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Formulation of Distributed Electronic Patient Record (DEPR) System Using Openemr Concept

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Abstract: **Clinical information is usually distributed among several independent systems that may be syntactically or semantically mismatched. Clinical information is usually distributed among several independent systems that may be syntactically or semantically incompatible. In this work, we address the semantic interoperability of OpenEMR this being represented through prototype. The solution presented here is capable of transforming OpenEMR prototype into DEPR and vice versa by combining Semantic Web and Model-driven Engineering technologies.**

Keywords: **OpenEMR, EHR, DEPR, Distributed System, Distributed Database.**

1. Introduction

Database is a core component the Electronic Health Record (EHR) system, and creating a data model for that database is challenging due to the EHR system's special nature. Because of complexity, spatial, sparseness, interrelation, temporal, heterogeneity, and fast evolution of EHR data, modeling its database is complex process. The electronic health record (EHR) is an evolving concept defined as a longitudinal collection of electronic health information about individual patients and populations. Primarily, it will be a mechanism for integrating health care information currently collected in both paper and electronic medical records (EMR) for the purpose of improving quality of care. Although the paradigmatic EHR is a wide-area, cross-institutional, even national construct, the electronic records landscape also includes some distributed, personal, non-institutional models.

2. Progress and Models: Analysis

As EHR models have struggled towards maturity, some key questions have arisen. Debatable issues include the following: whether the originating record should supply complete data or a summary; whether the data subsequently generated is episodic or longitudinal; and whether patients and providers will either control which information is "pushed" to the central record or be spectators as comprehensive data is "pulled" by remote systems. The EHR models that are developing in Australia and the United States suggest some divergent answers to these questions. Although less visible than institutional (provider or governmental) models, a third EHR model focuses on a web-based, distributed "personal" longitudinal record. This model raises discrete quality and confidentiality issues.

Australia

Australia's proposed national health information network is called Health Connect [1]. The basic HealthConnectmodel is to extract a summary record from locally collected patient data which is then aggregated to create a centralized HealthConnect record that may then be shared among participating and authorized providers [2].

A HealthConnect "event summary" consists of the "critical information considered to be useful to other health care providers involved in the future care of the consumer." [3] Thus, HealthConnect does not create a comprehensive longitudinal record. Rather, patients, with their providers, will choose which elements may be extracted from an existing health record and transmitted to the HealthConnect record. Providers, with the consent of their patients, may subsequently add data to the HealthConnect record. It follows, therefore, thatHealthConnect is a "push" system, selectively sending data to a centralized record [4].

The patient controls which elements of the centralized record may be used for which purposes or displayed in which "views" [5]. For example, a patient might elect to include details of his psychotropic prescriptions in an event summary and consent to all his prescribing doctors viewing that data, but only consent to other mental health professionals viewing his psychiatrist's discharge order. The system's dedication to voluntary participation is desirable based on demonstrated patient interest in confidentiality. However, the summary data that is centralized may not fully support the system's secondary goals of disseminating professional education, supporting research, furthering utilization, increasing access, and improving quality [4]. HealthConnect has completed 2 years of pilot testing. It is estimated that the system will save AUD $300 million per year by reducing errors and duplication of effort [4].

United States

The institute of medicine (IOM) has been critical of the rate of technology adoption by US hospitals [6]. Notwithstanding, and representing the public sector, the Department of Veterans Affairs is committed to process reform and technologically mediated delivery of services [7]. More broadly, the Consolidated Health Informatics (CHI) initiative is accelerating the use of common clinical vocabularies and messaging standards across federal agencies that process health data [8]. In addition to projects of national scope, some state governments have EHR launch initiatives; for example, Massachusetts has recently announced a statewide initiative, partially funded by the health insurer Blue Cross Blue Shield, with the goal of having a statewide electronic records system in place within five years [9]. Similar initiatives are being undertaken by some of the largest private providers; for example, Kaiser Permanente, the largest nonprofit health management organization (HMO) in the United States, with some 8.4 million members in 9 states and 12000 participating physicians, has recently adopted a 3-year, $1.8 billion electronic records program [10].Providing additional direction in developing EHR models have been the Connecting for Health initiative funded by the Markle Foundation [11], and the work of the EHR Collaborative [12], which consists of the major professional stakeholders such as the American Medical Association, and the Healthcare Information and Management Systems Society.

