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Research

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Abstract

Enterprises exist in the context of their dynamically changing environment, which has a strong impact on service design and delivery. Within areas such as ambient intelligence or robotics, most relevant context has a physical nature. However, the context of an enterprise requires a different conceptualization of context awareness. Beyond physical context, enterprises need to be aware of their market, legal and social context. Moreover, in order to monitor context and configure services systematically, we need a context modelling method that is integrated within enterprise modelling and supports information and communication technology (ICT) engineering and runtime. The work in this paper has been performed as part of developing Capability Driven Development (CDD), a new paradigm for ICT design where services are customised on the basis of the essential business capabilities and delivery is adjusted according to the current context. The contributions of the paper are (i) the investigation of industrial needs for context modelling, (ii) eCoM, a context modelling method for enterprise ICT addressing such needs, iii) application of the method in an industrial use case and (iv) the evolution of eCoM based on various evaluation cycles by means of Framework for Evaluation in Design Science Research (FEDS).

Keywords: Context Modelling, Context Awareness, Capability Modelling, Capability as a Service, Enterprise Modelling, Information Systems, e-Services.

1 Introduction

Enterprises are dynamic, active and open systems that have an internal organisation and operate in pursuit of organisational goals, guided by rules and informed by communication. The true systemic properties of enterprises are that they respond to changes caused by the system environment and, in turn, cause changes in it (Falkenberg, 1998). Thus, context has a strong impact on enterprises (Capon, 2004). Enterprises offer business services to satisfy customer needs and to support the exchange of business values (Andersson et al., 2009). Due to the achievements in information and communication technology (ICT), business services are electronic-oriented and can be offered digitally. Although such e-services are developed for a specific customer group, they need to be configured in line with the application context. Hence, enterprises and their supporting ICT need to be adapted to changes in regulations, market demands, customer expectations, societal and technologic trends, etc.

Context awareness has been a matter of computer science research for some years, especially within the areas of ubiquitous computing, ambient intelligence, embedded systems and robotics (Dey, 2001), (Wood *et al.*, 2008) and (Smirnov *et al.*, 2013). In these types of systems, the most relevant context has a physical nature (e.g. temperature, luminosity, presence sensors) but there also exist works that focus on information systems (Silva Souza *et al., 2013*). However, the context of an enterprise and its operations requires a different conceptualisation to the existing ones. In order to allow running organisations to monitor context and adapt to changes systematically, we need (i) a context elicitation and modelling method integrated within enterprise modelling, (ii) a context platform that monitors and reports changes in the environment, and (iii) adjustment algorithms that aid in deciding how to change the organisation and its ICT to react to contextual changes. The work presented in this paper has been performed within the research FP7 project Capability as a Service (CaaS), a project that is developing Capability Driven Development (CDD). CDD is a new paradigm for ICT development where services are customised based on the essential business capabilities and delivery is adjusted according to the current context. CDD consists of both a methodology (comprising enterprise modelling, capability design and capability delivery -i.e. runtime-) and a suite of tools for capability modelling, monitoring and adjustment. In this paper, the focus is on the method for context elicitation and modelling, which is an integral part of the CDD methodology. The contributions of the paper are the following:

- We investigate industrial needs for context modelling and enumerate a set of requirements.
- We present eCoM, an enterprise information systems context modelling method that covers the elicitation and specification of relevant context elements, suits CDD and fulfils the requirements.
- We report on the evolution of eCoM based on various evaluation cycles.

The remainder of the paper is structured as follows: Section 2 describes the research method. Section 3 investigates the needs of industry and reviews the state of the art in context modelling. Section 4 introduces the use cases, presents the eCoM method and exemplifies its application in one use case. Section 5 reports on the evaluation aspects, i.e. how the method evolved through different phases based on the evaluations. Section 6 presents conclusions and addresses future work.

2 Research Method

The main goal of this work is to design a context modelling method that suits capability driven-development and fulfils industry needs. We formulate these research questions, targeting knowledge and practical problems, according to guidelines from (Wieringa, 2009):

- RQ1. What are the current problems in context modelling for enterprises and what are the requirements for a potentially successful solution? (Section 3.1)

- RQ2. Which methods are available for enterprise context modelling? (Section 3.2)
- RQ3. How should a method for context modelling be engineered in order to facilitate context elicitation and specification? (Section 4)
- RQ4. What benefits and drawbacks are obtained from evaluating the eCoM? (Section 5)

The research method is structured in terms of the design science framework (Wieringa, 2009) since it aims at creating new artefacts (e.g. eCoM) and acquiring new knowledge (e.g. discovering the requirements for such a method, validating the method to assess its strengths and weaknesses). In addition to that, the work adopts the Framework for Evaluation in Design Science Research (FEDS) to evaluate the artefact (Venable *et al.*, 2014). To investigate the problem (see Section 3), we elicited industry needs by means of interviews to several companies (cf. (Bērziša *et al.*, 2015), (España *et al.*, 2014)) and reviewed the state of the art on context modelling to identify limitations (Koç *et al.*, 2014). The result is a set of requirements that eCoM needs to fulfil. To design the solution (see Section 4), we engineered a method consisting of several interrelated method components that include procedures, notations and guidelines. The method components have been applied in close collaboration with two industrial partners. *everis* is a multinational consulting firm providing business and strategy solutions, application development, maintenance, and outsourcing services in the sectors of banking, healthcare, insurance and the public sector. *SIV group* is a vertically integrated German enterprise that acts both as an independent software vendor (ISV) and as a business service provider (BSP) in the utility industry. To do this, we enacted several rational problem-solving cycles as described in (Wieringa and Moralı, 2012). We also use the *BSP clearing case* as a running example to illustrate the method application.

