

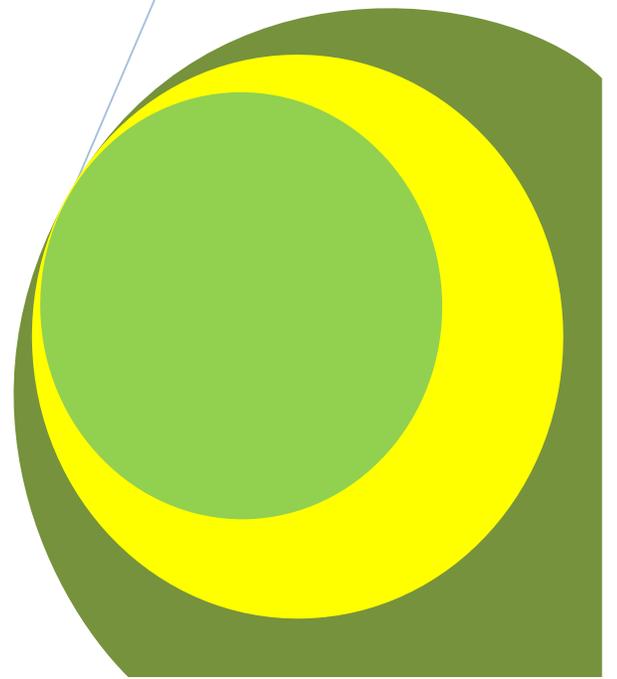
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# **Improve Of Health care Systems for Smart Hospitals Based on UML and Semantic Web Technology**

By

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*Research Article*

# Improve of Health care Systems for Smart Hospitals Based on UML and Semantic Web Technology

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## ABSTRACT

The convergence of information technology systems in health care system building is causing us to look at more effective integration of technologies. Facing increased competition, tighter spaces, staff retention and reduced reimbursement, today's hospitals are looking at strategic ways to use technology to manage their systems called smart hospital. The concept of the smart hospital is about adding intelligence to the traditional hospital system by covering all resources and locations with patient information. Patient's information is an important component of the patient privacy in any health care system that is based on the overall quality of each patient in the health care system. The main commitment for any health care system is to improve the quality of the patient and privacy of patient's information.

Today, there is a need of such computer environment where treatment to patients can be given on the basis of his/her previous medical history at the time of emergency at any time, on any place and anywhere. Pervasive and ubiquitous environment and Semantic Web can bring the boon in this field. For this it is needed to develop the ubiquitous health care computing environment using the Semantic Web technology with traditional hospital environment.

This paper is based on the ubiquitous and pervasive computing environment based on UML and semantic web technology, in which these problems has been tried to improve traditional hospital system into smart hospital in the near future. The key solution of the smart hospital is online identification of all patients, doctors, nurses, staff, medical equipments, medications, blood bags, surgical tools, blankets, sheets, hospital rooms, etc. In this paper efforts is channeled into improving the knowledge-base ontological description for smart hospital system by using UML and semantic web technology, Our knowledge is represented in XML format from UML modeling(class diagram).

**Keywords:** UML- Smart Hospital (SH) - Semantic Web Technology - health care system –and XML.

## INTRODUCTION

With more than 89 percent of hospital administrators involved in constructing a new building or renovating an existing facility to meet the ever-increasing demands for space. Today, hospital executives have to look closer at their work flow processes earlier in the game, in order to capitalize on the latest technology to optimize clinical, financial and administrative processes. And it involves more than advanced healthcare information systems. It also includes ancillary technology such as medical-device integration, advanced nurse call, and advanced patient tracking.

There are many organizational units or departments in the hospital, from which, it is necessary for them that there should be good coordination in each other. Even the available health care automation software also does not provide such coordination among them. These softwares are limited up to the hospital works but do not provide the interconnectivity with other hospitals and blood banks etc. Thus, these hospitals cannot share information in-spite of the good facilities and services.

Many changes and developments in Health care environment in the last decades are due to new technologies such as mobile and wireless computing. On the one hand, where the main aim of hospital is to provide better services and facilities to the patient, his/her proper care brings success to the hospital's name. Along with this, hospitals also adds many new facilities and services with existing facilities and services in one place for their patient. Having all facilities and services in the same place, hampers hospital's ability to provide sufficient care to the patient at any place and time.

The major problems with the health care environments are related to the information flow and storage of the patient's data and other entities of the health care system. These problems are further categorized below:-

- One problem is when there is information gap among the medical professionals, users/patients and various data source.
- Another problem is that there is a need to present and organize the information flow among the hospital members and other entities so that information can be accessed at any time and any place.
- Other problems are related to the various types of data used and no common format for holding it in a common way.

