CONTEXT AWARE BUSINESS PROCESS ASPECT MODELER

Mariam Keriakos, Hoda Hosny and Sherif G. Aly
Department of Computer Science and Engineering, The American University in Cairo, Road 109, New Cairo, Egypt

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Abstract: Informed decision making and flexibility have grown to be important standard requirements in the field of business process modeling and design due to the emergence of intrinsically complex variables within the various business environments. Traditionally, researches on business process modeling and informed decision making have focused on the configurability of business process models. Our review of literature makes us confident that researches have considerably neglected the main drivers of flexibility and decision-making which have an extensive impact on business process flow. Such drivers form, in our opinion, cross cutting concerns that need to be extracted from the context of business processes. Context can include, but is not limited to, work force availability, work force experience, system failures, weather conditions, environmental hazards, and financial constraints. This paper presents a new general purpose methodology for modeling the context of business processes within different business domains as Open Aspects, and accordingly, deducing recommendations for improving the business process flow. We envision how context can be conceptualized as Open Aspects, how to classify the different contextual aspects into different business operational levels according to the goals of the business processes, and how to present business process flow recommendations based on the aspectized contextual facts.

1 INTRODUCTION

Business process modeling has been an important area of research for a number of years due to the need for simulating and automating business processes in the software industry. The flexibility of business processes has been a strong motivation for many researches as it offers a means to make business process models both configurable and adaptive. Flexibility is defined as the capability to change without loss of identity (Regev, Bider and Wegmann, 2007). The need for business process flexibility stems from the variance in the context of application of the same business process. The context of a process is basically defined as the surrounding conditions of a business process that cause alteration in its behavior (Rosemann, Recker and Flender, 2008). These surrounding conditions or "context" may be viewed as a collection of cross cutting concerns which affect the decisions that should be taken and hence directly affect the business process flow and may enforce certain key decisions or customizations on the business model. The changes that are made throughout the process lifecycle can be wider than just changes in the process flow. Adopting context awareness and advanced context modeling; representing context in terms of aspects are therefore critical for process change strategies. Despite, the growing importance of the business process context and the advantages of its aspectization, it has not yet drawn researchers' attention. Most researches involving context awareness focused on pervasive systems and mobile computing. So far neither the aspectization of business process nor contextual business items in general have been considered. In this research we focus on modeling business process context (as aspects) within the business processes. Our aim is to enrich the field of business process modeling by taking advantage of context modeling and aspectization for more effective decision making within the business processes.

The rest of the paper is organized as follows: section 2 discusses the research problem and motivation, section 3 summarizes the research background of this work, section 4 describes our high level solution approach, section 5 demonstrates an example and section 6 concludes the paper.

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2 RESEARCH PROBLEM AND MOTIVATION

With the growing number of variables and concerns involved in the decision-making process of any sizable business, designing and adapting business processes is becoming a very complicated task. Within the business domain, concerns surrounding the environment where the processes are executed give indications that are essential for a business process-related decision. For example if a certain airline company knows that there is a high probability of weather problems on a specific day, this would normally affect the business processes of take-off and landing and if there is a problem in check-in counters, this would very likely change the behavior of the check-in process. If the context of a business process is aspectized and modeled efficiently, this will provide a stronger cause-effect relationship between the demands for process flexibility and their impact on processes and vice versa (Rosemann, Recker and Flender, 2008). Hence, the business processes would be able to automatically change their behavior as if decision makers were present to analyze the situation and give an immediate solution. For more complex problems where human intervention is a must, knowing the aspects that are affected would help decision-makers better analyze the situation and take important decisions which would save time, effort and money. Representing context variables as aspects is an important addition to the world of business process modeling and context awareness for the following reasons:

1) Modularization of contextual elements/items to allow for reuse of same context elements in different kinds of business process and in different business domains
2) The dynamic nature offered by the open Aspects concept of the adaptation model. This allows the weaving of events and advices/actions to happen at run time which is most appropriate for the dynamic environments in which most business processes run
3) The concept of aspects/cross cutting concerns is more appealing to business people and business process experts than the idea of a process, in business process management, away from the world of computing and software. Business decision-makers always consider aspects before making a decision but the term and idea of context is more distant from the business world

Today many business process modeling and management frameworks/tools exist, but they do not adequately support the context-based definition and configuration of business process variants. As a result, the process of adaptation of business processes in such tools is time consuming and error prone (Hallerbach, Bauer and Reichert, 2008). In the current business process modeling tools, the 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 (Rosemann, Recker and Flender, 2008).

