

Model-driven Service Engineering in Home Telecare

Christian Flender, Michael Rosemann

Faculty of Information Technology, Queensland University of Technology, Brisbane, Qld, Australia

Health care systems are highly dynamic not just due to developments and innovations in diagnosis and treatments, but also by virtue of emerging management techniques supported by modern information and communication technology. A multitude of stakeholders such as patients, nurses, general practitioners or social carers can be integrated by modeling complex interactions necessary for managing the provision and consumption of health care services. Furthermore, it is the availability of Service-oriented Architecture (SOA) that supports those integration efforts by enabling the flexible and reusable composition of autonomous, loosely-coupled and web-enabled software components. However, there is still the gap between SOA and predominantly business-oriented perspectives (e.g. business process models). The alignment of both views is crucial not just for the guided development of SOA but also for the sustainable evolution of holistic enterprise architectures. In this paper, we combine the Semantic Object Model (SOM) and the Business Process Modelling Notation (BPMN) towards a model-driven approach to service engineering. By addressing a business system in Home Telecare and deriving a business process model, which can eventually be controlled and executed by machines; in particular by composed web services, the full potential of a process-centric SOA is exploited.

Keywords: Business Process Management, Service-oriented Architecture, Enterprise Architecture, Home Telecare

1. Introduction

In post-industrial societies Home Telecare is gaining more and more importance due to the increasing number of elderly people. A major goal of Home Telecare is to provide services enabling older people to live in their own homes in comfort and safety and in the best possible health, for as long as they wish to do so [1]. In terms of service quality and costs, Home Telecare is facing challenges due to many different stakeholders (e.g. patients, general practitioners, nurses or relatives) and the heterogeneity of existing Information and Communication Technology (ICT), which holds encouraging potentials for inter-stakeholder process control and automation [2]. In order to design innovative and flexible business models facilitating high-quality and low-

cost services for the increasing number of elderly people, service-oriented methodologies for the design and implementation of viable enterprises are of utmost importance. In line with designing and implementing viable enterprises, process orientation continues to receive significant attention as a top priority, and building business process improvement capabilities is seen as a major challenge by senior executives in many companies [3]. One of the most prevalent improvement capabilities is the support of organisational processes with underlying application systems (so called process-aware information systems), for example application systems for process control and execution [4]. By conceptually describing a process from different and complementary perspectives (e.g. from a control and data flow perspec-

tive) using a business process modelling language like BPMN [5], the deployment of the resulting process description into an execution environment facilitates automatic process enactment and control and thus decreases human interventions. Additionally, Service-oriented Architecture (SOA) provides the necessary application system infrastructure by allowing for the composition of loosely-coupled and distributed components (i.e. services) accessible through widely-used internet protocols and standards like HTTP and XML [6]. By defining an executable process in the course of identification of services, either to be consumed or to be provided, a linkage between both a business process model and its application system components can be established. Furthermore, flexibility in terms of reuse and composition

of services is maximised and processes can be defined beyond organisational borders by integrating the services of a wide scale of different stakeholders such as customers and suppliers. Although scholarly work related to BPM and SOA has been extensively conducted during the last years, a complete and holistic approach to business system engineering incorporating sound and theoretical foundations as well as prevalent standards like BPMN and the Business Process Execution Language (BPEL) is still missing.

BPMN is a graphical and informal notation targeted at analysts, while BPEL is a textual and executable language targeted at application system developers [7]. BPMN seems to have become the state-of-the-art business process modelling language [5] and a number of tools providing a BPMN to BPEL transformation already exist, e.g. Intalio (<http://www.intalio.com>). Despite of the acceptance of BPMN, there is no approach combining process and service paradigms from the top starting with the definition, analysis and decomposition of high-level tasks until eventually, based on an underlying SOA, a derived business process model is executed.

In this paper, we aim at closing the gap between the development of new and innovative electronic business models and SOA as a promising technological enabler for the design and implementation of future enterprise architectures. Therefore, we proceed as follows. In the next section, we discuss the notion of enterprise architecture capturing a whole business system as a complete and holistic model. Based on a general architectural understanding, we introduce the Semantic Object Model (SOM), which provides an enterprise architecture including guidelines for process and service decomposition. Furthermore, we integrate BPMN and SOM, so that we are able to exemplify the service-oriented design of an entire enterprise architecture in Home Telecare by means of a scenario of high relevance with respect to an increasingly ageing population.

2. Background and Related Work

In general terms, architecture provides an integrated view of a system being designed or studied. At the level of an entire business system it is commonly referred to as an “enterprise architecture” [8]. A widely applied definition of an architecture is given by IEEE (1471-2000): “Architecture is the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principle guiding its design and evolution” [9]. Hence, architecture is understood as a process defined by guiding principles as well as a product described in terms of components and relationships. Besides guiding principles for model construction, architectures are often organised as multi-dimensional frameworks defining components and relationships as interrelated dimensions. For instance, dimensions could represent information types (e.g. process or technology), scope (e.g. industry sector, organisation or domain), stakeholder (e.g. client, end-user or developer) or meta levels (e.g. instance, model or meta model).

