Web-based Medical Informatics to Support Telemedicine System

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***Abstract*—The remarkable growing of telemedicine implementations around the world allow users to enjoy better health services by increasing attention, patient comfort and opportunities to achieve good diagnosis among other advantages. This is achieved by using web-based applications including Modern Medical Informatics Services which is easier, faster and less expensive. This system will be efficient by finding the suitable informatics and electronics solutions for the Tele-medicine healthcare. An approach to manage multimedia medical databases in a telemedicine system is proposed. In order to manage, search, and display patient information more efficiently and effectively, we define a doctor and patient information package as a concise data set of a doctor's data and patient's medical information from each visit. We also provide the methodology for accessing various types of patient medical records as well as design two types of user interfaces, high-quality data display and web-based interface, for different medical service purposes.**

***Index*-- Telemedicine, Medical Informatics, Teleconferencing, Teleconsultation, Telediagnosis, web-based medicals applications , World Wide Web (WWW).**

1. INTRODUCTION

Due to insufficiency of medical resources and lack of opportunities for continuing education, physicians may be reluctant to serve in rural areas or geographically isolated regions. Therefore, people who live in these areas may receive lower effectively medical care than those who live in urban areas. It is very important to develop a telemedicine system for improving the quality of medical services and providing more educational opportunities to physicians in rural areas [1]–[4]. Telemedicine can be defined as the providing of medical services over a distance. When telemedicine service requires patient history, medical images, and related information, telemedicine and the Picture Archiving and Communication System (PACS) become very similar [5]. Based on PACS [6]–[11], an integrated telemedicine system must consist of the following five subsystems:

1. Acquisition subsystem , Wireless Sensors Network (WSN)
2. Viewing subsystem, web-portal Interface
3. Teleconferencing subsystem, by Internet
4. Communication subsystem
5. Database management subsystem

The acquisition subsystem collects multimedia information [12] and converts it to a standard format (e.g., DICOM 3.0 [13]). The viewing subsystem displays and manipulates the images and other patient medical information [14]–[15]. The teleconferencing subsystem, which is not usually included in a PACS, allows face-to-face interactive dialog between physicians in rural areas and medical centers [16]–[18]. The communication subsystem includes local area networks (LAN's) and a wide area network (WAN) to transmit and receive data [19]–[21]. Patient medical information consists of chief complaint, history of illness, results of physical examination, laboratory tests, and diagnostic images. This information may be of the following types: text, voice, still image [e.g., x-ray, computed tomography (CT), or magnetic resonance imaging (MRI)], and dynamic video (e.g., video esophagogram, cardioangiography, sonography, and endoscopy) [22]–[24]. Thus, it is essential to design a medical information database for managing a huge amount of heterogeneous data. In some studies [14],[25]–[27] However, this approach may complicate archiving operations and introduce an inconsistency problem while concurrently accessing the image data [28]. The dynamic video may be stored and managed using analog videotapes [29], [30]. This management approach may make it difficult to access the videotapes and share them simultaneously. Moreover, it may perplex the integration of video with text and images in a telemedicine system.

To solve these problems, we propose a data management methodology by which medical information can be organized based on the patient's complaint as well as his/her medical history. We also support a unified interface for manipulating and accessing the different types of medical information mentioned above. The management of medical databases and the user interface has been implemented as major components of a telemedicine system implemented in AinMedical.com.

2. SYSTEM ANALYSIS AND DESIGN

2.1. Telemedicine System Services

We proposed a telemedicine system that supports teleconsultation, telediagnosis, and tele-education. In *teleconsultation*, medical specialists at a medical center provide second opinion to rural physicians who have referred, their patients to the specialists. The rural physicians and the specialists share the patient's medical records and discuss the symptoms of the patient's conditions interactively. The patient's final diagnosis is reached following discussion between the two physicians. In teleconsultation, a synchronous two-way videoconferencing system and a document-sharing mechanism are needed to allow rural physicians to send their patient's medical information to specialists and engage in face-to-face conversation. In *telediagnosis*, similar to teleconsultation, the specialist makes a diagnosis based on the received information. The major

difference between telediagnosis and teleconsultation is that the former requires high-quality data and images to achieve an accurate diagnosis, while the latter requires a synchronously interactive conference environment. Telediagnosis can be performed asynchronously. That is, the specialist can make the diagnosis at his convenience and then forward the diagnosis report to the rural physician. In *tele-education*, a rural physician playing a student role obtains advanced medical expertise from the specialists. There are two ways to deliver education to rural physicians. First, knowledge may be delivered from the specialist in a face-to-face manner through teleconferencing. So, real-time videoconferencing system is required for interactive communication. Second, the medical teaching materials may be organized and converted to a digital multimedia textbook presented on the World Wide Web (WWW). A network discussion panel may also be created for exchanging ideas and discussing problems among students and teachers. Rural physicians can access these materials and educate themselves via the Internet. In this operational mode, an authoring tool for compiling teaching materials and a user friendly interface for browsing and discussing the multimedia textbook are required.

