technical controls when possible, such as control over anything installed by users and password creation rules, or with education sessions, for instance on not sharing personal credential, public Wi-Fi connection and policy jail-breaking.

Risk is usually considered as the likelihood of an attack multiplied by its impact, where the likelihood of an attack is given by the probability that a threat can exploit a particular vulnerability. A typical approach to reduce risk is therefore to add some control over the vulnerabilities, so that they are no longer exploitable. However, the usage of mixed-usage devices raises the problem of who is responsible for applying this control. Here, control refers to 'a measure that is modifying risk' [14].

Moreover, we differentiate between different levels of control that may help maximally reduce risk with: full control over devices; partial control over devices; or no control over devices. Table 3 adapted from [18] shows four possible cases of combination of a device owner and a device manager: 1) company provides employees with devices and takes full control of these devices, e.g. typical BlackBerry 'work phone'; 2) company provides devices, but does not manage them, e.g. common for universities, having partial control over the devices; 3) employees own devices are controlled by companies partially, e.g. can be registered to be wiped in case of loss; 4) employees are allowed to work with their own devices, but have to take care of security themselves, resulting in company having no control over the devices.

Table 3. Company control of devices depending on ownership and management

		Device Manager	
		Company	**Employee**
Device Owner	**Company**	(1) Full control	(2) Partial control
	Employee	(3) Partial control	(4) No control

The first case (1) is the case of full control: a company both owns and manages the device. Depending on how restrictive the security policy is and compliance levels, there are still possible threats and corresponding risks to the assets of the company, e.g., zero-day vulnerabilities. In case (2) a company provides devices, but does not manage them, or in case (3) employees use their own devices, and the company manages them or the company does not manage them as in case (4). In cases (2) and (3), a company may apply some security policy to protect the employee's personal or corporate devices with DLP and/or MDM tools. In case (4), there is a danger of uncontrolled threats, as an employee might not use all, or any, protection measures, such as an anti-virus, software updates, passwords, etc.

5. Nudging for mitigating security risks and improving productivity

A security policy should be seen as a protective measure, which employees should comply with. In addition to punishments for risky behavior and rewards for secure ones, it should take into account the employee's perspective. A highly restrictive security policy that limits flexibility for employees might result in a rebellion effect and push employees towards ignoring it. Fundamentally, such behavior would expose the company to security risks and corresponding costs that should be taken into account when developing a security policy. The problem of non-compliance with security policies has highlighted the existence of a compliance limit for each user (probably, varying from user to user) known as the "compliance budget" [21]. Further research [22] focused on understanding non-compliance and workaround strategies employees apply in order to be more productive and perform their tasks faster.

Moreover, too restrictive security policies may be insufficiently flexible to the dynamic context, in which security decisions are made. For instance, a security policy, may only allow employees to connect to Wi-Fi's in the *whitelist* of a company. However, there may be no available white-listed Wi-Fi's at the employee's current location. Hence, the employees would be unable to work if the policy is enforced on their device, or if the policy is not enforced, they may choose to breach policy and connect to a publicly available Wi-Fi. Unfortunately, at the moment of making security decisions there is often no objective information to aid the user in evaluating the consequences of each possible choice and/or the decision makers might not realize the risks and consequences of possible security breaches. However, the choices are still made (e.g. one of the Wi-Fi's should be selected for work) and the decision maker must take responsibility for the consequences of such decisions.

The traditional approach for helping employees making better security decisions is via education and training sessions about the security policy of the company [16], [18]. This is a time-consuming approach that requires conscious reflection of employees on security issues and possible consequences of such decisions for them and their company. However, awareness and knowledge does not necessarily lead to the required behavior as it does not provide cues to action, at the moment the behavior is initiated. Alternatively, nudging is an explicit recommendation or more subtle influence emphasizing some choice, but not forcing it. It has a reputation of being able to make a big difference by small changes while leaving the freedom of choice to the decision maker. This is important when security decisions are made in situations of uncertainty, where an employee might have better situational awareness than the company had when creating the policy.

5.2 Nudging for security and productivity: What is it?

In this work, we investigate a possibility of applying a recently proposed 'nudging' approach [23] to influence information security choices as a 'soft' alternative to more restrictive security policy. Nudging provides a framework, called choice architecture, which presents available alternatives in such a way that influences the decision maker's final choice [23]. This approach is referred to as libertarian paternalist, in the health and social behavior domains 'people are free to do what they choose, but that it is legitimate to influence people's behavior in the positive direction' [24]. This approach has been adopted by the governments (e.g. UK and USA) to encourage behaviors promoted by government policies while still providing freedom of choice.

Nudging has been widely used in healthcare [3] and social policies [4] to change the behavior of people with minimal interventions. In these initiatives the nudged behavior is widely accepted as the 'best' by both governments and citizens, such as fighting obesity or paying the right amount of tax. The research results on applied cases of nudging are very encouraging and show that, indeed, the manner, in which the information is presented to the decision maker, influences the choice. For instance, it was shown that rearranging menu items in student's cafeteria may increase/decrease consumption of a particular item by up to 25%, since the first options in the list have higher chances of being selected [23].

Similarly, nudging can be adapted to influence people's choices in information security. The behaviors towards which nudging will direct people should be based on rigorous models developed using quantitative risk assessment techniques. They should take into account the trade-offs between productivity benefits and security risks for each particular scenario, and nudge the decision maker towards the best compromise trade-off solutions, but also taking into account context of the decision-making, security policy of the company and preferences of the particular decision maker when possible. Assuming that uncertainty is present in such security scenarios, the outcome of the rigorously assessed models will be used to frame choice architecture for decision makers in such a way that it nudges decision-makers to make the 'best' information security and productivity decisions, but still leaves the final choice for the decision maker. This assumes that the decision maker understands what is better for them in the context of the decision-making.

5.3 Nudging for security and productivity: How to influence?

Six techniques are presented in [23] to support the creation of nudges: incentives, understanding mapping, defaults, give feedback, expect error and structure complex choices. They can be used to build a choice architecture that aims to influence choice made by the decision maker.

To develop incentives for information security, we need to understand the rewards that would encourage employees to make the choices we want, and the punishments that would stop them from making choices we do not want. For instance, would warning messages when connecting to a fast unsecure Wi-Fi network encourages employees to switch to a slower but more secure Wi-Fi that does not present such warnings?

To understand mappings between available options and consequences that follow, we need to be aware of the risks employees take and the convenience employees gain. For instance, studies looking at choosing between more secure Wi-Fi not protected by a password and less secure Wi-Fi protected by a password shows that people perceive more secure solutions as being more complex by default, and less secure solutions being easier and faster to implement [25].

Default choices are selected by people who 'go with the flow' and do not pay much attention to them. Default choices for security-related decisions should be pre-selected to the most secure ones, leaving the freedom for users to uncheck selections or change defaults if desired.

Giving feedback on choices, whether positive or negative, helps users to learn from their past decisions and use this experience in the future. Knowing that users make errors and expecting errors means those developers should provide choices in a simple and understandable manner, as well as guide choices with explanations and help options. They should also ensure that the user is protected against any unrecoverable decisions. One last point is also important, the

presentation and structuring of complex choices should reduce people's cognitive load, e.g., sectioning decisions so that there are clear steps and a limited number of options to choose from at any point in time [26].

In addition to the six techniques provided by choice architecture, organizational psychology and behavioral economics have identified many different factors that influence behavior. The MINDSPACE framework [27] summaries these influencing techniques some of which are common to those presented in [23]: messenger; incentives; norms; default; salience; priming; affect; commitment; and ego. Messenger effects suggest that the person delivering the message and not the message itself influences people. Norm effects suggest that people will behave in the way that those around them behave, or in ways they think people expect them to behave. Salience refers to how to present choices so that the desired choice stands out from the others and grabs the attention of the decision maker. Priming addresses framing effect, which is related to our subconscious processing of information. This is an implicit memory effect where exposure to a stimulus influences how a person responds to the next stimulus. Affect refers to people's emotional reaction to a stimulus. Commitment refers to a person's desire to keep promises they have made to another person, particularly if the commitment is written down. Ego refers to acting in a way that makes people feeling good about themselves. These factors can be used when designing choice architectures in security to optimize the chances of the nudge succeeding. In addition, [28] outlines a process by which companies can explore the creation of nudges to solve specific security problems within their companies by using MINDSPACE as part of creative workshops with staff to identify factors influencing their security behaviors within the company and to identify possible approaches of designing ways of increasing security compliance.

5.4 Nudging for security and productivity: When is it appropriate?

The company may decide when to apply nudging depending on the level of control the company has over the device. Recalling Table 3 with four various cases of device ownership and management, resulting in three levels of control: full, partial and no control for the company. Taking into account the context in which the security related decisions are made, here, we argue about the appropriateness and benefit of nudging, see Table 4. Similarly to Table 3, we consider the owner and manager of the device (company or employee) and context (working or not, e.g. public places, home, private houses, other companies). In the Nudging column of Table 4, '+' indicates a situation where nudging may be desirable and '-' indicates cases, where nudging is not beneficial.

Table 4. Devices control and nudging

#	Device Owner	Device Manager	Context	Control	Nudging
(1)	Company	Company	Working	Full	-
(2)	Company	Company	Public/Private	Partial	+
(3)	Company	Employee	Working	Partial	+
(4)	Company	Employee	Public/Private	Partial	+
(5)	Employee	Company	Working	Partial	+
(6)	Employee	Company	Public/Private	Partial	+
(7)	Employee	Employee	Working	Partial	+
(8)	Employee	Employee	Public/Private	No	-

Note that in this context we can also include services that the employee is allowed to use. For instance, in the case where publicly available services are used by employees at work on working devices, such as Dropbox or social networks, the scenario should no longer be classified as the first case of full control.

Indeed, nudging is appropriate for all cases presented in Table 4 with the exception of case (1) of full control, where a company controls and manages devices and they are only used for work and case (8) of no control, where there is no control over an employee owned and managed device used in a non-work context. For instance, an Information Security policy may state that users should not access social networks from a work device. A company may restrict access to such a websites and prevent access in case (1). However, that would not be possible in case (3), where an employee is managing a corporate device, or in case (6), where an employee works on a personal device providing some managing privileges to the company, and such a restriction would disturb the employee's sense of ownership. On the contrary, nudging employees away from social network websites during working hours would be seen as advice from the company that an employee can override when justified, e.g., for working purposes in order to advertise some company products or jobs in social networks.

5.5 Nudging for security and productivity: Examples of tested scenarios

Nudging has been explored in information security, for instance, for nudging users away from privacy invasive choices [5]-[8] by using color to positively and negatively frame information. Traditionally, red is associated with danger, e.g. red in traffic light or the infamous 'red button', and green with safety or 'to go' in a traffic light signal. Traffic light color schemes are widely applied in cyber security design, e.g., for indicating what can be done with shared information in a traffic light protocol [29] or for framing choice options [5].

One of the possible applications of nudging in the security context is presented in [8], [11], where a traffic light color scheme is used for a choice of public Wi-Fi. In this work an example of nudging a user towards selecting a more secure Wi-Fi is considered. Choice architecture is organized so that available Wi-Fi's are ordered in such a way that the most secure networks are placed at the top of the list and their names are colored 'green', while names of less secure Wi-Fi's are 'yellow' and open Wi-Fi's are 'red'. The results show that the color was effective in influencing the choice of users, more than the order, which did not change the choice significantly. However, in preliminary evaluations the combination of order and color was the most effective nudge, encouraging more people away from insecure networks than one factor alone.

5.6 Nudging for security and productivity: Examples of potential scenarios

The following scenarios are considered as examples of scenarios where nudging can be applied efficiently, choosing a new password and determining whether to accept or decline a mobile application's permissions. In these scenarios decision makers are facing a trade-off decision of choosing between being more productive or more secure. For instance, creating a new password, which is similar to the old one, is fast and takes less time and effort to remember, however, this strategy leads to creating weak passwords according to security metrics [36]. Similarly, accepting all permissions that an application requests during installation on a mobile phone is fast and easy, however, it might compromise the user.

Regular password renewal is a common procedure used by companies to provide protection from potential malicious attackers. Many academic papers have highlighted both the need for secure passwords and how to create them [37] ('strength' meters are now commonplace). Equally important, however, is the frequency and rules that govern this process (how often passwords are updated and their complexity). It is essential to strike a balance between maintaining security and inconveniencing users. If a password is renewed too frequently then the chance of forgetting them is increased, and the users' willingness to comply decreases [38]. Forcing users to create too strong passwords may lead either to difficulties of memorizing passwords, create security breaches as a result of writing passwords down and exposing them to potentially malicious attackers or forgetting them. Alternatively, nudging may help with creating a more secure, memorable password.

At its core, a nudge should be holistic and not annoying. This is essential for password creation, as we do not want to over-burden users with additional time consuming requests or cognitive load. At the same time users should be able to override a nudge if they have strong preferences towards an option different from the one suggested by a nudge. The

nudge for password creation must be present at the point where the password is being formulated, for instance, a point immediately after requesting a user to create a new or to update an old password and before the cognitive process is started. The point of password entry is too late. The experiment described in [39] has demonstrated the direct impact of forcing users to wait a fixed time period in order to improve their password strength. Perhaps a social nudge would also be beneficial here. Social nudges work by playing on social norms. For instance, users can be informed that a high percentage of people in their company update their passwords regularly with strong alternatives, e.g. a popup is presented '74% of employees choose a stronger password than this one'.

