

## Three Conceptual Modeling Patterns of Semantically Integrated Method

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**Abstract** — System modeling patterns are similar to workflow patterns, which were established with the purpose of delineating the requirements that arise during business process modeling on a recurring basis. Traditionally, only dynamic aspects are used for specification of modeling patterns leaving aside the static aspects of business processes. The paper presents three conceptual modeling patterns where integrity of totally different aspects can be analyzed. The advantage of such a modeling approach is that it enables visualization and integration of different modeling dimensions of information system specifications in a single diagram. Many graphical representations do not allow such a visualization and an integration of static and dynamic aspects.

**Keywords**-Modeling patterns; service-oriented constructs; static and dynamic aspects; synchronization, selection and enclosing patterns.

### I. INTRODUCTION

Analysis patterns are groups of concepts that represent a common construction in business modeling [7]. They are similar to workflow patterns that were originally established with the aim to define and visualize the fundamental requirements that arise during business process modeling on a recurring basis [19]. Workflow patterns are usually defined by using Business Process Modeling Notation, Unified Modeling Language (UML) Activity Diagram [16], or a Colored Petri-Net model [15]. All these notations are able to express process behavior but do not take into account the static aspects of business processes. They do not explicitly show what happens with the objects, which represent data, when some activity takes place. Integration of static and dynamic aspects is important for the control of semantic integrity among interactive, behavioral and structural aspects of a system [9]. Semantic integrity is critical to maintain a holistic representation of system specifications. To capture the holistic structure of the problem domain, it is necessary to understand how various components are interrelated. Analysis patterns presented in this paper are constructed using the principles of service orientation and they are called conceptual modeling patterns. These patterns are important for two major reasons. Firstly, they can be used for demonstration of the interplay among fundamental constructs that are used in system analysis and design

process. Secondly, patterns are important for the evaluation of the expressive power of semantic modeling languages [18]. Comprehension and visual recognition of these patterns is necessary for building more specific pattern variations and composing them in different ways. Each modeling pattern language can be formally described using a set of modeling constructs and semantic rules.

Service-oriented modeling method [9] presented in this paper is based on the ontological principles [2] of the concept of service [6], and on a common understanding of the general structure of service, which is not influenced by any implementation decisions. The most fascinating idea about a service concept is that it can be applied equally well to organizational as well as technical settings. It means that conceptual representations of service define computation independent aspects of business processes. Business processes can be seen as service compositions, which are used to specify service architecture. Service architecture can be applied for specification of business processes in terms of organizational or technical services. Our assumption is that service-oriented representations can be communicated among business experts and system designers more effectively. Using service-oriented modeling, information systems can be structurally visualized as evolving conceptualizations of service architectures. The interplay between UML diagrams and service-oriented constructs can be also found there [10].

The concept of service in the area of information systems is mostly bound to the term of service-oriented architecture. According to Hagg and Cummings [12], Service-Oriented Architecture (SOA) is a software architectural perspective, where service is the same as component in component-based system development methodologies. It represents a set of guidelines and design principles, such as loose coupling, encapsulation, reuse and composability [5] [22], in which business processes can be effectively reorganized to support the business strategy [17]. From a business management perspective, SOA can provide the possibility to reach business flexibility. It enables business processes to be analyzed in terms of services. Conflicting views on the concept of service is one of the obstacles to the attempts to develop a new science of services [3] and new academic programs focusing on

services [1]. This discipline takes a broader perspective of services as opposed to technical descriptions [20].

We use the concept of service as in the sense of service science. It “can be understood as an action or a set of actions that are performed for some value” [21]. In the context of enterprise modeling, it is necessary to have a broader understanding and interpretation of the service concept as the definition of service goes well beyond activities that are realized using software applications. The definition of service provided by Sheth [20] emphasizes a provider - client interaction that creates and captures value. It emphasizes a value exchange between two or more parties and a transformation received by a customer [3]. The concept of service facilitates a change of business data from one valid and consistent state to another. In the public sector it sometimes denotes organizational actions. According to Ferrario and Guarino [6], services are not transferable, because they are events, not objects. The main purpose of service orientation is to capture business-relevant functionality. Taking into account the nature of the service concept, which is based on interaction between different actors to create and capture value, a service-oriented way of thinking could be applied for a computation-neutral analysis and design of business processes as well as for creation of conceptual modeling patterns.

