An Integrated Telecommunication Pilot Platform for the Provision of Telematic Health Care Services

Stavroula G. Mougiakakou, Homer Papadopoulos, Panagiotis Telonis, Georgios Konnis, *Member, IEEE*, Konstantina S. Nikita, *Member, IEEE*, and Dimitrios Koutsouris, *Member, IEEE*

Abstract—Aim of the paper is to present a platform that will enhance the provision of medical services for both citizens and traveller`s in remote/isolated regions of southeast Mediterranean, and on board ships travelling across it. This platform will allow the distribution of knowledge and collaboration among the health personnel of these areas, making use of wireless and terrestrial broadband telecommunication lines. The platform will provide the following health care services: i) Tele-collaboration and tele-consultation services between health care personnel, ii) home care telemedical services for "at risk" citizens, e.g. elderly, patients with chronic diseases, and post-surgery patients, iii) tele-medicine services in emergency situations, and iv) eLearning services for the continuous training through seminars for both health care personnel (doctors, nurses etc.), and persons supporting "at risk" citizens. The above services will be provided through the combined use of already evaluated systems. These systems supports capabilities for ultrasound images, ECGs, vital signal measurements, video conference, and elearning, along with communication gateways for data transmission over ISDN/DSL, satellite, GPRS, and WLAN networks. Furthermore, the implementation of an Electronic Patient Record (EPR) infrastructure to support proposed system's interoperability will provide the fundamental basis for future collaboration and information technology projects in the area.

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S. G. Mougiakakou is with the Institute of Communication and Computer Systems, National Technical University of Athens, Greece (telephone: +30-210-772-2968; fax: +30-210-772-3557; e-mail: smougia@cc.ece.ntua.gr).

H. Papadopoulos is with the National Center for Scientific Research, "Demokritos", Greece (e-mail: homerpap@dat.demokritos.gr).

P. Telonis is with the National Center for Scientific Research, "Demokritos", Greece.

George Konnis is with the Faculty of Electrical and Computer Engineering, National Technical University of Athens, 9 Heroon Polytechneiou Str. 15780 Zographou, Greece (e-mail: konnis@biomed.ntua.gr).

Prof. K. Nikita is with the Faculty of Electrical and Computer Engineering, National Technical University of Athens, 9 Heroon Polytechneiou Str. 15780 Zographou, Greece (e-mail: knikita@cc.ece.ntua.gr).

Prof. D. Koutsouris is with the Faculty of Electrical and Computer Engineering, National Technical University of Athens, 9 Heroon Polytechneiou Str. 15780 Zographou, Greece (e-mail: dkoutsou@biomed.ntua.gr).

I. Introduction

The regions of southeast Mediterranean are characterized by expanded inner space and isolated areas. Those makes difficult the socially, technologically, and economical integration and consequently, the equally and efficient provision of health care services.

The evolution on telemedicine system supported by advanced algorithms, high performance computers, sensors, monitoring devices, and telecommunication networks permits the provision of good quality of medical care to remote/isolated regions, the information exchange, and the distribution of medical knowledge among health care professionals [1].

Telemedicine applications have been successfully used for the provision of emergency telemedicine in understaffed areas like, among others, rural health centers [2-3], ambulance vehicles [4], ships [5], as well as for home monitoring [6-7], whenever is needed. Furthermore, various services have been developed for remote collaboration of health care professional [8], and their needs for life-long education [9].

One of the major limitation to the widespread usage of the aforementioned applications is that, most of the time, are developed either for one type of disease, or only for emergency cases. Usually they concern only a small part of the needed by the community health care services.

In this paper an integrated broadband telecommunication platform is presented. The platform, which is able to cover a wide range of the aforementioned services, can be used to:

- Support the collaboration and consultation between remote located health care personnel.
- Enable the home tele-monitoring of "at risk" citizens, e.g. elderly, patients with chronic diseases, and post-surgery patients.
- Handle emergency cases in rural health centers, ambulances and/or ships.
- Enable the continuous training through seminars for both health care personnel (doctors, nurses etc.), and persons supporting "at risk" citizens.

