Research Agenda for Mobile Context Sensitive Business Processes

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ABSTRACT

Mobile devices like smartphones and tablets are ubiquitous and have affected many daily work activities such as maintaining contacts via a mobile CRM. Furthermore, mobile devices provide many sensor data. They measure physical quantities like location or acceleration. In addition, the connection to wireless networks made it feasible to query data in real time, like customer history or the next calendar appointment. These sensor information and data could be used to enhance business processes with context. The context information could be utilized to adapt business process and mobile applications automatically to the current situation. Therefore, this paper aims at evaluating existing approaches for mobile business process and business process adaption in a literature review. Furthermore, it shows how existing approaches cover the business process lifecycle and reveals gaps for a further research agenda.

KEYWORDS

Context Sensitive Business Process, Mobile Business Processes, Process Adaptation, Literature Review, Research Agenda

INTRODUCTION

Business process modeling has become a widely used practice and has been adopted to support tasks regarding organization, communication or workflow across different industries (Hammer und Champy 1993; Becker et al. 2011; Vom Brocke und Rosemann 2010; Scheer 2000; Niesen et al. 2016). The emergence of smartphones has changed the working conditions of the employees and employers. 47% of interviewees stated that they used smart phones for their daily tasks on the workplace, according to a survey by Intel Research (Intel IT Center 2013). Moreover, 18% stated that they use a tablet for their job. HEINRICH and LEWERENZ (2015) indicate that context can be used to reduce information by pre-selecting services. Moreover, FALK and LEIST (2014) show that mobile applications have positive impact on business processes in terms of cost and time reduction, as well as in quality and flexibility improvements. In addition, it is possible that certain parts of a business process can be conducted by applications on mobile devices through the measurement and interpretation of context. This trend is likely to increase by current trends like 'bring your own devices' (Kerr und Koch 2014; Morabito 2014) or 'mobile devices management' (Rhee et al. 2013), and illustrates the influence of mobile devices on the workplace. Moreover, many tasks of daily work activities can now be executed anywhere and anytime. The change from stationary computers to mobile devices can also be used to redesign business processes to more flexible mobile business processes and consider sensor data captured from these devices. These data include physical quantities like location, acceleration or brightness, which could be measured through the mobile devices. Furthermore, data could be queried from different information systems via mobile or wireless network. These capabilities of mobile devices could be used to measure and provide context for business processes.

Context is defined by DEY as any information that can be used to characterize the situation of an entity (Dey 2001). Entities can be a person, place or object which is considered relevant to the interaction between a person and an application. Context evaluation and interpretation can be used to enhance the whole business process lifecycle (BPL). The BPL has been defined by many researchers and companies (Puchan und Schöppner 2016) like WESKE (2007), SCHEER and JOST (2002; 2005), DUMAS et al. (2005), ALLWEYER (2012), GADATSCH (2017), SCHMELZER and SESSLMANN (2003), BAYER and KÜHN (2013) and others. Some define only three phases (Schmelzer und Sesselmann 2003; Scheer et al. 2005; Scheer und Jost 2002), others define four (Allweyer 2012; Weske 2007; Dumas et al. 2005) and more phases or structured the lifecycle in more detail (Gadatsch 2017; Bayer und Kühn 2013). However, for the purpose of investigating the support of context in the BPL, a lifecycle with four main phases is sufficient. These phases are design, implementation, execution and controlling, which are included in the aforementioned lifecycles. In the design phase the business process will be defined and/or (re-)planned, depending on whether it is the first or a further iteration. In the implementation phase the designed business process will be implemented, which means that a set of policies and procedures have to be communicated and software tools for business processes have to be adapted. Business

process instances will be initiated to fulfill the business goals of a company in the execution phase. In addition, the business process management systems control actively the execution of the processes and gather and save data about it. The gathered data will be used to analyze and evaluate the business processes in the controlling phase. The goal is to improve the process models and their implementation. These four phases are sufficient because BPLs with more phases often split up one of these phases to detail the tasks in each phase. In addition, the aim is to cluster the findings of the literature research, but more phases are leading to less expressiveness of the results. Another problem of considering more than these four phases is that the demarcation of the single phases to each other becomes more difficult just as the classification of the findings.

Although, prior research has investigated adaptation or context sensitivity in single phases of business processes (Becker und Delfmann 2007; Burkhart et al. 2012; Gottschalk et al. 2007), however there is no holistic approach for the mobile context sensitive business processes. Therefore, we aim to create a research agenda for mobile context sensitive business processes. It is based on a literature review in order to figure out what parts of the BPM-lifecycle already are covered by mobile context sensitive business processes. Therefore, this paper answers the following research questions (RQ):

RQ.1: *What are the existing approaches in literature that already explore the impact of context on business processes supported by mobile devices?*

RQ.2: *Which phases of the business process lifecycle do these approaches cover and what is their contribution?*

RQ.3: *How should a research agenda for mobile context sensitive business processes look like?*

To address these question, we conducted a rigorous and in-depth systematic literature research in the field of information systems (IS). The remainder of this paper is structured as follows. First we introduce the scientific approach of our literature review, explaining the research procedure. From our review findings we present the main topics in the literature and discuss them. Lastly, we lay out the implications for this research field.

RESEARCH METHOD

The selection of a research method is related to the research questions and the derived targets of these questions. For every research, the research method has to be determined individually, and cannot be decided a priori (Seel 2010). The selection is a critical and reflective decision.

