

# The Potential of Telemedicine System: An Approach Towards a Mobile Doctor

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**Abstract** *In developing countries Doctors or Physicians don't like to go to the rural areas and people of rural (backwards) areas are not facilitated up to the mark. Thus the disaster situation occurs when these people are transferred to the city hospital for tertiary and mostly even for primary care. Advancement in the field of communications provided the solution in the form of Telemedicine. Telemedicine is "the practice of health care using interactive audio, visual and data communications. This includes health care delivery, diagnosis, consultation and treatment, as well as education and transfer of medical data". Today, Telemedicine systems are supported by State of the Art Technologies like Interactive video, high resolution monitors, high speed computer networks and switching systems, and telecommunications superhighways including fiber optics, satellites and cellular telephony.*

*This paper deals with the design and analysis of a telemedicine system. We have proposed a cost effective multipurpose model of the telemedicine system needed for the developing countries. The proposed telemedicine system has two major parts: a telemedicine unit (patient side) and a base unit (Doctors side). We have shown that how the interconnectivity through high-speed network forms the complete system. The applications of this system includes as: Ambulances, Rural Health Centers (RHC) and Ships navigating in wide seas are as possible emergency sites, while critical care telemetry and Telemedicine home follow-ups are important issues of telemonitoring. By using these facilities we approach towards a mobile doctor.*

**Keywords:** *Telemedicine System, Mobile Doctor, Health care modernization, New Trends in Health in Pakistan Perspective.*

## 1. INTRODUCTION

Telemedicine now has the potential to make a difference in the lives of many people. For example, telemedicine can improve the delivery of health care in any country by bringing a wider range of services such as cardiology, radiology, mental health services and dermatology to communities and individuals in underserved urban and rural areas [1]. In remote rural areas, where the distance between a patient and a

health professional can be hundreds of miles, telemedicine can mean access to health care where little had been available before[2]. Telemedicine is the use of any electrical signal to transmit medical information. However, According to the WHO definition, telemedicine includes "The practice of health care using interactive audio, visual and data communications. This includes health care delivery, diagnosis, consultation and treatment, as well as education and transfer of medical data" [3].

Telemedicine usually means transmission of information followed immediately by medical care. Telemedicine has numerous advantages as leveling of regional differences, improved efficiency of medical care, improved service for patients, and physicians will have greater opportunities to deliver medical care to patient in places where medical care is not otherwise accessible [4]. It has been expanded to ships, planes, and even spacecrafts. It has been widely used in USA, European countries, Australia, Canada, Japan, & China. India has also well utilized this technology. For example on 26<sup>th</sup> January 2001 when a devastating earthquake occurred in Gujarat Some 40,000 lives were lost, and over one lakh people were badly injured [5]. In this gloomy scenario one promising technology that made its impact is Telemedicine. The Ahmedabad-based Online Telemedicine Research Institute (OTRI) came to rescue and succeeded to prevent people at high level.

Today, Telemedicine systems are supported by State of the Art Technologies like Interactive video, high resolution monitors, high speed computer networks and switching systems, and telecommunications superhighways including fiber optics, satellites and cellular telephony [6]. Ambulances, Rural Health Centers (RHC), incidents occurring in backward areas (particularly for Sindh) or other remote health location such as Ships navigating in wide seas, space are common examples of possible emergency sites, while critical care telemetry and telemedicine home follow-ups are important issues of telemonitoring.

In order to support the above different growing application fields regardless of the usually used telemedicine systems i.e only store and forward, we

have designed a combined system that supports real-time consultation as well as store and forward facility. It comprises of two major units i.e. base unit (Doctor's Unit) and a telemedicine (mobile) unit. This integrated system can be used when handling emergency cases in ambulances, RHC or ships by using a mobile telemedicine unit at the emergency site and a base unit at the hospital-expert's site. It enhances intensive health care provision by giving a mobile base unit to the ICU doctor while the telemedicine unit remains at the ICU patient site and enables home telemonitoring, by installing the telemedicine unit at the patient's home while the base unit remains at the physician's office or hospital.