Aim of the platform is the collaboration between doctors and/or citizens located in countries with different health care systems, different technology infrastructure, and different needs, in order to enhance the quality of health care services

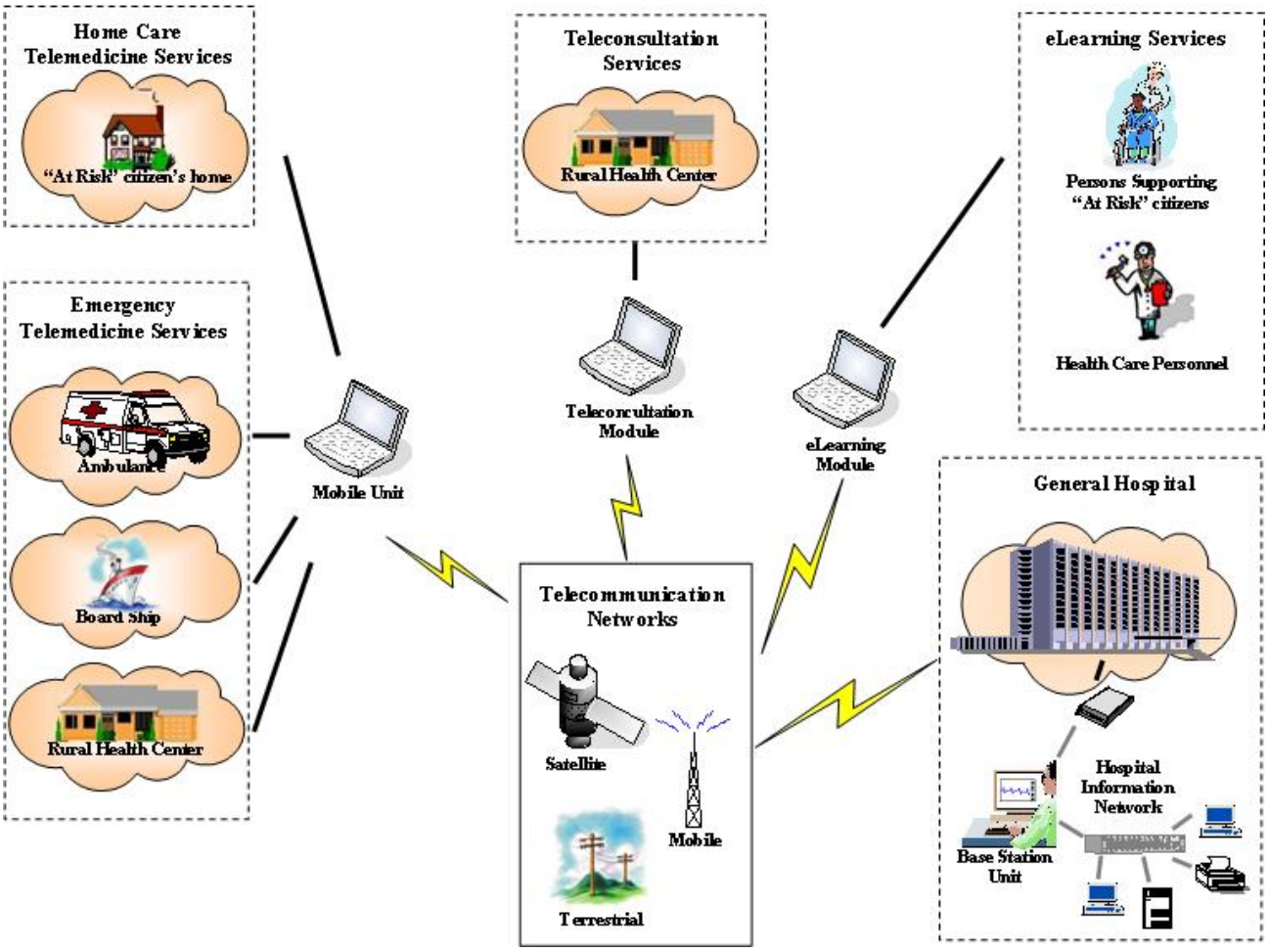

Fig. 1. Overview of the platform architecture.

