A Priority Traffic Models in Wideband Mobile Networks

Georgi R. Balabanov[1], Seferin T. Mirtchev[2]

Abstract – **The wideband mobile networks give us a lot of new and different services. This kind of networks will give the subscriber full mobility with the guarantee of best Quality of Service (QoS). The different type of services will have different QoS. The characterization of source traffic is particularly important for the analysis of control, protocol, and architecture issues of the wireless mobile networks. Computer simulation provides a valuable tool for engineers and scientists to better understand such issues as network control, protocol and architecture without the need to do real hardware installation.**

Keywords – **Priority traffic, Traffic model, Wideband mobile networks, QoS**

I. Introduction

The 3G and 4G wideband mobile networks give us a lot of new and different services. This kind of networks will give the subscriber a full mobility with the guarantee the best Quality of Service (QoS). The different type of services will have a different QoS. Unlike the current generation services, it is natural to admit for the future a broad range on the characteristics and the sensitivities of the calls. Voice calls have time constraints, constant (and low) rates and can tolerate some losses. Video calls need guaranteed throughput but have variable rate and bounded delays. Conventional data traffic is loss sensitive but requires no bounded delay nor guarantee. Critical data can have more stringent requirements towards losses and the need for real-time constraints. Additionally, it should be possible to have groups of individual QoS-different calls, such as multimedia connections of audio, video and data. A guaranteed QoS for each of these classes have to be provided while maximizing the use of the network resources available. In this paper we investigate the handoff in the wideband mobile networks from 3G and 4G. We investigate the usage of priority traffic models to model Qos and handoff in wideband mobile networks. We analyze handoff in wideband mobile networks using models with priority traffic systems.

II. Priority Traffic Systems

There are a number of models developed for this subject [4-6], who examine the mobile networks (GSM/GPRS/EDGE) and generally dividing the traffic in voice traffic and data traffic. The problem was discussed and studied and several solutions were offered for design of UMTS network on the basis of priority queueing systems, with the assumption that the voice traffic priority is higher than the data traffic.

In [4] QoS is studied in GSM/GPRS network and it is accepted that the arriving flows both from new calls and from requests for transfer of connection are of Poisson nature and have two levels of priority. Here prioritization is examined at the level of connection transfer, and two priority levels are defined depending on the channels.

[5] uses another approach, simulating again voice traffic and data traffic, but here the data is simulated with ON-OFF sources. Prioritization is applied with simulation of the interactive class using two approached – priority queue and non-priority queue.

Another approach is chosen in [7], where the access of different service classes to the common network recourses is simulated. Considering the priorities of different classes they receive different access rights to the recourses. This is performed on the grounds of access to a separate transfer cycle for the basic service. Different services depending on their priority receive access to the transferring medium (преносната среда) during a specific cycle. The QoS in this case is negotiated upon building the connection and is maintained to the end.

III. Data Traffic Modeling

ON/OFF process

The large number of ON/OFF processes may describe the varied traffic very well. The ON/OFF process is respectively in ON or OFF status. We determine the time series by monitoring the number of ON processes in any point in time. If the ON-times and OFF-times are drawn according to their distribution in lines similar to the Pareto distribution in parameters and then the resulting stochastic process in some of its parts is similar to the Gauss process.

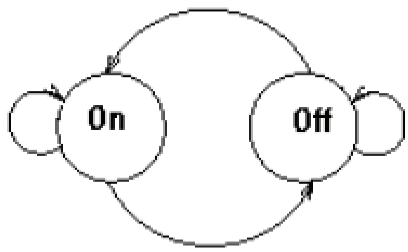

Fig. 1 On – Off process

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Markov Modulated Poisson Process

An MMPP is a doubly stochastic Poisson process. The MMPP has been extensively used to model various sources, such as voice and video and to characterize superposed traffic. In general, MMPP is a n-state model where the holding times and inter-arrival times in each state are exponentially distributed. Also, if individual traffic sources are modeled by

Fig. 1 On – Off process

an MMPP, the superposition of different sources can be described by another MMPP. The arrivals occur in a Poisson manner with a rate that varies according to a n-state (phase) Markov chain, which is independent of the arrival process. The two state model has been widely used in the study of voice and video traffic.

