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Contextualization of Business Processes

Michael Rosemann*
Faculty of Information Technology,
Queensland University of Technology, Australia
E-mail: m.rosemann@qut.edu.au
*Corresponding author

Jan Recker
Faculty of Information Technology,
Queensland University of Technology, Australia
E-mail: j.recker@qut.edu.au

Christian Flender
Faculty of Information Technology,
Queensland University of Technology, Australia
E-mail: c.flender@qut.edu.au

Abstract: Flexibility has emerged as an important requirement in the design of business processes. Research on process flexibility, however, has traditionally been focused on the intrinsic capability of a process to adapt to a new environment (e.g. workflow escalation, ad-hoc modeling). This paper proposes to extend the existing body of research by studying the extrinsic drivers for process flexibility, i.e., the root causes that actually drive the demand for flexible business processes. The drivers for flexibility can be found in the context of a process and may include among others time, location, weather, legislation or performance requirements. We argue for a stronger and more explicit consideration of these contextual factors in the design of business processes in order to make processes more adaptive. The paper discusses why context matters and how context can be conceptualized, classified and integrated with existing approaches to business process modeling. We use a goal-oriented process modeling approach to be able to identify relevant context elements and propose a framework and a meta model for classifying relevant context. These extensions are an essential foundation for the definition and implementation of truly agile processes, and as such of high practical and theoretical value.

Keywords: Business Process Flexibility; Business Process Modeling; Context-awareness.

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Biographical notes: Dr Michael Rosemann is a Professor for Information Systems and co-leader of the Business Process Management (BPM) cluster at Queensland University of Technology, Brisbane, Australia. He is the author/editor of five books, more than 130 refereed papers and Editorial Board member of seven international journals. His book Process Management' has been translated into German, Russian and Chinese. He has extensive consulting experience in BPM across various industries including telecommunications, banking, insurance, utility, logistics and media.

Jan Recker is a PhD Candidate at the Business Process Management cluster at the Faculty of Information Technology, Queensland University of Technology Brisbane, Australia. He received his BScIS and MScIS from the University of Muenster, Germany in 2004. His research interests include Business Process Modeling, Representation Theory, Process Flexibility and Reference Modeling. Findings from his research have been published in more than forty refereed scholarly publications.

Christian Flender is a PhD Candidate at the Business Process Management cluster at the Faculty of Information Technology, Queensland University of Technology Brisbane, Australia. He received his MScIS from the University of Bamberg, Germany in 2006. His research interests include System Modeling and Enactivism.

1 INTRODUCTION

Business Process Management (BPM) continues to receive significant attention as a top priority, and building business process improvement capabilities is seen as a major challenge by senior executives (Group, 2007). In line with the rising popularity of BPM, over the last decade, scholarly work has tried to address some of the challenges related to process modeling and management. One of the most prevalent and dominating research foci that has emerged is the notion of agile, or flexible, business processes (Balabko et al., 2005).

The need for increased attention to flexibility stems from two main drivers. First, the trend towards decreasing time-to-market and time-to-customer demands and an increasing frequency of product innovations combined with market changes such as globalization and new levels of compliance require adaptive business processes. The observation that organizations often face continuous and unprecedented changes in their respective business environments can be seen as an emerging demand for process flexibility (Quinn, 1992; Pine, 1999). 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 react to perturbations, viz. they need to be flexible with regard to the mutual specification of processes and environment (Knoll and Jarvenpaa, 1994; Soffer, 2005). Second, there is a technology-driven opportunity for process flexibility in the form of Service-oriented Architecture (SOA) and advanced workflow technology. While the general idea of encapsulating functionality and applications related to object orientation and component technologies have been discussed in research for many years, it has been only the breakthrough in widely accepted XML - and related standards - that made the implementation of this concept feasible. Web services now provide unseen flexibility in the internal orchestration and overall choreography of business processes and trigger the design of entire new business models (Mulholland et al., 2006). In many cases, however, it is not known what processes within the organization's process landscape would actually benefit from such flexibility.

In simple terms, flexibility is the capability to change without loss of identity (Regev et al., 2007). Business process flexibility can be seen as the capability of a process to yield to externally triggered change by modifying only those aspects 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 (Bider, 2005; Regev et al., 2007). Thus, process flexibility consists of an extrinsic trigger for change and intrinsic change mechanisms toward self-organization. However, not every change necessarily requires process changes. Instead, necessary and sufficient pre-requisites have to be fulfilled before it becomes relevant and feasible to change the process.

Yet, existing related research that deals with change management and evolution management typically addresses issues of change only after requirements have already been identified and evaluated (Arnold and Bohner, 1996). The focus traditionally is on requirements traceability and impact analysis when a change has already occurred (Ramesh and Jarke, 2001). The same holds for research related to process flexibility. Most of the existing approaches have concentrated on intrinsic ways of adopting or modifying business processes after a need for process change has arisen. 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 lack contextualization, i.e. the stimulus for change.

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 and vice versa. Relevant changes in the business environment can be anticipated and subsequently trigger the timely adaptation of business procedures. Hence, 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, decreased reaction time and improved risk management.

This paper discusses the challenge of process contextualization. We proceed as follows. First, in section 2 we will provide a motivating example to clearly position what drives our research and to outline research objectives addressed in this paper. Second, in section 3 we will discuss related work on context awareness in other research disciplines in order to introduce a useful definition and understanding of context in the environment of business process management. Third, in section 4 a meta model will be used to formalize the identified relationships. Current process modeling techniques will be briefly evaluated and an extension of these techniques with an explicit consideration of context is proposed. In section 5 we then introduce an 'onion model' as a first framework for classifying relevant context. Fourth, in section 6 we present a procedure of how the onion model can be applied for identifying and typing relevant context. A further case study will provide empirical evidence to support this procedure. Fifth and finally, in section 7 we will briefly summarize the paper and outline where we see fruitful research directions.

2 A MOTIVATING EXAMPLE

In the following we will provide brief insights into an example that we encountered during our research project on deadline-based escalations (van der Aalst et al., 2007) and which motivates dealing with context-aware business processes. Our case describes a scenario in which the demand to include an environmental element such as *weather* as a contextual variable in a process model is prevalent in order to call the correct process.

In most cases, process models are disconnected from the relevant context in which they are valid and there is often no traceability to the situation in which the process should take place. A workaround that can 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". Yet, such a workaround 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. A second commonly employed workaround, which is discussed in our example, is to design multiple process models for different scenarios (e.g. for different countries) and to highlight process deviations within these models (e.g. by color coding). The shortcoming of this approach is the high degree of redundancy between the models. Figure 1 shows how such a workaround has been employed in one of Australia's largest insurance companies that faces a need for swift and rapid process changes in certain weather conditions, e.g. during storm season (October-March). The considered process is designed to handle inbound phone calls from customers who have a range of different insurance claims including household, car, etc. The process is supported by a call center operating in Brisbane.

