A Study on the aspect of data transmission on SMS interface

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ABSTRACT: *We, in this paper identified an aspect of data transmission that could help address the existing gap between the availability of the second and third generations of mobile telephony in the light of increased demand for growth of machine-to-machine applications using mobile data technology. Our approach helped to findout the reliability of sending data through the SMS interface as an alternative means to transmit data over newer technologies such as GPRS. The research primarily focused on transport performance, and looked into dierent factors of integrity and reliability, such as transmission time and number of retries. Further our study was then divided into construction, testing and analysis phases wherein the output was an analysis of the data gathered from testing packet data transmission via SMS and GPRS in key locations around a specic locale. The empirial findings we have developed show that the SMS in general works in a slow but steady pace of delivery, while GPRS (using the UDP protocol) oers a quicker but slipshod transmission.*

Keywords: Data transmission, Network reliability, SMS Interface, GPRS, Packet transmission, Network performance

Received: 15 November 2010, Revised 19 December 2010, Accepted 24 December 2010

1. Introduction

The rise of the Internet culture along with mobile phones has called for a converging of the two technologies. The availability of the diverse and abundant information the Internet provides, and the accessibility of mobile phones with more than a billion users worldwide, has pushed the advancement of mobile technology. As of the GSM wave of mobile technology, mobile phones used radio signals to transmit and receive data reaching transfer speeds of around 115.2 kb/s. Further advancements of the said technology, including the 3rd and 4th recognized mobile technology generations, y up to 11mb/s [8].

With the coming of these newer technologies, the better and more advanced 3G and eventually 4G were commonly thought to replace the already established 2G services. Business factors however, such as infrastructure cost and market demands, hinder 3G from replacing 2G anytime soon. In places like Nigeria, the demand for higher-end wireless services contributes less than 1% of the total population [14]. With a target margin this small, wireless service carriers are forced to put higher premiums on 3G services and only place 3G capable towers in strategic locations. This kind of inconsistencies between 3G capable areas and 2G only capable areas lead to poor signal strength, connection diculties, poor quality and low overall customer satisfaction.

While the use of wireless services is growing, with more than a billion SMSs sent everyday [7], it is expected that Philippine telecommunication carriers are better equipped to provide quality SMS services to its clients compared to more premium services such as GPRS. It is therefore more practical to take advantage of this and nd innovative ways to broaden the spectrum that SMS currently addresses. The result will most certainly not make SMS replace the higher-end technologies, especially in terms of performance, but simply give a share of the demand to SMS as the market progresses and transitions to the next generation technologies.

1.1 Objectives

In order to provide a thorough study on the reliability of data transmission over SMS versus GPRS, this study aims to first design and construct a robust SMS and GPRS data transmission (sending and receiving) interface based on the network protocol proposed in [24]. This research also seeks to define a measure of network reliability and performance for data transmission with variables such as target locations around Metro Manila, SMS and GPRS/EDGE technologies, and data size. To quantify GPRS performance, the UDP protocol is used. Fragmented payload (UDP-F) is also used to allow for a like to like comparison since SMS can only hold smaller payloads. This allows for ease of conversion of existing machine-to-machine applications to use the same PDU size constraint and also makes it easier to compare use cases, wherein the system was originally built for SMS then modied to support GPRS/UDP at a later time (or vice versa). This study, however, does not attempt to compare the reliability of network providers and machines used; hence, such factors will be controlled throughout the study. Lastly, this paper aims to test two (2) over the top networks: SMS and UDP-fragmented (UDP-F).

1.2 Signicance of the Study

More and more mobile machine-to-machine applications are being developed in the fields of health care, telemetry and navigation among others; and this growth area will denitely benefit from a more pervasive and reliable data transmission [24]. GSM technology worldwide is enjoying a wide coverage for its subscribers; however, the newer and more advanced 3rd and 4th generations' coverage area remain focused only where there is existing demand for such services. Although newer and more advanced mobile technologies exist and allow faster data transmission, these services reach only a small fraction of the user population. Therefore, the need for alternate and robust data transmission methods still exist for the Third World.

