Knowledge Modeling Guideline for Reentrant Features in SAGE

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Abstract. Separation of clinical knowledge from the hospital information system is important to maintain the both efficiently. It is the reason why the clinical organization adapt the knowledge engine and guideline formalism for CDSS(computerized decision support system). In this paper, we suggest the way to encode the time or workflow-related knowledge in SAGE. Also, we implemented additional component for executing this. With this encoding method and extended knowledge engine, separation of the knowledge form the application can be possible.

Keywords: guideline, SAGE, workflow, time-related, knowledge modeling

1 Introduction

Many researchers have proved that computerized decision support system (CDSS) in clinical guideline can lead clinician's compliance with suggested best practices in patient care[1,2]. In CDSS, a core component is guideline which specifies best practice and evidence-based knowledge. Clinical practice guidelines define evidence-based policies for managing health care in specific clinical circumstances. Among the several guideline formalisms, SAGE can be powerful knowledge representation and strong communication tools among the medical knowledge engineers[3].
Even though SAGE has very powerful knowledge representation formalism, it is not easy to encode time or workflow-related knowledge. These kinds of knowledge are very common in clinical knowledge modeling, especially in ubiquitous service.
It is very important the separate the guideline and application service since we can maintain and extend both independently. It is the important advantage guideline-based

CDSS. Maintaining the guideline belongs to clinical knowledge engineer but the responsibility of maintaining the application service is the IT engineers'. So, if time or workflow-related knowledge cannot included in the guideline, the , the implementation of these features are the part of application service. It means the guideline cannot be the complete and the advantage of guideline-based CDSS.
In this paper, we suggested efficient knowledge modeling method for representing the time-interval guidelines in SAGE. Also we extended rule-based guideline engine to manage new knowledge representation.

2 How to represent the multi-entry knowledge in SAGE

2.1 Requirements

Knowledge in CDSS is running for just one patient. It means every instance of knowledge is based on one patient information. One guideline in SAGE is executed immediately from the entry point to exit point of guideline and make the result as recommendation, suggestions, or alert exactly to the client of service. Some guidelines require several entry points. If new lab data is required in every 10 minutes so guideline should be waited for 10 minutes and restarted. While the knowledge execution should be suspended for waiting another user input values or once again.

2.2 SAGE Modeling Guide

We identified three use cases for multi-entry knowledge representation. (1) reentrant input without time-related, (2) reentrant input with time-related but just one more time, (3) reentrant input with time related and many times.

Reentrant input without time-interval. In this case, guideline execution should suspended and guideline request additional input values. *Inquiry* element in SAGE represent that guideline need more information.

Reentrant input with time- interval but just one more time. In this case, guideline execution should waited for additional input values in specific time interval. To encode one more input, *Scheduling Constraint* expression with time limit should be specified. In this case, additional input means that client should measure the something one more time. Guideline should notice the client how much interval is required for re-measurement. To encode the time interval, *Time for Comparison* property should be specified. Figure 1 shows simple guideline and encoding sample which if the first test value is not normal, guideline move to *Repeat Once* node and execute the *Action spec* specified in *Scheduling Constraint*.

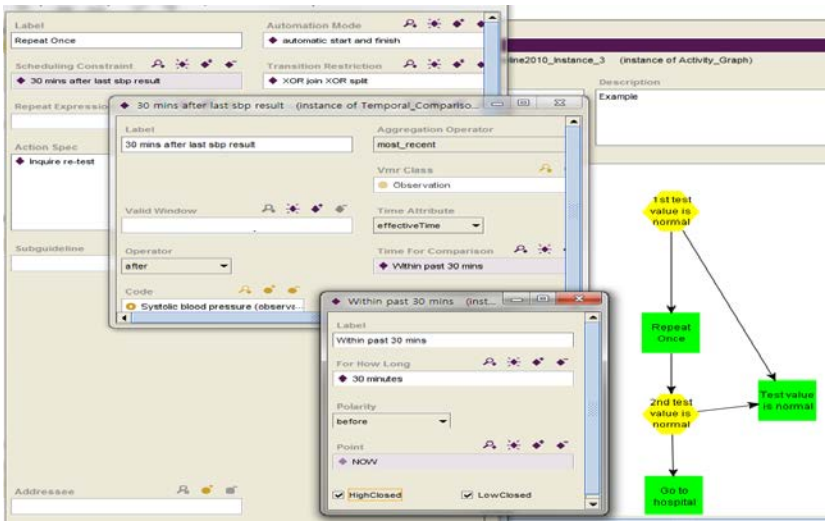

Fig. 1. Guideline and encoding sample for 2nd case

Reentrant input with time-interval and several times repeatedly. In this case, guideline execution should waited for additional input values repeatedly to meet specific goal value in the same time interval.

