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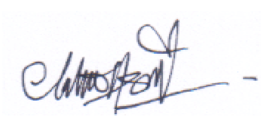

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PERFORMANCE STUDY OF GPRS IN MOBILE COMMUNICATIONS

HALIZA BINTI MAT HUSIN

A project report submitted in partial fulfillment
of the requirements for the award of the degree of
Master of Engineering
(Electrical – Electronics & Telecommunication)

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NOVEMBER, 2005

I declare that this project report entitled "Performance Study of GPRS in Mobile Communications" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved mother

and

my dearly loved fiancé ...

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ABSTRACT

The General Packet Radio Service (GPRS) is a packet-switched enhancement of existing Global System for Mobile Communications (GSM) networks. It is developed to allow large amounts of data to be sent over cellular networks at speeds three to four times greater than conventional GSM systems. Because GSM is the most widely used mobile system in the world for most operators, GPRS is the easiest and most logical way of offering customers fast simultaneous data services, such as multimedia messaging, gaming, entertainment, and news. The success or otherwise of GPRS will be dependent on its ability to deliver the data speeds and services that the industry has been promising the subscriber. In order to measure the performance of GPRS, as seen by the subscriber, would then depending on many different factors. Thus, the aim of this project is to analyse the performance of GPRS services that network operators are promising to the subscribers and to discuss the measurement results of GPRS end-user application performance subject to various channel conditions. A detailed comparison between two GPRS networks, Maxis and Celcom for HyperText Transfer Protocol (HTTP) application and Packet Internet Groper (PING) application performance is provided.

ABSTRAK

GPRS ialah pembaharuan di dalam teknologi GSM menggunakan pensuisan berpaket (*packet-switched)*. Ianya dibangunkan untuk membenarkan penghantaran sejumlah data yang besar melalui rangkaian selular pada kelajuan di antara tiga ke empat kali ganda berbanding teknologi GSM yang sedia ada. Oleh kerana GSM adalah sistem bergerak yang paling meluas digunakan di dunia oleh kebanyakan penyedia perkhidmatan, GPRS adalah servis yang paling mudah, pantas dan berkesan di dalam memberi perkhidmatan data seperti mesej multimedia, permainan interaktif, hiburan dan berita. Penentu kejayaan servis GPRS adalah bergantung kepada kebolehan untuk menghantar data pada kelajuan tinggi yang telah dijanjikan kepada pengguna. Pelbagai faktor mempengaruhi di dalam mengukur prestasi GPRS di kaca mata pengguna. Oleh itu, projek ini dijalankan adalah untuk menganalisa prestasi servis *GPRS* seperti yang dijanjikan oleh penyedia perkhidmatan dan juga untuk membincangkan prestasi *end-user application* di dalam pelbagai situasi rangkaian. Perbandingan prestasi GPRS secara terperinci di antara dua penyedia perkhidmatan iaitu Maxis dan Celcom untuk *HyperText Transfer Protocol (HTTP) application* dan *Packet Internet Groper (PING) application* juga turut dibincangkan.

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LIST OF ABBREVIATIONS

2G	-	2^{nd} Generation
3G	-	3^{rd} Generation
APN	-	Access Point Name
BSS	-	Base Station Subsystem
BTS	-	Base Transceiver Station
CS	-	Coding Scheme
ETSI	-	European Telecommunications Standards Institute
FTP	-	File Transfer Protocol
GGSN	-	Gateway GPRS Support Node
GMM	-	GPRS Mobility Management
GMSC	-	Gateway Mobile Switching Centre
GPRS	-	General Packet Radio Service
GSM	-	Global System for Mobile Communications
HLR	-	Home Location Register
HTTP	-	HyperText Transfer Protocol
IMSI	-	International mobile Subscriber Identity
ISDN	-	Integrated Services Digital Network
LLC	-	Logical Link Control
IP	-	Internet Protocol
MAC	-	Medium Access Control
MS	-	Mobile Station
MSC	-	Mobile Switching Centre

NSAPI	-	Network Service Access Point Identifier
PCU	-	Packet Control Unit
PDN	-	Public Data Network
PING	-	Packet Internet Groper
QoS	-	Quality of Service
RAI	-	Routing Area Identification
RF	-	Radio Frequency
RTD	-	Round Trip Delay
SGSN	-	Serving GPRS Support Node
TBF	-	Temporary Block Flow
TDMA	-	Time Division Multiple Access
VLR	-	Visitor Location Register

CHAPTER 1

INTRODUCTION

1.1 Introduction

The rapid growth of the Internet has prompted a need for wireless data access to the Internet. Although GSM systems provide a fixed rate data service, they result in inefficient use of bandwidth for data users due to bursty nature of data traffic.

The GPRS is a standard from the European Telecommunications Standards Institute (ETSI) on packet data in GSM systems [1]. By adding GPRS functionality to the existing GSM network, operators can give their subscribers resource efficient wireless access to external Internet Protocol (IP) based networks, such as the Internet and corporate intranets. The basic idea of GPRS is to provide a packet-switched bearer service in a GSM network. As impressively demonstrated by the Internet, packet-switched networks make more efficient use of the resources for bursty data applications and provide more flexibility in general.

This report will therefore examine the GPRS performance at application layer against a server reachable over a public IP network conducted using QVoice System. Performance results for HTTP and PING application are given for different GPRS networks. The measurement results obtained are analysed and compared to see how well each GPRS networks perform.

1.2 Objectives

The objective of this project is to analyse and benchmark the GPRS data application performance between Maxis and Celcom for HTTP and PING application conducted using QVoice System obtained experimentally on live GPRS networks.

1.3 Scope of Work

The scope of work of this project can be outlined as follows:

i. To understand GPRS functionalities.

ii. To review and address GPRS data performance.

iii. To understand the affect of GPRS parameters to application performance.

iv. To measure HTTP and PING performance on live GPRS networks.

v. To analyse and examine performance measurements result for different GPRS networks.

vi. To evaluate and benchmark the analysed results.

1.4 Outline of Thesis

The thesis comprises of seven chapters and the overview of all the chapters are given below.

Chapter 1: This chapter gives the introduction to the project, objective and scope of work involved in accomplishing the project.

Chapter 2: The literature review on GPRS Technology.

Chapter 3: The fundamental processes required in the measurement of the end-user application for the project are discussed in this chapter

Chapter 4: This chapter covers the experimental equipments utilized in the project.

Chapter 5: The methodology used to conduct the measurement.

Chapter 6: The measurement results, the analysis and the discussion are presented in this chapter.

Chapter 7: Conclusion of the project and suggestions for future work are presented in this final chapter.

CHAPTER 2

GENERAL PACKET RADIO SERVICES TECHNOLOGY

2.1 GPRS Overview

In response to customer demand for wireless Internet access and as a stepping-stone to 3rd Generation (3G) networks, many GSM operators are rolling out GPRS. This technology increases the data rates of existing GSM networks, allowing transport of packet based data. Under ideal circumstances, GPRS could support rates to 171.2 kbps, surpassing Integrated Services Digital Network (ISDN) access rates. However, a more realistic data rate for early network deployments is probably around 40 kbps using one uplink and three downlink timeslots [4].

Unlike circuit-switched 2nd generation (2G) technology, GPRS is an "always-on" service. It will allow GSM operators to provide high speed Internet access at a reasonable cost by billing mobile-phone users for the amount of data they transfer rather than for the length of time they are connected to the network.

Introducing GPRS will enable the following:

i. Allows reduced connection set-up times and high transfer speeds.

ii. Provides an efficient usage of radio link resources.

iii. Supports within the network existing packet-oriented protocols such as X.25 and Internet Protocol (IP).

iv. Charges customers on the amount of data transferred and not on time spent online.

v. Allows different service profiles and quality of service for customers.

In brief, GPRS can be described as a service providing optimized access to the internet, while reusing to a large degree of existing GSM infrastructure. The GPRS concept allows volume-oriented charging, which permits users to have cheap, permanent connections to the internet.

2.2 GPRS Network Architecture

In order to incorporate GPRS into the existing GSM architecture, a new class of network nodes, called GPRS Support Nodes (GSN), has been introduced. GSNs are responsible for the delivery and routing of data packets between the mobile stations and the external Packet Data Networks (PDN). Figure 2.1 illustrates the GPRS networks architecture.

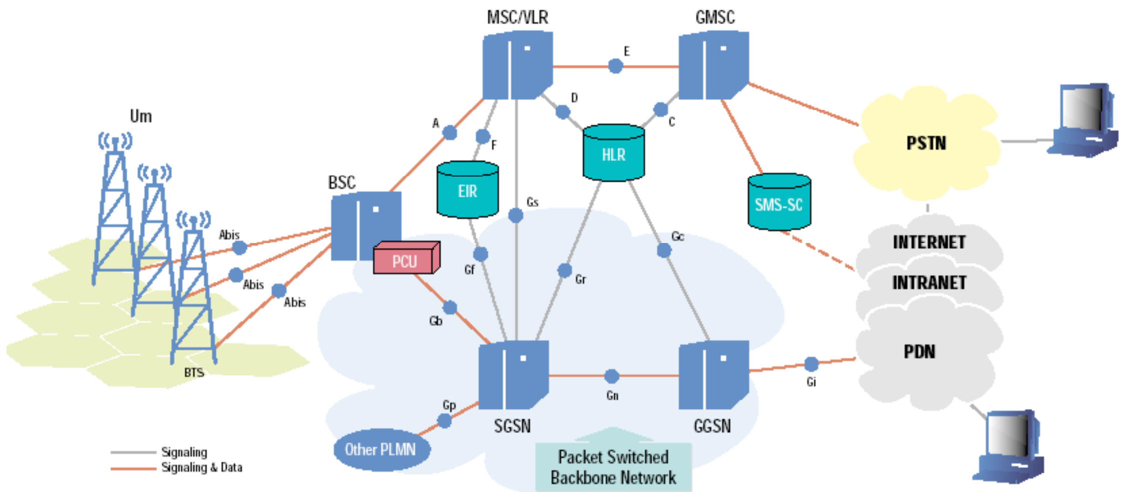


Figure 2.1 GPRS Network Architecture

2.2.1 Gateway GPRS Support Node (GGSN)

The GGSN is similar to the GSM Gateway Mobile Switching Center (GMSC) and provides a gateway between the GPRS network and the PDN or other GPRS networks. The GGSN provides authentication and location management functions, connects to the Home Location Register (HLR) by means of the Gc interface, and counts the number of packets transmitted for accurate subscriber billing.

