TM_BDU: A PROPOSED FRAMEWORK FOR USING TOPIC MAPS TO MANAGE INFORMATION IN BLOOD DONATION UNITS

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Abstract: The manner in which medical information is expressed and perceived in electronic form, is essential to the success of any attempt to profit from applying web technology in healthcare. Topic Maps as a new technology of the semantic web, seem to subscribe to the satisfaction of this requirement, as they were introduced in order to build a bridge between knowledge representation and information management. In the context of this paper we will discuss the potential of using topic map to manage medical information, make a brief review of related attempts and consequently propose a framework for incorporating topic map technology for information management in Blood Donation Units.
Keywords: medical information , semantic web, topic map, retrieval, navigation, merge

Introduction

The rapidly increasing popularity of World Wide Web as an ubiquitous information service resulted to a proportional increase of the expectations and requirements towards the opportunities and challenges of applying new technologies in medical information systems [1]. The manner in which medical information is expressed and perceived in electronic form, is essential to the success of any attempt to profit from applying web technology in healthcare [2]. Emerging technologies of the Semantic Web can subscribe to the satisfaction of these requirements.

The topic map technology as a new semantic – ontological approach intends to organize information in such a way that it is optimized for navigation and knowledge representation [3,4]. Topic Maps described as the "GPS of the information universe", is a knowledge representation applied to information management from the perspective of humans [5], and they can be seen as a description of what is about a certain, by formally declaring topics, and by linking the relevant parts of the information set to the appropriate topics [6,7]. Topic maps are suitable for large or dynamic information sources, better querying than a static index can be implemented and they make the merging of

diverse information resources possible [8], hence there are a lot of potential applications of this new technology.

In the context of this paper we will discuss the potential of using topic map to manage medical information, refer what there is so far and consequently propose a framework for incorporating topic map technology for information management in Blood Donation Units.

Topic maps and medical information.

The first occurrence of topic maps was in 1993 when the concepts of topic maps where first described. In 2000 topic maps became the ISO/IEC standard 13250:2000 [3]. A year later, the standard was revised to include the XTM syntax of XML, the topic maps language [4].

Since topic maps work as an organizational layer between the end-user and the information itself, they have three main characteristics. They are suitable for large scale information resources (organizing them), they are suitable for resources that contain diverse data types such as HTML, Databases etc. (XTM provides different tools for accessing these data types, such as SQL querying) and finally, topic maps are suitable for information which can be used by different users with different needs and different perception of the information itself (as multiple diverse interfaces can access the topic maps at the same time).

One of the promising applications of the topic maps is the large scale ontological re-organization of medical information. According to Walter Fierz [9] the structured content and connectivity of medical information will lead to a medical data Web. Furthermore, he describes the principles on which this "Medical Data Web" must be based [2]. He says that medical information resides in the connectivity of data. An isolated data element on its own has little information content. The Semantic Web provides the conceptual and technical framework for a Medical Data Web. Information profiling is pivotal to the success of a Medical Data Web.

There are three basic data sets of medical information.

1. Medical literature information (there have already been attempts for standardizing the medical knowledge and creating a universal set of terms and ontologies, but not a data map integrating the relations between knowledge nodes i.e. pathology, hematology and cardiology)

2. Information about morbidity (causes of illnesses, deceases, treatments and finally mortality)
3. Personal patient information (patient record)

All these three layers of information can be integrated through the web, using the topic maps technology. We can group the benefits of switching to a topic maps based large scale information system into the following [6]:

1. It will replace the hand-written patient information record
2. It will allow access from different information systems (already owned by hospitals)
3. It will be able to hold considerable mass of information about the patient
4. It will be utilized by many different interest groups, such as medical staff, researchers, the patient, the administration of the hospitals etc.

Related Works

A medium scale project called MedIS is being developed by the FAW (Institute for Applied Knowledge Processing), Austria for the Barmherzige Schwestern Hospital (Linz, Austria). The project MedIS (Medical Information System) uses topic maps and extends the SAP-system with the modules IS-H and IS-H*Med. The aim is to establish a common patient management and medical documentation for the hospital [10].