2. Review of Related Literature

2.1. Global System for Mobile Communications (GSM)

With the aid of a subscriber identity module (SIM) that carries the user's personal number, GSM systems have enhanced lives by providing mobility [17]. Since the start of the GSM network operations, a variety of value-added services have been oered. This research will only focus on two of such services, the short message service (SMS) and general packet radio service (GPRS).

SMS enables users to send and/or receive alphanumeric messages up to 140 bytes in length. Messages are stored and transmitted via a short message service center (SMSC) [15], and could be sent as text or binary. General packet radio service (GPRS), on the other hand, aims to enlarge the 9.6 kb/s data transfer rate of GSM services to over 170 kb/s so as to enable multimedia communication [4]. It applies a packet radio principle to improve and simplify wireless access between mobile stations and packet data networks. It then oers data connections with higher transfer rates and shorter access times [3].

In the context of this study, the GPRS mechanism shall use the User Data- gram Protocol (UDP) as specied in the Internet Protocol (IP) for data transmission. The reason for this is that GPRS transmission will be done using traditional sockets as usually used in computer networking further specified in the Methodology portion of this paper. Therefore the use of the UDP protocol is more suited in this scenario since the said protocol does not have implicit handshaking mechanisms, which allows flow-control to be handled at the Application Layer of the Open Systems Interconnection Model (OSI Model) for several logging and documentation functions specific to this experiment, as compared to other IP protocols such as TCP/IP, which has functions that handle this at the Transport Layer.

2.2 Data Transmission through SMS

Although more advanced technologies, such as GPRS, allow faster data transmission, it is not always reliable in developing countries, where SMS is predominantly used. It is therefore important to look into the feasibility of using SMS in transporting different types of data. Its nationwide coverage, aordability, security, and compatibility of with future technology upgrades, are some of the many factors why the GSM-SMS network has been deemed ideal for information transmission [1][24].

Medical. SMS is widely used in the medical field since it is not only instantaneous, accessible and mobile, but also cost effective. Computer and online access is not needed, and given that physicians have to make rapid decisions, SMS provide the brevity and immediacy they need. Urgent medical advice could now then be sought. In Italy, an SMS wassent toa surgeon stating that a 22 year old male arrives, coughing blood. A reply was received a minute later advising an angiogram to identify aortic rupture [22]. Similarly, SMS has been also used in collecting diary data from patients for monitoring and self-management of asthma [2], sending reminders and results to patients, as well as collecting data from outpatients to evaluate overall patient satisfaction. Advantages include convenience, immediate results, reduced costs, and reduced paper use. Condentiality and the inability to convey a large amount of data, however, are some concerns [20].

Alerts and Other Services. Moreover, SMS could be used to enable access to network equipment using a mobile phone. An application of such is a network alarm monitoring system wherein alarm messages generated by a network management program are forwarded to mobile phones of members of the network operations center (NOC) using a simple mail transfer protocol (SMTP) to SMS gateway [23]. Wireless value-added data services based on SMS, such as sending and forwarding emails, and accessing train schedules, could also be deployed. Users could query local schedules via SMS based on train class, time, and target destination. The said schedule service may also be used for other ticket reservation services like the ones for airlines [18].

Likewise, *MobileDeck*, an engaging front end environment that used SMS as the main communications channel, integrated a graphical user interface (GUI) with a server that feeds the appropriate content through instructions contained in binary SMS. Due to the relatively low cost and accessibility of SMS, MobileDeck has proven to be an suitable alternative to services running on top of other mobile data technologies such as GPRS for data transfer and content distribution [19].

SMS has been perceived to continue leading the peer-to-peer mobile communication data service, as it is the most accessible, easiest to use, and not to mention the cheapest. Other applications and data services could also be introduced through SMS, such as personal instant messaging and SMS-based money transfer [6]. However, due to its limited size, using SMS for data transmission will require the division of the total data to be sent into one or more packets with a ratio of 1:1 packets per SMS. In order to fulll this, a header is used to specify the sequence of the segments [5].

