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DESIGN OF TELEMEDICINE SYSTEMS FOR RURAL AND URBAN AREAS IN IRAQ

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ABSTRACT

Telemedicine is the use of information technology to deliver medical services and information from one location to another. The evolution and growth of telemedicine is highly correlated with the developments in communication technology and IT software development. In Iraq health services was degraded not only in rural areas, but also, in the big cities because of the migration of doctors, especially, specialist doctors. There is a great shortage in the advance medical equipments so that there is a great need for telemedicine. This paper introduces two issues related to the telemedicine; the first issue is to introduce and discusses the possibilities of all available technologies that can be used to implement telemedicine facility in Iraq. Three scenarios of different levels and requirements were analyzed to cover the possible cases (big city, small town and mobile unit in a rural area). The second issue is to introduce the design and implementation of E-Hospitals to facilitate the process of medical data exchange.

Keyword: telemedicine, wireless communications, network, e-hospitals, tele-education, web technologies**.**

1. INTRODUCTION

Telemedicine is the practice of medicine in which the information between doctors, or the doctor and the patient, circulates over an interactive communication network in the form of audio, video, fixed images and/or data (typical Multimedia application).

Telemedicine may be as simple as two health professionals discussing a case over the telephone, or as complex as using satellite technology and video-conferencing equipment to conduct a real-time consultation between medical specialists in two different countries [1, 2].

Applications of telemedicine nowadays cover a growing number of medical specialties such as [3]:

- Teleconsultation
- Teleconferencing
- Teleradiology
- Telepathology
- Tele-education
- Telemonitoring
- Telesurgery

Rural areas lack sufficient experienced doctors; Telemedicine can eliminate the rural/urban health divide caused by the dichotomy that many of the qualified doctors live in urban areas [4].

2. PROPOSED SCENARIOS FOR RURAL AND URBAN AREAS IN IRAQ

Iraq as a developing country lacks a high speed communication network infrastructure; the available infrastructure is a Public Switch Telephone Network (PSTN) to be used with conventional modems (max speed of 56 Kbps).

This paper proposes a high speed, cost effective, best coverage telemedicine system that accommodates the current facilities available in the country; through the use of hybrid satellite/wireless/terrestrial delivery platforms,
The proposed system consists of three phases, and each phase has its proposed network infrastructure and software applications for medical data exchange that run over it:

The proposed system is an IP based hardware architecture, which uses the VSAT and Wireless LAN communication modalities for telemedicine purposes through the transmission of physiological data and medical images with video conferencing. Figure-1 shows the three proposed phases.

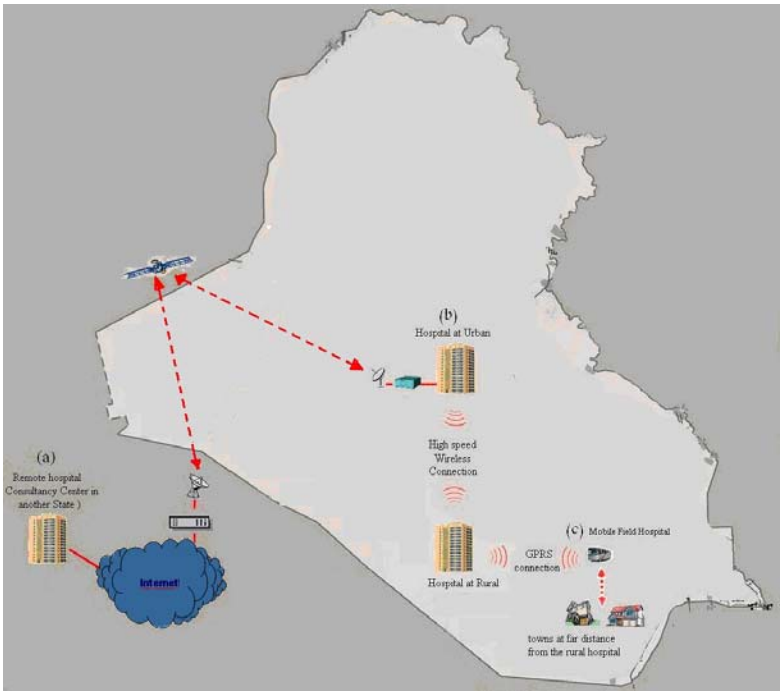

Figure-1. Proposed telemedicine services.

