# PRIORITY ORIENTED SCHEDULING IN CELLULAR SYSTEMS WITH DYNAMIC PACKET ASSIGNMENT

*N R Karthikeyan,Mani Sridhar,G Praveen Kumar,K Ramakrishnan,R.Jayaparvathy, S Srikanth*

AU-KBC Research Centre,
MIT Campus, Anna University, Chennai – 600 044.
*srikanth@au-kbc.org*

**ABSTRACT**

In this paper, we study the performance of channelized cellular systems when using dynamic packet assignment (DPA) based Medium Access methodology in the downlink. We present a near-distributed approach to resource allocation with a minimum level of co-ordination between base stations. We have implemented a priority based scheduling scheme at the base stations to provide Quality of Service (QoS) guarantees. We show through extensive simulation results that our scheduling model improves the delay performance of real-time traffic with no significant decrease in the throughput of the system as compared with first come first serve (FCFS) model.

## 1. INTRODUCTION

**C**ellular systems of the next generation are expected to provide both voice and data services. To achieve high data rates, packet switching on the wireless access is deployed as in GPRS [1]. The proliferation of pure data services and real-time traffic over wireless systems has necessitated a sophisticated data network design that effectively uses the available spectrum.

Systems with dynamic channel allocation (DCA) for voice traffic were studied in [2]. However, the DCA method has difficulties introduced due to rapid channel reassignment and intensive receiver measurement requirements. To facilitate rapid channel measurements, orthogonal frequency division multiplexing (OFDM) [3] can be used in the physical layer. A dynamic packet assignment (DPA) based system that uses OFDM in the physical layer has been proposed in [5] in which resources are assigned on a packet by packet basis. An increase in the system capacity can be obtained when DPA method is used as compared to WCDMA as shown in [4].

We have implemented a similar scheme that uses dynamic packet assignment (DPA) for allocation of channels for every data burst. We consider the data traffic into the system to have three different classes, namely, A, B and C. Scheduling of packets belonging to the different classes of traffic, is performed at the base stations. We propose a scheduling scheme which assigns different priorities to different classes of traffic. Class C packets belong to real time traffic and are accorded the highest priority followed by class B which is large file size traffic. Class A is the best effort traffic characterized by small size and is not given any priority at all. To evaluate the system performance, we consider metrics such as average delay and average system throughput. We compare the performance of our scheduling scheme using DPA in terms of average delay and average system throughput with that of a system that provides first come first serve (FCFS) service.

The rest of the paper is organized as follows. In Section 2, we describe our system model. In Section 3, we present our simulation results followed by conclusions in Section 4.

## 2. SYSTEM MODEL

We consider a cellular system with 61 cells as shown in Figure.1. The objective is to simulate the performance of this system with dynamic packet assignment (DPA). The performance metrics of interest are mean delay and average throughput of the system. We consider a data call to consist of packet bursts and idle periods.

A channel is allocated and held only for the packet burst of the call. The following assumptions are made in our simulation model.

- The cells are assumed to be circular and the base stations are located at the centers of each cell. All cells are assumed to be of equal radius. We assume that there is no power control mechanism incorporated at the base station.

- The fading characteristics of the propagation channel are independent and identically distributed for all carrier frequencies used. The whole spectrum is divided into channels that have a capacity of 64kbps.

- The call arrival process into the system is a Poisson process and the call holding times are exponentially distributed.

- The traffic distribution in the whole system is uniform, i.e all the cells have the same rate of call origination. Even within a cell, the traffic distribution is considered to be uniform, i.e. the probability of call origination is the same throughout the cell area.

The channel allocation scheme is as follows. Whenever a call destined for a particular mobile arrives at the base station (BS), the interference at the mobile end on all the channels is measured. This interference is calculated in the simulation by the Clarke's path loss model that takes into account the attenuation due to distance between the mobile and the base station, Rayleigh fading and Log-normal shadowing [7]. A channel is allocated for a call if the interference measured at the mobile end on the channel is less than a specified threshold. Among the channels that satisfy the interference threshold limit, the base station (BS) allocates the channel with the least interference to the mobile and transmits the call in that channel. Even when multiple channels are required, only the channels with the least interference are used. . Mean delay is determined by the ratio of the sum total of the delay experienced by the packets to the number of packets. The average throughput is obtained as the fraction of the time for which the channels are occupied to the total simulation time. In the downlink, three different classes of traffic have been assumed. Scheduling at the base station is done according to the class of the data traffic. These traffic classes are similar to the traffic classes described in the fixed wireless standards proposals.

