Generation of choreography skeletons from web service definitions

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Abstract—Modern IT landscapes underlie constant evolution. Modeling activities - as a basis for continuous monitoring and maintenance - stay often behind. Service models describe the way how services interact. We propose reverse engineering techniques to generate choreography skeletons from web service definitions. We describe the necessary transformation to generate a detailed and consistent choreography than can be easily completed and merged with existing choreographies. We discuss the restrictions of the generated WS-CDL skeletons and how they can be overcome.

Index Terms—web service, choreography, service model, reverse engineering

I. INTRODUCTION

IT landscapes in industry or finance are often a result of a long evolution. Despite continuous efforts to keep models of systems and components up-to-date, rarely IT landscape models are consistent and complete.

The landscape model (sometime also called system model) consists often of two parts: the physical infrastructure and the service model. The physical infrastructure reflects in great detail components composed in the following groups: computer hardware (e.g. processing power, memory, etc.), computer software (e.g. OS, server applications), and network devices (e.g. links, traffic controllers - hubs/switches/gates/routes).

The service model is an abstraction of the set of all services. It defines the way how the services interact by exchanging messages and how more complex services are created by combining services. The terms orchestration and choreography describe two different aspects of creating business processes from composite web services.

Orchestration refers to an executable business process that can interact with both internal and external web services. Orchestration represents the composition from the viewpoint of the parties involved in this composition.

A choreography description concerns the composition of web services seen from a global viewpoint focusing on the common and complementary observable behavior. Choreography is particularly relevant in a setting where there is not a single coordinator. Choreography tracks the message sequences among multiple parties and sources - typically the public message exchanges that occur between web services - rather than a specific business process that a single party executes [1]. Typical examples are a travel agency that offers a broad range of services including air and train travel, bus tickets, hotels, car rental, excursions, insurance etc. or a company that wishes to purchase a fleet of cars from automobile suppliers, which in turn request quotes for specific bill or material items from their component manufacturers [2].

The main use of a choreography description is to precisely define the sequence of interactions between a set of cooperating web services in order to promote a common understanding between participants and to make it as easy as possible to automatically validate conformance, ensure interoperability and increase robustness [2].

We want to automate the generation of service models, more specific of web service choreographies. This reduces the modeling effort for existing service landscapes. Normally, IT service landscapes underlie constant evolution due to newly added or modified business functions. Quite often web services from partners or external service providers have to be integrated into the existing network. Examples are services from B2B partners or external data services, like Dun&Bradstreet to get business information and company assessments from business partners. In this case, our work helps to keep the service models up-to-date and to monitor changes in constantly changing service infrastructures.

We use reverse engineering techniques to extract the necessary information from the implemented web services. Main information source are the web service definitions, which provide the documentation for distributed systems and are available to all communication partners. As the information in the web service definitions is insufficient to build a complete service choreography, we concentrate on the generation of consistent skeletons, which then can be enhanced manually or enriched with business process information.

The paper continues with a description of related work. The basis features of WS-CDL and WSDL are addressed in Sections III and IV. In Section V, the transformation from web service descriptions to a choreography model is described. In Section VI, we discuss how the generated choreography skeletons can be completed. Our implementation of the transformation process is described in Section VII. In Section VIII, we conclude this paper and discuss further work.

II. RELATED WORK

The most known languages to specify web services choreographies are Web Service Choreography Interface (WSCL,
Web Service Choreography Description Language (WS-CDL, [4]), and Ontology Web Language for Services (OWL-S, [5]). All are XML-based and support WSDL [6][7], the well-established standard to describe web services.

WS-CDL – sometimes considered as predecessor of WS-CDL (the last update was released in 2002) – describes the observable behavior of only one web service including temporal and logical dependencies in the message flow. WS-CDL and OWL-S are more powerful to express the collaboration of 2 parties. WS-CDL describes peer-to-peer collaborations of web services taking part in a choreography. It defines a set of agreements about ordering and constraint rules. The aim of OWL-S is to automate the discovery, invocation, composition, interoperation and monitoring of web services. A detailed comparison of the 3 languages can be found in [8].