The number of existing architectural frameworks and their dimensional variety and diversity mostly emerged from different contextual situations and originated from diverse goals. Greefhorst et al. (2006) analysed twenty three state-of-the-art architectural frameworks and identified a base of description elements including nine base dimensions [10]. Amongst others, examples of architectural frameworks in information systems are the Zachmann Framework, the Open Group Architecture Framework (TOGAF), the Architecture for Integrated Information Systems (ARIS), the Process Method (PROMET) or the Semantic Object Model (SOM). The Zachmann Framework [11] covers two dimensions, one describing the information type (data, function, network, people, time and motivation) and one specifying perspectives that complement each type by facilitating different viewpoints (contextual, conceptual, logical, physical, imple-

mentation and out-of-context). Similarly, TOGAF [12] covers two dimensions, one describing the domain (business, data, applications and technology) and one capturing the architecture continuum (foundation, common systems, industry and organisation). ARIS [13] mainly consists of five views of enterprises (organisation, data, control, function and output) and three descriptive levels within each view according to their proximity to information technology (requirements definition, design specification and implementation description). In line with process engineering, PROMET [14] specifies three horizontal dimensions (organisation, data and function) aligned with three vertical dimensions (strategy, process and information system). Many other existing frameworks comprise more or less appropriate dimensions depending on a specific contextual situation (e.g. focussing on business or technology).

Irrespective of context and specific dimension, Sinz (1997) defined a generic architectural framework providing a tool for analysing and building complete and holistic enterprise architectures [15]. A generic architecture divides a concrete architecture into several model layers according to a corresponding meta model. Convenient views are defined for each layer. Design patterns, modelling rules and heuristic knowledge are applicable to each layer. Relationship patterns and transformation rules may be provided to support the connection of different model layers. The backbone of SOM is an enterprise architecture based on the generic architectural framework. SOM is both an object-oriented and process-oriented approach developed for business system analysis and design [16]. Its enterprise architecture allows for the division of a complex model into the layers enterprise plan, business process model, and resources, each of them describing a complete business system at a different level of abstraction. Two complementary views of business systems, namely system structure and behaviour, allow for a complete description of each of the

three model layers. By adopting BPMN to the enterprise architecture of SOM, in the following, we come up with a sound methodology adapted to the needs of new and innovative electronic business models.

3. Model-driven Service Engineering

In this section, SOM and BPMN are introduced and integrated within an enterprise architecture. On the basis of a generic architectural framework, an enterprise architecture completely and holistically describes an organisation by means of three layers, the enterprise plan, the business process model and the resource layer [16]. Starting with the global task of the enterprise layer, through process and service decomposition in the business process layer, a flat and execution-ready BPMN model is derived. The BPMN model is the glue to distributed, loosely coupled and web-enabled components in the resource layer.

3.1. Enterprise Architecture

In line with using SOM, the organisation to be modelled is perceived and conceived as a multi-layered system from a structural perspective (e.g. business objects and relations

between business objects) and a behavioural perspective (e.g. tasks and transitions between tasks). Within each layer of the enterprise architecture a system is completely described in terms of structure and behaviour at a certain level of abstraction. Each layer describes a whole business system in a complementary manner from a different perspective (cf. Figure 1). For example, the business process model captures a whole business system in terms of coordinated business objects (structure) and their flow of tasks (behaviour). The resource layer describes actors (either machines or humans) assigned to and carrying out these tasks previously defined and composed in the upper layer.

3.2. Enterprise Plan

The enterprise plan describes the global task and main purpose of a business system (e.g. produce product x , provide service y) from an outside perspective. Requirements for resources, either personnel or application systems, are derived from the global task and have to meet the capabilities of available resources (e.g. existing ERP system, staff members). Both parts, global task and resources, are determined mutually. Furthermore, the global task is related to strategies (e.g. market, product and finance strategies) and implements

main goals and objectives. Based on the global task, the business process model is derived through process and service decomposition in the layer beneath.

3.3. Business Process Model

The business process model constitutes an inside view of a business system and implements its global task specified in the enterprise plan [16]. It specifies main and service processes. Main processes contribute directly to the goals of the business system (e.g. operations). Service processes (e.g. procurement) provide their outcome to other main or service processes. In SOM, a process model is a set of distributed and autonomous business objects, which cooperate in pursuing joint goals. In line with their cooperation business objects produce and deliver services (services are either physical or informational products). Furthermore, business objects coordinate behaviour by carrying out tasks associated with the exchange of services via transactions. By using SOM, the cooperation of business objects is represented by two complementary views of a system. The Interaction Schema (IAS) describes a system from a structural view and the Task-Event Schema (TES) represents a process from a behavioural view. The latter schema captures the flow of tasks within the same business object or between different objects, whereas IAS describes the coordination of business objects within the scope of production and delivery of services.

Figure 2 shows both schemas IAS and TES and exemplifies associated coordination principles revealed by decomposing business objects and transactions. Transactions facilitate the exchange of services, e.g. materials (physical) or messages (informational). The IAS on top in Figure 2 illustrates the structural relationship between “Server Object” and “Client Object”. Both objects coordinate the exchange of services via transactions according to the negotiation principle (non-hierarchical coordination). Beside a non-hierarchical negotiation, the feedback control principle facilitates

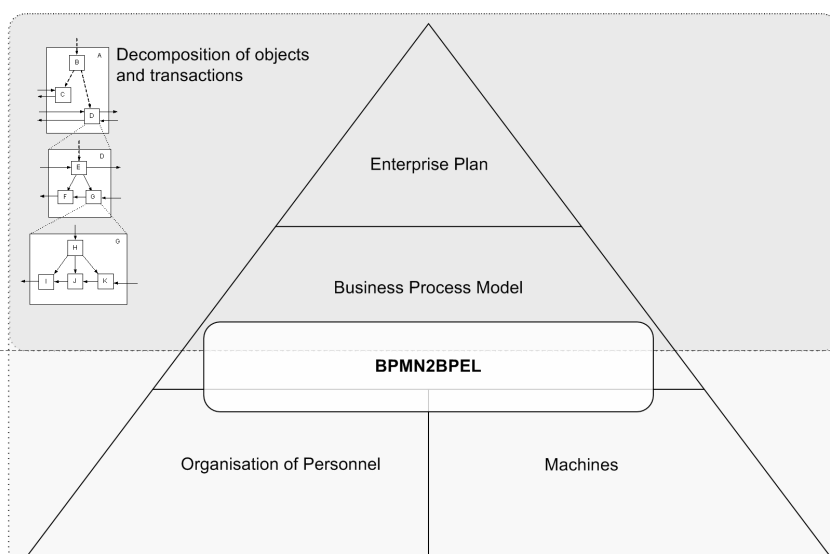


Figure 1: SOM Enterprise Architecture adapted from Ferstl et al. (1997)

