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Multi-Threshold with One-Level Buffer for Call Admission Control in Mobile Cellular Systems

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Abstract

Mobile wireless network supports different multimedia applications with different quality of service (QoS) requirements. Meeting these demands requires an efficient allocation of channels in order to cater appropriately for each application. In this paper, we propose a multi-threshold channel allocation scheme with one buffer to care of real time and non-real-time handoff calls in a wireless mobile network with priority. The different traffics considered are, Real-time new call, Real-time handoff call, Non-real-time new call, and non-real-time handoff call. The size of each threshold is dynamically adjusted based on the in-coming traffic rate. The channels in each cell are divided into three parts: one is for real-time new call, the second is for real-time handoff, the third is for non-real-time handoff call and the last one is for non-real-time new call. In addition, a real-time handoff call can preempt non-real-time handoff call in the buffer to be allocated free channels available. The scheme is simulated under different scenarios and simulation results demonstrate that the proposed scheme is able to simultaneously provide satisfactory QoS to the different call types and maintain relatively high resource utilization in a dynamic traffic load environment.

Keywords: Handoff call, network, real-time call, non-real-time call, buffer, channel.

Introduction

Wireless multimedia network aim to provide integrated services via inexpensive low-powered mobile computing devices over wireless infrastructures [7]. As the demand for multimedia services over the air has been steadily increasing over the last few years, wireless multimedia networks have been a very active research area. Since multimedia applications have inherently different traffic characteristics, their QoS requirements may differ in terms of bandwidth, delay, and connection dropping probabilities. It is the networks' responsibility to fairly and efficiently allocates network resources among different users to satisfy such differentiated QoS requirements for each type of service. However, quality of service provisioning has been a challenging problem due to the scarcity of wireless resources, i.e. radio channels, and the mobility of users. Call admission control (CAC) is a fundamental mechanism used for QoS provisioning in a network. It restricts the access to the network based on resource availability in order to prevent network congestion and service degradation for already supported users.

In order to support a true combination of real-time service and non-real-time service and maximize the utilization of network infrastructure, an efficient scheme is necessary to avoid generation of very heavy signalling traffic thereby resulting into a dramatic decrease in blocking probabilities. In the literature, most past researches have focused on this issue in cellular networks, e.g. [14], [15], [4], [6], [9], [8], [17], [3]. With the development of integrated wireless mobile systems, non-real-time service has to be incorporated and its effect needs to be taken into account [11]. A handoff scheme for a non-real-time wireless network only has been studied in [13]. However, future wireless networks will be required to support multiple types of services simultaneously. In order to meet future demands, a handoff strategy needs to take different features of these services into account, i.e., the ideal handoff processes have to be service-dependent. A two-dimensional model for integrated service cellular mobile systems has been proposed in [14], which assigns preemptive priority to real-time service calls. However, no distinction is made between originating and handoff requests. In [15], a handoff scheme for the integrated voice/data wireless network has been introduced, while only data service handoff requests are allowed to be queued. In [1], [2], [12], [16] service priority technique is used to improve system performance when dealing with resource allocation issue. As for the technique of queueing, [1], [2], [16], [12] have incorporated it into resource allocation to reduce blocking/forced termination probability. If multiple classes of requests are queued in the same buffer, different level of thresholds can be set to further adjust QoS requirements, for example, [1] used such threshold control to get different blocking (with respect to new voice call) and forced termination (with respect to handoff voice call) probabilities.

In this paper, we propose a dynamic multiple-threshold channel allocation scheme for cellular wireless networks with one-level buffer. The thresholds are dynamically adjusted according to the current network traffic situation and QoS status. The single buffer is used to queue both real-time and non-real-time handoff calls in case of unavailability of channel at the arrival of such calls. The objective of the proposed scheme is twofold. First, the scheme provides QoS provisioning by keeping the real-time and non-real-time handoff connection dropping probability below the predefined bound even under a network congestion situation. Second, in a fair manner, it maintains the relative priorities among real-time calls and non-real-time calls in terms of the new connection blocking probability according to their traffic profiles and instantaneous traffic situations.

The rest of the paper is organized as follows. Section II describes the channel allocation scheme. Section III shows numerical results and performance evaluation. Finally, section IV concludes the paper.

System Model

To meet different QoS requirements for real-time and non-real- time traffic, we take into account their distinct traffic characteristics. Real-time services are sensitive to delay, whereas non-real-time traffic could tolerate some delay without deteriorating service quality perceived by the mobile users.