### Concept of Ontology

There has been much development in the ontology (Grainger, 2002; Dean et al., 2004; Guided Tour of Ontology, John F. Sowa, <http://www.jfsowa.com/ontology/guided.htm>; Victor Foo Siang Fook et al., 2006) process since the last decade and many good thinkers gave its meaning and its various definitions. It is a set of primitive concepts that can be used for representing a whole domain or part of it that defines a set of objects, relations between them and subsets of those in the respective domain. It is also a man-made framework that supports the modeling process of a domain in such a way that collection of terms and their semantic interpretation is provided. Our knowledge is represented in XML format.

In artificial intelligence (AI Watch - The Newsletter of Artificial Intelligence. Vol. 4-6. AI Intelligence, Oxford, UK). The term -Ontology is an explicit specification of a conceptualization, where ontology is defined as:

- a vocabulary - the set of terms used for modeling.
- a structure of the statements in the model.
- the semantic interpretation of these terms.

Ontologies have become ubiquitous (Bardram, 2007) in information systems. They constitute the Semantic Web's (Berners-lee, 2001; Horrocks, 2001) backbones, facilitate e-commerce, and serve such diverse application fields as bioinformatics and medicine. Many times the meaning of the word 'Ontology' is taken as a branch of philosophy that is the science, of the kinds and structures of objects, properties, events, processes and relations in every area of reality. Sometimes, it is used as a synonym of 'metaphysics' and having broader sense which refers to the study of what might exist and which of the various alternative possible ontologies is in fact true of reality. In simple term, Ontology can be defined as a collection of Classes, Sub-classes that makes the relationship among them. Our knowledge base of ontology is represented in XML format.

### Smart Hospital

I (Press Release - The Smart Hospital at The University of Texas at Arlington School of Nursing becomes a Laerdal Center of Excellence in Simulation. Available at-<http://www.uta.edu/nursing/simulation/pr-laerdal.pdf>; Bardram, 2004) is a type of hospital that is able to share the domain's knowledge with same or other domain and fulfill the requirement of the ubiquitous and pervasive computing (Weiser, 1993) environment. The smart hospital offers a number of advantages:-

- It provides a beneficial strategy for the better education and training simulation among the health care professionals.
- It ensures the higher levels of competence, confidence and critical thinking skills.
- It helps to manage the complex and changing health care system.
- It also supports the faculty for developing and evaluating new educational models, modalities, and teaching-learning strategies at no risk to patients.
- It also helps to integrate the better combination of ICT technologies, product and services.

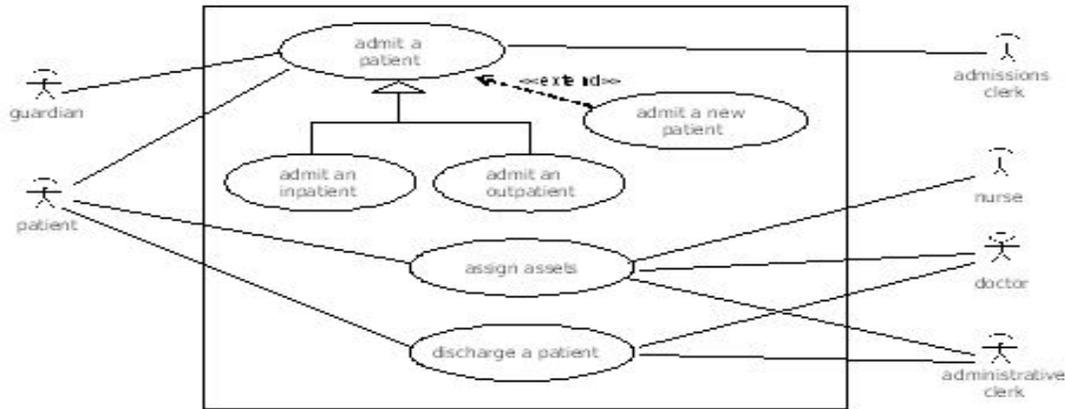


Figure 1a: Use-case diagram of SH

**Ontology for Smart Hospital (SH)**

The upper-level of ontology for the health care system is a major component where end user interacts with it and the information encompasses a conceptual component i.e. information that plays a role in hospital care outcomes, including errors and difficulties. To deal with the events, Deployment of SH in a particular hospital setting will involve developing the middleware to relate the ontological knowledge base (Alani et al.,2003) with existing information systems and by creating instances of ontological categories that is based on the information in the hospital databases (Favela et al.,2007). Our knowledge base is represented in XML format from UML modeling. Knowledge representation has been defined as "A set of syntactic and semantic conventions that makes it possible to describe things. The syntax of a representation specifies a set of rules for combining symbols to form expressions in the representation language. The semantics of a representation specify how expressions so constructed should be interpreted (i.e. how meaning can be derived from a form). In the proposed system, the knowledge representation methodology uses XML format. Where, two elements of knowledge, facts and model rules are represented using XML format. The overall knowledge structure is shown in figure 1b.