in the region Mediterranean, and the equal access to the health care systems. Through the platform will be possible the efficient handling of patients with chronic diseases, the early response to emergency incidents, and the reduction of human lives losses. The platform, which will be developed during the project INTERMED: An INTEgrated broadband telecommunication pilot teleservices-platform for improving health care provision in the Region of MEDiterranean [10], will be tested and validated in 17 different pilot sites in Greece, Italy and Cyprus. The platform and the provided services will be assessed by citizens, travelers, patients, crew members, and physicians in the aforesaid sites.

II. Platform Description

The platform, which is based on the integration of terrestrial, satellite and mobile networks, provides to the direct beneficiaries (residents, travelers, crew members, medical staff), the following services

- Tele-collaboration and tele-consultation services between health care personnel. Those services will support the provision of expert's advices from central hospitals to rural medicine centers and smaller health facilities, in order to support the diagnosis procedure with a second opinion.
- Home care telemedical services for "at risk" citizens, e.g. elderly, patients with chronic diseases, and post-surgery patients. Those services will include the utilization of wireless communications for the provision of on site expert's advices after evaluation of the transmitted vital signals.
- Tele-medicine services in emergency situations, e.g. passengers onboard a ship. Those services will be provided through interconnecting a ferry serving a Mediterranean Sea area via satellite with the hospitals of the network.
- Public health and elearning services for the continuous training through seminars for both health care personnel (doctors, nurses etc.), and persons supporting "at risk" citizens.

Furthermore, an Electronic Patient Record (EPR)

provides the fundamental basis to support the proposed system's interoperability.

The design of the platform is based on the requirements for:

- high speed broadband connections
- streaming audio/video services
- full duplex, real time communications

A. Services Description

As aforementioned the platform provides a series of services, which will be supplied through the combined use of already evaluated systems, results of EU founded project. These systems supports capabilities for ultrasound images, ECGs, blood pressure and oxygen saturation meters, video conference interfaces, and numerous communication gateways over satellite, mobile and terrestrial telecommunication networks.

1) Teleconsultation Services: The teleconsultation services will be mainly provided by the Wavelet based INteractive Video Communication System (WinVicos). WinVicos is a high-end, interactive video conference system providing real time video, still-images and audio transmission [11]. The system has been designed mainly for medical applications, like intra-operative teleconsultation, in various EU founded projects. WinVicos supports communications via satellite, Local Area Network (LAN), Internet, ATM, xDSL etc.

Furthermore, teleconsultation services will be provided by the systems presented in the following paragraph.

2) Telemedicine Services: For both the home care telemedicine services and the emergency telemedicine services two different systems will be used. The first one consists of two separate units: i) mobile unit, at patient's site, and ii) base station unit, at health care professional's site. The mobile unit is comprised by four (4) modules:

- Biosignal acquisition module, which is responsible for biosignal collection. More specifically, the module is able to collect 3 to 12 lead electrocardiogram (ECG), oxygen saturation (SpO_2), Heart Rate (HR), Non-Invasive Blood Pressure (NIBP), Invasive Blood Pressure (IBP), temperature, and respiration.
- Real time image acquisition and processing module, which is responsible for image capturing (video and still images of the patient).
- Processing module, which is the core module of the mobile unit. This module for the automatic control of all system modules. The module mainly consists of four sub-modules: user command, local storage, biosignal local display and data compression and encryption. Data collected form biosignal and image modules are stored locally on the mobile unit and displayed on a local display. After compression and encryption the images and/or biosignals are transmitted to the communication module.
- Communication module, which is responsible for the communication with the base station unit. Communication can be performed through i) GSM mobile telecommunication network, ii) satellite links (where GSM is not available), and/or iii) Plain Old Telephony Systems (POTS) where available.