We consider a system with homogenous cells where S number of channels assigned to each cell is assumed. In such a system, the S channel in the cell is divided into four groups, namely, real-time new call, real-time handoff call, non-real-time new call, and non-real-time handoff call. The channel allocation scheme for each cell is illustrated in Fig. 1. In this figure, point ***a*** stands for a threshold for the number of real-time handoff calls with capacity S_h, ***b*** stands for a threshold for the number of non-real-time handoff calls with capacity S_n, ***c*** stands for a threshold for the number of real-time new calls with capacity S_{rn} and the remaining channel is for non-real-time new calls with capacity S_{rr}. When the number of real-time handoff calls reaches point *a*, subsequent calls

channel. The same thing happens to non-real-time handoff calls (i.e subsequent non-real-time handoff calls are send to queue when there is no idle channel. However, when the capacity of available channel is reached in point c, subsequent calls are blocked due to the fact that there is available buffer to take care of such calls. The remaining channels belong to non-real-time new calls and if its capacity is exhausted, subsequent calls are blocked. The threshold for each traffic type is dynamically adjusted based on input traffic load. We assume the arrival rate of real-time handoff calls is λ_h, the arrival rate of non-real-time handoff calls is λ_n, the arrival rate of real-time new calls is λ_{rn}, and arrival rate of non-real-time new calls is λ_{rr} respectively, with their service rates μ_h, μ_n, μ_{rn} and μ_{rr}, respectively

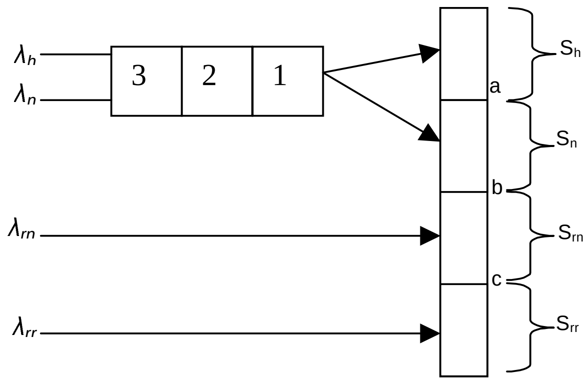

Figure 1: System Model.

Simulation Results

To evaluate the performance of the proposed scheme, a network model of a single cell was constructed with a discrete-event driven simulator. The system parameters were set as follows: $S = 10$, $\mu_h = 1$, $\mu_n = 1$, $\mu_{rn} = 2$, $\mu_{rr} = 2$, $\lambda_h = 5$, $\lambda_n = 4$, $\lambda_{rn} = 5$, $\lambda_{rr} = 4$, a=b=c=3 (for simplicity).

Fig. 2 shows the dropping probability of real-time handoff calls, dropping probability of non-real-time handoff calls, blocking probability of real-time new calls, and blocking probability of non-real-time new calls under different traffic loads. It is obvious that real-time handoff calls always shows the lowest probability because of the queue and priority attached to it; non-real-time handoff have the second. However, both real-time new calls and non-real-time new calls have high probability due to the fact that no queue is attached to them, and calls are blocked immediately there exist no free channel.

In figure 3, the average delay of non-real-time new calls has the highest delay time because there is no buffer to store any subsequent calls when the channel is exhausted. Real-time and non-real-time handoff calls enjoy a very low delay time because they are sensitive to delay and loss respectively. This explains the reason for given them priority over others to enjoy buffer facilities. Delay is very high for all the calls when the threshold value is small. This means a very little number of calls can be accommodated while others are queued and some retransmitted by the users.

By using our proposed dynamic scheme for threshold selection, the real-time handoff call achieves the highest targeted channel as shown in figure 4. The dynamic change of the threshold for achieving the target channel is a signal that the scheme has the ability to adapt to any traffic (heavy or light) change without deteriorating the quality of service requirements. The higher the traffic load, the higher the threshold value for all the traffic supported by the new scheme. This really agrees with our objective as input load determines the threshold value.

We also investigate the performance comparison of real-time handoff call and non-real-time handoff call to determine the effect of the queue on their blocking probabilities. We vary the arrival rate from 0.3 to 0.95 calls/s while maintaining all other settings. The result shown in figure 5 implies that the blocking probability of real-time handoff calls is at a very low rate while that of non-real-time handoff call is a bit high. This result is similar to the result in fig 2. It is therefore of note that queue has a significant impact in reducing the blocking probability of calls.

