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Editorial

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.

It is our great pleasure to bring you the fourth number of the fifth volume of IJISPM. In this issue readers will find important contributions on assessment of business intelligence (BI) in public hospitals, virtual teamwork, Business Process Model and Notation (BPMN) to model Internet of Things (IoT) behavior, and cloud sourcing.

The first article, “An assessment of business intelligence in public hospitals”, is authored by Rikke Gaardboe, Niels Sandalgaard and Tom Nyvang. In this paper, DeLone and McLean's information systems success model is empirically tested on 12 public hospitals in Denmark. The study aims to investigate the factors that contribute to BI success. 1,352 BI end-users answered a questionnaire. A partial least square structural equation model was used to empirically test the model. The authors find that system quality is positively and significantly associated with use and user satisfaction, and that information quality is positively and significantly associated with user satisfaction. User satisfaction is positively and significantly related to individual impact. The other paths in the model are insignificant. The findings also provide empirical support for the role of user satisfaction as a mechanism that mediates the relationship between information quality or system quality and individual impact. User satisfaction is not only a critical construct in the information systems success model but it also serves as a mediator. Generally, the model finds empirical support, as it has a good fit and predictive value.

As Birgit Großer and Ulrike Baumöl state in the second article “Virtual teamwork in the context of technological and cultural transformation”, megatrends affect all individuals and organizations in our society. Mobility and flexibility are examples of megatrends that influence our everyday lives and also intensely alter the ways we work. The deployment of virtual teams meets the new chances emerging with these trends. Employees aspire to work virtually due to benefits, such as flexibility regarding the locations and hours for working. Organizations deploy virtual teams to remain competitive regarding new technological opportunities, employee retention and cost efficiency in an increasingly digital environment. Organizations can guide their change towards virtuality by building on the knowledge of practice as well as scientific insights regarding the deployment of virtual teams. In order to provide a holistic view on the structures and processes affected by such a change and thus provide guidance, a framework for analyzing and planning organizational change is adapted to virtual teamwork and presented in this paper. The framework shows that the deployment of virtual teams affects the whole organization. This comprehensive view on the implementation of virtual teamwork allows an integration of virtual teams and focusses on their performance. The adapted framework furthermore provides links for further in-depth research in this field.

The third article “Using BPMN to model Internet of Things behavior within business process” is authored by Dulce Domingos and Francisco Martins. Whereas, traditionally, business processes use the IoT as a distributed source of information, the increase of computational capabilities of IoT devices provides them with the means to also execute parts of the business logic, reducing the amount of exchanged data and central processing. Current approaches based on BPMN already support modelers to define both business processes and IoT devices behavior at the same level of abstraction. However, they are not restricted to standard BPMN elements and they generate IoT device specific low-level code. The work presented in this paper exclusivelly uses standard BPMN to define central as well as IoT behavior of business processes. In addition, the BPMN that defines the IoT behavior is translated to a neutral-platform programming code. The deployment and execution environments use Web services to support the communication between the process execution engine and IoT devices.

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As Björn Johansson and Mirella Muhic state in the fourth article "Relativism in the Cloud: Cloud Sourcing in virtue of IS Development Outsourcing - A literature review", Cloud Computing and Cloud Sourcing is on the agenda in many organizations. Many Chief Information Officers (CIOs) that urge for alternatives to traditional outsourcing are interested in how they can take advantage from Cloud Computing, by sourcing IT from the cloud. This paper provides an overview of the research direction of Cloud Sourcing in the Information Systems (IS) field. A literature review based on selected papers from top IS journals and conferences was conducted. Findings from the review indicate that the attention of Cloud Sourcing in IS literature has mainly been directed towards security and risk as well as adoption issues, and that Cloud Sourcing is claimed to be the next generation of outsourcing. Unfortunately, this is where this strong claim ends without any further evidence, which indicate that there is a need for more research on Cloud Sourcing, especially in the direction of investigating relationships and implications when organizations start using Cloud Sourcing.

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 80 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 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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An assessment of business intelligence in public hospitals

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An assessment of business intelligence in public hospitals

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Abstract:
In this paper, DeLone and McLean's information systems success model is empirically tested on 12 public hospitals in Denmark. The study aims to investigate the factors that contribute to business intelligence (BI) success. 1,352 BI end-users answered the questionnaire. A partial least square structural equation model was used to empirically test the model. We find that system quality is positively and significantly associated with use and user satisfaction, and that information quality is positively and significantly associated with user satisfaction. User satisfaction is positively and significantly related to individual impact. The other paths in the model are insignificant. Our findings also provide empirical support for the role of user satisfaction as a mechanism that mediates the relationship between information quality or system quality and individual impact. User satisfaction is not only a critical construct in the information systems success model but it also serves as a mediator. Generally, the model finds empirical support, as it has a good fit and predictive value.

Keywords:
IS success; evaluation; business intelligence; healthcare information system; quantitative method.

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1. Introduction

Business intelligence and analytics are increasingly important technologies for organizations. In many organizations, Information Technology (IT) managers prioritize investments focused on establishing or operating a technology infrastructure that is not only able to handle the increasing volume of data but also make that data accessible to analysts and decision makers [1]. One driver of this development is the desire of many executives to develop data-driven organizations [2]. According to Madsen [3], “data-driven” means that “information must be consumable and contextual, to encourage action that will modify behavior over time.”

One sector that generates large amounts of data is the healthcare industry owing to its need to meet requirements related to patient records, compliance, and patient care [4]. Therefore, use of business intelligence (BI) to data from healthcare information systems (HIS) is relevant. BI is an umbrella term that covers the applications, infrastructure, tools, and best practices that enable organizations to access and analyze information with the aim of improving and optimizing decisions and performance [5]. Notably, a study by Parente and Dunbar shows that healthcare organizations that use HIS have higher operating margins and total margins than organizations without HIS [6].

Healthcare is one of the most knowledge-driven and complex sectors in the world. In addition, the area represents one of the most significant economic challenges [7]. As such, BI has the potential to improve the quality, efficiency, and effectiveness of health services [8]. More specifically, Mettler and Vimarlund [8] suggest that, in the field of healthcare, BI can add value to patient services, marketing management, operational analyses, and personal development, as well as enhance financial strength. These authors also point out that real-time data is essential for improving the quality of healthcare services and decreasing the risk for patients. However, implementing and succeeding with BI is a complicated process [9], and BI technologies are expensive, given the costs associated with software, licenses, training, and wages [10]. Notably, many organizations fail to realize the expected benefits of BI [10–12].

In the Scandinavian countries, the majority of hospitals are funded and operated by the public sector. Private hospitals and privately funded health insurance account for only a small part of the industry. According to the Scandinavian welfare model, citizens have a fundamental right to proper care and equal treatment. A fundamental principle in this regard is that all citizens have a right to healthcare regardless of their social background, and healthcare benefits are not linked to health insurance or other forms of user payment [13]. Notably, however, the Scandinavian healthcare sector has been reluctant to use BI in conjunction with its data because of the complexity of such systems and the data itself [3]. However, in Denmark, the public hospitals use BI in combination with HIS, accounting, and payroll systems, and the users of BI have a variety of job functions (e.g., doctors, nurses, managers, administrative staff). In some cases, users have access to both the source system and BI, while the BI systems must be used to access certain types of information in other cases.

A theoretical issue that has dominated the information systems (IS) research for many years is IS success. The literature offers numerous definitions and measures of IS success [14]. DeLone and McLean introduced the IS success model, which consists of six constructs: system quality, information quality, user satisfaction, use, individual impact, and organizational impact [15]-[16]. Like the healthcare sector, the public sector has a significant amount of data and a complex system landscape [17]. Moreover, there are differences between IS evaluations in private and public organizations [18]. Most studies of IS success have been carried out in private organizations [14], while empirical assessments of IS success are lacking in the public sector [14]/ [19]. Consequently, research on IS success in relation to BI in the healthcare setting is needed and, for this purpose, DeLone and McLean’s model [15] is relevant. In this regard, our goal is to assess business intelligence success in public hospitals in Denmark. In this paper, we extend the paper presented at the HCIST 2017 conference [2].

We test DeLone and McLean’s IS success model on 12 public hospitals and their administrations. The article contributes to the subfield of "BI success," especially "BI success in public hospitals." The remainder of the article is organized as follows. In the next section, we present the IS success model, while we discuss our method in Section 3. In Section 4, we present the results, which are discussed in Section 5. The final section covers our conclusions.

2. Related literature and research model

2.1 Business intelligence systems

A wide range of BI systems can be found in organizations [20]. BI can be understood from both technical and business perspectives [21]. Technical definitions of BI focus on applications, infrastructure, tools, and best practices [5]. In such contexts, BI systems are often categorized as: (a) extraction-transformation-load (ETL) systems in which data are transferred from the transaction systems to the data warehouse; (b) data warehouses (DWs), which are databases for storing and aggregating data; (c) analytical tools, such as online analytics processing (OLAP), which enable users to access, analyze, and share the information stored in DWs; and (d) the presentation layer, which is the user interface [21].

The definitions that adopt a business perspective emphasize BI as concepts and methods aimed at improving decision making in the organization [22] and distributing "the right information to the right people at the right time" [23]. According to Bach et al. is the importance of BI related to; "…the generation of timely, relevant and easy to use information which will have positive impact on making better and faster decisions at different management levels."[51]. Wixom and Watson [24] define BI as "commonly used to describe the technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help users make better decisions." This definition implies that if BI is utilized to enhance decision making, it can affect the organization's performance.

A considerable amount of literature focuses on the value of BI. The general finding is that BI enhances organizational performance by accomplishing a goal, such as increasing revenue and productivity, or reducing costs [25]. BI also contributes to customer and employee satisfaction. A second discussion in the extant literature centers on the organizational impact of BI. In this regard, "impact" refers to "a state when organizations have achieved one or more of following outcomes: improved operational efficiency of processes; new/improved products or services; and/or strengthened organizational intelligence and dynamic organizational structure" [25]. Several researchers have shown that BI can have an impact on transforming business processes [26], minimizing mistargeted customers [26], enhancing organizational intelligence, and developing products or services [25].

In sum, the definition of BI contains technical, organizational, and individual perspectives. The technology makes it possible for system users to make better decisions. Against this background, behavioral change and, thereby, an impact on organizational performance occur.

2.2 Information systems success

A common method of assessing the success of information systems is DeLone and McLean's IS success model [27]. At the first International Conference on Information Systems in 1980, Peter Keen asked: "What is the dependent variable?" [28]. From 1980 to 1992, numerous researchers contributed to the debate with research on the dependent variable. Based on these contributions, DeLone and McLean prepared the IS success model. In his 1980 article, Keen also called for a theoretical foundation for IS research [28]. In response, DeLone and McLean chose to anchor their model in Shannon and Weaver's three levels of communication [29] and in Mason's information influence theory [30]. The model focuses on three levels: technical, semantic, and effectiveness [15].

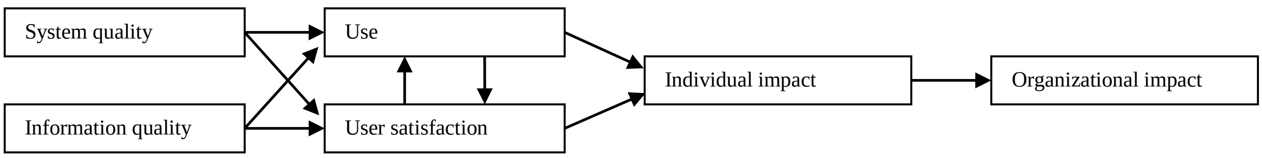

Fig. 1. IS success model [15]

Figure 1 illustrates the interrelated IS success factors. System quality and information quality characterize the IS. An end-user operating the system can experience various levels of satisfaction, which influence the individual impact. Finally, the individual impact affects the impact at the organizational level. According to the model, system quality occurs at the technical level, while information quality is on the semantic level. User satisfaction, individual impact, and organizational impact reflect the effectiveness of the system [15]-[16].

System quality measures the quality of the inputs and of the IS itself as a piece of software [31]. Petter, DeLone, and McLean [32] define system quality as the desirable characteristics of the system. Often, this aspect is measured in terms of ease of learning, ease of use, flexibility, and response times. Information quality refers to the quality of the information produced by the IS. It is an essential construct because the information user makes decisions based on the information provided by the IS [33]. The construct is typically measured in terms of understandability, accuracy, relevance, conciseness, completeness, understandability, currency, usability, and timeliness [32]. Use is defined as the manner and extent to which the staff utilizes the IS's capabilities [32]. According to Seddon [33], use is related to the benefits of the system [33]. The construct can be measured as the frequency of use, the nature of use, the amount of use, the extent of use, or the purpose of use [32]. User satisfaction can be defined as "the sum of one's feelings or attitudes toward a variety of factors affecting [a certain] situation" [34]. It can be measured as transactional or overall satisfaction. Transactional satisfaction is the satisfaction associated with an individual transaction, while a series of transactions give rise to overall satisfaction [35]. DeLone and McLean define individual impact as "*an indication that an information system has given a user better understanding of the decision context, has improved his or her decision-making productivity, has produced a change in user activity or has changed the decision maker's perception of the importance or usefulness of the information system*" [15]. The final construct in DeLone and McLean's IS success model is organizational impact, which measures the impact arising from the use of the system in terms of organizational performance [15]. This measure may focus on organizational costs, cost reductions, overall productivity, e-government, and business-process change [32].