Applications are requesting more and more permissions to access information and services on your mobile phone, for instance your personal information, your precise location, or full network access. New communication technologies such as Near Field Communication (NFC), Bluetooth LE (Low Energy) provide new methods to share data stored on given devices. These new technologies, however, are utilized by applications (e.g. NFC typically used for card payment methods and Bluetooth LE by sport fitness accessories) that must first call operating system methods that are governed explicitly by permissions. On installation of an application, these permissions are presented to users in order to detail what the application has access to and some indication of why it is necessary. Unfortunately, current implementations of this process are poor and end users have little, comprehensible information on which to base their decisions. An application may request (perhaps legitimate) access to the address book, but without direct statements regarding why such access is required, it is unclear whether or not these should be accepted. For instance, why would a torch application on a mobile phone require access to your location? The path to finding out exactly what permissions is being requested, and what they mean may well be made deliberately difficult by app developers – to nudge people to simply accepting all permissions! Recently, Facebook [40] received negative press coverage for their applications due to the way in which the permissions were presented and worded when in fact the core functionality of the applications remained the same. It was the permission text that had changed thus generating negative connotations of privacy invasion to users. Here adding more information on the usage of the requested data by the application would help in nudging users towards more selective responses.

By extending the permission text to include possible implications of accepting the permission, the user would be more informed as to whether or not they wished to accept and thus install the application. This would potentially prevent significant data leakage and personally identifiable information via uploading of contacts or media on the device for example. Similarly to the previously discussed Wi-Fi study [8], ordering and coloring could be adopted to highlight the most significant threats to security. As demonstrated in the previous study, ordering and coloring had a significant positive effect on the security of the chosen Wi-Fi network. To demonstrate, access to the address book or media could be highlighted red and given prominence by ordering it at the top of the list (with additional related text to highlight the potential impact of sharing this). Typically less security invasive permissions would conversely be ordered towards the bottom and highlighted green (permission to change the ringtone for instance). The combination of these visual nudges enforced with priming would allow users to make more informed decisions as to whether the application was indeed trustworthy or whether it was suspicious (why does a solitaire game require my location?).

Both of the above examples of potential nudges provide an interesting test bed for future investigations and highlight the complex nature in which security decisions are made. Encouraging users to make more secure decisions should not prevent them from being productive when needed and nudging appears to be an easy form for such soft influence, which can be applied together with other complementary ways of influencing users by educating and training them on a regular basis.

6. Conclusions

In this work, we have discussed the recent trend of both large companies and SMEs towards adopting the consumerization of IT. In addition to the commonly recognized risks and opportunities that this trend carries for the companies and their employees, we highlighted the uncertainty that consumerization introduces. This uncertainty is due to the changed ownership model and context of the potentially unsecure environments, in which an employee is using private or company owned devices and corporate data. To help reduce potential risks, we have suggested the adoption

of a 'soft' strategy of nudging that tries to influence the choices of employees by subtly pushing them towards more appropriate decisions, leaving the final choice and the responsibility for its consequences to employees. This approach can be used to optimize compliance with the company's Information Security policy. In addition, such an approach takes into account the ownership model and considers the dynamics of the context, in which employees might have more awareness of the situation to make an informed decision, than a policy maker can ever have.

When compared to more restrictive and less flexible Information Security policies, which leave no choice to decision makers, an alternative 'soft' nudging approach looks appealing when freedom of choice is at stake. This approach allows users to take responsibility, when dealing with corporate data/device, which may also be advantageous.

We considered several tested and potential examples of nudging in the security context and showed how users can be softly influenced towards choosing some of the options that are considered to be 'better' from security and or productivity points of view. At the same time nudging assumes that decision makers are well informed and are free to override nudges.

As future work, we are considering the development of rigorous risk assessment of trade-off solutions for concrete security scenarios to ground options towards which nudging is performed. It is a complex task of trading security and productivity objectives of a decision maker, while taking into account security policy of the company and the employee's personal preferences. We also aim to create a methodology to construct choice architectures in security, and to be able to evaluate the impact in corporate risk through nudging techniques.

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Development and assessment of an instrument to measure equivocal situation and its causes in IS/IT project evaluation

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Abstract:
Project evaluations are vital for organizations to manage and balance the costs and benefits of their IS/IT investment. Despite the importance of project evaluations, equivocal situation may limit the effectiveness of an evaluation and hinder decision-makers in generating purposeful resolutions. There is a dearth of empirical studies with regard to equivocal situation, which this study addresses by developing and measuring a construct of an equivocal situation and its causes. The equivocal situation construct is derived from the notion of equivocality and its causes are extracted from the extant literature. The developed constructs are subjected to empirical validation through Partial Least Squares (PLS) analysis by employing the data collected from knowledge professionals in IS/IT project management. The developed instrument provides a firm foundation for future studies of equivocality in IS/IT project evaluation.

Keywords:
evaluation; equivocality; information system/technology projects; measurement; instrument; development; assessment.

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1. Introduction

Many organizations invest enormously in information systems and technology (IS/IT) and become reliant on the success of their IS/IT portfolios and projects. Charette [1] reminds organizations of the importance to improve their IS/IT project execution due to many project failures and their related costs. Proper evaluations are beneficial to discover problems during project development and implementation. Evaluations are processes conducted by groups of decision-makers or evaluators to describe the realization of resources for their merit and worth; they judge and compare a set of standards suitable for the context, followed by decisions [2]. The prior-justified plans and business cases can then be reestablished to maintain adequate returns of the investments, and to further proceed with well-positioned strategies [3]. However, evaluations are not perceived as trouble-free practices. For instance, evaluating the progress rate of the development of an information system is problematical due to its intangibility especially during the initial stage [4]. Hence, organizations seem to have difficulty deploying proper evaluations [5].

From a research perspective, evaluating information systems and technology in organizations still remain a challenge and an interesting subject to explore. Especially as studies related to the evaluation of on-going projects are still limited. This study connects IS/IT evaluation literature to the continuation decisions of IS/IT projects. Arguably, evaluations are performed to justify choices of actions which result in decisions [3, 6, 7]. We introduce the concept of equivocal situations, derived from the notion of equivocality, by subscribing to Bowen's Decision Dilemma theory [8]. An equivocal situation raises potential problems of unwarranted continuation and premature termination in decision-making and hinders organizations in deciding purposefully on the projects' next course of action [9, 10]. Despite the importance of equivocal situations in affecting continuation decisions, the causes of equivocal situations are not well recognized [11]. Moreover, empirical studies of factors that affect an equivocal situation and their influence on project evaluations demand the development of a reliable and valid instrument. From a practical perspective, the instrument will provide practitioners with the knowledge to analyze their project execution in order to lessen the equivocal situations especially at the time of evaluation. By understanding of the characteristics of equivocal situations and their causes, organizations take the first step to structure and manage their IS/IT project portfolios as well as to sustain effective project execution.

The purpose of this study is to develop and assess an instrument to measure equivocal situations in IS/IT project evaluations. The stages comprise qualitative exploration, instrument development, and quantitative assessment. The study proceeds as follows: we describe the extant studies and the relevant theoretical background on the main concepts of our study, i.e., evaluation, continuation decisions, and equivocality. Next, we describe the methodology and procedure for instrument development and assessment; we present in detail the development process, the analysis through Partial Least Squares (PLS) and the result of the developed instrument. Subsequently, we highlight our contribution to research and practice, and the entailed limitations. Finally, we conclude the study with suggestions for further development.

2. Theoretical foundation

2.1 Evaluation

Irani, et al. [12] define IS/IT evaluation as *"a decision-making technique that allows an organization to benchmark and define costs, benefits, risks and implications of investing in IT/IS systems and infrastructures"* (p. 213). Additionally, Farbey, et al. [13] describe IS/IT project evaluation as "*a process, or group of parallel processes, which take place at different points in time or continuously, for searching and for making explicit, quantitatively or qualitatively, all the impacts of an IT project and the programme and strategy of which it is a part*" (p. 190). Evaluation can be construed as a way to manage and balance the costs and benefits throughout project execution in relation to new emerging insights of the project [14]. Thus, the aim of evaluating on-going projects is: (1) to specify the projects' progress and likely success; (2) to consider the value of continuing the projects, and; (3) to allow the intervention of projects which deviate from their plan [7, 15, 16]. As the evaluation outcome will be the reference point of project continuation decisions and

the subsequent strategies, evaluation should ascertain the project's condition unequivocally [15, 16]. However, evaluation is challenged by the difficulty to determine the project's condition and the equivocality of information surrounding the project [4, 15, 17, 18]. Decisions to continue IS/IT projects become a problematic issue for organizations [19].

2.2 Equivocal situation

One of the prominent theories as to why decisions are taken by organizations to continue with troubled IS/IT projects is the Decision dilemma, coined by [8]. We subscribe to Bowen's conjecture of equivocality, referring to information for which multiple (positive or negative) interpretations can be constructed [8]. The theory posits that continuation decisions of troubled IS/IT projects are seen more as dilemmas rather than errors of decision-making. When information surrounding the projects is deemed to be ambiguous, equivocal situations might emerge and lead to escalation [20]. Evaluating and deciding on the continuation of IS/IT projects in an equivocal situation may lead decision-makers to an unwarranted continuation or a premature termination. Decision-makers are unable to grasp a clear picture of the likely success or failure of the projects. Decision-makers may not be able to make a purposeful decision on the next course of action. Unwarranted continuation decisions may be seen as irrational behavior, which traps decision-makers in a difficult situation. Unwarranted continuation causes the project to absorb a great deal of resources without a clear end point. In many cases, the projects often end up being abandoned or are redirected, but usually too late. Likewise, premature abandonment is also considered as problematical as it may cause organizations to miss opportunities or future benefits from the investments and to lose on deployment costs [10]. Continuation decisions, inevitably, become crucial for organizations in the management of their IS/IT portfolio.

Several causes of equivocal situations are implicitly mentioned in some studies. For instance, lack of clarity about projects' success and failure criteria, vagueness of project charter, or ambiguity of information surrounding the projects execution [15, 21, 22]. These are deemed to induce equivocal situations. However, extant studies have not explored the concepts of equivocality in IS/IT projects specifically, thus the phenomenon and the causes are not well understood. Evaluating the IS projects is often challenged by disagreement due to multiple interpretation of information surrounding the project and the difficulty to establish evaluation criteria, utilize the evaluation techniques and tools, and to obtain adequate data to support the decision-making. This situation raises confusion and dilemma, as described by Bowen.

3. Instrument development process

We describe the approach taken when developing and testing an instrument to measure the extent of an equivocal situation as well as the causes of such situations [23]. Fig. 1 depicts the stages and the employed methods to develop and assess the instrument.

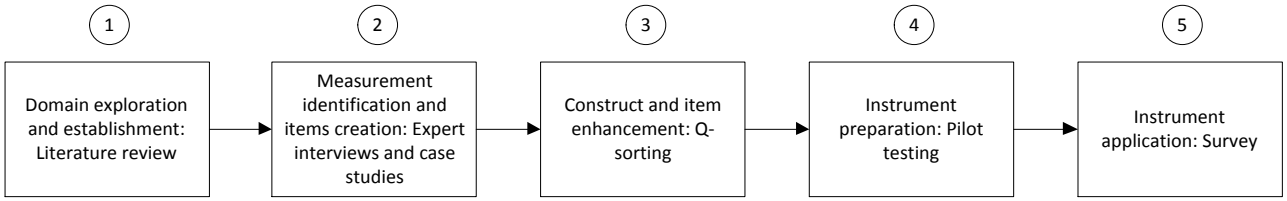

Fig. 1. Stages and methods

3.1 Domain exploration

In the first stage, we examined the notion of equivocality to improve our understanding of the notion and to identify its common characteristics. The literature was collected by entering the key terms: (escalat* OR abandon*) AND (information equivocal*) into two databases, i.e., EBSCOhost (Business Source Elite, EconLit, PsycARTICLES and Psychology and Behavioral Sciences Collection) and SciVerse Scopus (subject areas includes Social Science & Humanities). Equivocality is associated with multiple interpretations, conveyed meanings or perceptions with regard to particular information. Indeterminacy of analyzed data, demand of "richer" or different types of information, and exchange of views and judgments to settle disagreement and reach consensus specify the emergence of equivocality. From that derived notion, we developed the concept of equivocal situations in the context of IS/IT project evaluations. We further defined equivocal situations in IS/IT project evaluations as the state when decision-makers or evaluators encounter a lack of clarity and confusion in deciding on the continuation of a project, which occurred due to lack of knowledge or the existence of diverse knowledge with regard to information surrounding the project, especially its past performance and future attainment. In our initial review of the literature, we found a limited number of studies in the context of IS/IT projects which directly describe the causes of equivocal situations; thus, we extended our analysis to other similar contexts. The review included a thematically iterative process and analysis [24] resulting in eight conceptually substantiated categories of causes of equivocal situations. Then, we delineated the initial definitions of the categories.