2.1 Scenario-I

International telemedicine service

It includes providing the urban hospitals with high speed Internet connection VSAT, Wireless, ISDN, Fibre Optics, to facilitate the direct connection of these hospitals with the hospitals and medical centres in the world.

The requirements for this phase are the Very Small Aperture Terminal (VSAT) link with the following hardware and specifications:

- Outdoor unit: Comprises of Radio Frequency Transmitter (RFT) and a 3.8m dish antenna;
- Indoor unit: Comprises of IP based satellite modem, and a personal computer; and
- Specifications:
  - Provide a variety of data transfer rates.
  - Have the advantage of operating all over the world.
  - Works in the C-Band.
  - Uses the GSAT satellite for the communication.

- IP based where the medical data transmission and video conferencing can be carried out simultaneously by assigning a static IP address between the transmitting and receiving systems.

In order to provide an urban hospital in Iraq with high speed Internet connection, it is recommended to provide the hospital with VSAT SCPC DAMA connection with minimum bit rate of 384 kbps up to 1Mbps.
Two configurations can be used for VSAT connection:

A- Point-to-point connection

The VSAT would provide network connection between the server and the client, in which it uses private static IP addresses for the server and the client; its advantage is that it will provide dedicated connection and its disadvantage the connection would be limited between two points. Figure-2 shows the layout of this configuration.

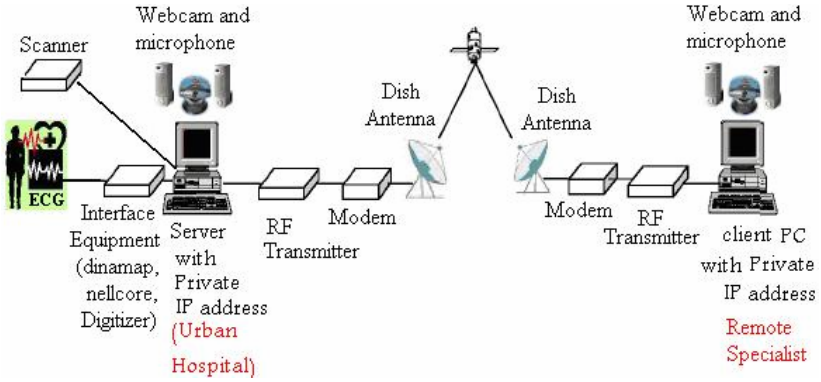

Figure-2. Point to point connection using VSAT.

B- Point to multi-point connection

In which the VSAT would provide Internet connection for the PC with public IP address, as an advantage it is possible to connect to any consultation (hospital, specialist) connected to the Internet and use the various applications that are running on the Internet such as the IM (Instant Messaging) programs like Yahoo Messenger, MSN Messenger, AOL Messenger etc. which provide chat, voice and video streaming facilities.

Even more Web and FTP services can be run on the server computer thus enabling the remote specialist direct access to the medical records. Figure-3 shows the layout of this configuration.