DeLone and McLean encouraged other researchers to validate and further develop their model. Based on numerous contributions, DeLone and McLean then updated the model in 2003 by introducing three changes. First, individual impact and organizational impact were incorporated into a new "net benefits" construct to reflect the fact that IS success can affect workgroups, industries, and societies [36]-[37]. With this revision, the model could be applied to any level of analysis that a researcher found relevant [32]. Second, DeLone and McLean clarified the construct of "use." The construct "intention to use" was included in the updated version of the model because increased user satisfaction can increase the intent to use the system [32]. Finally, a "service quality" construct was added to the model. Pitt et al. [38] evaluated SERVQUAL from an IS perspective and suggested adding the construct to IS success. SERVQUAL measures the quality of the service delivered by the IT department [32]. The updated model is presented in Figure 2.

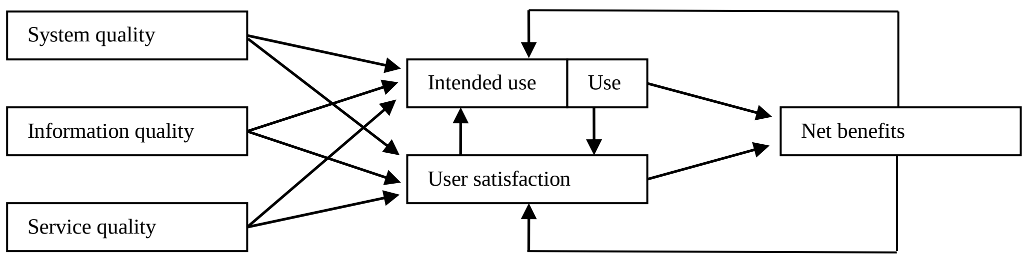

Fig. 2. IS success model [16]

In this paper, we analyze how to ensure success by applying BI to HIS. To do so, we use the 1992 version of the IS success model. Our aim is to evaluate the effects of the individual's use of the system rather than the impacts on the organization. Research has shown that assessing costs and benefits related to the system can be difficult because those benefits and costs cannot always be expressed in monetary terms [39]. Therefore, we measure individual impact. The organizational impact construct is excluded from the model because of the absence of quantitative data. Figure 3 presents the modified model in which the level of analysis is at the individual level.

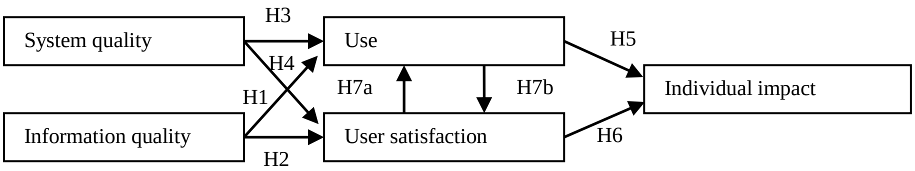

Fig. 3. Modified IS success model [16]

Below, we present our hypotheses, which are based on Figure 3. In other words, they are based on the individual level of analysis.

Direct effects:

H1: Information quality is positively and significantly related to use.

H2: Information quality is positively and significantly related to user satisfaction.

H3: System quality is positively and significantly related to use.

H4: System quality is positively and significantly related to user satisfaction.

H5: Use is positively and significantly related to individual impact.

H6: User satisfaction is positively and significantly related to individual impact.

H7a: User satisfaction is positively and significantly related to use.

H7b: Use is positively and significantly related to user satisfaction.

Indirect effects:

H8: Information quality has an indirect effect on individual impact through use.

H9: Information quality has an indirect effect on individual impact through user satisfaction.

H10: Information quality has an indirect effect on individual impact through use and user satisfaction.

H11: Information quality has an indirect effect on individual impact through user satisfaction and use.

H12: System quality has an indirect effect on individual impact through use.

H13: System quality has an indirect effect on individual impact through user satisfaction.

H14: System quality has an indirect effect on individual impact through use and user satisfaction.

H15: System quality has an indirect effect on individual impact through user satisfaction and use.

3. Methodology

3.1 Sample procedures

This paper is based on a survey of Danish public hospitals. The Danish public-hospital sector is organized into five regions. Each region is governed by a regional council composed of elected politicians, and the regions are funded by taxes. We collected data covering one of these regions. The focal region had more than 1 million citizens and around

25,000 employees. At the time of the study, the region used the Tableau BI system for several purposes, including follow-up on Key Performance Indicators (KPIs), resource planning, and different kinds of analyses.

The data were collected by sending out a questionnaire to employees at 12 hospitals in the focal region. Hence, the unit of analysis is the individual user level and not the organizational level. Only employees registered as users of the BI system were chosen to participate. First, a general email was sent out that explained the project and encouraged employees to participate. Then each respondent received an email with a link to the questionnaire. The questionnaire was prepared using an online survey program. The first question focused on whether the respondent had actually used the BI system. If the respondent answered "no," then no further questions were asked. The questionnaire was sent to a total of 4,232 employees, including members of management, nurses, doctors, and administrative staff. We sent a reminder two weeks after the initial distribution of the survey to encourage respondents to complete the questionnaire. In general, we followed the guidelines set by Dillman [40].

Of the 4,232 employees invited to participate, 1,351 responded, giving a response rate of 32%. Of these, 605 indicated that they did not use the BI system. This left us with 746 responses to be used for the data analysis.

Table 1 presents the measures used. In addition to the items listed in Table 1, the questionnaire contained questions requesting data not used in this paper, as the survey was part of a larger research project. In the questionnaire [BI] was replaced with the organization's term for BI for instance Tableau.

Table 1. Constructs and questions

Construct	**PLS identifier**	**Questions**
System quality	SysQua01	BI is easy to learn. [41]
	SysQua02	BI is easy to use. [17]
	SysQua03	The information in BI is easy to understand. [31]
Information quality	InfQua01	Data are displayed in a consistent format in BI. [31]
	InfQua02	The data in BI have high validity. [31]
	InfQua03	Other employees in the region also think the data in BI have a high validity. [31]
Use	Use01	What is the approximate share of your total work tasks that were solved using [BI] in the past month? [15]
User satisfaction	UseSat01	BI has all of the functions and capabilities I expect it to have. [17]
	UseSat02	If a colleague asked, then I would recommend BI. [42]
	UseSat03	Overall, how satisfied are you with BI? [17]
Individual impact	IndImp01	I can effectively make my reports using BI. [41]
	IndImp02	I can complete my reports quickly using BI. [41]
	IndImp03	I can complete my reports using BI. [41]

3.2 Measures used

Our measures, which are shown in Table 1, have all been used in previous studies. However, we translated the questions into Danish and ensured that they fit the specific context of our sample. The questionnaire was tested on three colleagues with knowledge of IS. In addition, we undertook a pilot study in another organization. In that study, 24 employees tested the questionnaire.

System quality was measured using three items based on the measures used by Lewis [41], Wang et al. [17], and Lee et al. [31]. According to Hair et al. [43], convergent validity is tested by looking at the loadings of the items in each measure, which should be above 0.7. All three items had loadings above the threshold. The average variance extracted (AVE) for system quality was 0.748, which is above the threshold for convergent validity of 0.5 set by Hair et al. [43].

The reliability of system quality was analyzed by calculating composite reliability and Cronbach's alpha. Both of these measures were above the threshold of 0.7 recommended by Hair et al. [43]. Furthermore, the Heterotrait-Monotrait ratio (HTMT) did not include the number 1, which indicates acceptable discriminant validity.

Information quality was based on the measure used by Lee et al. [31]. It consisted of three items rated using a five-point Likert scale. All three items had high loadings (above 0.7), which indicates good convergent validity. The AVE of 0.657 also supports this conclusion. Composite reliability for information quality was 0.851, while the Cronbach's alpha was 0.744, indicating good reliability. The HTMT did not include the number 1, which suggests acceptable discriminant validity.

Use was measured using one item asking about the share of the respondent's total work tasks that were resolved with the help of the BI system. The respondents were asked to indicate their responses on a five-point Likert scale. The measure was based on a similar measure developed by Delone and McLean [15].

User satisfaction was measured using three items. Two of the items were based on Wang et al. [17], while the third had previously been used by Batenburg et al. [42]. The item focused on the respondent's willingness to recommend the system. All three items had high loadings (above 0.85) and the AVE for the measure was 0.809, indicating convergent validity. The composite reliability of 0.927 and Cronbach's alpha of 0.882 indicate high reliability. The HTMT did not include the number 1, which suggests acceptable discriminant validity.

Individual impact was measured using three items based on Lewis [41]. All of the items had high loadings (above 0.80), and the AVE was 0.762, which indicates good convergent validity. With a composite reliability and a Cronbach's alpha of 0.906 and 0.844, respectively, the reliability is also satisfactory. As the HTMT did not include the number 1, discriminant validity also appears to be acceptable.

4. Results

The fifteen hypotheses were tested based on DeLone and Mclean's model [15], as illustrated in Figure 3. The tests used smart PLS (version 3.2) with 5,000 bootstrap replications. Even though our sample was sufficient in size to use covariance-based structural equation modeling, we used the PLS approach because it makes no distributional assumption. As our measure of *use* was not normally distributed, we found PLS to be the most appropriate approach. The results from PLS-SEM are shown in Table 2.

Table 2. Results

		Model 1		Model 2		
	Hypothesis	Coefficients	P-value	Coefficients	P-value	Results
H1	Information quality -> use	-0.019	0.657	-0.008	0.839	Not supported
H2	Information quality -> user satisfaction	0.234	0.000	0.234	0.000	Supported
H3	System quality -> use	0.193	0.000	0.219	0.000	Supported
H4	System quality -> user satisfaction	0.565	0.000	0.560	0.000	Supported
H5	Use -> individual impact	0.015	0.528	0.015	0.522	Not supported
H6	User satisfaction -> individual impact	0.746	0.000	0.746	0.000	Supported
H7a	User satisfaction -> use	0.045	0.331	-	-	Not supported
H7b	Use -> user satisfaction	-	-	0.023	0.335	Not supported

In the model there is a mutual influence between user satisfaction and use, which leads to a test of two models. In Model 1, user satisfaction is the predictor of use, while the reverse is true in Model 2. In both models, 56% of the variance in individual impact is explained (R^2). The R^2 for user satisfaction is 51.5% in Model 1 and 51.4% in Model 2. The p-values are less than 0.001 for all of the hypotheses listed as “supported” in Table 2.

Information quality is positively and significantly associated with user satisfaction ($p < 0.001$) but not with use. System quality is positively and significantly associated with user satisfaction and with use ($p < 0.001$). User satisfaction is positively and significantly associated with individual impact ($p < 0.001$), but the hypothesis about a relation between use and individual impact is not supported. The mutual relation between user satisfaction and use is not supported.

We also assessed the effect size, which is referred to as f^2 [43]. To do so, we follow the guidelines provided by Cohen [44]. In Model 1, information quality has a medium effect on user satisfaction of 0.234 and no effect on use. System quality has a substantial effect of 0.565 on user satisfaction and a medium effect of 0.193 on use. User satisfaction has a low effect on use of 0.045. User satisfaction has a large effect of 0.746 on individual impact, while use does not affect individual impact. In Model 2, information quality has a medium effect of 0.234 on user satisfaction and no effect on use. System quality has a large effect on user satisfaction of 0.560 and a medium effect on use of 0.219. Use has a low effect of 0.023 on user satisfaction. User satisfaction has a large effect of 0.746 on individual impact, while use does not affect individual impact.

In Models 1 and 2, the indirect effects of user satisfaction and/or use are evaluated. In both models, information quality has significant and positive indirect effect on individual impact through user satisfaction ($p < 0.001$), and system quality has a significant and positive effect on individual impact through user satisfaction ($p < 0.001$). This finding provides empirical support for the role of user satisfaction as a mechanism that mediates the relationship between information quality or system quality and individual impact. In all cases, the mediator effect is complementary partial mediation, and the indirect effect and the direct effect are both significant and in the same direction [43]. The values are shown in Table 3.

Table 3. Results of specific indirect effects in the model

		Model 1		Model 2		
	Hypothesis	Coefficients	P-value	Coefficients	P-value	Results
H8	Information quality -> use -> net benefits	0.000	0.834	0.000	0.913	Not supported
H9	Information quality -> user satisfaction -> net benefits	0.174	0.000	0.175	0.000	Supported
H10	Information quality -> user satisfaction -> use -> net benefits	0.000	0.714	-	-	Not supported
H11	Information quality -> use -> user satisfaction -> net benefits	-	-	0.000	0.895	Not supported
H12	System quality -> use -> net benefits	0.003	0.556	0.003	0.543	Not supported
H13	System quality -> user satisfaction -> net benefits	0.422	0.000	0.418	0.000	Supported
H14	System quality -> use -> user satisfaction -> net benefits	-	-	0.004	0.366	Not supported
H15	System quality -> user satisfaction -> use -> net benefits	0.000	0.708	-	-	Not supported

Another relevant measure is the predictive relevance (Q^2) of a dependent construct. If the value of Q^2 is higher than zero, it indicates the path model’s predictive relevance for the dependent construct [43]. In Models 1 and 2, the Q^2 is above zero in all cases. According to Hair et al. [43], the standardized root mean square residual (SRMR) is relevant if PLS is used for theory testing. A value of less than 0.08 indicates good fit. In both models, the SRMR is 0.075.

5. Discussion

This study set out to empirically test DeLone and McLean’s IS success model in a public hospital setting. The results of this study show that user satisfaction is an essential construct in the IS success model. System quality is positively related to user satisfaction (H4), which is similar to findings described in Iivari [19], Tona et al. [14], and Wang and Liao [17]. We can conclude that employees in public hospitals will utilize BI more if the system is easy to understand and use. This is not surprising, but one should keep in mind that those who use BI in hospitals (i.e., nurses, doctors, and medical secretaries) are not typical BI users [45].