3.2 Instrument development

In the second stage, we identified extant measurements with similarities to our categories. We constructed a pool of candidate items with high content validity by considering our initial defined categories and the identified problems of equivocality. A category was conceived as a common denominator for items under its delineated definition. The existing items which were too context specific were adapted and reworded to ensure suitability with the domain of our study. We tried to word the items in a simple and straightforward and excluded jargon or potentially unfamiliar words. Then, we corroborated and enhanced our initial development of the measurements and items using seven in-depth interviews with experts from academia and practice [25], and ten semi-structured interviews with practitioners of four project case studies [26]. We opted for this action to ensure adequate content validity of the constructs and the items before further utilization. We invited experts from academia and practice who hold a doctoral degree (or a candidate) and/or have experience managing and evaluating IS/IT projects. For the project case studies, we invited practitioners who were involved in IS/IT project evaluations and decisions. A minimum of two participants is required per case to obtain different perspectives and sufficient triangulation among people within a group of decision-makers. In the interviews, we defined the equivocal situations and presented characteristics of equivocality in the context of IS/IT project evaluations. We asked the participants to recall a project with similar condition during its evaluation. We first allowed the participants to express their thoughts on the project and the evaluation; then we focused on the causes of the described condition. We provided our categories, their definitions and measurements afterwards. We asked them to comment on the categories and the measurements, and whether they could suggest additional issues or problems that cause such a condition based on their experience. Their suggestions served as input to modify the initial items. We further requested the participants to assess the degree to which they agree with the category of the causes and their importance on affecting the described condition (i.e., equivocal situation in project evaluation) using a 7-point scale (1 indicated a strongly disagreed/an unimportant cause, and 7 indicated a strongly agreed/an important cause).

One of the researchers transcribed and coded the interviews. The coding was then discussed with other researchers to gain additional perspectives. We consolidated our initial findings from the literature review with the results of the interviews. We redefined the categories and modified the items accordingly with the results of this stage. The aforementioned process was conducted to ensure content validity by selecting the right items for the construct based on the categories' definitions and the identified problems of equivocality. Eight categories of equivocal situation causes were established Table 1 provides definitions of the constructs and the supporting references as well as examples of quotations from qualitative studies.

Table 1. Developed constructs

Construct	References	Quotation from qualitative studies
Complexity in process (CP): *the extent to which the process of developing IS/IT involves substantial intricacy*	Brun and Saetre [27], Chang and Tien [28], Fazlollahi and Tanniru [29], Jones and Kydd [30], Koufteros, et al. [31], Lim and Benbasat [32]	*"...[the situation] was actually [occurred because] the [number] of stakeholders is too big to organize in that certain time limit..."*
Sophistication of technology (ST): *the extent to which the design of the IS/IT product or solution is considered innovative or advanced*	Brun and Saetre [27], Fazlollahi and Tanniru [29], Kydd [33]	*"...there is no other project that [is] comparable with our project in [the] whole [region] based on [the theme]..."*
Challenges in project management (CPM): *the extent to which the IS/IT project encounters substantial management challenges*	Mähring and Keil [22], Jones and Kydd [30], Kydd [33], Hantula and DeNicolis Bragger [34], Levander, et al. [35], Pan and Pan [36]	*"...I made several attempts [at] the [project] to make [the] goals more specific, there were quite [a few] reports about it, but it [did] not [really become] specific, no, it was still a bit [of a] vague project."*
Lack of standards (LS): *the extent to which evaluators/decision-makers utilize evaluation criteria to ascertain the project value*	Bowen [8], Brun and Saetre [27], Chang and Tien [28], Fazlollahi and Tanniru [29], Jones and Kydd [30], Koufteros, et al. [31], Lim and Benbasat [32], Hantula and DeNicolis Bragger [34]	*"...so there were no plans for uhm go-no-go for the project board... most of it was in the head of the project manager that time..."*
Changes in external state (CES): *the extent to which the project is affected by organizational environmental dynamics*	Chang and Tien [28], Fazlollahi and Tanniru [29], Carson, et al. [37]	*"...there are a lot of political pressures as well in the project [which] makes people quite nervous [be]cause of [the] political pressure..."*
Different frames of reference (DFR): *the extent to which evaluators/decision-makers have diverse viewpoints when evaluating the project*	Fazlollahi and Tanniru [29], Jones and Kydd [30], Levander, et al. [35], Daft, et al. [38], Frishammar, et al. [39], Zack [40]	*"...you have different stakeholders and different user groups.. and they have different [backgrounds]... So their evaluation is different..."*
Failure of evaluation methods (FEM): *the extent to which evaluators/decision-makers apply techniques or tools to evaluate the projects*	Bowen [8], Tiwana, et al. [9], Keil and Flatto [41]	*"No no nothing.. no no.. there was a zero method here... Yes [we have a certain method], just chose not to use it..."*
Lack of evaluation data/information (LED): *the extent to which evaluators/decision-makers use data surrounding the project to support decision-making*	Bowen [8], Newman and Sabherwal [42]	*"...there was an evaluation moment but there [were] really very [few] materials to make the, uhm, that you could use to make a decision..."*
Equivocal situation (ES): *the extent to which evaluation of the project is hampered by equivocality*	Lim and Benbasat [32], Daft, et al. [38], Watts Sussman and Guinan [43]	*"...equivocality means ambiguity, the existence of multiple and conflicting interpretations about an organizational situation. Equivocality often means confusion, disagreement and lack of understanding."* (from literature review)

3.3 Instrument enhancement

In the third stage, we employed two rounds of Q-sorting exercises to assess the convergent and the discriminant construct validity of the items. We followed the procedure set by Moore and Benbasat [23]. The procedure comprises a technique to specify the "hit" ratio, i.e., the desirable placement of items within different constructs or categories of causes. The technique is useful to assess and measure the construct validity. The result of the two rounds of Q-sorting exercises indicates reliability of the categorization and the items. Although some quantification can be made, the reliability and validity analysis of this procedure should be seen as being more qualitative instead of purely quantitative

[23]. WebSort/OptimalSort online card sorting was used to conduct the sorting exercises (Fig. 2). The website has features to conduct the sorting exercises remotely and simultaneously and to download the raw data swiftly (http://www.optimalworkshop.com/optimalsort.htm). The website also provides useful outputs such as dendrogram (Fig. 3) and popular placements matrix. Different sets of participants were used in the two-rounds of sorting exercises. The participants in the first round consisted of four master students (unfamiliar with the research topic) and the second round had a combination of four doctoral students and faculty members (familiar with information systems field but not with the research topic specifically).

Prior to the exercises, we introduced our research briefly and described the objectives of the exercise. Then, the participants opened the website using their internet browsers and read the instructions. We clarified the instructions further, when necessary; when ready, we asked the participants to proceed with the exercises. The participants were provided with the categories, including one labeled "Indecisive" for ambiguous and indeterminate items, and they had to sort or group the randomized-items into the categories. The exercises lasted 20 to 30 minutes on average for each participant. We discussed the sorting experience with the participants after the exercises; specifically, the categorization and the items within the "Indecisive" category. We collected and analyzed the data from the first round before continuing with the second round. We constructed a matrix and calculated the inter-judge agreement levels, the computed Kappas and the "hit ratios". The averages in the first round were: "hit ratios" 68%, raw agreement 69%, and Kappa 64%. Furthermore, we examined the remarks and suggestions from the participants, and highlighted several points to improve the items. For example, negative and positive expressions seemed to influence the participant decision to put items into particular categories. We made several revisions by rewording the items to fit the intended category better, especially items that were frequently misplaced and deemed as ambiguous or indeterminate. Several candidate items which were often put into more than one category were revised as well. Several items were flagged because of their potential lack of distinctiveness and convergence, for instance the item "*several of the decision-makers who evaluate the project have switched a few times*".

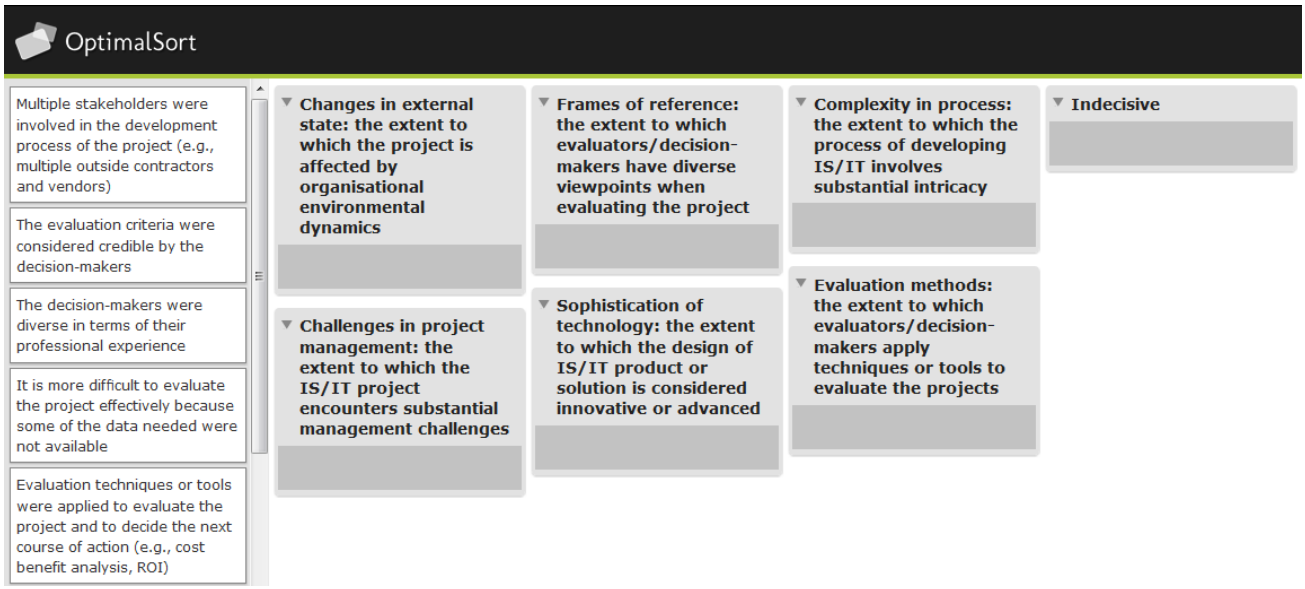

Fig. 2. Q-sorting exercise panel

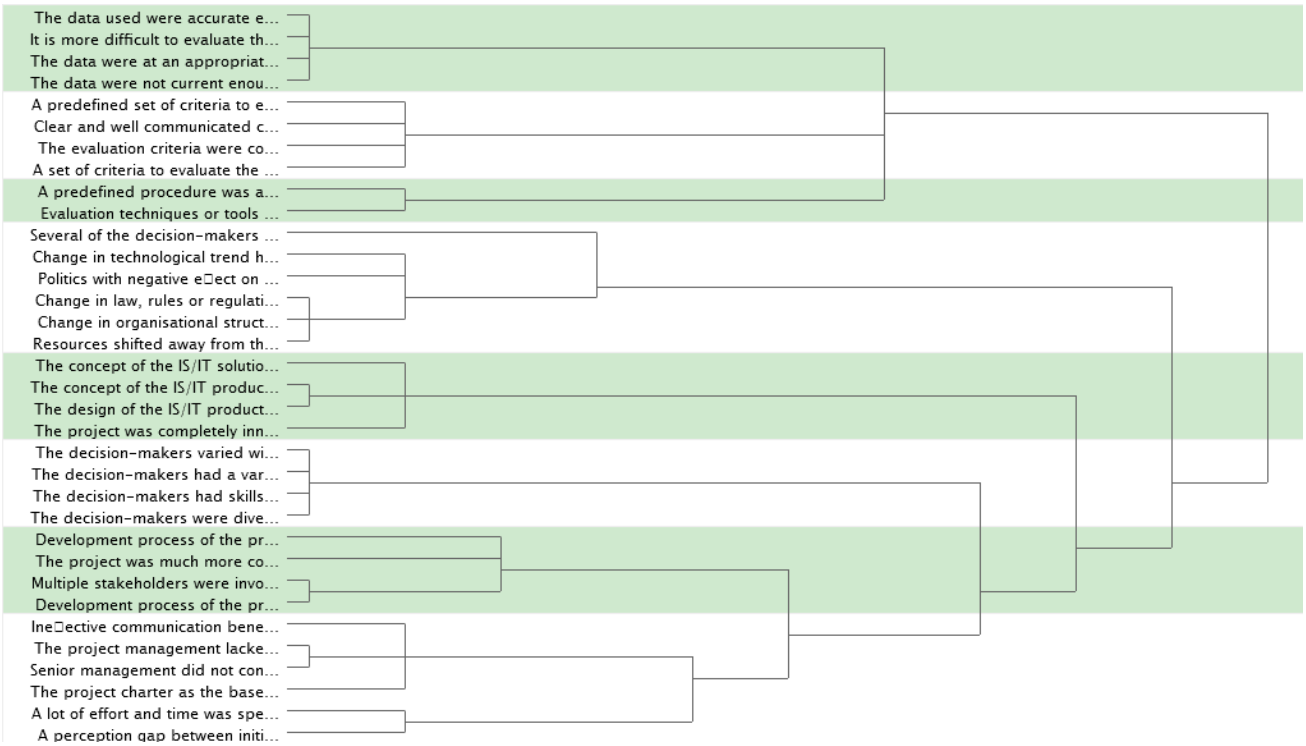

Fig. 3. Q-sorting exercise output (dendrogram)

The final modifications were employed in the second round. We repeated the calculation to measure improvement after the modification. The construct averages in the second round were: "hit ratios" 86%, raw agreement 85%, and Kappa 83%. The percentage of items placed in the target constructs were high, showing reliability of the items, which suggests the items tap adequately into the respective constructs. The overall result indicates an improvement of convergent and discriminant construct validity of the items as well as an achievement of appropriate levels of agreement, i.e., a Kappa value higher than 0.6 and a placement ratio higher than 0.8 [23]. In addition, we reconsidered the flagged items and items which seemed redundant conceptually or semantically. Table 2 provides a summary of the agreement measures for both rounds. Table 4 provides the candidate items used to measure the developed constructs. Based on the overall improvement of the items, we considered the measurement to be adequately valid for the next stage, i.e., application of the instrument. We then composed a draft of the survey based on the Q-sorting result.

