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The Spanish Ministry of Defence (MOD) Telemedicine System

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1. Introduction

Telemedicine is an important tool for the medical deployments of the International Missions. The Medical Treatment Facilities (MTFs) and the medical evacuation means (terrestrial and rotatory wing ambulances) are the main components of the military medical evacuation chain in the Operational Areas. The right diagnosis and the adequate treatment for casualties (battle and non battle injured) are key points which together with a rapid evacuation timing assure a high quality medical support on the field.

Tactical and strategical medical evacuations (MEDEVAC) are carried out to move the patients to the right places to be treated. The Role 3 units (campaign hospital) have many different medical specialists, but these units do not have the complete crew of the Role 4 (Hospitals in national territories).

The Telemedicine systems provides the capability to connect on real time the Role 4 units with their lower ones, but nowadays the whole MTFs have to be interconnected to support the medical deployment and to get medical information from the field. For these reasons the different MoDs are working to improve their Telemedicine systems and to be able to interconnect them.

The Military Medical Communications and Information Systems of NATO countries are being developed under the idea to interconnect with a common system, the MEDICS, which is the NATO common platform to obtain, to transmit and to store the medical information on the field.

The information and communication technologies are going to be applied in all echelons of the medical deployments. In this document is described the state of the Spanish Military Medical Systems and some of the projects which are being carried out to improve the system.

The Spanish MOD is actually carrying out several outland humanitarian missions all over the world. Troops are deployed in Afghanistan, the Lebanon…., almost all the missions are operating in politically unstable countries where skirmishes and terrorist attacks are frequent, and in hostile and hard-to-reach areas where environmental and hygienic conditions may be a potential source of disease. Providing the troops with the adequate medical support is hence of paramount importance. Unfortunately this is not an easy task, since medical people deployed in the operation area need assessment very often.

Consequently it is imperative to provide the medical people in the operation area with a decision support system to improve and speed up the quality of diagnostics and to fulfill the main goals of a medical mission, namely, the prevention of disease, treatment of sick and injured patients, and patient evacuation and hospitalization. Governments are making a great effort to equip their troops with telemedicine systems relying on the latest information and communication technologies. However, these systems must be able to operate together in a common framework; for this reason NATO (North Atlantic Treaty Organization) is dealing with integration and convergence of all the national standards into a new unique telemedicine system common to all member states.

Figure 1 shows the big picture of medical care principles and campaign logistics. The evacuation process goes through four steps: ROLE1 through ROLE4. Roles 1 through 3 are situated in the deployment area, whereas Role 4 is in the home or host country.

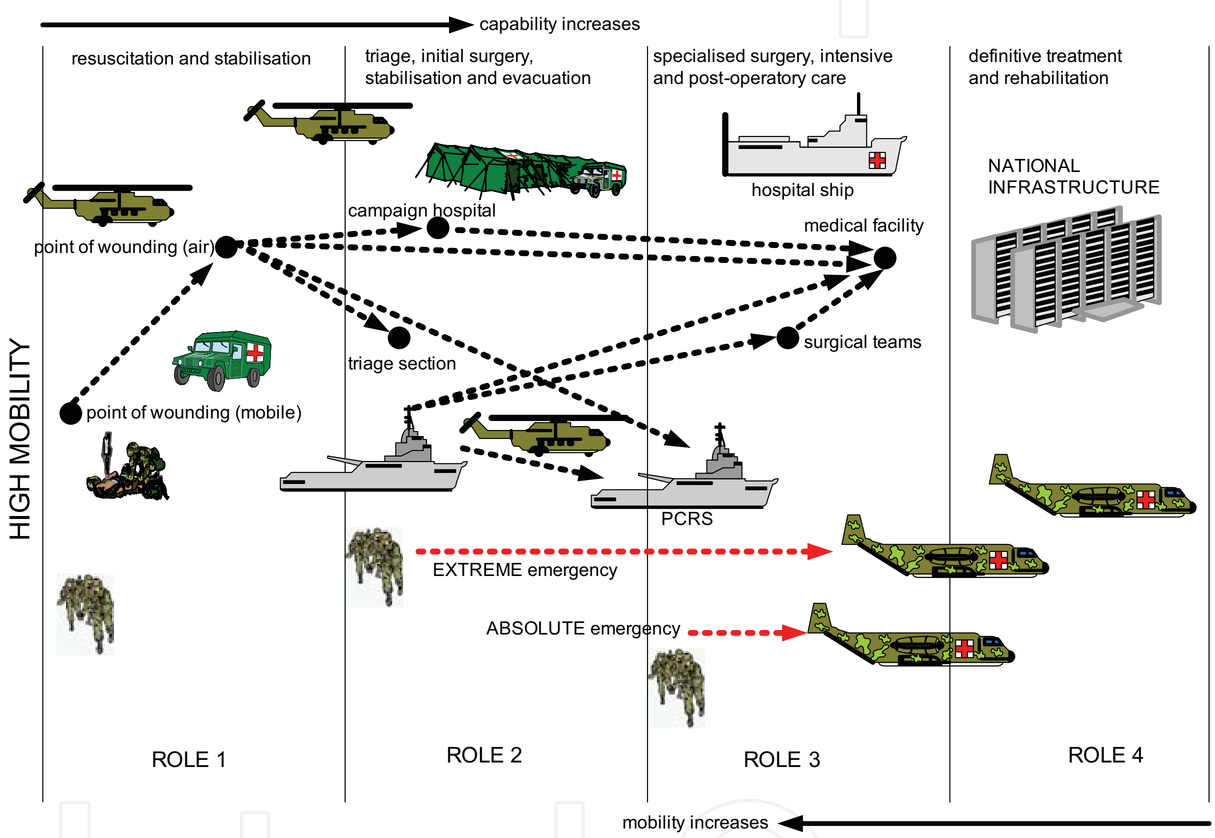

Fig. 1. Campaign Logistics and Evacuation Process.