3 Problem Investigation

3.1 Problem Statement and Industrial Requirements

To investigate the problem, we selected two industry settings in which context is highly relevant in the design and delivery of e-services: SIV group and everis. We selected them because (i) they are partners of the CaaS project (ii) they work in several domains, and (iii) according to our experience, their current problematic phenomena are representative of other companies'. We performed semi-structured interviews to understand their use cases (i.e. the projects) (Bērziša *et al.*, 2015) and identify current methodological and technological limitations.

SIV group as an ISV, has a market presence in developing and selling the industry-specific ERP platform kVASy®, which is widely used by public utilities in Germany. Within the European Union the commodity markets are strictly regulated, which in turn leads to complex business relationships between the players of the utility sector. Public utilities thus increasingly consider outsourcing of their business processes to external service providers. This is where the SIV group acts as a BSP and deals with the business processes subject to bulk data exchange between market players, such as transmission of the energy consumption from one market role to another. Taken the complex relationships and the regulations of the market into consideration, exchange of data may easily get into conflict with other data, which requires the initiation of a *clearing* procedure.

everis performs a case study in CaaS to implement, evaluate and improve capability design and management in a collaborative and changing context of the public administration sector. Of particular relevance are the services provided in a Service Oriented Architecture (SOA) platform with a catalogue with up to 200 e-Government services in 250 municipalities. Different factors have to be taken into account during service delivery, such as diverse public administration's laws, regulations, administrative consortia and calendars, as well as various technological tools.

In the SIV case, the conflicts triggering a clearing procedure cannot be resolved programmatically by kVASy®. Currently, the clearing can be done either by the client or by the BSP, which involves the manual interaction of a human agent and causes extra costs. The company envisions a dynamic outsourcing of the e-services, i.e. it should be resolved at runtime whether or not the individual case should be routed to the BSP. This decision is based on runtime data such as the number of the messages that needs clearing (backlog size), the type of contractually supported services and exceptions, which can be captured in a context model. In the everis case, the e-services need adaptation every time the platform is deployed in a new municipality and whenever the context changes. For the time being, service customisation is done at code level (Zdravkovic *et al.*, 2013). Consequently, the companies would benefit from a method for context modelling that facilitated variability management, automated decision logic and supported customisation in line with the service delivery context (c.f. section 4.2.).

We conducted workshops with the CaaS project partners to identify the requirements of the industry for such a method. In addition to that, requirements towards the CDD were taken into account. Details on these workshops and interviews are documented in CaaS project deliverables D1.2, D1.3 and D1.4[1]. Thus, the specified requirements consider the perspectives of the CaaS project and the industry.

- R1: eCoM should be flexible and situational. The proposal should not be a monolithic block but should allow for flexible and situational use of parts of the method. For this purpose, the method should be based on an established, modular method conceptualisation (Sandkuhl and Koç, 2014).
- R2: eCoM should be compatible with the CDD methodology and the CDD Meta-Model (Zdravkovic *et al.*, 2013), i.e. it should help in identifying and modelling both the business context and its relation to business processes and enterprise goals.
- R3: eCoM has to provide guidelines to properly configure the services described in Section 3.1 (needs of the industry), by integrating context and process variability (Koç and Sandkuhl, 2015).
- R4: Practical relevance should be ensured. The final method has to provide a comprehensive manual with clear guidelines to follow in order to result in an applicable context model. This development process is supposed to meet the premises of effectiveness and efficiency and the trade-off between value added and efforts has to be reasonable.

3.2 Related Work: Context Modelling in Computer Science

The concept of context is widely used in various domains of computer science and is adapted by different disciplines such as cognitive or social sciences. Due to its widespread use in the literature, the interpretation of context depends on the field of knowledge that it belongs to (Bazire and Brézillon, 2005). In computer science, it is possible to differentiate between linguistic context, situational context, relational context and organisational context.

In the scope of this paper, we interpret context from the perspective of enterprises and information systems (IS). Due to the ever-shifting environments that the enterprises operate in, IS are subject to continuous changes. Different factors such as the operational environment of the customer, the regulatory requirements, customer preferences and socio-technical circumstances affect the service delivery of an enterprise, which is usually reflected in business processes. Consequently, IS need to be adjusted to different runtime contexts that have an influence on its design and delivery. This requires a dynamic utilisation of resources and has brought new challenges: managing the process variability and aligning the IS with the enterprise strategic goals. For instance, an e-government platform, through which citizens can register for obligatory services or public activities, would benefit from a flexible promotion of these services, depending on e.g. available resources, the citizen's interests, the current season or weather (see use cases in 4.2). The CDD approach addresses this need by explicitly modelling the con-

[1] http://caas-project.eu/deliverables/

text surrounding the delivery of an e-service. We adopt the context definition as '*any information that can be used to characterise the situation of an entity'* (Dey, 2001). The definition suits to the CDD approach since it encompasses the aspects of causality (*information…to characterise*) and of variability, i.e. how the information affects the situations, in which the service should be provided.