Our finding of a positive and significant relationship between information quality and user satisfaction (H2) is consistent with previous research (e.g., [14]/[17]/[46]). Furthermore, we find that information quality has a medium effect on use. In relation to data collection, respondents were provided with our email addresses, and some sent additional comments after the data had been collected. In addition, respondents were given an opportunity to comment in the questionnaire. In their comments, respondents generally highlighted areas of dissatisfaction with BI rather than aspects that worked well. This echoes the experience of Tona et al. [14]. Some users were unsure of data availability because they could not match the BI system with the source system (such as HIS). This may be a validity-related problem or it may be that the calculation methods in the two systems differ. Other users found that the data sets were incomplete and, therefore, difficult to use. This user type was generally excited to work with BI, but this group’s data needs had not been met. The result was that they were somewhat unsatisfied. The last user type found BI challenging to use because it was only relevant to a small part of their job. In other words, these users did not regularly rely on BI. As mentioned above, many different employee types use BI in this context, ranging from administrative staff to management to health professionals. Therefore, perceptions of user-friendliness can differ.

Surprisingly, we found no relationship between information quality and use (H1) in either Model 1 or Model 2. Therefore, our findings indicate that an improvement in information quality does not lead to more use of BI. These findings are consistent with those of Tona et al. [14], while Iivari [19] found a relationship between information quality and use at $p < 0.1$. Moreover, McGill et al. [47] measured intended use instead of use and did not find a relationship between information quality and use.

Our study did find a positive and significant relationship between system quality and use (H3). These results are identical to Tona et al. [14] and Iivari [19]. If the BI system is easy to use and understand, then users will utilize it more. There are several possible explanations for this relationship. Of all of the items about system quality, users gave the item "The information in BI is easy to understand" the highest rating. Subsequently, users found the system "easy to use" and "easy to learn." It is not surprising that users rated system quality high, as the focal region used Tableau. In 2017, Gartner undertook a survey about which BI system was easiest to use. The results of that survey pointed to Tableau as one of the best [48], together with QlikView and Microsoft. Another explanation could be that the region focuses on ease of use by encouraging, for example, user involvement and work with personas in the development and maintenance of the system. Therefore, one possible explanation may be the combination of BI tools and the way in which the region chose to implement and maintain its BI solution.

In this study, the relationship between use and user satisfaction, and vice versa, is insignificant (H7a and H7b). Rodan and Leal [49] derived the same finding. Against this background, Rodan and Leal [49] proposed using intended use instead of use. Another possible explanation is that BI was implemented less than two years prior to the start of the study. According to Pick [50], the use of the system over time increases user satisfaction. This explanation is also supported by the fact that the results for H5 are insignificant, which implies that there is no relation between use and individual impact. In other words, our findings indicate that more use does not lead to a higher impact. This is equivalent to Iivari's [19] finding. In their 2003 article, DeLone and McLean's [16] emphasize that a relationship exists between use and individual impact when use is voluntary. In our study, the use of the BI system is mandated, as there are several KPIs and statistics that cannot be analyzed with the help of other systems. This might explain the lack of significance.

We find a significant and positive relationship between user satisfaction and individual impact (H6), which is consistent with several studies [14]/[19]. This can be interpreted as follows: if the BI system's capabilities support users' needs, then users will experience the benefits of using the technology. Another interesting finding is that user satisfaction serves as a mediator between the two quality constructs and individual impact. Moreover, user satisfaction, which is an attitude, plays an essential role in the IS success model, as there are not only significant and positive relationships, but the construct also functions as a mediator. At the same time, use (i.e., behavior) is not significantly related to individual impact. Although there may be other explanations, the fact that it is a mandated system implies that management can instruct employees to use the system to resolve tasks, regardless of the quality of the information or the system.

6. Conclusion

In this paper, DeLone and McLean's [15] IS success model is tested in relation to the BI used in 12 public hospitals. The model is partially confirmed. In the study, eight direct relationships are tested along with eight indirect relationships including one or two mediators. Four direct relationships were significant at $p < 0.001$: information quality and system quality are significantly and positively related to user satisfaction; user satisfaction is positively and significantly related to individual impact; and system quality is positively and significantly related to use. The other paths are insignificant. The largest effects are the effect of system quality on user satisfaction and the effect of user satisfaction on individual impact. Moreover, user satisfaction has a mediating effect on the relationship between system quality and individual impact, and on the relationship between information quality and individual impact. Therefore, information quality, system quality, and user satisfaction are essential elements in relation to achieving individual impact. Use does not play the same role, probably because the use of BI is mandated in the focal region. The study also shows that the model has a good fit and predictive value.

Although the study is based on many respondents and validated questions, we highlight several limitations that should be addressed in future research. First, this study is based on Danish public-sector hospitals using a universal BI system. Two comments must be made in this regard. Denmark has a central public register. In principle, this means that all personally identifiable data can be combined if allowed by law. Moreover, the hospitals are managed according to the principles of the Scandinavian welfare-state model. This model is not necessarily transferable to, for example, private hospitals. Therefore, the IS success model must be tested on other BI systems, and on both private and public hospitals in other countries.

Another limitation is that the "use" construct is not fully explained in the model. As mentioned above, this may be because the use of BI is mandated in this context. Use is a behavior that can be determined to a certain extent by management, while the key construct of user satisfaction is an attitude that can only be controlled by the user. This aspect should be addressed in future research. In addition, it may be relevant to use other independent variables, such as task compatibility, user characteristics, BI experience, level of education, and job features.

Third, the study only measures the impact on the individual level. Therefore, it may be useful to measure the effects of BI when used for HIS at an organizational level. There may be situations in which the individual user does not experience an impact, but there is still an impact on the organization.

Finally, the model was validated using quantitative data supplemented with users' own comments. A better understanding of the circumstances of BI success could be gained through the use of qualitative methods.

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Virtual teamwork in the context of technological and cultural transformation

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Abstract:
Megatrends affect all individuals and organizations in our society. Mobility and flexibility are examples of megatrends that influence our everyday lives and also intensely alter the ways we work. The deployment of virtual teams meets the new chances emerging with these trends. Employees aspire to work virtually due to benefits, such as flexibility regarding the locations and hours for working. Organizations deploy virtual teams to remain competitive regarding new technological opportunities, employee retention and cost efficiency in an increasingly digital environment. Organizations can guide their change towards virtuality by building on the knowledge of practice as well as scientific insights regarding the deployment of virtual teams. In order to provide a holistic view on the structures and processes affected by such a change and thus provide guidance, a framework for analyzing and planning organizational change is adapted to virtual teamwork and presented in this paper. The framework shows that the deployment of virtual teams affects the whole organization. This comprehensive view on the implementation of virtual teamwork allows an integration of virtual teams and focusses on their performance. The adapted framework furthermore provides links for further in-depth research in this field.

Keywords:
Virtual teams; teamwork; change management; integrated framework; megatrends.

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1. Introduction

Mobility and connectivity are only a few examples of megatrends in the context of digitalization that extensively alter society with its individuals and its organizations[1]. Almost all organizations, from start-ups to so-called incumbents such as large industrial enterprises, are affected by these trends that constantly require changes. As a consequence, they need to address these changes by adapting their structures and processes in order to remain competitive and strengthen their value creation. Daimler e.g. evolved from an automobile manufacturer to a "mobility service provider"[2] and actors in the medical sector embrace big data drawn from connectivity for unprecedented possibilities of disease analysis and prediction[3].

These megatrends introduce change into people's everyday lives and open up ample opportunities but also challenges regarding e.g. mobility, technology use, and flexibility. Mobility directly increases through technological innovations, e.g. high speed rails. But technological solutions paired with cultural adaptions also have an indirect effect on mobility. Communication tools support social bonding and relationships across large distances (e.g. Skype, Instagram) and remote working is enabled through secure communication channels (e.g. VPN clients). These examples also present changes in technology use which rapidly transformed over the last decades. This change process has not yet stopped, but still seems to accelerate. Virtual worlds emerge that are inhabited by millions of players (e.g. World of Warcraft, Final Fantasy online), television is more and more replaced by streaming on demand for home and mobile devices (e.g. Netflix), daily errands are settled online (e.g. banking, purchasing tickets and consumer goods) and people embrace these products and services by tending to be "always-on".

Considering this current technological evolution and progression, respective changes can be assumed to intensify in the next years and decades. Future generations of employees currently growing up with increasing virtuality in their everyday life may show an easier adoption of virtual work environments [1]. Even though the current employees are socialized with face-to-face communication, as well as the "normality" to see, touch and feel results and products of their work, the changes in products and production, organizational structures and processes already affect this current workforce and will for sure affect future employees. People, as employees of these organizations and also in their everyday lives, adapt to and at the same time influence these changes. As a symptom and also driver of virtualization, the occupational profile of "digital nomads" evolved over the last years [2], being paradigmatic regarding the requirements and wishes of the current and upcoming workforce: the longing for flexibility and freedom, the affiliation to a fluent and dispersed group replacing the former continuity of traditional workplaces.

The deployment of virtual teams (VTs) is recognized by organizations and research to meet many of these facets of societal and technological evolutions. Virtuality as a driver for change in organizations impacts work-environments. But virtuality can also be a result of change. Technological innovations, inducing new ways of communication and mobility as well as triggering cultural trends, result in extensive opportunities to virtualize, e.g., work related processes. Therefore, virtuality in work environments as well as in other areas of people's lives and existing and emerging information and communication technology (ICT) can be regarded as interdependent. Several factors influence the relevance of virtual teamwork for practice as well as for research. Organizations now have the opportunity to introduce technological solutions into the work environments that match the technology use of the potential employees' everyday lives. This helps to meet the requirements of the employees concerning the work environment as described above. Due to the high demand for qualified employees also new ways of acquiring and retaining employees emerge. One way for organizations to remain competitive on the labor market is offering a work environment that provides flexibility of time and workplace. The adaption of virtual teamwork is supported by technological and societal changes and appears to be

[1] https://www.zukunftsinstitut.de/dossier/megatrends/
[2] https://www.daimler.com/innovation/digitalisierung/digitallife/
[3] https://www.medica.de/cgi-bin/md_medica/lib/pub/tt.cgi/Daten_sammeln_Daten_nutzen_%E2%80%93_Vom_Segen_der_Datenberge.html?oid=84248&lang=1&ticket=g_u_e_s_t

relevant for employee retention [3]. Moreover, well-known cost-related factors, such as saving on travel costs and real estate for office space, can be addressed.

Current research on virtual teamwork focuses on a variety of perspectives. As a consequence, available results provide answers to many very specific topics, such as leadership of VTs [4] and employee motivation for VTs [5], as also shown by literature studies [6]. But an integrated view on VTs, derived from comprehensive analyses of organizations and scientific insights on structures and processes of organizations deploying VTs, are still open for research. Results derived from such comprehensive analyses are fundamental for providing guidance for organizations and for understanding drivers and interrelations in the field of virtual teamwork.

The goal of this paper is thus to present a holistic organizational framework of structures and processes regarding the deployment of VTs as result for change. This framework can serve for analyzing organizations, guide organizational change when introducing or enhancing virtual teamwork and the teams' performance as well as for planning new organizations or organizational units that are supposed to include virtual teamwork.

As first steps, we analyzed existing organizations that are mainly based on virtual teamwork in a case study analysis [3] in order to provide insights on structures and processes. We additionally performed a literature review on current knowledge on VTs in scientific literature [7]. Both works serve as foundation for this paper and their results are thus referred to in the respective sections.

Table 1 shows the components of this paper and the procedure of the associated knowledge creation.

Table 1. Components and procedure

Component of framework adaption process		Implementation and section
1.	Research question	How do the processes and structures manifest for organizations deploying virtual teamwork? Section 2, section 3.
2.	Conceptualization	The scope includes organizations with various degrees of virtuality in teamwork. A concept for virtual teams, a suitable framework and the state of the art are derived in section 2.
3.	Synthesis of insights	The framework is adapted to virtual teamwork along the results of the case study analysis and literature review in section 3.
4.	Conclusion and agenda	The main results, limitations and links for further research are given in section 4.

2. Conceptualization

Numerous definitions of VTs exist, serving the diverse research focuses of current studies in the field. In order to define a concept for VTs for this paper and as a proposition for future research, definitions of VTs are synthesized in section 2.1, resulting in a precise yet conveniently simple concept for VTs [8]. A framework that is applied for analyzing the integration of VTs is described in section 2.2, providing a fundamental understanding of organizational structures and processes that are to be taken into account when implementing virtual teamwork. The procedure and results derived throughout a comprehensive literature study [7] are shown in section 2.3, providing scientific insights for the subsequent adaption for the framework (section 3).

2.1 Virtual teams

Teams differ from groups, as team members share a mutual goal and act towards achieving it [9]. Teams can furthermore be distinguished from virtual communities that do strive towards a mutual goal but are usually not bound to a specific organization, such as a company. Teams can be distinguished between virtual and traditional teams. Teams that work completely virtually only interact via ICT and their members are geographically dispersed, often even worldwide, and they furthermore communicate and perform their tasks asynchronously. The sole occurrence of both criteria, asynchronicity and geographic dispersion, is sufficient to define a team as virtual [8]. The two contrasting types of teams present opposing endpoints of a continuum [8] as shown in Fig. 1. Most teams in organizations and especially those teams performing knowledge related tasks can nowadays be defined as VTs to a certain extent, being located somewhere along this continuum.

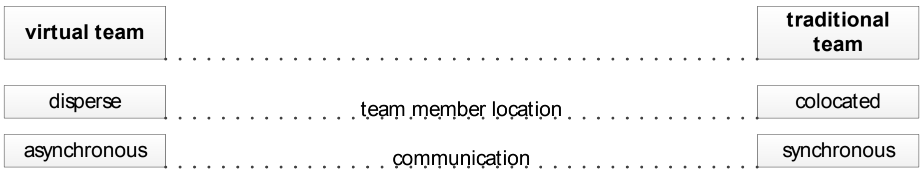

Fig. 1. Degree of virtuality [3]

VTs always rely on ICT to a certain extend. The application of ICT ranges from communication via email and local data storage in rather traditional teams to innovative virtual solutions such as three dimensional virtual environments (3DVEs) and the deployment of avatars.