In order to meet the requirements of teleconsultation, telediagnosis, and tele-education simultaneously, patient medical records and the associated images must be organized in such a way that a physician can access the database based on a patient's clinical history and a medical student can access the database based on particular cases (clinical problems). It means the database must meet different purposes by providing both patient-oriented data folders and problem-oriented data folders. A patient-oriented data folder is used to store the medical records of a single patient; a problem-oriented data folder is used to store the medical records of one specific case.

2.2. Conceptual Databases Models

In clinical practice, a physician makes a diagnosis and treatment plan not only based on the patient's current situation, but also on a review of the patient's history and references in similar disease symptoms. Traditional medical databases are constructed according to the type of material in the records. Records, laboratory data, physicians' notes, consultant comments, and diagnostic medical images from different sources were managed in separate files. Although this management method is relatively easy to maintain, it is difficult to trace the history of particular problem. To resolve this difficulty, we have defined a database as a concise data set containing all of the medical diagnostic information. Besides, the database package can manage and save any change of status or new information that emerges from the subjective description, objective description, assessment, and plan; these derivations are based on subjective, objective, assessment, and plan (SOAP) medical record methodology [30].

The subjective description (S) refers to the description of a patient's chief complaint and the history of the disease problem. It is interpreted from the patient's point of view, and in **this** study, includes symptom code, duration, location, severity, description, and chief complaint. The objective description (O) records the results of all measurements during the current visit and factual plan results as noted by the physician during the previous visit concerning the same problem. In this part, physical examination results, laboratory data, and diagnostic plan conclusions are summarized in the fields of item, location, finding, sign-code, and description. The assessment information, part A, records the physician's diagnosis and a description of the disease problem based on the information in part S and part O It is expressed with the problem ID and an assessment description. The plan information, part P refers to the diagnostic and therapeutic plans made by the physician specifically addressing the patient's problem.

2.3. Database Implementation

It is noteworthy that, as in Fig. (1), part of the medical record is a form of multimedia. An important point in system design is how to build a **medical information database system** to manage heterogeneous data. Although the relational database provides a set of powerful tools to manipulate data, its template of predefined data type limits its ability to manage large objects. In our implementation, the attributes of Video and Images are defined as FILE type. The attributes of Report, Chief Complaint, Description and other attributes are defined as TEXT type. More importantly, they can be uniformly manipulated in SQL queries.

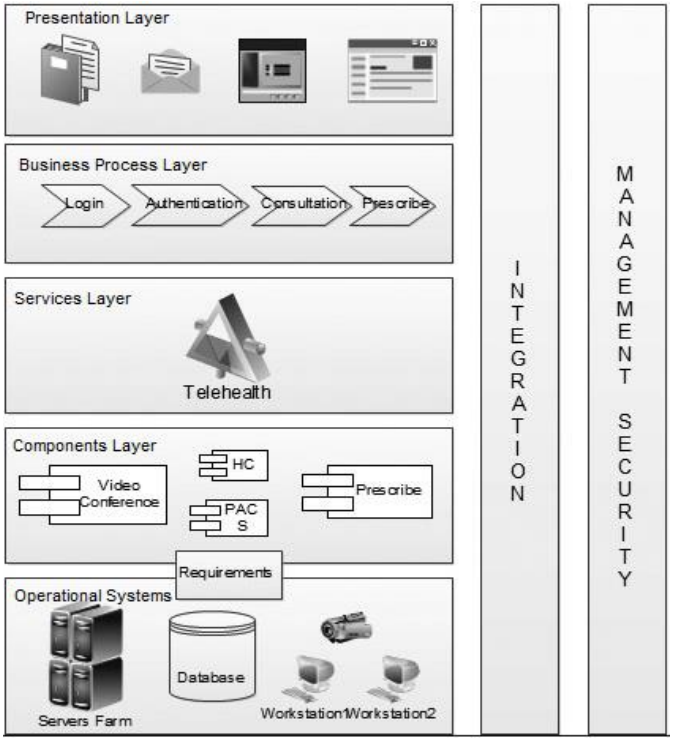

Fig. 1. Web-based telemedicine system Arch. [1]

In addition to data integration, speed of data retrieval is also a factor that affects the performance of the telemedicine system. In this paper, a three-layer hierarchical **medical information database system** is created; the three layers consist of main

database, long-term database, and local database. The main database stores medical information concerning patients who have visited within recent months. After this period, the data are moved to a long-term database. Then the long-term database server packs the image data according to time of creation and manages it in the DICOM media storage directory (DICOMDIR) format, which is introduced by the American College of Radiology and the National Electrical Manufacturers Association (ACR/NEMA) to store DICOM-formatted medical images in permanent media [31].