As the research question aims to ascertain the state of affairs of mobile context sensitive business processes, a literature review would be an appropriate research method. To carry out a methodically correct and scientifically appropriate literature review, the framework of VOM BROCKE et al. (2009) will be applied, which is depicted in Figure 1. teps I, II and III will be conducted and discussed in the section "Definition Of The Review Scope" and "Research Concept". Afterwards, the findings of the review (Step IV) will be presented in the section "FINDINGS OF THE LITERATURE REVIEW". Finally, the results of the review will be reflected on, and further work in the area will be discussed (Step V). The literature review was sequentially conducted (Vom Brocke et al. 2015).

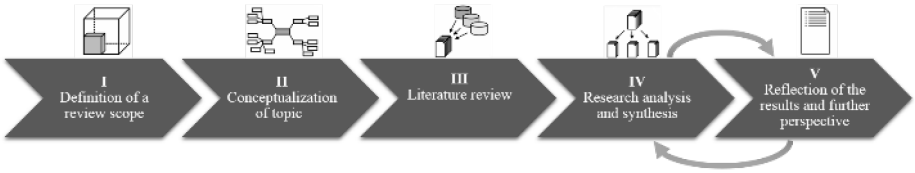

Figure 1. *Research framework for a literature review based on VOM BROCKE et al. (Vom Brocke et al. 2009)*

THE FOUNDATION OF A SYSTEMATICAL LITERATURE REVIEW FOR MOBILE CONTEXT SENITIVE BUINSESS PROCESSES

Definition Of The Review Scope

Some useful limitations have to be put in place. It is helpful to limit ourselves in order to reduce the scope of the review. These limitations will be set up by describing the characteristics which the search objects have to show. A typical limitation is a time constrain for the search objects. An appropriate instrument to describe the scope of a literature review is the taxonomy table after COOPER (Cooper 1988), which was adjusted by VOM BROCKE et al. in 2015 (Vom Brocke et al. 2015). He defined four characteristics and assigned categories to each of them. The scope for this literature review is depicted in Table 1.

Table 1. *The scope of the literature review as recommended by Vom Brocke et al. (Vom Brocke et al. 2015)*

	Characteristics	Categories		
1	Process	Sequential	Iterative	
2	Sources	Citation indexing sevices	Bibliographic databases	Publications
3	Coverage	Comprehensive	Representative	Seminal works
4	Techniques	Keyword search	Backward search	Forward search

Since the aim of this paper is to clarify the current state of the art of the impact of mobile devices on the business processes and the BPL, the focus of the review is on the research outcomes. The goal, therefore, is to conduct a sequential literature review in bibliographic databases as well as publication outlets and based on a keyword

search, which will be completed by a backward and forward search.
The coverage is not comprehensive, owning to the task to collect as much literature as possible (cf. Research Concept). A time frame will not be set, although the massive spreading of mobile devices began with the launch of the iPhone in 2007. However, ideas about how to mobilize and contextualize business processes may be older.

Research Concept

After the classification of the review scope, the research concept has to be described in greater detail. Hence, the search string with its keywords for the literature search has to be presented and the research sources have to be introduced. Afterwards, the quantitative findings will be depicted. Our keywords were the result of a brainstorming process. To combine our keywords into a search string, we used a keyword matrix (cf. Table 2). The checked marked words are combined with "AND". For example, the strings "mobile adaptable" and "business process" result in the search string "mobile adaptable AND business process". The keywords, like "context sensitive" and "business process", are selected according to the topic. We also added synonyms for the term "context sensitive", such as "context aware", "adaptable" and "configurable". Since we only wanted to get literature about *mobile* business processes, we added mobile in front of "context sensitive" and its synonyms. To not exclude papers which outline adaptable processes or business process management, we additionally added only the term "process". Furthermore, with the basic form of the term "process", we also included variations of it, such as "process*es*". The word "model" was added to include all papers which present a way to model mobile context sensitive business processes. For the same reason that we added the word "process", we also added the basic form of the term "model", including all kinds of variations like "mode*ll*ing" or "mode*l*ing". The term "framework" has been added to get access to papers about a generic functionality about mobile context sensitive business processes. The resulting keywords were used in every chosen search engine to find hits in every possible field like title, keywords, abstract or full-text.

Table 2. *Search term matrix*

search term	mobile adaptable	mobile context sensitive	mobile context aware	mobile configurable	business process	framework	model	process
mobile adaptable					✓	✓	✓	✓
mobile context sensitive					✓	✓	✓	✓
mobile context aware					✓	✓	✓	✓
mobile configurable					✓	✓	✓	✓
business process	✓	✓	✓	✓				
framework	✓	✓	✓	✓				
model	✓	✓	✓	✓				
process	✓	✓	✓	✓				

Table 3 shows the results of our database research. The second column lists all hits in the databases. The initial search yielded a high number of total hits (5858), because of the general nature of the terms *process* and *model*. These were included to get the full range of the publications which may concern our topic. To narrow down these results, we conducted a selection process. In a first step, we analyzed the titles as well as the abstracts and chose only articles related to our topic *mobile context sensitive business processes*. Most of the discovered titles concerned only "normal" processes, not mobile processes, which explains the relatively low number of relevant titles in the third column. The second step was to sort out duplicates across the different sources.
The remaining articles were analyzed in greater detail by reading the introduction and the conclusion to get an idea of the findings (third step). In this step we excluded articles that did not indicate or refer to mobile context sensitive business processes. In the last step, we executed a forward and backward search (Webster und Watson 2002) within the remaining articles to find additional input. This meant screening the references used as well as searching publications citing these articles. Our final sample consisted of 21 relevant articles, which we categorized in our literature analysis (cf. FINDINGS OF THE LITERATURE REVIEW).