While this process runs smoothly for most of the year, the organization faces a dramatically increased number of incoming phone calls (from 9,000 to more than 20,000) during the Australian storm season. In order to cope with this increased call traffic, the insurance company operates an event-based response system that differentiates calls into a number of categories of situations based on how severe the storms are. Individual response strategies have been defined for each of these categories, utilizing additional external resources together with changes in the procedure by which claims are lodged. First, additional resources are utilized through redeployment of employees from other departments and hiring of casual staff (highlighted blue in Figure 1 as *Call center agent (novice)*). 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 of claim*" process (see Figure 1) 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 environmental setting 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 environment requires flexible process adaptation. A process model should be linked to its relevant context in order to be able to select the applicable model so that there is a direct relationship between context and the way the process is executed and the selection of the organizational resources. This change can then be anticipated and triggered when the relevant change occurs (e.g. a change in weather). The knowledge of the cause effect chain (here: storm season → more damages → increased volume of claims → increase call pick up time → decreased customer satisfaction), the capability to effectively monitor the contextual variable and the demands in terms of speed of change will determine what context factor will be monitored (e.g. weather changes or call pick up time). Current process modeling techniques, however, provide only little support for modeling the relevant stimuli for change.

We conclude that challenges exist to identify, document and analyze the requirements for flexibility, viz. factors that drive change, *explicitly* within a process model rather than implicitly or outside of it. This will help to better understand the interrelationships between changes in the relevant environmental setting of an organization and the imposed process changes. Overall, such contextualized process landscapes can provide an efficient source for impact analyses. The potential benefits are improved process modifications (as described in our example), better risk assessments or more agile process executions. The combination of all implicit and explicit circumstantial requirements that impact the situation of a process can be termed the context in which a business process is embedded (Schmidt, 2000).

But what exactly constitutes the context of a business process? This question can be broken down into two research 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, but the same processes in Italy do not)? This in turn leads to the question of how the context of a business process can be conceptualized. We subsume these and related questions under the notion of *contextualized (or context-aware) business processes.*

The *objective of our research* is to take current process modeling research out of its narrow focus on the control flow and its immediate constructs and to put it into the wider scope of the organizational environment by studying the mutual specification of processes and context. This has been motivated by repeated calls for a research agenda on process modeling that provides a holistic view on prob-

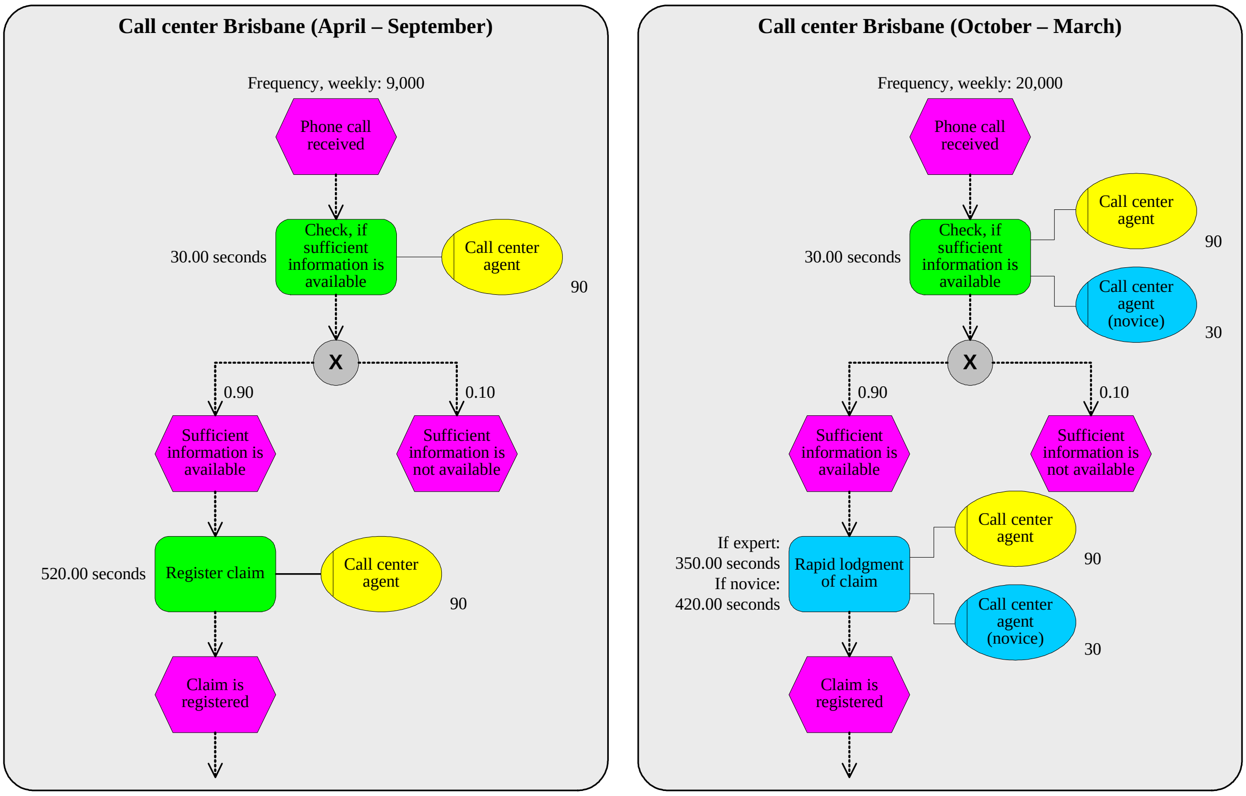

Figure 1: An example for weather as a contextual variable that impacts control flow and the involved organizational resources

lems, issues and phenomena associated with process modeling (Dalal et al., 2004). The *aim of this paper* is to make a first step towards a conceptualization of the context of business processes that may be used as a reference frame for the development of improved and extended, theoretical sound and practically applicable process modeling techniques. As a second objective, we propose a conceptual integration of context with process models by means of a meta model so as to be able to derive a procedure for identifying context relevant to a given process. This information would then allow to leverage the formalized notion of context-awareness in support for process flexibility, e.g. by means of context monitoring or context mining approaches.

3 BACKGROUND & RELATED WORK

Our research can broadly be subsumed under the two research streams of process flexibility and context awareness, both of which denote established research areas. We do not claim to be the first to discuss the notion of context. Contextualization has, for instance, been suggested as an abstraction mechanism for conceptual modeling (Analyti et al., 2007). As this and other examples show, we see potential and first evidence that our research can leverage and integrate existing approaches whilst facilitating a new and extended, and overall more comprehensive, perspective to the field of process modeling. In the following we briefly recapitulate theories and approaches that we deem suitable as a starting point for our investigation.

3.1 Process Flexibility

A reasonable argument for the increased consideration of context in the area of Business Process Management is the relationship of an organization to its changing environment. The continuously, and often in an unprecedented manner appearing turbulences of the situation (e.g. in addition to the previous examples, changes of national policies, new taxes, terror attacks) in which business processes are embedded and enacted creates a demand for flexibility in the processes themselves in order to be able to cope with such dynamics. At the same time, like outlined before, emerging technologies such as Service-oriented Architecture (SOA) or adaptive workflow technology provide increased opportunities for flexible business processes.

