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Alignment of viewpoint heterogeneous design models
Case Study "Emergency Department"

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I. Introduction

Our goal is to simulate the design (modeling) of a complex system via a collaborative process. Each model − corresponding to a viewpoint on the system − will be built by separate (teams of) designers who work independently. First, the produced models will be analyzed and treated by a design expert named "integrator expert" so as to remove conflicts due to possible contradictions (e.g. incompatible attribute values, contradictory relationships among classes, etc.). Then the cleared models will be aligned by means of correspondences so as to produce a correspondences model. The Kernel of our approach is detailed [1, 2]. Our approach has two variants: (i) a mono-user version in case an integrator expert is capable of defining the correspondences at metamodel level [1, 2, 4], and (ii) a collaborative version in case all concerned viewpoints designers are involved in the definition of the correspondences model [5].

Our case study aims at modeling the application domain of an Emergency Department (ED) (of a hospital). The choice of this case study is relevant because it involves different designers, working on several aspects of the domain. Each of them represents a point of view. We have identified a set of points of view, but to simplify we will consider the following ones: medical, computing, process.

II. Description of the case study

Emergency Departments (EDs) represent a critical branch of any country's health system. Such departments are usually faced with emergency situations (accidents, natural disasters, terrorist attacks, wars, epidemics, etc.) that need special skills provided by a multidisciplinary approach where viewpoints are complementary. Moreover a need of coordination between actors must be taken into account in the design phase of such systems, so that the different models developed in this phase be synchronized. Non optimal management of EDs - which can be noticed quite often - comes partly from an insufficient consideration of these factors at design time. In addition, models can evolve because laws, regulations, business rules, operating procedures, security constraints and personal data protection, etc., may have to change. In this study, we place ourselves specifically in the context of the ED of a public hospital.

The designed models are connected to ensure the overall coherence of the system as well as scalability in order to take into account inevitable changes. Many actors are involved in the proper functioning of an ED, from nurse's aides to emergency physicians (i.e. surgeons). In order to model this application domain we represent the scope of three business domains managed separately by the following actors:

- Medical report designer: responsible for building digital mockups that define an Emergency Examination Report (EER). He creates a model expressed through a form metamodel,
- Software designer: responsible for the representation of organizational data of the information system. He creates an organizational model expressed through an object-oriented metamodel,
- Business protocols designer: responsible for the establishment of medical protocols to be applied by ED staffs. He creates a medical protocols model expressed through a process-based metamodel.

Various partners to participate in the elaboration of partial models describing parts of this complex system. Table 1 shows an overview of designers and their produced models whereas Figure 1 provides a detailed vision in an extension of SPEM called CMSPEM [12].

Table 1. Teams involved in the partial models' production

Actor, Laboratory	**Role**	**Model produced**
Bennani S., ADMIR	Designer	Organizational design model
Beugnard A./ Bach JC., Telecom Bretagne	Designer	Medical protocol model
Jamoussi Y., RIADI	Designer	Emergency Examination Report (EER) model
Osterweil L./ Shin SY., UMASS	Designer	Medical protocol model
Tran HN., IRIT	Designer	EER model
El Hamlaoui M., ADMIR	Supervisor	M2C, M1C

