The U-R-Safe project.

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Abstract

The U-R-Safe project (IST-2001-33352)aims at creating a mobile telemedicine care environment for the elderly, thus helping to mitigate the problems of health care provision observed in the Western societies caused by the aging population and the associated increasing costs, but also in countries where the medical coverage cannot be complete, due to geophysical constraints: deserts, low population density areas, etc.

The technological solution designed by U-R-SAFE maximizes the concepts of independent living and quality of life for the patient, in alignment with the emerging models of health care provision, while at the same time covering safety issues and alarm detection. The concept is to let a patient wear medical measuring devices, all connected via short range Wireless Personal Area Network (WPAN) to a central, portable electronic unit called Personal Base Station (PBS). Electrocardiograms and oxygen saturation will be recorded using wearable ECG sensors and portable oxygen saturation sensor, while a Shock/Fall detector will send an alarm when patient falls or pushes a button. Thanks to speech recognition algorithms, the PBS will allow the exchange of simple sentences with the patient in order to better analyze the patient condition. Information coming from the different sensors and from the shock/fall detector will be gathered. Based on these data, preliminary aided diagnosis will be performed by the PBS. Then, data will be sent to a medical call center. The feasibility of the U-R-Safe solution will be tested in two field trials taking place in Toulouse (France) and Barcelona (Spain) by mid 2003.

Keywords:

Health care; Telemedicine; Ambulatory Monitoring;

1. Introduction

The provision of health care in most of the EU countries is facing the common problems: an aging population, the burden of chronic conditions, the increase in the associated costs and the lack of efficiency of current health models to provide a satisfactory solution. Other areas have to consider incomplete medical coverage, either due to geophysical features (e.g. desert region) or to very low population density (e.g. saharian regions or sub artic areas). Experiences in the home care domain have proved to be effective but limited to a selected group of patients. Telemedicine seems to hold the promise to significantly expand the number of patients that could benefit from this new approaches, by facilitating a close patient follow-up and, additionally, detection of alarm situations.

U-R-SAFE [1] is the acronym of a two year IST [2] telemedicine project, set for "**U**niversal **R**emote Signal **A**cquisition **F**or h**E**alth". The project started in January 2001 and aims at. allowing convalescent, elderly, patients and disabled to be treated and monitored either at home (so-called indoor mode) or in open space (outdoor mode) ; therefore it will contribute to:

- **improving quality of life** (including mobility) without any security compromise,
- **controlling** the exploding **health costs**,

- providing medical monitoring in **areas lacking complete medical coverage**.

To support the transition to the new paradigm in an efficient manner, this project aims at developing a technology platform with all the appropriate hardware and software tools dealing with a global telemedicine service concept of people at home and out of their home, either for regular follow-up or for emergency situations.

The concept is to have the patient wear medical monitoring devices, all connected via short range Wireless Personal Area Network (**WPAN**) to a central, portable electronic unit called the Personal Base Station (**PBS**). The short range wireless connection will be done using the Ultra Wide Band technology. (**UWB**)

It allows to:

- Receive and pre-process the measured medical data, which have been sent from the measuring devices,
- Send the pre-processed data to the external service:

  Via the wireless public Network (GPRS, UMTS and/or GEO satellites), when the patient is out of home or

  Via the Fixed Access Network (e.g. telephony, cable, wireless), when the patient is at home.
- Communicate with simple sentences with the patient and extract information, (particularly valuable in emergency situations).
- Establish direct and hands-free communication between the patient and the external service and /or a medical doctor through the public wireless network (GPRS and UMTS), when this is required.

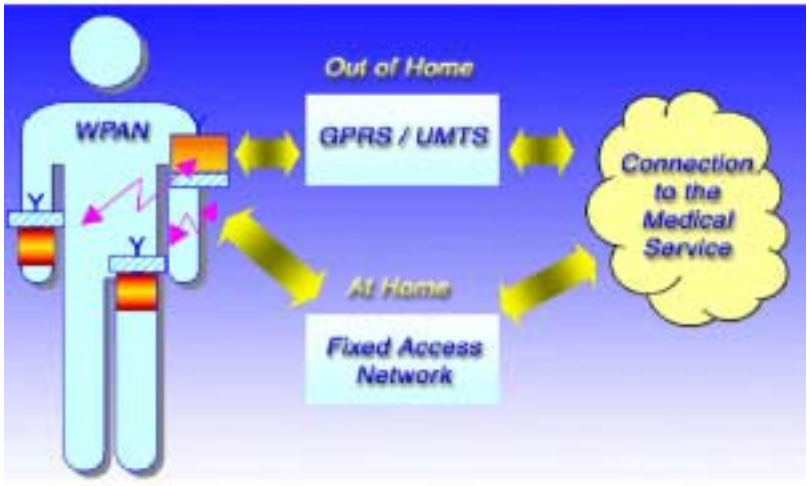

Figure 1 - General U-R-Safe concept.

