

# Design of Knowledge Engine of SAGE in CDSS

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## Abstract

Clinical Decision Support Systems are "active knowledge systems" which use two or more items of patient data to generate case-specific advice. Architecture for implementing independent, extensible, and interoperable clinical decision support service (CDSS) in perspective of EHR. In this design, components for implementing independent knowledge service and interface mechanism with EHR service or existing hospital information system are identified. In this paper the design of knowledge engine is critical component for implementing knowledge service of SAGE guideline model.

## Keywords

CDSS, EHR, SAGE

## I. Introduction

A clinical decision support system has been coined as an "active knowledge systems, which use two or more items of patient data to generate case-specific advice" [1]. This implies that a CDSS is simply a DSS that is focused on using knowledge management in such a way to achieve clinical advice for patient care based on some number of items of patient data. The main purpose of modern CDSS is to assist clinicians at the point of care. This means that a clinician would interact with a CDSS to help determine diagnosis, analysis, etc. of patient data. Previous theories of CDSS were to use the CDSS to literally make decisions for the clinician.

In field of medical sciences, a significant new trend and challenge of IT in clinical guideline system is to separate clinical knowledge from clinical application system. So far, evidence based guideline practice promises to improve health care quality. There have been many researches and practical services for clinical decision supporting services. But in these approaches, knowledge is embedded in specific application and each decision support service is built on its own mechanism. In other words, health care organizations suffer from the problem of systems and knowledge service integration [2].

In our approach, we suggested sharable common architecture for difference CDS service. So, we suggested centralized knowledge repository instead of fragmented knowledge and core component for knowledge management. Also we suggested how to integrate independent CDS service with hospital information system like EMR and with standards defined in EHR. Even though different CDS service, knowledge can be stored in centralized knowledge repository and can be used in same technical environment.

In recent years, many researches have proved that computerized decision support system (CDSS) in clinical guideline can clinician's compliance with suggested best practices in patient care. So CDSS can improve the quality of patient care. In CDSS, core component is guidelines. Guidelines specify best practice and evidence-based knowledge. In clinical guideline, approaches for modeling the clinical guideline have been proposed. Arden syntax, PRODIGY, GUIDE, and SAGE (Standard-based Sharable Active Guideline Environment) are the most popular modeling formalism. With these guideline modeling formalisms, knowledge engineer specify the guideline for each practice of point or care service or other clinical services. But there are no practical and efficient guideline execution engines for clinical guidelines. So,

IT developers understand the guideline models and implement those in programming languages. These guidelines are embedded in application logic so it is not easy to identify or to separate the knowledge from other application functionalities. Also programming language is not easy for knowledge engineer to understand and verify. These are obstacles for extending CDSS in hospital information systems. Several researches reported commercially available rule engine system can be execution engine for clinical knowledge [3, 4].

In this paper, the suggested an approach and architecture is for implementing scalable and maintainable clinical decision support service with process engine and rule engine, which are used in other business areas. We evaluated 2 kinds open source engine for clinical knowledge and applied these engines to execute the SAGE guideline model.

## II. Principles of CDSS architecture

Our architecture is described with enterprise framework so we define 4 difference perspectives. (1) Business architecture defines the CDS service scope and alignment strategies with hospital's goal. (2) Application architecture defines common components for implementing independent, scalable, and interoperable CDS service. (3) Data architecture defines the structure of knowledge repository and interface repository to integrate with EHR standards and clinical data record. (4) Technical architecture defines available technical platforms and standard profiles for SOA (Service-oriented Architecture) implementation.

For constructing the architecture we define 4 principles (1) Integrated: Even though the individual service of CDSS is different, the architecture is common. For example, there are several representations of knowledge and several mechanisms for handling the knowledge, mining mechanism or rule execution, so on. Even though several approaches are possible but one integrated architecture is necessary for consistency (2) Customizable: Our architecture is national-wide architecture but can be customized according to the scale of hospital. (3) Component-based: each component of architecture is pluggable and reusable. (4) Practical: our architecture should be implementable. It means our architecture should be refined into physical level.

Example, for implementing the above principles is COMPLETE III environment for Support for Vascular Diseases in Community Practices. Fig. 1 shows the design aspects of the environment.

