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The Role of Wireless Technology in Home Care Delivery

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Abstract

Health care delivery is changing drastically. In its current state it tends to use the home care model in order to increase quality of life, to rationalize costs and to achieve wellness. Pivotal to these purposes are contact centers, which act as mediators between the medical staff and the citizens seeking advice and/or therapy. Main platforms used for the development of such applications are the INTERNET and PCs, and the telecommunication networks, including mobile solutions. In this paper, a generic contact center model shall be presented, which is under development in the context of an IST European project in health telematics entitled 'Distance Information Technologies for Home care. The Citizen Health System (CHS)'. After the description of this generic contact center, an application for health care delivery to diabetic patients shall be described. In this application we shall see the possible use of the Wireless Application Protocol (WAP) scheme. This application proves the usefulness of wireless technology in providing health care services all around the clock and everywhere the citizen is located, it shows the necessity for restructuring the medical knowledge for education delivery to the patient, and it shows the virtue of interactivity by means of using the limited, yet useful browsing capabilities of the WAP technology.

Keywords:

Home Care, Telecare, Telemedicine, WAP, Contact Center, Telecommunications

Introduction

A number of reports confirm that healthcare informatics are pivotal in preventive medicine [1]. These reports also stress the importance of home care delivery as an important option as well. On the other hand there is evidence that distance information technology has more solutions available today, and that consultation, education, and data exchange sessions can occur over the telephone network and over the INTERNET as well [2,3].

However, although technology is becoming more mature, affordable and manageable, still widespread applications of such solutions in health care delivery are not accomplished. In fact, awareness of the public and the physicians is low when it comes to the use of IT, and even more important politicians' awareness of IT based health delivery solutions is even lower. It is finally observed that there is a considerable time interval that needs to be transversed from the time a specific technology becomes available to the actual time when this technology becomes widely acknowledged, at least in the literature domain [4].

Over the past decade there has been an explosive growth in mobile telecommunications. The prospects in fact for the mobile telecommunications growth are extremely positive. This growth has enabled largely telematics applications in all facets of life including health care.

Although today access to the INTERNET is mainly through home PCs, in the future the trend is expected to increasingly shift in the use of mobile phones (Figure 1). Although mobile phones are easier to use than a PC, the information that can be transmitted and browsed through them is limited. This major limitation renders medical knowledge modeling for use with mobile phones extremely important.

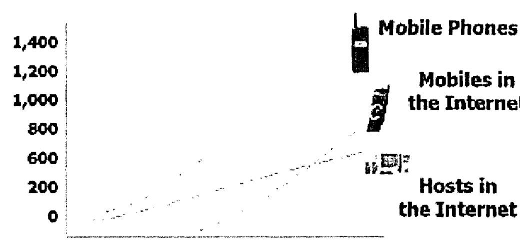


Figure 1 – Trends in mobile technologies related with INTERNET access

Today, 2G digital cellular systems such as GSM, IS-95 and IS-136 provide good voice quality anytime, anywhere [5]. However 2G systems provide low speed and hence low quality data services, and from the medical data perspective they can be used for basic parameter, clinical narratives and signals (such as ECG and other cardiovascular signals) transfer, without degrading data quality. On the other hand, for multimedia medical data transfer, it is impossible to use

2G systems, although they are very well established, and they are reliable in the functions they perform.

The goal of this paper is to present the structure of a generic contact center, identical to the one proposed in the IST project 'Distance Information Technologies for Home Care. The Citizen Health System (CHS)', and to present an implementation on interactive exchange of messages and data through a mobile WAP phone. It can be shown that this type of technology gives promising results and introduces the interactivity level that is necessary for such applications to be acceptable by the users. It is argued that in order for these applications to gain wide acceptability the restructuring of medical knowledge, as well as the further development of prompting systems are extremely important.

