A Suitable, Efficient, and Low Cost Telecommunication Solution for Telemedicine for Northeastern Region of Thailand Remote Rural Areas

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ABSTRACT

The development of information technology and telecommunication leads to the emergence of telemedicine. Telemedicine provides medical diagnosis and treatment to people in remote areas via telecommunication technology. It could alleviate the problem of lack of expert or physician in distant locations. Thus it can help improving the quality of life not only for city people, but also for people who live in the remote rural areas. One of the core technologies required for telemedicine system is telecommunication, which is also a focus of this paper.

Exploring telecommunication to support telemedicine system must be useful for Thai citizen especially for people in Northeastern Thailand where it is known that most of populations are poor and the number of hospital or health centre comparing to number of population in such region is very low.

In this paper, the review about resent telemedicine related researches, technologies used for telemedicine, some existing telemedicine projects, and interesting issues to concern of implementing telemedicine system can be found. The methodology of exploring suitable, efficient, and low cost telecommunication solution supporting telemedicine for northeastern region of Thailand, which is the purpose of this research, is discussed. The possible future research in telemedicine can be also found at the end of this paper.

KEYWORD : Telemedicine, Northeastern Thailand, Communication, Telecommunication, Rural Area.

1. INTRODUCTION

Telemedicine refers to the utilization of telecommunication technology for medical diagnosis, treatment, and patient care. Telemedicine aims to provide remote medical services to distant communities using current and emerging technologies. Possible telemedicine could range from scheduling appointment online to performing complicated remote surgery.

In some countries, the telemedicine started from a voice conversation with a doctor over telephone or radio. Nowadays, the development of information technology and telecommunications, especially wireless and mobile communications, leads to the improvement of telemedicine.

Telemedicine can alleviate the problem of lack of expert or physician in distant locations. Telemedicine makes providing healthcare to people living in anywhere possible. Thus the quality of life of people living in both city and rural areas can be improved. The medical education can also become accessible via telemedicine.

Current telemedicine systems can be roughly grouped into 3 categories:

- Store-and-forward: digital data is stored at one site, then transmitted at later time (e-mail is a form of store-and-forward system)
- Real-time system: works synchronously
- Hybrid system: combines capability of real-time and store-and-forward

For the store-and-forward, there must be delay of response time while the real time system could response immediately. The quality of image transmitted via real-time system usually cannot be in high quality, but for store-and-forward is opposite. The most important characteristic of real time system is interactivity. The patient can interact with doctor or expert with real-time system, while the store-and-forward cannot [14].

To implement the telemedicine system, many technologies must be involved such as communication technology, decision support system, image/audio/video transmission, and hardware such as digital camera, video camera, and computer. It can be seen that any existing technologies and emerging technologies could be applied to build up telemedicine systems.

2. LITERATURE REVIEW

For a decade, many researchers have been working on telemedicine system in different respects. Some groups address the problem of communication infrastructure, data transmission, medical images transformation and transmission, decision support system for diagnosis, and many more. In this section, technologies used for telemedicine and some existing works and researches related to telemedicine are described.

2.1 Technologies Used for Telemedicine

Many technologies have been applied to telemedicine system. Obviously, telecommunication technologies which are radio, telephone, microwave, satellite, Wi-Fi, Ad-Hoc network, GSM, and Internet must be included. Such telecommunication technologies can be selected to apply with telemedicine system according to different conditions of each location. As the new technologies emerge, they could also be applied to the telemedicine system.

Digital image processing is also one of important technologies that support telemedicine. Digital images could be sent from a remote host to the hospital for diagnosis. Video camera can be used for video conference with a doctor or used for recording video clip and send to expert for diagnosis of treatment. A simple video-telephony over typical PC is also useful. Even the digital camera is applicable. Nurse may take pictures of patients at patient's home using a digital camera, and store them on PC. The doctor can check those pictures afterwards and make a diagnosis if further treatment is necessary [6].

Moreover, the decision support system (DSS) can be used to support telemedicine for improving level of intelligence. Many researchers have been researching in decision support system for medical treatment in variety approaches such as the work in [18].

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Furthermore, in most telemedicine system, there are a lot of data kept in database such as images and video clips. Information warehousing and data mining are also useful technologies for telemedicine.