As a result, the decisions related to changes in the flow of a business process are taken manually and usually at a late stage after identifying a major contextual variance in the environment of the business process. This could lead to faulty decision-making due to contextual ignorance or right decision-making at a late stage, and in both cases, the outcome is degraded efficiency in the business process management and consequently unnecessary financial costs which could be avoided. In this research work, we propose a new methodology that enables business process experts to model context-aware, aspectized and configurable business processes which change their flow and decision according to contextual information obtained from the ambient surrounding of the business process environment. Our solution approach is to extend an existing context awareness framework by adding Open Aspects for business contextual elements apriori then use the aspectual facts modeled as decision making criteria for business process modelers to add context intelligence to the modelers.

3 RESEARCH BACKGROUND

Our research contribution mainly extends on two major research domains, namely: Aspect oriented software development (AOSD) and context awareness. We integrate with another area of research which is business process modeling by introducing aspectized context awareness. We are not the first to discuss the idea of context within business process modeling as it has been discussed as a high level concept by Rosemann et al (2008, pp. 3-4) but we do introduce the idea of conceptualizing business process context in terms of aspects and we define the idea of a solution that extends on existing frameworks of both context awareness and business process modeling to realize the new approach of aspectized context aware business processes. In this section we summarize the theories, approaches, tools

and concepts which served as the basis for our work.

3.1 Aspect Orientation

Aspect oriented software development (AOSD) is a relatively new emerging technology and methodology (Chavez, Garcia, and Lucena, 2001; Tarr and Ossher, 2000). The general purpose of AOSD is the modularization of crosscutting concerns. However, researches in AOSD focused mainly on concerns related to logging, tracing, debugging, security and program verification (Kiczales, 2001; Anon, *Microsoft Researches in Cross Cutting Concerns*, 2011; Anon, *Microsoft Enterprise Library*, 2011) and little research was done on aspectization of scenario based requirements modeling (Whittle and Araujo, 2004). Other crucial areas of research like business process modeling and context awareness which incorporate cross cutting concerns have yet to be discovered. Open Aspects is a new approach for mitigating unplanned changes in systems based on aspect-oriented composition at run time (Hirschfeld and Hanenberg, 2006). Open aspects support the so called adaptation models system change events being observed and the corresponding corrective actions to be taken. The main motivation behind open aspects is the flexibility to change, at runtime, the aspect composition according to the base system and the set of aspects that it is applied to. There is a clear separation of base, aspect and adaptation models. In open aspects the weaver derives a model of the running base system needed for making the aspect model effective (both marked with a 'start' tag). While doing so, the weaver examines an adaptation model (also marked with a 'start' tag) detailing all involved system change events to be observed and all corrective actions to be taken in correspondence to the system elements involved.

3.2 Context Awareness State of Art

Context awareness exists in many other disciplines other than business process modeling and has received much attention in these areas e.g. Web-based systems (Kaltz, Ziegler and Lohmann, 2005), Mobile applications (Mikalsen and Petersen, 2004) and conceptual modeling (Analyti, Theodorakis, Spyratos, and Constantopoulos, 2007; Rolland, Souveyet and Achour, 1998). In the computing domain, the term 'context-aware' was coined by Schilit and Theimer (1994, pp.5-6) as approaches to incorporating contextual factors into various systems, such as in the area of Mobile applications. They typically focus on users and their interaction with the systems (Dey, 2001; Schilit and Theimer, 1994). Existing frameworks (such as the ECOIN framework (Firat, Madnick, and Manola, 2005))attempt to represent context as properties that can be interpretation-based either on the inbuilt framework structures or based on a generic ontology that has no structure prior to design time. Almost all context-aware frameworks currently available in the market and even developed for research purpose were coined within the field of pervasive systems and its applications (e.g. smart hospitals and smart homes). The main problem with most of these context-aware frameworks is that they are focused on pervasive systems and mobile entities, that they lack customization for context of business processes and that they are not open source so their usage or extension must be under the supervision of their developers.

