Modeling the framework for obstetrics-gynecology department information systems

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Abstract

Objectives: The paper models business processes of an obstetrics–gynecology department (OGD) using the Generic Component Model (GCM) as modeling framework. The core application OGD Information System (OGD IS) is developed based on that model. Modeling the OGD workflow and using the HL7 CDA standard for communication with other Information Systems will lead to advanced interoperability with benefits clinical practice. **Methods:** Following the GCM core principles, first the analyzed system is defined. In the second step, the domain of interest is separated from other domains which are not relevant for the moment. The third step consists in composition/decomposition of the system in consideration. Finally, the OGD system is model-driven developed, using the ISO 10746 RM-ODP views and appropriate tools according to the Unified Process. For modeling the OGD business process and the ICT models, Business Process Modeling and Notation (BPMN) and Unified Modeling Language (UML) are used, respectively. **Results:** The resulting OGD IS model and its exemplifying implementation is developed for a medium hospital, respecting all the GCM core principles. The OGD system communicates with other medical units using the HL7 CDA standard. The result is a useful model for quick and real future implementation ready to easy interconnect with other systems. **Conclusions:** The paper presents a generic model-driven approach for advanced interoperability between health information systems. It has been demonstrated at quickly and flexibly developing an OGD information system (OGD IS).

Keywords

Model, GCM, BPMN, UML, HL7 CDA, interoperability

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EJBI 2012; 8(3):57–64

1 Introduction

To meet the challenge for efficient, high quality, safe and sustainable care in developing countries, there is a need to extend and improve communication and cooperation between all actors participating in better patients' care by creating interoperable health information systems.

Shared information is the foundation for seamlessly caring empowered patients with the strategic targets of high professional care quality, shorter waiting times and high level of user satisfaction, better information about service quality, efficient use of resources, and freedom of choice.

The paper presents the real current workflow in OGD of a medium hospital modeled using Business Process Modeling and Notation and the communication between OGD and other units using HL7 CDA standard.

The paper is structured as follows: Section 2 addresses the interoperability between EHR systems: requirements and interoperability levels; Section 3 presents the modeling of the OGD Information System; Section 4 describes the methodology and Section 5 presents the conclusions.

Table 1: Details on structure and content of the structured body of the CDA document "SAE report"

Interoperability Level	Instances
Technical interoperability	Technical plug & play, signal and protocol compatibility
Structural interoperability	Simple electronic data exchange
Syntactic interoperability	Messages, clinical documents, agreed vocabulary
Semantic interoperability	Advanced messaging, common information models and terminology
Organizations/service interoperability	Common business process

2 EHR Systems Interoperability

This section describes several requirements to be met for communication between different systems and presents the interoperability levels defined to meet the objectives and requirements of the actors involved in communication and cooperation.

2.1 Interoperability requirements

Communication between different systems and their components in a complex and highly dynamic environment must fulfill several requirements [1, 2]:

- openness, scalability, flexibility, portability
- distribution at Internet level
- standard conformance
- business process orientation
- consideration of timing aspects of data and information exchanged
- user acceptance
- lawfulness
- appropriate security and privacy services

2.2 Interoperability levels

For enabling meaningful communication and purposeful cooperation between actors, information and knowledge about the business objectives and the related business process must be shared. Depending on the established degree of shared information and knowledge, the involved systems have to accomplish this sharing by appropriate interoperability levels between the systems involved. Beyond the technical interoperability needed for any ICT-based communication and cooperation, five interoperability levels can be defined to meet the objectives and requirements of the actors involved in communication and cooperation, as shown in Table 1 [3].

3 Modeling Healthcare Information Systems

In [5], a model is defined as: „a partial representation of the reality. It is restricted to those attributes the modeler is interested in. The interest in the model depends on the addressed audience, the reason and the purpose of the modeling exercise as well as the use of the resulting model for certain objectives and time instead of real world. Therefore, the model as a result of an interpretation must be interpreted itself".