In the United States, as is the case in Australia and the UK [13], the purer EHR model is evolving at the national level. To date, the IOM [14] and the National Committee on Vital and Health Statistics (NCVHS) [15, 16] have focused primarily on the technical aspects of EHR implementation in the United States. Both have identified two core components in the project: first, building a national health information infrastructure and, second, establishing data interoperability and comparability for patient safety data. In order to achieve data interoperability and comparability, NCVHS and IOM have recommended the adoption of core standardized EHR terminologies (eg, ICD-9 for diseases or symptoms [17], CPT-4 to code medical procedures, and services [18], and RxNorm for drug names and doses [19]). Considerable development is also underway to standardize event taxonomy (eg, adverse event or near-miss reporting using the College of American Pathologists' SNOMED CT taxonomy [20]) and to express knowledge representation such as clinical practice guidelines.

At this stage in the development of the US national model, its architects are concentrating on the interoperability and comparability of all patient safety-related data [21], designing a full "pull" architecture such that centralized and local records can import semantically similar data. Currently it is unclear which data consumers will choose to extract from remote systems or what limitations will be imposed, or by whom.

The Internet Alternative: the Personal EHR

Most EHR initiatives are national in scope and frequently government initiated or funded. EMR initiatives are typically hospital-or system-wide, yet are being designed with an eye to broader push or pull systems that will make wide-area use of such institutional data. A personal EHR model is quite different in concept. It assumes that individual patients will aggregate their diverse records and then make them selectively available to new or emergency providers. There are several subscription, web-based personal EHR systems such as PersonalMD.com [22] and Vital Vault [23] that provide secure web space in which patients can aggregate their medical data. Some of these systems also offer automated updating from select providers. Thus, the emerging model emulates popular personal finance applications (such as Microsoft Money or Intuit's Quicken) that allow for both end-user input and importation of data from institutional records to allow management of accounts. As with many emerging Internet-based health-related services, personal EHRs are immature, tend to exhibit limited functionality, and lack permanence [24, 25].

3. Distributed Systems

Distributed computer system is a computer system that allows applications to operate in an integrated manner on more than one separate physical environment. Health information system consists of the components of a distributed application (in the doctor's office, in hospitals, in pharmacies and health insurance companies). Characteristic of distributed computer systems is heterogeneity in various ways: hardware, operating systems and programming languages. It is impossible to develop a homogeneous distributed systems compulsion, because naturally distributed computer systems grows from a heterogeneous environment. Keywords in bridging the differences that arise are interoperability.

4. Distributed Data Base

In the distributed database system data is stored scattered in several places. Each storage area is managed by a DBMS independent. In order to view transparent distributed database view, it must meet two things, namely independence atom is it as distributed data and distributed transactions. With the independence of distributed data, the user can perform a simple query without specifying where the data or the data replicas or fragments of data that is stored. This satisfies the principle of physical data independence and data logic or data logic is independent of physical data. Furthermore the query process should also take into account the cost of the physical data storage through data communication or stored as local data (replica). With a distributed transaction atomistic users should be able to perform daily transactions, update or data access to distributed data, as if the data is stored locally. Effect of transactions on distributed data must be atomic, that is persistent changes to the remote data and local data if the transaction has been committed, or there is no change at all if the transaction fails (can not commit). Although in general both of these must be met, but the situation in case of heavy traffic and a delay of the transmission, it would require a special mechanism to handle relating to administrative overhead and performance DBMS.

5. OpenEMR System

The OpenEMR system is an open source software solution for EMR systems. It focuses on applications such as medical billing, prescription writing, and medical records. In this article, we will focus on the medical records.

OpenEMR is one of the more widely used software solutions in more than thirteen countries including the United States. It is designed to make the EMR systems available to more and more people. Let's take a look at some of the advantages of this system.

- Reduces the cost of the EMR systems as it is completely free.
- Effectively supports the interoperability between different EMR applications.
- Allows customization of the application at no cost.
- Provides access to important medical information gathered from over 70 different medical software vendors. This reduces the time and cost for the hospital to gather information.
- OpenEMR is compliant with HIPAA, HL7, and the ANSI X12 EDI standards. This ensures the quality of service offered by the system.
- OpenEMR is licensed under the GNU General Public License.

The OpenEMR system has a lot of user and developer support. This is a versatile system that operates in Linux, FreeBSD, MacOSX, and Microsoft Windows.

6. Architecture of the Solution

Our solution combines a series of technologies, namely, archetypes, ontologies, and MDE. The input to our transformation process is an OpenEMR and the output is an OpenEMR model. The architecture of this solution is depicted in below figure 1. There, two layers can be distinguished, namely, ontology and MDE. The ontology layer comprises a series of ontologies that model EMR-related knowledge for the different standards. The MDE layer contains the metamodels corresponding to the semantic representations defined in the ontology layer. The transformation mappings are formalized and the transformation of the archetypes is done in the MDE layer. Next, more details about each layer are provided.

