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Exploiting Internet of Things for Business Process Improvement

Christoph Stoiber[1]

Abstract: Companies are increasingly performing costly projects to exploit the value propositions associated with Internet of Things (IoT) applications. Therefore, efforts are made to integrate IoT into existing business processes aiming at beneficial Business Process Improvements (BPI). By implementing IoT technologies into certain processes, process entities can be connected, workflows can be automated, and the generated data can be utilized. However, the resulting research area of IoT-based BPI has only received little attention so far. This led to a scarcity of mature models and methods to facilitate a goal-oriented selection of appropriate IoT applications and its integration into existing business processes and information systems. The PhD Research Proposal at hand discusses arising challenges and existing research gaps regarding the exploitation of IoT for BPI and gives an overview on both relevant research questions and current and upcoming research.

Keywords: Internet of Things, Business Process Improvement, Business Process Management

1 Introduction

The widespread of the Internet of Things (IoT) led to a great variety of different applications in almost each sector of everyday life. With more than 34 billion IoT devices, the number has more than tripled from 2012 to the year 2018 [Bu09]. IoT can be defined as a network that connects uniquely identifiable things to the internet. Through the exploitation of unique identification and sensing, information about the thing can be collected and the state can be changed from anywhere, anytime, by anything [Mi15]. The main idea therefore is the pervasive presence of things or objects, such as Radio-Frequency Identification (RFID) tags, sensors, actuators, or mobile phones, which can interact and cooperate with each other [At10]. Especially industrial companies are progressively using IoT technology for efficient management and controlling of industrial processes and assets to increase productivity and reduce operational costs [Si18]. Integrating IoT can therefore positively influence, optimize, and even redesign processes. The resulting Business Process Improvements (BPI) can be measured using Process Performance Measures (PPM), which are mostly constituted as cost, quality, time, and flexibility [Du18]. As the Devil's Quadrangle theory states, that an improvement in one PPM dimension almost inevitably results in a deterioration of another, BPI is mostly focused on individual PPMs [RL05]. In contrast to incremental BPI achieved with ordinary process redesign, IoT technology can fundamentally transform processes. Just a

[1] University of Regensburg, Institute of Information Systems, Universitätsstraße 31, 93053 Regensburg, christoph.stoiber@stud.uni-regensburg.de

recent study of Harmon and Garcis [HG20] shows that IoT reveals many extensive possibilities for process improvement. The generation and use of comprehensive process data in real time and the connection of process entities can be used to improve all types of business processes and thus optimize value creation [Gi16]. An exemplary IoT application with BPI reference is the retrofitting of propane gas vending machines operated by the company Linde plc. Attaching sensors and installing a gateway, an edge device and connecting the machine to the cloud via 3G technology enables beneficial BPI of many kinds. For example, an improved authentication and authorization process of the customer by connecting the vending machine with an ID reader is possible. Also process deviations can be detected by installing sensors that recognize empty and full propane cylinders. In addition, the process guidance for customers can be improved with a combination of sensors and light bars that guide the customer during the return of empty cylinders and the picking of new full cylinders. These BPI result in reduced processing time, improved process quality, and less labor costs due to activity automation.

The pressure on companies to integrate IoT technology is growing steadily, to the point that companies, that don't adopt IoT, may not be competitive in the near future [Li17]. Although IoT is anticipated to have massive benefits for businesses, a survey of more than 500 business executives revealed, that 90% of organizations are remaining in the proof of concept or even early-stage planning phases for IoT projects [Bo16]. This lack of IoT application maturity stems from the fact, that adopting IoT technology and integrating it into existing information systems is quite different compared to adopting other technologies [Bo13], as IoT comprises multiple different technologies such as sensors, communication protocols, or servers that can be highly complex to connect to existing information systems. The efforts for integrating IoT strongly depend on already present systems, such as Business Process Management Systems (BPMS), as well as ERP, MES, or SCADA systems. Considering these factors, companies need to have an understanding on how to integrate IoT technologies into their existing information systems. In addition, expected value propositions and potential BPI areas must be clarified and illustrated to motivate decision makers to integrate IoT. Furthermore, applicable methods and models for selecting appropriate IoT technologies and applications need to be developed. The research project illustrated in this PhD research proposal addresses these challenges by investigating a set of interrelated research questions.

