Capability-based Communication Analysis for Enterprise Modelling

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Abstract. *Capability-oriented enterprise modelling can provide effective solutions to face changing business context. In the business domain, the notion of capability has gained a lot of attention since it guides the activities of service specification and design. Simultaneously, the research community has been promoting the integration of model-driven development (MDD) approaches with enterprise modelling to support the link between enterprise and software specifications. This integration has becoming vital to ensure the traceability of enterprise models and software implementations, acceleration of software time to market, quality assurance, and enterprise model evolution support. The capability-driven development (CDD) method has been recently developed and applied in various industrial use cases. But, the link between the CDD method and strong funded MDD approaches has not been explored. In this paper we explore the integration of the CDD method with the Communication Analysis method (a communication-oriented business process modelling method), which is supported by means of MDD frameworks. Among the advantages to add the communicational perspective to the CDD method, we want to highlight the possibility to offer a high level analysis of business process models that focus on the communications between different organisational actors, as so as to offer further transformation facilities into software components. With this integration, we give the first steps to offer automation facilities to capability-driven environments.*

Keywords. Capability-driven Development • Communication Analysis • Enterprise Modelling • Method Integration Framework • Enterprise Context • Variability Analysis

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1 Introduction

Enterprise modelling can be seen as the process of understanding an enterprise's business and improving its performance through the creation of enterprise models. Capability-oriented enterprise modelling can provide an effective and promising solution to face well-known problems in changing environments, e. g. how select the most convenient enterprise architecture, how to link strategy, context and operation, how to deal with changing business contexts and how to integrate applications designed for different execution contexts that are part of common business processes. Modelling is part of a goal-driven communication process, where analysts decide which aspects of an enterprise are relevant and should be represented in models (Lankhorst 2017). Organisational modelling frequently involves the specification of IT-infrastructure, goals, products, business processes, services, capabilities, as well the relations between them. Different methods, techniques, and tools are needed in order to support the modelling process. In this point, analysts, enterprise

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architects, and organisational modellers play the main role to conduct enterprise modelling projects. In this context, sound integration framework to connect model-driven development (MDD) and enterprise modelling, bring the support for designing conceptual models that captures organisational knowledge and gives the necessary motivation and input for designing information systems.

In a business context, the notion of capability mainly refers to the resources and expertise than an enterprise needs to offer its functions. As pointed out by Zdravkovic et al. (2013), it is a notion that has gained more and more attention in the last years because it encompasses business investment focus, it can be used as a baseline for business planning and leads directly to service specification and design.

While capabilities have been used quite extensively in the context of business architecture, enterprise modelling and enterprise architecture, the link with MDD approaches has not been analysed in a clear and convincing way. Different models are needed to specify a conceptual map to be used for building an integrated business where the relevant different views (i. e., strategy, process, information, organisation. . .) must be properly integrated.

We start from the definition of capability used in the FP7 CaaS project (http://caas-project.eu/definitions/), as 'the ability and capacity that enables an enterprise to achieve a business goal in a certain operational context'. A capability meta-model (CMM) determines the main conceptual primitives that conforms the approach. How to specify the different modelling perspectives that are present in this CMM becomes an essential decision to instantiate it in a particular method. Three main aspects can be used to structure the CMM (see Fig. 1): context, enterprise modelling, reuse, and variability. To have an open architecture, it should be possible to select different modelling proposals to cover those modelling perspectives incorporated in the meta-model. In this paper, we want to develop this open assumption for any associated framework. Our long-term goal is to provide the model-driven organisation (MDO) with capability-based solutions that offers the most accurate pieces for context, enterprise modelling, reuse and variability to be selected according to the modeller's choices.

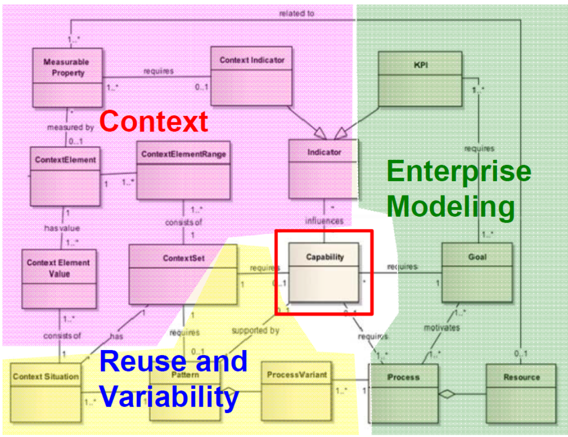

Figure 1: The three main aspects of the Capability Meta Model

We consider that a process is a series of actions that are performed in order to achieve a particular result, supporting goals and consuming resources (see Fig. 1, Capability requires Process). In this way, the notion of process is the most relevant as a starting point for capability design (see the relationship between the different models in Fig. 2). Goals motivate the specification of Business Rules, which trigger the definition of Business Processes. Business Processes produce Concepts that are used for modelling the static aspects of the business, such as, product structures, customer profiles, material as well as information used and produced by the business processes.

In CDD, Concepts are also used for modelling context. All in all, these concept models can be seen as knowledge models of the organisation. Business Processes, Goals, Actors, and Resources require and define the Technical Components and Requirements that are necessary for supporting the knowledge of the organisation. We explore the link between CDD and MDD through the notion of process by focusing on the Enterprise Modelling perspective of the Capability Metamodel. In order to link the CDD and MDD, we use the Communication Analysis (CA) method, which is a communication-oriented business process modelling method that analyses the communicative interaction between the information systems and its environment (España et al. 2009). The CA is integrated in full model-driven development frameworks allowing the automatic generation of software code from requirements models (Pastor et al. 2013). The rationale of selecting CA is that it will allow us to experiment to what extent capabilities can be linked with MDD approaches. In this way, we establish the main goals of this research:

- Integrate a high level analysis of business process into the CDD method by using the CA method. In this way, organisational models will focus on the communications between different organisational actors, as so as to offer further automation facilities to capability-driven environments.
- Give the first steps to establish the link between CDD and MDD. In this way, it is possible to make explicit the traceability between capabilities and software components.

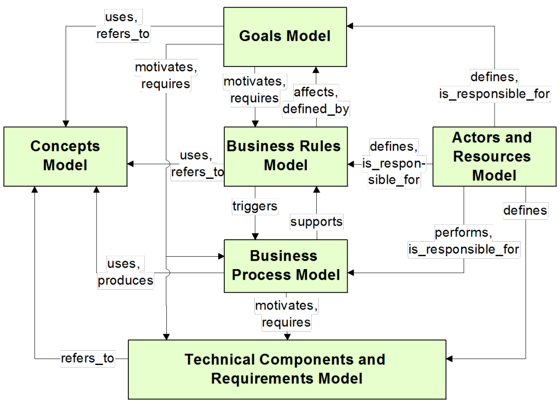

Figure 2: A starting point for capability design in an enterprise modelling scope

We use the Communication Analysis method to describe business processes. The use of Communication Analysis in a CDD environment is one of the major contributions of the paper. With this objective in mind, after this introduction in Sect. 2 we present the CDD method (also referred to as 'the CDD', in this paper) and in Sect. 3 we present the Communication Analysis method components exploring the 'open' aspect of the CDD. In Sect. 4 we will analyse the method component integration of the CDD and the Communication Analysis, in Sect. 5 we presents a laboratory demonstration in which we guide the application of the integrated methods, in Sect. 6 we present the related works, and finally, Sect. 7 discusses advantages and disadvantages of the integrated methods.

2 The CDD method in a nutshell

In ever-changing environments, enterprises need to adjust their products and services to the customer needs, technological trends and regulations. The changes affect both the organisational structures and supporting IT systems, which requires a holistic approach to successfully handle both perspectives. In this respect, the systematic management of the capabilities of an enterprise, which often are reflected in the business services offered to customers and the technical services associated to them, is emerging into a key activity for achieving efficiency. To this end, a FP7 project Capability as a Service (CaaS) develops an integrated approach consisting of a method, tools, and best practices that enable enterprises to sense and take advantage of changes in business context. This section presents the Capability Driven Development (CDD) method.