It is worthy of note that at home two Wireless Networks will be interconnected. The first is the Wireless Personal Area Network (WPAN) worn by the person, connecting the different sensors to the personal base station. The second is the wireless indoor local area network (LAN), installed in the house, which allows the Personal Base Station to communicate via a Gateway to the Fixed Access Network using radio waves.
Regarding the sensors and medical data acquisition, four kinds of sensors have been chosen. First, a miniaturized ECG sensor will be integrated on the wireless platform. Second, a portable SpO2 sensor will be developed and integrated with the present technology. Moreover, a shock/fall detector will be developed and positioned on the patient body. The fourth sensor to be integrated in the platform is the speech sensor (microphone-headphone system) itself, which is considered as an important source of information: thanks to a local dialog between system and patient, information can be gathered in complement to the medical data measured by the various sensors.

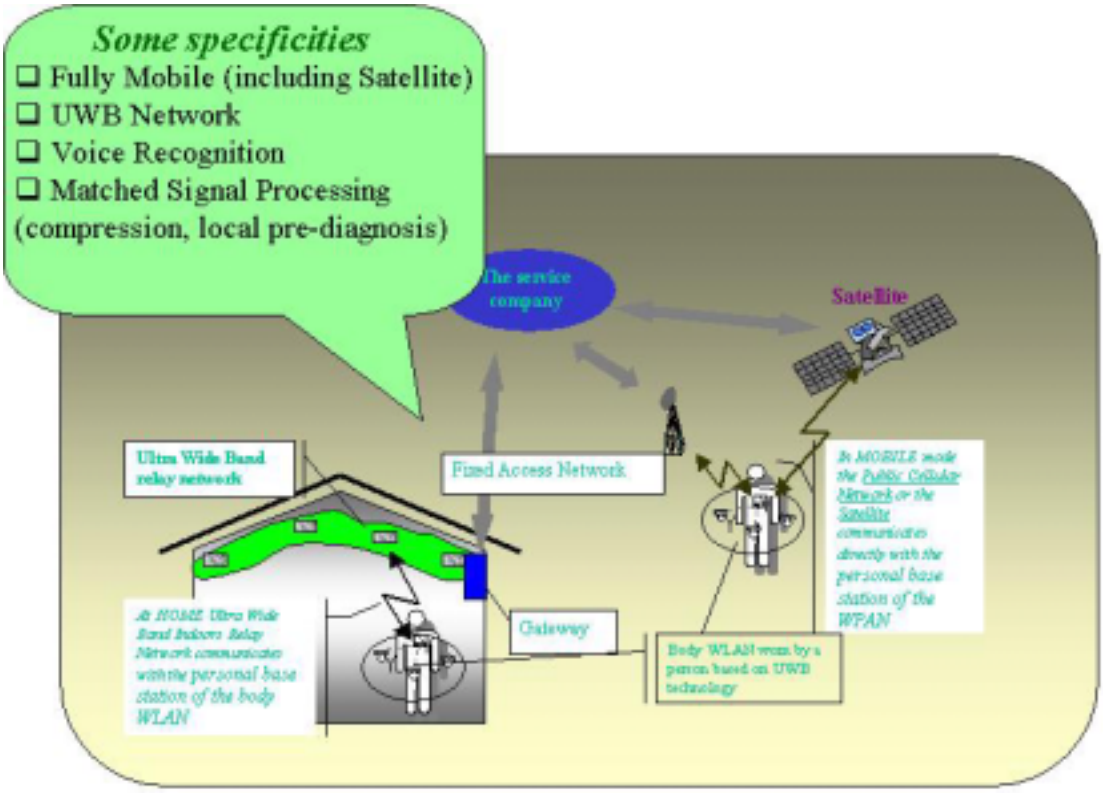

Figure 2 Overall System Architecture

Within the framework of the present project, patients suffering from either COPD (Chronic Pulmonary Obstructive Disease) or CHF (Congestive Heart Failure) or both will be considered in the URSAFE model. Two field trials will be organized within the project, sized to demonstrate the functionality of the complete system. The trial will be done in the GPRS standard. The whole platform will be completely designed to be compatible with UMTS.