In the base station unit a health care professional at the general hospital telematically "move" to the patient's site and instruct unspecialized personnel when handling an emergency or telemonitoring case. Due to the need of storing and archiving of all data interchanged during the telemedicine sessions, the hospital site is equipped with a multimedia database able to store and manage the data collected by the system.

The system prototype is the results of two EU founded projects named AMBULANCE [4] and Emergency 112 [12].

The second system, named TeleInVivo, is a custom made device integrated in one solid case [13]. It is comprised by a portable Personal Computer (PC) with telecommunication capabilities and a light, portable 3D ultrasound station. The system using advanced image processing techniques is able to collect 3-dimensional ultrasound data of a patient. With 3D ultrasound, a volume of data is shipped to a remote expert who can examine the data in much the same way that he/she would examine a person on-site. Furthermore, TeleInVivo has DICOM-3 read capabilities, which permit the transaction with other DICOM enabled imaging modalities like MRIs, CTs, etc. The data are stored at the PC and can be uploaded to a Picture Archiving and Communications System (PACS) server at the hospital site. The data transmission can be either on-line, or off-line using various communication ways from a simple phone line and Internet to ISDN, GSM, and satellite.

The system prototype is the results of the EU founded project TeleInViVo [14].

3) eLearning Services: eLearning services will be provided using the Corporate Learning and Information eXchange (CLIX) web based learning application [15]. CLIX is platform independent based on 3-tier client-server architecture. The end-user is able to communicate with the application via a web browser, while the end-user communicates with the application via standardized internet protocols (http or https).

The EPR will permit the clinician to have real time and secure access to patient health record information whenever and wherever it is needed [16]. A Virtual Patient Record (VPR) is an ideal EPR that is a decentralized and contains heterogeneous and distributed medical and clinical data [17]. To this end an XML schema that operates as an interface between different heterogeneous patient records will be used [16]. The scheme, which is based on standards like HL7,

DICOM, VITAL, GEHR and prENV 13606-4, is developed using state of the art java and XML based techniques. Through the XML scheme is feasible the system interoperability and distributed system interaction, allowing the patient mobility while still having an EPR at any time.

B. *Network Description*

Aim of the platform is to support the multidisciplinary collaboration in selected pilot sites, especially in regions of southeast Mediterranean characterized by poor terrestrial infrastructures. As aforementioned, the broadband telecommunication network that will be implemented during INTERMED, will integrate three types of networks, terrestrial, satellite and mobile. The network will be based on nodes of universities (University of Cyprus, University of Catania), research institutes (Institute of Communication and Computer Systems - ICCS, National Center for Scientific Research "Demokritos" – NCSR), hospitals (Paphos General Hospital, Sotiria Hospital, Hospital of Catania), regional medical centers in Greece, Sicily (Italy), and Cyprus, and ferries traveling across southeast Mediterranean. The network will provide broadband coverage to all the partners in Greece (Institute of Communication and Computer Systems - ICCS, National Center for Scientific Research "Demokritos" – NCSR), Cyprus (University of Cyprus, Paphos General Hospital), and Italy (University of Catania), thus ensuring communication between different and remote parties allowing for data transmission and bidirectional communication by means of audio-visual content transmission.

Via the platform will be exchanged clinical data collected by distributed nodes (e.g. regions supported by low-bandwidth earth network, such as rural areas in Samos Island etc.) among various nodes located around the East Mediterranean area.

In the last year, a growing area of interest is that of integrated networks, networks that contain both terrestrial and wireless links, which is one of the platform objectives. More specifically in the platform will be integrated broadband terrestrial network infrastructures with satellite broadband technologies. This interconnection of the two heterogeneous telecommunication network parts satellite on one hand and internet on the other hand is realized via both employing standard IP-based interfaces and developing upgrades where necessary. For example during the project INTERMED it will be integrated the terrestrial network between NCSR - University Hospital of Patras with the Satellite network NCSR - Hospital of Samos etc.