The Generic Component Model (GCM) was developed at the University of Regensburg Medical Center, eHealth Competence Center. The GCM is: "an architecture framework that enables the representation of any real or virtual system; includes the system architecture from its business prospective and the system's development process for ICT solution supporting or enabling that business" [3]. The OGD will be modeled using the GCM framework to reduce the complexity of the considered system and the development process by considering the appropriate level of system granularity and decomposing the complex real process of design, specification, implementation and deployment by representing and interrelating different views [5].

GCM supports the design of advanced EHR systems, representing the perspectives of different domains' experts using their special ontologies, expressed by their terminologies, so realizing and harmonizing a multi-disciplinary approach. It can be used to model the computation independent and ICT specific views on the systems and their interoperability during the development process [3, 6]. The GCM is presented in Figure 1 [6] and considers the system in three dimensions: one reduces the complexity of interrelated domains through separation, another reduces the structural complexity of systems by decomposing them, and the third reflects the viewpoints of ISO 10746 "Information Technology – Open Distributed Processing. Part 2: Reference Model" (RM-ODP) representing the 5 views: Enterprise, Information, Computational, Engineering, and Technology.

For managing the OGD process based on comprehensive patient data and the related obstetrics-gynecology process information, an EHR system as repository for OGD data must be established. Because of the OGD specific features, the EHR also includes ultrasound analysis