Table 2. Inter-judge agreements

Agreement Measure	Combination	Round 1	Round 2
Raw agreement	1 and 2	0.71	0.90
	1 and 3	0.68	0.81
	1 and 4	0.66	0.85
	2 and 3	0.71	0.82
	2 and 4	0.69	0.91
	3 and 4	0.66	0.81
Average		0.69	0.85

Table 3. Inter-judge agreements (cont.)

Cohen's Kappa	1 and 2	0.67	0.88
	1 and 3	0.63	0.78
	1 and 4	0.61	0.82
	2 and 3	0.67	0.80
	2 and 4	0.65	0.90
	3 and 4	0.61	0.78
Average		0.64	0.83
Placement ratios summary			
Complexity in process (CP)		0.44	0.81
Sophistication of technology (ST)		0.50	0.94
Challenges in project management (CPM)		0.65	0.71
Lack of standards (LS)		0.67	0.88
Changes in external state (CES)		0.75	0.85
Different frames of reference (DFR)		0.85	0.85
Failure of evaluation methods (FEM)		0.63	0.88
Lack of evaluation data/information (LED)		0.94	1.00
Average		0.68	0.86

It is important to note the way equivocal situations were measured. The items were synthesized from the initial literature review by considering the extant studies listed in Table 4. The construct consisted of four candidate items which had more complex syntaxes and seemed to be double-barreled. Double-barreled expressions are commonly avoided in item creation since they might be considered psychometrically inadequate. This reason mainly arises from the difficulty to precisely pinpoint which facets respondents refer to and the difficulty to describe how respondents combine all the facets when generating their responses [44, 45]. However, longer and more complex syntaxes as well as multiple terms (or barrels) in one item have been used in certain cases. For example, [46], [43], and [47] use items which are relatively longer, more complex, and contain multiple items to assess new service development (NSD) culture ("*Our firm emphasizes its human resources and places a premium on high cohesion and morale in its new service development activities*"), task ambiguity in software development projects ("*During system development, to what extent can information be interpreted in different ways, which can lead to different but acceptable solutions?*"), and top management involvement in new product performance ("*Individuals and teams settled their own disputes and came up with ways to reconcile differing views or opinions that developed*"). In these cases, the items might appear to be double or multiple-barreled; however, they are usable because [45]: (1) the use of multiple terms in one item can be interpreted as one united idea; (2) particular items may require multiple terms for the idea to make sense and thus have to exist together. The use of multiple terms works as long as it does not make the main idea of an item confusing [45].

We consider equivocal situations as relatively complex conditions and since the studies which explore and examine equivocal situations in the context of IS/IT project evaluation are still limited it is important to define and construe the idea into these candidate items although they become seemingly longer and complex. In our case, when assessing whether the level of an equivocal situation was high or low, it is merely a concern whether the respondents considered only a particular facet existed or all the described facets existed together to a great extent or did not exist at all in the items.

Table 4. Candidate items

Item		Reference
CP1	Multiple stakeholders were involved in the development process of the project	Perceived complexity in software development [43].
CP2	The development process of the project involved a lot of integration with other systems	Information systems development project (ISDP) complexity [48]. Project complexity in new product development [49].
ST1	The concept of the IS/IT product was very novel	Concept complexity and novelty in the new product development [50].
ST2	The design of the IS/IT product involved the use of immature technology	Project complexity in software project risks [51, 52]. Innovation in black swan IS/IT projects [53].
CPM1	The project had NOT set out project milestones adequately	Project planning and project monitoring & control in software projects [54].
CPM2	Senior management did NOT control the project adequately in order to keep it on track	Requirement diversity in information systems development project [55-57].
CPM3	Ineffective communication among people in the project management structure	Project management in new product development project [58].
CPM4	The project charter, as a basis for managing the project, was vague	
LS1	Clear and well communicated criteria for go/no-go decisions and significant resource adjustments were set by the decision-makers (reverse)	Decision-making clarity in innovation projects [58].
LS2	The evaluation criteria were considered credible by the decision-makers (reverse)	Formal evaluation system in innovation projects [50].
LS3	A set of criteria to evaluate the project was agreed by the decision-makers (reverse)	Credibility and efficiency in innovation project proposal screening [59].
CES1	Changes in law, rules or regulations had a significant impact on the project	Organizational environment in software projects' risks [51, 52, 60].
CES2	Changes in organizational structure external to the project had significant impact on the project	Environmental volatility in new product development [47].
CES3	Politics had a negative effect on the project	
CES4	Resources were shifted away from the project because of changes in organizational priorities	
DFR1	The decision-makers had different backgrounds	Team diversity in software development agility [61].
DFR2	The decision-makers had skills and abilities that complement each other (reverse)	Senior team heterogeneity [62].
FEM1	A predefined procedure was applied to evaluate the project and to decide the next course of action (reverse)	Formal evaluation system in innovation projects [50].
FEM2	Evaluation techniques or tools were applied to evaluate the project and to decide the next course of action (reverse)	
LED1	The data used were accurate enough to evaluate the project (reverse)	Information systems users' satisfaction with the data [63].
LED2	It is difficult to evaluate the project effectively because some of the needed data were NOT available	Data quality in ERP implementation [64].
LED3	The data were at an appropriate level of detail to evaluate the project (reverse)	

Table 5. Candidate items (cont.)

Item		Reference
ES1	The project status or condition was hard to ascertain due to different interpretations among decision-makers of information surrounding the project	Environmental ambiguity in new product development [47]. Ambiguity in software development [43]. Information equivocality in organizational work units [65]. Perceived equivocality in text-based and multimedia representation [32].
ES2	Decision-makers lacked clarity and understanding of the condition of the project and thus were confused concerning the next course of action	
ES3	It was problematic to analyze the condition of the project since insufficient objective data was available to base the decisions on	
ES4	Decision-makers needed to exchange opinions, share meanings and beliefs toward the project to settle disagreement and reach consensus for the next course of action	

3.4 Instrument preparation

In the fourth stage, we created a draft of an invitation letter and developed an online survey based on the draft questionnaire. A feature of the online survey was prepared to monitor the distribution and to capture the response data of the respondents. We tested the online survey on colleagues from academia who have knowledge of the IS/IT field via a survey link. Each person went through the questionnaire and made remarks and suggestions after completion. Several of the remarks were mostly related to the flow of the questions and the estimated time to complete the survey. Notes were taken during the discussion to improve the easiness and the clarity of the questionnaire further. The questionnaire was comprised of two parts: the first part encompassed the questions used to investigate the equivocal situations and their causes as well as the decisions and the actual implementation of the projects; the second part questioned the respondents about themselves and their chosen projects. The questionnaire asked the respondents to recall a recent review or evaluation of a challenged IS/IT project they were involved in and to keep this one project in mind throughout the questionnaire. We mostly employed the 7-point Likert scales that typically range from (1) Not at all and (7) To a great extent, for each of the measurements. On acquiring the remarks and suggestions, several refinements were made to improve the survey, such as recasting the survey's main and section openings as well as adding questions related to the project and the respondent profile. We collected the responses of the pilot test after (1) sending an invitation to personal contacts; (2) sending and posting the invitation to several relevant LinkedIn groups; and (3) requesting IS/IT professional organizations to partake in our survey. Around 60 people had access to the survey and 33 respondents filled the survey in completely within two weeks, in November 2013.

We created a straightforward path model between equivocal situations and the categories of causes, giving a one-level relation. Each candidate item serves as a formative indicator of the eight categories of causes (the first-order constructs) since it represents a problem of equivocality, developed inductively from the prior stages, i.e., literature review and qualitative studies [66]. Each category of causes is conceived as a composite construct that pulls together different facets of equivocality problems under a common denominator; thus each category is expected to be affected by the items or indicators [66, 67]. It is also important to note that the items within each category cannot have the same number since they are uniquely identified from the prior stages. Moreover, we consider the equivocal situation (ES) as a reflective construct since the items are a manifestation of the construct and are interchangeable [68]. The eight categories of causes are posited to have a positive association with the degree of equivocal situation in IS/IT project evaluation. Eight categories of causes serve as the independent variables and the degree of equivocal situation serves as the dependent variable. Fig. 4 presents the proposed research model. We further assessed the instrument based on the data acquired in this stage using SmartPLS 2.0 (M3) [69].

Unidimensionality of the construct of equivocal situation with reflective indicators is required to show validity and reliability. Unidimensionality is tested using Cronbach's alpha with a threshold of 0.7 [70, 71]. The conditions for convergent validity to be met are shown by three aspects: (1) the indicator loadings for all items are significant and fulfill the 0.7 threshold; (2) the average variance extracted (AVE) fulfills the 0.5 threshold; and (3) the composite reliability score fulfills the 0.7 threshold [70, 71].

All the values of equivocal situations (ES) construct exceed the required threshold. The result shows the measurements were good quality. Furthermore, multicollinearity is a threat to the eight causes of equivocal situations using formative indicators. Multicollinearity is examined by inspecting the variance inflation factor (VIF) values, which should not exceed 3.3 [70-72]. The maximum variance inflation factor (VIF) for this test was 2.72. This suggests multicollinearity is not a problem. We further checked the correlations between the constructs; these were below the suggested 0.71 threshold [73], which suggests limited information concerning discriminant validity of the constructs [73]. Thus, we developed the application based on the described assessment further by adding respondents to increase the sample.

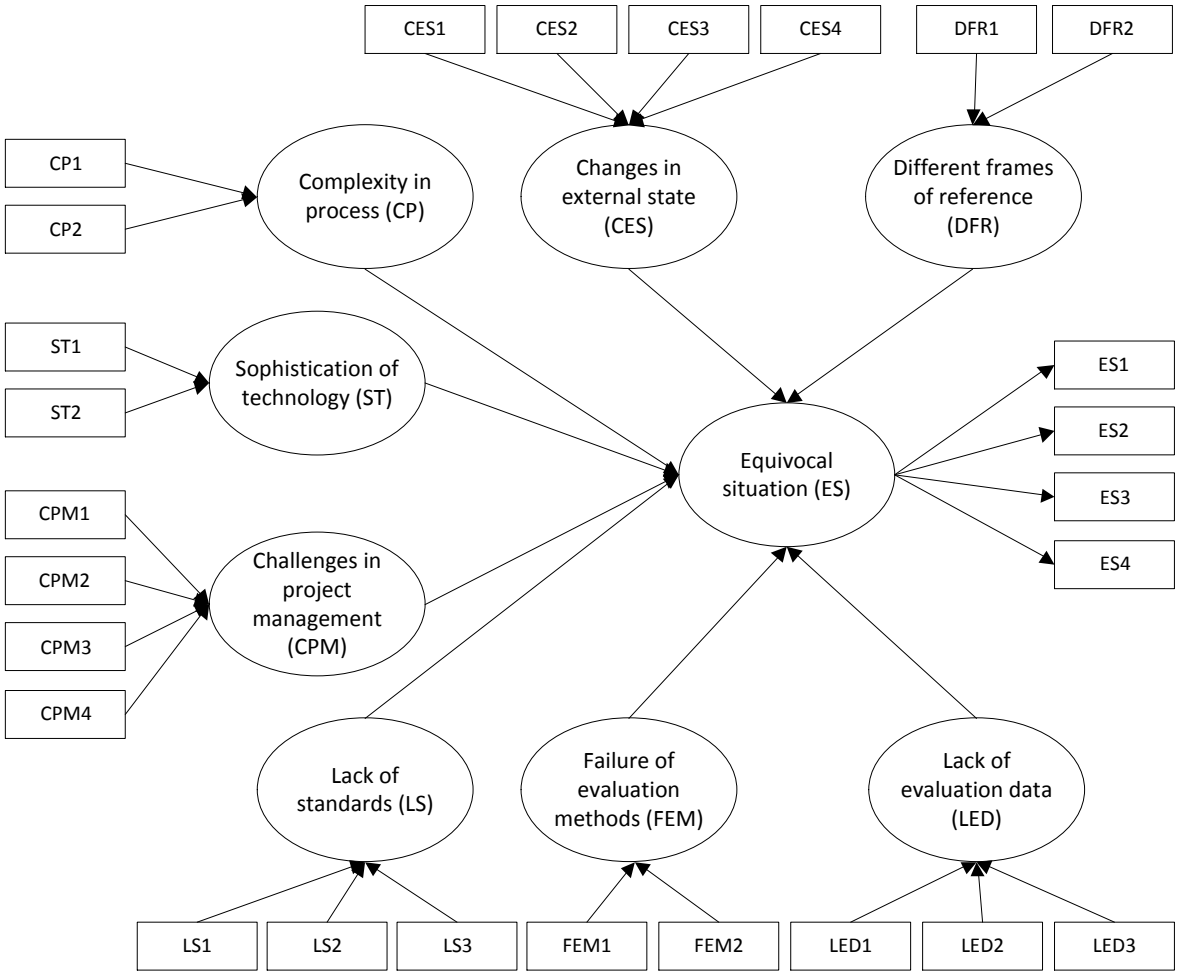

Fig. 4. Formative model of the causes of equivocal situation

3.5 Instrument application

In the fifth stage, we collected more data in a similar way to that described before, to acquire relatively quick responses and to keep the costs low. Two IS/IT professional organizations helped with our data collection by publishing the survey invitation on their website and sending it via newsletters. A total of 111 respondents partook in our survey within a period of seven months (January-July 2014). The profiles of the respondents can be described as follows: senior managers of IS/IT or CIO (23%), project managers (21%), IS/IT managers (19%), and the rest includes non-senior or non- IS/IT managers and other roles such as consultants, auditors, etc. The top three sectors in which the respondents worked were banking (financial) (16%), IT services (14%), and Government (13%). More than half of the respondents (52%) worked in a larger than average organization/industry.