Hence medical care is provided progressively ranging from first aid (ROLE 1) to definitive care and rehabilitation (ROLE 4), as the patient is evacuated rearward in the medical support chain. Tasks, structure and equipments of the medical teams involved at the different levels of the evacuation chain are very different. At ROLE 1 the first aid is provided by highly mobile medical teams whose main goal is immediate lifesaving, patient resuscitation and stabilization of the vital functions. Subsequently, patients are evacuated to a triage section where they are classified according to the severity of their clinical status. If they deserve intensive cares or specialized surgery already at an early stage, they are immediately evacuated to the upper levels of the evacuation chain. Otherwise, cares are provided by the campaign hospital.

The infrastructure at ROLE 2 Light Maneuver level allows damage control surgery, whereas specialized surgery may be only performed at ROLE 3 level.

The evacuation process is extremely complex since it may require the cooperation and coordination among land, sea and air forces, and the units deployed in the MTFs (Medical Treatment Facilities) at different roles. In addition, medical, transportation and rescue units involved in the process may not only belong to different DOBs (Deployed Operating Bases), but also to different States of the Allied Forces that are carrying out the mission. This further complicates the evacuation process; also, the evacuation must comply with the timelines established by AJP 4.10 NATO Medical Support Doctrine. According to this document, the patient must be provided with advanced trauma care within one hour from the first aid, with damage control surgery within two hours, and with primary surgery within four hours from the first aid.

To accomplish with such strict requirements the use of the modern information and communication technologies is compulsory. It is possible to apply to each role one or more technologies to support and improve communication and information flow between all the agents implied in the rescue and evacuation process. Figure 2 depicts the technological scenario that characterizes the different levels of the medical evacuation chain.

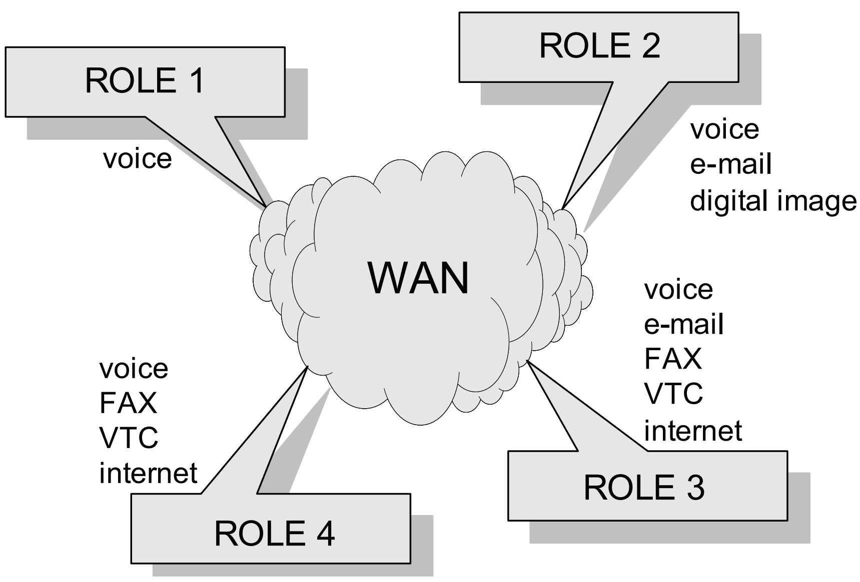

Fig. 2. Teleconsulting Capabilities.

Each role has different technological capabilities that increase with the complexity of the task that has to be carried out. The interaction among roles is guaranteed by a Wide Area Network (WAN). The spectrum of adopted technologies is broad and ranges from dedicated two-way voice channel (telephone or radio), fax and e-mail, to mail systems with support for large attachments (motion picture MPEG, digital pathology JPEG, or digital radiography DICOMM), real-time videoconferencing systems (VTCs) and distributed web-based platforms with multimedia and streaming video support.

The Spanish Government is currently developing, through projects SISANDEF (Spanish MEDICS) and SALVANY (RIS-PACS) its own telemedicine platform covering roles 3 and 4. Project deadline is 2012, but the system at role 3 level will be operating in 2011. Hence one of the goals of this paper is to define system requirements and specifications at the lower levels of the evacuation chain, namely roles 1 and 2. The system must be suitable to operate in critical scenarios and must comply with the highly mobility requirement of role 1 and 2 levels. Consequently it must be robust, low power-consuming, light and secure.

Electronic devices and communications networks have increased their presence in the latest years in almost all aspects of life, even in the medical field. On this way, the medical instruments are being useful tools for the personal health care to diagnose and to treat patients at hospitals or ambulatories centres. Telemedicine is the application of information and communication technologies to the medical diagnostics and therapies. The purpose is to allow the diagnostic of patients at the distance by means of Teleconsultations. The Spanish Ministry of Defence Telemedicine System (SMDTS) has an extended network to provide medical supports for the troops deployed outside the national territory.

