A Dynamic Analyzer for Traffic Management and Control in Mobile Telecom Systems

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Abstract

The blocking of call connections in mobile telecommunication systems (MTSs) is highly because of excess traffic volumes and the unavailability of the channel to service call requests. This is one of the key factors that affect the quality of service (QoS) on the network. In this paper, we develop a Graphic User Analyzer (GUA) that models some MTS traffic parameters to minimize the traffic intensity and the blocking of calls in the network. The analyzer has capabilities for dynamic channel allocation for operators wishing to implement this design and can handle handovers. To test the workability of the analyzer, a "Partial Dynamic" channel allocation strategy is made, such that cells have fixed channels. This strategy is able to reduce the blocking of calls. The Java programming language is used to simulate the traffic control system, which manages three adjacent cells simultaneously with varied channel sizes. However, the designed model has adaptability for n cells, n>0. The design will assist MTS operators monitor the traffic and evaluate the average QoS at the network or cell level, and will also be useful if plugged to users cell-phones to enable them estimate the QoS actually served them.

Keywords: *GUA, MTS, GRPS, GSM, SMS, QoS*

Introduction

Recent technologies like the General Packet Radio Service (GPRS) in GSM network has made it possible that several services now become available to GSM subscribers. The GPRS was designed as an extension of the GSM network to provide an efficient way for transporting packet data through wireless channel since the traditional GSM network is circuit-switched oriented and waste bandwidth.

These services which include the traditional voice calls, music or video clips and short message service (SMS) messages over a period has generate huge traffic in the network because of the wide patronage the GSM technology has enjoyed. The problem of congestion, attenuation of voice calls and delay in delivery of data among others then arise. The blocking of call connections within the network or unsuccessful delivery of data occurs if adjacent base stations are highly utilized.

According to Allen, Fitzpatrick & Ivanovich (2003), traffic in GSM networks is basically classified into two types: circuit-switched traffic and packet-switched traffic. The former includes voice calls, SMS and circuit-switched signally traffic. The later is characterized by the GPRS technology for GSM. Its traffic involves the transportation of packetized data and allows for efficient allocation of bandwidth compared to the circuit-switched traffic that wastes bandwidth. Its traffic include GPRS packet data, GPRS Attach and Detach plus Routing Area updates. Each of

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these different traffic types place different demands on the available radio resource produced by the base station system.

Three common phases are identified during transmission of traffic streams: Paging, Dedicated signaling and user traffic transmission, (Allen, Fitzpatrick & Ivanovich, 2003). These phases are correlated into the three logical channels under the following:

(i) **Paging:** done by the common control channel (CCH), a channel used to control paging and to grant access.

(ii) **Dedicated Signaling:** The Standalone Dedicated Control Channel (SDCCH) is responsible for this. Majority of call setup occurs in this channel.

(iii) **Traffic Channel (TCH):** A logical channel which carry either encoded or user data for circuit-switched voice traffic or Packet Data Traffic Channel (PDTCH) for packet-switched data traffic.

Various traffic models of Wireless Telecommunication Systems (WTSs) have been studied; for instance the traditional model (ITU approach), (Zhon, 2000), Internet traffic model, (McMillan, 1991; Ho, Zhu & Madhavpeddy, 1998; Iverson & Glenstrup, 2000; Oliver, 2004).

Related Literature

In cellular systems (wireless telecommunication systems), two main issues must be addressed, the Radio Resource Management (RRM) Scheme and the effect of users mobility on the traffic Volume Per Cell, (Hong & Rappaport, 1986; Markoulidakis, Lyberopoulos & Anagmostou, 1998; Silva & Mateus, 2003). Data traffic in wireless telecommunication networks has emerged as one aspect more important in third generation networks planning, (Guri, 1987; Sidi & Starobinski, 1997; Jabari, 1996; Zhon, 2000). Data traffic in current mobile telecommunication systems should take into account a variety of services (voice, data, video) and environments (e.g. private, outdoors, indoors, as well as user mobility behaviour. Traffic volume estimations based on simple mobility models, assuming simple cell shapes are presented in Hong and Rappaport (1986); El-Dolil, Wong and Steele (1989); Jolley & Warfield (1991); McMillan (1991); Rappaport (1991); Montenegro, Sengoku, Yamaguchi and Abe (1992); Foschini, Gopinath and Miljanic (1993); Nanda (1993); Yoon and Un (1993).

