An Experience of using SoaML for Modeling a Service-Oriented Architecture for Health Information Systems

Fernanda G. Silva[1], Jislane S. S. de Menezes[1], Josimar de S. Lima[1], Joyce M. S. França[2], Rogério P. C. do Nascimento[1] and Michel S. Soares[1]

[1]*Department of Computing, Federal University of Sergipe, São Cristóvão, Brazil*

[2]*Faculty of Computing, Federal University of Uberlândia, Brazil*

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Abstract: Service-oriented applications have been modeled with different modeling languages and diagrams, which suggests a lack of standardization. Although UML concepts for modeling SOA can be regarded as a good starting point, it is not an entirely feasible approach, as UML has not been proposed with the purpose of modeling services and SOA applications. Besides, the proper concept of service is absent in UML. SoaML is a UML profile for the specification and design of services within a service-oriented architecture. One of the advantages of using SoaML to model interoperability between systems in health care is that it is possible to model the consumers and service providers. This would be quite difficult to achieve using UML only. Therefore, the main contribution of this work is to manipulate a relatively new modeling language to real operational problems related to the integration of health systems.

1 INTRODUCTION

Service-Oriented Architecture (SOA) is a paradigm to implement loosely-coupled, platform-independent distributed software systems using communicating services. SOA has been applied successfully in many domains, including financial systems (King et al., 2010), healthcare information systems (Khoshkbarforoushha et al., 2010), (Monsieur et al., 2012), research-oriented applications in engineering (Vescoukis and Dulamis, 2011), academic software applications (Baghdadi and Al-Bulushi, 2013), and for varied activities such as refactoring legacy systems (Khadka et al., 2011), integration of systems and for developing new software systems (Alonso et al., 2010). Therefore, it is safe to assume that SOA has been widely applied in projects both in academia and industry.

SOA applications have been modeled with different modeling languages and diagrams, which suggests a lack of standardization in this area. For instance, dataflows are applied in (Monsieur et al., 2012) and Flowcharts are applied in (Wu et al., 2009). Regarding UML, Activity diagrams are used in (Granell et al., 2010), Sequence diagrams in (EL Yamany et al.,) and (Kannan et al., 2011). The work presented in (Perepletchikov and Ryan, 2011) uses Class, Collaboration and Sequence diagrams all together.

Existing models for describing system architectures are insufficient to describe SOA in a precise and standardized way. Although UML concepts for modeling SOA can be regarded as a good starting point, it is not an entirely feasible approach (Stojanovic et al., 2004). UML has not been proposed with the purpose of modeling services and SOA applications, and is considered too general for the purpose of describing SOA (Todoran et al., 2011). Besides, the proper concept of service is absent in UML.

SoaML (OMG, 2012) is a UML profile for the specification and design of services within a service-oriented architecture. SoaML extends UML with six main areas: participants, service interfaces, service contracts, services architectures, service data and capabilities. Although SoaML has already been applied to some cases (Gebhart et al., 2010) (Elvesæter et al., 2010) (Hu et al., 2014), the language has hardly been mentioned in the literature (this is a result of a systematic literature review performed by the authors). Reasons for this are not yet clear, but one possibility can be the novelty of the language, officially released on March 2012. Another one is because UML is well-known in academia and software industry, which makes it a suitable choice for most authors.

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This paper describes an attempt to use SoaML in a specific domain, health information systems, with the purpose of modeling a real problem of system interoperability. SoaML was applied in a real case, in which services of some information systems are modeled. After a brief introduction to SoaML in Section 2, we present the description of the Health Information Systems to be modeled (Section 3), the description of the provided services in Section 4, the case study and the conclusions in the last two sections.

2 INTRODUCTION TO SOAML

UML (OMG-UML, 2011) alone does not perfectly match the needs of service-oriented projects (Todoran et al., 2011). For this reason, in 2009, OMG proposed SoaML (Service Oriented Architecture Modeling Language), a UML profile specifically targeted to SOA systems. SoaML specification provides a metamodel and a UML profile for the specification and design of services within a Service-Oriented Architecture (Object Management Group (OMG), 2012). Therefore, SoaML represents SOA artifacts using UML as a core-modeling standard (Casanave, 2009).

SoaML addresses the following topics: identification of services and their dependencies; specification of services, protocols and information exchanged; definition of communication between service consumers and providers, definition of policy for consumers and providers. Thus, it is possible to perform an entire analysis of service-oriented architecture, showing how the services and service participants work together to provide business value.

Support of SoaML for SOA design is important for two reasons (Mohammadi and Mukhtar, 2013): service modeling as a first step is essential for developing successful SOA systems regardless of implementation details, and SOA modeling helps to better understand and communicate between business users and IT experts. SoaML introduces five types of diagrams: Service Interface Diagram, Service Participant Diagram, Service Contract Diagram, Services Architecture Diagram and Service Categorization Diagram. A brief description of each of these diagrams is presented as follows (Object Management Group (OMG), 2012).