Telemedicine systems have to implement tools between the network points that allow the personal communication and the transmission of patient's explorations results. In addition, it should be possible the record of all the material produced during the teleconsultations (videos, conversations, images, signals…). The Spanish Ministry of Defence Telemedicine System fulfils with a lot of features that make the system to be a worldwide leading reference in this field. However, it is wanted to increase the system effectiveness in relation with Telemonitoring capacities, that is, the transmission and storage of biomedical signals.

Telemonitoring is a key important aspect in a telemedicine system. It consists on the transmission and storage of biological signals, images or videos from the explorations. That information can be attached into the electronic health recorder (EHR) of each patient to be accessed lately, for medical diagnostics or studies. With this aim, it is necessary the creation of applications that collect data from the monitoring devices and transmit them to a central database.

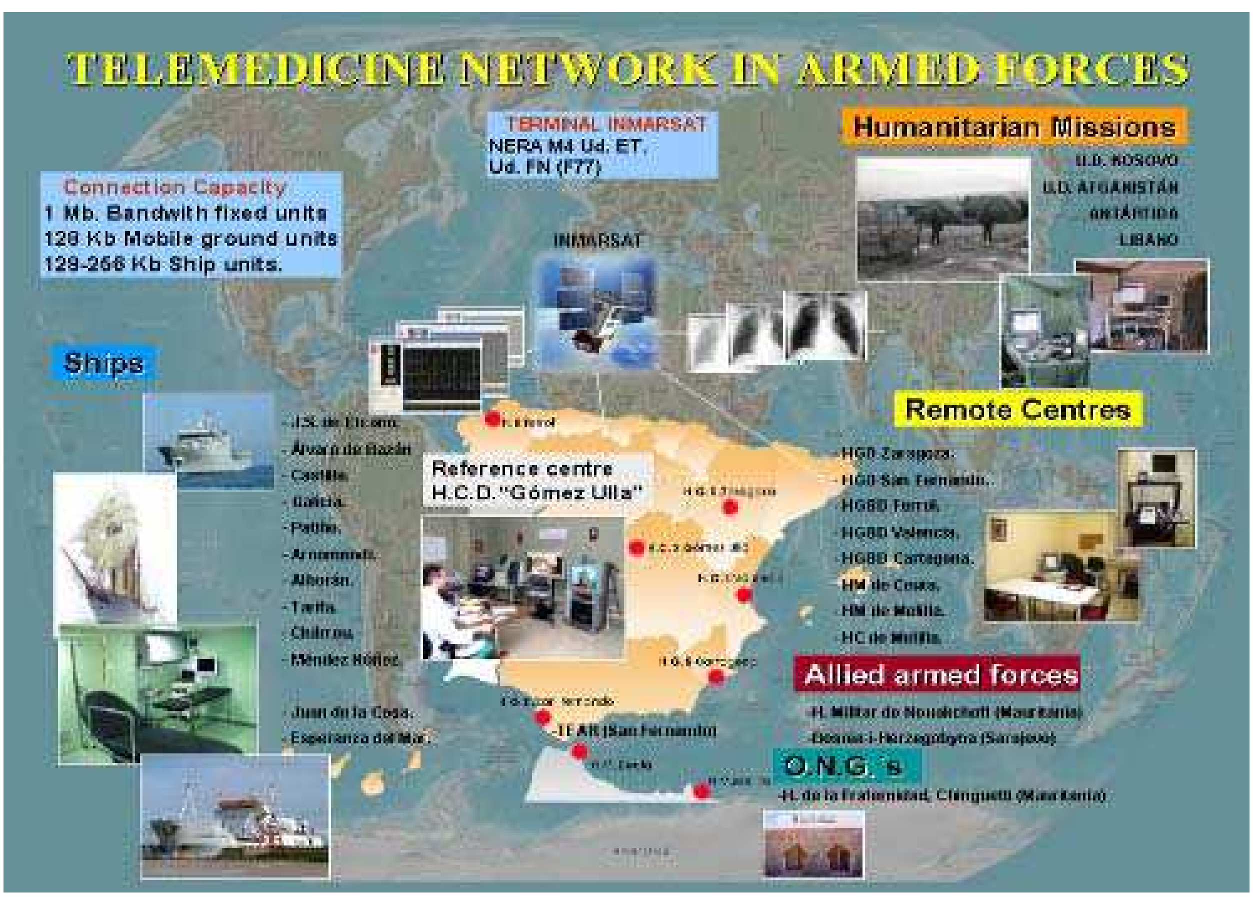

Fig. 3. A view of the SMDTS.

The scheme of the system consists on a reference centre (the CHD in Madrid, with back-up centre in the Military Hospital in Zaragoza), that provides the medical support to the rest of the points in the network, the remote centres. Those remote points are care units placed in ships, international missions or other military centres. Each one of these points has a telemedicine station used to communicate with the reference centre for advanced medical consultations.
The system uses an intranet for the communication, this is, a private and dedicated circuit that provides privacy, confidentiality and security to the connections. Depending on the emplacement, the bandwidth available for the consultations varies and it has influence in the quality of the communication and in the video and data transmission. For example, ships and not fixed emplacement connect by satellital modems with low bandwidth (up to 256 kbits/seg). The Spanish MoD has a satellital network that is used for medical purposes.

2. Equipments

The remote centres have a medical monitoring solution with a lot of tools to carry out a great variety of explorations on patients. They are fitted with the following equipment:
- Videoconference Camera.
- TV monitors.
- Personal Computer.
- X-ray picture scanner.
- Vital Signs monitor.
- Electrocardiography recorder.
- Router.
- High resolution external exploration camera.
- Ultrasound explorer machine.