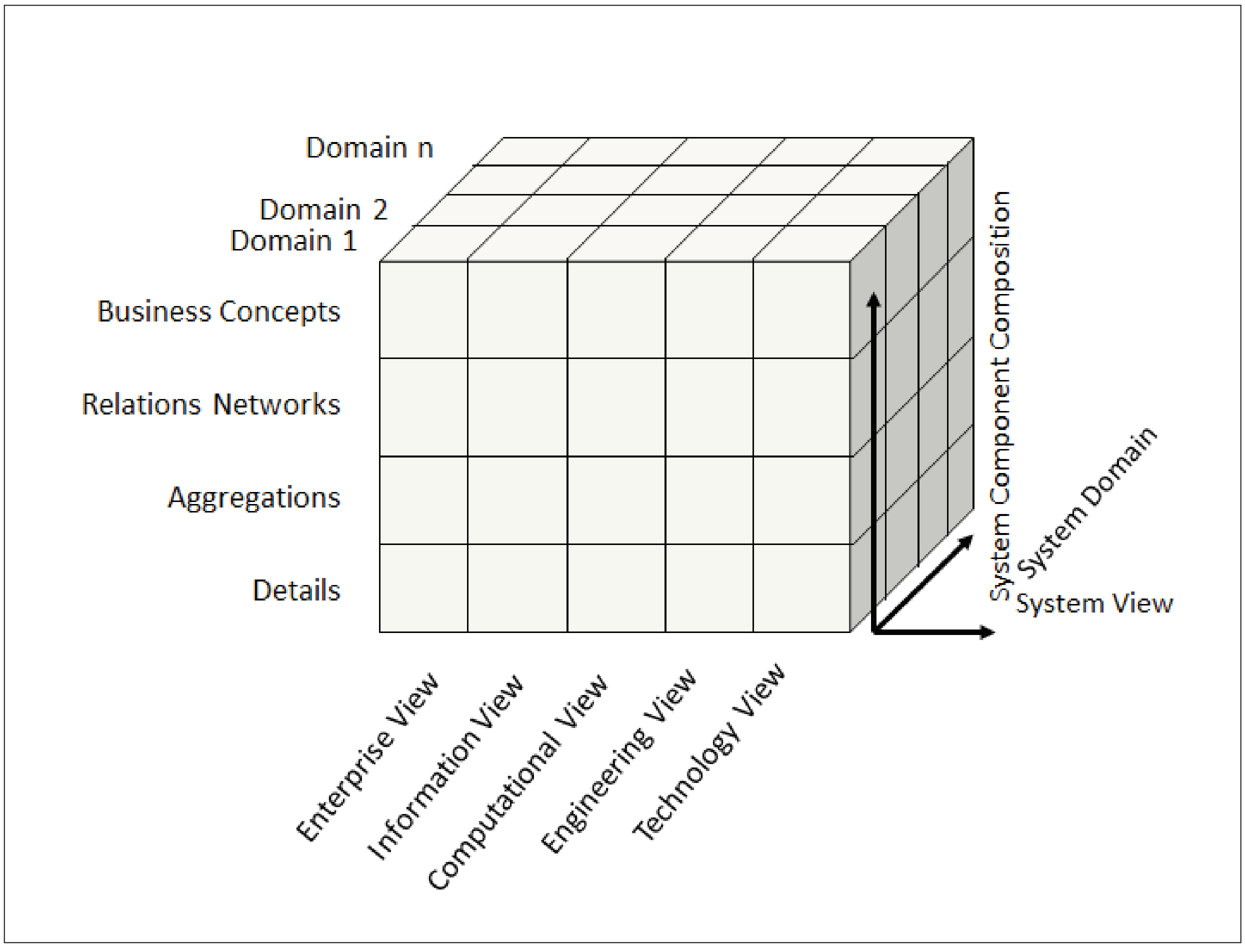

Figure 1: Generic Component Model

and other relevant information about the patients. As the OGD process often covers two patients in one when dealing with pregnant women, fast and easy access to information about drug interactions and effects on fetuses can be very helpful, or even vital. Ob-gyn specific, high quality EHR systems provide a helpful tool to getting information just in time, making a practice safer, more efficient and effective [7].

A computer-based observation chart contains all information about the patient necessary for the clinical management. Information can be fast and easily added to the chart as well as easily accessed by the medical staff. It contains data about consultations, diagnostics, patient evolutions, investigation results, additional treatments, and images resulted from different examinations [8].

Modeling the OGD system will be performed according to the GCM Framework [2].

The first step consists in defining the analyzed system, in our case the OGD IS.

The second step deals with the separation of the domain of current interest (here the medical) from other domains which are not relevant for the moment (e.g., financial, administrative, security).

The third step addresses the composition/decomposition of the analyzed system, considering four granularity levels (business concepts, relations network, aggregations and details).

The fourth step consists in the model-driven development of the real OGD system based on the five RM-ODP views previously mentioned.

4 Methodology

In Figure 2, the communication between the OGD application and other departments (pediatrics and neonatology) is presented using HL7 CDA standard [9]. If the OGD IS receives a request from other medical departments, it will analyze the request, extract the needed data, and send it to the requestor in CDA format as presented in [10].

The GCM-based modeling of the OGD IS has been described in general in Section 3 already.

Modeling the OGD system is performed according to the GCM Framework [2].

Regarding the third step of reducing the structural and behavioral complexity of the OGD IS by decomposing it, the considered OGD IS is composed by two major medical subsystems: gynecology and obstetrics.

