Web Based Medical Information System (WBMIS) Derived From Software Reuse and Reference Model in Medical Informatics Area

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ABSTRACT

The research goal in our study of medical information systems tools is to improve the performance of patient decision making by integrating medical professional information with computer augmented information available on the world wide web environment. Our research focuses on software development based on a software reuse reference model in developing medical educational system in headache domain from reusable object design to customize for software products in the same area. Developing software from reusable object design models appears likely to realize significant savings in time and effort and makes it feasible to create an entire product line. In part, this goal may be reached by cost-effective software development with validated reusable PCESs object design models, UML and with the help of a valid WBMIS derived from these models.

Key Words: Web-based systems, patient education, object-oriented development, software reuse, reference model, medical informatics teaching and patient care.

INTRODUCTION

Currently, there are numerous clinical systems, decision support systems and medical database systems in healthcare delivery. These systems help clinicians in research, administration and in patient care management. These systems provide valuable patient data to manage and improve patient care and patient satisfaction with health care delivery system. Mannai [1] reported that researchers need the data to support and validate research, healthcare providers need these automated systems and clinical data to support and enhance the quality of their services, and regulators need such data and its associated statistics for decision support. Information technology (IT) playing an increasingly important role in its delivery to support and enhance healthcare delivery system. The health care industry spent $12 billion to $16 billion on information technology in 1996. Further growth is expected as the health care industry implements electronic medical records, upgrades hospital information systems, sets up Intranets for sharing information among related participants and uses public networks. Most hospital and health care delivery professionals recognize the significant impact of Internet on health care and medicine. The Internet can be used to distribute health-related information and provide remote diagnostics via telemedicine [2]. The emergence of smart card technology has been recognized in managing patients' medical record using web technology. Inspite of this growth in information technology and in the health care industry, use of IT in health care is presumed to be several years behind than other IT sectors such as financial institutions, airlines, and manufacturing. Today's healthcare practitioners have realized that they are in an era of modern cyber technology and that they should be running at the same pace as internet technology is growing. The information super highway has played a major role in many forms in establishing connections, maintaining and organizing health information in a secure and efficient manner and helped health care providers and patients to make better decisions on health related issues.

THE INTERNET PROMISE AND INFORMATION ACCESS

Computer professionals are working on how web technology can bring changes that would affect health care delivery systems and make then more efficient and effective. Healthcare providers and computer professionals, specially in web development have introduced many applications in healthcare systems with system integration, designing effective and efficient systems to help health care providers to improve consumer's satisfaction. The various applications in health care developed in the 1990s include: patient billing system, patient medical record system, patient monitoring system, clinical decision

support system, drug interaction system, medical imaging system and many more. Several web-based systems such as WebMedline, CliniWeb and Dxplain to provide medical information to the patients, clinicians and other care providers. Felkey et al. [3] has reported that the health care moves towards being more evidence-based, a goal all managed care organizations share. To this extent, technological information management is the major driving force in health care. Trends in managed care, business, national infrastructure and the Internet are moving rapidly to support connectivity of a huge amount of data and information at the point of care. This point of care may be in a physician's office, in the pharmacy or via telephone wire to patients' house. These innovations are making new levels of data and information available to educate patients and health professionals as well. According to Felkey et al. [3] eighty two percent of Americans learn better visually than by any other means. But patients typically receive very little visual information about their health. One common and clear obstacle to the use of automated patient education systems is concern that patients may resent sharing personal information with and receiving health suggestions from a machine. Soderlund et al [4] reported that web based system which is aimed at encouraging and aiding a diabetic in self-care by offering a convenient way to record and access essential data related to diabetes using a web browser. The system also gives healthcare personnel access to a more detailed and up-to-date data of the status of their diabetic patients and a possibility to give immediate feedback on the web.

Our major focus of this study is also to contribute to and improve health care delivery systems by providing medical information to the patients on the web for headaches illness. We emphasize improving the quality of patient care and improve patient's decision making by integrating professional medical information with Internet technology and educating patients about their illness. Inspite of tremendous growth and involvement of technology, health care delivery systems have several holes that need to be filled.