2.3 Other Technologies

In this study, the group will use mobile broadband dongles as modems to send and receive data using over the top networks, particularly SMS and UDP-F. Once a serial connection to the dongle has been opened, data could now be transmitted using AT commands, also known as Hayes commands, and the open-source PySerial module in Python [16]. Checksums, particularly cyclic redundancy checks (CRCs), are then generated to determine data integrity. These are error detection mechanisms created by summing up all the bytes in a data to create a checksum value, which is appended to the message payload and transmitted with it. If the computed checksum of the data received matches the received checksum value, then there is a high probability that there was no transmission error [13]. The checksum function used in this research is the built-in crc32 function in Python’s zlib module, which is calculated using the following formula:

$$x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^{8}+x^{7}+x^{5}+x^{4}+x^{2}+x+1 \qquad (1)$$

2.4 Network Protocol Security and Eciency

The study uses a simple authentication protocol between the transmitting and receiving ends, which are held as constants, to ensure that ends are operational during a test. It is therefore less secure, as it can easily be mimicked to disrupt proper transmissions, than the traditional Session Initiation Protocol (SIP) that the Internet uses, where it caters to multiple users at the same time, but is nevertheless sucient for this study’s purposes. A recent study seeks to eliminate at least one of the security issues experienced over the Internet when using SIP which can also be applied to a broader implementation of this study [11].

The concern of eciency also comes to question once a more comprehensive and possibly decentralized application is in view. Another study highlights the comparison of proactive, reactive, and hybrid routing protocols for mobile ad-hoc networks that allows optimal traversing in a decentralized structure [25].

2.5 Network Reliability

Reliability is dened as the probability of a tool to perform successfully over a given time interval under specied conditions [12]. It is hence a number between zero and one, or 0% and 100% [9], which may be estimated by:

$$R = \frac{N_t - N_f}{N_t} \qquad (2)$$

where R = estimated reliability;

N_t = total number of trials; and

N_f = number of trials resulting in failure [10].

R is only an estimate due to the nite number of trials taken. In general, a tool is reliable if it yields consistent results when measured across various contexts [21]. The estimated reliability approaches true reliability as the number of trials approach innity [9].

3. Framework

This study will be structured around the network protocol proposed in [24]. The said protocol has two legs: transmitter and receiver. In this research, however, the application will not terminate until all data has been successfully transmitted. After sending each packet, the transmitter application will listen for feedback, and will only continue or terminate once an acknowledgment packet indicating good transmission has been received, or otherwise called the automatic repeat request (ARQ) mechanism. This only happens if the packet received indicates faulty transmission or when the application after a certain amount of time still does not receive anything (a timeout). The process ow for the transmitting and receiving leg of the application is shown in Figures 1 and 2, respectively.