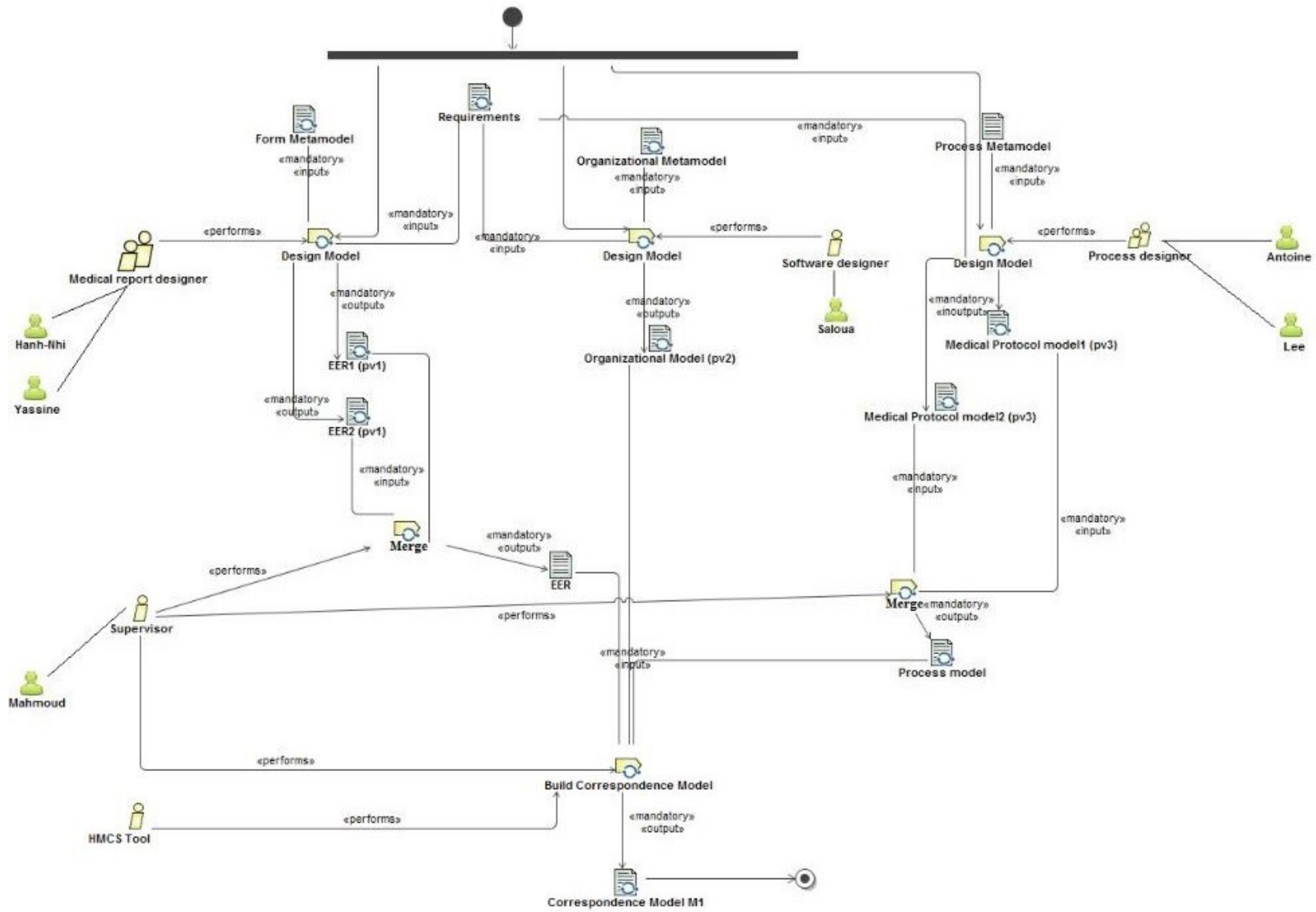

Figure 1: Alignment process instantiated with ED actors

In the following sections, we present the requirements identified for the elaboration of the models, and their respective metamodels. We do not consider the concrete syntax of DSLs, so, in the context of this study, a DSL can be seen as a metamodel defining an abstract syntax.

1. Organizational model of the ED

The organizational model must be conform to the metamodel shown in Figure 2. This latter represents a simplified version of an organizational metamodel in an object oriented form. The basic concept is the *package* which contains *classes* and *interfaces*. Each of them may have *attributes* and *methods*.

