Requirements and solutions for advanced Telemedicine applications

George J. Mandellos, George V. Koutelakis, Theodor C. Panagiotakopoulos, Michael N. Koukias and Dimitrios K. Lymberopoulos
Wire Communication Laboratory, Electrical & Computer Engineering Department, University of Patras, GR 265 04 Panepistimioupoli - Rion Greece

1. Introduction

Telemedicine, as the term means, is the provision of medicine and the exchange of heath-care information at a distance. Moreover, it is the use of advanced telecommunication and information technologies to transmit and exchange health information and provide health care services across geographic, time, social and cultural barriers [Vikas Singh, 2006]. It includes both, the clinical (diagnosis, treatment, medical records and prevention of disease) and academic medicine (research, continuous education, knowledge exchange, evaluation and training). In general, telemedicine is not a new technology, but term encompassing diverse information and communication technologies aiming to offer health-related activities wherever and whenever these are needed or requested.

Telemedicine is the only solution to several situations of healthcare provision. Two of the major cases, where there is no alternative to telemedicine, are emergencies and lack of expertised and/or experienced medical staff either in rural areas of developing countries or across the majority of the health care network of underdeveloped countries.

Many published studies [C. Weston et al., 1994] have shown that an early and specialized pre-hospital management of emergency cases contributes to the patient's survival. Especially in cases of serious injuries, spinal cord or internal organs trauma, the way that injured persons are treated and transported as well as the time period of their transportation is crucial. This is where telemedicine can contribute to an initial diagnosis, initial treatment during the patient's transportation and proper preparation at the hospital's premises for the patient's in-hospital treatment. Furthermore, in rural areas and in some occasions at health centres where primary care is provided, there is a lack either in medical staff or in specific expertise of the existing medical staff. In such cases, telemedicine is of great importance, as it eliminates the need for transportation, where in some cases such as islands cannot be easy. In addition it offers cost savings and immediate treatment administered by the expertised physician lying at a central hospital.

Despite the fact that telemedicine seems to be a necessity in several cases and has a huge impact both in personal and social level, there are many obstacles that need to be overcome so that an effective, efficient and cost effective telemedicine application is realized.

Generally, the problems telemedicine providers and consumers have to deal with are summarized in three major categories, juridical, financial and technological. On the other hand, telemedicine is not always easy to be implemented or supported, because a long list of factors affects its evolution.
This chapter will mainly focus on the technological problems, aiming to provide efficient and effective solutions. Taking into account the fact that telemedicine is realized by the fusion of communication and information technologies, the provided solutions will involve two directions. First, towards the communication part, which forms the platform for any kind of e-health application and, second the information structuring structure offering adaption to the medical treatment demands, each health related incident sets.
Before the comprehensive analysis of the problems and requirements of telemedicine, as well as the technological solutions adopted by several telemedicine applications, we consider that the presentation of some information, regarding general attributes of telemedicine, is quite necessary. For this reason, the next section will report on the types of telemedicine, the reasons why telemedicine is not only being implemented, but seems to be the only solution in several occasions, the telemedicine applications and the players having either a major or less important role in several levels, spanning from the design to the market analysis of telemedicine systems and applications.

2. General attributes of telemedicine

2.1. Types of telemedicine

Telemedicine sessions can be distinguished according to the interaction taking place between the clients and the expert and the type of the exchanged information.
The two types of interaction are the Real-time (synchronous) and the Store and Forward (asynchronous).
In Real-time telemedicine, a synchronous interaction between providers/patients/ healthcare professionals at distant locations is established, using some kind of communication technology providing audio/visual/data exchange and wireless or microwave signals. This type of telemedicine often renders increased accuracy and offers better assessment of the overall patient's health condition resulting, among other things, in more satisfied patients. Keep in mind that patients' satisfaction is a key factor so that telemedicine will be integrated in our everyday life, as stated in many researches existing in the literature. The main disadvantage is that the parties involved must be scheduled, because in the real-time telemedicine usually two healthcare providers are involved, so they both need to be available at the same time. In Real-time telemedicine, apart from video-conferencing, peripheral sensing devices (biosignal measurement devices) can also be attached to the patient or to the equipment, in order to offer the ability of remote interactive examination. This type of telemedicine is used most often in accidents, psychiatry, internal medicine, rehabilitation, cardiology, paediatrics, obstetrics and gynaecology as well as neurology.
The Store and Forward or prerecorded (asynchronous) technology involves the acquisition of medical data (images, bio-signals) and its transmission by the referrer to a medical expert for consultation, evaluation or other purposes, at a convenient time. This type of telemedicine does not require simultaneous communication between the referrer and the healthcare professional in real time. E-mail is a common example. The diagnostic accuracy is

