Towards Context Aware Business Process Modelling

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Abstract. For surviving in their complex and dynamic environments, organisations should be adaptable and interoperable with these environments. Stakeholders' expectations change unpredictably and are often dependent on the contextual information. A context sensitive BP model is able to adapt the execution of the instances to the changing contexts and then to the stakeholders' requirements. Our objective is to overcome the challenging issues related to the contextual factors. To this end, we discuss in this paper the relevance of context awareness for the adequate design of business processes (BP) and present a new approach for modelling BP that supports the description of the execution context.

Keywords: Business Process Modelling, Context, Adequacy.

1 Introduction

Due to the economic and technological progress, customers' expectations are becoming imprecise and varied following the context in which expectations are formulated. Hence, context related knowledge (*CRK*) becomes an essential resource to adapt the behaviour of BPs. A conventional BP model may fit customers' needs in a given context and not in another one. Although context-awareness has been investigated in several applications, there are numerous other areas of computer science that can take advantages from context-awareness. In this work we focus in particular on the field of BP modelling.

Despite innovative works proposed by the BP community, there is a lack of approaches that support variability according to the contextual requirements of each BP model instance. The ability to integrate the *CRK* allows BP models to be active, flexible, fine-grained and able to express a variety of business rules. These features provide better adequacy with stakeholders' requirements. In addition, from the administration point of view, context awareness allows BP to be self-managing and automatic, demanding minimal administrator's guidance. To this end, we discuss research challenges related to the development of a new promising paradigm for BP modelling supporting explicit definition of the *CRK*. Also, we extend the role-driven BP modelling approach (RBPM) presented in [8] for supporting context awareness.

The paper is organised as follows: Section 2 presents our motivation and the related work. Section 3 proposes an approach for supporting context related knowledge by business process models. Section 4 concludes the paper and sets perspectives for future work.

2 Motivation and Related Work

Historically, the concept of context has been adapted from linguistics, referring to the meaning that must be inferred from the adjacent text [10]. The context has various meanings according to the application. Dey et al. [3] define context as "*any information that can be used to characterize the situation of entities that are considered relevant to the interaction between a user and an application, including the user and the application themselves*". Winograd [10] gives a more specific and role-based definition: "*context is an operational term: something is context because of the way it is used in interpretation, not due to its inherent properties*". Most recently, Coutaz et al. [2] define context as "*is not simply the state of a predefined environment with a fixed set of interaction resources. It is part of a process of interacting with an ever-changing environment composed of reconfigurable, migratory, distributed, and multiscale resource*". The context plays an important role in several science applications such as natural language semantics and artificial intelligence, knowledge management, and web systems engineering. In the domain of BP modelling, context awareness is relatively new field of research. However, some papers on this subject have already been published. In [7], a BP context is defined as: "*The minimum of variables containing all relevant information that impact the design and execution of a BP*". A context-aware modelling framework is introduced in [2].

RBPM [8] is a role driven approach for modelling flexible BPs. It has two major benefits: (i) it offers flexibility in assigning functions to roles since a function can be performed by several possible roles according the performance context rather than a specific one, and (ii) it gives to actors some autonomy allowing them to develop strategies for performing operations, operational goals and functions. As shown in Figure 1, RBPM is composed of entities and relationships between them which are called also assignment relationship. In evolving environments, the stakeholders' expectations change unpredictably. So, it is inaccurate to identify the behaviour of all realisations of a BP in a static way. With respect to RBPM, it is difficult to define BPs, roles requested to participate in their achievement, actors playing roles, operational-goals satisfying functions and operations requested for achieving operational goals in a static manner. A context sensitive BP approach offers the ability to adapt the BP behaviour to changing contexts.

