Clinics management system (CMS) based on patient centric process ontology

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Constantly created new specialties, different roles, public and private organizations in patients' healthcare have resulted complexity issues. An ontological framework is very much promising to develop interoperable IT solutions for various segments of today's healthcare systems. In this paper we report an on-going project that develops patient centric process ontology. As a useful application of this framework, we brief Clinics Management System (CMS) for General Hospital, Matara, Sri Lanka.

Key words: Ontology, Patient Centric Process, Layered Processes, Clinics Management

1.   Introduction

A major problem faced by today's healthcare is the increasing diversity and differentiation. New medical specialties are constantly created: there exist a large number of roles in patient care, and many different public and private organizations. All these roles in healthcare organizations are involved in the care of a single patient. This differentiation creates a need for the interoperability of organizations as well as their supporting systems and applications. A key instrument for achieving such interoperability is to develop a sharable Healthcare Ontology.

However, today's process oriented business ontologies are developed in customer centered manner in order to develop business applications to provide more and more value added services to consumers. This trend is also valid in healthcare sector although there are some restrictions and limitations that can be noticed in Sri Lankan scenarios. In this context, we would like to report on some interesting and noticeable developments are taking place at the General Hospital, Matara, Sri Lanka. Among these, one of the initial IT solution, called CMS (Clinic Management System) has been introduced in this paper. CMS will be one of the sub systems developed by the (EC^4)[1] research group at the department of Computer Science, University of Ruhuna to be deployed at General Hospital, Matara.

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[1] (EC^4) :   Electronic   Commerce   and   Collaboration   Competence   Center, http://www.ruh.ac.lk/Uni/science/computer/ec4

The rest of the paper is organized as follows: Section 2 reports related research in process oriented ontology in general and in the healthcare context. Section 3 describes proposed Patient Centric Process Ontology developed in the selected domain. In sections 4, as a useful real world application, we summarize the proposed system giving its basic functionalities. The paper concludes with explaining possible benefits and future directions of the Clinic Management System.

2.   Related Research

One of the important trends in business managements is the focus on processes to create value added services for their ultimate customers. This is to get rid of unwanted, time consuming, unnecessarily repeated business activities of the processes and to monitor how value for customer is as efficiently as possible (Vissers J. M. H, 1998, (Johannesson and Jayaweera, 2000). This is also very much valid for healthcare industry and there is a great need for process orientation and transparent communication between various healthcare roles and healthcare applications. In addition to process orientation, to achieve aforementioned inter and intra communication (or in other words interoperability) between healthcare units, utilization of sharable Healthcare Ontology is the promising approach.

In general, "An ontology is an explicit specification of a conceptualization", which is a widely accepted definition by Gruber (Gruber, 1993). This definition is an elaboration on "An ontology is the object, concepts, other entities that are assumed to exist in some area of interest and the relationships that hold among them" found in Genesereth and Nilsson's work (Genesereth and Nilsson 1987). We adapt these definitions also in developing our Healthcare Ontology.

As mentioned earlier, patient centric approaches are providing more competitive advantages also in healthcare industry. Some of the interesting work in these converging areas are listed below.

Interesting orthodox process thinking can be found in SAMBA (SAMBA, 2006) (Structured Architecture for Medical Business Activities). SAMBA is a process modeling technique to define the concepts of the health care processes. The concepts to support continuity of healthcare processes have been dealt in CONTSYS (CONTSYS, 2006).

For the development of proposed Healthcare Ontology, we have looked into the above mentioned and some other related approaches. This Healthcare Ontology is the basis of Clinic Management System developed for the General Hospital, Matara. In our work, BPMN (Business Process Modeling Notation) has been used as notational framework for process specifications. The main motivation of selecting BPMN is the popularity of service composition in particular web services for specification and enactment of business processes. In that context, BPMN is much more convenient in mapping to process execution languages such as WSBPLE (WSBPLE, 2006). However, complete service specification and healthcare process enactment and monitoring are out of the scope of this paper.