As several of the TM stations are located in mobile units, the devices are assembled in a rugged box that makes easier the transportation and the storage of the equipments as well as acting like a protection container.
The reference centre must work as the link between the doctors in the hospital and the patients in the remote centres so that the devices installed in the HCD are oriented to reception, visualization, diagnostic and storage of the consultations. These are the devices and tools implemented:
- Videoconference camera.
- Plasma Monitors.
- DVD recorder.
- Ultra High resolution monitor for radiological images.
- Personal Computers.
- Email consultation inbox.
- LAN access – IP serial converter (reception of Telemonitoring signals).
- Surgical assistant tool.

With these devices it is possible:
- Audiovisual conference at real time.
- Visual Explorations: general explorations, endoscopies, teledermatology, teleotolaryngology…
- Diagnostic imaging (as fixed as dynamic): radiology, ultrasound explorations, Computerized tomography (TC), MRIs, PET-CT ...

Fig. 4. Remote centres telemedicine equipments.

Fig. 5. The Spanish Military Telemedicine Reference Centre.

- Telemonitoring of Vital Signs: 12 leads Electrocardiogram, Heartbeat, Blood pressure, oxygen saturation…
- Consultations by email.
- Surgical indications for the remote centre with the virtual assistant board.
- Recording of consultations.

3. Operative mode

The system allows two types of consultations:

- ***"Asynchronous" or "Storage and forward"*:** The data are received and storage to be analyzed and diagnosed later. The doctors analyze the content and the response is sent back to the applicant. It is used to attend not urgent consultations. This service has a response time up to 24 hours.
- ***"Synchronous" or "Real time"*:** The remote centres establish a videoconference with the HCD. The specialists are requested to come to the Telemedicine Service and to attend the consultation. During the connection, the data are sent to the centre simultaneously.

The following table shows a resume of the type of teleconsultations:

System	Priority
Videoconference + data	Urgent/planned
Radio / phone	Urgent/planned
Email	Not at real time

4. Teleconsultation procedure

The reference centre is one of the points which are always connected to the intranet, waiting for incoming calls. When a remote centre wants to come into the net the router must link up the communication that allows the station works as a point of the system. When the consultations only require videoconference, the available bandwidth is used completely, but, in the case that the consultations required the digital transmission of medical data (X-ray, telemonitoring of vital signs) it is reserved a minimal bandwidth for its transmission.

Once the station has connection to the intranet, the different operations can be performed. Sometimes is not always necessary to establish a call for the consultations, and the e-mail results enough to send questions or to attach data as pictures or videos. For example, the X-ray images are sent to the reference centre before the consultation is carried out, with a PC application that collects the image and then send it to one inbox in the HCD. In the case of the Ultrasound or visual explorations, the way to send the video is connecting these equipments to the external input of the videoconference camera. This device digitalizes the analogue signals and it sends these ones as images of the videoconference. The videoconference is recorded in the HCD with the DVD recorder, to have a register of all the consultations.

When explorations require Vital Signs monitoring and ECG signals, it is necessary to activate the transmission a perfect synchronization between the remote station and the HCD. Otherwise, the application collapses and the reception of data do not work correctly. For this reason these explorations only can be carried out on live, when a call is activated to have communication between the two points. The application that collects data from the electromedical devices is a customization because the SV monitor installed does not have a

computer application, and the ECG computer tool given out by the manufacturer is only for local use, not to transmit the signals. The devices are connected by a com port to the computer, and in order to transmit the signals what is done is to make virtual the input com ports and to duplicate each of them. Then, the local application connects to one of the dual port, and the other port is used to collect the data and to encapsulate the information into IP packets. These IP packets are sent to the reference centre and the LAN access IP-serial converter extracts the data from the packets, and it puts them in its output com ports. The PC in the reference centre connects to this output com ports which simulate the acquisition equipments on the destiny, and the application reads the signal from these ports.
The Spanish MoD Medical Deployments are demanding new features to the Telemedicine System to achieve higher performance on the teleconsultations. The current system presents limited capacities and capabilities to transmit and storage efficiently biomedical signals. Nevertheless, the system should be able to transmit and to record the monitored information automatically in a database together with the patient's electronic health records. On this way, the results can be consulted lately or they can be used to perform data mining to extract statistical information. That is because it is necessary the creation of one application capable to acquire the signals from the monitoring devices, to visualize on graphical interfaces and to storage these in a central database (repository). This is called Telemonitoring, and it would add complete functionality to the SMDTS on creating an electronic register of all the consultations.
On a different aspect, the communications channels are a key factor in the Telemedicine Systems. The SMDTS counts with a wide variety of media channels through them the remote centres can connect with the HCD, i.e. satellital connections, military intranet, and internet connection with fixed IP address. To enhance the privacy and security of the system, the Telemedicine Network can be framed under a VPN that would protect the traffic of its applications.