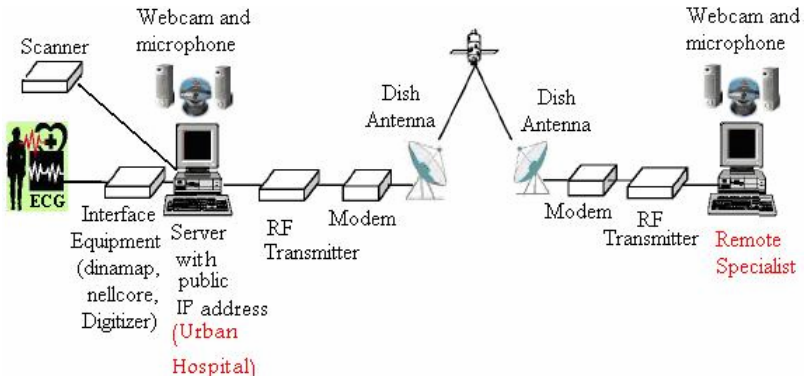

Figure-3. Point to multi point connection using VSAT.

For Iraq it is recommend to use the Multi-point connection, i.e. server PC with public IP address, thus providing the ability of connection between any remote specialist, hospitals even making use of the local consultancy from local hospitals (if they are provided with Internet connection) thus there will be no full dependency on the foreign consultancy.

2.2 Scenario-II

Local telemedicine services

It includes connecting the rural hospitals with urban hospitals via high speed wireless network and ISDN; to increase the capabilities of the rural hospitals in a wide range of health care.

These services are carried between the urban and rural hospitals and the urban hospitals themselves; WLAN presents an appropriate selection to connect urban to rural hospitals in Iraq; WLAN provides high speed connection:

- Up to 11Mpbs for 802.11-b Access Point devices (APs)
- And 54 Mbps for 802.11-an access point devices.
- Coverage may vary depending upon:
- Antennas type (omni or high directional).
- Power amplifiers used,
- Transmission scheme.
- The type of the devices and manufacturer.

For example using (M24500 Trango 2.45 GHz Access Point) would provide point to multipoint connection with 5Mbp over a distance of 40 km. The WLAN will provide IP network infrastructure, thus it is possible to make use of the high speed intranet connection to run IP based applications such as:

- The Windows NetMeeting which provide chat, voice, Video conference, File ……transfer facilities to enable live communication (discussions, suggestions).

Web and FTP services to hold the medical records of the patients.

Media acquisition still applies here with the urban hospital as the remote hospital and the rural hospital as the local hospital. Figure-4 shows the layout of this scenario. The theoretical maximum distance for an RF system in an outdoor environment can be calculated by using the following equations [5]:

Distance = (300 / Freq) * EXP [(System gain) / {6 * log (2)}] ---------- (1)

Then the overall system performance based on antennas, cables, and radio capabilities is calculated:

System gain = Transmitter power + Antenna 1 gain - Cable 1 loss + Antenna 2 gain - Cable 2 loss + Receiver sensitivity -10 ----------(2)

The system gain determines how much overall path loss is possible. It takes into account the gain of antennas at both ends of the RF link, the transmitter power and minimum receiver sensitivity, and any associated RF cables. Subtracting from this value 10 dB in the formula provides an extra 10 dB of margin (fade margin) in the event of environmental condition changes [5].

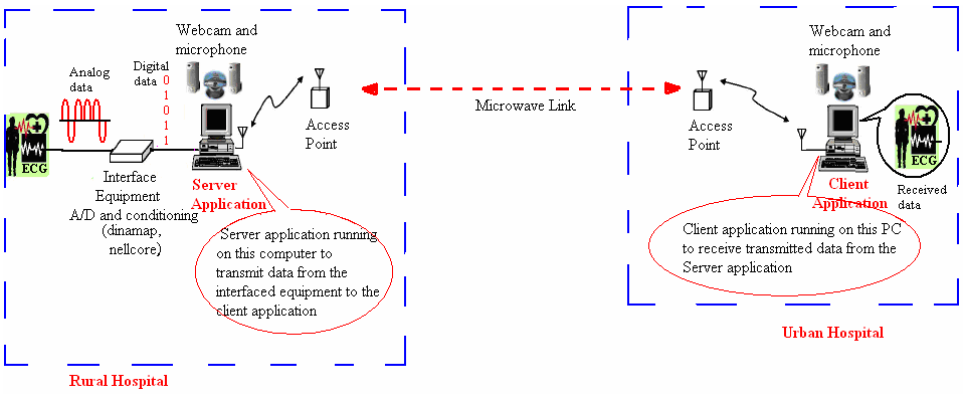

Figure-4. Data transmission from the server application of the rural hospital to the client application of the urban hospital.