In prior work (Koç *et al.* (2014), a systematic literature review (SLR) on the state of the art of context modelling methods in IS research was conducted following the guidelines defined by Kitchenham et al. (2009). In short, the review has shown that the the method support on how to develop context models is scarce (Koç *et al.*, 2014). First, the term "method" is used synonymously with modelling approaches or 'development steps'. Here, Model Driven Development (MDD) techniques are applied frequently in developing context models. Hoyos *et al.* (2011) present a Domain Specific Language (DSL) and show steps on how to model context quality. Similarly Serral *et al.* (2008) propose steps to develop context-aware systems applying MDD methods and Hussein *et al.* (2011) introduce a model based approach to develop context-aware adaptive software systems. Further, Kapitsaki and Venieris (2009) describe six steps on how to develop context-aware web applications using MDD techniques. Second, some authors of context-based systems describe requirements and ways of developing context models for their specific application, yet do not provide a general view (e.g. Martín *et al.*, 2012, Ben Mena *et al.*, 2007). In this respect, works focus on what elements context typically consists of, how to identify and represent them in models. The requirement engineering (RE) field has made valuable contributions. Lapouchnian and Mylopoulos (2009) propose a process to explore contextual variability and analyse its effects on goal models. Also, Ali *et al.* (2010) introduce a goal-based RE modelling and reasoning framework for systems operating in various contexts. Both proposals are helpful for identifying and formalising the contextual factors. Nevertheless, understanding the application context of a business service requires more than analysing the variability in the objectives of an enterprise. That is, goals may be stable and valid for over a long period of time, whereas the actions that fulfil the goals may vary depending on the application context. Moreover, extending modelling languages with more primitives entails the risk of drifting from the intended use of such languages, overloading the models and, thus, hindering their comprehensibility. Instead, we advocate defining a separate context model whose elements can be referred to from other models.

From the CDD point of view, approaches for context modelling do not meet the requirements listed in Section 3.1. The procedures proposed in the literature follow conceptual research (R1) by focusing on how to model the physical and situational context (sensory environment, interaction between a user and an application) rather than business context as addressed in CDD (R2). Although fulfilling both requirements to some extent, the approaches from the RE area do not provide guidelines to incorporate the context models into the business process models required to deliver services (R3). The identified approaches in the literature do not cover the areas such as important concepts when modelling context, graphical notations to represent such concepts, tool support, skills of the modeller and preconditions of method use. Consequently, a comprehensive method for context modelling showing what steps to take and how to identify relevant context elements affecting service delivery of an enterprise has not been proposed yet.

4 Solution Design: the eCoM Method

4.1 Method Engineering

4.1.1 Method Overview

The eCoM should be situational and flexible (R1), and it will be a part of the superior CDD method that is compounded itself by independent parts (R2). For these reasons, a component-oriented method view was selected, parts of which are described in this section briefly.

The eCoM is intended to be a ready-to-use method, including pathways from it to proprietary methodologies applicable to certain business cases (Sandkuhl and Koç, 2014). The whole CaaS consortium has applied the method framework proposed by Goldkuhl *et al.* (1998). The tenets of the framework are that (i) a method is prescriptive and explains a course of action in a given problem context to arrive at certain goals, and (ii) it describes the perspective on the method, framework, cooperation forms and all method components. The framework is extended, i.e. i) the procedures are refined with additional elements such as *steps* with certain *inputs*, *outputs* and *tool support* and ii) the terms *perspective* and *framework* are replaced by *purpose* and *overview to method components* respectively. An exchangeable and reusable method component defines concepts, procedures and notations. Concepts are important aspects of reality used by the method. The procedure defines actions to perform to identify these concepts and notations specify how to document the results by means of semantic, syntactic and symbolic rules. The overview describes the components' relationships. Cooperation forms describe organisational preconditions to be established before using the method. Finally, the purpose emphasizes the objectives that is fulfilled by the method application.

4.1.2 Important Concepts

The eCoM is based on several concepts, whose interrelations are presented in the CDD meta-model (Figure 1) (Zdravkovic *et al.*, 2013). Following Bērziša *et al.* (2015), a *capability* is the ability and capacity that enable an enterprise to achieve a business goal in a given context. *Goals* are internal means for designing and managing the organization. Each capability requires or is motivated by one business goal. The *context* is any information that can be used to characterize the situation (Dey, 2001), in which the capability can be provided. In the CDD meta-model the *context set* denotes a set of circumstances, such as geographical location, platforms, as well as business conditions, which are represented by the *context elements* and categorized by different *context types*. For instance, based on the change rate, the context can be static (e.g. contract details) or dynamic (weather); we can also make cohesive groups such as legal (data privacy regulation), social (customer satisfaction, social network feedback) or environmental context (pollution, noise). The attributes required to calculate the value of a context element is captured as *measurable properties*. The context elements have a range of valid values as identified by their *context element ranges*. The purpose of context element range is to represent the actual ranges of value of relevant context elements for a specific context set.

