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FILE SENDING VIA DIFFERENT MOBILE CHANNELS: AN OPPORTUNISTIC APPROACH

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ABSTRACT

Data and information transfer among mobile devices is very important in this technology-driven world. The Short Message Service (SMS), Multimedia Messaging Service (MMS), and Third Generation (3G) mobile technology are such services that allow users to relay data among mobile devices. However, these channels are faced with their own corresponding challenges and issues which affect the reliability and cost efficiency of data transfer.

This paper presents implementations of applications that allow the transfer of any form of data using the three channels specified above. In addition, it introduces an opportunistic system which has the ability to incorporate all three channels, as well as to choose which one to use in sending data at any given time. However, such system is very costly in resources. It is costly in memory because it uses threads, and also in mobile credits because of its use of SMS, MMS, and 3G services. The project, nonetheless, established a reliable data transfer protocol among mobile devices by allowing each channel to compensate for one other's disadvantages.

1. INTRODUCTION

Mobile phone usage has surged in the Philippines, totaling to about 92.2 million by the end of 2010 [6]. These mobile devices have made sending and receiving of data much easier. Sending of information usually comes in the form of SMS messages, with the larger ones being separated into a set of messages. Furthermore, systems such as chitSMS [12] and CaReSMS [10] showed that sending all types of data is possible through SMS. These applications sent database updates using the said systems. However, it is worth-noting that data size is directly proportional to the number of messages sent, meaning, the SMS channel proves to be inefficient for larger data. To make up for this disadvantage, other mobile network channels such as MMS and 3G were considered.

Four Android applications were developed, three of which corresponded to the different channels mentioned above, and the fourth used all three channels. Android is a software stack for mobile devices that includes an operating system, a middleware and key applications. Furthermore, the Android SDK provides programmers with the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language [2].

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Android was chosen since development of this software is free, and development tools and resources are readily available online. In addition, Android does not differentiate between the phones' core applications and third-party applications. This means that third-party applications can be built to have equal access to a phone's capabilities, providing programmers and application users with a broad spectrum of applications and services [1].

However, the first three applications do not always guarantee successful file sharing since there are many factors affecting the reliability of successful data transfer. SMS messages experience transmission delays, propagation delays, and loss [13]; 3G and MMS require internet connectivity which is very unstable during the occurrence of calamities like typhoons, not to mention, unavailable in most rural areas. Because of these, data transfer using one channel may be interrupted anytime during its execution. As a solution, the fourth application is an opportunistic system that incorporates all three channels. The system can decide which channel is most suitable for data transfer at a given time or scenario. For example, when a sudden change in the current channel occurs, (e.g. mobile device becomes disconnected from the internet), the system adapts by selecting a different channel to continue transferring data.

2. RELATED LITERATURE

2.1 Related Technologies

2.1.1 SMS (Short Message Service)

SMS, commonly referred to as "text messaging," is a service for sending and receiving short alphanumeric messages to mobile devices, including cellular phones, smart phones and PDAs. A text message can process a maximum of 160 characters (letters, numbers or symbols in the Latin alphabet). SMS text messaging is the most widely used data application in the world. In fact, according to the International Telecommunication Union, 6.1 trillion SMS text messages were sent in 2010 alone. That equals to 192,192 SMS per second [5].

2.1.2 MMS

MMS, or Multimedia Messaging Service extends the core SMS capability, allowing mobile phones to send messages that include multimedia content. It was popularized mainly because of its ability to send photographs from camera phones. It is also used as a popular method in delivering news and entertainment content including videos, pictures, text pages and ringtones, among others.

Although the MMS standard does not specify a maximum size for every message, 300kb is the current recommended size used by networks due to some limitations on the WAP gateway side [9].

2.1.3 3G

3G, or 3rd Generation of mobile telephony technology, is a standard for mobile telecommunication services that fulfills the International Mobile Telecommunications - 2000 (IMT-2000) specifications by the International Telecommunication Union (ITU). 3G provides mobile broadband to smartphones and some wireless devices.

Some of the standards branded as 3g are the following:

- UMTS
  - W-CDMA
  - TD-SCDMA
  - HSPA+
- CDMA2000

Globe Telecom and Smart Communications, the leading telecommunication companies here in the Philippines, use W-CDMA(UMTS) operating at 2100 MHz frequency[7].

2.1.4 Android

According to its official website, Android is a software stack for mobile devices that includes an operating system, middleware and key applications [3]. On the other hand, the Android SDK provides programmers with the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language.

The researchers chose Android since it can be developed free of charge. Development tools and resources are also readily found online. In addition, Android does not differentiate between the phones' core applications and third-party applications. This means that third-party applications can be built to have equal access to a phone's capabilities, providing programmers and application users with a broad spectrum of applications and services.