The CDD method consists of method components; each engineered applying Goldkuhl's method framework and addressing different modelling aspects (Goldkuhl et al. 1998). The purpose with dividing the method into several method components is to make it easy to apply selected parts of the method only. In other words, the modularity allows for the users to focus only on those parts of the method that are needed for their work. Furthermore, the use of method components makes the method extensible. Following Goldkuhl's framework, procedures inform the method users about the actions to be performed as well as its orders. Concepts capture the aspects of reality that are regarded as relevant in the modelling process.

Notation specifies how the result of the procedure should be documented.

To structure the method, the method components have been divided into upper-level method components. Each upper-level component is describing a certain applications area, and contains method components relevant for that area. The upper-level method components are the following:

- Getting Started with CDD. Supports decision-making whether or not the CDD is suitable for an organisation. Furthermore, the required steps to get started with the CDD are described.
- Capability Design Process. Contains an overview on how to design, evaluate, and develop capabilities by using process models, goal models and other types of models.
- Enterprise Modelling. The component contains method components that guide the creation of enterprise models that are used as input for capability design.
- Context modelling. Describes the method components needed for analysing the capability context, and the variations needed to deal with variations.
- Reuse of Capability Design. This component contains guidelines for the elicitation and documentation of patterns for capability design.
- Run-time Delivery Adjustment. Describes the components needed to adjust a capability at runtime.

2.1 Capability Design Process Method Component

As we aim for a capability-based communication analysis method, the Capability Design Process is the most relevant method component to investigate potential mapping and integration of the two methods. Hence, the following introduces the Capability Design Process method component briefly. In the CDD method, capability design is considered as the process of developing organisational designs that can be configured according to the context in which they will be used, i. e. this captures a set of solutions applicable in different business situations. The purpose of this method component is to give an overview of alternative ways to design a capability. Capability is the ability and capacity that enable an enterprise to achieve a business goal in a certain context. Goals are internal means for designing and managing the organisation. 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 and environment, which are represented by the context elements. 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. Last but not least, the delivery of capabilities is supported by adjustments that enables the execution of a process variant based on the values of the context elements and their allowed ranges. The meta-model in Fig. 3 illustrates the relationships between the important concepts of the Capability Design Process method component.

Regarding the procedures, existing enterprise models, e. g. goals models, business process models, concepts models and patterns can be used as input when modelling the capabilities. The CDD differentiates here between three alternative capability design strategies, namely goal-based, process-based, and concept-based pathways. The goal-based strategy has the primary view that capabilities exists as a way to fulfil long-term business objectives of an organisation. The process-based

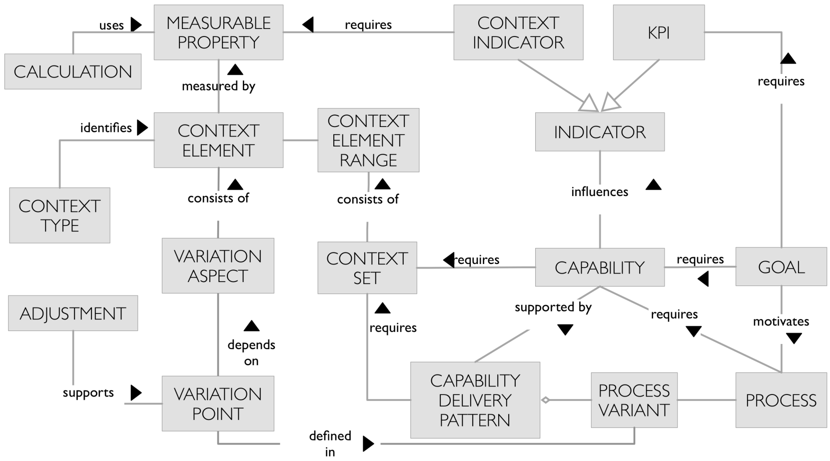

Figure 3: CDD meta-model

pathway proposes that the starting point of the capability design is a process underlying a business service. The business service is further refined and extended by adding context awareness and adaptability, so as to establish a capability that can deliver this service in varying circumstances. Concept-based pathway requires the design of the capabilities by starting with analysing the existing knowledge structures and their relationships with the application context. Details of each strategy can be found in España et al. (2015). The business process orientation of the Communication Analysis method makes the process-based path a natural choice, which denotes that a capability is operationalized as a set of processes (cf. Sect. 5.2). The process-based capability design pathway consists of the four main activities as depicted in Fig. 4 and described in the following.

Define Scope

The organisation offers services based on business processes that are already modelled. In order to design the capabilities by means of business processes the capability designer first selects the service and sets the scope of the capability design. The selection can depend on various factors, such as optimizing the services with high process costs or managing services that frequently change and hence require the adjustment of business processes. Then the abstraction level is determined, at which the processes supporting the business service to be improved are identified.

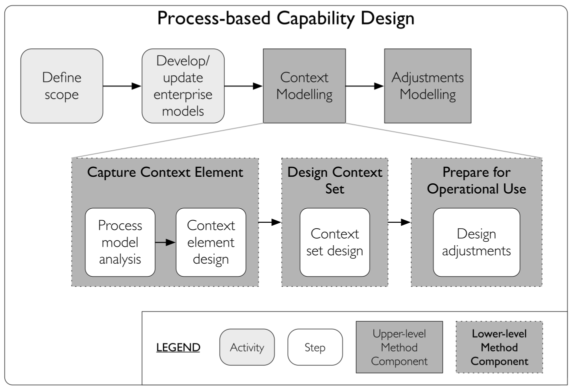

Figure 4: The procedure of the process-based capability design pathway. The particular focus is on Context Modelling upper-level method component, since it defines procedures and provides guidelines to identify variability in business process models

Develop or update enterprise models

This activity analyses whether the selected business process models are up-to-date and applies changes if required. Moreover, the capability should be aligned with the goals that an enterprise aims to achieve. To check if business goals are satisfied during the capability delivery, KPIs are used to measure the achievement of goals. If no goals model is available, then they can be developed based on the guidelines proposed in España et al. (2015). Since an alignment of goals is required on the business service level, method user should rather model the capability related goals and not the enterprise objectives on a general basis.

Context Modelling

A capability is defined by specific business services, a defined application context for these business services and goals of the enterprise to be reached. To cope with the variability issues, the process-based capability design applies the Context Modelling method component to identify and represent the relevant business context. The general purpose of Context Modelling method component is to specify the potential application context where the business service is supposed to be deployed. This specification also has to capture at what points in the process what variation will have to happen. Hence, a context model captures the deployment contexts in which a capability can be used. The Context Modelling Method Component consists of three lower-level method components, which are explained in the following and illustrated in Fig. 4.

Capture Context Element: consisting of two steps, process model analysis and context element design, this method component analyses factors influencing variability in service provision to identify contextual information. Factors are drivers that cause variations in the process models, such as varying expectations of the stakeholders, changing user needs, technology advancements, scheduling constraints, market demands etc. An analysis of such factors helps to design a context element. The method component provides the method user with guidelines to identify variability in business process models.

Design Context Set: links the capability under study to the contextual influences by creating a ‘container’ (a context set), including the permitted ranges of the context elements for capability delivery (context element range).

Prepare for Operational Use: describes the way of adding part of the specifications such as preconditions for using the context model during operations to the context model. This method component is a preparation before the Adjustments Modelling method component, which the calculations and adjustments are documented. Other parts of the specifications are added in Adjustments Modelling method component.

Adjustments Modelling: Capabilities are delivered in ever-changing contextual situations. The purpose of capability delivery adjustments is to alter capability delivery in response to the changing context and delivery performance without the need for redesigning the capability.

3 The Communication Analysis method

The Communication Analysis (CA) is a communication-oriented business process modelling method that analyses the communicative interaction between the information systems and its environment (España et al. 2009). This method is integrated in an MDD environment in order to facilitate automatic software generation from business process models (España 2011). CA consists of various method components addressing different modelling purposes, such as business process modelling from a communicational perspective (Communicative Event Diagrams), structuring of textual requirements and constraints of information systems (Event Specification Template), and specifying of meaningful information that is conveyed in information systems (Message Structures). Figure 5 presents an excerpt of the CA metamodel, the full version can be consulted in España (2011).