Other dimensions besides asynchronicity and geographic dispersion that are found to correlate with team virtuality are proposed by literature [6] and shown in Fig. 2 below.

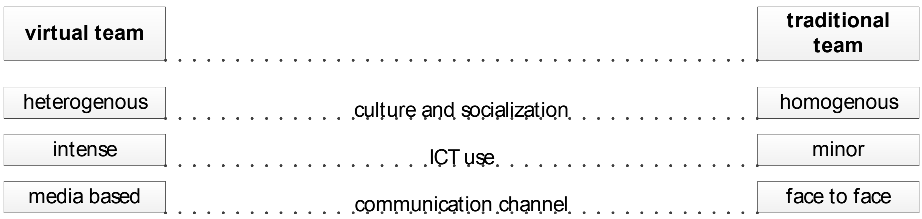

Fig. 2. Dimensions of virtual and traditional teams [3]

We therefore define a VT for this study as a group of geographically dispersed people working together in an organizational work environment using ICT.

2.2 Framework

A framework is used in order to provide an integrated overview of structures and processes for organizations deploying VTs. The application of the framework following described allows providing a holistic view on the relevant structural components and processes of organizations and has been validated by case studies [3], [10]. As this framework can also be used for planning organizational change of an existing organization [11] or even during the planning phase of a yet to be realized enterprise, it was selected over other frameworks, such as the business model canvas. Even though other frameworks allow building a comprehensive image of the analyzed organization, the selected framework provides a focus on change and addresses the strong interrelatedness of the organization's components [12]. The framework applied for this study provides this holistic view on an organization with respect to the governance and context it is embedded in [12], [13], [14] from an information systems perspective. The framework consists of various connected layers. As the functional layers are regarded to be co-dependent, the strategy influences the realized processes, the processes influence which technology is used and vice versa. The layers regarding culture, leadership, etc. are also intertwined and provide the environment for the embedded functional layers. Fig. 3 shows the framework with functional layers on the left side and emotional-culturally-oriented layers on the right side, embedded in governance and the context for the organization. The term "governance" used here covers two perspectives: first of all the performance management of the organization and secondly legal and ethical regulations and guidelines [12]. The context includes all factors that are relevant for the design of the embedded layers, e.g. trends and norms, which are not aspects of the following drivers [12]. The arrow entering from the top illustrates the drivers triggering change regarding internal and external factors as well as innovations of ICT.

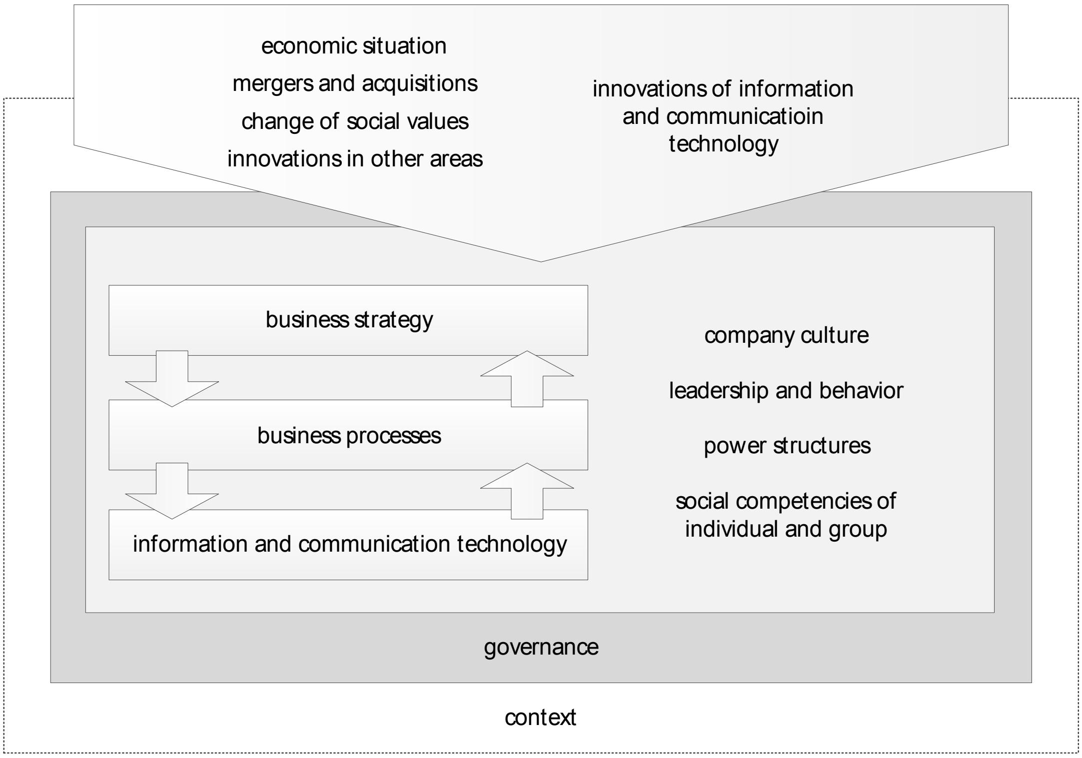

Fig. 3. Framework for analyzing organizational structures and processes [12]

The framework will be adapted for organizations deploying virtual teamwork (section 3) along the properties of VTs (section 2.1) and the results of the literature review regarding factors influencing the performance of VTs (section 2.3).

2.4 State of the art

In order to define the state of the art regarding the factors influencing the performance of VTs, we performed a structured literature review [7]. The results of the literature review show if the insights offered by research are in line or contradictive and present a contribution by synthesizing the insights and providing an overview. The goal is thus to understand what factors influence the performance of VTs and what impact a team's degree of virtuality and the ICT used have on this performance. Even though an interdisciplinary approach from the perspectives of sociology, psychology, informatics and information systems research allows a comprehensive analysis of virtual teamwork, this literature review from an information systems research perspective provides intriguing insights as a first step.

The literature review is positioned as shown in Table 2. In order to provide an overview on existing research, the focus of the study is on research outcomes and the case studies taken into account provide insights on practices and applications of virtual teamwork. The goal of the literature review is the extraction of performance factors as explained above. This goal is addressed by the integration of results and identification of central issues. A neutral representation is aspired by carrying out a structured and transparent study. The coverage can be regarded as exhaustive with representative citation, as a broad search using several databases is performed. The analysis of the results is performed along conceptual categories that are derived from defining the topic, as shown below. Specialized and general scholars and practioners are addressed as audience, as this literature review can serve as link for further research and provides ideas for practical deployment of VTs.

Table 2. Positioning of literature review following the taxonomy by Cooper [15]

Characteristics	*Categories*				
focus	research outcomes	research methods	theories	practices or applications	
goal	integration	criticism	identification of central issues		
perspective	neutral representation	espousal of position			
coverage	exhaustive	exhaustive with representative citation	central citation	representative	central or pivotal
organization	historical	conceptual	methodological		
audience	specialized scholars	general scholars	practioners	policy makers	general public

The following databases and conference proceedings were searched regarding peer-reviewed articles: EBSCO, Business Source Complete, eBook Collection, AISeL and IEEE. The HICSS proceedings were additionally studied regarding the minitrack specialized on virtual teamwork. Only papers with full text availability were taken into account and news articles, blog articles and other not peer-reviewed results were excluded from the search. Regarding the time span, a peak in quantity was found around 2011 and 2012, followed by fewer articles in 2013. A first analysis revealed that the studies from 2014 to 2016 mainly built upon the findings of this era including and updating its insights. Therefore, only papers from 2014 until 2016 were selected as final sample [7]. Further research could include research from other fields, as for this study from an information systems research perspective, articles from the fields of psychology, sociology, etc., were not taken into account, excluding databases such as PsychINFO and SocINDEX.

The search terms were derived from the goal of the literature review and are shown in Fig. 4. Education was excluded from this study as study groups and other teams in the educational context are assumed to strongly differ regarding their goals and obligation compared to teams in an organizational context.

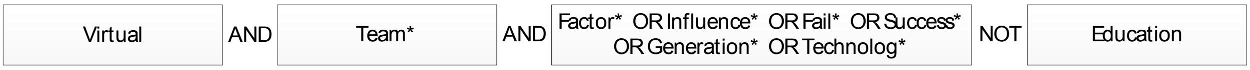

Fig. 4. Search terms and their combinations [7]

The following Table 3 summarizes the process of the paper count. The final set of findings consisted of 30 research papers.

Table 3. Paper count

Literature search	Number of findings
Initial database search	265
After title and abstract check	65
AISeL, IEEE and HICSS proceedings	23
Preliminary count	88
Backward search and recommendations	14
Preliminary count	102
Final count for 2014-2016	**30**

From the definition of VTs (see section 2.1) we derived six categories for structuring and analyzing the papers. These categories present lines of research and each paper was assigned to one category, regarding its main focus. The first category subsuming comprehensive case studies was added after a first review [16]. The categories and numbers of assigned papers are [7]:

1. Examples of implemented VTs presented as *case studies*: 3
2. *Communication* patterns or information processing: 5
3. *Distance* in time, space or culture: 3
4. *Goal* comprehension and shared mental model: 3
5. *Group* properties and individual traits: 5
6. *Management* and roles: 5
7. Use and properties of information and communication t*echnology*: 6

Fig. 5 shows the main results of the literature review. Factors that influence the performance of VTs were extracted for each of the seven categories. These are described below and in further detail, providing all source information, in [7].

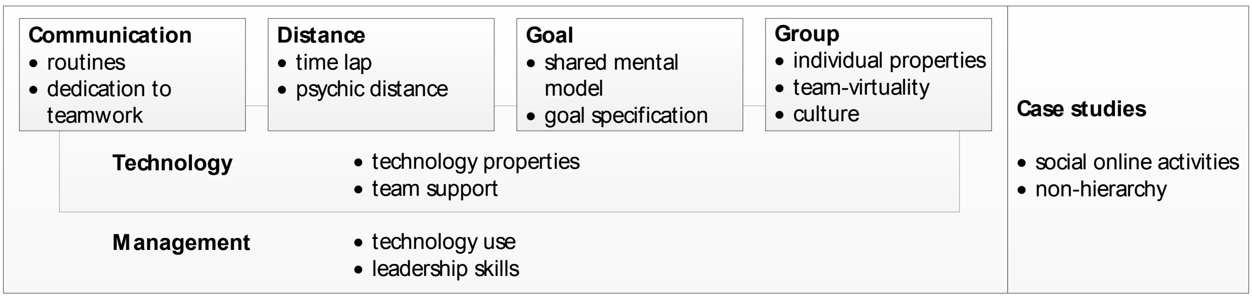

Fig. 5. System of factors influencing the performance of virtual teamwork [7]

The factors that were extracted from the *case studies* address social bonding in VTs as this is regarded to impact the performance and work results of teams. Isolation of team members or groups by means of a traditional hierarchical system should be avoided also for not discriminating employees from certain regions [10]. Non-work-related activities should be introduced. These activities should not require the employees to travel but be realizable online. Examples from organizations are yoga-classes [17] and games [18].

VTs rely on *communication* via ICT even more than rather traditional teams that also use ICT for some knowledge transfer. Some technical solutions exist that support informal and dynamic conversations in VTs [19] but for most VTs routines and standards are regarded as crucial for supporting a successful communication and thus performance. Even though there are no guidelines offered by research yet for these routines and standards that fit all VTs, several aspects can be applied for supporting communication. These aspects concern the when, how and what kind of ICT to use [20], [21], [22]. The second factor that seems to be vital for team communication is a fundamental dedication to teamwork by the team members. This also applies for traditional teams, but communication related behavior appears to need more support in VTs than in traditional teams. Behavioral aspects that are concerned are e.g. dynamics in group discussions and the appreciation of different positions by team members [9], [23], [24].

Research addressing the effects of *distance* in VTs presents the two factors, time lap and psychic distance as main factors influencing the performance of VTs. Time laps are typical for asynchronous work, usually as a result of employees working together geographically dispersed across time zones. This leads to challenges regarding teamwork and communication [25] but also provides chances, as interdependent tasks can be executed consecutively, even exploiting a whole 24-hours work-cycle. Psychic distance as second factor addresses cultural barriers that occur increasingly when team members are socialized differently, by e.g. generation, region and language. The psychic distance can be tackled by social interactions as described above. Also psychic distance can be regarded as chance to increase performance when it is handled with care and approached by creating an open and trustful atmosphere [9], [22], [26].

The factors in the category *goal* are a result of the two aforementioned categories, communication and distance [7]. Extensive and structured communication is needed in VTs to achieve a mutual and precise understanding of the collective goals. Therefore the team members should be guided to obtain a shared mental model regarding the goals as such [9], [27], [28] as well as the processes and structures to achieve these goals [29].

Individual properties, team-virtuality and culture were extracted as factors regarding characteristics of the *group*. The affiliation to a certain generation with its technological and work socialization is a relevant individual property influencing the performance within a team. Having the skills to work in a team again appears to be more important when the team operates virtually [30], [31], [32]. The analysis of generational impacts on the performance of VTs opens links for future research on VTs [1], [6]. Cultural factors have positive and negative influences on the performance [32]. Challenges that occur regarding disparities in culture in VTs are also found to be a chance for increasing performance [22], [33]. The degree of virtuality of teams impacts structures and processes of the teamwork and how it is embedded in the organization. Decision making processes e.g. require to be adapted for VTs [32], [34].

The *management* also needs adaption regarding planning and leading VTs especially concerning the technology use of the management and the management skills as such. Besides focusing on a good technology-task-fit for the employees, the management is also required to adapt to virtual teamwork and the use of virtual management tools [28], [34], [35]. An innovative adaption could even be, to replace managing employees by surrogates [36]. Besides technological skills, it is also essential that management and leadership are trained for working with VTs, regarding cultural and social intelligence [18], [25], [33], control, motivation etc. [28], [34], [35], [37].