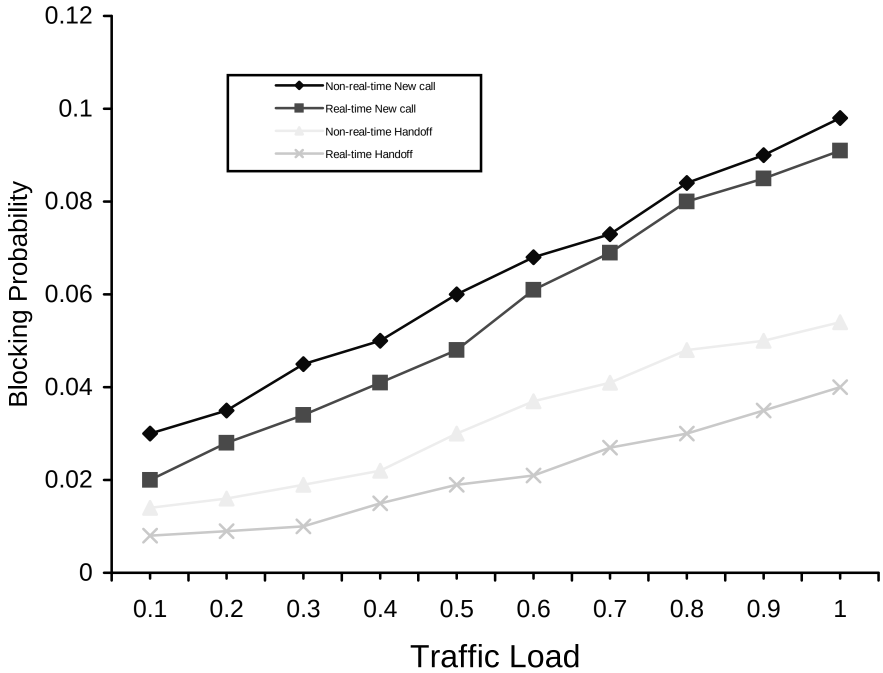

Figure 2: Blocking probability against Traffic Load.

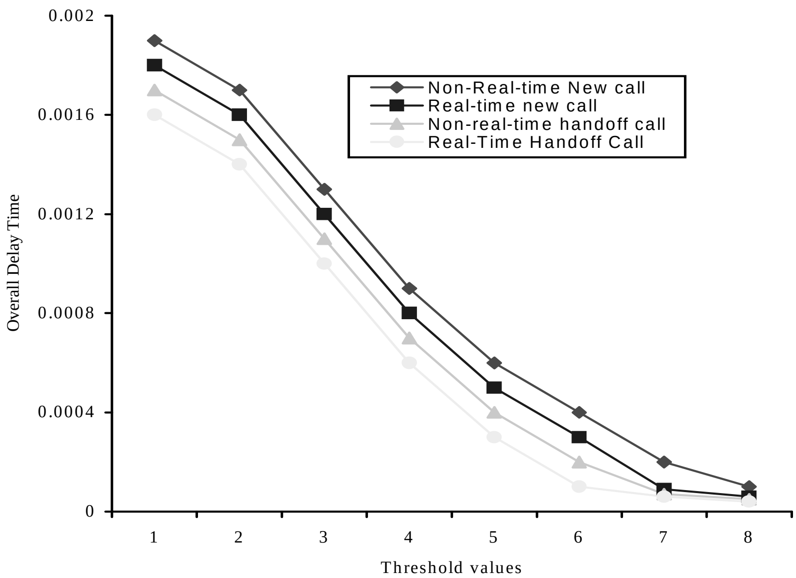

Figure 3: Average delay time versus threshold values.