3.3 Context Description and Structure

Context structuring and linking context to real causes is a prerequisite to context conceptualization within the business process modeling discipline. A substantial amount of research has already been conducted on structuring and describing context. In the area of context modeling, for example, there is the form of context ontology (Chen, Finin, and Joshi, 2003). In another effort, the Context Ontology Language (Strang, Linnhoff-Popien, and Frank, 2003) is designed to accommodate selected aspects of context such as temperature, scales, the relative strengths of aspects and further metadata.

Rosemann (2008, pp.3-4) identifies an onion model for structuring contextual elements related to a business process. Rosemann widens the scope of contextual elements consideration to include environmental context (related to the economy or the general environment where the business process operates) as well as immediate context elements (which directly affect the flow of a business process). The Rosemann onion model is the basis of the context model structure that we adopted within our research work. Rosemann (2008, pp.3-4) divides the context into four disjoint categories as follows

1) *Immediate Context:* includes those elements that go beyond the constructs that constitute the pure control flow, and covers those elements that directly facilitate the execution of a process.
2) *Internal Context:* The immediate system (viz. the process) which is embedded in the wider system of an organization. Various elements of an organization have indirect influence on a

business process and he calls this second layer, the internal context.

3) *External Context:* Compromises the elements that are outside the organization control but reside within the business network where the organization operates (Parkinson and Baker, 2005).
4) Environmental Context: This is the outermost layer and it captures the overall environment as a system with comprehensive boundaries.

3.4 Context Modelling Techniques

Context modeling techniques have been the focus of research in the last few years. Most of the techniques were designed for use in pervasive systems and ubiquitous computing while a few techniques were targeted for requirements modeling and process modeling. In this section we discuss some of the most relevant models to our methodology and research on modeling context related to business processes.

Rolland et al. (1998, pp.6-7) suggested a context-oriented procedure based on objectives to identify requirements chunks in goal-based modeling. Their basic idea for determining goals and relevant context in a model is based on the notion of a requirement chunk, which is a pair < Goal, Scenario > and denotes a potential way for achieving a goal within a given scenario (i.e. one instantiation of the process).

Rosemann et al (2008, pp.6-7) define a goal-oriented process modeling approach to be able to identify relevant contextual elements. The granularity and scope of a business process model is closely linked to the goals of the depicted process. 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 predetermined 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).

Nurcan and Saidani (2009, pp. 5-6) introduced a context model for BPM (CM4BPM) and a role-based business process model (RBPM). They presented an approach allowing the enactment of processes with respect to context. Nurcan and Saidani (2009, pp. 5-6) presents an approach for business process (BP) modeling which supports the explicit definition of the context-related knowledge in order to make instance adaptations "context-aware". The approach consists of using contextual knowledge in order to enhance the adequacy and the coherence of the assignments during the enactment of the business processes, such as actor-to-role or process-to role assignments. In order to efficiently use the contextual information in business process enactment rules, they suggest that context related knowledge (CRK) should be formally defined.

We evaluated and compared the above mentioned context modeling techniques (Table 1) according to the following criteria:

1) Quality of contextual information (QC): this criterion measures the quality of modeling the contextual information as sensed by various types of sensors which varies with time and depends on how accurately the model reflects the real contextual facts.
2) Formality (FR): this criterion measures the levels of understandability, standardization, preciseness and traceability of contextual facts.
3) Ease of use (EU): this criterion measures how easy it is for industry/business experts to understand the context model and the contextual facts and to map them to real business aspects for a better decision making process.
4) Adaptability/Change tolerance (AC): this criterion measures the flexibility of the context model to change by incorporating the knowledge of the business domain experts at run time according to the changes in the environment where the context model will be applied.
5) Relevance to environment (RV): this criterion measures the relevance of the contextual model to both the environment in which it is sensed and the environment in which it will be used to support context aware decision making

Table 1: Modeling techniques comparison.

Example column 1	QC	FR	AC	RV
Rolland Context Oriented Procedure	Fulfilled	Partially Fulfilled	Not Fulfilled	Not Fulfilled
Rosemann Goal Oriented Process Modeling	Fulfilled	Partially Fulfilled	Not Fulfilled	Partially Fulfilled
Nurcan Context Model for BPM	Fulfilled	Partially Fulfilled	Not Fulfilled	Not Fulfilled

The relevance to environment (RV), adaptability to change (AC) and ease of use (EU) are the main edges of the solution methodology proposed in this paper.