The FAW institute is responsible for:

- Creation of a companywide data model based on the SAP-system
- Establishing prerequisites for the application of a rule-based system
- Implementation of parameterized documents
- Quality insurance

Conducted research states that text matching methods fail to represent implicit relationships between data, e.g. the relationship between HIV and AIDS. The international organization for standardization (ISO) topic maps standard provides a data model that allows representing arbitrary relationships

between resources. Such relationships form the basis for a context sensitive search and accurate search results [11].

De Bruijn and Martin [12] support that literature mining offers powerful methods to support knowledge discovery and the construction of topic maps and ontologies and review the recent developments in medical language processing. One of the advantages of such a project is that the same collection of information can be used for more than one purpose or audience. On top of a medical information system a Topic Map can be defined that will give precise information for both a cardiologist and a lung specialist. A number of topics will be equal for both – like blood vessels and cholesterol – but their relations with other topics can be quite different [13].

On the other hand, Beier and Tesche from the hyperCIS [14] have developed a front end topic map application that works with text search engines in the background. More specifically, the access to relevant, up-to-date and reliable information is a time critical, but nevertheless very important task in the daily work of physicians and nurses. HyperCIS developed an intelligent information retrieval system (IRS) with a knowledge-guided user front-end and an automatic generation of search engine queries.

The medical knowledge of MeSH (Medical Subject Headings) classification was transferred into a Topic Map, the new XML-based knowledge representation standard (ISO 13250). A graphical user-interface allows the fast and associative browsing in networks of themes. Each theme or topic, as a node of the topic map, contains information on title, synonyms, translations, definition, scope, sub- and superclasses. This domain-specific knowledge of a topic is exploited by the hyperCIS IRS to automatically generate search queries.

Health Level 7 (HL7) is an American organization working on medical information systems and connectivity and is recognized by the ANSI as a standards producing capable organization. One of the HL7 projects is the Kona project which intents to integrate all hospital filing systems across all the American hospitals and clinics into one comprehensive web XTM system [15].

Even within the US, clinics come in many varieties and keep records that are consistent with their missions, but inconsistent with the record-keeping practices of other clinics. Health maintenance organizations and health insurers in general are imposing increasingly uniform record-keeping requirements on almost all healthcare providers, but the special record-keeping requirements of special-purpose clinics, and of hospitals with teaching and research missions, are at odds with the insurers' attempts to impose such uniformity.

The result is often a welter of forms on which healthcare personnel must enter information redundantly, and even in such a way as to appear inconsistent with one another, in order to meet all of the conflicting requirements. The Kona architecture being developed in the context of the HL7 initiative is an "SGML inheritable architecture" designed to permit global interchange of medical records, while continuing to support multiple levels of local control [16].

SNOMED® International is a division of the College of American Pathologists (CAP), where they focus on advancing excellence in patient care through the delivery of SNOMED® (the Systematized Nomenclature of Medicine) and terminology and implementation support products and services. SNOMED Clinical Terms® (SNOMED CT®), is the universal health care terminology that makes health care knowledge usable and accessible wherever and whenever it is needed. This strong foundation is leading the health care industry in building a seamless infrastructure of worldwide care while integrating an overwhelming amount of clinical data [17].

Potential advantages of using TM for managing medical information

According to Walter Fierz [9] the principles on which this "Medical Data Web" must be based [2] include

- the granularity of data elements;
- the way to attach semantic information to the data elements, links and structures;
- the storage of the data together with their structure and the connections between the data elements;
- a query system for the extraction of the information contained within the structure and connectivity as well as from the data proper;
- and the display of the query result in a way that structure and connectivity are intuitively and usefully expressed and can be stored again in a structured, machine-accessible way.

Topic map technology seem to meet these requirements. Talking about Topic Maps is talking about knowledge structures which are the basis for knowledge representation and knowledge management. In topic maps, topics have characteristics of various kinds: names, occurrences and roles played in associations with other topics [5,6]. Moreover, in topic maps assertions are n-ary, as an association may have any number of roles and can thus easily express more complex relationships [6].

Topic maps provide a more abstract layer of data modeling, storage and querying. The special characteristic of the Topic Maps model is the clear separation between the description of the information structure and the physical information resources. TM-based applications offer possibilities for searching, navigating, and visualizing both the conceptual and resource layers [6,7].

