Communication infrastructure in a Contact Center for Home Care Monitoring of Chronic Disease Patients

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ABSTRACT

The Citizen Health System (CHS) is a European Commission (EC) funded project in the field of IST for Health. Its main goal is to develop a generic contact center which in its pilot stage can be used in the monitoring, treatment and management of chronically ill patients at home in Greece, Spain and Germany. Such contact centers, which can use any type of communication technology, and can provide timely and preventive prompting to the patients are envisaged in the future to evolve into well-being contact centers providing services to all citizens. In this paper, we present the structure of such a generic contact center and in particular the telecommunication infrastructure, the communication protocols and procedures, and finally the educational modules that are integrated into this contact center. We discuss the procedures followed for two target groups of patients where two randomized control clinical trials are under way, namely diabetic patients with obesity problems, and congestive heart failure patients. We present examples of the communication means between the contact center medical personnel and these patients, and elaborate on the educational issues involved.

INTRODUCTION

Information technology (IT) applications in medicine are rapidly expanding, and new methods and solutions become available everyday since they are considered pivotal in the success of preventive medicine [1]. In the past days, IT applications were mainly applied at the secondary health delivery level, and even at specialised hospital departments. These applications were difficult to use, maintain, and they were quite expensive. Today, due to the fast growing and penetration of the INTERNET and mobile telephone technology, the IT applications in the health care environment are focused at e-consultation [2] and home care delivery [3] and the use of triage systems [4]. Home care delivery is a very important issue, starting from the management of chronic diseases such as diabetes, congestive heart failure, coronary heart disease, etc. These chronic diseases demand a continuous monitoring of basic parameters of the patient so as to avoid complications. IT based applications for home care delivery, are important media to increase health care quality, increase quality of life, and create a better educational platform with carefully designed and customisable patient prompting which in turn is expected to be instrumental in increasing the collaboration degree between the patient and the physician, something which is beneficial to both [5]-[6].

Pivotal to these purposes are call centers, which act as mediators between the medical staff and the citizens seeking advice and/or therapy. Main platforms used are INTERNET and PCs, and telecommunication networks, including mobile solutions. In this work, a generic contact center model is presented, which currently is used in the CHS clinical sites for the management of diabetes and congestive heart failure patients. A number of modules are used to transmit and authenticate information, filter received data, process and manage queries from both patients and doctors and provide decision support and intervention tools at the clinician's site for quality and timely health delivery.

Interactive sessions are carried out through the use of computer telephony (CT), WAP platform, and through INTERNET according to the choice of the patient. The patient transmits vital signs and signals and answers to simple questions related to his health.

METHODS

A. CHS Objectives

The overall objective of the CHS project is the use of Information Technology (IT) for the increased quality of health care delivery in the home settings

for chronically ill patients. In particular, the CHS objectives can be divided into three categories:

Information technology related objectives

- Development of new generation telemedicine services for home care.
- Integration techniques for developing a complete health system for home care addressing issues such as integration of telematics technologies, data acquisition devices, educational material through the WWW, data security and data fusion.

Quality of health care objectives

- Cost effectiveness of health care delivery via the use of the home health care system, which would permit the avoidance of unnecessary patient visits to the hospital.
- Citizen involvement in health care delivery by use of recording micro-devices, and by the continuing education process delivered through the health system to be developed in this project.
- Better diagnosis opportunities for the clinical staff through the increased sampling frequency of vital parameters and signals from the patients through the home care system platform.

Economic and business objectives

- The creation of a major market for health care delivery, analogous to that of the INTERNET market, through penetration to European and US homes through applications of the home health care system.
- Running of clinical trials to support through evidence based medicine the feasibility of the CHS system in health care delivery.

B. Overall System Design

The designed system has to be user friendly for daily use. The system has to be customisable and each patient's profile should designate the kind of information delivered to/from the patient. Besides, the system has to be open and flexible offering the patients a number of platforms to choose from, in order to communicate, according to their life style and adaptation to technology.