lower related to the real-time telemedicine, because the expert evaluates the data with a delay and he doesn't interact with the patient while care is provided, but it has advantages considering hardware and software complexity, cost and convenience. This type of telemedicine is often used in radiology, pathology and dermatology.
The type of information exchanged between the parties during a telemedicine session can be comprised of data, audio, video or a combination of them. Data includes patient's demographic information, biosignal measurements acquired through sensors connected to the patient and peripheral devices, etc. Audio includes the conversation (voice signals) between the two parties. Video includes still images and/or video pictures concerning the medical incident.

2.2. Necessity of telemedicine

A significant percentage of emergency cases are due to car crash accidents and coronary artery diseases. Statistics for car accidents in USA and Europe prove that many thousands of people loose their lives and many more drivers or passengers are severely injured. Studies performed in Greece, a country with a very high death rate due to car crashes, proved that most of the fatal injuries in accidents happened far away from any competent healthcare institution, thus resulting in long response times [Mandellos et al., 2004]. The long response time (ambulance arrival, transportation time, evaluation time and treatment initiation) [Mandellos et al., 2004] leads a significant percentage of victims caused by accidents in rural roads to die on the scene, or during the transportation [A. G. Heriot et al., 1993]. Some of the above cases had a 50% chance of survival, if adequate pre-hospital care existed.
Heart disease is another common example of high death rates in emergency cases, since two thirds of all patients die before reaching the central hospital [T. Evans, 1998]. The delay in administering the appropriate therapy [T. Kereiakes et al., 1990] comes either from the patient's failure to recognize the seriousness of his symptoms and seek emergency care, or the needed pre-hospital evaluation and transport time, or the time required for diagnosis and initiation of treatment in the hospital.
The above show the great necessity of telemedicine in emergencies. The emergency cases comprise a major case, among many others, where telemedicine can play an extremely vital role. Airplanes, ships, rural areas and disaster areas constitute some other important cases where telemedicine appears to be either the only or the most efficient and effective solution.
Moreover, the use of telemedicine offers several benefits in the traditional healthcare network as it:

- Increases the accessibility of and to professional caregivers
- Increases the quality, efficiency and continuity of healthcare to patients
- Increases the focus on preventive medicine through early intervention
- Reduces the overall cost of healthcare both for care providers and consumers
- Reduces the unnecessary transfer of patients to regional hospitals
- Enables the education and training for both medical stuff and citizens, and improves the medical knowledge
- Provides services to remote areas in case of natural calamities, disasters and military and space operations.
- Enables the patient's remote monitoring
- Reduces the time needed for diagnosis extraction and patient treatment.
- Leads to a rapid response time in pre-hospital actions.

2.3. Telemedicine applications

Because of the above benefits telemedicine has, telemedicine is utilized for providing various services that spawns numerous specialties and can be broadly categorized as home-based care, telepsychiatry, teleradiology, general telemedicine, telecardiology, teleconsultation, telemedicine in disaster areas teledermatology, ambulatory and emergency care, telepathology, self-care teledentistry and telesurgery.

In order to be applied to the above fields, telemedicine applications use the same basic components, e.g. capturing infrastructure, communication media, processing equipment to display, process and manage the information and deliver feedback.

The used infrastructure to capture the necessary information includes a Biosignal Acquisition Module, for biosignal acquisition through sensors connected to the patient and peripheral devices, and in some cases a Digital Camera, for patient's digital image or video capturing. The processing module such as a Personal Computer or Personal Digital Assistant from the patient's side integrates the acquired data (biosignals, demographics, videos, geolocation, etc.) in order to be transmitted. On the expert's side it displays the received data and gives the necessary tools to doctor in order to evaluate them. The communication medium connecting the telemedicine parties makes use of various communication technologies such as POTS networks (PSTN or ISDN), GSM cellular phone networks, 2g, 2.5g and 3g networks, Bluetooth and RF technologies, Satellite Systems, LAN, WLAN, WiMAX, Home/Personal/Body Area Networks, Mobile ad-hoc networks or MANET's.