Markoulidakis, Lyberopoulos & Anagnostou (1998) develops a traffic model for MTSs. In their model they utilize a set of simplified assumptions regarding the distribution of certain random time intervals (e.g. call duration and “cell residence time”) and the handover arrival process. Their models mainly focus on the estimation of the cell boarder-crossing rate and the time taken by a busy mobile to leave a cell area. This allows for the estimation of the handover rate and the call duration within a cell, which in turn, using an iterative method, allows for the computation of the offered traffic load per cell.

Nousiainen, Kordybach & Kemppi (2002) presents a model framework for cellular network simulations suitable for implementation and support of features such as user classes and street types. Their implementation is a numerical simulation that illustrates the effect of some of the features of mobility model in regular Mahattan scenario and real Helsinki area scenario.

Silva & Mateus (2003) presents an analysis of data services in a third generation mobile telecommunication network based on simulation. In addition, they illustrate the need for simulation in order to characterize the mix of several traffic types for capacity and quality of service (QoS) planning.

Kajackas, Batkanskas & Medeisis (2004), suggested that QoS observation and management in cellular networks should be performed not only at the network level, as is done today, but also individually in each and every user terminal. However, existing centralized network QoS systems only allows for the evaluation of average QoS at the network or cell levels; they do not provide any objective information for estimating the QoS actually served individual mobile users (MUs).

The data traffic from the wireless network is modeled by Pareto distribution, where the traffic is generated by use of distribution inverse function. Like wireless Application Protocol (WAP), Data services has quickly developed, (Kunz, Barry, and Mahoney, 2000).

This paper improves on Silva & Mateus (2003) by providing a dynamic GUA that models telecommunication traffic parameters like average duration of calls, average calls per second, traffic intensity, call failure ratio and traffic congestion. The simulator also handles handovers. The paper also implements the interesting suggestion of Kajackas, Batkanskas & Medeisis (2004), by providing a dynamic assessment, recording and subsequent analysis of the actual QoS received by a particular MU in an easy to read GUI. In addition to the GUA, the simulator has a command line output that analyzes and outputs the traffic parameters values at each call attempt. A log file output that records the total/ average traffic parameters is also made available.

Materials and Methods

When a MU wants to communicate with another MU, it first obtains a channel from one of the base stations that is alert depending on the signal strength. If a channel is available, it is assigned to the user or the Mobile station (MS), (Silva & Mateus, 2003). In the case of busy channels a new request is denied or blocked. Blocking as a result of congested channels is referred to as new call blocking. In a situation where a MS moves from one cell to another during a call, handover or handoff occurs. During this process, the MS requires the base station to allocate an available channel in a new cell to ensure continuity of the call. If there are no free channels, the handoff call is blocked. Such blocking is referred to as blocking of ongoing calls due to mobility.

The ‘manual’ mechanism used to control traffic in situations of congestion is the increase in the channels of E1, which is a 2.048mbit/s rate channel used by European CEPT (Conference des administrations Europeennes des Postes et Telecommunications) carriers which transmit thirty 64kbits/s digital channel for voice or data calls and 64kbits/s signaling channel for framing and maintenance. Due to the exponential growth of the network in respect of the number of subscribers to the network, in a short while, the situation of congestion still reoccurs. Also the buffer size for undelivered packets when they are very large constitutes a long queue of these undelivered packets especially during peak periods.

