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Evaluation of Paris Metro & Shadow Pricing as a Congestion Management Scheme in Packets Based Network

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Abstract: Network congestion is becoming a serious issue due to the constantly increasing demand for mobile services offered by GSM communications. GSM congestion needs to be reduced or controlled since it is extremely important. Numerous efforts have been undertaken to prevent and control congestion in cellular networks, such as the GSM network. This research intends to combine Paris metro pricing and Shadow pricing scheme in management of congestion of packets in GSM. The experimental result is simulated and evaluated using flutter framework application. The application consists of a single page with multiple widgets to display information about the simulation. The two dynamic pricing methods' respective performances are shown. The outcome demonstrates that shadow pricing is a more effective way to control traffic. The combination of Paris metro price and shadow pricing successfully reduced traffic and increased income.

Keywords: *GSM, Congestion, Flutter, Cellular, Radio, Shadow Pricing, Paris Metro Pricing.*

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I. INTRODUCTION

The issue with wireless networks is that there is a finite amount of radio frequency spectrum that is unable to meet the growing demand. Upgrading the network switching system and base station subsystem was the first step taken in increasing the network's capacity. However, this could not solve the problem. Cities and towns currently have nearly their maximum number of cells, and further increase in the cells would result in greater technical overheads than loss of revenue. Various dynamic pricing approach used was more complicated and result to high overhead cost, poor service quality and congestion. Presently, the Internet merely offers best-effort service, handling each packet equally. There is, however, widespread dissatisfaction with the perceived performance, and it seems widely agreed upon those future applications particularly real-time applications like packet telephony will necessitate modifications to the way the Internet functions. It's a primitive instrument, pricing. For example, different applications have different needs in terms of jitter, latency, and bandwidth. Network congestion is becoming a serious issue due to the constantly increasing demand for mobile services offered by GSM communications (Alarape *et al*., 2011). GSM congestion needs to be reduced or controlled since it is extremely important. Numerous efforts have been undertaken to prevent and control congestion in cellular networks, such as the GSM network. According to (Johansson & Steensland 2012), congestion control refers to the measures made by the network to reduce the severity, length, and spread of the congestion. Since bandwidth is the most expensive resource for mobile communication, spectrum efficiency, which is determined by the number of users per cell, is a crucial indicator of cost (Whitehead., 2000).

In packet networks like the Internet, a straightforward method called PMP (Paris Metro Pricing) is recommended for offering differentiated services. The PMP approach involves dividing networks logically into independent channels. The costs associated with using these channels would be the sole difference. Pricey channels would draw fewer viewers and offer superior service as a result. The main instrument for traffic management would be price. The most straightforward differentiated services solution is PMP. It is intended to take user preferences into account, albeit at the expense of a little network use efficiency (Andrew, 1978).

The development of this research involved investigating the use of Erlang-B and critically analyzing call data collected during a busy hour for a week. The data collected were used to explain a model that estimates the maximum capacity of the channel based on the number of Er1ang's channels. The information were utilized to calculate the effective load or successful setup call (times), blocking rate, TCH congestion ratio (%), the accessible channels, successful TCH assignments, and the overall load per call setup attempt. Correlated analysis hypothesis was used for this. From the work's visual result analysis, it was found that many of the channels that are available are underutilized, particularly in places which has low blocking ratio and available channels exceed the required channels for effective load transmission. (Emuoyibofarhe *et al.,* 2015).

In order to reduce congestion, some traffic that would typically have been transported must be delayed or refused to be carried. Congestion control is prioritized at the source end as well as during connection setup. Dijkstra's Routing Algorithm model was proposed for the connection admission control. Application of the suggested model significantly improved the monitoring effect (Olabiysi & Afolabi, 2012).

The authors of this research suggested an auction-based pricing strategy for allocating resources in GPRS networks, which are mobile data networks. Additionally examined were the trade-offs between revenue optimization and performance enhancement, as well as the auction method on the average system latency of the networks. The numerical results show that a higher auction reserve price greatly lowers the amount of network congestion as demonstrated by a decrease in the network's mean system latency (Saravut & Harmantzis, 2006).

II. OVERVIEW OF GSM NETWORK

To ensure consistent coverage throughout the area, a number of base stations are positioned about equal distances from one another. But occasionally, unique cell size which could significantly vary from the typical cell size is used, aerial in these cells are positioned accordingly. Base transceiver stations (BTS) are connected to base station controller (BSC), and BSCs are connected to a mobile service switching center (MSC). A public switched telephone network (PSTN) serving as backhaul connects the MSCs to one another. A wired network or microwave link is also used for the connections between BTS and BSC as well as between BSC and MSC. Based on requirements and location, the base tower height at which the antenna is mounted, antenna's transmitting and receiving power is determined. While antennas are usually erected on a hilltop, water tank, rooftop, or street light pole, they can also be placed atop a metallic or concrete tower above the ground. In addition to managing a number of BTSs, each BSC is in charge of allocating channels to the BTSs, determining the mobile device signal strength, and facilitating BTS handovers. In order to prevent interference in places where they overlap, neighboring cells in the cellular network operate at distinct frequencies. To prevent the existence of the signal across adjacent cells, which might cause interference and crosstalk, the transmitter power level at the cell base station must be optimized. Increasing the number of cells is also necessary to improve the geographic coverage. Every cell has a fixed capacity due to the established frequency range. In order to accommodate more devices in the same space, a region's cell size must be decreased in order to increase the number of cells there. The following methods are frequently employed in cellular networks to enhance a cell's capacity: sectoring, zone micro cells, splitting a cell into smaller cells, and frequency borrowing from neighboring cells. Because each cell's base station and mobile devices must run at lower signal strength and radiated power level, cell splitting results in an increase in cell count that not only boosts system capacity but also lowers power consumption for each individual cell. Cell splitting, on the other hand, decreases the coverage area of each cell, as seen in Figure 1.