Also, optional equipment (GPS receiver, microscope, etc) can be used so that various incidents can be managed through telemedicine.

2.4. The players involved

Telemedicine is a very complicated scheme. The implementation of a telemedicine application requires the cooperation, among different type of players. There are directly and indirectly involved players who can be categorized in the following categories:

- Healthcare consumers (especially patients)
- Health professionals (experts, family doctors, nurses, paramedic, obstetrician, etc.)
- Other professionals involved in the wider area of healthcare (directors, researchers, epidemics, technicians, IT engineers, statistician, etc.)
- Hospitals and health centers
- Communication companies
- Complementary (non-medical) services suppliers
- Infrastructure manufacturers and suppliers
- Hardware and network manufacturers
- Universities and research institutes
- Insurance companies
- Pharmaceutical companies
- Health ministry
- Health management organizations
- Organizations for standardizing and licensing.

The above list shows one of the major intrinsic difficulties in establishing a telemedicine application, as it needs a huge effort put on management, administration and cooperation among different types of participants.

3. Potential problems and requirements

Telemedicine is not always easy to be implemented or supported. Our long experience as a telemedicine R&D group of University of Patras, during design, development and implementation of several projects since 1992, and the cooperation with the players involved demonstrated a long list of factors affecting the evolution of the telemedicine. Generally, we can divide them in three main categories, juridical, financial and technological. Although these categories do not have clear border against each other, they can be broadly classified into the following groups:

3.1. Juridical problems

Medical malpractice liability. Medical Malpractice Liability is a big case for healthcare providers with iniquitous costs because of penalties. The nature of telemedicine, the communication network interruptions, and the errors caused by hardware failures during the transportation makes it vulnerable to malpractice lawsuits. In many countries, there is a significant uncertainty regarding whether malpractice insurance policies cover services provided by telemedicine. Telemedicine networks that cross border lines for example in countries line US, create additional uncertainties regarding the state where a malpractice lawsuit may be litigated and the law that will be used. Is the law to be considered in the state of the provider, the patient, or in another state which covers the network?

Absence of legislative regulations on attribution of responsibilities. In some countries like Greece there aren't legislative regulations to define the telemedicine service operation. A major barrier in this case is who is the responsible on the telemedicine incident evaluation, the local paramedic or the remote expert? Another barrier is the financial of the people involved in a telemedicine session.

Absence of Licensing and Credentialing. It is a consequence of the above absence of a suitable law for telemedicine services.

Absence of rights. Usually, the ambulance staffs have not the required advanced theoretical knowledge and experience to handle emergency situations. Moreover, it is not certified to provide medical care without a medical expert's advice. On the other hand, expert physicians such as cardiologists, neurosurgeons, orthopaedics cannot participate in ambulance staff for financial aspects or practical reasons.

3.2. Financial problems

Cost and Reimbursement for Telemedicine Services. Often telemedicine services are established during research projects. Most of the telemedicine projects around the world are still funded by state or federal grants. Although the communication costs and the cost of the basic equipment generally are falling, many public and private payers are reluctant to set standard for payment or reimbursement because of the uncertainty inherent in telemedicine because of its evolving nature and lack of conclusive evidence of its effectiveness and range of applications.

Telecommunication regulations – limitations. The limited competition for telecommunication services in some areas caused by country regulations leads to a significantly decreased number of available network types. So the absence of competition keeps the communication cost high.
Equipment costs. The majority of the already existing hardware and software components designed for telemedicine purposes have a relatively high cost which most of the people cannot afford.

