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A PATTERN-BASED WORKFLOW TO AN AUTOMATIC PLANNING AND MONITORING OF MEDICAL ACTIVITIES' PROCESSES

Abdelhak Kaddari, Mohammed Ouçamah Cherkaoui Malki and Said Benomar Elmdeghri

FSDM, Math and Informatics Department
University of Sidi Mohammed Ben Abdellah
BP 1796, Fez, Morocco
abdelhak.kaddari@usmba.ac.ma; cherkaouimmo@hotmail.com; said.benomar@gmail.com

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Abstract. *Several health projects are developed in order to improve the quality of healthcare services that are provided in medical field. In addition, interoperability establishment between health care information systems is one of the principal objectives of these projects. Hence, it allows implementing a sophisticated cooperative platform that will orchestrate the access to the distributed information systems' data bases. In practice, several obstacles are encountered during the implementation of most proposed solutions. This is due to many complexities related to resources handling, organizations structure and functionalities, etc. In this paper, we addressed the problem of communication between healthcare actors. Actually, in a patient's complex medical process, the lack of planning tools and supports leads to a weak communication quality between involved actors. In order to resolve that, we adopted a unified modeling approach to implement a workflow system that allows: planning, managing and controlling the common work space between stakeholders in a medical activities' process. Moreover, we employed many Business Process Management (BPM) technologies such as: BPMN, BPML, WS-BPEL, OWL-S and CEP-Engine via SOA architecture in order to organize the global medical activity by running a workflow between stakeholders.*
Keywords: Pattern-based workflow, Medical activities' planning, Cooperative system, Medical processes

1. **Introduction.** In many countries such as Morocco, the problem of interoperability of Hospital Information Systems (HIS) is a challenge. The problem arises when care units that are not belonging to the same hospital bodies are involved in the same care process. The "paper document" becomes then the only means to exchange information. Inter-operative systems are often conceptually heterogeneous and do not have any particular constraints to adopt a standardized communication model, e.g., HL7. Each system produces its own data related to a given patient and his pathological case. However, the automatic integration of all these data in the same context would provide a similar quality of care to the one obtained if all workflow phases have been performed in a single hospital. We consider here that this data integration is performed in real-time and without any data transcription (rekeying). The situations where interoperability is important (or even crucial) are becoming more frequent. Because of the increasing fragmentation of care processes, patient mobility and professional overload, the course of treatment must necessarily pass through several points. This requires interoperability between systems not originally designed for this purpose. We find in the literature several health projects that attempt to meet the collaboration and/or cooperation needs through the construction of poles and networks between various health institutions. However, the proposed

solutions are limited to some functions such as human resources management, messaging and appointment making.

Through this paper, we will provide an interoperability platform that will allow these HIS exceed the constraints of heterogeneity through a "virtual pooling" of human, hardware and software resources involved in each care unit. Based on a service-oriented architecture SOA, we thought of a unified approach of workflow. In this approach, each medical unit may intervene in a common medical process with other partners, while having the ability to preserve its initial deployment strategy of hardware and software resources. Beforehand, each participant (HIS) is invited to present the activities it wants to share by modeling them as web services provisions that are available on the Net. Based on this services-oriented architecture, we relied then on the pattern of global medical activity to integrate the data that are produced by each actor which is involved in a care process. We thus reached a unification pattern and a system of the following procedures' automation:

(1) Planning of global medical activities (complex pathological cases);
(2) Execution of planned activities;
(3) Monitoring and control of medical processes.

The rest of this paper will be as follows. In Section 2, we briefly represent our work's context. In the third section we discuss the tools and technologies of our proposal. Then we interpret obtained results in the fourth section. Finally, we discuss and conclude in the last section.

2. **Background.** Health care is functionally organized in various types of institutions as they may belong to public or private sector (primary care units, hospitals, home care units...). Each of these institutions has its own more or less isolated information systems. Specifically, these systems were created at different points in time; therefore, they were implemented using different development's paradigms and so, different hardware and software platforms are proposed. Consequently, it is difficult to integrate them and make them collaborate on a patient's common process. Regarding these constraints and according to experts, it will be practically impossible or undesirable to get rid of the existing information systems and develop new ones from scratch. To this end, researchers are debating in order to develop and introduce methods and tools that can seamlessly integrate existing resources while the new information systems can be easily accommodated. Moreover, it is required to find solutions for interoperability between these systems.

From this point of view, the implementing interoperability architectures of such systems can be established according to the following three approaches [1]:

(1) Integrated approach which ensures interoperability using shared runtime environments and shared communication conventions;
(2) Unified approach that provides interoperability using meta-models and shared concepts and specification environments;
(3) Federated approach which establishes and maintains collaboration between autonomous local services, in which each one runs a local business process.

In the late 19$^{\text{th}}$ century, the integrated approach is used in the development of various works and particularly in traditional middleware EAI (Enterprise Application Integration) under situations such as the one detailed with Bernstein et al. [2]. As soon as the Service Oriented Architecture with Web services is emerged at the beginning of the 20$^{\text{th}}$ century, the unification buses become increasingly service oriented. Hence, Enterprise Service Bus (ESB) applied in SOA architecture is one of such applications [3] that was applied in e-business. Currently, a second type of oriented federation ESB appeared where implementation standards are specific to protocols rather than services' providers/clients.

This allows loose coupling via federated systems as the one implemented by authors in [4]. They proposed a large-scale ESB federation architecture of SOA. They also studied the conceptual level and they did not discuss in detail how to use semantic technologies to solve semantic problems. Liu's work [5] analyzed this technical problem and proposed an advanced federation architecture SSB (Sementic Service Bus) entitled Ontology-Based and Goal-Driven (OBGD) architecture. The medical field is characterized by the autonomy of its services, the distribution and heterogeneity of its information systems. This causes high mixed complexity at the organizational level as at the functional level. It is very difficult to implement or adopt the general proposed solutions as in e-business or e-commerce, etc.

