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THE VIRTUAL BUT REAL PATIENT IN THE I.C.U.

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Abstract—**We intend to take the patient virtually from the ambulance to the I.C.U. (Intensive Care Unit), and the staff from the I.C.U. virtually to the ambulance.**

We propose a low-cost system of hybrid communication equipped with a wireless device in narrow band (radio-modem), with analysis, treatment and safe transmission of data in real time, which are received in movement and in situations out of range (due to orographic barriers), through UMTS/GPRS and a microcomputerized system (radio-cable) with Ethernet connection, for establishing transmissions via cable (Internet – virtual net). The system has shown to be valid with the information obtained, even if the Repeater Units are not situated in the best places for transmission of signals.

Key Words—**Monitorization, critical patient, transport of critical patients, real time telemetry, radiomodem, teleambulance.**

I. INTRODUCTION

Transporting of critical patients is a challenge that the moving equip must face in each situation. The medical ambulance is considered an extension of the I.C.U. of the hospital, but in fact, the medical specialists are in the I.C.U., not in the ambulance.

Quality of medical care of critical patients who are carried to a hospital by ambulance with traditional methods can be improved if we could use a monitorization system; biomedical signs of the patient can be sent to the hospital, where specialist medical staff in the I.C.U. could assess in real time the possible crisis of problems that may arise during the transporting. We have made a survey, both technical and bibliographical on the present technologies of wireless communications, and also a study of mobile telemonitorization. We have found some bibliographic references as described later [1].

They mention a system for sending electrocardiogram signals, blood pressure and other biomedical signs from an ambulance, using parameters the mobile telephony system UMTS/GSM but this method does not have alternative media that allow better autonomy in case of saturation of short distance Repeater Units or failure. Another interesting project has been done by the University Hospital of Rion in Greece [2]. In this project, they use cellular communication lines (GPRS and GSM) and a Wireless LAN (IEEE 802.11), in order to study the possibility of sending life-support signs and images of the patient in real time from the field of the accident or from the ambulance to the hospital. This project has also the same problems as the previous one, as it does not have alternative media.

We propose a low-cost system of bi-directional hybrid communication equipped with a wireless device in narrow band as a radio-modem and radio-cable connections, through a micro computerized system with Ethernet connection, in order to establish transmissions via cable (Internet – Virtual net) and an alternative by mobile telephony system.

This work is under the auspices of the Research Project "Wireless System of monitorization applied to Mobile Services in medical emergencies" (Sistema Inalámbrico de monitorización aplicada a los Servicios Móviles de Emergencias Sanitarias, SISMES). This project is financed by Research Plan I+D+I 2000-2003 of the Ministery of Science and Technology (TIC 2003 – 07953- CO2 – O2), the firm General Electric Medical System and Torrecárdenas Hospital in SAS (Andalusia Health Service).

At present this project is within a period of assessment and technical improvement regarding the addition and adaptation of new alternative systems, as the last technologies in mobile telephony (UMTS) and communication systems via satellite.

II. OBJETIVES

Our aim is to take the patient virtually from the ambulance to the I.C.U., and the staff from the I.C.U. virtually to the ambulance, through an interaction between both units and thus:

a) Assuring a better attention and care during the transporting, as the staff receives in the ambulance in real time, direct instructions from the people in charge of the I.C.U., according to the information received in the hospital.

b) Fitting the diagnostic and therapeutical resources to the characteristics of the patient when he arrives at the hospital, since all the information transmitted during the transporting is already there.

c) In this way, ailments could be treated immediately and so, we could attend earlier and faster the initial and acute complications that may arise which can risk the

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patient's life or cause its final clinical evolution.

III. Development

We have used a hybrid telemetry system (radio-Internet) which have already been tested and developed in the gypsum Karst in Sorbas (Almeria, Spain), for its application in the telemonitorization of environmental and physical parameters. Project CICYT 1FD97-1577, supplied by funds of FEDER [3], In this project the information is obtained from different sensors placed along the 1300 m. of cave where the only possible communications are through radio with narrow band (due to the orographic barriers in the land, the distance, the isolation, out of range of mobile phones, and without electrical net or connections). So, the data are taken in situ through a computerized system powered by sun energy, and sent via radio-modem to a Repeater Unit which is situated at 50 Km. In this way, the data are received in real time at University of Almeria.

