Response to OMG/CORBAmed

Request for Information (RFI) on Clinical Decision Support (RFI3)

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1. Introduction

This document is a response to the Clinical Decision Support Request for Information (RFI3) issued by CORBAmed task force. Our intention here is to offer an international contribution towards the Decision Support RFP.

UNIFESP - Federal University of Sao Paulo through its Health Informatics (CIS) has a 10 year tradition in R&D in the area of health Informatics in Brazil. The Institute of Informatics of the Federal University of Rio Grande do Sul - UFRGS has one of the top graduate programs in Computer Science in Brazil, whereas the University of São Paulo besides a solid tradition on the development of Health Informatics applications, has the largest university hospital (HC-FMUSP) in Brazil (about 2,200 beds), and is presently modernizing its HIS. UFRGS, HC-FMUSP and CIS-UNIFESP are working together in a national project that aims at exchanging health care data among different university hospitals across the country (PROTEM /SIDI and RUP projects). A minimum data set to be exchanged among the institutions has already been defined and can be found in this URL: http://www.sbis.epm.br/sbis/docs/ruprelease3.html

For the health informatics community in Brazil, this is a very special moment when several initiatives, headed by the Brazilian Society for Health Informatics, are pushing a national discussion on standards for health care. In a global scenario where frontiers became fuzzy as we all communicate electronically and patients and diseases are the same across nations, we would like to see a suite of CORBAmed objects available worldwide. For this reason, UNIFESP decided to join OMG and work together towards a global definition of CORBAmed objects.

This is our first response to CORBAmed. We hope that the more experienced members will guide us through this process making the necessary revisions in order to improve our recommendations.

2. Object Interface Requirements for DSS Interoperability

Generically DSS are any type of application that support the decision making process. A generic DSS receives a certain amount of data as input, processes it using a specific methodology and offers as a result some output that can help decision-makers.

The input data could be clinical, administrative or financial. In addition, the input data can also be a signal automatically acquired from a medical device. Depending on the methodology used by the DSS some additional data should also be available such as certainty factors for uncertainty handling by either symbolic or connectionist based DSS.

Although the basic assumption is that the Lexicon Query Services [1, 2] will offer all the necessary mapping to the local controlled vocabularies, one should also take into account that maybe, in some situations, these services will not be available, or will not be enough to offer data for the DSS component. For this reason, it is important to have an alternative interface to gather input data for the DSS component, totally independent from the Lexicon Services. (We know this is not the best situation and should be an additional functionality but might be necessary, especially for those places where the Lexicon Services are not yet operational).

The DSS output can be available in many different formats: a classification (diagnostic, protocol, a work-up plan), an alert, a guideline, or a more complex type of data such as consolidated tables or reports from a retrospective evaluation or constructed in a datawarehouse or OLAP application.

It would be very difficult to make a proposal for a unique output standard. The ideal situation would be a flexible output format, possibly defined by each implementation of the DSS component. This object should be able to explain the content and format of its output. Also, whenever present, the output relationships to the Lexicon Services should be pointed out. For example, if the DSS is a diagnostic support tool then the list of suggested diagnoses should be mapped onto the correspondent diagnoses described by the Lexicon services.

Thinking of a global suite of CORBAmed DSS components, it might be useful to have a set of documentation traits that would explain what kind of DSS is being offered, the methodology upon which it is based, the input required and the output offered, and its relationship to the Lexicon Services. In addition, depending on the methodology used, the DSS should contain traits to further define specific features of each type of DSS, like for instance, the neural model used in a connectionist DSS.