Information, especially for educational purposes, should be presented with friendly, multilingual, easily understandable and accessible interfaces, avoiding too much information in printed material.

From a development point of view it is crucial that such a system should be modular and provide integration of different communication means and modules of independent functionality, like the artifact rejection module and the customisation module. Basic modules in each new interface should be re-usable and the overall application should be expandable to new technologies. Finally, system security is crucial since the system deals with sensitive personal.

The technical architecture for the CHS System is based on distributed, multi-tiered systems. CHS System was implemented using a three-tiered architecture dividing applications into parts that run on different types of computers. The three-tiered architecture is decomposed as follows:

Client Tier: The user component displays information and processes data input. Consists of:

1. Call Center Patient I/F
2. Call Center Clinician I/F
3. Signal/Image Receiver
4. Web Patient I/F
5. WAP Patient I/F
6. Web Clinician I/F
7. Clinician Client Application

Middle Tier: A set of sharable, multitasking components that interact with clients and the database tier. It provides a controlled view into the underlying Database. Consists of:

8. Device Specific Modules
9. Authentication Module
10. Patient Session Module
11. Signals Server Module
12. Clinician Application Server Module

Database Tier: The Database Tier consists of the CHS Database.

This three-tiered approach enables to separate the business logic from the processing logic and business changes to be more rapidly incorporated into applications. New software modules and program objects can be written to work with existing databases, taking advantage of the resident programming logic.

C. Implementation Issues

For the Contact Center Unit, where the database information includes complicated relationships between several tables and the number of clients grows, a multi-tiered application is preferable. In multi-tiered database applications, an application is partitioned into pieces that reside on different machines. A client application provides a user interface to access data. It passes all data requests and updates through an application server. The application server, in turn, communicates directly with a remote database server. Multi-tiered applications include middle tiers that centralize the logic that governs the database interactions, so that

there is centralized control over data relationships. This allows different client applications to use the same data, while ensuring that the data logic is consistent. They also allow for smaller client applications because much of the processing is off-loaded onto middle tiers. Multi-tiered applications can also improve performance by spreading the data-processing tasks over several systems.

For communication over the network the CHS server located at the contact center is able to concurrently communicate with multiple home-clients, to support security and to provide data integrity.

Three different technologies have been chosen for the patient interfaces, so that patients may choose the commu-nication means of their preference:

1) Computer Telephony: Fully automatic telephone Contact Center
2) Wireless Technology through: WAP
3) INTERNET

Each of the communication means has different characteristics, although they all ensure 2-way communication, e.g. user interaction in a simple manner. The cheapest technology with the widest penetration is the use of regular telephone with call-center automation. Web interface is user-friendly but the required infrastructure is not available in every house. Besides, among elderly people, who might be an important target group for chronic disease home-care management, computer literacy is not granted. WAP is an emerging technology which is popular among certain population categories. WAP is a defacto open standard for the presentation and delivery of wireless information and telephony services on wireless devices. WAP technology is based on existing standards (e.g. XML, TCP/IP, HTTP, URL). WAP applications can be upgraded to faster platforms, as e.g. the GPRS platform, and other 2G and 3G mobile telecommunication platforms.

In order to integrate different interfaces (communication means), an intermediate is required between client interface and database. Thus, a client/server (3-tier) architecture as described in the previous subsection has been selected (Figure. 1). The middle-tier include objects that are compiled software components based on Microsoft's Component Object Model (COM) technology and they are basically modular programs designed to give specific functionality to a parent application. COM is a language independent software component model designed by Microsoft to enable interaction between software components and applications. The key feature of COM is that it enables communication between components, between applications, and between clients and servers through clearly defined interfaces.