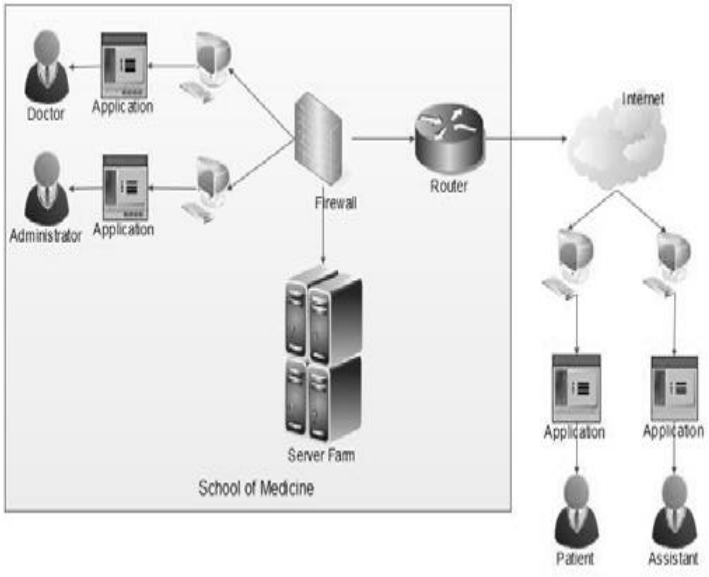

Fig. 2.AinMedical.com Telemedicine Architecture

The local database provides a short-term storage location for the medical records of patients currently visiting. It functions to reduce workload of the database server and traffic of the network. In order to prepare the most frequently used data, the PREFETCH mechanism, which works to reduce the data accessing time, is incorporated into the local database installed in the medical center. During teleconsultation, the PREFETCH precedes the diagnosis and accesses medical records according to the schedule. In telediagnosis, the medical records must also be prefetched if the diagnosis report has not yet been completed. Moreover, the REFRESH mechanism is also incorporated in the local database at the rural site to maintain acceptable communication reliability. It stores the medical records of newly visiting patients in the local database and forwards these records when the communication channel has been successfully connected. Thus, it can avoid data loss caused by failure of the communication channel.

3. Web Architecture Implementation of Medical Information Database System

With the previous requirements, the architecture is implemented through web platform. In Fig. (3) navigational map interface is shown based on the patient profile who is the main user. Fig. (4) shows the navigation map for a doctor who is responsible of creating an electronic medical record based on the established standards by the national law and working. The entire process is implemented with security standards to protect recorded medical information. The medical specialist gives his diagnosis according to previous profiles.

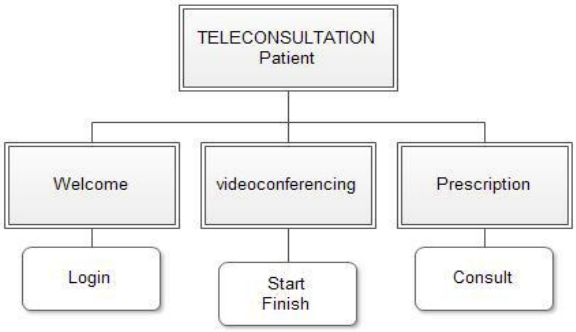

Fig. 3. Navigational Map for the patient

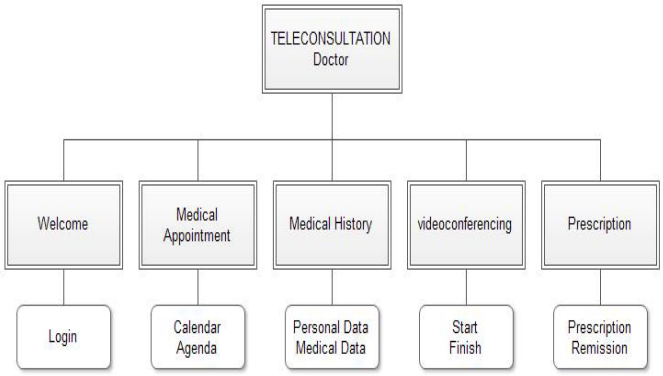

Fig. 4. Navigational Map for the Doctor

We will discuss the details of each stage as following:

1) ***Patient Registration Profile***, the system Requirements are registration of a new user as Patient which allows him to a new patient to become a member of the AinMedical's portal. This Use Case describe the Actors as: Patient who uses website with Pre-condition having a valid email address to complete registration. AinMedical portal sends message to new doctor to activate his/her account. A Message is also sent to AinMedical's Administrator (new Patient has been registered), AinMedical presents welcome page for New Patient and provide link to login his account. As indicated in Fig. (5).