3.   Patient Centric Process Ontological Framework

The development of patient centric process ontology for healthcare mainly focuses on the different roles around a patient to provide different healthcare services and different activities those roles are to play in order to provide services. However, construction of a single complete ontological framework to cover all aspects of healthcare is tedious and time-consuming task. In this work we have selected one of the initial phases to offer specialty-services at clinics in general hospitals.

The paper reports on-going project at the Department of Computer Science, University of Ruhuna to develop clinics registration system for the General Hospital, Matara, based on the proposed ontological framework.

3.1.   Three Layered Processes

The clinic management of general hospitals are complex involving many different healthcare roles and systems. These roles perform activities in providing wide spectrum of healthcare and related services towards a patient. As we have been proposing in our earlier work [Jayaweera and Johannesson, 2004], one of the approaches to tackle down this inherited complexity in healthcare is also to apply separation of concern where we take particular perspective at a time.

This approach results three different layers that can be considered different activities happening in selected domains. The following are those we can consider in our study at the General Hospital, Matara:

1. Referring Processes
2. Registering Processes
3. Clinical Processes

Some of the high level activities that are possible in each of layers mentioned above are shown in Figure 1. BPMN (BPMN) notation has been used here to illustrate process semantics.

3.1.1.   Referring Process We have identified referring healthcare process as the first triggering process of particular patient's clinic management scenario. In the Referring Party set, there can be various healthcare roles directing patients to relevant clinics. Illustrated Figure 1 in above is a couple of typical such activities where the referring parties could play for a given case.

A patient could be directed to a specific clinic by a Consultant, a District Medical Officer, another Clinic, or some other authorized healthcare unit or personnel.

3.1.2.   Registering Process Having referred to a specific clinic by an authorized healthcare personnel or unit, it is the registering process which triggers next. This process basically collects required information about the patient and about the party who made the reference together with referral note. As the final step of the process it makes an appointment to meet a physician at the clinic.

3.1.3.   Clinical Process Final and the most important healthcare process is the clinical process where patient is subjected to clinical diagnosis, tests and various forms of healthcare treatment. However, for the sub-systems that we are discussing in the paper detailed coverage of these processes are beyond our scope.
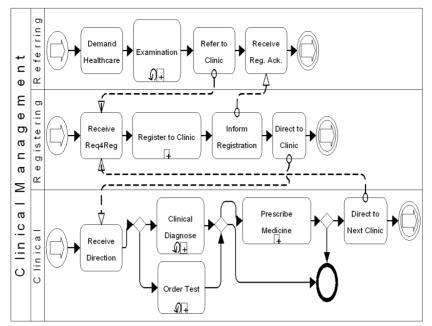
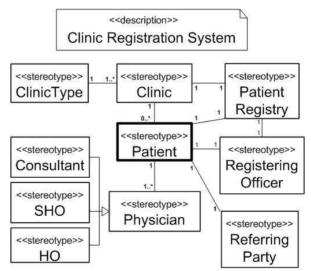**Figure 1**   Three Main Layers of Clinic Management Processes.

Figure 2   Metamodel of the Clinic Registration System (Key Healthcare Roles).

3.2.   Clinics Registration Ontology

As introduced in the Section 2, there are many research going on in ontology development in general and also Healthcare Ontology in particular. However , rather than adapting very formal specification, we have developed a metamodel for our purpose as depicted below in Figure 2.
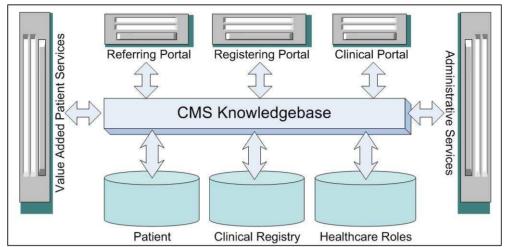
Figure 3   Architecture of the Proposed Clinic Management System.

In the above metamodel, different roles in registration of clinics are highlighted. Our understating here is identification of roles in healthcare is the key to model different activities those are authorized and in position to perform (see Figure 2).

