Mobile telemedicine system application for telediagnosis using multimedia messaging service technology

Andik Setyono*

Faculty of Information Technology,
Multimedia University,
Cyberjaya 63100, Malaysia
and
Faculty of Computer Science,
Dian Nuswantoro University,
Semarang 50131, Indonesia
Email: setyonoandik@gmail.com
*Corresponding author

Md. Jahangir Alam and C. Eswaran

Faculty of Information Technology,
Multimedia University,
Cyberjaya 63100, Malaysia
Email: jahangir.alam.mmu@gmail.com
Email: eswaran@mmu.edu.my

Abstract: The purpose of this paper is to design and implement mobile telemedicine system applications for telediagnosis using Multimedia Message Service (MMS) technology. The development process consists of two components, namely client-side and server-side applications. On the client-side, adapted compression and splitting techniques are used to perform mobile multimedia computing and to enhance the capability of MMS technology in message delivery. On the server-side, merging and decompressing techniques as well as mobile telemedicine applications are developed and implemented which are required for telediagnosis. The proposed techniques on the client and server sides ensure that the quality of data is preserved which is critical for accomplishing the diagnosis process. The experimental results show that the proposed framework can be used to develop a practical mobile telemedicine system.

Keywords: mobile telemedicine system; MMS; multimedia message service; multimedia communication; telediagnosis; multimedia message; client-server application.

Reference to this paper should be made as follows: Setyono, A., Alam, M.J. and Eswaran, C. (2014) 'Mobile telemedicine system application for telediagnosis using multimedia messaging service technology', *Int. J. Wireless and Mobile Computing*, Vol. 7, No. 4, pp.348–361.

Biographical notes: Andik Setyono is currently working as a Lecturer in the Faculty of Computer Science at Dian Nuswantoro University, Indonesia. He received his Bachelor's and Master's degrees in Computer Science from Dian Nuswantoro University, Semarang, Indonesia, in 2003 and 2005, respectively. In year 2012, he received his PhD degree from the Faculty of Information Technology at Multimedia University, Cyberjaya, Malaysia.

Md. Jahangir Alam is currently working as a Lecturer at Multimedia University, Cyberjaya, Malaysia. He received the BSc (Honours) and MSc degrees in Physics from Jahangirnagar University, Dhaka, Bangladesh, in 1989 and 1991, respectively. He received PhD in Information Technology from Osaka University, Osaka, Japan, in 2004. He also worked as Assistant Professor in the Department of Electronics and Computer Science at Jahangirnagar University.

C. Eswaran is currently working as a Professor in the Faculty of Information Technology, Multimedia University, Malaysia. He received his BTech, MTech and PhD degrees from the Indian Institute of Technology Madras, India, where he worked as a Professor in the Department of Electrical Engineering until January 2002.

1 Introduction

Telemedicine field is one of the research areas of biomedical engineering that needs multidisciplinary technologies such as electronics, computer, telecommunications, transfer protocol and medical procedures (Yoke et al., 2006). Similarly, the mobile telemedicine system application is developed by using several multidisciplinary technologies. There are many types of mobile telemedicine technologies, such as Wireless Local Networks (WLANs), Mobile Ad Hoc Networks (MANETs), Wireless Personal/ Patient Networks (WPANs), third generation (3G) cellular phone technologies, Radio Frequency Identification (RFID) technologies and Wireless Sensor Networks (WSNs) (Pennie et al., 2008). Currently, many telemedicine applications are using mobile technologies, such as mobile telemedicine using Multimedia Message Service (MMS) (Asadullah et al., 2008; Ashraf, 2008) that is supported by 2.5G or 3G network, WAP (Kevin and Yuan, 2003) and 3G network (Yuechun and Aura, 2004; Polley et al., 2006). The most used method for telehealth including telemedicine is store and forward modality where MMS is one of the technologies; the study case of Asian countries (Hammad and Shariq, 2009). In this research, we propose a mobile telemedicine system using MMS technology which will be used by a user to send the message in a mobile environment. The developed system is different from the existing mobile telemedicine system applications in the sense that it makes use of compression and splitting file techniques before sending the multimedia messages. This facilitates the delivery of a large multimedia data without degrading the quality which is not possible using the existing MMS technology. By using the proposed system, the user (nurse or patient) can transmit a large file so that the doctors can analyse and diagnose the patient's disease more accurately.

The proposed system consists of two parts, namely client-side and server-side. On the client-side, mobile devices such as mobile phones are used, where the mobile application is installed in the form of MMS. It is used to transmit and receive multimedia data to and from the server. The proposed framework provides a major contribution to the existing telemedicine system in the sense that the mobile device at the client-side can be used to send data larger than the size which is permitted with the existing MMS technology, namely 300 KB. By using compression and splitting techniques, the message will be reduced in size first so that the messages can be sent through the existing network. On the server-side, merging and decompressing processes are implemented before storing the data into the database server. Further, the implementation of these processes does not affect the quality of the original data.

The aims of this paper are: (a) to present a client-server system application with improved MMS technology; (b) to describe a mobile telemedicine system prototype for telediagnosis using the improved technology; and (c) to evaluate and analyse the performance of the proposed mobile telemedicine system application. This system is expected to be more efficient than the conventional system. The proposed system is developed using Java technology. This system will enable the doctor to diagnose the patient's information using a good-quality data without visiting the patient physically and the patient can get the diagnostic result from the doctor without visiting the hospital. The nurse, who is at the patient's home, can communicate and consult with the doctor for further clarification using SMS, phone or chat facilities of GPRS/UMTS.

The remaining part of the paper is organised as follows: Section 2 discusses the existing mobile telemedicine system. Proposed system design is presented in Section 3, mobile telemedicine system applications are presented in Section 4, testing and experiments are presented in Section 5, evaluation and analysis are discussed in Section 6 and conclusion and future work are presented in Section 7.

2 Mobile telemedicine system

Mobile telemedicine is defined as the delivery of healthcare and sharing of medical knowledge over a distance using telecommunication means. The aim of telemedicine is to provide expert-based healthcare to patients at remote sites and to provide advanced emergency care through modern telecommunication and information technologies (Drishya, 2006).

The growth of Information and Communication Technologies (ICTs) has made a tremendous impact on our society. MMS is one of the branches of mobile messaging technologies, which is a rich-content message sending system that not only sends text but also image, voice, audio, video or combination of them. MMS can be sent to mobile phones and also to email server. MMS is used widely for many purposes, such as streaming (Nemati et al., 2008; Govind et al., 2010; Miraj, 2005), mobile learning (Kin and Sintiani, 2008; Hilmi et al., 2010), mobile commerce (Leida and Gordon, 2005), mobile banking (Hilmi and Aklili, 2010) and mobile telemedicine (Ashraf, 2008; Cheng et al., 2007; Ching et al., 2007; Figueredo and Dias, 2004).

In developing mobile telemedicine system, MMS application is used as a client application on the mobile instrument which serves as the input device. On the server-side, telemedicine system is implemented as an internet application. We use the MMS technology to develop a mobile telemedicine system. This technology can be applied using GPRS mobile network only, where the network coverage is the same with GSM mobile network that already coverage and establish reaching rural or remote areas. When the available mobile network is GPRS only, the use of web-based services using desktop computer or smartphone takes a long time and often fails to transmit the large data size. The proposed framework can be implemented not only for MMS protocol but also web-based service protocols (e.g. FTP and HTTP) on the multimedia communication.

The development of this mobile telemedicine system is very suitable to be applied for the rural or remote areas that have limited bandwidth for mobile communications system.

The ordinary mobile phone is used to develop the mobile telemedicine system. This is to show that with simple equipment that is affordable, the proposed framework can work well so it will be effective and efficient and can also be reached out by people widely. This facility is quite useful in countries where these new technologies (3G or 3.5G) are still not fully developed. For example, in countries such as Indonesia and Malaysia, the coverage of GPRS mobile network reaches up to 98% of whole areas (Telkomsel, 2007), while 3G and latest mobile network is available only in big cities and densely populated areas. Under these conditions, the use of MMS technology will be very helpful in implementing the mobile telemedicine system. Besides the network availability factor, another advantage of using MMS technology is the possibility of sending packaged and encrypted files to the recipient. Further, security is ensured as the message is not directly received by the database server, but it is received by mobile phone or email server as a gateway between the mobile client and computer server. It makes the telemedicine system on the server-side more secured because only authorised people such as administrators and registered doctors are allowed to access the system.