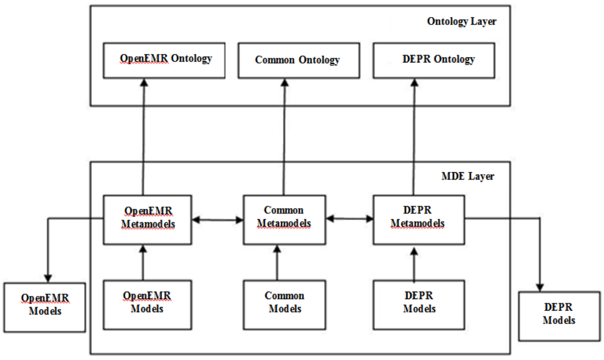

Fig.1. Architecture of the System

Ontology layer

The ontology layer provides the formal semantics of our domain, developed for the EMR standards. In particular, our current semantic infrastructure includes ontologies for DEPR and OpenEMR. These ontologies might be enough to define the transformations between both standards. However, we aim to develop a generic and extensible architecture, capable of dealing in the future with other standards such as HL7 v3 or the Detailed Clinical Models [14]. This self-imposed requirement led us to develop a common ontology for EMR standards. This ontology covers the global aspects of model in dual model approaches and offers a common representation for them. Figure 2 shows the relationship between the common ontology and the specific ones of the clinical standards.

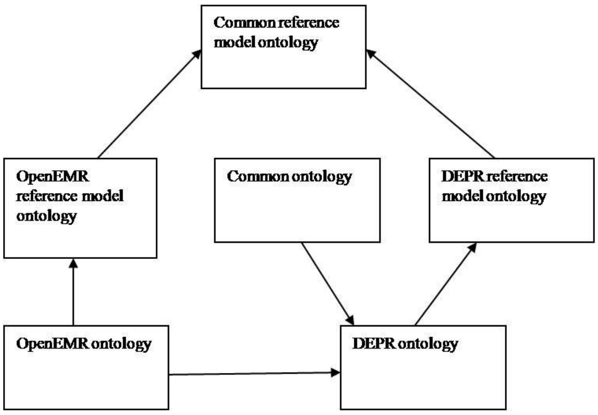

Fig.2. Ontology Layer

This ontology was built by identifying the common and disjoint knowledge defined in the ontologies of both DEPR and OpenEMR, so it is not a global EMR ontology. The detection of the equivalent concepts and data types was supported by the ontology integration methodology developed in our research group [15]. The structures shared by both standards were merged into a single concept by combining their properties.Concepts suchas FOLDER, COMPOSITION, SECTION, CLUSTE R, ELEMENT are common to both standards.Thus, they were added to the common ontology as a single concept.On the other hand, some concepts are defined only in one standard. In this case, they are included in the Common ontology. For instance, ACTIVITY and ISM_TRANSITION are defined only in OpenEMR.

MDE layer

Model-driven Engineering (MDE) is based on the idea of using models at different abstraction levels for developing systems. The Object Management Group [19] defines a four-level meta-modeling architecture [20], among which models (e.g., an ADL archetype) and metamodels (e.g., theADL language) are relevant for thiswork.Amodel is an instance of a articularmetamodel.MDE approaches facilitatethe development of formal,maintainable solutions, so they constitutean optimal technological infrastructure for achieving our goals.

In this layer, the transformations between the standards are formalized. Consequently, metamodels for the DEPR, OpenEMR and the Common ontologies were developed by using the Ontology Definition Metamodel [21] standard and the Protégé environment [22]. Once the metamodels have been obtained, the correspondences among them were defined. In order to transform OpenEMR moddels into their DEPR representation and vice versa, the mappings were defined between the particular standard and the Common metamodel. These mappings have been conceptually defined at concept and property levels and implemented using the model transformation language.

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The transformation of OpenEMR models into DEPR (and vice versa) requires the definition and implementation of two sets of mappings [13]:

- Mappings from the OpenEMR/DEPR metamodel to the Common one.
- Mappings from the Common metamodel to the DEPR/OpenEMR one.

7. Solving the Traditional System Challenges With OpenEMR

The physicians' frustration with keeping track of a patient's medical records is coming to an end with the help of EMR systems. In this section, we will see how to solve the challenges of a traditional system using OpenEMR.

Reduces space, cost and time:

OpenEMR enables the doctors to concentrate on patients instead of paperwork and information technology needs. By maintaining the records electronically, the hospitals cut down the cost and space involved in maintaining the records on paper. The time involved in searching for a piece of information is reduced to the click of a button. As all of the departments, pharmacies, and laboratories are interconnected, they can share the patient's data electronically, thus eliminating the waiting time for data transfer.

Data is well organized:

OpenEMR maintains the complete data of the hospital and the patient's record in a central data repository. The patient's demographics pop up on a single page when the patient's details are opened, as shown in figure 3. Hospital administration can find the patient's data more quickly.