System Program Design

Basic Call Sequence

The basic call sequence is shown as follows:

MT if (send button pressed = True)
initiate outgoing call setup
{the mobile terminal sends a SERVICE REQUEST message to MSC. The service request message does not contain any confidential information as it is transmitted over a clear channel on the TMSI and the service identity is included}

MSC forward Request to the VLR
{as a PROCESS ACCESS REQUEST message}

VLR if (user registered in VLR = True)
initiate authentication procedure

VLR if (authentication = success)
Begin
issue TMSI
SEND ACCESS REQUEST TO MSC

{in reply to request for service by the MSC on behalf of Mobile terminal}

End

MT acknowledge TMSI

send information for outgoing call

{with a secure channel in place, the mobile terminal sends called party's address to VLR in a SEND INFORMATION FOR OUTGOING CALL SETUP message}

VLR if (number called not barred)

{the VLR checks the number and type of service against the user subscription parameters}

send COMPLETE CALL

MSC inform the mobile terminal that the call is processing.

if (called party = mobile user)

get routing information from HLR

{The called party's HLR is interrogated to the mobile current location}

if (called party = fixed network user)

determine routing information from number supplied being call establishment to the destination.

inform mobile terminal of called party status

{send a CALLED PARTY ALERTING or CALLED PARTY BUSY message to the mobile terminal}

if (Call is answered)

send CONNECT MESSAGE to mobile terminal

MT if (CONNECT MESSAGE received)

send CONNECT ACKNOWLEDGE MESSAGE to the MSC.

End Call Sequence

Channel Assignment Strategy

When a mobile telephone initiates a service request at a particular location, usually, a choice of base stations in the surrounding area to which it could connect is ascertained.

For the purpose of this paper, a location may be considered as a place within the network area of coverage from which the vector of signal strengths reaching nearby base stations approximately takes the same time to connect to the network when a service request is made.

We will employ a fixed assignment strategy such that channels are permanently assigned to cells but channel borrowing shall be possible such that a free channel in a neighbouring cell can be borrowed to service a new request. This strategy is considered to lower the probability of blocked calls. Also for data traffic we shall consider to make the buffer as small as possible to eliminate long queues.

Proposed Model

Assumptions

The following are the assumptions made in the proposed model:

(i) A balance between the amount of signaling and traffic resource is reached to avoid congesting one of them when the other is under-utilized.

(ii) Voice calls are assumed to be blocked, whereas other traffic types take a queue for service in a congested situation.

(iii) The main parameters for the traffic types are mean inter-arrival time and the interconnection duration and they follow a poison distribution.

Some of the parameters considered in the model include traffic volume, traffic intensity and channel allocation time. These parameters allows for the evaluation of system behaviour and resource utility (Silva & Mateus, 2003).