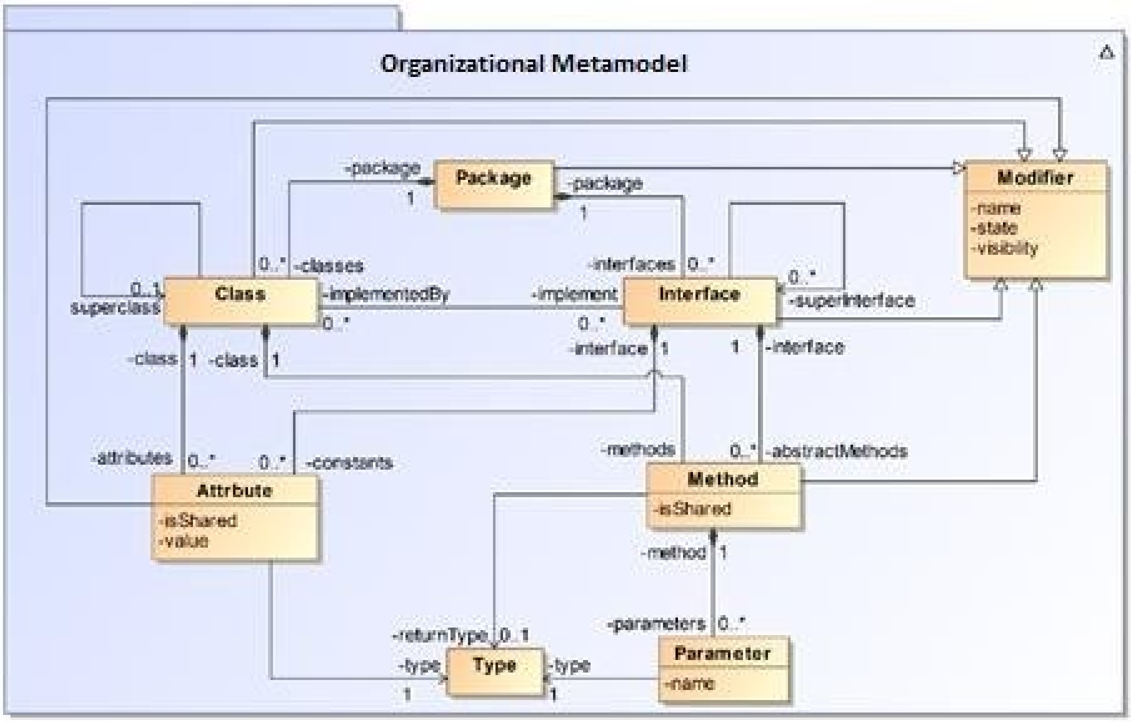

Figure 2: Organizational metamodel

Figure 3 presents the organizational model of an ED. This model presents the organization of an ED. An ED is characterized by a set of staff (administrative staff, technical staff, nurse, emergency physician and surgeon), its patients and examination rooms. For each staff member, it is possible to know his certifications and skills, spoken languages, his hire date and his schedule. The role of a technical staff is to maintain and order machineries. The Administrative Staff class contains methods to book rooms, to give information about a given doctor, etc. The emergency physician gives advices and treats his patients. A diagnostic has a name, a description and an act code. A surgeon performs a set of surgeries, each of them being described by a patient, a date, a type and an act code. The model contains also information about each patient such as his insurance number (if any), allergies, his medical history, diagnostics and prescriptions, etc.