In essence, a business process connects different views upon an organization (e.g. data, organizational resources and information technology). A business process model is typically a graphical depiction of at least the activities and control flow logic that constitute a business process (Curtis et al., 1992). Additionally, many process models also include information regarding the involved data, actors (either human resources or machines) and potentially other artifacts such as external stakeholders or performance metrics (Scheer, 2000). Goals that define the purpose of a process may also be included in a business process model

(Soffer and Wand, 2005). Usually, hard-goals (i.e. *functional*, e.g. purchase goods in a timely manner) and soft-goals (i.e. *non-functional*, e.g. minimize purchasing costs) are differentiated.

Recently, a number of research efforts have been undertaken to extend this traditional notion of business process modeling towards agility on the one hand and the integration of some contextual elements on the other. Regarding the former, several approaches have emerged for "adaptive" or "flexible" process designs that are able to cope with changes that may occur during the lifetime of a business process. Rosemann and van der Aalst (2007), for instance, developed a process reference modeling technique that supports adaptability by extending traditional techniques with variation points. Schmidt (2005) suggested an approach to support process flexibility through the use of web services, and Narendra (2004) introduced a method to provide support and management for adaptive workflows. Other research has proposed to extent traditional process modeling approaches with some contextual information. Rosemann and zur Muehlen (2005), for instance, showed how risk modeling can be integrated with event-driven process chains, and Regev et al. (2005) extended the scope of process models to include regulatory perspectives by means of use and misuse cases.

3.2 Context Awareness and Understanding

The basic idea of context awareness is not new. However, a commonly accepted comprehensive understanding of this idea is still outstanding. In order to progress the state of research, we adopted the idea of context-awareness from related disciplines such as Web systems engineering (Kaltz et al., 2005), mobile applications research (Mikalsen and Kofod-Petersen, 2004) and, indeed, conceptual modeling (Analyti et al., 2007). In the IS discipline, the term "context-aware" was coined by Schilit and Theimer (1994). A very generic definition of context is provided by Dey (2001) who defines context as "any information that can be used to characterize the situation of an entity". Typically, approaches to incorporating contextual factors into information systems, such as approaches in the mobile applications area, focus around the user and their interaction with the systems (Schilit and Theimer, 1994; Dey, 2001). Context in this area of research is often reduced to the notion of locality (e.g. what is the closest restaurant? How do I make a booking? How do I disable incoming phone calls if I am in a meeting room?), and user characteristics (e.g. what type of food does the user of the mobile application like?). Existing frameworks such as the ECOIN framework (Firat et al., 2005) attempt to represent context as properties that can be interpreted based either on the inbuilt framework structures or based on very generic ontologies that have no structure prior to design time. However, attempting to introduce these interaction-focused approaches to the area of process flexibility requires that the process is aware of its surroundings *irrespective* of user interactions. In order to facilitate this general awareness in a structured manner, categories and layers could be used to develop a sound understanding of the relevant context.

Regarding approaches for structuring and describing context, we found that in the area of context modeling a substantial amount of research has already been conducted, for example in the form of context ontologies (Chen et al., 2003). For instance, the Context Ontology Language (Strang et al., 2003) is designed to accommodate selected aspects of context such as temperature, scales, the relative strengths of aspects and further metadata. It is designed to relate measurements back to the semantics expressed in a system. In terms of limitations for the process flexibility discussion, however, it lacks linkages to causes, both in terms of guiding goals and environmental stimuli.

Another fruitful area for investigating the notion of context-awareness in process modeling can be found in the requirements engineering discipline. A number of authors have investigated contextual factors in the engineering, elicitation, documentation and use of requirements for systems development. This work has in common that, often, goals are used as a basic concept to distinguish between intrinsic (i.e. system or system description-inherent) from extrinsic factors (i.e. those that have an influence but are traditionally not explicitly included). Rolland et al. (1998), for instance, suggest a context-oriented procedure based on objectives to identify requirements chunks in goal-based modeling. The basic idea for determining goals and relevant context in a model is centered around the notion of a requirement chunk, which is a pair $< Goal, Scenario >$ and denotes a potential way of achieving a goal in a given scenario (i.e. one instantiation of the process). As a second example, Yu and Mylopoulos (1994) use the i* framework to capture rationales behind processes relating to goals, tasks, resources and actors. Their framework allows for the explicit articulation of the inter-dependencies between a process and (some parts) of its environments, mainly the stakeholders and related environmental resources.

4 INTEGRATING CONTEXT

We conclude from our research review that a number of authors already recognized the need for contextualizing processes, i.e. to provide more explicit consideration of the environmental setting of a process. Several researchers have attempted to provide solutions to some of the related challenges, e.g. by using goals to identify environmental requirements or by explicitly linking location with user information. While these approaches are stimulating and seem promising, a general and generic understanding of the contextualization of process models is still missing. In the following, we approach this challenge and discuss how context information, on a generic level, can be integrated with current approaches to process modeling.

The scope of a business process model, which incorporates external context factors into its design, must be large enough to include factors that may implicitly be recognized by the designer but may not necessarily be constant across the lifecycle of the process. For example, the national interest rate has impact on inventory management strategies, and varies, of course, over time. Relevant context is characterized by the fact that it impacts the structure of the process model (e.g. the control flow, the involved organizational resources, the required data etc.). Contextual changes that have impact on the detailed execution of a step in a process (e.g. the sequence in which a number of purchase requests are approved) will not be considered. This also means of course that the granularity and scope of the process model influences the relevant context.

The granularity and scope of a business process model is closely linked to the goals of the depicted process. It would appear then that goals could also be used to answer the questions "is a certain context variable relevant?" and "what potential values of context should be considered?" These goals, when applied to process modeling, determine relationships between process steps, in terms of their strategic, operational, or otherwise regulatory steps (Regev et al., 2007). Attempts to incorporate goals into process models have been already made in the past. For example, Kueng and Kawalek (1997) suggest an approach in which goals provide the basis for process definition. Their suggestion combines the identification of goals and corresponding constraints, the definition of measurement criteria and decomposition of goals so that they can be transformed into activities. Khomyakov and Bider (2001) suggest a state-oriented view on processes that focuses the changes that each activity introduces to the given process, and suggest that each change brings the process closer to its goal, i.e. its final state. They represent a process model as a trajectory in the space of all possible states.

It follows then, similar to related approaches in the requirements engineering discipline, that the use of the notion of process goals is promising for identifying and integrating context in a process model. By examining why a process exists and what the objectives and goals of the process are, the context factors that pose relevance to the process can be pre-determined and modeled at a formal level over and above the typical description levels of organization, data, resource and IT (Jablonski and Bussler, 1996; Scheer, 2000). By integrating contextual aspects with goal-oriented business process modeling, the flexibility required to handle changing environmental circumstances can be modeled to provide for the determined set of soft-goals in relation to the desired hard-goals. As an example of incorporating goals into processes with reference to contextual factors, consider the following banking industry example. A banks' overall goal is to provide banking services. In fulfilling this goal, the banks' major objective is to provide shareholders with maximum profit. Many contextual factors must be taken into account in achieving this goal. Arguably, a factor with great impact in this case is the savings/investment (supply and demand) curve. In a situation where more money is being saved in the bank compared to the money being lent out, the bank would have a short term soft-goal to increase loans to profit from its cash supplies. This short term soft-goal is linked to both context, i.e. timeframe or interest rate of the national bank, and the overall strategic goal, i.e. maximizing profit. The chain of events needed to increase loans may be modeled formally by a business process model, which relates the current context (demand-supply relationship) to the identified soft-goals and proposes required process changes, if necessary.