2) ***Doctor Registration Profile***, the system Requirements are registration of a new user as Doctor which allows him to a new doctor to become a member of the AinMedical web-portal. The Doctor who uses website with Pre-condition having a valid email address to complete registration. AinMedical portal sends message to new doctor to activate his account. A Message is also sent to AinMedical's Administrator to approve his/her account or delete it. if AinMedical's Administrator approved the doctor registration, AinMedical presents welcome page for New Doctor and provide link to login his account. As indicated in Fig. (6).

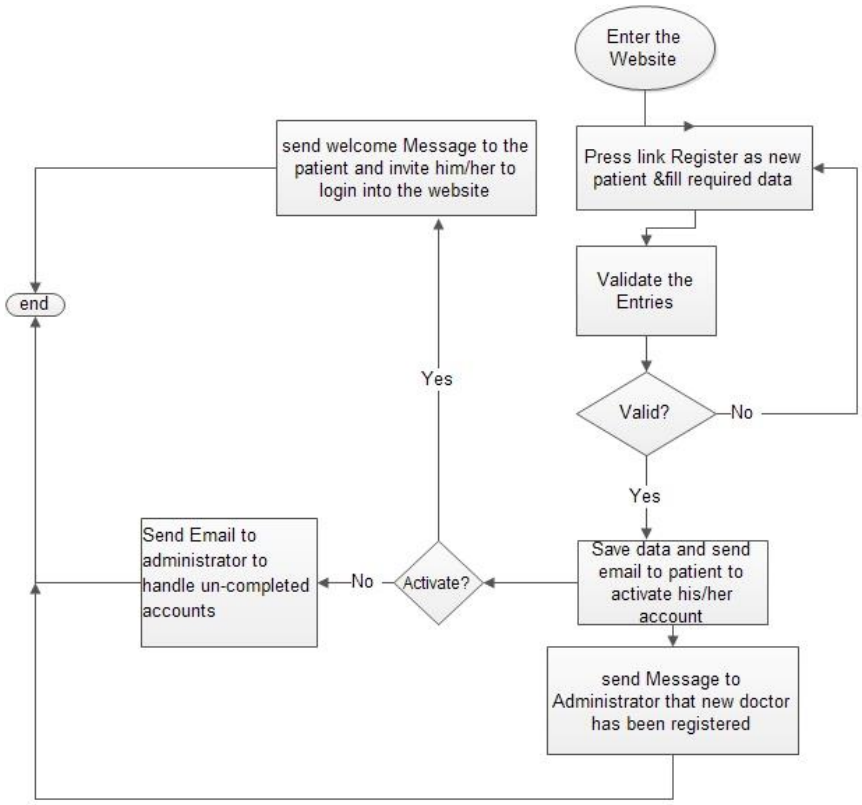

Fig. 5. Patient Registration Profile

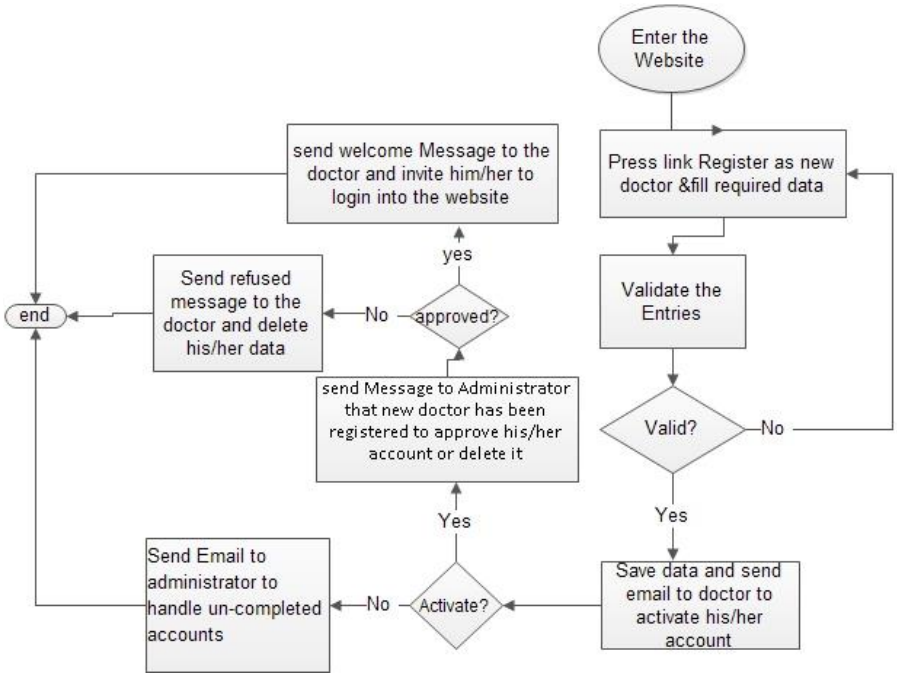

Fig. 6. Doctor Registration Profile

3) ***Telemedicine services Activation,*** From Doctor side, the requirements of telemedicine services activation needs to manage doctor's account, the doctor already activated this service for his account then user press "Add/Manage Telemedicine service" link to activate it for the first time or manage his data in it respectively and the flow chart appeared in Fig.(7)