Moreover, the profiles of the projects could be described as follows: the primary purposes are mostly strategic systems (19%) and business transformation (19%). The types of projects were: packaged software implementation (35%); in-house new development (30%); and enhancement of existing software/systems (15%). 69% of the projects were considered larger and 70% were of longer duration than other IS/IT projects undertaken by the organizations. Concerning the decision of evaluation, 18% of the projects had suffered total and substantial abandonment. 51% of the projects were categorized as escalated, and another 26 % of the projects were proceeding as planned. Around 40 percent of the projects were considered as not being over budget, 23% as not behind schedule, and 32% as not lacking requirements or required specifications.

We continued to utilize PLS with SmartPLS 2.0 (M3) [69] since it suited the nature of our study. This is a theory-building study and at an early stage we attempted to define the equivocal situations and to identify the causes and thereby to develop an instrument to measure them. The proposed research model, which includes a mix of reflective and formative measures, is also well suited to a PLS analysis [74]. We ran the PLS algorithm to re-examine the model. Regarding the reflective items, the ES4 had a loading below 0.7 (0.55); thus, we decided to drop the item. On doing so, the conceptual domain of the construct still remain intact given that reflective items are interchangeable [68]. Table 6 provides the loadings of the reflective items and the quality criteria of the reflective measure for the equivocal situation construct. We developed a matrix of latent variable correlations (Table 7) and generated the values of variance inflation factor (VIF) for the formative items (Table 8).

Table 6. Loadings and quality criteria for reflective measure

Construct	Item	Standardized Loading	AVE	Composite reliability	Cronbachs Alpha
Equivocal situation (ES)	ES1	0.81	0.67	0.86	0.75
	ES2	0.85			
	ES3	0.79			

Table 7 shows that none of the correlations are above 0.90 and below 0.71 [73]. The maximum variance inflation factor (VIF) is 2.69. There are two types of VIF in Table 8, i.e., the outer and inner VIF. The outer VIF shows the severity of collinearity among items within a construct; additionally, the inner VIF shows the severity of collinearity among constructs (latent variables) in the model [75]. Overall, the value of the VIF suggests that multicollinearity is not a threat in our study as might be suggested by a more restrictive VIF threshold, i.e., a value of 3.3 [70-72]. Table 8 also provides the weights, the outer loadings, and the statistical significance of the formative items. The weights of the items show the relative importance or contribution, and the relevance of the items to the corresponding constructs [75]. More than half of the weights of the items reported here are not significant; however, this does not indicate a poor instrument [75]. The outer loadings, which show the absolute importance or contribution of items to the corresponding constructs, are significant except for the CP1, ST2, and CES1 [75]. We opted to retain the three items this time despite less empirical support of their relevance. This was done to avoid compromising content validity of the constructs since the items stemmed from the prior qualitative studies.

Moreover, the ST2 and CES1 are negative but the correlations between items in the CES and ST constructs are all positive. Co-occurrence of negative and positive item weights may occur when a suppressor effect is involved [67]. High correlations occurred between ST1-ST2 (0.33) and between CES1-CES4 (0.33). The magnitude of the correlations among these formative items may invert the signs of these items [67]. The negative figures can be interpreted as: when all other items being equal, increased amounts of ST2 or CES1 reduce the degree of the corresponding constructs (i.e., ST and CES) [67]. Fig. 5 exhibits the proposed model with the item weights. The figure shows the weights for each item and their significance; however, it does not display the path coefficients and the coefficient significances. We limited the assessment to the formative and reflective measurement model since this is the primary objective of the paper. An assessment of the structural model is outside the scope of this paper.

Table 7. Latent variable correlations

	CES	CP	CPM	DFR	ES	FEM	LED	LS	ST
CES	-								
CP	0.29	-							
CPM	0.25	0.17	-						
DFR	0.24	0.18	0.36	-					
ES	0.36	0.20	0.58	0.42	-				
FEM	-0.09	-0.10	0.28	0.30	0.22	-			
LED	0.34	0.08	0.42	0.22	0.51	0.12	-		
LS	0.14	0.04	0.43	0.48	0.41	0.61	0.33	-	
ST	0.13	0.19	0.09	-0.02	0.19	-0.22	0.12	-0.11	-

Table 8. Variance Inflation Factor (VIF) and weights for formative measures

Construct	Item	Outer VIF	Inner VIF	Weight	Outer loading
Complexity in process (CP)	CP1	1.06	1.17	0.17	0.39
	CP2	1.06		0.95***	0.99***
Sophistication of technology (ST)	ST1	1.12	1.12	1.05***	0.97***
	ST2	1.12		-0.26	0.09
Challenges in project management (CPM)	CPM1	1.46	1.48	0.31**	0.75***
	CPM2	1.44		0.48***	0.79***
	CPM3	1.44		0.15	0.65***
	CPM4	1.27		0.42***	0.71***
Lack of standards (LS)	LS1	1.96	2.10	0.04	0.71***
	LS2	2.53		0.58*	0.95***
	LS3	2.69		0.46	0.92***
Changes in external state (CES)	CES1	1.13	1.29	-0.11	0.23
	CES2	1.24		0.11	0.51**
	CES3	1.13		0.11	0.39*
	CES4	1.33		0.94***	0.98***
Different frames of reference (DFR)	DFR1	1.00	1.41	0.41**	0.45**
	DFR2	1.00		0.89***	0.91***
Failure of evaluation methods (FEM)	FEM1	2.73	1.75	0.73	0.98***
	FEM2	2.73		0.32	0.90***
Lack of evaluation data/information (LED)	LED1	2.10	1.38	0.02	0.47***
	LED2	1.26		0.97***	0.99***
	LED3	2.05		0.03	0.45***

Bootstrapping results (n = 5000)
*Significant at the 0.10 level (two-tailed)
**Significant at the 0.05 level (two-tailed)
***Significant at the 0.01 level (two-tailed)

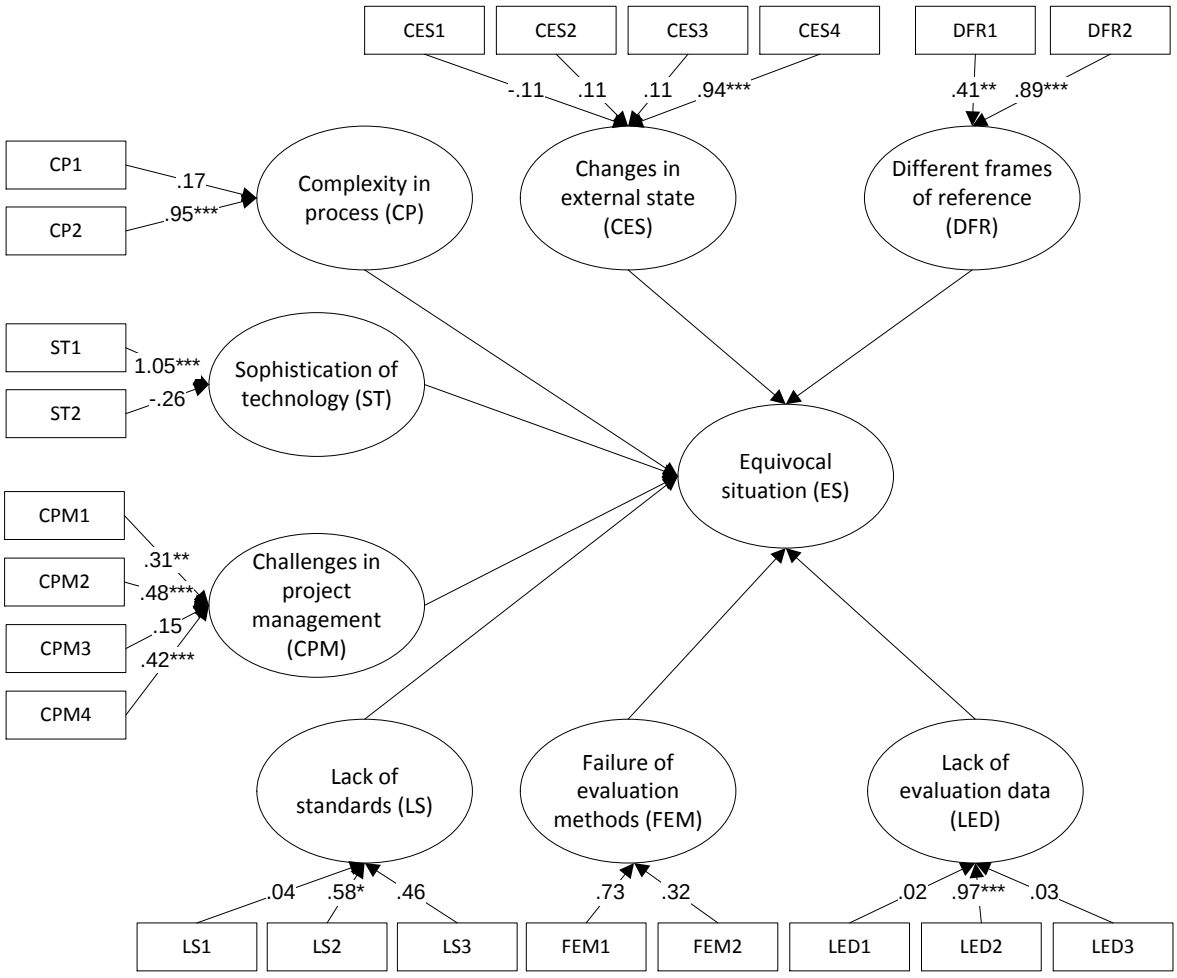

Fig. 5. Indicator weights of the model (N=111)

Furthermore, we utilized the importance-performance analysis by using a feature of SmartPLS 3.0 [76]. The matrix provides the impact of each distinct cause of equivocal situation on the equivocal situation construct (ES) and is a priority map for organizations to provide extra consideration and concentration to different areas of project management. The matrix plots potential causes which warrant improvement. Fig. 6 visualizes the relative performance and importance among causes of equivocal situations. To lessen the level of an equivocal situation, consideration should be given to aspects of high importance and performance. In Fig. 6, the X axis represents the total effect or the importance of the causes based on the impact of the causes affecting the equivocal situation. The Y axis represents the performance of the causes. To illustrate this, four clusters of equivocal situation causes can be made from the figures based on the similarity of their importance. The CPM (first cluster), which lies on the left side of the matrix, is portrayed as being the most important cause. The first, the second, the third, and the fourth cluster have a distinct impact on the occurrence of an equivocal situation. Extra consideration should therefore be given to CPM. In our case, a high performance score (Y axis) means more room for further improvement.

Within a cluster, attention should also be given to causes with a high performance (Y axis). DFR, ST, and CP are the causes which could be improved further by the organization to lessen the amount of equivocality in the project evaluation. For instance, a problematic situation due to Different frames of reference (DFR) may be improved by ensuring the capability of each decision-maker to collaborate and proceed with effective evaluation (DFR2).