With this experience we have coped with the subject of communication, first adapting it to a system of analysis, treatment and safe transmission of data in real time which is taken in a vehicle. Second, we use a transmission by mobile telephony UMTS/GPRS, as an alternative for communications out of range (orographic barriers).

A. Communication Systems

The communication system is formed as in figure 1:

a) A mobile Unit (ambulance), where the live-support signs of a critical patient are obtained, treated and sent. It is formed by a patient simulator, a medical monitor and a microcomputerized system with Ethernet connections (embedded system) which is in charge of analyze, treat and send the information in real time via radio-modem or GRPS, and establish the request for information to the medical monitor.

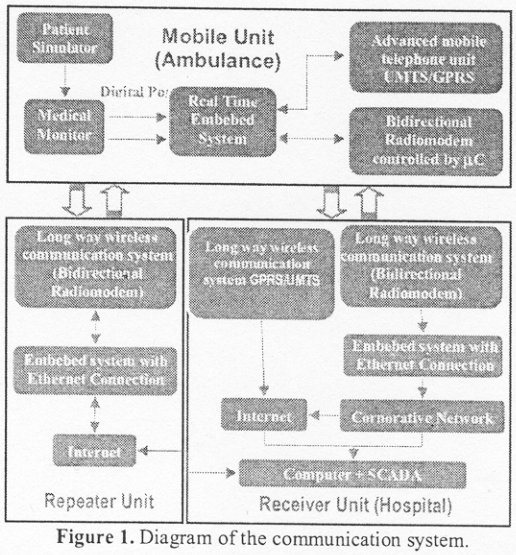


Figure 1. Diagram of the communication system.

b) A receiver Unit (situated in Torrecardenas Hospital in Almeria), where the data are received directly by radio-modem or Internet. All the information is presented on a screen by a dual/interactive application (Microsoft Windows), shown is in figure 2. So, we can see the graphic and numerical information with colored indicators of parameters which are not normal, as well as alarms, indicators of the communication quality and the channel reliability. All this information and any other we want to add, can be re-sent via radio-modem to the mobile Unit (ambulance) or to other hospitals via Internet.

c) Repeater Units, which are situated in corporation centres of Andalusian Health Service and University of Almeria. These Units are formed by a radio-modem and a microcomputerized unit with Ethernet connection

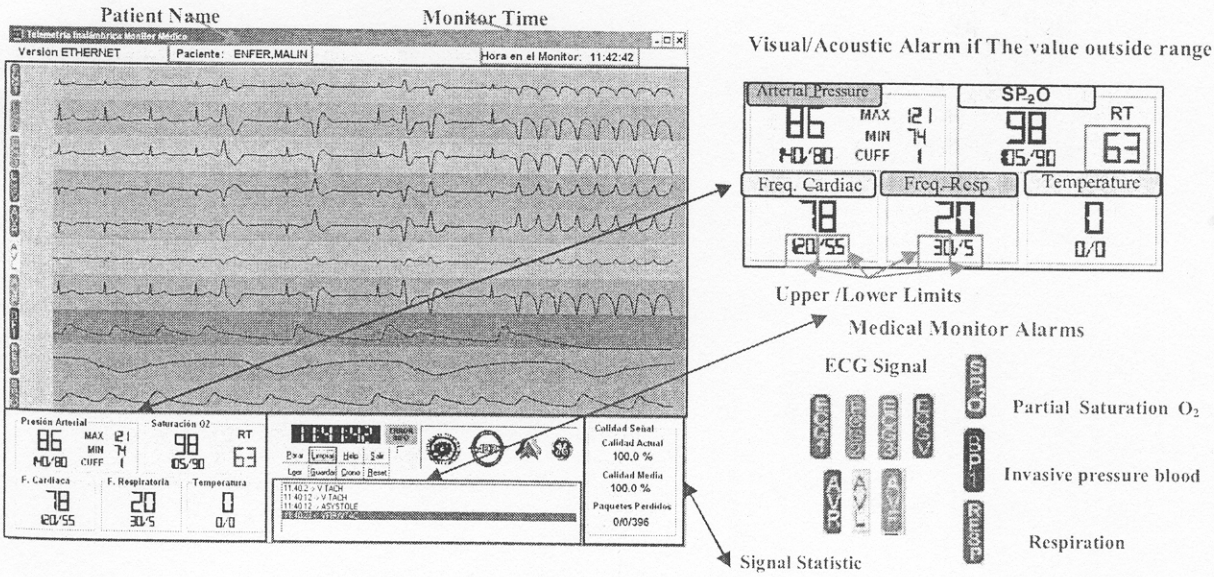


Figure 2. Interactive application to present the information and data broadcasting to Internet.

that sends the information taken with a wireless method, and re-sent to the receiver Unit via Internet.