The service enabled by the capability is supported by a *process*. In many cases, there is a master or reference process and several adjustments on it, which are called *process variants*. A *variation point* denotes the precise position within a process model, where several alternatives are available, each leading to different *process variants*. The delivery of capabilities is supported by *adjustments* that enable the execution of a process variant based on the values of the context elements and their allowed ranges. The eCoM uses the context modelling notation developed in CaaS Project to represent these concepts. In addition to that, the concepts *process* and *goal* are represented by the business process modelling notation (BPMN) and the 4EM notation respectively (Sandkuhl *et al.*, 2014).

The notion of context plays several roles in capability design: (i) scoping the achievement of capabilities (i.e. it specifies under which circumstances can a company deliver a given capability), (ii) influencing process variability resolution (i.e. it influences which process variant should be selected), (iii) being an input for a business activity (i.e. some activities besides requiring data provided by the users, also require contextual information –e.g. recommending a swimming pool based on the user preferences and the weather forecast-), and (iv) specifying the applicability of an adjustment (i.e. context determines the preconditions for applying adjustment algorithms used during runtime to increase system adaptability). In this paper, we focus on the first two: (i) a context set is a collection of context element ranges that define under which circumstances a capability can be achieved. For instance, a given company has the capability of renting paddleboats in a secure and cost-effective way as long as the temperature is between 15ºC and 40ºC, the wind force is low or mid, the beach warning flag is green or yellow, and there is no sports event going on. (ii) A context element influences a variation point by informing the decision making over the possible variants. For instance, when preparing the paddleboat for a rent, if the weather is sunny and wind force is low, the worker installs a canopy.

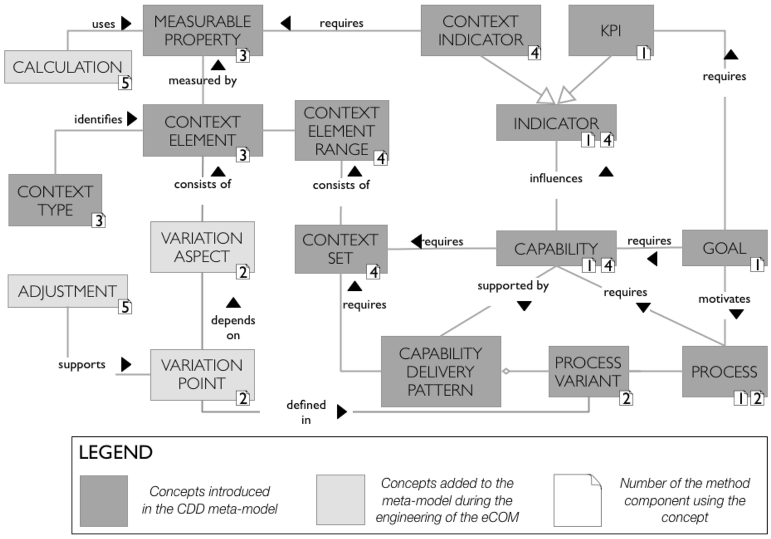

Figure 1: Meta-model used in the engineering of the eCoM based on (Zdravkovic et al., 2013)

4.1.3 Purpose of the Method and Preconditions

The eCoM aims to provide guidelines to (i) identify the business context, in which the company deploys a service, (ii) represent it in a context model and (iii) relate it to the corresponding business processes. The resulting context model serves as an input for the capability delivery adjustment in line with the changes in the service delivery (Bērziša *et al.*, 2015). There are several preconditions that ensure applying the eCoM efficiently: (1) the method user should be knowledgeable in enterprise modelling, specifically in business process and goals modelling. (2) Skills in elicitation techniques to identify relevant information in the respective business environment and to gather information from secondary data are required. (3) Being acquainted with the CDD approach is a certain advantage, whereas it does not strictly apply as a prerequisite to apply the method. (4) The Capability Design Tool (CDT) that incorporates a module for context modelling has to be accessible for the modeller.

4.2 The Use Cases

4.2.1 SIV Group Use Case

SIV group faces the challenge of continuously changing business contexts affected by new regulations, by-laws and other circumstances. Change requirements may not only be driven by external regulations but also by business opportunities that are be related to technological advances (such as cloud computing) and changing customer preferences. This leads to a need for the context-aware solutions that deliver business value to an ever-changing market in the provision of clearing services.