This paper is organized as follows. In the next section, static and dynamic aspects of service interaction are described. Three different modelling modeling patterns of an integrated method are presented in the third section. Finally, in the fourth section, concluding remarks are presented.

## II. SERVICE AS AN INTERACTION

The action being goal-driven always results in some value to the actor. To get the result, which provides value on demand, four key elements are necessary: service requester, service request, service performer and service response. Interrelations among these elements construct an interaction loop which is necessary to represent service structure. Without one of these four elements, the concept of service loses its meaning. Service performers receive service requests and transform them into responses that are sent to the service requesters. Service can be characterized by an interaction loop that can be defined by a number of flows in two opposite directions. This idea is represented graphically by an elementary service interaction loop, which is delineated in Figure 1.

The main principle of service-oriented method is based on designing services as interactions among different enterprise actors. Service architecture can be represented by a composition of interaction loops. Actors in interaction loops can be seen as active elements. These elements can be organizational or technical subsystems. Organizational subsystems can be individuals, companies, divisions or roles, which denote groups of people. Technical subsystems can be represented as software or hardware components. Any coordination flow between actors [4] must be motivated by the resulting value flow. In such a way, any enterprise system can be represented and analyzed as a set of

interacting loosely connected subsystems that form service architecture.

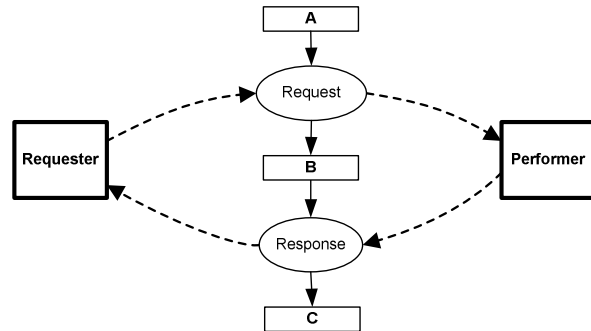


Figure 1. An elementary service interaction loop

A service cannot be defined without specifying the interaction, the result of which creates value to the actors [8] involved. Service is first of all a dynamic act of doing something to somebody. It means that there are more elements necessary to construct a concept of service than just the process of ‘doing’. As there are always some actors involved in such process, it signifies that it is a communication act or an interaction between human, organizational or technical components. One is asking for something and another actor provides it. The purposeful action always takes place in a service. It prescribes responsibilities for the actors involved [1].

The dynamic aspect of service includes not just interaction (....►) between actors, but also the resulting behavior among passive classes of objects when service actions are initiated. The transitions between passive classes of objects are resulting from interactions between active concepts. The internal behavior or so called objective perspective defines the dynamic aspect, which is expressed by object transitions between various classes of objects. Classes A, B, and C define the structural aspects of data. In such way, service modeling enables integration of business process and business data (see Figure 1).

There are two basic events for semantic modeling of service construct: creation and termination [9]. These two events are used for the definition of a reclassification event, which is considered as a generic modeling construct. A creation event is denoted by an outgoing transition arrow to a post-condition class. A termination event is represented by a transition dependency directed from a pre-condition object class. Before an object is terminated, it must be created. Since a future class makes no sense for a termination event, it is not included in a specification of action. Pre-condition class in a termination action can be understood as final during an object’s life time. Reclassification of an object can be defined in terms of a communication action that is terminating an object in one class and creating it at the same time in another class. Sometimes, objects pass several classes, and then they are removed. A graphical notation of the reclassification action is presented in Figure 2.