The rural hospital can be also provided with Internet connection from the urban hospital (if it is provided with Internet connection) thus there is ability for a remote hospital to get remote consultant, i.e. all the services running in Scenario I can be utilized here.

2.3 Scenario-III

Mobile field hospital (MFH)

Population in the rural areas of Iraq is not distributed uniformly as a result some towns may be more than 20 Km from the nearest rural hospital, some medical cases would require urgent medical treatment with experienced doctors, so that it is necessary to connect the medical units or mobile field hospitals with the nearest hospital to get the necessary consultations.

In Scenario two Access Points were used to establish wireless network connection between the hospitals thus providing intranet connection. This phase also intends to provide intranet connection with mobility which is necessary for MFH.

The GPRS network can be used to provide intranet connection between any number of GPRS devices (mobile devices), in which mobile devices would be attached to computers providing them with intranet connection thus it is possible for a MFH doctor to have a video conference with another doctor uses the GPRS network (everywhere through the network) as shown in Figure-5.

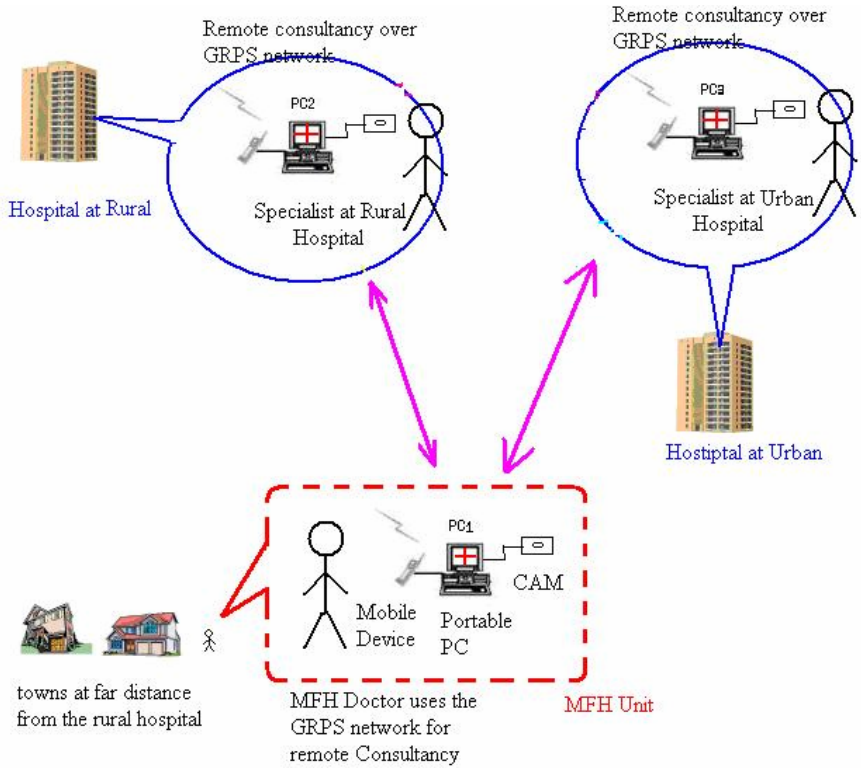

Figure-5. Remote consultancy service for MFH.

3. PROPOSED MEDICAL DATA EXCHANGE SYSTEM (E-HOSPITAL)

In this section an efficient medical data exchange system (E-Hospital) would be designed to run over the proposed network infrastructures discussed in section two. This section introduces the design and implementation of the software necessary for this process.