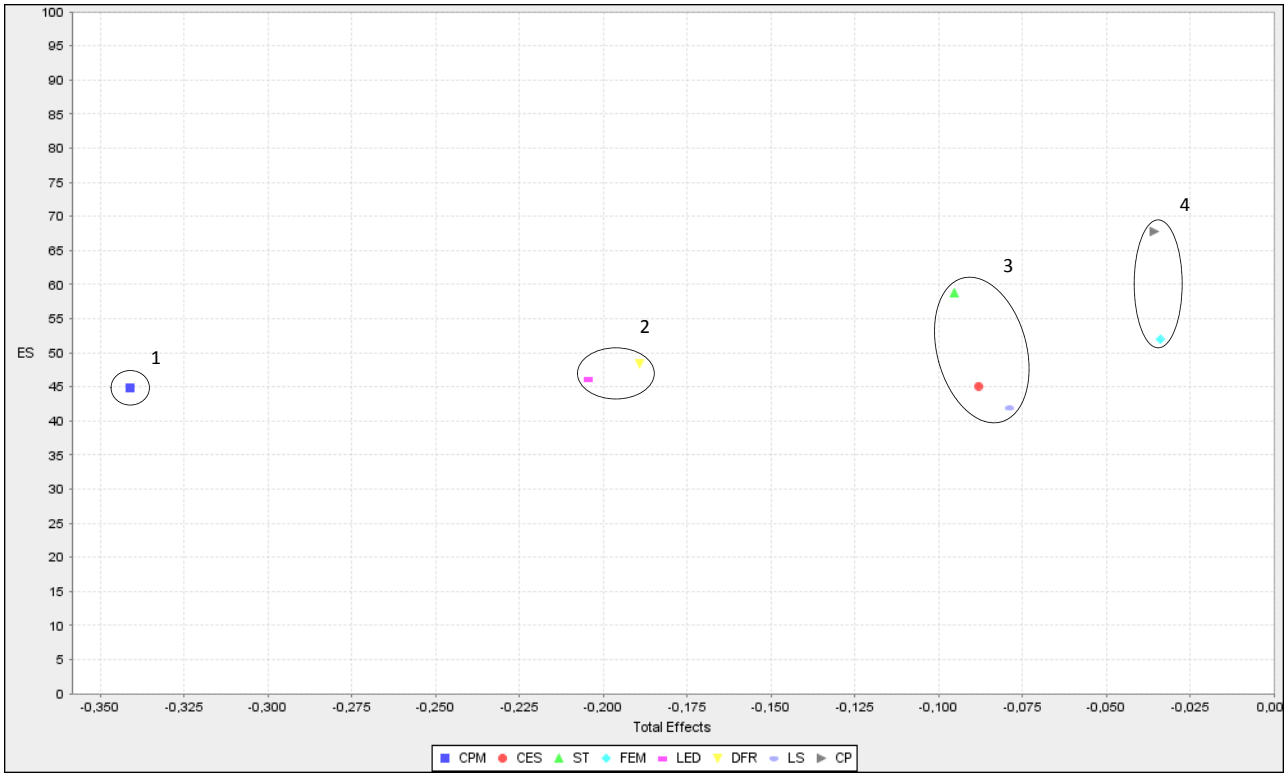

Fig. 6. Importance-Performance matrix

4. Discussion and limitations

Despite the importance of equivocality in affecting the continuation of IS/IT projects, antecedents of equivocal situation are not well established. In this study, we describe the development and assessment of an instrument to define equivocal situation and eight causes of equivocal situations in the context of IS/IT project evaluation. The stages of the instrument-development process provide a meaningful instrument that has been assessed thoroughly. In the exploratory domain, we examine extant literature to provide insights into the notion of equivocality and its causes. During the instrument development, we employ a qualitative method to corroborate and improve the developed constructs and items. To further enhance the instrument, we utilize Q-sorting exercises. After a pilot test, we apply the instrument by acquiring responses from knowledgeable practitioners in IS/IT project management practice.

This study contributes to current research by means of the development and validation of instruments to measure equivocal situation and its causes in IS/IT project evaluation. This study offers a conceivable description and explanation of equivocal situation and the causes of such a situation via emerging issues associated with: the complexity

of the process used to develop the IS/IT, the sophistication of the technology being developed, the challenges met when managing IS/IT projects, the dearth of criteria used to evaluate IS/IT projects, the dynamics of the environments surrounding the projects, the divergence of the decision-makers' frames of reference, the failure of evaluation methods, and the lack of evaluation data to support decision-making. Moreover, this study is of practical relevance for practitioners: the availability of a usable instrument to gauge their IS/IT projects execution and evaluation, and to forestall the occurrence of an equivocal situation. The gained insight from this study does not mean that extra devotion should be given only to the causes which have a high impact on the occurrence of equivocal situation per se. The knowledge of how the causes emerge from different issues of project management and are then translated into problematic situations (i.e., confusion and dilemma) should be looked at and worked on in detail. It will make practitioners more aware and will stimulate them to be critical about their current practice.

Nevertheless, this study entails some limitations. First, the composition of the constructs and items derived from the literature review and qualitative studies may not be exhaustive. Likewise, the constructs do not contain equivalent numbers of items due to the way we identify and derive the problems of equivocality. To a certain extent, this may influence certain causes with large numbers of items, as the impact on an equivocal situation may be greater. Second, the way we model equivocal situation and its causes may not be definitive and the way we specify the constructs is debatable. One should consider and compare other possibilities to model the relations. Third, we do not consider the heterogeneity of our sample. This may have limited the accuracy of the PLS computation and the result.

5. Conclusion and further research

The purpose of this study was to develop and assess an instrument to measure equivocal situation and its causes. The study contributes to extant literature on IS/IT project management literature by establishing the concept of equivocality in IS/IT project evaluation, identifying the causes, as well as developing an instrument to measure them. Further examination of equivocal situation and its causes can be warranted by considering alternative or competing ways to model the equivocal situation and its causes in the context of IS/IT project evaluation. This includes the possibility to improve the current model by constructing a hierarchical component model (HCM) or higher-order constructs. For instance, the formative-formative type IV model could be developed. According to [77], "*the formative-formative type model can also be useful to structure a complex formative construct with many indicators into several sub-constructs*". This is also beneficial to reduce the number of competing causes that connect to the equivocal situation construct by arranging the causes into theoretically-supported categories or groups [75]. Analyzing the heterogeneous groups within IS/IT projects (e.g., different types of information systems or technology) and extending the nomological network of other constructs associated with equivocal situation (e.g., evaluation decision) can be warranted as well. Furthermore, as around 41 per cent of the respondents were willing to discuss their answers to the questionnaire further, it merits post-hoc analyses of relationships among the constructs and on how the respondents coped with equivocal situations.

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SOA enabled ELTA: approach in designing business intelligence solutions in Era of Big Data

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Abstract:
The current work presents a new approach for designing business intelligence solutions. In the Era of Big Data, former and robust analytical concepts and utilities need to adapt themselves to the changed market circumstances. The main focus of this work is to address the acceleration of building process of a "data-centric" Business Intelligence (BI) solution besides preparing BI solutions for Big Data utilization. This research addresses the following goals: reducing the time spent during business intelligence solution's design phase; achieving flexibility of BI solution by adding new data sources; and preparing BI solution for utilizing Big Data concepts. This research proposes an extension of the existing Extract, Load and Transform (ELT) approach to the new one Extract, Load, Transform and Analyze (ELTA) supported by service-orientation concept. Additionally, the proposed model incorporates Service-Oriented Architecture concept as a mediator for the transformation phase. On one side, such incorporation brings flexibility to the BI solution and on the other side; it reduces the complexity of the whole system by moving some responsibilities to external authorities.

Keywords:
Big Data; Business Intelligence; BI; ETL; ELT; ELTA; SOA.

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1. Introduction

Companies are following different strategies in order to be competitive on the market, show permanent growth in generating revenue, increase return on investment (ROI) [1]. According to Porter [2], the advantages can be derived from following two aspects: operational efficiency and unique value creation for customers. Both aspects involved in building such enterprise structures and designing such business processes that function in a systemic and unique way.

In order to meet the two goals, operational efficiency and unique value creation, in most cases the business models and processes should become more complex and, because of such behavior, more performance power for systems is needed. However, not only system performance is important. According to the prior experience, the budgets of such projects originally dedicated more money for the hardware and software costs. However, the situation is changing and nowadays, hardware become less expensive than human sources, and we have situation in which we see the "people *versus* hardware" is contradictory in comparison with situation existed couple of decades ago - "computers were expensive and people were cheap" [3].

Therefore, discovering new value adding business process based on business historical behavior (extracted from data) to overcome competitors is emerging. Such efforts can be achieved with the support of business intelligence (BI). According to [4] current BI implementations suffer from several shortcomings:

- Missing focus on individual needs of particular analysts, analytical team or decision makers. These users are forced to rely on standard reporting tools and predefined analytical methods that often do not respond to all individuals and very case-specific needs. They strongly depend on either IT administration or own technical skills and IT expertise;
- The lack of information on business context level, such as definitions, business goals and company strategies as well as business rules and best practices for the provided analytical data. Hence, business users have to understand the semantics of data by themselves and take decisions besides deriving strategies using additional information sources (often may lead to an escalation of efforts and costs);
- Poor alignment between business and IT department. The setup and configuration of current BI systems requires deep insight in the data to be analyzed and the intended analytical tasks. Content and data models have to be provided in advance by the IT department and it must support the whole information in the decision-making process;
- The mean time for new BI implementations is between 3 and 6 months causing implementation and support costs to deter companies from having a wider BI deployment;
- BI solutions have a strong focus on structured, enterprise-internal data but lack the capability of integrating external and/or unstructured information in an easy, (near) real-time and effective way. Consequently, a lot of useful information is never included in the analysis. Not considering this information might provide a distorted or incomplete view of the actual world and consequently, it might lead to wrong business decisions.

Current work focuses on presenting a new approach for designing BI solutions. It will address the following goals: time reduction that is spent on BI solution's design phase, flexibility achievement in BI solution by removing "data agnosticism" and preparedness of BI solution to be used with big data. This research extends the existing ELT (Extract, Load and Transform) concept to an ELTA (Extract, Load, Transform and Analyze) one.

2. Background

2.1 Business Intelligence

Business intelligence systems support and assist decision-making processes. It is also taking part in the organization of strategic plans, which are normally addressing the achievement of management effectiveness. BI is defined as "a set of methodologies, processes, architectures and technologies that transform raw data into meaningful and useful information used to enable more effective strategic tactical, and operational insights and decision-making" [5]. Effective BI systems give decision makers access to quality information, enabling them to accurately identify where the company has been, where it is now, and where it needs to be in future. Despite the immense benefits that an effective BI system can bring, numerous studies showed that the usage and adoption of BI systems remain low, particularly among smaller institutions and companies with resource constraints [5].

According to [6], each BI system should have the following basic features:

- **Data Management**: including data extraction, cleaning, integration, as well as efficient storage and maintenance of large amounts of data;
- **Data Analysis**: including information queries, report generation, and data visualization functions;
- **Knowledge Discovery**: extracting useful information (knowledge) from the rapidly growing volumes of digital data in databases.

The most important feature to succeed in building BI solutions is to perform well on the stage of Data Management. Data Management is the foundation of any BI solution. It is usually the most stressing and time-consuming part. Nowadays, there are many companies offering their own solutions [7]. However, their applications do not assure that all necessary information in the decision-making process will be available. Rather than focusing on necessary information to build good solutions, most of these providers are focusing on the technological aspects. Such behavior is not satisfying real business needs, and not supporting the fact that there is not alignment between the business and technological domains.

2.2 Big Data

Big Data is entrenched term that is well understood by industry, academia and mass media. However, there are still debates about the exact meaning of this term. Historically, the first one who mentioned and used the term Big Data with its nowadays meaning were Weiss and Indurkhya in their publication [8]. Informally, Big Data is defined as the limitation of analytics and storage capabilities of standard data processing tools like database management systems. Nowadays, the majority of people involved into the process of working with Big Data understand it through its triple "v" concept: volume, velocity and variety. Volume states the fact of data processing limitations that are coming from huge size of data. Velocity argues that data input speed is also crucial, because data is generated and inserted into data storage on high speed. Variety states that data is coming from different heterogeneous sources (social networks, sensors, transactional data, etc.) [9].

Despite Big Data is kind of buzzword, the business cannot ignore it without losing competitiveness on the market. Datameer Inc. (2013) reported that the major goals for the companies to implement big data are [10]: increase revenue; decrease costs; and increase productivity.

Data and its knowledge extraction are too different things, but they cannot be separated. When data is stored, proper analytical methods must be applied in order to get value out of it. Mainly, there are two ways that are used to implement analytics over data: SQL and MapReduce [11]. SQL proved its applicability by the long and robust history of usage (more than 40 years). While MapReduce appeared less than a decade ago, it is already one of the most popular programming models to support complex analysis over huge volumes of structure and unstructured data. Multiple researches stated that SQL was not designed for current needs, and new models and ways, like MapReduce, should deal

with analytical challenges addressed in the era of Big Data. But, [12] and [13] showed that database management systems with SQL on board were significantly faster and required less code to implement information extraction and analytical tasks. However, the process of database tuning and data loading takes more time in comparison with MapReduce.

As was mentioned before, the major feature of Big Data are increasing revenue, decreasing costs, and increasing productivity. These three features are very desirable for any BI project. In the typical architecture of BI system, it is very common to have data warehouses with the whole information needed or even several data marts together to conform to the data warehouse, in this point.

The domain where the big data can be efficiently utilized is an optimization. In particular, game industry can use big data's triple "V" vision while understanding the background process of the ongoing game and optimizing data heavy process usually maintained in such companies. Game industry, especially during the last period saw a huge growth towards online game platforms. However, despite focusing more on online games, the goals of the game companies remains the same. They always tried to increase acquisition and retention of their customers (gamers) and improve monetization policies in order to generate more profit. In addition, one of the roads to follow to reach established goals is to improve satisfactory rate of their customers (gamers). Big Data can be handy for achieving such goals, for example, one of the possible scenarios is to bring together user profiles and game event logs to better understand users' behavior and interactional models during the game. Normally, the tremendous amounts of data generated by users' interactions are simply ignored, very rarely used to generate some information-based insights, or just stored "forever" to be processed "afterwards". Understanding such models can help to create better user experience for gamers and increase revenue for companies [10].