By following the method notion of Goldkuhl et al. (1998), we briefly introduce the Communication Analysis method components that are selected for an integration with the CDD: 3.1 Communicative Event Diagrams (CED), 3.2 Event Specification Templates, and 3.3 Message Structures.

3.1 Communicative Event Diagrams method component

The purpose of this method component is to provide a business process modelling technique that adopts a communicational perspective and facilitates the development of an IS that will support those business processes.

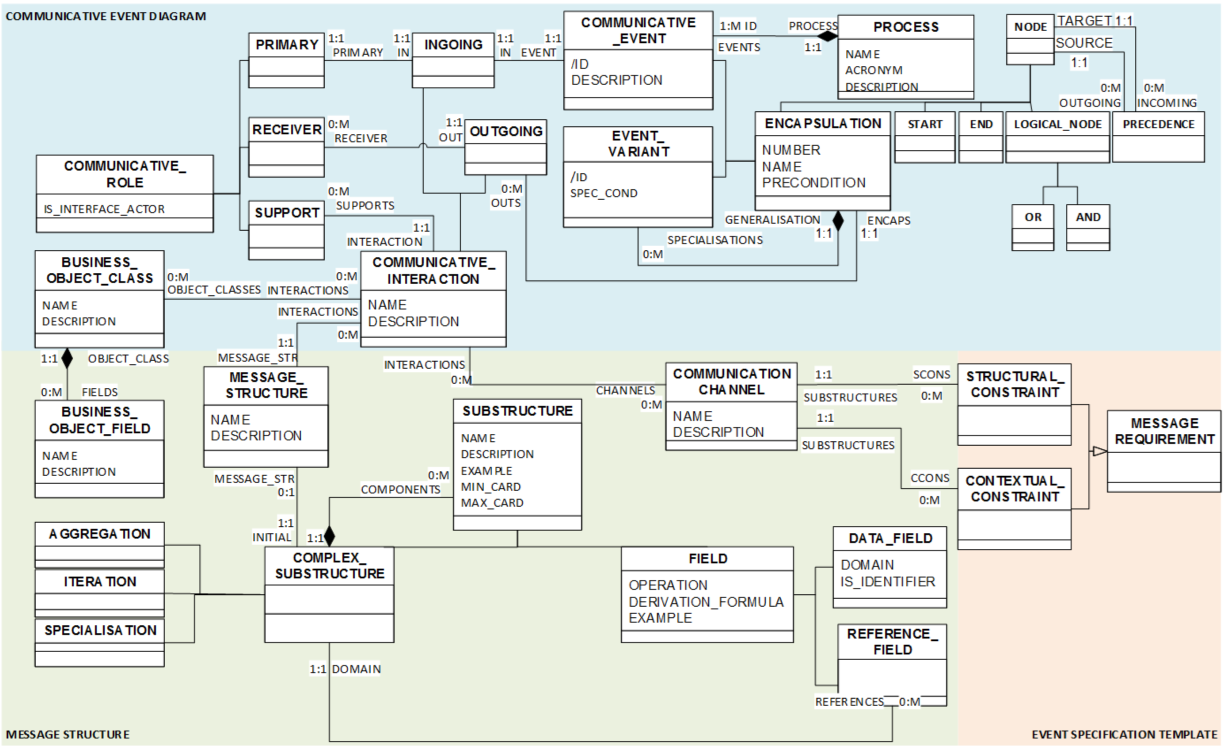

Figure 5: Excerpt of the Communication Analysis metamodel and its method components

The Communicative Event Diagrams (CED) consist of communicative events that are organisational actions triggered as a result of a given change in the world. Communicative events occur in a complete and uninterrupted way (acquisition, storage, processing, retrieval and/or distribution). Communicative events are identified by the norms and guidelines referred as unity criteria (España et al. 2009), which act as modularity guidelines and are presented in the following:

- Trigger responsibility is external. Communicative events occur motivated by an external interaction that determine organisational reactions. Some organisational actor establishes the contact with the information system and triggers the organisational reaction
- Each and every event involves providing new meaningful information. An interaction needs to provide new information in order to be considered an event
- The event triggers information systems reactions as a composition of synchronous activities. Communicative events are carried out in a complete and uninterrupted way, on the occasion of an external stimulus. In this way, events are asynchronous among each other.
- Regarding to the actors of the organisational system. The CED provides support to specify three different types of actors: (i) the actors that trigger the communicative events and provide the input information are identified as primary actors; (ii) the actors who need to be informed of the occurrence of an event are the receiver actors; and (iii) the actors that are in charge of editing and introducing input information are the interface actors.

The relationships from primary actors to the communicative events are categorised as ingoing communicative interactions. Ingoing communicative interactions represents the feeding of information systems memory with new information provided by primary actors. On the contrary, an outgoing communicative interaction represents the checking of the information system memory and distributes known (or derived) facts to receiver actors. In order to indicate the flow of occurrence of communicative events, the precedence relationships are specified among communicative events indicating the sequence flow.

For the CA, the CED notation is not what is important. The criteria for identifying meaningful information (unity criteria) and the concepts on how to analyse information systems from the communicational perspective is what add value to analyse business processes in real world conditions. The concepts for the CED are formalised in the metamodel proposed by España (2011).

The procedure for modelling with CED indicates the input, objective, activities, output, tools, and contributors or participants that are involved in the modelling process. The input for the procedure are existent textual description of information systems, organisational charts, flow chart, glossary of terms, and existing business process models (if any). The objective is to specify a communication-oriented business process model for a particular information system. The activities that are related to the procedure are presented in Fig. 6.

The first activity (see Fig. 6) is to define the scope of the organisational system that is going to be modelled with CED. Later on, the contributors (business analysts and business managers) provide existent textual descriptions of the business process and all the meaningful information for the modelling tasks. Thanks to the unity criteria of the CA method, the events and primary actors are identified. At this point, the main elements of the CED are specified and it is necessary to indicate the flow of information (ingoing and outgoing relationships among events and actors). Finally, precedence relationships need to be established. At the end of the process, the CED is ready for application and its further evolution. The GREAT Modelling tool is an Eclipse-based tool that supports modelling tasks for CED (Rueda et al. 2015).

3.2 Event Specification Templates method component

The Event Specification Template (EST) is a requirements engineering technique of the Communication Analysis method that structures the requirements associated to communicative events (España 2011). Among other requirements, EST contains a description of new and meaningful information that is conveyed to the information system in the event, which is specified using Message Structures (MS) (see Sect. 3.3). For each event, an EST is specified. An EST is composed by a header and three categories of requirements: (i) contact, (ii) message and (iii) reaction requirements. The header contains general information about the communicative event; that is, the event identifier, its name, a narrative description and, optionally, an explanatory diagram. An EST describes the organisational actors conveyed to an event. In the EST the actors that are described are the ones who play the role of primary, support or interface actor.

(i) As part of the contact requirements, in an EST a certain analyst could specify availability requirements and constraints that refer to the degree to which the information system is in a position to engage in the ingoing communicative interaction. In addition, it is possible to specify medium requirements that refer to the technology or paper-based supporting ingoing communicative interaction. Some events involve accreditation requirements (protocols that the organisational system prescribes for each actor participating in the ingoing communicative interaction) that need to be also specified. Finally, the analyst can specify verification requirements that refer to a) ensuring the validity of provided documentation, and b) checking availability of resources.

(ii) Message requirements specify the message communicated from the primary actor to the information system. The Message Structures technique stands for the specification of messages (see Sect. 3.3).

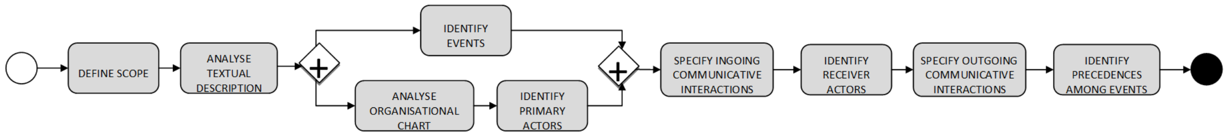

Figure 6: Procedure for modelling with CED

(iii) Reaction requirements describe how the information system reacts to the communicative event occurrence. The common activities of reaction are: update the system memory (record new information and update new one), distribute information to other actors, and treatment of new information. In addition, it is necessary to define the treatments that define what changes occur in the information system as a result of the communicative event (e. g. what processing takes place, what information is stored). Some linked behaviours could be also specified in order to refer to how the occurrence of a communicative event affects future occurrences of events (business rules or complex conditions that determine future reactions depending on the values provided in the current communicative event). Finally, in the ESTs is also necessary to indicate the linked communications that indicates to whom the occurrence of a certain communicative event needs to be informed.

