

Development of Ontology for Smart Hospital and Implementation using UML and RDF

Sanjay Anand[1], Akshat Verma[2]

[1] Noida, UP-201301, India

[2]Centre for Development of Advanced Computing (C-DAC)
Noida, U.P 201301, India

Abstract

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.

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 others. 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.

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 with traditional hospital environment. This paper is based on the ubiquitous and pervasive computing environment and semantic web, in which these problems has been tried to remove so that hospital may be smart hospital in the near future. This paper is the effort to develop the knowledge-base ontological description for smart hospital.

Keywords: Ontology, Smart Hospital, knowledge-base, Pervasive and ubiquitous, Semantic Web, RDF.

1. Introduction

Many change and many of the developments in Health care environment for the last decade are due to new technologies such as mobile and wireless computing. On the one hand where the main aim of hospital is to provide the better services and facilities to the patient, on the other, his/her proper care makes success to the hospital. Along with this, hospital also adds many new facilities and services with existing facilities and services in one place for their patient. Having all facilities and services to the same place, hospitals system is not able to provide sufficient care to the patient at any place and at any 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 associated when there is information gap among the medical professionals, users/patients and various data source.
- Another problem is that in which there is a need to present and organize the information flowed among the hospital members and other entities so that information can be accessed at any time and any place.
- Other problem related to the various types of data used and no common format for holding it in a common way.

2. Concept of Ontology

There are being much development in the ontology [4][7][9] process for the last decade and many good thinkers gave its meaning and its various definitions. It is a set of primitive concepts that can use 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 a collection of terms and their semantic interpretation is provided.

In artificial intelligence [11] the term -Ontology is an explicit specification of a conceptualization, where ontology defines:

- 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 [1] in information systems. They constitute the Semantic Web's [2] [3] backbones, facilitate e-commerce, and serve such diverse application fields as bioinformatics and medicine.

Many times the meaning of word 'Ontology' is taken as a branch of philosophy that is the science of what is, 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, the Ontology can be defined as a collection of Classes, Sub-classes and makes the relationship among them.

3. Smart Hospital

The smart hospital [14] is a type of hospital that is able to share the domain's knowledge with same or other's domain and fulfill the requirement of the ubiquitous and pervasive computing [5] 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.

4. Ontology for Smart Hospital (SH)

The upper-level of ontology for the health care system is 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 [8] with existing information systems and by creating instances of ontological categories that is based on the information in the hospital databases.

The following Figure-1 illustrates the part of the top/upper level of the SH ontology.

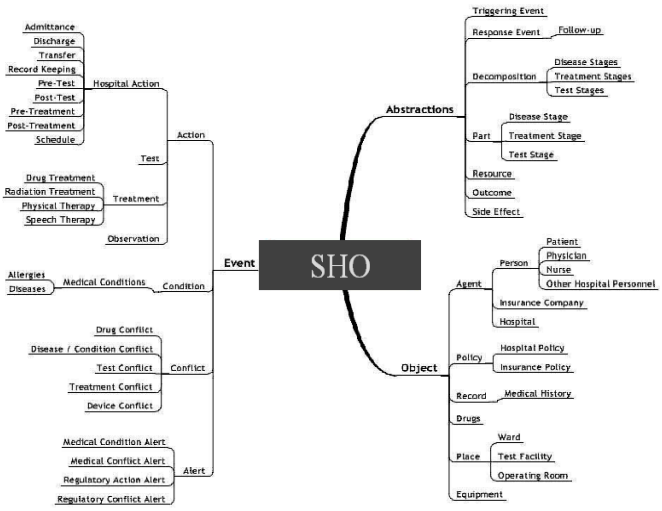


Fig. 1 Top/Upper level of the SH ontology

In the above figure the components are events, actions, person, policies, alerts etc. For example, in the SHO 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

Often ontology of the domain is not a goal in itself. Developing ontology is to 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.

5. 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 [10] methodology.

This methodology is described below-K**nowledge 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-

5.1 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 question so that we could be able to easily determine it:

-What is the domain that the ontology will cover?

