Multiagent Home Telecare Platform for Patients with Cardiac Diseases

V Traver, E Montón, JL Bayo, JM García, J Hernández, S Guillén

Bioengineering, Electronics and Telemedicine Group-ITACA, Universidad Politécnica de Valencia, Valencia, Spain

Abstract

Paper presents a home telecare platform for patients with cardiac diseases usable by medical staff or patients through several agents: a Personal Digital Assistant, a Set-Top-Box (STB), a laptop, and a Personal Computer (PC), being valid for different cardiac disease scenarios: home intensive telecare, autonomous monitoring, and home hospitalisation.

Platform is accesible via web through different technologies (xDSL, HFC, POTS, GPRS, and UMTS in a next future) and main features are videoconference, electronic history record, e-prescription, on-line and off-line monitorisation, scheduler, alarms managers and user customised cardiac information.

Home telecare platform is being validated by the Cardiac Unit of 9 d'Octubre Hospital and Home Hospitalisation Unit of La Fe Hospital in Valencia, Spain with satisfactory results.

1. Introduction

Cardio-vascular diseases (CVD) are the leading cause of death in the western world. More than 20% of all European citizens suffer from a chronic cardio-vascular disease and around 45% of all deaths are due to CVD [1]. Annually, Europe spends some hundred billion euros on the management of CVD and indirectly associated costs like lost productivity, sickness and premature death. For example 13% of all direct healthcare costs in Germany are due to cardiovascular disease exceeding 20 billion euros.

Information and communication technologies may be applied to cover most CVD needs at any stage, in order to reduce sickness, related expenses, and deaths, improving also patient' quality of life.

Up to now, different isolated products or projects have succeed covering one stage of the disease [2], but have failed to cover patients needs at any time for cardiac diseases (i.e. home telecare activities shall not be the same just after a surgical intervention than a continuous follow up). Therefore, due to hospital and patient needs, we aim at the deployment of a home telecare platform, providing customised services (videoconference, assisted or autonomous telemonitoring, customised disease information, e-disease management) at different levels making it available through the use of different technologies: HFC, ADSL, GPRS or POTS, always under IP connection.

Therefore, the use of Information Communication Technologies (ICT) in the cardiac diseases field may give as a result a patient continuous care at any stage with any device [3]

2. Materials and methods

The design, development and deployment of a modular home telecare platform for chronic patients (i.e. people with cardiac diseases) has requested a deep requirements & use case analysis and the definition of features to be developed for the following scenarios (not exclusively): home intensive telecare, autonomous monitoring and home hospitalisation unit, covering mostly any stage of cardiac disease out-of-hospital [4][5].

After compiling and analysing all this information, a technical architecture has been designed to fulfill all requirements taking also into account issues as interoperability, connectivity, reliability, flexibility and scalability.

2.1 Requirements and scenarios

Provision of care services for cardiovascular diseases requires a wide set of available features to be managed properly.

- Telemonitoring: on-line & off-line monitorisation of different vital signs: ECG (12 leads), blood pressure, heart rate, temperature and pulsioximetry. Data can be stored locally or transmitted to a data centre.
- Alarms: according the patient profile, some alarms may rise when any of his/her thresholds has been reached. These alarms can produce some actions and warnings to the patient or the medical staff who is taking care of him/her.
- Agenda: tool for scheduling appointments, visits and even for reminding periodically 'pills to take' at that moment.
- Electronic Health Record (EHR): used for the

medical staff; as much information as they have, diagnosis shall be more accurate and administrative data time shall be reduced.

- E-prescription: exercises, recommendations or pills ordered by the doctor can be consulted any time by the patient through the database.
- Customised patient information: according to the patient profile, they can get personalised complementary information about their disease.
- Videoconference: it can help to achieve the feeling of virtual presence, being used also for visual exa minations.

Table 1. Features available for patient and medical staff

Feature	Patient	Medical Staff
Telemonitoring	x	x
Alarms	x	x
Agenda	x	x
EHR		x
E-prescription	x	x
Information	x	
Videoconference	x	x

This home telecare platform for cardiac diseases management may be used for different devices, to ensure interoperability and easiness of use, looking for the best option at any moment of the CVD. Available devices are PDAs, PCs, mobile phones, Tablet PCs, and Set Top Boxes (STB).

Three scenarios with their corresponding use cases have been utilised as the basis for the development of the home telecare platform, being described more in detail in the following lines:

- Home intensive telecare – Synchronous service mainly addressed for patients after surgical operations. Patients are at home but they need a very close follow up, i.e., patients and medical staff keep a videoconference session weekly including ECG (12 leads) and blood pressure monitorisation. In addition, patient can start a teleconsultation when anything is going wrong.
- Autonomous monitoring – Asynchronous service where the patient self-monitorises daily. Biomedical data is stored in the Hospital database. Alarms can be raised if something goes wrong, generating events for the patient or the medical staff, depending on the alarm level.
- Home hospitalisation unit – Scenario in which nurses and doctors from a Home Hospitalisation Unit have a set of tools to manage all the patients that are visited by them daily. Medical staff has all the information related to the patient available at any moment and they can monitorise the patient and transmit acquired data to the hospital through GPRS (out of the hospital) or IEEE802.11b (when they are back to the hospital). Home Hospitalisation Unit may also follow chronic patients making use of videoconference capabilities. [ideas]