For specifying EST, the contributors (Business analyst, business manager) provides existing textual description of the information system to model, organisational charts, flow charts, glossary of terms, CED, existing business process models (if any), contextual and structural constraints. The former information serves for the specification of the EST for each communicative event. The activities to specify EST are presented in the Fig. 7.

3.3 Message Structures method component

Each group of elements [primary actor, ingoing, communicative event] and [communicative event, outgoing, receiver actor] has one related message structure that describes the information that is provided/consulted. Message Structures (MS) are not graphically represented in the CED; they are specified in the Event Specification Template (González et al. 2011b).

MS are specified by means of substructures that can be fields and complex substructures. A field is a basic informational element of the message that is not composed of other elements. A data field is a field that represents a piece of data with a basic domain. A reference field is a field whose domain is a type of business object. A complex substructure is any substructure that has an internal composition. An aggregation substructure specifies a composition of several substructures. It is represented by angle brackets < >. An iteration substructure specifies a set of repetition of the substructures it contains; it is represented by curly brackets {}.

For specifying MS, the contributors (business analyst, data analyst) provide all the information related to the communications and meaningful information that needs to be stored or modified in the information system. The business forms and textual documentation conveyed to each communicative event serve as input to specify and categorise the message. For each communicative event of a CED, one message structure is specified. Thus, the CED needs to be analysed together with the business forms. For each message structure, it is necessary to identify the complex substructures and it fields. Finally, the message structure is related to each communicative event and it is documented in the corresponding EST (see the procedure in Fig. 8).

4 Integrating the CDD and CA methods

In order to combine the Capability Driven Development and Communication Analysis methods,

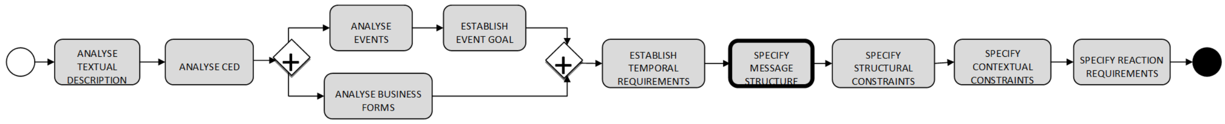

Figure 7: Procedure for modelling with EST

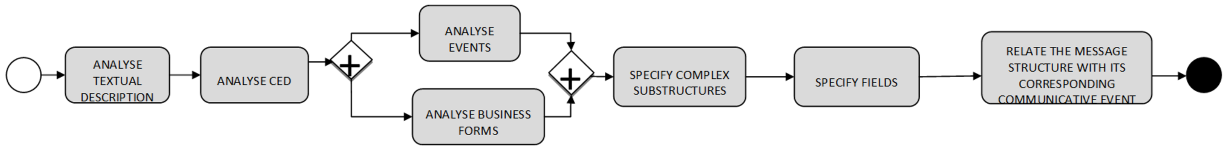

Figure 8: Procedure for modelling with MS

we follow the method integration as a learning process proposed by Goldkuhl et al. (1998), where the CDD and CA are considered method candidates and where the integration should be examined on the method components level. Figure 9 presents how we have operationalised each of its activities to the corresponding sections.

In Sect. 2 and Sect. 3 we have presented the method components of the CDD and CA by following the Goldkuhl's integration method framework. Thanks to this framework, each method component of the CDD and CA have been categorised and presented using the same basis. Mainly, the concepts and notions of the CDD and CA help on the design of the integration strategy. For example, the communication-oriented nature of CA makes a call to use this method as a business process modelling support when using the CDD and CA. In this case, the BPMN proposed by the CDD could be applied or not depending on the demands of the information systems project under analysis (if the information systems need the specification of physical processes and fine-grained details about the business processes, it is necessary to make use of BPMN instead of the high-level granularity of CA). The design about how to integrate both methods are detailed in Sect. 4.1. For a capability-based communication analysis method, the integration points should be defined. The integration points will guide the combined use of both methods. In Sect. 4.2 the integrated method is explained by means of a set of integration points. Finally, the integrated method needs to be applied in order to demonstrate its feasibility and applicability. In Sect. 5 we illustrate the application of the integration points to a laboratory demonstration. As a result, we collect a set of joint practical experiences of the CDD and CA.

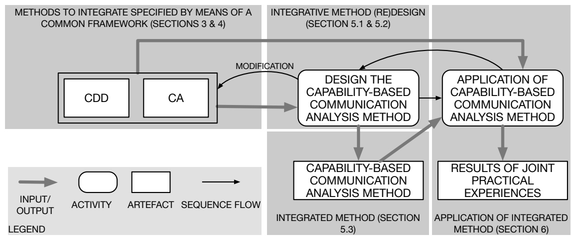

Figure 9: Method integration process of CDD and CA

4.1 Integration strategy

For the integration strategy, we analyse the concepts and the purpose of each method component. In this integration strategy, we focus then in the objective to incorporate the communication-oriented perspective into the CDD method aiming at: (1) bringing CDD to be part of MDD frameworks; (2) demonstrate the adaptability of CDD to new methods; (3) use the communicational event notion as a basic conceptual building unit to specify processes; and (4) enrich the CA with the formalities provided by CDD when modelling goals, variability, capabilities, contextual constraints and measurable properties.

Figure 10 illustrates the method component integration of the CDD and CA. For this integration, the process concept of the enterprise modelling

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method component of the CDD is substituted by the communicative event concept. The message structures will represent the information that is conveyed in the information system under analysis and are properly related with the measurable properties for the context modelling method component. In this approach, the communicative event diagrams will be enriched with its link to goal modelling, capability modelling, variability and contextual modelling. The goal and contextual specifications that are detailed in the EST are now formalised by means of goal models and capability models of the CDD. This analysis of connected and substituted concepts establishes the basis for the identification of connection points that will guide the further combined modelling of the CDD and CA.

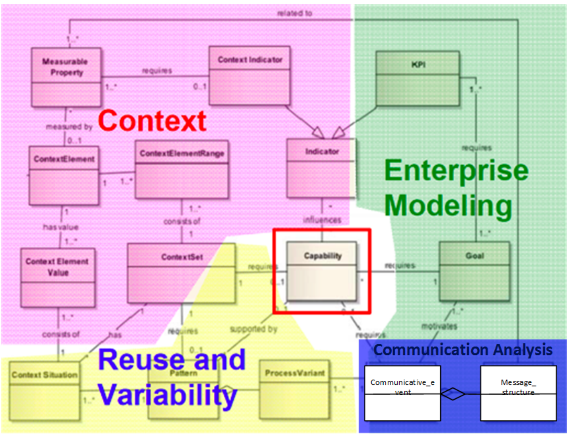

Figure 10: Method integration process of CDD and CA

4.2 Connection points of the CDD and CA method components

For the combined modelling of the CDD and CA methods, we have identified a set of integration or connection points. In the following we present the reasoning of each connection point that will be further exemplified in Sect. 5.