-For what we are going to use the ontology?

-For what types of questions the information in the ontology should provide answers?

-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.

5.2 Consider reusing existing ontology

The second step is to consider about the existing ontology. The benefit of considering the existing ontology is that 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.

5.3 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 its all properties that the concepts may have, or whether the concepts are classes or slots.

5.4 Define the classes and the class hierarchy

The forth 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 the more salient concepts first and then generalize and specialize them appropriately.

5.5 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.

5.6 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.

5.6.1 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).

5.6.2 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

6. 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.

7. UML Diagram for Smart Hospital

UML provides the graphical representation of visualization, specifying, constructing and documenting the artifacts. Following figure-2 shows the use case diagram for patient treatment-

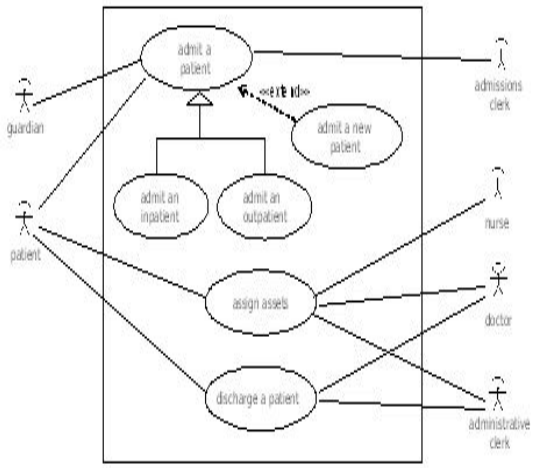


Fig. 2 Use-case diagram

Class diagrams for Smart Hospital are given below-

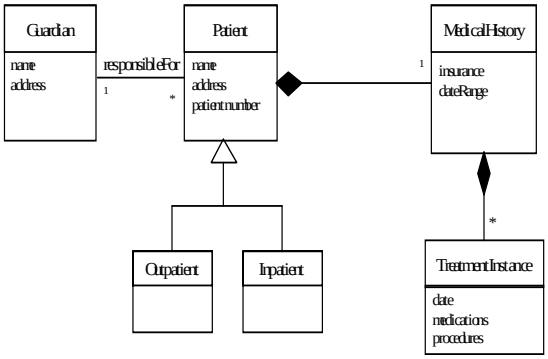


Fig. 3(a) Class diagram for patient record

Following Figure 3(b) shows the Class diagram for patient Treatment-

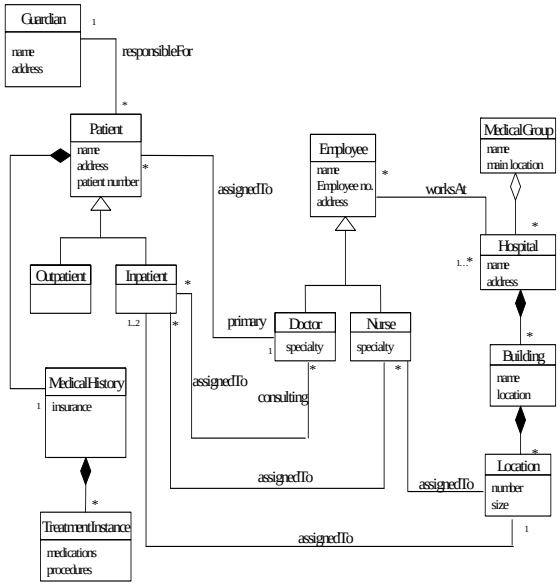


Fig. 3(b) Class diagram for patient Treatment

Following figure- 3(c) shows the Class diagram for Asset Assignment -

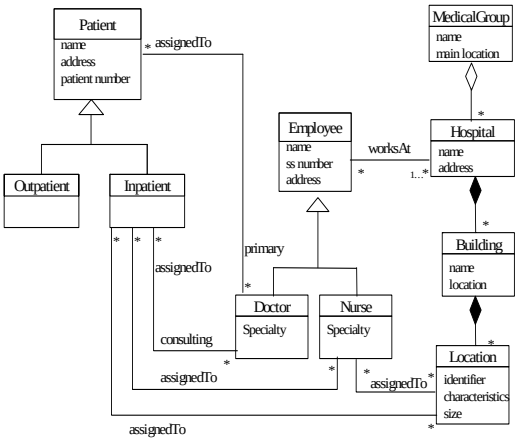


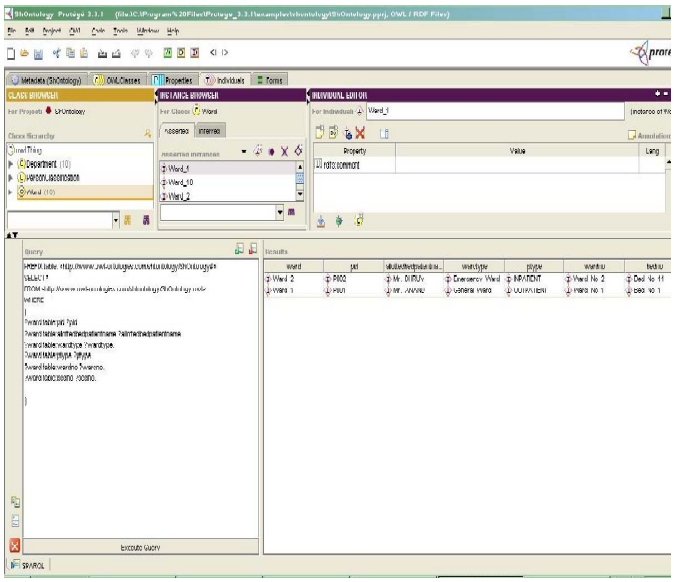
Fig. 3(c) Class diagram for Asset Assignment

8. Implementation

For querying, SPARQL is used, a W3C recommendation towards a standard query language for the Semantic Web. It is focus on querying RDF graphs at the triple level. It can be used to query an RDF Schema to filter out individuals with specific characteristics.