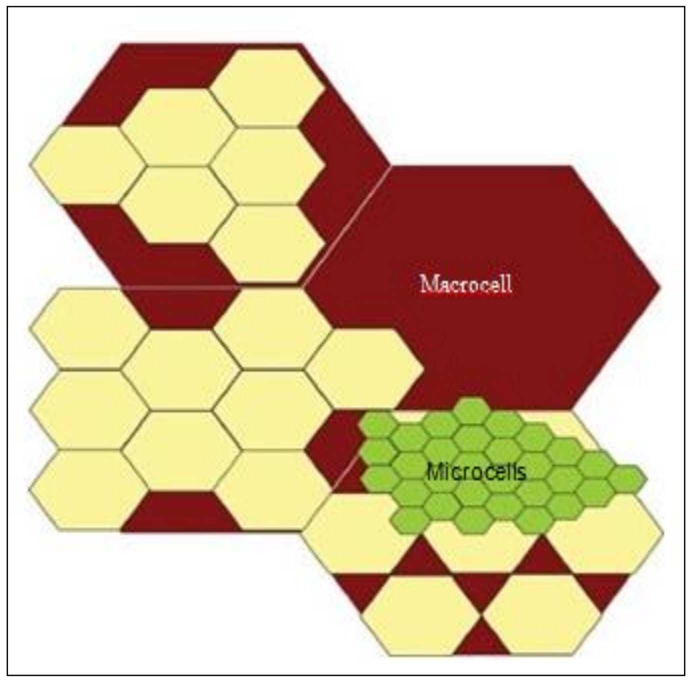

Fig 1: Cell Splitting (Easley *et al.*,2018)

Instead of using omnidirectional antennas to cover a cell, sectoring uses directional antennas. The number of sectors in a cell can be computed based on the directional antenna's angle of coverage. As shown in Figure 2, cell could be divided into sectors of 60° or 120°. Although sectoring keeps the cell's size constant, it does not contribute to a decrease in handovers because each sector is made of channel. Implementing sectoring is challenging because multiple antennas need to be handled at the base station, and performance deteriorates due to reflections from different urban structures, which causes interference in the sectors. A cell has one or two unidirectional antennas for specific applications, instead of having three or six sectors in the cell to cover the complete 360°. "Selective cells" are the name given to such cells. Dead or non-signal zones within a cell can be avoided with the aid of zone micro cells. Dead zones can be found in basements, tunnels, the shadowed portion of hills, spaces with reflectors, and thickly walled buildings. These micro cells within the cell are equipped with antennas to provide transmission signals to these dead zones. Thus, by adding more antennas, micro cells are produced that operate on the same frequency as the parent cell. A single micro cell can contain several, and each micro cell needs to have its own antenna. Typically, a wired network connects the antennas of the cell's micro cells to a base station. When a zone microcell's antenna count increases, the base station's control operation becomes more complicated. The base station also manages the handover between micro cells.

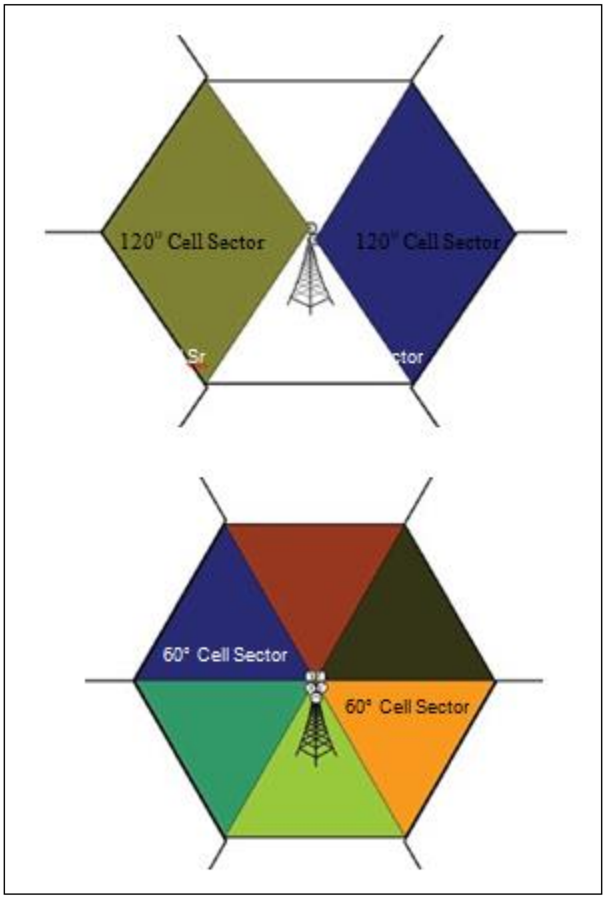

Fig 2: Cell Sectoring (Easley *et al.*,2018)

❖ *GSM Network Architecture*

Multiple functional entities make up a GSM network. A generic GSM layout is depicted in Figure 3. There are three main sections of the GSM network. The base station subsystem interacts with the mobile station through a radio link and mobile Station. Network Subsystem perform authentication, switching between mobile users and network. Its primary component is the Mobile Services Switching Center.