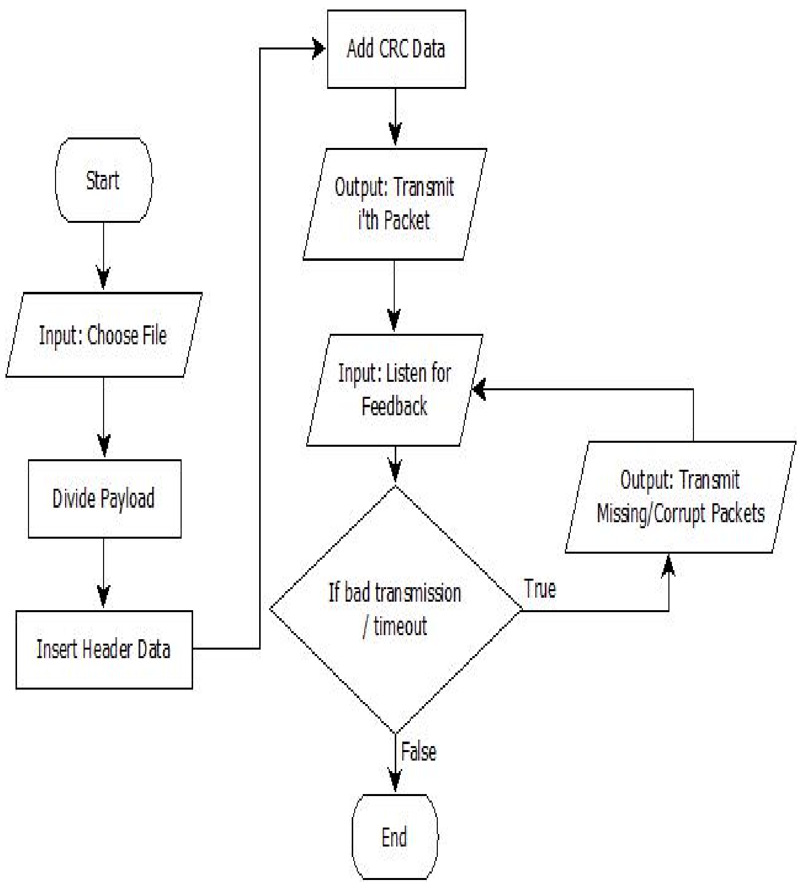


Figure 1. Transmitter Protocol Flow

Transmitting data larger than what a single SMS can conventionally hold will require the data to be split and sent over numerous SMSs depending on the size of the data. For better comparison, the GPRS mechanism will also be structured similarly. The data will be divided into several packets and will form the payload data of every packet. The header data of every packet on the other hand, will basically contain necessary information about the respective packet such as the packet's queue number, the total number of packets to be sent and other necessary data supporting le integrity. The number of packets will then be inuenced by variables such as data size other functional schemes like for instance le integrity checking, encryption and compression schemes.

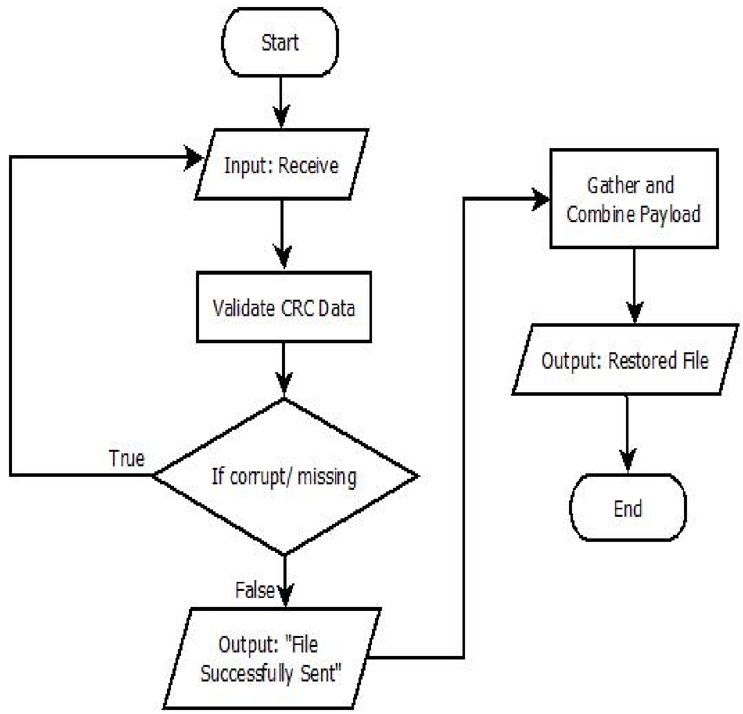


Figure 2. Receiver Protocol Flow

The receiving leg will more or less be the reverse of the transmitting leg of the protocol. The receiving device will wait until it collects all of the packets, check them for le integrity, request for resend of packets if necessary, and nally stitch the data back into its original form. If in the event that the application is waiting for a certain packet and does not receive it in a given amount of time, the receiving application will be deemed to have timed out. It will then stop the current test and proceed with the next one or terminate the application depending on user input.

4. Method

4.1 Interface

The transmitter and receiver applications were coded in Python 2.7 [16]. The checksum function used is the built-in crc32 function in Python's zlib module. The applications were used to send and receive data over SMS and GPRS, in which UDP-based transport was used. To be able to better compare the reliability of data transmission over the two networks, SMS-based and UDP-fragmented mechanisms were created. Each sending mechanism has its own conguration le that is read upon running the application. It contains specic information necessary for each mechanism to transmit data such as the destination number, SMS Center number and COM port number for SMS, the destination IP address and port numbers for UDP, and the le to be sent. It also allows for multiple tests to be done in a single application run.

4.2 SMS-based mechanism (SMS)

The SMS-based interface utilizes AT Commands to communicate with the serial devices on a low level scheme. These are sent and received through the built-in serial module of Python as they normally are through other telnet applications such as PuTTY or Windows HyperTerminal. They are used for a number of actions: (1) set the device to PDU-mode, (2) send and receive messages, and (3) check for signal strength.