2.2 Existing Works on Telemedicine

There are numbers of researchers working on telemedicine in different areas. At the beginning, many researchers focused on studying of the barriers of telemedicine. Areas of telemedicine-related researches can be roughly grouped as follows: Decision Support System (DSS) that support telemedicine [3], medical image search/retrieval for telemedicine [20], customized ambulance (or other vehicle) for telemedicine [26],[28], pervasive healthcare [19], patient monitoring [17], remote lecture for preventive medicine and distance learning [27],[2], image/video/audio transmission over a low bandwidth [31], medical image processing for telemedicine [21],[23], communication solution for telemedicine system [5],[11],[6],[7],[8],[12],[2],[15],[25], telemedicine for remote/rural area [13],[22],[29], healthware [18], applications supporting telemedicine [24], and using mobile agent for web-based medical image retrieval [16]

Some selected areas of research in telemedicine are described in next sections.

2.3 Communication Technologies for Telemedicine

To establish a connection among nodes, a variety of telecommunication technologies can be used. Telephone is the simplest and easiest one, but does not work for the area that telephone line does not reach. Wireless communication can be a better solution. It can be radio, microwave, wireless LAN, GSM network, or satellite. Using mobile phone is a new trend for telemedicine as it became commercially available. Nevertheless, it is still limited to send a high quality medical image or even worse for video. Some researchers focus on using mobile phone to support telemedicine. One of those has done experiment on using mobile phone to transmit medical image [5]. The result of experiment shows that Global System for Mobile Communication (GSM) network is suitable, reliable and provides efficient service for the transmission of medical image. However, the application used in this experiment, Logo Manager from Nokia, is not suitable for sending medical image since it transform image in JPEG or BMP format to NLM format resulting in different transmitted image from the original one. Transmitted medical image can be somehow different from the original image, but it must be in acceptable condition that does not effect to the result of analysis. Moreover, the compact system for using in variety of emergency scenarios based on mobile phone was implemented by Woodward and Rasid [11]. The design and development of a modular mobile integrated telemedicine system using conventional mobile telephone was explored in [14]. In this project, the mobile patient unit was designed as a waist-mounted holster. The data were transferred from the flash ROM mobile patient unit through the GSM network and into the server. The authors claimed that no transmission errors have yet been observed, although it is anticipated that the error performance will be degraded if the patient unit is truly mobile. The authors planed to develop an encryption method and subsequent decryption method of the signals to ensure medical confidentiality in the future.

Furthermore, the microwave can be another option of telecommunication technologies to be selected. Microwave can send data in long distance, but the repeaters are needed [4]. Microwave was used for telemedicine network in the project of Shioda [6]. The P-P mini-microwave system with high capacity for rural and remote areas in developing countries was proposed. The author chose to use microwave due to its long propagation hop distance capability, high capacity characteristic, and low power consumption. It was shown that the hop distance of microwave is larger than wireless LAN. Not only applying proposed network to telemedicine system, but it can also be applied to local office, post office, educational institutions, disaster prevention and digital TV program for remote area in the future.

Moreover, typical wireless LAN has been also used. The experiment of using simple 2.4 GHz wireless LAN for telemedicine is shown in [2]. The characteristic of 2.4 GHz wireless LAN as stated by the authors are no radio-wave license required, little degradation by weather conditions, and tolerance of interference required. Thus, the wireless LAN systems are particularly suitable for networks in rural areas where there is little radio interference and sufficient line-of-sight between antennas as stated in [2]. This experiment was done in rural islands in Japan. Doctors are resident only in the Setouchi Clinic located in Ohshima, where beds and medical devices are equipped. The wireless LAN is used to connect from rural islands to clinic. In this work the authors concluded that common products and applications such as wireless LAN, video-telephony over windows PC, digital cameras, etc. can be fully utilized to support telemedicine. Furthermore, it can be seen that wireless LAN can be applied for connecting nodes if the distance between each node is not very long. Thus, it is suitable for the geography that composes of many islands which are not far away from each other.

Another type of wireless networks is Ad Hoc network. The mobile Ad Hoc network is quite new to the telemedicine in a rural health care. An interesting communication solution for telemedicine in rural area was proposed in [15]. This work was done for rural area in India. The authors suggested that for developing countries, especially in rural sectors, the telemedicine projects should begin with only very basic equipment. Thus, the goal of this project is the system which is both cost-effective and suitable for the need of rural sectors using benefit offered by Ad-Hoc network which are: an autonomous network does not rely on fixed network infrastructure, network can be formed and un-formed on the fly, an topology changes as mobile hosts migrate, disappear, or adjust their transmission, and network can be formed anywhere at anytime.