Service Interface Diagram: Such as a UML interface, a Service Interface Diagram defines or specifies the service and can be the type of a service port. This diagram has the additional feature of being able to specify a bi-directional service with a protocol. Therefore, both providers and consumers have responsibilities to invoke and respond to operations, send and receive messages or events.

Service Participant Diagram: this diagram contains the participants to collaborations based on services. They are characterized by services and ports, which are similar to interfaces from UML Components.

Service Contract Diagram: this diagram represents an extension of the UML Collaboration diagram which shows the relationship between participant roles. Consumers or providers of services are materialized through service channels.

Services Architecture Diagram: diagram to model global collaboration, based on the use of service contracts, and connects all suppliers and consumers.

Service Categorization Diagram: SoaML introduces a generic mechanism for UML elements with categories and values to describe information about these elements. Categories can be organized into a hierarchy of named catalogs. The same element can be classified for many categories, and the same category can be applied to various elements. This diagram is intended to be a very flexible and dynamic mechanism to arrange the various elements in orthogonal hierarchies.

3 DESCRIPTION OF THE HEALTH INFORMATION SYSTEMS

Information Systems in the Health Ministry in Brazil have been actively re-engineered, as it is well-understood that high qualification of information management is of fundamental importance to provide quality services for citizens. An Electronic Health Information System (e-HIS) for basic services (e-HIS BS) is an strategy to re-structure basic health services nationwide. This e-HIS BS has as purpose to offer computer-based tools to improve management for basic health units and allow interoperability between health information systems.

e-HIS BS has as purpose to follow actions and results from activities performed by teams from the Family Health Program (FHP). By using e-HIS BS, anyone can have access to families information, individual health situation, general house and sanitation conditions, and about each health professional team. All generated data from e-HIS BS will feed another system, the Information System for Basic Health (ISBH), which main characteristic is to structure individual information with the purpose to improve the possibilities of care actions by the health teams, as well as creating traces of health actions in

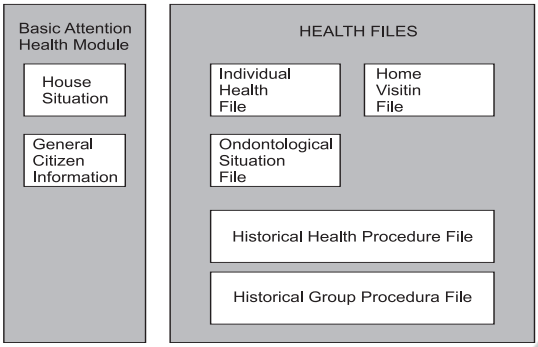

Figure 1: e-HIS Architecture.

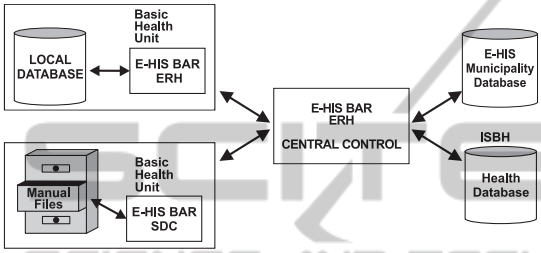

Figure 2: e-HIS Basic Health Attention Architecture.

all national territory.

e-HIS BS has as assumptions: detailed individual information for each citizen, allowing to register each health occurrence and each treatment by a health professional; integration of information systems dealing with basic health services; production of dynamic reports; reduction of inefficient tasks and activities, including registering data in a computer tool; and finally, using information for better management and health care.

e-HIS BS presents two main modules: Simplified Data Collection (SDC) and Electronic Health Record (EHR). Module SDC allows integrated and simplified registering by using a variety of files, including, for instance, house situation, general information about the citizen, odontological situation, historical health procedures, and information about home visiting by a health professional. All these collected information will be stored into the ISBH. SDC module uses seven files for data registration, divided into two blocks, as depicted in Fig. 1.

Module Basic Attention Register (BAR) is an extension of National Health Register (HNR). This BAR module helps health teams to register health, social and economic characteristics for a given population. NHR is a national information system which allows identification of users in all activities and services by means of a unique number for each citizen. In addition, NHR allows one to identify each professional and health organization responsible for a given treatment.

e-HIS EHR was proposed to help health teams located in small health organizations which fully use or even partially use computer tools. Among other functions, e-HIS EHR provides management of patients, organizes professionals' agenda, and register health activities.

One important functionality implemented in the management module of e-HIS EHR is to import data from National Record of Health Organizations (NRHO), an official database with information from all health organizations in the country, both private and public. NRHO has as main functionalities to record health organizations and existing infrastructure, individual professionals and teams, and many kinds of reports.