3 Context Awareness in Business Process Modelling

We believe that context modelling should be used as an integral part of the BP modelling. Indeed, it provides information that will help to decide between assignment options. With respect to RBPM [6], CRK (i) may concern BP elements,

for instance, the "competency" concerns the entity "actor" of the BP model, and (ii) has impact on assignment relations, for example, the "experience" and the "urgency", together, have impact on the actor to role assignment: in an urgent situation, it is better to assign a given role to an expert actor rather than a novice one.

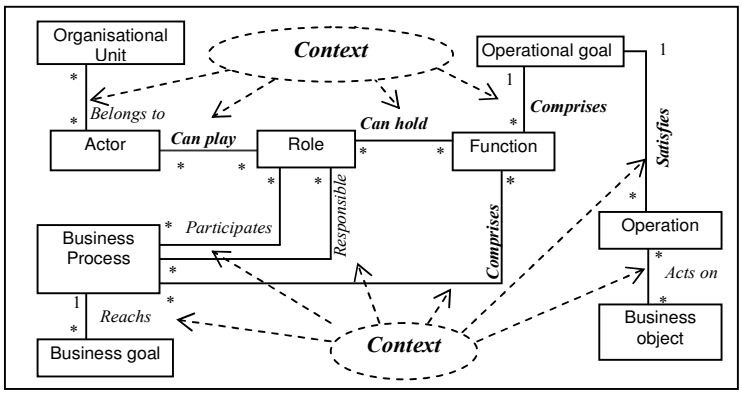

Fig. 1. - The Impact of the Context on the Meta-model of RBPM

The introduction of the context has impact on all assignment relations of RBPM. With respect to the assignment relation *Can play*, actors are assigned to roles according to their capability in a particular context. Let us take an example: *Steve* belongs to the *loan handling service*, he plays the role *Loan_assistant* and he has a good experience in the domain of loan handling. He can be assigned to the role *Loan_manager* if and only if all actors which can play the role *Loan_manager* are unavailable. Note that this assignment is related to a specific context and can not take place nowhere else:

<<"he has a good experience" and "all the actors that play *Loan_handling* are unavailable>>

With respect to the assignment relation *can hold*, conventional role based approaches define processes in such manner that a given operation should be executed by one specific role. But, this can not be always possible at the instance level. In fact, if all actors playing a given role are unavailable, a function should be performed by selecting one of the roles provided rather the fixed role. Including the context allows answering this question: "In which context a function can be held by a given role?". Then, functions can be held by several roles in several contexts for flexibility and adequacy purposes. In the following, we set some questions aiming to capture the requirements related to the context knowledge support:

– Which functions a business process comprises in an "*urgent situation*"?
– Which employees are members of a particular role in a "*particular organisational unit*"?
– Which roles a particular employee "*usually*" holds?
– Which operations an operational goal requires at which "*point of time*"?

To answer the above mentioned questions, the following issues need to be discussed.

– What kind of *CRK* is relevant to BP management?
– Can we categorise the contextual information and how?
– Which kind of contextual information is relevant for a specific BP?
– How the *CRK* can be used during the instantiation of BPs?
– Is there a relevance relationship between the nature of the context and the BP model components?

3.1 Context Related Knowledge Elicitation

With respect to the literature, context is often characterised by a space. For instance, Lenat [13] characterises the context in the domain of artificial intelligence by a space that includes a number of dimensions or parameters (e.g. "time", "location"). Maus [12] introduces parameters for a workflow context space (e.g. "function", "behaviour", "causality"). We presume that the *CRK* is closed to the application domain taken into account. So one should (i) understand and find out about the organisation, (ii) identify the BPs that are currently performed, and (iii) identify the internal and external dependencies between elements of the organisation (e.g. actors, BPs).

We believe that any information reflecting changing circunstances during the execution of a BP can be considered as contextual information. We define the context as: "*the collection of implicit assumptions that is required to activate accurate assignments in the BP model at the process instance level*". With respect to RBPM, the notion of the context covers any circunstance that impacts the assignement relations.