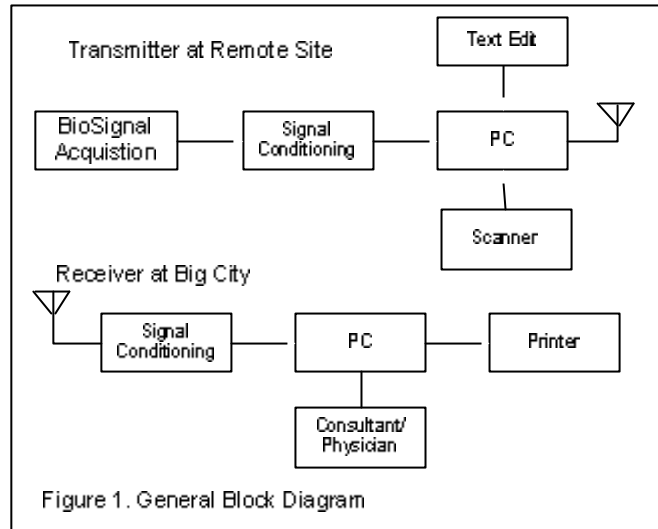
The main objective of this designed system is to measure the potential at the remote site and store them in central database. For this purpose equipment are required for measuring non-invasive blood pressure and invasive blood pressure, ECG, Ultrasound, heart rate, temperature, oxygen saturation and still images. The biosignals that are recorded will be transmitted by using ISDN(Integrated Service Digital Network), Satellite or POTS (Plain Old Telephone Service) communication means. The user friendly software's are installed on both sides that can receive and transmit the data from base unit to telemedicine unit and vice versa. At the base unit after having proper consultation by a physician the software should be capable to transmit the information back to telemedicine unit and store all data in a database at the base unit. The communication between two parts is based on TCP/IP protocols.

## 2. A SIMPLE TELEMEDICINE SYSTEM

Let us elaborate a simple type of a telemedicine system, its prerequisites, requirements, deploying, cost as well as usage. Prerequisites for developing a system in any backward area are electricity, telephone line, Internet or fax facilities and other necessary things. A doctor, nurse and an attendant are also required [1].

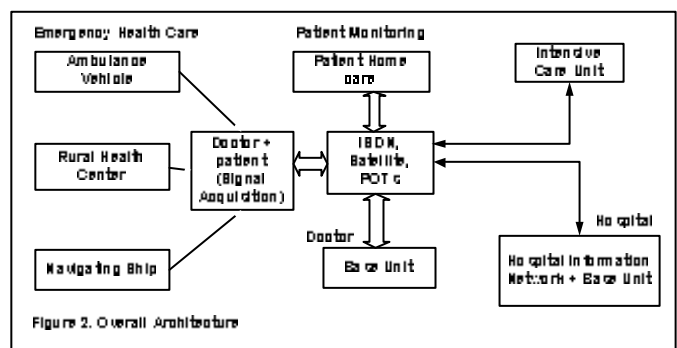
A very basic telemedicine system shown in fig. 1 can do with a data acquisition unit, PC, telephone and scanner, it needs to be scaled up as needs increase. A store-and-forward basic product with a normal Pentium PC, a webcam, telemedicine tools (to capture patient data or images) and an Internet dial-up connection would provide the same results as a fancy real-time application. But for communication between any tertiary-to-tertiary care hospital, we would need a type of infrastructure as: video conferencing equipment with software, a minimum of 384 kbps leased line connectivity, X-ray scanner,

digital camera, flatbed print scanner, digital ECG recorder, ultrasound machine with digital output, digital microscope, and two Pentium IV PCs. The money needed to deploy this kind of solution is around Rs 20-30 lakh per site, with a recurring cost of Rs. 3-4 lakh per annum.