One obvious question is why using topic maps to manage medical data instead of a relational database. Although a relational database can model just about anything , the problem is that in order to add or change properties and relationships between things there is the need to change database table structure all the time, and also keep changing all SQL queries. By modeling things in a topic map, someone can keep changing properties and relationships, without having to change code or queries. So if your data is something that will change a lot, and has rich relationships, topic maps offer a viable solution to manage information [18].

One of the advantages of such a project is that the same collection of information can be used for more than one purpose or audience. TM allow users to create different personalized views of the same set of resources capturing viewpoints through the use of scopes [6,7]. Different user groups can see the world in different ways as different user interfaces, tailor made to the needs of each group, can be utilized exposing small portions of the information and saving time for the end user.

Additionally, topics Maps permit the representation of knowledge in an interchangeable form [7]. Thus TM-based applications promote reuse, sharing and interoperability of information resources and could support exchange of information with other health organizations [19].

Furthermore topic maps were designed from the start for ease of merging. The concept of subject identity and the ability to establish a topic's identity through a subject address and multiple subject indicators are key to this capability [6,7]. Hence they support merging of information with other health organizations [19].

Another key requirement in every database management system is an appropriate mechanism to query the data. In the same way as relational databases can be queried, a structured retrieval of Topic Map data, is offered using TOLOG language [20]. TM structure enables intelligent retrieval of information through the use of inference-based queries. TOLOG can query topic maps for topics of specific types, which participate in certain combinations of associations, and also supports inference-based rules.

The scope of this work is to propose an architecture for managing medical data in blood donation unit, and eventually exploit the aforementioned potential advantages of using this new technology for knowledge representation and information management of medical information.

TM_BDU (Topic Map based Blood Donation Units) proposed architecture

The scope of this work is the provision of an integrated system providing easy access to blood reserves, statistics, medical records of blood donors and other related information on a large scale . It aims to illustrate how topic maps could be applied to manage medical information and has discussed some potential benefits of encoding these information as a topic map.

In Thessaloniki area there are four blood donation units. Two of them are Blood Donation Centers (at AHEPA Hospital and Ippokratio Hospital) and the other two are Blood Donation Stations A Class (Papanikolaou Hospital and Agios Pavlos Hospital). None of them possesses an electronic filing system. On the contrary the U.K possesses an integrated blood donation system with a centralized database (blood stocks and donors medical records [21].

The data of such a system should be complete, comprehensive, consistent, reliable, and timely. All medical information acquired from a web based topic maps medical application should be available to authorized users anywhere (on-site, off-site) and at any time (seven days a week, twenty-four hours a day). The data repository should be seamlessly integrated with the transaction-oriented patient care systems. Data should be available in a timely manner in the repository within some time interval after being generated; for example, lab results are available ten minutes after the lab technician certifies them in the lab system. Any part of the medical record generated using computer systems should be available to the physician and researcher in an electronic format [25]. The data should be internally consistent and reliably available across system boundaries.

Access to the medical data may have:

- The blood donation units
- Researchers looking for statistics
- The hospitals looking for blood

- The patient

For achieving the above scope the following partial objectives are necessary (Figure 1):

- Creation of a user friendly database application for the blood donation units (easy data input even by a doctor with no IT background)
- Setting up of the equipment at the blood donation units (computers, databases, and classes/workshops given to the doctors about the use of the system)
- Using a software tool for encoding database information to topic map and vice versa
- The same tool should offer enhanced navigating enables powerful navigational functionality within different representative forms
- as well as retrieval functionality, by providing enhanced features for employing rules and queries in TM.
- Interconnection with other semantic web medical applications