PROBLEMS AND ISSUES: PATIENT CARE DELIVERY & MEDICAL INFORMATION SYSTEM

Patient satisfaction is a major issue even though the health care industry has employed state of the art technology in health care delivery systems. Patients are not always satisfied with the outcome and no one is to blame. This inadequacy is due to the lack of medical providers, sometimes about hospital systems, lack of software tools, and improper system integration, sometimes about health insurance companies and regulations and policies. Ultimately patients suffers whatever the reason is. The literature has published work on patient satisfaction and out comes of health systems [5]. There could be many reasons why patients are unhappy and unsatisfied medical provider did not spend enough time with him because doctors are busy, lack of communication skills, do not provide enough education so he or she can manage their illness better, doctor and patient does not speak the same language so the patient can not comprehend. Finham and Werthimer [6] found that physicians little spent time with patients in educating then about health care prevention. Our research hypothesis is that better-informed patients will:

i) receive better care

ii) better comply with the treatment plans and therapies

iii) will have more of their questions answered and satisfaction

iv) an automated tool helps healthcare delivery system to be efficient and effective

v) availability of medical information to the patients when live help is not available

It appears that there is clear need to have web based medical information system patient educational tools to provide education about their illnesses while doctors are busy or unavailable. Moreover patients do not feel comfortable asking questions to health care providers or the lack of communication skills.

THE IMPORTANCE OF THE PROBLEM

Patient satisfaction is an important issue and patients can help themselves through education in making and managing illness better. Health care providers and specially HMOs has always encouraged patient education concept and in a way they have enforced this in many disciplines such as pregnancy, weight loss program, hypertension, quit smoking, diet, exercising and side effects of OTC products. HMOs also provides variety of literature, booklets, pamphlets and flyers that how patient can be better educated and comply with prevention plans for illnesses. Many efforts has been done in this direction from health care providers, communities, many federal agencies has participated to educate and inform patients and make the patient aware, but still there is a gap needs to be filled out. The patient

expectations are not met and they are still needs to be educated and make their lives better. We have developed a web based automated educational system in headache domain to educate patient about their illness and how they can educate themselves and manage their headaches better. We took a new and cost-effective approach to develop medical instructional software reuse and referencing modeling approach to provide effective and efficient way of quality web based medical information system (WBMIS) educational tool for patients. The major role of our WBMIS would be educating patients in headache area providing quality education in three headaches such as: Migraine, Tension and Cluster on the Internet.

SIGNIFANCE OF SOFTWARE REUSE AND REFERENCE MODELS

Many organizations, in both private and public sector are proposing to invest, and have already invested money, time, and resources into software reuse. They hope to improve their competitive edge and time-to-market through decreased effort in the software development process and increased quality in the software product developed [7].

The reference model provides important relationship between the technical and organizational activities of software reuse within software engineering process. Utilization of an appropriate software reuse reference model in a software development organization allows software engineering management to identify both technical and organizational activities needed for successful software reuse in implementation plan [8].

In this paper our reuse reference model derived medical information system evaluation focused on education for headache patients. This particular medical information system was effectively and efficiently derived using a software reuse reference model to generate a domain model of common requirement in headache patient education. Then, from this general reference model, a specific migraine specific headache model was derived.

RESEARCH THESIS

This research confirms that there is need for a more effective software reference model that incorporate technical and organizational facets of software reuse. It contains two major steps:

i) To develop an effective web based patient headache care education system (PHCES) for headache patients

ii) To expand the WBMIS customer base by increasing efficiency in the process of developing effective web based products with variations.

DERIVING THE REFERENCE MODEL FOR PHCES

To begin our study, we gathered information related to headaches from books, Internet, journals, pharmaceutical company's brochures, and interviews with medical experts. Reviewed literature on software reuse for identifying reuse of technical and organizational factor and explaining relationship with software development effort, quality and time-to-market. We also determined if the implementation level of reference model of the software reuse reference model activities is predictive of:

a) decrease products development effort
b) decrease time-to-market the product
c) reuse domain model (for new product)
d) customize product (product line)

RESEARCH APPROACH: USE CASE MODELING

We used the Unified Modeling Language (UML) tool to build our reference model as use case diagrams [see figure 1]. Use case diagrams represent a basic and overall functionality of the PHCES. The UML is a graphical language that uses a variety of visual elements to show the semantic elements in a way that is easily grasped and manipulated by a modeler. Each use case associates software functions with “actors” in the system environment.