- Connection point 1: The CDD method uses BPMN to specify the business process perspective of information systems. By replacing BPMN with the CED of CA, the business process models in CDD get the communication-oriented nature. The CDD method focused hitherto rather on orchestration aspects to analyse variability. With the integration of CED into the CDD, it is possible to also analyse choreography aspects in the CDD. One important decision to make when using CED is the notation to use. The CED suggests a specific notation for describing communicative events, communications and actors. It is relevant to highlight that notation is not what is important for the CA, the communicative event notion and the basics of unity criteria are the ones that add the communicational 'flavour' to the business process modelling notation in use. For the CDD, it is decision of the analyst to apply the notation of CED or apply a BPMN like communication analysis.
- Connection point 2: The EST does not provide any formal specification for goal modelling. With the integration of CDD and CA, the strategic focus of CDD enrich the CA method. In this way, each communicative event has one or several goals and KPIs that will describe organisational objectives. In previous research we have study the connection between CA and goal-oriented modelling languages by connecting CA with the i* (Ruiz et al. 2014). The nature of i* could bring a complementary agent-oriented perspective to the current goal modelling support of CDD.
- Connection point 3: The event variants of the CED add expressiveness to the current BPMN support in the CDD. Thanks to the event variants it is possible to visualise the variability that is present in each communicative event. Further, the context elements are elicited having into account what are the causes of variability and how to specify each one.
- Connection point 4: The message structures of CED feed the measurable properties of the CDD, where the last ones indicate the possible operations and management of the information related in the information system. On the contrary of the CA method that there is

one message structure for each communicative event, the measurable properties make use of the information present in the information system without having into account to which communicative event is conveyed.

- Connection point 5: For each CED there is one capability model. The contextual information enriches the CA by formalising the contextual structural, reaction, and temporal requirements. With the defined CDD models the analyst can evaluate the need to specify or preserve ESTs.

We recommend to have into consideration each connection point in order to implement the advantages of a capability-based communication analysis method. We conceive further research regarding on how to apply each connection point to different information systems projects as well as how to integrate both methods from other perspectives, e. g. based on a comparison at meta-model level.

5 Laboratory demonstration

To investigate the feasibility of the integration of the two methods, this section illustrates the application of the application of our proposal to the fictional use case client management process. This actual case is an adaptation taken from the SuperStationery Co. case proposed by España et al. (2011).

5.1 Use Case Description

SuperStationery Co. is a company that provides stationery and office material to its clients. The company acts as an intermediary: the company has a catalogue of products that are bought from suppliers and sold to clients. Most clients call the Sales Department, where they are attended by a Salesman. Then the client requests one or several products that are to be sent to one or many destinations. The Salesman takes note of the order. Then the Sales Manager reviews the order and assigns it to one of the many suppliers that work with the company, using his own judgement. An order form is sent by fax to the supplier. The supplier receives the order form and checks whether they have enough stock or not. In case they have enough stock of all the products requested in the client order, they accept the order; otherwise, they reject it. In case the order is rejected, the Sales Manager assigns it to a different supplier (this can happen many times until the order is accepted).

Whenever a client places an order for the first time, the salesman creates a client record. The client can request a premium status, which assures a higher service quality, such as faster delivery and online order tracking. The premium status request can be generated only by the client itself and is received by the accountant, sales manager, and the company director, latter of which decides whether to give the client the premium status. In detail, the accountant gives a recommendation based on the client history, in addition, the accountant collects the quantitative data regarding the client (e. g. total sum of orders, order frequency, profitability). Following that, sales manager makes some recommendations by information the company director about the number of overall sales in a particular time frame, the size of the client´s current order and the number of the clients, which have the premium status. Depending on such information, the company director decides whether to provide the client a premium status.

As the company prospers, the amount of requests increases and, thus, the company needs new solutions to respond to the premium status requests and minimize the communication costs between different roles.

5.2 Integrating CA and CDD

The CA method analyses the interaction between the information systems and its environment from a communicative perspective. CA is a communication-oriented business process modelling method (cf. Sect. 3).

CDD method supports the design of information systems from various perspectives. One perspective concerns the business process orientation, which is termed as process-based capability design and introduced in Sect. 2. In the following, we present how the aforementioned use case can be modelled with both methods and investigate possible interactions and intersections between them.

5.2.1 Modelling with the CA method

For the SuperStationery Co. case, the business process modelling will be supported by means of the communicative event diagrams (CED) of the CA method. For this method component, the most important activities are to define the scope of the case, review existent material, identify communicative events (follow the guidelines presented by the unity criteria in Sect. 3.1), identify organisational actors by means of current organisational charts and human resources files, identification of primary actors and specification of precedence relationships among identified communicative events. The use case description presented above serves as input for modelling the CED, which is presented in Fig. 11 In this CED we present the client management process for the SuperStationery Co. case. The full description of the SuperStationery Co. (including the sales management process) is available at España et al. (2011).

As we mentioned in Sect. 3, each communicative event has its conveyed EST. The EST for this case presents the general information for each communicative event, including the goals, actor description, temporary requirements, and structural and contextual restrictions. In addition, the EST describes the conveyed message structure presenting the communication requirements. For the sake of brevity, Fig. 12 presents the EST for the communicative event CLIE 4. The EST for the rest of the communicative events for the client management process is available at https://goo.gl/nnNxI5.

We identify several points that could serve as potential integration with the CDD models. Mainly, the ESTs describe valuable information that needs to be formally specified. For the goal modelling part, the CDD provides the connection with the enterprise modelling support for strategic and intentional specification. In addition, the variability represented by means of the event variants will be enriched thanks to the variability support from the CDD. The capabilities and contextual information will represent in a formal way all the temporal, structural, and contextual requirements defined by the ESTs. Modelling with the CA method provides mainly the communicational perspective for a high level business process analysis. The CED and MS method components serve to perform the activities for modelling with CA. Having the possibility of combined modelling of CDD and CA opens the possibility to use all the modelling facilities provided by CDD instead to use the template-oriented solution of ESTs. In the discussion and lessons learnt we discuss more about this points and the way ahead of the Communication Analysis and its role in capability-based communication analysis approaches.

5.2.2 Modelling with the CDD method

For modelling the SuperStationery Co. case, we use the process-based capability design method component in the following.

The first activity concerns the scope definition. For this, CDD selects the most appropriate service represented as business process models by investigating the service enhancers. Service enhancers are success factors of business processes, such as time, automation, flexibility, cost (Andersson et al. 2009). For SuperStationary Co. the premium status service is selected. The underlying business process of the premium status service is the client management business process, which is illustrated in Fig. 13. The business process model is current and requires no updates.

Currently, due to its high communication effort between various departments, it is a time-consuming task for the company owner to decide whether a client gets a premium status. SuperStationery Co. envisions to redesign the workflow in order to reduce the communication costs and enable a faster client selection process. The service under study should thus be supported by the 'premium status decision support' capability. In doing so, the information system should provide the relevant client data (context modelling) during run-time, calculate them, and increase the rate of automation in decision-making (adjustment modelling). Moreover, it should be possible to use