Multimedia Message Service provides the complete multimedia knowledge and its use to the user that is definitely going to increase in the future (Swadesh et al., 2009). MMS is considered as the best and proven messaging technology and it has surpassed email and SMS (David, 2011). MMS has experienced dramatic growth, for example in the USA more than 10.3 billion MMS messages were sent in the first-half of 2009 indicating a growth of 4.7 billion compared to the previous year (Comverse, 2009). The initial standard for MMS allowed file sizes up to a maximum of 30 KB. The standard was then raised to 100 KB (OMA, 2005) and with the current 3G standard; the maximum file size can go up to 600 KB (OMA, 2008).

The proposed system is very open for using smartphone that now easy to find in the market. The use of smartphone will provide a solution within the limited size of the display or screen that is owned by mobile phone. For example, an image will be seen more clearly if it is displayed on a wide screen. It is because smartphone can display wider image size than any other ordinary mobile phones. Bandwidth constraint in the rural or remote areas is main consideration for developing the mobile telemedicine system using MMS technology. This is because to build 3G or 3.5G networks, the network operator requires a large investment fund.

In this study, we propose an innovative mobile telemedicine system application for telediagnosis process using MMS technology. We want to create an MMS framework that will be very efficient and adaptive for the mobile telemedicine application system. We do not make modifications on the network which is provided by the service provider. We propose some improvements on the current MMS application by which one can transmit file sizes larger than the capacity that is permitted with the current standard. Figure 1 shows an MMS architecture for data transmission.

The MMS server, also known as MMS centre (MMSC) has several functions such as store MMS messages, forward MMS messages to external networks, send MMS messages as email using the SMTP protocol over the internet, send MMS messages via the SMS for enabling users of non-MMS phones to receive MMS messages and view the text as SMS messages and as the whole message via Web or WAP and perform content adaptation (Comverse, 2009). On the client-side, we develop MMS application by implementing techniques such as compression, splitting, masking and cropping to get an adaptive and cost-effective delivery of large multimedia files. On the server-side, we develop an internet application to retrieve and process the data which are sent by user to the mobile phone recipient as the gateway between client and server. We implement merging and decompression techniques when downloading data from the gateway into the database server. An overview of the architecture of the proposed mobile telemedicine system is shown in Figure 2.

Figure 1 MMS architecture for data communication (see online version for colours)

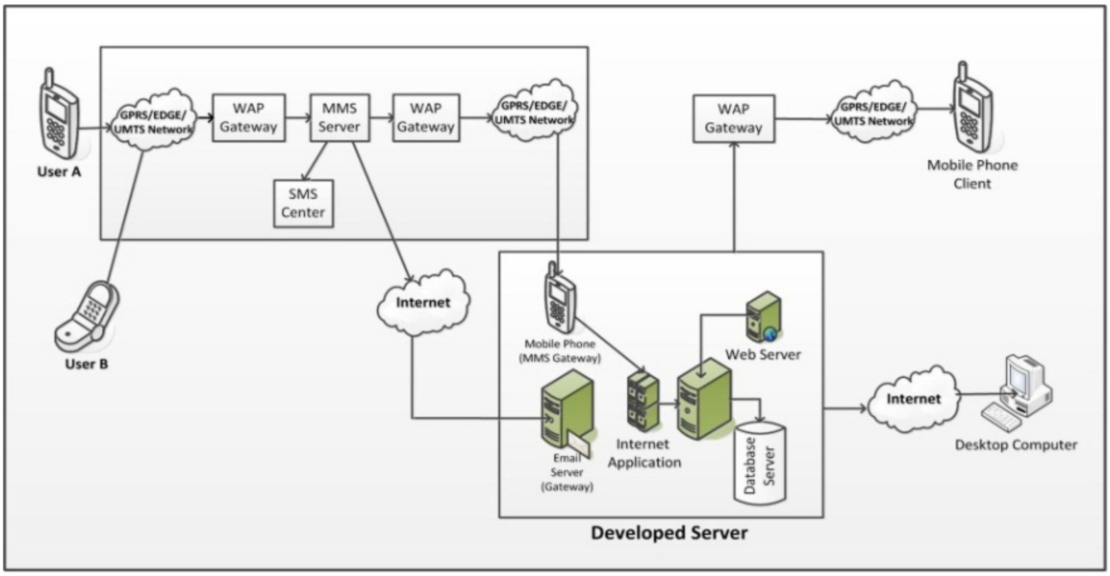
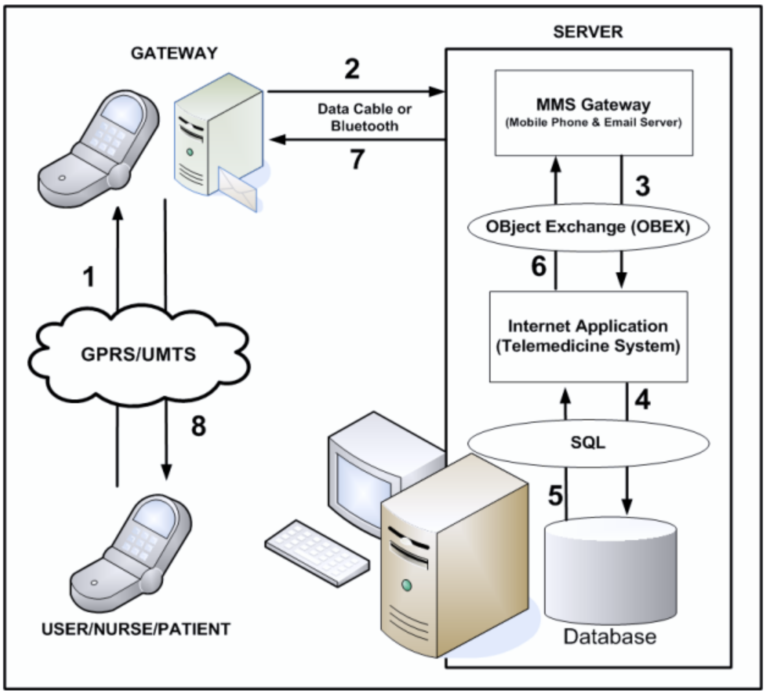


Figure 2 The global process of the mobile telemedicine system (see online version for colours)



A mobile phone is used as an MMS client that contains the application for implementing the compression and file-split techniques before transmitting the multimedia messages. After going through the 3G network, the multimedia messages are received by the MMS gateway. By using a data cable or Bluetooth connectivity, the data are retrieved with the applications in OBject EXchange (OBEX) one by one and then the multimedia message files are merged and decompressed before storing the data into the database server. In this case, MySQL is used as the database server. The details of the transaction processes between the client and server are shown in Figure 3.

Figure 3 shows that before sending the multimedia message to the server, the message is compressed and split and finally it is packaged based on the MIME-type and encoded to binary message. These transaction processes are implemented by the applications on the mobile phone devices. On the server-side, several processes are implemented such as retrieval (download) of message from gateway (or internet email server), merging of split messages and decompression of the merged file before storing the data into the database server (like MySQL).

In mobile system, the used mobile device and mobile communications network commonly have limitation in capacity of file size which can be transferred based on offered bandwidth by network operator. It has influence when developing a mobile client-server. Multimedia data including image tends to take up a large amount of storage or transmission capacity. Compression is essential for any application in which storage capacity or transmission bandwidth is constrained. Combination of the compression and splitting technique is to optimise data transmission via a mobile network. The large multimedia files without compression have a large amount of data, while the mobile communications network and storage capacity are limited and expensive. For example, a bitmap (BMP) image without compression with size 600×800 pixels will generate file size 1.37 MB. Having performed with a compression ratio of 16:1, it will produce a file size of about 86 KB. The available channel bit rate is much smaller than the row bit rate. This would greatly complicate of the storage and transmit the data.

It explains how the nurse at patient's home can send patient's information, such as symptoms of illness, picture of wound, voice or video of patient to the doctor in the hospital. The information can also be sent through the email system in the form of multimedia content. The data received from the mobile phone or from the email server are converted into a format that is suitable for storing in the MySQL database server. It also updates the database contents automatically. The stored database will be a very useful asset because it can be used for any future diagnosis or research purposes.