3.3. Technological problems

Closed Systems. There is a significant number of telemedicine services used by healthcare providers. Many of them are provided by closed systems without offering interoperability with other medical systems (such as Electronic Health Record Systems).
Wide range of telemedicine. Telemedicine lies across a wide range of medical activities resulting in redundancies, lack of interoperability, cost sharing and incompatibilities between systems.
Communication Networks. The limited competition for telecommunication services in rural areas and islands leads to a significantly decreased number of available network types (such as GSM, 3G, etc.) in the above areas. Also, the available signal strength in those areas is rather limited and the frequent interruptions or even the signal absence in some areas (caused by the geomorphology) during a telemedicine session render telemedicine unavailable.
User refusal against new technologies. People do not want to involve any new technologies in their life, especially when they are constrained by thirds (e.g. profession guidelines). So they are negative in the introduction of new equipment and claim legislative and financial reasons in order to abstain.
Telemedicine resources. In order a telemedicine system to be able to serve a wide area of medical cases, it needs various interconnected medical devices. The barrier here is whether this equipment is sufficient to meet clinical standards and whether its usage inhibits healthcare professionals from using it. Some times the quality and resolution of radiographic images transmitted doesn't meet the standards. Another factor is the lack of know how in order to make a proper use of the equipment's features. Telemedicine, in most occasions, requires expensive infrastructure and highly complex setup which is a limiting factor for small providers and physician clinics or health centres established in small islands.
Information structuring. With respect to the information structuring we highlight the following:
Variability of incidents served by telemedicine. A telemedicine system can be addressed to serve various incident types (patients suffering from heart diseases, pneumonics, several injuries etc.). Every single incident requires a different collection of diverse vital signs or relative information in order to determine the condition of the transported patient.
The absence of a protocol able to handle all the selected data in order to allow the interoperability between Medical Information Systems. There are many protocols handling an information subtotal.
The capability of scalable user access depending on his type/specialty. Telemedicine systems as they are applied in a wide area of activities have to introduce control processes, in order to keep the information confidentiality.

4. Methods for structuring, processing, archiving and transmitting the medical information

The successful design, implementation and utilization of a telemedicine system needs the resolution of several problems listed in the previous section. Resolving the aforementioned problems is often a very difficult task demanding the cooperation of various social groups. Being engineers we will focus on providing solutions to the technological problems not addressing the other two groups (i.e. juridical and financial)
In order to overcome some of the technological limitations, we adopt solutions that will be presented in the following paragraphs. These solutions have been succesfully implemented in a telemedicine system [Mandellos et al., 2008 (a)] resulted by a project tuned by the Greek Information Society and the Greek Ministry of Defense. This telemedicine system (fig. 1) supports diverse types of endpoints including moving transports (MT) (such as ambulances, ships, planes, etc.), handheld devices and fixed units, using diverse communication networks. The above telemedicine system targets to the improved pre-hospital patient treatment. Although vital sign transmission has the priority against other services provided by the telemedicine system (videoconference, remote management, voice calls etc.), a predefined algorithm controls provision, switching and QoS of the other potential services. A distributed database system controlled by a central server, aims to manage patient attributes, exams and incidents handled by several Telemedicine Coordination Centers (TCC). Doctors and other mecical personnel are able to participate for observation purposes, during the incident evaluation through workstations in TCCs or through Regional Teleconference Rooms (RTRs).

4.1 Bandwidth limitations lead to the adoption of an adaptive protocol

In many medical incidents, the correct diagnosis depends on the amount and type of data relative to patient's health state [Mandellos et al., 2008 (a)]. In some cases the referring doctor needs to know more data for the patient's state from those provided by the acquired measurements. Such data are patient's demographic data, mnemonic and medical history, patient's allergy state, patient's ancestry, etc. These data affect the correct treatment (e.g. pharmaceutical allergy precludes some drugs) or the patient's handling (e.g. blood transfusion is prohibited by some religions; patient must be treated separately from other patients if he suffers from infectious diseases or has sensitive immunizer system). The doctor, takes different measurements on patient's Vital Signs (for cardiac diseases he takes an ElectroCardioGram - ECG, for pulmonary diseases he takes measurements of blood oxygen saturation - SPO_2 while on other cases he takes body's temperature (TEMP), non invasive blood pressure (NiBP), etc) depending on patient's symptoms. Consequently, the total amount of data collected during an incident could have diverse length type compared to another incident.