Table 3*. Results of literature research*

Databases	Total hits after all search string inquiries	Relevant after title and abstract analysis	Relevant after full text analysis	Relevant after forward and backward search
EBSCOhost	87	1	1	1
SpringerLink	1684	7	5	5
ACM DL	1934	1	0	0
ScienceDirect	294	4	3	4
IEEE Xplore	1757	11	6	9
AISeL	102	1	1	1
Others	0	0	0	1
Sum of all relevant hits				**21**

FINDINGS OF THE LITERATURE REVIEW

The 21 identified and relevant articles will be mapped to the BPL phases to classify the literature body. The phase is separated into architecture and modeling. Articles proposing an architecture or a framework for context sensitive applications to simplify the implementation are grouped as *architecture*. If an article presents an approach concerning the question of how to depict context in modeling languages to create context sensitive business processes or supportive applications then it is grouped as *modeling*. In the following, we first introduce the meta-data analysis, then present the content of the relevant articles.

Meta-Analysis

The research was conducted in late 2016. For almost every year since 2001 papers were found. This is in line with our expectation that no relevant paper had been published before the definition of context was introduced and established in the scientific community. This was a process from the early 1990s (Weiser 1991; Schilit et al. 1994) until the turn of the century (Dey 2001; Schmidt et al. 1999). After 2000 one to three relevant papers were

found for almost every year, which indicates that this topic is relevant to the scientific community. Figure 2 shows in which year the identified papers were published.

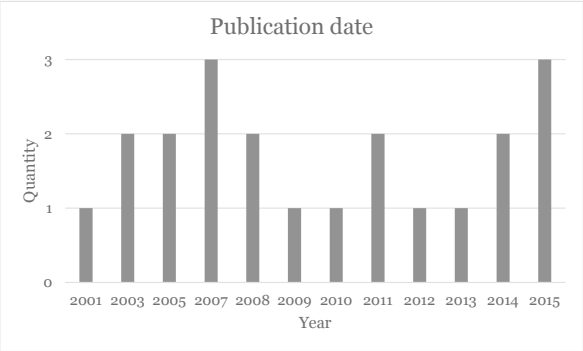

Figure 2 *Publication date of the identified articles*

In Figure 3 the distribution of the identified articles across the different phases (design, implementation, execution and controlling) of the BPL is presented. Three articles were assigned to two phases because they cover both (cf. Content Analysis). The design phase was divided into modeling and architecture. This became necessary in order to differentiate between model language approaches for context sensitive business processes or applications, and the architecture (design) of a context sensitive application or framework. The distribution shows that 21 articles refer to the design phase. Eleven articles are related to the subdivision architecture and ten to modeling. The other phases are poorly covered. Only two articles are related to implementation, one to execution and none to controlling. This lends support to our expectation that a holistic approach for all phases of the BPL has been missing until now, and indicates a gap for further research.

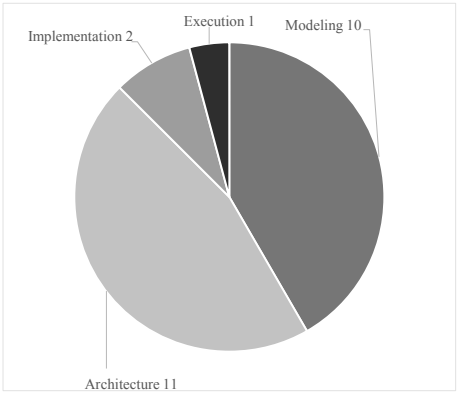

Figure 3. *Distribution of the papers across the phases. The design phase is split up in "architecture" and "modeling"*

Based on the results, a partial answer to the research question "*How deeply has the body of the literature explored the impact of context on business processes supported by mobile devices?*" can be given. The main focus of the research so far is on how a context sensitive application can be constructed and how to depict context in modeling languages. A deeper insight will be given in the next section.

Table 4. *Findings of the literature review*

Literature	Design		Implementation	Execution	Controlling
	Modeling	Architecture			
Al-alshuhai and Siewe 2015a	x				
Al-alshuhai and Siewe 2015b	x				
Barrenechea and Alencar 2011		x			
Berardinelli et al. 2010	x				
Boudaa 2014	x				
Capra et al. 2003		x		x	
Caus et al. 2009		x			
Choi 2008		x			
Daniele et al. 2007	x				
Gu et al. 2005		x			
Hamann et al. 2008		x			
Heinrich and Schön 2015	x				
Jang et al. 2001		x			
Karen Henricksen et al. 2003	x				
Kim et al. 2011		x			
Mizouni et al. 2014		x			
Reiter et al. 2013		x	x		
Sheng and Benatallah 2005	x				
Shrestha et al. 2012		x			
Simons and Wirtz 2007	x				
Tao and Yang 2007	x		x		
∑	10	11	2	1	0

Content Analysis

After the meta-analysis, we studied the literature to extract all relevant information to answer the research questions from the introduction.
Therefore, presents the findings of the literature review. We assigned every article to at least one category: the phases design, implementation, execution and controlling of the BPL. This helps to identify which phases have been examined in the literature so far, and which are less covered.

Design
All identified papers are related to the design phase. In the papers, two kinds of design approaches exist. The first kind is the designing of an architecture or a framework for context sensitive applications to simplify the implementation. The other approach concerns the question of how to depict context in modeling languages to design context sensitive business processes or supportive applications.