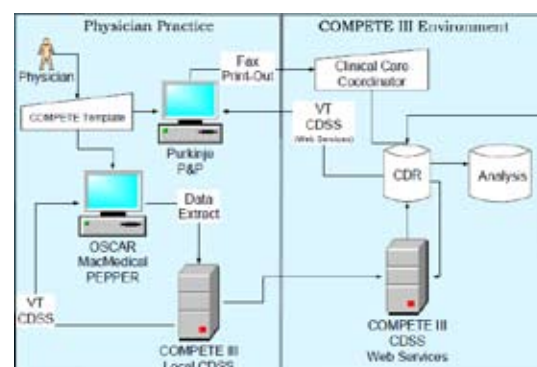


Fig. 1: Architecture of COMPLETE III Environment

In field of medical informatics, for constructing the architecture, we start to define the quality attributes based on attribute-based architecture development methodology [7]. We researched CDSS architecture in terms of EHR and national-wide service. So interoperability is the most important quality attribute. Each hospital has different information systems and different technical architecture. But national-wide knowledge and standard can be applied into each hospital and patient information can be shared to execute the knowledge even though the different implementation. Reusable and modifiability is also important attribute also. Since CDSS service is for care program in hospital, system should respond to events. In this stage we are focused on interoperability and reusability.

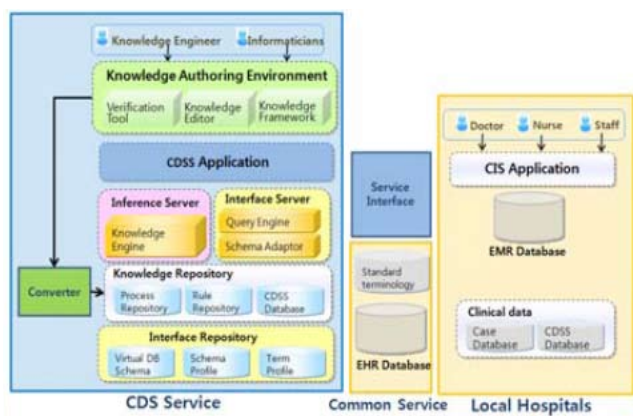


Fig. 2: CDSS Design

Fig 2 shows the application architecture design, which consists of 5 core components. (1) Knowledge authoring environment: Knowledge engineer capture the domain knowledge and translate the computer interpretable representation. (2) Knowledge repository: contains the knowledge from expert and case based gathering the real practice (3) knowledge engine execute the knowledge stored in knowledge repository and interface the CDSS application. (4) Interface server has responsibilities to get the clinical information from legacy hospital information system. Knowledge is independent from the schema of each hospital system. To reuse the knowledge and integrate with different hospital, interface server adapts the schema and terminology.

### III. Case study for implementing the design

A clinical practice guideline (CPG) is contains systematic statements of evidence-based policy rules or principles to assist clinicians and patients make decisions on healthcare alternatives. The SAGE Guideline Model is a computable knowledge representation "format" for encoding the content and logic of executable CPGs [5,6] SAGE guideline model encode guideline knowledge needed to provide situation-specific decision support and use standardized component for interoperability [3]. Also SAGE defines the knowledge deployment process and knowledge execution architecture. Therefore, SAGE can be strong and concrete knowledge representation model for clinicians. Major component of SAGE guideline model is Fig.3.

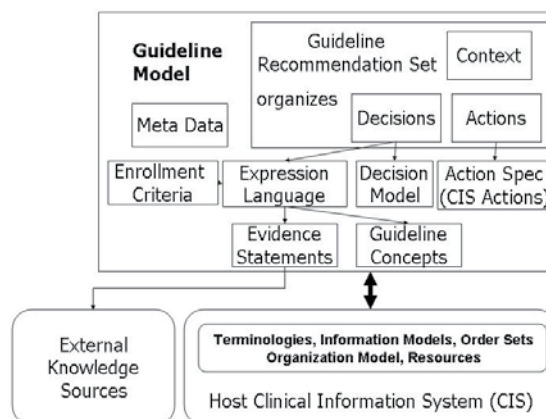


Fig. 3: Guideline Component Model Architecture

This fig shows the architecture with knowledge engine. From SAGE guideline model, translator translates the guideline representations to KE knowledge model and stores them in knowledge repository. KE retrieve the knowledge from repository according to event from CDSS application. For executing the knowledge, knowledge engine should retrieve the patient data in run time.

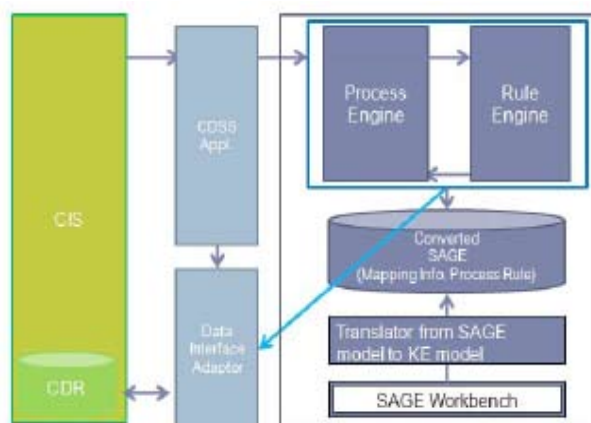


Fig. 4: Knowledge Engine Design

Data interface adaptor component access the clinical data repository and return to Knowledge engine. Fig 5 shows the workflow of knowledge acquisition.