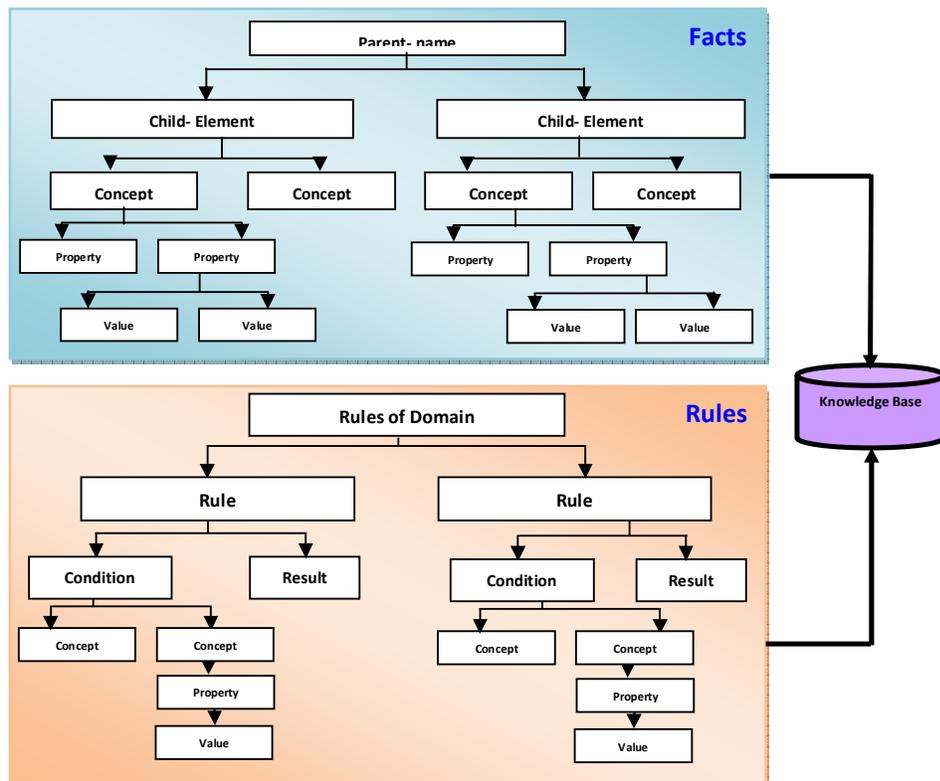


Figure 1b: Overall knowledge structure

The sample of the developed facts in our knowledge is shown in figure 2.

```

<DiagTestVal>
  <ConceptVal Name="Total Bilirubin"/>
    <ValueVal Val="Normal / Increased"/>
      <ValueVal Val="Increased"/>
    </ConceptVal>
  <ConceptVal Name="Conjugated Bilirubin"/>
    <ValueVal Val="Increased"/>
    <ValueVal Val="Normal"/>
  </ConceptVal>
  <ConceptVal Name="Unconjugated Bilirubin"/>
    <ValueVal Val="Increased"/>
    <ValueVal Val="Normal / Increased"/>
      <ValueVal Val="Normal"/>
    </ConceptVal>
  .
  .
  .
</DiagTestVal>
    
```