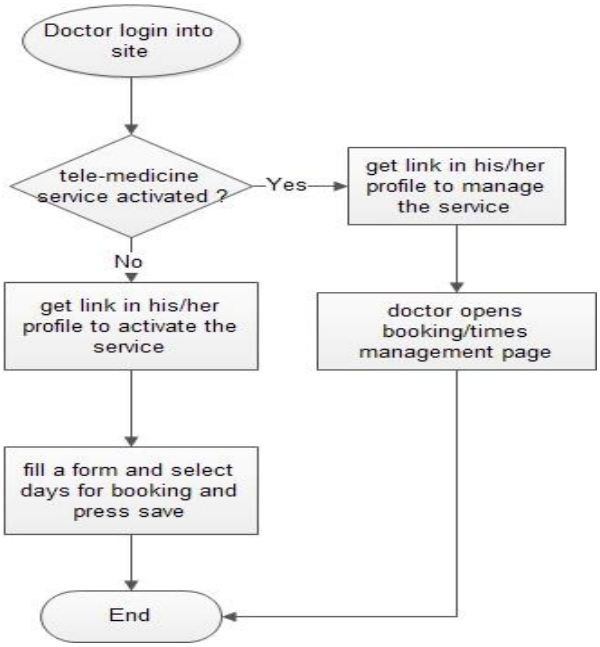

Fig. 7. Telemedicine services Activation

4) ***Doctor Manage telemedicine services & their setting (days & time-slots /cost)***, If Portal's doctor needs to review/mange telemedicine services, it requires him to login with his account then press "Manage Telemedicine service" link to review his telemedicine services, add new services and change them. If Portal's doctor needs to review/mange telemedicine setting (days & time-slots /cost), it requires him to login with his account then press "Manage Telemedicine service" link to review service setting, add new times and change days & time-slots /cost.

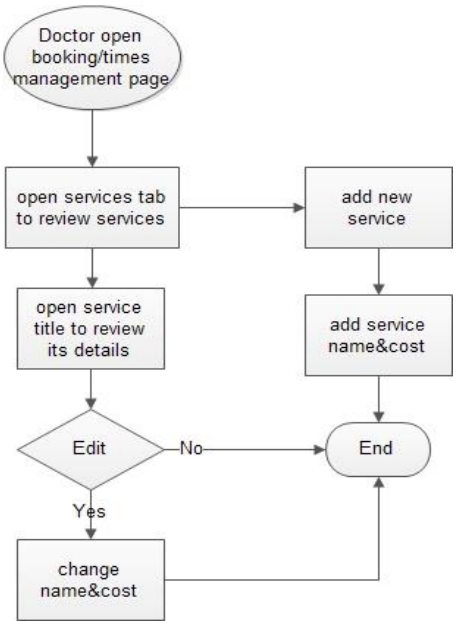

Fig. 8. Doctor Manage telemedicine services

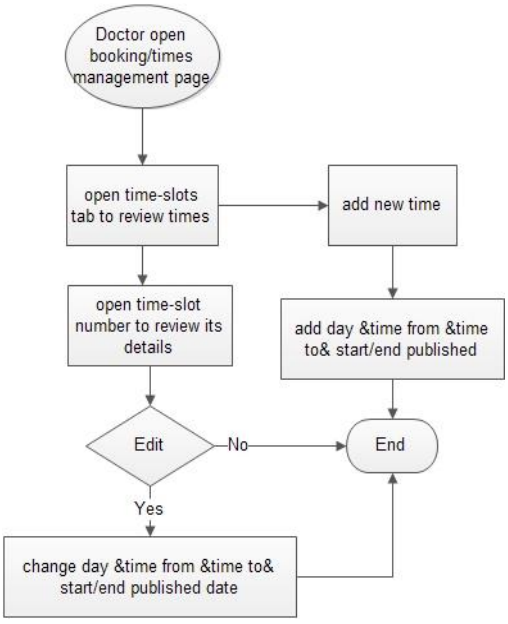

Fig. 9. Doctor Manage telemedicine settings

5) ***Doctor Manage booking requests***, If Portal's doctor needs to review/mange booking requests), it requires him to login with his account then press "Manage Telemedicine service" to review booking requests and user select request to review its details (patient data, time, patient medical history), user can change request status or add prescription and required radiograph & tests.