Design – Modelling
In two papers, AL-ALSHUHAI and SIEWE present extensions for two unified modeling language diagrams (UML) (Object Management Group (OMG) 2015) to depict context within these diagrams. In the first paper (Al-alshuhai und Siewe 2015a), the class diagram is extended. The second paper (Al-alshuhai und Siewe 2015b) extends the activity diagram so that it becomes context sensitive. In both diagrams, the authors introduce new annotations to represent context in the proper way, and empower the UML diagrams for context modeling. A similar approach for extending the UML diagram is introduced by SHENG and BENATALLAH (2005) who name it "ContextUML". It is strongly related to the UML class diagram and can be used to design software components for context sensitive applications. SIMONS and WIRTZ (2007) also introduce an extension for depicting context in UML.
Another extension for a UML diagram can be found in the work of BERARDINELLI et al. (2010). They introduce a way to cover performance parameters, context management and software architecture in one model. With this approach, it is possible to model context behavior related to performance parameters, like remaining battery level or wireless connection. The next extension for the UML is presented by BOUDAA (2014). First, he presents the meta model extension of the UML use case diagram. Next, he introduces new annotations for the diagram to depict interdependencies between the use cases.
DANIELE et al. (2007) present in their work a domain specific language (DSL) rule engine which expresses the behavior of context sensitive applications. With this engine, it is possible to execute the rules on JESS (Jess, the Rule Engine for the Java Platform 2016). Another design approach presents a new modeling language and is proposed by HENRICKSEN et al. (2003). The language is based on the object-role modeling (ORM), which means that context is modeled through different roles and their relations. The authors also introduce different relation types and expressions to depict context.
In the work by Heinrich and Schön (2015) it is mentioned that business processes must consider "non-static" context events which change the process execution immediately, for instance, an upcoming thunderstorm in an outdoor business process. They present an algorithm which supports automated process planning for context-sensitive processes. This makes it easier to select the appropriate task in a business process at runtime. However, they do not present a solution of where the context data originates.
In order to make business processes more flexible, Tao and Yang (2007) propose a particular mechanism. Their solution is to design an abstract business process with all functionalities for all users. However, its concrete functionality can vary depending on the user who is conducting the business process.

Design - Architecture
The first approach was conducted in 2001 by Jang et al. (2001). They developed an architectural concept with three parts. On the top is the graphical user interface (GUI) which handles the user interaction and is adapted to the identified context. Beneath is the "service management" layer, which offers different context services to the adaptive GUI. It also provides the appropriate context information to the different services. At the bottom is "context management", which maintains the different context sources. With this architecture, the logic is encapsulated in the "service management" layer. This concept, reminiscent of the model view controller (MVC) architecture, is well known in software engineering. It also separates the graphical representation, the logic and the data sources from each other. Similar approaches were made in (Barrenechea und Alencar 2011), (Caus et al. 2009) , (Choi 2008), (Gu et al. 2005), (Kim et al. 2011) and (Shrestha et al. 2012).
The proposed architecture of Barrenechea and Alencar (2011) is also a three layer architecture. Their architecture is event based, which means that independent software components can subscribe or publish events. These components are placed in the "context-aware application" layer. The middleware layer maintains the subscriptions and advertisements along with content and context filtering. The "distributed event-based system" layer is the distribution environment. In this approach, the authors do not differentiate between source and receiver components, because one component can be both. As a result, they have only the logical encapsulation.
To standardize context functions, Caus et al. (2009) presented a framework called "Hydra". This is also a three layered framework which encapsulates the context logic in layer two, the application logic in layer three, and the communication technologies in layer one. This framework is supposed to simplify and accelerate the implementation of mobile context sensitive applications.
Choi (2008) investigates how context influences software system development. He separates the development into requirements, context modeling, software architecture

and design, and introduces a context architecture called "watcher controller action model" (WCAM), which meets all the requirements he reveals in the analysis. The "watcher" monitors all the changes on the sensors. In the "model", so called "context reducers" gather all context attributes from the sources and infer the current context. The "controller" maps context information to services and transfers the information. In the "action" component, the "action manager" provides the context services to third party components.

In the article by Reiter et al (2013) they introduce a Business Process Management System (BPMS) architecture for a closer alignment of telecommunication technology and BPM. They propose that a BPMS could serve as a source for context identification in business processes. Therefore, they investigate how different context dimensions, like location, presence or task, could be identified through the datasets of a BPMS and how satisfying the result is. They also present an example program that could discover this specific contexts. However, this architecture is limited to BPMS as a source for context and furthermore only to communication context. Some contexts are not captured by BPMS like machine states or smart device data.

The work of Gu et al. (2005) introduces first an ontology for context sensitive systems and then proposes a new framework called SOCAM. This refines the work of Jang et al. (2001) by adding some components. However, it is also based on the three different layers model. The same can be said about the approach of Kim et al. (2011). They focus on the best way to aggregate information from the different context sources to generate context information and provide it to the different services. Mizouni (2014) also introduce a framework architecture for context sensitive applications.

A context aware mobile application (CAMA) architecture is introduced in (Shrestha et al. 2012). They present a very detailed architecture. However, it also basically consists of a service provider which offers the different services to the applications. A logic system called "context aware system" handles the context information aggregation over the different context sources. The last part of the model are information databases, like internal and external sources.

Another architectural approach in this category tries to resolve conflicts when more than one defined rule can be applied on context changes (Capra et al. 2003). The authors have designed an algorithm which tries to resolve these conflicts with a maximum of "social welfare". They named their algorithm CARISMA.

Hamann et al. (2008) present a development methodology. This helps develop an architecture for mobile context sensitive applications. It basically consists of two steps. In a first step an "abstract system design" has to be modeled. Hereafter, the specific components can be modeled in more detail.

Implementation

The findings for the implementation phase contain only the papers by TAO and YANG (2007) and REITER et al. (2013). Not only do TAO and YANG present a way to design business processes more flexible in terms of context, they also describe an approach to implement these business processes. Their work is based on the idea of designing an abstract business process which contains all generic activities. In a second step, context configured business processes are designed, which support users with different functionalities and provide differentiated services based on context. To map the relationship between the generic business process activities, which can be applied to every user, and the context configured business processes, policies are defined. To implement this business process method, the authors also present an algorithm for the mapping. Therefore, their work does not only show how to design context sensitive business processes, but they also present a way to implement them.