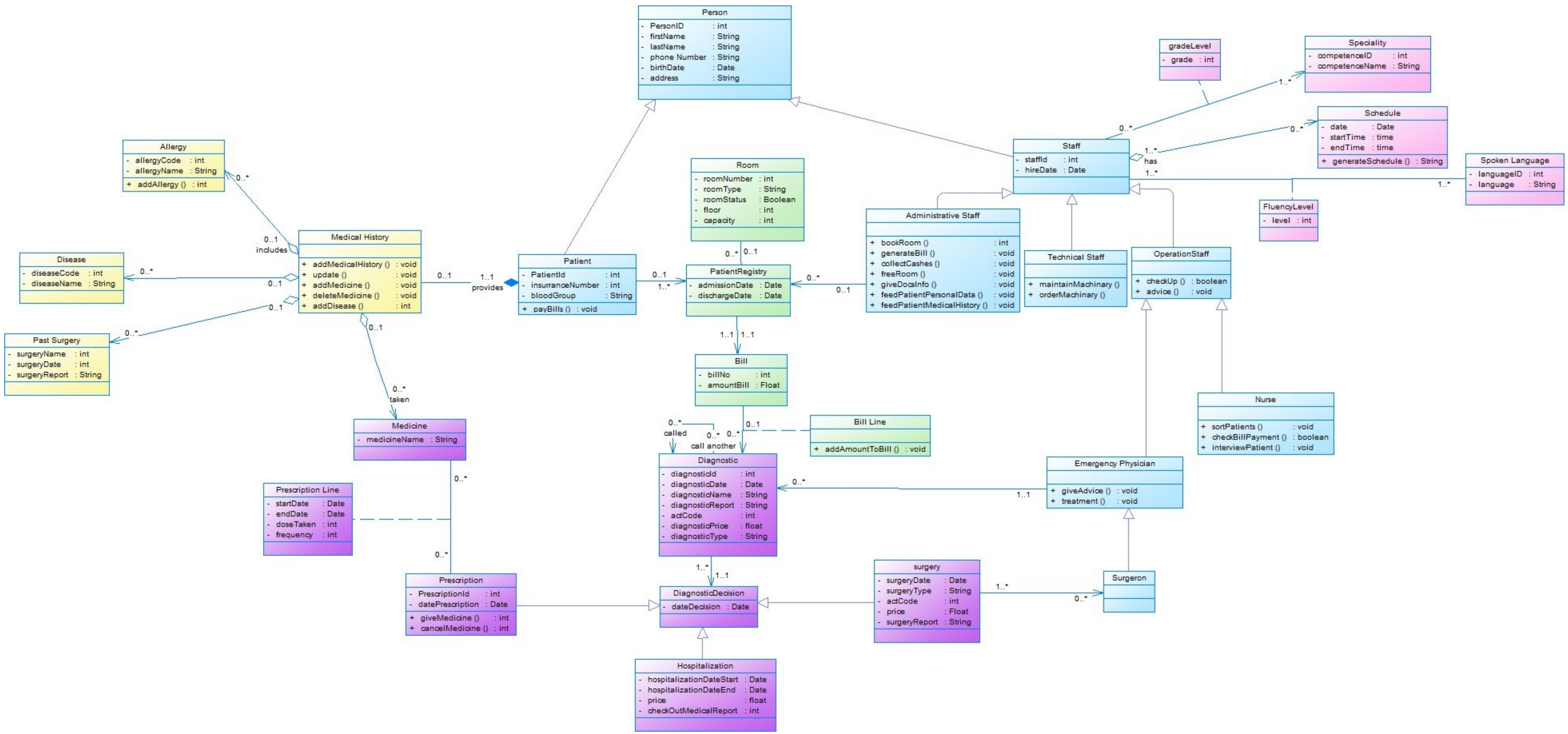

Figure 3: Organizational model

2. Model of an Emergency Examination Report (EER)

The metamodel proposed in Figure 4 allows the representation of an EER as a form with a set of optionally composite fields.