3.1 E-hospital website

The key idea of this work is to enable the remote specialist and local doctors to act as they are working together in spite of distance between them, this is achieved via the E-hospital were medicine would be practiced over the Internet, the E-hospital should simulate the functions and services provided by the real hospital as possible. Figure-6 shows the designed homepage of the proposed E-hospital.

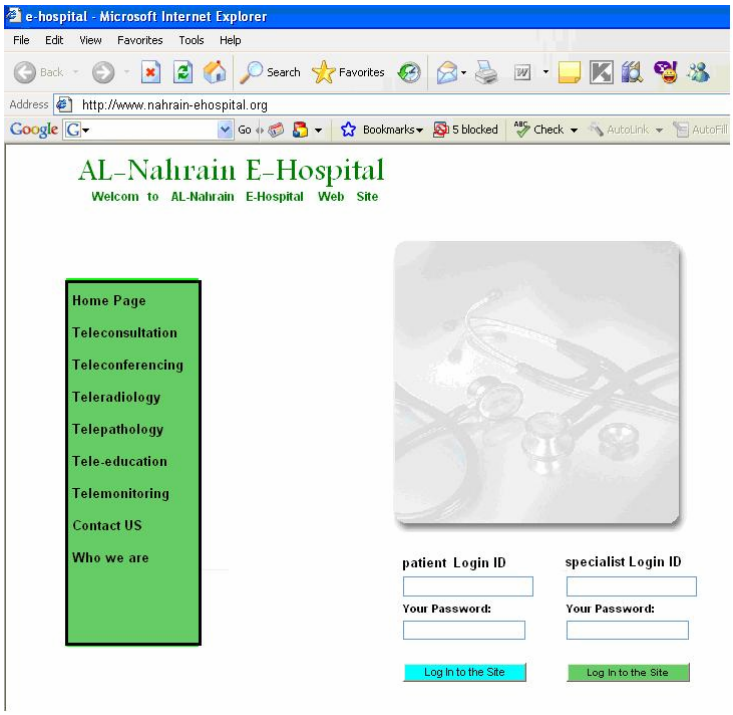

Figure-6. Home page of the proposed E-hospital.

The right side of the site contains the login fields of the patients and the specialist were each one of them would be directed to his working area.
The left side of the site contains the available departments and other management services.

3.2 E-hospital software requirements

An e-hospital would require:

a) An effective network infrastructure which is discussed in section two.
b) Electronic medical records of the patient so they can be exchanged on the Internet
c) Web and Data base servers to hold the web pages and the data.
d) Software for interfacing and networking the medical devices.

3.3 e-hospital software design

It is apparent that for the e-hospital there would be a huge data exchange between the hospital and the remote specialists, time is a governing factor in this process, i.e. upload and download time should be minimized as possible, for this reason we recommend to have the Servers (Web, Ftp and Database) in the hospital it self, thus reducing the upload and download time to 50% as explained below:

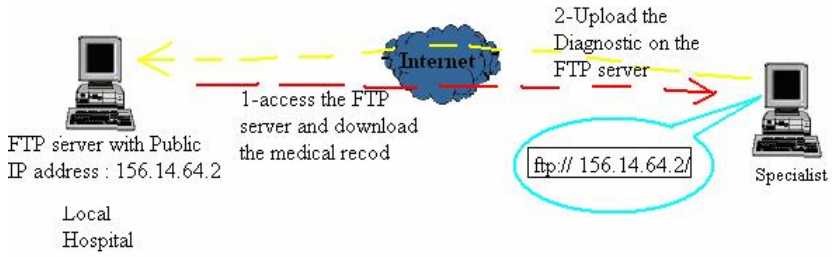

Figure-7. Medical data exchange using the proposed FTP service.

Figure-7 shows that only the remote specialist has to upload and download via the Internet, the hospital has the server locally i.e. it is accessible within LAN speed.