2.2.2 Serving GPRS Support Node (SGSN)

The SGSN, like the GSM Mobile Switching Center and Visitor Location Register (MSC/VLR), controls the connection between the network and the Mobile Station (MS). The SGSN provides session management and GPRS mobility management functions such as handovers and paging. It attaches to the HLR via the Gr interface and to the MSC/VLR via the Gs interface. It also counts the number of packets routed.

2.2.3 Packet Control Unit (PCU)

Functions of the PCU include converting packet data into a format that can be transferred over the air interface, managing radio resources, and implementing Quality of Service (QoS) measurements.

The signaling links between the GPRS nodes and the GSM blocks will be SS7 MAP interfaces. The signaling between GPRS nodes is defined by the GPRS specifications. New physical interfaces include the Gb interface, which connects the SGSN to the PCU and is usually located in the base station subsystem (BSS); the Gn interface, which connects the GGSN and SGSN; and the Gc, Gr, and Gs interfaces, which carry SS7-based protocols.

2.3 GPRS Mobile Classes

GPRS mobile can be divided into three classes:

i. Class A (GSM/GPRS)

Class A mobiles can attach to the GPRS and GSM network simultaneously. They can receive GSM voice/data/SMS calls and GPRS data calls. For this to happen, the mobiles must monitor both the GSM and GPRS networks for incoming calls. Class A mobiles also can make and receive GPRS and GSM calls simultaneously. Operational requirements of this class include an additional receiver in the mobile phone for neighbour cell measurements.

ii. Class B (GSM/GPRS)

This class is similar to class A with the exception that Class B mobile phones will not support simultaneous traffic. If a GPRS call is ON, the phone cannot receive GSM calls and vice versa.

iii. Class C (GSM or GPRS)

This class of mobile phones will have both GSM and GPRS functionality but will attach to only one network at a time. Thus, if the phone is attached to the GPRS network, it will be detached from the GSM network and will not be able to make or receive GSM calls. Conversely, if it is attached to the GSM network, it will not be able to make or receive GPRS calls.

Today most manufacturers are building Class B phones [4].

2.4 GPRS Transferring Data Packet

Before a mobile station can use GPRS services, it must register with an SGSN of the GPRS network. The procedure is called GPRS attach. The disconnection from the GPRS network is called GPRS detach.

2.4.1 GPRS Attach Procedure

A GPRS attach is a GPRS Mobility Management (GMM) process that is always initiated by the mobile phone. Depending on the settings of the mobile phone, the GPRS attach may be performed every time the phone is powered on, or it may be initiated manually by the user.

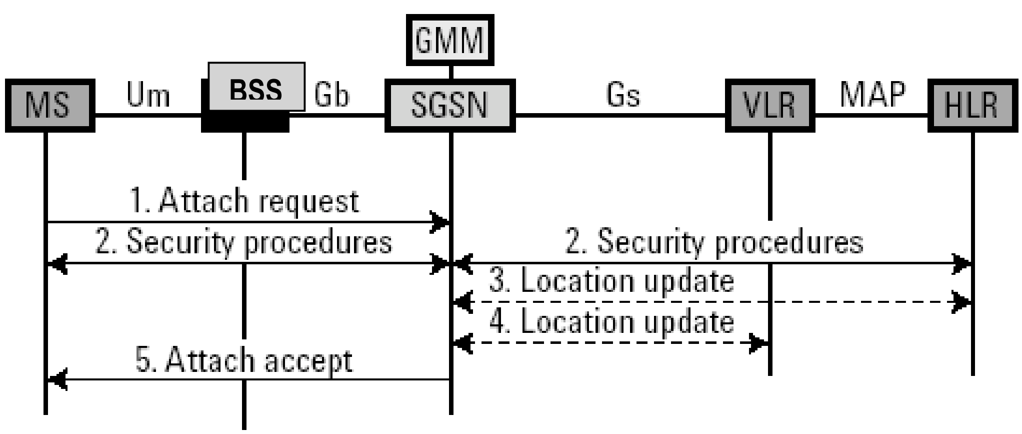


Figure 2.2 GPRS Attach Procedure

The request for a GPRS attach is made to the SGSN in a process that is transparent to the Base Station Subsystem (BSS). First the mobile notifies the SGSN of its identity as an International Mobile Subscriber Identity (IMSI) or P-TMSI. Then it sends its old Routing Area Identification (RAI), classmark, and desired attach type. [2,4]

The latter indicates to the SGSN whether the mobile wants to attach as a GPRS device, a GSM device, or both. The SGSN will attach the mobile and inform the HLR if there has been a change in the RAI. If the desired attach type is both GPRS and GSM, the SGSN will also update the location with the VLR, provided that the Gs interface exists. The GPRS attach procedure shown in Figure 2.2.

Note that a GPRS attach does not enable the mobile phone to transmit and receive data [4]. For this to occur, the mobile has to activate a communication session using PDP context.

2.4.2 GPRS PDP Context

A PDP context activates a packet communication session with the SGSN. During the activation procedure, the mobile phone either provides a static IP address or requests a temporary one from the network. It also specifies the Access Point Name (APN) with which it wants to communicate for example, an Internet address or an Internet service provider.

The mobile requests a desired QoS and a Network Service Access Point Identifier (NSAPI). Because a GPRS mobile can establish multiple PDP context sessions for different applications, the NSAPI is used to identify the data packets for a specific application.

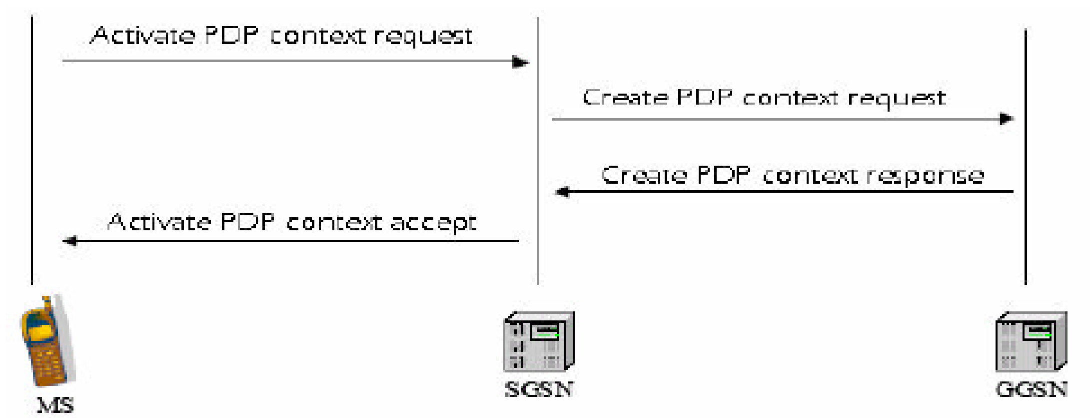


Figure 2.3 PDP Context Procedure

Upon receiving information from the mobile, the SGSN determines which GGSN is connected to the APN and forwards the request. The SGSN also provides a negotiated QoS based on the user's subscription information and the availability of services. If the mobile phone has a static IP address, the GGSN directly connects the mobile to the desired access point. Otherwise, it obtains a temporary IP address from the APN. The GGSN also provides some transaction identifiers for data communication between GGSN and SGSN. Once the communication and activation procedure at the GGSN is successful, the appropriate data transfer information is forwarded to the mobile. The PDP Context Procedure is shown in Figure 2.3.

2.5 GPRS Protocol Layers

The GPRS provides a bearer service from the edge of a data network to a GPRS MS. The GPRS protocol layering is illustrated in Figure 2.4. The physical radio interface consists of a flexible number of Time Division Multiple Access (TDMA) time slots (from 1 to 8) and thus provides a theoretical raw data rate of 171 kbps. A Media Access Control (MAC) utilizes the resources of the physical radio interface and provides a service to the GPRS Logical Link Control (LLC) protocol between the MS and SGSN. The two most important features offered by LLC are the support of point-to-multipoint addressing and the control of data frame retransmission [5]. From the standpoint of the application, GPRS provides a standard interface for the network layer.

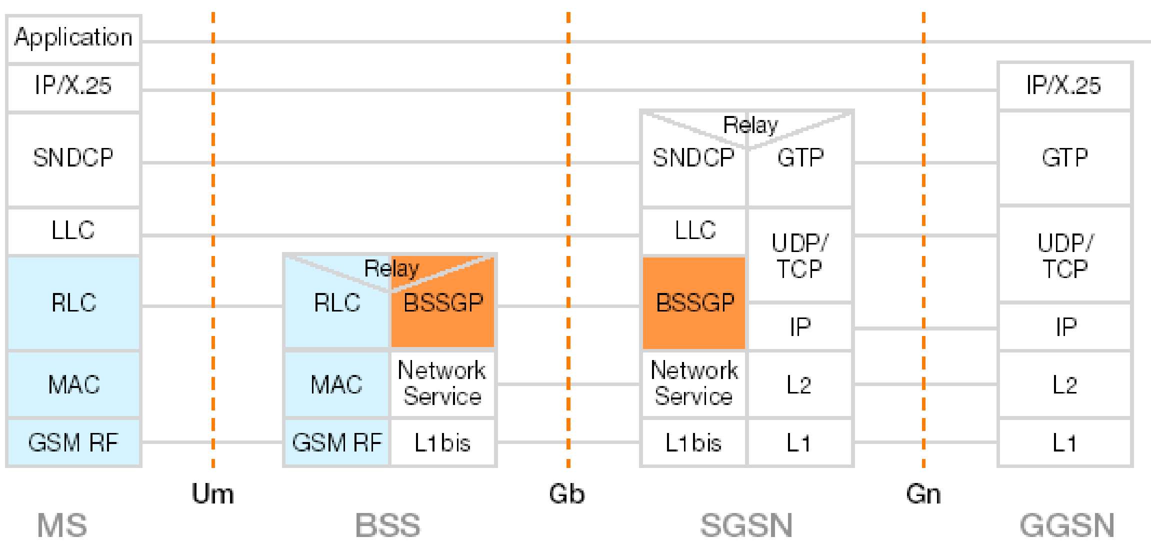


Figure 2.4 GPRS Protocol Layer

CHAPTER 3

END-USER PERFORMANCE MEASUREMENT

3.1 GPRS Performance Measurement

GPRS measurements, which illustrated in Figure 3.1, can be divided into three categories: data performance, signal quality and Radio Frequency (RF) performance [2].