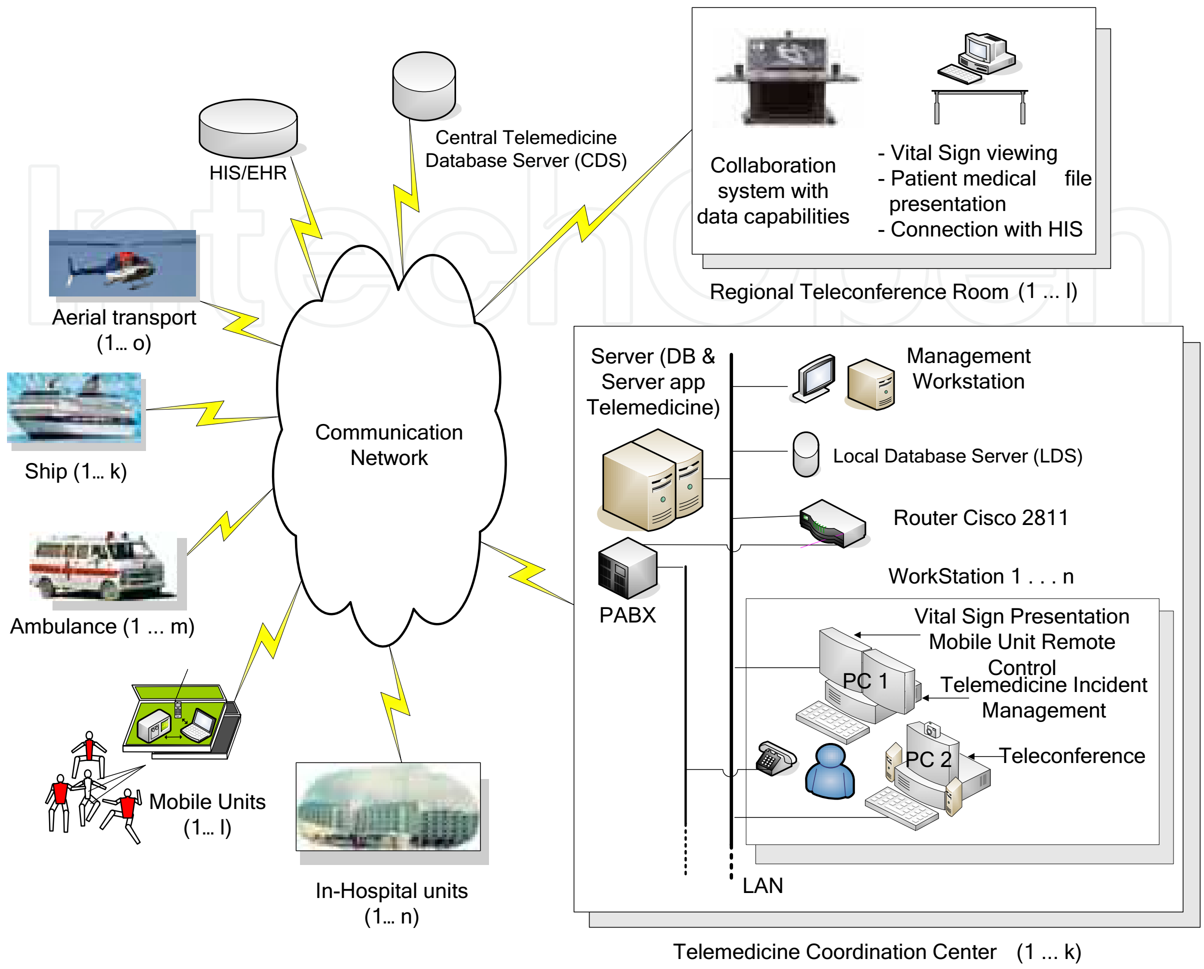

Fig. 1. General structure of a Telemedicine System.

This diversity of data led to the necessity of an adaptive protocol in order to minimize the required transmission time, the recovery time and finally the storage space. Authors have proposed some extensions in order the new protocol to be able to handle more data based on the file format of SCP-ECG protocol [Health Informatics, 2002] which handles a basic set of demographics data and also ECG measurements. The new protocol is referred as e-SCP-ECG+ protocol [Mandellos et al., 2008 (b)]. The finally used protocol has significant changes and constitutes a newer version of the aforementioned protocol. This version made extensions in order all types of data collected during an incident to be handled. The protocol consists of a sections collection, each of them handling different types of data. A main section is defined to control critical data on other sections (e.g. existence, offset, length, etc.). Thus, the protocol's structure permits the handling only of the existing data.
The data handled by the latest protocol version covers patient demographic data, ancestry data, profession data, mnemonic and medical history, a quick description of the incident, a first diagnosis, allergy state and measurements on ECG, SPO_2, NiBP, TEMP, Heart Rate and CO_2.
The user has the ability to manage the acquired data such as user inputs and Medical Monitor (MM) measurements and define the data set describing each incident via a PC

connected between MM and communication media. Afterwards, the formatted data can be transmitted to the TCC.

The new expanded protocol can be used in a big variety of medical incidents. The possibility to manage only the data that characterize each medical incident has the advantage of minimal possible volume of data, which results in a high flexibility regarding their management and in a very fast transmission.