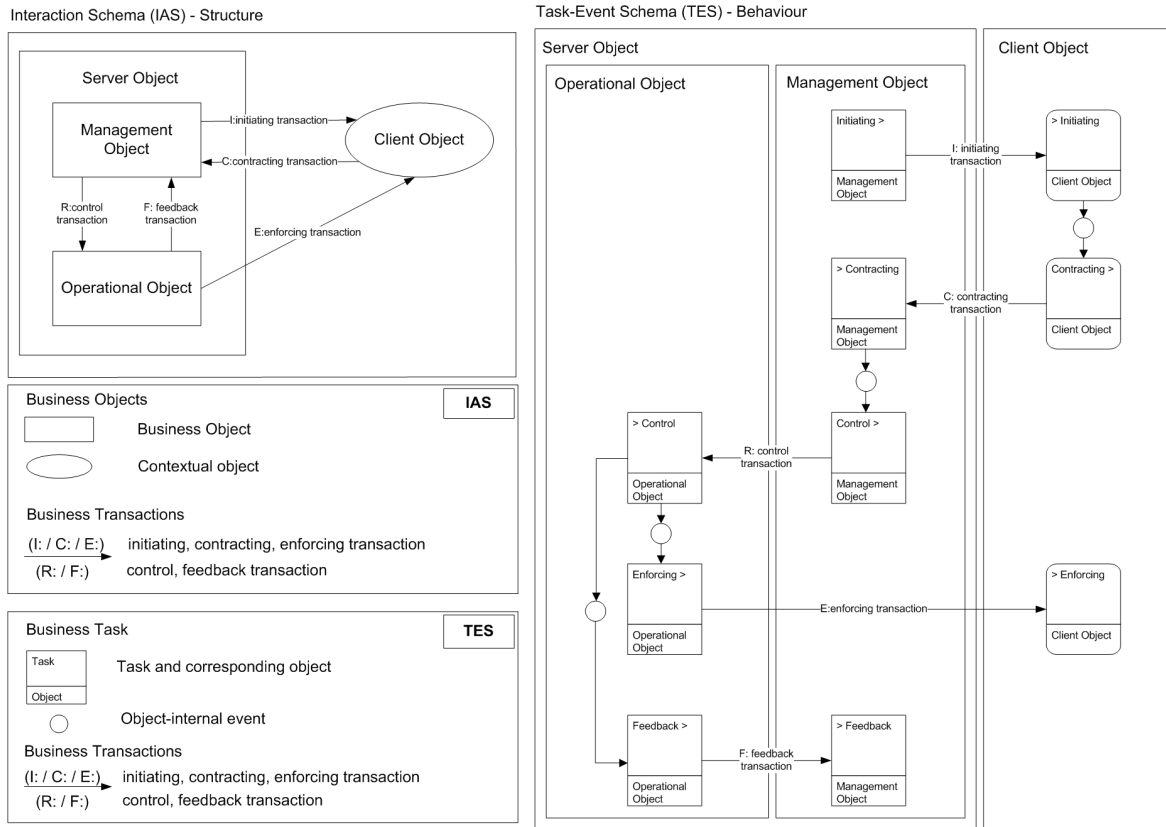


Figure 2: IAS and TES

a hierarchical coordination of business objects (cf. “Management Object” and “Operational Object” in Figure 2). An overview of the coordination principles and corresponding transactions is provided in Table 1.

Once the structure of a business process model is revealed, the behav-

our can easily be derived by transforming IAS to TES. Each transaction, irrespective of coordination principle, is performed by exactly two tasks of different objects. Tasks within the same object are connected by object-internal events. For example, the hierarchical coordination

between “Management Object” and “Operational Object” as shown by the IAS in Figure 2 was transformed to the behavioural view (TES). The task names in the TES are derived from the name of the transaction. Here, the task “Control >” (say “send control message”) of “Management

Coordination Principle	Transaction	Description	Examples
Negotiation (non-hierarchical)	Initiating I	Objects get to know each other and exchange information on deliverable services	Offer, Advertisement
Negotiation (non-hierarchical)	Contracting C	Objects agree to a contract on the delivery of services	Order, Agreement
Negotiation (non-hierarchical)	Enforcing E	Objects exchange services as agreed upon	Material, Message
Feedback control (hierarchical)	Control R	Management object prescribes objectives or sends control messages to the operational object	Advice, Goal, Objective
Feedback control (hierarchical)	Feedback F	Operational object reports to the management object	Report, Confirmation