To this purpose, various works are developed but they are still in consideration in order to achieve powerful solutions. Among the proposed solutions aiming to solve interoperability's problem in medical field we find DAMIS architecture (Distributed Agents for Medical Information Systems) which is based on an oriented federation approach [6]. It is composed of a set of autonomous cooperative agents that are geographically dispersed and belong to heterogeneous information systems. This architecture is viewed as a society of agents forming a multidisciplinary intelligent system that cooperates in order to meet a common goal which is exchanging and sharing of medical information to fully support patients. Another different approach called mediation architecture was introduced in [7]. They used an integration approach in order to establish interoperability criterion in medical information systems. This integration was done via three interesting aspects: data integration, function integration and workflow integration. Moreover, it provides a modular organization of information systems to access many network connected data sources. The mediation is based on a central component called mediator [8], which is responsible of the processing that allows client's applications to get data from local data sources. In a vision through a unified approach, the authors in [9] have proposed an SOA architecture model, by starting from the reality of the medical activity process practiced on the patient. It is a model that will enable the realization of a patient-centered cooperation platform by directly exploiting the latest web service technologies on SOA. We observed that this model provides, for each intervening actor, the opportunity to transmit its services by modeling their functionalities via web services. However, the problem lies in the inability of the intermediate layer (see Figure 1) of this model to manage and control the common working space between the participants of a medical activities' process. The workflow management's systems constituted one of proposed solutions to address this kind of problems. This solution was the subject of several research works such as [10-12]. For example, in [12], Schlegel and his colleagues have developed an approach that implements a workflow's management platform to use a complex events' management engine by assuming the composition of complex business processes. In light of the cited works, and in order to achieve a best practice of medical activities, we seek via present work to

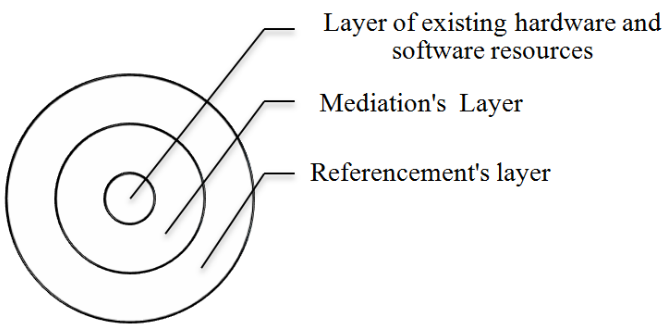

FIGURE 1. Our urbanization view for developing interoperability of systems

develop a proposed mediation layer [9] between heterogeneous medical systems, through the implementation of models based workflows' unification approach.

3. **Methodology.** We seek to implement a workflow system that offers an automatic planning, managing and controlling of common work space between stakeholders in a medical activities process. We adopted a unified approach to model our workflow. Using SOA architecture, we employed web services technology via this approach, to organize a global medical activity by running workflow between stakeholders. In the rest of this section we will discuss the basic elements of our proposal.

3.1. **Workflow system.** In healthcare organizations, patients who have complex pathological cases (i.e., patients require the intervention of several specialists), the cross inter-service missions are often imposed in order to fully support these patients. The cross missions require research of interoperability solutions between information systems to facilitate cooperation between actors. To this end, we seek to enhance interactions of health inter-organizational by modeling a workflow system via a unified approach based on medical activity model. We may implement this system at the mediation layer in order to meet the interoperability between existing systems (Figure 1). As cited in the second section, it is impossible to eliminate existing information systems and rebuild them from scratch or replace them with others. For this, we set among our work principles: (1) keep as much as possible existing hardware and software resources of each system, (2) integrate them via the unification of medical processes' workflow.

The WfMC consortium proposes the following definition of a workflow, "A workflow is a process of an organization, manageable by a workflow tool. It is established with the primary purpose to automate the execution of the process, it can also serve to stimulate and analyze this process". So we deduce that an enterprise can automate its processes by defining an executable workflow via a specific tool. This tool will become a workflow system when multiple processes of a company or several companies must be mutually automated. According to the same consortium WfMC "a workflow system defines, manages and implements procedures by implementing programs whose execution order is predefined in a logical computer representation of these procedures". We comprehend from this definition that workflow system implementation starts by defining procedures which are corresponding to medical acts. These procedures will be practiced during the execution of a corresponding medical activity. Then, the implementation step will be terminated by definition of programs and computerization of representations that are adequate for system development. Now we proceed to specify suitable type of workflow system for our situation, and to discuss possible methods to define procedures and programs that will be implemented in process. The McCready classified the workflow systems into three categories [13].

(1) First category: Administrative workflow systems (General Purpose Workflow Management Systems) used to implement administrative processes. The obtained Workflows are repetitive with high predictability, simple structure and without complexity. In addition they undergo very rarely changes and updating.
(2) Second category: Ad hoc workflow systems allow management of unstructured process, i.e., the tasks cannot be known during the activation of a workflow.
(3) Third category: Transactional workflow systems allow management of processes and structurally complex tasks (especially activities' processes which are spread over several sites). These processes are high-value and they realize the processing of transactions' large volume.

In the medical field, two first types of workflow systems are often used to automate some simple features such as updating patient records, scheduling of rooms and technical platforms. However, the workflow modeling procedure becomes more complicated specifically in case of managing and controlling of distributed tasks between participants through a cooperative space. The cooperative work, unlike the collaborative work, will be completed by the completion of assigned tasks to the participant distributed services [14]. In this case it is very interesting to exploit the advantages of the third category of the workflow system (transactional system) that allows solving composition problems of distributed services. This type of workflow system requires the adoption of a reference model to facilitate the automation of a large number of transaction flows between stakeholders.

3.2. **Modeling approach of workflow via SOA architecture.** In order to implement a powerful workflow system, it is very important to previously ask the question "how?" in the studied context. For this it is crucial to think about the appropriate approach to model such situation. Generally, a workflow modeling is based on two approaches [15]: the functional approach centered on activities and the relational approach centered on roles.

Most existing modeling methods are based on the first approach that starts with definition of the task list and then the persons who carry them. The main applied coordination mechanism in this approach is based on processes standardization. While the relational approach which focuses on the roles, reinforces the group as a social system. The process is described as a network of relationships between involved actors in actions that are grouped into processes. The applied coordination mechanism is based on the standardization of skills. And the objective of this approach is to create a dynamic group.