Following, the fourth step, which reflects the system

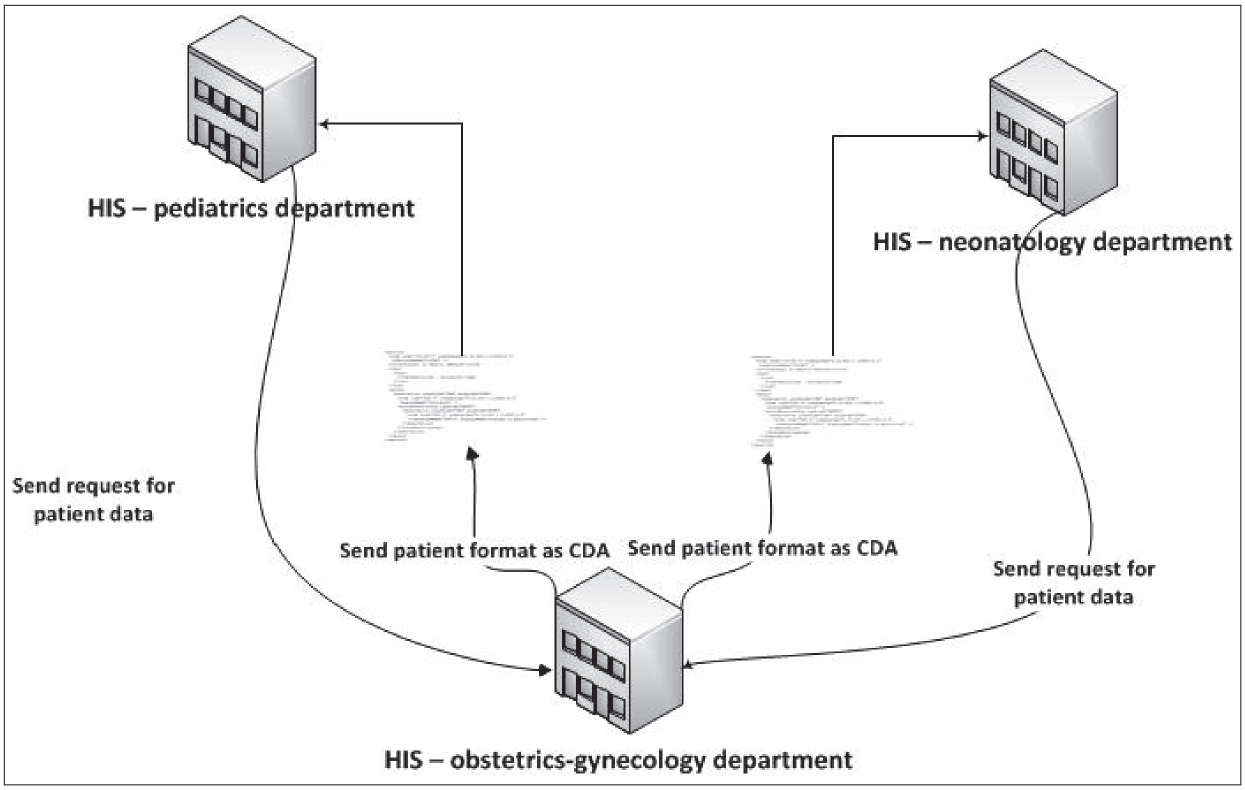

Figure 2: HIS departments' communication

development process based on the RM-ODP views, is described.

The first viewpoint is the Business view, in the RM-ODP called Enterprise view. In this view, the real workflow of the OGD is described, using Business Process Modeling and Notation for representing the process and UML for the IT perspective.

Figure 3 is presents the OGD workflow in BPMN.

In Process 1, the main actor is the doctor. If he wants to enter new data about a patient, the first step is to authenticate her to the system. The system verifies identity of the actor and his role regarding the privilege assignment for entering new data about the patient. If he is the right person in the appropriate role, he can enter patient data (demographics, gynecology and obstetrics) in the Patient Record previously created.

In Process 2, the main actor is the nurse which wants to access the report for getting patient data and using the report monitor. Firstly, she has to authenticate herself. After the system checked and verified that she has the appropriate privileges, she can receive the reports.

In Process 3, the main actor is the doctor. If he wants to add a new patient, the first step is to authenticate himself/herself, and when the system verified he/she is an appropriately privileged actor for access, the data will be added. Based on the right role, he can enter patient data (pregnancy monitoring data).

In Process 4, the main actor is the administrator. If he wants to make changes in the system, the first step is again the authentication. After the system verified the actor's access privileges, the changes into the system are operated. As actor with the privileged role, he has the possibility to create new accounts, delete accounts, to confirm the created or the deleted accounts. In most jurisdictions, medical data can never be deleted!