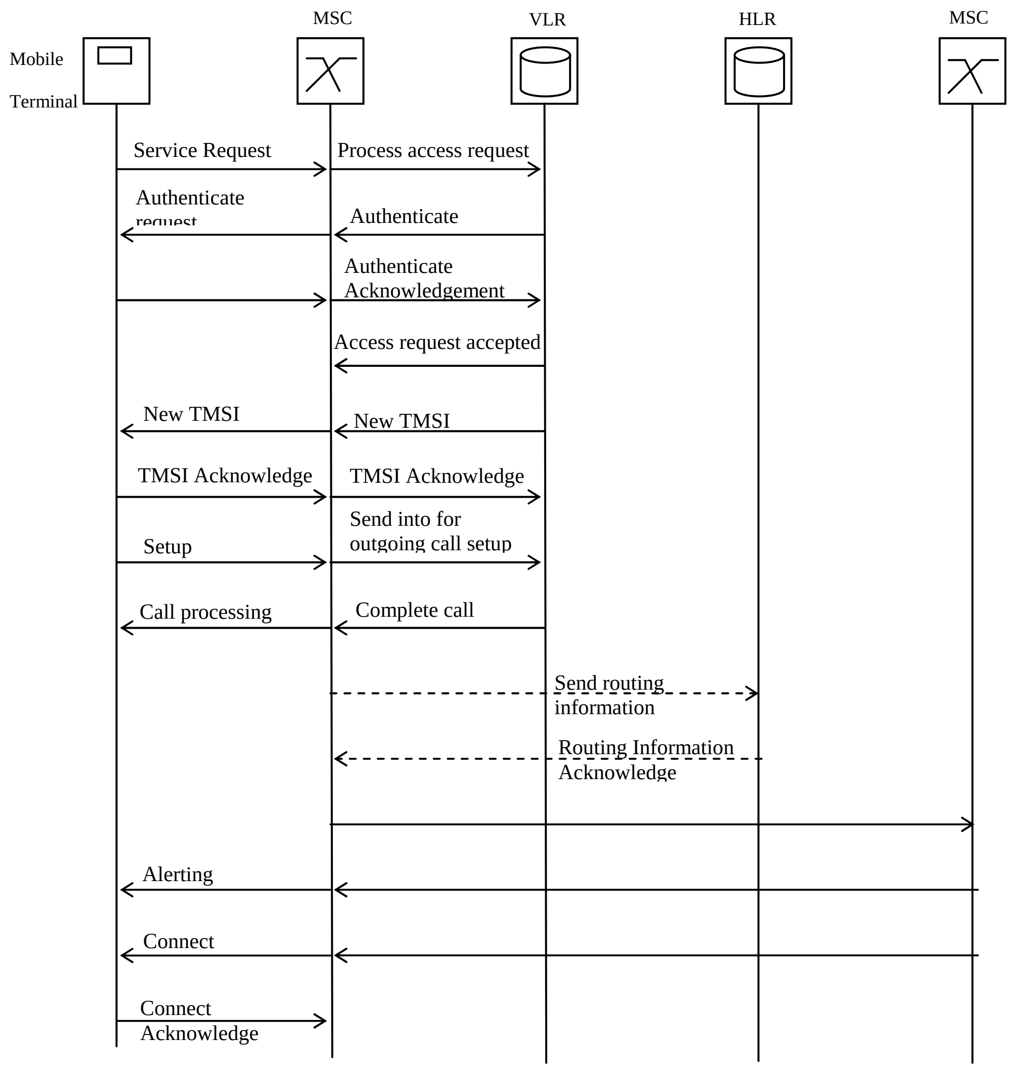

Fig. 1. GSM Signaling procedure for mobile originated call

Research Model

The research model is represented as a Finite State Transducer (FST) below:

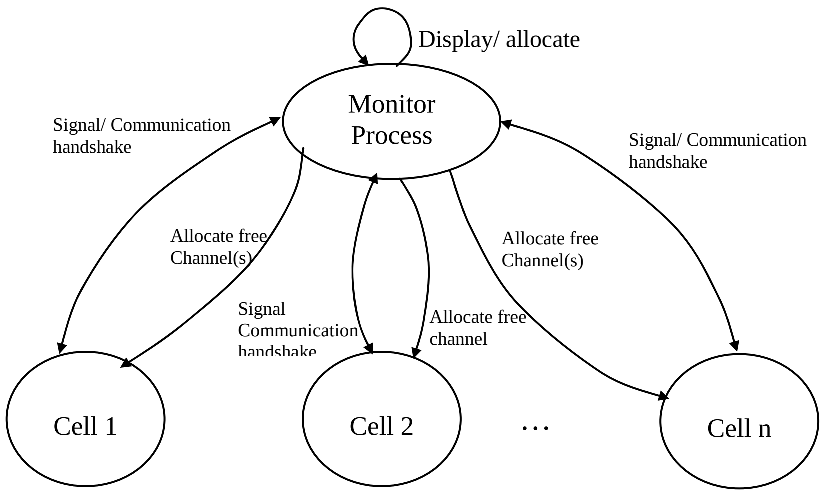

Fig. 2. A FST representation of the research model.