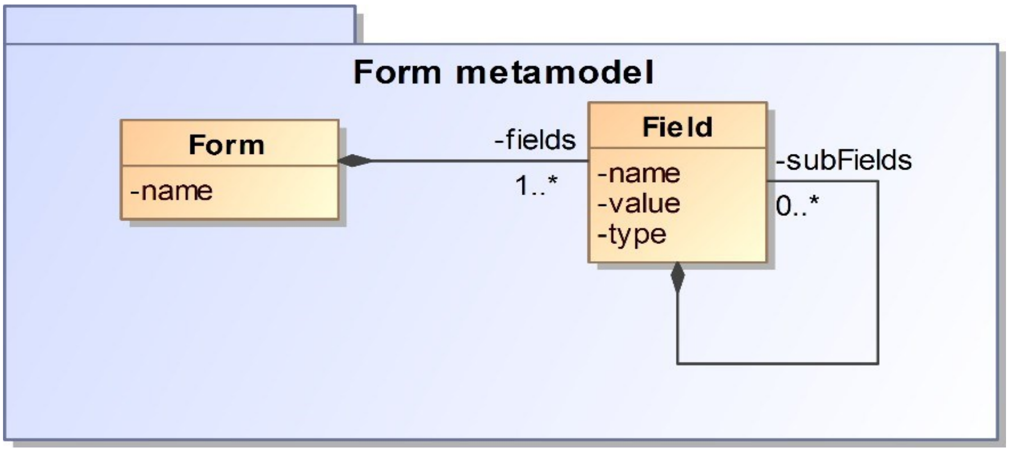

Figure 4: Representation form metamodel

An EER model represents information that will be produced by an emergency physician for a given patient. In a general way, it contains the identifier of the physician, information about the patient (social security number, first name, last name and age), the arrival date of the patient and a clinical observation. This latter is made using codified abbreviations and associated explanations. It identifies the pathology in order to direct the patient towards the appropriate service within the same institution or in another one. An emergency examination report can use a non-exhaustive list of abbreviations among:

- HR: hospitalization reason,
- ATCDT: antecedents,
- PT: past treatments,
- ALL: allergies,
- DH: disease history,
- Clinical Ex: clinical examination,
- Paraclinical Ex: biological and / or radiological tests.

Figure 5 presents one of the two proposals that we have received for this model. The model shown in Figure 5 is the one usef to align the ED system.

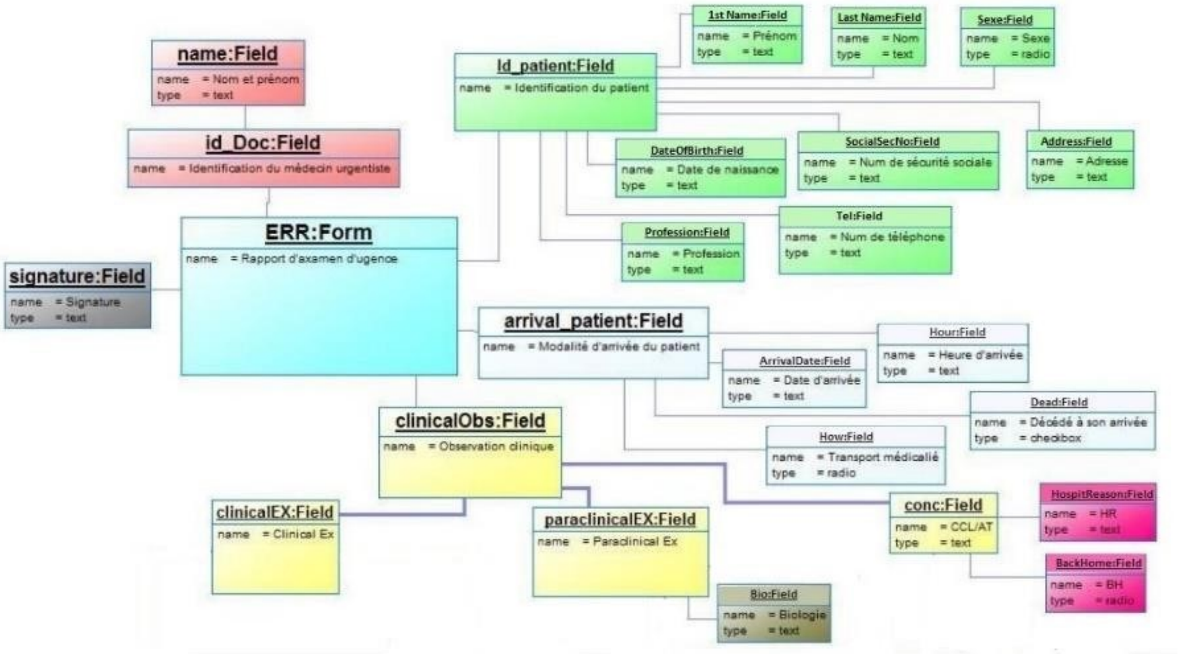

Figure 5: EER model proposed by *Jamoussi Y.*

3. Model of medical protocols

The metamodel represented in Figure 6 is the process metamodel used to construct the medical protocols model. It defines a concept called "processModel" that includes products, roles and activities, as well as relations between them. Activities are related to each other through the abstract concept ActivityEdge. An activity is also related to the abstract concept ActivityNode.