In our proposal, we model according to the second approach because firstly, our architecture must be open to all organizations which can and want to participate in shared medical processes; therefore, we cannot specify previously the actor list who will participate in each process. Secondly, the medical processes will be modeled dynamically depending on the availability of classified actors according to their roles (or skills) which they can play.

To effectively implement the business processes (which are directly visible from the outside) in order to integrate systems through a workflow, it is essential to model these processes before modeling workflow [16]. And for a perfect medical process modeling via approach centered roles it is crucial to define roles within health organizations. From our viewpoint, definition of roles is based on reference model that corresponds to each medical activity because, as will be explained later, this model presents features or skills which are necessary to start the corresponding medical process. After roles definition, it comes modeling stage of medical process. In light of services oriented architecture SOA, a medical process will be modeled as composition of tasks that are associated with distributed web services. For this it is necessary to establish a mapping between:

(1) Medical process that is corresponding to a given medical activity and which is represented by set of medical acts that will be realized by the corresponding actors;
(2) And web services which represent possible roles and skills of each actor.

When performing a given medical activity, each actor in its medical unit must deliver the results of tasks execution that are assigned to him by the system. For this purpose we must search for each medical process actor who can play required roles. And we must seek how to return results after task achievement. Practically we use web services, as distributed applications on the web for a possible access via specific protocols [17] through SOA architecture. In this manner, we can present for each actor tasks and skills that he can perform; and again we can present expected results after medical process execution. So good modeling of medical process is necessarily based on Web services modeling.

And to achieve a perfect modeling of web services that allow meeting requirements of a given care process, we use the same reference model adopted in roles definition stage. Finally we summarize the adopted workflow automation scenario in our approach as follows:

(1) The adoption of a reference model of medical activities from BMA model;
(2) Services modeling according to reference model;
(3) Modeling and implementation of workflow that allows automation of invocation and control procedures of web services that constitute a given process.

3.3. **Unification model: reference activity.** We seek to establish, by basing on medical activity notion, a planning and control automation mechanism of medical processes between various stakeholders. For this purpose, we make this activity really viewed in a visible structure and may be treatable by the processors. So it is required to adopt a standard structure which we can represent any activity. To this end, we use a proposed design pattern of a medical activity by authors in [18]. This design allows translation of process care into a visible tree of medical activity (activity, sub-activity, etc.) and retaining the chronological sequence of steps that make up them. In order to adapt this design pattern for service-oriented architecture in hospital, it is detailed by authors in [9] with the improvements; and *i*'s titled by Basic Medical Activity (BMA) (Figure 2).

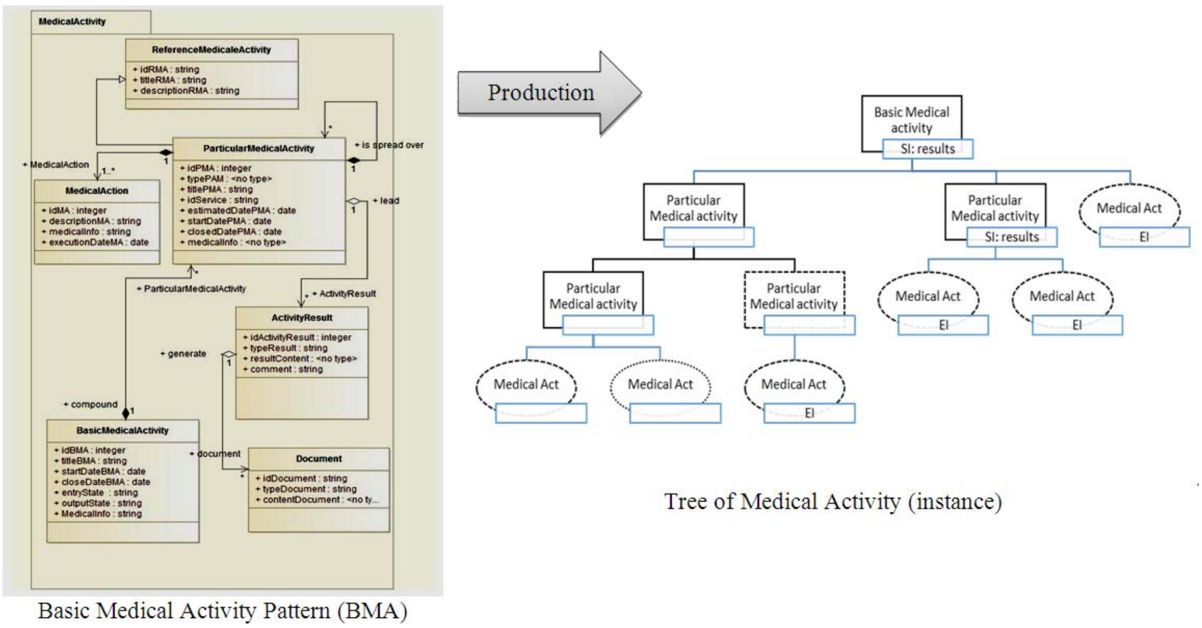

FIGURE 2. Design pattern for production of a tree structure of global activity medical

A present design pattern is a standard UML model which is transformable into any definition format of model such as XSD (to be discussed in the next section). The BMA model enables to generate a medical activity as a tree structure. The header of this tree is titled as name of input activity which is assigned by the attending physician when the first contact of occurring patient. This name can be updated after consultation. Nodes of this tree are the activities to be achieved by corresponding actors (each according to his specialty). These activities titled by Particular Activity (PA) or specific activities which consist of medical acts and/or other PAs. From this point of view, a medical activity tree is designed, for one hand, as an abstract medium that helps health care providers to specify the treatment to realize on the patient by consulting the tree. And secondly it is a concrete support that allows the recording of all relevant information. This information may be an elementary information EI or synthetic information SI in the exact position of patient medical record [19]. So it will be possible to record the tree of medical activity that associated to a patient in any kind of data base. We supported this design pattern in order to contribute unification architecture of work space between actors who want to share their patient care processes. This is not an exhaustive pattern but this is just a model in a standard format that enables us to evaluate our proposal.