In Process 5, the main actor is the patient who can create a new account after her authentication and the verification by the system verifies as privileged actor. If allowed and if the actor has the right role, she can express the will to delete an account or request a report about monitored information about the pregnancy.

In Process 6, the main actor is an external hospital which requests data about a patient. Firstly, it had to authenticate itself, and the system checks the privileges. If they are correct, the data is send as an XML message in HL7 CDA format. The process is described in detail in Section 4.

Following, a scenario is presented, using an UML use case diagram. Figure 4 demonstrates the use case for adding new information about a patient by a doctor.

Doctor: The doctor uses the OGD IS for adding a new patient, or for amending information to an existing patient record. He can add demographic data, and thereafter he can enter gynecology and obstetrics data.

Interactions: The scenario starts when a doctor wants to add new information to a patient record. Once the doctor has logged into the system and the system checks that he has the privileges to add information, he can add or modify the medical record, registering the gynecology and obstetrics data, etc. It is important for them to cre-

Table 2: Interactions in sequence diagram for OGD IS 'sending information' use case

Interactions	Description
Interaction 1	An external hospital sends a request to the OGD IS.
Interaction 2	To receive data, the external hospital has to authenticate itself.
Interaction 3	The OGD IS is requesting username and password.
Interaction 4	The external hospital sends the username and password.
Interaction 5	A confirmation is sent.
Interaction 6	The external hospital sends a request with the person id of the patient.
Interaction 7	The message system requests data to demographic record.
Interaction 8	For receiving data the message system must authenticate.
Interaction 9	The OGD IS is requesting username and password.
Interaction 10	The message system sends the username and password.
Interaction 11	A confirmation is sent.
Interaction 12	The message system requests data from a certain patient's demographic record.
Interaction 13	The user privileges are checked.
Interaction 14	The message system receives the request data.
Interaction 15	The message system requests data of the obstetrics record.
Interaction 16	For receiving data, the message system must authenticate itself.
Interaction 17	The OGD IS is requesting username and password.
Interaction 18	The message system sends the username and password.
Interaction 19	A confirmation is sent.
Interaction 20	The message system requests data from a certain patient's obstetrics record.
Interaction 21	The user privileges are checked.
Interaction 22	The message system receives the requested data.
Interaction 23	The message system requests data to gynecology record.
Interaction 24	For receiving data the message system must authenticate.
Interaction 25	The OGD IS is requesting username and password.
Interaction 26	The message system sends the username and password.
Interaction 27	A confirmation is sent.
Interaction 28	The message system requests data from a certain patient's gynecology record.
Interaction 29	The user privileges are checked.
Interaction 30	The message system receives the requested data.
Interaction 31	The external hospital receives the requested data in CDA format.

ate first an account by filling in firstly the patient's demographic data, before adding gynecology and obstetrics data. If the patient is already registered, he can add the gynecology and obstetrics data directly.

Figure 5 presents the sequence diagram for the use case described in Figure 4. It shows the interaction between objects in the sequential order when specific interactions occur.

In Table 2 is presented the interaction which occur in sequence diagram for 'adding data' use case.

Figure 6 presents a use case demonstrating the possibility of OGD IS to send patient information to other medical units. The communication between the OGD IS and other medical units (e.g., pediatrics department information system, neonatology department information system) was detailed in Section 4.

Message system: The message system represents a component of the OGD IS that has the possibility to extract needed patient data and transform them into an XML message in HL7 CDA format.

External department/hospital: This actor can be the pediatrics department information system or the neonatology department information system and can request data about a certain patient from the OGD IS.

Interactions: The scenario starts when an external department/hospital requests information about a certain patient from the OGD IS. Firstly, the external hospital must authenticate itself, and secondly, the Message System checks whether the external hospital has the privileges to receive certain information. Thereafter, it extracts the data needed and converts it into an XML message in CDA format and sends it to the external hospital.