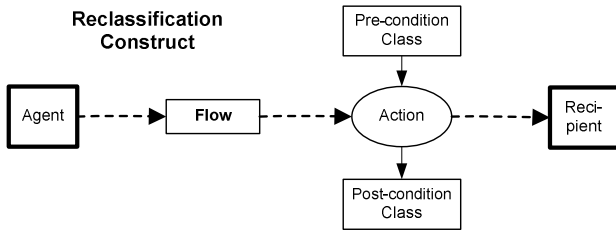


Figure.2. Graphical representation of a reclassification action

Fundamentally, three kinds of changes are possible during any transition (—►). An action is either terminating or creating an object, or it can perform termination and creation at the same time. Pre-condition and post-condition classes typically define constraints on objects, which restrict the sending and receiving of communication flows between technical or business components. A reclassification action in a computerized system can be implemented either as a sequence of one or more object creation and termination operations. Request and response flows, together with created and terminated object classes, are crucial to understand the semantic aspects of service interactions. A pre-condition object class and the input flow should be sufficient for determining a post-condition object class.

The attribute dependencies are stemming from the traditional data models. Semantics of static dependencies in object-oriented approaches are defined by multiplicities. They represent a minimum and maximum number of objects in one class that can be associated to objects in another class. We use only mandatory static dependencies from at least one side of association. A graphical notation of the attribute dependencies and their cardinalities is represented in Figure 3.

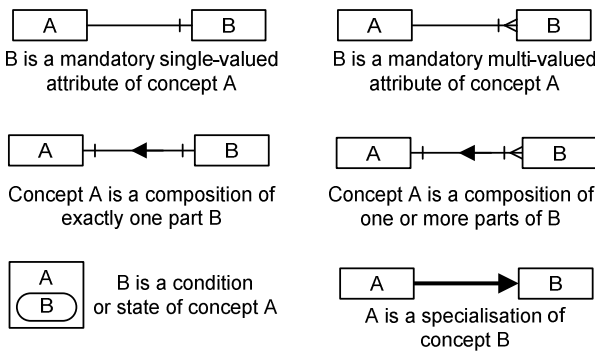


Figure.3. Graphical notation of the attribute dependencies

This notation corresponds to a classical way for representing associations between two entities [13]. One significant difference of this notation in service-oriented modeling method [9] from the traditional approaches is that the association ends are nameless. Dependencies are never used to represent association names or mappings between two sets of objects in two opposite directions. Any two

concepts (in the same way as any two actors) can be linked by the attribute, inheritance or composition dependencies [9].

### III. MODELING PATTERNS

Constructs based on service orientation were used for the design of three modeling patterns. A single diagram type helps to focus on modeling integration of static and dynamic aspects. Various combinations of dependencies are able to express the main workflow control patterns such as selection, synchronization and enclosing of transaction. Synchronization and enclosing patterns are presented the first time in this paper. Ignoring the static aspects of data in the pattern modeling research creates fundamental difficulties. If just dynamic aspects are taken into consideration, then the quantity of patterns increases and their usage for business process modeling becomes more complex. Comprehensibility and visual recognition of the fundamental patterns is necessary in constructing more specific pattern variations by composing them in various ways.

#### A. Synchronization pattern

A synchronization pattern is used when some activities must be performed concurrently. This pattern combines two parallel paths of activities. Both paths must be completed before the next process can take place. The primary interaction loop is composed of a more specific loop on a lower level of granularity. In this case, a service interaction loop on the lower layer of decomposition is viewed as an underlying interaction loop. The execution of the underlying loop must be synchronized with the primary interaction loop. The synchronization pattern is presented in Figure 4.