Regarding the last category, *technology*, two main factors influencing performance are proposed by research, technology properties and team support. Both factors are strongly intertwined with factors from the aforementioned categories due to the continuous and fundamental support of VTs by ICT. Norms for the technology should be established on the one hand [38], while still being open for individual preferences on the other hand [25]. The design of the deployed ICT is also vital for the performance, therefore feature richness should be provided and for highly virtual teamwork [39], 3DVEs are found to be promising [40], [41]. Regarding a proper team support, ICT should serve the reduction of conflicts, the integration of team members [38], [39], [42] and the realization of all processes needed, e.g. documentation, innovation, and communication [23], [25], [41].

These insights by research are synthesized with properties from examples of organizations that implemented and strongly rely on virtual teamwork [3], resulting in an adapted framework as follows.

3. Organizational framework for integrating virtual teams

The framework for analyzing and guiding successful change [12] is adapted regarding the integration of virtual teamwork and described in the following. Propositions are derived for pivotal results.

The drivers, illustrated in the arrow shape in Fig. 6, present a holistic view on the various changes that are met by deploying virtual teamwork in an organization. Internal changes that are addressed by deploying VTs are e.g. the lowering of travel and real estate costs. Direct labor costs can be either lowered by including a workforce from regions with lower salaries or can rise, if the employees required are rare and highly skilled. Changes affecting the organization’s constitution are e.g. the innovative restructuring of departments for the deployment of VTs and the new foundation of respective start-ups. The drivers concerning changes of social values also address changes in the workforce, not regarding potential customers as in the original framework [12]. The changes leading to virtual teamwork affect several aspects of internal organizational culture as well as societal culture and generational effects that also have impact on expectations towards employment, as shown above (section 2.3). Innovations in external areas that serve as driver to deploy VTs are e.g. the increasing mobility of people, the custom to be “always-on” and the worldwide interconnectedness. Innovative technologies that induce change in organizations are e.g. new opportunities of teamwork via 3DVEs, options for external storage in clouds with remote access, virtual work via VPN (virtual private network) clients and the opportunity to introduce feature rich platforms for teamwork as well as for private interaction.

Proposition 1: The deployment of VTs likewise meets the changes induced by drivers located in- and outside of an organization.

The context for organizations introducing virtual teamwork contains current and changing trends, such as certain hard- and software standards. Organizational governance in such a change project has to regard the context and to adapt to virtual teamwork due to its potential internationality and the work online. The regulations regarding internationality can be adapted from traditional organizations that operate transnationally, e.g. for adaptions along employment law. Requirements that arise with online work include challenges regarding security of communication, data transfer and data storage as well as safety of network stability. These need to be governed and the governance of those changes needs to be integrated in the corporate governance [12]. Adapting ethical regulations in order to allow and support the deployment of VTs follows the same logic. Metrics should be established that allow measuring the value creation and contribution of the deployed VTs. Therefore, the governance faces the vital duty to enable the organization to deploy VTs in the first place and to subsequently provide a setting that allows VTs to work successfully and without hindering constraints.

Proposition 2: The governance is required to allow, support and secure virtual teamwork.

The core of the framework, the functional and the emotional-culturally-oriented layers are embedded in the context and the governance and are equally affected by change when integrating virtual teamwork. The co-dependent functional layers (core, left side) include the business strategy, the business processes and the utilized ICT. The deployment of VTs can affect the business strategy, as VTs provide chances, e.g. regarding international expertise, 24 hour reachability and selected highly skilled employees. Organizations mainly consisting of VTs were found to rather follow a one product strategy, providing an example of the described changes in strategy [3]. This leads to changes in business processes. E.g. communication and documentation processes are adapted due to asynchronicity and accessibility, and standards and routines are defined for the procedure of these processes in order to support team members to work autonomously.These adaptions for business processes and the findings regarding communication and reporting in VTs lead to the following proposition:

Proposition 3: Business processes regarding communication and task procedure require precisely specified rules and standards in order to enable VTs to work independently.

The adapted business processes might require new ICT for their realization, and new solutions in ICT in turn allow changes in business processes. E.g. secure data storage in the cloud provides members of VTs equal access without restrictions regarding time zone and location. ICT presents the fundament for VTs to be able to work together and cooperate. The choice of ICT should serve the employees' requirements, or otherwise they would draw on individual solutions. The choice of ICT is based on an analysis of the process requirements from an organizational perspective and on an analysis of the employees' requirements, also taking into account their private technology preferences and cultural aspects. The choice should repeatedly be monitored and reflected, as innovations in ICT again introduce change as described above. The use of the selected ICT should then follow agreed upon standards (see Proposition 3). These challenges lead to the following support centered proposition:

Proposition 4: Deployed ICT should be selected regarding the goal to support virtual teamwork in all work-related and social processes.

The change towards virtual teamwork influences the manifestations of the emotional-culturally-oriented layers (core, right side) which also serve as foundation for the functional layers. The organizational culture focuses on employee retention instead of customer acquisition and retention [3]. This is also supported by the changes in leadership and behavior in terms of small teams and a supportive workplace. The importance of trust in VTs is realized by simple hierarchies and the avoidance of micromanagement of the employees. This issue of trust is not only relevant for the management perspective but also for trust among the employees. This can be enhanced by hiring employees and a management based on their social competencies and by deliberately training these skills. These aspects are again intertwined with the technology use by employees and management and group related characteristics (see section 2.3) leading to following proposition:

Proposition 5: Individual teamwork skills by employees, leaders and management and workplace design should serve the mutual goal of employee retention.

The key elements of the framework described above, adapted to change regarding virtual teamwork are shown in Fig. 6.

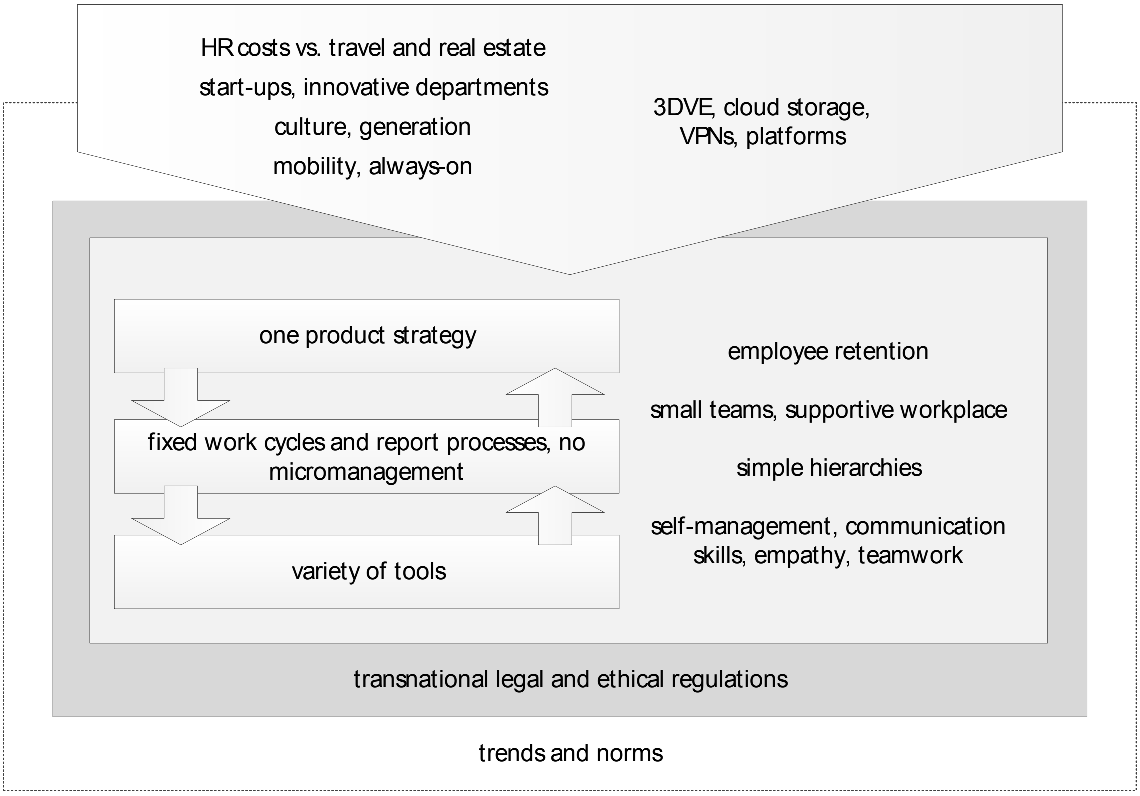

Fig. 6. Framework for deployment of VTs

4. Conclusion

Organizations profit from the deployment of VTs in many ways as shown throughout this study. But in order to successfully integrate virtual teamwork into the organization, structures and processes need to be adapted to this deployment. We therefore answered the research question regarding “how do the processes and structures manifest for organizations deploying virtual teamwork” along the proposed framework. These adaptions of structures and processes to this change at first seem vast and hard to capture. But the detailed inquiry into these various aspects by using the integrated framework as shown above, proved to provide clear and processable insights. These insights allow answering the research question and therefore enlighten the manifestations of the framework’s components for the deployment of virtual teamwork.

Some limitations of the approach could be discussed. First of all, the used framework has been selected due to its apparent fit to the object of analysis. This could be verified by testing other frameworks in the set context. Moreover, the analysis was based on an information systems perspective and could be enhanced by including other scientific perspectives, such as psychological and information technological expertise.

However, when analyzing the presented framework for VTs in further research, an in-depth analysis could furthermore provide insights on the timeline and sequence of adaption steps that organizations have to run through when introducing virtual teamwork. Further research might very well allow precise conclusions on the interrelatedness of the layers and further insights on the potential manifestations of the layers. These analyses could also include further variations regarding the characteristics of the organizations, such as the degree of virtuality, the industrial sector, and the age of the organization.

These future research works can advance the insights of the paper at hand which provides structured results to build upon. The propositions present essential current knowledge on virtual teamwork that requires a steady updating in an ever-changing environment.

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Using BPMN to model Internet of Things behavior within business process

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Abstract:
Whereas, traditionally, business processes use the Internet of Things (IoTs) as a distributed source of information, the increase of computational capabilities of IoT devices provides them with the means to also execute parts of the business logic, reducing the amount of exchanged data and central processing. Current approaches based on Business Process Model and Notation (BPMN) already support modelers to define both business processes and IoT devices behavior at the same level of abstraction. However, they are not restricted to standard BPMN elements and they generate IoT device specific low-level code. The work we present in this paper exclusivelly uses standard BPMN to define central as well as IoT behavior of business processes. In addition, the BPMN that defines the IoT behavior is translated to a neutral-platform programming code. The deployment and execution environments use Web services to support the communication between the process execution engine and IoT devices.

Keywords:
Internet of Things; Business Process modelling; BPMN; IoT-aware business process.

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1. Introduction

In the last years, organizations have been using more and more business processes to capture, manage, and optimize their activities. A business process is a collection of inter-related events, activities, and decisions points that involve actors and resources and that collectively lead to an outcome that is of value for an organization or a customer [1]. In areas such as supply chain management, intelligent transport systems, domotics, or remote healthcare [2], business processes can gain a competitive edge by using the information and functionalities provided by Internet of Things (IoTs) devices. The IoT is a global infrastructure that interconnects things (physical and virtual). IoT devices connects things with communication networks. These devices can also have capabilities of sensing, actuation, data capture, data storage, and data processing [3].

Business processes can use IoT information to incorporate real world data, to take informed decisions, optimize their execution, and adapt itself to context changes [4]. Moreover, the increase in processing power of IoT devices enables them to become active participants by executing parts of the business logic: IoT devices can aggregate and filter data, and make decisions locally, by executing parts of the business logic whenever central control is not required, reducing both the amount of exchanged data and of central processing [5]. Indeed, sensors and actuators can be combined to implement local flows, without needing central coordination.

However, decentralizing business processes into IoT devices presents two main challenges. First, IoT devices are heterogeneous by nature. They differ in terms of communication protocols, interaction paradigms, and computing and storage power. In addition, business modelers define processes using high-level languages (such as Business Process Model and Notation version 2.0 [6], henceforth simply referred as BPMN), as they must know the domain, but do not need to have specific knowledge to program IoT devices, nor want to deal with their heterogeneity. Therefore, this decentralization requires design as well as execution time support.

At design time, current approaches allow modelers to define both business processes and IoT devices behavior at the same level of abstraction, using, for instance, BPMN-based approaches [7], [8], [9], [10], [11], [12]. BPMN already provides the concepts to define the behavior of various participants, by using different pools. The interaction amongst participants is specified through collaboration diagrams. Supporting the execution of these hybrid processes requires bridging the gap between high-level BPMN and the programming code that IoT devices can execute. These approaches use a three-step procedure: (1) translation of the process model to a neutral intermediate language; (2) translation of the intermediate code to a platform specific executable code; and (3) deployment of the executable code into IoT devices.

By taking advantage of these approaches, business modelers can define both business processes and IoT behavior at the same (high) level of abstraction. However, they still use non-standard BPMN to integrate, for instance, IoT device information into business processes and they generate IoT device specific code, so that it must be generated again for each different IoT device.

The proposal we present in this paper only uses standard BPMN to define both central and IoT behavior of business processes. Besides using pools and collaboration diagrams, we use the BPMN resource class to integrate the information about IoT devices into the model, and we use the BPMN performer class to define the IoT devices that will be participants of the process. In addition, the BPMN that defines the IoT behavior is translated into Callas bytecode [13]. We use the Callas sensor programming language as an alternative to the target platform-specific languages taken by previous proposals, since it can be executed in every IoT device for which there is a Callas virtual machine available. This way, we abstract hardware specificities and make executable code portable among IoT devices from different manufacturers. Business process and IoT devices communicate via web services (directly or indirectly through gateways). In addition, Callas also supports remote IoT devices reprogramming, a feature that is the first step to support ad-hoc changes [14] in the parts of business processes that define IoT behavior. A preliminary version of this work can be found elsewhere [15].