figure 2: Sample of developed facts in our knowledge

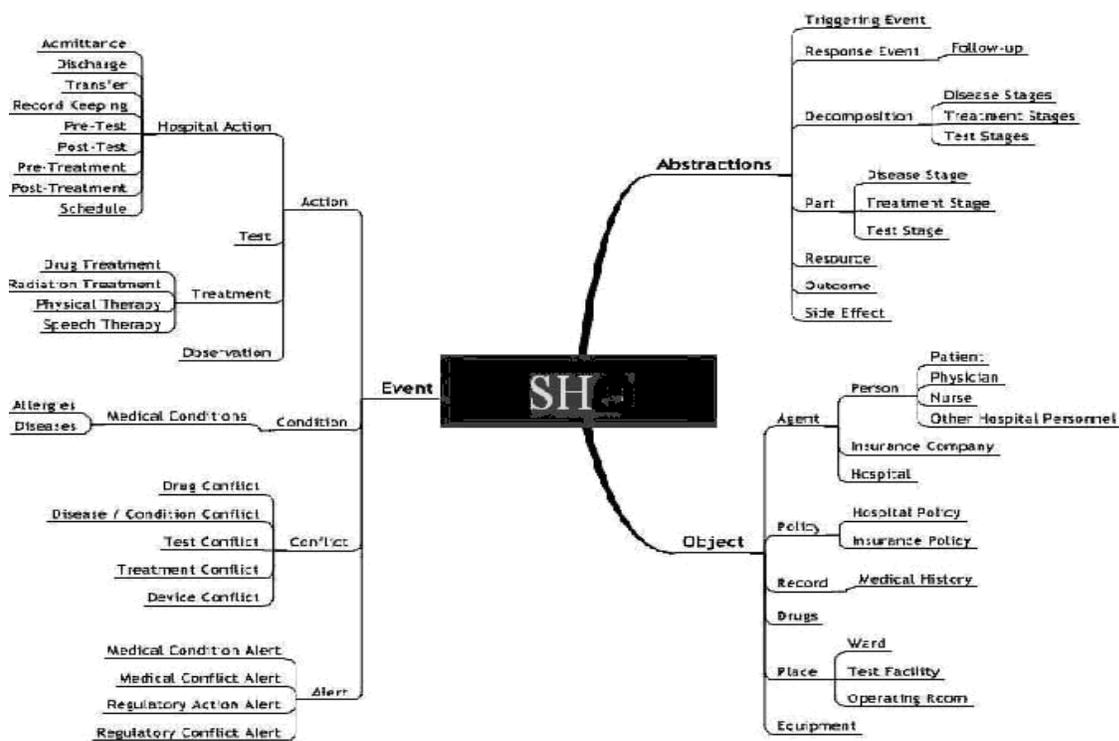


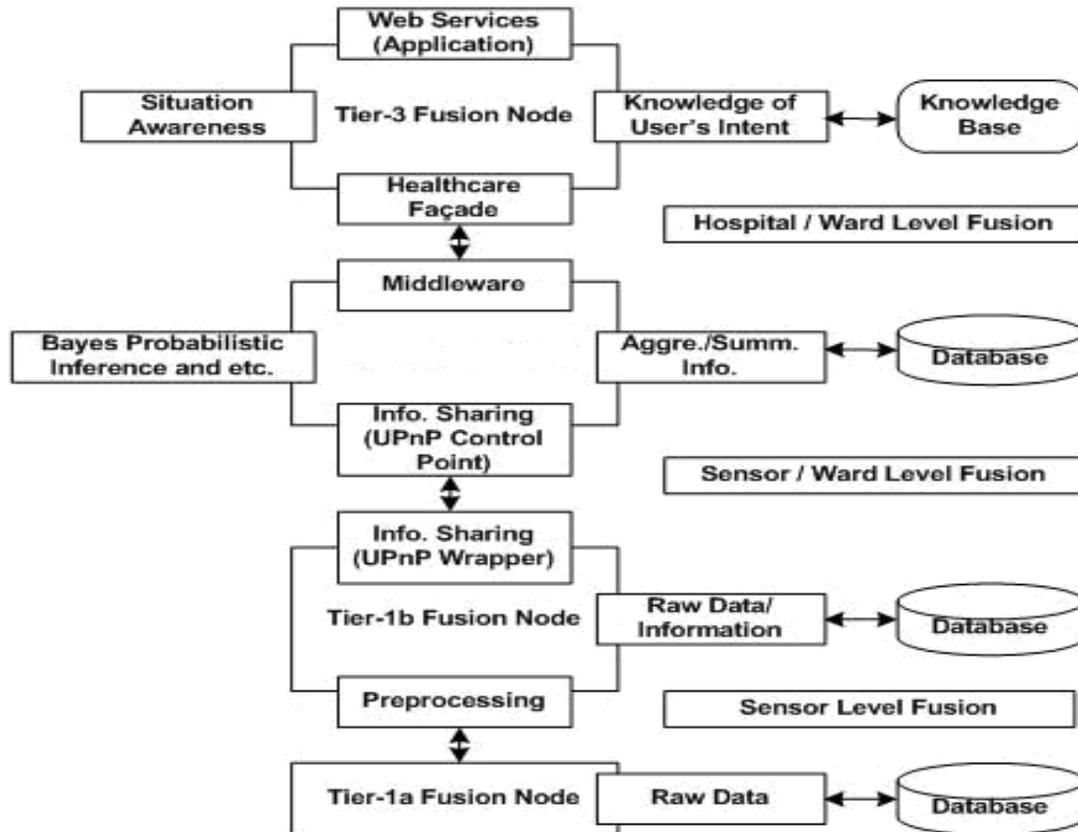
Figure 3: Top/Upper level of the SH ontology