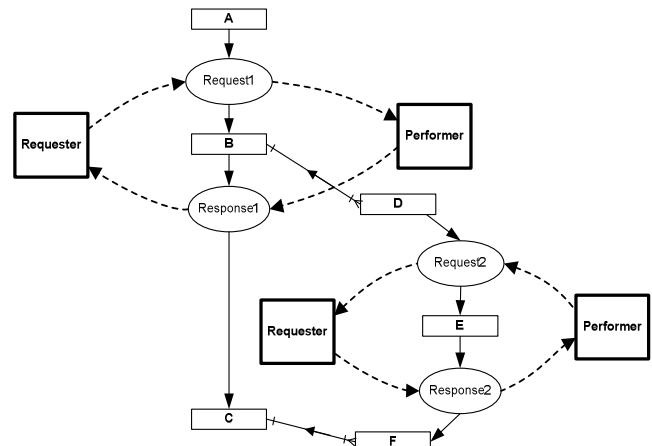


Figure 4. Synchronization pattern

This pattern illustrates that the action of Request1 creates a compositional object B, which consist of parts D. At least one part D must be created. Then object B is reclassified to C, object D must be also reclassified to E and then to F. If a compositional object is created, then the parts are created as well. If a compositional object is removed, then the parts are terminated at the same time. That is the reason why the

action is propagated from a whole to a part according to the rule of class composition. The propagation of actions is a useful modeling quality. It allows a natural modeling of concurrency. Synchronization pattern is similar to concurrent activities (fork and merge of control) in an activity diagram [16].

The graphical example of synchronization is illustrated in Figure 5. In this example, the object reclassification effects represent the important semantic details of an unambiguous scenario in which three interaction loops are combined. Create Reservation action propagates to parts on the lower level of abstraction. Termination of *Hotel Reservation Request* requires termination of *Hotel Room[Desirable]*. Creation of *Hotel Reservation* requires creation of one or more *Hotel Room[Reserved]*. According to the presented diagram, the underlying interaction loop action *Select Room* can be reiterated more than once, because *Hotel Reservation* is defined as the composition of one or more *Hotel Room[Reserved]*.

The underlying interaction loop describes a Customer's response to the Hotel Reservation System's request. If a customer expects to receive a Reservation flow from the Hotel Reservation System, it is necessary for him to get a reply in the underlying loop from the technical component. The request and reply of the second underlying loop is specified as follows:

If Offer Rooms (Hotel Reservation System  $\bullet\bullet\bullet$  Customer), then Select Room (Customer  $\bullet\bullet\bullet$  Hotel Reservation System).

The actions of the underlying loop are synchronized with the primary interaction loop. According to the presented description, Create Reservation is a reclassification action, which is composed of the Offer Rooms and Select Rooms actions on the lower granularity level. The Select Room action cannot be triggered prior to the Offer Rooms action. It can be performed several times for each *Hotel Room[Available]*. *Hotel Reservation* is a compositional object. When it is created, such parts as *Hotel Room[Reserved]* and *Customer[Logged-in]* must be created