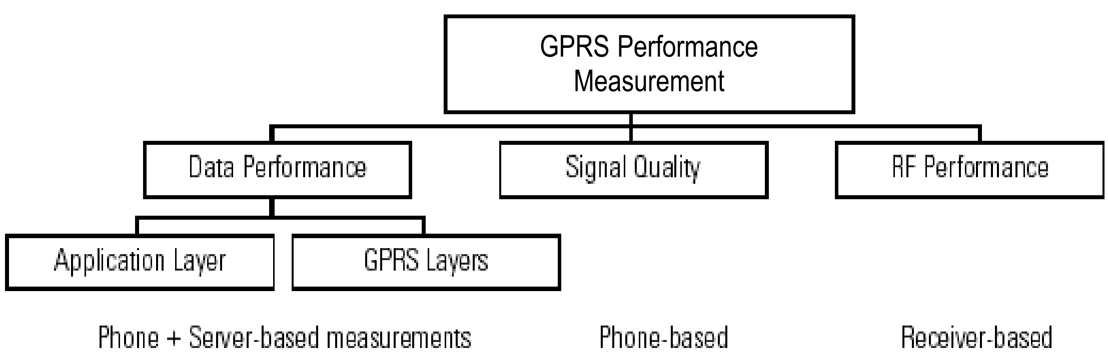


Figure 3.1 GPRS Performance Measurement

3.1.1 Data Performance

This category emphasizes data transfer quality measurements (as perceived by customers) and GPRS layer specific measurements. Data performance measurements are used to establish quality benchmarks and to detail the performance of individual layers.

The data performance can be divided into two categories:

i. IP/Application layer measurements are made by measuring the parameters directly perceived by the user such as throughput and delay.

ii. GPRS layer measurements are made at the layers below the application layer and are hidden to the user. These measurements offer insight about events on the GPRS layers that can impact the application layer performance.

In both cases, the measurements are made using a test mobile connected to a laptop PC with special data measurement software [2,4].

3.1.2 Signal Quality

This category consists of physical layer measurements and a subset of RLC and MAC layer measurements. The measurements are made using a test mobile phone.

3.1.3 RF Performance

This category consists of network independent measurements such as interference, scanning, and spectrum analysis. The measurements require sophisticated RF test tools such as Digital Signal Processing (DSP) based RF measuring receivers.

3.2 GPRS Measurement on Protocol Stack

The relationship between GPRS measurement for data performance and the various protocol stacks is shown in Figure 3.2. Performance is measured at three layers: end-to-end data performance at the application layers, GPRS layer data performance at the GPRS layers, and RF quality performance at the air interface.

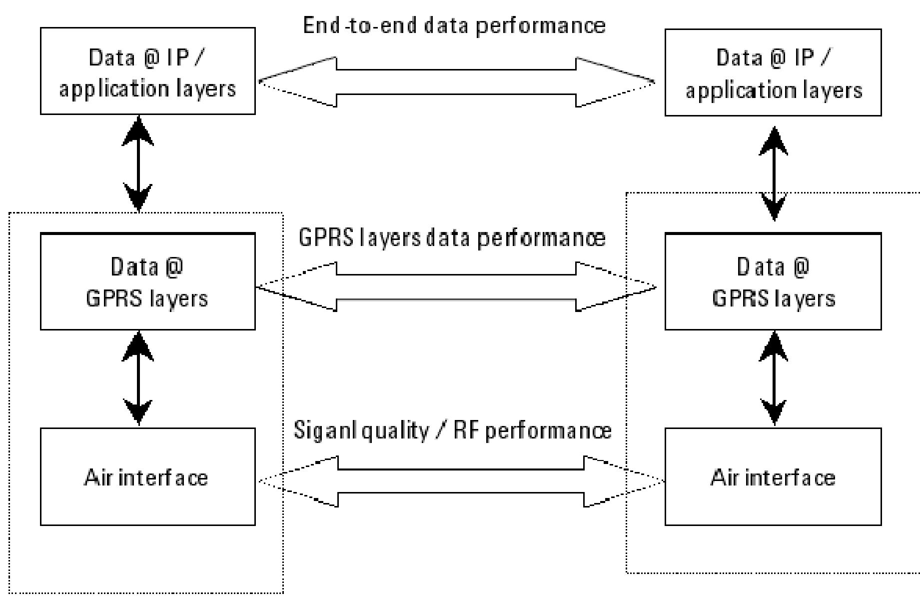


Figure 3.2 GPRS Measurement on Protocol Stack

3.2.1 Application Layer Data Performance

Data performance at the application layer is measured end-to-end, that is, simulate a real world data pattern and send it to the other end, a test server, which performs the measurements and stores or sends the results back to the client, a mobile phone (MS). These measurements are made to quantify the user perception of data performance, and they are analogous to the voice quality measurements in GSM networks [7].

3.2.2 GPRS Layer Data Performance

Data from the application layer is first processed by the GPRS layers and headers are added before it is sent onto the air interface. To a certain extent (depending on quality of service levels), the GPRS layers are capable of providing data performance information such as LLC and RLC layer performance.

3.2.3 Physical Layer Data Performance

These measurements provide signal level and quality information. The category may include optimization measurements such as interference monitoring and scanning.

3.3 Data Transfer at Application Layer

Figure 3.3 shows the process of transferring data at application layer. The application layer at the MS communicates with the IP layer of the MS and passes the application layer datagram to the IP layer. This IP layer (which is standard TCP/IP) forwards the information to the GGSN by way of the different GPRS nodes and protocol layers. At the GGSN, the datagram information received from the MS is returned to the IP datagram level. Then the IP layer at the GGSN communicates with the IP layer at the other end of the call (at the PC) through the Public Data Network (PDN) IP interfaces.

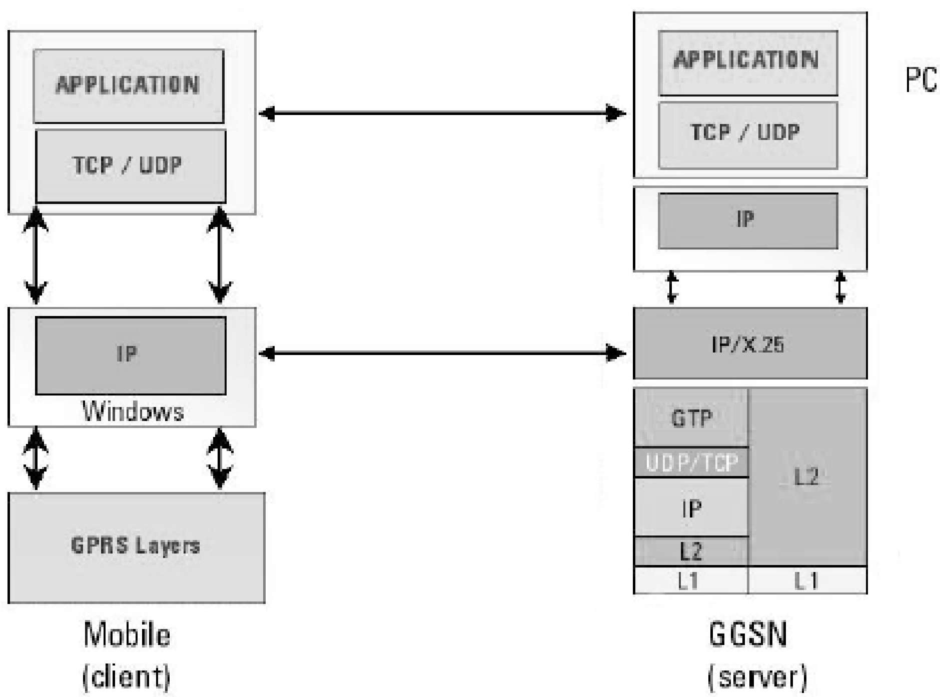


Figure 3.3 Data Transfer at Application Layer

3.4 Types of Data Applications

This section gives a quick overview of the user applications whose data performance can be measured. Four common types of applications in order to measure GPRS network data performance are :

i. File Transfer Protocol (FTP)
ii. HyperText Transfer Protocol (HTTP)
iii. E-mail
iv. Packet Internet Groper (PING)

3.4.1 File Transfer Protocol, FTP

FTP is a common protocol for transferring files in the Internet. FTP assumes that the data is highly error-sensitive and therefore uses TCP to ensure data integrity. FTP is characterized by continuous operation (uninterrupted stretches of downloading). Hence the average throughput over a period of time is likely similar to typical instantaneous throughput figures during that period [7]. Simulation of FTP requires unidirectional, bulky data.

3.4.2 HyperText Transfer Protocol, HTTP

HTTP (Hypertext Transfer Protocol) is the protocol used on the World Wide Web. Like FTP, HTTP prioritizes data integrity and uses TCP. HTTP defines how messages are formatted and transmitted, and what actions web servers and browsers should take in response to various commands.

For example, when an address is entered in a browser, this action sends an HTTP command to the web server directing it to fetch and transmit the requested web page. HTTP is called a stateless protocol because each command is executed independently, without any knowledge of the commands that came before it. This is the main reason that it is difficult to implement web sites that react intelligently to user input [3].

3.4.3 Email

This common data application at any given instant is asymmetrical that is, the data transfer is in one direction, as the customer either reads or sends a message. The volume of data on average has not been high because most messages are textual, but email service increasingly can involve downloads and uploads of large attachment files.