The authors suggest that instead of relaying data over long distance, which can be expensive and power hungry, transmitting data over short point-to-point links between village and mobile access points (mounted on bus) is better. The architecture of proposed system is shown in figure 1. The bus used in proposed system is a district hospital bus with a wireless receiver/transmitter physically transporting health

care consultation requests from each village kiosk to the district hospital main server. As the Mobile Access Point (MAP)-equipped vehicle comes within range of a village Wi-Fi enabled dispensary, it automatically senses the wireless connection and then uploads and downloads tens of megabytes of data. When a MAP-equipped vehicle comes within range of main hospital, it automatically synchronizes the data from all the rural dispensaries.

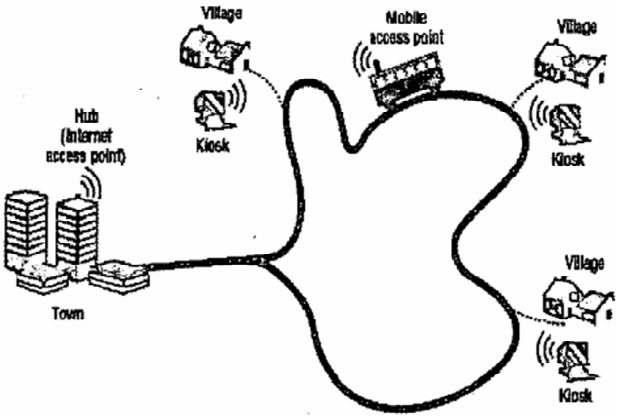

Fig. 1. Mobile Ad Hoc network architecture for telemedicine in rural health care (picture taken from [15])

The proposed system in [27] does not rely on plain old telephone system, thus it can be used to provide health services in remote areas where telephone lines have not yet reached and it can be formed and unformed on the fly. However, this system has many disadvantages. With this system, the doctors in the district hospital have to frequently check the requests and give necessary consultations and guidelines. These consultations and guidelines are uploaded to the bus when it passes a district hospital and downloaded by each village dispensary when the bus passes each village. The district hospital bus used in this project may pass by the main hospital and stops at each village three to six times per day depending upon the frequency and urgency of patients. Having a hospital bus traveling all around many times a day might waste a lot of gas and time. Furthermore, it is very obvious that this system can not support a real time data transmission.

Finally, one of the most popular telecommunication technologies applied for telemedicine is satellite. Satellite is the widest coverage technology. It can cover any areas [28]. Thus, many projects selected to use satellite for communication. Some researchers proposed the network for telemedicine using satellite such as the work in [1], [22], [24] and [25]. The work in [24] presents the problem of determining which protocol may best support the applications for telemedicine based on satellite. The authors have modeled three types of link protocol, circuit switched (ISDN), packet switched (TCP/IP) and cell switched (ATM) to determine how their characteristics affect the performance when bandwidth is severely restricted.

Even though using satellite gives a clear channel and covers any areas, the most outstanding drawback is a high cost. The cost of setting up the ground station to transmit data through satellite is quite high. In addition, the larger data rate transmitted through satellite compensate with the transmission power and antenna size. Furthermore, the error rate of data transmission depends upon the weather. The higher frequency satellites, which give a profit of allowing smaller antennas and smaller ground station, even more suffer substantially from deleterious effects due to the weather. While reliability is much more important in telemedicine than in other commonly used data transmissions, communication through satellite can thus have a weakness in this aspect. A propagation delay is another drawback of using satellite [13], [21], [27], [28].

2.4 Decision Support System (DSS) for Telemedicine

Level of intelligent of the telemedicine system can be improved by decision support system (DSS). Kamel, Rachid, and Mohamed have proposed the framework for a telemedicine multilevel diagnose system called SOSS [3]. This work is to insure an accurate diagnosis wherever there is a lack of experts. The DSS in this work can help physician getting the most possible accurate and fast diagnosis for his patient. Such DSS is a multilevel diagnose system which composed of four levels. Level 1 and 4 are human diagnosis while level 2 and 3 are computerized automatic diagnosis. However, there are many more research works on DSS for telemedicine which are not mentioned in this paper.

2.5 Transmission of Audio, Digital image and Digital Video for Telemedicine System

Quality of digital video and video transmission seems to be a major barrier of telemedicine**.** Due to the diagnostic use of medical images, medical image compression techniques have primarily focused on lossless methods, where the image can be reconstructed exactly from its compressed format [9]. One suggestion to address this problem is that we can highly compress original image only the part that are not necessary for doctor to diagnose and lowly compress (or not at all depending on level of necessity) for important part of image. Important part of medical image depends on image for each type of diagnosis. Wavelet compression is one of the most efficient lossless compression algorithms for the medical image such as the work of [4].