By contrast, a store-and-forward system is extremely cost-effective. A central server can store all the information about cases to be referred to the concerned specialist. The expenditure to deploy this kind of solution is around Rs 2-3 lakh per site, which is ten times less than the interactive model. Moreover, all the sites in the network can share the cost of the central server.

The proposed system [Fig. 2] is the combination of these both type of telemedicine systems i.e. real time and store and forward. This figure depicts that the system comprises of a telemedicine unit and a base unit. The system is useful for home telemonitoring, for rural health centers and for ambulance monitoring when a critical situation due to sudden incidents.



The Telemedicine device is responsible to collect data (biosignals and images) from the patient and automatically transmit them to the base unit. The base unit is comprised of a set of user-friendly software modules, which can receive data from the

Telemedicine device, transmit information back to it and store important data in a local database.

### 3. SYSTEM DESIGN REQUIREMENTS

For developing a telemedicine system trained Professionals, sophisticated tools as well as secure network are required. The emergence of all three components assures the probability of an ideal telemedicine system. In relating to the technical contrast as compare to the usual telemedicine system this system for consultation requires high data rate, high-resolution camera supporting to high frame rate at standard 30 frames/sec for images, well trained professionals, tight network security, and high color flow for picture [7].

System mainly consists of two parts: Telemedicine unit and base unit. The Telemedicine unit is responsible for collecting and transmitting biosignals and still images of the patients from the incident place to the Doctor's location while the Doctor's unit is responsible for receiving and displaying incoming data. The information flow (using a layered description) between the two sites can be seen in Figure 3.

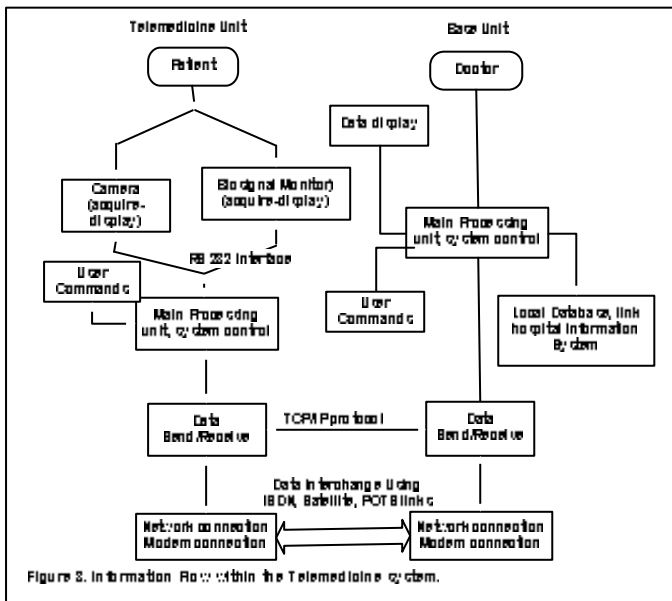


Table 1: Overview of current trends and needs in Telemedicine System.

Telemedicine Application	Cost	Portability	Autonomy	Small Weight & size	PC Type	Camera Quality	Communication means	User Friend lines
Ambulance	M/H	H	H	H	Palmtop	M/H	ISDN	M/H
RHC	M/H	L	L	L	D/L	M/H	POTS, ISDN	M/H
Ship	M/H	L/M	L/M	L	D/L	M/H	ISDN, Satellite	M/H
Home care	L	L/M	L/M	L	D/L	H	POTS	H
Intensive Care Room	M/H	L	L	L	D	H	POTS, ISDN	M/H

Note: L=Low, M=Medium, H=High, DL=Desktop/ Laptop, D=Desktop

For the software development we have the Windows based client server model that may easily be implemented for windows 95/98/2000/NT. Telemedicine unit site is the client while the Base unit site is the server. Communication between the two parts is achieved using TCP/IP as network protocol, which ensures safe data transmission and interoperability over different telecommunication means (ISDN, Satellite, and POTS). System communications are based on a predefined communication protocol for data interchange, which is used to control and maintain connection between the two sites, thus ensuring portability, interoperability and security of the transmitted data.