In the above figure 3. the components are events, actions, person, policies, alerts etc. For example, in the SH different type of objects are taken such as-agents, policies, record, drugs, place and equipment etc. further, agent is categorized in many different type of agents type such as- person, insurance company and hospital also. So, this ontology is able to describe which action and event is performed in what time and what place. This is also useful to alert the different type of domain time to time with different type of alters such as-medical condition alert, medical conflict alert, regulation action and regulatory conflict alert.

The major benefits of ontology in health care environment are:

- To find out the common understanding of the structure of information among hospital entities or software agents and share it.
- Domain knowledge can be reuse.
- Domain assumptions can be made explicit.
- To separate domain knowledge from the operational knowledge
- To analyze domain knowledge

Figure 4 illustrates the middleware layer of architecture of a patient data collection system for smart hospital(SH):



**Figure 4: Middleware Architecture of a patient data collection system for SH**

Often ontology of the domain is not a goal in itself. Developing ontology is defining a set of data and their structure for other programs to use. Problem-solving methods, domain-independent applications, and software agents use ontologies and knowledge bases built from ontologies as data. For example, we develop ontology of patient, doctor and nurse and appropriate combinations of patient with doctor and nurse.

### Methods and Approach

The basic approach used to develop the ontology/knowledge base is the iterative approach that is used to identify the various super classes and sub classes and its properties which is based on the simple knowledge/ontology engineering (Gandon,2002) methodology. This methodology is described below: **Knowledge**

### Engineering Methodology

No specified methods or approaches are still developed for the development of ontology. Proposed methodology depends on an iterative approach to ontology development. All the steps are revised and refined in the process of iterative approach to evolve the ontology.

The process in iterative design is likely to be continued through the entire lifecycle of the ontology. Based on the various literature survey, the proposed steps for the processing of developing ontology are:-

## Finding the domain and scope of the ontology

The first step of the development of ontology is to determine and define its domain and scope. During the determination and definition of it, we must have to consider the following four questions so that we can be able to easily determine it:

1. What is the domain that the ontology will cover?
2. For what are we going to use the ontology?
3. For what types of questions should the information in the ontology provide answers?
4. Who will use and maintain the ontology?

The answers to these questions may change during the ontology-design process, but at any given time they help limit the scope of the model. Figure 5 shows the class diagram of a Patient Record in smart hospital.

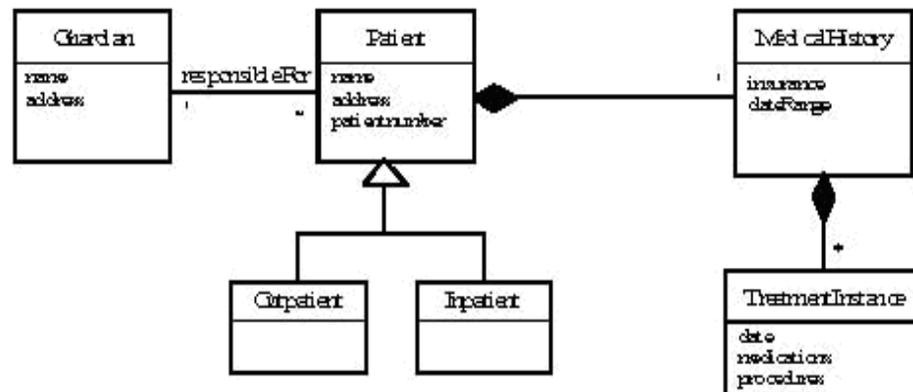


Figure 5: Class Diagram of a Patient Record in SH

## Consider reusing existing ontology

The second step to consider is about the existing ontology. The benefit of considering the existing ontology is about what someone else has done and checking if we can refine and extend existing sources for our particular domain and task. Reusing existing ontology may be a requirement if our system needs to interact with other applications that have already committed to particular ontology or controlled vocabularies.