2 Research Questions

The fact, that a successful implementation of IoT applications constitutes a major challenge for many companies, testifies to the presence of hurdles and inhibition thresholds. This necessitates an investigation of the research area of IoT-based BPI, whereby three central research questions can be defined (see Table 1). At first, companies must have a clear and realistic understanding of value propositions that can be associated with IoT technology and how it could affect business processes. Secondly, companies need to be supported at the selection phase for specific IoT technologies and applications

that fit the anticipated BPI goals and the underlying processes. Finally, the integration of IoT technology into existing information systems and business process landscapes must be facilitated. Therefore, companies must comprehend existing organizational and technical requirements and be aware of their own maturity level regarding the integration of IoT technology.

RQ#	Focus Area	Research Question
1	Propositions	What beneficial BPI propositions can be expected from the integration of IoT?
2	Selection	Which methods can serve as a process-oriented decision basis for selecting appropriate IoT applications and technologies?
3	Integration	How can IoT be integrated into companies' business processes and what are the requirements for enterprises?

Tab. 1: Research Questions

The first research question deals with value propositions of IoT applications and which beneficial BPIs can be expected by adopting companies. It must be clearly elaborated to what extend IoT can be exploited for BPI and what value propositions, fitting the respective processes, can be anticipated by decision makers. The second research question addresses the need for selection methods that support the decision on specific IoT applications and technologies. There has been no research that addressed a structured decision model for selecting IoT applications, which also considers anticipated process improvement goals. Existing decision support models are mainly based on key learnings from other industrial use cases or generic frameworks to build up an IoT strategy [Li12]. Moreover, there are only a few clues how a process should be transformed from the actual to the target state [SS21a]. In practice, these decisions are left to the process owners without structured guidelines [Fo06]. The third research question focuses on the integration of IoT applications into existing information systems and business processes including the requirements for adapting companies. Most companies already have matured and sophisticated process landscapes and information systems that often prevent an easy implementation of IoT technologies [SS17]. One inherent cause for this situation is the need for IT systems to adapt to the flexible and near real-time continuous data flow that is generated by IoT devices [BD10].

3 Research Design and Roadmap

The research project aims at elaborating the main topic of IoT-based BPI by addressing each of the research questions individually. By eventually synthesizing the research streams into a comprehensive contribution, the subject of effective and beneficial exploitation of IoT for BPI will be illuminated. The different contributions will follow distinct methodologies including literature reviews, surveys, and the design of models and metamodels based on design science research (DSR) principles.

The first research question will be tackled in a bottom-up approach to derive actual value propositions of IoT applications that originate from their integration into business processes. Due to a comprehensive research cooperation with the Linde plc and insights into the production processes of BHS Corrugated, existing IoT applications in several business areas will be analysed with respect to BPI potentials. The goal is to unmask generic value propositions of IoT and to investigate actual benefits that can be expected by companies. This will be achieved by conducting surveys on relevant employees, mapping existing value propositions with real instances, and analysing PPMs before and after the implementation of IoT applications. In addition, the design and implementation of further applications is being considered. A first set of processes have already been selected that contain multiple IoT applications and can be used to analyse the actual impact on PPMs.