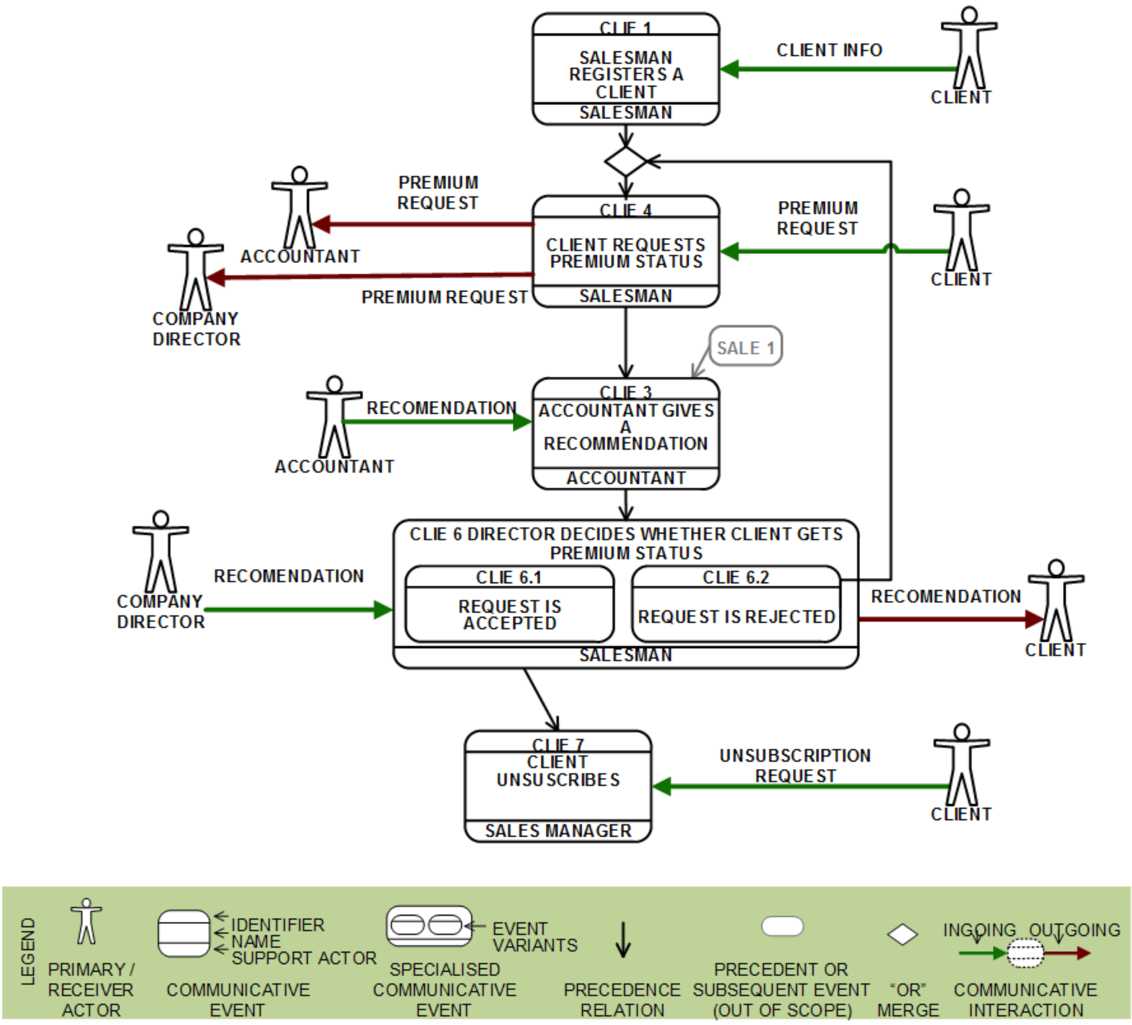

Figure 11: Client management process for the SuperStationery Co.

various parameters for various clients by changing the context models. The relevance of this vision to the enterprise objectives should be reflected in the goals model.

The second activity develops enterprise models or updates them. Although the enterprise objectives are documented, SuperStationery Co. did not specify the organisational goals. In the EST the goal for each communicative is presented but it is not formally specified and related with the rest of organisational goals. CDD method applies 'For Enterprise Modelling' (4EM) method for enterprise modelling in general and goal modelling in particular (Sandkuhl et al. 2014). An excerpt of SuperStationery Co's goal model is illustrated in Fig. 12. Note that opportunities, problems and KPIs are omitted for brevity reasons.

The third activity applies the Context Modelling upper-level method component, which includes three lower-level method components. In the first step, the business process model of the client management process is analysed and the factors causing variability are extracted. A detailed investigation of the extracted factors follows in the second step context element design, where the variability causes are eliminated. For this, a taxonomy is created and a dependency analysis, i. e. weather the factor is represented in the goals model, is

CLIE 4. CLIENT REQUESTS PREMIUM STATUS

1. General information

Goals

The objective of the organisation is to attend the clients when they request premium status.

From the point of view of the information system, the objective of this event is to record the requested status and to let the Accountant and Company Director to know that a new premium requests has been recorded.

Description

Clients can request a premium status; the Salesman is in charge to take note of the requested status. The premium status assures a higher service quality, such as faster delivery and online order tracking. The premium status request can be generated only by the client itself and is received by the accountant, and the company director.

2. Contact requirements

Actor responsibilities

- **Primary actor**: Client
- **Communication channel**: In person, by phone, by fax or email
- **Support actor**: Salesman

Temporal requirements

- **Frequency of occurrence**: 20 new requests per month.

Business forms

Form 1. Example of a premium form

PREMIUM

Premium status information

Premium number: 1017569

Description: In average, Mr. Papiro places 5 orders per month. Since 2022, he has placed 90 orders and had pay during the corresponding payment period. Mr. Papiro is one of our frequent Clients and fulfils the requirements to deserve the premium status.

Assignment date: 25/07/2023

Client information

Client name: John Papiro Jr.

VAT number: 56746763-R

Telephone: 030 81 48 31

Registration date: 20/07/2023

3. Communication requirements

Message structure

FIELD	OP	DOMAIN	EXAMPLE VALUE
PREMIUM=			
< Premium number +	i	number	1017569
Client+	i	Client	John Papiro Jr.
Registration date	i	date	20/07/2023
>			

Field	Description
Premium number	A sequential number that identifies the premium request
Client name	The name and surname of the client
Telephone	Telephone number to contact the client at work
Registration date	The date in which the premium status is created

Structural restrictions

One client can request one premium status.

Contextual restrictions

Clients have associated one premium number.

4. Reaction requirements

Treatments

The premium request information is recorded.

Linked communications

The Accountant and the Company director are informed of the premium request.

Figure 12: EST for the communicative event CLIE 4 of the client management process

performed. Based on their goal influence (strong or weak, cf. figure 14), which is assessed together with relevant stakeholder roles, context elements are elicited.

The CED component in the CA method can provide an alternative for the aforementioned variability analysis guidelines in the CDD. In fact, identifying variability in a CED is expected to be easier than in a process model depicted in BPMN, since the variability is represented with specialized communicative events in the CA-notation explicitly. To investigate its feasibility, the variability causes are analysed in the CED of the client management process. Consequently, the specialized communicative event CLIE 6 Director decides whether the client gets premium status was selected. To extract the factors that cause accepting/ or rejecting the status request, we extensively used the EST method component (cf. 'Process variant analysis' column in figure 14). Figure 14 presents

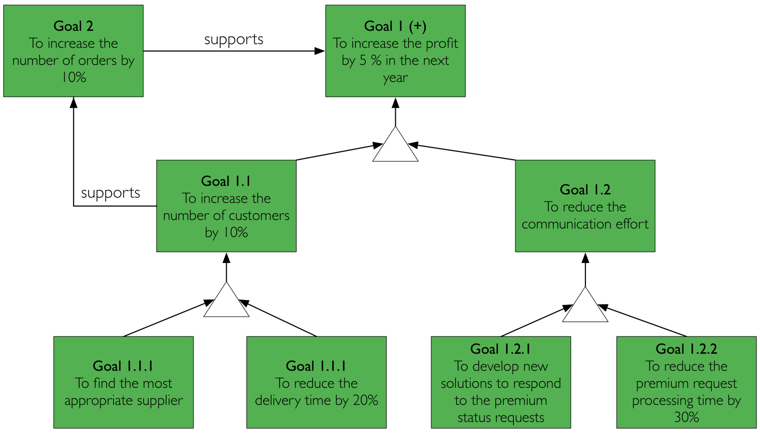

Figure 13: Goal model of SuperStationery Co.

an example of factor and goal fulfillment analysis based on identified communicative events. Based on this, the context elements are sum of client's orders, client order frequency, client profitability, size of the current order (of the customer requesting a premium status) as well as the number of premium clients.[1]

Now that the context elements are extracted, one should determine how the values of context elements are obtained. These are called 'measurable properties'. As a guideline, the CDD method recommends to search for the measurable properties in the factor analysis specification (see Fig. 14), i. e. the factors that have a weak or indirect goal contribution may help to design the measurable properties. Still, it does not guarantee that the factor analysis table contains them all. The message structures in the CA method describe the information that is provided/consulted for the events. The data-oriented aspect of the message structures helps to extend the way of finding measurable properties. Figure 13 illustrates the measurable properties, which are (to a large extent) extracted from the message structures.

[1] On the other hand, the CA method can benefit from the guidelines and procedures to identify variability provided within the lower-level method component 'Capture Context Element', which may be investigated in the future work but left out of the scope for the purposes of this paper.

Measurable properties are not restricted to the information conveyed to each communicative event. The measurable properties make use of the information specified in the message structures for the information system that is under analysis. For example, the measurable property 1 (that calculates the net income from the sales to each client) accesses the information of the all the orders for a certain client. By accessing this information this measurable property consults the data structured by the message structures ORDER – from the communicative event Sale 1 of the sales management process (España et al. 2011) and the CLIENT message structure from the client management process. In summary, the measurable property 1 makes use of the information specified in the information system thanks to the sales and client management processes.