The different classes of traffic considered are:

Class A

This class of traffic is constant bit rate, small file size traffic. An example of this class of traffic is electronic mail carrying messages with no attachments. This class of packets is assumed to constitute 70% of the total traffic in the system.

Class B

This class of traffic is constant bit rate, large file size traffic. An example of this class of traffic is downloading of large files by a mobile. This class of packets is assumed to constitute 20% of the total traffic in the system.

Class C

This class of traffic is real-time variable bit rate traffic. An example of this class of traffic is video traffic. The bit rate varies according to the information content of the source signal. For simplicity, it has been assumed that the bit rate requirement can only take 3 values that have been fixed at 64kbps, 256kbps and 1Mbps. It is assumed that low bit rate class C traffic (64kbps) constitutes 6% of the total traffic in the system while medium bit rate bit rate (256kbps) and high bit rate (1 Mbps) class C traffic constitutes 3% and 1% of the total traffic respectively. The 256 kbps and 1Mbps traffic require 4 and 16 channels respectively.

To provide improved QoS for real-time traffic, we have implemented a scheduling scheme at the base station that gives varying priorities to the varying classes of traffic mentioned above. This enables provision of different delays to the various classes of traffic.

The scheduling scheme we have implemented is explained below.

When a base station does not find any suitable channel for the transmission of a packet to a mobile in its cell, it buffers the packet. The buffer at each base station implements priority-based scheduling. This scheduling algorithm gives first priority to Class C packets. Class B packets with larger holding times are given second priority followed by class A. Within packets of the same class, the service is first come first serve (FCFS). The scheduler arranges the buffered packets in the order of priority. When a channel becomes free, the scheduler tries to assign channels for the highest priority packet it contains. This scheduling scheme ensures that the delay experienced by the real-time Class C packets gets reduced at the cost of higher delay for Class A packets. The performance of the system with FCFS scheduling and with priority-based scheduling is evaluated using simulations.

The flow diagram delineating the program implementation is given in Figure.2.

## 3. RESULTS

In this section, we present the results obtained using our simulation model. We consider a 250-channel system with a capacity of 64 kbps each. The mean value of the rayleigh fading component is 1 and the lognormal shadowing has a standard deviation of 8. The file size and the holding times for the different classes of traffic are enumerated in Table 1.

| Traffic type | Mean filesize (in bytes) | Mean holding time |
|---|---|---|
| Class A | 1496 | 187 ms |
| Class B | 8000 | 1s |
| Class C(64k) | 8000 | 1s |
| ClassC(256k) | 320 | 10ms |
| Class C(1M) | 128 | 1ms |

Table 1: Traffic characteristics

To measure the gains accrued by implementation of priority at the base station buffers, we compare the two schemes, priority oriented scheduling and FCFS in terms of system parameters like average delay and throughput. Figure. 3. shows the average delay experienced by class A packets as a function of traffic per cell in Erlangs. It is observed from Fig.3 that the delay for class A packets is greater in the proposed priority oriented scheme rather than in the FCFS scheme. This is because of the fact that class A traffic is given the least priority.

Figure.4 shows the delay experienced by class B packets as a function of traffic per cell in Erlangs. From Figure .4 it is observed that there is a significant reduction in delay for class B packets when priority based scheduling is implemented. This is a result of the higher priority given to the class B packets compared to class A packets. It can be observed that the average delay with priority-oriented scheduling is only 25 % of the delay with the FCFS scheduler at a traffic load of 36 Erlangs per cell. Our priority-based scheduler thereby enhances the quality of service accorded to Class B traffic. It is also noted that the degradation in delay values for class A traffic in Figure.3 under priority based scheduler is less compared to the performance improvement obtained in the case of class B traffic.