The doctor can access the patient data in the database server for diagnosis. Once the diagnosis is completed, the doctor can input the diagnostic data into the system and the system will automatically send the diagnostic results to the nurse at the patient's home through mobile phone or email server based on the available communication system. The nurse, who is at the patient's home, can communicate and consult with the doctor for further clarification by using SMS, phone, chat or other facilities of GPRS/UMTS (Andik et al., 2010a). The architecture of the proposed mobile telemedicine system is shown in Figure 4.

Figure 3 Transaction processes on the client and server sides

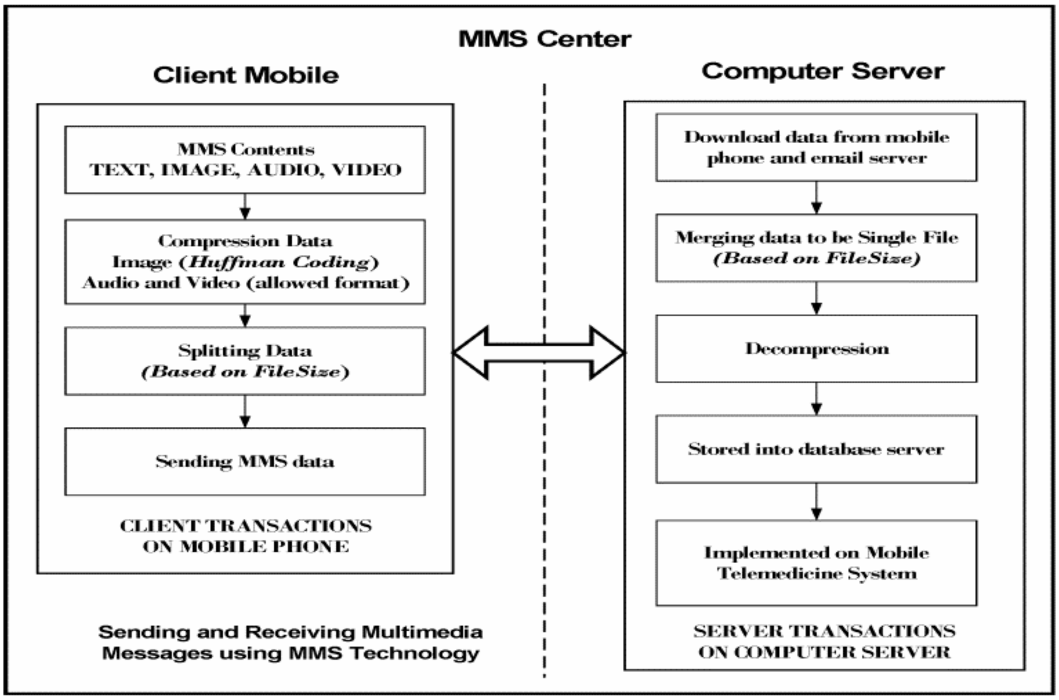
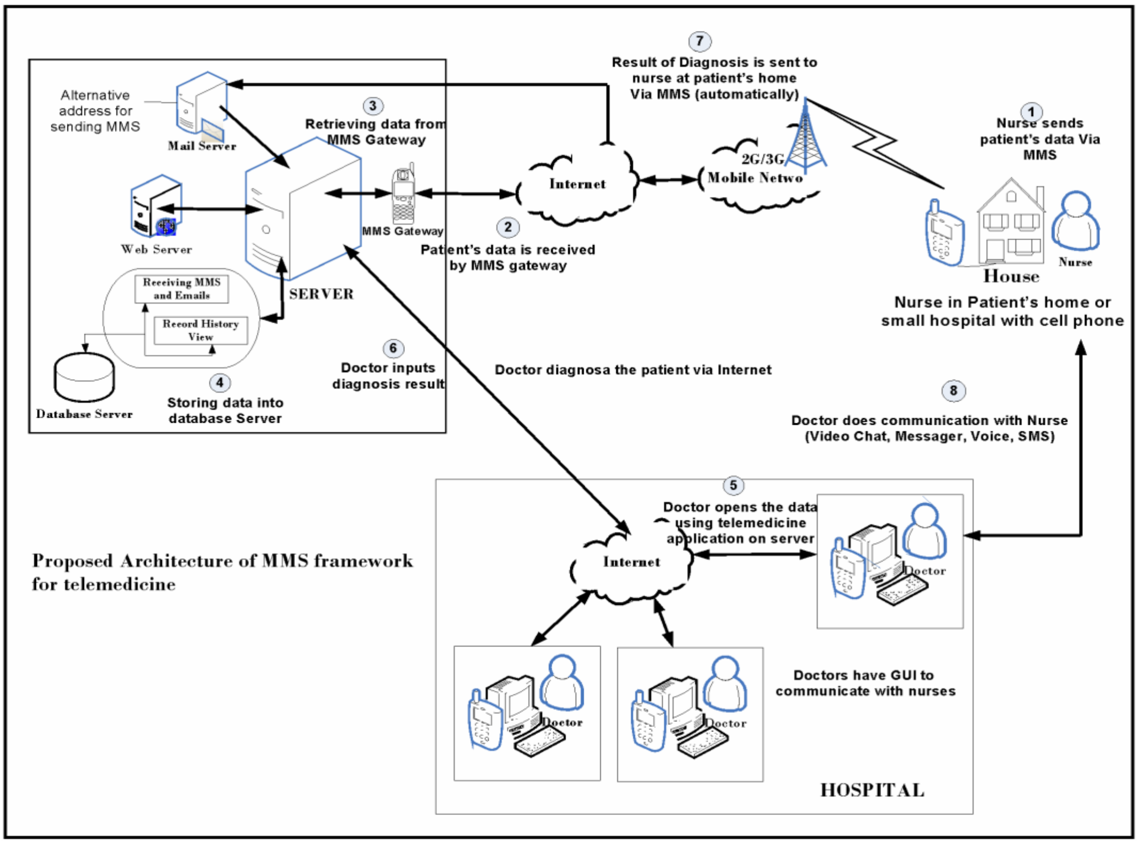


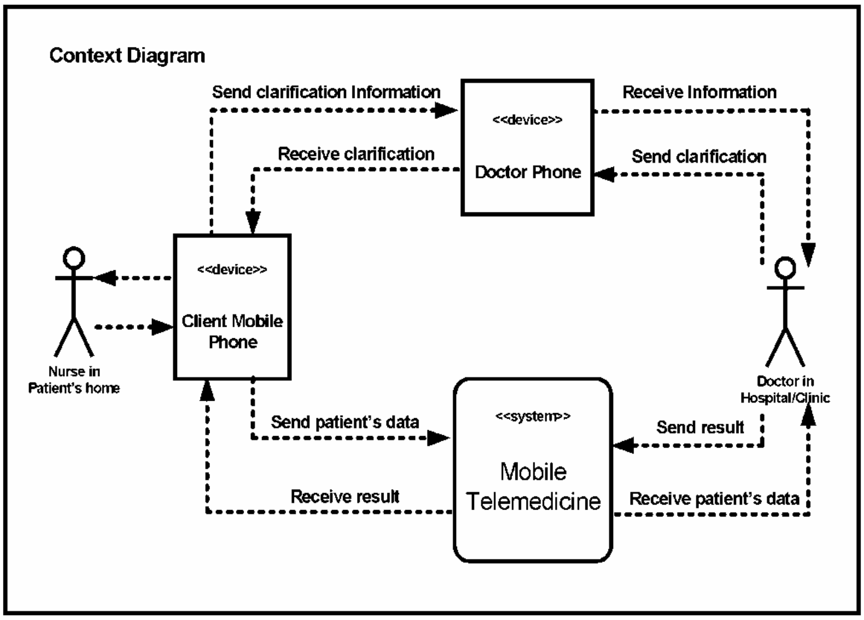
Figure 4 Proposed architecture of the mobile telemedicine system (see online version for colours)



3 System design

This section explains the system design for the telemedicine application on the server. The proposed mobile telemedicine application system is developed using software tools such as Java 2 Micro Edition (J2ME) (JENI, 2007), Java 2 Enterprise Edition (J2EE) (Greg, 2001) along with Multimedia Messaging Service (MMS) technology. The system design is divided into two parts: design of telemedicine system application and design of database which are explained in Sections 3.1 and 3.2, respectively.