5. Network traffic management

When it is necessary exchange information through a network, we have to take in consideration the security and the priority of the data. The router is the element that is in charge of the network access and the packet exchange. The Telemedicine network will be based in different remote points working as Local Area Network (LAN) but connecting through a WAN (Wide Area Network).
Creating a VPN (Virtual Private Network) to work across the remote points and the reference centre (the central database), the system would guarantee the privacy, the authenticity and the integrity of the data. The routers provide the possibility to create a tunnel link between two routers. AES encryption support has been introduced. The data encryption is carry out over the router input/output packets, so all the communications (videoconference and PC applications) will be encapsulated under the same SA (Software Application). The remote point's router has to connect to the VPN server that will be installed in the HCD to access into the Telemedicine VPN (TVPN). The same VPN server can attend several VPN clients, so that, several remote points can access within the Telemedicine Intranet at the same time.
The remote centre equipments with communication capacities (this is the videoconference camera and the PC) has one IP fixed address. These elements are connected to the router to exchange data with other points in the net. The routers provide traffic management tools to control the workflow. In example, data packets of VS (Vital Signs) and ECG

(Electrocardiography) applications have higher priority than others frames because those applications need a constant data flow to run correctly. To organize the applications traffic, it is necessary to define some rules by which the router will manage the packet streams (QoS). However, the IPsec encryption has problems to provide QoS correctly, because the TCP/UDP header packet information is encrypted before that the QoS acts over the frame. The command "QoS pre-classify" allows to the IOS to create a temporary copy of a packet in memory to be used for classification so that QoS actions can be performed on the final packet after encapsulation and/or encryption.

6. Standardizing the Telemonitoring System - ISO/IEEE 11073

The problem developing Telemonitoring applications are mainly the communications with the medical devices, and to extract, to sent and to store the medical data. The devices exchange data using proprietary protocols with communication paradigm and format defined by each manufacturer. This inconvenient makes complicated the creation of applications to manage the devices and the replacement and updating of devices in the systems.

The International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) proposed the ISO/IEEE 11073 Point of Care Medical Device Communication (PoCMDC) as a set of standards which purpose is to standardize the communications of medical devices supporting interoperability, transparency, plug-and-play, and easy of use and configuration.

ISO/IEEE 11073 standards enable communication between medical devices and external computer systems. The primary goals are to:

- Provide real-time plug-and-play interoperability for patient-connected medical devices.
- Facilitate the efficient exchange of vital signs and medical device data, acquired at the point-of-care, in all health care environments

In the standard, the interoperability at local level is solved with a central element to which all devices are connected, the *gateway.* This element acts as a main connection and it controls the interaction with the different medical devices, creating a patient network. Besides, this gateway has to connect the patient network with the Telemonitoring server to transmit the signals.

With the purpose of improving the medical support that the Spanish Ministry of Defence Medical Corp (SMDMC) provides to the personnel deployed on international missions, the Spanish Central Hospital of Defence "Gomez Ulla" started the Spanish Ministry of Defence Telemedicine Unit (SMDTU) activities on 1996. The system was designed in such a way that the CHD served as the core centre of the network (the reference centre) where all medical specialities are supported. When the medical personnel deployed (the remote points) requested advanced medical support, they could connect to the reference centre.

First communications in the early services were based on calls made by means of analogue videophones which allowed the establishment of calls along with video transmission using the switched circuit network. The development of data packet networks and the proliferation of communication tools for these networks permitted to include medical and communication devices which accomplished more variety, accuracy and reliable diagnostics. The wide variety of available features to diagnose, have consolidated the service as a new diagnostic tool by means of the specialists can give out better support to the missions. However, new needs are required to the system in order to achieve much more performance and easiness of Telemonitoring from the remote centres.

Telemonitoring seems to have a great functionality as a tool for remote medical diagnostics, avoiding the transportation of patients from remote centres. It implies to save a big amount of money because of medical transportation. Besides, telemonitoring could be applied for home-care in patients with scheduled consultations at care centres. But what is important to extend these kinds of medical tools, is the standardization of the medical devices and their communication protocols. For this purpose there is a working group into the IEEE organization developing the standard IEEE 11073, which concerns to the interoperability and data exchange between medical devices.

Another aspect to take in account is the communication link. The system is used in the military environment and the medical field; both require confidentiality and security during the information exchange. A private network provides these features. Virtual Private Networks (VPN) allow the establishment of private connections over the public networks (Internet, ATM) reducing the cost of the communications and holding similar capacities.

7. Projects on development:

7.1 The tactical telemedicine system:

This paper describes also the work-in-progress carried out by the Central Hospital of Defence "Gomez Ulla" toward the design of new devices for the military telemedicine system that is intended to give support to the medical people in the deployments. Previous studies have demonstrated that a decision support system is a major concern since 50% of the diagnostics performed in the operation area need reassurance. Consequently, such a system will help to improve considerably the quality of the diagnostics and to reduce the management and evacuations costs.

Following the NATO inputs the Spanish Ministry of Defence is developing a telemedicine system to be interoperable with this three main concepts:

1. Patient tracking:
   A system that has to be able to track the casualties into the evacuation chain, following their way along the Medical Treatment Facilities (MTFs) deployed into the areas of operation.
2. Patient regulating:
   With the information acquired from every patient tracing, the Medical Advisors have to decide where to redirect the casualties (to the right MTF considering the casualties classification and the level of operativeness of these units).
3. Disease surveillance:
   The system has to give epidemiological information about the difference diseases and kind of wounds which are detected into the operational area.

With this aim a system that accomplishes these features is under development. Some aspects of this project are going to be described on this document:

The hardware/software platform we describe will integrate the services and functionalities available from the existing e-health infrastructure and provide the medical people with a decision support system in remote and hard-to-reach areas. The specific aims are:

1. To design and implement a low-power Military Medical Information Carrier (MMMIC). A MMIC is a device that is intended to hold personal medical information that may be accessed by a medic through a specialized terminal, namely a MMMDA (Military Medical Digital Assistant).
2. To provide the MMDA with the software capability to interact with the MMIC and its local database of patient information. It is anticipated that our design will contribute to

improve the efficiency in the use of communication resources in telemedicine. In a bigger scope, this project should enhance our understanding of the limitations that hardware and software impose on the operation in critical scenarios.