Figure.5 shows the delay experienced by the Class C traffic in the system as a function of traffic per cell in Erlangs. A significant improvement in delay performance as in the case of class B can be observed from Figure.5.

It is evident from the graphs that the priority-oriented scheduling policy implemented at the base station has fostered a reduction in the average delay experienced by the real-time Class C traffic. This demonstrates the ability of the system to support different QoS requirements.

The priority-based scheduling implemented at the base stations is directed towards providing QoS guarantees to different classes of traffic and this might sometimes result in adverse effects on the system throughput. It is observed from Figure.6 that the throughput of the system decreases only slightly due to implementation of priority in scheduling. In other words, the number of bits transmitted over the system does not decrease by much and this provides a strong motivation for using priority-oriented scheduling.

## 4. CONCLUSION

We have implemented a priority oriented scheduling policy for real-time traffic in the downlink of a channelized cellular system using dynamic packet assignment. Simulation results obtained show that our scheduling policy reduces the delay experienced by real time traffic and thus supports provision of aggressive QoS guarantees by the service provider. The scheduling scheme can be modified to provide near-zero delays for real time traffic. This can be done by terminating one or many of the packets in service and transmitting real-time traffic in those slots. This will increase the delay for other classes of traffic but will minimize the delay for real-time traffic. The system performance with adaptive modulation is under study.

## 5. REFERENCES


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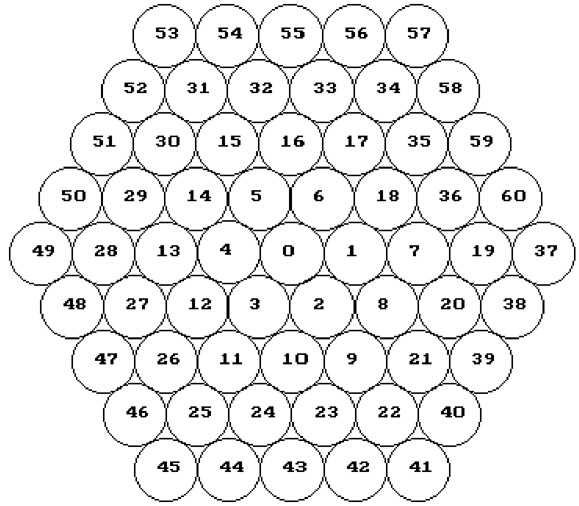