Figure 5 Context diagram of the mobile telemedicine system



3.1 Design of mobile telemedicine system

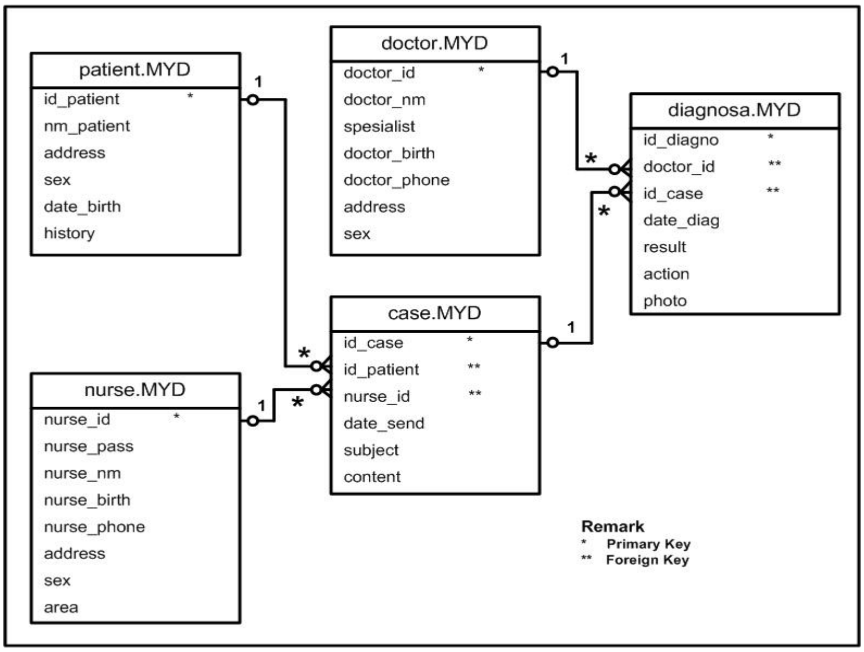
The context diagram of the mobile telemedicine system is shown in Figure 5. This figure describes the interaction between a nurse in the patient's home and a doctor in the hospital. The nurse can transmit patient's data to the doctor for diagnosis and subsequently, she can also consult with the doctor using SMS, voice or message and video conference.

The applications installed on the client mobile phone perform four important tasks: namely composing, compressing, splitting and transmitting the multimedia message. The applications installed on the server perform several tasks, such as retrieving the data from the MMS gateway, merging and decompressing the data, storing the data into the database, message processing, facilitating the diagnosis process, storing the diagnosis result into the database and sending the results to the patient. The split or fragmented files are sent from the client sequentially, one by one each with a header containing overhead information about the message. The fragmented files are indexed using sequential numbers. For the case of unsuccessful and incomplete files, the server will notify the nurse for retransmission.

3.2 Design of database

Figure 6 shows the relationship diagram indicating the relations that exist among the various tables stored in the database server. The case table is used to store the information about patients sent by the nurse and the diagnostic table is used by the doctor to store the diagnostic results.

Figure 6 Relationship diagram



The telemedicine system application on the server uses seven tables of which five are for processing the telemedicine system and two are for authentication and control purposes. Each user has different access rights, for example a nurse is only able to open the menu and add the data about the patient and himself/herself, but the nurse cannot erase the existing data, while the user administrator can control all the menus of the system. The designed database is implemented using MySQL database.

4 Mobile telemedicine system applications

4.1 Mobile client application

The client application uses Java 2 Micro Edition (J2ME). We make a design to describe the flow of developed application. It is used to send the multimedia messages using compression and split techniques on it before sending. The application consists of interface for receiving files that will be compressed, split and finally, sent. The multimedia message file that is successfully split will be sent one by one. Each fraction file will be given a header in accordance with the MMS format in order to the messages can be recognised by the MMS centre. The message header contains the information that is required by the MMS centre to forward it to the recipient. One of the important information is the provision of the identity of the fragmented file to be sent using the sequential indexed number. It is used to know the breakdown result of the files belonging to a single file. If one or more of the fragmented files do not reach the server, it will provide information to the sender so that these files can be retransmitted.

The developed MMS application can send multimedia files such as image (JPEG, PNG, GIF and BMP), for audio (AMR, WAV and AAC), and then for video (MP4, 3GP) (Gwenael, 2005). Since Java technology does not support transmission of audio and video files (Atanas, 2009), we use a masking technique to add a header for each split-file which can be received by MMSC. Figure 7 shows the MMS application to create multimedia message.

This application is used by nurse at patient home to create the multimedia message. Once the multimedia message has been successfully established, the next step is to send the message one by one to the recipient target. We deliberately separate the MMS creation and sending applications in order to make the retransmission process of split files easier. The created messages are stored temporarily in the mobile phone till confirmation is received from the server. If confirmation is not received for any split-file, it will be retransmitted. The retransmitted split-file will be merged with other split-files belonging to the same message as the split-files of the given message will have the same identity. Figure 8 shows the MMS application for sending multimedia messages.

The mobile telemedicine system is quite complex because it involves several processes such as compression and split techniques on the client-side and some applications such as download, merging, decompression and telemedicine application on the server. Before sending, the message is packaged into bytes and a header is added for each split-file message. In order to be identified by MMSC. We can also use masking technique to send the non-standardised file on MMS protocol by adding a header for each split-file message using the allowed image format such as JPEG, PNG or GIF.

Figure 7 Development MMS application to create message (see online version for colours)

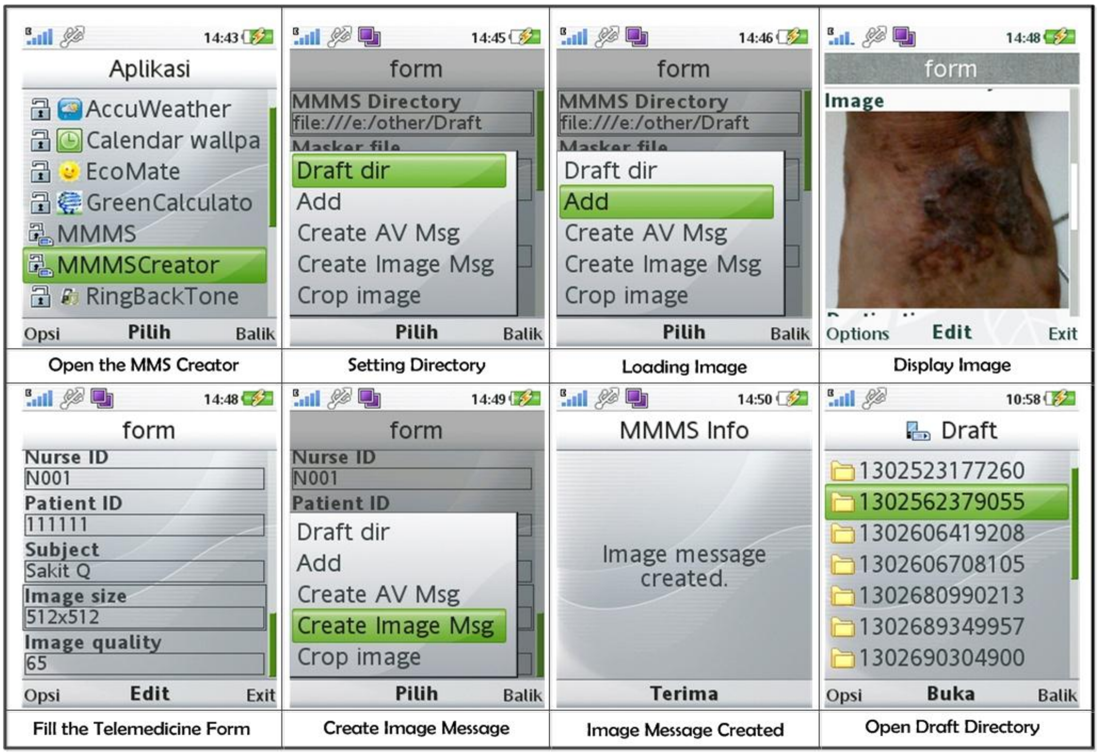
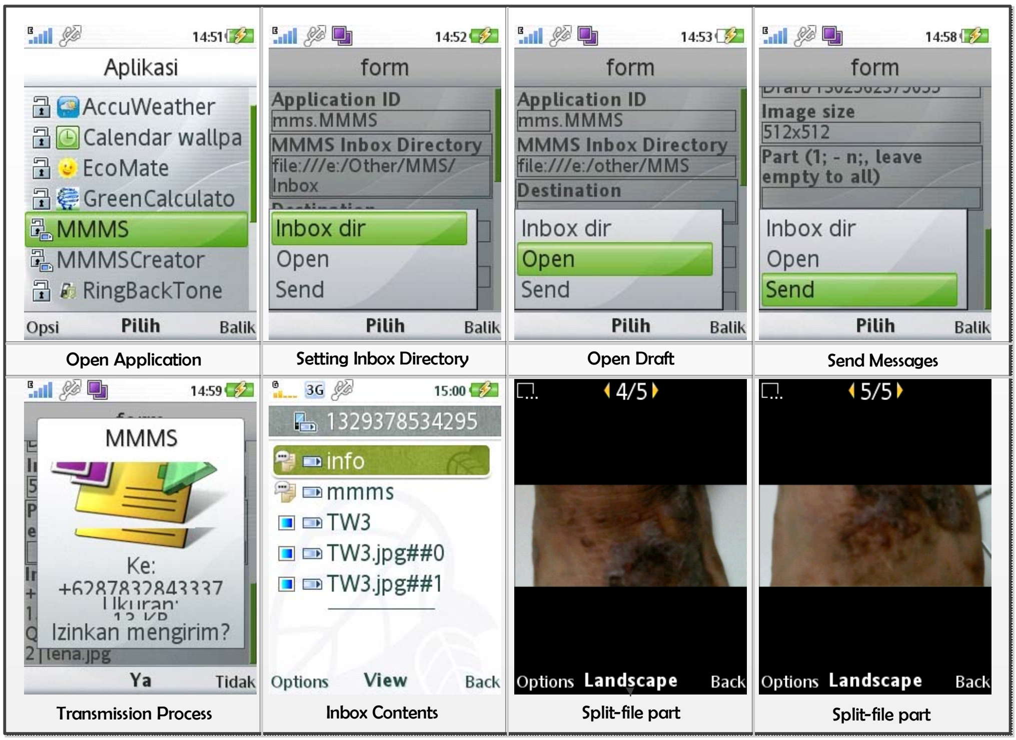