This paper is organized as follows. Section 2 presents the related work. Our proposal is described in the following two sections: whereas section 3 describes how we support modelling IoT behavior within BPMN business processes, section 4 focuses on the implementation aspects, including the description of the translation procedure into Callas source code, and the overview of the deployment and execution phases. Finally, section 5 concludes the paper and hints for future work directions.

2. Background

Business modelers define business processes with languages such as Web Services Business Process Execution Language (WS-BPEL) [16] or BPMN, which use an abstraction level closer to the domain being specified. At this level, modelers should not deal with IoT devices heterogeneity and specificities: IoT devices use different operating systems (e.g., TinyOS, Contiki [17]), different programming languages (e.g., nesC [18], Protothreads), and different communication protocols. Traditionally, web services are used to provide IoT information and functionalities, abstracting and encapsulating low-level details. This way, web services are the glue between IoT and business processes, as model languages already support their usage. In addition, more recent approaches take a step forward by supporting IoT behavior definition within the business process [19], [20].

2.1 IoT as web services – the centralized approach

Current IoT technology exposes IoT information and functionalities as web services, facilitating interoperability and encapsulating heterogeneity and specificities of IoT devices. Zen, Guo, and Cheng survey two approaches to implement IoT web services [21]. Some works provide web services directly in IoT devices: they simplify, adapt, and optimize Service-Oriented Architecture (SOA) tools and standards to deal with the well-known limitations of resource-constrained devices. Other approaches provide web services indirectly through middleware systems. This way, IoT devices that do not support web services can still be accessed.

Taking a step forward on integrating IoT into business processes, some authors propose the explicit integration of IoT concepts into business process models. Domingos et al. [22], [23] and George and Ward [24] extend WS-BPEL with context variables to monitor IoT information, abstracting the set of operations to interact with IoT devices. The IoT-A project proposes some BPMN extensions to explicitly include IoT devices and their services in an IoT-aware process model, as well as some characteristics of IoT devices, such as uncertainty and availability [25], [26]. The uBPMN project adds ubiquitous elements to BPMN: it defines the BPMN Task extension for Sensor, Reader, Collector, Camera, and Microphone, as well as an IoT-driven Data Object to represent the data transmitted from IoT devices [27], [28].

GWELS [29] provides a graphical user interface to design IoT processes and send them automatically to IoT devices as a sequence of operation calls that have been uploaded to IoT devices in advance. It uses proprietary communication protocols to interact with IoT devices. IoT processes are provided as web services and, in this way, can also be integrated into business processes.

The above approaches assume a centralized control of the process execution, where a single central system executes and coordinates processes and communicates with IoT devices using web services. However, business modelers are unable to define the behavior of IoT devices, they can only use services whose behavior is previously defined.

2.2 IoT as active participants of business processes – a decentralized approach

In a decentralized approach, IoT devices can work together to execute parts of business processes, reducing the number of exchanged messages and promoting the scalability of central process engines, since information is processed locally. Another important advantage, present in many scenarios, is that the lower network traffic between the central engine and IoT devices improves battery lifetime of IoT devices. To model business processes according to this decentralized approach, business modelers need a unified framework where they can specify the behavior of IoT devices as well as their interactions with the central system. BPMN already provides the concepts to define the behavior of various participants by using different pools; their interactions are specified through collaboration diagrams.

Following a decentralized approach, Caracas and Bernauer [7], [8], [9] use standard BPMN to model both central and IoT behavior. However, IoT device information is integrated to the BPMN model in a non-standard way, by appending it to the pool name or with additional attributes added to the pool element. They translate the BPMN that defines the IoT behavior to target IoT device specific code. The authors state that the sensor code they generate does not perform much worse than hand-written code.

Casati et al. [10] propose the makeSense framework. They extend BPMN with attributes to support the new intra-WSN participant, which contains the part of the process that IoT devices will execute. To model IoT behavior, makeSense uses a second meta model [10], [30], [12]. The translation procedure into executable code for IoT device uses two models: the application capability model has information about available sensors and actuators and their operations, while the system capability model has additional information about the target IoT devices, which is used to generate different code based on IoT device capabilities. MakeSense uses its own message format and transmission encoding to support the communication between the central process engine and IoT devices [12].

Whereas in these two proposals, IoT devices execute device specific code, Pryss et al. [31] follow a different approach by executing process engines in IoT devices. Despite the advantage of avoiding generating the executable code for IoT devices, this option is only applicable for IoT devices with higher computational capabilities.

In our work, we exclusivelly use standard BPMN to define all the business process, and IoT device information is added to the model by using the BPMN resource class. We translate the BPMN that defines the IoT behavior into Callas bytecode [13], a non-platform-specific language that IoT devices with an available Callas virtual machine can execute.

3. Modelling the behavior of IoT devices

This section describes how we use the BPMN language to model IoT behavior within business processes, both at the same level of abstraction. It starts by presenting the use case scenario we choose to illustrate the application of our proposal.

3.1 Use case scenario

Fig. 1 presents our use case scenario, a simplified process for automatic irrigation control. The process includes three participants: the central process (named Irrigation) and two IoT devices, the IoT irrigation device and the IoT read rainfall device. The behavior of each participant is modelled in separated pools.

The IoT read rainfall device, periodically, wakes up. Its process starts by reading the rainfall sensor, and only sends a message to the IoT irrigation device if it is not raining; otherwise, it stops. When the IoT irrigation device receives the message from the IoT read rainfall device, it starts the irrigation by activating an actuator, which lasts for a pre-defined period. Upon finishing the irrigation, the IoT irrigation device reads the flowmeter sensor to make sure it is sealed. If water still flows, it sends an alert to the central process. This way, the central process receives a notification when the IoT irrigation device detects a water leek that needs human intervention to be fixed.

This simplified process omits a lot of details, such as the functionalities to change both timers (the irrigation interval and duration), for instance.

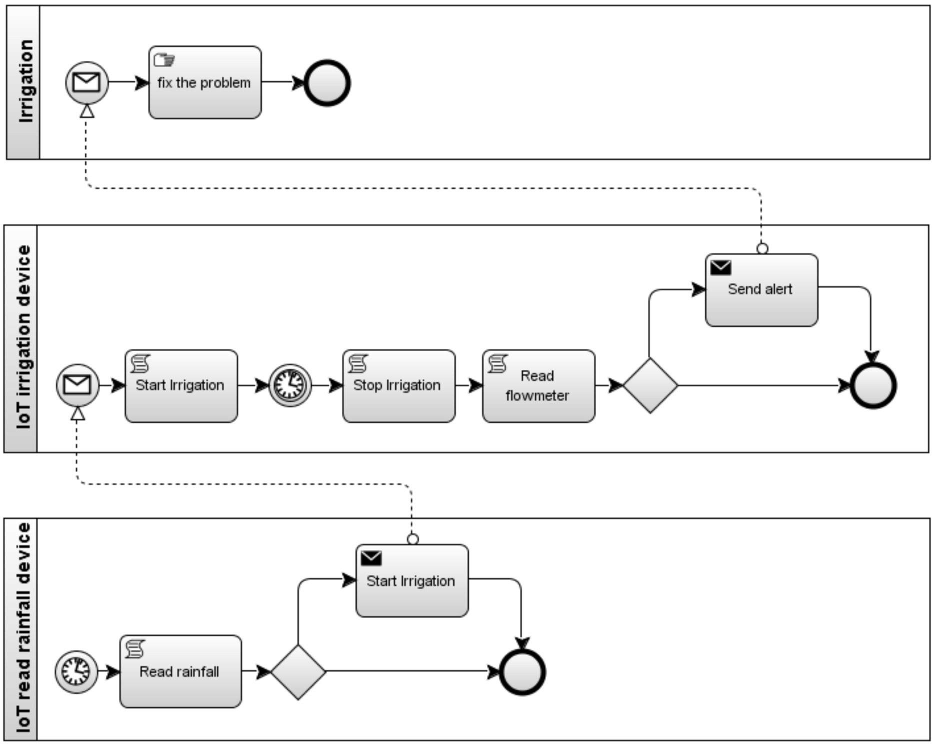

Fig. 1. BPMN use case scenario

3.2 Using BPMN to model the behavior of IoT devices

To model all the business process, including the behavior of IoT devices, we only use standard BPMN elements. BPMN already provides the concepts to define the behavior of various participants, by using different pools, as well as the interaction amongst participants, through collaboration diagrams. This approach is illustrated making use of our use case scenario described in the previous subsection.

We select a subset of BPMN to model the behavior of IoT devices, avoiding the use of two different meta models. The selection of the subset considers two main factors:

- To model the behavior of IoT devices, business modelers do not need all BPMN elements, as stated by Caracas [9]. This way, we include in our subset the BPMN elements that Caracas use to model the IoT programming patterns, and
- Callas already considers general IoT devices limitations, for instance, it does not support parallel tasks. In addition, it is a block-structured language, consequently, it also does not support unstructured control flow, unlike BPMN, which allows gateways to loop back and forward. Fig. 2 illustrates an example of a flow control that we do not support in IoT behavior definitions, since there is no way to represent the flow from Task B to Task A.

The BPMN subset includes the following elements:

- Flow control: events (message received, timers, and the start and end events), activities (script task, send task, and receive task), and gateways (exclusive gateway and merging exclusive gateway);
- Connecting objects: sequence flow, message flow, and data associations; and
- Data: data objects.

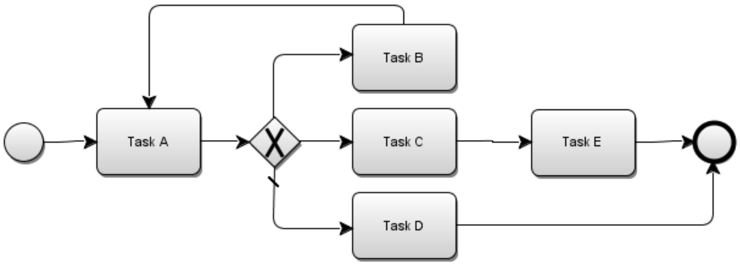

Fig. 2. Example of a non-block control flow structure

We use script tasks to define the tasks that corresponds to invocations of hardware functionalities of IoT devices. For instance, in our use case example, IoT read rainfall device has a rainfall sensor, and we use the script task Read rainfall to model the sensor data acquisition. In a similar way, within the process of the IoT irrigation device, we also use a script task (named Start irrigation) to model the activation of the actuator that starts the irrigation.

The BPMN Resource class and the BPMN Performer class are used to define the IoT device that will execute the processes, avoiding the integration of this information into BPMN models in a non-standard way. The Resource class is used to specify resources (i.e., IoT devices) that can be referenced by processes, whereas the Performer class defines the resource that will perform the processes. Fig. 3 presents a simplified example based on our use case scenario, which can be reused in other business processes. It includes the definition of the resource named IoTdevice with three parameters: deviceType, address, and operations. The performer definition exemplifies the way we apply the deviceType resource parameter in queries for resource assignment. We use the operations parameter to access to the list of the hardware functionalities of the IoT device and their signatures, i.e., the name, its return type, and the type of its parameters.

```
<resource id="IoTdevice" name="IoTdevice">
  <resourceParameter id="deviceType" name="deviceType" type="xs:string"/>
  <resourceParameter id="address" name="address" type="xs:string"/>
  <resourceParameter id="operations" name="operations" type="ns1.xsd:tOperations"/>
</resource>
…
<performer id="performer" name="performer">
    <resourceRef>IoTdevice<resourceRef>
    <resourceParameterBinding parameterRef="deviceType">
      <formalExpression>IoT irrigation device<formalExpression>
    </resourceParameterBinding>
</performer>
```

Fig. 3. Example of using the BPMN resource class and the BPMN performer class

4. Implementing the behavior of IoT devices

The implementation phase includes the translation of BPMN processes into Callas bytecode (the executable program for IoT devices), and how to deploy and execute it in IoT devices.

4.1 Translating BPMN to Callas code

Unlike related work approaches that use platform-specific code to specify the behavior of IoT devices, we translate it into Callas bytecode [13]. By choosing the Callas programming language, we take advantage of some of its characteristics and functionalities specifically tailored to address IoT devices. For instance, Callas takes, as a pattern, the path followed by the Java programming language, and proposes a virtual machine for IoT devices that abstracts hardware specificities and makes executable code portable among IoT devices from different manufacturers. The Callas language is founded on a well-established formal semantics and, along with its virtual machine, statically guaranties that well-typed programs are free from certain runtime errors (type-safety). Moreover, the Callas virtual machine is sound, that is, its semantics corresponds to that of the Callas language. It includes domain-specific IoT operations, such as for sending and for receiving messages from the network. These Callas operations are supported directly at the Callas virtual machine level, and may have different implementations depending on the hardware where it is deployed. Currently the Callas virtual machine is available for SunSpot, TinyOS, Arduino, VisualSense, and Unix platforms (more information can be found in the Callas website http://www.dcc.fc.up.pt/callas/). Other interactions with the hardware of IoT devices are performed by calling external functions of the language. This typically corresponds to operating system calls or to direct implementations (on the bare metal) of functions on the Callas virtual machine. The operations made available by each kind of device is described by a type in the Callas language, allowing the compiler to verify if the source code is adequate to run on a specific target device. A distinguished feature of the language is its ability to deploy executable code, which we use to install the code in IoT devices, remotely. We also consider this feature as the first step to support ad-hoc changes [14] in IoT business process parts.