The purpose of the use case is the transmission of energy consumption data from one market role to another role. Before being processed, messages are checked for correct syntax and then validated against an underlying informal data model. For the exchange of energy consumption data, the use of the MSCONS format is mandated, which is a member of the EDIFACT specification family. Upon reception of an MSCONS file, the market partner imports the transmitted values into kVASy®. This process includes a file-level check, a validation step and the processing of the individual meter readings. The exceptions in the former two steps can be remedied automatically by kVASy®. However, the problems in the processing of the meter readings cannot be resolved without a manual intervention of the BSP or the client, as the conflicts are caused by the complex and dynamic nature of the market rules. For any exception, the BSP acts as a clearing centre with costly manual interaction. Having a direct access to the client's environment, a knowledge worker regularly checks the client's Business Activity Monitor for failed MSCONS import processes. Then, based on the contractual agreement between the BSP and the client, the routing procedure to clear a message is defined. The procedure depends on the *contextual factors*, such as the backlog size of the customer, message type that has thrown an exception, the type of the commodity or the BSP's staff availability. The agreement as such cannot respond to changing customer demands, particularly when certain regulatory deadlines must apply to the message. SIV aims to design a flexible solution related to the routing of the exceptional cases, which is termed as "Dynamic BSP Clearing". The envisioned solution has to support a dynamic behaviour in order to decide whether an exceptional case has to be cleared by the client or by the BSP.

4.2.2 everis Use Case

The everis use case is based on the public sector and the main emphasis is put on e-services provided to municipalities, which are then used by citizens and companies. These services can be of threefold nature – automated, semi-automated or non-automated services. Automated services can be consumed completely online, semi-automated services provide only partial functionality through the e-Government SOA platform, while non-automated services require complete face-to-face actions in the municipality's offices.

The use case focuses on the registration module of the e-Government SOA platform. This module offers citizens of a municipality to enrol online for public activities (e.g. cooking or language courses) and to register for other public services (e.g. marriage registration or swimming pool reservation). Generally, there is a defined procedure on how to design a registration process, though depending on the context, the business process that describes the registration service can change its behaviour. For instance, the marriage registration service might require the execution of additional activities, such as checking the staff availability and number of applications, which depend on the calendar of events and type of the day. Likewise, in order to execute the swimming pool registration service, various factors have to be taken into account such as the location of the user, temperature, precipitation, municipality size and registration capacity. If the number of the applications is higher than the capacity of the municipality, the services cannot be provided. In contrast, if the service is not yet fully booked, it can be promoted in the municipality service catalogue. These are the typical parameters that need to be configured each time the platform is deployed in a new municipality or the regulations change.

4.3 Method Components (MC)

This section introduces the method components and their application in the SIV use case (cf. Section 4.2.1). The method application is explained in the bordered italic texts. The method components are illustrated in Figure 2 and the resulting context model is shown in Figure 3.

MC1: Preparing to Context Modelling. eCoM proposes to analyse or create enterprise models from the variation point of view, since the variations and their causes can be used to elicit the context elements influencing the service provision.

SIV group extensively uses enterprise models in general and business process models in particular. Hence, the MC1 was only applied to update the models and select the service under study. For this selection, the guidelines from service enhancers approach by Andersson et al. (2009) is adopted and the business processes related to the clearing cases are updated.

MC2: Find Variations. In this MC, the modeller analyses the structures that will form the context element in the following method components. The MC2 focuses on identifying possible variations in the business process models. The main motivation of this MC is that such variations in the business models arise due to the factors, from which the context elements can be extracted.

The variability identification begins with capturing the variation points. In the previous MC, we already modelled the solutions for different types of clearing cases, which resulted in 15 different business process models. To identify the process variants, the guidelines provided by eCoM are applied. In line with the guideline "use a superset of all variants, if all variants are known" (also policy-4 in Hallerbach *et al.* (2010)*), each of these 15 models represents process variants and the gateway before them. Further, they identify a variation point that needs to be resolved depending on the context.*

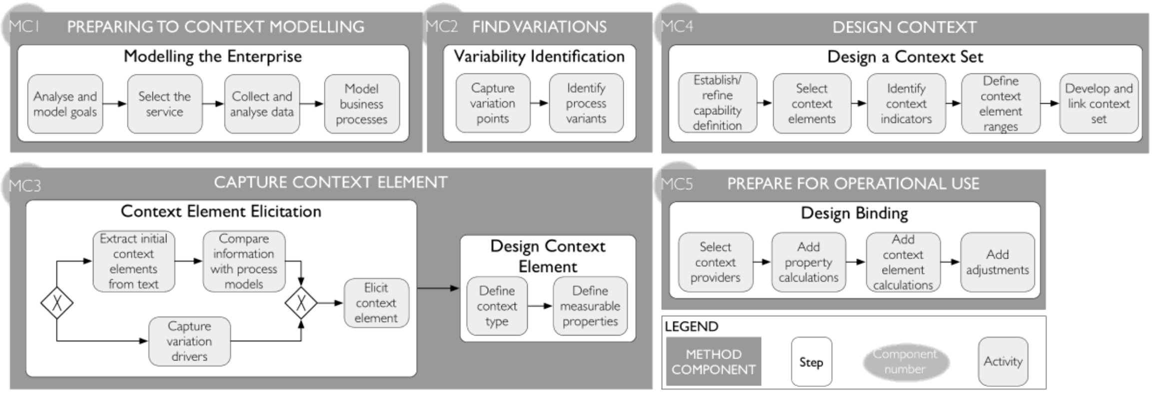

Figure 2: The latest version of eCoM

MC3: Capture Context Element. Focuses on investigating the entities and aspects of the context by eliciting the factors, which cause variations in the processes that were identified in MC2. To do so, eCoM provides the method user with two different pathways (cf. MC3 in Figure 2). Subsequently, by defining the attributes and measurable properties, the method user defines a context element.