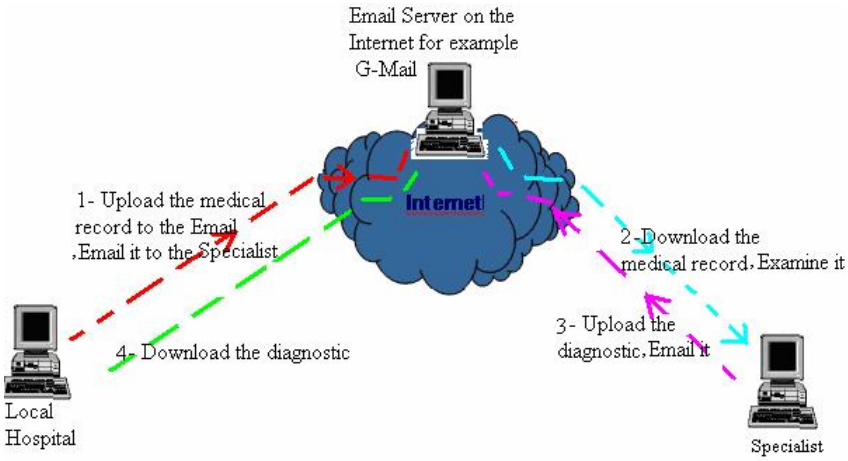

Figure-8. Medical data exchange using the conventional way (Email).

Figure-8 shows the conventional method which uses Emails in which both the hospital and the specialist would have to upload and download via the Internet.

3.4 E-hospital software implementation

The web site of the e-hospital is programmed in PHP and mounted on the e-hospital web server which will be provided with Apache web server and PHP script engine as shown in Figure-9.

PHP is used to query user inputs and inject them into database thus allowing information update by using browsing technology.

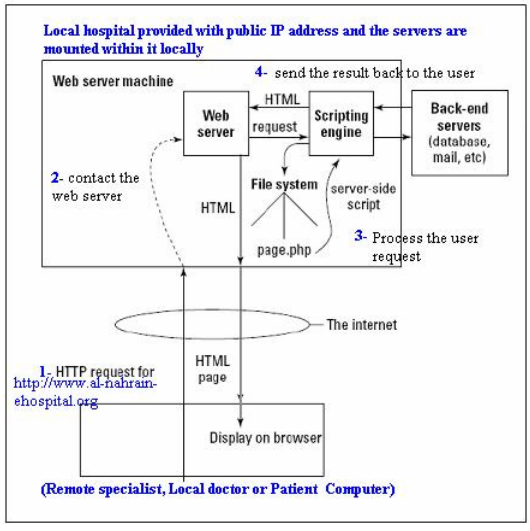

Figure-9. Page request process.

3.4.1 E-medical records on FTP server

The step in constructing an e-hospital is provide the medical information about the patients in digital form i.e. to converting it from paper form to E-medical records which can be exchanged on the Internet, thus the medical records would be converted to digital format by scanning them in the local hospital or by converting them to Excel, word documents and save them on the File Transfer Protocol (FTP) server of the hospital, the remote doctors

would be provided with FTP accounts (user-name and password) this authenticate them to access the FTP server, download the record, examine it, and upload the diagnostic to FTP server of the hospital.

3.4.2 Medical records using web pages

A template Web-page for medical record is implemented as shown in Figure-10, the Web-Pages would be saved on the Web-server (in the local hospital); The page has Two buttons "Submit" and "edit" the remote specialist is authorized to use the submit only which allows him to change the fields marked with single quota (*) the other fields are editable by the local staff, thus a remote doctor can browse the medical record of a patient and make an instant recommendation by using the "submit" feature.