The second research question has already been partly addressed by designing a method for deciding on specific IoT applications that incorporates desired BPI goals and considers the underlying process details. In [SS21a] we proposed a structured decision model that considers IoT application clusters, anticipated BPI goals, and details of the process where the application should be implemented. At first, specific IoT application clusters were developed by conducting an extensive literature review. These clusters were examined regarding several characteristic such as their value propositions or technical aspects. Using this information, an Analytical Hierarchy Process (AHP) model has been proposed, that comprises the main objective, relevant BPI dimensions, and the formulated application clusters. To validate the approach, the model was applied to a real-life business process. Another publication, which is currently ongoing, addresses the design of an IoT-based BPI pattern metamodel which enables the illustration of generic IoT application patterns. In the context of enterprise and systems modelling, patterns describe a generic solution to a problem that has been useful in one practical application and is likely to be useful in others [Fo96]. Therefore, patterns can display all relevant IoT application elements such as the underlying problem (or BPI goal), industry examples, performance indicators, or specific characteristics of the technical solution. Figure 1 shows a draft of the metamodel that is currently work in progress. The metamodel will be evaluated by illustrating several specific IoT-based BPI patterns extracted from a literature review and the analysis of actual applications of industrial companies. This will support decision makers with investigating and selecting appropriate applications that tackle an existing challenge or provide BPI possibilities.

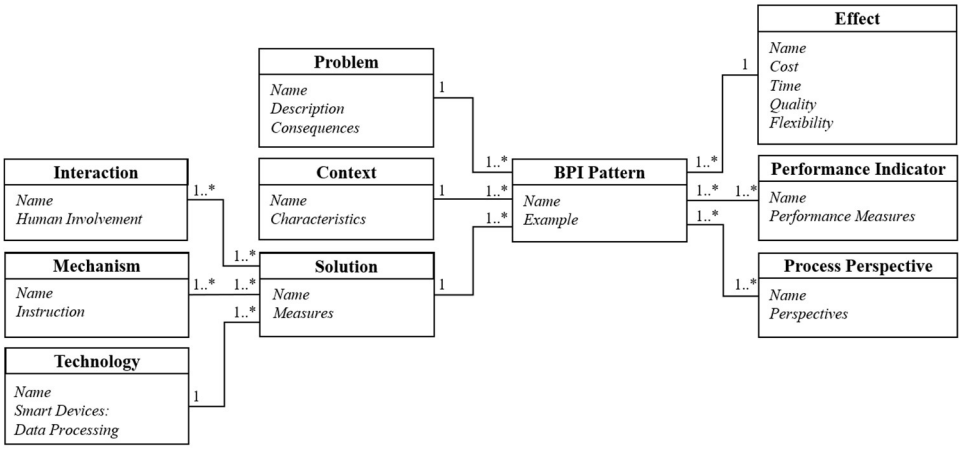

Fig. 1: IoT-based BPI Metamodel

For the third research question, an extensive literature review about Event-Driven Business Process Management (EDBPM) has already been conducted focusing on its capabilities to enable an effective integration of IoT technologies into business processes [SS21b]. We provided a comprehensive survey on existing literature about EDBPM and performed a clustering of main contributions to investigate the status quo. EDBPM constitutes an interesting approach that combines two different disciplines, namely Complex Event Processing (CEP) and BPM, to tackle the challenges of high-volume event integration. This combination leads to a system that can deal with event-driven behaviour and processes real-time data from distributed sources such as IoT devices [vAm08]. Another facet of the focus area raises the question, what requirements are needed to integrate IoT into their processes and how companies can measure their fitness in this regard. Concerning this question, a capability maturity model will be designed to assist organizations in measuring their competencies regarding the implementation of IoT-based BPI applications. As the kind of realizable BPIs and their corresponding costs highly depend on the company's culture, skills and competences, IT infrastructure, and other criteria, a capability maturity assessment is necessary. This model will form an evaluative and comparative basis for improvement as it will be designed in a prescriptive manner. To follow a rigorous methodology, the model will be designed according to DSR principles while incorporating an extensive Delphi study on industrial and academical experts.

4 Expected Outcomes

This PhD research project is aimed at illuminating the research area of IoT-based BPI including *i)* the investigation of value propositions, *ii)* the design of selection models, and *iii)* the illustration of prerequisites for a successful integration. This comprehensive approach is expected to provide a starting point for further research and concrete support

for companies to facilitate the implementation of IoT projects. The inhibition threshold for conducting IoT projects should be lowered and the probability of a successful project execution may be increased by proposing an orientation and suitable toolset. As two individual publications of the overall research project have already been accepted at recognized conferences, the relevance of the research topic is given.

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