Methods

CHS objectives

The overall objective of this project is the use of Information Technology for the increased quality of health care at the European and Transatlantic level. From the business point of view, the creation of a new large market that would involve every single home and every single health care level is the ultimate objective. In particular, the objectives of the project can be divided into three major categories:

Information technology related objectives

- Development of new generation telemedicine services for home care.
- Development of user acceptable Man Machine Interfaces (MMIs) and graphical user interfaces (GUIs) for easy and error free data fusion, browsing and education.
- Development of new generation decision support systems based on Neural Networks, Digital Filtering and/or Fuzzy Logic for artefact rejection due to sensor and microdevice related errors, and due to the wrong use by the citizens.
- 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 microdevices, 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.
- Development of a transatlantic network for home care delivery and exchange of data and experiences for health care delivery harmonisation in diverse cultural environments.

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.
- Deployment of the new technology of microdevices for routine daily use by patients and citizens at home, increasing sales and the IT sector economic basis.
- Integration of the Neural Network and Fuzzy Logic modules for artefact rejection in the home health care system, increasing job opportunities and industry income in this area.
- The industrial partners of CHS, consider a good metric of success the ability to obtain reimbursement for the products/services derived by the CHS project.

The overall structure of the generic contact center of the CHS project

The Citizen Health System (CHS) is intended to be developed to meet home health care needs of patients with various chronic conditions such as diabetes, congestive heart failure and post trauma in culturally diverse countries. The system will consist of two units. The clinical centre unit that is going to be deployed in the hospital, speciality clinic, or ambulatory care centre where home care is co-ordinated. The home care unit will be deployed in the patients' home. Figure 2 shows a general scheme of the CHS modules that shall be developed and/or used. Observe the modularity of the system, where all modules can be developed and implemented independently.

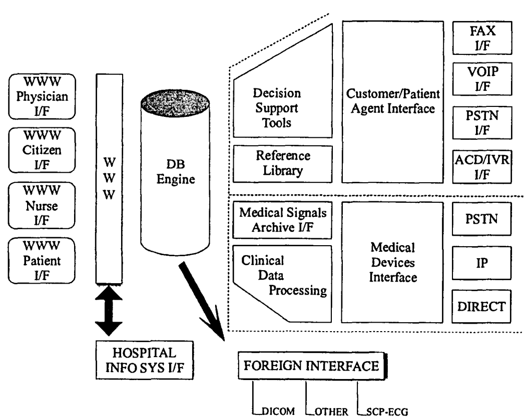


Figure 2 – The CHS contact center model

As can be seen in Figure 2, the CHS contact center model comprises of modules dealing with the following:

- Interfaces between the user and the database
- Decision support tools
- Medical signals archive
- Clinical data processing
- Reference library
- Customer/patient agent interface
- Medical devices interface

The CHS can be linked with hospital information systems as well as with specialized applications such as DICOM and SCP-ECG based applications that shall be implemented in this project. Thus, we have modules where the MMI is very important, modules where information processing methods are the key, modules where decision support and use of reference material can be important, and finally the hardware part of the CHS where we can find either service oriented applications as well as the portable devices that can be used to monitor and acquire various physiological parameters and signals. These modules can be developed independently of each other and subsequently can be integrated according to each application needs. Each one of the technical partners of the CHS project has specific areas of interest and expertise, and shall be involved in one or more of the above mentioned modules of the CHS. In the above scheme we should bear in mind that there is a middleware layer where the development tools reside (e.g. ORACLE, BORLAND C-BUILDER, INTERBASE, DCOM, JAVA etc) and a system layer (e.g. MICROSOFT NT/2000).

The WAP environment and architecture

WAP is positioned at the convergence of two rapidly evolving network technologies, wireless data and the INTERNET. In order to address the constraints of a wireless environment, and adapt existing INTERNET technology to meet these constraints, the WAP Forum developed a standard that scales across a wide range of wireless devices and networks. Key features offered by WAP and used in our development are:

Wireless Markup Language (WML) - WMLScript

The content provided by the WAP-enabled devices was encoded in WML format. WML is a markup language based on the Extensible Markup Language (XML) and was developed for specifying content and user interface for narrowband WAP-enabled devices, such as cellular phones and pagers. WML is designed to work with small, wireless devices that have special characteristics e.g. small displays, limited input facilities and limited computational resources (memory, CPU).

Dynamic features, such as computational logic and input validity mechanisms, can be added to the WML content by using WMLScript, a client-side scripting language similar to Javascript™.