Figure 7 shows the sequence diagrams for the use case presented in Figure 6.

In Table 3 is presented the interaction which occurs in sequence diagram for OGD IS 'sending information' use case.

Figure 8 represents a part of the class diagram of the use case represented in Figure 5. The class diagram shows the data needed in the OGD IS.

Table 3: Interactions in sequence diagram for 'adding data' use case

Interactions	Description
Interaction 1	The medical doctor wants to add a new patient.
Interaction 2	The doctor has to authenticate himself/herself in order to enter data.
Interaction 3	The OGD IS is requesting username and password.
Interaction 4	The medical doctor sends the username and password.
Interaction 5	The medical doctor is logged into the system.
Interaction 6	The medical doctor wants to add demographic data.
Interaction 7	The OGD IS verifies if he has rights to introduce data.
Interaction 8	If the medical doctor has appropriate privileges, the data can be added.
Interaction 9	The medical doctor receives a confirmation that the demographic data were introduced successfully.
Interaction 10	The medical doctor wants to add patient's gynecology data.
Interaction 11	The doctor has to authenticate himself/herself in order to enter data.
Interaction 12	The OGD IS requests username and password.
Interaction 13	The OGD IS requests username and password.
Interaction 14	The medical doctor is logged into the system.
Interaction 15	The medical doctor wants to add gynecology data into the OGD IS.
Interaction 16	The OGD IS verifies if the medical doctor has rights to introduce data.
Interaction 17	If the medical doctor has appropriate privileges, the data is introduced.
Interaction 18	The medical doctor receives a confirmation that the gynecology data were introduced successfully.
Interaction 19	The medical doctor wants to add patient obstetrics data.
Interaction 20	The doctor has to authenticate himself/herself in order to enter data.
Interaction 21	The OGD IS requests username and password.
Interaction 22	The medical doctor sends username and password.
Interaction 23	The medical doctor is logged into the system.
Interaction 24	The medical doctor wants to add obstetrics data.
Interaction 25	The OGD IS verifies if the medical doctor has appropriate privileges to enter data.
Interaction 26	If the medical doctor has rights the data is introduced.
Interaction 27	The medical doctor receives a confirmation that the obstetrics data was introduced successfully.

Figure 8 presents 7 classes: Patient, Account, Consultation, Admission, Discharge, Chirurgical Intervention, Specialty Examination, and Laboratory test Results. The whole class diagram contains more classes: Medications, Anatomo-Pathologycal Examination, Cardiological Examination, Echography Examination, Radiology Examination, Digestive Examination, UroGenital Examination, System Examination, Objective Examination, Diagnostics, Oncology Examination, Respiratory Examination, Epicrisis and other classes for the obstetrics part.

This class diagram describes a part of the Information viewpoint.

All the terminology is in English, but it will be adapted to Romanian language in order to be practically applicable to the Romanian healthcare system.

5 Conclusions

This paper presents the design of an architecture based model-driven approach for developing an OGD IS system enabling advanced interoperability according to all the GCM framework. The steps for modeling the OGD IS according to GCM are:

- the first step consists in defining the analyzed system, in our case the OGD IS.
- the second step deals with the separation of the domain of current interest (here the medical) from other domains which are not relevant for the moment (e.g., financial, administrative, security).
- the third step addresses the composition/decomposition of the analyzed system, considering four granularity levels (business concepts, relations network, aggregations and details).
- the fourth step consists in the model-driven development of the real OGD system based on the five RM-ODP views.

