Contention-Free Distributed Dynamic Reservation MAC Protocol with Deterministic Scheduling (C-FD^{3}R MAC) for Wireless ATM Networks

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***Abstract*—This paper proposes a novel MAC protocol for wireless ATM networks, which is characterized by a contention-free mechanism of the reservation request and a deterministic nature of mobile-assisted (distributed) uplink scheduling under a framework of the dynamic reservation TDMA, as discussed in the current standardization activities of ETSI Project BRAN (broadband radio access network) and the wireless ATM working group in the ATM Forum. The design objective of the proposed MAC protocol is to *guarantee the real-time constraint* of real-time VBR (rt-VBR) traffic class while *maximizing the multiplexing gain* among all ATM traffic classes, especially with a fixed length frame. The proposed deterministic scheduling scheme for the rt-VBR traffic class lends itself to implementing the minimal configuration of control data units for reservation request as desired under the limited wireless resources. Simulation experiments using statistically multiplexed MPEG-2 video streams are performed for a 25 Mbits/s wireless ATM access link scenario. It has been shown that the proposed framework guarantees the delay constraint of rt-VBR sessions along with its cell loss rate significantly reduced, while improving the average delay performance of the nrt-VBR in the range of 10%–30% without compromising the channel utilization as compared to the DSA++ system.**

***Index Terms*—Broadband radio access networks, dynamic slot assignment, medium access control protocol, wireless ATM networks.**

I. Introduction

IN WIRELESS ATM networks, the medium access control (MAC) protocol should play a central role in providing a statistically multiplexing capability over the wireless access interface [1]–[21]. Its design objective is to maximize the multiplexing gain over the wireless interface while guaranteeing the various QoS requirements for all ATM traffic classes, especially for the stringent real-time constraint of CBR and rt-VBR services. The dynamic slot assignment becomes essential for achieving the statistical multiplexing gain among the various types of service classes with different traffic characteristics, as implied in most of the existing MAC protocols for wireless ATM. In particular, the dynamic reservation MAC protocol with a proper scheduling algorithm has been recognized as a useful choice for the VBR traffic class, since it simply serves to coordinate the varying traffic demands among the independent and spatially distributed wireless terminals. For the CBR traffic class, on the other hand, a simpler scheduling algorithm is assumed for the fixed slot assignment. However, we note that the existing approaches fail to provide a unified framework to guarantee the delay-oriented QoS requirement of the real-time services while maximizing the utilization of the allocated spectrum bandwidth.

Existing MAC protocols are typically involved with an excessive overhead to transmit the buffer state information, e.g., instantaneous queue length, residual lifetime (urgency parameter), or cell arrival rate, as the *dynamic parameters* in a timely and accurate manner [2], [4], [5], [10], [11], [14]–[16]. This is critical, especially for variable bit rate traffic, which requires that the instantaneous rate variation of all the virtual circuits be tracked so that the estimate can be made of the bandwidth requirement for every wireless terminal. As for how to transfer the dynamic parameter information from the individually distributed wireless terminals to the access point, there exist mainly two different types of access schemes: contention-based and contention-less (contention-free) schemes. The contention-based scheme is to transmit the dynamic parameter over the predesignated contention slots (typically given in minislots to reduce wastage of bandwidth in case of collision) with a random access protocol, e.g., a slotted ALOHA protocol. If two or more terminals transmit their reservation request with the dynamic parameters in the same contention slot, collision occurs, which subsequently turns out to be incurring unnecessary power consumption [14]. On the other hand, the contention-free scheme is based on either a piggyback mechanism, which piggybacks the dynamic parameters on the uplink data burst, or polling mechanism, which dynamically assigns an uplink dedicated slot to an individual terminal on a demand basis for transferring the dynamic parameters.

In [2], these different schemes are respectively referred to as out-of-band control and in-band control. For the in-band control, for example, the instantaneous buffer state information is coded into a few bits, which are transmitted via the predesignated field in the wireless ATM cell header. It has been demonstrated that the explicit buffer state information via out-of-band control signaling along with the UPC-based prorating rule leads to superior scheduling performance as compared to the less explicit information due to the limited signaling bits in the in-band control signaling [2]. The out-of-band control signaling, however, suffers from random access delay, especially under high traffic load, which results in the significant cell loss performance degradation for the rt-VBR services and furthermore, involves the extra power consumption.

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