We propose taxonomy of most common contextual information. We identify four important kinds of context:

– **Location related context**: represents the location characteristics. For exemple, the assignement of an actor to a role in a given process depends on the specific area wherein the actor is working. Taking into account this CRK allows expressing rules as: <actors may be able to participate or not to a BP depending on their physical location>.

– **Time related context**: reflects the features related to the time. This may include (i) performing time (some examples are "time in day"), (ii) urgency, (iii) work duration, (iv) frequency, (v) saving of time. This CRK allows expressing rules such as <the function "*Loan Handling*" can be handled by an actor which play the role "*Loan assistant*" only in the context of "lack of resources" (e.g. if there is no free actor playing the role "*Loan handler*" and only if the process time-to-finish is less than 3 days)>.

– **Resource related context**: copes with material and humain resource properties. (i) Human properties such as "age" and "gender". Some properties are in relation with the work (eg. "motivation", "performance", "participation", "ego involvment", "job involvment", "mobility". Other humain properties may reflect the relationship between actors: "actors hierarchically nearby", "quality of communication and relationships between actors", "collaboration sensitivity". (ii) Resource properties may concern characteristics of business objects, such as "lack of resources", "resources availability", as well as features concerning financial resources (e.g. "expensive operation"), time resource (e.g. "time consuming function").

– **Organisation related context**: concerns (i) the workplace characteristics, e.g. "relationship of the actor with his/her workplace", (ii) the type of the organisational structure (e.g. "hierarchical", "transversal"), (iii) the cultural and social aspects.

The above mentioned taxonomy of *CRK* is not exaustive. We will enrich it progressively during our research. There exist other categories like those related to external factors of the environment (e.g. "uncertainty", "weather", "technology capability", etc). Note than the attribute is an atomic context which can be static or invariant (e.g. "date of birth", "social security number") or dynamic or changing (e.g. "relationship between colleagues"). It may be external or internal to the organisation.

3.2 Context Related Knowledge Categorisation

Given the wide range of *CRK*, it is clear that a structure allowing the categorisation is required. This helps application designers and developers to manage context information efficiently. Most of the existing context models are based on one of these methods: *Set theory* [9], [11], *Directed Graph* [4], *First-order Logic* [6], *Preferences and user Profiles* [5]. The mentioned categorisations are useful, nevertheless they are incomplete and contextual information is not clearly delimited. In order to overcome these limits, we require models and methodologies allowing to structure the contextual information and to use it adequately.

We introduce a context model (CM) allowing to exhaustively structure the contextual information in a convenient way. From our point-of-view, context can be categorised from various aspects, such as temporal aspect, location aspect, and so on. CM uses a three-dimensional space to describe the *CRK* (Formula (1)).

$$S =< ASPECTS,\ FACETS,\ ATTRIBUTES > \tag{1}$$

$$CONTEXT = \{ASP_{i \in I}\},\ asp_i = \{name - asp_i, value - asp_i, \{FAC^{asp_i}\}\} \tag{2}$$

$$fac_j = \{name - fac_j, value - asp_j, \{ATT^{fac_j}\}\}, \tag{3}$$

$$att_k = \{name - att_k, value - att_k, type_k, impact_k, perimeter_k, dynamicity_k\} \tag{4}$$

$$\{FAC^{asp_i}\} \subseteq \{FAC_{j \in J}\},\ \{ATT^{fac_{ji}}\} \subseteq \{ATT_{k \in K}\} \tag{5}$$

The *CONTEXT* is captured using *aspects* which are non-functional features; each of them is addressed by some *facets* (formula (2)). *Facets* are described by *attributes* (formula (3)). *Attributes* have *features* that are directly measurable (formula (4)).
CM can be represented using a structure of graph. We introduce the *context tree* (CT) for representing the CM. CT is a three-level tree which root represents the global context, nodes at the first level refer to the aspects, nodes at the second level refer to facets and leaves at the third level refer to attributes. Figure 2 illustrates an example of CT using the CRK identified in sub-section 3.1.

