HeCaSe2: A Multi-Agent Ontology-Driven Guideline Enactment Engine

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Abstract. HeCaSe2 is a multi-agent system that intends to help doctors to apply clinical guidelines to their patients in a semi-automatic fashion. HeCaSe2 agents need a lot of (scattered) information on health care organisations, as well as medical knowledge, in order to provide an efficient support to health care practitioners. Modelling all these data is certainly a hard task. The paper describes how the inclusion of an especially designed ontology allows different agents to coordinate their activities in the enactment of clinical guidelines.

1 Introduction

A *clinical guideline* (GL) indicates the protocol to be followed when a patient is diagnosed a certain illness (*e.g.* which medical tests have to be performed on the patient to get further data, or what steps have to be taken according to the results of those tests) [1]. However, the inclusion of a guideline execution engine in the daily work flow of practitioners is a hard task. Taking this situation into consideration, in previous papers ([2]) we introduced a system called HeCaSe2 that proposes an open agent-based architecture, which represents different entities of a healthcare organisation. The system helps doctors to collect and manage information about patients and coordinates some complex tasks, such as scheduling meetings or looking for a required service. HeCaSe2 includes the management of clinical guidelines by doctors in the diagnosis or treatment of diseases. All these tasks require an external element to be more flexible and efficient: a representation of the care flow and the terminology used among all entities.

This paper presents a case of study that shows how practitioners are able to enact GLs through a distributed platform with an ontology that stores the medical knowledge. The designed ontology ([3]) has three main aims: *a*) to model healthcare entities with their relationships, *b*) to represent all medical terminology used by all partners, and *c*) to assign semantic categories to those medical concepts. With that approach, care is improved at least in three ways: *i*) *ontologies* provide a common understandable semantic framework to execute clinical guidelines; *ii*) *agents* can understand what they must perform at any moment and negotiate or coordinate their activities with the appropriate partners; and *iii*) ontologies provide a high level abstraction model of the daily work flow; that model can be *adapted* to each particular organisation, without the agents having to change their internal behaviour.

2 Ontology-Driven Clinical Guideline Execution

The combination of the designed medical ontology with the multi-agent system provides a flexible framework to follow the execution of clinical guidelines. In that process, two main tasks are required: *a*) to know the source of a data contained in an enquiry, and *b*) to identify the actor that provides an action and its result. In order to illustrate the procedure followed by agents, a simplified GL of *Deep Venous Thrombosis* (DVT) is used as an example. The GL was adapted from the National Guideline Clearinghouse and coded in *PROforma* [4]. The following case of study is focused in the diagnosis phase.

First of all, the doctor selects the DVT guideline from the repository (the descriptions of the available guidelines are provided by the Guideline Agent (GA)). The diagnosis is divided in two steps: 1) the doctor evaluates the risk to suffer a thrombosis-like pathology with different parameters, and 2) if the risk is moderate or high, the doctor makes some further tests. The associated Doctor Agent (DRA) analyses the GL and observes a first enquiry that includes nine parameters required in the risk evaluation. For each one, the DRA asks the Ontology Agent (OA) in order to obtain more details about it. The OA replies with the associated information contained in the Medical Ontology. Moreover, the DRA collects all available data in the patient health record (PHR) through the Medical Record Agent (MRA).

At this point, the DRA starts the execution of the GL by showing all the available data to the doctor, who can check all values and confirm any request to be performed. Imagine that the first required item is if the patient has any *Pitting Edema*. If the DRA does not find any information in the PHR about that concept, the DRA will make a request to the OA in order to know more details about it. OA responds that *Pitting_Edema* has the code *C0333243*, it has a Boolean result with a *false* default value, it is a *Sign_or_Symptom* (semantic type provided by UMLS), and it is responsibility of a *Family_doctor* or *Nurse* or *Physiotherapist*. With this data, the DRA determines that the doctor has to provide that Boolean result through the interface after asking the patient. Other concepts required to evaluate the risk, such as *Sore_to_touch*, *Swollen_calf*, *Swollen_legs*, *Superficial_vein*, *Immobile*, *Bed-ridden*, *Active_cancer* or *Changed_status*, are collected in the same way (by an examination of the patient or by collecting stored past values). All these values will remain in the PHR and they could be used in another visit or in other guidelines. Once all parameters have been filled, the guideline can continue the execution without the intervention of the doctor. The next task in the GL is a decision that evaluates the risk according to the values filled in the previous enquiry. The influence of each collected parameter allows the DRA to decide the risk to suffer DVT. At the end of that sub plan, an internal variable stores that risk (low, medium or high). If the risk is medium or high, the doctor recommends a first test with *ultrasounds*.

The DRA requests the OA in order to know more details about the action *Ultrasound*. The OA responds that it is a synonym of the concept *Ultrasonography*, which has the code number *C0041618* which is a *Diagnostic_Procedure* that is responsibility of a *Radiologist_Service*. In that case, the DRA cannot accomplish that action because it requires another agent. The DRA begins a search through the same medical centre or outside. The DRA will eventually receive the name of the desired Service Agent (SA) (an instance of a *Radiology_service*) and they (the DRA and the SA) will negotiate a meeting for the patient to perform the visit. After that appointment, the doctor suspends the execution of the medical guideline until the action is performed and the results have been received. According to the results of that first test, the doctor can arrange an appointment to perform a venogram or not. In any case, as the result of that sub plan, an internal variable of the guideline will save the diagnostic result put by the doctor: *DVT Confirmed*, or *DVT Ruled out*.

3 Conclusions

A practical example of an ontology-driven guideline execution has been discussed. The use of ontologies in the medical domain is increasing and offers some advantages such as making domain assumptions explicit, separating domain knowledge from operational knowledge, and sharing a consistent understanding of what information means.

The presented work brings the following advantages to a guideline-based execution system: *a*) To identify the required actors that are able to accomplish an action and to know the source of a data, *b*) to adapt the execution framework to the particular structure of any healthcare organisation without modifying the MAS implementation, and *c*) to provide an application independent context. Thus, by changing the ontology and its relations, the execution procedure also changes. Note that the only issue that should be addressed is the manual definition of the appropriate task ontology. This question usually requires the intervention of a domain expert, but UMLS provides a large corpus of concepts and relations that can be easily reused.

References

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