Development of ICT-based Mobile Telemedicine System with Multi Communication Links for Urban and Rural Areas in Indonesia

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Abstract

This paper describes the development of ICT-Based Mobile Telemedicine system with multi communication links for both urban and rural areas in Indonesia. The mobile telemedicine system is particularly needed in many remote and underserved areas in Indonesia, such as Sukabumi. The system has two main units, namely a Mobile telemedicine unit (patient side) and a base unit (doctors side). Data transaction between these units will be implemented via multi communication links, viz. radio, internet, GSM/CDMA mobile phones, and fixed phones. To alleviate communication management problems, a unit called telemedicine arbiter will be developed. This unit consists of a communication manager module and medical information concentrator/interface module. The operation of the system will be controlled by a dedicated software that handles information exchange based on TCP/IP protocol. Selection of the communication links depends on the availability of the local infrastructure.

At the moment, measurement of signal strength and line of sight distances includes elevation of target locations is in progress; the current results are encouraging. In general, the telecommunication infrastructure in Sukabumi mostly satisfy the requirement. The next step is to design and implement the telemedicine arbiter unit starting from the communication manager that meets with the specification. Meanwhile, medical information transmission tests between BME laboratory ITB and RSUD Syamsudin Sukabumi through the Internet are in progress.

Keywords: ICT, mobile telemedicine, multi communication links, mobile telemedicine unit, base unit, telemedicine arbiter, communication manager, biosignal concentrator.

1. Introduction

Telemedicine is defined as the delivery of health care and sharing of medical knowledge over a distance using telecommunication means. The aims of telemedicine is to provide expert-based health care to understaffed remote side and to provide advanced emergency care through modern telecommunication and information technology [3][5]. Information technology has been confirmed as an effective and efficient tools for delivering health services to widely distributed population such as Indonesia.

Since November 2002, our biomedical engineering research group has been developing Internet based telemedicine system. The system has been focused on primary Community Health Care mostly for reducing Maternal Mortality Rate (MMR).

Currently, the system has been operated mainly in Bandung (West Java), and ‘only’ covers relatively small number of Community Health Centres (CHCs, Puskesmas). In Indonesia, there are more than 7600 (seven thousand and six hundred) Community Health Centres which serve more than half the total Indonesian population. Hence, if the system is compared to national requirement, it is far from enough.

The developed system operation relies on existing public communication infrastructure, i.e. fixed public phone which is a non mobile system. The problems with a non-mobile telemedicine system are:

- It is not easy to be developed and less flexible, particularly in areas where the communication and transportation infrastructure has not been available yet.
- Deployment of the system could be very problematic especially in case of emergency for natural disaster such as tsunami, earthquake, and flooding as just happened in Aceh, and Nabire.
- Indonesia has a population more than 220 millions which are spread out all over the country. Because of the demography condition of Indonesia, a mobile system will be demanding because a fixed system is difficult to be reached by patient who lives in rural area so he or she can not be given a proper health services [6].

In order to alleviate these problems and support different growing application of telemedicine, the Development of ICT-Based Mobile Telemedicine Systems with Multi Communication Link is being carried out. One of the crucial problem to deliver health services in Indonesia is the demography, and the availability of needed infrastructure. The proposed system will exploit the advantage of wireless technology and combine it with other communication technologies such as wide band radio packet to satisfy different locals and geographic requirements.
2. Methods

2.1 Overview of the System

The aim of this research is to design and implement a working tested model of a mobile telemedicine system based on ICT. The system is expected to be used for community health care in Sukabumi area. Sukabumi has been selected because it is the largest kabupaten in Jawa-Bali that covers an area of 420,000 ha (kabupaten) and 4,800,231 (city) with population of 2,059,920 (kabupaten) and more than 269,142 (city). The altitude is vary within the range of 0 – 2,958 m above the sea, and the topography consists of highlands, hills and offshores. With such kind of conditions, Sukabumi is the best choice for representing terrain in Indonesia in order to develop a mobile telemedicine system.

Figure 1 shows the architecture of the proposed system. Mobile telemedicine directs a mobility aspect of patients, medical data, health services, and emergency team mobility. The system is based on the deployment of a mobile unit provided with computer, and diagnostic devices and processes, which is set up to acquire the patient’s medical information. The system can be operated in both on-line and indirect (store and forward) modes.

Data may be transmitted to a base unit within a reference hospital or CHC which enables the doctor or medical staffs to diagnose or monitor the patient’s condition in real time. The data interchange is conducted using TCP/IP network protocol. It is expected that the system will be ‘bandwidth independent’. To achieve this objective, the system will be provided with options of variety communication links from ordinary telephone lines, both GSM and CDMA mobile phones, and packet radio. Depending on the geographic location, a user can determine the mode of communication that suits her or his requirement.

2.2 Mobile Telemedicine Unit

The telemedicine unit is responsible for collecting medical information that includes biosignals and image from the patient and display the critical signals, e.g. ECG signal, BP and fetal heart signal (FHR). The unit must also be able to write and to record the data, and support the data transaction with variety of communication links. The unit will automatically transmit the patient’s biosignals to the base unit [1]. Basically the unit comprises of: 1) medical devices which perform measurement and medical data acquisition; 2) a digital camera to capture image; 3) a telemedicine arbiter; and 4) a processing unit that usually a PC or laptop.

