A STUDY ON GPRS THROUGHPUT AT NORTHERN REGION BSC NETWORK

S.M.Rizaudin[1], S.Roslan[1], A. Hasnain[1], M.I. Imran[2], Fadzil A[1]

[1]Faculty of Electrical Engineering, Universiti Teknologi Mara Pulau Pinang

[2]Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka

rizaudin2003@yahoo.co.uk, rosem@ppinang.uitm.edu.my, hasnain@ppinang.uitm.edu.my, imranibrahim@utem.edu.my, fadzil_ahmad@ppinang.uitm.edu.my

Abstract

General Packet Radio Service (GPRS) is bearer service of Global System for Mobile (GSM) that has been deployed worldwide and is widely considered a technology precursor to the evolving third generation (3G) wireless network. In order to improve the GPRS traffic performance, the study on the factors contributed to the low performance of GPRS is carried out. This paper applied the data analyzing method of the real practice of GPRS services in Celcom (M) Berhad which covers the Northern Region. One of the factors contributed to low performance in GPRS traffic is the throughput performance. The parameter that interested to be focused in this paper is throughput performance whereby it including both uplink and downlink throughput.

Keywords: *GPRS, traffic, uplink, downlink, throughput*

I. INTRODUCTION

The GPRS is an enhancement over the GSM and adds some node in the network to provide the packet switched services. These network nodes are called GSNs (GPRS Support Nodes) and are responsible for the routing and delivery the data packets to and from the MS and external Packet Data Networks (PDN). The Figure 1 below shows the architecture of the GPRS system.

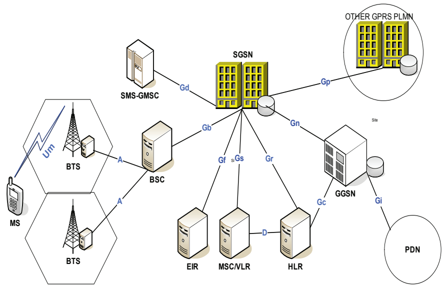

Figure 1: GPRS architecture

The most important network nodes added to the existing GSM networks are:

- SGSN (Serving GPRS Support Node)
- GGSN (Gateway GPRS Support Node)

The Serving GPRS Support Node (SGSN) is responsible for routing the packet switched data to and from the MS within its area of responsibility. The main functions of SGSN are packet routing and transfer, mobile attach and detach procedure (Mobility Management), location management, assigning channels and time slots (Logical Link Management), authentication and charging for calls. It stores the location information of the user (like the current location, current VLR) and user profile of registered users in its location register.

The Gateway GPRS Support Node (GGSN) acts as interface between the GPRS backbone and the external Packet

Data Network (PDN). It converts the GPRS packet coming from the SGSN into proper Packet Data Protocol (PDP) format before sending to the outside data network. Similarly, it converts the external PDP addresses to the GSM address of the destination user. It sends these packets to proper SGSN. For the purpose the GGSN stores the current SGSN address of the user and his profile in its location register. The GGSN also performs the authentication and charging functions. In general there may be a many to many relationship between SGSN and GGSN. However, a service provider may have only one GGSN and few SGSNs due to cost constraints. A GGSN proved the interface to several SGSNs to the external PDN.

The parameter that we interested to study in term of performance is throughput. The expected throughput of the system is defined as the amount of data that correctly transferred in a time interval t, divided by the duration t, when t approaches infinity

Throughput=lim N(t) x packet_length / t (kbps) (1)

Where N(t) is the number of packets transmitted in the system, and packet-length is the length of the packets, assuming they are all equal length. Notice that the number of packets N(t) divided by t is equal to the inverse of expected packet service time, when t approaches infinity. Therefore

Throughput = packet_length / T (kbps) (2)

Where T is the average transfer delay excluding the random access phase that takes place before the uplink channel assignment [1].Both the network and the MS can initiate the establishment of a Temporary Block Flow (TBF) on the Packet Control Channel (PCCH) allocated in the cell. The access is carried out on the PCCH in either one or two phase access is used if the requested RLC mode is unacknowledged mode to ensure a safe establishment or if more than one time slot is requested by the MS [2].