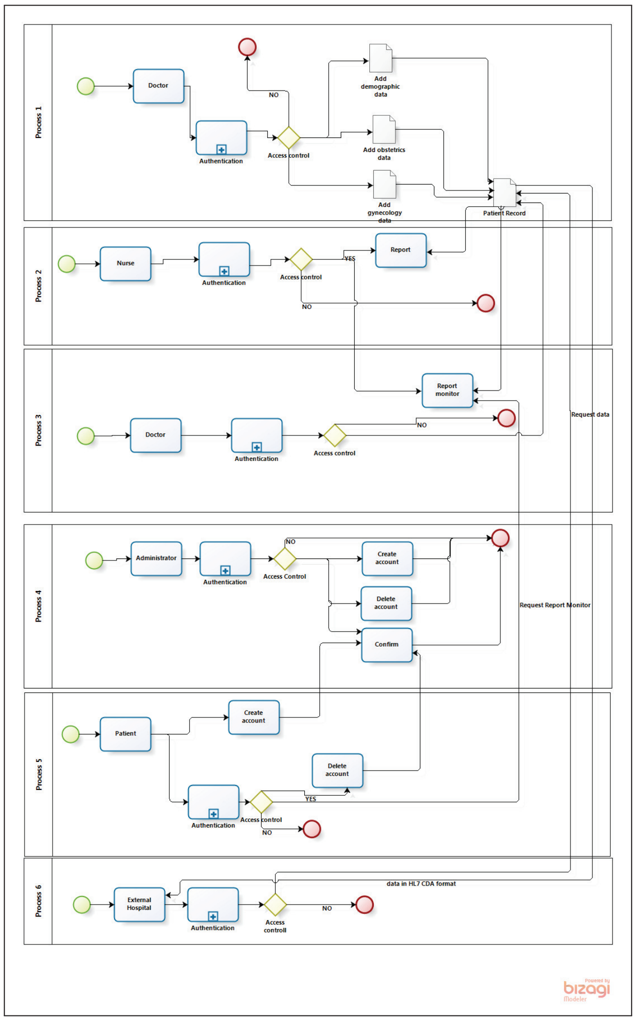

Figure 3: The real workflow in OGD

It addresses the real workflow in an OGD using BPMN and UML. The class diagrams for the presented use cases showing the Information Viewpoint are described. An important issue in the healthcare domain is the communication between health information systems. In this paper, we demonstrate how the OGD IS system can communicate with other departments (pediatrics and neonatology) or medical units, using the HL7 CDA standard.

The work presented in this paper prepares a framework for flexible and quick development of OGD ISs offering comprehensive interoperability.

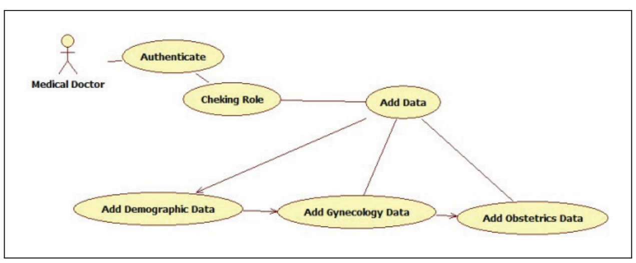

Figure 4: Use case 'adding data'