2.3 ETL vs. ELT

In a typical BI infrastructure, data, extracted from Operational Data Sources (ODS) are firstly transformed, then cleaned and loaded into a data warehouse. Before data are loaded into a data warehouse, it is necessary to process or perform a kind of "data wrangling" with the input raw data. For example, a data warehouse typically consolidates a multitude of different ODS with different schemas and metadata behind. Hence, incoming data must be normalized and brought into a common view, transformed if needed and then loaded. Also, the ODS may contain erroneous, corrupted or missed data, so the process of cleaning and reconsolidation are needed. This pre-processing is commonly known as Extract, Transform and Load (ETL): data are first extracted from the original data source, then transformed including normalization and cleansing and finally loaded into the data warehouse [14].

While database technologies used for data warehousing had seen tremendous performance and scalability enhancements over the past decade, ETL has not been improved in scalability and performance as database technology. As a result, most BI infrastructures are increasingly experiencing a bottleneck: data cannot be easily acquired to the data warehouse with necessary actuality. Clearly, in order to provide near real-time BI, this bottleneck needs to be resolved.

Costs of data storage were always a significant factor, but they are becoming cheaper with time, and as a result, analysis can be performed over bigger amounts of data with less investment. And in changing circumstances, former (but robust) Extract, Transform and Load approach cannot be easily applied to meet all business needs, which includes a strong desire to work with big data and, as a result, new approaches and/or architectural changes are needed. Main disadvantage of ETL is that data must be firstly transformed and only then loaded. It means that on transformation phase, mass amounts of potentially valuable data are thrown out. However, to eliminate drawbacks of ETL, latest improvement of storage techniques can be used. One of the approaches that addresses such challenges is called Extract, Load and Transform [15]. The basic idea is to perform the Load process immediately after the Extract process, and apply the Transformation only after getting the data stored.

ELT, in comparison with ETL, has these four advantages:

- The flexibility in adding new data sources (extract and load parts);
- Aggregation can be applied multiple times on same raw data (transform part);
- Transformation process can be re-adopted even on legacy data; and
- Speeding-up the process of implementation (usually, most of the time during the "data wrangling" is spent on the transformation).

According to [2] the competitiveness of the enterprise strongly rely on the time needed to perform decisions (will not be at least destructive for the business) and bring more added value. To make such decisions, BI solutions became "de-facto" standard. As long as time is considered a very important factor, it is crucial to design BI solutions in shorter period. One of the shortcomings, according to [4], is that the time spent on the BI solution's implementation phase causes increasing of costs and may lead to budget extension, replanting, and overall delay. The next shortcoming is that BI solution needs to be flexible in order to reflect environmental changes and adopt them in shorted possible period. Addressing flexibility of the BI solutions in the rapidly changing world can be treated as a sustainability factor for a smoother company development.

ETL process is not addressing flexibility in terms of reflecting environmental changes and therefore, classical BI solutions need vast amount of time to be implemented. The nature of ETL process is to perform *transform* operation immediately after *extract* operation and only then initiate *load* process. Such approach makes the data inserted into a data warehouse only during the last step. In contrast, ELT allows executing firstly the extraction and loading processes over data, and then applying the transformation on the consolidated data. *Transform* can be done "on demand" and multiple times if needed. Such nature is a very important goal for fast changing business models. Moreover, transformation with ELT can be applied and re-applied taking into account changes in business requirements. Based on the above reasons, it is more preferable to adopt Extract, Load and Transform (ELT) instead of Extract, Transform and Load (ETL) in BI solutions.

2.4 Service-Orientation

This section describes the service-orientation concept enabled by Web Service technology. Service-oriented Architecture can be referred to as a software architecture model that provides services to end-user applications, executable (business) processes, or to other services by means of published and discoverable service interfaces. The OASIS SOA Reference Model group defines SOA as follows: "Service Oriented Architecture (SOA) is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations" [16].

Business functionalities in SOA can be realized and implemented in form of self-expressed and reusable building blocks called services. These services:

- Provide high level business concepts representation;
- Can be published and discovered in a distributed network; and
- Can be reused to build new (business) functions and applications.

Service can be defined as "the means by which the needs of a consumer are brought together with the capabilities of a provider" where the service provider represents "an entity (person or organization) that offers the use of capabilities by means of a service" [16].

Several SOA implementations can be found in academia and industry. One of these implementations extended the concept of service-orientation with concepts of lightweight semantic enablement using Resource Description

Framework (RDF) statements to group Web Services based on predefined criteria. This implementation is called Semantic-enabled Enterprise Service-Oriented Architecture (SESOA) [17]. More detailed information about SESOA can be found in the following research papers: [18], [19].

In this paper, we will enhance the ELTA concept with the service-orientation concept that is similar to the one applied in SESOA in which the semantic service repository assembles services based on their business area. However, to achieve that, the transformation services have to be split into two groups to be integrated within the service repository provided in SESOA. These groups will be explained more in details in section 3.3.

3. The Proposed Model

3.1 Introduction to ELTA Model

This paper defines ELTA term as follows:

(a) A process called *Extract* enables data extraction from heterogeneous sources in different formats (transactional data, machine-generated data, etc.);

(b) The *Load* process provides the ability to store data inside dedicated storage systems;

(c) The *Transform* process provides the ability to transform data from raw state, on demand and according to the needs of decision-making process;

(d) The *Analyze* phase enables business users to efficiently utilize the preprocessed data to understand enterprise behavior through implementing and trying different analysis methods and algorithms over already prepared data.

Based on the approach proposed in [20], a framework to define an Enterprise Architecture (EA) as a solution foundation is required. There are various available EA frameworks. Among them, the Zachman Framework [21] is selected as a core EA framework. Zachman EA's major idea is that the same EA can be viewed by different people involved into a project from different aspects. Importance of particular aspect can be very high for a particular person and not considered as a critical one by other person or group of persons. This is because there is a different responsibility of each particular member. Besides responsibilities, the viewpoint is also highly depended on the expertise of each member, and the framework goal is to consolidate all expertise in most optimal and understandable way. However, Zachman framework lacks in modelling for detailed EA components and relationships among them and does not provide concrete implementing method. It is valuable in the point that it presents general framework that every enterprise can use to build its own EA [22]. Besides that, "the Zachman Framework is an ontology - a theory of the existence of a structured set of essential components of an object for which explicit expression is necessary, and perhaps even mandatory for creating, operating, and changing the object (the object being an enterprise, a department, a value chain, a solution, a project, an airplane, a building, a product, a profession, or whatever)" [23]. We are considering only the first four rows of the framework, which are defined as follows: strategy model; business model; system model; and technology model.

In accordance with what previously expressed and for better understanding, the proposed model is depicted as component diagram and it contains different packages. This model can be mainly divided into three packages with out-of-package component called "Analyze Component". As shown Fig. 1, the model consists of following packages: "External Data Sources", "Enterprise Architecture" and "Big Data Processing". Each package consists of different components. The package "External Data Sources" is consolidating external sources of data needed for further processing. All possible data sources can be included in this package and the main purpose of the package is to group data sources on a logical level. The package "Enterprise Architecture" contains components related to Zachman's framework implementation and it also contains "Balanced Scorecard" (BSC) as a separate component, because the output artefacts of the BSC are directly used by the "Analyze Component". The package "Big Data Processing" consists out of three independent components: "Data Storage"; "Service Repository" and "Virtual Data Marts". Component "Data Storage" is acting like "a single point of truth" or mediating for all types of data used in one single BI solution.

This component is dedicated to store raw data, perform "extract" and "loading" processes and also interacts with the other two components of the package through means of transformation process. The goal of the "Virtual Data Marts" component is to perform transformation "on demand" and pass (publish) the transformed data to the "Analyze Component". The "Service Repository" is acting like an intermediate transformer between raw data storage and virtual data marts.

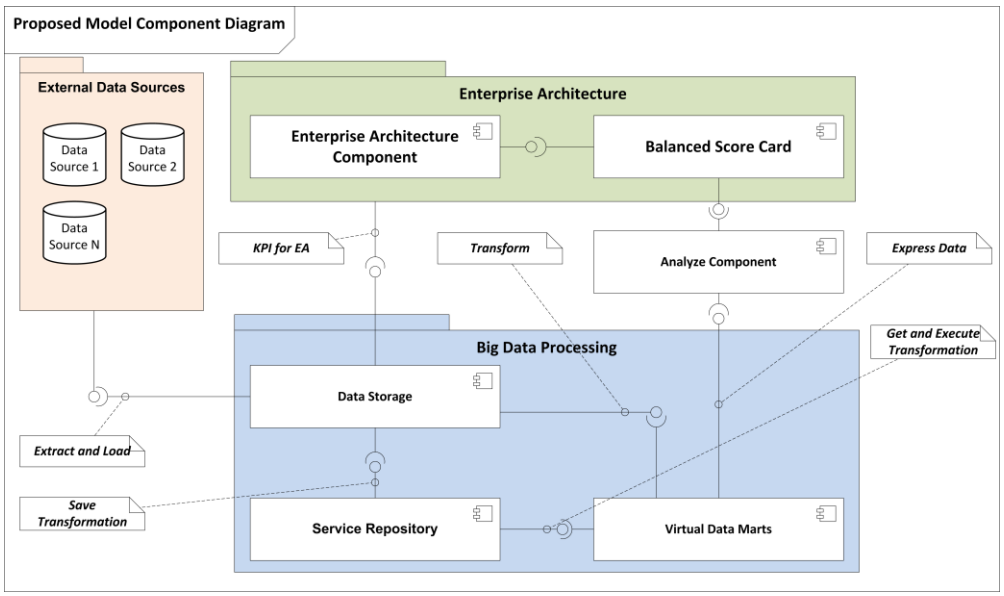

Fig. 1. Component Diagram Extract, Load, Transform and Analyze

3.2 Guideline

Guideline section consists out of seven steps: EA fulfillment; Extract and Load Processes; Management Control Tools; Transformation Process; Virtual Data Mart Layer; Develop BI System; and Analysis.

Step 1 EA fulfillment: According to the structure defined in [21], Zachman EA must be completed by rows, where each row represents a top level with respect to the one that follows in order. Nevertheless, there exists a big dependency among each of the elements of the columns. Table 1 shows the proposed dependencies between cells. The order in which cells must be fulfilled depends on the relationships and dependencies between them. The "*What*" column represents the modelling perspectives of EA. The "*How*" column represents the processes of EA. The "*Where*" column represents a location where the implementation should take place. The "*Who*" column addresses the organizational structure within the organization. The "*When*" column represents the timelines and time-related artifacts. The very first row named "Scope Contents" is more important for management rather that technical aspects. However, with each new row, the importance of the row for the technical level is increasing and the significance for the management level is decreasing.

Table 1. Proposed rules to fulfil Zachman EA

	What	*How*	*Where*	*Who*	*When*
Scope Contents	A1	B1	C1	D1	E1
Business Concepts	A2=(A1)	B2=(B1+A2)	C2=(C1+B2)	D2=(D1+B2+C2)	E2=(E1+A2+C2)
System Logic	A3=(A2+B2+C2)	B3=(B2+C2)	C3=(C2+A3+B3)	D3=(D2+C2+B3)	E3=(E2+B3+C3)
Technology Physics	A4=(A3)	B4=(B3+A4)	C4=(C3+A4+B4)	D4=(D3+A4+B4)	E4=(E3+D4)

Step 2 Extract and Load Processes: Based on the information defined in step 1, users can extract all necessary for business information from heterogeneous data sources and load it in data storage. The necessity of some particular piece of data or information is defined on the previous step of current guideline and it should be extracted from completed Zachman's EA. As long as data wrangling is not a trivial process for the business to be implemented, this step should be implemented by IT users.

Step 3 Management Control Tools: The main goal of this step is to define all necessary information for the decision-making process. The idea is to use data from data storage to create a new global indicator for the Balanced Scorecard perspective as described in [24]. This assures the reduction of the gap between strategic and tactical levels, because it is possible to know, how to link each indicators from different management levels and to improve the enterprise knowledge. Methodology as in [24] includes one step with Principal Component Analysis (PCA) [25] in order to discover the correlation among the whole indicators. This step should be performed by business users.

Step 4 Transformation Process: The main goal of this step is to properly transform all data based on the necessity of information for the decision-making process. Based on the data storage, which should be populated with data from external data sources through extracted and loaded processes and the indicators defined during step 3 of the current guideline, it is possible to know which transformations are necessary to support the entire business report requirement. This step should be implemented by IT users and stored in the service repository.

Table 2. Detailed description how to fill each cell of Zachman's EA

	What (A)	*How (B)*	*Where (C)*	*Who (D)*	*When (E)*
Scope Contents (1)	Create list of organizational entities related to the particular case	Create list of processes related to the particular case	Create list of geographical locations involved into particular case	Create list of organization units involved to the particular case	Create list of triggers and time loops involved to the particular case
Business Concepts (2)	Depict entities from the **A1** with Entity Relationship Model to demonstrate relationships	Model processes from the **B1** taking into account relationships from **A2**	Use locations from the **C1** and model them demonstrating **B2**	Create relationship model between roles from the **D1** taking into account results from **B2** and **C2**	Create events model using time elements from **E1** and taking into account **A2** and **C2**
System Logic (3)	Create data model diagram based on model from **A2** taking into account **B2** and **C2**	Describe processes verbally based on the **B2** and **C2** without referring to implementation	Describe locations verbally based on the **C2**, **A3** and **B3** without referring to implementation	Describe roles according to the types based on **D2**, **C2** and **B3** without referring to implementation	Describe events related to each other based on **E2**, **B3** and **C3** without referring to implementation
Technology Physics (4)	Specify on more detailed level data model diagram from **A3**	Describe processes using technology specific language based on **B3** and **A4**	Describe physical infrastructure components and their connectivity based on **C3**, **A4** and **B4**	Assigned roles and tasks on very detailed level based on **D3**, **A4** and **B4**	Describe events flows and states based on **E3** and **D4**

Step 5 Virtual Data Mart Layer: The main goal of this step is to define several virtual data marts in accordance with the business report requirements. In-memory approach [26] is used to accelerate creation and usage of data marts. Such solution is bringing more flexibility and unprecedented performance due to its in-memory nature. In this step, service repository is acting as a storage place of the previously designed and performed transformations. Using service repository brings an experience from older transformation activities to the newly created.