Fig. 4 presents the Callas source code that implements the behavior of the IoT devices of our case study. The left column has the source code that corresponds to the behavior of the IoT read rainfall device, whereas the right column has the source code that corresponds to the behavior of the IoT irrigation device. Programs start by declaring two module types: Nil, an empty module type used to represent void function returns; and a second module that defines the message signatures that flow on IoT devices.

The implementation of the IoT_read_rainfall_device spans from line 9 to line 17. Each function is implemented using the def construct. The checkIrrigation function reads the rainfall sensor (using the readRainfall external function) and binds it to the isRaining variable. Then, in case it is not raining, the function continues by sending a message to start the irrigation (send startIrrigation). The main program (lines 19–24) loads the module into the device's memory and installs a timer to call checkIrrigation every day.

Within the implementation of the IoT_irrigation_device, upon receiving the startIrrigation message, it invokes the startIrrigation external function. The system irrigates for 20 minutes, stops by calling the stopIrrigation function, and checks whether the water valve is sealed. It alerts the central process in case there is a water leak (send waterLeakAlert).

```
1  defmodule Nil:
2    pass
3
4  defmodule IoT_irrigation_system :
5    Nil startIrrigation ()
6    Nil waterLeakAlert ()
7
8  # declare module IoT_read_rainfall_device
9  module m of IoT_irrigation_system:
10   def checkIrrigation (self):
11     isRaining = extern readRainfall ()
12     if not isRaining :
13       send startIrrigation ()
14   def startIrrigation (self):
15     pass
16   def waterLeakAlert (self):
17     pass
18
19 mem = load                 # load the device memory
20 newMem = mem || m          # update with Sampler module m
21 store newMem               # replace the device memory
22
23 # invoke tasks every day
24 checkIrrigation () every 24∗60∗60∗1000
```

```
25 defmodule Nil:
26   pass
27
28 defmodule IoT_irrigation_system:
29   Nil startIrrigation ()
30   Nil waterLeakAlert ()
31
32 # declare module IoT_irrigation_device
33 module m of IoT_irrigation_system:
34   def startIrrigation (self):
35     extern startIrrigation ()
36     sleep (20∗60∗1000)
37     extern stopIrrigation ()
38     curFlowmeter = extern readFlowmeter ()
39     if curFlowmeter > 0
40       send waterLeakAlert ()
41   def waterLeakAlert (self):
42     pass
43
44 mem = load                 # load the device memory
45 newMem = mem || m          # update with Sampler module m
46 store newMem               # replace the device memory
```

Fig. 4. The Callas code of the use case scenario

The translation from BPMN to Callas is divided into three phases: (1) parse of BPMN XML files; (2) syntactic and semantic validations of BPMN processes; and (3) translation into Callas.

The parsing phase takes the BPMN XML file and creates an abstract syntax tree (AST) representation. At this phase, we rule out programs with constructs that are not compliant with the BPMN subset we define for modelling IoT devices' behavior.

The second phase traverses the AST multiple times for validations: it verifies that (a) the control flow is plausible for being translated into a block-structured language, and that (b) the domain-specific script tasks are valid. The former checks that tasks and events only have one input and one output sequence flow and that every possible control flow path from an outgoing exclusive gateway arrives at the corresponding incoming exclusive gateway. Otherwise, it denotes a control flow only possible to represent using a goto statement (absent in Callas). This validation is challenging, since we need to figure out the correspondence between the outgoing and the incoming exclusive gateways, and that control flow may include various exclusive gateways (corresponding to nested if statements in structured languages). As for the latter, valid domain-specific script tasks have well-known names fixed in advance, associated with information specific per each task.

Semantic validation checks that the domain-specific tasks are used correctly on what concerns the types of the data objects being used and that these types are in conformance with the domain-specific task signatures (also provided in advance).

The translation from the AST into Callas proceeds as follows:

- Event elements: (a) message received start events are translated into function calls and the process triggered by these events are translated into function definitions. We figure out the function signature from the types of the values in the message. The function name can be set arbitrarily, since the whole interaction process is going to be generated automatically at compile time and set for both participants (the BPMN engine or the IoT devices). In Fig. 4 we do not use arbitrarily function names for the sake of legibility. Upon message reception, the Callas virtual machine takes the responsibility of invoking the correct message handler function. For instance, upon reception of an irrigation message by the IoT device, the Callas virtual machine dispatches it to the `startIrrigation` function that implements the behavior of the `IoT irrigation device`; (b) There are two distinct behaviors for business process timers, depending whether they are attached to starting events or used in the middle of processes to model the passing of time. The former are directly supported by a Callas timer that invokes a function encoding the timer behavior (*vide* line 24, Fig. 4). The latter, is naturally implemented using the Callas `delay` function; (c) the end event is twofold: when it happens inside a process, it is translated into a `return` statement inside the function that models the process; when it marks the end of the top-level process there are multiple ways to interpret it. The simplest is just to ignore the event, since we can think of a IoT program as a never-ending program, always ready to handle new requests. The other extreme is to end the Callas virtual machine, but then we need to get explicit access to the IoT device hardware to reset it, or put in place an additional software procedure to reset the IoT devices remotely. We have decided to follow the former option and simply ignore the end event;
- Activity elements: send and receive tasks have a direct correspondence with the `send` and `receive` constructs from the language. The script tasks we support are predefined and implemented as part of a Callas library for the BPMN subset. As an example, the `Read rainfall` script tasks is translated into a call to the hardware functionality named `readRainfall` (*vide* line 11, Fig. 4);
- Gateway elements: Exclusive gateways are represented by `if` statements. In case the gateway has more than two alternatives, it is translated into a series of nested `if–else` statements. Merging exclusive gateways are ignored during the translation process, since their behavior is captured by the Callas sequential composition statement. It is just used during semantic validation as described above;

- Connecting object elements: sequence flows are modelled by Callas control flow mechanisms, which is sequential composition, branching, looping, and function calls. The validation phase guarantees that the IoT BPMN model can be represented by these control flow primitives. Message flows are initiated with a send task, concluded with a receive task, and the flow itself is supported by the underlying data layer of the communication protocol stack of IoT devices;
- Data elements: data objects and their associations are modelled by Callas program variables that store objects and, when used in expressions, represent data associations, capturing the data flows specified at the BMPN model.

During the whole translation procedure, we keep track of each BPMN element identification, defined in the XML model file. We use them to map the errors we unveil during the validation and the translation phases, and report them to modelers in the BPMN design tool context.

4.2 Deployment and execution

Deployment and execution phases include the installation of Callas bytecode in IoT devices as well as the creation of the web services to support the communication between the process execution engine (jBPMN) and IoT devices.

The steps our deployment algorithm performs are the following:

- Generate the Callas code and deploy it to the IoT device by invoking the install code service. For that, we provide the target IoT device identification taken from the IoT device database, by using a query based on the parameters of the resource, and the bytecode produced during the Callas compilation;
- Remove IoT pools from the BPMN model file, since this behavior is going to be performed by IoT devices, instead of the jBPM server;
- Update the BPMN model file by setting send message tasks (or throw events) that target the IoT pool to use IoT web services, providing its address; and
- For each receive message tasks (or catch event) that initiates at an IoT pool, we take its address and pass it to the IoT devices so they can deliver messages using the jBPM RESTful API.

4.3 Prototype

In our prototype, we use the Eclipse IDE [32] and the jBPM [33], a BPMN server from RedHat. Our irrigation use case is composed of two types of components: the IoT devices and the application. For the IoT side, the one installed in the garden, we devised a hardware board for controlling irrigation. The board uses the ATmega644PA processor from Atmel corporation. We adapted the Callas virtual machine for this processor and programmed a firmware that controls the garden’s irrigation following a programmable schedule. The devices address directly jBPM via its RESTful API; likewise, the application can address each IoT device using its service address. The application includes several irrigation related processes modeled and deployed with our proposal. We currently have the prototype deployed at Avenida da Liberdade in collaboration with Lisbon city council, where we control four electrovalves managing a total of 40 sprinklers. The project is running with success for three months.

5. Conclusion and future work

The IoT opens an opportunity to create a new generation of business processes that can benefit from IoT ubiquity, taking advantage of their computational power, networking, and sensing capabilities. IoT devices can even execute parts of the business logic.

The work we present in this paper allows modelers to define IoT behavior within business process and with the same level of abstraction, by only using standard BPMN. By translating BPMN, the IoT behavior part, into Callas, we generate neutral-platform portable code, which can also be sent to IoT devices remotely. Our approach opens new opportunities to bring together process modelling and information and functionalities provided by IoT devices.

Modelers do not need to cope with IoT specificities, and use BPMN without any extensions; Callas allows to abstract from the hardware, making the generated code able to run on different devices, if these devices offer the required functionalities. Moreover, the Callas ability for remote reprogramming facilitates code deployment and adds support for dynamic ad- hoc business process changes.

As future work, we want to support the automatic decomposition of business process to determine which process parts can be executed by IoT devices.

In addition, this decentralized approach brings new challenges considering security, as we need to assure confidentiality and authenticity between central process and IoT devices as well as between IoT devices.

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Relativism in the Cloud: Cloud Sourcing in virtue of IS Development Outsourcing - A literature review

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Abstract:
Nowadays Cloud Computing and Cloud Sourcing is on the agenda in many organizations. Many Chief Information Officers (CIOs) that urge for alternatives to traditional outsourcing are interested in how they can take advantage from Cloud Computing, by sourcing Information Technology (IT) from the cloud. This paper provides an overview of the research direction of Cloud Sourcing in the IS field. A literature review based on selected papers from top Information Systems (IS) journals and conferences were conducted. Findings from the review indicate that the attention of Cloud Sourcing in IS literature has mainly been directed towards security and risk as well as adoption issues, and that Cloud Sourcing is claimed to be the next generation of outsourcing. Unfortunately, this is where this strong claim ends without any further evidence, which indicate that there is a need for more research on Cloud Sourcing, especially in the direction of investigating relationships and implications when organizations start using Cloud Sourcing.

Keywords:
Outsourcing; Cloud Sourcing; Cloud Computing; IT operations; IT maintenance; IT development.

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1. Introduction

Information Technology (IT) outsourcing has been around for many years [1, 2] and organizations have been using outsourcing of IT for different reasons [3, 4]. Outsourcing of information systems development represents a significant transfer of assets, leases, and staff to a vendor that assumes profit and loss responsibility [5]. One of the reasons have been to more or less close down their own IT department and instead use another organization to deal with both IT operations as well as IT development but also IT maintenance. The IT operation part, which includes hosting of data centers, seems to be easy to replace with the Cloud Sourcing phenomena. However, it could be questioned if the other two parts, IT development and IT maintenance also could be replaced by a Cloud Sourcing solution. The first and maybe most obvious answer to that question is perhaps that Cloud Sourcing will not replace that, since Cloud Sourcing is basically delivery of services, and services are basically IT operation.

Outsourcing is traditionally based on a complex set of contractual relationships between a focal unit and a vendor. This is adopted to externalize simple tasks and refocus on core competencies, resources and capabilities. We believe that the implementation of a Cloud Sourcing solution in an organization would not change the IT-department drastically except excluding IT operations from their agenda, and giving them more time to work on IT development and IT maintenance (which indeed could be outsourced in a traditional way). Especially since adopting a cloud sourcing solution does not include a transfer of staff or any other assets. Cloud Computing or Cloud Sourcing is seen as a force to count on, and even companies that were skeptical in the beginning have now started to use cloud computing to retain their competitiveness on the market. Cloud computing has become the companies backbone of many social media intensive businesses such as Facebook, Google and Microsoft. According to Babcock [6] and Leimeister et al. [7], cloud computing is an evolution of outsourcing. Cloud computing or Cloud Sourcing as referred to from now on (these definitions will be used interchangeably) also entails similar purchase processes as the more traditional IT outsourcing which is defined by de Looff [8] as the act of shifting some or all of the IS-activities to be performed externally by contractual agreement. Thereby Cloud Sourcing can be defined as the outsourcing of IT resources [6]. The main reasons for outsourcing is according to Lacity et al. [9] cost reduction, access to technological expertise and shifting focus on the organizational core competences. Hirschheim and Lacity [10] suggest more studies to be conducted on how to manage IT outsourcing relationships the best way. It can definitely be said that this also relates to studies about Cloud Sourcing, especially since the estimation of usage of Cloud Sourcing is high. Muller [11] stated based on a survey published by Avande in 2011 “Global Survey: Has Cloud Computing Matured?” that an estimation is that 74 percent of enterprises are using some form of cloud services which is a 25 percent growth since 2009, which tells us that this is a highly relevant topic of research. The survey is based on 573 C-level executives, business unit leaders, and IT decision makers in 18 countries.

In this study we aim at providing new light on Cloud Sourcing as means of outsourcing. It can be stated that previous scientific studies have not addressed the relationship between IT outsourcing and Cloud Sourcing in depth. While it is true that Cloud Sourcing or the Software as a Service (SaaS) model has been discussed in sources aimed at practitioners, it does not necessarily as stated by Martens and Teuteberg [12] follow that the topic of concern has been as discussed in journals aimed at a scientific audience.

Vaquero et al. [13] defines cloud as a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms, and/or services). Which but also entails the possibilities of outsourcing IT development and IT maintenance in the cloud. These virtualized resources can be modified and adjusted to utilize the most of organizations’ resources. Although there are concerns of security, privacy and vendor lock-ins being the negative side of Cloud Sourcing [14]. Indeed the main benefit of Cloud Sourcing is the elasticity and flexibility of computing that Cloud Sourcing offers.