For digital video, it is important to distinguish among the requirements for real-time video transmission, offline video transmission, medical video and audio for diagnostic applications, and non-diagnostic video and audio. Real-time video transmission for diagnostic applications is clearly the most demanding. Offline video transmission is essentially limited by the requirement to provide patient doctor interaction. Real-time diagnostic audio applications include the transmission of stethoscope audio, or the transmission of the audio stream that accompanies the diagnostic video. Real-time diagnostic video transmission will most likely require the adoption of the MPEG-4 standard.

2.6 Telemedicine for rural area

Obviously it should not have significant barriers for city areas where there exist of high-speed network infrastructure and other equipments to implement telemedicine system. In contrast, most of the rural areas in many countries have common obstacles. Most of the rural areas, especially in developing countries, confound with common problems, which are:

- Lack of telephone line
- Lack of communication infrastructures
- Lack of electricity
- Lack of expert/physician
- Lack of medical instrument
- Lack of computer and technology
- Geographic access problem
- People have low income
- Low geographic density of target population

There have been some numbers of researchers worked on telemedicine for rural area of many countries such as India [27], Japan [6], South Africa [25], etc.

It can be notices that each country might have some characteristics in common with others, but some conditions are different. The telemedicine system must be designed according to geography, economy, law, politics, and other related conditions of each country.

2.7 Pervasive Healthcare

The wide scale deployment of wireless networks can improve communication among patients, physicians, and other healthcare workers as well as enable the delivery of accurate medical information *anytime and anywhere*, which is the key of pervasive computing.

Pervasive computing [23] is the next generation computing environments with information and communication technology everywhere, for everyone, at all times. In pervasive computing environment, the devices might be connected via either wire or wireless connection or both of them. Thus, users in pervasive computing environment could change his/her connection from high speed and stable to lower speed and fluctuated by changing from wire access to wireless access.

The ability to transmit critical information about victims to hospital before they arrive, or to let specialists diagnose and recommend treatment from a distance can make different between life and death. Thus, the mobile telemedicine is very useful for saving people's life.

Wireless LANs and personal area networks make it possible to continually monitor patients almost anywhere and immediately notify healthcare workers, the nearest hospital, or an emergency service of any critical change in status. Location-based service can also be useful for healthcare. We can use network sensors and radio frequency ID badges to alert staff members when patients leave a designated safety zone. Network or satellite positioning technology can be used to quickly and accurately locate wireless subscribers in an emergency and communicate about their location. Furthermore, location-based health information services can help find people with matching blood types, organ donors, etc.

Pervasive access to medical data is possible. Patient can use a handheld device to upload their personal medical history and insurance data into their healthcare provider's database. Alternatively, such information could be downloaded from a Web-based health information system with proper authentication. Patient could use mobile devices to update their personal and family medical information and physician contacts, receive alerts to take prescribed medications, check for drug interactions, or dynamically change restrictions on who can access their health data. One example of pervasive healthcare was presented in [31].

In addition, portable devices can detect certain medical condition such as pulse rate, blood pressure, breath, and so on from user's touch. Such capabilities could be integrated into a handheld wireless device that also contains user's medical history. It may even be possible to detect certain contextual information, such as user's level of anxiety, based on keystroke patterns.

In the mobile and pervasive computing environment, the level of connectivity will vary over time as a consequence of the mobility. The connection could also change from wire to wireless and vice versa in pervasive computing environment. To cope with this variation, the systems should be able to adapt itself to the quality of service offered by the network. Moreover, the healthcare data should be available anytime anywhere, but only to authorized persons.

3. Telemedicine in Thailand

Thailand is one of countries that most of the areas are considered as rural area. The characteristics of Thailand's rural area are quite close to other developing countries. However, there are slightly differences. Since there are many people living in remote rural areas where lacking of physician and expert, the telemedicine could be a suitable solution for medical care in such areas. There have been very few numbers of researchers working on telemedicine for Thailand. Anyhow, the telemedicine project in Thailand was initiated by Telemedicine & Tele-education System Department of Loxley Public Company Limited lately. The telemedicine system provided by Loxley transmits video and image via satellite network. Such telemedicine system provides a patient consultation and continuing education to doctors in remote hospitals. There are 19 remote hospitals linked to master hospital via satellite network. The wavelet compression plug-in is used to transmit large X-ray images through slower media [10], [30].