3.4.4 Packet Internet Groper, PING

PING is a utility used to determine whether a specific IP address is accessible. It is based on the ICMP protocol and does not use a transport layer, TCP or UDP. PING works by sending a packet to the specified address (ICMP echo request) and waiting for a reply (ICMP echo reply). PING is used primarily to troubleshoot Internet connections [7]. A variety of Ping utilities are available for personal computer.

PING can be used to:

i. Determine if packets have been dropped, duplicated, or reordered. The utility places a unique sequence number on each packet it transmits, and reports which sequence numbers it receives back.

ii. Detect some forms of damaged packets. Each packet exchanged by PING is check-summed.

iii. Calculate the Round Trip Time (RTT). PING places a timestamp in each packet, which is echoed back and can easily be used to compute how long each packet exchange took.

3.5 Measurement Configuration

There are two ways to carry out data performance measurements at the application layer, Loopback Measurement and End-to-end Measurement.

3.5.1 Loopback Measurement

This approach requires a fixed unit at the network node, which collects the data coming in from the mobile and then sends the data back to the mobile (creating a loopback). The mobile compares the data sent with the data received. The process also can be reversed by simulating data traffic and sending it from the fixed unit at the network to the mobile and then back to the network.

The loopback approach does not precisely support real world application models such as simultaneous, asymmetrical data transfer. Rather than measure uplink and downlink separately, it measures uplink and downlink as a total loop. Consequently, we do not know whether a problem exists on the uplink or the downlink. A better approach uses end-to-end measurements [2], as described in the following section.

3.5.2 End-to-End Measurement

At the application layer, end-to-end measurements can be described as follows:

One node transmits data and another node receives the data and measures its performance. One end node is the mobile and the other is a measurement server. This server can be a located at the GGSN or somewhere in the PDN. Since the measurements are made end-to-end, in the uplink the server measures the data received from the mobile and sends back the results. In the downlink, the measurements are made by the same software that generated the uplink data [2].

3.6 Measurement Methodology

Performance measurement can be conducted using two ways of client-server architecture. There are two choices for server as illustrated in Figure 3.4.

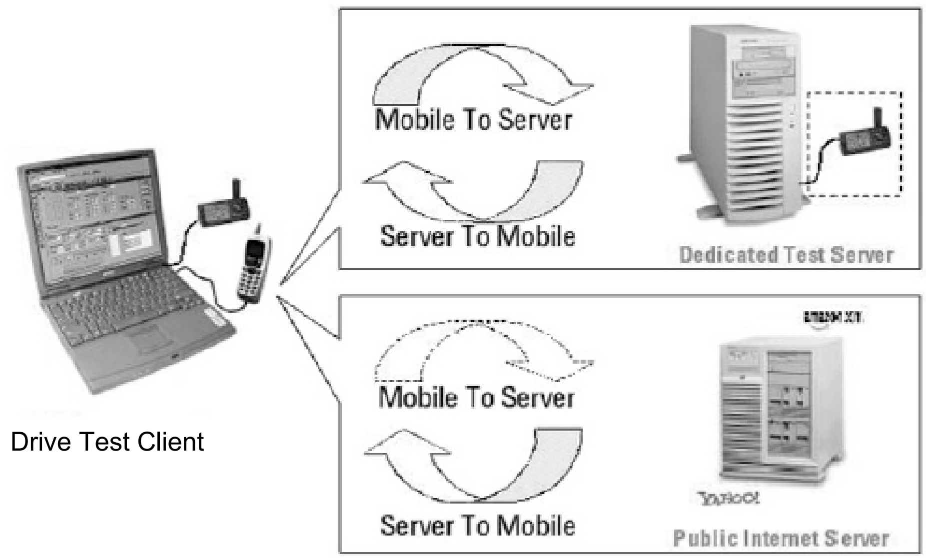


Figure 3.4 Measurement Methodology

i. **Measuring with a public server** - this approach tests over a wide area and provides measurement results that reflect that reflect the customer's viewpoint.

ii. **Measuring with a dedicated test server** – a dedicated test server providing uplink and downlink measurements and normally is located at GGSN.

CHAPTER 4

QVOICE SYSTEM

4.1 QVoice System Overview

To aid the understanding of the measurement methodology described in the following chapter, it is useful to have an overview of the QVoice System.

QVoice is an exceptionally efficient and versatile test system for analysing the quality of connections in mobile radio networks. QVoice consists of the data acquisition part QVMS and the data evaluation part QVP. During data acquisition with QVMS, connections are set up, usually between a mobile piece of equipment QVM and a stationary piece of equipment QVS, which is connected to a fixed network [9]. Figure 4.1 shows the QVoice System overview.

QVoice can be used to make comparison between GPRS networks available at the same location, by set up test connections with several mobile phones simultaneously [9,10].

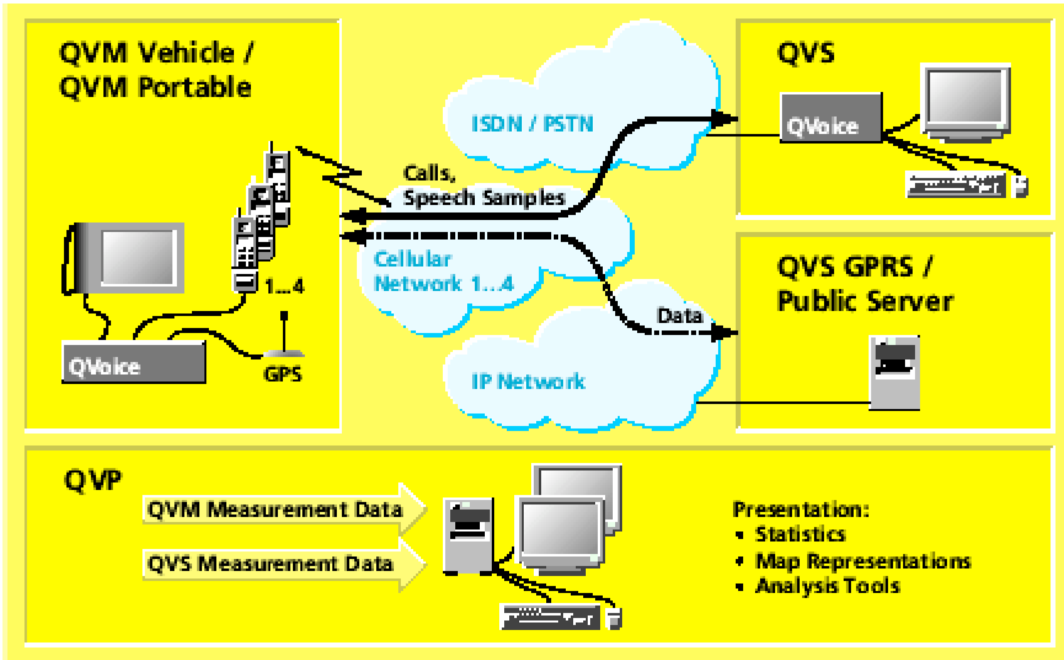


Figure 4.1 QVoice System Overview

4.2 Data Acquisition Part QVMS

QVMS is the data acquisition part of QVoice. QVMS sets up test connections, measures the speech quality, records the data from the connection set-up and radio interface, and stores the data in measurement files. Data acquisition runs entirely automatically. The nature and quantity of data acquired depend on the selected measuring program and the set measuring program parameters. The measurement files are stored on the internal hard disk.

QVM is operated using the stylish, lightweight operating unit and its touch screen as illustrated in Figure 4.2. The user interface is Windows-based and is extremely user friendly. QVM plays the role of the mobile subscriber to set up or receive mobile data transfers. During the transfer, the performance of the network and the air interface engineering data are recorded [9].

Figure 4.2 Operating Unit with Touch Screen

QVMS records the following main data:

i. Connection set-up and clear-down
ii. Radio interface data
iii. Speech quality / data transfer quality
iv. Service availability
v. Location (in the case of outdoor measurements by the GPS)

4.3 Data Evaluation Part QVP

QVP is a client-server architecture system with a database. The measurement data are evaluated in the QVP system part. Once the data has been transmitted to QVP, it can be imported into the database. Data of no interest can be filtered out during the import [9,10].

QVP is a versatile representation and analysis tool, which means that the evaluations can be represented according to purpose. QVP uses a very powerful PC with high-resolution graphics. The QVP allows efficient evaluations which is consists of four main modules, QVP Administrator, QVP Report, QVP Map and QVP Network Analyzer.

4.3.1 QVP Administrator

This module is used for tracking the relational database and provides the following main functions:

i. BTS Management

Base Transceiver Station (BTS) data can be inserted, altered and deleted here, in a clear layout. Flexible import functions are used for transferring data efficiently from other applications.

ii. Region Management

Regions can be managed just as clearly. A distinction is made between three Region Types:

- BTS Regions
- Geographical Regions
- Indoor Locations

iii. Data Management

The data measured can be imported by QVMS into the database and of deleting uninteresting data. A wide range of filtering possibilities is available.

iv. Database Management

To generate new databases, allocate user rights and change the size of the databases.

v. Expert Management

Controls the Expert System, which provides support with analysis and diagnostics.

4.3.2 QVP Report

This tool is used for creating revealing statistics and highlighting trends. The database queries are controlled by Reports.

4.3.3 QVP Map

QVP Map is used for the clearly structured presentation of measured data on digitized maps and floor plans. Maps in vector and raster format can be used. Measured values and BTS locations are overlaid on separate representation levels.

The basic choice available with QVP Map includes:

i. Measurement presentation
ii. Map (region or route) with selected measured data
iii. Statistic presentation
iv. Map with pie charts
v. Coverage presentation
vi. Coverage area of the participating BTSs

4.3.4 QVP Network Analyser

The Network Analyser is a file-based system. It provides functions for a targeted search for specific problems in the network.

Dedicated tools are available for precise analysis which are:

i. Line Chart - The line chart shows the temporal course of the measured values.

ii. Message Explorer - The Message Explorer can be used to analyse what is happening in full detail.

CHAPTER 5

PROJECT METHODOLOGY

5.1 Test Methodology

In order to investigate a complete user experience of data services, drive tests on live GPRS network at centre Universiti Teknologi Malaysia (UTM) have been done using QVoice System. Several test have been conducted at various channel condition.