2.2 Related Literatures

2.2.1 chitSMS: Community Health Information Tracking System Using short Message Service

The chitSMS is generally an extension of the Community Health Information Tracking System (CHIT). CHIT is a computer-based information system that serves the needs of health centers. miCHITS is it's mobile extension. chitSMS establishes a remote connection between the server and the mobile application of miCHITs, allowing the sending of records or databases via SMS. The system used compression algorithms and TCP-like protocols to ensure that the records reach the server in a fast and guaranteed way [12]. In chitSMS, the connection is between a mobile phone and a server. For this project, however, the connection is between two mobile phone users.

2.2.2 CaReSMS: A Calamity Response System Utilizing SMS

CaReSMS is a system for gathering information concerning calamities and their facts. CaReSMS explored the idea of Crowd sourcing. That is, reports about calamities supported by measurements come from the community. The system will plot the input from the community to produce a visual map of the situation.

3. PROBLEM STATEMENT

Today, mobile devices are commonly used to transfer data and information from one person to another, and transferring any form of data has been shown to be possible through the use of different channels. However, there are many factors that hinder the reliability that the data can be received.

Even though SMS is the most widely available among the three channels, it experience transmission delays, propagation delays, loss and reordering. Also, it is limited to short alphanumeric messages. On the other hand, MMS has file type limitations and it involves compression techniques thus the file received by the receiver might be a low-quality version of the original file. Likewise, the advent of 3G now allows users to easily connect to the internet and send files using their mobile devices. However, since 3G coverage is limited in the Philippines, its potential as a file sharing medium is not maximized especially in rural areas.

The opportunistic file sharing application in this study incorporates the three channels mentioned above, it is designed in such a way that each will compensate for each other should an issue arise on one channel. The switching of channels introduced in this paper ensures the continuity of file sharing regardless of interruptions in one channel, thus, increasing the chance of having a reliable data transfer.

4. METHODOLOGY

Figure 4.1 shows the system setup. First, the data underwent compression before it was sent through one of the three channels. Gzip was used as compression algorithm since it gives good and balanced compression/speed ratio with emphasis on speed [4]. After compression, the data was translated into ASCII string format via base64 encoding. Base64 allows the conversion of binary data into ASCII by translating it into a radix-64 representation. The encoded string generated from the translation was further divided into parts, called packets. A packet's size is equal to the maximum size possible for one SMS. This was done since SMS has the smallest size limit among the three channels.

The application on the side of the sender is responsible in selecting which channel to use. It also coordinates with the application on the receiver side for it to be able to adjust with the current situation of a given channel (e.g. if the receiver is available for 3G). The sender receives feedbacks or acknowledgements from the receiver, indicating which packets are missing. The receiver collects these packets and compiles them all back to one string. The string, then, undergoes decoding and decompression to finally arrive at the original data, concluding the data transfer.

The initial approach was to implement the data transfer application on each channel separately. The observed performance of these applications would, then, form the basis of the combined algorithm. As such, the following sections would first discuss the general protocol adapted by the individual channels, followed by a discussion of the strategies used by the individual channels, and finally the introduction of the combined system.

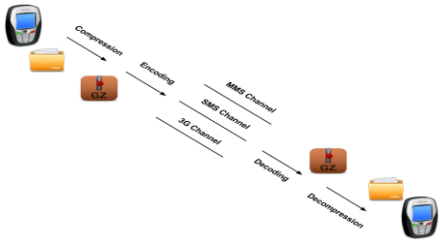

Figure 4.1: System Setup

4.1 General Protocol

Because the three channels send data differently, a general protocol was adapted by each to establish similarity and simplicity. Figure 4.2 describes the general protocol implemented. Initially, the sender will send a message handshake informing the receiver that a file will be sent. This also includes information regarding the number of packets expected to be sent. The receiver will, then, send a message confirming that he wants to receive the file. After receiving the confirmation, the sender sends N packets, where N is the number of packets corresponding to the channel (10 for SMS, 100 for MMS and 400 for 3G), to the receiver. The receiver sends an acknowledgement for every N packet it receives, including a resend list for any lost packet. The sender will, then, send another N packet and the process repeats itself until the receiver receives all the packets.

Each message begins with a sequence number to aid the receiver in arranging the messages in their proper order, and distinguishing between duplicated messages and new messages.

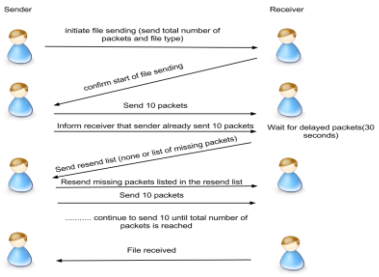

Figure 4.2: General Protocol

4.2 SMS Channel

Even though SMS already includes several reliability mechanisms, an additional protocol is still needed because according to a 2011 study on the reliability of a nationwide short message service, the message delivery failure ratio is as high as 5.1% during normal operation conditions[11].