II. DATA ANALYSIS

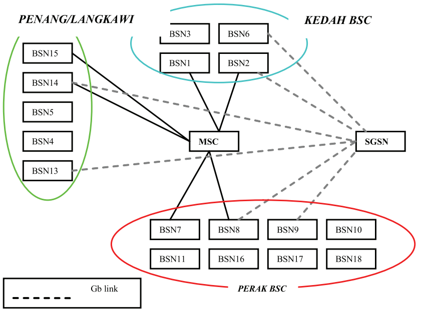

Figure 2. BSN network in Northern Region

In Figure 2, the BSCs in Northern Region are grouped in Base Station Network (BSN) where by BSN is referred to Base Station Controller (BSC). There are about 17 BSN that located in the Northern Region. These BSN are grouped in 3 respective regions which are Penang/ Langkawi BSC, Kedah BSC and Perak BSC [7].

A. Uplink and Downlink Throughput

Firstly, we considered the uplink and downlink throughput in July 2006 to identify the BSN that produced the lowest throughput. The throughput data is taken in daily average (kbits/s).

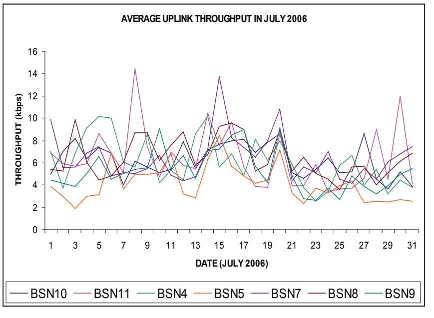

Figure 4. Average uplink throughput for BSN10, BSN11, BSN4, BSN5, BSN7, BSN8 and BSN9

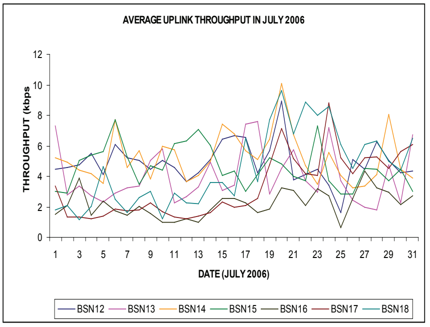

Figure 5. Average uplink throughput for BSN12, BSN13, BSN14, BSN15, BSN16, BSN17 and BSN17

Among the 17 BSNs in the Northern Region, BSN16 recorded the lowest average uplink throughput in July 2006. The average uplink throughput is shown in Figure 4 and Figure 5.

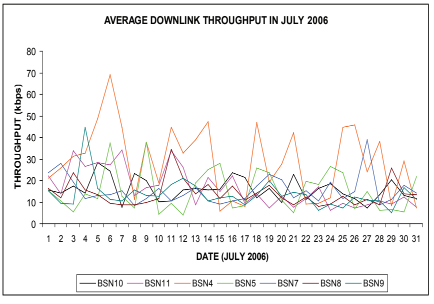

Figure 6. Average downlink throughput for BSN10, BSN11, BSN4, BSN5, BSN7, BSN8 and BSN 9

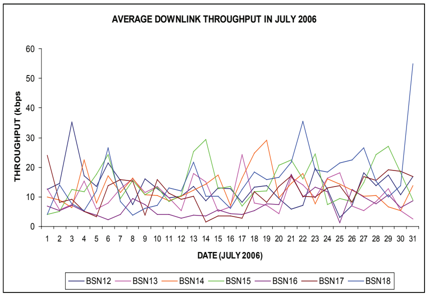

Figure 7. Average downlink throughput for BSN12, BSN13, BSN14, BSN15, BSN16, BSN17 and BSN18

Figure 6 and Figure 7 shows the average downlink throughput in July 2006. After considered the uplink and downlink throughput, it found that BSN16 is the lowest BSN that produced the lowest throughput. The throughput seems to fluctuate dramatically.

B. TBF Establishment

The TBF establishment analysis is carried out to verify the BSN that reflects the lowest performance among the 17 BSNs in the Northern Region.

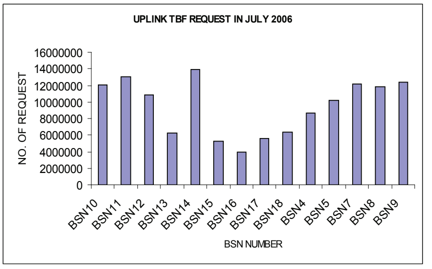

Figure 8. Uplink TBF request in July 2006

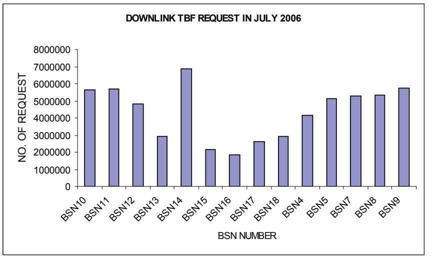

Figure 9. Downlink TBF request in July 2006

The TBF establishment request for uplink and downlink in July 2006 were summarized in Figure 8 and Figure 9 respectively. BSN16 stated the lowest uplink and downlink TBF request with 3923706 requests and 1856142 requests respectively. Next, we have to consider the TBF success percentage due to TBF request for both uplink and downlink.

