Chapter XXII
Supporting Real-Time Service in Packet-Switched Wireless Networks

Maode Ma
Nanyang Technological University, Singapore

Zheng Xiang
Nanyang Technological University, Singapore

ABSTRACT

The requirement of providing real-time data service by wireless networks is a critical issue in the design of current wireless networks. Distributed Queueing Request Update Multiple Access (DQRUMA) has been proposed as a demand assignment medium access control (MAC) protocol to efficiently control the medium sharing by multiple mobile users. With the help of a packet transmission policy, DQRUMA has a potential to provide QoS service for the time-constrained burst data traffic. In this article, we study the problem of providing real-time service to fixed-size packets with or without time constraints in wireless networks. In particular, we propose a novel scheduling scheme for the DQRUMA protocol to control the packet transmission in packet-switched wireless networks. We have conducted extensive simulation experiments to evaluate the performance of the proposed algorithm and to compare its real-time performance with those of other packet transmission policies. This study proves that the new algorithm is an efficient transmission policy for the DQRUMA to support real-time service in wireless networks.

INTRODUCTION

With the recent development in wireless technology, wireless networks have been widely employed to support data and multimedia applications. One good example of the successful development of wireless networks is the deployment of wireless LAN systems. The wireless LAN has become a very popular wireless access network, which can be found in operation on university campuses,

airports, company offices, homes, and even in cafés like McDonald's in recent years. Within the coverage of a wireless LAN system, anyone can enjoy the great mobility offered by the wireless technology in order to access huge amounts of information through the Internet with a notebook or a PDA. Wireless LANs have more functions, especially with mobility, to substitute the wired local area networks. Another example is the wireless access network or WiMAX, which is a promising technology for future broadband services due to its capacity to provide different kinds of communication services in various application environments and, at the same time, guarantee an agreed quality of service (QoS). Theoretically, there are two types of system structures of the wireless data networks. One is the centralized network with a base station to control the entire network. The other is the ad hoc network, in which every mobile works in peer-to-peer fashion. The wireless air interface consists of the wireless physical layer and data link control layer, which contains a medium access control (MAC) and a logical link control sublayers.

Based on the network structure, a medium access control (MAC) protocol is needed to schedule packet transmission over limited wireless channels. In particular, the design of a medium access control protocol that makes efficient use of the limited resources while satisfying the constraints on the transmitted packets and the network is highly expected. The collision-free MAC protocols proposed for the centralized structure of the wireless network can be divided into two categories: polling-based techniques and reservation-based techniques (Gummalla, 2000). The polling-based techniques (Tang, 1998; Zhang, 1991) assign transmission rights to different nodes by polling each node in the network ahead of transmission. In the reservation-based protocols (Bolla, 1997; Mikkonen, 1998; Wong, 1993), channel access requests are transmitted to inform the base station of the required timeslots and constraints on the transmission by competing the transmission channel or another channel; time slots on the transmission channel will be assigned for the individual mobile node, based on the channel access requests from them. Reservation-based techniques are more dynamic in nature to meet different QoS requirements of packet transmissions. The objective to design the reservation-based protocol is to efficiently schedule packet transmission while effectively meeting QoS requirements of the transmission and the constraints on the data and the network.

The DQRUMA is an efficient demand assignment MAC protocol proposed for centralized wireless networks (Karol, 1995). It is designed for fixed-length packets transmission in a TDM system. Its operation can be divided into two phases: a request access (RA) phase and a packet transmission phase. The DQRUMA uses two physical transmission frequencies that serve as up-link and down-link channels, respectively. The up-link channel is divided into a series of mini-slots used for requesting access (RA channel), each one followed by a slot for packet transmission (transmission channel). When a packet arrives in an empty buffer at a mobile, it will send in contention with other mobiles an access request (transmission request) to the Base Station (BS) on the up-link RA channel. When the BS successfully receives a transmission request from a mobile, it sets the corresponding entry in its Request Table (RT) to indicate that a mobile has a packet to transmit. The BS informs the reception of the transmission request by broadcasting the Access ID over the down link. When there is no acknowledgment received, the mobile will try to retransmit after a back-off interval, for which the truncated binary exponential back-off algorithm could be used. Slotted Aloha or some other random access MAC protocols could be adopted to access the RA channel. According to a desired scheduling policy, the BS chooses one of the mobiles that has a non-empty entry in the RT and broadcasts the Access ID over the down-link channel to allow the desired mobile to start its transmission. With