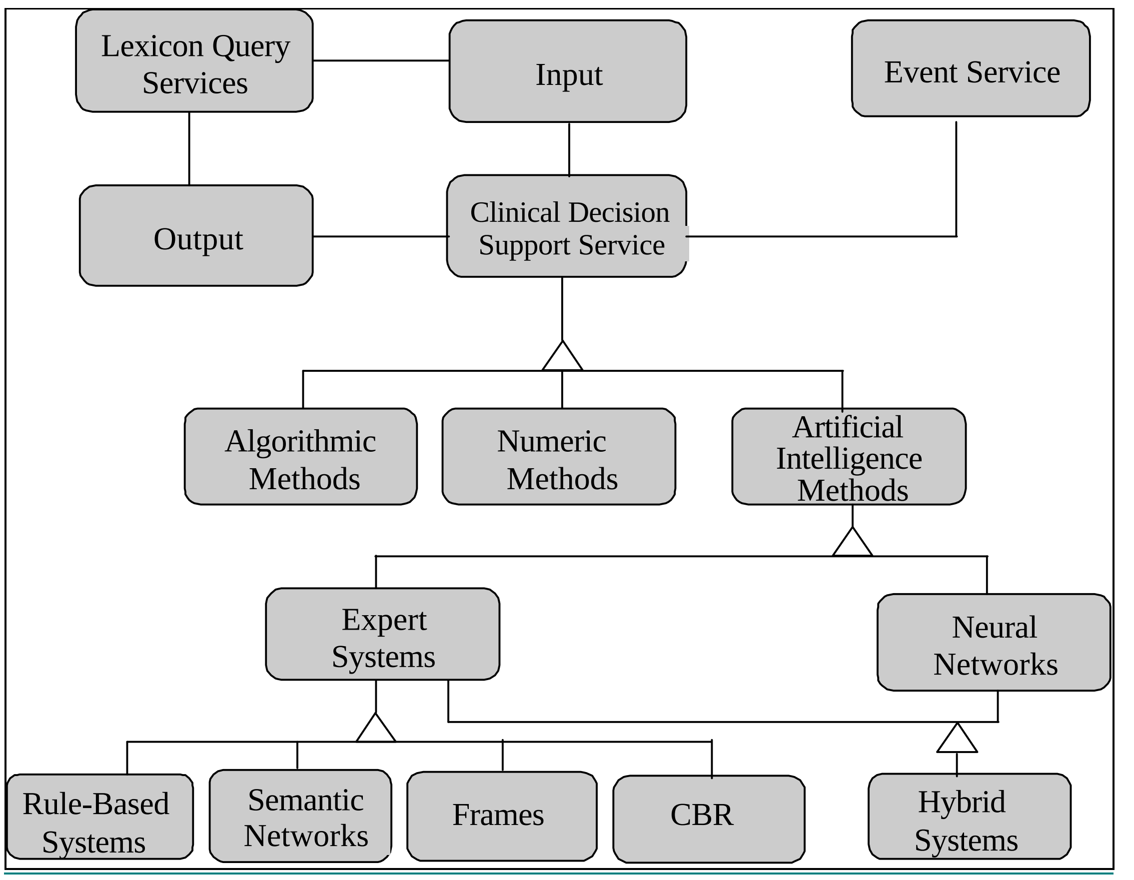
Historically and for teaching purposes DSS can be classified according to different perspectives: type of interaction (active or passive), type of orientation (diagnostic or therapeutic) and basic methodology. For the active systems, the relationship with CORBA Events Service[3] should be considered.

By far, the most important classification is the one that describes the methodology upon which the DSS was constructed. From clinical algorithms with simple YES/NO branches to sophisticated hybrid systems that integrate the symbolic and connectionist approaches, there is a wide range of solutions offering different functionality and depicting specific features. These features are crucial for the IDL definition, since they characterize the way the DSS interacts with its environment.

According to the methodology used, the DSS can use clinical algorithms (pre-computational phase), mathematical methods such as statistics, and AI techniques. These systems can use a symbolic or connectionist or, even, a hybrid approach. The symbolic approach leads us to the well-known expert systems applications based on a knowledge base that represents knowledge in production rules, semantic networks or frames. More recently, Case Based

Reasoning-CBR applications are offering an attractive alternative to constructing decision support applications. For each knowledge representation paradigm a different type of interface could be required. For example, Medical Logical Modules expressed in the Arden Syntax [4] can be easily used to describe the knowledge base contents and could be very useful for the explanatory mechanisms. Since it is desirable that all DSS offer an explanatory mechanism, there should be a specific interface for that, offering the explanation in a standard format such as: Arden Syntax, Knowledge Interchange Format (KIF) [5], Knowledge Query and Manipulation Language (KQML) [6].

Figure 1 below depicts a proposal to describe a generic DSS.



Based on Figure 1, a *DSS* component uses an *input* object that offers the necessary data, according to the DSS needs, whereas the output object offers the DSS recommendations and explanation, according to the inference methodology. Whenever present, the input and output objects should depict their relationships with the Lexicon Services. If the DSS presents an active behavior, such as alerts or guidelines applications, CORBA Event Services could be used to define which events will activate the DSS.

According to the methodology used, sub-classes of DSS could be defined such as:

- **Algorithmic or Procedural DSS** – this sub-class could contain all the classical procedural applications based on a simple logic and written in procedural languages, not using any AI technique;
- **Mathematical DSS** – this sub-class could contain all the statistical DSS, such as belief networks or Bayesian analysis.
- **AI DSS** – this sub-class would probably be the largest one comprehending the state of the art of decision support for healthcare. The two basic paradigms to build these systems could be used to define the two sub-classes: **Symbolic** and **Connectionist**.

  The **Symbolic DSS** could be further specialized according to the type of knowledge representation formalism mostly used to build the knowledge base. Some of the specialized sub-classes could be: **rule-based, semantic-networks, frames and Case Based Reasoning (CBR)**. The **Connectionist DSS** sub-class would hold all the applications based on neural networks. The Hybrid DSS would inherit form both the Symbolic and the Connectionist DSS, since these types of systems integrate both paradigms.

The reason to present this classification here is that we believe for each different DSS sub-class there will be the need to define specific IDL interfaces.

3. Healthcare standards for DSS

Besides the standards *Arden Syntax [4], HL7 [7], Knowledge Query and Manipulation Language (KQML) [6], Knowledge Interchange Format (KIF) [5], Ontolingua [8], Intermed Guideline Interchange Format (GLIF) [9],* already mentioned in the Utah's response [10], we would like to also recommend that the DSS should have a relationship with the SQL3 standard [11].