Rather than developing stand-alone context models, the CDD method aims to identify contextual influences in order to capture in what conditions the capability should be delivered. For this purposes, the lower-level method component Design Context Set links the capability under study to the contextual influences by creating a 'container' (context set), including the permitted ranges of the context elements for capability delivery (context element range). Following that, the mathematical operations to define the values of context elements ranges (e. g. Client profitability is high if the value assessed by 'cost of sales/net

Process Variant	Condition	Process variant analysis	Factor	Goal influence
CLIE 6.1 CLIE 6.2	Reject or accept based on the information set	Company director either rejects or accepts the client request based on the provided information. The accountant informs the director about the number of orders, order frequency and profitability of the client. This information is enriched by the sales manager, with the number of overall sales in a particular time frame, the size of the client´s current order and the number of the clients with the premium status	- Total sum of client orders - Client order frequency - Client profitability - Size of the current order - Number of premium clients	Strong (see Goal 1.2 and Goal 2)

Figure 14: Identifying and analysing factors causing variability

income' is higher than 66$. In other cases, the client profitability is low) and the decision logic (e. g. Accept the premium request if the client profitability is high and the client order frequency is often) are documented. In Adjustment Modelling upper-level method component, the calculations and adjustments expressed in natural language or in pseudo notation will be coded either in Java an MathML. Given the fact that CA and CDD are supported by means of Eclipse[2] -based tools (GREAT Process Modeller[3] and CDT[4]), it is possible to specify natural language or pseudo notation that make reference instantiated models. In this way, the traceability between natural language specification and models is ensured.

The overall capability model is shown in Fig. 15. The model covers four main aspects, each of which are numbered on the upper-right frames attached to the models. The premium status decision support capability needs to be aligned with the enterprise objectives, which is represented in goals model. In this respect, CA method can support the CDD method with the applying the EST method component. More concrete, the textual description in the general information section of the ESTs can be a starting point to gather relevant information prior to goal modelling. On the other hand, CA can benefit from the detailed procedures including the relevant stakeholders and guidelines for goal modelling in the CDD method. Furthermore, the tool support in CDD allows to connect business process models with goal models and formally represent enterprise objectives.

The second aspect concerns the factors that influence resolving variability and specifies them in a context model. The context elements show why the variability is needed and the context element ranges allow for a scenario-based, flexible definition of the allowed values for different clients. The CDD method delivers detailed support for variability analysis and context modelling. Still, the information provided in the ESTs and message structures helped to design context elements, measurable properties and context element ranges.

The third aspect incorporated by a capability model is the business process modelling. The support of the CDD method is limited to the services that are modelled from an orchestration point of view and requires following certain procedures to distinguish a standard gateway from a gateway, which is resolved based on runtime context, or variation points. The example showed that CA method extends the capabilities of the CDD method by allowing for the variability identification also from a choreographic aspect. The specialized communicative events in CEDs show exactly, which variations happen during service provision. Additional investigation to distinguish

[2] http://www.eclipse.org/
[3] http://www.pros.webs.upv.es/great/
[4] http://caas-project.eu/tool-support/

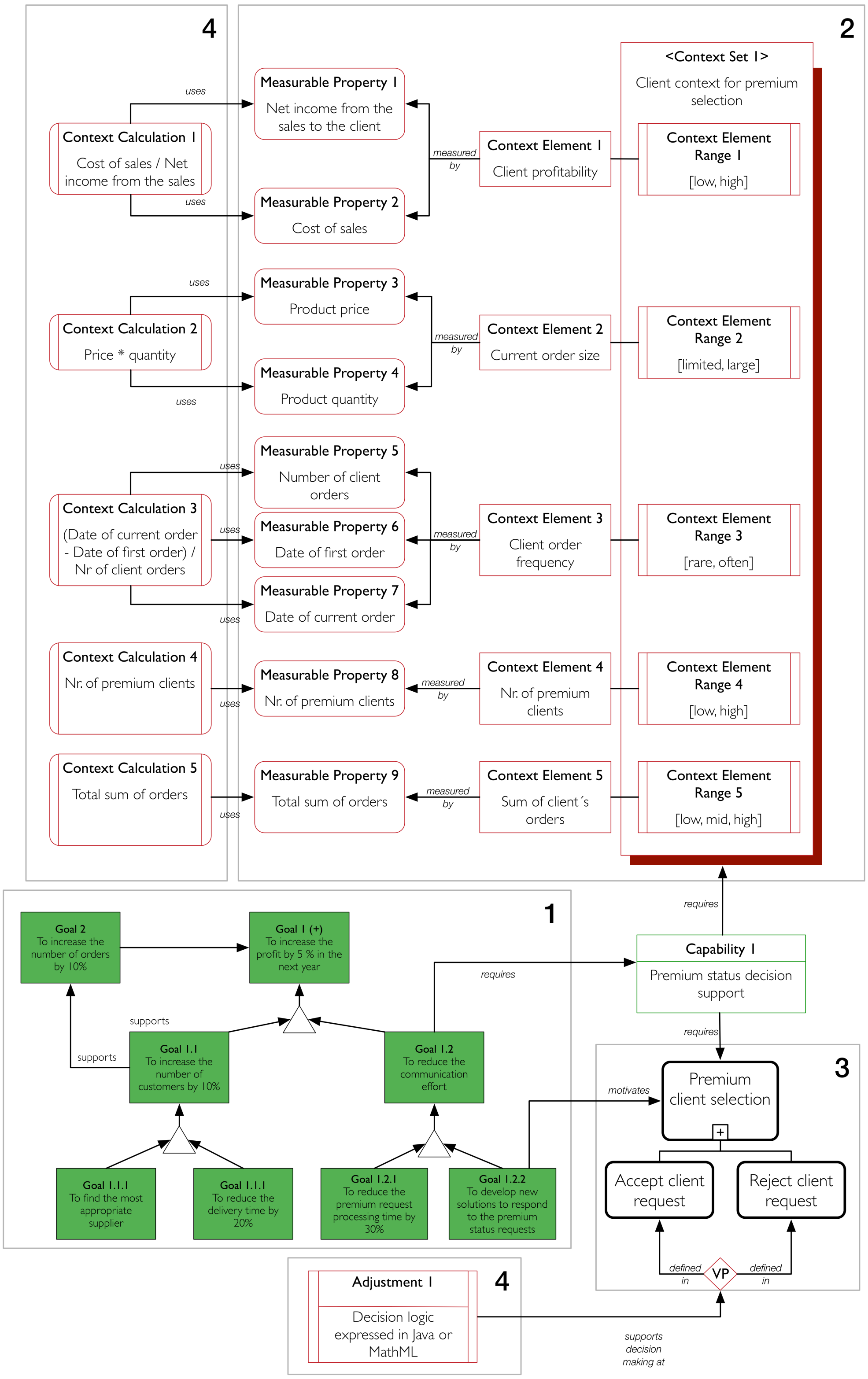

Figure 15: Capability model of the use case, including the goal (1), context (2), process (3) and adjustment (4) perspectives

the standard gateways from the variation points, as it may be in the CDD method, are not required.

The last aspect represents the business logic in form of adjustments and calculations. The calculations are operations that define the context element values at runtime. They operate on the data gathered by enterprise information systems (e. g. product price, number of client orders etc.). The adjustments incorporate the decision logic and they help to increase the automation rate, which could reduce the premium request processing time. Although yet not extensively analysed, message structures in the CA method may support the CDD to point out the domains, from which the raw data can be gathered for further calculations.

6 Related works

Capability is a term usually associated to the enterprise management landscape as a main source of profitability. Several works in the management area have highlighted the importance of understanding and support the organisational capabilities of an enterprise. For instance, Stalk et al. (1992), highlight that capabilities enable the competition between companies and are essential for the business success and market differentiation. These ideas are also supported by Porter (1985), which interprets capabilities as the main driver for competitive advantage. Because of their importance, several works have included this concept as key element in their business value models. Some examples are the modelling value proposition defined by Osterwalder and Pigneur (2003) or the decision models proposed by de Kinderen et al. (2009). However, none of these works, present a systematic approach on how introduce capabilities in IS models to guide the development of software to enable them. Hence, capabilities are defined at the strategic level rather than operational level.