SPARQL is both a query language and a data access protocol which retrieves the data about the domain through the data which is stored in RDF (Resource Description Framework). A query language and data access protocol for the Semantic Web. It is defined in terms of the W3C's RDF data model and will work for any data source that can be mapped into RDF. Syntactically, it has probably been the most popular and widely implemented. This is perhaps surprising given the very different models that lurk behind relational databases.

Using the Protégé tool, click on the Open SPARQL Query panel... menu item. This will open a panel at the bottom of the screen in the Snapshot-



In the Query panel on the left, we can enter our query in the SPARQL syntax, press the Execute Query button and the query results will be shown on the right-hand side. In the snapshot above, the query selects the patient ID (pid), patient name (pname), Allotted ward name, Ward Type, Ward No and Bed No. of all the patient in the SH ontology-ward table.

9. Conclusion

9.1 Result Discussion

RDF is an open standard for the digital storage which is based on XML [6]. XML files are human readable by design, but this feature is not always desirable for security reasons.

An interesting effort is the use of UML has the ability to present a modeling visualization of data process flow.

This paper uses the RDF and use the RDF based query and database as a background. RDF query is simple then other database query. The reason behind of this is-

- Supporting a graph oriented API via a textual query language ala SQL.
- Load/Reload an RDF file from a URL into the database.
- Scalable to millions of nodes and triples.
- Provide support for RDF Schemas.
- Provide support for some basic forms of inference.

The RDF database stores the data in the form of object property and data type of the instance. It is a simple, scalable, open-source and object oriented database which keeps it to separate from the other database. That is the reason that it has been used in semantic web and web 2.0 which is the extension of running web.

Furthermore, the implementation of the patient ontology and its other related entities provides an explicit representation of the semantic and lexical connections that exist between information carried. A mapping mechanism facilitates the unified querying and presentation of information originating in medical Record. This system would be a filtered display of query results, presenting a merged view of valid and consistent information. Furthermore some meta-analysis of the results will help the user reason over the imposed queries.