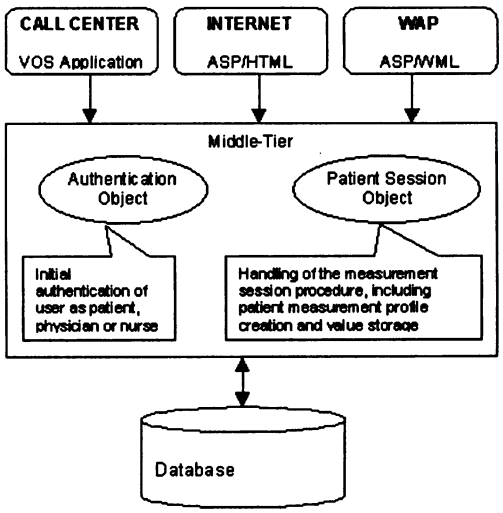

Figure 1. The structure of the communication modules of the CHS contact center.

The advantages of such an implementation are:

- Encapsulation of business logic in a shared middle-tier.
- Different client applications all access the same middle-tier, avoiding the redundancy of duplicating business rules for each one.
- Client applications can delegate more of the processing to middle-tiers.
- No need for installing/configuring the database connectivity software for client applications.

Computer Telephony (CT) functionality was implemented as an automated call center which is programmable and controlled by a personal computer via a Dialogic card. Parity VOS development platform was used. This platform embeds the functionality of scheduling, outbound calls and reminders.

In order to provide dynamic characteristics to the WEB/WAP content, the technology of Active Server Pages (ASP) was adopted. ASP is a server-side scripting technology that can be used to create dynamic and interactive Web applications. An ASP page is typically an HTML page that contains server-side scripts that are processed by the Web server before being sent to the user's browser.

ASP can be combined with HTML, Extensible Markup Language (XML) and Component Object Model (COM) to create powerful interactive Web sites and extend scripting capabilities. It is interesting

that the same COM components can be used in both Web and WAP interfaces.

In our case, the Active Server Pages that contain the HTML/WML content are hosted in the Microsoft Internet Information Server (IIS), which is a widespread Web server system integrated with Windows NT Server. IIS makes it easy to publish information and bring applications to the Web.

A WAP Gateway is also needed, in order to provide the connection between the wireless environment and the Internet. Its basic role is to convert protocols of the wireless domain to the corresponding Internet protocols and vice versa. Furthermore, it encodes content in a specific binary format and provides security mechanisms, guaranteeing a secure communication environment. The gateway resides in the wireless network provider's infrastructure and is available to the mobile phone users.

User authentication is a separate module used in all interfaces for security reasons. It is also important that direct database access is prevented since all database interactions are hidden by the middle-tier. In general for security advanced techniques such as SSL, TLS, SAP, S/MIME and PKI are used to provide security especially over the INTERNET.

D. The application scenario for a patient

Figure 2 shows the application scenario for a patient. The patient who can be a diabetes obese patient or a congestive heart failure (CHF) patient can run a session with the choices depicted in Figure 2. The CHS contact center is manned by nurses. Training of the patient on how to use the contact center is done once by nurses at the contact center site, following a doctor's visit and it takes 2 hours to complete this task.

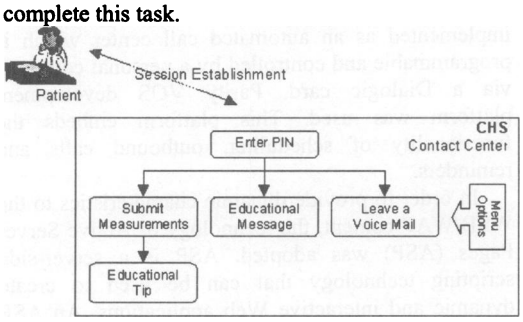

Figure 2. The patient session scenario using the CHS contact center

The services provided via the home care system are:

- Measurements. Each patient may send measurements like blood pressure, glucose, pulse or weight. These measurements are taken at home using simple devices (like a home glucometer). Complementary to the measurements are a number of questions asked to the patients, since the corresponding answers may be explanatory of their condition. The values are keyed in using the selected technology (WAP, WEB or regular phone). The set of required values and questions may be personalised for each patient. Vital signs like ECG may also be transmitted to the system by use of transtelephonic devices. Figure 3 shows sample screens of a typical WAP based session.