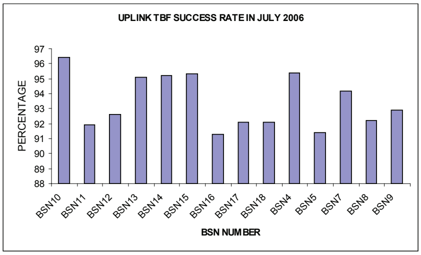

Figure 10. Uplink TBF success percentage in July 2006

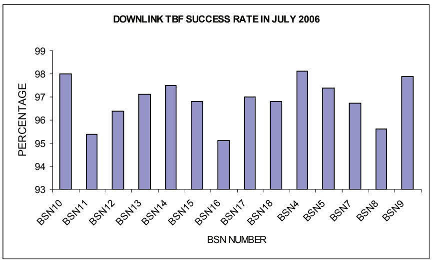

Figure 11. Downlink TBF success percentage in July 2006

From Figure 10 and Figure 11, it showed that BSN16 stated the lowest TBF success percentage for both uplink and downlink. Then BSN16 located in Perak is analyzed to identify the cell which produced the lowest throughput.

C. TBF Drop

There are 89 BTSs located under BSN16 control. In order to identify the lowest BTS that produced the lowest throughput, Celcom (M) Berhad had provided the TBF drop data in BSN16 which is related to call drop per cell in October 2006. The TBF drop data then been selected to represent it into graph.

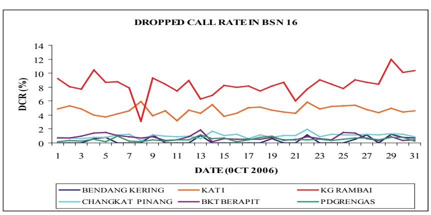

Figure 12. Call drop per cell in October 2006

According to the Figure 12, BTS in Kampung Rambai and Kati recorded the high call drop per cell. It reflects that the high TBF drop in those cells.

D. Locations

For further analysis, we need to identify the location of Kampung Rambai and Kati. It is important to identify the locations in order to consider the throughput performance. Kampung Rambai is located near to North-South Highway and surrounded by forest. Kampung Rambai location is shown in Figure 13. Location of Kati is shown in Figure 13 whereby it is surrounded by hills and forest.

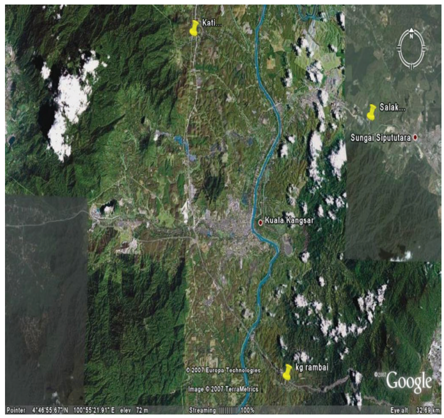

Figure 13. Location of Kampung Rambai and Kati

III. FACTORS CONTRIBUTED TO LOW THROUGHPUT PERFORMANCE

After the locations had been identified, we come out with the factors contributed to the low throughput performance in those cells. In this case study, we considered the following factors:

i. low TBF establishment
ii. traffic congestion
iii. fading due to geographical condition

A. Low TBF Establishment

Previously, we had identified that BSN16 produced the lowest TBF establishment. The low TBF establishment showed that how the cells in BSN16 close to saturation. Then the TBF blocking changes exponentially with network load, so once a network experiencing blocking, small increases in the offered network will be translated into higher TBF blocking [3]. Consequently, the low TBF establishment will reduced the throughput transmission in the respective cells.

B. Traffic Congestion

The traffic congestion record for BSN16 is tabulated in table below. For example, we considered the request, intra cell congestion and inter cell congestion in January 2007. Then we compared to congestion record in September 2006, October 2006 and November 2006.