The adopted topology consists of eleven (9) main nodes as presented in the Fig. 2. Each node is connected to its appropriate router via an Ethernet link and runs TCP/IP protocol.

The terrestrial network is based on, dedicated bi-directional tunneling structures, between the main nodes over the GU-NET network and dedicated broadband leased lines. For example NCSR is in connection with Sotiria Hospital via 2 Mbps PCM leased line and with University Hospital of Patras via 1 Gbps with a tunneling mode. This adopted two-directional tunneling approach is structured on the CiscoTM 2600 router and enables the network of the University Hospital of Patras to send its data through the NCSR network's connections.

Satellite communication on the other hand combines broad geographic coverage, multicast capabilities, mesh topology etc. The satellite communication network which will be used is the DSAT 2000 by EUTELSAT TM with wideband DAMA service over W2 satellite. The chosen satellite solution adopts Linkway satellite modems (technology developed by COMSAT Laboratories in the USA) with LAN interfaces which will be used for communications with a bandwidth of up to 2 Mbps. The proposed platform provides multinode and multisite collaboration taking advantage of the multicast capabilities and the wide-band capacity of current satellite systems. For the platform will be used three satellite stations: one satellite station at Samos Hospital, one satellite station at University of Catania, and one satellite station on board (pilot site) Superfast XII. The satellite system onboard the ship consists of the tracking Seatel antenna by COMSAT, the Linkway satellite modem using the DSAT 2000 by EUTELSAT TM service over W2 satellite.

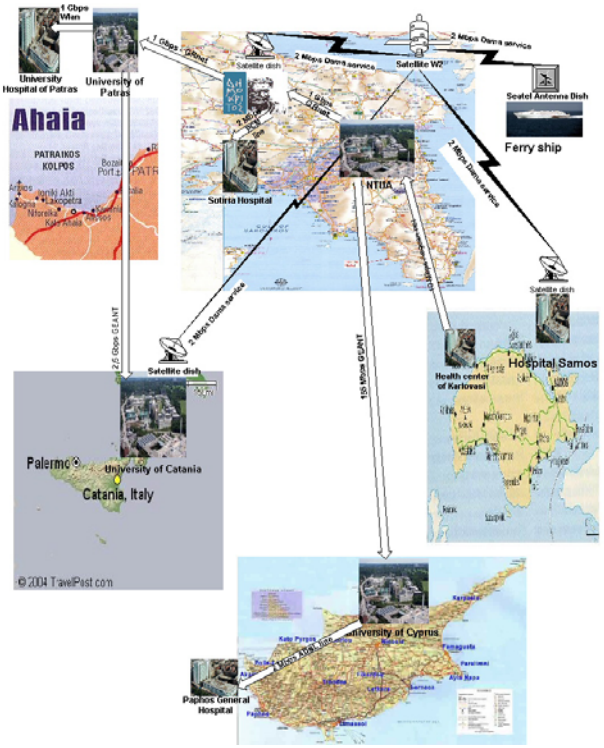

Fig. 2. Integrated Satellite-Terrestrial Connection - Overview of the nodes (pilot sites) over INTERMED platform.

C. *Security*

Security issues in health care information systems are of great importance. In the proposed integrated telematic platform security mechanisms is incorporated in order to protect the information during the transmission and storage as well as at the system level (logical access control, legitimate and availability). As aforementioned in the

platform will be integrated heterogeneous telecommunication infrastructures. More specifically it will be integrated terrestrial, satellite, GPRS network, and Internet, wired and wireless LAN. For each network type an efficient security policy must be deployed.