More choreography languages, like Let’s Dance and BPEL4Chor, are emerged in the last years. Let’s Dance [9] is a language for modeling service interactions and their flow dependencies targeting business analysts. It is a language for high-level analysis and design. WS-CDL is a potential implementation language for Let’s Dance models. BPEL4Chor [10] is an extension of Business Process Execution Language (BPEL, [11]). It adds participant behavior descriptions, i.e. control flow dependencies, the participant topology and their interconnection using message links and participant groundings, i.e. concrete configurations for data formats and port types to the standard BPEL.

To our knowledge, it is a novel approach to reengineer WSDL files to create a service model. But there are reverse approaches to generate WSDL descriptions (skeletons) from choreography models. In [12], the authors describe an approach to generate the orchestration behavior (BPEL stubs) and the necessary WSDL templates automatically from WS-CDL models. The same functionality is implemented in the visual modeling tool known as pi4SOA [13]. pi4SOA, an open-source implementation that plugs into Eclipse, is one of the few WS-CDL implementations available today.

There are many approaches, complementary to our approach, to recreate the process flow of interacting web services. Business process mining, or process mining for short, aims at the automatic construction of models explaining the behavior observed in the event log [14]. For example, based on event logs, it is possible to construct a process model expressed in terms of a Petri net or Event-driven Process Chain (EPC). Beside the process perspective, process mining can also focuses on the originator field (organizational perspective), to find out, which performers are involved and how are they related. The goal is either to structure the organization by classifying people in terms of roles and organizational units or to show relations between individual performers (e.g., build a social network [15]).

III. CHOREOGRAPHY

The goal of specifying web service choreographies is composing peer-to-peer interactions between any kind of services, regardless of the programming language or the environment that hosts the service.

We have chosen to use WS-CDL for our service model, because its tight coupling to WSDL files and the recommendation of the W3C Web Services Choreography Working Group. A WS-CDL model consists of 3 parts:

- **Collaborating parties**: describing the entities that exchange information, their roles and their relationships,
- **Collaborative behavior**: describing the physical order (message flow) of the information exchange and assigned constraints,
- **Exchanged information**: describing the type of information used in the information exchange.

A. Collaborating parties

Within a choreography, information is always exchanged between participants. A participant – described by a participant type – groups all the parts of the collaboration that must be implemented by the same entity. A role type enumerates potential behaviors of a participant within an interaction. A channel type is a point of collaboration between participants specifying where and how information is exchanged. Finally, a relationship type is used to identify the mutual obligations between participants that must be fulfilled to succeed.

B. Collaborative behavior

A choreography defines re-usable common rules that govern the ordering of exchanged messages. A choreography contains collections of activities that may be performed by one or more participants. There are three types of activities in WS-CDL, namely control-flow activities, WorkUnit activities and basic activities. In the first category, there are three types of activities: Sequence, Parallel, and Choice. These activities enclose a number of sub-activities. A WorkUnit activity describes the conditional and, possibly, repeated execution of an activity. The basic activities include Interaction, NoAction, SilentAction, Assign, and Perform. The most important element of WS-CDL is the Interaction activity that corresponds to an operation of a web service.

C. Exchanged information

InformationTypes describe the type of variables, tokens and messages used in the choreography. Their description at the package level makes them available to all enclosed activities. They normally refer either WSDL 1.1 message types, WSDL 2.0 schema elements or XML schema elements/types.

IV. WSDL

A web service is described by a web service description (WSDL file). Currently, there are 2 versions of the specification. WSDL 1.1 [6] is the widely accepted standard. Although WSDL 2.0 [7] is recommended by the W3C since June 2007 and promises an easier implementation, its adaption by SOAP servers, vendors and tools is still reluctant.