In order to introduce and better understand the notion of context in process modeling, we refer back to the understanding of a 'business process' as a structured flow of activities, which supports business goals and is facilitated by data, supported by applications and enacted by organizational resources (Harmon, 2007; Sharp and McDermott, 2001). It requires business objects as input (e.g. raw material, an incoming invoice) and transforms them within the process to outputs (e.g. a final product, a paid invoice). The core of a process is its control flow, i.e. the temporal and semantic relationships between the activities of a process. Various transition conditions can be used to specify this control flow.

The business process meta model (Figure 2) captures these elements and their relationships in detail. This meta model is based on the model developed by zur Muehlen (2004). The separation of the 'core' process model elements into control flow, data, application and resource is inspired by the perspectives originally proposed by Jablonski and Bussler (1996) in the Mobile framework, which has emerged as the standard reference for distinguishing core elements in process modeling, see, for instance, (Scheer, 2000; van der Aalst et al., 2003; Russell et al., 2006). This meta model has also been used in prior research to suggest the incorporation of process-related risk symbols into process models (Rosemann and zur Muehlen, 2005). Forthcoming from our discussion of the relevance of goals to process modeling (Khomyakov and Bider, 2001; Soffer and Wand, 2005; Kueng and Kawalek, 1997), we have further included hard- and soft-goals as relevant elements and show how context is related to the goals of a process.

Our meta model in Figure 2 describes how the notion of context can be integrated with traditional perspectives and elements in process models. It shows how goals determine which of the (potentially unlimited) sets of contextual elements in the environment of a process is *relevant* in the sense of being a factor in how well a process achieves a determined set of goals. The next section of this paper will discuss the elements in the 'context' part of the meta model in more detail.

As the discussion above already indicated, context is a very comprehensive concept. A large variety of elements and variables can be imagined to influence the way a process achieves its goals. The range of context elements and variables can hence potentially be unlimited. Accordingly, we suggest an approach to structure the range of context elements into disjoint categories (i.e., context subtypes). This will allow conceptualizing and operationalising different types of context. As the meta model shows, we propose a taxonomy that divides the different facets of context into four layers.

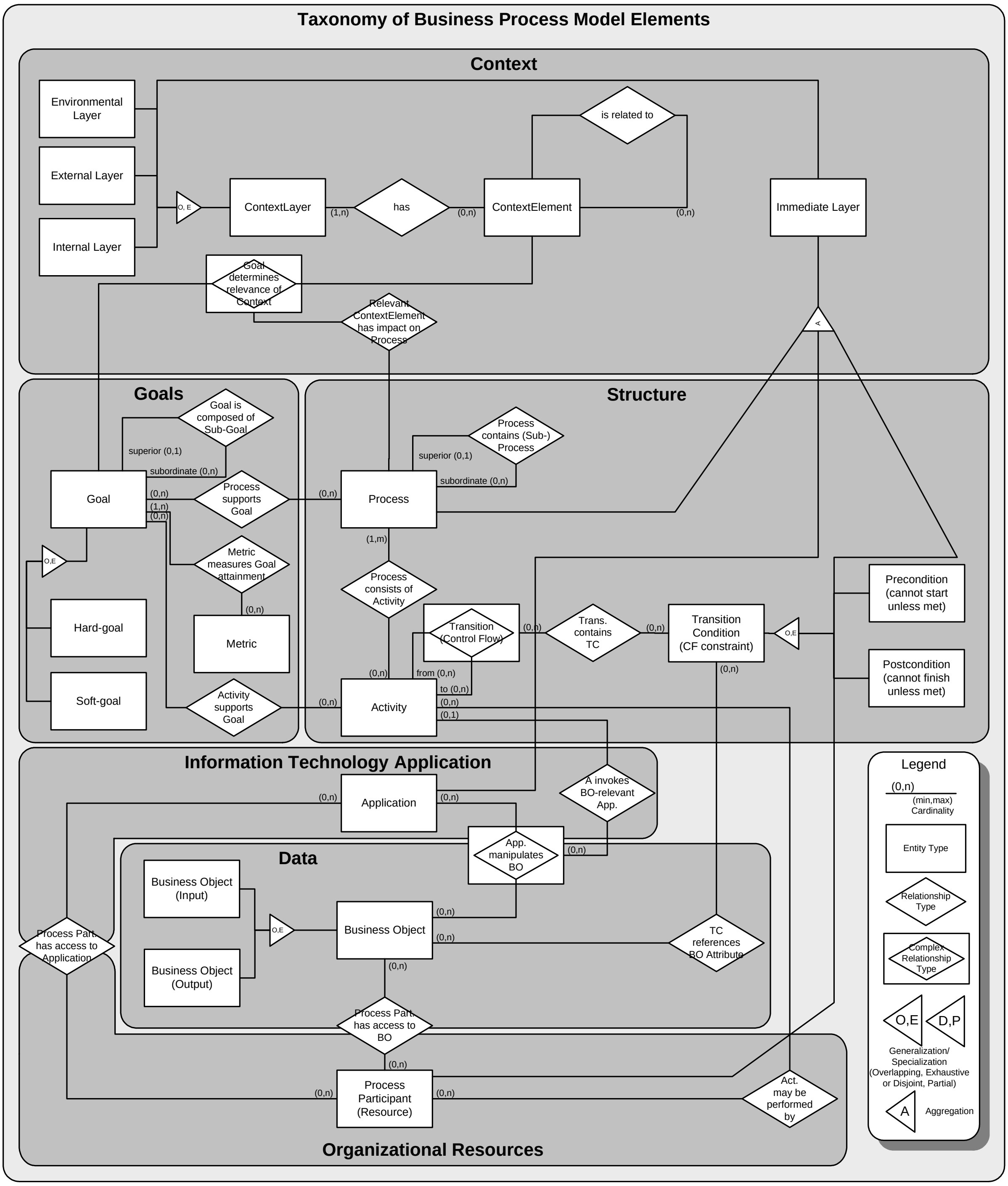

Figure 2: Extended business process meta model. Based on (zur Muehlen, 2004)

We call all elements that are directly related to the traditional focus on control flow information (viz. control flow, data, application, resources) the *immediate context* of a business process. As indicated above, existing process modeling research (for instance in the workflow area) typically considers exactly these elements as a standard process description in their studies (Jablonski and Bussler, 1996), for instance, in the definition of exception handling procedures in workflow models (Russell et al., 2006). In order to determine how current process modeling techniques support capturing context, they can be differentiated by the degrees to which they are able to capture information that goes beyond this traditional description of control flow, i.e. the sequence of activities and events/states including required transition conditions, the related data, resource and application. Table 1 provides an overview about the components of this immediate context that are supported in popular process modeling techniques. In this table, a "+" indicates a direct support for a context element, a "+/-" indicates a partial support and a "-" indicates a lack of support. Extended EPCs, for instance, provide a means to integrate data models with process models (Scheer, 2000) and as such provide explicit and comprehensive support for the data perspective in process models. BPMN, on the other hand, restricts its support for the articulation of process-related data to the modeling of 'Data Objects' with which function may be annotated. Yet, no information about data structure, data types or data relationships can be articulated. Thus, BPMN's support for this perspective is only partial.