Interrupted Poisson Process

The IPP is a Poisson process that is alternatively turned on for a period distributed exponentially and turned off for another exponentially distributed period, like the On-Off model. The difference however is that during the active periods, the inter-arrival times of packets are exponentially distributed (i.e. in a Poisson manner). Let r1, r2 and l respectively denote the average duration of active and silence period, and the cell generation rate during active period. The simplest way to determine these IPP parameters is to set the mean active duration to the mean sojourn time of the packet arrival process r1, and to set the mean silence period length to r2. And the mean cell generation rate during an active phase is set to that of the packet arrival process(T)

IV. A Priority System Model in Wideband Mobile Network

Let the random quantity T_{CV} be the time for occupation of the channel by a voice call. This is the duration of a voice call if it not interrupted. A call must be interrupted if handover of the connection is required and the handover is not completed before the end of the call. For the time for occupation T_{CV} we assume that there is exponential distribution with mathematical expectation

$$M_{[T_{CV}]} = \left(1/\mu_{CV}\right). \tag{3.1}$$

Let us mark the time for occupation of channel from data call with the random quantity T_{CD}. This is the sum time necessary for the data transfer. We assume that it has exponential distribution with mathematical expectation

$$M_{[T_{CV}]} = \left(1/\mu_{CD}\right). \tag{3.2}$$

Let the random quantity T_{dwell} be the time of the stay of the mobile user in the cell. Again we assume that this time has exponential distribution with mathematical expectation

$$M_{[Tdwell]} = \left(1/\mu_{dwell}\right). \tag{3.3}$$

The channel assigned for serving a voice call will be occupied until the call ends within the cell limits or until the mobile user leaves the cell before the call ends. Thus, the cannel occupation time of a voice call T_V is equal to the smaller of the times T_{dwell} and T_{CV}.

$$M[T_V] = \frac{1}{\mu_V} = E\left[\min\left(T_{dwell}, T_{CV}\right)\right] = \frac{1}{\mu_{CV} + \mu_{dwell}} \tag{3.4}$$

(1)

The channel assigned for data call which was not interrupted because of priority request for transfer, will be occupied until the data transfer is completed within the cell limits or until the mobile user moves to a neighbouring cell before the transfer is over. Similar to the case with the voice call, the cannel occupation time of a data call T_D is equal to the smaller of the times T_{dwell} and T_{CD}. And again, in this case T_D has exponential distribution with mathematical expectation:

$$M_{[T_D]} = \frac{1}{\mu_D} = M\left[\min\left(T_{dwell}, T_{CD}\right)\right] = \frac{1}{\mu_{CD} + \mu_{dwell}} \tag{3.5}$$

We assume that the processes of arrival of new voice calla and data calls in a single cell are Poissonic with intensity λ_{OV} and λ_{OD}.

If the time for occupying one channel (времето за заемане) by a mobile user is longer than the time of stay in the cell (времето за престой в клетката), the transfer request shall be initiated in a neighbouring cell. Let λ_{HV} marks the intensity of arrival of transfer requests, including voice, and λ_{HD} marks the intensity of arrival of transfer requests for data transfer. It is clears from the above explanations that:

$$\lambda_{HV} = E[C_V]\mu_{dwell} \tag{3.6}$$

where $E[C_V]$ is the average number of channels occupied by voice calls in the cell. And:

$$\lambda_{HD} = E[C_D]\mu_{dwell} \tag{3.7}$$

where $E[C_D]$ is the average number of channels occupied by data calls in the cell. We assume that the processes of arrival of both types of transfer requests are Poissonic with the above-mentioned intensity. A data call in the queue of one cell shall be transferred to the queue of a neighbouring cell when the user leaves the first cell before the call is given a channel. The intensity of arrival of such transferred requests λ_{TD} in the marked cell is given with the equation:

$$\lambda_{TD} = L_D\mu_{dwell} \tag{3.8}$$

where L_D is the average number of calls waiting in the queue *Q*. And again, we assume that the process of arrival of transferred data calls is Poissonic.