Data is inserted into the NRHO system through SNRHO software applications. NRHO is also used as a basis to centralize information from many other health information systems, including Outpatient Information System (OIS), Hospital Information System (HIS), Basic Attention Health Information System (BAHIS), and Local Information System (LIS). All these systems have some participation in the national health process, as depicted in Fig. 2.

As can be observed in Fig. 2, there are still paper files being used by Basic Health Units (BHU). Paper forms, containing the same information presented in e-HIS SDC, are printed and manually filled, every day, and delivered to a computer operator, who will insert data into e-HIS SDC. By the end of the day, before he/she finishes all inserted data, the computer operator has to verify if there is any alteration in data present in NRHO. If the operator finds any change in data, he/she has to download the new file from the NRHO and update databases of e-HIS EHR and e-HIS SDC systems. This is a manual operation. After the update, e-HIS SDC becomes available again to insert all paper files generated in that day. This operation is performed by a computer operator, who saves all data into a memory stick device, and delivers it to the municipality health secretary. Then, all information is collected to be transmitted to the national database, at the federal ministry health department. This process is described in Fig. 3, in which one can observe the need to automate communication between NHRO and e-HIS SDC, in order to avoid errors and late delivers everyday.

4 DESCRIPTION OF THE PROVIDED SERVICES

As paper files contain data to be inserted, and as this procedure is error-prone and needs to be often up-

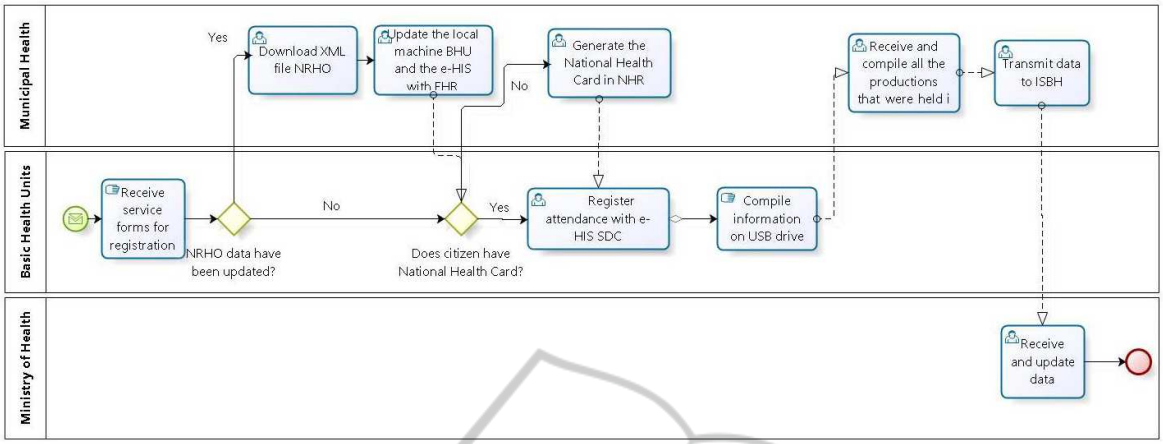

Figure 3: Defined process.

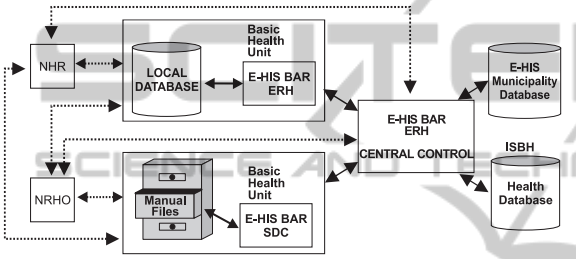

Figure 4: e-HIS Basic Health Attention with Services.

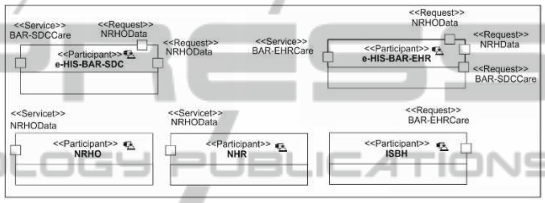

Figure 5: Service Participant Diagram.

dated, it is clear that these data can be treated as responses to request services. Data to be treated as services are described as follows.

Professional ID. Number of the national ID Card of the professional who inserted the citizen/family in NRHO. Mandatory field.

NRHO Unit Code. Code to identify the health unit in NRHO. Mandatory field.

NRHO Team Code. Code to identify the health team in NRHO. Mandatory field.

Citizen ID. Number of the national ID Card of the responsible for the family.