SMS sending mechanism. After reading the conguration le, the application will nd the le specied, split and convert it into streams of hexadecimal octets and assign them in an array where each element represents an individual packet to be sent. The checksum value of each packet is also appended at the beginning of the said packet. Next, it will prepare header data containing the destination number and SMS Center numbers necessary for sending SMS in binary mode.

Data transmission will begin with an invitation, which contains the filename and file size, to check whether the receiving application is ready. Once a confirmation is received, a single data packet will be sent and will be resent on timeout or upon request of the receiving application through an acknowledgement packet; otherwise the application will move on to the succeeding packet and repeat until all data has been transmitted. Once all data has been successfully transmitted, the application will either terminate or move on to the next test if any.

SMS receiving mechanism. Upon application start, it will repeatedly loop and wait for an invitation. Once an invitation has been received, it will allocate space for the file, send a confirmation back to the other application and wait for the actual data packets. When a data packet arrives, the header data and payload is extracted and is counterchecked with the calculated checksum. Acknowledgement indicating successful transmission or a request for retransmission is sent afterwards. The receiving application does not timeout and will always just wait to receive data until all packets have been successfully received. After the final acknowledgement is sent, the data is written to a file and the application will once again wait for invitations. The application will only terminate on user intervention.

4.3 UDP-based mechanism

Network connection is established by use of the given carrier application where it is always explicitly specied to set to GSM-only thus forcing the serial device to use the GPRS network. To validate if the connection has already been established properly, a connection check function is included before the actual packet data transfer. The connection setup time, or the time it takes for a network connection to nally get established, will be recorded separately from the actual transmission time. Traditional socket data transfer is then employed to send and receive data.

Both applications of both the fragmented and whole versions of the UDP-based mechanisms make use of two sockets. Sending applications use one socket to send data and the other to listen for acknowledgements. Receiving applications use one socket to listen for invitations and data and use the other one to send acknowledgements.

UDP-fragmented mechanism (UDP-F). This particular mechanism has exactly the same structure as that of the SMS-based mechanism. This means that the data sent and received has both PDU specific header and payload data that is otherwise required in the SMS-based mechanism but is not at all required in this one. The applications in this mechanism, both transmitting and receiving, also have the exact same structure and ow as that of the SMS-based. This is so that the only dierence between this mechanism and the SMS-based mechanism is the medium that the data uses to get from one application to the other.

4.4 Test Instruments

Two files of different sizes, each making a test case, have been prepared. For simpler packet integrity validation, only images were used for the preliminary testing. Two images were sent, snowman.gif (388 bytes) and crab.gif (4713 bytes), respectively. There are three (3) packets for snowman.gif and thirty-seven (37) packets for crab.gif, giving a total of forty (40) packets per test sample. In this study, the transmitting end was situated at St. Charbel Executive Village, while the receiving end remained at New Manila Rolling Hills Village in Quezon City. For easier future reference, the test locations are briefly labeled in Table 1.

Test Locations	Reference
St. Charbel Executive Village	CHARBEL
New Manila Rolling Hills Village	NEWMANILA

Table 1. Test Location Reference

4.5 Procedure

The mechanisms created (SMS and UDP-F) are composed of two ends: transmitter and receiver. The test sample (consisting of two images with a total of 40 packets) was transmitted thrice for both mechanisms, while the receiving end collected and waited for all of the sent packets to arrive. It automatically requested for a resending of the missing or corrupt packets, if the transmission was not successful. The time for every significant action, such as dividing or combining packets, and transmitting or receiving packets, was recorded. The number of times the data was resent, if applicable, was also noted.