Table 1: Coordination Principles

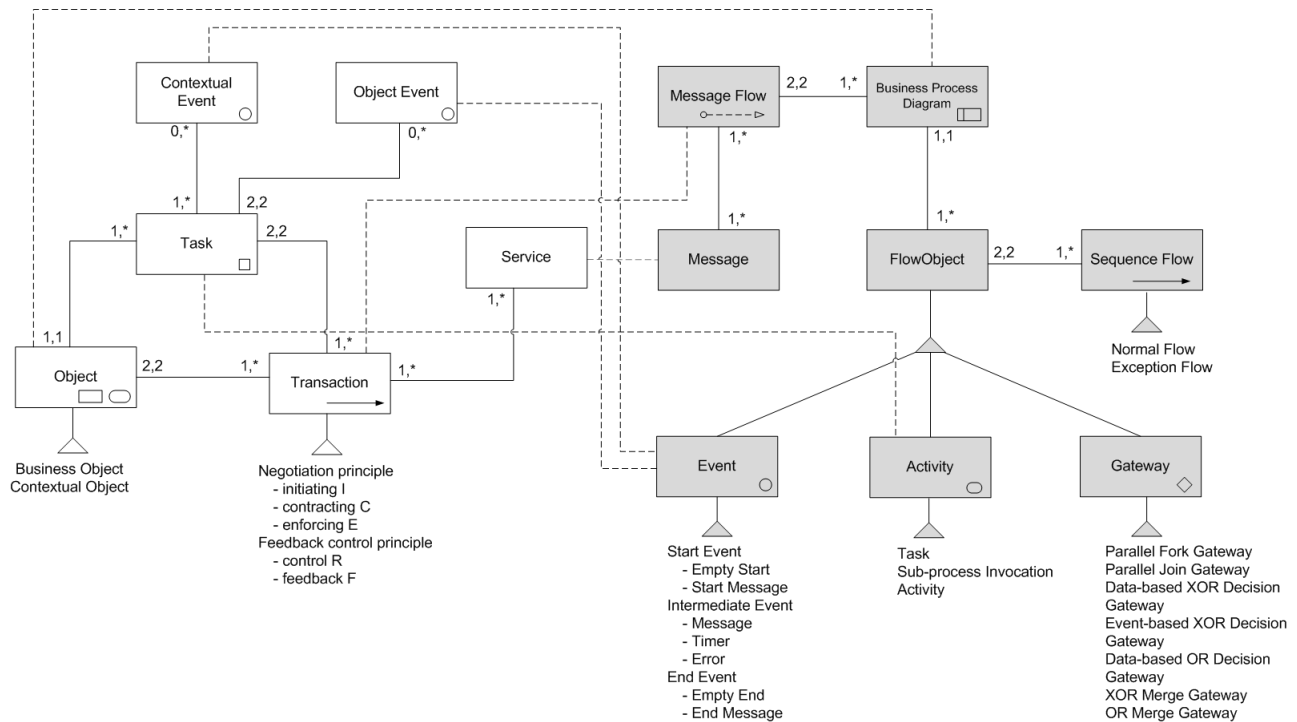


Figure 3: Integrated Meta Model of SOM and BPMN

Object” regulates “Operational Object” by sending a message to the task “> Control” (say “receive control message”). The transition within “Operational Object” is visualised by an object-internal event between its receiving task “> Control” and its sending task “Feedback >”. The decomposition of objects and transactions according to the introduced coordination principles facilitates the deduction of a flat process. If the control and message flow of a decomposed system satisfies previously defined modelling goals and objectives, BPMN and BPEL come into play. In comparison to BPMN, BPEL code is meant to be totally hidden from process modellers designing an enterprise architecture. Therefore, a further discussion of BPEL is outside of the scope of this paper. Ouyang et al. (2006) present a formal mapping of BPMN onto BPEL [7].

A core BPMN model mainly consists of a set of Business Process Diagrams (BPD). Each BPD contains a set of flow objects. Flow objects can be partitioned into a set of activities, events (e.g. start and end events, intermediate message or timer events) and

gateways (e.g. AND and XOR decision gateways). A set of sequence flow relations connects objects within a BPD. Message flows connect different BPDs.

Tasks in SOM correspond to activities in BPMN. Transactions between SOM objects refer to message flows between BPDs in BPMN. Services are equivalent to messages. Object-internal events match intermediate events (except for incoming messages), whereas contextual events refer to start events or incoming messages from another BPD. Hence, a contextual event is either an entry point of a BPD defined as a start event, or it is an intermediate message event. As shown in Figure 3, all SOM elements have a corresponding core BPMN element. According to the SOM meta model and its compatibility with the core BPMN elements, a transformation from TES is straight forward and will be shown by a case study in the next section. Once a flat process is decomposed and transformed to BPMN, tasks can be assigned to actors according to their potential for automation.

3.4. Actors

Personnel and machines are resources carrying out tasks as specified in a business process model. Within the enterprise architecture resources are considered to be independent (autonomous, loosely-coupled and distributed). The assignment of resources to tasks strongly depends on the potential for automation. A partially automated task can be split into sub-tasks which are not automated or fully automated. A fully automated task is exclusively conducted by a machine, whereas a person is exclusively assigned to a non-automated task. For example, a stock quote web service is a machine, in particular an application system, electronically delivering data about the stock market. The decision about making an investment on the stock market is mostly a non-automated task conducted by a person. Some tasks can only be partially automated, so both a machine and a person act together during task enactment. An employee assessing claims for an insurance company normally uses software to handle an application.