Table 1: *Popular process modeling techniques and supported perspectives*

Technique	Control flow	Data	Application	Resource
eEPC	+	+	+	+
BPMN	+	+/-	+/-	+
Petri Nets	+	-	-	-
IDEF3	+	+/-	-	-
YAWL	+	+	+/-	+
UML AD	+	+	-	+/-

From Table 1 we conclude that existing techniques focus on different aspects of business processes and their immediate context. Hence, they only suit selected perspectives and objectives. In particular we observe a missing consideration of contextual aspects that transcend the traditional close proximity to regular control flow. As a counter-example, EPCs, for instance, can be extended to support the explicit representation of business-related risks in process models (Rosemann and zur Muehlen, 2005). Across all process modeling techniques, however, we observe a lack of consideration for further contextual elements beyond the traditional immediate context in a structured way. This in turn hinders the development of advanced process models that provide an enhanced ability to conceptualize, communicate and understand business processes and their context of operation.

5 A CONTEXT FRAMEWORK

In order to provide a structure for research on context-aware process models that extends the focus beyond elements within the immediate context, we propose a stratified layer framework that extends the scope of process modeling by incorporating and differentiating four types of context, i.e., immediate, internal, external and environmental context into concentric layers of an *onion model*.

This onion model can be interpreted as an intuitive graphical description of a concept derived from cybernetics and systems theory. It depicts embedded layers surrounding organizational processes as dynamical systems (Wiener, 1948). We have turned to cybernetics as a theoretical foundation for our onion model for at least four reasons. First, cybernetics essentially is a model to describe the formal structure of regulatory systems (von Bertalanffy, 1968), such as organizations. Second, processes themselves have been suggested to be regulatory systems (Regev et al., 2005). Third, cybernetics as an approach to understand organizations stresses the importance of uncertainty, organizational complexity and dynamics. Fourth, some of the well-established process modeling techniques (e.g. EPCs) were originally based on principles of cybernetics and systems theory (Scheer, 2000). It would appear then to be only reasonable that an onion model that draws on similar principles can be useful for understanding the inter-relationships between an organizational system and its environment, and how these inter-relationships affect complexity and dynamics, in short: flexibility, of processes within the system. Such models are widespread in related discipline such as management science (Rüegg-Stürm, 2005), and actually, a similar onion model has previously been used in the process modeling area to identify, and display, the relationships between different types of stakeholder roles relevant to business process fit (Alexander, 2004).

The core of our onion model comprises the processes and its immediate contextual variables. While such process could be seen as well-defined and executable sequence of steps and involved resources, it is heavily impacted by its context. The further we move out of this core of the onion model, the wider we consider relevant context and elements that potentially impact this process. A second layer comprises the system organization and all the elements that facilitate the execution of a process. Again, the organization as such can be seen as a open and self-regulating system. However, it will be impacted by its relationships with elements external to this system (layer 3) and the overall environment in which the organization is embedded (layer 4).

Figure 3 shows a populated onion model, which serves as a taxonomy and can be used to identify, classify, understand and integrate relevant context with business process models. Our onion model is populated on each layer with *exemplary* contextual factors. We have identified these factors in our exploration of current process modeling projects in large Australian organizations (Raduescu et al., 2006), most notably in case studies of the coffee and airline industry, e.g. (Rosemann et al., 2006). As a first attempt, the taxonomy provides an initial reference on which future research in the area of process contextualization can be based. As described above, we differentiate four types of context based on their proximity to the 'core' business process (i.e. the traditional perspectives in a process model that we have labeled immediate context). In the following we introduce and discuss these different types, starting with the immediate context that, as noted above, is the traditional core of business process models.

5.1 Immediate Context

As briefly discussed above, the immediate context of a business process includes those elements that go beyond

