# Context-aware Process Design: Exploring the Extrinsic Drivers for Process Flexibility

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**Abstract.** Research on process flexibility has traditionally explored alternative ways of considering flexibility during the design of a business process. The focus typically has been on ways of how the demand for process flexibility can be satisfied by advanced process modeling techniques, i.e., issues *intrinsic* to the process. This paper proposes to extent current research by studying the *extrinsic* drivers for flexibility. These drivers can be found in the *context* of the process, which may include among others time, location, legislation, culture, performance requirements etc. Exemplary scenarios for such extrinsic flexibility drivers will be discussed and preliminary thoughts on context-aware process design approaches will be shared. The paper ends with a proposed research agenda in this area.

## 1 Introduction

The notion of flexibility has emerged as a pivotal research topic in Business Process Management (BPM) over the last years [1, 2]. The need for flexibility stems from the observation that organizations often face continuous and unprecedented changes in their respective business environments. Such disturbances and perturbations of business routines need to be reflected within the business processes in the sense that processes need to be able to adapt to such change. Business process flexibility is the capability to yield to externally triggered changes by modifying only those parts of a process that need to be changed and keeping other parts stable, i.e., the ability to change the process without completely replacing it [1-3]. Thus, process flexibility consists of an *extrinsic trigger for change* and mechanisms for *intrinsic process adaptation.*

Recently, a significant number of research efforts related to process flexibility have been undertaken, mostly in the form of approaches for "adaptive" or "flexible" process models that are able to cope with such changes. Rosemann and van der Aalst [4] for instance developed a process modeling technique that supports adaptability by extending a process modeling language with variation points; and Schmidt [5] suggested an approach to support process flexibility through the use of web services. Reinhartz-Berger, Soffer and Sturm [6] approached the adaptation of process models via reuse-by-specialization, while Narendra [7] introduced a method to provide sup-

port and management of adaptive workflows. Regarding empirical work in this field, Olsson and Henfridsson [8] developed and tested design principles for context-aware interactive applications.

This body of research has in common that it is concentrated on intrinsic ways of adopting or modifying business processes. However, the actual drivers for flexibility have not yet been discussed thoroughly. As a consequence, current process modeling techniques only capture the reactive part of process flexibility, but not the stimulus for change. However, we argue that it is exactly this stimulus for change that needs to be taken into consideration. The motivation for an increased consideration of context in a process model is that it provides a stronger cause-effect relationship between the demands for process flexibility and their impact on processes. Such an explicit context awareness encourages monitoring of the relevant process context (e.g., weather, competitors' price changes, etc.). The early identification of context changes together with knowledge about what type of process changes are required leads to increased process flexibility and decreased reaction time.[1]

The related challenge is to identify, document and analyze requirements for flexibility. The combination of all situational circumstances that impact process design and execution can be termed the *context* (aka situation) in which a business process is embedded. In short, a business process context consists of values of variables, which, when being changed, require a business process to adapt to the modified set of context variables.[2] But what exactly constitutes the context of a business process? This question can be broken down into the two sub-questions: 1) What contextual variables have impact on process design and/or execution (e.g., location, but not legislation), and 2) How do different values for these variables actually impact process design and subsequent changes (e.g., processes in France require an additional quality assurance, while the same processes in Italy can be completed without such a check)? This leads to the question of how the context of a business process can be conceptualized. Moreover, how can processes be designed so that they adhere to certain contextual values ("design for context")? We subsume these and related questions under the notion of *context-aware business processes*.

This paper seeks to discuss the concept of business process context and its constitution. In particular, we seek to identify and discuss research challenges related to the development of a context-aware process design approach. We will proceed as follows: In Section 2, we present selected business examples to highlight the need for context awareness in business process design. Then, in Section 3 we outline and briefly discuss research questions that need to be approached in order to develop an

[1] Note that generally, process flexibility has to cover both expected and unexpected cases ('planned', e.g., escalation procedures, and 'ad hoc', e.g., exception handling, as per the taxonomy of process flexibility [9]) of context changes, in the latter of which it is not clear what process changes a new context requires. Technical solutions for ad hoc changes in processes such as exception handling are already available; see, for instance, [10]. Thus, this paper focuses on a subset of all possible cases of process flexibility, i.e., those cases in which there is a clear, anticipated correlation between a change in context and corresponding process changes.

[2] In the following we tend to refer just to variables, but typically this will also include the values of these variables.

understanding for the context requirements for process flexibility. We suggest potential approaches towards these research questions and point to some relevant related literature. We close in Section 4 by recapitulating the main arguments and presenting some outlook to further research.