- Medical devices

The selection of medical devices in the telemedicine unit is based on the identification of requirements for emergency condition. Most likely a mobile telemedicine unit is always provided with a stethoscope, an oxygen tube, a blood pressure (BP), and an ECG monitor [1][2][4][7][9]. The availability of the mobile telemedicine unit is also aimed to reduce MMR particularly for people in rural areas, so a fetal heart rate (FHR) monitor is included as well.

- Telemedicine arbiter

This is a functional unit that consists of a medical information concentrator module and a communication manager module. The arbiter is responsible for polling biosignals which is done by a concentrator module. Basically a concentrator is an interface to be connected to each medical devices. The module functions as vital biosignals acquisition module. The module will be provided with signal conditioning circuits, a microcontroller, and a portable power supply or batteries.

To manage data interchange within the system, a communication manager module will be designed. This module is a modem array that comprises of mixture a number of GSM, CDMA, radio, PSTN, and satellite (optional) modems. The specification of the module is independent zone, and able to select a most suitable communication link to transmit the data. Moreover, it depends on the geographic condition, the module is also able to do limited self tuning directivity and limited automatic antenna adjustment. Since the IP protocol will be applied for communication, hence the specification must be based on IP port.
2.3 The Base Unit

The base unit is located at a hospital or CHC. In this research, the base unit will be placed at RSUD R. Syamsudin, SH in the city of Sukabumi. This unit is equipped with a personal computer (PC) to display incoming signals from the Telemedicine unit, and a communication manager module that functions as a transceiver. This module will implement a continuous scanning to monitor incoming information and responds to them as soon as possible.

In addition, a hospital data base that contains of patient information record will be integrated to the unit. All information relating to the case handled must be recorded into the data base. Information includes the patient history such as past illness, present illness, treatment details, etc. and patient demographics, i.e. patient identity[7].

2.4 Software

A special purpose software will be developed as a protocol for data interchange by applying TCP/IP network protocol, that allows operation over several communication means [1]. Another important aspect of using wireless IP for telemedicine is the data transmission speed can reach 2Mbits/s with a TCP/IP platform [8]. Such transfer rate is sufficient for supporting telemedicine interactive communication that most likely is multimedia communication.

The telemedicine software must be able to acquire information concerning to the patient, store and display data of the patient, maintain and control connection between the Telemedicine unit and the Base unit, schedule doctor appointments, and capture image/other data from the output of the medical equipments. Furthermore, the software can also support Patient Information Record (PIR), because PIR is a part of acquisition data process.

3. System Design

In order to obtain the best system performance, an overview of the current trends and an existing telemedicine system is carried out. Hence, the different requirements will be taken into account for designing the Mobile Telemedicine system with multi communication links. Moreover, the design and implementation of the system is also based on the detailed user requirement analysis.

Basically, the design and implementation of the system is divided into eight stages, as follows:

- accomplish a survey of target locations, and measure signal strength within the locations to determine the maximum coverage areas;
- design and realize a communication manager that consists of modem array i.e. GSM, CDMA, radio, and PSTN;
- design and implement of biosignals concentrator module that interfaces medical devices, i.e. Non-Invasive BP, ECG signal, and fetal heart rate (FHR), to the PC;
- design the telemedicine software which based on the client server model. The Mobile Telemedicine unit is the client, and the Base unit acts as a server;
- integrate system and laboratory testing;
- conduct a field testing at Sukabumi area;
- integrate the whole Mobile Telemedicine system;
- evaluate the system that covers technical verification, clinical test and user survey.

In general the major design specification of the Mobile Telemedicine unit should: 1) be portable and lightweight; 2) have power autonomy of more than 60 minutes to support patient transport; 3) have a user friendly interface; 4) collect and display critical biosignals, i.e. EGC, BP, and FHR; 5) record patient information and data; 6) support multi communication links. Furthermore, the design specification for the base unit should fulfil the requirements viz. it has to be able...
to: 1) display incoming biosignals and analysis the data; 2) record, retrieve and manage patient information and data; 3) have user friendly interface; 4) monitor the connection with a client and send commands; 5) control of the whole telemedicine session; 6) be connected to the Internet [1][4][9].

4. Closing Remarks
The research will be conducted within two years, starting from July 2005. Currently, we are still doing the survey of signals strength and the availability telecommunication infrastructure in Sukabumi areas. The survey is implemented in three stages, i.e. 1) South Sukabumi; 2) East and North Sukabumi; 3) city of Sukabumi and West Sukabumi. At the moment, we have just finished the survey on eight CHCs located in the city and South Sukabumi. We have measured signal strength and line of sight distances includes elevation of each location which refers to RSUD R. Syamsudin, SH as the Gateway. The current results are encouraging. In general, the condition of telecommunication infrastructure in Sukabumi mostly satisfy the requirement, since all CHCs have been provided with PSTN. In addition the wireless communication, particularly GSM, is good. After the survey is completed, the next step is to design and implement the telemedicine arbiter unit starting from the communication manager that meets with the specification. Meanwhile, medical information transmission tests between BME laboratory ITB and RSUD Syamsudin Sukabumi through the Internet are also in progress.

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