Cloud Sourcing could be seen as part of an organizations IS strategy, just as traditional outsourcing has been in many ways. Dhar [15] compared the similarities and differences between traditional outsourcing and Cloud Sourcing and concluded that Cloud Sourcing creates a fundamental shift in the evolution of IT service delivery by reducing costs and increasing flexibility to a greater extent, which traditional outsourcing also does but in Cloud Sourcing these strategic benefits are greater. Formalization, benefits and operationalization of Cloud Sourcing has not yet been fully addressed in academic research according to Hahn et al. [16] who also claims that Cloud Sourcing certainly is a form of outsourcing. Cloud computing vendors are competing with traditional vendors [17] and it is a matter of time to tell whether Cloud Sourcing indeed can replace traditional information systems development (ISD) outsourcing. Until then there is a huge lack in research on cloud strategies such as on cultural impact, application adoption risk profile, etc. that need to be addressed.

More specifically our research objective is to explicate visions and insights that have been researched and discussed in the academic world guided by the following questions:

- What is discussed in IS research around Cloud Sourcing?
- How does research in IS on outsourcing relate to Cloud Sourcing?

The first purpose of this paper is to review the field of Cloud Sourcing in IS literature. The second and foremost purpose is then to observe whether Cloud Sourcing in IS literature is seen as a future mean of outsourcing.

The rest of the article is organized as follows: In the next chapter, we present the research method that consisted of a literature review. The findings from the literature review is then presented in chapter 3. Finally we discuss the findings, presents some concluding remarks, and suggest future research.

2. Methodology

As presented in the introduction it is a fact that Cloud Sourcing is already in vision as seen by practitioners, however, a question to ask is how Cloud Sourcing has been addressed in research studies. What studies has been done and what are the focus of these studies. To say something about this a literature review was conducted. The review aimed at investigating what is written about Cloud Sourcing in relation to outsourcing. This means that a sober analysis of the IS sourcing literature on Cloud Sourcing was done. One reason behind doing the literature review is that Cloud Sourcing is claimed to even increase the benefits of sourcing [11]. This conclusion adds weight to the aim to reveal what has been researched on Cloud Sourcing and if it corresponds to the perception of Cloud Sourcing being the next generation of outsourcing as predicted by Gartner [18].

The literature review was based on IS top conferences: ECIS, AMCIS, ICIS, PACIS and the AIS basket of eight journals: European Journal of Information Systems, Information Systems Journal, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, MIS Quarterly, and Information Systems Research. The key words used for the search were Cloud Sourcing, IT sourcing, Outsourcing, IT outsourcing, and IT strategy. The reason for choosing both top journals and top conferences in the field of IS, is to be able to get hold of both the hottest topics of the conferences and what has been published academically in the journals. The searches were delimited to abstract, title and subject, and the publication time was not delimited even though it became obvious that the notion of cloud computing and Cloud Sourcing has not been discussed further back than to 2008. In total 33 papers were reviewed. Admittedly, the review process did involve to some extent personal interpretation of the definitions applied in the research papers. The majority of the papers focusing on Cloud Sourcing were written between 2011-2013.

Each papers abstract, introduction, analysis and conclusion sections were read. The selection criteria for papers to be included in the review was that the article must focus on Cloud Sourcing. We are aware that searching in other sources and databases might have resulted in different results to some degree.

In order to conduct our literature review we used a systematic way adopted by previous scholars in IS [19, 20] and is based on Dubé and Paré [21]. In particular, the steps we followed were: 1) Selection of Journals and Conferences 2) Identification of relevant articles 3) Classification of the articles into categories based on their content 4) Assessment of the number of articles in each category 5) Analysis of the categories for discovering research trends and future recommendations. Especially, in the fifth step we also included a comparison between the Journals and Conferences.

3. Cloud sourcing in the IS-sourcing literature

The literature review, which initially focused on the publication years 2008 –2013, found 33 papers. These paper were distributed among the years in the following way (year: number): 2008: 2, 2009: 1, 2010: 2, 2011: 9, 2012: 14, 2013: 5. Number of papers published 2008-2010 on Cloud Sourcing were evenly low in the IS field. This was followed by a boom in 2011, and then it increased almost to the double in 2012. The upcoming year 2013 shows a remarkable decrease in published Cloud Sourcing papers in the IS field. This decrease is believed to be temporary due to a shift in the Cloud Sourcing debate, which most likely will be followed by an increase again. A follow up search indicates that this is the case, however, in this specific paper we focus on the years 2008 – 2013, as the first 5 years in which Cloud Sourcing has been discussed.

The 33 papers were categorized in seven different topics, which resemble the main discussion in the presented papers and their contribution. The seven categories are as follows: cost, benefits/risks, strategies, capabilities, research, IS development and other. In table 1 we illustrate the categorization of the 33 papers found in the top IS conferences and IS journals that matched the search criteria.

Analyzing the areas and description gained from the identified literature, we can conclude that published papers have a focus on cloud adoption and different questions related to adoption. This is most likely expected if looking at Cloud Sourcing as a new phenomenon. Another highlighted area that seems common in relation to Cloud Sourcing is the question about contracts and security issues as well as strategies. This finding was also expected since literature as previously presented argues for the importance of this issue. However, one interesting finding that gives space for rethinking is that not much research seems to focus on the relationship between providers and customers despite the fact that this would be of high interest in the Cloud Sourcing area, and specifically when comparing it to traditional information systems development outsourcing were this is one of the key issues for successful outsourcing. This goes in line with what Hirschheim and Lacity [10] describe as an area which shows lack of research on and they suggest more studies to be done in specific on the relationship between provides and customers in Cloud Sourcing of ISD. The first finding is actually surprising and an unexpected result is that we actually found more papers in the journals than among the conference proceedings (13 conference papers and 20 journal papers). It is surprising primarily because, it could be suggested that a new phenomenon first shows up among conference papers and secondly, it could be suggested that publications in journals takes longer time to get published. However, one explanation could be that the journal papers discuss Cloud Sourcing as something related to outsourcing and that the conference papers discuss Cloud Sourcing from a more practical viewpoint. It is found that the journal papers have a much stronger focus on outsourcing. The fact is that the major part talks about open source which could be seen as a starting point of the Cloud Sourcing phenomenon. However, only two papers specifically mention Cloud Sourcing and one of the two papers suggests a framework for doing research on Cloud Sourcing. So, this indicates that research on Cloud Sourcing is in its infancy and we could predict but also suggest that more research especially in the direction of how Cloud Sourcing is related to IT outsourcing would be needed.

In order to get a better grasp of the analyzed papers discussion on Cloud Computing and in specific Cloud Sourcing we have categorized them into seven categories based on their topics. We found that the most common topic of Cloud Sourcing is within Strategy – were we found papers from 2008-2013 and mostly being published in journals. Second most common topic was benefits and risks with papers from 2011-2013 and most papers published in conferences. Third place shares topics on capabilities (most papers published in conferences from 2011-2013, research (all papers published in journals from 2011-2012) and IS development (all papers published in journals from 2008-2013). The topic of cost was unexpectedly on fourth place with only two published papers 2010-2013. Cost was expected to be a highly relevant topic in Cloud Sourcing as one of the main motives behind Cloud Sourcing adoption. A recent follow up search after papers gave a couple of articles; however, only 2 of them were added into Table 1, both of them is basically a call for more research on Cloud Sourcing.

Table 1 Description of the 33 papers on Cloud Sourcing

Category	Year	Area	Short Description	Authors	Source
Cost	2010	Cloud BI	Reducing cost of BI through the Cloud	[22]	PACIS
	2013	IT outsourcing	Study on relation between IT outsourcing and decrease in IT operating costs	[23]	MIS Quarterly
Benefits/risks	2011	Open Source Software in small to medium sized enterprises	Evaluation of benefits and challenges of OSS	[24]	European Journal of Information Systems
	2011	Options in Application Software selection	Comparison of Open source and traditional software development	[25]	European Journal of Information Systems
	2011	Cloud Adoption	Cloud Adoption, benefits and risks	[26]	ECIS
	2011	IT outsourcing and Cloud Computing	Taxonomy development for IT risk management	[27]	ECIS
	2012	Cloud Sourcing security risks	Percieved IT security risks in outsourcing through the cloud	[28]	ECIS
	2012	IT events and CAPM outsourcing	Limitations around announcement periods of CAPM on IT events	[29]	PACIS
	2013	Cloud Sourcing strategy	Cloud Adoption, benefits and risks as well as related strategies	[16]	AMCIS
Strategies	2008	Middlemen in Offshoring	How to facilitate offshoring obstacles	[30]	Journal of Information Technology
	2009	Cojoint analysis of IT outsourcing and decision	The complexity of outsourcing and the motivation behind the decision	[31]	Journal of the Association for Information Systems
	2011	Institutional logics and IT management	Disentanglement from constraints of institutional environment in IT outsourcing	[32]	European Journal of Information Systems
	2011	Collective agility	Systems development in a global collaborative community	[33]	Information Systems Journal
	2012	Innovation diffusion and IT strategy	Cloud Computing changes the IT strategies for SME's	[34]	ICIS
	2012	Contractural governance and IT outsourcing	The role of IT in IT governance outsourcing	[35]	ICIS
	2012	Cloud Computing at universities	Cloud Adoption and the driving force behind	[36]	PACIS
	2012	Value creation and value capture from open source software	Network collaboration and governance to create and keep value	[37]	European Journal of Information Systems
	2012	Challenges of Open Source Software	Lock in customers strategy in proprietary software	[38]	Information Systems Research
	2012	Cloud Computing and CIO	Cloud Computing helping and CIOs to focus on strategic value	[39]	Journal of Strategic Information Systems
	2013	IT outsourcing	Chinese IT service suppliers expanding to new markets globally exploting new opportunities	[40]	MIS Quarterly

Table 2 Description of the 33 papers on Cloud Sourcing (cont.)

Category	Year	Area	Short Description	Authors	Source
Capabilities	2011	IT capabilities	IT capabilities and IT resources affecting business processes	[41]	Journal of the Association for Information Systems
	2012	Crowdsourcing and capabilities	Capabilities development for facilitated Crowdsourcing	[42]	ICIS
	2013	Capability development though sourcing	Attaining new capabilities through IT sourcing	[43]	ECIS
Research	2011	Opening up the IS as a discipline	Opening up the IS field a commentary on IS research methods	[44]	Journal of Information Technology
	2012	Cloud Computing	Framework on Cloud Computing research - a review of theory and practice	[45]	Journal of Information Technology
	2012	Future and identity of Strategic Information Systems	A longitudinal review of SIS research	[46]	Journal of Strategic Information Systems
	2016	Future directions of sourcing	A literature review of sourcing and future directions	[47]	Journal of Information Technology
	2014	Looking at cloud computing as an emerging form of IT/IS outsourcing	A literature review of cloud computing research in relation to traditional IT outsourcing	[48]	Journal of Information Technology
IS Development	2008	Offshoring intermediaries	Bridging gaps between vendor and client	[49]	Journal of Information Technlogy
	2010	Coordination of Open Source Software development	Studying the Core-periphery movements in Open Source Projects	[50]	Journal of Information Technology Theory and Application
	2013	Coud Computing migration theory	End-user migration from client-hosted computing to cloud computing	[51]	European Journal of Information Systems
Other	2012	Intersection of CSR and Global Information Technology Outsourcing	Outsourcing relationships and the importance of CSR	[52]	PACIS
	2012	Compliance between research and practice on the topic of outsourcing	The trends of outsourcing in practice	[53]	PACIS
	2011	Generation of business value from information services	Customer satisfaction predicted by information analyses of information services	[54]	European Journal of Information Systems
	2012	E-government initiatives and service providers	Service sourcing in E-governments and theoretical planning	[55]	Information Systems Journal

4. Discussion of Cloud Sourcing as the next generation of Outsourcing and suggestions for future research

Following from the literature review on Cloud Sourcing in top IS conferences and top IS journals (AIS) there is to some extent a discussion and statement about Cloud Sourcing being the next generation of outsourcing. Albeit, it can be concluded that it ends as an empty statement with no well-grounded evidences. No studies have been found, in the searched databases, only dedicated to this provoking statement and perhaps obsolete paradigm shift. Cloud Sourcing is barely mentioned and focus is instead shifted on capabilities, resources, processes entailing outsourcing, adoption of cloud computing etc. By only mentioning Cloud Sourcing and stating its future impact in the reviewed papers, the authors overlook the deeper problem of the lack of evidence for its claim. More recent papers extend to include other aspects outside of the security, risk and adoption issues [47, 48, 56-60] which are opening up for broader discussions on the topic. Still the topic is lacking in evidence based research.

As literature shows that cost reduction, flexibility and access to talent are the motives for outsourcing [61], and literature also claims that Cloud Sourcing could increase the benefits of the factors for motivation. It is puzzling that no research has been done on this topic which at first glance might seem researched, but on closer inspection reveals to be lacking in depth. If Cloud Sourcing is predicted to create an evolutionary shift in outsourcing of IT, then why is this evolutionary statement with a great impact not justified through research and with empirical evidence? Of course, many will probably disagree with this assertion that what is discussed in practice on Cloud Sourcing is still not captured by the academic world in published papers. But the growth of Cloud Sourcing as a field is real and, arguably, might be the most significant factor in the historical development of outsourcing. Whereas the literature review of this paper provides ample evidence that there is a lack of research on Cloud Sourcing that supports the statement made on its significance for an outsourcing evolution, Gartner [18] and Muller [11] convinces us that this is an area to catch up on in academic research. This research would be fruitful to both practitioners and academics bridging the gap and formalizing Cloud Sourcing especially in the fields of transaction cost economics, resource dependency theory, and knowledge management as it would offer a novel phenomena and give good grounds for critique of traditional outsourcing. Limitations of our study regard mainly the uneven amount of papers studied and compared between selected journals and conferences which might at first thought appear to affect the results negatively. Although, we have delimited our study to specific sources of material in which we have used the papers that exist – and as such under those conditions we believe to have covered what was available with regards to amount of papers and their distribution.

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