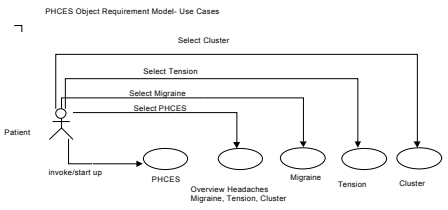

Figure 1. Represents Patient Use Case

An actor is an object outside the scope of the system but interacts with the system [9]. This actor may refer to the systems user's such as patients in our case, as represented in figure 1. Secondly, we analyzed from our reference model what level of language, vocabulary and interface should be used in WBMIS system, so that patients do not feel lost but enjoy the education they have received from the system in order to manage their illness better.

We considered number of elements in our WBMIS reference model:

- Modeling tool (UML)
- WBMIS reference model
- Text, language, terminology and vocabulary
-Graphical user interface (e.g. buttons commands, color etc.)
- Images
- 4GL
- Databases and
- Internet technology

We evaluated and analyzed a good user interface for our patients so that they do not have to spend many hours and efforts in learning or navigating the system. Shniederman [10] has suggested screen representation, color combination for designing a good user interface for application development and to make system user friendly and simple. Visual Basic programming language was used to develop for front end user interface and centralized database was used to store, retrieve and update headache educational information. Hayes [11] has reported that users experience difficulty and dissatisfaction when interacting with a poorly designed interface that has an excessive number of icons, menus, or options; requires the user to remember lengthy complex commands; and/or offers insufficient navigational control.

5. SYSTEM OVERVIEW

Today, medical and clinical computing environment consist of Internet, graphical user interface, integrated database, data import tools and user friendly systems for computing patient data, clinical data and other types of medical related information to make healthcare delivery much more efficient and satisfactory. Our system provides the mechanism to access information

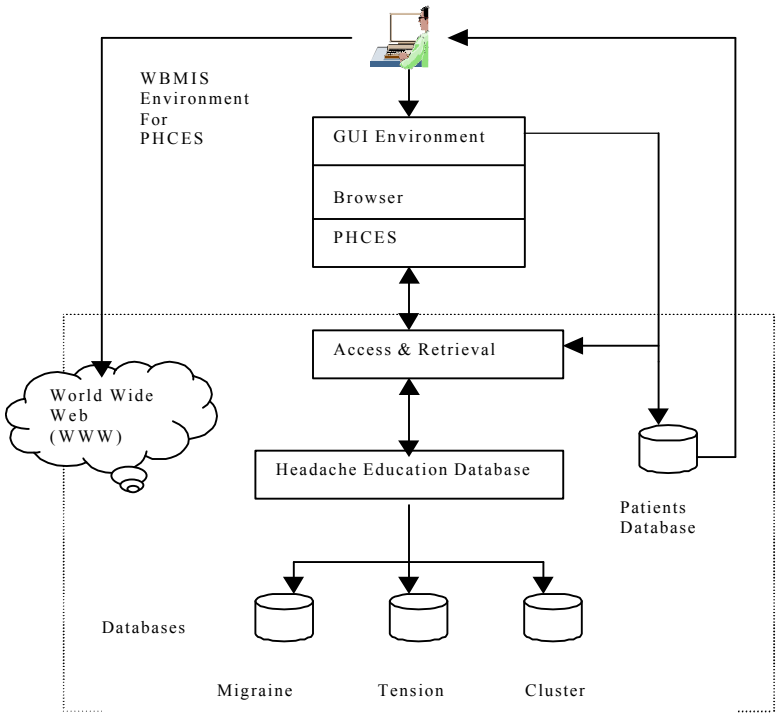

Figure 2. Represents System Overview (WBMIS)

from different databases within PHCES to support multi-database retrieval process. In our system we allow user (patient) to interact with the PHCES in graphical user interface environment as represented in figure 2. The patient invokes the Internet browser and selects the defined URL for PHCES and then it is ready to provide number of capabilities to the patients as represented in figure 2.

1. Access to three different headaches databases (Migraine, Tension and Cluster) through a unified interface. This capability provides control to the patient to access any desired headache information, as they preferred
2. Ability to select advance or general headache information depending on their prior knowledge on headaches from the databases
3. Ability to select and store their headache symptoms into the patient record and retrieval
4. Ability to access computerized headache diary to keep track their headache triggering factor, occurrence, time, severity etc. and;
5. Ability to access help and tutorial, if needed.