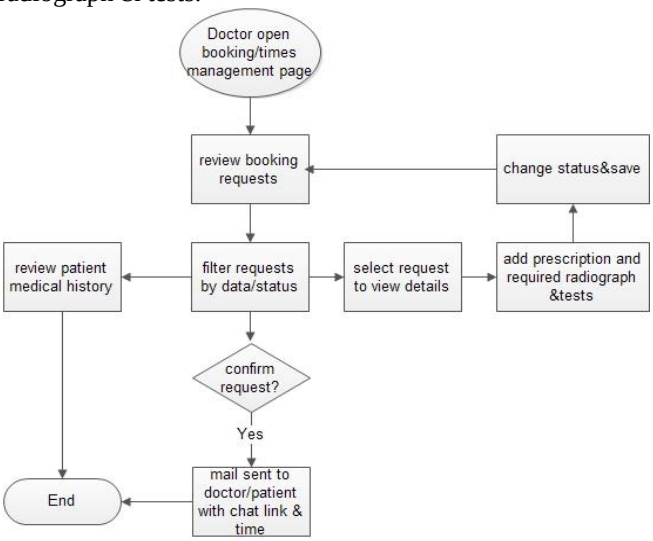

Fig. 10. Doctor Manage booking requests

6) ***Patient add basic information & medical history***, From patient side, the requirements of telemedicine services activation needs to manage doctor's account, Portal's patient need to add his basic information. The patient enter to Telemedicine link, then user press " Add/View medical history", and select the needed link to review/add data for (basic information, diseases, symptoms ,pharmaceuticals, surgeries, sensitivities, radiograph, tests).

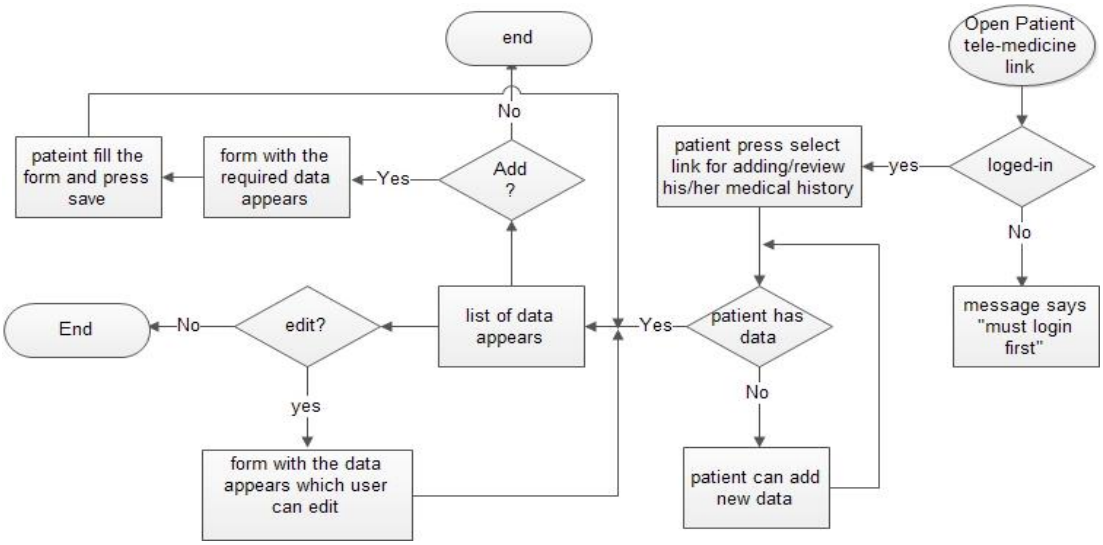

Fig. 11. Patient add information of medical history

7) ***Patient makes booking & reviews his booking list***, If Portal's patient needs to use telemedicine services and make booking, this requires the patient to review doctor list or search doctors. The patient press "book now" which beside the doctor he needs, fills the form of booking and select the time and press send. The request will be sent and the payment taken from patient credit.

If Portal's patient needs to review his booking list. the patient enter to Telemedicine link, then user press “booking data” link & review his booking list. If the conversation with doctor done, patient can review the prescription and required radiograph & tests.