Currently, there are three operators that provide GPRS services which are Digi, Maxis and Celcom. For this project purpose, I only focus on Maxis and Celcom. Both operators have been selected base on their market share of GPRS service providers.

End-to-end data performance testing has been done between a client (a GPRS mobile) and an external public internet server, « www.google.com » for two types of applications which are HTTP and PING. QVoice was used in comparative measurement between the two operators using the same public server conducted at the same time. Figure 5.1 depicts the measurement arrangement between QVM and a public server.

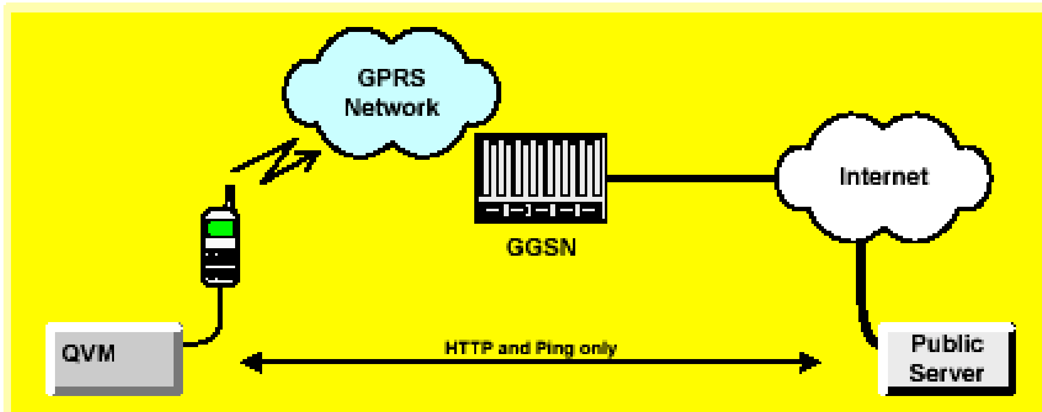


Figure 5.1 Measuring with a Public Server

5.2 Measurement Program

A measurement program is a file in which all the measurement parameters are specified. With QVM a measurement program can carry out different measurements simultaneously on different channels. For this project, the measurement programs have been created to specify the parameters for PING and HTTP measurement.

5.3 HTTP Measurement

HTTP measurement to a public server is a test from the user's viewpoint as depicts in Figure 5.2.

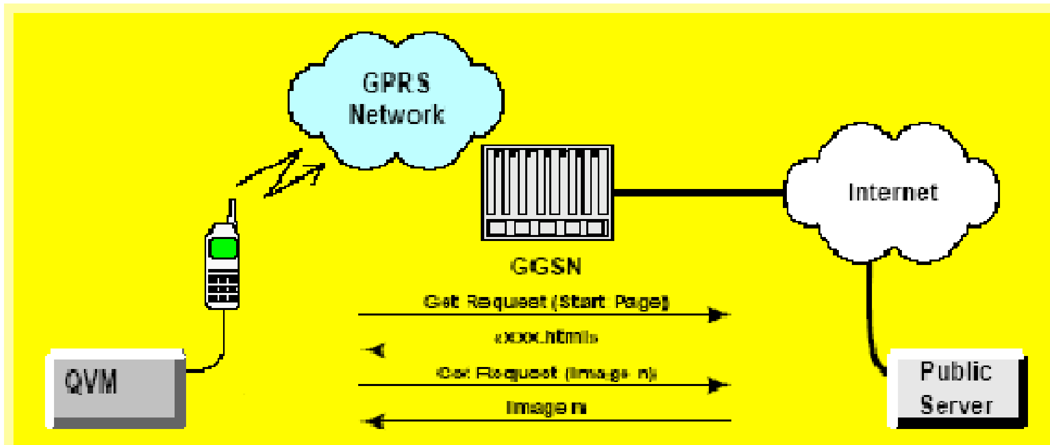


Figure 5.2 HTTP Measurement with a Public Server

The result is obtained for each file received. QVMS downloads the specified Internet page and scans it. If the page contains frames, the frames are first downloaded in sequence. Next the image files of each page or each frame are downloaded, including the background image. The sequence of an HTTP access to a public server is shown in Figure 5.3.

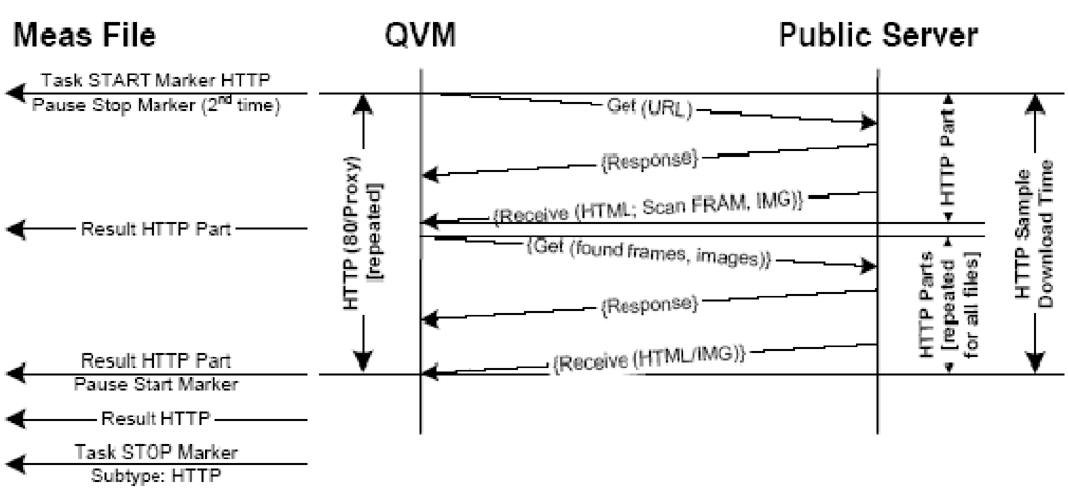


Figure 5.3 Sequence of an HTTP Access to a Public Server

Measurement results will give the download time of the web page and coding scheme usage. Channel coding is a technique used to protect the transmitted data packets from errors. Four channel coding schemes are defined on GPRS standards for packet data traffic channels.

These coding schemes are marked as CS 1, CS 2, CS 3 and CS 4. CS 1 has highest error correction and lowest data throughput. The more efficient channel coding used, the smaller is the proportion of the payload in the emission. Thus, higher data rates are achieved by reducing or removing the error correction bits. Figure 5.4 presents the most important parameters for different coding schemes [4].

Coding scheme	RLC data and header	RLC/MAC header and data	Data rate-kbps	USF	BCS	Tail bits	Total raw bits	Coding	Puncturing	Encoded bits
1	22 octets	181 bits	9.05	3	40	4	228	Half rate	No	456
2	32 octets	268 bits	13.4	6	16	4	294	Half rate	132	456
3	38 octets	312 bits	15.6	6	16	4	338	Half rate	220	456
4	52 octets	428 bits	21.4	12	16	0	456	No	No	456

Figure 5.4 GPRS Coding Schemes

5.4 Defining HTTP Parameters

Figure 5.5 shows the parameter settings underlying the performance test for HTTP Measurement.

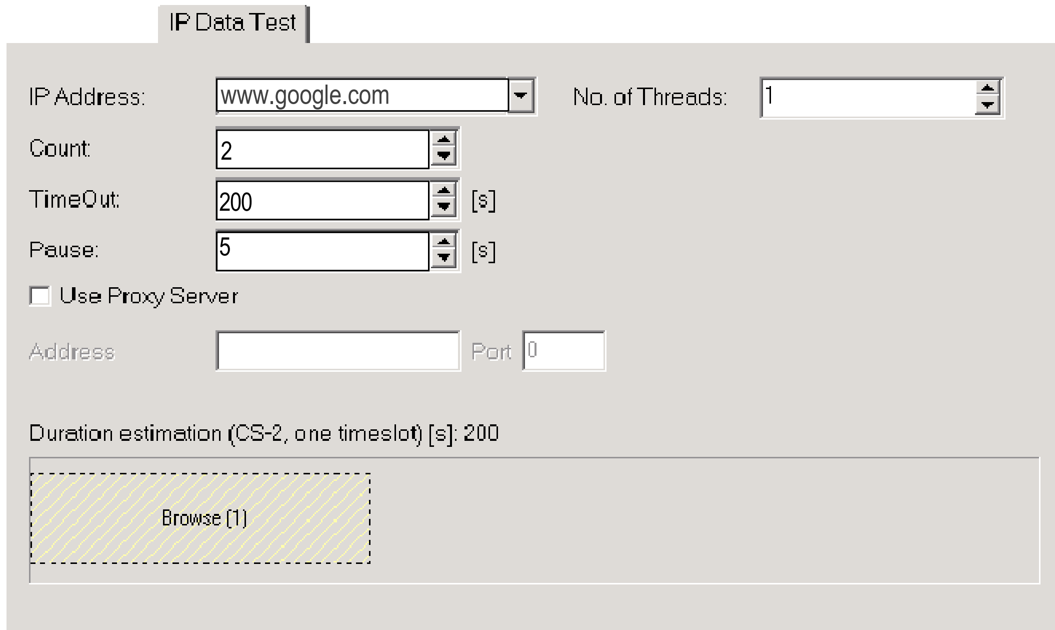


Figure 5.5 Measurement Program for HTTP Measurement

Parameters used for HTTP Measurement can be summarized as follow:

i. IP Address : QVS or address of public server
« www.google.com »

ii. Count : The number of times the Internet page is retrieved
« 2 »

iii. Timeout : Maximum delay until the end of transmission
« 200 s »

iv. Pause : Wait time between each retrieval if the internet page is retrieve several times (Count = >1)
« 5 s »

5.5 PING Measurement

In the PING Measurement, QVM sends ICMP Echo Request messages to the public server as shown in Figure 5.6. The results are generated with every ICMP Echo Reply that QVoice receives from the server and when a timeout expires. Messages that arrive too late are ignored and do not affect the subsequent Echo Replies. The sequence for PING Measurement to a public server is illustrated in Figure 5.7.