## 2 Examples of Contextual Variables with Process Impact

As an example for contextual changes that demand process flexibility, we consider the ”teleclaims” process of a large Australian insurance company. The teleclaims process deals with the handling of inbound phone calls, whereby different types of insurance claims (household, car etc.) are lodged over the phone. The process is supported by two separate call centers operating for two different organizational entities (Brisbane and Sydney). Both centers are similar in terms of incoming call volume, average call handling time, number of call center agents and performance objectives. The main differences between the two centers are the underlying IT systems, the physical locations and the modes of operation (24 hrs. versus 9 am to 5 pm).

While this process runs smoothly in a regular business context, the organization faces an increasing number of incoming phone calls during the Australian storm season (October-March). Storms cause a higher number of damages and increase the number of incoming weekly phone calls to more than 20,000. This change in the context not only puts significant burden on both call centers, but also on the succeeding back-office processes related to evaluating and managing these claims. In order to cope with increased call traffic, the insurance company operates an ”event-based response system” that differentiates a number of categories of situations based on how severe the storms are. Based on the guidelines of this system, the first category includes localized storms and flooding and leads to a call volume of 10-50 % above average and an increased wait time of about 5-10 minutes for a period of at least two hours. The second category is triggered when strong winds, hail and structural damage occurs. This leads already to a wait time of 10-30 minutes and the call volume is 50-100 % above the forecast for at least two hours. The third category covers widespread damage leading to wait times of more than 30 minutes.

Individual response strategies have been defined for each of these categories, utilizing additional external resources as well as changes in the procedure by which claims are lodged. First, additional resources are utilized through redeployment of employees from other departments (e.g., sales) and hiring of casual staff. While most of these people are trained, their performance in terms of average call handling time is lower than the performance of the professional call center agents. Second, a streamlined way of lodging the claims is applied in order to reduce the average call handling time and to reduce the waiting time in the queue. In this so-called “rapid lodgment process” only a reduced amount of information is collected from the claimant. This leads to an average call handling time of 380 seconds for experienced call center agents and 450 seconds for additionally employed agents, down from the usual average of 550 seconds. One mechanism to deal with the different performance of these two types of agents is call routing which directs new and straight-forward cases to the casual additional workforce, while more complicated follow-up calls are directed to

the experienced workforce.

Two managers in charge for claim services and the related back-office processes evaluate the severance of the weather conditions, i.e., they monitor the relevant context of this business process, and trigger the different escalation categories leading to different variations of the process.

This example shows how a change in the context requires flexible process adaptation. This change can be anticipated and is triggered when the relevant contextual change occurs (e.g., change in weather). Current process modeling techniques, however, provide no support for modeling the relevant context. A work-around that can often be observed in modeling practice is that relevant contextual variables become an explicit part of the control flow leading to a decision point such as "Check, if process occurs within storm season". Such an explicit consideration leads to unnecessary model extensions, mixes individual run-time with build-time decisions and tends to reduce the acceptance of the process models by end users who would not be exposed to this decision in the daily execution of the process. An operational process model is supposed to focus on the intrinsic control flow; information related to the underlying context should rather be modeled in an orthogonal view that has potential impact on a number of process and other models (e.g., the organizational model).

Another example for context would be the impact of locations. While location as a contextual factor is widely discussed as part of research related to mobile applications [11, 12], it has wider implications for process management. Usually, the impact of location on the execution of a process is explicitly captured within a process model, for instance by including a decision point "Check the state in which the process occurs". Again, information regarding the location should rather be "outsourced" to a model dedicated to capture relevant contextual information. The main advantage of capturing context information external to a process model is the potential to build a library of contextual variables, which can be easier maintained and extended as opposed to context information that is buried within various process models.

Consider another example. Internet banking applications allow overseas transactions up to a certain threshold. The maximum transferable amount is geared by the respective legislative regulations of the country. The "overseas money transfer" process thus contains a business rule that is context-dependant, viz., the business rule $r$ is a function of the context $c$ [r = f(c)].

The process model depicted in Fig. 1 adheres to the principle of maintaining context information external to the process. The model merely captures a generic business rule, and a separate business rule editor specifies the rule as dependant on certain context information (i.e., country, currency and threshold). The context-dependant process information itself is described orthogonal to the process. As an example, a business rule editor could specify placeholders for relevant context variables, the values of which could be kept in a context library. When the process is instantiated, relevant values are filled into the accordant business rule and the process can be enacted within that particular context. Such an approach would follow the general concept of depicting business rules in separate views, see, for instance, [13].

However, in contrast to such an approach it can also be observed how organizations with global operations try to increase the number of context-independent business rules as part of international process standardization initiatives. In such cases

organizations seek to identify and capture business rules that are *independent* from a given context (or that should be enacted regardless of the respective context), in order to allow for a wider uptake of the process across various contexts. Nevertheless, to be able to streamline processes across contexts even in these scenarios firstly those parts of the processes need to be identified that have a need to be locally individualized due to the impact of context on its design and execution.

