Semantic-Web Architecture for Electronic Discharge Summary Based on OWL 2.0 Standard

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ABSTRACT

Introduction: Patients' electronic medical record contains all information related to treatment processes during hospitalization. One of the most important documents in this record is the record summary. In this document, summary of the whole treatment process is presented which is used for subsequent treatments and other issues pertaining to the treatment. Using suitable architecture for this document, apart from the aforementioned points we can use it in other fields such as data mining or decision making based on the cases. **Material and Methods:** In this study, at first, a model for patient's medical record summary has been suggested using semantic web-based architecture. Then, based on service-oriented architecture and using Java programming language, a software solution was designed and run in a way to generate medical record summary with this structure and at the end, new uses of this structure was explained. **Results:** in this study a structure for medical record summaries along with corrective points within semantic web has been offered and a software running within Java along with special ontologies are provided. **Discussion and Conclusion:** After discussing the project with the experts of medical/health data management and medical informatics as well as clinical experts, it became clear that suggested design for medical record summary apart from covering many issues currently faced in the medical records has also many advantages including its uses in research projects, decision making based on the cases etc.

Key words: Electronic discharge summary, semantic web, service-oriented architecture, ontology.

1. INTRODUCTION

The medical record summary is one of the most important documents in the patient`s record which will be edited by his/her physician upon release (1). This document is very important as it can be used to continue treatment in subsequent visits (2).

Owing to the fact that it includes an abstract of the whole treatment process of hospitalized patient, it can also have several other uses. But due to traditional structure it can`t be used in other areas (2-4).

In this study based on XML and SEMANTIC-WEB standard, a structure for medical record summary has been suggested. This structure has many other uses such as transferring correct data of patients between the centers and different treatment systems, collect patients' data, doing data mining-based researches on the data of hospitalized patients.

Semantic web

A thousands of pages will be released daily in the Internet environment based on Web technology. Many of these pages are in the area of medical knowledge. To perform automatic processing on this information, special infrastructures are needed. One of such structures is semantic web which is introduced by Berners-Lee. The aim of Semantic Web is to read and interpret information automatically by machines (5).

Semantic web usage

Using Semantic Web and its related technologies in the field of data processing can be carried out many activities that the two groups of the most important ones are as follows:

a) collecting data from various sources in different places with different structures;

b) sharing the collected data.

There are several studies on above topics (6-9).

Related works based on semantic web in health domain

Semantic Web is frequently used in health studies (10-15) including:

- Genetic molecular and cellular studies;
- Implementation of decision support systems based on Semantic Web;
- EHR design based on the Semantic Web;
- Information retrieval based on the concepts of Semantic Web.

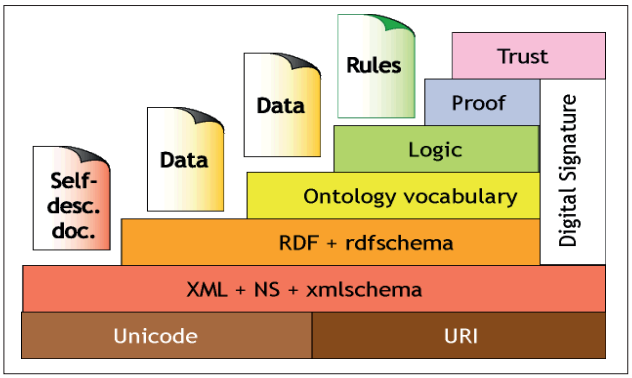

Figure 1. Semantic web architecture

2. MATERIAL AND METHODS

In this study first by running an expert panel the current weaknesses of the print medical record summary were dealt with and the issues were categorized. Then, based on semantic web architecture a structure for the medical record summary was offered. Designing and running the software able to extract this structure was the last stage of the study.

Weaknesses of the current model of the medical record summary

According to information management professionals and physicians several weakness for medical record summary exist. These problems are grouped as follows:

a) Many sections of the record summary are still written as an ordinary text. In medical record summaries overwriting texts can have the following problems:

- Unreadability of the text;
- Incompleteness of the whole data related to the record summary;
- Inability to convert the medical record summaries.

b) Not using standard coding system to code all the items contained in the record summaries;

c) Problems in converting the data of record summaries of the patients between the medical centers due to the lack of a standard for the retrieving of information from the record summaries;

d) Problems in information processing of the medical record summaries for uses such as data mining.

The modified structure based on the Semantic Web

The following corrections have been offered for the record summary model

a) Making new structures in each of the sub-sections of the record summary to convert the record summary from semi-structure to full-structure;

b) Running hash-MD5 and encryption algorithm on record summaries for safety reasons as well as digital signature;

c) Making a Schema to confirm the reliability of the record summary document;

d) Coding the available concepts contained in the record summary based on UMLS standard;

e) Making a unique serial number for the record summary which is not repeated in the whole domain, based on the URL layer of semantic web.

Suggested Structure

The standard semantic web structure, will be added to the record summary per available layers. Thus the following advantages will be achieved:

a) The record summary of the patient will become more structured;

b) Processes such as data mining will become simpler;

c) Transferring patients' data from the record summary becomes simpler;

d) Using all semantic web processing technologies in order to process the data.

The following proposed changes in every layer of the Semantic Web architecture is explained.