2. Equipments and Methods

2.1. Sensors

Three different sensors will be implemented on the patient : an electrocardiogram (**ECG**) sensor, an oxygen (**SPO2**) measurement system and a shock/fall detector. An important point is the presence of Digital Signal Processors on-board each sensor, allowing to implement even very sophisticated signal processing methods. Among the features of these signal processing methods, let us quote the **event detection** (i.e. alarm generation), **automatic classification** (i.e. automatic diagnosis), **data compression**, etc . Signal processing algorithms will be implemented on these sensors in order to analyze medical data and to perform some pre-diagnosis. Based on the results of these analyses, the sensors will raise an alarm and begin the transmission of relevant medical data to the Personal Base Station (PBS).

The ECG sensor will measure heart and respiration rate. It will perform a continuous acquisition in the monitoring unit and transmission to the Personal Base Station (PBS) will be automatically triggered as soon as an alarm or emergency situation is detected. The connection between the ECG sensor and the monitoring unit will be a wired one and the connection between the monitoring unit and the PBS will be wireless, based on Ultra-Wide-Band (UWB) technology. The data rate will be running up to 5 kbps.

The second sensor is a SPO2 one and will measure oxygen saturation. There is no need to perform a continuous measurement in this case ; therefore, the measurement will be done every 10 minutes. In this case also, the transmission to the PBS will be done when a threshold is exceeded. The connection between the SPO2 sensor and the PBS will be wireless, based on UWB technology. The data rate related to the SPO2 will be very low, one value every 10 minutes.

The third sensor is a **shock and fall detector**: it will send alarm when the patient falls. The connection between the sensor and the PBS is a wireless UWB one. As soon as the alarm is received by the PBS, a vocal

dialog process will be initialized between the patient and his PBS. It is worthy of note that this automatic dialog implies the PBS is able to perform both speech synthesis and speech recognition.

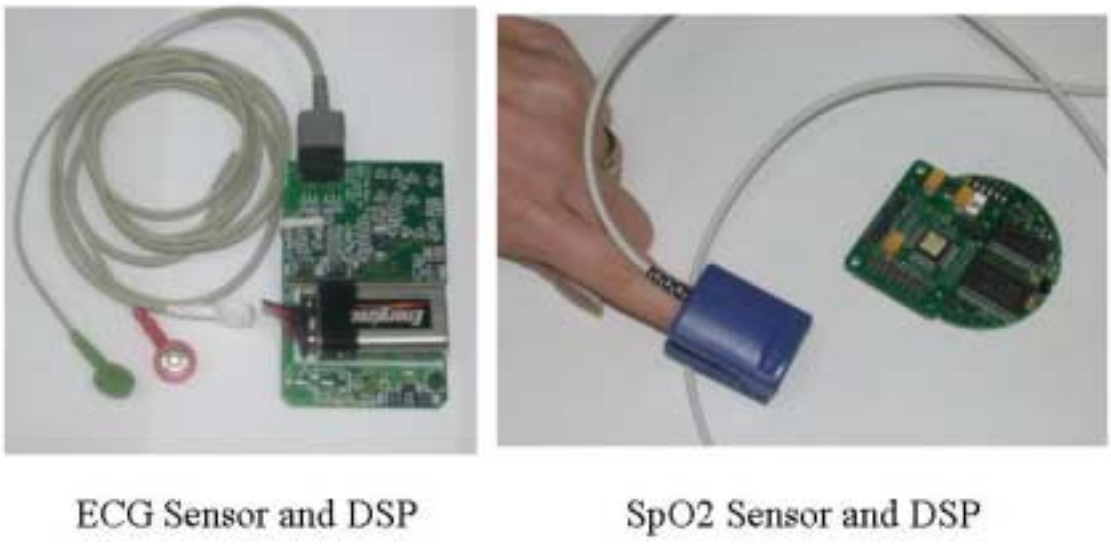

Figure 3 Examples of Sensors and their DSPs

2.2. Personal Base Station (PBS)

The personal base station (PBS) is the core of the U-R-Safe concept. This compact unit will be worn by the patient, on the belt, like a walkman (the size of this PBS will be approximately the one of a walkman, see Figure 4). The PBS aims at **receiving medical data** coming from the different sensors and relaying these informations over **home or mobile networks**. The PBS will also host a digital signal processor (DSP) in charge of the **voice recognition and synthesis modules**.

Various interfaces will be implemented in the PBS : interfaces with UWB relay network to receive data from sensors and to transmit data to the gateway in indoor mode, interfaces with GSM/GPRS device to transmit data over the mobile network in outdoor mode and interfaces with the satellite terminal in outdoor mode, out of the GSM/GPRS coverage.