The result of how efficient the system is was not reported. However, there are some noticeable weaknesses of this system. First, the system mainly focuses only on exchanging medical education from master hospital, where there exist of experts, to the doctors in remote hospitals. In addition, the investment of this system must be quite high because it relies on the satellite and complex equipments. This system also does not reach villages in remote rural areas at the moment, thus people from villages still have to travel to hospital that is far away from their homes.

Villages in Thailand's rural areas usually lack of computer and telecommunication infrastructure. Low geographic density of population in remote rural villages is one of the characteristics of Thailand's population distribution. Yet, an access to good medical care and treatment of those populations

without traveling a long way to the main hospital in the city are still necessary.

High investment on telecommunication infrastructure does not seem to be a good solution considering a low density of population in each village. Exploring a simple, efficient, low cost, and a suitable telecommunication solution to Thailand remote rural areas with respect to geography, law, population, economy, politics, and other related conditions of Thailand is one of the challenges. However, each region of Thailand is different in geography and other characteristics; the telecommunication solution for each region should be different.

4. Telecommunication Solution for Telemedicine in Northeastern Thailand Remote Rural Areas (Villages)

According to the problem of lacking of doctor or expert in remote rural areas (villages) of Thailand, telemedicine system should be established. Telemedicine system composes of many components. Many parts of the system can be explored as a research. Telecommunication is one of the most important components of telemedicine system. Even though the telemedicine system was initiated in Thailand lately, such system still has weaknesses on high cost of using satellite, complexity of equipment and does not reach villages in remote rural locations.

Furthermore, the telecommunication solution based on Ad-Hoc network proposed by Paritosh Kumar Srivastava and Sandeep Sahu [27] still has many weaknesses even though such system can be formed and unformed on the fly and need a lower cost than using satellite. Unable to support a real time consultation, wasting gas for the hospital bus traveling around many times from villages to district hospital, and the need of doctor to keep checking the request for consultation frequently are disadvantage as described in section 2.3.

Northeastern region of Thailand comprises one-third of the Kingdom's total area. It is considered the nation's poorest region because of its arid and infertile soils. The geography of northeastern Thailand is plateau. The Phu Pan mountain ranges run down the middle of the plateau, effectively dividing the region into 2 parts, the Mekong River Valley and the Khorat Plains.

This region holds the largest area of agricultural land used and largest number of agricultural holdings in Thailand[2]. Most of people in this region are agriculturist and have the lowest household income comparing to other regions. Talking about information and communication technology in this region, the number of computers in year 2003 is 1.18 units per 100 people which is the least among all regions of Thailand.

Since telemedicine could be one factor to improve the quality of life of people in Thailand's remote rural areas, exploring telemedicine IT solution should be useful for Thai citizen especially for people in Northeastern Thailand where it is known that most of the population are poor and lack of medical care. 3 provinces out of top 5 provinces that people lack of healthcare are provinces in northeastern region. The number of hospital or health centre comparing to number of population in northeastern region is low. Over 70 percent of people in such region live outside municipal province.

Accordingly, the purpose of this research is to propose a *simple, efficient, low cost, and suitable* telecommunication solution for telemedicine system for the north eastern Thailand remote rural areas (focusing on remote villages) with respect to geography, law, population, economy, politics, existing technologies and other related conditions of those locations. A framework (or a guideline) of telecommunication for northeastern Thailand's telemedicine system will be obtained from this research.

4.1 Methodology

To achieve this, the simulation must be done to investigate a solution that support a purpose of this research in prior to implement a prototype and test with real environment. To obtain important factors for simulation, many data must be collected.

User requirements must be collected. Users could be doctors, patients, and any person related to telemedicine system. Keys to measure how efficient the proposing solution is could come from user requirements. In addition, user requirements can be factors for a process of solution selection.

Moreover, a study on existing and possible future components required by telemedicine system such as applications, equipments, communication technologies, etc. must be done. Characteristics of each existing and incoming communication technologies must be carefully considered in order to create a novel telecommunication solution. Furthermore, the characteristics of data to be sent over communication link in telemedicine system must be collected. Not only consider the characteristics of data to be sent, but the actions and requirements of transmitting data in telemedicine system must also be studied.

Finally, the most important data among all are the conditions of northeastern region of Thailand such as geography, politics, law, population, economy, and others that effect to the system must be gathered.