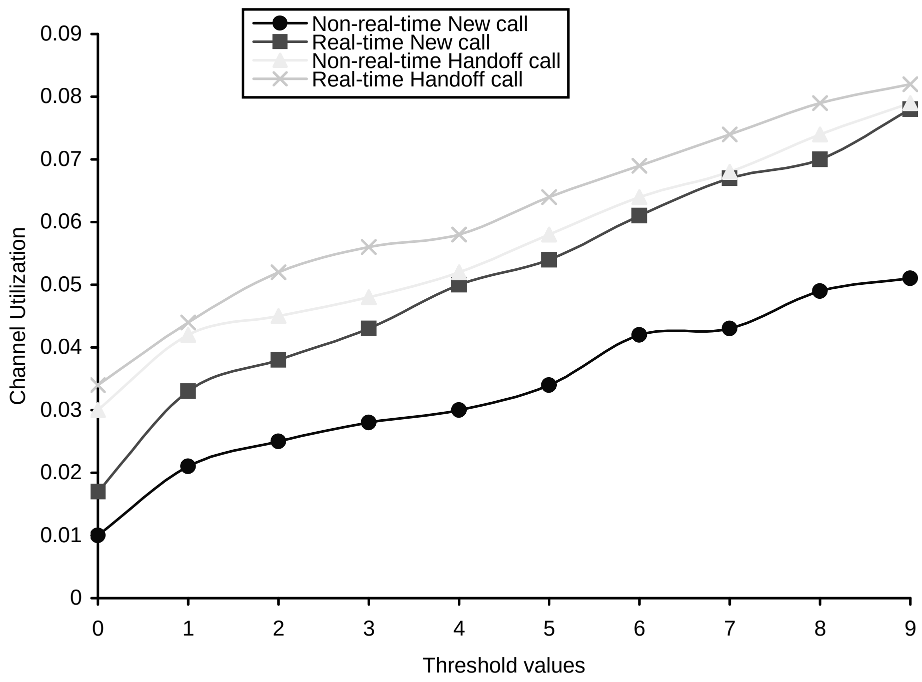

Figure 4: Channel utilization under different threshold values.

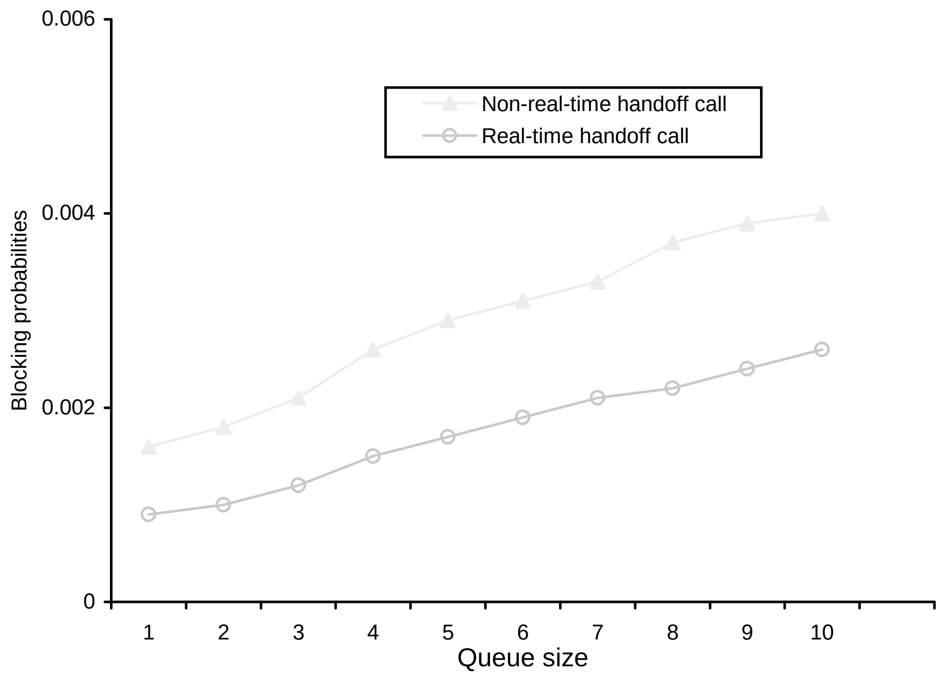

Figure 5: Blocking probability against Queue size.

Conclusion

We have examined the improvement of multi-threshold channel allocation scheme with one-level buffer to enhance QoS requirements of traffic in cellular network. The integration of both real-time and non-real-time traffic in an indication that the scheme support multimedia (heterogeneous) network. The simulation results show low blocking/dropping probabilities for each of the different calls. The priority given to real-time handoff calls is to ensure that delay sensitive calls QoS does not deteriorate. The overall performance of the scheme demonstrates its ability to meet the quality of service desired and achieve a reasonably high network utilization.

Current work can be extended in the following directions in the future: to incorporate the analytical approach to have a quick tool on system performance and to consider the heterogeneous cells etc.

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