We first analysed the documents such as service descriptions, customer specifications and contractual agreements, to extract initial context elements. We then compared them with the business process models captured in the previous MC to assure that these elements cause variability. The context element candidates are then filtered in the "context elicitation" activity and a tabular list of elements is created. For this purposes we applied the guideline provided by eCoM "observe the extent to which the candidate context elements influence the fulfilment of the capability. If they are related to many process variants, then it is likely to treat them as context elements." After eliciting the factors that are related to most of the process variants, another guideline was used, which states "context is an external factor to the process instance. An information produced by the process itself is a process variable and not a context element". For the clearing services in SIV, typical context elements were, "message type, message status, exception type, metering point status, type of measurement, commodity and backlog". In the last step, we defined the attributes to measure the aforementioned context elements.

MC4: Design Context. In this MC, value ranges of the context elements need to be defined for the certain capability and are then aggregated into a context set. The capability defined in the earlier activities can also be refined in this method component, since the method user now has a better view of the context, goals and business processes.

The modelling activities enabled a better understanding of the selected service. As a first step, we defined the capability as "Dynamic BSP Clearing". Note that the capability is distinguished from the conventional service provision as the delivery considers the application context. In this respective "exception type, commodity and backlog" were selected as context elements (cf. Figure 3)*. Based on the contractual agreement, the context elements can assume different values, each of which are captured as context element ranges. A set of these ranges are put in a "container" (context set) and linked to the capability. For different clients, the context elements may be reused, whereas the ranges might* *be interchangeable, e.g. if the client wants to outsource the process related to a different commodity. The MC produces a context model supporting a capability as shown in* Figure 3.

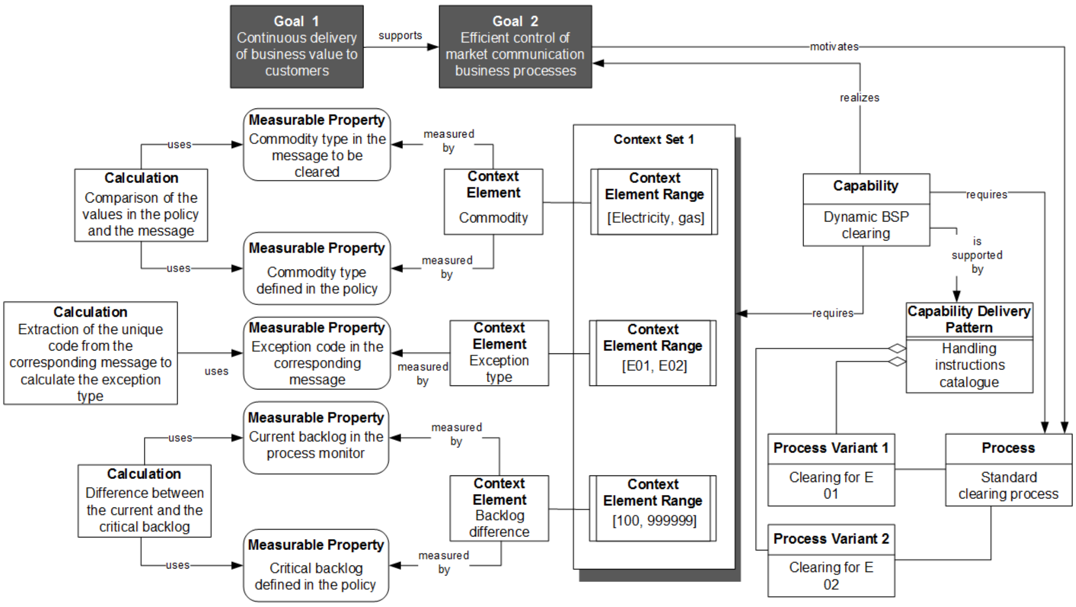

Figure 3: The context model of the SIV use case

MC5: Prepare for Operational Use. The context model serves as means to adjust capability delivery during runtime. This requires adding specifications to the model, which enables the calculation of the context element values. Based on such values, the ERP system is supported with an additional decision logic that takes the context of the client into account. This MC describes the way of adding part of the specifications to the context model to generate code from the model and make it implementable.

First, we investigated the sources of the contextual information for selected context elements. For the Dynamic BSP Clearing capability, the contract management system is identified as the context provider. Next, the calculations of the selected context elements are expressed in a natural language (IF {backlog> critical threshold} ∧ {commodity ∈ {gas, electricity} THEN apply "Process Variant 1") which should be transformed to Java code. The property calculations step was skipped, since the measurable properties are obtained directly from the context providers as raw data. Finally, the supported values of the context element are assigned to the adjustment to represent the decision logic. The model is now ready to be deployed to the runtime environment.

5 Method Evaluation and Evolution

The design process of the eCoM is iterative, i.e. in each cycle we designed a version of the method, which was then evaluated in a given setting, and the results were the input for the following cycle. For evaluating the method versions, we applied the FEDS framework by Venable *et al.* (2014) . The method evaluation cycles are shown in Table 1.