4 THE SOLUTION METHODOLOGY

In this research work we propose a solution that senses and identifies different types of business contextual elements. The solution models the contextual elements related to different business domains by building a library of aspects for each business domain inside one of the existing context awareness frameworks. The output of the extended Context awareness framework is a set of apsectized contextual elements related to business processes for a specific industry. The aspectized contextual facts can be formulated in any mark-up language (e.g. XML) and fed into any business process modeler to model the business process and its embedded decision-maker according to a simple intelligence tree defined by business domain experts. Our methodology of aspectized context-awareness for business processes could be summarized in the following steps and sub steps:

4.1 Context Sensation and Identification

As our main focus is on contextual aspects related to a business process, the main aspects that we take into consideration are non-human resource utilization, human resource utilization, human resource experience level, organizational strategies, risk factors associated with a process, industry regulations and practices affecting a process, timing and season of process execution. Context sensation happens by utilizing sensors and context entities of an existing context awareness framework which is the Java context Awareness Framework (JCAF), designed initially for pervasive systems. JCAF has several edges which made it the most convenient tool to extend on and to test our new methodology:

1) JCAF is an extensible Open Source tool
2) It supports the extraction of context information from the different types of context sensors (physical, virtual and logical context sensors)
3) It allows the addition of new libraries of aspects which makes it possible to model contextual concerns as aspects/cross cutting concerns related to the business process entity
4) It provides easy ways to add classes representing different types of entities
5) It takes the quality of context (QoC) aspect into consideration. It has a get_Accuracy and Secure methods within the JCAF Context Item class and these methods can be overridden to specify the combination of quality guarantees for the context items (Bardram, 2005)

We added a library of aspects to the JCAF framework, where all the types of cross cutting concerns are defined as well as the weaving method. The open aspects approach is utilized in this library to allow proper combination of change events and corrective actions. Thus the extended framework serves in producing aspectized contextual entities representing the state of the context of the targeted business process.

4.2 Aspectized Context Classification

After appropriately extracting and sensing contextual information, the contextual data is classified into the four contextual layers defined by Rosemann (2008, pp.3-4): Immediate, Internal, External and Environmental.

The importance of context classification lies in the fact that the layer to which a contextual variable, or its constituent elements belong, defines the level of impact of this contextual variable or element on the business. In more specific terms, each contextual layer would have a specific set of goals (whether high level business goals or operational goals) that it impacts (i.e. the contextual variables or elements that belong to this contextual layer and would also impact the high level goals and operational goals that this contextual layer impacts). The goals that are impacted by each of the four contextual layers defined by Rosemann (2008, pp.3-4) would differ for each industry considered within the scope of our framework.

Through these important links between the contextual variables and constituent elements and goals we are able to identify which contextual variables affect which business process. As we link the goals of the business process with the goals of the contextual variables and detect the common goals, we identify which contextual variables and elements affect which business processes and which business process steps to take.

The contextual variables/elements classification cannot be automatically deduced as it would differ from one industry to another and various industry experts may have their different views about them (e.g. weather could be an immediate context item in one industry while in another industry it could be an environmental context item). As a result, the most appropriate approach for classification is to allow the industry/business process experts to define their own classification in an easily updatable way. Thus we can have two repositories, a repository for each

industry/ business domain (where the business domain experts define in any near natural language syntax the industry goals, the most important context elements related to the industry, the business processes under this industry) and another business process repository defined by business process experts (having information related to the business process steps and alternatives, the business process specific goals as well as possible recommendations for business process flow).

4.3 Context Variables and Business Processes Matching

The goal of this step is identifying which aspectized contextual variables/ elements affect which business processes and which steps to take within these processes. This can be achieved by identifying the goals of the business process under investigation. It comes by studying the business behind the process and the wider picture that the business process fits in, which comes from the understanding of the overall business domain. As mentioned above, the goals of the industry as well as the business process goals should be defined by business domain and process experts in an easily updatable format. This is followed by comparing the goals of the business process to the goals of the different aspects of contextual elements that are of interest to the industry under which the business process lies and detecting any common goals. If common goals are found then the business process is affected by the context and through common goals we will be able to identify which business process steps are affected.