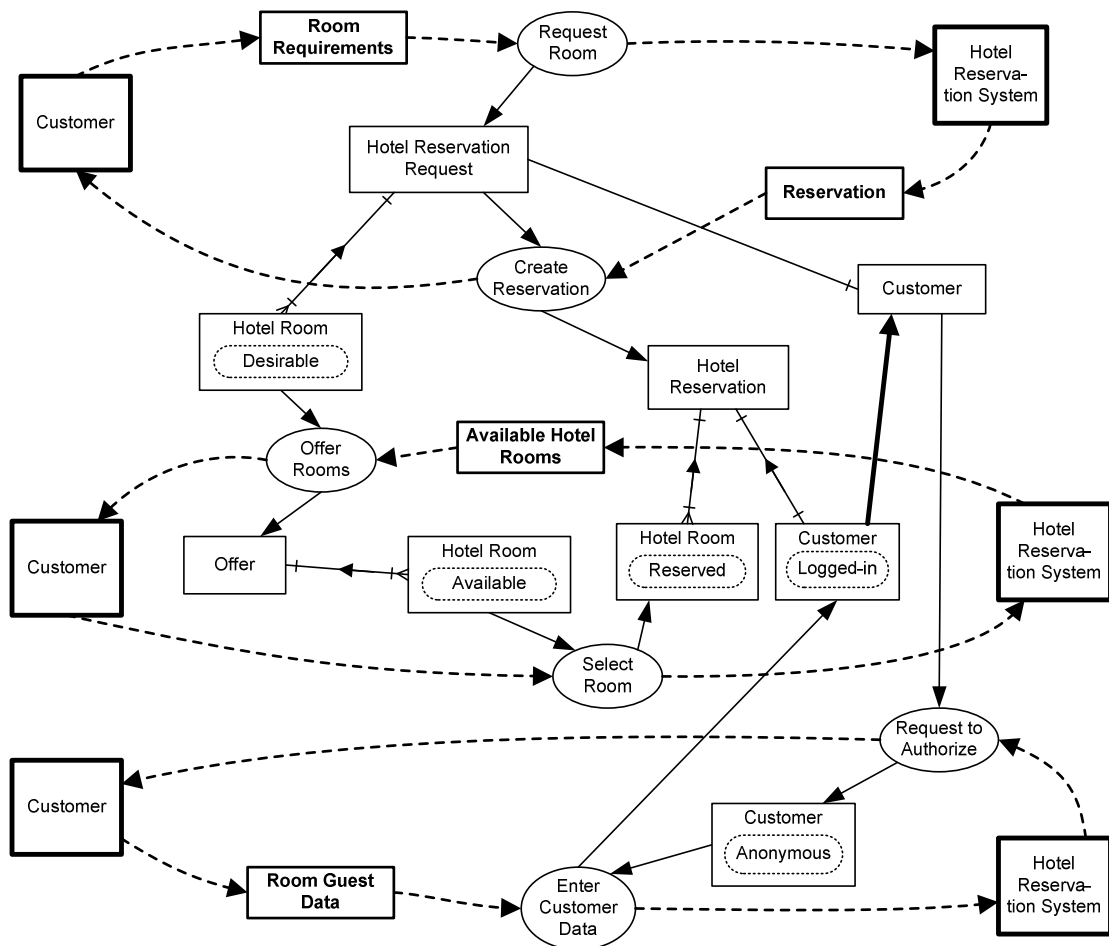


Figure 5. Example of a synchronization pattern

as well. The first underlying loop is necessary for offering available rooms and selecting of a desirable room. Creation of *Customer[Logged-in]* object requires to initiate Request to Authorize and Enter Customer Data actions that are represented by the second underlying loop.

**B. Selection pattern**

The *Selection* pattern can be expressed using a composition of two different sequences between the same two actors. It represents two alternative outcomes of a service request that can be selected by service provider. Two possible ways of replying by service provider are mutually exclusive. Only one type of response is expected by a service requester. If the first alternative is rejected, then the performer is trying to invoke the second alternative. The selection pattern was previously published and it can be found in [11]. It is similar to branches in UML [16]. The selection pattern is represented graphically in Figure 6.

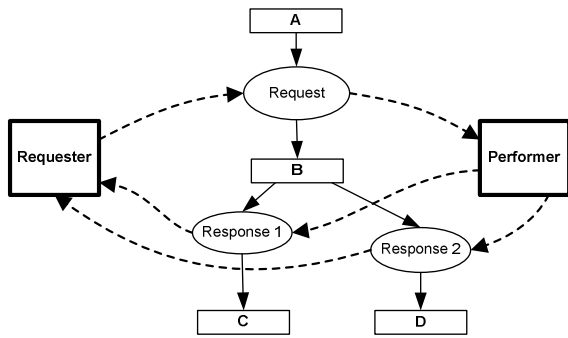


Figure 6. Selection pattern

Response 1 and Response 2 are two exclusive actions of a performer. If Response 1 is initiated, then a pre-condition class object B is removed and a post-condition class C is created. If Response 1 has failed, then Response 2 is triggered, which reclassifies object B to D. The example of selection pattern is represented in Figure 7.