Figure 8 Development MMS application to send message (see online version for colours)



4.2 Server application

Telemedicine application installed on the server computer also has a high complexity because management of multimedia database requires substantial memory. The memory problem can be overcome by suitably upgrading the memory in accordance with the needs of the system. This would allow the development of server applications without any constraints. Figure 9 shows the installation of the telemedicine server application on the server.

4.2.1 Download, merge, decompression and storing applications

The server application consists of several interfaces for downloading, merging, decompressing and storing the files into the database server. After the multimedia message reaches the MMS gateway, it will be downloaded periodically at a specific interval of time and stored it into the database server (MySQL) after merging and decompressing. The interface for downloading and storing is shown in Figure 10.

Figure 9 Installing telemedicine server applications on the server (see online version for colours)

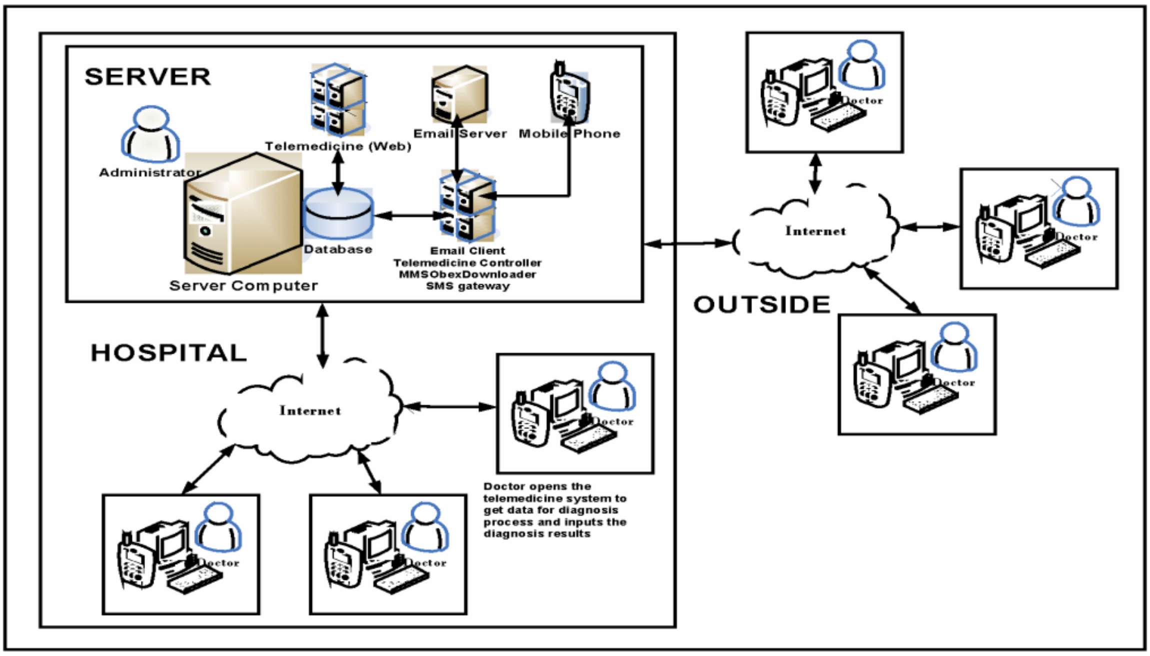


Figure 10 Downloading and storing process at the server

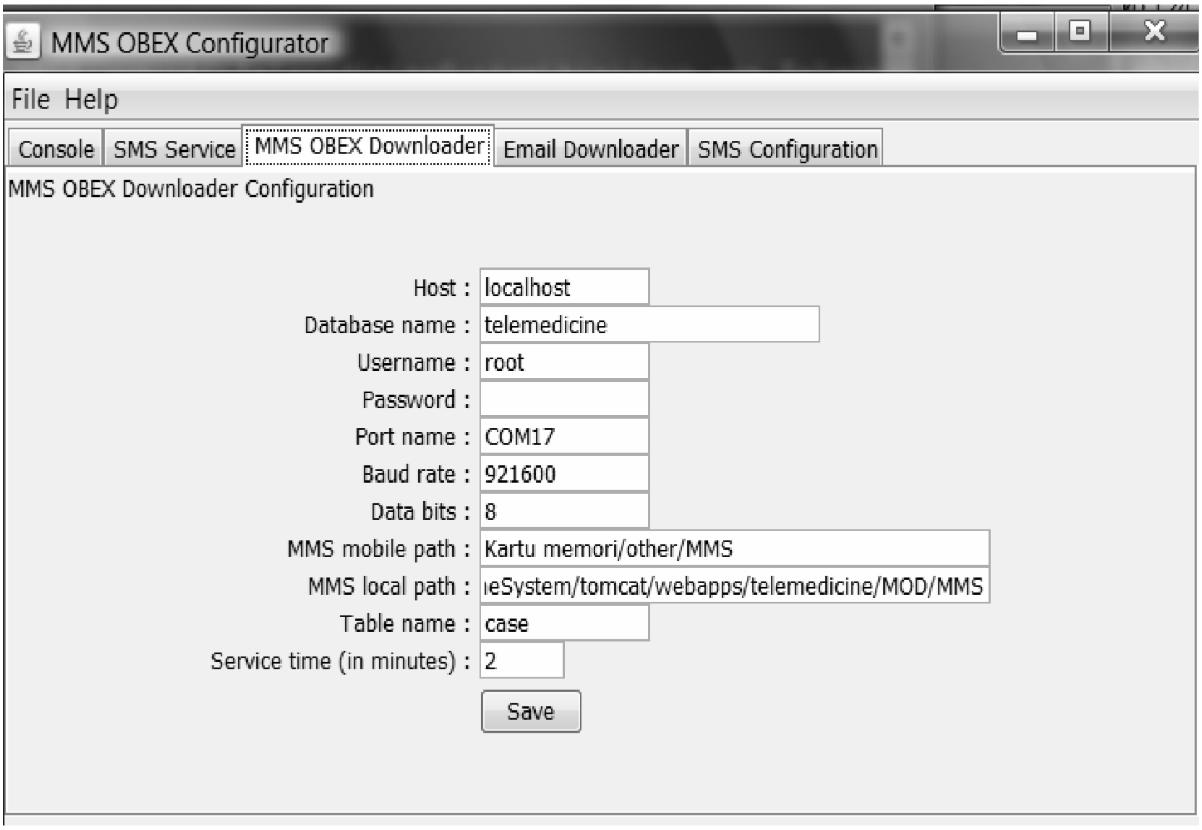
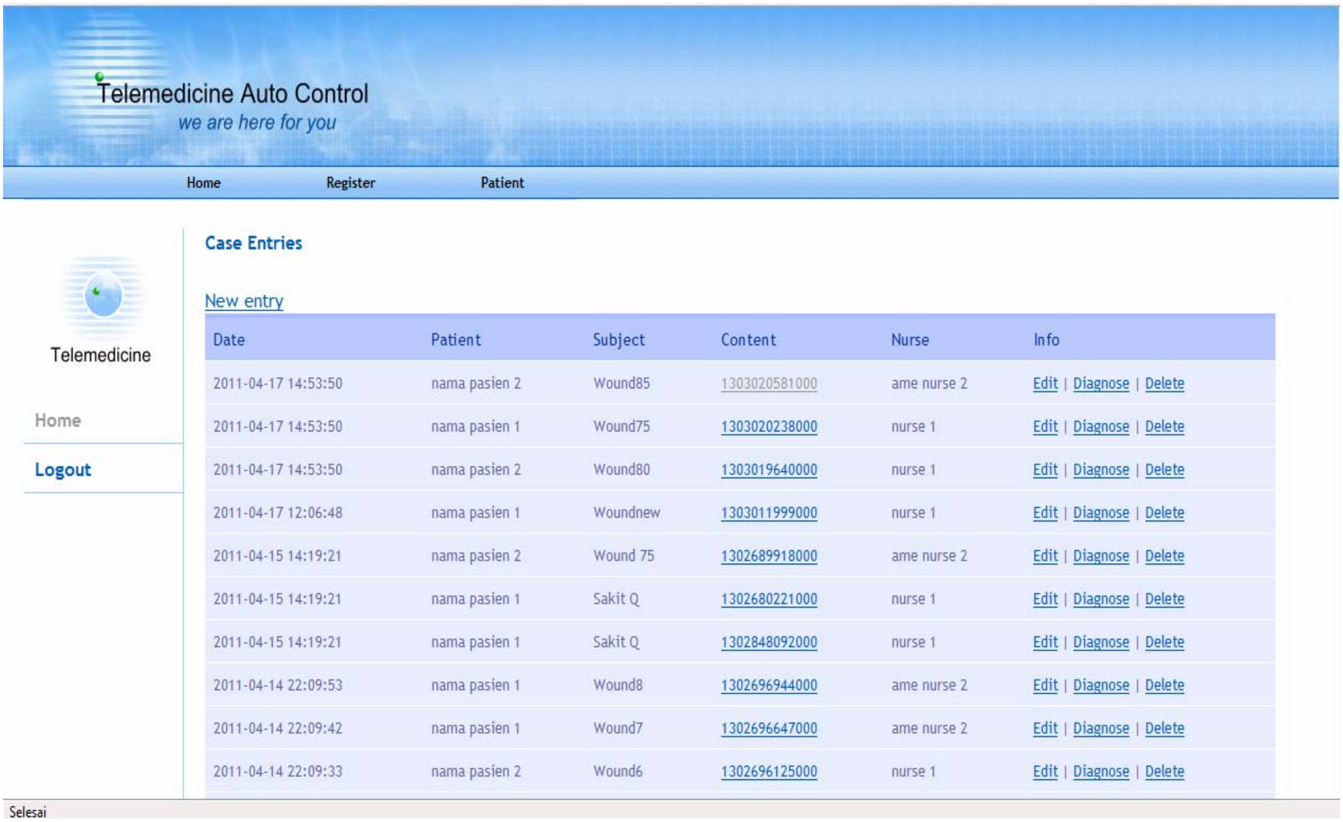


Figure 11 Layout of telemedicine system application (see online version for colours)



After the message is stored in the database, doctors can perform the diagnosis by viewing the content of the message. The content column comprises links for the multimedia messages received.

4.2.2 Telemedicine application

The telemedicine application consists of several interfaces, such as menus and submenus, for telediagnosis purpose. In this paper, we have shown some significant parts of the telemedicine system application. Figure 11 shows the telemedicine application interfaces.

The main menu interface contains several sub-menus. The main menu is the homepage of the system, and this homepage will be automatically opened for every opening the system. Once opened, the user can log into the system with the user identification. There are several groups of users, such as admin, doctor and nurse, with different authorities, who have already registered in the system. Any patient who will use this system is required to register first. Information about the patient can be observed on this layout. There is one column in the layout of case history which contains data about the patients sent by the nurse. After the diagnosis process is over, the doctor can enter the diagnostic results into the system, which can be delivered to the nurse/patient by clicking the send button of the system.

5 Testing and experiments

For testing the system, we send image files larger than the allowed capacity and evaluate the performance of the proposed system with regard to (a) compression and splitting processes and (b) time needed for sending the split files.