A WSDL 1.1 description containing six major elements (In this paper, we concentrate on WSDL 1.1, but the same information is also available in WSDL 2.0):
• types, which provides data type definitions used to describe the exchanged messages.
• message, which represents an abstract definition of the data being transmitted.
• portType, which is a set of abstract operations, which refer to input and output messages.
• binding, which specifies concrete protocol and data format specifications for the operations and messages defined by a particular portType.
• port, which specifies an address for a binding, thus defining a single communication endpoint.
• service, which is used to aggregate a set of related ports.

To generate the choreography skeletons, only the elements message, portType with operations and service are used. The name of service element is used to name the activities and collaborating parties in the choreography.

V. TRANSFORMATION

Our goal is the generation of a valid web service choreography (*.cdl file) out of one or several web service definitions (WSDL files). In the following, we describe the needed transformations to create the 3 essential parts of a WS choreography.

A. Collaborating parties

The service element of a web service description is used to generate the collaborating parties of the choreography. Each service element represents a relationship between service provider and consumer. The name of the service element is used to generate the relationship type and the role types related to web service provider and consumer. In Figure 1, the graphical representation of such a relationship is shown.¹

![Fig. 1. Graphical Model of a WS-CDL Relationship](image)

The role types enumerate potential observable behaviors a participant can exhibit in order to interact. This behavior corresponds to the portTypes (interfaces in WSDL 2.0) of the WSDL. In Figure 1, each role type has 3 behaviors assigned.

The optional behavior of the role types in the relationship is not filled during the transformation. In this case, all the behaviors belonging to this role type are identified as the commitment of a participant for this relationship. The right values have to be selected manually in a later stage.

The generated relationship type is assigned to the choreography (see in Figure 2) and bound to all interactions created from the WSDL file (see Section V-B).

¹In this and the following examples, we used a public web service for bar code generation available with its WSDL under http://www.webservicex.net/WCF/ServiceDetails.aspx?SID=40.
B. Collaborative behavior

The collaboration behavior of two partners is described by activities with an ordering structure. The web service definition contains no information about the order in which the different operations are called, therefore we assume an unrestricted parallel activity, in which one or more activities can be executed in any order or at the same time (see Figure 4). By nature, all operations of a web service can be called at any time and in any order. Ordering restrictions are only given by the using business process. Our skeletons could be enriched later with the real ordering structure, either manually or automatically by integrating the information from, e.g., a business process model.

The basic activities generated from the WSDL files are interaction activities. Each web service operation corresponds to one interaction (see in Figure 5 a generated example interaction). The name of the web service operation is used to generate a name for the interaction and the operation attribute.

An interaction activity description has 3 main parts corresponding (i) to the participants involved, (ii) to the information being exchanged, and (iii) to the channel for exchanging the information.

The information about the involved participants is contained in the element participate and refers to the role types and relationship types described in Section V-A. The attribute fromRoleTypeRef refers the web service consumer role, the attribute toRoleTypeRef to the web service provider role, and the attribute relationshipType to the relationship between the two.

The exchanged information is described in the message part of a WSDL. The operation input and output elements connect the related messages to a WSDL operation. The information from the message element is transformed to the exchange element in the WS-CDL interaction. Depending on the operation type the action attribute of the exchange is generated differently: input messages → action=request and output message → action=respond.

The attribute informationType of the exchange element refers to the information type used for the exchanged information. All information types are defined at the package level of the choreography. The elements send and receive, which contain application-dependent or state information are generated without attributes.

The channels used during the interactions are also derived

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To illustrate parallel activities, we have chosen a weather web service available under http://www.webservicex.net/WCF/ServiceDetails.aspx?SID=48

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Fig. 4. Graphical Model of Parallel Activities

Fig. 5. Generated WS-CDL Interaction
from the web service operations. The associated channel types are defined on package level and only referred via channel variable in the interaction (attribute channelVariable).