To prove the approach REITER et al. (2013) present a software prototype in their article. They want to detect some communication context from BPM-Systems. Therefore, they present the architecture of the software which is based on the Liferay portal and jBPMN as a workflow engine. The software is built on loose coupled components which each have specific tasks. Thus, it could be easily extended by additional components or single components could be exchanged. Hence, they do not only present an architectural design of a context detection framework for BPMN, they also present the implementation of it.

Execution

Similarly to the implementation phase, only one identified paper can be classified as belonging to the execution phase. It is the work of CAPRA et al. (2003). With their architecture of context sensitive applications, they also introduce an algorithm which solves problems at run-time. This is the reason for classifying this paper as also dealing with the execution phase. The algorithm solves the problem when more than one rule or policy can be applied to change the behavior of context sensitive applications. The idea is to treat this problem like an auction where agents make a collective choice from a set of possibilities. The auctioneer collects all bits and selects the best alternative which maximizes the "social" welfare. In the case of mobile context sensitive applications, the "auctioneer" selects that alternative which does not violate any rules but promises the best performance.

Controlling

Unfortunately, no articles were found for the controlling phase of the BPL. We had hoped to find papers about how context sensitive applications influence the controlling of business processes or which new opportunities arise with them.

IMPACT OF THE FINDINGS TO THE RESEARCH QUESTIONS

In this section the three declared research questions for our literature review will be answered. The body of the literature review has mainly explored the architectural design of mobile context sensitive applications. In

addition many papers were found which presented a way to depict context in a modeling language. Especially UML diagrams – six out of ten design articles – were used to represent context.
Nevertheless, the BPL parts *implementation* and *execution* were poorly covered. Only two papers in the *implementation* and one in the *execution* phase were found. The two papers in the *implementation* phase show a concept-proof implementation of the proposed ideas of a context-sensitive services application. The paper for the *execution* phase introduces an algorithm to cope with different opportunities which could be applied to adapt a business process.
Even worse, no paper could be related to the *controlling* phase. However, this phase could also profit from a contextualization through mobile devices. It has different functions, such as monitoring the business goals by continuously identifying deviations, and correcting them. One possibility to do so is through comparisons, like the target-actual comparison. When measuring deviation, the determination of key performance indicators (KPI) plays an important role. Traditional KPIs are process time, costs of the process, or process quality. However, these traditional KPIs can be refined or extended by context information about business processes. Let us assume that a field sales employee, A, boasts a substantial difference in the sales numbers compared to employee B. With traditional KPIs, one would conclude that A works less than B. However, the new KPI *duration of travel time* reveals that A has to spend more time traveling from customer to customer. This KPI can be measured via a mobile context sensitive application. This example indicates the potential of mobile context sensitive applications for the controlling phase of the BPL. The poor results in the implementation, execution and controlling phases indicate that the literature has hardly investigated the impact of mobile devices in other parts of the BPL.
The main topics of the identified literature were the extension to design context sensitive business processes or the architecture of context sensitive applications. The architectural approaches seem to be similar, but they differ in details. They all have a three layered design in common to construct a service platform. The platforms then offer the sensor evaluation and information aggregation for the different use cases. The articles in the modeling section presenting approaches to extending existing standard modeling languages like BPMN, EPC or UML. Some papers show newly developed modeling languages. Only three papers, CAPRA et al. (2003), REITER et al. (2013) and TAO and YANG (2007), present interesting approaches which also impact other phases (cf. Content Analysis).
However, the amount of papers over all phases was low. Only 21 articles could be identified as relevant to the BPL in a mobile context. The answer to ***RQ. 1*** is that the body of literature has only poorly explored the impact of mobile devices on the BPL. The coverage is concentrated on the *design* phase with 88% (Modeling 42% and Architecture 46%). The *implementation* phase gains 8% of the identified articles and the *execution* phase only 4%. The *controlling* was not discussed in the literature at all. So, only the first phase is sufficiently examined by literature. In the other phases there is room for improvement, which finally answered the ***RQ. 2***.
The conclusion of these two questions indicates gaps or potential for further research ***(RQ. 3)***. First, the other three phases have to be addressed to utilize the contextualization of business processes and mobile context sensitive applications. Secondly, a holistic approach which covers all phases of the BPL is missing in the literature. Such an approach could take advantage of context sensitivity and raise the efficiency of business processes. Furthermore, it may lead to faster adjustment of business processes, or even a faster re-engineering.

CONCLUSION AND RESEARCH AGENDA

The purpose of this literature review was to provide an overview of the research topics and its contribution as well as challenges and opportunities of the impact of mobile devices on the BPL. Therefore, the meta-analysis of the identified articles revealed that the topic of mobile context sensitive business processes is relevant to the scientific community. Additionally, it revealed that only the design phase of the BPL is sufficiently covered by scientific papers. However, the amount of contributions overall was low. The phases' implementation and execution were poorly represented by two papers in the implementation and one paper in the controlling phase. For the controlling phase no paper was found.
In the section Content Analysis the relevant articles were discussed. Due to the fact that all of the papers are related to the design phase, we separated the articles in two categories. This increased the clarity and made it easier to analyze the papers. Most of the articles describe an architecture presenting an approach with different layers. In the modeling category most of the findings introduced a way to extend a UML diagram or made an approach from scratch without using established modeling languages. At the end of our research we determined that a holistic approach for the BPL phases is missing in the scientific literature.
To close this gap, this research will be embedded in a more comprehensive research project to create an extensive framework for mobile context sensitive business processes and its phases with the following agenda ***(RQ. 3)***:
First we create a new and dedicated business process modeling language which supports mobile context sensitive processes. To save effort and profit from a well-known language and existing execution engines BPMN was selected for the extension. (Design)
Hereafter, a new modeling language for sensor modeling will be created. Context is based on different sensors that can be interdependent, which leads to complex models. Therefore, a dedicated modeling language seems more reasonable than an integration in BPMN. (Design)
The third part will be the creation of a modeling tool for the extension of the BPMN and the sensor modeling language. The aim of this tool is to generate code for the