## Enumerate important terms in the ontology-preparing vocabulary

The third step is to write down a list of all terms that are used in the system. We need to enumerate all properties that the concepts may have, or whether the concepts are classes or slots.

## Define the classes and the class hierarchy

The fourth step is to define the classes and its hierarchies. There are several possible approaches to develop a class hierarchy. These are:

- A top-down development process starts with the definition of the most general concepts in the domain and subsequent specialization of the concepts.
- A bottom-up development process starts with the definition of the most specific classes, the leaves of the hierarchy, with subsequent grouping of these classes into more general concepts.
- A mix development process is a combination of the top-down and bottom-up approaches.

Here, it is defined as the more salient concepts first and then generalize and specialize them appropriately.

## Define the properties of classes—slots

The fifth step is to define the properties of the class that is called the slots. Once we have defined some of the classes, we must describe the internal structure of concepts. For each property in the list, we must determine which class it describes. These properties become slots attached to classes. In general, there are several types of object properties that can become slots in ontology (Rodriguez et al., 2005; Moran et al.2006;Stanford 2006;favelaet al.,2007; Manhattan Research inc. , “Physicians in 2012: The Outlook for On Demand, Mobile, and Social Digital Media”. A Physician Research Module Report, 2009, New York, USA.) .

## Define the facets of the slots

The sixth step is to define the facets of the slots. Slots can have different facets which describe the value type, allowed values, the number of the values (cardinality) and other features of the values the slot can take.

## Slot cardinality

Slot cardinality defines how many values a slot can have. Some systems may have single cardinality (allows at most one value) and some may have multiple cardinality (allows any number of values).

## Slot-value type

A value-type facet describes what types of values can fill in the slot. Most common value types are String, Number, Boolean, Enumerated and Instance.

## Create instances

The last step is to create the individual instances of classes in the hierarchy. Defining an individual instance of a class requires: Choose a class, Create an individual instance of that class, and Filling in the slot values.

## UML Diagram for Smart Hospital

UML provides the graphical representation of visualization, specifying, constructing and documenting the artifacts(Moran et al.,2006; Manhattan Research inc. , “Physicians in 2012: The Outlook for On Demand, Mobile, and Social Digital Media”. A Physician Research Module Report, 2009, New York, USA) . The following figures [6.a],[6.b] shows the use of class diagram for patient treatment and Asset Assignment.