5. Results

5.1 Transmission Time

SMS generally has a greater transmission time and distribution while DP-F has more constant and smaller ones. In Figure 3, the plots for the sending

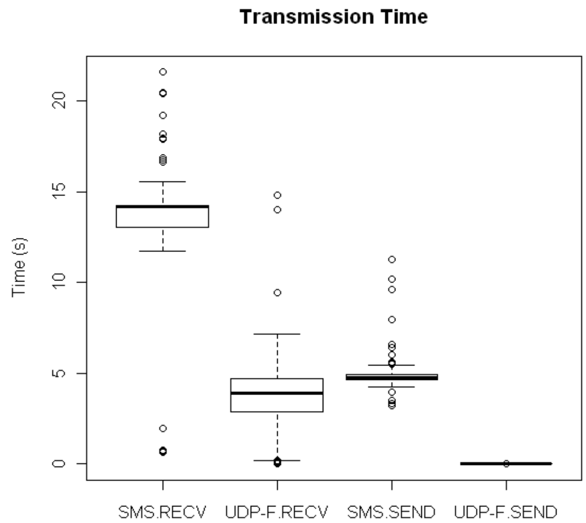


Figure 3. Transmission time

interface of both SMS and UDP-F refers to how long it takes the application to successfully send a packet to the network while for the receiving applications,the time it takes for them to receive a packet on wait. For better comparison, the transmission time per packet for SMS is compared to GPRS (UDP-F), as presented in Table 2 and Figure 4.

Mechanism	snowman.gif (388 bytes)	crab.gif (4713 bytes)
SMS	8.75 seconds	8.84 seconds
UDP-F	3.57 seconds	1.88 seconds

Table 2. Transmission time per packet

The total duration for each file transmission is the time starting from when the sender application begins to send an invitation up until conrmation of a successful file transmission is received. The average values for SMS is 379% and 275%, for snowman.gif and crab.gif respectively, greater than that of UDP-F. These are shown in Table 3 as well as Figures 5(a) and 5(b).

Mechanism	snowman.gif (388 bytes)	crab.gif (4713 bytes)
SMS	1 minute and 12 seconds	12 minutes and 28 seconds
UDP-F	0 minutes and 19 seconds	4 minutes and 32 seconds

Table 3. Average total duration for each le transmission

5.2 Number of Retries

A retry is described as a transmission failure where the sending application has timed out and resent the previous packet and waits once more; that is to say, the sending application has already waited for a certain amount of time and has either received an invalid acknowledgement or none at all which then leads the application to re a retry. SMS only reached a maximum of 1 retry, while UDP-F reached as much as 6 and 8 retries. Although data transmission over GPRS is faster, the initial test results also show the wide disparity in the number of retries when data was transmitted over SMS versus GPRS (UDP-F), as presented in Table 4 and Figure 7.

5.3 Reliability

As given by the reliability formula in [10], $R = \frac{N_t - N_f}{N_t}$ where R = estimated reliability; N_t = total number of trials; and N_f = number of trials resulting in failure, we could likewise see the wide disparity in the estimated reliability when data was transmitted over SMS versus GPRS (UDP-F) shown in Table 5 and Figure 8. For more accuracy, these are calculated using the actual number of retries and total packets of 6 tests (3 per le) per mechanism and not the average values used above. Nt has a base value of 3 x 40=120 for both mechanisms where there are 3 + 37=40 packets, three packets for snowman.gif and thirty-seven packets for crab.gif, for 3 test cycles with no retries.