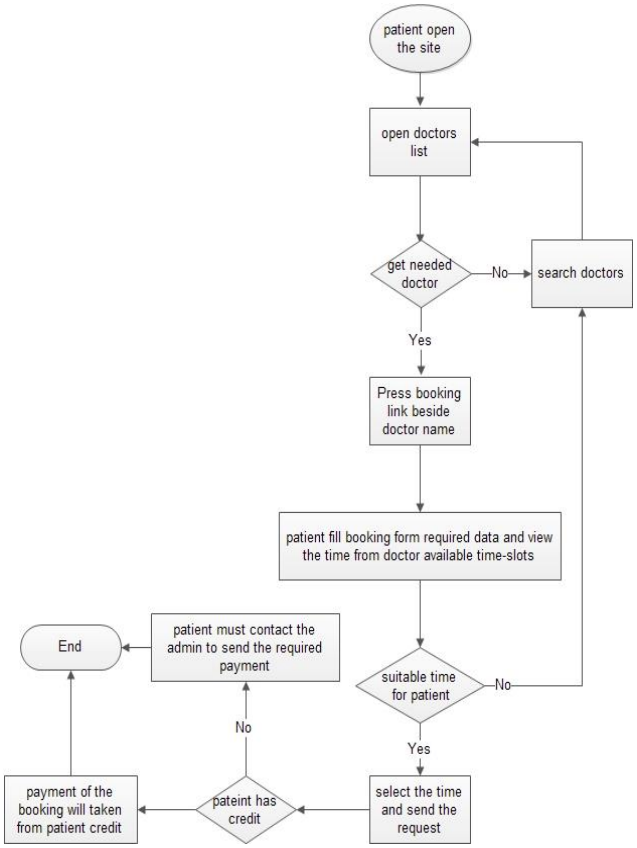

Fig. 12. Patient makes booking

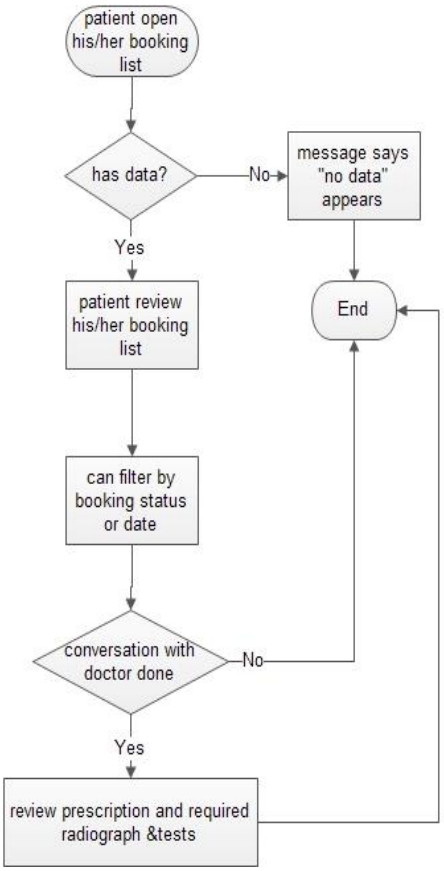

Fig. 13. Patient reviews his booking list

4. SCREEN SHOOTS OF IMPLEMENTED MEDICAL SERVICES

In this section will show the implemented services of each stage in Ain Medical portal as following:

1) *Patient & Doctor Registration Profile*.

http://ainmedical.com/index.php?option=com_community&view=register&task=register&Itemid=501&lang=en

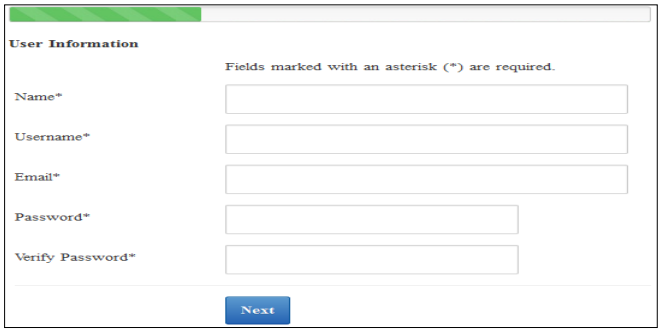

Fig. 14. Registration Profile in AinMedical.com

2) *Telemedicine services Activation*.

http://ainmedical.com/index.php?option=com_rsappt_pro2&view=advadmin&lang=en

Fig. 15. Telemedicine services Activation

3) *Doctor Manage telemedicine services & their setting (days & time-slots /cost)*

http://ainmedical.com/index.php?option=com_rsappt_pro2&controller=admin_detail&task=res_detail&cid[0]=2&frompage=advadmin&tab=1&lang=en

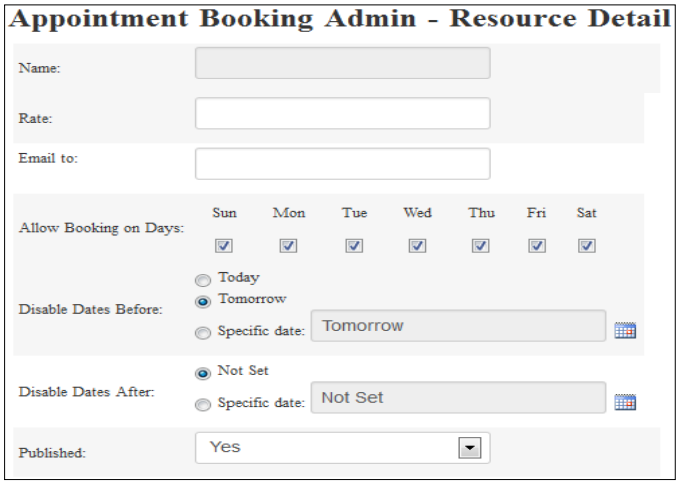

Fig. 16. Doctor Manage telemedicine services in AinMedical.com

4) *Doctor Manage booking requests*.

http://ainmedical.com/index.php?option=com_rsappt_pro2&view=advadmin&Itemid=&current_tab=1&lang=en