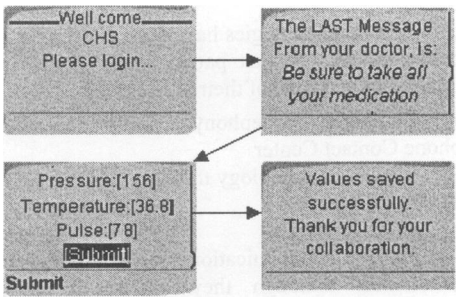

Figure 3. Screen sequences for a patient session using WAP, with the following units: (a) login and authentication, (b) read possible messages from physician, (c) enter measured values and answer questions, (d) save values.

- Education. Each patient can attend educational sessions, either on demand, when he/she needs some information on a specific subject, or scheduled ones where the system calls automatically the patient for more detailed educational sessions on subjects that are of importance. All educational messages are also available in text form, so Internet can be used alternatively for educational purposes. Besides, a pool of Websites with useful information for disease management is available as a reference library.
- Communication with the medical personnel. Depending on the communication media, written or voice messages can be exchanged between patient and the medical personnel.

E. Multilinguality Issue

In a customized and personalized system such as the CHS multilinguality is an important issue, concerning both knowledge presentation and interface. The main issues taken into account to ensure control of language used for information presentation are:

- Keeping information in a structured way that is controlled, e.g. in a database.
- Developing configurable systems, (set language as a parameter). Along these main axes, some initial actions were taken towards multilinguality.

Written educational tips/messages were stored in a database in order to be easily translated. Voice educational messages were also maintained in a structured form, so that they are easily controlled and translated.

RESULTS

According to the scenario presented above, the patient can send data from virtually everywhere, provided he/she has the portable devices necessary for the measurements of basic parameters such as arterial blood pressure, blood glucose etc. These recording devices are getting smaller and smaller, and many of them are supporting transtelephonic transmission, which may decrease the session duration, and reduce the number of errors due to erroneous data entries. This technology together with prompting physicians can increase the effectiveness in preventive care in the future [7-8].

Home Care is facilitated since multiple means of communication are offered, thus different patient groups are not excluded. This increases patients' involvement in their own health, and hopefully reduces the need for hospitalization. In particular, elderly patients use the computer telephony solution at a rate over 90%, while younger patients use the WAP and INTERNET interfaces at a rate of over 25%. It is expected that WAP usage will increase as WAP/GPRS rates will fall. For the diabetic and CHF patients, the average contact session using mobile is around 60 seconds, something that makes future widescale use of the mobile platform highly probable.

From a technical point of view, the proposed system is a new idea offering multiple platforms and customization according to user's needs and thus contributes to customization of health care delivery (personal profile). The system is flexible, allowing incorporation of new communication technologies, for example mobile telephony and in the future interactive TV, with minimal development effort, thus, serving the idea of an integrated system for health care delivery through any communication platform.

A very important feature of the CHS system is the capability of providing continuous patient education through its structured educational knowledge base, which is accessible via the three communication platforms. The educational knowledge base is restructured according to the browsing and interfacing capabilities of the communication platform the patient uses, the patient's age and pre-existing medical knowledge.

CONCLUSIONS

This paper describes a home care contact center able of extending beyond data collection by generating feedback and supporting patient education. It combines initial screening, use of measurement micro-devices, patient education, decision support, appropriate telephone/WAP/WEB contacts and physician access.

This system is currently tested in three clinical trials for the management of diabetes, congestive heart failure and post trauma wound patients. These trials will help assess user acceptance of the system and its clinical effectiveness.

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