Figure 4.3 describes the protocol used for the SMS-based file sending application. Initially, the sender sends a message informing the receiver that a file will be sent. The receiver, then, sends a message confirming that he wants to receive the file. After receiving the confirmation, the sender sends 10 packets (1 packet is equivalent to 1 SMS message) to the receiver. A 3-second interval was used in packet sending to regulate the number of outgoing messages. Immediately after sending the 10th packet, the sender sends a receipt informing the receiver that 10 packets have been sent. Upon receiving the receipt, the receiver first waits for delayed packets for 30 seconds. After the waiting period, the receiver now checks if he received the expected packets. If there are missing packets, the receiver creates a resend list for the sender, otherwise "resend none" will be sent.

On the other hand, upon receiving the resend list, the sender sends the requested packets specified in the list. If the special message "resend none" was received, the sender proceeds on sending the next set of 10 packets. The process of sending packets will be repeated until all packets are already sent. Finally, upon successfully receiving all packets, the receiver sends a done message to the sender, indicating success of the file sharing.

In 90 seconds have elapsed after the sending of receipt and the resend list still has not reached the sender, the sender automatically resends the receipt to maintain the transfer.

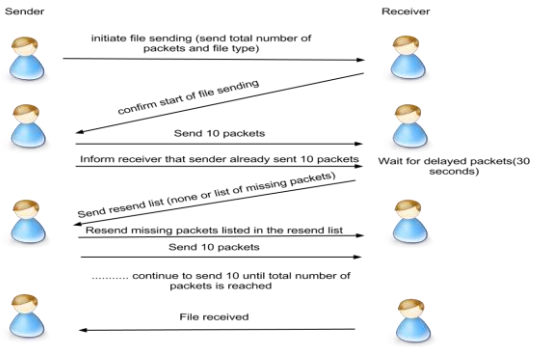

Figure 4.3: SMS Protocol

4.3 MMS Channel

The application asks the sender for information of file destination and type. After pressing the send button, it sends an SMS to the receiver, informing the start and end number of packets as well as the file type to be received.

After receiving the SMS, the receiver also prompts the sender via SMS that he is ready to receive the MMS. The sender then starts sending the MMS, 100 packets at a time, and waits for a prompt from the receiver that he has already received the MMS. When the receiver prompts the sender that he has received the MMS, the latter sends the next 100 packets via MMS. When the receiver finishes receiving all the expected packets, he sends an SMS to the sender indicating the completion of the file sharing.

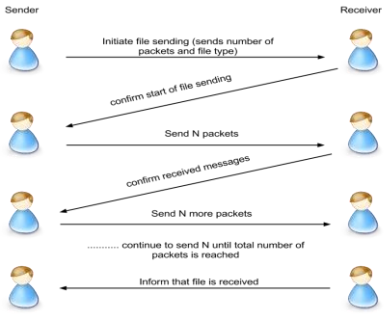

Figure 4.4: MMS Protocol

4.4 3G Channel

The application for this channel takes advantage of the Extensible Messaging and Presence Protocol, or XMPP service offered by Google Talk. It uses Smack API, an Open Source XMPP client library which is implemented in java and used for instant messaging and presence [8]. Using this, the application becomes an XMPP client, connecting to the Google Talk Server and transforming into a chat-like program between the sender and receiver.

Initially, the application prompts the sender to log in with his Google account, and it establishes a connection with the Google Talk server. If the target receiver is not available, or if he is offline, the data transfer is terminated.

Otherwise, the sender sends a request for file sending to the receiver. After receiving confirmation from the receiver, the sender proceeds on sending chat messages. Each chat message contains 40 packets, repeated 10 times before waiting for an acknowledgement. The receiver, in turn, sends a confirmation for every 10 messages or 400 packets received. After every confirmation, the sender sends another set of messages, and the process repeats itself until all packets are taken cared of. Upon receiving all packets, the receiver informs the sender, and the file transfer is completed.