As a first step, an online survey was conducted, which partly focused on the problems of context modelling in enterprises. Based on the results, the requirements that the method should fulfil were collected. Then, an SLR on the approaches in context modelling was conducted (Koç *et al.*, 2014). Both the requirements and the SLR results defined the basis, on which the method was developed. The first version of the method (from now on eCoMv1) included the initial procedures providing answers to the questions. Here, four levels focusing on the different phases of context modelling are described, each addressing the participation of the diverse stakeholders.

<table>
<tr><th>#</th><th>Functional Purpose</th><th>Paradigm of Study</th><th>Method</th><th>Evaluation Perspective</th><th>Contributes to</th></tr>
<tr><td>1</td><td>Formative</td><td>Artificial</td><td>Criteria-based</td><td>Actual effectiveness</td><td>R1 and R2</td></tr>
<tr><td>2</td><td>Formative</td><td>Naturalistic</td><td>Action research</td><td>Perceived usefulness</td><td>R1 and R4</td></tr>
<tr><td>3</td><td>Summative</td><td>Naturalistic</td><td>Case study</td><td>Perceived usefulness
Perceived ease of use</td><td>R1, R2, R3 and R4</td></tr>
<tr><td>4</td><td>Formative</td><td>Naturalistic</td><td>Client feedback</td><td>Actual effectiveness</td><td>R2 and R3</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Formative</td><td rowspan="2">Naturalistic</td><td>Action research</td><td>Perceived usefulness
Perceived ease of use</td><td rowspan="2">R1, R2, R3 and R4</td></tr>
<tr><td>Client feedback</td><td>Actual efficiency</td></tr>
</table>

Table 1. Method evaluation cycles

The methods are designed to improve performance of a task, which can be reached by increasing the efficiency (reducing the inputs of the task) or effectiveness (improving the quality of outputs) (Moody, 2003). We prioritized ensuring the effectiveness of the artefact, i.e. the degree *to which a method achieves its objectives*. As we develop a socio-technical artefact, it should also perform in its real environment, which in this context requires evaluating its perceived usefulness, fit with the organisation, perceived ease of use and comprehensibility. To minimize the costs, we conducted the evaluation cycles in the existing research projects that the method engineers work in. Consequently, we selected the "Human Risk & Effectiveness" evaluation strategy, i.e. formative evaluation methods should be applied in artificial settings, which then should be scaled up rather fast to the more naturalistic settings (Venable *et al.*, 2014). Finally, we planned the individual episodes (cf. Table 1) required to evaluate the artefact as elaborated in the following.

Evaluation 1. The evaluation of eCoMv1 has a formative-artificial character and adopts the criteria-based method. The enterprise modelling experts discussed eCoMv1 and checked whether it fulfils the requirements R1 & R2. We updated the method according to the results, specified the concepts in eCoMv2 and aligned them with the CDD meta-model, added notations to the method. Moreover, we introduced the tools that the method user needs to model the context. We redesigned the levels from eCoMv1 as method components and refined them with steps, activities, input(s), objective(s) and output(s). We conducted workshops with the stakeholders and created the initial skills required to apply the method. Lastly, we proposed initial guidelines for modelling goals and business processes.

Evaluation 2. To gather feedback concerning how the method works in real settings, we applied action research, where the real user (practitioners) also participated to the formative design. Regarding the perceived usefulness and fit with the organisation, initial concerns were raised for a clear separation between scope setting, variability analysis and operationalization of the context model. In this respect, we removed in eCoMv3 the activities related to the analysis of the factors causing variability from the scope setting and enriched the steps for variation point identification. To provide support for operationalization, we added a new MC (cf. MC4 in Figure 2) and integrated an approach for context element classification.

Evaluation 3. We adopted a single case study approach to gather the feedback from the method application in a naturalistic setting. Since the method was evaluated in the course of a master thesis with the participation of everis, the evaluation is rather summative and not ex-post. The company stakeholders involved in the evaluation stated that the method provides an effective solution for analysing a business service's contextual influence and enhances the communication of the contextual influences to the stakeholders of the business service. The method was perceived easy to use and to understand, nevertheless the stakeholders asked for additional guidelines to identify key concepts better. Thus, eCoMv4 provided guidelines to identify i) what constitutes a context element and how to distinguish it from other information objects and ii) variability and variation points in business process models. Moreover, we designed a notation for the context model, and supported it with the CDT.

Evaluation 4. We collected client feedback regarding the perceived usefulness and fit with the organisation. The evaluation results showed that the need for operationalizing the context model rose and the method could not cope with the run-time aspects. Consequently, a new MC was engineered for eCoMv5 that described the way of adding part of the specifications such as preconditions and rules for using the context model during operations (cf. MC5 in Figure 2). Based on the experiences with the use cases, eCoMv5 enriched the guidelines for context identification. Furthermore, it provided different starting points to investigate the contextual factors, namely "goals-based, process-based and concept-based" strategies (España *et al.*, 2015). This added a prerequisite to the method, which is *the availability of the enterprise models*. To address this, eCoMv5 suggested the application of *4EM* (Sandkuhl *et al.*, 2014), a method for enterprise modelling focusing on the objectives of an enterprise.