This communication system is registered with the patent nº P200 40 1499 (in Spain) [4].

The communication system can work in three different ways (fig. 3):

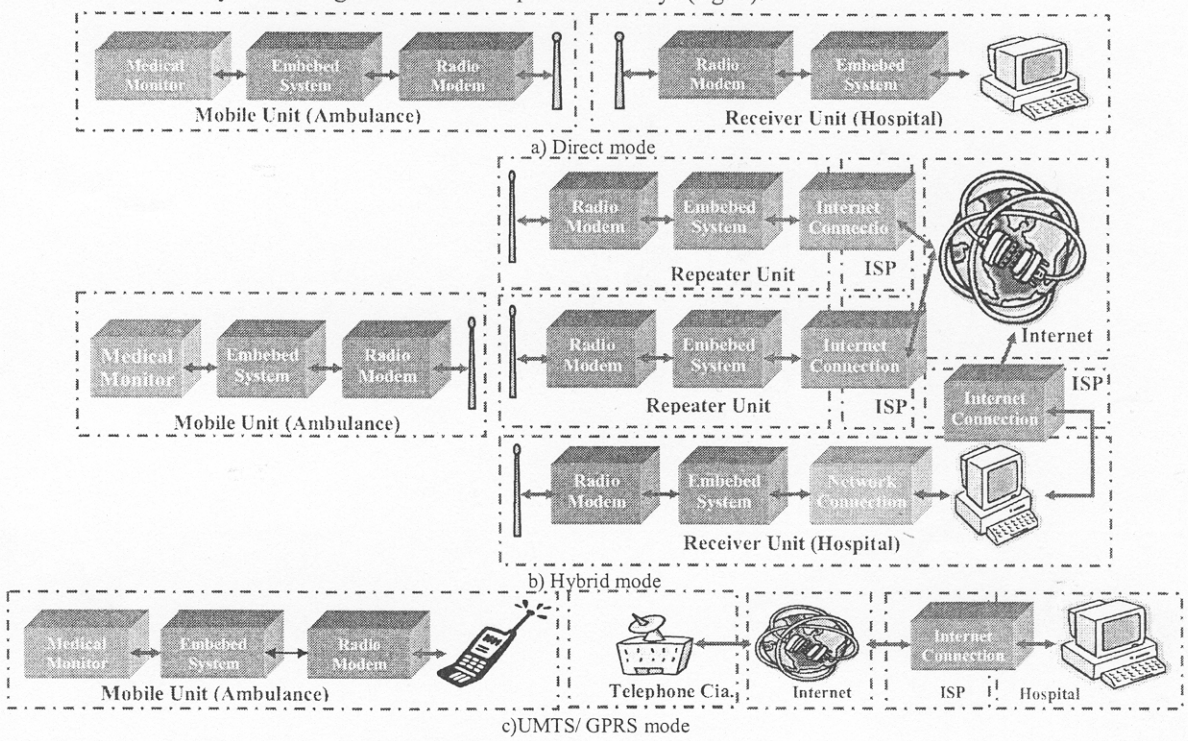


Figure 3. Operation mode of communications.

a) Direct mode. In this case, communication is set directly via radio-modem between the mobile unit and the receiver unit. This method is adequate for short distance communications between the ambulance and the hospital.

b) Hybrid mode. The data are transmitted from radio-modem to Internet using the repeater units. This method is useful in urban and extra-urban routes.

c) UMTS/GPRS mode. This method establishes communication between the Receiver Unit and the ambulance through mobile telephony. It will be used only when the previous two modes are not possible.

In the future it is planned that the GPRS mode will be completed with new systems related to mobile telephony (UMTS) and even with satellite communications.