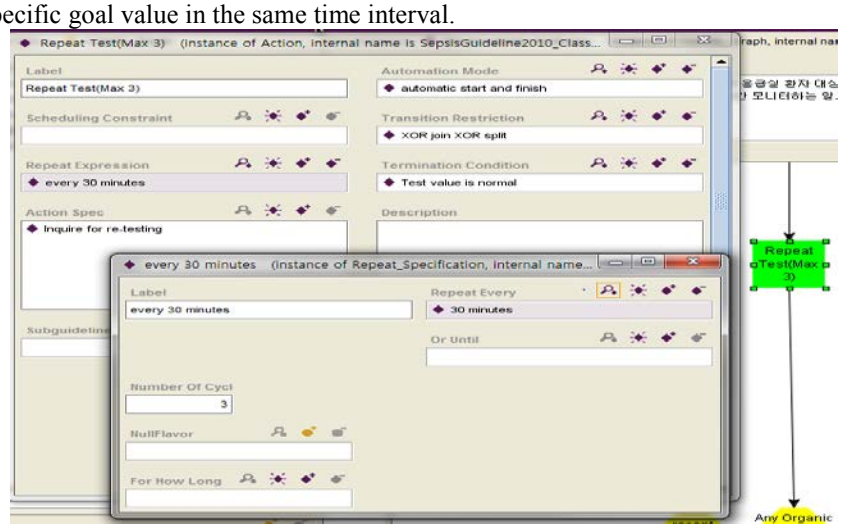

Fig. 2. Guideline and encoding sample for 3nd case

To encode the several times iteration of re-measurement, *Repeat Expression* should be specified with iteration criterion. *Repeat Expression* in SAGE has *Repeat Every* property so we can specify the time interval. Stop condition of iteration should be specified in *Termination Condition*. Encoding sample in figure 2 shows that guideline waits for additional input value in every 30 minutes and maximum iteration number is 3. It mean guideline notify that client should re-test and give additional value in every 30 minutes and guideline should move predefined steps after 3 trials.

3 Additional SAGE Execution Components

To manage the time or user intervention related guideline, we extend SAGE execution engine(Brain)[4,5]. Figure 3 shows the overall architecture of extended components.