4. Home Telecare Case Study

Home Telecare is gaining more and more importance due to the increasing number of elderly people. A major goal of Home Telecare is to provide services enabling older people to live in their own homes in comfort and safety and in the best possible health, for as long as they wish to do so [1]. From a business-oriented perspective, the question posed is how those services can be supported by an adequate methodology for the design and implementation of business models in Home Telecare. Problems Home Telecare is facing at the moment mostly emerge due to many different stakeholders (e.g. patients, GPs, nurses or relatives) and the heterogeneity of existing ICT, which holds encouraging potentials of inter-stakeholder process control and automation [2]. By using SOM and BPMN, the enterprise architecture of an Australian Home Telecare provider was designed from scratch. Starting top-down, the enterprise plan demarcates the global task of the Home Telecare business (see subsection below). By decomposing the global task into distributed sets of objects, eventually, an execution ready BPMN model is derived in terms of its message and control flow.

The following informal problem description was provided by the Home Telecare management:

- Participants, either humans or machines, are patients, community nurses, GPs, central care teams, relatives, ambulances, Home Telecare devices, Decision Support Systems

(DSS) and Electronic Patient Records Systems (EPRS).

- Home Telecare devices measure among others blood pressure, heart rate, weight, spirometry, blood oximetry and temperature. Furthermore, devices support questionnaires regarding the patient's health status and the control of medications taken by the patient.
- Measured data is stored in an EPRS, where a patient's health history is maintained.
- A DSS determines the patient's health state based on measurements, medications, and medication history.
- The central care team makes a decision on the patient's state and informs an adequate care service. Either it makes an immediate decision (e.g. it sends an ambulance or community nurse) or it informs relatives, GPs or nurses.
- In response to a notification from the central care team, the care service decides on the appropriate therapy for the patient and delivers an adequate health service, e.g. medication, home care etc.

4.1. Enterprise Plan

The global task and main goal of the Home Telecare business is the provision of health services for elderly people living at home. In line with providing care services a main objective is the use of ICT to support health services and integrate stakeholders such as GPs, relatives and nurses. Furthermore, in consideration of increased service quality, the aim is to shorten response time for handling

patient's needs and to reduce the overall costs of a patient's residual housing and home care. Among others, existing resources are application systems such as DSS, EPRS and applications running on Telecare devices. In the following, the deduction of a flat business process model is shown by means of process and service decomposition. Starting with the global task identified in line with the problem description given by the Home Telecare management, the system structure (IAS) and behaviour (TES) as well as the execution-ready control and message flow (BPMN) is revealed.

4.2. Business Process Model

We start with system analysis from a structural perspective using IAS. The Home Telecare enterprise is modelled as a business object providing the global task of enforcing care services to homes, in particular patients. A home is a service receiver and modelled as a contextual object representing a stakeholder (cf. [1] in Figure 4).

In the next step, according to the negotiation principle, the enforcing transaction is decomposed into three transactions (cf. [2] in Figure 4). Firstly, the measurement of a patient's health status must be triggered or initiated (I:HealthCheck). Secondly, in order to coordinate actions appropriate to the patient's state of health, results are sent back to "HomeTeleCare" (C:Results). So both the contextual object "Home" and the business object "HomeTeleCare" can agree upon the health status of a

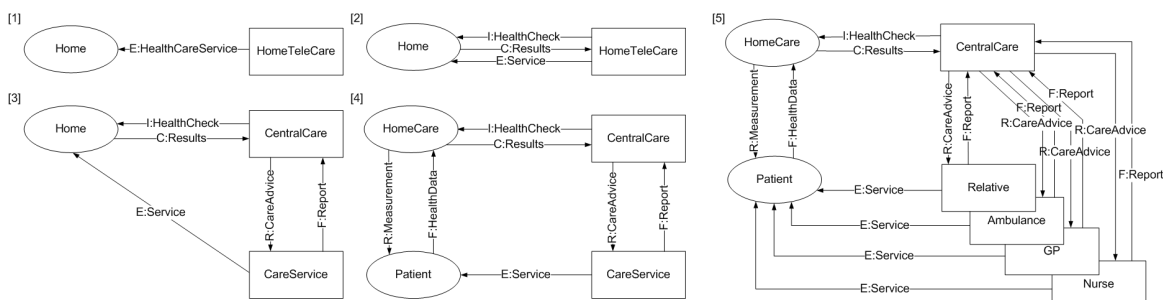


Figure 4: Home Telecare Interaction Schemas

patient. Eventually, on the basis of the provided health data, a decision about further proceedings is made and an adequate care service is enforced (E:Service). In line with object decomposition according to the feedback control principle, the business object “HomeTeleCare” is split into the controlling object “CentralCare” and the servicing object “CareService”. The former object gives an advice (R:CareAdvice) to the latter in terms of a problem description and receives a detailed report (F:Report) after the care service was provided on site (cf. [3] in Figure 4). The measurement of the patient’s health status is revealed by hierarchically decomposing the contextual object “Home” into “HomeCare” and “Patient” (cf. [4] in Figure 4). After properties like blood pressure, heart rate, weight, spirometry, blood oximetry or temperature have been measured (R:Measurement and F:HealthData), results are recorded by the controlling object and forwarded to “CentralCare”, which makes a decision based on the results. The decision to be made includes the choice of an appropriate service provider; in particular the choice whether a relative, GP, ambulance, nurse or any combination of them should enforce care services. Hence, in a final decomposition step the business object “CareService” is split into four business objects each of them providing different care services. “Relative”, “Ambulance”, “GP” and “Nurse” are hierarchically coordinated by “CentralCare” (cf. [5] Figure 4).