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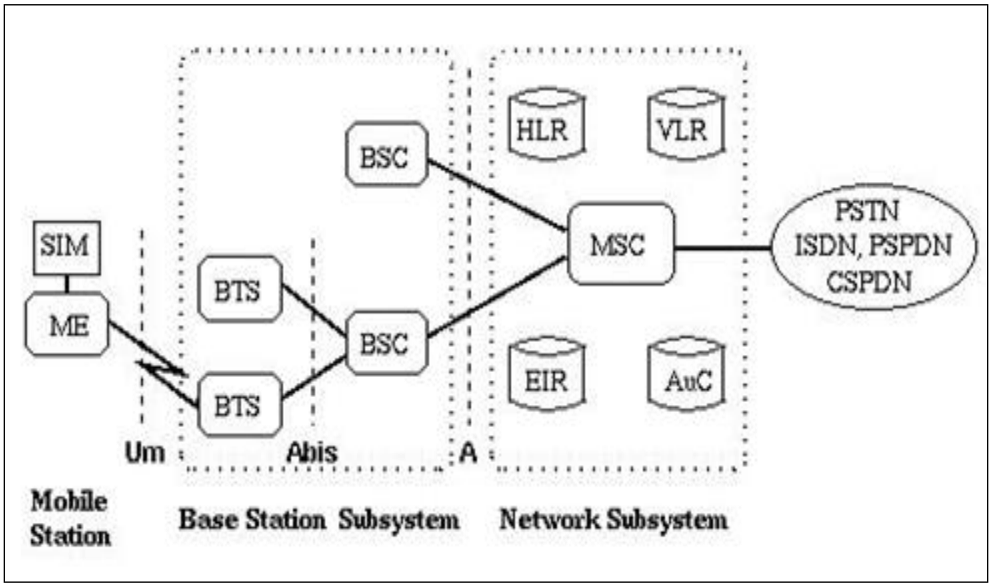

Fig 3: GSM Network Architecture (Williams C.Y. Lee 2012)

➢ *Mobile Station*

The mobile station (MS) is made up of display, smart card, digital signal processors and radio transceiver. The smart card also called the subscriber identity module (SIM) allows for mobility. The International Mobile Equipment Identity (IMEI) provides a unique identification for the mobile equipment. A secret key for authentication, additional user data, and the subscriber's International Mobile Subscriber Identity (IMSI) are all contained on the SIM card.

➢ *Base Station Subsystem*

The Base Station Subsystem is made up Base Transceiver Station (BTS) and Base Station Controller (BSC). They communicate via designated abis interface. The base transceiver station manages the radio link with the mobile station. The BTS perform various functions such as radio channel setup, frequency hopping and handover. The BTS and BSC are linked to the mobile switching centre through the base station subsystem.

➢ *Network Subsystem*

The Mobile Switching Center (MSC) is the core component of the Network Subsystem. It performs registration, authentication, location updates, handovers and call routing to subscriber. It functions as a typical PSTN or ISDN switching node. The ITUT Signaling System Number 7 (SS7), which is utilized in ISDN, is widely used in contemporary public networks for signaling between functional entities. The MSC provides the link to the public fixed network (PSTN or ISDN).The GSM's call routing and features are offered by the MSC, the Visitor Location Register (VLR) and Home Location Register (HLR). The HLR includes mobile device's current location as well as all of the administrative data for every subscriber registered in the relevant GSM network. The Visitor Location Register receives data from the HLR . This data is required for call management and the provision of subscription services. While each functional entity can be implemented independently, most switching equipment manufacturers combine one MSC and one VLR so that the MSC's controlled geographical area. Security and authentication are the uses for the other two registers.

III. METHODOLOGY

The application is built using the Flutter framework. The application consists of a single page with multiple widgets to display information about the simulation. The first widget, which is the graph chart, shows the bandwidth being used by the simulation. The default maximum bandwidth is 2500MBps; this can be adjusted by the operator using the control data section of the application. The bandwidth using the text field in the control data section can be increase or decrease. This is used to manage congestion of packets within a specified period. The control data section of the application display current price indicator, which shows the current price per megabyte of the system. The default price when there is no congestion is $4 per MB, but it changes per MB if the cells in the BTS are almost occupied. The Price per MB ($) for the standard price and Congested Price per MB ($) for when the system is experiencing congestion is fixed. There are two toggle switches; the one on display information about the simulation is used to change the pricing algorithm and the second on the simulation data page is used to pause or continue the simulation. By default, the system uses shadow price, but you can toggle the switch to change it to Paris metro pricing.