Even in the metamodel for Clinic Management System, we can notice that the patient being the centered concept and very much motivated in selecting patient centered approach. The two common abstraction levels defined in (Fowler, 1997) and (Martin and Odell, 1994), are the *operational level* and the *knowledge level*. The operational level models concrete, tangible individuals in a domain. The knowledge level models information structures that characterise categories of individuals at the operational level. Martin and Odell, (Martin and Odell, 1994), employ the concept of power types to refer the correspondence between the objects of the knowledge and operational levels. A power type is a class whose instances are subtypes of another class. The power type of Clinic, called Clinic Type, is also added for the purpose of differentiating between the modeling of concrete, tangible objects in a domain, and the abstract characteristic categories of these objects.

4.   Clinic Management System

In healthcare industry there is an increasing demand to find affordable, easy-to-deploy technology to improve patient oriented services and communications effectiveness among all the parties involving in the hospital activities. The patient centric process ontology which was proposed in section 3.2, has been adapted in the development of our Clinic Management System.

In Figure 3, the architecture of the Clinic Management System is shown. The main idea here is to develop and maintain a central knowledgebase that extracts necessary information from the databases layer down. There may be several of databases to hold patient, clinic and healthcare roles' information.

There are five interfaces to the CMS knowledgebase. Three of them are to interact and to monitor the process layers mentioned in Section 3.1. The remaining two

interfaces are to provide value added healthcare services to patients and also to administrative services to relevant authorities.

4.1.   Clinic Management at the General Hospital, Matara

The first step of the clinic process starts from directing patient to a clinic by different referring parties. A referring party can be a consultant, other hospital, a ward of a hospital, the OPD (Out Door Patient Department) or any other medical authority. The next step of the process is registering a patient to a particular clinic by a registering officer. After the registration the patients are directed to the relevant clinic for the clinical activities. In each clinic the patient is examined by a consultant at the first time. The patient has to visit the clinic more than once in some cases. In the existing procedure, each and every time the patient has to register to a clinic in order to get an appointment to meet a consultant. The proposed system is designed to cater different types of users with different levels of accessibilities to the clinic information. The main purpose of having different user levels is to provide more secure and flexible environment to all the participants in the clinic system. The sub-systems described here work with existing manual systems at the hospital. Therefore to support the existing manual processes patient registry information are printed on a sticker and could be pasted on patient's clinic record document (which is currently a printed book). Based on the architecture of Clinic Management System the portal which is designed to register a new patient is described in the next section.

4.1.1.   Registering a new patient
Registering officer has the authority to register a patient. The proposed system is to issue a colored registration sticker for the patient at different stages when they are directed to a clinic. The registration sticker holds the registration number, clinic number, name of the patient, clinic date and the time and the room number. The color codes are as follows. The red color issued for those patients who are registered for a clinic at the first time. The blue color is for the patients second and consequent visits and the black color is for patients those who are to submit prescribed test reports (e.g. blood tests, X-rays, etc). Then the authorized persons can identify the patients by the color code and it will help arrange clinical activities in efficient manner. Figure 4 is the web portal to register a patient at the first time to a clinic (Issuing red color card). In this interface it could be noticed that there are three different areas of information shown. Firstly, patient information; secondly, reference made; finally, the clinic details. When selecting the clinic, some essential data is filled automatically such as the Registration Number of the patient, the Room Number and the current date and time. In the appointment time slot, it contains additional information such as the number of maximum places for that slot within brackets and occupied places immediately left outside the brackets. This will be much helpful for patients when finding most convenient time slot to come to clinics.

5.   Concluding Remarks and Future Directions

In this paper we have reported an on going project at EC[4] research group. The theoretical contributions of this work is the development of patient centric process

Figure 4   New Patient Registration Portal.

ontological framework to serve as the basis for achieving interoperability in health-care systems and its applications and also for developing value added healthcare services for consumers, in this context - patients.

As a real applicability of proposed patient centric ontological framework that has been proposed, we have developed an application to Clinic Management at General Hospital, Matara. Although the system yet to be deployed, we are very much certain of possible benefits not only to patients but also healthcare personnel to carry out in their day-to-day activities.

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