In the next section, we presented our modeling approach to implement a workflow system that allows automation of necessary planning and monitoring procedures of medical activities processes.

4. **Our Proposal.**

4.1. **Modeling approach of medical workflow system.** We spoke above about of design pattern BMA that defines any global medical activity. Such activity represents a medical process in medical field. As for standardization reasons, we saved this design pattern in one standard format such as XSD. The instantiation of this model means the instantiation of all component parts. These components are set of Particular Medical Activities (PMA) and Medical Acts (MA) that correspond to a given pathological case. At the end of a medical process, the details of execution and monitoring of patient's healthcare are recorded as an instance of XML model (Figure 3). Thus this instance represents a storage medium for patient care process (all traces of acts carried out with produced relevant information). Once a medical activity is finalized and closed, we keep the corresponding instance of model as a reference medical activity associated to the treated pathological case. This reference activity will be further operable to track an identical case.

FIGURE 3. Instancing of XSD model to an XML instance

In our proposed approach we adopted the reference activity as input of workflow system. And we proceed via three important tasks.

(1) Find a modeling mechanism of web services which are basic elements for an automatic composition of medical processes. (Subsection 4.2)

(2) Find an automation mechanism for planning procedure of a medical process that is associated with a given pathological case by basing on the corresponding reference activity. (Subsection 4.3)
(3) Find an automation mechanism of the invocation and control procedures of each generated medical plan. (Subsection 4.4)

The first task allows, in light of reference activity, to put an appropriate method of medical web services' modeling for all stakeholders (Actors) in a given process. The second task allows defining a workflow which will be implemented in a generation tool of a medical plan. This plan's generator performs the planning of medical activities through calls to web services available, by using the basis of ontologies and mapping rules. In the third task we set up a workflow to be implemented in a CEP engine (Complex Event Process), which is responsible of the execution of generated BPEL medical plan. And again it is responsible to control all process's tasks (Figure 4).

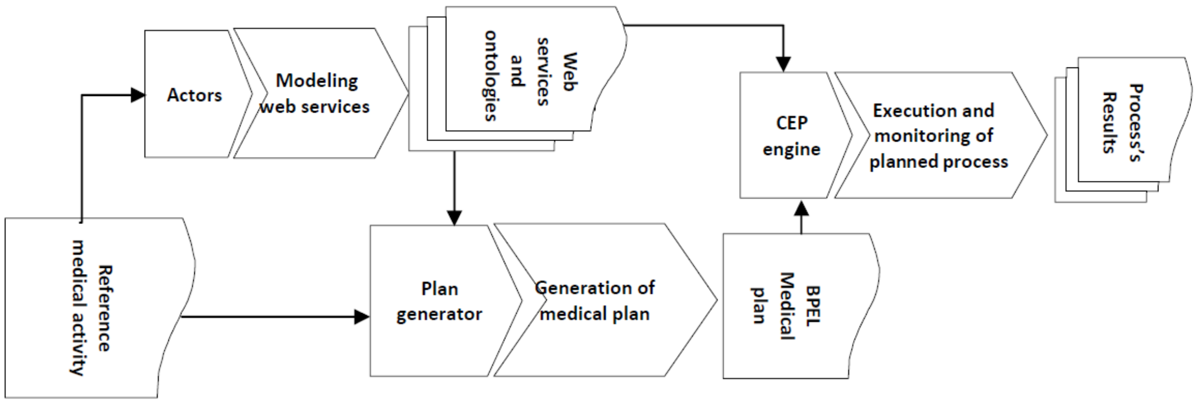

FIGURE 4. Our approach to model a medical activity workflow

After the patient's identification (or registration), Doctor begins an initial diagnosis in order to specify an appropriate procedure to start patient's healthcare process. For this, according to our approach, the patient has two possible cases:

(1) First case: the patient presents complex symptoms which obligate the physician to follow a personalized and specific procedure;
(2) Second case: the patient presents symptoms that refer to a known pathological case which is saved as a reference medical activity.

In this study, we model the second case in which the Doctor is responsible for starting a cooperative workflow to fully support patient that presents a known pathological case. Hence, after choosing the appropriate reference activity, Doctor invokes a medical plan generation tool (medical plan generator). The output of the generator is a medical plan in two versions; the first is intended after printing for human use (the patient, the attending physician and other); the second version is written in BPEL executable language on the execution engines. After validation by Doctor, BPEL plan will be given to the CEP engine which is in charge to make calls of planned services with process progress control.

The corresponding workflow diagram is made on BonitaBPMCommunity-6.4 platform [20] (Figure 5).

4.2. **Web services' modeling.** To achieve assigned objective to a group via a cooperative work space, each stakeholder in this group should complete assigned tasks by the workflow system. In medical field, it is said that an actor (doctor, radiologist, surgeon,