Evaluation 5. We designed two episodes for the evaluation. In the first episode, the method was evaluated from perspectives of perceived usefulness and perceived ease of use during a collaborative working week with SIV. The results proved that the method fit into the existing enterprise landscape of SIV and helped them to offer context-aware business services. Yet, further refinement of the concepts was required to enhance the comprehensibility and ease of use, new elements should be added to the meta-model to fulfil such requirements. The prerequisite of enterprise models´ availability hindered the method acceptance. eCoMv6 covered this gap and supported the situations, where enterprise knowledge is captured in form of textual specifications and no formal models exist. Moreover, it provided guidelines on how to select the service(s) that should be implemented context-aware, updated the concepts and aligned them with the procedures. The latest method version is illustrated in Figure 2.

In the second episode, we collected client feedback to support the aforementioned findings for the use case described in section 4.2.1. Here, we evaluated the actual efficiency and observed how understanding and modelling of context improved the way of working. The approach taken was to compare the situation of the clearing service before context modelling and the situation after the use of eCoMv5 and implementation of changes resulting from the context model. More concrete, we compared the process of setting up the clearing service for a new client, operating and maintaining it "before" and "after" the eCOMv5 use. Looking from "business value of IT" perspective (Gregor et al., 2006) the new process clearly shows transactional (automation of steps in clearing) and strategic benefits (faster adaptation to new market sectors) compared to the old process. Although these benefits were observed so far in just one case and cannot be fully attributed to eCoMv5, but also to the context models that are developed and implemented with it, they indicate the potential business value of eCoMv5.

All in all, the company stakeholders involved in the project have stated that eCoM improves the flexibility of the business processes. This redounded to new features that were previously not offered by the business services. Moreover, from a cognitive perspective, the modellers felt that having a single model specifying the factors that influence process variability helped them apprehend the dynamicity of the environment and its impact on the business services. As a trade-off, another model had to be maintained. Moreover, if the context model becomes very big, it might become unmanageable, requiring entropy reduction mechanisms (e.g. model partitioning, refinement).

6 Conclusions and Future Work

The enterprises need systematic ways of identifying the business context and modelling them to offer flexible services. Although the contemporary literature provides approaches for context modelling, we found that these are not supported with methods that should meet the requirements described in Section 3.1 (RQ1). The proposed approaches are analysed in section 3.2 and the methods were not found to be sufficient for an immediate use in CDD (RQ2). Following a design science approach, this paper provides a method for developing a context model in the frame of CDD. After setting the scope of its application, the method analyses the variability of a predefined capability and integrates a context model, which represents how business context impacts the capability delivery (RQ3).

The benefits and drawbacks of the method are obtained by evaluating eCoM based on the FEDS approach and applied a variety of methods, such as action research, survey and use case. We compared the results with the industrial requirements (RQ4) and incorporated them in newer method versions. We observed a number of benefits by the method application and to some extent by the implementation of the resulting context models. First, eCoM provided a solution for analysing a business service's contextual influence. This allowed creating standardized contract templates (SIV) and configurable processes (SIV, everis), which both use parameters identified in the context model. Second, the resulting context models increased the rate of automation in the clearing processes and reduced the time and effort for adapting a business service to a new delivery context (SIV). Third, the method enhanced the communication of the contextual influences to the stakeholders of the business service (SIV, everis). The drawbacks concern the perceived ease of use and comprehensibility; initial results indicate the need for improvement in further method versions.

For the method development, we used a modular approach to method engineering and documentation, by dividing the methodology into several method components (R1) (Goldkuhl *et al.*, 1998). The method is well documented and its application satisfied the everis' (service promotion based on the municipality context) and SIV´s (flexible contractual agreement, dynamic case routing) cases effectively and efficiently. Although we identified both use cases as representatives of other companies in their problem setting, no generalized statement of the method's applicability can be made (cf. external validity in Wieringa and Moralı, 2012). Still, we conclude that eCoM is applicable for business cases, where process variability is driven by its context. The trade-off between value added and efforts can be managed by selecting the essential components and steps in eCoM. For instance, while MC 2 consists of mandatory tasks when modelling business context, the steps in MC1 were determined as optional, i.e. dependent on the availability of enterprise models developed in an organisation (R4). The underlying meta-model is aligned with the CaaS Consortium (R2), an integration of the produced context model in business process variability management is provided (R3). Although the bias of the method engineers, who also played a role in validation, cannot be completely eliminated, we minimised this threat by involving other researchers without expectations, as well as industry practitioners.

Future research needs to investigate the interaction with the CDD tool suite, which includes a Context Platform that provides information, a Capability Navigation Application that applies adjustments to resolve variation points, and a Capability Delivery Application that supports the organisational work practice with capability delivery patterns. This environment will surely require the specification of the method components (e.g. for operationalising context, identifying patterns or building a pattern repository). Subsequent versions of eCoM should investigate more detailed cooperation principles without losing the big picture of CDD. Moreover, it should improve the perceived ease of use and comprehensibility. We are going to execute a final evaluation cycle, which should be summative-naturalistic to assure rigour of the method as well as its application in the practice.

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