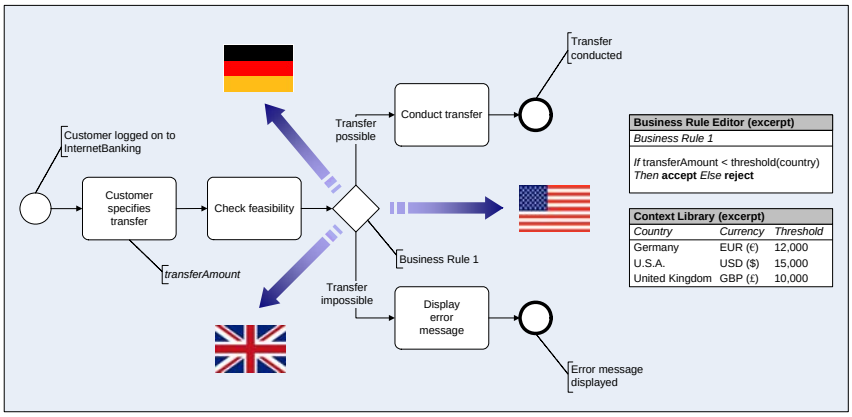


**Fig. 1.** Example of a context-dependant business rule

## 3 Context-aware Process Design. Selected Research Questions

As the selected examples indicate there is a need to identify and document extrinsic requirements for process flexibility. We argue that the model-based design of processes needs to take into account these external conditions and we propose the conception of *Context-aware Process Design* in order to approach the problem of identifying contextual variables that drive the need for flexible business processes. Overall, we see in context-aware process design a path towards a deeper exploration of the root causes of process flexibility as it investigates the initial flexibility drivers. As such, it precedes existing and future technical solutions that deal with intrinsic ways of adopting processes to change, e.g., [4, 5, 7, 10].

The idea of context awareness is not really new. In fact, we adopted it from related disciplines such as web systems engineering [14], knowledge management [15] and mobile applications research [16]. Even within the Information Systems discipline itself has contextualization emerged as a notion related to conceptual modeling [17]. The term "context-aware" was coined by Schilit and Theimer [18] and a very generic definition of context is provided by Dey [19, p. 5], who defines context as "any information that can be used to characterize the situation of an entity". Transferring this definition to the domain of business process management, a useful definition of a business process context in alignment with the definition above could be:

*The minimum set of variables containing all relevant information that impact the design and execution of a business process.*

Forthcoming from this definition we essentially foresee three main research challenges related to a context-aware process design approach (see Fig. 2), namely *context description*, *design for context* and *process adaptation*.

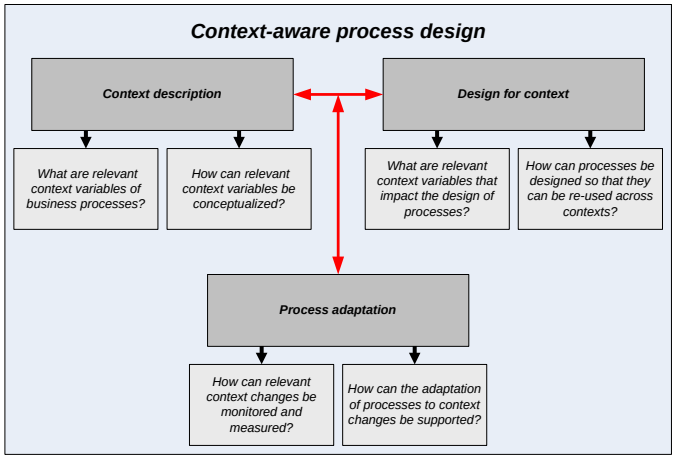


**Fig. 2.** Challenges related to context awareness in process design

We see a significant demand for research on context-aware process design. Consequently, we propose a first set of research questions in order to derive a starting point for a possible research agenda in this area. Each of the research questions will further be described in the following using selected investigative questions.

### RQ1: How can the context of a business process be conceptualized?

1. What are the relevant constituent variables of a business process context?
2. What is an appropriate taxonomy for contextual variables?
3. How can these variables and their relevant values be captured in a conceptual model that appropriately complements existing process models?

We see research challenges related to the identification and appropriate description of business process context variables, in particular in the development of appropriate conceptualizations of context and notations for context models. Also, how can context modeling be integrated with business rule specifications? Another challenge is related to the required extensions to existing meta models of process modeling languages.