System Overview

Our main goal is to design a complete network hierarchy of cooperating wireless, ad-hoc and hand-held devices for military telemedicine use at role 1, role 2 (light maneuver and enhanced) and role 3 levels of the evacuation chain. The network will integrate the services and functionalities available from the existing e-health infrastructure and provide the medical people with a decision support system in remote and hard-to-reach areas. Such network is formed by three classes of devices:

1. Military Personal Tag (MPT).
2. Military Medical Information Carriers (MMICs), and
3. Military Medical Digital Assistants (MMDAs).

These devices cooperate with a wireless ad-hoc network. A mobile, wireless, ad-hoc network is a collection of mobile nodes that are dynamically and arbitrarily located in a certain region. The dynamic character of the nodes implies that the interconnections among them, the network actual topology, may change with time frequently.

The main feature of these networks is that routing is performed by the nodes in the absence of a fixed infrastructure. The nodes act as routers which discover and maintain routes to other nodes in the network. The network itself emerges as the result of a collective effort of self-configuration of the nodes deployed.

There are several strategies to solve the routing problem in these networks. We will be specifically concerned with source-initiated, on-demand routing. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible or the route is no longer desired.

Since mobile nodes are required to probe their surroundings trying to find routing nodes, and nodes are essentially hand-held terminals operated with batteries, power consumption is of paramount importance in the operation of these networks.

Ad-hoc networks have been proposed in many communications and remote-sensing settings. Among the emerging research topics, sensor database, sensor information storage and sensor network programming deserve particular attention.

System Architecture

A MMIC is a battery-operated device that is intended to replace "dog tags" and to hold medical information that may be accessed by a physician through a specialized terminal, namely a MMDA or a pocket PC through a RF (Radio Frequency) channel. The use of a wireless instead of a hardwired link (such as universal serial bus-USB or secure digital-SD) is motivated by the following reasons:

1. A wireless link is not affected by the operating conditions. In fact, external agents such as sweat, water, sand and mud may deteriorate a physical, plug-based, connection;
2. A physical connector increases the ruggerisation costs and complicates package and shield design;

3. The use of communication ports such as USB or SD implies the integration in the system of a controller unit with its own firmware and software. This, in turn, increases system complexity and requires more memory leading to increased costs and power consumption.

On the other hand, a wireless link is intrinsically unsafe; although this problem may be tackled by reducing MMIC emission radius to a few meters. This, in turn, helps to reduce power consumption as well.

The MMIC must have the following features:

1. A baseband processor to run the communication stack;
2. A RF module to implement wireless communications in the desired band;
3. A visual external interface with patient and communication status information.

The external interface is implemented by a set of five LEDs (Light Emitting Diodes) placed on both sides of the MMIC package. The diodes implement a color code whose meaning is represented in Table 1.

Diode	**Meaning**
Blue (flashing)	MMDA in the MMIC range
Blue (fixed)	Link established between MMIC and MMDA
Red	Patient status: critical
Yellow	Patient status: severe
Green	Patient status: soft
White	Patient status: recovered

Table 1. MMIC Visual Interface Color Code.

The patient status diodes may be adequately programmed by the physician by means of the MMDA, once a link with the patient has been established.

The MMIC must be capable to operate at very low voltages to minimize power consumption.

The MMIC operates on the patient side and stores all its clinical information in a local non-volatile memory. In addition, the device must have the capability to communicate with other MMICs or with MMDAs through a RF channel. This capability is implemented both in hardware and in software.

Device drivers implement the glue layer between the physical interface and the upper levels. They are a set of assembly language routines that control directly the hardware resources. These routines are then invoked by the system library and interrupt management routines to implement complex functions. This approach guarantees independence between hardware and software and hence full software compatibility between the protocol stack and processor future versions.

The MMDA operates on the medic side.

The major design concerns in the development of the system are:

1. **Technology**. Since the goal is to implement an analogue RF and digital baseband processor into a single chip, there exist severe restrictions on the fabrication process to use. This, in fact, limits the choice to expensive analogue and mixed-signal processes that must also provide the designer with the capability to embed RAM and ROM memories on chip.
2. **Area occupation**. The RF transceiver must be almost completely integrated in a single chip reducing as much as possible the number of external components to reduce the

overall fabrication costs. Nevertheless, integrated analogue components such as capacitors and inductors occupies large areas subtracting die area to the digital baseband, so chip floorplanning must be carefully carried out.

3. **Packaging**. Also packaging is a major concern in the design. In fact, medical information must be stored in a non-volatile memory, namely a flash memory. The use of a flash memory guarantees high storage densities, speed and versatility, since this kind of memory may be programmed and erased on-the-fly. Nevertheless, for technological reasons, flash memory may not be implemented on the same silicon substrate that hosts baseband processor and RF module.
4. **Power consumption**. The device must be battery-operated, so power consumption and battery lifetime are major design concerns. This implies that a trade-off must be found among chip-core operating voltage, transmission and reception bandwidths, device operating frequency, and device operating range.
5. **Modulation scheme**. The modulation scheme of the RF front-end is a crucial part of the design since it determines hardware complexity, power efficiency and transceiver bandwidth. Complex modulation schemes may also affect digital hardware and protocol stack.