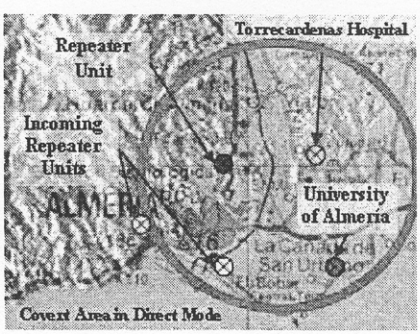


Figure 4. Localization of repeater units for the field tests.

B. *Field Tests*

We analysed three interurban and urban routes of shorter than 50 km. and less than 30 minutes, transmitting the data from patient simulator (fig. 5):

- A patient with normal situation.
- A patient suffering from heart ventrique crisis.
- A patient suffering from hypovolemic shock (bradicardia and low blood pressure).
- A patient suffering a heart breathing stop.

The data is registered on a standard monitor (see fig. 5a) and it is sent by a microcomputerized system of information treatment, and a bi-directional narrow band radio- modem, using a different number of Repeater Units (radio-Internet, radio-radio).

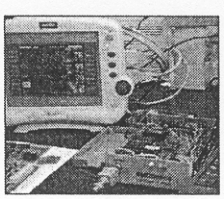
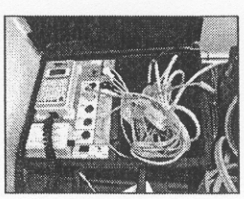
a)  b) 

Figure 5. a) Medical monitor DASH 2000 GE and communication system (radiomodem), b) Patient simulator Data Sim 6100 from Dynatech Nevada Inc.

In Torrecárdenas Hospital, the data are presented by a SCADA system through a dual/interactive reception system, and it shows both numerical (TA, FC, FR, SPO2) and graphic (EGG 12 derivations, breathing curve and SPO2 curve...) information, (see fig. 2). It also shows any event that may arise during the route which will be recorded. All of this can cause the functioning of acoustic and visual alarms which will also be recorded together with the dialogue and conversation held between the staff in the ambulance and the I.C.U. in the hospital.

This system allows recording all the information and there the possibility of reviewing it again at any other time.

IV. Results

For the validation of the system we have used a register in a data base situated both in the transmitter and the receiver, and we have done a statistic survey making a dual and matched comparison of the data obtained in real time during the whole route. Thus, we have determined the average situations, routes, time and space where the data are correct and enough for a reliable patient evaluation and treatment. And so, we have also tried to show the homogeneity of the measures, as well as the possible limitations of the study and the variables. For this purpose we have used the statistic packet SPSS, with an alfa error of 0.05, and making an hypothesis about the medical validity of the system.

For 20 routes with an average of transporting of 30 minutes and a radius of coverage of 50 km, in the direct mode, the quality of the connection has been 65% and it has been possible to assess and verify all the events proposed in the real tests. The quality of data reception in the hybrid mode tests rises up to 85%. The results in the GPRS mode are still being tested.

V. Conclusions

When seeing the collected data and taking in to consideration that the repeaters are not located in the best geographic surroundings for the signals transmission, the following conclusions have been obtained:

1) Long-distance telemetry systems of wireless medical monitors for its application in transporting critical patients by ambulance. They give an improvement of the attendance quality and the management of the process. This improvement is related both with the patient and with the staff, as well as a greater implication of more than one professional and specialist if necessary. Thus the clinical practice improves since there is a constant contact between the ambulance and the hospital.

2) These means of communication improve the adaptation of the diagnostic and therapeutically resources to the characteristics of the patient when he arrives to the hospital, and the Urgency Staff – I.C.U., Radiology, Surgical- and all the necessary means for a fast and better treatment and care are already prepared and under alert.

3) At the same time, this communication system has an influence on the quality of life of the patient –if he does not die-, because the most efficient therapeutical resources are immediately applied and agreed, thus obtaining the best response and the least sequels.

4) They also involve an economic benefit because an only doctor is the responsible in the hospital of reference and he supervises different cases simultaneously. Besides, the doctor in the ambulance can be substituted by some staff with the appropriate training and formation, depending on the cases [5-6].

5) From the results obtained we can deduce that the system of monitoring and long-distance transmission telemetry is suitable for this aim and it is also viable; with few economic resources we could install a highly efficient net of communication Units with intraurban and interurban range.

Now we are working out and designing the improvement of the quality of the signals by increasing the number of Repeater Units, so as to get the best values in order to be able to cope with all the possible roads within a radius of 50 kms from Torrecardenas Hospital.

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