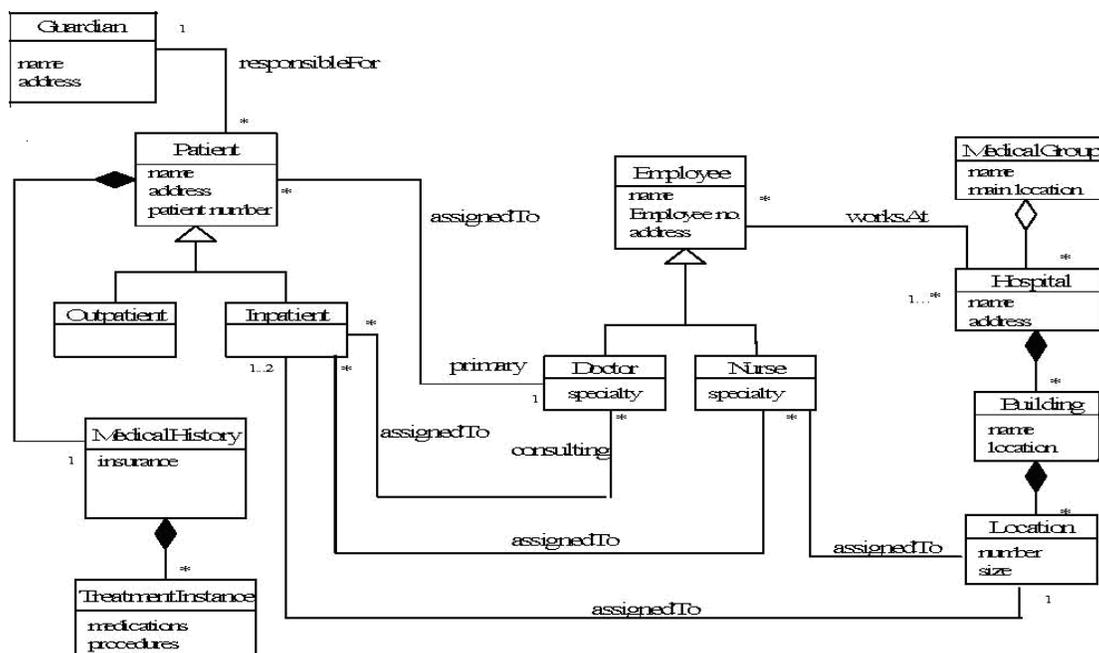


Figure 6(a): Class diagram for patient Treatment

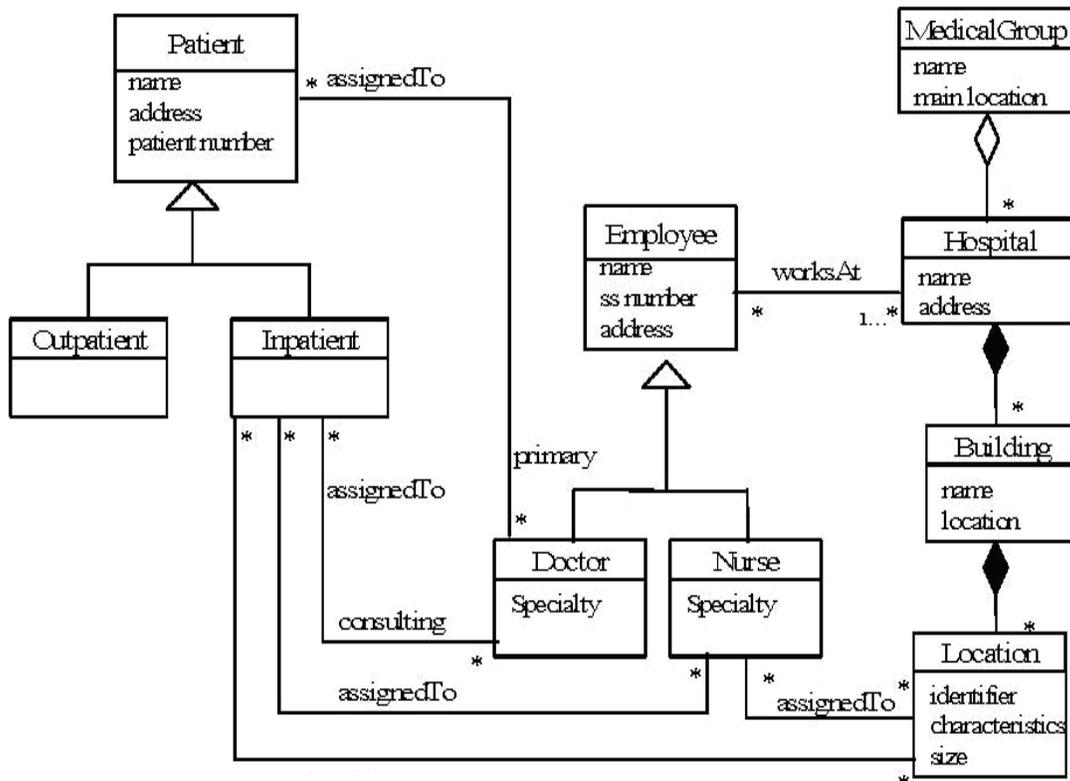


Figure 6(b): Class diagram for Asset Assignment

The sample of the developed facts in our knowledge is shown in figure 7. The sample of the developed rules is shown in figure 8.

```

<DiagTestVal>
  <ConceptVal Name="Total Bilirubin"/>
  <ValueVal Val="Normal / Increased"/>
  <ValueVal Val="Increased"/>
  </ConceptVal>
  <ConceptVal Name="Conjugated Bilirubin"/>
  <ValueVal Val="Increased"/>
  <ValueVal Val="Normal"/>
  </ConceptVal>
  <ConceptVal Name="Unconjugated Bilirubin"/>
  <ValueVal Val="Increased"/>
  <ValueVal Val="Normal / Increased"/>
  <ValueVal Val="Normal"/>
  </ConceptVal>
  .
  .
</DiagTestVal>
    
```