Active Server Pages (ASP) Technology

In order to provide dynamic characteristics to the WML 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 Extensible Markup Language (XML) and Component Object Model (COM) to create powerful interactive Web sites and extend scripting capabilities.

Comparing with Gateway Interfaces such as CGI (Common Gateway Interface) and ISAPI (Internet Server Application Programming Interface), ASP is easier to create and change and completely integrated with HTML files. As an additional advantage, the developed ASP pages that include WML content, can be easily modified in order to include the same content encoded in HTML format, providing this way the service alternatively from the Web.

WAP Gateway

The WAP Gateway provides 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.

In our case, the Nokia® WAP Server 1.0™ (trial version) was used, a software product running on Microsoft® Windows NT™ environment. The Nokia® WAP Server 1.0™ connects WAP-enabled terminals to content and applications hosted by web servers or any other servers on the Internet or a private Intranet. It can be also used as a WML/WMLScript server. Management facilities and security techniques are among other features that the product provides. This software product is considered one of the most excellent and reliable solutions currently available.

Web Server

The Active Server Pages that contain the WML content are hosted in a Web server. The Microsoft® Internet Information Server 4.0™ (IIS 4.0™) was chosen to provide Web server features. IIS is a widespread Web server system integrated with Windows NT Server™ that makes it easy to publish information and bring applications to the Web.

Evaluation Software

In order to develop and evaluate the service, the Nokia® WAP Toolkit v.1.3 was used. Mainly, it involves a simulation environment, providing tools for creating services on the WAP platform. Among its basic features are: (a) a WML browser, including WMLScript interpreter and WMLScript libraries, (b) a WAP phone user interface simulation module, (c) WML and WMLScript encoders, (d) WML, WMLScript, and WBMP editors, (e) Debugging mechanisms

The simulator application reads the WML/WMLScript code and shows the application in the user interface simulation window, simulating the look and feel of a mobile phone user interface. This software product is freeware. The result was that this application is operating satisfactorily and a demo of this application shall be subsequently presented.

The WAP Architecture

The Internet World-Wide Web (WWW) architecture provides a very flexible and powerful programming model (Figure 3). Applications and content are presented in standard data formats, and are *browsed* by applications known as *web browsers.* The web browser is a networked application, ie, it sends requests for named data objects to a network server and the network server responds with the data encoded using the standard formats.

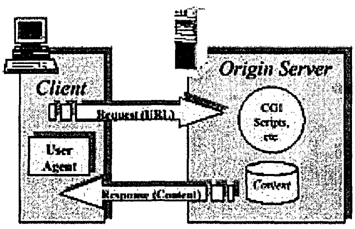


Figure 3 - The WWW programming model

The WAP model

The WAP programming model (Figure 4) is similar to the WWW programming model. This provides several benefits to the application developer community, including a familiar programming model, a proven architecture, and the ability to leverage existing tools (eg, Web servers, XML tools, etc.). Optimisations and extensions have been made in order to match the characteristics of the wireless environment. Wherever possible, existing standards have been adopted or have been used as the starting point for the WAP technology.

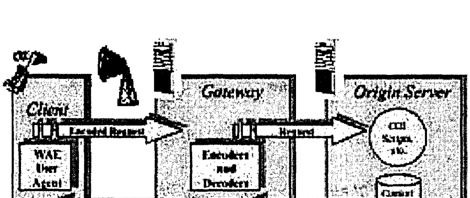


Figure 4 - The WAP programming model

WAP content and applications are specified in a set of well-known content formats based on the familiar WWW content formats. Content is transported using a set of standard communication protocols based on the WWW communication protocols. A *micro browser* in the wireless terminal co-ordinates the user interface and is analogous to a standard web browser.

The application scenario for a diabetic patient

Figure 5 shows the application scenario that was used to test this technology. In particular the scenario was as follows:

- Every diabetes patient has to submit the values of some basic measurements that were taken at home (e.g. blood pressure, glucose) on a regular basis.
- The data will be transmitted via WAP-enabled device (mobile phone, PDA), checked according to a medical knowledge prototype and stored automatically in a database located in the corresponding clinic.