For simplicity we will use a scheme with channels with fixed assignment. That means that a certain number of channels are constantly assigned to a cell. We examine a system with numerous homogeneous cells, each cell with S channels. However, we will concentrate on one cell. We will call this cell “a marked cell”. As shown on fig.1 in the base station we have a queue Q with capacity M for data calls.

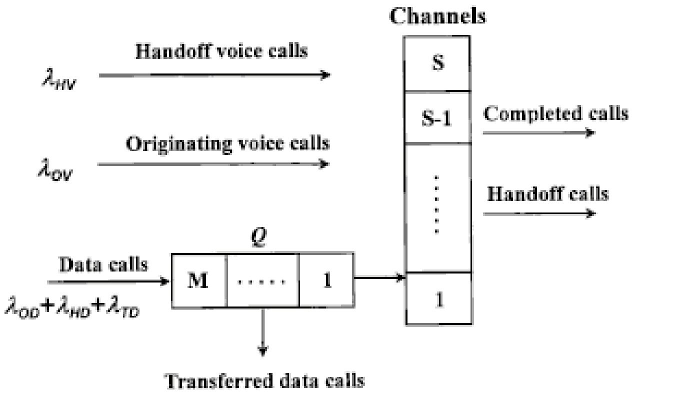

Fig. 2 A teletraffic priority queueing system model for handover

When a user using a channel in a neighbour cell is getting closer to the “marked” cell and the strength of the signal received from the current base station is reduced to the transfer threshold – a request is generated for the transfer of the call to the marked cell. Priority is given to voice transfer requests. If on arrival of a voice transfer request, it turns out that there are no free channels, and there is a channel occupied by a data call, this channel is vacated. The data call is sent to the queue where it will wait till a channel is vacated.

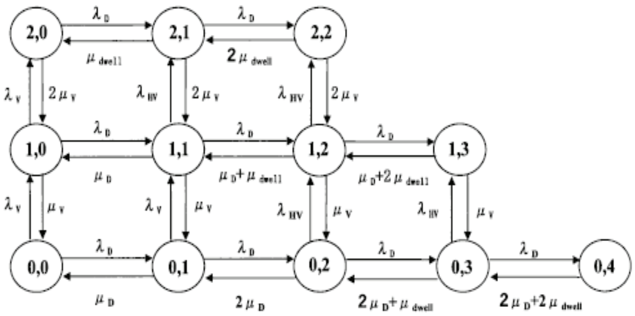

Fig. 3 State transition diagram

On arrival on newly generated voice calls they will be blocked if at the moment of their arrival there are no free channels. The data transfer request is put in the queue Q, when upon its arrival it turns out there are no accessible channels. It shall be blocked only if the queue is full.

To receive specific results a simulation a MATLAB program was developed. The program aims at simulation of the system behaviour in different arriving traffic and different correlation between the data traffic to general traffic. We define the general traffic of new calls in the marked cell (A)

$$A = \lambda_{OD} E|T_{CD}| + \lambda_{OV} E|T_{CV}| \qquad (4.1)$$

and γ- coefficient giving the correlation between the data traffic to general traffic.

$$\gamma = \frac{\lambda_{OD} E[T_{CD}]}{A} = \frac{\lambda_{OD} E[T_{CD}]}{\lambda_{OD} E[T_{CD}] + \lambda_{OV} E[T_{CV}]} \quad (4.2)$$

V. RESULTS

The simulation program aims at showing how the values of the blocking probability and number of calls in the queue are influenced by changes in the general traffic or data traffic. We define the following initial data for the program:

S number of channels in the system;

Sc – number of voice channels;

M – capacity of queue Q;

Time of occupation of a channel by a voice call;

Time of occupation of a channel by a data call;

Time of stay of an user in the cell ;

general traffic to the system – we will vary it from 0 to 10 Erlangs;

correlation between the data traffic to general traffic– we will vary it from 0 to 1 , i.e. 0% to 100% data traffic.