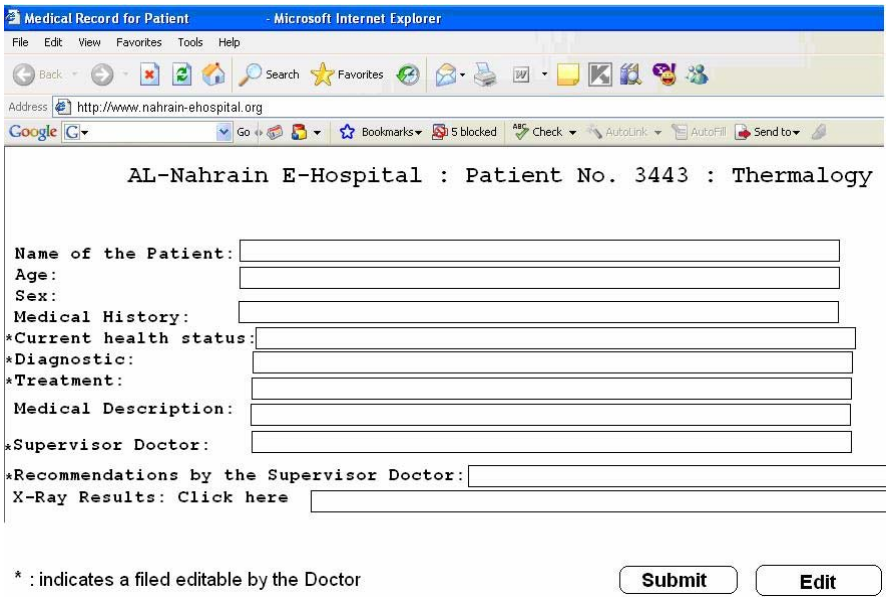

Figure-10. Template webpage for the implemented e-medical form.

The e-record is written in PHP and the data is stored in MySQL data base.

c) Multi-consultations

The e-hospital can also provide multi-consultation facilities by allowing the specialists to post their recommendations based on the medical info and the recommendations of the previous specialists as shown in Figure-11.

This page is implemented in PHP and the data is hold in MySQL database.

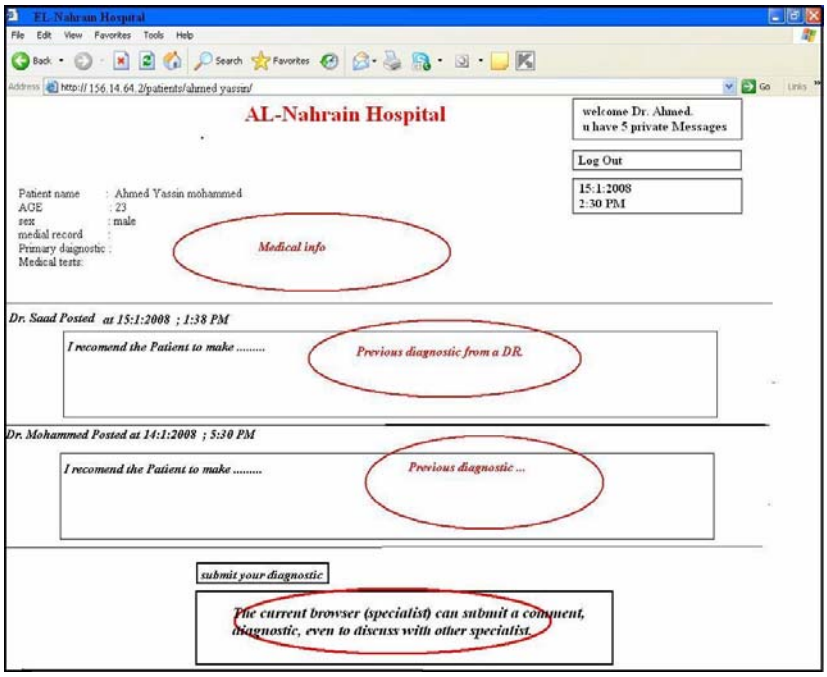

Figure-11. Multi-consultations on e-record.