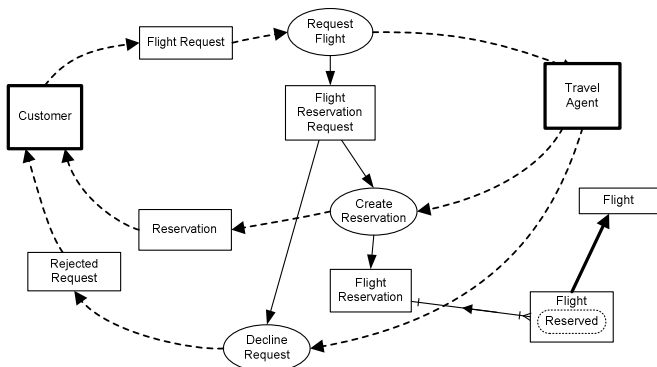


Figure 7. Example of a selection pattern

The selection pattern in the presented example can be explained as follows. The *Flight Reservation Request* is created and then it is reclassified into *Flight Reservation* in the *Create Reservation* action from the *Travel Agent*. If *Travel Agent* cannot create a *Flight Reservation*, then the alternative action of *Decline Request* is taking place. In this case, the *Flight Reservation Request* is terminated and a flow of *Rejected Request* is sent to the *Customer*. This action allows the *Customer* to reiterate the search again.

**C. Enclosing pattern**

An *enclosing pattern* is defined by a primary and a secondary interaction loop between requester and performer. In carrying out the work, a performer may play the role of requester in the secondary interaction loop by initiating further interactions. In this way, a network of loosely coupled actors with various roles comes into interplay to fulfill the original service request. Organizational systems may be composed of several interaction loops, which are delegated to more specific components. Enclosing pattern is similar to the enclosing of a transaction [4]. An enclosing pattern is represented graphically in Figure 8.

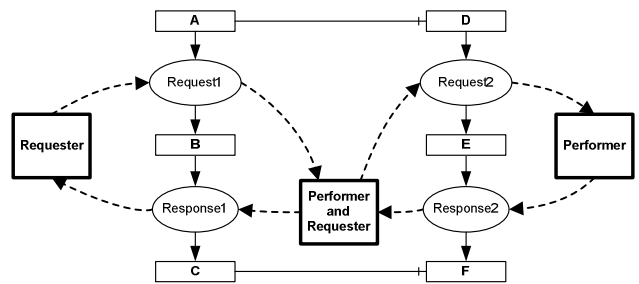


Figure 8. Enclosing pattern

The primary interaction loop consists of Request1 and Response1 actions. For the creation of object B in the primary loop, it is necessary to create its property E in the secondary loop. The reclassification of object B to C requires the removal of E and creation of F. So, the enclosing loop cannot be completed if the secondary loop is not finalized.

**IV. CONCLUDING REMARKS**

The goal of this paper was to demonstrate how the suggested service-oriented constructs can be used for the creation of three different modeling patterns. Traditionally, modeling patterns are constructed taking into account just dynamic aspects of business processes. The advantage of the suggested modeling constructs is that they allow integration of both static and dynamic aspects. One of the main contributions of this paper is the presentation of two new patterns such as synchronization and enclosing. The separation of static and dynamic details of the presented patterns creates fundamental difficulties for two major reasons:

- 1) Since the static aspects must somehow be compensated by using dynamic constructs, the number of patterns becomes bigger than is really necessary. Sometimes, the pattern differences are difficult to understand and they are visually unrecognizable by business experts.
- 2) If static aspects are not taken into account, then patterns will become more complicated to use them for the purpose of blending enterprise and software engineering.

The semantics of service architecture can be defined by using one or more interaction loops. Each interaction loop is composed of creation, termination or reclassification actions. By matching the interaction dependencies from requesters to providers, one can explore opportunities that are available to different actors. The static dependencies define complementary semantic details, which are important for reasoning about service interactions. The examples of corresponding behavior are presented in this paper as well. The novelty of such a way of modeling is that it enables integration of static and dynamic aspects, which are important to maintain a holistic representation of information system specifications. Service-oriented way of modeling is computation-neutral. Diagrams follow the basic conceptualization principle in representing only computationally neutral aspects that are not influenced by any implementation solutions. Since computation-neutral representations are easier to comprehend for business experts as well as system designers, they facilitate understanding and can be used for bridging a communication gap among different types of stakeholders.

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