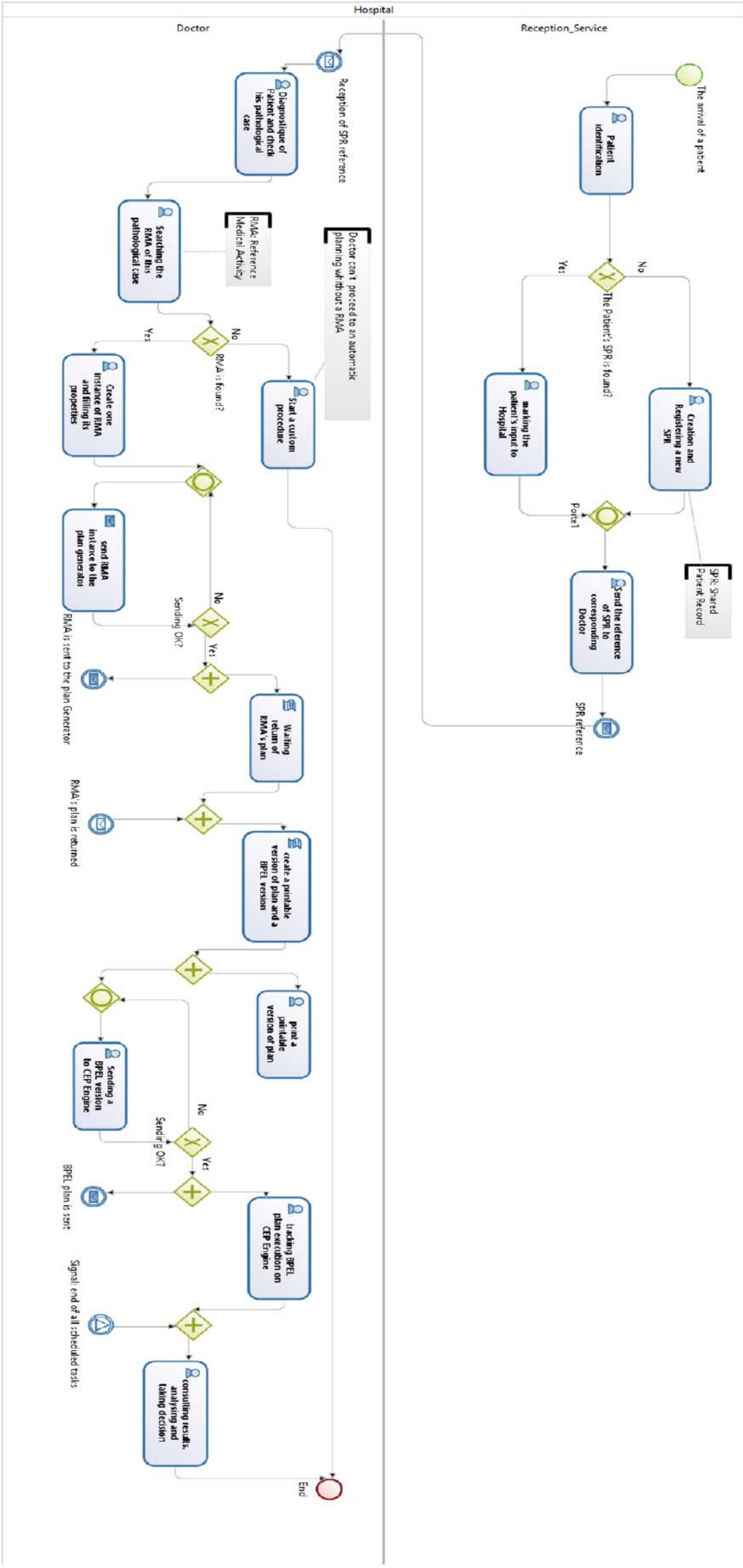

Figure 5. Workflow automation based on reference medical activity

etc.) well finalized its work if he has provided the results after completion of tasks already entrusted to him. We sustained web services via SOA for entrusting the tasks and even returning the results to participants which are involved in a working group. In this part of paper we have addressed issues concerning our modeling approach of web services (implementation and publication) in the case of a patient's care by a distributed system on various health organizations. This is a case that implicates use of composition's techniques of distributed and complex services. The modeling of WSs is a procedure that is used to define and build elements that form the basis components of each WS [21]. In our study we have defined them as follows.

(1) The consumer (customer) service: is the CEP engine that is responsible to execute the medical plan via calls to planned WSs, and is also responsible to monitor the process that comprises the called WSs.
(2) The service provider: each actor that is involved in a process after the planning of its services in the medical plan. It is therefore responsible for carrying out requested tasks by the CEP engine and then provides the results.
(3) Service delivery: each result to be delivered by an actor after performing of requested tasks by the CEP engine.
(4) The interface of the service: definition of service components.

The consumer (or customer) of each service in the medical field is in fact the patient which is the final beneficiary of the entire process. However, from our architecture's perspective, the client is the CEP engine that is responsible for calling the planned services for patient healthcare. A service provider (actor) must provide its services through its web services to CEP engine. This requires making a good correspondence between the medical activities to practice on the patient in one hand, and associated web services with involved actors in process in second hand. A web service is, for an actor, a tool that allows him define and publish its provisions (functionalities). It is also an interface to present the results requested by the process manager (engine). The execution of each medical act, which is part of a medical activity, causes one or more medical information to communicate to another actor. In our study this means that the functionalities to be modeled for a given web service are expected results (information produced) after execution of corresponding medical activity.

By using reference model of medical activity, we can easily deduct the skeleton of results that will be modeled as provisions of web services to be implemented. So a reference activity is a unification model that will be starting point for an adequate modeling of such web service in our approach. The problem that will be discussed in this procedure is dynamic (automatic) composition of these services. We look for a mechanism research, invocation and execution from an automated workflow. For this purpose it is necessary to use a modeling language that takes into consideration the semantics of web services via integration of ontologies in medical field. After modeling via an appropriate language, it comes the composition steep of the web services that will participate in a medical process. It is crucial to establish the suitable algorithms that allow a perfect dynamic composition of web services by running the generation tool of medical plans. We will discuss this procedure in the rest of this section.

4.3. **The workflow of automatic generation of medical plans.** Assuming the implementation of web services of each actor is based on the associated reference model with a global medical activity; we seek to establish an automated mechanism for planning a medical process that will be performed on the patient. A global medical activity may consist of several sub activities of various specialties and sub specialties. To schedule the medical acts of such activity, the scenario begins by searching the actors who can play the roles (skills and specialties) and check their availability; then set appointments, and finally put their access points in the plan of medical activity.

The automation of this procedure requires the adoption of an executable workflow that results in a generation process of medical plan associated with a given activity. In the next step, as discussed above, the execution of this plan gives rise to constructive calls of planned web services. The tool called medical plan generator receives at its input a reference activity and will proceed to automatically find and discover web services available and suitable for present situation. These web services may be selected by exploiting the semantic side of these services and mapping rules. Before generating the final plan, the generator must confirm the availability of each actor to be planned, and must put in order the execution of composed services.

The most important tasks to be implemented in this process are as follows.

(1) Search for actor's web services that can play roles or skills presented in the reference model. This research step is performed using the reference data of web services and ontological bases.
(2) Check availability of found services and make the composition based on the mapping rules and ontologies. The optimization of time and distance (the nearest and available service) is required in this steep.
(3) Signal medical acts (or medical activities) to be achieved by each service.
(4) Mark the appointment of planned services.
(5) Mark the access points to available web services.