In our domain knowledge (Khaled et al.,2011), the facts is represented as shown in figure 7 where the concept "Total Bilirubin" is a one of the diagnostic test for "Jaundice" and the concept has possible values are "Normal / Increased " and " Increased ". The property of each concept here is default as "Value". The knowledge can be formulated as shown in the following simple statements: IF the 'traffic light' is green THEN the action is go, as for example: IF the 'traffic light' is red THEN the action is stop. These statements represented in the IF- THEN form are called production rules or just rules.

```

        >DiagConcept<
          >ResultConcept Name="Prehepatic" NoTrueFinding="1"<
            >TestConcept Cpt="Total Bilirubin" Val="Normal / Increased</"
              >TestConcept Cpt="Conjugated Bilirubin" Val="Increased</"
                >TestConcept Cpt="Unconjugated Bilirubin" Val="Increased</"
                  >TestConcept Cpt="Urobilinogen" Val="Increased</"
                    >TestConcept Cpt="Urine Color" Val="Normal (urobilinogen</"
                      >TestConcept Cpt="Stool Color" Val="Normal</"
                        >TestConcept Cpt="Alkaline Phosphatase Levels" Val="Normal</"
                          >TestConcept Cpt="Alkaline Transferase and Aspartate Transferase Levels"
                            Val="Normal</"
                              >TestConcept Cpt="Conjugated Bilirubin in Urine" Val="Not Present</"
                                />ResultConcept<
                                  >ResultConcept Name="Hepatic" NoTrueFinding="4"<
                                    >TestConcept Cpt="Total Bilirubin" Val="Increased</"
                                      >TestConcept Cpt="Conjugated Bilirubin" Val="Normal</"
                                        >TestConcept Cpt="Unconjugated Bilirubin" Val="Normal / Increased</"
                                          >TestConcept Cpt="Urobilinogen" Val="Normal / Increased</"
                                            >TestConcept Cpt="Urine Color" Val="Dark (urobilinogen+conjugated bilirubin</"
                                              >TestConcept Cpt="Stool Color" Val="Normal</"
                                                >TestConcept Cpt="Alkaline Phosphatase Levels" Val="Increased</"
                                                  >TestConcept Cpt="Alkaline Transferase and Aspartate Transferase Levels"
                                                    Val="Increased</"
                                                      >TestConcept Cpt="Conjugated Bilirubin in Urine" Val="Present</"
                                                        />ResultConcept<

```

**Figure 8: Sample of developed Rules in our knowledge.**

The term 'rule' in artificial intelligence, which is the most commonly type of knowledge representation, can be defined as IF-THEN structure that relates given information or facts in the IF part to some action in the THEN part. A rule provides some description of how to solve a problem. Rules are relatively easy to create and understand. Any rule consists of two parts: the IF part, called the antecedent (premise or condition) and the THEN part called the consequent (conclusion or action). The basic syntax of a rule is: IF <antecedent> THEN <consequent> . The rules in XML format have a different structure with the previous meaning but in different format. Sample of rule built in the proposed HCSysSystem is shown in Figure 8; it can be interpreted as following:

1. <DiagConcept>; represents the root in the domain of the Jaundice.
2. The node of "*ResultConcept*" represents a rule consequent and has attribute "*Name*" its value takes the consequent as "*Prehepatic*".
3. The child nodes "*TestConcept*" represent the decision rule for each part in Jaundice diagnosis that has two attributes are "*Cpt*", and "*Val*". For example the antecedent of rule is "*Total Bilirubin = Normal / Increased*".
4. The attribute "*NoTrueFinding*" represents the number of rule antecedent selected.

## CONCLUSION

Today's hospitals are looking at strategic ways to use technology to manage their systems called smart hospital. The concept of the smart hospital is about adding intelligence to the traditional hospital system by covering all resources and locations with patient information's. Patient's information is an important component of the patient privacy in any health care system that is based on the overall quality of each patient in the health care system. The main commitment for any health care system is to improve the quality of the patient and privacy of patient's information. For this, it is needed to develop the ubiquitous health care computing environment using the Semantic Web with traditional hospital environment.

This paper is based on the ubiquitous and pervasive computing environment and semantic web technology, in which these problems has been tried to improve traditional hospital system into smart hospital in the near future. The key solution of the smart hospital is online identification of all patients, doctors, nurses, staff,

medical equipments, medications, blood bags, surgical tools, blankets, sheets, hospital rooms, etc. In this paper, efforts are to improve the knowledge-base ontological description for smart hospital system by using UML and semantic web technology, Our knowledge is represented in XML format from UML modeling(class diagram).

Finally, to update- the health care system of the citizens of Saudi Arabia has been provided largely by a Smart Hospital, for examples: King Saud Medical Complex(KSMC) hospitals and King Faisal Specialist Hospital(KFSH).

## Appendix A:

Implementation of smart Hospital model; is a useful system for any hospital.

Smart hospital concerning with all aspects and issues related to a hospital included patients, doctors, employees, treatment and departments.

By using internet, doctors can access the system from any place around the world as shown in pictures below.

Our smart hospital provides access to its system by using a smart card through three levels:

- Write.
- Modify.
- Full control.



**Implementation of our smart Hospital Class Model.**

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