Such research could benefit from research in related disciplines. In the field of mobile and ubiquitous computing, for instance, a series of workshops on the Modeling and Retrieval of Context or on Context Awareness have been initiated over the years, refer, for instance, to [20]. We found that in the area of context modeling and

description a significant amount of research has already been conducted, for instance in the form of context architectures [21] or context ontologies [22]. Future research approaches could furthermore leverage existing work on ontology-based method engineering [23], and could aim at extending modeling language meta models with context-related concepts.

**RQ2: How can contextual elements be incorporated in the design of business processes?**

1. Which contextual variables are relevant to process design?
2. How can the impact of context on the design of a business process be modeled?
3. How can flexible business processes be designed so that they can be re-used in different contexts?

Forthcoming from the identification and description of process context variables is the need for embedding and utilizing this knowledge in what we call "process design for context". In particular, in light of context information, the question is how flexible processes can be designed and modeled so that they support process *adaptation* to a contextual change (i.e., the support for a process to maintain its general design in the face of context change while modifying only those parts of the process that are impacted by the change), and process *re-use* (i.e., the support for a process design to be modifiable in a way that the same design can effectively and efficiently be implemented across different contexts). As an example, the approach by Andersson et al. [24] allows for flexible adaptation of the structure of processes on both design and run-time, meaning that forthcoming from general business models more detailed, i.e., operative, process models can be tailored to contextual changes ("the situation at hand") based on a selection of process patterns. This set of patterns could be developed and maintained in a context-oriented information base, e.g., a "case base". Generally, existing approaches related to process flexibility, e.g., [4], could be utilized and extended in order to incorporate the identified reasons for flexibility, i.e., the stimuli for change.

A significant challenge is related to the identification of contextual variables that ought, respectively should, be embedded in the design of processes. Some contextual variables may not be relevant, others may not be observable. Facets of a context that cannot be observed cannot be subjected to control; hence, such variables should be not be taken into consideration in the design of processes. Further challenges related to design for context stem from the fact that contextual change may have various facets (for instance, anticipated or not (exceptional), aware or not (hidden), durable or not (temporary), etc.). Hence, context-aware process design should incorporate monitoring capacities for observing and controlling contextual variables upon their impact on process design and/or execution. Work that may be of interest in this context includes previous research on process stability (see, for instance, [25]).

Yet another important challenge in process design for context stems from the observation that context awareness and adaptation may also lead to increased risk and instability of the resulting process. In this context, again, we see an opportunity to benefit from existing work. Rosemann and zur Muehlen, for instance, [26] outline an

approach to incorporate aspects and measures of risks into process models including risk structures, risk goals and risk states.

**RQ3: How can context-aware business processes be supported?**

1. How can adaptive process management systems be designed so that they are able to monitor and measure changes in the relevant process context?
2. How can adaptive process management systems be designed so that they support the re-use of processes across different contexts?
3. How can adaptive process management systems be designed so that they support the adaptation of processes to context changes?

Recently, efforts have been undertaken to make process management systems (PMSs) more flexible. ADEPT [27] for instance offers flexibility at both process type and instance level, and CAKE [15] offers support for both empirical processes, i.e., ad-hoc processes that are subject to changes during enactment, and knowledge-intense processes, by providing expansible general data and process models for specific domains. Other approaches, e.g., the work by Adams [10], rely on case-based reasoning to support the ad-hoc change of workflows during run-time.

However, these approaches have in common that they have not yet addressed the question how knowledge about process changes can be discovered and used for deriving optimized process models from it, and how we can learn from such additional information. Nevertheless, extensions of frameworks such as ProM [28], which build upon process mining techniques, offer a promising perspective for context-aware extensions and may enable future PMS architectures to discover, use and learn from process context changes in an intelligent manner. A first step towards such an effort would be a consolidation of existing approaches in order to counteract an increasing fragmentation of the field with multiple technical proposals. If these and related research problems within the field of adaptive PMSs can sufficiently be resolved we anticipate that process support can be offered that takes into account the relevant context when designing and enacting flexible business processes via adaptive PMSs.

## 4 Conclusions

In this paper we sought to discuss drivers and requirements for process flexibility. Our discussion rests on the observation that business processes are always situated in a certain context, i.e., a set of extrinsic environmental variables that, upon their modification, require a process to adapt to these changes. These context variables denote the drivers and requirements for process flexibility, and thus, first of all, need to be identified, classified and described. We introduced the notion of context-aware process design as an approach that we envisage to support the engineering and use of flexible business processes in adherence to the underlying context. In particular, we discussed a set of research questions around this approach that we think need to be approached in related research efforts.

We perceive this paper as a starting point for further exploration of the issues presented as well as other related challenges. We sought to give initial guidance on research on process context and flexibility by detailing important research questions and providing some background on these questions including links to related research. Ultimately we envisage a holistic process management approach that embodies and aligns contextual variables that drive process flexibility with appropriate design and support of process flexibility through adaptive process management systems.

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