5.1 Measurement performance based on compression and splitting

The compression and splitting techniques are tested using file sizes varying from 40 KB to 153 KB. In this experiment, we have used a hand phone which has a Mobile Information Device Profile (MIDP) 2.0, connected with limited device configuration (CLDC) 1.0 and Java software version JP-8.4.4. The mobile applications have been developed using J2ME on the mobile devices, like mobile phones which have limitations in processing the large data. Java libraries allow only 30 KB data in a single delivery. The experimental results are shown in Table 1.

Table 1 Measurement performance based on compression and splitting (QF = 50%)

Data Size	*Reduced File Size After Compression*	*Split files*	*Split File Sizes*
153 KB	15 KB	1 file	15
115 KB	33 KB	2 files	16, 17
112 KB	52 KB	2 files	25, 27
101 KB	12 KB	1 file	12
100 KB	69 KB	3 files	20, 26, 23
92 KB	23 KB	1 file	23
66 KB	19 KB	1 file	19
61 KB	48 KB	2 files	23, 25
55 KB	14 KB	1 file	14
40 KB	12 KB	1 file	12

5.2 Measurement performance based on the transmission time

We also have conducted experiments to measure how much time it takes to send a message that has been compressed and split. We have carried out the experiment for each sample data, and then we have noted the time required to send the split files. The only disadvantage of the system application is that the Java libraries allocate limited memory space on mobile phone to perform a Java application, which imposes a limit on the maximum file size that can be sent. The experimental results are shown in Table 2.

Table 2 Measurement performance based on allocation of time

Data Size	*Compressed (50%) Size*	*Sending Time (s)*			*Receiving Time (sec)*			*Total Time (s)*
		File 1	*File 2*	*File 3*	*File 1*	*File 2*	*File 3*	
153 KB	15 KB	30	–	–	85	–	–	115
115 KB	33 KB	25	20	–	75	65	–	185
112 KB	52 KB	20	23	22	55	40	–	160
101 KB	12 KB	40	–		105	–	–	145
100 KB	69 KB	22	25	23	83	45	55	253
92 KB	23 KB	40	–	–	70	–	–	110
66 KB	19 KB	55	–	–	65	–	–	120
61 KB	48 KB	25	20	–	53	56	–	154
55 KB	14 KB	50	–	–	65	–	–	115
40 KB	12 KB	45	–	–	57	–	–	102

5.3 Measurement of the quality messages

In developing this system, we use compression technique, and then we also implement splitting technique to breakdown the file into small files based on pixel or bytes method. To measure the data quality after the reconstruction process, we use some indicators such as Peak-Signal to Noise Ratio (PSNR) and Universal Image Quality Index (UIQI). The PSNR can be defined as follow (Athi, 2010):

$$PSNR = 10\log\frac{\left(2^n - 1\right)^2}{MSE} \tag{1}$$

where

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}\left(X_{j,k} - X'_{j,k}\right)^2 \tag{2}$$

The calculation of the UIQI is defined as follows (Zhou, 2002):

Let $x = \chi_i \mid i = 1,2,3,\ldots N\}$ as the original image.

Let $y = y_i \mid i = 1,2,3,\ldots N\}$ as the reconstructed or corrupted image.

