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Performance analysis of multi-service wireless network: An approach integrating CAC, scheduling, and buffer management

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Abstract

Traffic management (TM) mechanisms such as Call Admission Control (CAC), Scheduling, and Buffer Management (BM) play a key role in the design of multi-service wireless network by providing service differentiation from diverse applications and assigning the network resources (radio channels or buffer) according to the quality of service (QoS) requirements of each service class. We propose in this work two new models that integrate CAC, Scheduling, and BM in the design of multi-service wireless network. By presenting their Markovian models and their performance metrics, we investigate their respective design tradeoffs and compare their performance.

Keywords: Wireless networks; Performance models; Call admission control; Scheduling; Buffer management

1. Introduction

Work developed in these last years has revealed the explosive growth of wireless communications raised by technological advances in the telecommunication industry. The low price of the wireless terminals has also strongly contributed to the growth of the number of users. However, one of the main agents that has helped to increase the number of users is the ubiquitous wireless access to voice and data services. With the integration of these services, the quality of service (QoS) provisioning became more challenging and the design of the network has deserved special attention because the support of integrated services demands service differentiation in order to satisfy the diverse range of service requests and QoS requirements. In such context, Traffic

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Management (TM) mechanisms as Call Admission Control (CAC), Scheduling, Buffer Management (BM), and Flow Control play a key role in the design of multi-service wireless networks by providing service differentiation from diverse applications and assigning the network resources (radio channels or buffer) according to the QoS requirements of each service class.

1.1. Bibliographic review

Several works in the literature have been proposed to deal with the problem of designing multi-service wireless system using TM. Traditionally, CAC is employed on the first stage. Its task is to accept or to deny access to network resources based on the QoS requirements of the incoming requests thereby controlling the number of ongoing calls. A lot of CAC schemes have been proposed on literature. Generally, they are grouped in the following way: Complete Partition scheme (CP) and Complete Sharing scheme (CS). In CP, as the name implies, the radio bandwidth is partitioned among service classes. CP is simplest and may be rapidly deployed in real systems, but will result in poor performance when the traffic patterns do not conform to the partition [1]. In CS, the whole radio resources are shared among service classes. Mechanisms as preemptive priority may be assigned to voice service over data service. In order to mitigate the effect of this priority, data packets may be buffered while waiting for a free radio channel to be transmitted [2]. In CS, there is no distinction between handoff voice calls and new voice calls for channel allocation. Nevertheless, a handoff voice call is an user from an adjacent cell or even from another network, so that from his/her perspective, dropping an ongoing call is less desirable than blocking a new voice call. Thus, a lot of schemes have been proposed favoring handoff voice calls [2–6]. A well-established scheme is the guard channel, which reserves some radio channels for handoff voice calls. In that scheme, a new voice call is only admitted by CAC if the radio resource occupancy is below a threshold (the number of radio channels minus the amount of reserved radio channels); otherwise, it will be blocked. On the other hand, a handoff voice call will only be blocked if there is no radio channel available. This way, a guard channel scheme acts in favor of handoff voice calls at cost of a degradation of the QoS of new voice calls. Thus, there is a performance tradeoff between the QoS provisioning of new voice calls and handoff voice calls. Guard channel may result on low utilization of the radio channels, which is undesirable because they are scarce and expensive resources. A simple way to overcome this drawback is to share the guard channel between handoff voice calls and data packets with priority to the former [2]. Another approach to mitigate the forced termination of ongoing calls is to queue handoff voice calls when there are no available radio resources. This approach is quite feasible due to the handoff area (the region between adjacent cells). In this respect, there are important aspects to be taken into account on the performance of the system: the handoff area and the queue sizes [3,5]. A good overview about handoff prioritization schemes is found in [4]. Recent trends on the design of multi-service wireless network are the multi-threshold-based schemes in which the radio channels are divided into blocks that are shared among calls based on the priority of each one [1,7,8].

Another TM mechanism explored in literature is the scheduling, which is employed to give access to network resources to data packets already accepted. A traditional approach is the Weighted Fair Queueing (WFQ) that, as its name implies, provides fairness among flows by using weights to prevent monopolization of the bandwidth by some flows. Other scheduling approaches for wireless communication are the Idealized Wireless Fair Queuing (IWFQ) and Channel Condition Independent Packet Fair Queuing (CIF-Q) that have been proposed for wireless packet fair queuing [9–12]. In [13], it is proposed a Distributed Fair Scheduling (DFS) that achieves proportional fairness in wireless shared channels. A simple method that supports service differentiation is the Priority Queueing (PQ) [9]. In PQ each buffer queues its priority data packet traffic and the scheduler schedules the traffic classes based on the occupancy of the higher priority buffers.

BM has also been explored in literature. A simple strategy is the Drop Tail that discards a data packet when the buffer is full. A BM for fast handoff is proposed in [14], which aims at, among other things, supporting QoS during handoff process, while maximizing the buffer utilization. Another BM mechanism is the Random Early Detection (RED) that uses two thresholds to avoid overflow [9]. Some published works have proposed to integrate TM mechanism in the design of most effective schemes such as the integration of CAC and scheduling in a CDMA network [15]. In [16], a threshold on the buffer is used to decide when radio resources must be allocated to data, in such way that based on the buffer and radio resources occupancies it is decided whether