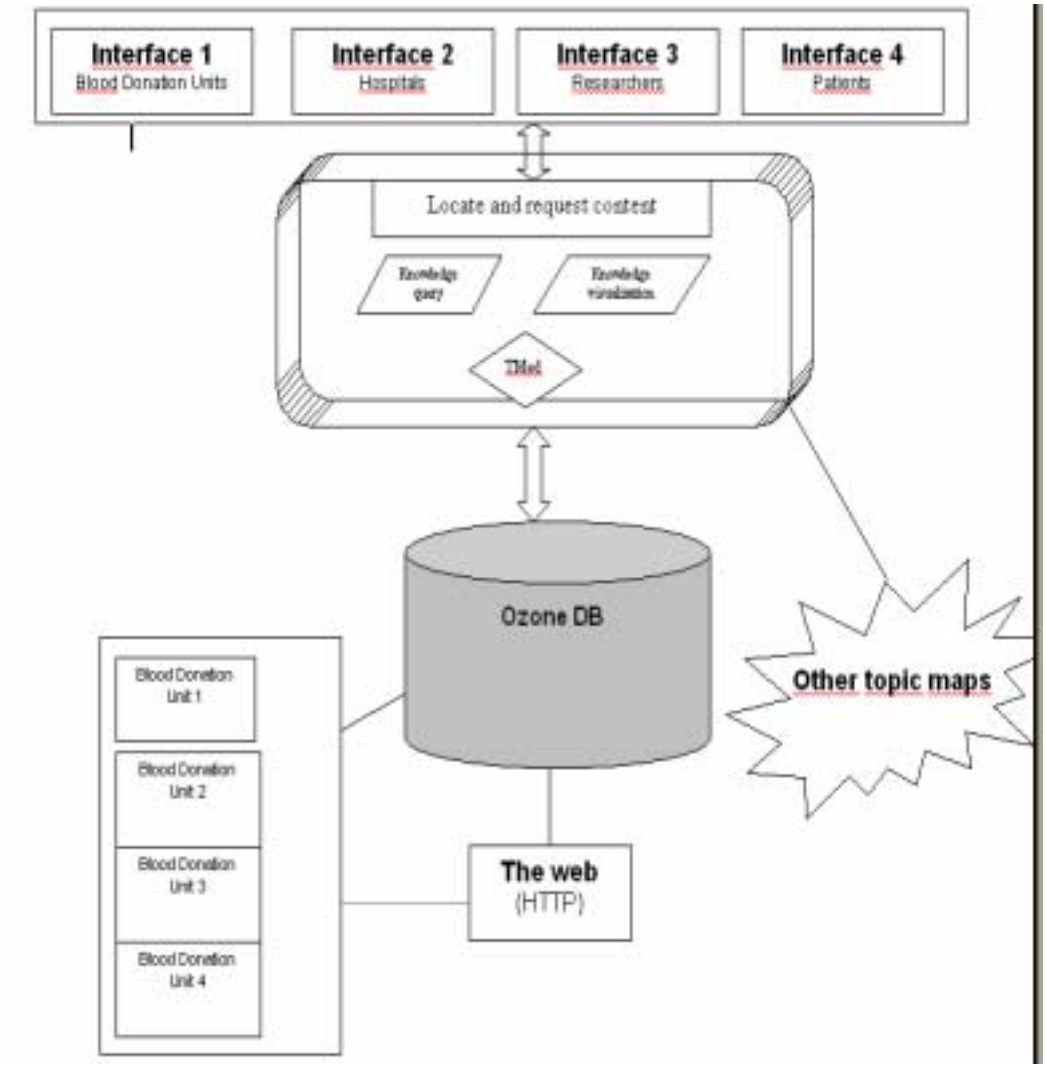

Figure 1: Proposed TM-based architecture

A key factor in a successful appliance of topic maps is a software application tool, which provides an integrated environment for editing, viewing, managing and merging topic maps. TM-Editor (TM-Ed) was designed and implemented in our Laboratory aiming to reap TM capacities and eventually to support the use of TM technology [22]. TM-Ed (Figure 2) enables the programmatic creation, manipulation and delivery of topic map

structures providing an enhanced and easy to use graphical user interface. It allows creation and management of new topic maps or opening ones that already exist. It provides facilities for building topic map structures, manipulating and converting them to their equivalent XTM form. In addition, TM-Ed also enables powerful navigational functionality within different representative forms as well as retrieval functionality, by providing enhanced features for employing rules and queries in TM [22].

This software application tool (TM-Ed) was implemented in Java as a module under NetBeans. The programming language of choice was Java because of its portability to different operating systems. It is powerful and easy to understand. This way we ensure the platform independent and portability of the developed application.