Figure 1: A 61-cell circular cellular system

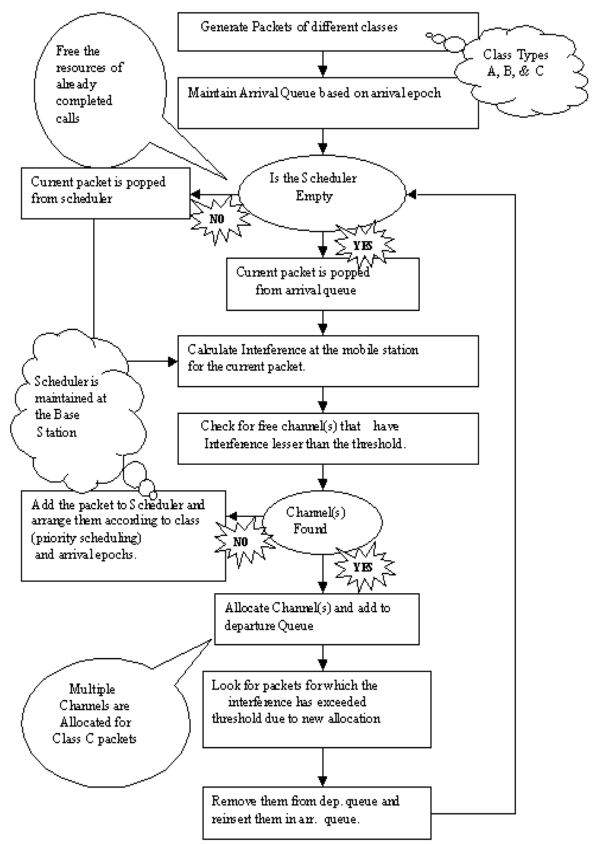


Figure 2: Flow diagram of the Simulation

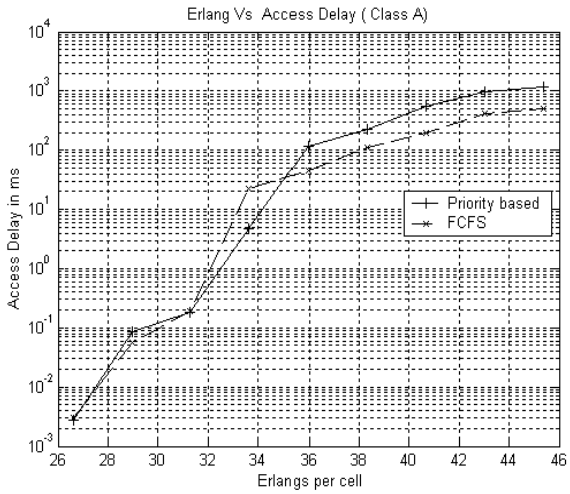


Figure.3. Average delay curves – Class A traffic

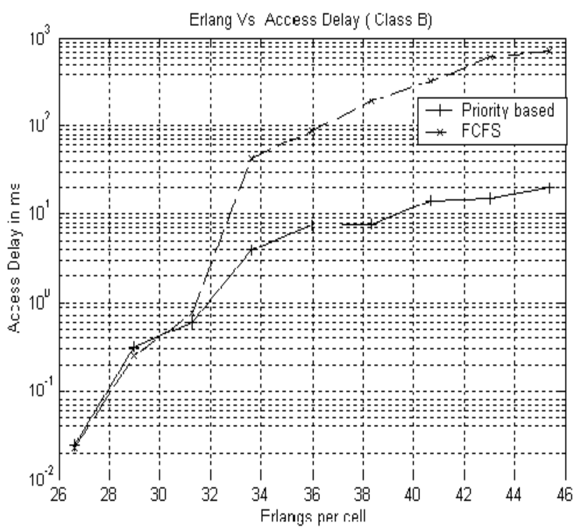


Figure.4. Average delay curves – Class B traffic

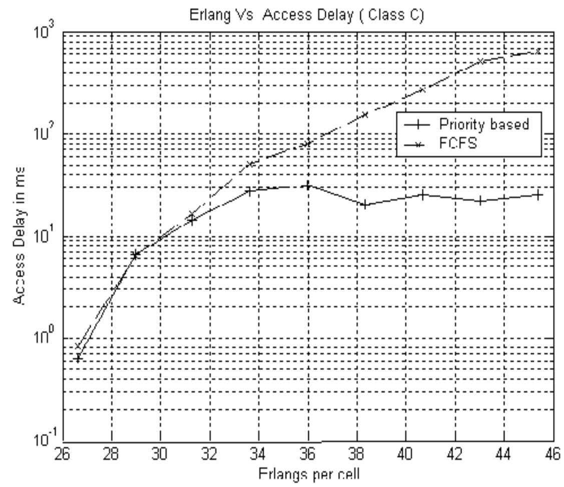


Figure 5. Average delay curves – Class C traffic

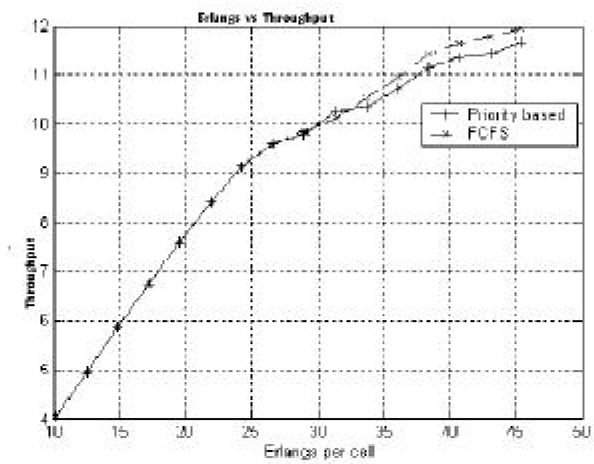


Figure 6. Spectrum Utilization