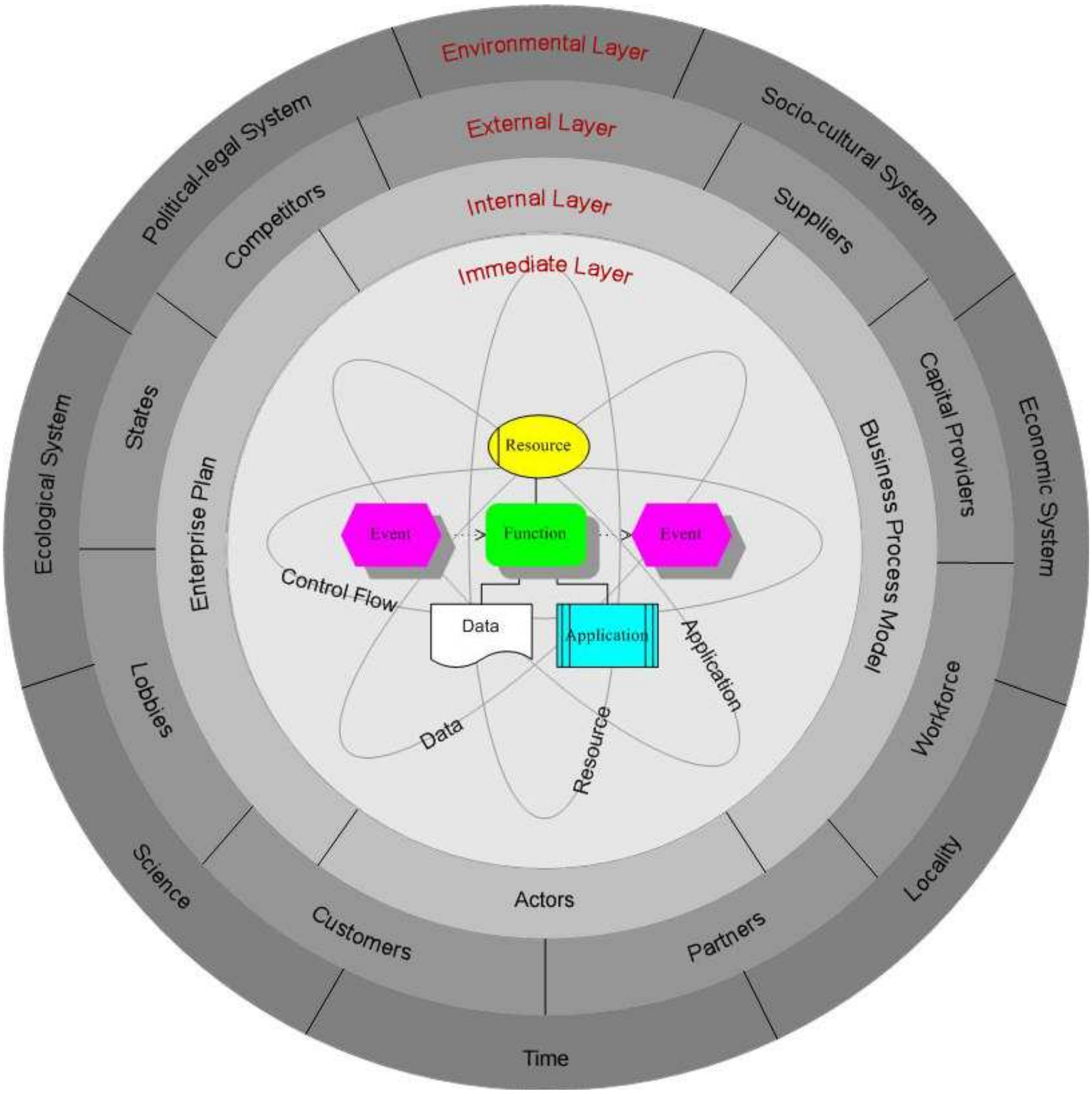

Figure 3: Onion model for context classification and typing

the constructs that constitute the pure control flow, and covers those elements that directly facilitate the execution of a process. Due to this central role elements tend to be already well-considered in existing business process modeling techniques (see Table 1). These elements are typically essential to the understanding and execution of a business process (e.g. What data do I require?, Which organizational resource is in charge for the next activity?, What application supports this process step?). Following existing classifications (Jablonski and Bussler, 1996; Scheer, 2000), the immediate context includes (input, output) data, organizational resources (e.g. organizational unit, group, position, person) and IT and related applications (e.g. middleware, web server, database system). Without any contextual changes, the elements that constitute the immediate system would be sufficient for the execution of a business process. This conception, still, is the prevalent approach to process modeling to date; however, we suggest extending this view towards a wider perspective on the environment of a business process.

5.2 Internal Context

The immediate system (viz. the process) is embedded in the wider system of an organization. Various elements of an organization have indirect influence on a business process and we call this second layer the internal context. The internal context covers information on the internal environment of an organization that impacts the process. Following the stratified layer model of an organizational system and its environment as used in (Rüegg-Stürm, 2005), the internal system of an organization incorporates elements such as resources, norms and values, concerns and interests, strategy, structure and culture. These categories cover, for example, the corporate strategy (enterprise plan) and related process objectives. A change from a quality-focused strategy to a cost-cutting strategy, for instance, will have an impact on a broad range of business processes (e.g., elimination of quality control activities, scaling down of special resources). Policies are another important internal context variable as they are the main constraining factor on business process design activities. An explicit understanding of the effect of a policy on a process provides not only guiding information for a process improvement discussion, but equally can be an important information for an intended change of a (counterproductive) policy. As can be seen, the internal context captures all elements that are part of the organizational system in which a process is embedded. Consequently, typical further examples for internal context variables are the main internal stakeholders in an organization and their risk perceptions, communication and logistical infrastructures (e.g. regional distribution of factories) and financial and other resources (legal experts, R&D). The latter one can form an important enabling or constraining factor in the capability to change. Moving from the immediate context of a process to the next layer of a surrounding system can lead, of course, to a different system than the typical boundaries of an organization. For collaborative business processes that span multiple organizations, e.g. the internal context would be the sum of the involved organizations.

5.3 External Context

The external context captures elements that are part of an even wider system whose design and behavior is beyond the control sphere of an organization. Yet, these elements still reside within the business network in which an organization operates. Although this context is not in immediate proximity to the day-to-day business operations of the organization, it still poses relatively high impact on the way the organization designs and executes its business processes. Drawing again on the view of an organization as a system within external and environmental systems (Rüegg-Stürm, 2005), the external context comprises, amongst others, categories of context elements related to suppliers, competitors, investors and customers. External context variables can further be identified from frameworks such as the Five Forces model (Porter, 1979) and may include the aforementioned stakeholders (e.g. suppliers, customers, financial and logistical service providers) as well as their strategies, demands, resources and occurring failures. Furthermore, it includes factors specific to the industry (e.g. overall demand for the services of an industry, technological innovations) and regulations such as industry-specific practices (e.g. supply chain management practices). In general, external context will often demand compliance of internal business processes and as such provide a set of constraints that have to be considered and continuously observed in order to achieve conformance objectives in addition, or substitution, to performance objectives (Parkinson and Baker, 2005).

5.4 Environmental Context

The environmental context, as the outermost layer, resides beyond the business network in which the organization is embedded but nevertheless poses a contingency effect on the business processes. It captures the overall environment as a system with comprehensive boundaries. In management science, often, an organizational systems's environment is characterized by the categories society, nature, technology and economy, in each of which contextual variables of relevance may reside (Rüegg-Stürm, 2005). These environmental variables include factors such as weather (e.g. increasing call volume during storm season), time (e.g. different business operating models on Sundays or before Christmas) and workforce related factors (e.g. overall shortage or strike). A well-known example is the US Homeland Security Advisory System with its alert levels green (low), blue (guarded), yellow (elevated), orange (high), and red (extreme). Each of these levels is clearly associated with a comprehensive set of process changes within the relevant departments and armed forces. While some of these environmental variables may change regularly and can have a very strong impact on a business process (consider our motivating example and the impact of weather conditions), many of these variables and especially their current values can have a very long life span (e.g. availability of natural resources in a country, currency, political system, preferred business language). Other factors can be attributed to the macro-economical setting in which an organization operates. Examples include legislative regulations such as national policies (e.g. workplace regulations) and other requirements (e.g. Sarbanes Oxley, Basel 2).

Having introduced four different layers of contextual categories and examples of elements within these categories, it is required to note that inter-relationships may occur between the elements on the various layers. This means in turn that not necessarily does any context element have a direct impact on a process. Instead, the impact may be of an indirect nature due to existing inter-relationships with other elements on the same or more inward layer. At least three different forms of links can be observed:

1. An element on the same or more inward context layer can *mediate* the impact of a context element.

2. An element on the same or more inward context layer can *moderate* the impact of a context element.

3. An element on the same or more inward context layer can *mitigate* the impact of a context element.

As will be seen in our case study below, examples for these indirect effects and links between contextual elements may take many forms and it would be a stimulating research challenge to explore these relationships further, which, however, is outside the scope of this paper.

6 APPLYING THE FRAMEWORK

6.1 Procedure

Above we have described an onion model that can be used to classify different types of context of relevance to business processes. The question that arises next is how to use this framework in order to identify which of the potentially unlimited types of contextual elements is relevant and should be considered and monitored so as to be able to anticipate required process changes.

Following the meta model shown in Figure 2, we suggest that the notion of process goals allows us to reason about potential contextual elements that are relevant to the process and should thus be included in the process model. Understanding a process as a set of states with the ultimate aim of reaching a final state (Khomyakov and Bider, 2001), we can use the notion of hard-goals and soft-goals as proposed by Soffer (2005) to distinguish between the set of information relevant to achieving a process goal that is contained in the traditional description of a process (i.e. in the immediate context) and the set of information that is relevant to achieving the goal but not explicitly captured in the description (and thus contextual). Having identified these contextual elements, our onion model shown in Figure 3 can then be used to type these elements based on their proximity to day-to-day business process operations.

In a basic format, a procedure for deriving relevant context information to be included in a process model should consist of the following steps. Figure 4 gives the overall procedure.