Specification ISO-JTC1-SC21-WG3-DBL/ANSI-X3H2 SQL3 [11-12]. The specification SQL/CLI [17] defines standards interfaces to access and manipulate the relational environment. The SQL3 language incorporates standards mechanisms to express behavior and knowledge in rules (triggers) control structures, external functions and abstract data types.
Although not specific to the health care scenario, these standards could be considered, since most of the DSS are today integrated with the database, such as alert and guidelines systems. Also the SQL standard should be considered for retrospective and data-mining services. For example, business rules could be specified in the database, activating through CORBA Event Services an external DSS.

4. Potential DSS Focus Areas

4.1 Drug Interaction & Dosing

2 Alerts and Guidelines
3 Diagnostic support or any other classificatory system
4 Care Plan
5 Information Retrieval

As already mentioned in Utah's response to this RFI, more important than the potential focus areas are the more general definitions of a unified architecture for decision support applications (not only health care), with further specializations for healthcare. For example, categorical expert systems apply not only to healthcare. Some CORBA based design patterns begin to appear for several different situations. The challenge for the CORBAmed task force is to maybe identify all these initiatives constructing design patterns for the DSS.

5. Existing DSS Applications

Nowadays, the state of the art for decision support applications are those that are fully integrated with the hospital information system, providing an alert or guideline in real time. The Delphi Oracle consultation mode, very common in the eighties is loosing its space for the automatic and integrated systems. From the AI community a whole new generation of distributed systems offering intelligent agents, based on several different methodologies such as neural networks, genetic algorithms and fuzzy logic open a new perspective and also demand for standards to achieve interoperability among these initiatives. There are not so many successful decision support systems for healthcare exactly because the integration and interoperability issues are so difficult to solve. Classical expert systems provide an adequate methodology to represent knowledge and to explain the conclusions reached; however, learning and knowledge acquisition still remain a problem. On the other side, connectionist systems attract increasing interest for their inherent learning and pattern recognition capabilities. Hybrid connectionist expert systems were, therefore, proposed, integrating the symbolic and connectionist paradigms, both supporting each other. The symbolic paradigm increases the semantics of the stored knowledge, simplifying its manipulation and understanding. The connectionist paradigm, on the other hand, offers the necessary resources for knowledge acquisition and refinement.

There is an urgent need to define a common framework or even better design patterns to construct these systems. These patterns should take into account the inference methodology and the knowledge representation formalism used by the DSS.

6. Relationship to Existing OMG Specifications

CORBA Externalization Service [14, 15]: This service allows for an object to be moved or copied to another localization, including to an environment external to the ORB. This service could be useful to share knowledge and data between different DSS in the international scenario.

CORBA Query Service [15, 16]: This service offers standards interfaces to query objects, based on a selection criteria matching with the object attributes contents. This service also defines interfaces to manipulate collections such as query results. The queries could be in SQL [12] or OQL (ODMG-93)[17]. This would allow for the construction of a collection of queries.
The CORBA Query Service, when applied to Decision Support, could offer a uniform interface to data access across a distributed and heterogeneous environment, including legacy applications.

CORBA Interface Repository Interface [18] e **Meta Object Facility** [19]:
These metadata services allow for the construction of an auto-descriptive environment, providing precious information to establish the interoperability among components.
These services could help in the data integration among different DSS such as data warehouse and data-mining applications.

CORBA Lifecycle Service [20]**:** the Lifecycle service should offer all the operations about the DSS life cycle such as create, delete, copy and move.

CORBA Event Service [34]**:** the DSS component should behave as a consumer and a supplier of events to the CORBA Event Services. DSS that interact actively with the user will be consumers of the events that activated them. For example, events such as the notification of occurrence of a new lab data could trigger an alert DSS. On the other hand, the DSS could also notify other objects about the conclusions reached, behaving then as a supplier of events for the event service. For example, when during the execution of a DSS there is a recommendation of doing some additional work-up, a notification event could be automatically generated and, therefore, consumed by the medical orders component.

CORBA Security Service [21,22]**:** the security service is crucial for all components dealing with confidential information. The DSS relationship with the Security Service is very tight - only those who have permission can access the DSS components. Different levels of permission and visions of the results should be considered, especially in consolidated and retrospective analysis.

CORBA Event-Condition-Action Management Facility RFP [23,24]**:** For those DSS that express knowledge in rules or use a simple procedural (algorithm) approach the ECA services could be used.

CORBAmed Lexicon Query Services RFP [1]**:** this service is one of the most important ones for the healthcare domain. Without it no other component will be able to share data and knowledge**.** The ideal situation would be the one in which all the data to be offered to the DSS could be mapped to the Lexicon services. Tools to perform these mappings should be offered by the Lexicon services. The output of the DSS should also be mapped to the Lexicon services even when dealing with consolidated data; the type of data that is shown should reflect an entity present in the Lexicon. For the explanation mechanisms it would be interesting to also take advantage of some Lexicon relationships such as *Causes, predisposes, is_influenced_by* .

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