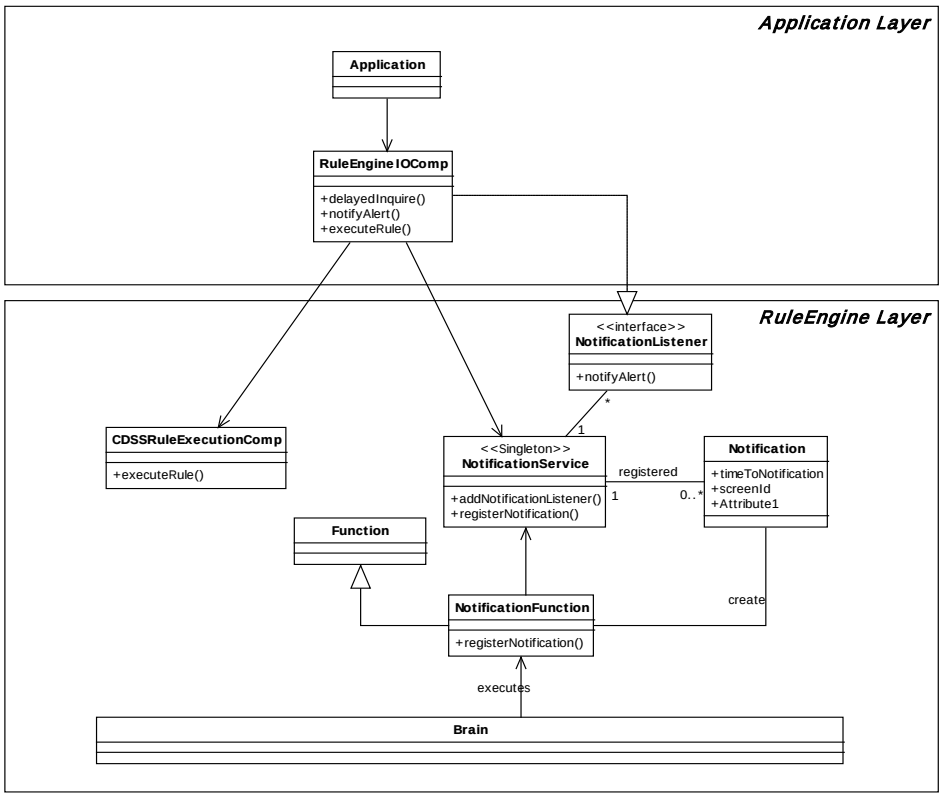

Fig. 3. Class diagram of extended components

To execute Reentrant input value feature, notification concept should be released since guideline should notify the necessity more input value to users. To implement notification concept, we implemented *NotificationListener, NotificationService, Notifcation, NotificationFunction* classes. *NoticationService* class implement the *Notification* interface as singleton class so there are only on instance for managing notication service. *Notification* has properties as time interval to notify, which user to send notification, and what attributes to request. At the starting time of guideline, SAGE execution engine should create the instance of *NotificationService*. At each reentrant SAGE element is executed, *NotificationFunction* is invoked to create the *Notification* instance and to register it into *NotificationService* with *NotificationSessionID*. Then *NotificationService* send the application component to make additional user input service such as pop-up window or input test fields according to user experience strategy. With this *NoficiationSessionID*, additional information are stored in Notification.

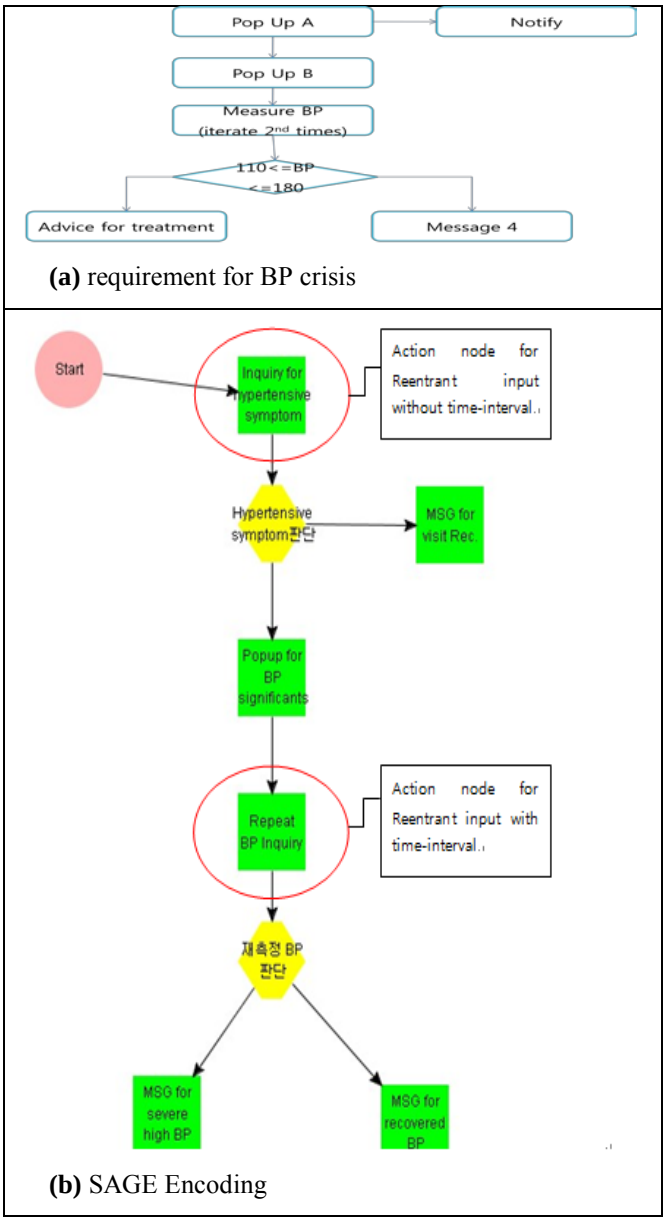

Fig. 4. SAGE encoding sample for guideline with reentrant feature

4 Discussion

For validating our approach, we applied SAGE encoding guideline to hypertension guideline. As shown in Figure 4-a, knowledge engineer defines the requirement for

user input as popup. To encode this, we can apply reentrant input without time-interval (in Figure 1) and reentrant input with time interval repeatedly (in Figure 2). Our new SAGE element and SAGE encoding components were applied to hypertension, metabolic syndrome, and diabetes mellitus ,guidelines for ubiquitous health care services of LG electronics company. With our additional component, clinical decision rule related time or user intervention can be encoded in SAGE guideline so that it is not necessary to develop additional module in application layer. With our encoding guideline, we can extend the scope of SAGE knowledge formalism. Strict separation of clinical knowledge and application might be strong so that the advantage of SAGE adoption is greater.

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