supportive mobile application, derived from the sensor model and the BPMN extension in a model driven architecture (MDA)-based approach. (Design, Implementation)
A systematical test of the complete framework will be conducted. The study will examine the quality and time of the framework compared to the traditional modeling and implementation steps. (Execution)
To utilize the advantages of mobile devices new KPIs should be declared. Therefore, we want to identify context KPIs which could deliver a more detailed view on mobile context-sensitive business processes. These KPIs could then be collected in the execution phase from mobile devices or other sensors and analyzed in the controlling phase. (Execution, Controlling)

Literaturverzeichnis

Al-alshuhai, A.; Siewe, F. (2015a): An Extension of Class Diagram to Model the Structure of Context-Aware Systems. In: The Sixth International Joint Conference on Advances in Engineering and Technology (AET). Cochin; India.

Al-alshuhai, Ahmed; Siewe, Francois (2015b): An Extension of UML Activity Diagram to Model the Behaviour of Context-Aware Systems. In: Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing (CIT/IUCC/DASC/PICOM). LIVERPOOL, United Kingdom, S. 431–437.

Allweyer, Thomas (2012): Geschäftsprozessmanagement. Strategie, Entwurf, Implementierung, Controlling. 5. Nachdr. Herdecke, Bochum: W3L-Verl. (IT lernen).

Barrenechea, Eduardo S.; Alencar, Paulo S.C. (2011): An Adaptive Context-Aware and Event-Based Framework Design Model. In: *Procedia Computer Science* 5, S. 593–600. DOI: 10.1016/j.procs.2011.07.077.

Bayer, Franz; Kühn, Harald (2013): Prozessmanagement für Experten. Impulse für aktuelle und wiederkehrende Themen. Berlin, Heidelberg, s.l.: Springer Berlin Heidelberg (SpringerLink). Online verfügbar unter http://dx.doi.org/10.1007/978-3-642-36995-7.

Becker, Jörg; Delfmann, Patrick (Hg.) (2007): Reference Modeling. Efficient Information Systems Design Through Reuse of Information Models. Conference on Reference Modeling; RefMod; Multiconference on Information Systems; Multi-Konferenz Wirtschaftsinformatik; MKWI 2006. Heidelberg: Physica-Verlag.

Becker, Jörg; Kugeler, Martin; Rosemann, Michael (Hg.) (2011): Process management. A guide for the design of business processes. 2. ed. Berlin: Springer.

Berardinelli, Luca; Cortellessa, Vittorio; Di Marco, Antinisca (2010): Performance Modeling and Analysis of Context-Aware Mobile Software Systems. In: David S. Rosenblum und Gabriele Taentzer (Hg.): Fundamental approaches to software engineering. 13th international conference, FASE 2010, held as part of the Joint European Conferences on Theory and Practice of Software, ETAPS 2010, Paphos, Cyprus, March 20 - 28, 2010 ; proceedings, Bd. 6013. Berlin: Springer (Lecture notes in computer science Advanced research in computing and software science, 6013), S. 353–367.

Boudaa, Boudjemaa (2014): Towards a Model-Driven Requirements Specification of Context-Aware Services. In: Tenth International Conference on Signal-Image Technology & Internet-Based Systems (SITIS). Marrakech, Morocco, S. 194–200.

Burkhart, Thomas; Werth, Dirk; Loos, Peter (2012): Context-sensitive business process support based on emails. In: Alain Mille, Fabien Gandon, Jacques Misselis, Michael Rabinovich und Steffen Staab (Hg.): the 21st international conference companion. Lyon, France, S. 851.

Capra, L.; Emmerich, W.; Mascolo, C. (2003): CARISMA. Context-Aware Reflective mIddleware System for Mobile Applications. In: *IIEEE Trans. Software Eng.* 29 (10), S. 929–944. DOI: 10.1109/TSE.2003.1237173.

Caus, Thorsten; Christmann, Stefan; Hagenhoff, Svenja (2009): Development of context-aware mobile services. An approach to simplification. In: *IJMC* 7 (2), S. 133. DOI: 10.1504/IJMC.2009.022439.

Choi, Jongmyung (2008): Context: From Birth to Design. In: International Conference on Advanced Language Processing and Web Information Technology. Dalian Liaoning, China, S. 347–352.

Cooper, Harris M. (1988): Organizing knowledge syntheses: A taxonomy of literature reviews. In: *Knowledge in Society* 1 (1), S. 104–126. DOI: 10.1007/BF03177550.

Daniele, Laura; Dockhorn Costa, Patrícia; Ferreira Pires, Luís (2007): Towards a Rule-Based Approach for Context-Aware Applications. In: Aiko Pras und Marten Sinderen (Hg.): Dependable and adaptable networks and services. 13th Open European Summer School and IFIP TC6.6 Workshop, EUNICE 2007, Enschede, The Netherlands, July 18 - 20, 2007 ; proceedings, Bd. 4606. Berlin: Springer (Lecture notes in computer science, 4606), S. 33–43.

Dey, Anind K. (2001): Understanding and Using Context. In: *Personal and Ubiquitous Computing* 5 (1), S. 4–7. DOI: 10.1007/s007790170019.