Communication architecture and medium access control

MMICs and MMDAs are wireless devices, so information interchange between them relies on a wireless communication link. Prior to discussing all the issues related to MMIC PHY (Physical) and MAC (Medium Access Control) layers and to communication and network architecture it is better to review briefly the main industrial standards for WPAN (Wireless Personal Area Network) and WLAN (Wireless Local Area Network). The main difference between a WLAN and a WPAN is, basically, the range of a wireless node. For a WPAN the transmitting range is up to 10 meters with transmission powers ranging from 1 to 100mW. For a WLAN the transmitting range is up to 100 meters with a transmission power between 100 and 300mW.

In this scenario we need a network with the following characteristics:

1. Support for ad-hoc and hand-held wireless devices;
2. High mobility and rapid deployment, and hence little or no infrastructure;
3. Low power consumption;
4. Ease of scalability;
5. Sufficient data rate to support the application and information interchange;
6. Support for the existing e-health infrastructure.

Figure 6 depicts the proposed network architecture at role 2 level.

The proposed architecture is hence a network hierarchy in which several ad-hoc and hand-held wireless devices cooperate. The lowest hierarchy level is the WPAN formed by MMIC devices that operate with the IEEE 802.15.4 protocol stack. The upper level is the WLAN formed by MMDA devices that relies both on IEEE 802.15.4 to interact with MMICs and on IEEE 802.11a/g to implement the WLAN and interact with a gateway wireless access point.

7.2 Tele Assistant (diagnostic and surgical procedures) System.

The Telemedicine Service has a system that is able to point or to draw over the dynamic images of the Video teleconference and send them back to the Remote Centre connected on real time.

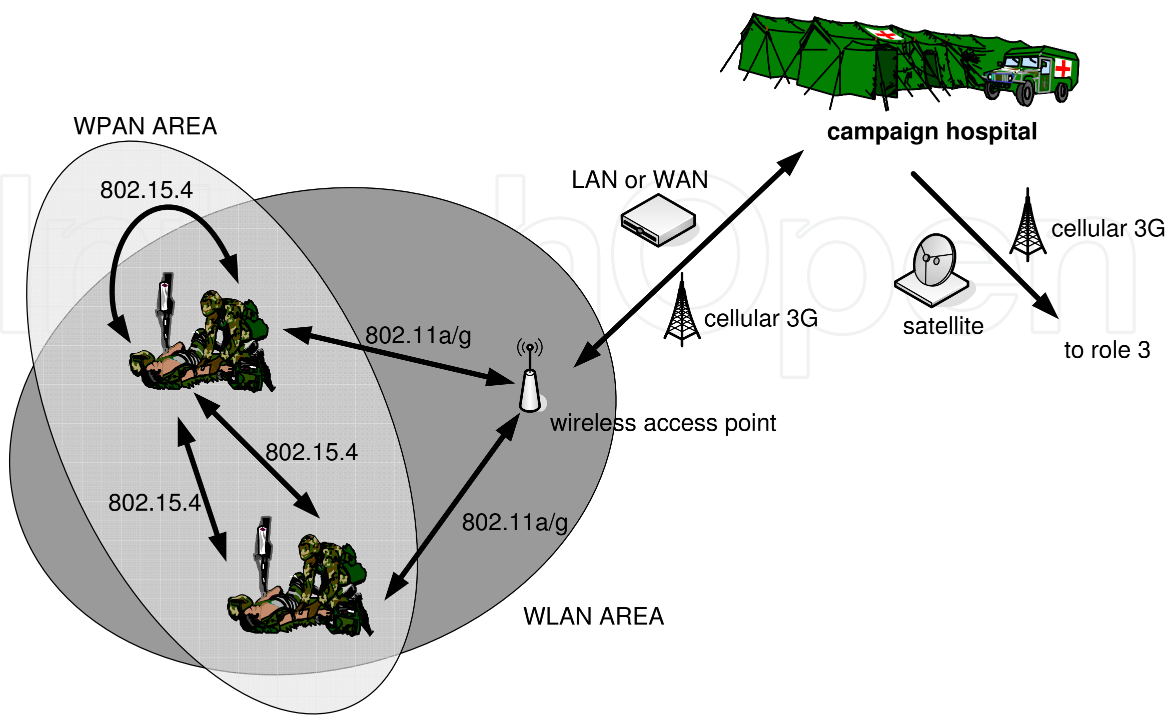

Fig. 6. Network Architecture at Role 2.

Picture 1. There is one view of the Tele Assistant system from the Reference Centre.

Picture 2. There is one view of the Tele Assistant system from the Remote Centre.

This is quite important for Telementoring purposes because it allows the specialist in the Reference Centre to show the medical personnel in the Remote Centre how to perform a diagnostic or therapeutic procedure on real time and to supervise it also.
This system is used for example to mark different points of interest in Tele Ultrasound examination on real time.
It was designed as a Tele Surgical Assistant System, but the experience showed to us that it was very useful for the majority of medical procedures.

7.3 Integration of an intelligent tele monitoring system.

Nowadays the monitoring vital signs devices have alarms (warnings) that can be set by the medical personnel to be activated when the values of these parameters arise to certain levels: The pulse rate may be set as 100 bites per minute as upper level and 60 as lower limit. When the cardiac frequency is higher than 100 of lesser than 60 an acoustic and visual alarms began to work warning about the situation.
This monitoring is quite important in Advanced Life Support because the Decision Making Process has to be on real time.
A next step is to include intelligent alarms for these devices with the aim to help the medical personnel about to realize as soon as possible, and with the highest accuracy what is going on in every moment during the management of critical casualties. One example of this kind of new monitoring could be that the devices would integrate the inputs from different vital signs: bradycardia + high blood pressure + irregular respiratory pattern = High intracranial pressure. This tool joint to a real time videoconference teleconsultation system is a powerful platform to mentor medical teams working on critical situations.