The flowcharting in Figure 6 illustrates the workflow that we have adopted for modeling this process.

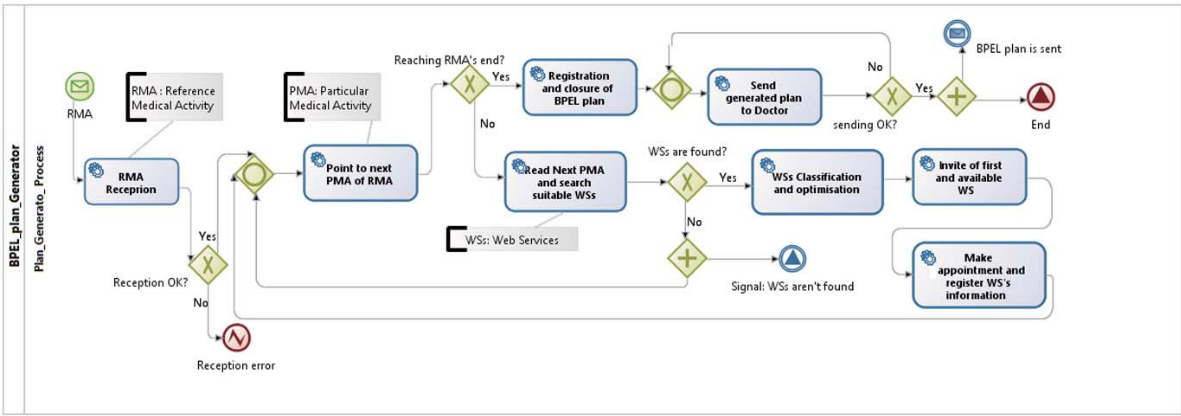

FIGURE 6. Workflow diagram for an automatic generation of medical activities' plans

The output of workflow execution is a medical plan written in standard format such as XML. In next step, by using the average of XSLT transformation this format may be converted into two versions of medical plan:

(1) A PDF version understandable of humans. It is a printing format that allows patients and even other actors to answer the questions as: what treatments to do, where and when?
(2) An executable version BPEL medical plan that is written in a process execution language such as WS-BPEL.

4.4. **A workflow of an automatic monitoring of medical plans.** After receipt of generated plan, the Doctor validates and sends its executable version to the tool responsible for content execution, by invoking planned web services. This tool can run various plans simultaneously; so it is normal that the boot of all corresponding process causes events which must be managed among different distributed services. This requires designing a special mechanism that will guarantee the progress control of each process. On the other hand we have treated the problem that is related with a process of activity which is composed of several distributed sub-activities. Monitoring this type of process is essential but it is a complicated task from classical tool perspective. To this end, it is crucial to model an appropriate workflow to be implemented on a CEP engine (Complex Event Process engine) that is able to manage complex events. And to prevent overloading and blocking of the CEP engine, we have adopted a management mechanism based on one agent tool by one process. In other words each generated medical plan for a given patient will be assigned to an agent called CEP agent who supervises the execution of scheduled tasks from start to end of corresponding process. To achieve this goal we proposed a workflow to model this procedure (Figure 7).

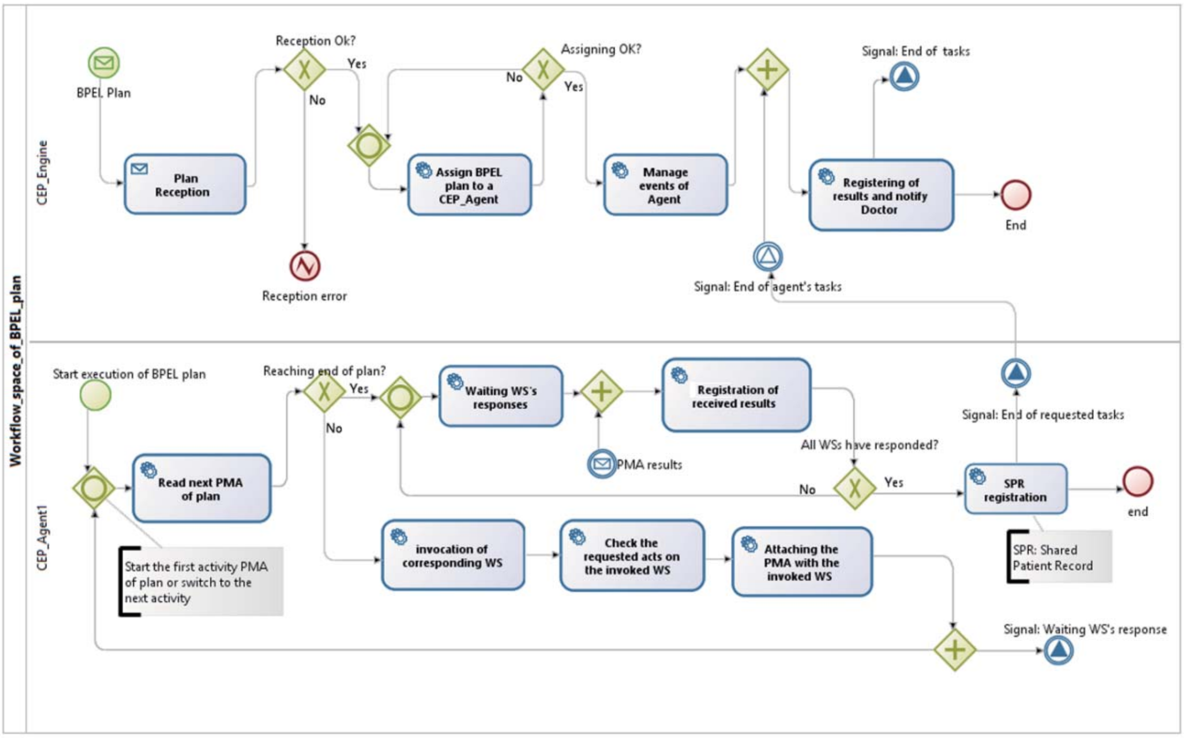

Figure 7. Automation workflow for execution and monitoring of medical activities' plans

CEP agent runs a medical plan by calling web services in planned time and may give them access rights to the necessary part of the patient record. Then he keeps in contact with called services to check the fulfillment of the tasks. When all tasks are completed the agent sent an end-signal to the CEP engine. This in its turn must save the results with updating a patient's record. And it finally sends the process's end-signal to Doctor.