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➢ *How the Pricing Algorithm Works*

For Paris metro pricing, the 36 channels are divided logically into three with different prices. There is a standard price, Paris metro 2nd price and Paris metro 3rd price. The different prices take effect base on the pre-set percentage of occupied channels. The current price changes when preset maximum percentage channels are reached. All new packets received are put through a random Boolean generator to simulate getting a yes or no response from the user. If the randomly generated Boolean value is true, the user packet is added to a waiting queue and given a wait time in seconds, depending on the type of packet. The wait time determines how long the packet should remain in the queue before being terminated. For audio packets, the wait time is 3 seconds; for text packets, the wait time is 5 seconds; and for video packets, the wait time is 2 seconds. If there is available bandwidth before the wait time expires, the packet is moved to the packet manager queue, where it will be processed. The current price becomes the congested price, and all new packets received are put through a Boolean generator to simulate getting a response from the user if is ready to pay the new price. If the user agrees to pay the new price the packets are processed and if not the packets are dropped. The system creates packet every 50 milliseconds. If the response gotten from the Boolean generator is true, the packet is added to the waiting queue and given a wait time in seconds, depending on the packet type. If the packet wait time expires before it is processed, it is removed from the list. If bandwidth is available, it is added to the packet manager queue for processing.

Fig 1: Simulation Window Interface

IV. RESULTS AND DISCUSSION

Three types of packets are considered;

- Audio
- Text
- Video

The flutter application use a random Boolean generator to generate packets within limits specified for processing. The packets are express in megabyte (MB) which can be varied to manage congestion on the network. The maximum bandwidth is set at 2000MB. This will allow proper capturing of relevant information needed for this research work. The following parameters are to be set for each generation and simulation of packets.

- Minimum audio size
- Maximum audio size
- Minimum video size
- Maximum video size
- Minimum text size
- Maximum text size
- Shadow price per MB
- Standard price per MB
- Paris metro 2nd price per MB
- Paris metro 3rd price per MB

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- Paris metro active price percentage (%)
- Paris metro 2nd active price percentage (%)
- Shadow active price percentage (%)
- Bandwidth (MB)

The following simulation data will be display during the processing of packets

- Maximum bandwidth
- Bandwidth used
- Data sent
- Channel used
- Video data sent
- Audio data sent
- Text data sent
- Revenue
- Waiting queue
- Current Price
- Standard price

➢ *Paris Metro Pricing Approach*

The Paris metro pricing scheme is configured using three pricing scheme; the 1st is the standard price ($4.00), 2nd price ($8.00) and 3rd price ($8.00). The percentage at which the different prices should take effect is set. This research uses 30% /70% pricing approach. The 30%/70% means the 2nd price takes effect when 30% of the cells are occupied and 3rd price takes effect when 70% of the cells are occupied. Subscribers are alerted when price changes and are given option of either accepting or reject. Once price is accepted packets are processed. If not packets are dropped. The amount of video, audio and text sent at every 10minutes is recorded. The total packets sent and revenue generated is also noted same time. The total packets sent at every instant of 3hours are simulated.

➢ *Shadow Pricing Approach*

The concept of shadow pricing notifies a user ahead as soon as there is congestion to decide when to submit packets. A packet receives marks when sent during congestion. A fixed price is assigned to every mark. There are two prices involve; standard price and shadow price. For the purpose of this research, the shadow price is set at 30% which means the shadow price of $8.00 takes effect when 30% of the cells are occupied.

Table 1: Paris Metro Pricing 1

Min Audio	Max Audio	Min Text	Max Text	Min Video	Max Video	Standard price	PMP 2nd Price	PMP 3rd Price	Band Width
10MB	20MB	1MB	5MB	50MB	100MB	$4.0	$8.0	$10.0	2000MB

Time	Video Sent	Audio sent	Text Sent	Data Sent	Revenue	Congestion
10mins	7.147Gb	1.50Gb	0.90Gb	9641MB	$0.07	No
20mins	15.392GB	3.18Gb	1.80Gb	21160MB	$0.15M	No
30mins	23.982Gb	5.11Gb	2.68Gb	32144MB	$0.23M	No
40mins	32.613Gb	6.83Gb	3.62Gb	43063MB	$0.31M	No
50mins	41.583Gb	8.26Gb	4.36Gb	54733MB	$0.39M	No
60mins	51.377Gb	10.11Gb	5.24Gb	66747MB	$0.49M	No
70mins	61.642Gb	11.83Gb	6.13Gb	79692MB	$0.58M	No
80mins	68.787Gb	13.43Gb	6.99Gb	89791MB	$0.65M	No
90mins	78.773Gb	15.51Gb	7.97Gb	102356MB	$0.75M	No
100mins	87.849Gb	17.00Gb	8.97Gb	113949MB	$0.83M	No
110mins	97.109Gb	18.76Gb	9.77Gb	125954MB	$0.92M	No
120mins	105.679Gb	20.37Gb	10.66Gb	137363MB	$1.00M	No
130mins	115.635Gb	21.94Gb	11.60Gb	149463MB	$1.09M	No
140mins	125.758Gb	23.70Gb	12.35Gb	162128MB	$1.17M	No
150mins	132.894Gb	25.50Gb	13.30Gb	172513MB	$1.25M	No
160mins	142.475Gb	27.52Gb	14.24Gb	184753MB	$1.35M	No
170mins	149.352Gb	28.96Gb	15.10Gb	193977MB	$1.41M	No
180mins	159.339Gb	30.65Gb	16.03Gb	206162MB	$1.50M	No