#### 3.1 Telemedicine Unit

The Telemedicine unit mainly consists of four modules, the biosignals acquisition module, which is responsible for biosignals acquisition, a digital camera responsible for image capturing, a processing unit, which is basically a Personal Computer, and a communication module (ISDN, Satellite or POTS modem).

In this system the biosignals that may be collected from the patient (and then transmitted to the Base Unit) are:

- ECG up to 12 lead, depending on the monitor used in each case.
- Heart Rate (HR).
- Blood Pressure (Non Invasive and Invasive)
- Temperature (Temp)
- Heart Rate
- Ultra Sound

The PC used depends upon the type of the Telemedicine application. As shown in table 1 in cases where the autonomy and small size of the system are important (mainly in ambulances), a sub notebook like portable PC is used. In cases where we need some autonomy but size is not considered an important element a typical Pentium portable PC is used. In case where we do not necessarily need autonomy, portability and small system size, a typical Pentium Desktop PC is used. As it is stated earlier the data interchange is done with TCP/IP network protocol. The PC will be equipped with a proper modem for each case i.e. ISDN, Satellite, or POTS. There are different types of modems for different means of communications as it depends upon the requirements and application. The telemedicine unit is also responsible for the collection and transmission of images of the patient to the base unit. The several cameras will be connected to the system. The control of this system will be automatic. The only thing the telemedicine unit user has to do is to connect the biosignals monitor to the patient and turn on the PC. The PC then performs the connection to the base unit automatically. Although the base unit basically controls the over all operation, the Telemedicine unit user can also execute a number of commands. This option is useful when the system is used in a distance health center or in ship and a conversation between the two sites takes place.

### 3.2 Base (Doctor's) Unit

The base unit mainly consists of a dedicated PC equipped with a modem, which is responsible for data interchange. In addition the base unit PC is responsible for displaying incoming signals from the Telemedicine unit. When an expert doctor uses the base unit located outside the hospital area (like in the Intensive Care Room application) a portable PC equipped with a ISDN modem or a desktop PC equipped with a POTS modem is used. When the base unit is located in the hospital, a desktop PC connected to the Hospital Information Network (HIS) equipped with a POTS modem can additionally be used; the expert doctor uses it as a processing terminal.

Through the base unit, user has the full control of the telemedicine session. The user is able to monitor the connection with a client (telemedicine unit), send commands to the telemedicine unit such as the operation mode (biosignals or images). The units connected on the network can be ICU telemedicine units or distance mobile telemedicine units connected

through phone lines. The Base Unit's user can monitor biosignals or still images coming from the telemedicine unit, thus keeping a continuous online communication with the patient site. This unit has the full control of the Telemedicine session. The doctor (user) can send all possible commands concerning both still image transmission and biosignals transmission.

## 4. Technical Perspectives

Telemedicine systems require programmable video, audio, image handling and compression to support applications ranging from typical video teleconferencing to providing "diagnostic-quality" video, audio and medical images interactively [8]. Typically required functions are MPEG (for a high-quality audio/video compression), JPEG (for still image compression), H.320 (for videoconferencing over ISDN), and H.324 (for videoconferencing over POTS)[9]. The H.320 family of international teleconferencing standards provides for simultaneous audio (G.700), video (H.261) and data transfer (T.120) using communication bitrates from 56 kbps to 1.92 Mbps. H.320 is designed to work with the range of bitrates available using ISDN [10]. Automatic negotiation between connected sites through H.221 and H.242 allows dynamic assignment of bits to individual audio and video channels based on the multimedia capabilities at each site and the available bandwidth[11]. Additional connections can be established as more bits are required and both audio and video compression rates can be adjusted up and down to match limited bitrates. Compatibility with H.320 ensures interoperability with the widest range of third-party teleconferencing systems. In addition, the acquisition, compression and processing, and the communication interface need to be tightly integrated to provide the necessary system efficiency.