4.2. Communication network instability or absence in many areas leads to the adoption of an alternative communication media structure

The reassurance of a stable communication between Mobile Units (MU) and TCCs, with the best possible quality regarding the available networks at the various access points is very important. It is more than obvious that the transmission of vital signs to the TCC is required by all means, so that the paramedical staff of the MT can offer crucial treatment the soonest possible. For this purpose, communication capabilities using multiple networks of diverse physical media are developed to guarantee the successful vital signs transmission under all circumstances (Fig. 1).

The development focused on mobile communications due to the fact that a patient transportation is taking place. GPRS offers wider geographical area coverage but low transmission rates. Mobile Asymmetric Digital Subscriber Line (M-ADSL) clearly offers higher transmission rates with lower cost but it lacks in geographical area coverage. In the occasions where the system was installed at ships transporting patients from islands to central hospitals of the mainland (University hospitals or other central hospital), satellite modems are used. The choice of the wireless network is mainly based on the offered Quality of Service (QoS) and not only on its availability. Moreover, priorities are embedded regarding the choice of the wireless network. The designation of the network to be used for call transfers and transactions is made depending on these priorities and the available networks. Thus, the result is a single network connection based on a priority algorithm (as mentioned above) that will host (in contrast with the previous pilot operation of the project) all the communications used to handle a single incident.

In any communication between MUs and TCCs two different and independent calls (C1 and C2) are made from the MU to the TCC. C1 call enables vital signs transfer and C2 call enables either telephone communication via an ordinary telephone set (wired or wireless) or communication via teleconference, where, depending on the available bandwidth, text, voice and video transmission will be possible in a respective hierarchical way. In all cases one or more connections are used within the same transmission media, to circulate all the information (data, voice and video) regarding a single incident.

Moreover, priorities are designated regarding the kind of data that must be transferred each time, when the available bandwidth is inefficient. Examples of validations (demarcation of situations/behaviour) carried out by this transmission sub-system according to these priorities are the following:

- In a GPRS network in case of low bandwidth only vital signs transmission is accomplished. If bandwidth is sufficient, text is also transmitted.
- In a wireless LAN (IEEE 802.11 a/b/g) or satellite modem in case bandwidth reaches low rates high priority is given to vital signs transmission in regard of teleconference.

It is obvious by the examples given above that in every case the bandwidth is not efficient, transmission of crucial medical information i.e. vital signs, has priority against the delivery of any other service offered by the telemedicine system.
Using the adaptive protocol described above, the vital signs transmission is performed by means of transferring packets of a fixed time period (e.g. 10 sec) from the MU to the TCC. These vital signs packets include all the acquired vital signs from the patient for the respective period of time. The application developed provides the potential to define the period of time in which transmitted vital signs are partitioned. Thus, it is possible to adjust the size of each transmitted packet. Detection of low bandwidth results in a larger packet size in order to limit the transactions with the database and prevent a possible flood in the network connection. This adjustment will result in a higher delay imported at the beginning of the real time transmission due to the initial control-process of the first large sized packet. Detection of high bandwidth results in a smaller packet size accompanied with lower delay imported to the transmission due to a fast initial control-process of the first small sized packet. The size of the vital signs packet can be dynamically adjusted depending on a periodically measurement of the available bandwidth.

4.3. A call management application controls the productive telemedicine system's operation

Each TCC hosts one Management Workstation (MW), three Treatment Workstations (TWs), as well as one Local Database Server (LDS) for storing the whole of incident data. The MW in its turn hosts a call management application, which is responsible the control and management of incoming calls from the MTs to the TCCs and the already established connections between them. When a call arrives at the TCC, optical and sound alerts are enabled to the MW to inform of the data arrival. MW selects a TW in order to handle the incident. The call management application enables TCC's administrator to route an incoming call to the TCC to a workstation, redirect an already established session from one workstation to another, to connect or disconnect any endpoint in an active session, to invite participants, etc.
Apart from these functionalities, the call management application provides control and management of the wider established telemedicine network outside the physical area of the TCC. It offers endpoint management (i.e. insertion, deletion, modification etc.), teleconference administration and management of users (i.e. insertion, deletion, access level designation and access data modification of users authorized to access TWs, MWs, RTRs and MUs).
The latest part, of which the call management application is responsible, is the maintenance of the telemedicine system. Through this application, the administrator is able to start/stop/restart the proxy servers which consist the intermediates of the communication between MUs and TWs. Furthermore, it provides the functionality to flag several types of incidents that either were not properly handled (e.g. due to connection loss between TCC's and MUs) or lack information and need further identification. These incidents are then handled in an offline mode by any willing TW, where the diagnostic reports are filled and the overall incident information is sent to the LDS.