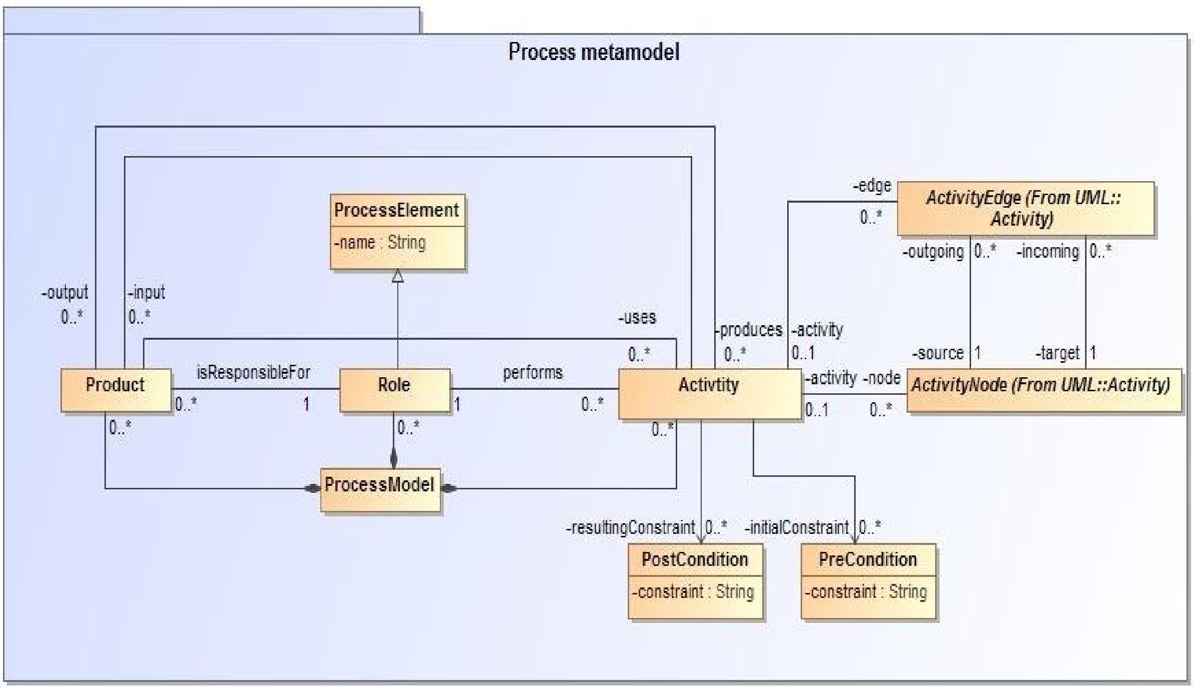

Figure 6: Process metamodel

This model describes the different protocols to be applied by each type of staff. Figure 7 presents the process model received. In an ED, each type of staff has a specific role. First, a sorting nurse receives each patient and directs him towards a medical service (medical or surgical). Then, a healthcare assistant installs the patient in a room (box) and prepares him. After that, a protocol interview is applied to the patient by a nurse in order to collect administrative data (i.e. social security number, etc.) as well as medical ones (i.e. antecedents, allergies, etc.). An emergency physician achieves a consultation and makes prescriptions. The nurse goes back to the patient and executes doctor's prescriptions that may include biological and/or radiological examinations, etc. Subsequently, the emergency physician sees the patient again and, according to the prescriptions results, performs the following actions:

- Diagnoses,
- Prescribes appropriate treatment adapted to the previous diagnose,
- Directs the patient to be: (i) Hospitalized locally, (ii) Transferred elsewhere or (iii) Back home.
- Performs act coding,
- Produces an Emergency Examination Report (EER).