3.5 Video conferencing

The video conferencing can be achieved by the available IM (Instant Messaging) programs which utilize Voice over Internet Protocol (VoIP) and multi-point videoconferencing client they provide chat, audio video streaming; even more they can be used for data exchange since they are provided with file transfer capabilities.

3.6 Media acquisition

This comprises the output from all the clinical instrumentation that would be attached to the telemedicine system to capture data from the patient. Some devices would provide the data in analog form and some in digital form; the output from analog devices would be connected to digitizer (A/D) and conditioning circuits.

The use of client server network application written in VC++ 6 can be proposed for data transmission i.e. to make streaming applications; the medical device would be interfaced to the parallel port, serial port, PCI slot, ISA slot of the PC (server) which runs the streaming server application that transmits the data to the receiving terminal that runs the client application. Figure-12 shows the layout of this scenario.

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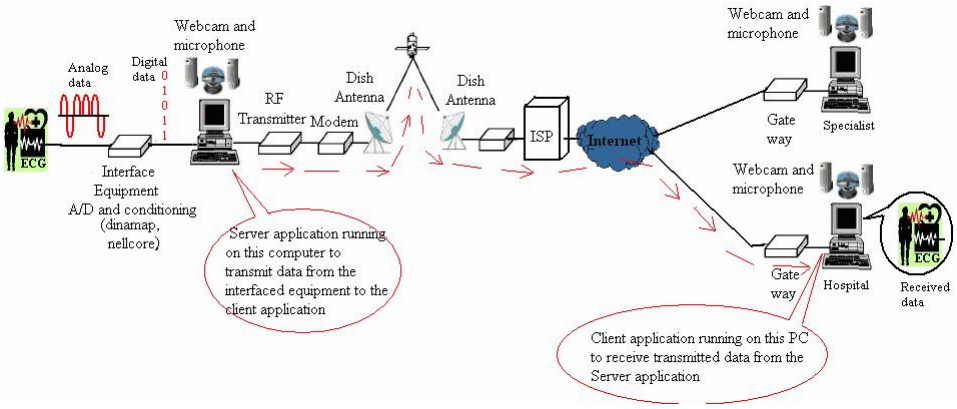

Figure-12. Data transmission from server to client application.

4. RESULTS AND DISCUSSIONS

The proposed scenarios give the opportunity to implement the telemedicine system according to needs and the available technologies.

The use of the locally mounted servers in the hospitals has reduced the download and uploads time to 50%; it also provided the local hospital with a better control for their data.

The e-hospital has provided the multi-consultations in real and non-real time between doctors nevertheless about the distance between them, the high speed Internet connection would allow the e-learning

because hospital patients and doctors are restricted in their mobility and can therefore profit from being independent on the time-space coordinates of conventional face-to-face learning. Social interaction and joint learning activities with peers become possible with the help of virtual tools. e-hospital would open a new field to the outside world thus it would create a medical education for the local doctors when they work with remote specialists.

A national telemedicine project is very important to be implemented nowadays in Iraq due to the following two reasons; the first is the great need to get specialist doctors consultations because of the migration of doctors, especially, specialist doctors, the second is economic wise, where the patient now has to spend a lot of money, effort and time to reach a specialist doctor abroad. The technology required for telemedicine is mature and available for implementation. There is support for encouraging countries to make use of this new field, especially the developing countries, from international organizations like WHO, UNOOSA, ITU, ESA etc. that could provide the support in financial and experience forms.

5. CONCLUSIONS

This paper introduces the design of telemedicine project and discusses the possibility of implementation for different system according to the available technologies and needs. Three scenarios of different levels and requirements were proposed and analyzed which can be used to reduce the suffering of the Iraqi peoples.

This paper also introduces the design and implementation of e-hospital to facilitate the process of medical data exchange. It gives different tools and optimized methods to facilitate the work for the specialist and patient.

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