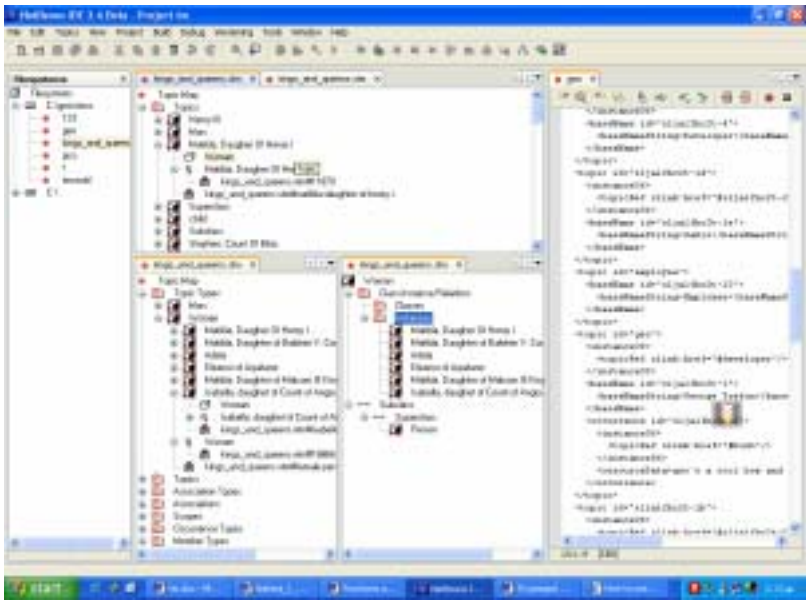

Figure 2. Screenshot of Tmed

We succeeded low level management of Topic Maps by using an open source code library, TM4J [23] and more specifically publication 0.9. TM4J is an open source software package supporting the XTM-standard, easy to use and provide all the operation needed to develop TM. The TM4J engine provides a comprehensive Application Programming Interface (API) to allow

programmers to create and modify topic map structures. The engine can be used to manage topic maps The Engine also provides interfaces for:

- querying topic maps structures using the TOLOG query language,
- writing topic maps to XTM syntax files.

TM-Ed provides the potential user of the proposed TM-BDU system the possibility to request and locate information, to navigate, browse and visualize medical data in an initiative way and additionally to query knowledge and retrieve the information they are looking for.

Another key issue that it should be taken under consideration is the database that we are going to use for data storage. TM4J supports two fully-featured backends - one based on storing the processed XTM file in memory and one as persistent storage in an Ozone OODBMS back-end.

Medical information could be hold in an XTM file. But we have realized that by adopting this solution, it would be difficult to have remote calls from client computers in order to update and manage the topic map, as it would be necessary to use ftp calls and change the txt file that holds the XTM files. Moreover, using a database technology could enforce the persistent of our system and enhance the size of the records saved in a topic map repository.

The ozone (OODBMS) database [24] is a fully featured, object-oriented database management system completely implemented in Java and distributed under an open source license. You can use any XML tool to provide and access these data. Ozone does not depend on any back-end database or mapping technology to actually save objects, but it contains its own clustered storage and cache system to handle persistent Java objects.

The administrators of the system can use all the features that TM-Ed offers in order to create and manage topic map and store it to the ozone database. On the other hand users of the system will have limited access to TM-Ed features. An easy to use graphical user interface will enable them to add data to the database.

The next scope of this work is the implementation of the system, and the steps to be followed could be summarized as follows:

- Creation of the date bases and installation of the necessary software (short/medium term)
- Launch and use of the system (short/medium term)

- Evaluation of the system (short/medium term)
- Expansion of the system (medium/long term)

Conclusion

Topic map technology as a new ontological approach in knowledge representation and information management seem to offer a feasible solution for managing medical data. The scope of this work was to discuss the potential advantages of using topic maps in order to manage medical data, and consequently propose a framework for an integrated system providing easy access to blood reserves, statistics, medical records of blood donors and other related information .

Topic Maps can facilitate access to information effectively without changing the infrastructure or the databases, and support navigation and information retrieval in a more associative and intuitive way. Furthermore medical information could be more easily obtained, reused, exchanged and merged with information from other health organizations.

The future scope of this work is the implementation of the proposed system, in order to exploit and evaluate the potential advantages that have been aforementioned, by incorporating topic map technology for medical information management.

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