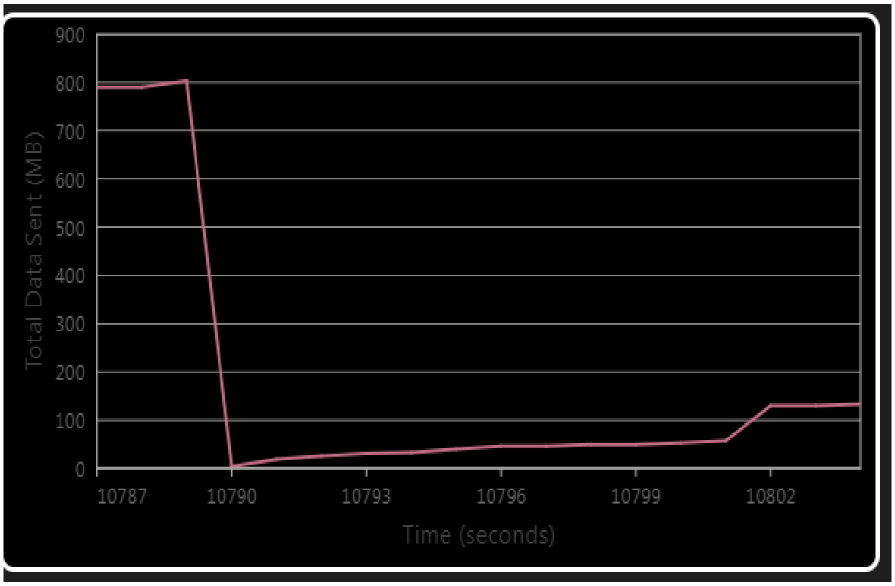

Fig 2: Paris Metro Pricing 1 Simulation Result

Table 2: Paris Metro Pricing 2

Min Audio	**Max Audio**	**Min Text**	**Max Text**	**Min Video**	**Max Video**	**Standard price**	**PMP 2nd Price**	**PMP 3rd Price**	**Band Width**
20MB	30MB	5MB	10MB	100MB	150MB	$4.0	$8.0	$10.0	2000MB

Time	Video Sent	Audio sent	Text Sent	Data Sent	Revenue	Congestion
10mins	16.287Gb	3.18Gb	2.12Gb	23129MB	$0.16	No
20mins	30.685GB	5.68Gb	4.71Gb	42199MB	$0.30M	No
30mins	45.103Gb	8.63Gb	7.06Gb	61089MB	$0.44M	No
40mins	58.493Gb	12.02Gb	9.36Gb	81388MB	$0.58M	No
50mins	74.277Gb	15.32Gb	11.80Gb	101432MB	$0.74M	No
60mins	87.892Gb	18.64Gb	14.36Gb	120995MB	$0.89M	No
70mins	101.649Gb	21.61Gb	16.76Gb	140216MB	$1.02M	No
80mins	114.881Gb	24.20Gb	19.24Gb	159397MB	$1.06M	No
90mins	128.52Gb	26.88Gb	21.68Gb	177594MB	$1.29M	No
100mins	142.515Gb	29.57Gb	24.45Gb	197358MB	$1.43M	No
110mins	159.383Gb	32.23Gb	26.99Gb	218912MB	$1.60M	No
120mins	173.787Gb	35.14Gb	29.61Gb	238881MB	$1.75M	No
130mins	188.369Gb	38.07Gb	32.01Gb	258979MB	$1.89M	No
140mins	203.714Gb	41.32Gb	34.28Gb	280033MB	$2.04M	No
150mins	217.757Gb	44.32Gb	36.89Gb	299901MB	$2.18M	No
160mins	231.206Gb	47.23Gb	39.35Gb	318139MB	$2.32M	No
170mins	245.235Gb	50.25Gb	41.73Gb	337925MB	$2.47M	No
180mins	260.934Gb	53.05Gb	44.06Gb	359055MB	$2.67M	No

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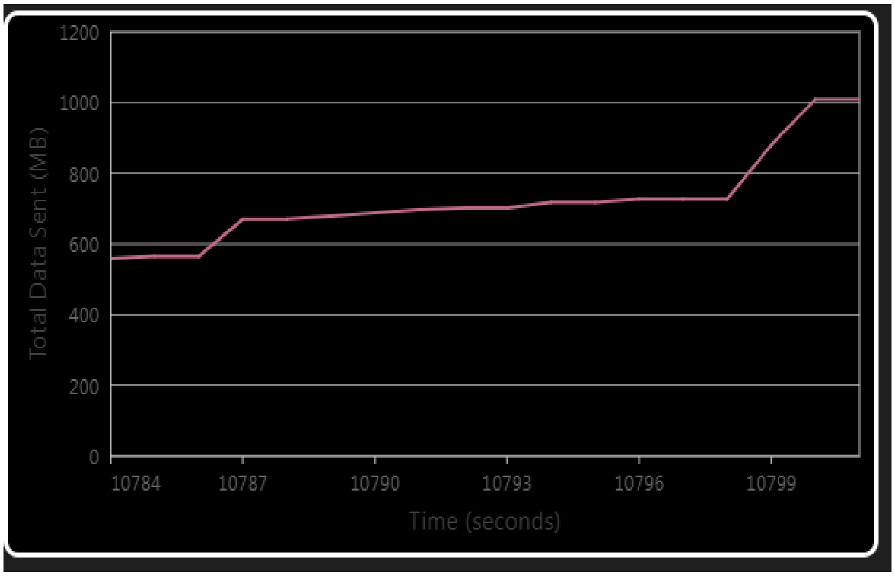