According to Chen and Tsou (2012), the success of a business model requires to link its capabilities to a set of IT services to fulfil them. However, it should be taken into account that capabilities are affected from changes in the business context, e. g., new law regulations, customer policies or hardware infrastructure performance. In other word, capabilities should be dynamic (Koç 2014) as companies currently are working in highly volatile and changing environments. Therefore, is critical to take into account the context for adjusting quickly both the business processes and the underlying IT services.

Model-driven development and Enterprise Modelling are two promising disciplines to deal with this scenario, in which several concerns (goals at a strategic level, business context and process variability at an operational level) should be simultaneously addressed. Several works support this working line. For instance, Uhl (2008) presents some successful experience of model-driven development in the organisational level whereas (Zikra et al. 2011), highlight the benefits of bringing Enterprise Modelling closer to MDD. In the same reasoning line, several works have introduced concepts closer to the capability notion in model-based methods. Sandkuhl et al. (2014) developed the 4EM method based in their real experiences applying Enterprise Modelling in practical scenarios. Quartel et al. (2009) present a goal requirements modelling language aligned with Archimate, a popular enterprise modelling tool, to apply best practices from requirements engineering in this context. Frank (2014) presents MEMO, a multi-perspective method which enables using a set of domain-specific languages the development of method support environment. Finally, in the field of enterprise architecture and organisational management, Lankhorst (2017) presents a capability map viewpoint to visualise the maturity level of organisational capabilities. This approach supports capability specifications by means of forms. A downside of this approach is the lack of traceability support to the other enterprise architecture viewpoints (process, actors, functions, infrastructure, etc.).

These methods provide sound foundations about the usefulness of enterprise modelling to tackle with the organisational/strategic goals, but they lack of the context adaptation concern. As systematic literature performed by Koç et al. (2014) about context modelling and capability modelling methods, there is still no common or accepted modelling language to address this problem (Koç 2015). Additionally, they usually do not address the development of the underlying IT services.

To overcome the aforementioned issues, the Capability-driven development method provide an approach in which capabilities and context are core components (Bērziša et al. 2015). This method not only provides a set of methodological components but also a set of tools to align capabilities with current operational services. However, the current version of the CDD still lacks from high-level organisational models closer to the strategic management. Also there is no MDD approach to support the transformation process of capability models into the underlying operational models. The latter has been previously considered by authors taking into account the transition from goal models (Ruiz et al. 2014) and Communication Analysis models (González et al. 2011a). We strongly believe that the CDD could benefit from those ideas to provide a more suitable method for strategic IS development.

To sum up, even several works have addressed the capability concept from an organisational point of view, only the CDD method provides an operational solution aligned with the development of IT services. However, there is still room for improving this novel method including models to address a high level of abstraction. This work addresses that gap by proposing the integration of the CDD with Communication analysis models.

7 Discussion and lessons learnt

In this paper, we have presented an explorative effort to integrate the Communication Analysis method and the Capability-driven Development method. We have various drivers that motivate us to conduct this research, among them we want to highlight the following:

- To demonstrate the feasibility of the CDD method to be integrated into MDD frameworks.
- Bring together enterprise modelling techniques to MDD frameworks.
- Enrich the CDD method by adding the possibility to automate the software components generation.
- Adaptation of the CDD method into organisational systems by adding the high-level analysis support of the CA method.
- Introduce into the CA a formal support for goal, capability, variability, and contextual modelling.
- The communication analysis business process modelling perspective gives to the CDD method a fresh and organisational-oriented information system analysis support. We preview stronger and robust application of CDD in industry where the focus of business process is on the communications and organisational actors.
- The CED notation facilitates the variability point's specification of CDD. In addition, the event variants of CED get enriched with their connection to formal contextual specifications that inform when each event variant or variation point take place.
- The message structure method components bring the guidance on how to clearly capture and specify meaningful information of information systems. The message structures are connected to the measurable properties that will inform about potential context changes to be performed.

We have integrated both methods thanks to the method integration framework of Goldkuhl et al. (1998). The method integration framework gave us the basis for identifying the potential method components to integrate. In addition, we took as basis for the integration strategy the explanation of both method concepts and the purpose. In this way, we have as objective to keep the best of both methods that are complement between each other.

As a result of the integration strategy application, we have identified a set of connection points that help on the combined modelling of both methods. We have discovered that the CA is enriched when is used in parallel with the CDD method. Mainly, we found that it is possible to avoid the use of the event specification templates, because the CDD provides all the formal models for the specification of goals and contextual requirements. On the other hand, the CDD gets more powerful when applying the communication-oriented perspective of CA for analysing variability and measurable properties.

When applying the communicative event diagrams (CED) of CA, it is possible to use the notation that is provided by the CED, or use BPMN for the business modelling activities but applying the unity criteria. It is decision of the analyst to use one notation or another, what is important is to have into account the unity criteria when specifying business models. One drawback of not using the CED is the lack of variability support of BPMN. There is a trade-off analysis that need to be performed in order to evaluate if it is affordable to change the notation. We want to perform further experiments in which different industrial users can give us feedback about their perceptions when they need to implement a new method and how is the impact because of notations' change.

The integration of CDD and CA needs to be evaluated. Given the lack of literature reporting the integration of capabilities into MDD environments, it is necessary to analyse different cases where CDD and CA are applied. For the near future, we plan to conduct case studies where the integrated approach is applied. As a result, it is expected to establish a theory that will serve as a basis for specifying the requirements that an integrated approach for CDD and CA must fulfil.

Since the integrated approach depicts a typical forward process from requirements (capability models, communication analysis models, goal models, etc.) to code, it is necessary to evaluate the role of the analyst and his/her implication in the development process. The current paper presents a MDD approach that reduces human participation but it doesn't intent to provide full automatic support from requirements to code. The complexity of software generation is rarely supported by automatic top-down approaches, that requires constant reengineering and adaptation. For complex tasks like reengineering and evolution, model-based solutions that involve human intervention for modelling design seems to be more adequate than automatic specifications. To take full-advantage of current MDD solutions for information systems evolution and maintenance, round-trip engineering needs to be tackled. Model-based engineering (MBE) solutions for round-trip engineering seems to be a feasible approach to take the most out of MDD when evolving information systems (Grau et al. 2005).

The potential end-users of the integrated approach might be capable to apply the CDD and CA methods. In this way, training and reference solutions describing the integrated use should be provided. It is expected that enterprise architects, business analysts, and requirements engineers can make use of the integrated methods in order to evolve and specify information systems for model-driven organisations.

Regarding to the laboratory demonstration, we showcased the feasibility to conduct the application of our proposed capability-based communication analysis method. We want to apply this concept with our industrial partners in order to evaluate the advantages and disadvantages of our proposal. As future work, we plan to carry out a set of comparative experiments where the performance and perceptions of end-users is evaluated. For this, we want to measure the efficiency, validity, and usability perceptions.

From the point of view of the CA method, this research open new lines of research in which the connection of the CED and BPMN need to be further evaluated and investigated. Currently, analysts can make use of the CED notation or BPMN when applying the CA method. When using the BPMN, it is necessary to follow the unity criteria described in Sect. 3. Since BPMN is widely accepted in industrial contexts, it is an interesting line of research to propose guidelines for the use of BPMN when applying CA.

The current connection of CA models with goal models need to be revisited in order to improve the processes and goal modelling combined specifications. A positive point to highlight is the integration of the CA method within contextual modelling supports. The steps performed in the current research open the door to make further investigation in the line of runtime communication analysis and model adjustment.

From the point of view of the CDD method and the CaaS project, this research demonstrates the adaptability of the CDD to be incorporated in different frameworks and MDD environments. This research demonstrates the huge potential of the CDD to be a strong-founded method with industrial acceptation. We plan to perform action research protocols and case study projects in order to analyse and categorise CDD-related projects in which the capability-based communication analysis is appropriated. Since this research focuses on the specification of the connection points between CDD and CA, we plan to investigate the need for providing transformation rules from capabilities to code. For this research, case studies are going to be conducted for identifying potential gaps between capability models and code. For the near future we are going to continue exploring the configurability nature of the CDD to provide project-adapted solutions for the required real world needs.

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