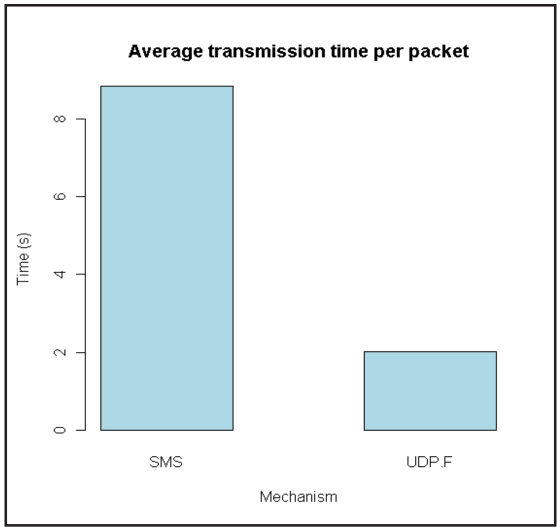
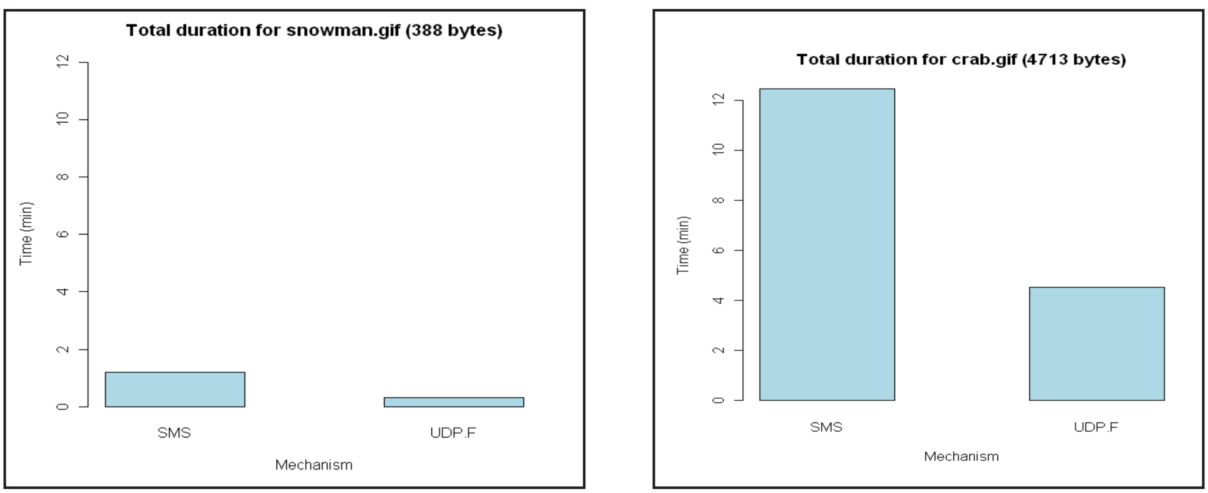


Figure 4. Transmission time per packet



(a) SMS (b) UDP-F

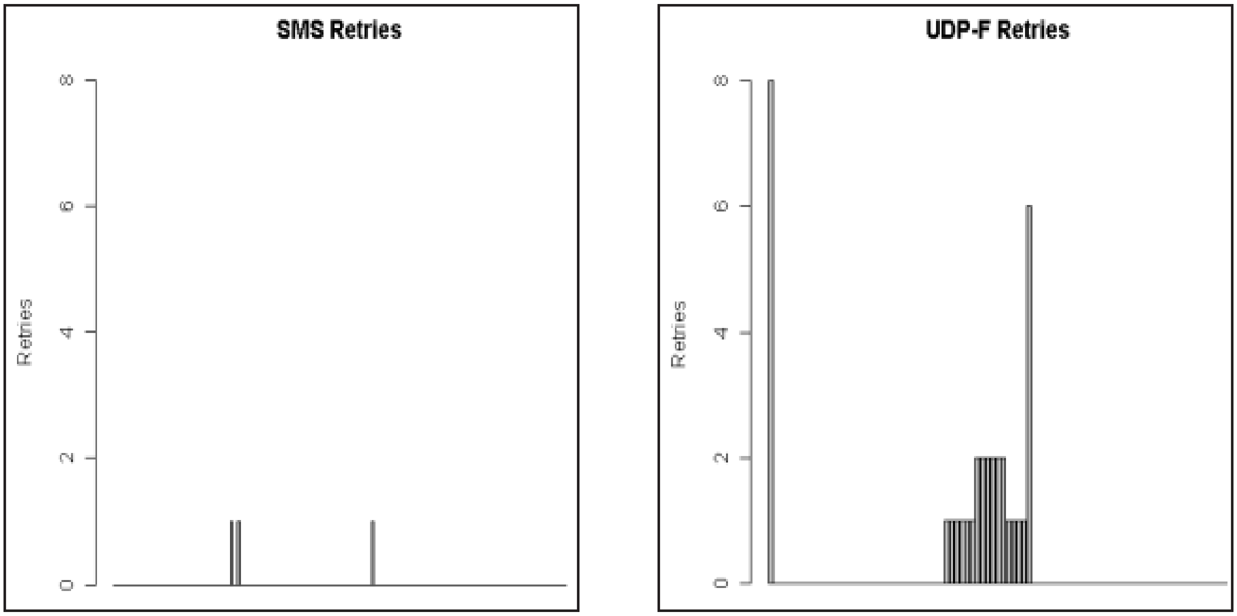
Figure 5. Average total duration for each le transmission