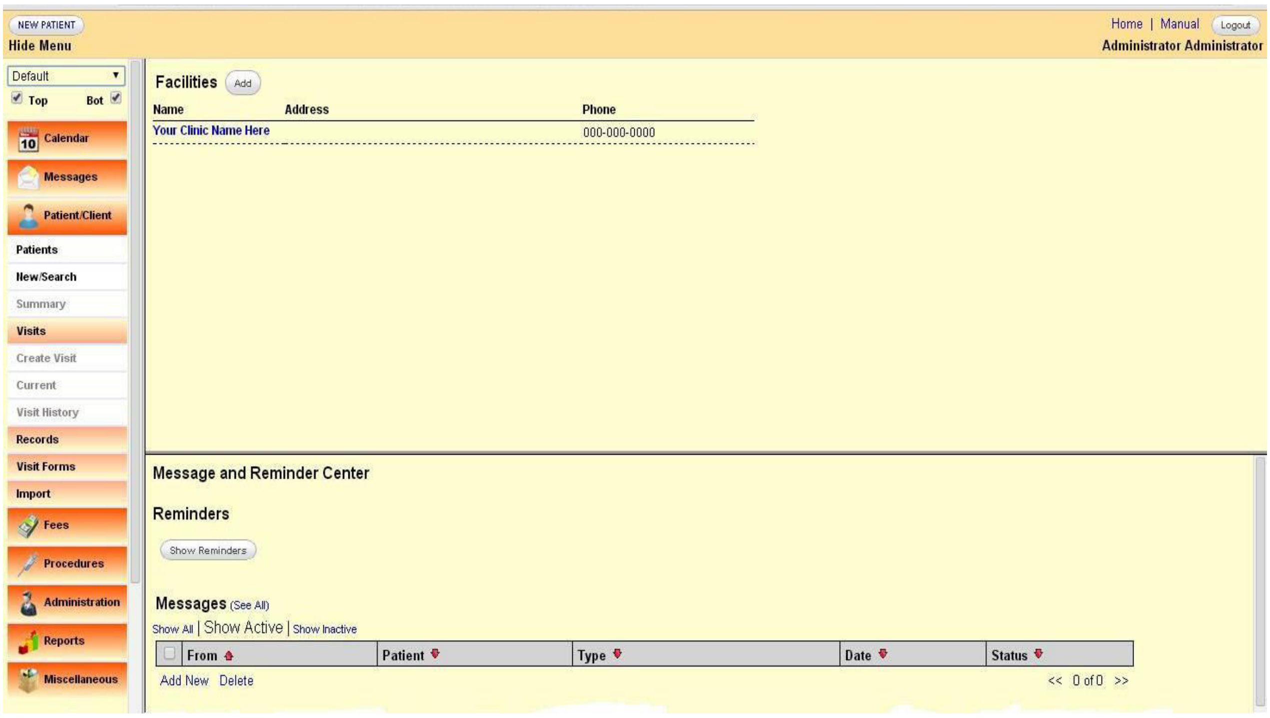

Fig.3.OpenEMR Screen

8. Conclusion

EMR systems are smart, reliable and efficient. In this article we have briefly explored how the paper based traditional system works. We have seen that traditional systems are more error prone, insecure, and unreliable. In today's world with its huge volume of medical data, the traditional system affects the quality of service offered by doctors. We have seen how EMR systems are overtaking the traditional systems.

We know the standards like HIPPA and HL7 mandated by the U.S. Federal Government for EMR systems. We introduced OpenEMR, an open source solution for EMR systems, we have seen how we can overcome the challenges of the traditional system using an OpenEMR system.

The architecture used in this work distinguishes two layers: (1) the ontology layer comprises a series of ontologies that model EMR-related knowledge for the different standards; and (2) the MDE layer contains the metamodels corresponding to the semantic representations defined in the ontology layer. The MDE layer processes and transforms the specific models by using the corresponding mappings. Thus, the core of the transformation process is located in this layer by means of applying model to model and model to text transformations rules. Given the development of a series of ontologies, it might be argued that the mappings and transformations could have been defined between the ontologies rather than the metamodels. However, two main reasons led us to make this decision: (1) the availability and maturity of tools based on metamodels is higher than based on ontologies; and (2) using the metamodels, the mappings are purely conceptual, without being linked to a particular ontology model. The definition of the concrete mappings come from our understanding and experience with both standards, but they do not correspond to any community consensus. So far, these mappings have not been formally expressed. We are currently evaluating different mapping languages from both the Semantic Web and Model-driven Engineering areas, since having a formal representation of these mappings will be useful for extending our approach to new standards.

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