Once all data are collected, the process of analysis can be done to find a solution that is fit to a purpose of this research. To facilitate this process, some optimal solution searching algorithms such as genetic algorithm can be applied. A simulation can then be set up to evaluate performance of proposing solution. In this stage, factors used to measure could obtain from collected user requirements under assumption that high performance system is the system that support what users need without annoying them. To set up simulation parameters, actual actions occurring when system is used can be taken into account. The prototype can be done after all in order to test a proposed telecommunication framework in real environment.

4.2 Some Interesting Issues

The number of mobile phone in household has been increased from year 1999 to 2003 and tends to keep increasing year by year. The number of Thai people who has mobile phone is over 28 percent out of total number of citizen who is over 6 years old. This could imply that the mobile phone network coverage in Thailand must be increasing and cover more rural areas to support more users. In addition, the percentage of

number of computers in household has been increasing year by year.

To support the Thai government policy that try to distribute Internet access to all locations including far away rural areas, the National Electronics and Computer Technology Center (NECTEC) of Thailand established a project called Rural Wireless Broadband Access (RWBA) in 2004. Since the cost of installing landline is high, wireless communication was then chosen as the solution. The goal of this project is to develop wireless equipment for less cost which utilizes voice-over IP with computer telephony to allow people living in rural area to talk to others as well as access the internet through the same wireless network. Satellite networks will be the backbone of the Internet, while people in communities will be connected via Wi-Fi networks. Using a wireless network instead of installing landline in remote villages effects in lower investment. This project is in a process of testing by the time this paper is written. [5]

It is un-skeptical that wireless communications in Thailand (or even in the world) are likely to become more important. The IEEE 802.11 wireless standard tends to cover longer distance. Moreover, the GSM is currently widely used as the global system for mobile communications.

Based on data having in hand at present, it seems like wireless communication might be possible solution for a low cost telecommunication framework for telemedicine in northeastern Thailand remote rural areas. However, using wireless communication might create some obstacles to the telemedicine system or might not giving high performance medical data. These assumptions are what left for investigation by methodology as explained in section 4.1.

5. CONCLUSION

Healthcare is a basis of improving quality of life. Quality of life of all citizens is one factor to help country move toward new economy and support country development. Thus, the accessibility to healthcare and medical treatment for all people in any areas in country is very important. Telemedicine which refers to the utilization of telecommunication technology for medical diagnosis, treatment, and patient care is the answer.

There have been numbers of researchers working on telemedicine related projects and experiments in many aspects including telemedicine for rural areas as roughly grouped in section 2.2. It is noticeable that a core technology required for telemedicine system seems to be the telecommunication technologies that make telemedicine possible.

Although rural areas in Thailand have some characteristics in common to rural areas in other developing countries, many conditions are still different. Exploring a framework for suitable, efficient, and low cost telecommunication solution to support telemedicine in Northeastern Thailand remote rural villages, which is a main contribution of this research, would result in high benefit because it could be used as a guideline for implementing telemedicine system in Northeast of Thailand remote rural areas in the future. To achieve such framework, an experiment must be done as described in section 4.

Although this research focuses on only northeastern region of Thailand, it could be considered as a starting step for other regions. Thus, this solution will highly support the telemedicine project in remote rural areas of Thailand, where the telemedicine project is in a very beginning step, driving a process of developing Thailand step further. In addition, obtaining telecommunication framework can also be applied to other countries that have similar or very close conditions to northeast of Thailand.

6. FUTURE RESEARCH

Investigating a suitable, low cost, and efficient telecommunication solution for Thailand's northeastern region, which is a purpose of this research, will be proceeded as described in section 4. The framework obtaining from this research can also be extended to remote rural area in other regions of Thailand or even in other countries in the future. In addition, there are many more interesting areas of research about telemedicine waiting for discovering.

Medical image and video transmission for telemedicine are interesting areas of research and still open. Many existing techniques of video streaming in video on demand might be applicable for video conferencing or video transmission in telemedicine environment. Introducing a novel image compression method for *each type* of medical images should result in advantages for image transmission and this topic is suggested to explore.

The mobile computing has been growing very fast leading to the rapid grow of pervasive computing which the computation is in everywhere at anytime by both of wire and wireless network. Thus, a *pervasive medical care* is an interesting growing research since it helps telemedicine grow one step further.

An enhancement to the guideline on deploying communication link for telemedicine system in Northeastern region of Thailand that will obtain from this research can be also done in the future to support a pervasive healthcare.

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