The proposed quality index is defined as:

$$UIQI = \frac{4\sigma_{xy}\,\overline{\chi}\,\overline{\gamma}}{\left(\sigma_\chi^2 + \sigma_y^2\right)\left[\left(\overline{\chi}\right)^2 + \left(\overline{\gamma}\right)^2\right]} \tag{3}$$

where

$$\overline{\chi} = \frac{1}{N}\sum_{i=1}^{N}\chi_i, \qquad \overline{\gamma} = \frac{1}{N}\sum_{i=1}^{N}y_i,$$
$$\sigma_\chi^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left(\chi_i - \overline{\chi}\right)^2, \quad \sigma_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left(y_i - \overline{\gamma}\right)^2 \tag{4}$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}\left(x_i - \overline{\chi}\right)\left(y_i - \overline{\gamma}\right) \tag{5}$$

$$Compression\ Ratio\left(CR\right) = \frac{Original\ image\ file\ size}{Compressed\ image\ file\ size} \tag{6}$$

We choose JPEG image because it is the most widely used image format on the mobile phones. The JPEG standard compression algorithm functions well and is currently widely applied in communications technology and multimedia information. This algorithm is very efficient for a mobile communication system. This is because the ratio of compression can reach more than 100:1, which greatly aids in storage and also the transmission of an image in a mobile network applied for internet applications. Lossless JPEG compression denotes the ideal solution, but this technique produces a small compression ratio. The lossless compression is ideal but it will not meet the requirements of applications requiring a maximum data rate or data size. The best lossless compression algorithm can produce compression ratio only around 3–4 times (Richardson, 2010). The best lossless image compression is GIF format. Unfortunately, the GIF format cannot handle image compression greater than 8-bits colour resolutions per pixel. PNG format is another lossless image compression that can compress in 24 bits or 48 bits colour resolutions. But the PNG image format has much larger file size than the JPEG image format so that this format is not suitable for mobile communication system.

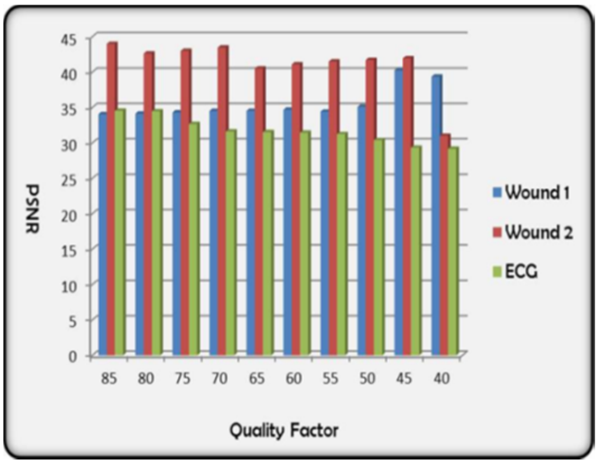
The developed framework is appropriate for mobile telemedicine system. The medical images that are captured using mobile phone directly stored in JPEG image formats are used as samples to perform experiments. The medical images used to perform experiments and measurements are shown in Figure 12.

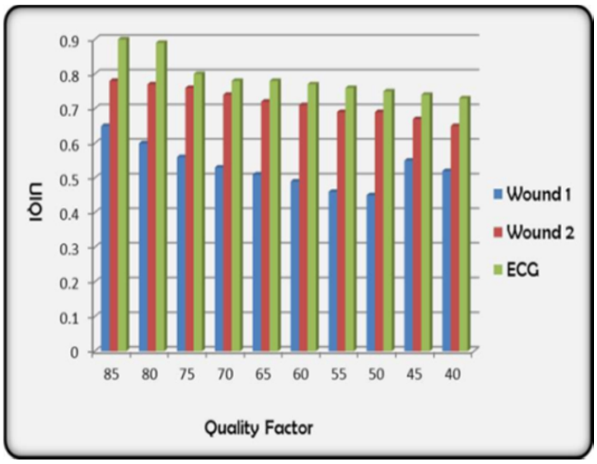
The experimental results show that all of the adapted techniques can run-well and developed applications can be installed on mobile phone devices. The proposed mobile multimedia computing and communication framework can transmit the real medical images from client's mobile to developed server and vice versa. The medical images are used for mobile telemedicine system applications especially for telediagnosis using ECG, skin diseases images. To know the system performance of the developed framework, three images are used to make sure that the developed framework can perform mobile multimedia computing for medical images smoothly. Figure 13 shows the experimental results of PSNR and UIQI values for several images (Wound1.JPEG, Wound2.JPEG and ECG.JPEG) that are transmitted using MMS application over mobile communications network.

The PSNR's values are more than 25 dB for both devices (for a QF range of 40–85). This means that the quality of the image is good enough for interpretation by the human eye (David, 2011). The proposed framework is appropriate for mobile telemedicine system especially telediagnosis for ECG and skin diseases.

Figure 12 Medical images for experiments (see online version for colours)

Figure 13 PSNR and UIQI of the three medical images for experiments (see online version for colours)





6 Evaluation and analysis

The mobile telemedicine system application, which has been developed using Java technology, is used to help the telediagnosis process by utilising MMS technology. The developed mobile telemedicine system is a client-server application system. The MMS application has been developed within the mobile device as a client which is used to connect the developed telemedicine applications in the server computer. In the client application, there are several applications such as compression and splitting the file before sending, then on the server-side, there are applications such as downloading, merging and decompressing the file to get back the original one.

In the simulation, the compression and split techniques have been carried out by mobile computing which has many limitations. The J2ME on the mobile phone uses Kilobytes Virtual Memory (KVM) which is unable to process the data with large size. Java technology is only as tool that is used to develop the system. This framework is for simulating the modification of MMS application on the client as pre-processing and telemedicine system on the server as post-processing. In these processes, we can send data only up to a maximum of 200 KB where a single delivery message (maximum size) allows only 30 KB. There are several applications installed on the server, such as downloading, merging, decompressing and storing the data into the database which can be accessed by the users in the mobile environment using the MMS technology. Server applications are web-based and have no problems with regard to the memory allocation because they are developed on the computer server.

The MMS applications on the client are installed on the mobile devices (mobile phone). As we know that the mobile devices have several limitations such as small memory size, small display, low processing power, the applications which are developed should be less complex so that they can be executed on the mobile devices. The Java application for a mobile device, such as Sony Ericson J105i mobile phone, has a limitation that it allows only 30 KB data to send out in a single transfer, so that in this application if the compressed data size is more than 30 KB, it will be split first before sending. This is Java technology constraint for developing MMS application on the mobile phone device. The splitting and merging techniques have been discussed in our previous research works (Andik et al., 2010b). Memory allocation problem on the mobile phone is not in our control, it solely depends on the vendor of the mobile phones. In this research work, we have used a low-price mobile phone device to reduce the cost of the developed system. In other words, the compression and split techniques provide the following benefits (a) the application can send files larger than the one that is possible with the existing application; (b) the application can maintain the quality of the original file by merging and decompressing the split files on the mobile phone receiver; and (c) the proposed method is suitable for client-server applications which require good quality data, such as telemedicine system. A comparison of the proposed and the existing methods is shown in Table 3. In this comparison, it is assumed that the applications use the same software and devices.

The proposed mobile telemedicine system is appropriate for mobile environments and limited bandwidth. It can cover larger areas than the existing system in general. The developed system can also be used in urban and rural areas using web-based services, if these areas have available bandwidth provided by mobile network operators such as 3G and latest mobile communication network. The developed mobile application adapted the techniques can also be installed on smartphone. It commonly has wide display therefore the information can be seen clearly. A comparison of the characteristics of the existing and developed system applications for mobile telemedicine system is shown in Table 4.