PATIENT INTERACTION WITH THE WBMIS

The UML provides two different forms of interaction diagrams: Collaboration and sequence diagram. Collaboration diagrams are nothing more than object diagram with small arrows representing the message sent during the course of the collaboration. A sequence diagram represents objects as vertical "instance lines" as shown in figure 3. Messages are shown as horizontal or downward-slanting directional lines that an actor "patient" is interacting with PHCES system and number are displayed for in what order the sequence took place. Figure 4 represents welcome screen for patients to select one of the headaches (Migraine, Tension or Cluster) in which patient can get an education on, and to proceed then click on next command button. This screen provides an opportunity to the patients to navigate the PHCES system back and forth with no efforts. This screen is parallel to developed domain model by using UML in figure 3 message trace diagram at state 3 displaying types of headache education is available in PHCES. This screen also provides help and assistance to the patients in order to tutor them about the PHCES system, if needed.

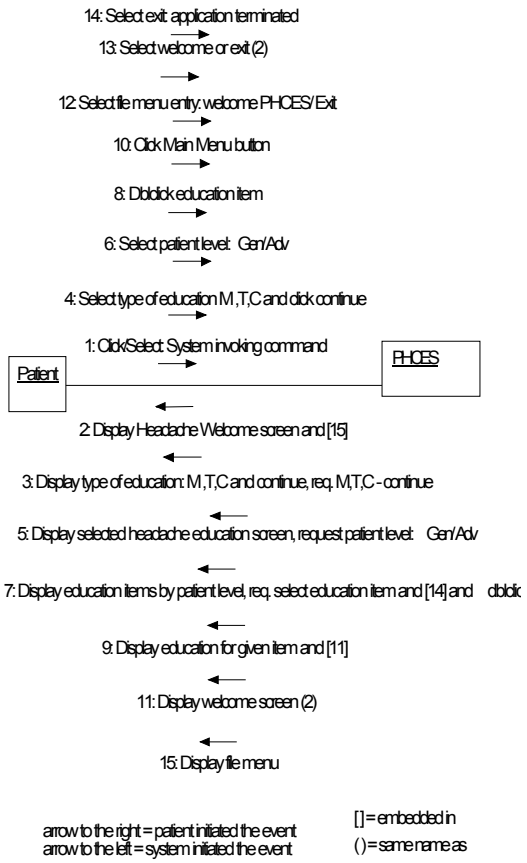

Figure 3. Message Trace Diagram for PHCES

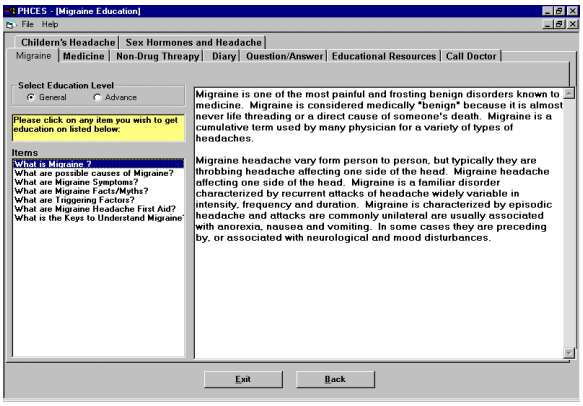

Figure 4. A Snap Shot for PHCES Representing Migraine Headache Screen

THE INTERFACE ASSOCIATION WITH WBMIS

A user interface is an important system development part for our WBMIS that helps communication between PHCES and user. Building the user interface is a major activity in

software development process. User judge system by the quality and effectiveness as it is the face of the system and appearance that user use to visualize and comprehend with the system. We chose the combination of standards documents in PHCES to capture user interface requirement. In PHCES interface specifies in the use case:

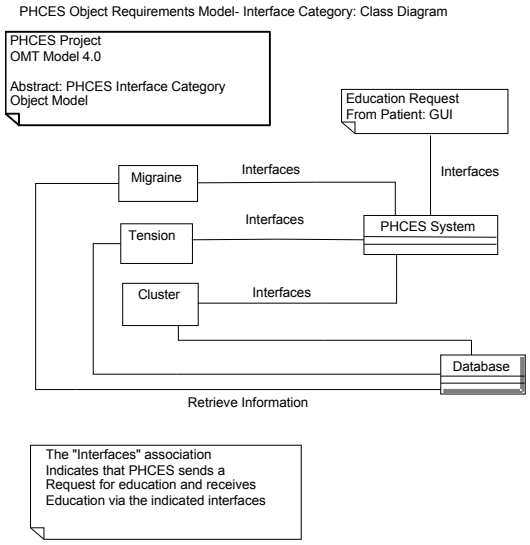

Figure 5. Represents the Interface Association with PHCES and Information Processing