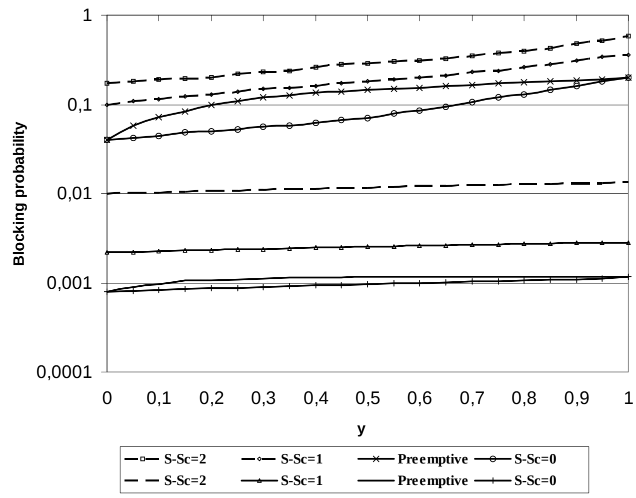

Fig. 4 Blocking probability of voice calls

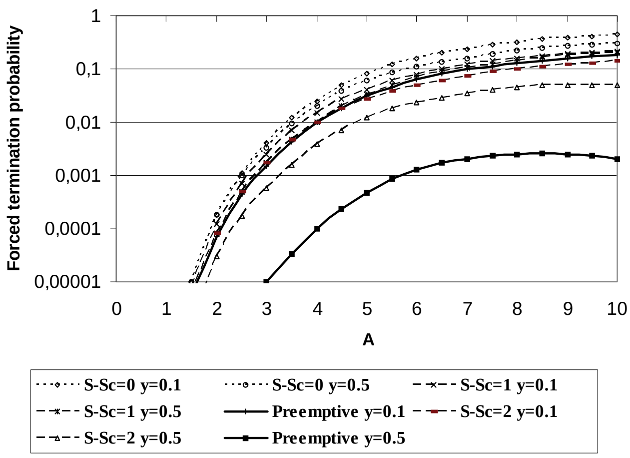

Fig. 5. Forced termination probability

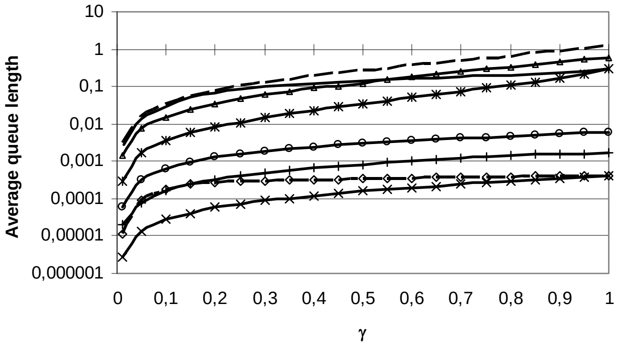

Fig. 6 Queue length results

VI. CONCLUSION

In this paper a model of priority traffic system in wideband mobile network is introduced and evaluated.

The calls generated are divided into three different classes: handoff voice calls, originating voice calls and data calls. Priority is given to handoff voice calls over the other two kinds of calls. Specifically, the right to preempt the service of data is given to handoff voice call if on arrival it finds no idle channels. Data calls are queued if no channels are available at the time of arrival. The interrupted data call returns to the data queue. Performance of the system is compared to that of another handoff scheme for integrated voice/data cellular mobile systems where cut-off priority for voice handoffs is considered.

To study how to adopt the preemptive priority handoff scheme into the system with dynamic channel allocation is also our future work.

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