4.4 Business Process Configuration

Configuring the affected business process according to the values of the contextual variables takes place as depicted in figure 1. After defining which business processes and which sub processes or steps are affected by which contextual variables and elements, the important issue now is the recommendations about possible configurations. In fact this could be done in two ways:

a. **Within our custom developed framework without integrating or extending any business process modeling software:** by having a recommendations engine which has ranges for different contextual variable/elements and for each range it gives recommendations for the steps of the business process. This method requires an easy way for industry experts to define recommendations. This could be achieved by having recommendations definitions inside the business processes repository which would have ranges for different contextual elements and according to these ranges, recommendations for alternative flows of the business process are made. In this case a decision maker class inside the framework compares the goals and defines which processes and steps are affected by which variables then reads the recommendations from the recommendation files and publishes them separately

b. **Using an external business process modeling framework:** this could take recommendations in a specific format and make use of the recommendations in addition to the modeler's capabilities, to make the right decision regarding the business process flow.

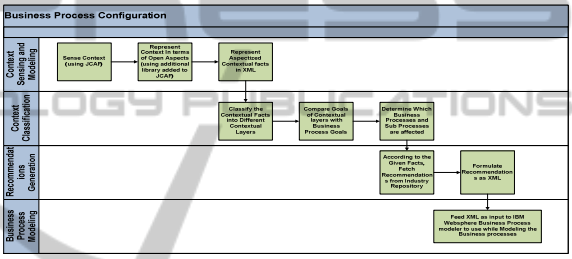

Figure 1: Business process configuration steps.

4.5 Extensibility of the Solution

The main source of the extensibility is finding an easy way for industry/business process experts to update information related to the business goals of the industry, its context variables, their classification as well as the different business processes and alternatives within the industry along with their associated goals.

The business experts can easily use the framework for defining new industries and for defining their business goals, contextual layers and contextual variables and their associated list of business processes. For each business process they can also define the business process and the recommendations according to contextual variables' threshold values that are defined by business process experts and advices to actions or best mitigation within each range of thresholds of contextual variables values.

5 EXAMPLE

Figure 2 presents an example of the airlines check in

business process configuration steps which could take place using the above explained methodology.

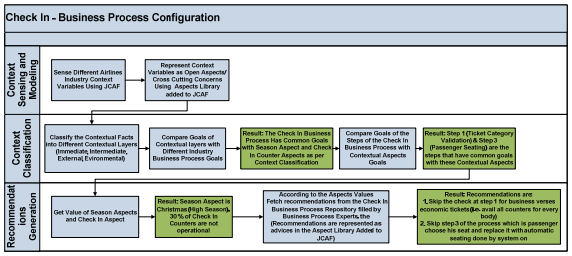

Figure 2: Check in- business process configuration.

In the above example the JCAF senses different contextual variables related to the airlines industry and represents them as open aspects. Classification of the contextual aspects takes place in the four contextual layers (immediate, internal, external, and environmental) defined earlier. According to this classification goals matching is done using additional goal matching classes added to JCAF and we discover that the season and number of check in counters aspects affects step 1(Ticket Category Validation) and step 3 (Passenger Seating Choice) of the Check In Business Process. The values of these two aspects are computed and recommendations for the ranges of values of these aspects are fetched from the business process repository (defined by the business process experts). The framework recommends skipping step 1 (thus availing all counters to everyone), skipping step 3 and making passengers seating automatic to speed up the process and avoid bottlenecks which resulted from the current contextual situation.

6 CONCLUSIONS

In this paper we present an aspect-oriented methodology for representing business process context to support informed business process decision making. The context is modeled in terms of Open Aspects and a goal driven approach is used to classify the contextual aspects and determine their impact on different business processes and operational levels. Recommendations about the business process flow are formulated based on aspectized contextual facts. We have so far implemented the first part of the framework which involves the extension of JCAF with the aspects library and the representation of sensed contextual items as aspects and converting them to XML format. This is in addition to the classification of contextual items and the relationships between the items and business processes through goals. Our next step is to combine the generated XML files with the IBM Web sphere business modeler tool to observe how the recommendations and contextual findings would affect the business process decisions.

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