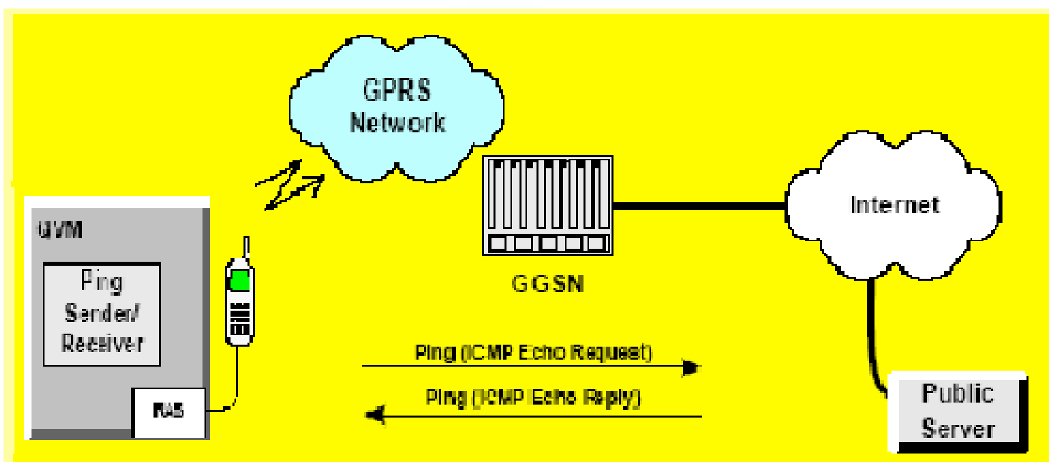


Figure 5.6 PING Measurement with a Public Server

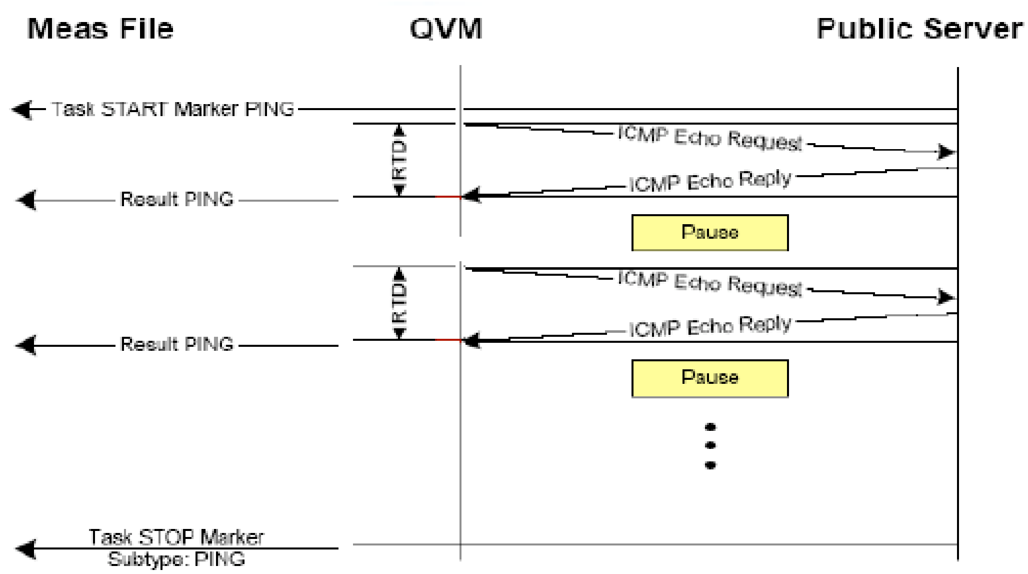


Figure 5.7 Sequence for PING Measurement to a Public Server

These measurements are used to determine the Round Trip Delay (RTD) between QVM and a public server. However the RTD measurement can be influenced by the operations of Temporary Block Flow (TBF) which is controlled by network settings.

TBF is the operation of allocating radio resources to a subscriber. If a TBF is open for him, it means that he has resources allocated and he can send or receive data. Conversely, a closed TBF means he cannot carry out data transfer.

If the TBF is closed, then he must make a request for radio resources and it will take a little time until the resources is allocated to him and the data transfer can be started. On the other hand, if he wants to transfer data and there is already an open TBF, then it will be much quicker because he does not need to wait for resource allocation.

5.6 Defining PING Parameters

Figure 5.8 shows the parameter settings underlying the performance test for PING Measurement.

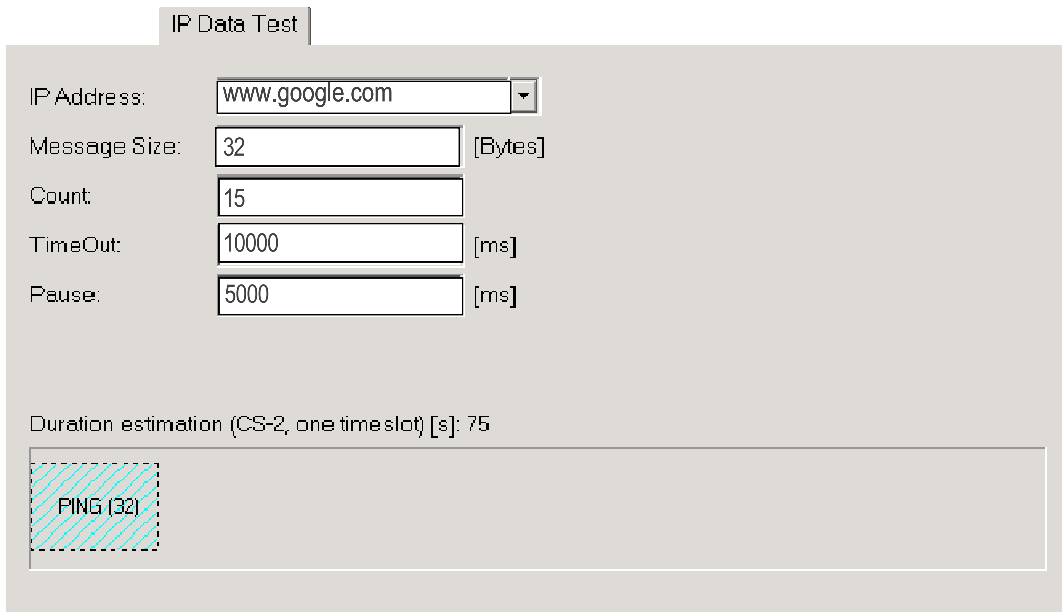


Figure 5.8 Measurement Program for PING Measurement

Parameters used for PING measurement are as follow:

i. IP Address : QVS or a public server that supports PING
« www.google.com »

ii. Message Size : Size of a message in bytes
« 32 bytes »

iii. Count : Number of messages to be transmitted
« 15 »

iv. Timeout : Max. echo delay. If the echo is not received within that time, the packet is considered lost and the pause until the next message begins
« 10000 ms »

v. Pause : Pause between messages
« 5000 ms »

CHAPTER 6

MEASUREMENT RESULT AND ANALYSIS

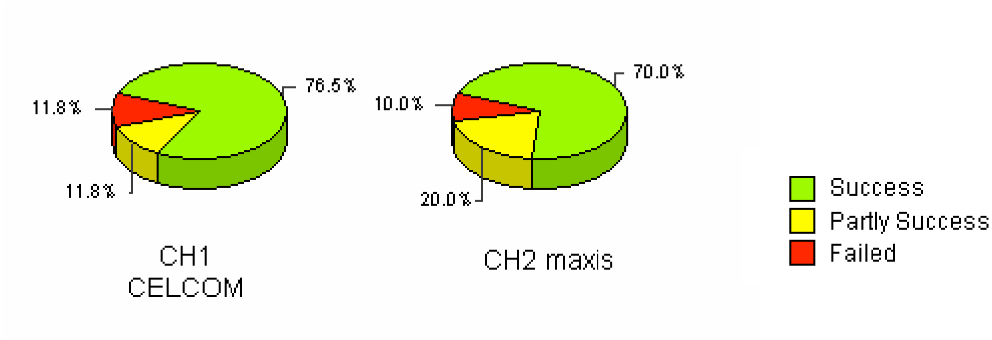
Before describing the measurement results in detail, it should be pointed out that this project only discusses results measured at the application layer. This is because the application layer measurements describe what user really receives.

6.1 HTTP Result and Analysis

HTTP Measurement was performed to get an overview of download transfer rate of web page for Maxis and Celcom. Results for coding scheme usage is also given.

6.1.1 Task Statistic Overview

Figure 6.1 present a comparative study of the two GPRS networks, Maxis and Celcom for the successful rate of downloading a web page conducted simultaneously. As performance measures, the parameters are as defined in Section 5.4.



Network	Success	Partly Success	Failed	Attempts
CH1 CELCOM	13	2	2	17
CH2 maxis	14	4	2	20
Total	27	6	4	37

Figure 6.1 Task Statistic for HTTP Measurement

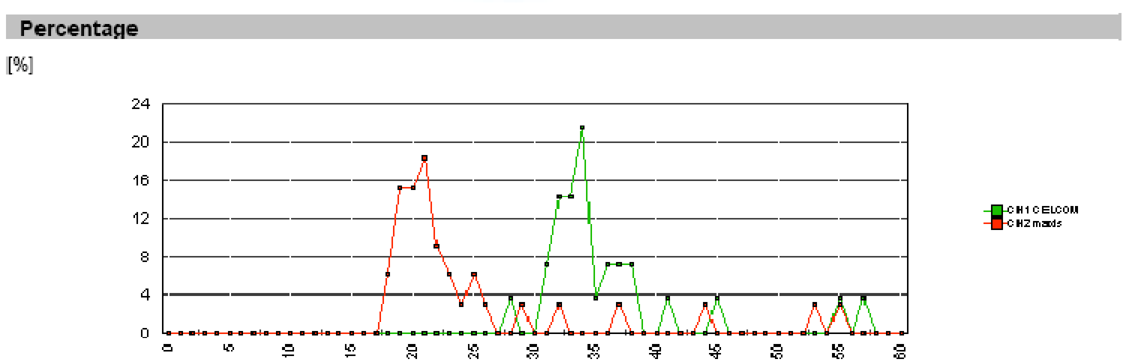
HTTP Success is defined as all the subtasks during downloading the web page were successful. HTTP Partly Success means not all the subtasks were success, or in other words not all the frames and image files were successful downloaded. HTTP Failed means all subtasks were failed.