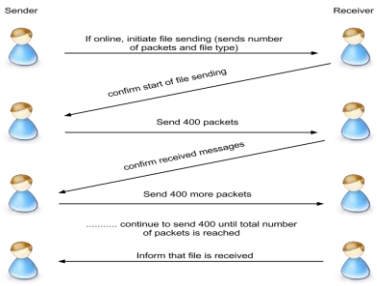

Figure 4.5: 3G Protocol

4.5 Combined System

The combined application is an opportunistic system that takes into account the challenges faced by the individual channels. Since SMS is the most widely available among the three, all preliminary handshakes are sent through this channel. SMS is chosen as medium of transfer since it is cheaper than MMS and is more readily available than 3G connectivity. The receiver will send an acknowledgement receipt via SMS that contains keywords indicating the availability of a 3G network on his side. If the receiver gets disconnected or connected to the internet, an SMS is sent to notify the sender so that it can adjust the channel used for data transfer. Acknowledgements and resend lists are also sent via SMS, as well as the terminating message indicating the end of a successful data transfer.

4.51 Version 1

Availability of 3G networks on both mobile devices gives the 3G channel the highest priority, since it allows the fastest data transfer. In its presence, all packets are sent using the 3G application. However, if either the sender or receiver gets disconnected, the system switches to the MMS channel. For MMS, a 5 minute-timer is set every time a packet is sent, and resets for every acknowledgement the sender receives. If the sender is unable to receive an acknowledgement within the given time period, a timeout occurs and a switch to SMS commences. If the SMS channel is used, the system takes note of the number of resends the receiver asks from the sender. Once the amount of resend request exceeds five for every ten packets sent, the system deems the SMS channel unreliable at the moment and switches back to MMS.

A shift to the 3G channel always occurs if both mobile devices are connected to the internet. Thus, when the receiver sends a notification on the availability of 3G connection, and the sender is also connected, a shift to the 3G channel is inevitable whatever the current channel is.

4.5.2 Version 2

There are two active channels at any given time. First, there is a separate thread which continuously sends packets via the SMS channel. Second, if both users are online, packets are sent via 3G; otherwise, MMS is used. Three separate threads for each channel are not recommended since MMS and 3G cannot run concurrently because of network connectivity type issues. Thus, the system only considers shifting between the 3G and MMS channels. It considers the 3G channel if and only if both devices are online; otherwise, it uses the MMS channel. The 5-minute timer is retained for the MMS channel; however, the system resends the previous packets instead of shifting channels upon timeout.

5. ANALYSIS OF RESULTS

The transmission time is the most integral part of the experiments. This is the amount of time from the beginning until the end of packet transmission and is calculated using the generated log files. Fields with NA mean that the standard set of tests was not conducted. For SMS, 20kb experiments were not pursued because initial results showed that the number of resends surpassed the total number of packets to be sent. For MMS, the 5kb experiment was disregarded since it is also equal to one MMS, similar with the 10kb experiment. For 3G, 5kb and 10kb experiments were not considered since the results are predictable.

Transmission Time (seconds)	5 kb	10 kb	20kb	50 kb
SMS	221.917	517.15	NA	NA
MMS	NA	79.2	149.708	NA
3G	NA	NA	18.56	40.22

For the individual applications, 3G offered the fastest data transfer among the three, easily surpassing the MMS and SMS channels. SMS proved to be very slow since it transferred only one packet per message. Some messages were even delayed, causing the receiver to request for a resend. 3G was superior in sending larger data sizes even if MMS sent more packets per message. This could be associated with the time it took for the receiver to download the packets from the server of the phone's network provider.

The opportunistic system based its design on these initial results.

Number of shifts	Transmission Time (minutes)	SMS Count	MMS Count	3G Count
0	26.33	102	0	709
1	46.87	108	4	789
2	65.17	115	9	716

Experiments using a payload of 3MB audio file were conducted for the combined application, while exposing the setup to controlled situations. This included sudden disconnections of one mobile device or the sudden availability of the 3G channel. This was done to force the shifting from 3G to MMS and vice-versa. From the results, transmission time increased when the application shifted from 3G to MMS. This increase was due to the faster transmission time of 3G. Furthermore, the notifications for shifting were sent through SMS, further increasing transmission speed. The SMS notifications were an added overhead.

Comment [U1]: 3g to MMS or MMS to 3g? please double check

6. CONCLUSION

Each channel is capable of sending any form of data between mobile devices, but there are different factors and unpredictable scenarios that may jeopardize the process. If important data are being transferred, the reliability and consistency of the transfer process far outweighs the costs. From here, the combined algorithm guarantees that the data would be received. Furthermore, by incorporating all available channels, each compensates for the failure of the other in sending the data packets.

7. RECOMENDATIONS

Voice calls is another channel for data transfer worth-investigating. The ability to send other forms of data aside from speech during periods of silence in voice calls presents a better alternative to MMS and 3G. This is due to the wider coverage of GSM. The channel is also cheaper than SMS, making it more cost-efficient. The researchers recommend further tests to investigate the behavior of the channels under different circumstances (time, location) during file transfer. Furthermore, since the opportunistic system is shown to be costly in resources, a search for a more cost-efficient approach is advised.

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