Once the decomposed IAS is on a sufficient level of detail, the tasks and transitions between tasks associated with the coordination of objects can be easily derived (cf. Figure 5). Each transaction irrespective of coordination principle is performed by exactly two tasks of different objects. Tasks within the same object are connected by object-internal events. For example, in pursuing its goals the contextual object “HomeCare” cooperates with “Patient” and “CentralCare”. By doing this, each transaction is associated with one task belonging to “HomeCare” and one task belonging to one of the other

objects. Here, “CentralCare” initiates the measurement of a patient’s status, and thus there is a sending task associated with “CentralCare” and a receiving task associated with “HomeCare”. The transition between receiving a health check advice and measuring the patient’s state of health is modelled as an object-internal event. After measurements have been conducted at the patient’s home and results have been sent back to the coordinating central care station, patient records are evaluated and appropriate care services are chosen and informed. Care services carry out their tasks by providing therapies, medications or special treatments and send a report back to the central care station after task fulfilment.

In order to exploit the full potential of a process-centric SOA, the aim is to deploy and execute the system model derived so far. Therefore, the message and control flow specified by the TES in Figure 5 is transformed to a BPMN model. As introduced in the previous section, a transformation from TES to BPMN is straight forward due to the SOM meta model and its alignment with core BPMN elements (cf. Figure 3). For all objects in SOM (contextual object or business object) a BPD is modelled in BPMN. The derived BPMN model is shown in Figure 6 in terms of its message and control flow.

For example, the business object “CentralCare” modelled with TES corresponds to the BPD “CentralCare” in BPMN. Furthermore, all tasks, either sending (S >) or receiving (> R), that belong to the same object in TES are translated into activities belonging to the corresponding BPD in BPMN. Start events and end events in BPMN are explicitly added at the beginning and at the end of each BPD. Object-internal events connecting tasks within a business object are implicitly modelled by sequence flows between activities within a BPD, e.g. the sequence flow between gathering and delivering health data within the BPD “HomeCare”. TES transactions are modelled by using BPMN message flows between BPDs, e.g. the TES transac-

tion “C:HealthData” corresponds to the message flow between the BPMN activity “Results >” (HomeCare) and the activity “> Results” (CentralCare). Services exchanged via transactions in TES are mapped to messages in BPMN. For example, a care advice that is sent from “CentralCare” to the care service providers is mapped to the message “CareAdvice” in the BPMN model. Gateways can be modelled explicitly in BPMN. For instance, decision making enforces an OR-split gateway as shown in Figure 6. The central care team makes a decision on the patient’s state and informs an adequate care service. Either it makes an immediate decision (e.g. it sends an ambulance) or it informs relatives, GPs or nurses, which is an inclusive rather than an exclusive choice. In an emergency it could be inevitable to inform ambulances, nurses and relatives simultaneously.

4.3. Actors

Once the control and message flow of the Home Telecare system is revealed, adequate actors can be assigned to activities as specified in the BPDs. Actors, either machines or human resources, are considered to be independent (autonomous, loosely-coupled and distributed). BPMN activities (and TES tasks respectively) are fully automated, partially automated or not automated. The message flow between activities of different BPDs is either automated or not automated. For example, activities and message flows belonging to the BPD “CentralCare” can be analysed regarding their suitability for automation (cf. Figure 7). A black filled rectangle symbolises a fully automated activity; a half-filled rectangle indicates a partially automated activity, whereas the absence of a filling represents an activity carried out by a human resource. The automation of message flows is represented by an oval-shaped symbol. For instance, sending a care advice (CareAdvice >) to care service providers is an activity currently automated in part, i.e. a human resource makes a decision and the DSS prepares the decision. Reports