From the chart in Figure 6.1, it can be clearly seen that, Celcom has successful rate of 76.4% from the total of 17 attempts and Maxis successful rate is 70% out of 20 attempts. Maxis has the higher rate of partly success (20%) compare to Celcom (11.8%). The result of failure in downloading the web page, Maxis has the lower rate (10%) compare to Celcom (11.8%).

This overall QoS maybe influenced by several factors like speed of downloading which will be discussed in the following section.

6.1.2 HTTP Download Time

Graph in Figure 6.2 shows the download time of the same web page for the two different networks. From the graph we can see the download time rate for each operator.



Statistic

Network	Min	Avg	Max	Samples	Success		Timeout	
CH1 CELCOM	28	36	57	34	28	(82.4%)	6	(17.6%)
CH2 maxis	18	25	55	40	33	(82.5%)	7	(17.5%)

Figure 6.2 Graph Download Time [s]

For Celcom, we can see the maximum download time is 57s and the minimum download time is 28s. Thus, average time required to download is 36s. For maxis, the maximum download time is 55s and the minimum is 18s. The average time to download is 25s.

Comparing the curves between the two operators, we find that the download time achieved by Maxis is much shorter compare to Celcom. This can be supported by looking at the Maxis timeout which has the lower percentage (17.5%) compare to Celcom (17.6%).

Figure 6.3 and 6.4 present drive test maps for the download time of a web page at centre of UTM for Celcom and Maxis respectively.

Drive test map for Celcom shows, 25 samples take between 1 to 40 s to download a web page and 4 samples take between 40 to 80 s. Drive test map for Maxis shows, 30 samples have download time between 1 to 40 s and 3 samples take between 40 to 80s to complete the downloads.

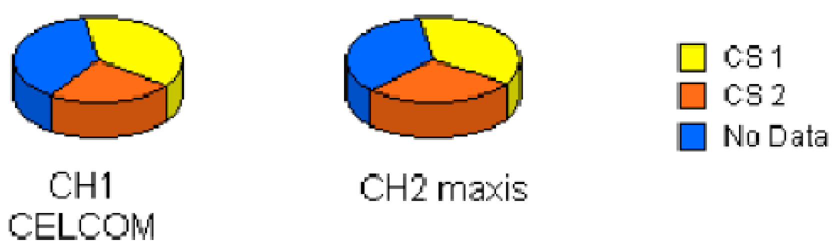
Figure 6.3 HTTP Drive Test Map for Celcom

Figure 6.4 HTTP Drive Test Map for Maxis

6.1.3 HTTP Coding Scheme Usage

The standard report from post-processing QVP in Figure 6.5 shows the distribution of CS 1 and CS 2 for the two different networks. The presented chart indicate that CS 1 is dominant coding scheme used for both Celcom (37.67%) and Maxis (36.99%) compare to CS 2, Celcom only use 24.01% and Maxis 28.36%.

If CS 1 is dominant, then it could also be an indication of interference in both networks, hence forcing the network to use CS 1 instead of CS 2.



%	CS 1	CS 2	No Data
CH1 CELCOM	37.67	24.02	38.31
CH2 maxis	36.99	28.36	34.65

Figure 6.5 HTTP Coding Scheme Usage

6.2 PING Result and Analysis

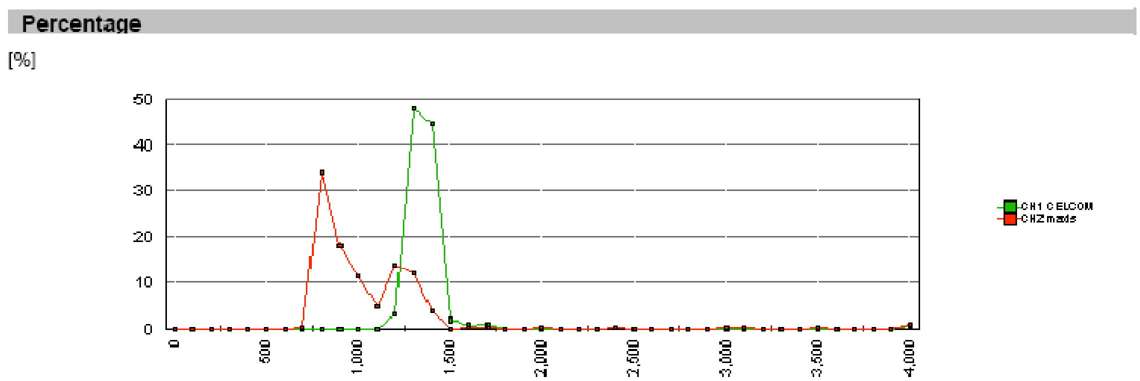
PING Measurement was performed to determine the RTD between QVM and a public server for both networks. Results for TBF usage in PING measurement is also given.

6.2.1 PING Delay

PING delay measurement result on a live GPRS networks for Maxis and Celcom can be shown in QVP standard report as presented in Figure 6.6. For Celcom, we can see the maximum delay is 5387 ms and the minimum delay is 1211 ms. The average delay is 1372 ms. For maxis, the maximum delay is 6079 ms and the minimum is 721s. The average delay is 1055 s.

Comparing the curves between the two operators, we find that Maxis has less delay compare to Celcom. Maxis also has lower percentage of PING loss, 1.2% compare to Celcom 5.3%.

However delay measurement can be influenced by operations of TBF, which is controlled by network settings. In the next section we will see the result for availability of TBF for both networks.



Statistic

Network	Min	Avg	Max	Samples	Success		Ping Loss	
CH1 CELCOM	1,211	1,372	5,387	400	379	(94.8%)	21	(5.3%)
CH2 maxis	721	1,055	6,079	500	494	(98.8%)	6	(1.2%)

Figure 6.6 Graph PING Delay [ms]

Figure 6.7 and 6.8 present drive test maps measuring PING delay at centre of UTM for Celcom and Maxis respectively.

Drive test map for Celcom shows, 21 samples have PING delay between 0 to 900 ms and 379 samples have PING delay more than 1050 ms. Drive test map for Maxis shows, 209 samples have PING delay between 0 to 900 ms, 54 samples for PING delay between 900 to 950 ms, 22 samples have PING delay between 950 to 1000 ms, 34 samples for PING delay between 1000 to 1050 ms and 181 samples for PING delay more than 1050 ms.

Figure 6.7 PING Drive Test Map for Celcom

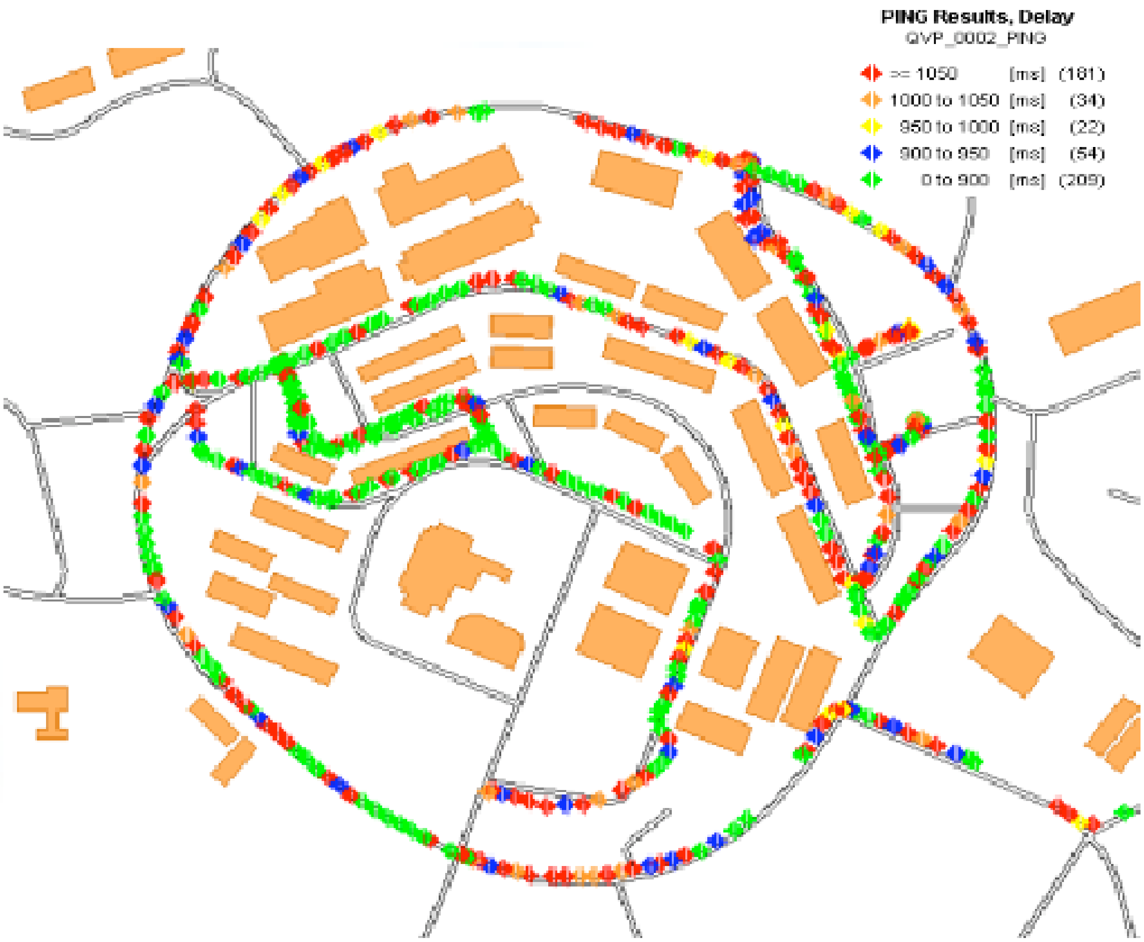
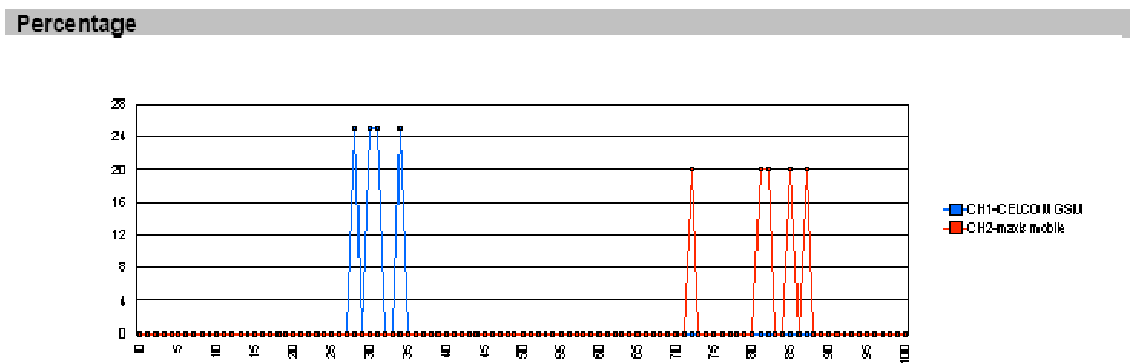