C. Exchanged information

Information types are mainly used in the exchange element of the interaction to describe the type of exchanged information. WS-CDL does not allow the construction of complex data types like possible in the types element of the WSDL. Therefore we have to generate new information types from the data type assigned to the WSDL 1.1 message parts.

The information types contain also the generated information type for the reference tokens (see Figure 3).

The complete mapping of web service definitions to a WS-CDL choreography is shown in Table I. Although the described transformation uses a single WSDL, the concept can equally applied to several files. Naming conflicts are anticipated by applying different namespaces for WSDL specific and generated elements.

VI. SKELETON COMPLETION

The following steps are necessary to complete the generated WS-CDL skeletons and to merge them into existing choreographies:

1) Create the participant types and assign the generated role types: Typically a participant type groups several roles. In a chain of interacting services, a participant can be the consumer of one service and the provider of another. Process mining techniques could be used to identify the roles that belong to one participant type.

2) Select the implemented behaviors in role types of the service consumer: The behaviors generated from the portTypes describe the different possibilities to communicate. But a specific service consumer could decide to use only a certain subset. This information belongs to the web service consumer’s client application.

3) Verify the behaviors of the relationship types: Per default, all generated behaviors are committed from both sides. But for a specific combination of service consumer and service provider only a subset could be used (in accordance with the selection in 2).

4) Remove or flag unused channel types: A channel type describes the communication channel for each interaction in accordance with a selected behavior. If a web service consumer uses only a subset of the communication channels, some of the generated channel types become obsolete and can be removed.

5) Select the correct channel for each interaction: Each interaction has exactly one channel type assigned. Per default, we select always the first generated channel type. In accordance to the selected behaviors for the relationship type, the right channel type has to be selected. If the interaction can be executed on several channels the interaction has to be duplicated.

6) Fill additional information: Information from the business process and description of all components can be added.

7) Merge the choreography: The completed skeleton can now be merged with existing choreographies. This is a manual step that is not supported by the pi4SOA tool [13].

8) Establish the flow: The last step is to establish the correct ordering structure of the activities from the merged choreographies. The generated parallel activities have now to be brought in the right sequential order and to be integrated in the complex flow of activities. As information source serves mainly the knowledge about the business process. Existing workflow descriptions of the business process or process models constructed with process mining techniques could enrich the choreography.

VII. IMPLEMENTATION

Our transformation process consists of 3 automated steps (see Figure 6) complemented by manual activities to add additional information and to merge the skeletons with existing choreographies (see Section VI).

The transformation process starts with the selection of one or several WSDL files. A XSLT transformation transforms the input into a *.cdl file containing the choreography skeleton in WS-CDL. We use a XSLT 2.0 engine. The *.cdl file can now be manually completed and merged with existing choreographies. After this, a validation against the XML schema provided by [4] verifies the correctness of the manual editing. In the last automated step, the *.cdl file is imported into the Eclipse Plug-in pi4SOA [13]. During the import, the *.cdl file is semantically validated and transformed in a graphical model (stored as *.cdm file) that can be visually modified.

VIII. CONCLUSION AND FUTURE WORK

We presented an approach to generate WS-CDL skeletons from web service definitions. The result is promising: we could generate complete and consistent choreographies that can be easily completed manually with the support of a graphical tool. Our approach of reengineering web service definitions facilitates the modeling process (the modeling time is reduced from several hours to a couple of minutes). It generates skeletons that describe the web service operations detailed as interactions including the cumbersome modeling and referencing of communication channels, behaviors, relationships, etc.
We plan to further reduce manual modeling efforts by automated enrichments of the choreography model from existing workflow descriptions, like BPEL, or process models constructed by process mining. In [12], orchestration behavior was generated from a choreography. We will also try to reverse this process.

We consider our work as a first step in the direction of automated service model generation as a basis for constant monitoring of steadily evolving service landscapes. So far, we concentrated on the functional feature of web services. In the future, we want also consider non-functional aspects, like security and dependability. This will require extensions to the choreography languages, like WS-CDL.

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