- Semantic Web Layer 1;
- Adding a mixed identifier based on the national code of the patient and the medical center`s code to make an identification code unique to each individual;
- Using UTF-8 standard for the record summary;
- Semantic Web Layer 2;
- Adding new feature in XML structure, each sections of the record summary become fully structured;
- Designing an XML-Schema to evaluate the record summary;
- Semantic Web Layer 3;
- Adding codes related to each section of the record summary based on UMLS standard;
- Semantic Web Layer 4;
- Making special ontology based on SNOMED standard within the knowledge domain and after consultation with the experts of that domain;
- Semantic Web Layer 5;
- Making electronic field of confirmation based on MDS algorithm according to the code of the medical council of the physical treating the patient

The software for making record summary

In order for the suggested model for the record summary to be more applied and also to use it in different data systems of hospital, the software was made for extracting record summary with service-oriented architecture using Java, MYSQL and MONGODB database. To save record summary, a special ontology was made in protégé as the main body of record summary`s information.

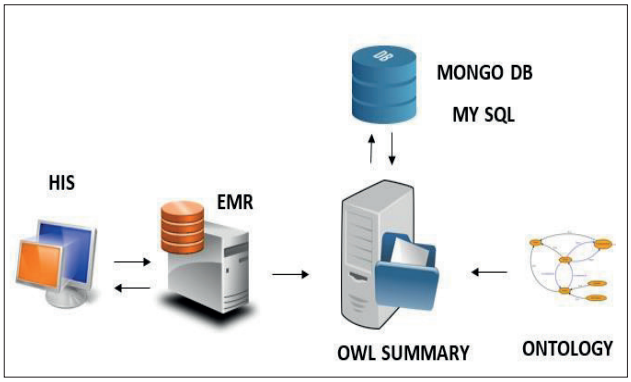

Figure 2. System Architecture

No	Question	Importance				
		1	2	3	4	5
1	How much effective is the conversion of print record to an electronic one?					
2	Does the electronic record summary have any positive effect on interoperability?					
3	How much the safety and confidentiality as important in transferring the data of the record summaries?					
4	How much important is the coding of the data contained in the record summaries based on the conventional standards such as ICD, UMLS?					
5	How much helpful do you consider adding META-DATA to the record summary of the patient in transferring the data?					
6	How much important is using the digital signature during transferring the data?					
7	How much important is the specification of the unique identifier in retrieving and transferring data?					
8	How much using OWL standard to transfer the data of the record summary acceptable?					

Table1. Health information manager's and medical informatics questioner

No	Question	Importance				
		1	2	3	4	5
1	How much the demographic data contained in the record summary`s structure sufficient?					
2	How much effective is using the suggested structure for the continuation of the treatment process?					
3	How much using suggested record summary be effective in decision making during the treatment?					
4	How much suggested structure for the record summary save time for the physician?					
5	How much suggested structure for the record summary be effective in reducing mistakes during the treatment procedure?					
6	How much medications data displayed in an appropriate way?					
7	How much coding and categorizing the data of treatment in medical procedures appropriate?					

Table 2. Physician's questionnaire

Evaluating the proposed model

Three different questionnaires were provided for the groups dealing especially with the record summary in the hospital. These questionnaires were distributed among groups which include physicians, health information managers and medical informatics experts.

3. RESULTS AND DISCUSSION

The questionnaire was distributed among 80 experts in three groups. 50 persons responded to questionnaire.

After analysis of each questionnaire, results are shown in Figures 3 and 4.

In different structures, the record summary has only been presented in print and so far in none of the previous studies there has been suggested the structure of the record summary based upon the semantic web and meta-data (16); in the suggested structure we have used structures for the different sections of record summary which minimizes the text, while in other structures of record summary entering the data must be done textually (17, 18). Using the above structure can facilitate transferring the data between the systems as well as saving and retrieving them and make it more correct. In suggested discharge summary structure, optimized tools for searching through medical documents can be much more effective retrieve the records. By using suggested structure, doing inference process on the record summaries can be done.

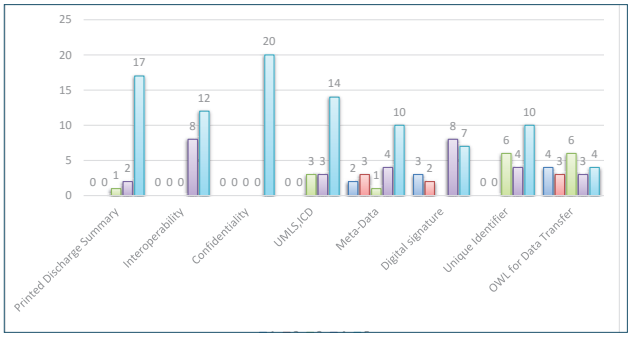

Figure 3. Medical informatics/Health data management Questioners Analysis

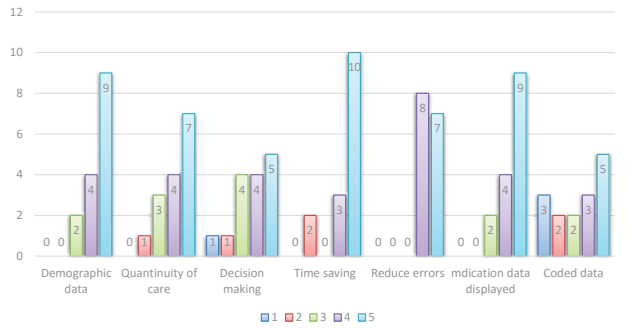

Figure 4. Clinicians Questioners Analysis

4. CONCLUSION

After completion of suggested structure and in future studies the following activities will be done:

- Developing a Case Based Reasoning system based on this structure for the chronic disease patients;
- Running data mining on the saved record summaries based on OWL standard;
- Providing rule-based expert systems in clinical domain and running inference process on the record summaries;
- Building a special ontology in nephrology to complete the CBR process.

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