4.4. Multiple TCCs

In order to ensure that a call initiated by a MU, will be served by a workstation in a TCC, in all cases, we established 3 networked TCCs. There were many occasions where all the TWs of a specific TCC were engaged while calls where arriving in this TCC. Furthermore, there were cases where the LDS of a TCC crashed or communications were broken due to various reasons. This led as to establish multiple TCC's in different central hospitals, not only to offer the ability of simultaneous handling of a relatively high number of telemedicine incidents, but also to be able to cope with such problems. So, in case all workstations in the referral TCC aren't able to treat a telemedicine call due to the reasons mentioned above, a predefined algorithm reroutes the call to another TCC which has available workstations.

4.5. Distributed database system

The information management in the telemedicine applications mainly follows an hierarchical structure represented by three basic information entities: Patient – Incident – Exams (Vital signs, still images and short time patient video). The archiving systems implemented by different TCCs result in a distributed system regarding the storage of information at the each TCC that any telemedicine-related information is being collected. A central database connects with peripheral databases located at the TCCs and this central database is responsible for the integration and coordination of the telemedicine databases.

Each Exam can be considered as a complete part of an Incident. Consequently, Exams are related only to one TCC and the attributes of one Incident are stored in its LDS. The different Incidents that comprise one Patient are often related to different TCCs. Thus, the Central Database Server (CDS) of the Telemedicine System is designed to keep records of the attributes of Patients and Incidents. However, the whole content of the Exams that is related to an Incident is stored in the LDS of the TCC that handled it. Inside the CDS, a reference connects user to the proper LDS of a TCC, which keeps the Exams data.

Thus, Exams remain locally stored, yet they appear as a reference link in the CDS of the Telemedicine. Each access of a LDS comes through the CDS and consequently any query related to Exams data is assigned to the proper LDS located at the respective TCC. The choice of the proper LDS is made regarding the attributes of the TCC that is related to the requested Incident.

Central telemedicine database should communicate with either the central Hospital Information System (HIS) or an Electronic Health Record (EHR) system in order to update the patient data corresponding to a telemedicine incident (Fig. 1). Central database also updates the HIS/EHR for possible changes to data regarding already registered patients or even registers new patients to the HIS/EHR whenever this is required during a patient identification process. Communication between central telemedicine database and HIS/EHR is accomplished exchanging the appropriate Health Level 7 (HL7) messages on occasion.

The distributed database can be implemented with robust grid database server software installed on a cluster of database servers. At the central telemedicine server, suitable proxy server software should be installed. This proxy server has the responsibility to perform the communication between the telemedicine system and the HIS/EHR. The proxy server undertakes to send and receive the (HL7) messages for the communication between the CDS and the HIS/EHR.

4.6. The necessity of participation more than one expert or educational reasons leads to the establishment of multiple RTRs

The designed Telemedicine System also defines a number or RTRs. A RTR is consisted of a collaborating system with data capabilities and a PC for vital sign viewing, patient medical file presentation and connection with the HIS. The RTR offers the capability of participation both in on-line incident evaluation and off-line incident's data observation. A RTR is able to connect or disconnect at any point in time during an active session.

This application can serve either for multi-expertise discussion on a specific incident or for educational purposes. For instance, practitioners in central hospitals, medical staff in secondary and primary care provision facilities could observe an incident while it is actually treated and receive feedback regarding the treatment methodology or specific medical information.

5. Factors confining the intensity of telemedicine systems' usage

During the previous decade the implementation of many Telemedicine systems begun aiming at connection remote regions with the nearest big hospitals or creation a Telemedicine network that is expanded in a wider geographic area. Telemedicine systems are also implemented aiming at the development of a national telemedicine network, which will be able to use the telecommunication infrastructure of a country in order to provide the capability of smooth enterprise operation regardless of the consequences.