The measured values that were acquired and sent during a contact session to the database by the patient were: 1. Systolic Blood Pressure, 2. Diastolic Blood Pressure, 3. Blood Glucose, 4. Pulse, 5. Temperature, 6. Weight.

The patient also had to answer specific questions with a simple 'Yes' or 'No', in order to provide the doctors with more information. These simple questions were:

1. Did you take your medicine?
2. Did you feel any symptoms?
3. Do you feel ill?
4. Did your lifestyle exceed normal?

All the above mentioned data were checked against artifacts (mainly typos) that could cause problems in the diagnosis procedure. The medical doctor subsequently, was able to browse these data, stored in the Electronic Health Record, review them, and contact if necessary the patient for further advice.

Results - Conclusion

Figure 6a shows the mobile telephone screen sequence followed by the patient while logging in the system. Figure 6b shows the sequence of screens where specific values are imported by the patient and sent to the database, and finally Figure 6c shows the screen sequence for the answer of specific questions. It can be said here that the time needed for the completion of a session is in the order of 3 minutes, even if a patient reacts very slowly. It is anticipated that the actual time needed would be in the order of 1-2 minutes once the patients get accustomed with the system.

Once the data are entered in the database, the doctor can run analogous sessions, browse the data, send educational messages, and consult with the patients if necessary. In the doctor's case the block diagram and screen sequences are analogous to the ones found in Figure 6 for the patient scenario.

From this application, we can see the tremendous potential of the mobile telecommunications and a contact center analogous to the one under development in the CHS project. 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 (ABP), blood glucose etc. These recording devices are getting smaller and smaller, and many of them are becoming transtelephonic, something that would decrease the session duration, and reduce the number of errors due to wrong key-in of the data. This technology coupled with prompting physicians can increase the efficacy in preventive care in the future [6]. WAP is just one of the platforms available today, but such applications like the ones described here would be feasible under other platforms as well that shall be available in the future.

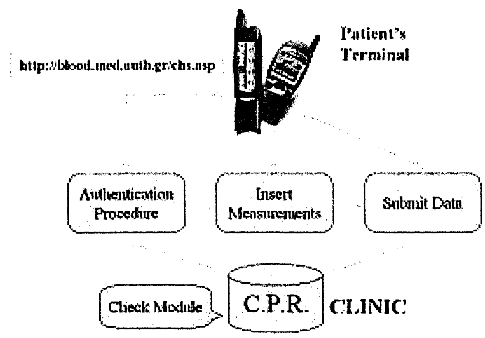
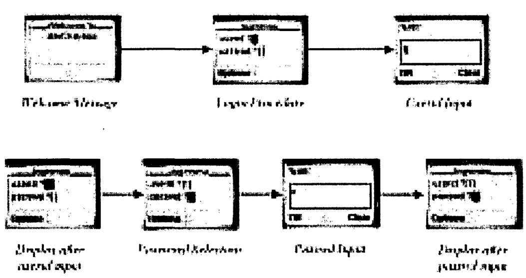
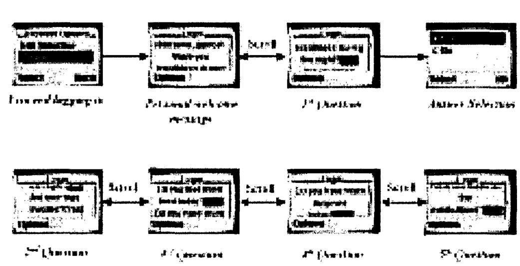


Figure 5 – The patient's scenario while using the CHS contact center and a mobile WAP phone



(a)



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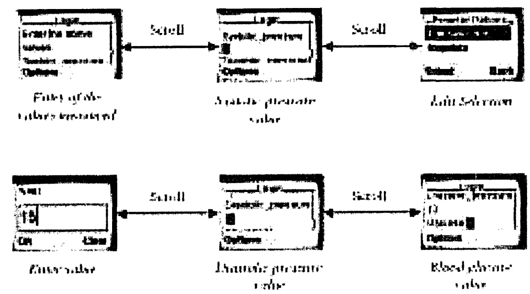

(c)

Figure 6 – Screen sequences for a patient session, with the following units: (a) login and authentication, (b) entering measured values, (c) answering simple questions

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