Fig. 2. above shows a FST for the research model. It uses the dynamic channel allocation strategy in the allocation of available channels in the wireless network. The model is extended to cover n cells, where n>0. The FST has a monitor that does traffic analysis and handles handover of calls to reduce calls blocking, hence improving the quality of service (QoS) of the network.

Teletraffic Formulae And Relationships

Below are the formulae and relationships of the traffic.

Fail (Blocked) Ratio = No. of Blocked calls / No. of Attempts

Average call duration = Total calls Duration / No. of successful calls

Average call per second = Total No. of Attempts / Time elapse

In the simulation the following assumptions were implemented:

(i) dynamic allocation strategy.

(ii) allocation of variable numbers of channels cells such that these channels remain fixed during a simulation.

(iii) three (3) adjacent or neighboring cells.

(iv) the mean duration time of calls or holding time for the channel varies exponentially between 1 second and 180 seconds.

Analysis of our Simulator (Traffic Porgram)

The Traffic Monitor (TMonitor) contains the main method, which starts the program and creates instances of Traffic display (Tdisplay). The Tdisplay presents the GUI Frame and creates three instances of cell. Each cell creates an instance of Call Generators and shows the animation of activities. The CallGenerator object each instantiates random number of callers from time to time. The callers created initiate a call request to its cell to seize a channel.

If there are free channels, the cell allocates a channel to the caller, but if no free channel exists, the cell requests for handover from TDisplay. The TDisplay then ask for assistance from adjacent cells to service the handover call(s). If any other cell has free channels, it accepts the request and services the caller. On event of no assistance from adjacent cells, the calls are blocked and a “Network Busy” message is sent to the caller.

Each caller that is connected holds the channel for a random number of time (in seconds) and then releases it after being serviced. When it releases the channel, the cell that connected it updates its free channel value. Each cell has a Call Parameter object, which holds the number of channels, Total number of attempts (to make a call), Number of successful calls and the number of call failures (blocked calls). Others are the Total number of call duration, Current number of active callers, Average call duration and Average calls per second.

Presentation and Discussion of Results

We here present the simulation results for varied number of channels and maximum number of attempts to test the effectiveness and workability of our analyzer. The tables show an instance of the number of channels, maximum number of attempts and the maximum duration for each of the cells.

Table 1: Allocation I. Available channels < Number of attempts

Cell	Avail. channels	Max. no. Of attempts	Max. duration
1	17	70	18
2	13	145	13
3	19	118	15

In this allocation, the number of available channels is less and cannot satisfy the maximum number of attempts. The result of the simulation shown below reflects that the call failure rate or the blocking probability is ever increasing because the available channels are relatively small.

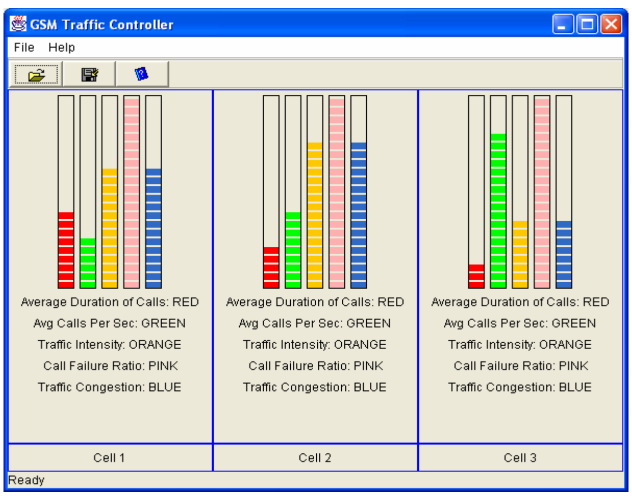

Fig. 3. GUA I. Less number of available channels

Increasing the number of available channels reduces the blocking ratio such that even in busy situations, handover calls are serviced by adjacent cells.