4.5. **Implementation.** To clarify our proposal, we conducted a case study on the global medical activity titled Diagnostic Analysis (Figure 8). It is an activity that will identify the presence, the type and the location of lung cancer. Thus it will allow the development of a treatment plan of a found cancer [22].

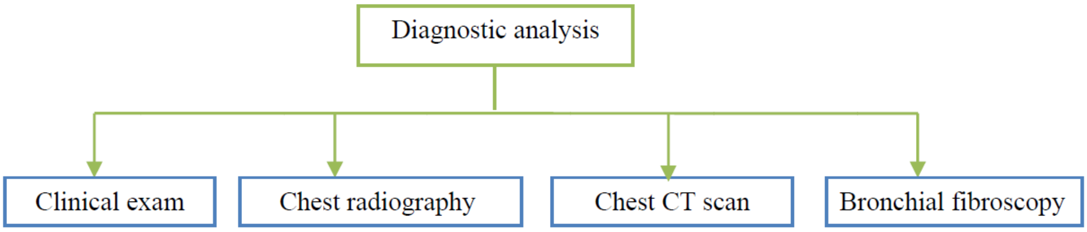

Figure 8. Proposed medical activity for case study

This case illustrates a medical activity which is composed of four sub-activities that require the intervention of several geographically distributed participants who have various specialties (Figure 8). We have instantiated this global medical activity for a patient X by instantiating sub-activities which are supposed performed by actors in various relevant medical units. The generated instance is registered as reference activity (Figure 3) that we use in this case study.

4.5.1. *Web service's implementation.* About the web services modeling language, we have chosen the OWL-S (Ontology Web Language for Services) [23]. It is available as plug-in implemented by a collection of individual tools like OWL-S editor, OWL-S matchmaker, OWL-S virtual machine, and OWL-S IDE [24]. Those tools must be installed on a web services modeler as Protégé-2000. They allow a definition with complete description of the services by implementing the following information:

(1) Ontological description of the inputs required by the service;
(2) A description of the provisions offered by the service;
(3) The interface that describes the method and conditions to invoke the service.

Technically, such information is available on OWL'S editor via the model we presented in Table 1.

Table 1. Components of OWL-S for semantic web services

	Service's module		
Module name	Service profile	Service process model	Service grounding
Module function	Presents a service What is does?	Describes a service How it works?	Supports How to access it?

About the example, which we have taken in our prototype, we generated web services from the reference activity that corresponds to the studied global activity (Table 2).

We presented in Figure 9 the relationship between presented web services in the table above and two other administrative services of patient's reception (PR-WS) and patient's identification (PI-WS). When the arrival of patient to the hospital, the reception service invokes the patient's identification service thereafter the caregiver doctor is invited to launch a required care process. In our present case, in order to identify a good treatment plan, the doctor must invite four other services of specialties before making the decision (Figure 9). After WS's modeling step, we show later the workflow implementation step in order to provide to Doctor a tool that allows him to automatically plan the involved services in the process; also this workflow tool allows him to follow the progress of each started process.

TABLE 2. Web services' details of studied medical activity

Particular medical activities	Chest radiography	Chest CT scan	Bronchial fibroscopy
Web service's name	CR-WS	CT-WS	BF-WS
Provisions to be provided by each WS	1. A chest radiography from the front 2. A chest radiography in profile 3. The anomalies 4. The report of the activity (produced medical information)	1. Size of anomalies 2. Locating anomalies 3. Lymph node status 4. The report of the activity (produced medical information)	1. Brushings and bronchial biopsies 2. Trans-bronchial biopsy

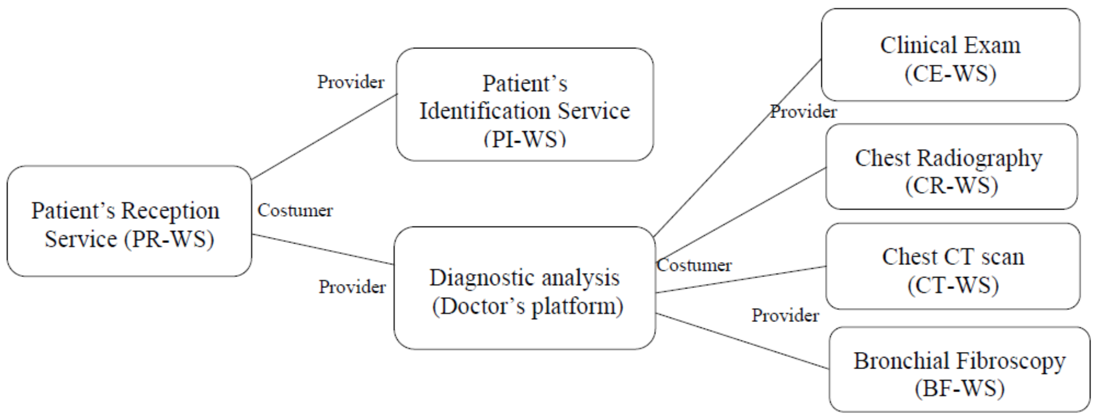

FIGURE 9. Relationship's examples between services under SOA architecture

4.5.2. *Workflow implementing.* The BonitaBPM-Community 6.4 platform offers a free environment that allows stimulating our case study. It is an environment that allows integration of various tools for our workflow implementation. The planning stage is assigned to the plan generator called PG1 that we have implemented as a process execution engine installed on Apache ODE. This is WS-BPEL server most often used for the business process's execution. The PG1 will receive as inputting a reference activity that we made for our case study. After, it produces in its output a corresponding BPEL plan. As for medical plan execution tool, we adopted a CEP engine in an event-driven architecture [25] in order to achieve treatment of complex events. This engine can be installed as a component available for the ".NET" platform under "Nesper" version, and for Java platform under "Esper" version. It is a framework which provides Web services interfaces component that can be used by any runtime processes for events transmission and management [26]. After inserting the CEP component on the server Apache ODE, it is possible to treat various occurring complex events of web services that comprise each process. The CEP component assigns the generated BPEL plan to a CEPA1 subcomponent that will monitor the process's progress from its start-point until its completion. The CEPA1 realizes successive calls to planned web services: CE-WS, CR-WS, CT-WS and BF-WS, which are invited to respond on planned time (Figure 10). By this way the caregiver doctor, by sending BPEL plan to the CEP engine, controls the care process progress and waits of alert completion of all planned activities. Thereafter he consults results of global activity titled "Diagnostic analysis" of lung cancer in our case study. Finally he makes the decision about treatment plan of cancer if found.