The construction of the CT requires the competencies of the application domain expert. He/she has to collect and to structure the relevant context aspects, facets and attributes, to define the appropriate functions allowing measuring them. Note that some attributes of the CT can be identified using the characteristics of the elements of the BP meta-model. For instance, "age" and "gender" are properties of the entity

"actor" (see Figure 2), they can be considered as well as leaves of the CT. Context embedded in CT nodes and leaves may act on the assignment relations linking the BP elements (see Figure 3).

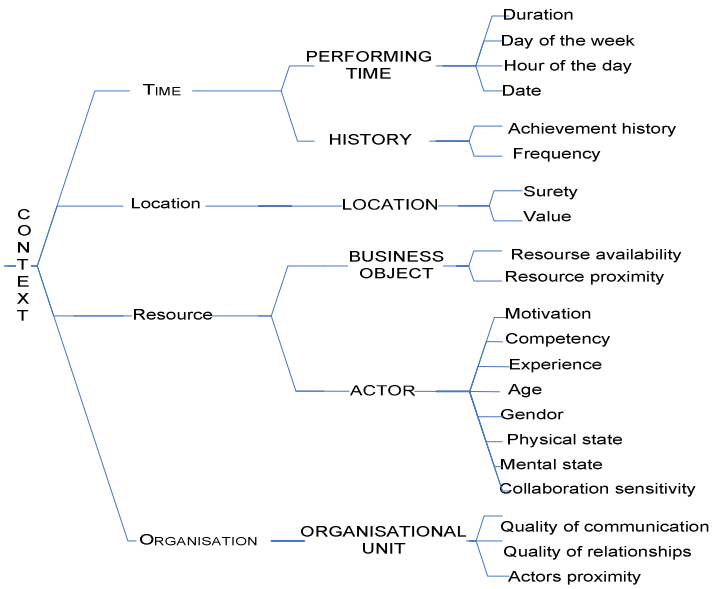

Fig. 2. An example of Context Tree

We assume that the CT in this stage is appropriate to a particular application domain, for instance the banking field. Hence, this step is a first adaptation of the CK to the organisation domain. The adaptation of the CRK to a given process is discussed in the following section.

3.3 Context Related Knowledge Adaptation and Measurement

This issue concerns the question 3: "Which kind of contextual information can be relevant for a BP?". That are a lot of information expressing the context, however, in a given BP or focus, only a part of these information could present an interest for the useful assignments. Accordingly, original CT (see sub-section 3.2) should be adapted so that, at a given time, it includes only contextual information which is relevant to a BP. The adapted context tree (ACT) will include only meaningful aspects, facets and attributes for the given BP.

3.4 Contexts-Aware BP Instantiation

This issue relates to the selection of the best instances among a set of available ones with respect to ACT. This raises two main issues: (i) evaluation the ACT and (ii) selecting the appropriate assignments to instantiate a BP based on the adopted CST.

– **ACT evaluation**: it raises two issues: (i) determining the significance of each context attribute and (ii) evaluating it. It is clear that all context attributes do not have the same relevance at a given time. We approach to associate weights to the attribute according to their importance. For example, in an urgent situation, matching the context attribute "urgency" is more significant than matching the context attribute "competency" or "hour of the day". Actually, CRK is diverse, some context is simple to calculate (e.g. "age") and other context is more difficult to qualify (e.g. "competency" or "motivation"). Determining how to measure the CRK is an important issue which requires more investigation.

– **BP Instantiation**: in order to instantiate BP using the ACT, we introduce a new concept: the *assignment activation* which means that only significant assignments have to be taken into consideration in a given context. Hence, the set of assignments which mach better the current value of ACT is activated. Assignments that are activated are those which variable values are included in the range of the ACT current values. This requires identifying valid ranges of acceptable context values for every assignment type. Figure 3 resumes the different steps of the BP instantiation.