III. Typical Operational Scenarios

A typical operational scenario of the platform would follow a script as below:

During an emergency case, a resident of Pyrgos village in Samos in the Aegean Sea feels a strong pain to his chest. The doctor of the small health centre uses the mobile telemedicine unit of the platform to perform an ECG, collect vital signals and/or even an ultrasound examination on the patient. The acquired medial data are directly transferred in real time to the hospital. In the meantime, through the videoconference application the doctors of the referral hospital have a clear view of the patient. Based on these clinical data and on the direct sight of the patient the doctors can assist the local doctor of the health centre for a safe diagnosis and moreover to apply an appropriate therapy. Furthermore, in case the diagnosis is difficult, experts from another hospital could join the videoconference session. Both ends can exchange chat messages, send files (like medical reports, etc.) to each other, point regions of interest to the other partner with the telepointer, and discuss in real-time the medical case. The whole process and the medical data of the patient are registered in the medical's register server. These data can be added into the electronic medical registry of the patient.

The same emergency case should be occurred onboard a ship for a passenger or a member of the staff and during a crisis situation where there is a need for a first aid. The services can provide added value to ships allowing in urgent medical cases a second opinion and an advice from a specialist as well as collaboration between experts.

Chronic conditions are mainly characterized by the need of ongoing management over a period of years or decades. This implies a very broad perspective ranging from non-communicable diseases (cardiovascular, cancer and diabetes) to long-lasting infections (HIV, tuberculosis) trough different levels of disabilities. A significant issue in some chronic diseases is the difficulty of maintaining an acceptable life-quality level on the one hand and the difficulty in transitions from the patient's home to the hospitals on the other. This scenario is focused in supporting and monitoring of patients with chronic diseases living at their houses from specialized doctors interconnected through diverse broadband networks, avoiding the routine transitions from and to the hospitals. An additional benefit from this scenario is the easier access of the patients to medical care and the decongestion of urban hospitals from routine examinations of chronic patients.

The scenario can be extended to emergency events at home. In this scenario, the patient's does not feel well and collect some vital measurements. The measurements are sending, via internet, to the physician, in order to assess the patient's physical condition.

Continuous learning is of high importance for both the health care personnel, in a rural health center, and persons supporting "at risk" citizens. Both of them will have the opportunity to connect via the internet to the elearning services and to select the needed credit seminar. The seminar will have a system for self-examination and remote assessment.

It has to be noted, that the doctors within the hospitals will act as end users and will be committed to provide medical services, will have broadband access to the collaboration environment with the patients from rural areas and staff from ships or rural health centers with different communication modes.

IV. Discussion and Conclusion

In the presented broadband telecommunication network the information and communication systems, and the medical equipments will behave as a telematic application platform. The three types of networks (terrestrial, satellite, mobile) will provide coverage to all the partners thus ensuring communication between different parties allowing for data transmission and bidirectional communication between specialized and non specialized medical personnel or civilians, by means of audio-visual content transmission leading to the confrontation of accidents (chronic or emergency incidents), the provision of healthcare without the physical presence of doctors, and the reduction of human lives losses.

In order to meet the goals of the platform it is necessary the close collaboration of different countries of sough-east Mediterranean, the sharing of their expertise and the collection of their needs. The success of the platform depends strongly of the following, among others, factors: system and services integration, user acceptance, usage of the pilot platform, impact of the platform in terms of efficient health care service provision in the community, and multiple cost reduction. To this end emphasis is given to the determination of communication and the information needs of rural health care personnel, citizens and travelers in various countries of southeast Mediterranean, and to the services systems suited to these needs.

The proposed integrated broadband telematic platform takes advantage from the technological evolutions in computing, networking, and telecommunication for the provision of health care services to health care personnel, patients with chronic diseases, citizens, and travelers. The platform will gives equal opportunities to all citizens to have heath care services and familiarize them with information technology. Furthermore, the platform will enhance the effectiveness of health care, integrate standards into services, thus ensuring interoperability in the medical field,

and supports the activities for a common way of communication in Mediterranean health care policy.

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