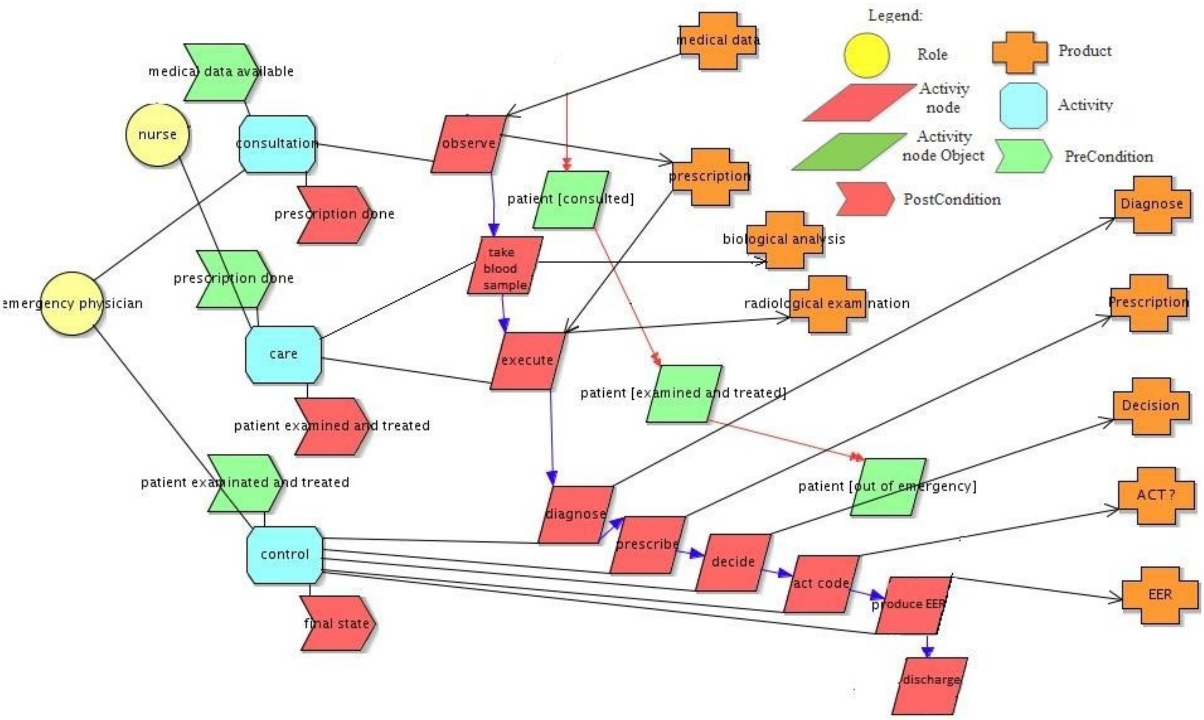

Figure 7: Medical protocol model proposed by Beugnard B. & Bach JC.

III. Enactment

For the sake of simplicity, we have limited our ED case study to three models. Other models could be also defined such as a model of ED's cartography, a model of drugs interactions, etc. After the decentralized phase of models designing, we have asked PhD students (outside our research team,), familiar with model driven engineering to enact the collaborative process of model matching presented in [5]. Thus, each one of them proposes correspondences at metamodel level (HLCs - High Level Correspondences). Table II recalls the proposed HLCs. We consider three designers, one per viewpoint. We call them: BP_{LC}, SD_{LC} and ER_{LC} which respectively refer to medical protocols viewpoint (Business Protocol - BP), Organizational (or Software Design - SD) viewpoint and emergency Examination Report (ER) viewpoint. A HLC is represented using the following syntax (where → is used for asymmetric relationships and ↔ for symmetric ones):

Relationship "["metamodel":" meta-element (→ or ↔) metamodel":" meta-element"]"