Fig 3: Paris Metro Pricing 2 simulation result

Table 3: Paris metro pricing 3 (30%/70%)

Min Audio	**Max Audio**	**Min Text**	**Max Text**	**Min Video**	**Max Video**	**Standard price**	**PMP 2^{nd}Price**	**PMP 3^{rd}Price**	**Band Width**
30MB	40MB	10MB	15MB	150MB	200MB	$4.0	$8.0	$10.0	2000MB

Time	Video Sent	Audio Sent	Text Sent	Data Sent	Revenue	Congestion
2mins	0.00Gb	0.00Gb	0.00Gb	1995MB	$0.00M	YES

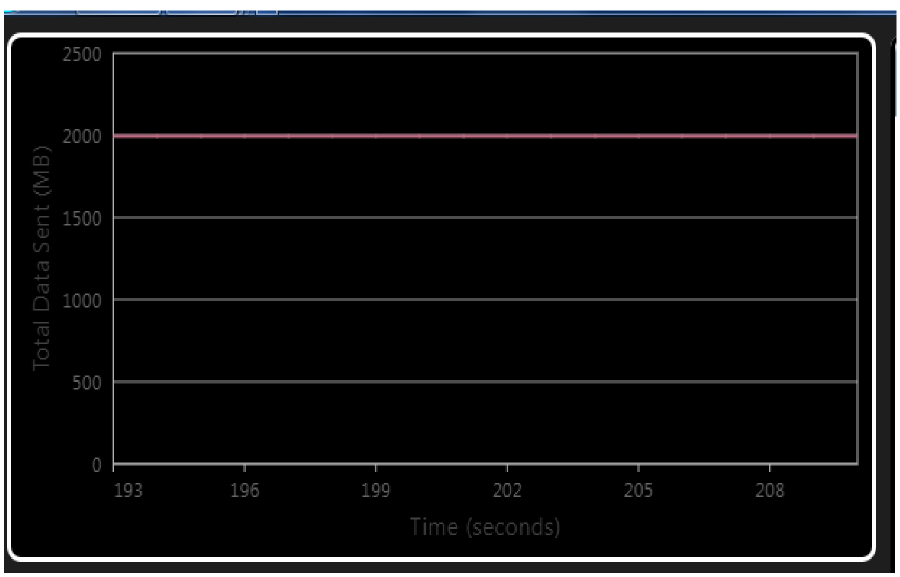

Fig 4: Paris Metro Pricing 3 (30%/70%)

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Table 4: Shadow Pricing 1

Min Audio	Max Audio	Min Text	Max Text	Min Video	Max Video	Standard price	Shadow price	Band Width
10MB	20MB	1MB	5MB	50MB	100MB	$4.0	$8.0	2000MB

Time	Video Sent	Audio sent	Text Sent	Data Sent	Revenue	Congestion
10mins	9.043Gb	1.49Gb	0.89Gb	112049MB	$0.08	No
20mins	18.11GB	3.18Gb	1.84Gb	23239MB	$0.16M	No
30mins	26.064Gb	4.77Gb	2.74Gb	34094MB	$0.23M	No
40mins	36.081Gb	6.63Gb	3.65Gb	46499MB	$0.31M	No
50mins	43.816Gb	8.09Gb	4.49Gb	56797MB	$0.38M	No
60mins	52.533Gb	9.71Gb	5.32Gb	67787MB	$0.46M	No
70mins	61.182Gb	11.24Gb	6.17Gb	79095MB	$0.53M	No
80mins	70.732Gb	12.80Gb	7.09Gb	90858MB	$0.61M	No
90mins	79.895Gb	14.23Gb	7.99Gb	102410MB	$0.69M	No
100mins	89.323Gb	16.22Gb	8.88Gb	114553MB	$0.78M	No
110mins	98.436Gb	18.12Gb	9.84Gb	126921MB	$0.85M	No
120mins	106.029Gb	19.65Gb	10.63Gb	136774MB	$0.93M	No
130mins	116.303Gb	21.45Gb	11.47Gb	149525MB	$1.00M	No
140mins	124.824Gb	23.19Gb	12.26Gb	160291MB	$1.28M	No
150mins	133.985Gb	24.87Gb	13.11Gb	172082MB	$1.17M	No
160mins	142.308Gb	26.43Gb	14.00Gb	183036MB	$1.24M	No
170mins	151.314Gb	28.11Gb	14.91Gb	194531MB	$1.32M	No
180mins	160.125Gb	29.79Gb	15.89Gb	206571MB	$1.38M	No