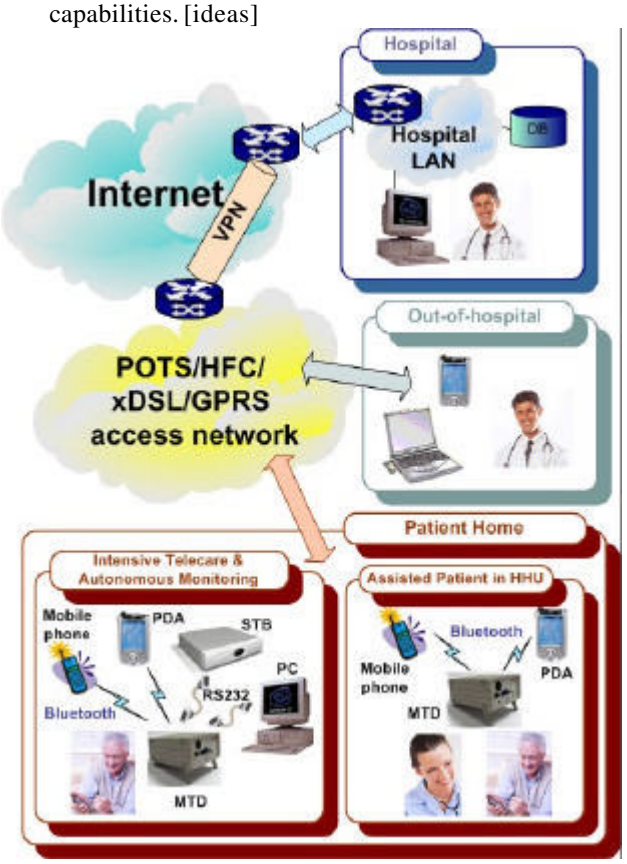

Figure 1. Scenarios & technologies in the home telecare platform

A matrix is shown in the Table 2 with the features used in each scenario, indicating also who is who uses them: patients, medical staff or all.

Table 2. Summary of scenarios and features

Scenario/ Feature	Home intensive telecare	Autonomous monitoring	Home Hospitalisation Unit
Telemonitoring – Acquisition	Patient	Patient	All
Telemonitoring – Visualisation	All	All	All
Alarms		All	All
Agenda	All	All	All
EHR	Medical	Medical	Medical
E-Prescription	All	All	All
Information	Patient	Patient	Patient
Videoconference	All		All

2.2 Technologies

The platform has been implemented in .NET technology [6] following the A's interoperability paradigm (Anytime, Anywhere by Anyone who is Authorised in Anyway), being accessible from a web environment.

Technological issues have been addressed in the following way:

- Connectivity: GPRS, xDSL, HFC, and POTS are the available technologies to reach the services provided by the platform in an outdoor environment (Wide Area Network) whereas Bluetooth and IEEE 802.11b have been used within Body and Local Area Networks respectively.
- Interoperability has been guaranteed by the use of IP. Additionally, web services, XML as tool for data exchange and storage, and SCP-ECG as standard for ECG, provide the mechanism for ensure interoperability.
- Modularity and flexibility: .NET framework, SQL databases and web services have allowed the development of the home telecare platform in a modular and flexible way, reducing times for reengineering processes and easing customisation for each specific case.
- Videoconference: H.323 standard has been used for IP videoconference. Netmeeting API and VCON VDK development kits have been used for medium and high quality videoconference respectively.
- Security and encryption: Secure Socket Layer (SSL) and Blowfish have been used for security and encryption, guaranteeing the privacy of any transferred data
- Compression: Gzip has been used for compression when size of data to be transferred was a critical issue, i.e. for a GPRS transmission, when the cost is proportional to the amount of data exchanged.

Concerning monitorization issue, a low cost modular Multiparametric Telemonitoring Device [7] designed for fixed and mobile scenarios, has been used. It measures ECG (12 leads), temperature, blood pressure, pulse rate and SpO2 level, being connectable to a PDA, PC or STB through Bluetooth or RS-232.

Figure 2. Multiparametric Telemonitoring Device

3. Results

3.1 Home telecare platform

A web-based home telecare platform has been developed, resulting a very valuable tool for the care and management of patients with cardiac diseases.

Usable by nurses, doctors and patients, main platform features are: telemonitoring, alarms, agenda, electronic health record, e-prescription, customised patient information and videoconference.