1. Identify the hard-goals and soft-goals related to a given process and their appropriate measures.

2. Decompose given process in accordance to the goals in a set of goal-relevant information that is either immediate (i.e. information that is contained in the traditional process specification) and a set of goal-relevant information that is not contained in the traditional process definition, i.e extrinsic (either internal, external or environmental).

3. Determine the impact of goal-relevant, extrinsic information on the achievement of the goal to determine the relevance of the contextual element. Repeat this step for each set of goal-relevant information that is extrinsic to the traditional process description.

4. Identify contextual elements and explore potential inter-relationships to other contextual elements that may mediate, moderate or mitigate the impact of the identified contextual elements.

5. Type contextual elements with the help of the onion model and identify relevant value ranges. If required, repeat steps four and five until all contextual elements have been identified and typed.

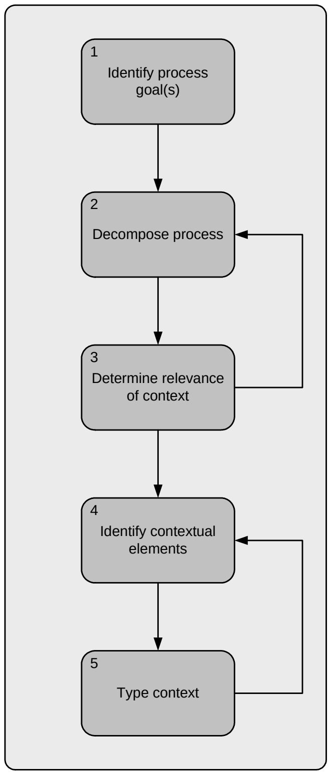

Figure 4: Procedure for context identification

In the following, we will use a case study to show how this procedure can be applied.

6.2 Case Study

In our study of current process modeling projects in large Australian organizations (Raduescu et al., 2006) we have explored the ticket reservation and check-in process of a major Australian airline. This process, while seemingly stable, is exposed to a large number of contextual impacts and is thus regularly required to change "on-the-fly".

Usually, the process is triggered when a customer selects their destination, along with departure and return dates and times. An online form can be used to draft an itinerary based on certain preferences such as departure times, type of plane, overall costs, etc. After confirmation and electronic payment an eTicket is issued, which is an electronic version of a traditional paper ticket. It allows travelers to check-in at the airport using photo identification and, were applicable, to check-in and select available seats over the Internet from home or at dedicated "quick check-in" terminals at the airport. Normally, also traditional counters are available for check-in. Independent from the check-in option selected, at some stage a traveler is required to undergo safety checks, i.e. passport controls for international flights and baggage checks before boarding the aircraft. Figure 5 gives the corresponding process model. In this model, parts of the process that are subject to change due to variations in the context are highlighted grey.

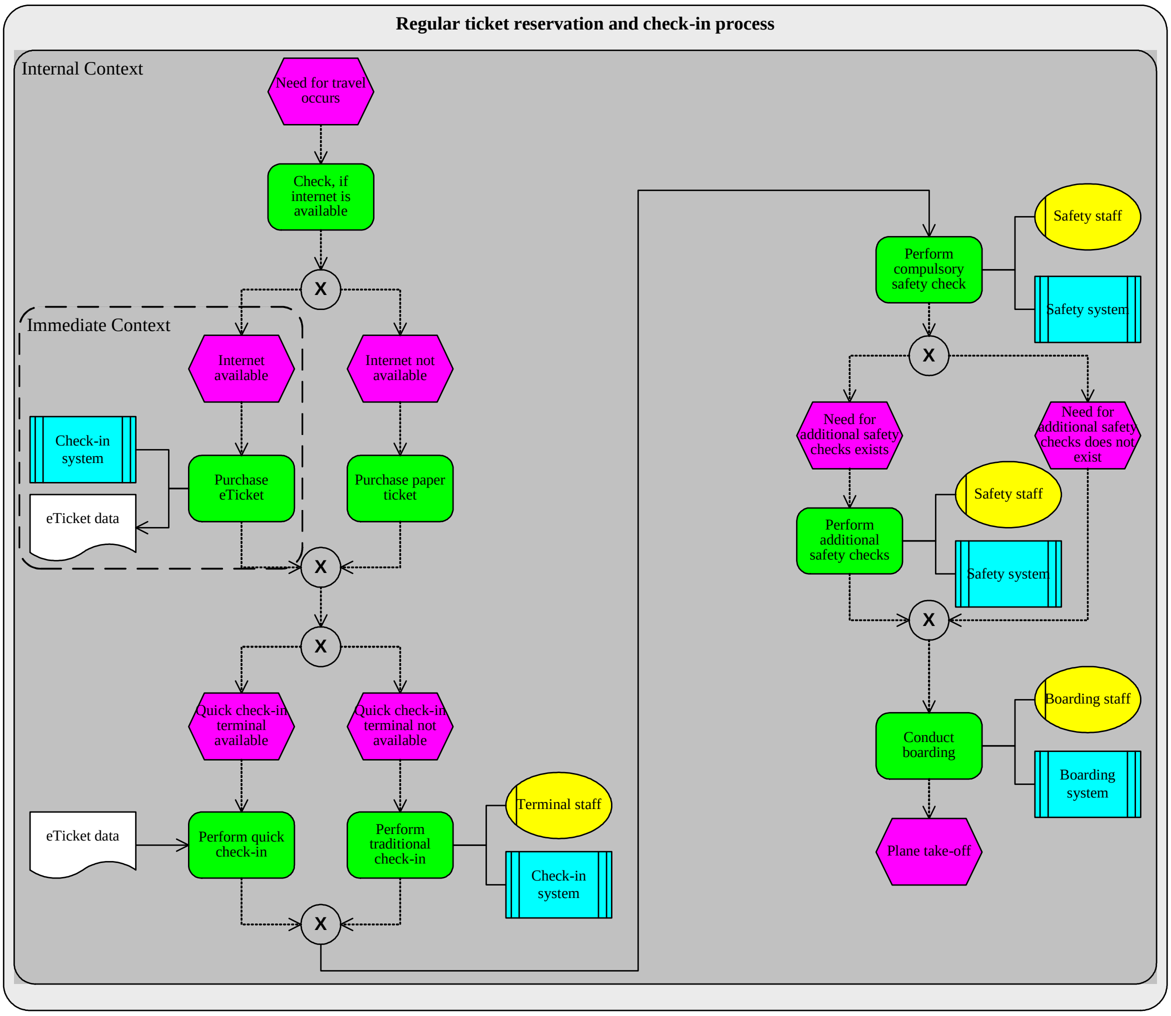

Figure 5: Airline process model with context consideration

The process typically runs smoothly in regular business environments. However, certain environmental situations may occur that require the process to change. For instance, staffing levels for traditional check-in counters are estimated based on an average 'eTicket to paper Ticket' ratio or the availability of quick check-in terminals. Weather conditions, server breakdown, holiday season, system failures and other circumstances may lead to more traditional check-ins than expected and/or catered for. Consequently, several mitigation strategies need to be executed in order to avoid having customers miss deadlines due to large check-in waiting queues. First, more check-in counters need to be staffed. Second, business and first class check-in counters are used to also process economic passenger check-ins. Third, the lodgment time of check-ins has to be reduced. Usually, this is achieved by disallowing seating modifications or special seating requests.