Table 3 Comparison of the methods for MMS

Item	*Existing Method*	*Developed Method*
Data Size	100 KB	> 100 KB
Resizing	Yes (smaller size)	No
Platform	Symbian C++	Java
Quality	Reduced	Preserved
Technique	Resizing	Compression and Split
Time	Average	Average-High
Cost	Low-cost	Average-High
Method	Sends single messages	Multiple messages sent in one go
Strengths/Weakness	– Automatic resizing before sending – It cannot be modified – It cannot send data larger than 100 KB – Quality and size are reduced	– Can send data larger than 100 KB – Quality is not reduced – There is proposed method for handling message failure

Table 4 Comparison between the developed and the existing systems

Mobile Telemedicine System (MTS)			
	The Existing System		*The Developed System*
1	Many researches about the development of MTS are to transfer ECG and to diagnose the chronic diseases (e.g. diabetes) using 3G mobile communication Network and web-based service methods.	1	The developed system is used for telediagnosis of skin diseases and ECG that can be used in limited bandwidth.
2	Generally, MTS is developed using the latest mobile technologies for developing in urban areas	2	The developed system uses ordinary mobile phone and limited bandwidth that can reach remote and rural areas.
3	Patient in remote and rural areas are still using phone or SMS to contact doctor for telediagnosis	3	Patient in remote and rural areas can send not only text or voice but also multimedia files for telediagnosis
4	Generally, the development of MTS needs high-cost and high performance system and device and also sophisticated technology	4	The developed system need low-cost and ordinary mobile phone but it is needed for patient in remote and rural areas where commonly in poor condition.
5	Generally, MTS is difficult to be operated by patient because many devices have to be used.	5	The developed system uses mobile messaging system especially MMS. It is very easy used because it is almost same like SMS where people commonly are already familiar.

In this research, we have developed the MMS framework which is adaptive and efficient for internet applications. This system is still a prototype and is very open for further research for improving the various techniques that are introduced before we can develop it in to a practical system. In any case, this pioneering research is expected to provide a direction for the researchers for developing a practical telemedicine system. We can implement lossy or lossless compression along with splitting technique on the mobile phone device.

7 Conclusion and future work

In this paper, we have discussed the development of a mobile telemedicine system. We have presented the implementation details such as the design of architectures, algorithms and applications. The system has been developed based on the Java platform where J2ME is used for the client applications and J2EE for the server applications. In the mobile applications, we have implemented the compression and split message techniques before sending the message and on the server, the merging and decompression techniques have been applied to store the received message into the database server. The main contribution of the proposed research work is that it enhances the ability of the existing MMS to send large multimedia contents. The outcome of this research work will be useful for developing a practical mobile telemedicine system which allows large data files to be sent without degradation for accurate diagnosis. In our future work, we intend to develop frameworks for telemedicine system applications that will be more efficient and adaptive.

References

Andik, S., Jahangir, M.A. and Raed, A.A. (2010a) 'Design of multimedia messaging service for mobile telemedicine system', *International Journal of Network and Mobile Technology*, Vol. 1, pp.11–14.

Andik, S., Jahangir, M.A. and Raed, A.A. (2010b) 'Split and merge for multimedia messaging service', *Proceeding ICEI*, University Technical Melaka, Malaysia.

Asadullah, S., Muhammad, M. and Muniba, S.M. (2008) 'A system design for a telemedicine health care system', *International Multi Topic Conference*, Jamshoro, Pakistan, 11–12 April.

Ashraf, A.T. (2008) 'Mobile personal electrocardiogram monitoring system and transmission using MMS', *Proceeding International Caribbean Conference on Device*, 28–30 April, pp.1–5.

Atanas, N. (2009) *MessagePart.java*. Available online at: http://members.fortunecity.com/neshkov/dj.html (accessed on 10 April 2009).

Athi, N.S. (2010) *Picture Quality Measures Calculation*. Available online at: http://www.ksrce.ac.in/ (accessed on 10 April 2010).

Cheng, W.Y., Ming-Feng, C., Kuang, C. and Ren-Guey, L. (2007) 'Real-time ECG telemonitoring system design with mobile phone platform', *Measurement*, Vol. 14, pp.463–470.

Ching, S.W., Hunang, J.L. and Tong, Y.C. (2007) 'Mobile telemedicine application and technologies on GSM', *The 1st International Conference on Bioinformatics and Biomedical Engineering (ICBBE 2007)*, IEEE, pp1125–1128.

Comverse (2009) *MMS is Growing in More Ways than One: The Dimensions and Implications of Surging MMS Growth*, November 2009.

David, H. (2011) *MMS, the Best Messaging Technology*. Available online at: http://technologycurrent.com/mms-%E2%80%93-the-best-messaging-technology (20 May 2011).

Drishya, A.G. (2006) *Mobile Telemedicine System*, Sree Narayana Gurukulam College of Engineering, Kerala, India.

Figueredo, M.V.M. and Dias, J.S. (2004) 'Mobile telemedicine system for home care and patient monitoring', *Proceeding of the 26th Annual International Conference of the IEEE EMBS*, Vol. 5:pp.3387–3390.

Govind, S.T., Ganish, S. and Vishal, G. (2010) 'Multimedia streaming technology 4G mobile communication systems', *International Journal on Computer Science and Engineering*, Vol. 2, No. 3, pp.695–699.

Greg, B. (2001) *Building Scalable and High-Performance Java™ Web Applications Using J2EE™ Technology*.

Gwenael, L.B. (2005) *Mobile Messaging Technologies and Services SMS, EMS, MMS*, 2nd ed., John Wiley and Sons, Ltd.

Hammad, D. and Shariq, K.A. (2009) 'Systematic review of the use of telehealth in Asian countries', *Journal of Telemedicine and Telecare*, pp.175–181.

Hilmi, M.H. and Aklili, K. (2010) 'Development of MMS-based receipt system for mobile banking', *International Symposium in Information Technology (ITSim)*, pp.2155–2897.

Hilmi, M.H., Nasleeni, S.H. and Nur, S.M.Y. (2010) 'Development of MMS-based examination results system', *Proceeding of the 9th WSEAS International Conference on Applications of Computer Engineering*, pp.157–163.

JENI (2007) *Java 2 Micro Edition*. Available online at: http://jeni.jardiknas.org/ (accessed on 10 April 2009)

Kevin, H. and Yuan, T. Z. (2003) 'Implementation of WAP-based telemedicine system for patient monitoring', *IEEE Transactions on Information Technology in Biomedicine*, Vol. 7, No. 2, pp.101–107.

Kin, C.Y. and Sintiani, D.T. (2008) *MILCA – A Mobile and Interactive Learning Environment on Campus*, Springer-Verlag, Berlin, Heidelberg.

Lei-da, C. and Gordon, S. (2005) *Mobile Commerce Development Application*, Cybertech Publishing, USA.

Miraj, E.M. (2005) 'Improved implementation solution and general mobile network architecture for interworking between mms and streaming', *International Journal of Communication Systems*, pp.335–357.

Nemati, A.G., Enokido, T. and Takizawa, M. (2008) 'A multi-source streaming model for mobile peer-to-peer (p2p) overlay networks', *Network-Based Information Systems*, pp.122–131.

Open Mobile Alliance (OMA) (2005) *Multimedia Messaging Service Encapsulation Protocol, OMA-MMS-ENC-V1_2-20050301-A*, Approved Version 1.2.

Open Mobile Alliance (OMA) (2008) *Multimedia Messaging Service Requirement Candidate Version, OMA-MMS-ENC-V1_3-20080128-C*, Approved Version 1.3.

Pennie, S.S., Tiffany, A.W., Carin, M.P., Caitlin, C.O., Patrick, D.P., Nichole, W., Michael, J.W., Jean, B. and Christian, G.Z. (2008) *Telemedicine Research: Opportunities and Challenges*, Boise State University, USA.

Polley, R.L., Max, Q.H.M., Fanny, F.L., Chen, X.J. and Peter, X.L. (2006) 'A 3G based network solution on the telehealthcare robotic system', *Proceedings of the 6th World Congress on Intelligent Control and Automation*, pp.381–384.

Richardson, I.E. (2010) *The H.264 Advanced Video Compression Standard*, 2nd ed., John Wiley and Sons, Ltd.

Swadesh, K.S., Jhon, W. and Mohammed, G. (2009) 'Special delivery: an increase in MMS adoption', *IEEE Potentials*, pp.12–16.

Telkomsel (2007) *GSM/GPRS Network Expansion in Indonesia*. Available online at: http://www.mobilecomms-technology.com/projects/telkomsel (20 May 2011)

Yoke, S.I., Allya, P.K. and Soegijardjo, S. (2006) 'ICT-based telemedicine system in management of public health problems', *Proceeding Konferensi Nasional Teknologi Informasi & Komunikasi untuk Indonesia*, STEI Bandung Institut Technology Indonesia, pp.223–226.

Yuechun, C. and Aura, G. (2004) 'A mobile teletrauma system using 3G networks', *IEEE Transactions on Information Technology in Biomedicine*, Vol. 8, No. 4, pp.456–462.

Zhou, W. (2002) 'A universal image quality index', *IEEE Signal Processing Letters*, Vol. 9, No. 3.