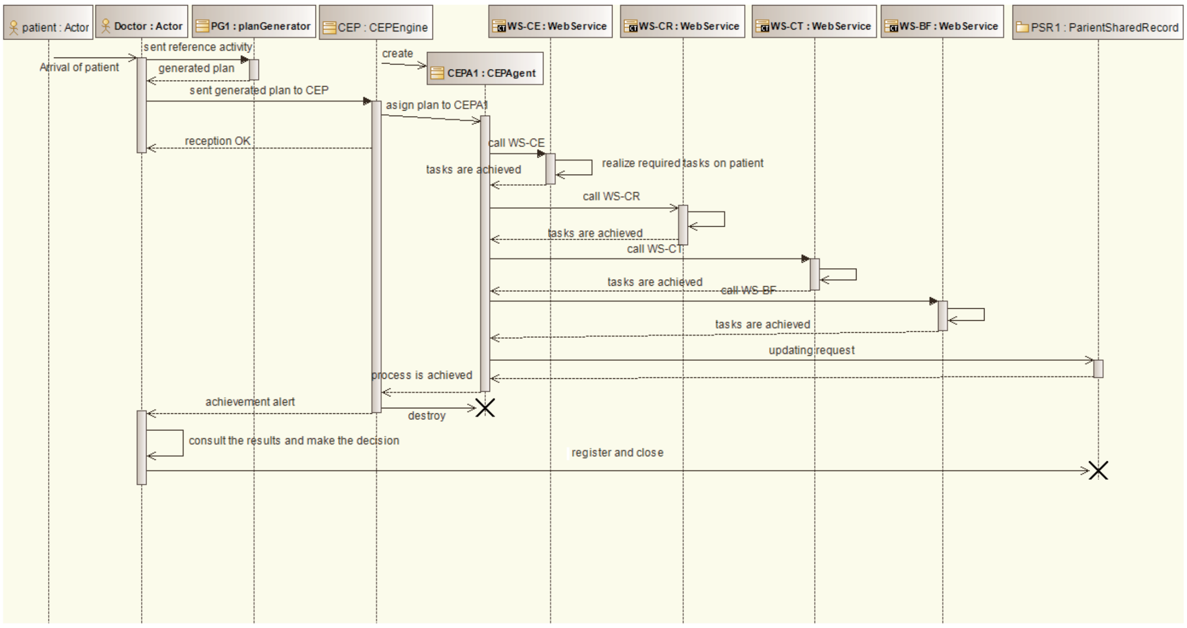

FIGURE 10. Sequence diagram for our case study

5. **Conclusions.** In this document we present our work that specifically concerns care units that are heterogeneous from hardware/software resource's viewpoint, and are also geographically distributed. The full support of medical processes that are common between these units remains a fastidious task for their actors as well as the patients themselves. This is due to the lack of interoperable platforms between the existing HISs. Thus, we mention that these platforms are able to provide the means of communication that will help to eliminate heterogeneity and distribution constraints. Therefore, to address this problem, we adopt a workflows unification approach for these HISs, using a services oriented architecture SOA. The basic used principle relies on modeling a unification pattern that reinforces the feature of interoperability between various stakeholders in a common process. Always offer each actor the opportunity to work with autonomy while executing its own tasks and using its specific resources. The modeling and the implementation, according to the unification approach, require the use of a unification model which is represented in our study by a reference model of medical activity. This model is presented in the third section. With this approach, the modeling procedure is partitioned into three major phases: (1) the first is the semantic web services modeling mechanism which is based on the reference model; (2) the second defines a workflow to automate the planning task of a business process that is associated with a complex pathological case; (3) the third phase is a workflow to automate the call and control procedure of each BPEL medical plan that is generated during the second phase.

We were able to highlight some problems that are related to web services composition via a medical workflow system. Among these problems we mention: (1) the web services based medical activities representation, (2) the medical processes decomposition into required web services, (3) finally the workflow system unification using a reference model of a given medical activity. When supporting particular patients, we were able to model a workflow system with three basic elements: BPEL medical plans Generator, CEP engine executing BPEL plans, and CEP Agents. Thus, when a patient arrives with symptoms which refer to a complex pathological case registered as a reference activity, Doctor can start the corresponding workflow. The generator outputs a BPEL plan corresponding to this case reference model. The CEP engine receives and executes the medical plan that was generated. By exploiting the CEP agents, it then continues performing scheduled tasks by inviting the corresponding web services. The control of the whole process is performed by managing all the invited stakeholders' generated events. We can conclude that the implementation of this architecture will give more strength to cooperative work in medical units. Especially the caregiver doctor can thus: (1) Automatically schedule his medical process by the automatic composition of required web services; (2) Ensure automated invocation of planned web services. This will help him to master the patients' flow; (3) Monitor and track the execution of each medical process through a software agent which is responsible to periodically inform the doctor about the state of the process progress.

Furthermore, each concerned patient (alone or with his companion) may move in proper synchronization with the associated CEP agent by using a printed version of its medical plan. In this way the patient: (1) can easily move between scheduled (assigned) medical units; (2) may perform required treatments in their planned deadlines; (3) can avoid undesirable back-and-forth due to disturbances between care units.

Finally, we can conclude that the success of this approach is related to the will and the authority of all stakeholders. However, a case study in a real environment is necessary for a meaningful assessment of these ideas. Given the time and maintenance constraints, we believe that at this stage we can only talk about a simulation implementation that will be soon followed by the real realization.

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