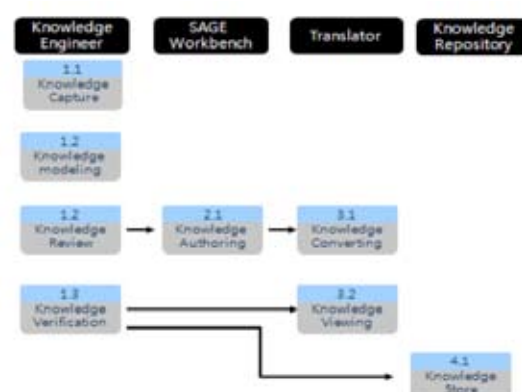


Fig 5: Knowledge Acquisition Workflow

For translating the SAGE guideline, we evaluate 2 approaches. SAGE guideline can be modeled with XML or OWL. One way to translate the guideline element defined in OWL tag to model element of knowledge engine. The other way is using object model of SAGE. SAGE defined Knowledgebase object model

so translation from properties of SAGE object model to properties of knowledge engine. In our prototyping second approach is more efficient for translating and more correct. To validate our knowledge engine and design is applicable in clinical guideline, we developed hypertension guideline. The research group consists of knowledge engineers and IT engineers. Knowledge engineers are domain expert and their background is clinician or nursing. Knowledge engineers capture the knowledge from several sources about hypertension and define the knowledge in ontology with concepts and axioms. Then they specify the knowledge in SAGE guideline model with SAGE workbench. In SAGE model, 137 indication rule and 6 medication class and 58 activities and 26 recommendation set is defined. With translator component, hypertension knowledge repository is constructed and is available for knowledge engine. To verify the correctness and completeness of knowledge repository, we apply black box testing. Knowledge engineers define the test case what consists of input test case and expected results. With this test case, test oracle generates input interface file to knowledge engine and compare the result from knowledge engine with expected results. For black box testing, 60 test cases and 18 factors in 60 test cases were tested. As the result, value of 1080 element was compared with expected results and all values are exactly matched. So we conclude our converted knowledge is correct and knowledge engine is available for clinical guidelines. Stress testing was planned to check the stable usability of knowledge engine in hospital environment. Clinical decision support service is executed at the point-of-care when the patient encounters the clinicians. So, real-time and fast response is critical. On the same technical environments with hospital information system, we got the following result in throughput and turnaround time for each knowledge execution.

#### IV. Conclusion

CDSS architecture is defined from 4 perspectives and conceptual level. Also to validate design developed several core components and applied them to hypertension guideline application. From this prototyping it is recognize CDS service can be developed and maintained independently from EMR or EHR. Also, common architecture can be used in several different CDS services. It successfully integrated the process engine and rule engine and apply knowledge engine for executing clinical guideline. In the paper, knowledge engine is applied to SAGE guideline model. But, almost guideline model are based Task-Network model, which are same model of process engine and based rule model. So, the design can be applied into several clinical guidelines. The research will focus on knowledge modeling process and knowledge representation constraints for efficient knowledge execution in knowledge engine since clinical guideline models don't modeling guidelines or constraints.

#### References

- [1] [Online] Available : [http://en.wikipedia.org/wiki/Clinical\\_decision\\_support\\_system](http://en.wikipedia.org/wiki/Clinical_decision_support_system)
- [2] S. M. Metev, V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
- [3] Vipul Kashyap, et al., "On Implementing Clinical Decision Support: Achieving Scalability and Maintainability by Combining Business Rules and Ontologies" AMIA 2006, pp. 414-418
- [4] Haward S. Goldberg, et al., "Evaluation of Commercial Rule Engine as a Basis for a Clinical Decision Support Service," AMIA 2006, pp. 294-298
- [5] [Online] Available : <http://sage.wherever.org/model/model.html>
- [6] Samson Tu, Julie Galsgow, SAGE Guideline Model : Technical Specification, SAGE Consortium, 2006
- [7] Mark H. Klein, Rick Kazman, Len Bass, Jeromy Carriere, Mario Barbacci, Howard Lipson, "Attribute-Based Architecture Styles", Proceedings of the First Working IFIP Conference on Software Architecture.
- [8] Janet Boss, "Knowledge management-enabled health care management Systems: capabilities", infrastructure, and decision support, Expert Systems with Application, 2003;24: pp.59-77.



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