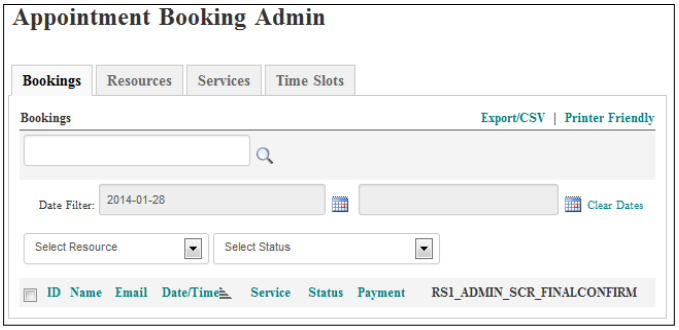

Fig. 17. Doctor Manage booking requests in AinMedical.com

5) *Patient add basic information & medical history*.

http://ainmedical.com/index.php?option=com_mtree&view=mypage&type=listing&caid=76&Itemid=487&lang=en

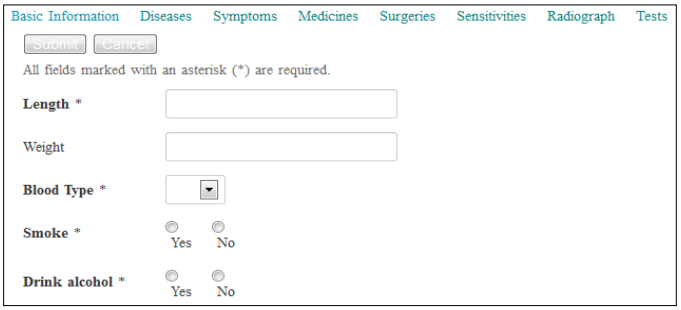

Fig. 18. Patient add information of medical history in AinMedical.com

7) *Patient makes booking & reviews his booking list*.

http://ainmedical.com/index.php?option=com_rsappt_pro2&view=mybookings&Itemid=486&lang=en

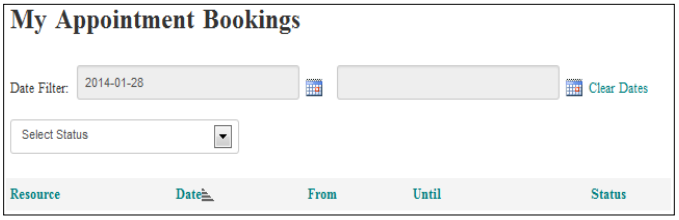

Fig. 19. Patient reviews his booking list in AinMedical.com

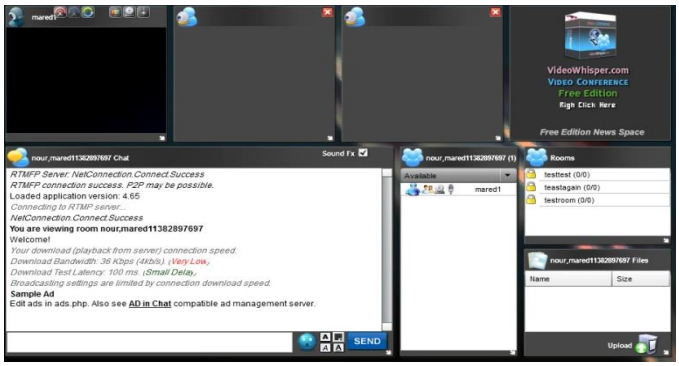

Fig. 20. Video conference through Ain Medical Portal

5. CONCLUSION

The medical services provided by the telemedicine system at the rural site are eagerly needed by the elderly. The system allows the elderly to avoid traveling a long distance to get better care. Evaluation results show that the telemedicine system is relatively feasible in the case of teleradiology. Telemedicine has shown the capability not only to improve the quality of healthcare, but also to increase the opportunity of continuing education for physicians at a rural site. According to the results of the survey, the WWW environment's features of multimedia and hyperlinking made the web-based browser suitable for displaying medical teaching materials.

We proposed telemedicine system used to provide medical services to a rural healthcare center. Three operational modes of the telemedicine system are explored through the system developed. In order to fulfill the requirements of medical practice, we implement Web portal application that functions as a database encapsulating medical information obtained during patient visits. The Web-based data structure can reduce the complexity of accessing medical information. In this study, we also integrate multimedia patient information within the same database system and provide two kinds of user interfaces for different medical service purposes.

FUTURE WORK

There are many other aspects that can be explored in the future. One is to add a data mining technique to the system [32]. This could allow the formulation of diagnostic behaviors and build a knowledge base to assist diagnosis and medical teaching. The other is to incorporate image compression technique to speed image transmission [33]. These advances may help researchers to not only explore the knowledge of medical behavior, but also expand the feasibility of the telemedicine system.

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