7.4 On call (cellular videoconference) medical specialist system.

The Reference Centre of the Telemedicine Service has a Gateway that transforms the Cellular Videoconference into ISDN (Integrated Services Digital Network) Videoconference.

This system gives the chance to access to the Reference Centre with a cellular phone with 3G (or upper) capability, videoconference and enough coverage.
We use this system from 2005 and its application is to telementor the people on duty at the Hospital taking care of the Telemedicine System if they had any trouble with the Teleconsultations.
It is quite useful because it allows us (Telemedicine Service personnel) to be on Telepresence 24/7 in our Reference Centre. We call it the "Big Brother" system.

Picture 3. There is one view of the Big Brother Videoconference.

8. Tele mobile intensive care ambulance

The Medical Evacuation (MEDEVAC) is essential in every Prehospital Emergency Care System. The Medical Transportation of patients with the trained medical personnel and with the right materiel (electromedical devices) and proper vehicles assure the necessary conditions for a good care. Many times these MEDEVAC are carried out with critical or potentially critical care patients. In spite of the MEDEVAC personnel were ready for attending these kind of patients if they had the capability to connect in real time with the medical specialists who will receive the patients is quite useful. This is a way to receive Telementoring on real time (with Videoconference and vital signs transmission) and to show the status of the patients prior to the arrival to their hospitals of destination. This system improves the time and the quality of the Medical Information between different medical providers.
The "Hospital Central de la Defensa" has one ICU (Intensive Care Unit) ambulance with the capability to connect on moving with the Reference Centre of the Telemedicine Service. Two different communications are used: 3G cellular phone coverage and satellital communications. These terminals are installed into the ambulance (two antennas and to interfaces) and one laptop is integrated as a hub that connects the medical devices and the videoconference system with a software application that allows by a communications network (Internet or Intranet) to keep in contact the ICU ambulance and the Reference Centre.
This tool gives the chance to perform ultrasounds examinations from the ambulance being telementored and assessed by the medical specialist on duty who is going to receive the MEDEVAC.

The system has been tested with both communications system (satellital and 3G) with the aim to have always the chance to connect with the Hospital when it was necessary without geographical constrains.

Picture 4. The ICU ambulance with the Telemedicine system integrated.

Picture 5. A view of the communication terminals inside the ICU ambulance.

9. Robotic tele ultrasound examinations:

Nowadays Teleultrasound is one of the most cost-effective techniques applied on Telemedicine. There are different ways of management in this field. This group began five years ago a trial with a Telementoring method in Teleultrasound using an agreed language between the medical specialist provider (radiologist or cardiologist) and the Teleoperator (Nurse or Radiology Technician), on the idea that a well trained human being is a good interface for Teleultrasound.

There are some commands which are used by the specialist to telementor the medical personnel on the Remote Center on how to perform the ultrasounds examinations on real time: Move to, stop, freeze, spin, tilt to, bend to, compress and relax pressure.

The procedure is being applied with the Telemedicine System from the Remote Centres to the Reference Centre where the requested specialist are (radiologists, cardiologists, vascular surgeons or orthopedic surgeons mainly).

We are trying to make easier these explorations with the integration of robots. These robots can be attached to the ultrasound machine probe and then the specialist can move the probe remotely with a joystick from the Reference Centre (on real time), with direct visualization of the probe position over the patient´s body surface and with the ultrasound image simultaneously (dual video layout).

We are still on the testing phase of these devices, but we think that this will be a very helpful tool for these examinations.

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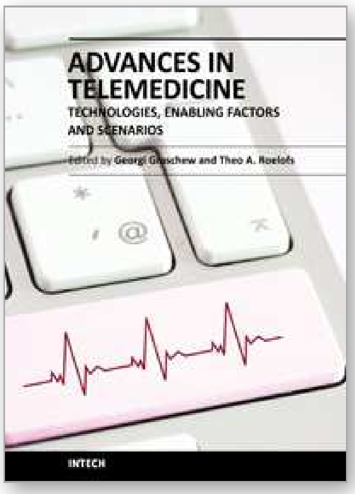

Advances in Telemedicine: Technologies, Enabling Factors and Scenarios

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Innovative developments in information and communication technologies (ICT) irrevocably change our lives and enable new possibilities for society. Telemedicine, which can be defined as novel ICT-enabled medical services that help to overcome classical barriers in space and time, definitely profits from this trend. Through Telemedicine patients can access medical expertise that may not be available at the patient's site. Telemedicine services can range from simply sending a fax message to a colleague to the use of broadband networks with multimodal video- and data streaming for second opinioning as well as medical telepresence. Telemedicine is more and more evolving into a multidisciplinary approach. This book project "Advances in Telemedicine" has been conceived to reflect this broad view and therefore has been split into two volumes, each covering specific themes: Volume 1: Technologies, Enabling Factors and Scenarios; Volume 2: Applications in Various Medical Disciplines and Geographical Regions. The current Volume 1 is structured into the following thematic sections: Fundamental Technologies; Applied Technologies; Enabling Factors; Scenarios.

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