Referring back to the procedure for identifying contextual impacts, we can investigate the above described process as follows. First, we start by identifying the process goal (minimize overall time for ticket reservation and check-in). Therefore, we assume a main goal, namely "Minimize throughput time" (Step 1: identify process goals). According to Rolland et al. (1998) we consider the relationship between a goal and a corresponding process as a requirement chunk in order to decompose and analyze (Step 2: decompose process) both goal and process simultaneously until we are eventually able to derive contextual elements having an impact on the sub-process with respect to its sub-goal. The identified chunk may look like $< Minimizethroughputtime, Airlineticketreservationandcheck-inprocess >$. In order to compare the deviation between goal and process, we consider a goal as well as the immediate context of the process as states. Both notions are necessarily comparable since the states a process attains during its execution necessarily affect the states of a goal definition (Soffer and Wand, 2005). For example, the time as part of a goal definition (e.g. within an operationalized goal "online ticket reservation must not take more than 10 minutes") is necessarily affected by the path of state changes the reservation process takes for its accomplishment.

The decomposition of the airline ticket reservation and check-in process and the goal of minimizing throughput time reveal more detailed sub-processes and sub-goals, so that eventually the immediate context of single functions facilitates the determination of contextual elements potentially occurring within the outer layers of our onion model (Step 3: determine relevance of context). In Figure 5, the EPC shows the highlighted immediate context of the function "purchase eTicket" on a sufficient level of detail. From there, contextual elements can be identified by posing the following question: Which elements distinct from the information contained in the immediate context of the function "purchase eTicket" have an impact on the goal "Minimize throughput time" (Step 4: identify contextual events). Contextual variables include, for instance, elements affecting the availability of an internet connection, a properly operating mode of the check-in system as well as the compulsory type and amount of data necessary for a ticket purchase. By applying the categorization and classification of context layers and categories for the typing of contextual elements, the environment in which a process is embedded in becomes increasingly tangible and enables the anticipation of potential external triggers and their causal relationships (Step 5: type context). Consider again the immediate context of "purchase eTicket". An internal server crash, for example, would affect the availability of an internet connection and would occur within the internal context, since it is related to the application system and networking infrastructure of the airline company. A negative effect on the check-system could be caused by the appearance of a system overload due to too many customers using the system at the same time concurrently, which would conceptually be located in a category 'customer' on the external layer. According to this procedure the context of a decomposed function or sub-process will successively lead to a clearer and more transparent idea of potential drivers having an impact on the ticket reservation.

Another example of a contextual 'impact' on the airline ticket reservation and check-in process that we derived by using the procedure relates to increased safety considerations. An alert system, similar to that used by the US Department of Homeland Security, is installed to distinguish three levels of awareness. Several scenarios (e.g. certain VIPs arrive or depart, major public events, terrorism, etc.) lead to different safety levels that in turn require safety procedures to change. For instance, tests for explosive goods that are usually conducted on a random basis become mandatory, or a second hand luggage safety check immediately prior to boarding is performed. Furthermore, some flights require additional identification procedures (e.g. biometric data verification for flights to/from the United States). One impact of these procedures is that for each case different staffing levels are required.

Forthcoming is the question of how the adaptation of the process to changing contexts can be supported and the relevant details explicitly captured and used. The related challenge is to identify different types of contextual influences and determine their consequences to each part of the traditional business process. This in turn would allow for comprehensive monitoring of the context, which would enable the early anticipation and execution of required process changes. By examining the chain of events that necessitates changes in the process, reactions can be anticipated based on observations in the early stages of the chain, i.e. at best in the environmental context. This demonstrates the importance of understanding relationships between contextual variables. As an example, a change in weather conditions (e.g. storm, Tsunami, Tornado) may lead to a significant number of travelers urging to re-route their flights on the departure date. The related process changes can be anticipated simply by regularly observing the weather forecast, which in turn enables, for instances, a pre-determination of required staffing levels. The same principle holds for later stages of the chain, even if the timeframe for process adaptation may be shorter. As an example, waiting queue dynamics (internal context) can be observed at the terminals in order to establish a potential need for further staffed terminals or for opening business and first class counters to economy class travelers.

In conclusion, based on the reference procedure described above (see Figure 4) we were able to identify, capture and classify relevant context, in particular changes within, and inter-relationships between, context, and their impact on the business process. In short, studying the goals of a process contributes to determining relevant context layers *outside* of an organization (i.e. external and environmental). With the knowledge of goals as well as the semantics of the different context layers (viz. the scope of the business process), types of context with a direct impact on the business process outside of an organization can be identified by asking questions of relevance to given goals (e.g. are weather conditions relevant to achieving the process objective?). In order to establish relevant context inside of an organization (i.e. on an internal and immediate layer), the direct effects of the context on the immediate layers are determined. The effects that external and environmental context has upon internal context (e.g. the establishment of new national legislative requirements leading to the modification of organizational policies).

7 CONTRIBUTIONS & CONCLUSIONS

This paper was motivated by various observations of current challenges in process modeling. While popular process modeling techniques are typically able to adequately handle the core constructs of a process and its immediate context in the form of data, applications and resources, a wider consideration of contextual information is still only limited supported. The present approach to process modeling may be a reason for some of the observable sub-optimal designs of business processes for different contexts (e.g. different times of the year, different customers, locations) with a high level of redundancy (e.g. due to multiple process models for different scenarios), significant maintenance efforts (e.g. changing processes at the beginning of each season), low scalability in the case of multiple contextual variables, and in general a poor understanding of the context-process relationship. In order to progress this area of research, we investigated the current body of knowledge and suggested an approach for integrating context into process models. We used a meta model to formalize our idea of how processes and their goals can be used to identify context that is relevant to the process. We also proposed a framework that helps to gain a better understanding of different types of context and their impact on business processes. We provided a basic procedure model on how to apply the framework for the identification and classification of context. We provided evidence for the applicability of the framework in a case study of an airline case study.

A noted limitation of the research described in this paper stems from the fact that in terms of research, the area of process flexibility and process contextualization is still in the explorative stages. The conceptual integration of our context reference framework with existing process modeling techniques and the development of a corresponding and appropriate notation are currently underway. Furthermore, our findings remain to be comprehensively tested with respect to the impact that explicit context consideration in process models has on further dependant variables of interest, such as the perceived understandability of the model, the agility of the described process to react to externally triggered changes, etc. However, our case study demonstrates first evidence for the general applicability of our approach.

Future research will derive extensions of selected popular process modeling techniques (e.g. EPC, BPMN) in order to explicitly integrate the identified different types of context into existing business process modeling techniques. Such enhanced models have the potential to provide the conceptual foundation for truly agile processes, in which, for example, process mining techniques could play an important role in monitoring and evaluating relevant contextual variables and events (e.g. weather) and triggering required process changes. Our work provides a theoretical reference cornerstone upon which different relevant types of context can be captured and monitored so that a stronger, potentially automated, link can be established between the stimuli for change and the reaction to the change within a business process model.

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