The percentage of congestion (% congestion) = Congestion / Request (3)

Table 1. Congestion in BSN16

Request	Intra Cong	Inter Cong	Congestion
3091053	7559	215	7774

% Congestion	Jan 2007	Nov 2006	Oct 2006	Sep 2006
0.25%	0.25%	0.06%	0.44%	0.04%

According to the Table 1, it is obvious that the highest congestion occurred in October 2006. The highest congestion occurred due to the Hari Raya Aidilfitri festive in that month. Usually in the festive season, the request for GPRS services by users will increase dramatically. Therefore the traffic congestion tends to increase due to high number of request.

C. Fading Due to Geographical Condition

According to satellite images, Kampung Rambai and Kati are surrounded by hills and forest. These locations are considered as suburban areas. The hilly geographical condition can be related to shadow fading. The mobiles used in a Public Land Mobile Network (PLMN) ordinarily move through areas with obstacles of various sizes, such as mountains, hills, buildings or tunnels [4]. Occasionally, these obstacles will shadow or completely cut off the signal. This type of fading will effects the GPRS signal whereby users need to attempt more than a time to retrieve the GPRS session.

IV. RECOMMENDATIONS

One of the ways in which capacity can be increased is through the technique known as cell splitting. In this case study, a congested cell is divided into smaller cells. Each smaller cell, a minicell will have its own BTS. Cell splitting thus allows the channels to be reused since the size of the cell has been reduced for a given geographical area. If each cell size is reduced by half, the power requirements will change [5]. Refer to Figure 15, the dark boarders indicate newly created cells. It is possible to calculate the reduction in power required at the cell boundary in an unsplit cell is Pu, we can write this expression as

$$P_u = P_{tu} R^{-v} \quad (4)$$

Where P_{tu} is the transmitted power, R is the cell radius, v is loss factor. The power received at the new, smaller cell boundary, P_{tu} is

$$P_{su} = P_{st} (R/2)^{-v} \quad (5)$$

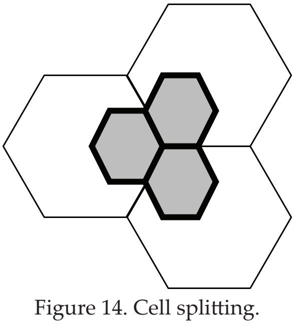

Figure 14. Cell splitting.

For the BTS in Kampung Rambai, the transmitted power is 47dBm (50.118W) and the cell radius is 7 km. In order to implement the cell splitting in Kampung Rambai, we need to keep the power at the boundary the same, regardless of whether the cell has been split or not. Then the equation is

$$PR^{-v} = P\,(R/2)^{-v} \qquad (6)$$

Assume that v = 3.2

where the left-hand side is the power at the boundary of the unsplit cell and the right-hand is the power at the boundary of the new cell (half the size). By substituting the given value, we obtained the P= 37.37dBm (5.457W), is the transmit power of the BTS of the newly created minicell.

The BTS transmit power in Kati is 47dBm and the radius is 7 km. Now we assume the loss factor, v = 3.5. By substituting the value in equation 7, we obtained P = 36.46dBm (4.43W).

Cell splitting also increases the number of channel capacity of a cellular telephone system by rescaling the system and increasing the number of channels per unit area [6].

If there 7 cells with 10 channels per cell, then we can determine the channel capacity by simple calculation:

Channel capacity (channels per area) = no. of channels in a cell x *no. of cells in an area* (7)

Substituting the value :
10 channels/cells x 7 cells/area = 70 channels/area
Then if each cell is split into 4 minicells
10 channels/cell x 28 cells/area = 280 channels/area
If each minicell is further split into 4 microcells
10 channels/cell x 112 cells/area = 1120 channels/area

It shows that each time the cells were splitted, the channels capacities will fourfold increase. The more channels in an area will minimize the traffic congestion whereby it able to cater high density of users. The cell splitting also assists to overcome the shadow fading in the hilly area by efficient coverage in minicell.

V. CONCLUSIONS

This paper presented the data analysis of the GPRS performance. The raw data is extracted to consider the throughput performance in the Northern Region. The percentage of TBF establishment in the GPRS network reflected the practical condition of those areas that perform the low throughput. The large area of Northern Region was zoomed in to identify the area that experienced the low throughput transmission. In this case study, the main factors that contributed to low throughput performance is the high GPRS traffic congestion and geographical area. The cell splitting seems to be the solution to the traffic problem. The cell splitting involving high cost since it required new BTS commissioning and proper cell planning.

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