Mechanism	N_t	N_f	$R = \frac{N_t - N_f}{N_t}$
SMS	123	3	0.976 = 97.6%
UDP-F	173	53	0.694 = 69.4%

Table 5. Estimated Reliability per data sample

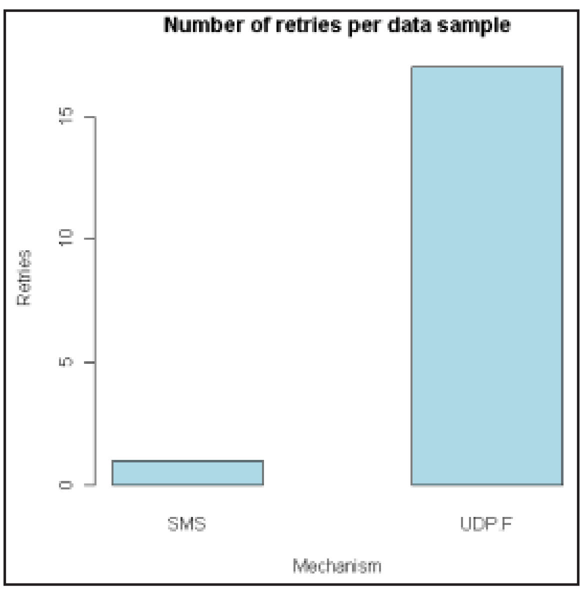
6. Conclusion

As per the results, SMS in general works in a slow but steady pace of delivery,while GPRS (using UDP as the protocol) others a quicker but slipshod transmission. Using the data gathered in sending 40 packets, SMS, with an average transmission time (ATT) of 8.84 seconds per packet, will need 353.6 seconds best case with no retries, while UDP, with an eective ATT of 6.76 seconds1,will take 270.4 seconds already with one retry for each packet. SMS therefore cannever replace UDP in sending data in large amounts because the time it will take UDP to transmit the correct data even with retries will still outrun that of SMS with perfect (no-retries) transmission. SMS however is generally the ideal choice in sending short and uncompromised data such as that of machine-to-machine transmissions.



(a) SMS (b) UDP-F

Figure 6. Number of retries



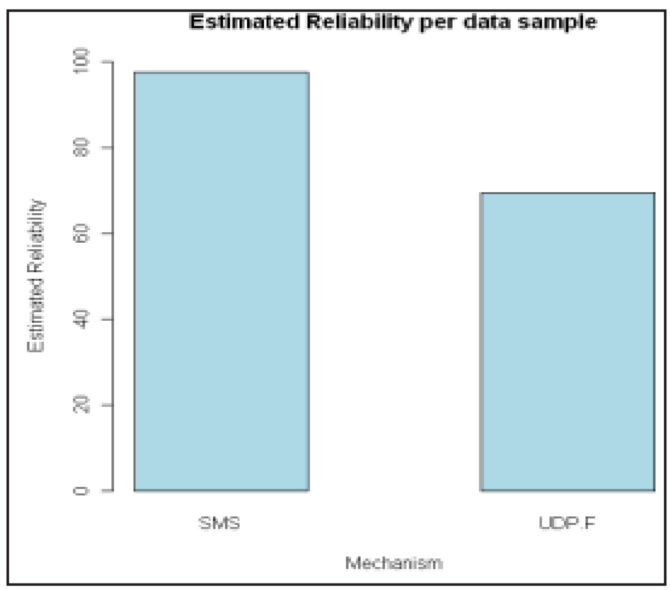


Figure 7. Average number of retries per data sample

Figure 8. Estimated Reliability per data sample

7. Further Studies

This paper details a study on the comparison between SMS-fragmented and GPRS UDP-fragmented transmissions and its results. Further research into the topic will include data transmission through GPRS UDP-whole (UDP-W) and uniform tests across multiple locations. Adding such dimensions to the study will emphasize reliability in terms of retransmission, ransmission time and geographical constraints.

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