Future Directions

This paper is basically using the semantic technology using the open standard- RDF and XML. Semantic web is the technology which is the extension of web where the research on this is going on. Actually, the different storage stores the different type of data on the web which increases the heavy load on the network. This project is the effort, based on the RDF as a background database which saves our time and space and near future this technology and improvement on this project may be possible which bring the boon in the health care environment.

References

[1] Bardram, J.E. and Christensen, H.B., 2007, “Pervasive Computing Support for Hospitals: An overview of the Activity-Based Computing Project,” IEEE Pervasive Computing, Vol. 16, No. 1, pp. 44-51.

[2] Berners-Lee, Tim, James Hendler, & Ora Lassila (2001)"The Semantic Web," Scientific American, May 2001.

[3] Horrocks, I.; Patel-Schneider, P. F.; and van Harmelen, F.2002. Reviewing the design of DAML+OIL: An ontology language for the semantic web. In Proc. of the 18th Nat. Conf. on Artificial Intelligence (AAAI 2002).

[4] Grainger, M.; Lee, J.: Ontology – Applications and Design. Communications of the ACM, Vol. 45, No. 2, February 2002.

[5] Weiser, M. 1993b. “Ubiquitous Computing”. IEEE Computer, 26(10):71--72.

[6] Erdmann, M. and Studer, R. (1999) "Ontology as conceptual models for XML documents". In Proceedings of the 12th Workshop on Knowledge Acquisition, Modeling and Management (KAW'99). Knowledge Science Institute, University of Calgary http://sern.ucalgary.ca/KSI/KAW/KAW99/papers/Erdmann1/erdmann.pdf.

[7] Dean, M.; Schreiber, G.; Bechhofer, S.; van Harmelen, F.; Hendler, J.; Horrocks, I.; McGuinness, D. L.; Patel-Schneider, P. F.; and Stein, L. A. 2004. OWL web ontology language reference. W3C Recommendation. http://www.w3.org/TR/owl-ref/.

[8] Alani, H., Kim, S., Millard, D. E., Weal, M. J., Hall, W., Lewis, P. H., and Shadbolt, N.R., 2003, “Automatic Ontology-Based Knowledge Extraction from Web Documents”, IEEE Intelligent Systems, Vol. 10, No 1, pp.14-21.

[9] Guided Tour of Ontology; John F. Sowa, http://www.jfsowa.com/ontology/guided.htm.

[10] F. Gandon, Ontology Engineering: a survey and a return on experience, Research Report of INRIA n°4396, France, March 2002.

[11] AI Watch - The Newsletter of Artificial Intelligence. Vol. 4-6. AI Intelligence, Oxford, UK.

[12] M. Uschold and Gruninger M. Ontologies: Principles, methods and applications. Knowledge Engineering Review, Vol. 11:2, 93-136, 1996. Also available as AIAI-TR-191 from AIAI, the University of Edinburgh.

[13] Bruno Bachimont "Modélisation linguistique et modélisation logique des ontologies: l'apport de l'ontologie formelle." In Proceedings of IC 2001, pp 349-368 Plate-forme AFIA, Grenoble 25-28 juin 2001.

[14] 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.

Sanjay Kumar Anand is a researcher and computer engineer. He has done the M.Tech in Information Technology from GGSIP University, Delhi. He has published one international and one national paper in conference. Currently, he is a reviewer of IJSCI and member of International association of Engineers. His research areas are Data communication and computer Network, Network Security, Software engineering, Database Management System and open source technology.

Akshat Verma is a researcher and a Freelancer Software Programmer. He has completed his M.TECH in Information Technology from C-DAC (Centre for Development for Advanced Computing), Noida, India and B.E in Computer Science and Engineering from Rajasthan University, Jaipur, India. His research interests are Steganography, Multimedia and Images, Network Security, Ontology, Cryptography and is working on Steganography in Images and audio/ video compression.