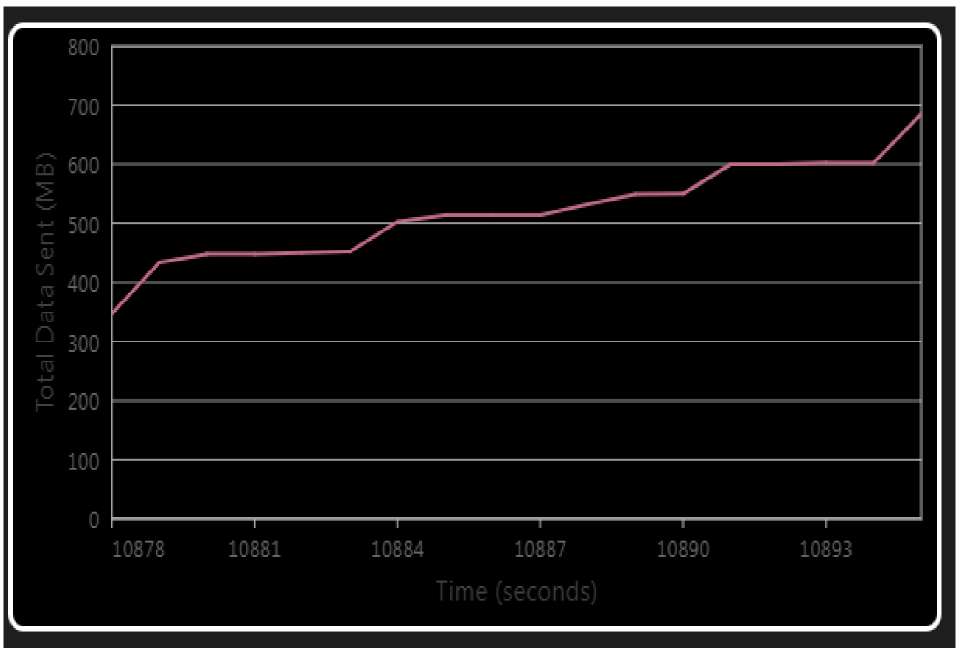

Fig 5: Shadow Pricing 1

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Table 4: Shadow Pricing 2

Min Audio	Max Audio	Min Text	Max Text	Min Video	Max Video	Standard price	Shadow price	Band Width
20MB	30MB	5MB	10MB	100MB	150MB	$4.0	$8.0	2000MB

Time	Video Sent	Audio Sent	Text Sent	Data Sent	Revenue	Congestion
10mins	13.243Gb	2.76Gb	2.25Gb	19760MB	$0.13M	No
20mins	30.606GB	5.81Gb	4.95Gb	42576MB	$0.28M	No
30mins	45.865Gb	8.07Gb	7.24Gb	61839MB	$0.42M	No
40mins	61.011Gb	11.22Gb	9.73Gb	82023MB	$0.56M	No
50mins	74.313Gb	13.82Gb	12.24Gb	100900MB	$0.68M	No
60mins	87.538Gb	16.99Gb	14.38Gb	119558MB	$0.81M	No
70mins	102.065Gb	20.04Gb	17.40Gb	140683MB	$0.95M	No
80mins	116.056Gb	22.66Gb	19.68Gb	158995MB	$1.08M	No
90mins	130.035Gb	25.52Gb	22.07Gb	178229MB	$1.21M	No
100mins	143.853Gb	28.57Gb	24.44Gb	197927MB	$1.34M	No
110mins	158.614Gb	31.49Gb	27.07Gb	217720MB	$1.48M	No
120mins	173.96Gb	34.21Gb	29.48Gb	238465MB	$1.62M	No
130mins	188.262Gb	36.97Gb	32.18Gb	258221MB	$1.75M	No
140mins	205.032Gb	39.64Gb	34.82Gb	280236MB	$1.90M	No
150mins	222.273Gb	42.97Gb	37.20Gb	302845MB	$2.06M	No
160mins	237.634Gb	45.09Gb	39.77Gb	323583MB	$2.20M	No
170mins	251.914Gb	48.67Gb	42.37Gb	343130MB	$2.33M	No
180mins	267.340Gb	51.95Gb	44.61Gb	364954MB	$2.48M	No

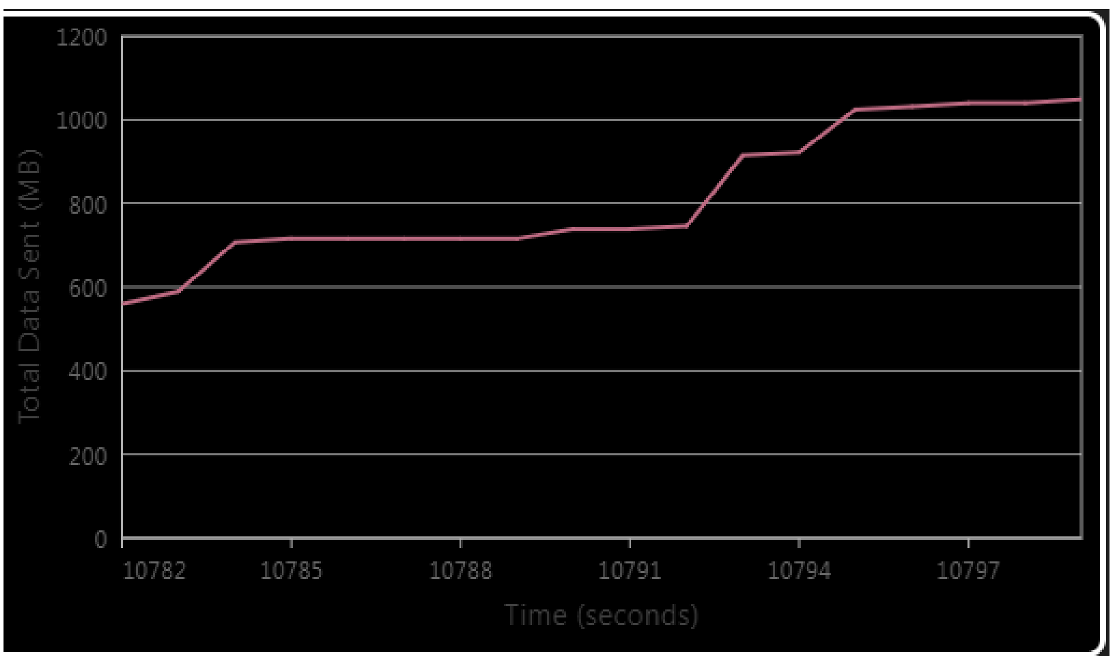

Fig 6: Shadow Pricing 2

Table 5: Shadow Pricing 3

Min Audio	Max Audio	Min Text	Max Text	Min Video	Max Video	Standard price	Shadow price	Band Width
30MB	40MB	10MB	15MB	150MB	200MB	$4.0	$8.0	2000MB