Step 6 Develop BI System: Based on the data marts, a structure is necessary to define the online analytical processing (OLAP) schema and business users' defined reports. There is a big variety of available tools for building BI solutions. One of the most popular solutions is Pentaho BI Suite [27]. Pentaho is popular due to its BI features and licensing policies. According to the authors experience, it is possible to achieve great flexibility in BI solution by combining Pentaho BI Suite with other tools like Birt Report [28].

Step 7 Analysis: The main goals of this step is to analyze most parts of the available information to support decision-making process and discover new patterns in the business by using data mining techniques, it will help in redefining the indicators in the Balanced Scorecard (in case it's necessary) and support the decision-making process. For this step, any external 3rd party tool like Weka [29], or integrated tool into the data storage component's analytical facilities, can be used.

3.3 SOA-enabled Transformations

The service repository component in the proposed model represents the component that is responsible of the management of transformation Web Service. This subsystem handles Web Service requests that are required to execute transformations coming from the processing unit component (where storing any kind of transformation or applying it during a process execution is needed). The processing unit is part of EA component in Fig. 1.

This component coordinates the storing of different types of transformation in form of Web Services. These transformation types are stored in the core database and the services that store these transformation types are published in the service repository. Furthermore, executing these transformation types is realized using another set of Web Services that are published in the service repository as well. The responses to the processing unit with the transformation services' availability and information are managed by service repository as well. This is done using the assemblage unit subcomponent that has an interface with the processing unit component to assist it in storing or executing transformations by responding with services' endpoints. It has another interface with the assemblage unit to ease the discovery and publication of storing and executing transformation services. Moreover, assemblages and Web Services information are stored in the core database via the DAO[1] interface between the assemblage unit and the core database. The internal architecture of this component is depicted in Fig. 2.

Fig. 3 provides an example on how to publish storing transformation services in the "Stored Transformations" assemblage.

As for executing the transformation services within the proposed model, the execution services are published in the "Transformation Execution" assemblage as shown in Fig. 4.

[1] DAO stands for a Data Access Object.

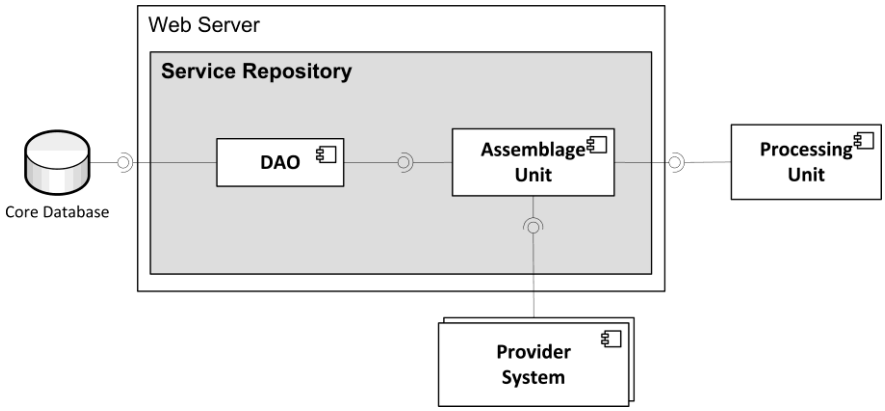

Fig. 2. Service Repository Component

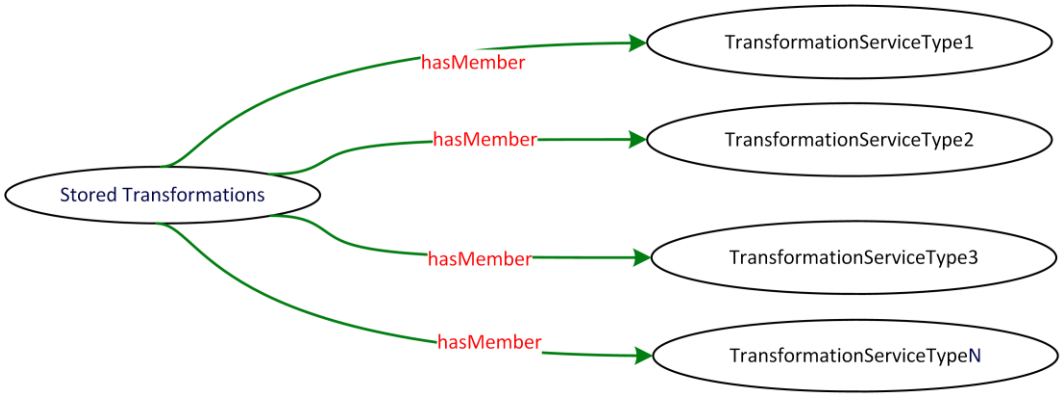

Fig. 3. Stored Transformation Services

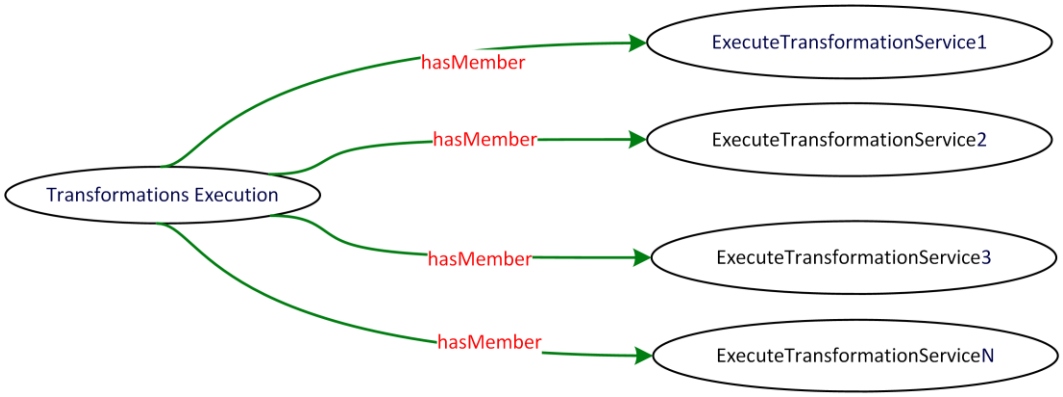

Fig. 4. Transformation Execution Services

In both transformation services, the graphs show that the relations between the transformation assemblages and services are represented using RDF[2] statements. In these statements, the transformation assemblages represent the subjects, the predicate is the "hasMember" relation, and the objects are one of the transformation storing or executing services.

4. A Banking Case Study

4.1 Description

For current case study, we are focusing on designing a new "data-centric" business service in the banking domain, and it is intentionally selected to be fully artificial and simple for understanding. The main parts that are covered by the current case study are the idea behind data-centric business product, the extraction and load processes besides transforming the big data storage's raw data and implementation of data marts after transformation. The rest parts like implementing BI system and performing complex analysis are left as "future work". While addressing the big data's 3Vs (**V**olume, **V**elocity and **V**ariety), it is important to select proper data sources. In the current case study, the following formats are used: relational, graph and log.

The description of the case study is as follows:

A bank came up with the idea to attract more clients and stimulate them to use more and more "services" offered by the bank. One way to attract new clients is by using already existing clients, however not in a way that the "other clients" will receive any kind of "spam" from bank. Rather to make it in a target-oriented style, by targeting just the proper clients. In order to meet the goal of targeting proper clients, data sources must be selected and huge amount of data needs to be analyzed. For this case, the following data sources are selected: user's social graph, user's transactional data and logs from the bank's Web server.

User social graph is used to understand new potential clients. *User transactions data* are used to understand the need of current clients and prepare good business offers. *Web server logs* are used to identify most active users and probably their interests in some products.

4.2 Application of the Proposed Model on the Case Study

Based on the guideline's *Step 1 EA fulfillment* (see Table 1 for general dependencies between different levels of the Zachman's EA and Table 2 for the detailed description of filling procedure), the next step is to perform extract and load operations.

Step 2 Extract and Load Processes is done with tools from Apache Hadoop software ecosystem [30]. In a particular case of the current case study, Apache Hadoop was selected as a staging layer for the raw data. Apache Hadoop is selected as it has its own cons and pros. The main reasons to select Hadoop as a central data-staging unit are:

1. the high scalability of its storage platform;
2. it is Fault-tolerance;
3. it is a de-facto standard for the big data world;
4. its cost effectiveness (open-source solution with active community; huge support from the major software vendors; utilization of commodity-hardware);
5. its diverse software components collections (very rich and dynamic software ecosystem) and
6. its ability to store and process variety number of formats.

[2] RDF is an official World Wide Web Consortium (W3C) Recommendation for Semantic Web data models and it stands for Resource Description Framework.

However, despite having many advantages, Apache Hadoop still remains a tool for batch processing and it needs additional workaround to be able to solve near-real time tasks. In the Apache Hadoop world, load operation can be performed in different ways. There are some standard loading routines and vendor-specific ones as well. However there are some tools which are used more often than others, for example Apache Sqoop [31] and Apache Flume [31]. Both tools have different application domains. The Apache Sqoop is designed to perform data load from structured databases. The Apache Flume was designed to mainly perform load of streaming and event based data. However in the current case study, a table and storage management layer for Apache Hadoop named Apache HCatalog [32] was used to perform data load process. Before loading data into big data storage, the extraction operation was performed. Due to the artificial nature of the case study, the extraction operation was replaced with data generation operation. Following sources of data (originally generated as csv files) were loaded into Apache Hadoop: (a) logs from Web server; (b) social graph; and (c) users' transactions.

Following the *Step 3 Management Control Tools*, meta-information about data staged in the Apache Hadoop was extracted and shared with the Enterprise Architecture level through an interface (see Fig.1) for further processing. As it was mentioned in the guideline, this step should be executed by the business user.

After having key performance indicators and understanding the necessary data needed for further processing, S*tep 4 Transformation Process* of proposed guideline advices to perform transformation. However, before executing transformation process it should be designed and stored inside repository. In particular case, we will have just tree transformation routines. Each routine transforms raw data into a structured form and prepare for further processing. For example, data that contains user's graph information are transformed into sparse-table format, data from Web server log are cleaned (groping repeated actions caused by "refresh" actions; removing information about image loading and expend fields with same IP address but different user activity), prune some of the details from transaction data.

S*tep 5 Virtual Data Mart Layer* suggests using an in-memory database to accelerate data accessibility. In current particular case study, SAP HANA is used as an in-memory database. It has multiple data process engines that meet the needs of online transaction processing (OLTP), OLAP, graph and text processing systems simultaneously [33]. As it is depicted in the diagram (see Fig. 1), the component "Virtual Data Marts" is accessing "Service Repository" component in order to get an access to the proper transformation routine. After getting from service repository the proper transformation operation and executing it, the result of the transformation is forwarded to the "Analyze Component" via a database table or a view inside SAP HANA. In current use case, the component "Virtual Data Marts" will create three tables with data from user's transactions, Web server logs and users' social graph. The structure of each table is dictated by the transformation itself. The data migration from Apache Hadoop during transformation is done with ODBC integration capability of SAP HANA. The last two steps in the guideline were not used for this use case.

5. Conclusion and Future Work

The situation with understanding benefits of using BI solution in the companies is far better than a decade ago. However, such understanding brought new challenges. For example, it is not enough for modern companies to implement a successful BI solution for making better decisions. It is also very important to make such implementations faster than the other ones in the BI market. Additional challenge to be considered in this context is the higher complexity of a particular process within companies. Nowadays, processes became tremendously complex, hard to maintain and not easy to support, extend and optimize. Such challenges should be faced and considered while offering a particular model, guideline or framework. In the upcoming era of big data, "data-centric" business services and processes of discovering new business strategies, based on historical behavior (mainly data), to achieve competitive edge over other competitors will play a huge role. Major factors succeeding in such completions is to prepare business IT solutions for the new "role-changing" requirements of the market. However, being successful cannot be achieved

only by fully applying new, modern and trending approaches and by neglecting robust and well-proved former techniques like BI. In such situation, it is more appropriate to modify or to prepare existing solutions for the market needs and benefit from the both robustness of well-proved existing techniques like BI and the promising advantages of the new approaches like big data. Our work presented ELTA (Extract, Load, Transform and Analyze) approach as one of such new approaches that can address the combination of business intelligence and big data by taking best parts from both, and in parallel, eliminating the disadvantages of business intelligence.
In future works, the proposed guideline will be enhanced with focus on the last two steps: *Step 6 Develop BI System* and *Step 7 Analysis*.

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