Dumas, Marlon; Van der Aalst, Wil; Ter Hofstede, Arthur (Hg.) (2005): Process-aware information systems. Bridging people and software through process technology. Hoboken, NJ: Wiley. Online verfügbar unter http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10300025.

Falk, Thomas; Leist, Susanne (2014): Effects of mobile solutions for improving business processes. In: *ECIS 2014 Proceedings*. Online verfügbar unter http://aisel.aisnet.org/ecis2014/proceedings/track16/9.

Gadatsch, Andreas (2017): Grundkurs Geschäftsprozess-Management. Wiesbaden: Springer Fachmedien Wiesbaden.

Gottschalk, Florian; van der Aalst, Wil M. P.; Jansen-Vullers, Monique H. (2007): Configurable Process Models — A Foundational Approach. In: Jörg Becker (Hg.): Reference modeling. Efficient information systems design through reuse of information models ; with 5 tables. Heidelberg: Physica-Verl., S. 59–77.

Gu, Tao; Pung, Hung Keng; Zhang, Da Qing (2005): A service-oriented middleware for building context-aware services. In: *Journal of Network and Computer Applications* 28 (1), S. 1–18. DOI: 10.1016/j.jnca.2004.06.002.

Hamann, Thomas; Hübsch, Gerald; Springer, Thomas (2008): A Model-Driven Approach for Developing Adaptive Software Systems. In: René Meier und Sotirios Terzis (Hg.): Distributed Applications and Interoperable Systems. 8th IFIP WG 6.1 International Conference, DAIS 2008, Oslo, Norway, June 4-6, 2008. Proceedings, Bd. 5053. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg (Lecture notes in computer science, 5053), S. 196–209.

Hammer, Michael; Champy, James (1993): Reengineering the corporation. A manifesto for business revolution. 1. ed. New York, NY: Harper Business.

Heinrich, Bernd; Lewerenz, Lars (2015): A Novel Concept for the Usage of Mobile Information Services. In: Claudia Linnhoff-Popien, Michael Zaddach und Andreas Grahl (Hg.): Marktplätze im Umbruch. Digitale Strategien für Services im mobilen Internet. Berlin: Springer Vieweg (Xpert.press), S. 319–329.

Heinrich, Bernd; Schön, Dominik (2015): Automated Planning of Context-aware Process Models.

Henricksen, Karen; Indulska, Jadwiga; Rakotonirainy, Andry (2003): Generating Context Management Infrastructure from High-Level Context Models. In: In 4th International Conference on Mobile Data Management (MDM) - Industrial Track, S. 1–6.

Intel IT Center (2013): Mobile Computing Trends: Insight into Today's Workforce. Hg. v. Intel. Intel Research. Online verfügbar unter http://www.intel.eu/content/www/eu/en/enterprise-mobility/mobile-computing-trends-for-the-workforce-study.html, zuletzt geprüft am 10.02.2016.

Jang, Sei-Ie; Kim, Joong-Han; Ramakrishna, R. S. (2001): Framework for Building Mobile Context-Aware Applications. In: Won Kim, Tok-Wang Ling, Yoon-Joon Lee und Seung-Soo Park (Hg.): The Human Society and the Internet Internet-Related Socio-Economic Issues. First International Conference, Human.SocietyInternet 2001 Seoul, Korea, July 4-6, 2001 Proceedings, Bd. 2105. Berlin, Heidelberg: Springer (Lecture notes in computer science, 2105), S. 139–150.

Jess, the Rule Engine for the Java Platform (2016). Online verfügbar unter http://herzberg.ca.sandia.gov/, zuletzt geprüft am 26.04.2016.

Kerr, Don; Koch, Christian (2014): A Creative and Useful Tension? Large Companies Using "Bring Your Own Device". In: Birgitta Bergvall-Kåreborn und Peter Axel Nielsen (Hg.): Creating Value for All Through IT. IFIP WG 8.6 International Conference on Transfer and Diffusion of IT, TDIT 2014, Aalborg, Denmark, June 2-4, 2014. Proceedings, Bd. 429. Berlin, Heidelberg, s.l.: Springer Berlin Heidelberg (IFIP Advances in Information and Communication Technology, 429), S. 166–178.

Kim, S.; Kim, E.; Choi, Y. (2011): Composite context information design and model approach for adaptive service decision. In: 13th International Conference on Advanced Communication Technology (ICACT), 2011. 13 - 16 Feb. 2011, Phoenix Park, Gangwon-Do, Republic of Korea ; proceeding. Piscataway, NJ: IEEE, S. 1593–1598.

Mizouni, Rabeb; Matar, Mohammad Abu; Mahmoud, Zaid Al; Alzahmi, Salwa; Salah, Aziz (2014): A framework for context-aware self-adaptive mobile applications SPL. In: *Expert Systems with Applications* 41 (16), S. 7549–7564. DOI: 10.1016/j.eswa.2014.05.049.

Morabito, Vincenzo (Hg.) (2014): Trends and challenges in digital business innovation. Cham: Springer.

Niesen, Tim; Dadashnia, Sharam; Fettke, Peter; Loos, Peter (2016): A Vector Space Approach to Process Model Matching using Insights from Natural Language Processing. In: Volker Nissen, Dirk Stelzer, Steffen Straßburger und Daniel Fischer (Hg.): Multikonferenz Wirtschaftsinformatik (MKWI) 2016. Technische Universität Ilmenau, 09. - 11. März 2016, I. Ilmenau: Universitätsverlag Ilmenau, S. 93–104.

Object Management Group (OMG) (2015): Unified Modeling Language 2.5. Online verfügbar unter http://www.omg.org/spec/UML/2.5/, zuletzt geprüft am 26.07.2016.