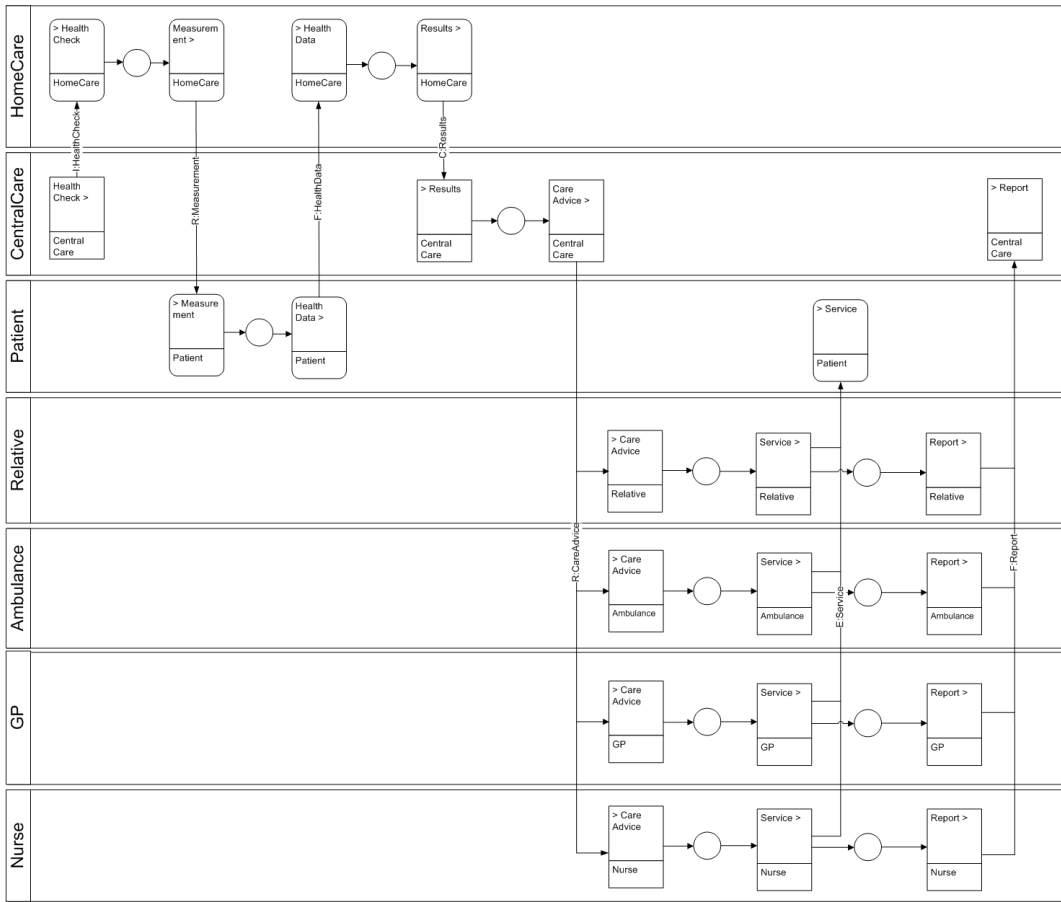


Figure 5: Home Telecare Task-Event Schema

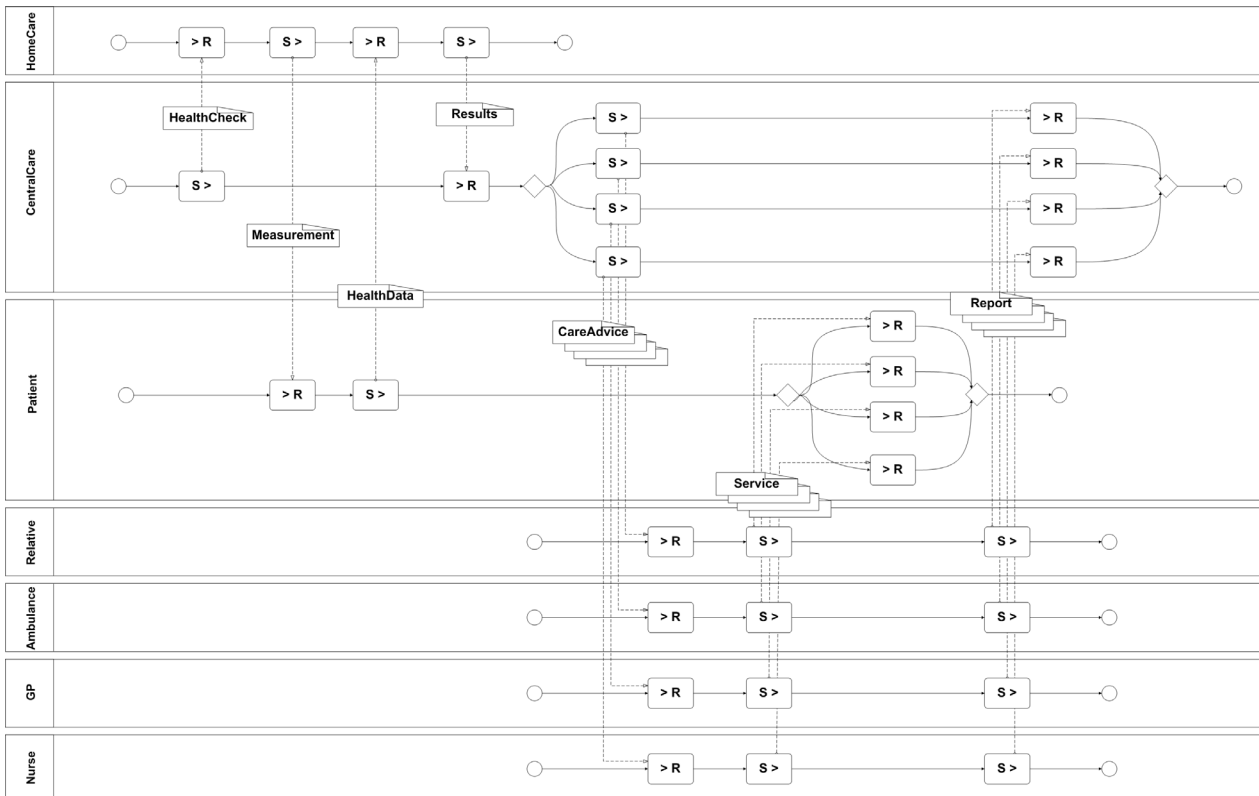


Figure 6: Home Telecare BPMN Model

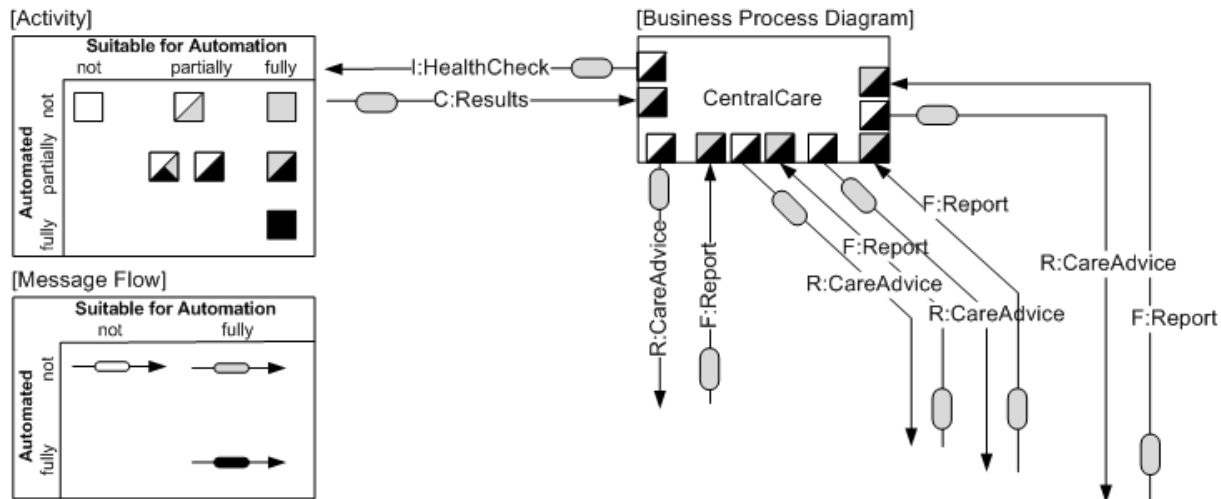


Figure 7: Automation of the BPD "CentralCare"