Table 2. Proposed HLCs for the ED system

N°	Initiator	High Level Correspondence	Decision-makers
1	BP_{LC}	Similarity [BP:Role ↔ SD:Class]	SD_{LC}
2	SD_{LC}	Similarity [ER:Field ↔ SD:Attribute]	ER_{LC}
3	BP_{LC}	Induction [BP:Activy, SD:Operation → ER:Field]	SD_{LC}, ER_{LC}
4	BP_{LC}	Generalization [BP:Role →SD:Class]	SD_{LC}
5	ER_{LC}	Deduction [ER:Field →SD:Attribute]	SD_{LC}

The five HLCs undergo an evaluation process, we do not detail here the evaluation process, but note that all of them were approved. The next step of the collaborative model matching process is performed automatically by our tool. This latter propagates the HLCs to the model level by (i) duplicating them by Cartesian product to models level, then (ii) filtering the generated correspondences (called LLCs- Low Level Correspondences) by keeping only those that satisfy the semantics of the relationship they use. Figure 8 presents the produced model of correspondences from the five approved HLCs.

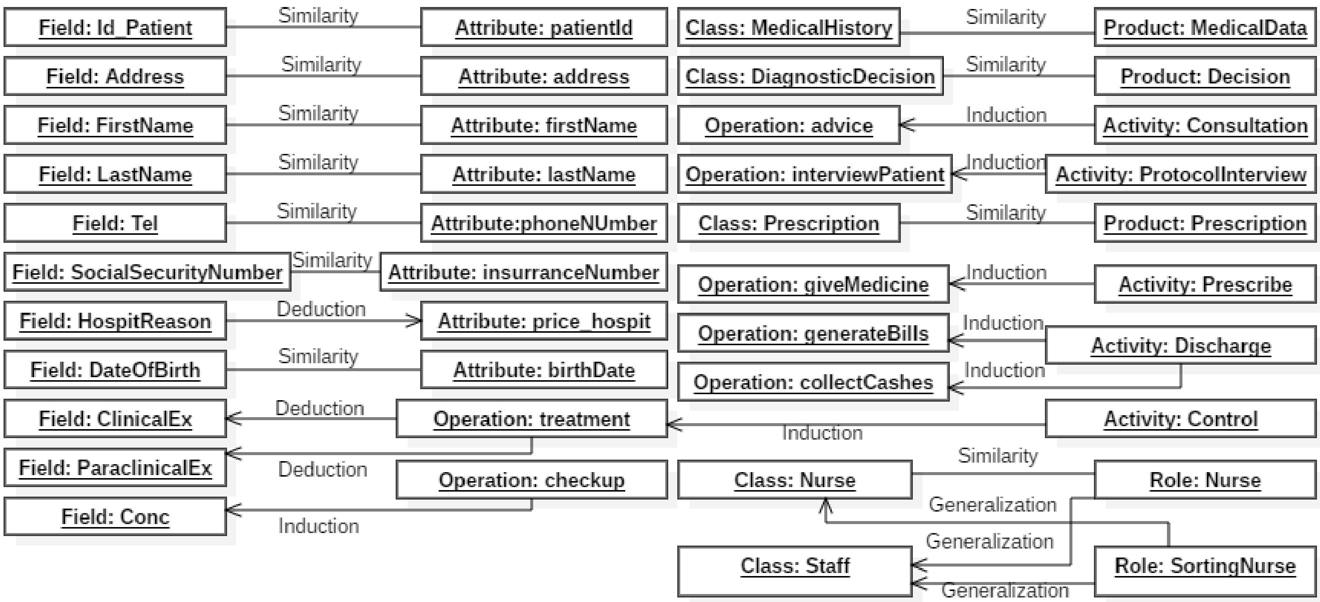

Figure 8: Model of correspondences of the ED system

IV. Conclusion

The Emergency Department case study allowed us to verify the feasibility of our approach. Partial models were designed in a collaborative way, by separate research teams. Each team focuses on a viewpoint and provides a model conforming to the metamodel of this viewpoint. The enactment of the collaborative matching was also performed collaboratively by involving PhD students (outside our team).

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