The other variety of technical properties, includes data transmission, speed or bandwidth, data quality (e.g., resolution), system functions and features, ease of use, reliability, and service or maintenance requirements [12].

The biosignals are transmitted at the different number of samples per second. For example ECG data can be sampled at a rate of 200 samples/sec by 10 bits/sample or 12 bits/sample, for all monitors used, thus resulting in a generation of 2000 bits/sec and 2400 bits/sec for one ECG channel.

The most important is the image transmission and its pixel resolution. The best pixel resolution for this

system may be  $380 \times 290$ . These pixels can be compressed by using the JPEG compression technique or any other technique that best suits for the application [13].

The signal transmission is done using ISDN, Satellite, & POTS. The PRI maximum data rate used by European countries including Pakistan is 1.92 Mbps and BRI data rate is 128kbps [14]. The satellite links transmission rate depends on the equipment and the satellite system used in each case; it has a range from 2400 bps up to 64000 bps. The use of different satellite systems can increase the cost of equipment and cost of use and it depends upon the designer how well he reduces the cost. Plain Old Telephony System (POTS) allows the transmission of data using a rate up to 56000 bps, thus enabling the continuous and fast information transmission.

In order to decrease the data size, a lossless ECG compression algorithm based on Huffman coding algorithm may be used in the system and can be applied on transmitted signals, when needed by the Base Unit user [15]. The different types of other present coder circuits may also be used to compress the data like A-law,  $\mu$ -law etc [14]. The best and the common choice for video information compression is MJPEG that is worldwide used. Compression and encryption of signals add some delay, especially when powerful system for the telemedicine unit PC is not used [13]. For that reason the encryption is made optional and can be disabled from base unit user.

## **5. Pakistan Perspective and Benefits of the Telemedicine System**

The designed multipurpose system has many benefits typical in developing countries where the rural areas are not facilitated upto the mark. The city hospitals are not capable to accommodate the huge influx of people coming from rural areas for tertiary even mostly for primary care. It is because the lack of resources, lack of management, unavailability of technology and due to lack of trained people as well.

The concept of telemedicine system and its potentials could serve well for such developing countries and particularly for Pakistan. Looking to the current scenario of Pakistan as seventy five percent of the population in Pakistan lives in rural areas where road and transport facilities are limited [16]. It is no exaggeration when one hears of patients being carried on donkey cart or Bull cart for one to two days to reach the nearest district or town hospital for an alignment which could have easily been cured in the patients home place provided information and medical

advise was available. The limitation of provisions for medical services in rural Pakistan is many fold, in particular lack of transport access/money problem due to lack of resources for infrastructure, shortage of doctors and their lack of motivation to work in rural areas.

However, despite limited resources to most parts of the country, telecommunications facilities are relatively well developed. National and international telephone links are available in most parts of the country Internet can be accessed from over 1800 cities of Pakistan and not only that more than 400 cities are on Fibre Optic all over the country [17]. Hence for Pakistan, which is circumscribed with medical expertise and resources, telecommunications can provide a solution to meeting health information need and provide a solution to health problems in rural areas through telemedicine. The concept could enable medical expertise to be accessed by local medical practitioners from district and central hospitals using telecommunications as well as opening the possibility to allow access to universal health information.

The implementation of the such type of systems at initial stage may not be able to provide quality assurances for the rural mass but it could provide solutions to emergency medical assistance, long distance consultation, distance medical education and supervision over space and time for basic yet fatal, common and preventable diseases such as tuberculosis, waterborne diseases and HIV and community awareness.