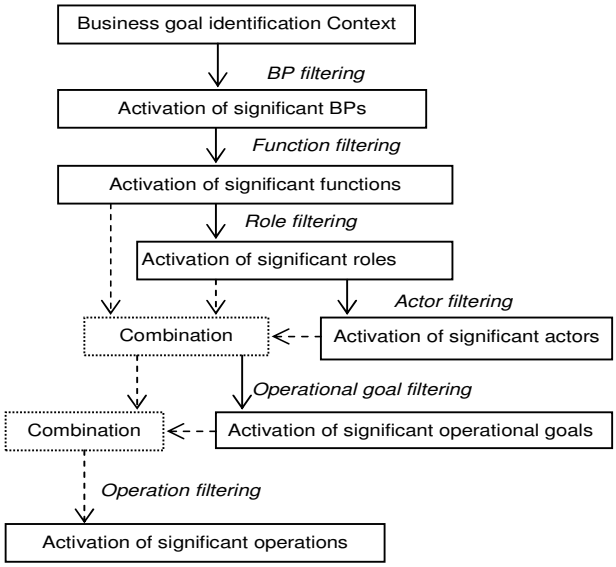

Fig. 3. An example of the BP instantiation process

3.5 Discussion

The support of the CRK requires four main steps (see Figure 4). The first one relates to the context elicitation which allows to capture, to assemble , and to structure the contextual information. The second one is about the context categorisation using the CT. The third step aims to adapt the CRK to a particular application domain and to measure it. The final step deals with the selection and activation of the appropriate instances of BP model entities and assignments.

Fig. 4. Steps of the support of the CRK

The construction of the CT is a complex task which requires the competencies of the application domain expert. He/she has to collect and to structure the relevant context aspects, facets and attributes. Afterwards, context values are determined based on the context tree. This is also done by an application domain expert. These administrative features are out of the scope of this paper and will be studied in our future work. As well, it is clear that BP instantiating with respect to the context is a complex task which requires mechanisms allowing guiding the BP administrators in order to correctly use the CRK.

3 Conclusion and Future Work

We addressed in this paper the relevance of the context related knowledge (CRK) for adequate BP modelling. Context awareness allows business rules to be self-adaptive with respect to contextual circumstances. We believe that context sensitive BP models fit better the customers' expectations which are often context-dependant. From an administration point of view, context awareness enables BPs to be self-managing and automatic, minimising as a result administrator's guiding.

We discussed key issues related to the support of CRK including the elicitation of CRK, its categorisation, its adaptation, its measure and use for BP instantiation. We introduced a taxonomy of context which captures most common CRK. We expect this taxonomy will evolve over time.

We proposed two structures for modelling and categorising the context: the structure of tree and a three-dimensional vector. The proposed context tree (CT) is general and flexible, so that it is possible to add new contextual characteristic at any time. We suggest adapting the CT to specific BPs, we obtain thus the ACT (Adapted CT). We also proposed to extend RBPM for supporting the context concept aiming to make easier the definition of customised business rules.

Context-awareness allows expressing a rich set of business rules and to adjust assignment activation and deactivation in a flexible way offering practical alternatives that depend on the context. It provides more appropriate matching so that only an actor which plays the appropriate role can perform an operation and only the suitable

functions will be included in a given BP, etc. This ensures that BP instantiation matches actual usage and needs. Therefore, the CPM offers the flexibility to activate assignments in specific BP instances. As well, a great amount of flexibility is brought by the concept of context. For example, in current approaches, when changes related to the actor-to-role relation happen, it seems necessary to modify some actor-to-role assignments according to the changes. Using contextual assignments allows assignments to be context-aware.

Our contribution presented in this paper offers a starting point for further investigations of context-based BP modelling. We will be interested in particular to the issues related to:

– Context-oriented process patterns;
– Metrics for qualifying *CRK*. It must be underlined that actually most of the contextual information depends on the way in which the actors interpret them;
– The dependency relations between diverse context information and the use of these dependency relations.

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