are meant to be electronically transferred (F:Report) and automatically received and stored in the EPRS (> Report) and thus are suitable for full automation. The same is valid for receiving health results from patients. Results are automatically transferred to the central care station (C:Results) and stored in the EPRS; in particular results are added to the patient's health record (> Results). Likewise all the other BPDs are analysed regarding their suitability for automation. By investigating the automation potentials of activities and message flows, requirements for the design and implementation of technical interfaces, e.g., service interfaces to web-enabled software components, are derived and eventually linked to activities in the BPMN model.

With regard to the assignment of web components to activities, system flexibility as well as component reuse is maximised since the structure of the business process model is harmonised with the service-oriented paradigm. Both the structure of a business process model and its underlying application system infrastructure are sets of autonomous, distributed and loosely-coupled components. Hence, the analysis of suitability for automation simplifies the choice and development of appropriate web-enabled software components and their assignment to activities significantly.

5. Summary and Conclusion

In this paper, we introduced the enterprise architecture of SOM as a multi-layered model providing a structural and behavioural view of a whole business system. The enterprise plan comprises the global task of an organisation and specifies the business system to be designed from an outside view as a black-box. From an inside view, the business process model reveals the structure and behaviour of the global task through process and service decomposition. In line with process and service decomposition, IAS and TES provide guiding principles in terms of decomposition rules. Once a flat process model is derived, transformation from TES to an executable BPMN model is straight forward. All process modelling elements in SOM are covered by BPMN according to their integrated meta model. Tasks in SOM are equivalent to activities in BPMN and the assignment of actors, either human resources or machines, to tasks or activities strongly depends on their suitability for automation. In consideration of automation potentials, activities composed within a process model provide indicators for software development and linkages to autonomous, loosely-coupled and distributed web components according to current SOA trends [6]. We demonstrated the integration of SOM and BPMN by

designing an enterprise architecture in Home Telecare. The focus of our study is on one domain; however, further evaluations in multiple domains are in progress.

In conclusion, there is a high demand for methods supporting model-driven service engineering. Due to the availability of SOA and established process modelling notations like BPMN, decomposition guidelines bridge two worlds still considered as being more or less distinct, namely business analysis and systems implementation. SOM contributes to mediate between business analysts, systems designers and software developers; however there may be other barriers impeding the effectiveness of the proposed method. For instance, as stakeholders involved in inter-organisational projects do have their own policies, goals and objectives, success of collaborations strongly depends on preserving their autonomy. Breakdown analysis might help to identify potential violations of internal policies and goals so that appropriate risk mitigation strategies can be implemented from the perspective of each stakeholder. Furthermore, collaboration efforts will crucially rely on trustful relationships emerging out of negotiations between autonomous actors. Hence, modelling interactions and their embedding in a socio-cultural setting will become more and more important. Having languages reflecting the context-sensitive nature of human

interactions will significantly contribute to more accurate conceptual models [17]. Our approach provides a methodology accounting for those social aspects beyond the intent of simple process automation. This contributes to the increasing importance of designing spaces for human communication and interaction as it will lead to expansion in those aspects of computing that are focused on people, rather than machinery [18]. The integration of social aspects also becomes clear due to the holistic nature of SOM's enterprise architecture. SOM allows for the high-level design of an enterprise plan, the embodiment of the enterprise plan through decomposition of actors (business objects) and their relations (transactions) as well as the implementation of a flat BPMN model mediating the interactions of concrete actors residing in the resource layer. In terms of model evolution, although we introduced our approach with a top-down procedure, this is not necessarily the only way to construct and maintain an enterprise architecture. In contrast to a single-layered monolithic model, the multi-layered system of SOM allows for local changes without affecting the overall system [16]. The process model specified from an inside view can be improved, whereas the enterprise plan defined from an outside view is retained and, additionally, actors in the resource layer are replaced by other ones.

Our proposal of a combined top-down and bottom-up approach to business analysis and systems design will be extended toward higher degrees of flexibility. Ongoing research addresses model synchronisation, in particular we look at ways of how higher layers of an existing model can be changed with minimal impact on lower layers. New results will continuously add to an integrated modelling environment which was initialised with the implementation of

a SOM/BPMN editor according to the research presented in this paper.

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Correspondence

Christian Flender
Faculty of Information Technology
Queensland University of Technology
Brisbane, Australia

Phone: +61 (0)7 3138 9477
Fax: +61 (0)7 3138 9390
<http://sky.fit.qut.edu.au/~flender/>

c.flender@qut.edu.au

Michael Rosemann
Faculty of Information Technology
Queensland University of Technology
Brisbane, Australia

Phone: +61 (0)7 3138 9473,
Fax: +61 (0)7 3138 9390
<http://sky.fit.qut.edu.au/~rosemann/>

m.rosemann@qut.edu.au