Some services were identified, as depicted in Fig. 4, considering systems NRHO and NHR as service providers. In order to insert data from the paper files into e-HIS BAR, services are requested from NRHO and NHR. For the file transmission, all generated files from each BHU need to be received. In the end, all files are validated, processed and transmitted to the ISBH, in the Health Ministry.

5 CASE STUDY

Proposed case study is the creation of a service-oriented architecture using SoaML profile as modeling language, considering the domain and the problems presented in previous sections.

Identifying all participants is the first task to be performed. Five participants are candidates to be modeled in this case study: e-HIS SDC, e-HIS EHR, NHR, NRHO and ISBH. Initially, all interdependencies between these systems were identified. Then, existing functionalities in involved systems that could be transformed into services were also identified.

One of the man advantages of using SoaML is that it is possible to represent the models both for the consumers and the providers of services. Fig. 5 depicts the service participant diagram in which all identified participants are modeled, as well as their services, being it as a consumer or as a provider. Stereotype “Service” identifies which participants will provide a service, and Stereotype “Request” means that the participant has consumed the service provided by other participant in the domain. Participants e-HIS SDC and e-HIS EHR both consume and provide services. On the other hand, participants NRHO and NHR only provide services. ISBH only consumes created services by other participants. SoaML has also the Service Contract diagram, which presents, in a different view, how each provider is related to a service consumer. Fig. 7 depicts an example of the Service Contract diagram. SoaML specifies one service contract diagram for each defined service. In Fig. 7, one ex-

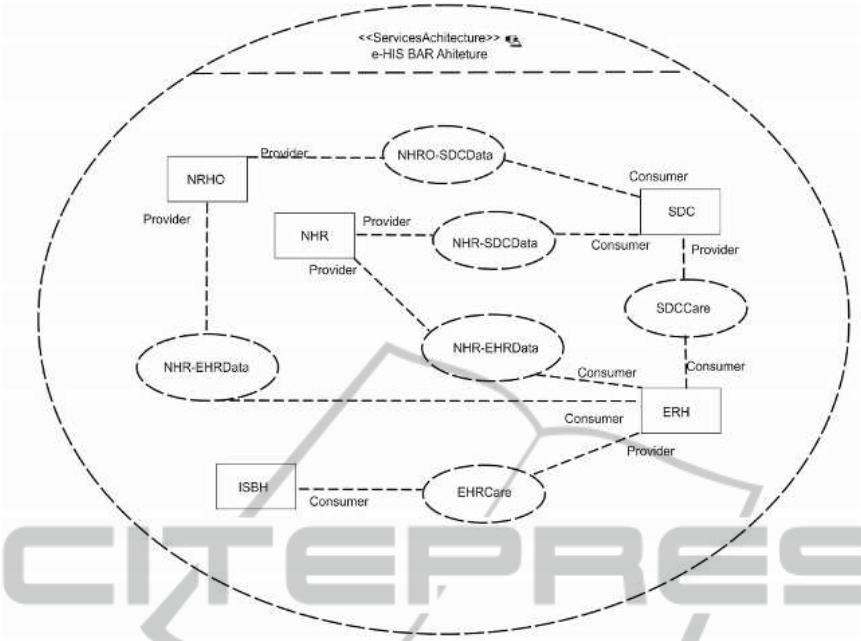

Figure 6: Service Architecture Diagram.

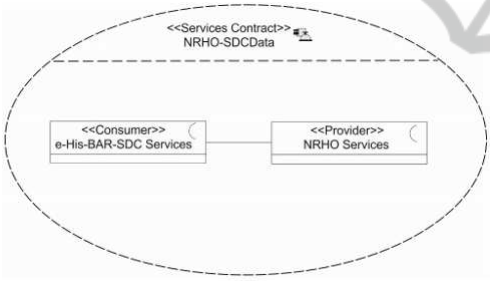

Figure 7: Service Contract diagram.

ample of Service Contract diagram for each relation between provider/consumer, a service contract, is created.

Another characteristic of SoaML is its capacity to represent a context of interaction between services and participants, representing a set of interaction between these contexts. Fig. 6 presents the Service Architecture diagram of the proposed domain. This diagram presents interaction between all participants and the contract services modeled in the variety of SoaML diagrams.

6 CONCLUSIONS

This study aimed to present the use of SoaML for modeling a service-oriented architecture (SOA) for health information systems. By supporting SOA, SoaML is an efficient modeling language to address interoperability between the various discussed systems. One of the advantages is realized by using SoaML to model a domain in health care is that it was possible to model the consumers and service providers. This would be quite difficult to achieve using UML only. Therefore, the main contribution of this work is to manipulate a relatively new modeling language to real operational problems related to the integration of health systems.

As for future work, the development of a simulator that implements the integration between systems through the use of web services is suggested. For this purpose, one can use the Java programming language and Apache Thrift framework.

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