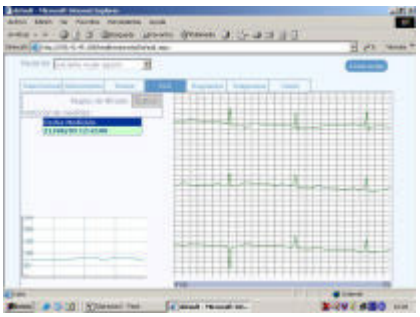

Figure 3. ECG web page example

Home telecare platform is located in an Internet Information Server at 9 d'Octubre Hospital and La Fe Hospital without high requirements (800 MHz CPU, 512 MB RAM). STBs and PCs minimum requirements are 400 MHz CPU, 128 MB RAM, 40 MB hard disk, sound card and VCON video card or a webcam, depending on the required video quality. Regarding mobile access to healthcare services with PDAs, it was decided the use of the PDA Ipaq H3540, since has integrated both IEEE 802.11b and Bluetooth wireless technologies in combination with Nokia 7650 mobile phone after trial results.

3.2 Evaluation results

The home care platform is being validated and evaluated within Hospital 9 d'Octubre Cardiac Unit since November 2001 (Home Intensive Telecare Scenario), May 2003 (Autonomous Monitoring Scenario) and September 2003 (Home Hospitalisation Unit Scenario) whereas up to now, at La Fe Hospital is being validated only the Home Hospitalisation Scenario since June 03.

The whole home telecare platform has been validated technically and it is still under long-term process evaluation, considering not only technical issues but also economical, social and medical aspects.

Anyway, significant evaluations results from Home Intensive Telecare scenario are available after almost 2 years use with 18 patients (each one use it weekly for an

average period of 6 months). Among these results, it's worth to remark that 71% patients stated that the home telecare services had increased their independence, 85 % patients expressed their wish to keep the service after the trial (willingness to pay) and 100% trusted on the medical act results through the home telecare service. In any case, both, patients and also medical staff, have considered the home telecare platform complementary and not substitute of the traditional health care services.

4. Discussion and conclusions

A complete home telecare platform is available and running in Valencian hospitals to complement traditional health care service for patients with cardiac diseases problems. Most stages of cardiac-related illness may be covered with the applications, devices and tools developed up to now within the platform. This platform offers the following advantages: [8] [9] [10]

- Continuous care at any stage from any device
- Acquisition and access to data in simple, fast, integrated and secure way.
- Improvement in the disease management, easing diagnosis and treatment in real-time.
- Diminution of insecurity feeling and stress of patients, careers and medical staff implied.

Nevertheless, there is still some work to be carried out in a next future:

- Health Promotion and Disease Prevention: most human and economical effort is being spent in palliative care but this home telecare platform might provide information and tools address to healthy patients, giving the proper guidelines in order to reduce cardiac diseases and promote healthy life.
- Wearable devices: in line with health promotion and disease prevention, use of wearable devices integrated within the platform should be extended. Proceeding in this way, pervasive monitoring shall increase the amount of patient data collected for an efficient preventive care, better diagnosis, and proper follow up.
- Features extension: new features can be added to the platform thanks to its modular design. For example, some tools for relationships among patients may be developed (chat, news, foro…).

An example of a R&D project that shall face with these issues is the Integrated Project My Heart, funded by the European Commission, whose mission is empower citizen to prevent cardio-vascular diseases by development of intelligent biomedical clothes for ubiquitous access to clinical excellence.

Acknowledgements

Authors thank Dr. F. Valls, Dr. B. Valdivieso, J. Cervera, J.M. Meseguer, C. Fernández, S. Vera and medical staff and patients from 9 d'Octubre and La Fe Hospitals for their support, motivation, commitment and enthusiasm.

References

[1] British Heart Foundation. European cardiovascular disease statistics 2000 edition; 2000.

[2] Yonghong Z, Jing B, Wen L. Development of a home ECG and blood pressure telemonitoring center. Engineering in Medicine and Biology Society, 2000. Proceedings of the 22nd Annual International Conference of the IEEE 2000,3: 2282 -2285.

[3] Cain M, Sarasohn-Kahn J, Wayne J. Health e-People: The Online Consumer Experience. California Healthcare Foundation; 2000.

[4] PISTACABLE project website. Available from http://pistacable.ono.com Accessed September 17, 2003.

[5] Ideas in e-Health IST 2001-34614 project website. Available from http://www.ideas-ehealth.upv.es Accessed September 17, 2003.

[6] Richter J. ADO.NET. Sams Publishing 2002.

[7] Healthmate project IST 2000-26154 project website. Available from http://www.healthmate-project.org/ Accessed September 17, 2003.

[8] Tsagaris MJ,Papavassiliou MV, Chatzipantazi PD et al. The contribution of telemedicine to cardiology. Journal of Telemedicine and Telecare 1997; 3(1):63-64.

[9] Khoor S, Nieberl K, Fugedi K, Kail E. Telemedicine ECG-telemetry with Bluetooth technology Computers in Cardiology 2001:585 -588.

[10] Shanit D, Greenbaum RA. Towards a comprehensive telecardiology monitoring centre for community-based services. Journal of Telemedicine and Telecare 1997; 3(1):60-62.

Address for correspondence.

Name. Vicente Traver
Full postal address: Bioengineering, Electronic and Telemedicine Group. Electronic Engineering Department. Universidad Politécnica de Valencia. Camino de Vera s/n Valencia 46022 Spain
E-mail address. vtraver@eln.upv.es