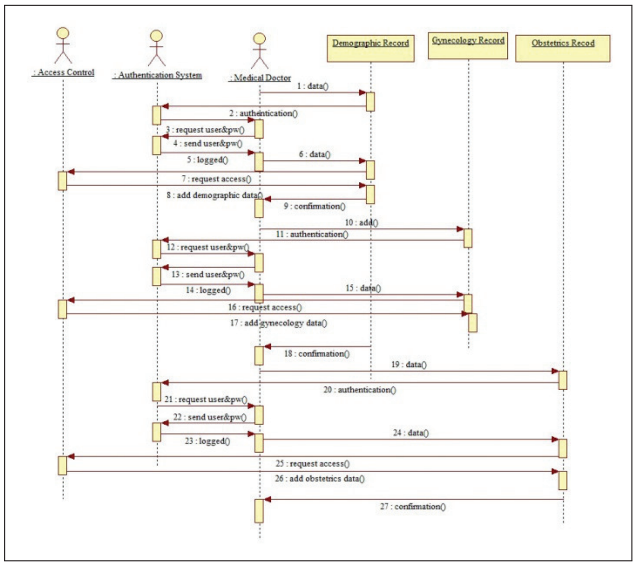

Figure 5: Sequence diagram for 'adding data' use case

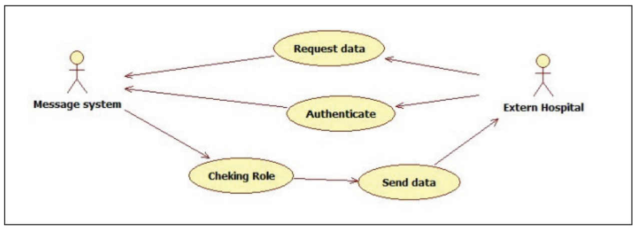

Figure 6: Use case 'OGD IS sending information to another medical unit'

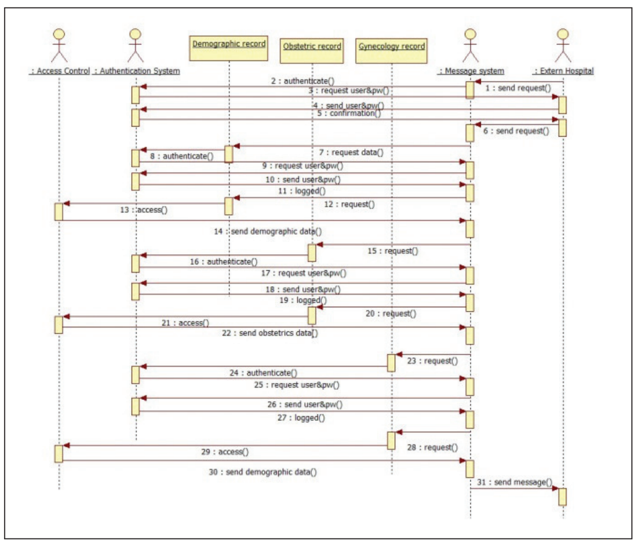

Figure 7: Sequence diagram for OGD IS 'sending information' use case

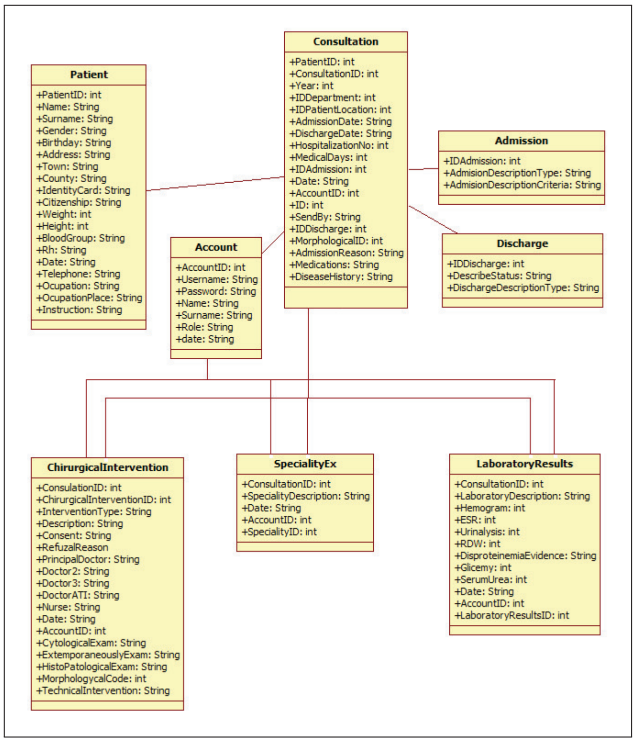

Figure 8: Class diagram which represents a part from OGD ISs.

6 Acknowledgements

This work was partially supported by the strategic grant POSDRU/88/1.5/S/50783, Project ID50783 (2009), co-financed by the European Social Fund – Investing in People, within the Sectorial Operational Programme Human Resources Development 2007-2013.

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