Table 2: Allocation II. Available channels > No. of attempts

Cell	Avail. channels	Max. no. Of attempts	Max. duration
1	164	10	18
2	143	14	13
3	119	1	2

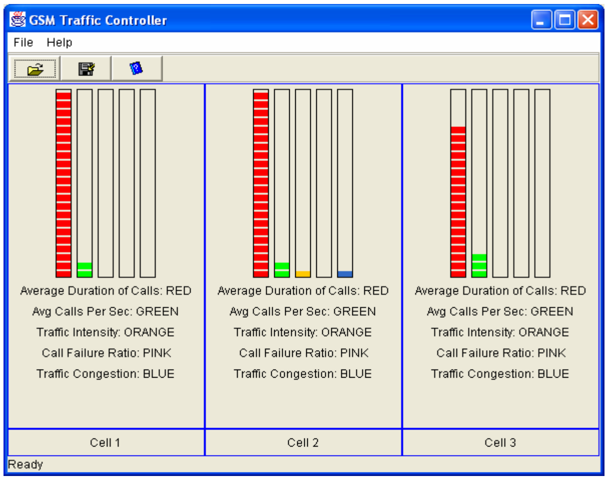

Fig. 4. GUA II. Increased number of available channels

Table 3: Allocation III. Available channels = No. of attempts

Cell	Avail. Channels	Max. no. Of attempts	Max. duration
1	100	100	18
2	145	145	33
3	70	70	15

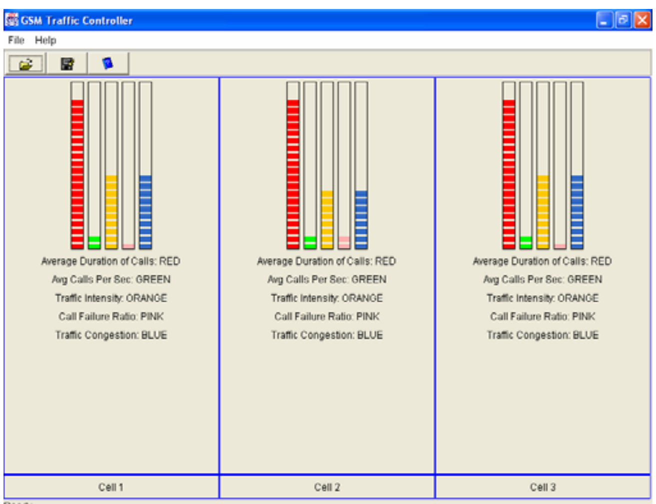

Fig. 5. GUA III. Equal number of available channels and number of attempts

Since the available channels equal to the call attempts, the handover of calls is minimized because each cell can easily accommodate its callers. Hence the blocking probability is reduced.

Conclusion

Traffic situation have been discovered to vary from time to time depending on the number of mobile subscribers requesting for limited number of available channels. Hence traffic carried by a particular cell depends on these channels available. Therefore rationalization of the channels could be done to satisfy both the network and subscribers regardless of congestions.

To reduce the traffic load in the network, the following recommendations are given:

(i) Since call requests require a channel to communicate, the rate of unnecessary calls should be reduces so that the traffic situation will improve hence reducing the blocking probability.

(ii) Mobility characteristics has a great influence on cellular network performance and capacity like the GSM network such that hand-over of calls affect channel utilization. It is necessary to avoid unnecessary movements while making a request for call connection. This will check unnecessary hand-over that may result in call blocking.

We have presented a graphic analyzer that considers some parameters such as blocking probability, traffic intensity and channel occupation time (Holding time) that makes it possible to evaluate the quality of service of mobile networks. The simulation shows that mobility directly influences these parameters and that the services depend on the traffic intensity. We hereby conclude that the call duration is exponentially distributed while the arrival rate to process new request follows a poison distribution.

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