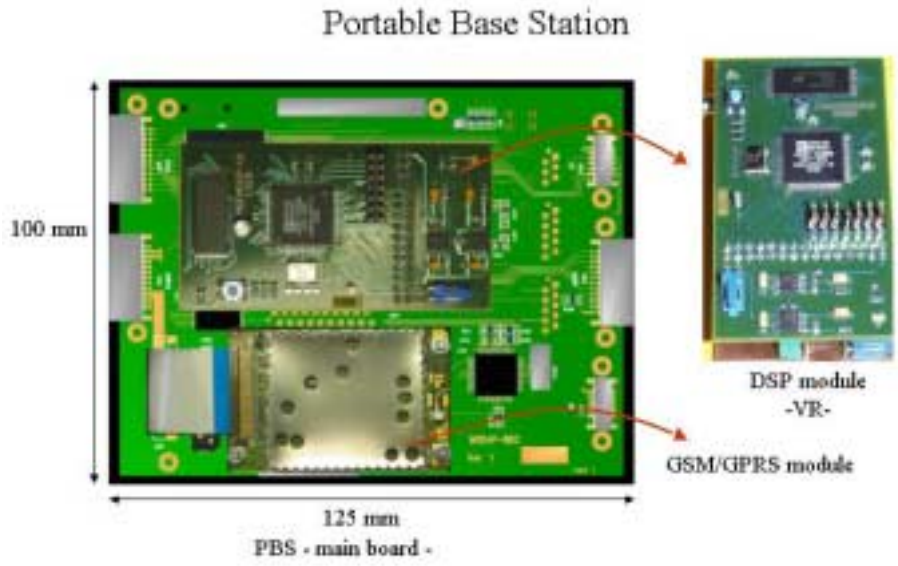

Figure 4. Portable Base Station Prototype

2.3. Home network

In the home network , an UWB node is present, allowing to relay information from the PBS to the gateway or to the satellite terminal. In the whole house of the patient, one or several UWB nodes will act as gateway access points. This home gateway relays the information in indoor mode to the services center (medical center) either over terrestrial network (PSTN) or satellite network (DVB-RCS). The gateway must detect which access network interface is up or down to route the information.

2.4. Network access

Different network accesses are forecasted in the U-R-Safe project :

- PSTN : enables transmission of information to the services center over terrestrial network in indoor mode and includes automatic dialing for transmission,
- GSM/GPRS : enable transmission of information to the services center over mobile network in outdoor mode. It will supports IP data and SMS transmission,
- GEO Satellite : enables transmission of information to the services center over satellite network in indoor mode in the case where no terrestrial connection is available or in outdoor mode in the case where the patient is out of the GSM/GPRS coverage.

2.5. Service center

The service center collects information from the different networks and manages medical data for analysis. It has to establish interconnection with the different networks (terrestrial, mobile and satellite), to include host servers for data processing. Health professionals will access these data through a specific application.

3. Field Trials

U-R-Safe field trials will take place in two different spots: one in Barcelona (Spain), the other one in Toulouse (France). The objectives of these field trials are to test the technical viability of the system, to check the medical pertinence of the concept and to perform an ergonomic evaluation of the project. Technical viability will consider the evaluation of the different sub-systems : sensors, PBS, terrestrial /mobile/satellite network transmissions, speech recognition. Medical pertinence will be given by a double measurement during the field trials thanks to other validated medical systems. Medical data coming from the U-R-Safe platform will be compared to medical data provided by some other medical systems (such as home monitoring systems or measures performed by a nurse) and validated by medical doctors. The ergonomic evaluation will be done through a questionnaire to be filled by the participating users (medical team, technicians, patients).

4. Conclusion

This IST project in telemedicine advances in the direction of new models of health care for fully nomad patient, allowing to monitor vital signals through a wide variety of networks providing a world-wide coverage of this monitoring. Some specificities of the project can be pointed out: First, the U-R-Safe basic idea is to allow the patient to be fully mobile, without any loss of security from a health care point of view. Second, the use of Ultra-Wide Band (UWB) technology in such system is new and it will be interesting to evaluate the performances of such wireless connection, specially from an ergonomic point of view. Third, the integration of voice processing ability in a telemedicine system, allowing the system to dialog with the patient is a new experience and here also, the evaluation of the patient on this U-R-Safe key point will shade a new light on patient behavior with respect to the ergonomics of this unknown environment.

5. Acknowledgments

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6. References

[1] http://ursafe.tesa.prd.fr/

[2] http://www.cordis.lu/ist/