- description of the actors and the functionality of the PHCES
- data flow and data processing
- information captured and displayed by each actor in PHCES
- information delivered by each actor; and
- information processing by the PHCES

In our PHCES processing flow described various components (migraine, tension, and cluster) relate to each other and also describe the differentiation. Figure 4 represents the migraine education snap shot screen (compare step 5 in Figure 2). Here the patient has an opportunity to choose between two levels of educational detail: General or Advanced. The other tabs also shown in Figure 4 (Medicine, Non-Drug Therapy, Diary, etc.) enable the patient to explore related topics by selecting any tab without leaving this screen. Having fewer screens has proven to be less confusing and more satisfactory for the user who feels more in control. Poorly designed interfaces can slow user performance and possibly distract them from the main purpose of their activity. Educational resources tab has been designed to provide more related links to the patients so they can explore and acquire more information about their illness.

ADOPTING REUSE AND COST EFFECTIVENES FOR WBMIS DEVELOPMENT EFFORTS

We observed that benefits from reusing the WBMIS product include improved productivity, lower overall development cost for new system in line and a testing process less tedious than for totally new code. Jacobson et al. [12] has suggested some guidelines for economic use of reuse efforts.

1. A component has to be used three to five times in an application project to recover the initial cost of creating it and the ongoing cost of its support.
2. It costs 1.5 to 3.0 times as much to create and support a reusable component as it does to implement a similar component for a single application.
3. It costs only one quarter as much to utilize a reusable component as it does to develop a new one from scratch.
4. It takes two or three product cycles, usually about three years, before the benefits of reuse become significant. Thus it takes time for the accumulating benefits to repay the startup cost.

We have proven using the appropriate mathematical formula that adopting reuse for PHCES development is cost-effective, and that a feasible return on investment (ROI) can be achieved with commercialization of the WBMIS development efforts. The two examples outlined below illustrate how adopting reuse for PHCES is cost-effective and reduces development efforts.

ABSOLUTE EFFORTS

$E_{PHCES} = (1-R)\ E\ new + R\ (A + MR/n)$

Where
E = Efforts for PHCES development over n builds
R = Portion Reused on each build
I-R = Portion not Reused on each build
MR = Making the reusable code components
A = Accumulative effort (cost) of building these instructions based on reusing components (code adoption effort, design adoption effort, integration effort) [13].

In sum, an object-oriented, reusable PHCES architecture provides the following benefits:

i) enhanced ability to overcome deficiencies in patient educational software design and development
ii) a more useful model for designing and implementing patient education systems
iii) greater planning domain components within the context of a general reference model, thereby adding a new level of potential reuse in health care applications
iv) higher software product quality
v) less effort required for software production
vi) shorter time required to bring products to market, and

an increased likelihood that the developers will fully recover their initial up front investment.

CONCLUSION

Our research focused on accomplishing a number of objectives:

i) Creating a reference model for WBMIS
ii) Designing a PHCES for web based environment
iii) Implementing a prototype extension of PHCES for different kinds of headaches, and
iv) Validating the prototype for web environment.

All of the research objectives were successfully achieved. This research impacts a number of aspects in the fields of software engineering, medical informatics, object-oriented modeling and health care emphasizing PHCES development using a "reuse reference model." It was demonstrated that new software product (family of products) could be generated from a reference model based on specifications and requirements appropriate to the new system for the web environment. This research also demonstrated well-defined activities that the WBMIS user can follow in generating a reusable software system from the reference model to produce a tailored for new web systems in health care or as well as in other related areas.

We concluded, modeling with UML to be a very useful both in developing software and in designing architecture for reference modeling. Another contribution from this research was to establish the relationship between reference modeling and a patient education system. We also conclude that by employing PHCES as a reference model, it will be possible to develop software systems in other healthcare education areas with less effort, and to bring the resulting products to market faster than other methods would require.

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