Puchan, Jörg; Schöppner, Pia (2016): Vergleichende Analyse verschiedener Business-Process-Lifecycle-Modelle sowie Ableitung eines Vorgehensmodells für das Business Process Management. In: Thomas Barton, Frank Herrmann, Vera Meister, Christian Müller und Christian Seel (Hg.): Prozesse, Technologie, Anwendungen, Systeme und Management 2016. Angewandte Forschung in der Wirtschaftsinformatik : Tagungsband zur 29. AKWI-Jahrestagung vom 11.09.2016 bis 14.09.2016 an der Technischen Hochschule Brandenburg. Heide: mana-Buch, S. 20–34.

Reiter, Markus; Houy, Constantin; Fettke, Peter; Loos, Peter (2013): Context-Sensitive Collaboration in Service

Processes through the Integration of Telecommunication Technology and Business Process Management. In: 46th Hawaii International Conference on System Sciences (HICSS). Wailea, HI, USA, S. 491–500.

Rhee, Keunwoo; Eun, Sun-Ki; Joo, Mi-Ri; Jeong, Jihoon; Won, Dongho (2013): High-Level Design for a Secure Mobile Device Management System. In: Louis Marinos und Ioannis Askoxylakis (Hg.): Human aspects of information security, privacy, and trust. First international conference, HAS 2013, held as part of HCI International 2013, Las Vegas, NV, USA, July 21 - 26, 2013 ; proceedings, Bd. 8030. Berlin: Springer (Lecture notes in computer science, 8030), S. 348–356.

Scheer, August-Wilhelm (2000): ARIS - Business Process Modeling. 3. ed. Berlin u.a.: Springer.

Scheer, August-Wilhelm; Jost, Wolfram (2002): ARIS in der Praxis. Berlin, Heidelberg: Springer Berlin Heidelberg.

Scheer, August-Wilhelm; Jost, Wolfram; Wagner, Karl (Hg.) (2005): Von Prozessmodellen zu lauffähigen Anwendungen. ARIS in der Praxis ; mit 6 Tabellen. Berlin: Springer. Online verfügbar unter http://lib.myilibrary.com/detail.asp?id=62311.

Schilit, B.; Adams, N.; Want, R. (1994): Context-Aware Computing Applications. In: First Workshop on Mobile Computing Systems and Applications (WMCSA). Santa Cruz, California, USA, S. 85–90.

Schmelzer, Hermann J.; Sesselmann, Wolfgang (2003): Geschäftsprozessmanagement in der Praxis. Kunden zufrieden stellen, Produktivität steigern, Wert erhöhen ; Neu: Six Sigma in Geschäftsprozessen, komplettes Praxisbeispiel. 3., vollst. überarb. Aufl. München: Hanser.

Schmidt, Albrecht; Beigl, Michael; Gellersen, Hans-W (1999): There is more to context than location. In: *Computers & Graphics* 23 (6), S. 893–901. DOI: 10.1016/S0097-8493(99)00120-X.

Seel, Christian (2010): Reverse Method Engineering. Methode und Softwareunterstützung zur Konstruktion und Adaption semiformaler Informationsmodellierungstechniken. Berlin: Logos (Wirtschaftsinformatik - Theorie und Anwendung, 20).

Sheng, Q. Z.; Benatallah, B. (2005): ContextUML: A UML-Based Modeling Language for Model-Driven Development of Context-Aware Web Services Development. In: International Conference on Mobile Business (ICMB). Sydney, Australia, 11-13 July, S. 206–212.

Shrestha, Aaratee; Biel, Bettina; Griebe, Tobias; Gruhn, Volker (2012): A Framework for Building and Operating Context-Aware Mobile Applications. In: Nalini Venkatasubramanian (Hg.): Mobile wireless middleware, operating systems, and applications. 4th international ICST conference, Mobilware 2011, London, UK, June 22 - 24, 2011 ; revised selected papers, Bd. 93. Heidelberg: Springer (Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, 93), S. 135–142.

Simons, C.; Wirtz, G. (2007): Modeling context in mobile distributed systems with the UML. In: *Journal of Visual Languages & Computing* 18 (4), S. 420–439. DOI: 10.1016/j.jvlc.2007.07.001.

Tao, Aries; Yang, Jiang (2007): Context Aware Differentiated Services Development with Configurable Business Processes. In: 11th IEEE International Enterprise Distributed Object Computing Conference (EDOC). Annapolis, MD, USA, S. 241.

Vom Brocke, Jan; Rosemann, Michael (Hg.) (2010): Handbook on Business Process Management 2. Strategic Alignment, Governance, People and Culture. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg (International handbooks on information systems). Online verfügbar unter http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10419688.

Vom Brocke, Jan; Simons, Alexander; Niehaves, Bjoern; Niehaves, Bjorn; Reimer, Kai; Plattfaut, Ralf; Cleven, Anne (2009): Reconstructing the giant. On the importance of rigour in documenting the literature search process. In: *ECIS 2009 Proceedings*. Online verfügbar unter http://aisel.aisnet.org/ecis2009/161.

Vom Brocke, Jan; Simons, Alexander; Riemer, Kai; Niehaves, Bjoern; Plattfaut, Ralf; Cleven, Anne (2015): Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research. In: *Communications of the Association for Information Systems* 37 (9), S. 205–224.

Webster, Jane; Watson, Richard (2002): Analyzing the Past to Prepare For the Future: Writing a Literature Review. In: *Management Information Systems Quarterly* 26 (2).

Weiser, Mark (1991): The Computer for the 21st Century. In: *Sci Am* 265 (3), S. 94–104. DOI: 10.1038/scientificamerican0991-94.

Weske, Mathias (2007): Business process management. Concepts, languages, architectures. Berlin u.a.: Springer.