Many telemedicine systems are implemented only as pilot applications. The results of the pilot operation of such systems range from moderately until to satisfactory enough. Nevertheless, most of these systems are abandoned after the end of the pilot use period or maybe the end of an extra short period of use. The factors, that such systems either are often not used in the desirable level or even in certain times are abandoned, can be summarised in the followings:

- Lack of specialised personnel for the enterprise operation of telemedicine systems.
- Complexity of the use case scenarios especially in that cases that two scenarios of telemedicine operation (real time – store and forward) are combined in the same information system.
- Lack of financing for sufficient service level agreements that would support and guarantee the sufficient operation of telemedicine systems
- Insufficient planning of the designed telemedicine solution viability, e.g. short-sighted risk analysis or not ensured essential economic support for the further enterprise operation of such a project.
- Design of autonomous telemedicine systems. No efficient collaboration with other hospital information systems, which participate in the management of the medical incident, is forecasted. Furthermore no collaboration of the designed telemedicine system with other existing telemedicine systems is taken into account. That means weakness of the implemented system to be interoperable.
- Many doctors and some patients are critical regarding the change of the traditional way of medical incidents' management, especially when an urgent incident takes place. This disposal of doctors (mainly) is often related with the lack of sufficient support in the problems appeared in the enterprise operation.

- Absence of a central institution for the management and exploitation of the telemedicine units. Lack of a central exploitation scenario for telemedicine. The extension of the fragmented telemedicine information systems in an integrated national telemedicine system, with the central responsibility and coordination of the corresponding Health Ministry is demanded. Only such an integrated system, which connects all the regional units of telemedicine with the central hospitals and allocates proper infrastructure and personnel for these hospitals in order to serve telemedicine incidents, can meet the requirements efficiently.

6. Conclusion

It is clear that telemedicine, when used correctly, enables health care provision where traditional health networks could hardly or were unable to do so and also improves the quality of the already existing healthcare services. There are several occasions, where telemedicine seems to be better than traditional methods such as the exchange of health-related information allowing a more accurate, faster and easier access to information. On the other hand many issues remain to be solved in order to telemedicine to be developed as a significant means of providing healthcare and be considered as an integral part of the mainstream healthcare. Coordinated and strategic planning, evaluation of the cost-effectiveness of telemedicine projects, funding and reimbursement are only some of the wide ranged needs of a process through which telemedicine services are commercially acceptable and harmonic integrated in the existing healthcare delivery in a significant degree.

Telemedicine, like all medicine, is constantly evolving. The growth and integration of new and emerging information and communication technologies into healthcare delivery surely holds great potential for all players. While the population of the elderly grows and chronic diseases are diffusing the requirements and expectations of citizens from the tomorrow health systems are evolving from the proper treatment and service provided in health centres to the provision of a more protective (proactive self-care), reachable (i.e. at home, at work, while travelling abroad) and high-quality health advice and assistance. Modern healthcare services are expected to be available around the clock, seven days a week, so that systems with pervasive access and near-absolute fault tolerance are indispensable. With introduction of new technologies in healthcare, the clinical practices are changing too, requiring healthcare professionals to collaborate across disciplines and organisational boundaries. Thus providers are looking for ways to deliver health services to the patient as promptly and as locally as possible, while supporting contact and collaboration between healthcare professionals and patients throughout the care episode.

With respect to these requirements from the tomorrow worldwide health systems, designed and developed frameworks should support a two-fold paradigm shift in health delivery:

- from symptom-based to preventive healthcare, and
- from hospital-centred to person-centred health systems.

Homecare and individualized monitoring systems are considered the segment with the greatest potential for financial and clinical impact in the forthcoming years, being considered a serious solution for life quality improvement by healthcare purchasers. Currently, the information level, penetration and usage rate is very much dependent on country development level. By assessing, evaluating and validating such systems in a clinically approved setup in more than one country around the world will improve acceptability of such systems at worldwide level, followed by market and business opportunities for innovative companies, and could help lower the costs of care.

7. References

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Biomedical Engineering can be seen as a mix of Medicine, Engineering and Science. In fact, this is a natural connection, as the most complicated engineering masterpiece is the human body. And it is exactly to help our “body machine” that Biomedical Engineering has its niche. This book brings the state-of-the-art of some of the most important current research related to Biomedical Engineering. I am very honored to be editing such a valuable book, which has contributions of a selected group of researchers describing the best of their work. Through its 36 chapters, the reader will have access to works related to ECG, image processing, sensors, artificial intelligence, and several other exciting fields.