## **6. Conclusion**

We have designed and discussed a multipurpose telemedicine system. The system is usable in both the cases i.e. in real time mode as well as in static (store and forward mode). The system uses ISDN, Satellite links or POTS links for telehome care. The different types of biosignals, still images and other types of data are collected and transmitted through these communication means. The system is very useful and can be tailored to many other applications. It may easily be put into practice if resources are provided with the trained professionals. The complete model of the system along with its telemedicine unit and base unit is given. The system approaches towards the mobile doctor in all aspects. The system has numerous advantages like cost effective, reduces the traveling time, increase physician efficiency, increase hospital management, decreases rush in hospitals,

saves lives in emergency cases, saves money of poor patients and what not!.

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## REFERENCES

- [1] Tayab Din Memon, BS Chowdhry, AK Baloch, “ Design and Implementation of a Telecardiologic System” , MUET, Research Journal, Volume 23, No. 4, Oct 2004,
- [2] B.S Chowdhry, Faisal Abro, “ Telemedicine Moderanization and expansion of health care systems”, ISBN 969-8680-00-4, published by Mehran Info Tech Consultants, 2003.
- [3] Sven- Olof Karlsson Leif Karlsson, A Report from the Project on “Telemedicine – Regional and National Collaboration” Subproject: “Incentives and Implementation by ” Stockholm, May 2000.
- [4] Tayab Din Memon, BS Chowdhry, Mohasin Sheikh, “Design and implementation of a Low-cost Instrumentation for a Telecardiologic System: A Miracle of Telemedicine”, Global Signal Processing Conference held at Santa Clara Convention Center, California USA, September 27-30, 2004, published for proceeding.
- [5] DR.K. Ganpathy, Neurosurgeon nd medical director, Apollo Telemedicine, Indian Express Group (Mumbai, India). URL: ww.emergency.html
- [6] E Kyriacou, S Pavlopoulos, A Berler, M Neophytou, A Bourka, A Georgoulas, A Anagnostaki, D Karayiannis, C Schizas, C Pattichis, A Andreou and D Koutsouris “Multi-purpose HealthCare Telemedicine Systems with mobile Communication link support”, BioMedical Engineering OnLine 2003, 2:7.
- [7] Telemedicine Association of Oregon, “ Benefits of Telemedicine” Revised: 16 January 2004. URL: <http://www.atasp.org/business/otalink/homepage.asp>
- [8] Donglok Kim, James E. Cabral Jr., and Yongmin Kim “Networking Requirements and the Role of Multimedia Systems in Telemedicine” University of Washington, Seattle, WA 98195-2500.
- [9] Final Report *Prepared for:* Office of the Assistant Secretary for Planning and Evaluation, Department of Health and Human Services Contact Number: HHS-10-97-0012 *December 2000 Prepared by:* The Lewin Group, Inc.
- [10] Stefania Seidenari, Giovanni Pellacani, “ Is JPEG compression of Videmicroscopic Images compatible with Telediagnosis? Comparision between Diagnostic performance and pattern recognition on uncompressed TIFF images and JPEG compressed onces”, Volume 10, Number 3, 2004.
- [11] Mario Cruz, Robyn Flaum Cruz, Elizabeth A. Krupinski, Ana Maria Lopez, M.P.H, Richard M. McNeeley, Ronald S. Weinstein, “ Effect of Camera Resolution and Bandwidth on Facial Affect Recognition”, Telemedicine journal and e-health, Volume 10, Number 3, 2004.
- [12] Telemedicine Report to Congress, January, 2001, USA.
- [13] Roger Crooks , “An Analysis of MPEG Encoding Techniques on Picture Quality”, A video encoding White paper, June 1998
- [14] Warren Hioki, “ Telecommunications”, Third Edition, pages# 483-487, ISBN 0-13-632043-0, Prentic Hall, Inc, 1998.
- [15] Schneier B Applied Cryptography *John Wiley & Sons* 1996, 336-339.
- [16] <http://www.tremu.gov.pk>
- [17] Daily Jang, “Five years to President Pervaz Musharaf”, Karachi Pakistan, 12<sup>th</sup> October, 2004.