Figure 6.8 PING Drive Test Map for Maxis

6.2.2 PING Temporary Block Flow (TBF) Usage

QVP standard reports in Figure 6.9 presents the availability of TBF taken from a live network measurement. For Celcom, we can see the maximum TBF open is 34 % of total time. The average percentage of TBF open 30.8%. For Maxis, the maximum TBF open is 87 % of total time and the average percentage of TBF open 81.4%.



	Count	Min [%]	Average [%]	Max [%]
CH1-CELCOM GS	4	28	30.8	34
CH2-maxis mobile	5	72	81.4	87

Figure 6.9 Graph TBF Usage [%]

Another investigation can be done with the post processing unit QVP/field analyzer . The statistics on the TBF usage for Maxis and Celcom is shown in Figure 6.10 and 6.11 respectively.

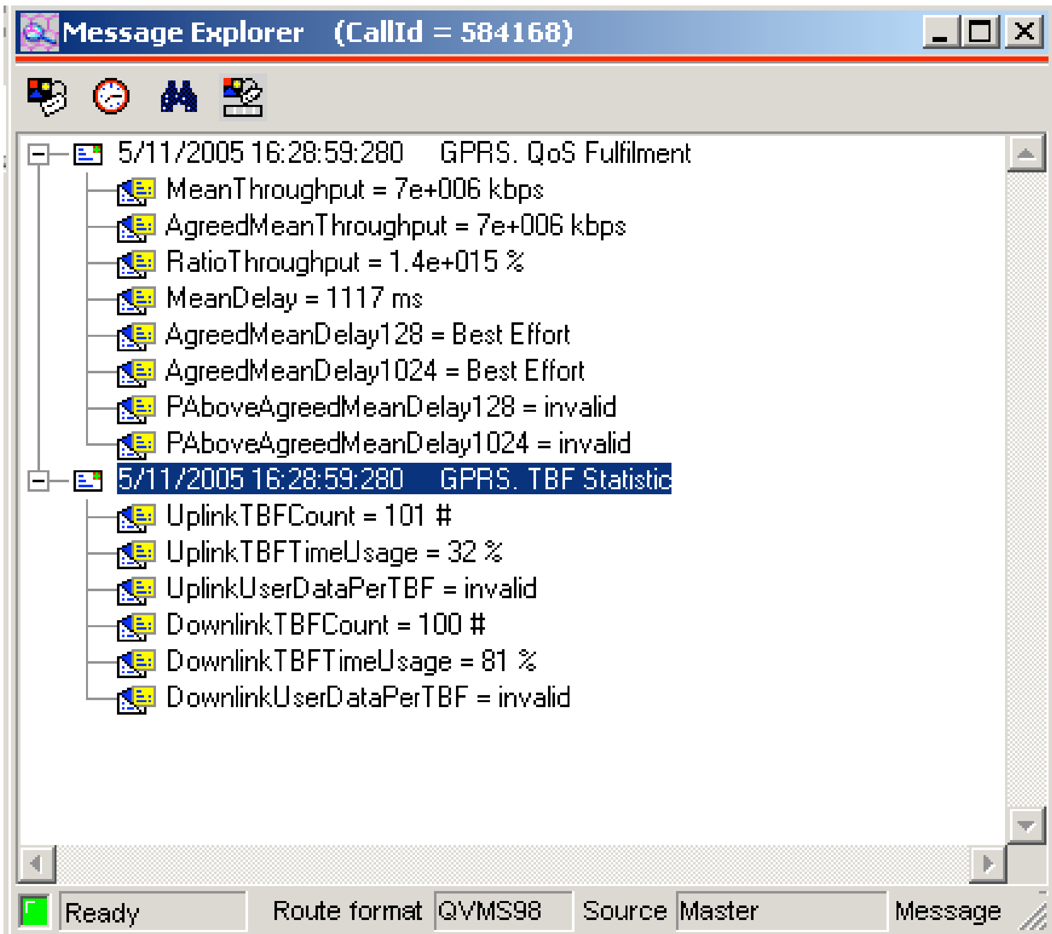


Figure 6.10 Statistic on TBF Usage for Maxis

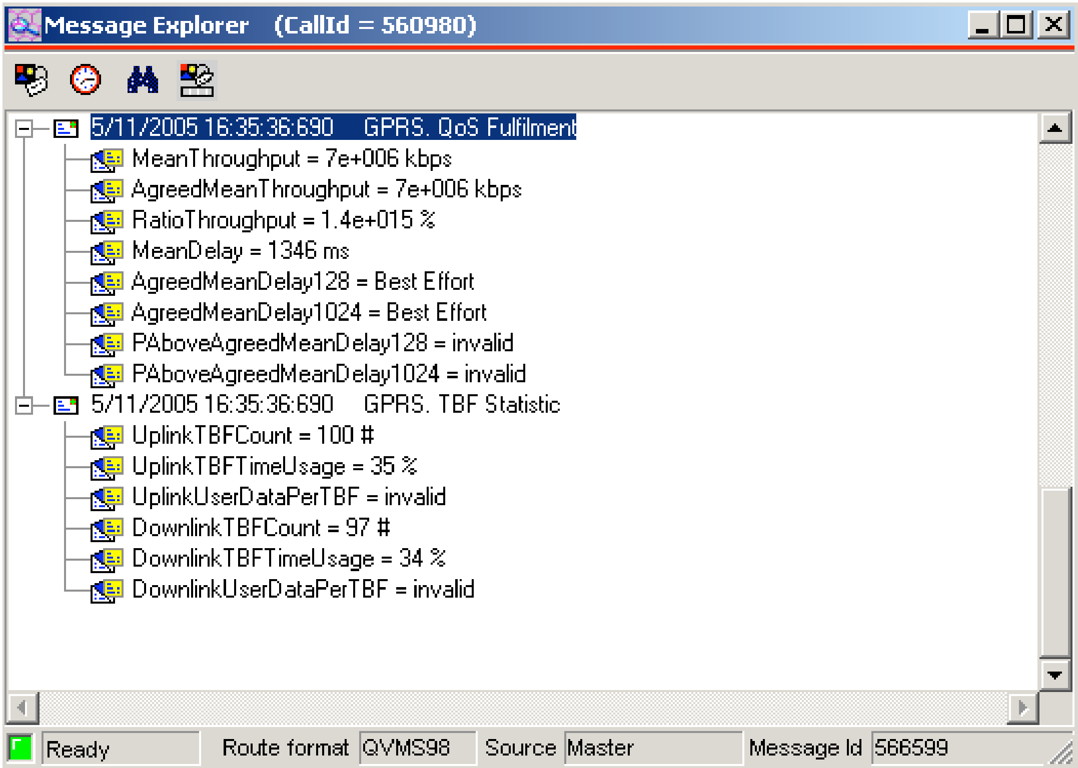


Figure 6.11 Statistic on TBF Usage for Celcom

From Figure 6.10 and 6.11, on the completion of this downlink measurement task, it can be seen that a total of 100 downlink TBFs have been used by Maxis and 97 downlink TBFs have been used by Celcom. For Maxis, TBFs have been open in downlink direction for 81% of the total time, and for Celcom TBFs have been open for 34% of the total time.

Comparing the curves and the statistics between the two operators, we find that Maxis has higher percentage in the availability of open TBF compare to Celcom. This indicate that cell of Celcom is congested during the measurement.

CHAPTER 7

CONCLUSION

7.1 Conclusion

This project report is presented a comprehensive performance study of the GPRS in mobile communications by focusing on the data performance at application layer. This is because the application layer measurements describe what user really receives.

Based on measurements made at the Universiti Teknologi Malaysia, common problems in GPRS networks can be identified and detected. Using Ascom QVoice, PING and HTTP performance results by conducting several drive tests was analysed. The QoS parameters for both applications were considered very detailed. These included, the downloading time of a web page and the Round Trip Delay. Moreover, the influence of different coding schemes is examined.

Furthermore, the data performance on live GPRS measurements was compared between two different network operators, Celcom and Maxis. Overall, measurement result shows Maxis offers better performance. However there are some other factors that may affect the performance of GPRS networks, such as, radio network capacity dedicated for GPRS and radio network quality.

7.2 Future Works

Due to complex interaction of TBF allocation algorithm, RTD, traffic conditions in the network at measurement time, coding scheme allocations, interference and etc, the measurements of HTTP and PING need careful planning before measurements. The results need some in depth analysis in order to understand the impact of different network environment.

GPRS networks are rapidly improving, but there are noticeable differences between infrastructures from different manufacturers. As the GPRS technology gradually matures, maybe these differences will narrow down and the subscribers can expect a reliable and high speed service everywhere.

For some more investigation work, the use of PING of different sized different timing can give clearer results. Latency measurement can be tested, which will shows the reaction time without the help of any already opened TBF. Measurement of data applications performance to the QVS GPRS can be carried out, to compare measurement results to a public server.

The challenge facing in the industry is now to improve the GPRS networks, and to ensure that the networks are tested in the right way.

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