Time	Video Sent	Audio Sent	Text Sent	Data Sent	Revenue	Congestion
10mins	14.567Gb	2.83Gb	2.41Gb	20728MB	$0.13M	No
20mins	29.124GB	6.13Gb	4.89Gb	41400MB	$0.26M	No
30mins	43.263Gb	9.19Gb	7.06Gb	59964MB	$0.40M	No
40mins	56.599Gb	11.87Gb	9.87Gb	78615MB	$0.53M	No
50mins	70.896Gb	14.74Gb	12.28Gb	97943MB	$0.67M	No
60mins	86.454Gb	17.47Gb	14.86Gb	119117MB	$0.81M	No
70mins	99.025Gb	20.14Gb	17.39Gb	137316MB	$0.93M	No
80mins	113.422Gb	23.13Gb	20.04Gb	156608MB	$1.06M	No
90mins	129.074Gb	25.79Gb	22.43Gb	177898MB	$1.20M	No
100mins	145.143Gb	28.80Gb	24.91Gb	199541MB	$1.35M	No
110mins	156.45Gb	31.90Gb	27.39Gb	217027MB	$1.46M	No
120mins	170.915Gb	35.23Gb	29.93Gb	236821MB	$1.60M	No
130mins	185.273Gb	38.81Gb	32.70Gb	256862MB	$1.74M	No
140mins	200.008Gb	41.44Gb	35.17Gb	277869MB	$1.87M	No
150mins	215.925Gb	44.84Gb	37.56Gb	299173MB	$2.02M	No
160mins	231.412Gb	47.71Gb	40.11Gb	332130MB	$2.17M	No
170mins	245.828Gb	51.19Gb	42.60Gb	339929MB	$2.30M	No
180mins	261.016Gb	53.88Gb	44.95Gb	360053MB	$2.49M	No

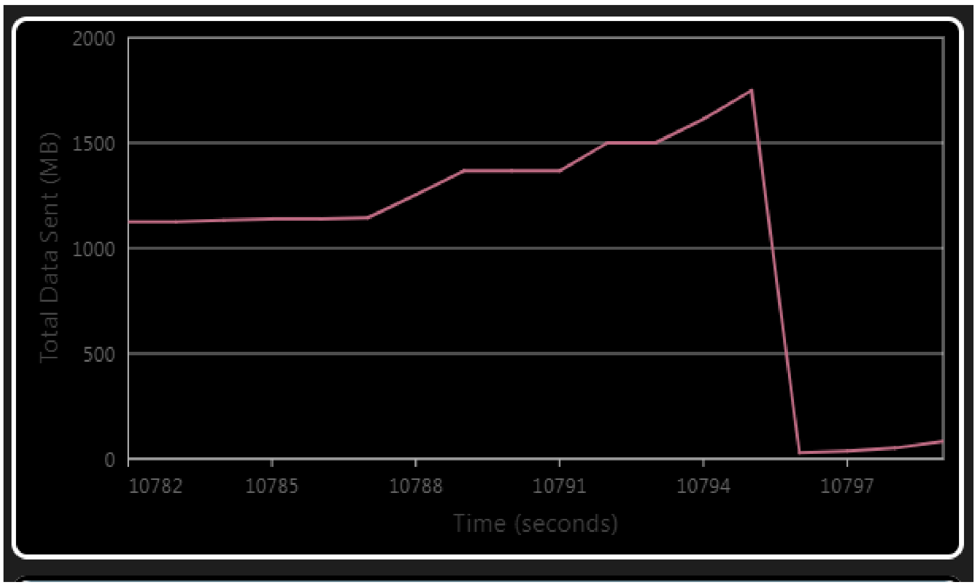

Fig 7: Shadow Pricing 3

V. DISCUSSION & CONCULSION

The combine effect of Paris metro and shadow price scheme in packet based network has been proved to manage congestion. It allows users to decide, based on their requirements and budgets. It provides congestion control and minor changes in the network infrastructure is being required to management congestion. It is evident from the result that as the size of packets increases the network will experience more congestion and collapse using Paris metro pricing approach only. The combine effect of Paris metro pricing and shadow pricing will manage congestion in base station subsystem.

The experimental results also show that the two pricing scheme incorporate open and close congestion control policy in managing congestion. The dynamic pricing scheme can be applied to the base station subsystem of a GSM network to manage congestion of packet based network. It is seen from the result that the combine effect of PMP and shadow pricing scheme managed congestion and greater revenue for service

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provider. Application of this two dynamic pricing scheme and increase in bandwidth of the base station subsystem (BSS) will ultimately manage congestion of packets network in GSM.

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