Reservation MAC protocols for Ad-Hoc Networks: Analysis of the Approaches

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ABSTRACT

Multimedia and real-time applications require bandwidth guarantees, which may be achieved by resource reservation. Several researches were done to propose efficient reservation MAC protocols for ad-hoc networks. In these schemes, channel is segmented into super-frames composed of fixed number of slots. They allocate slots to each traffic source, and make sure that neighbor nodes record the reservation in order to ensure consistency of reservations between neighbor nodes. However, resource reservation in ad-hoc networks remain a very challenging task due to the instability of radio channels, node mobility and lack of coordination between mobile nodes. Proposed reservation MAC protocols like CATA, FPRP, R-CSMA and SRMA/PA have limitations and are suitable only for particular situations. In this paper, we propose a comparative analysis of the most representative reservation MAC protocols. We identify the major issues unresolved by reservation MAC protocols. A performance evaluation and comparative analysis with the IEEE 802.11e are achieved through the NS-2 simulator. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: MAC Protocols; Ad-Hoc Networks; MANETs; QoS; Resource Reservation

INTRODUCTION

Mobile ad-hoc networks (MANETs) are collections of mobile nodes forming temporary networks without any infrastructure support. They can be set up anywhere anytime owing to their easy deployment and self-organization ability. As a result, MANETs become the primary mean of communication in several domains where the deployment of wired infrastructure is difficult. Such domains include battle fields, forestry fire, and disaster recovery.

The characteristics of MANETs like the lack of centralized coordination, node mobility and resource availability make the Quality of Service (QoS) support in MANETs a very
challenging task. MAC protocols for MANETs define the manner channels are shared between mobile nodes. They have significant impacts on the overall system performances and their design is a very challenging issue.

Many solutions have been proposed to support QoS at the MAC sub-layer. Those solutions attempted to improve the channel access mechanism to provide QoS guarantees to multimedia and real-time applications. Proposed solutions may be classified into two categories: contention-based and reservation-based schemes.

Contention-based protocols are non-deterministic and nodes compete to get access to the channel for the transmission of each data packet. The aim of these protocols is to avoid packet collisions, and resolve the hidden and exposed terminal problems. This is achieved through carrier sensing, handshaking and backoff mechanisms. Carrier sense ensures that nodes compete to access the channel only when the channel is detected idle. The handshake mechanism uses short control frames (RTS/CTS) exchange between the sender and receiver prior to data transmission in order to avoid the hidden and exposed terminals issues. The IEEE 802.11 MAC protocol is the most known example of contention-based protocols.

Reservation protocols seem to be attractive solutions for QoS provisioning in ad-hoc networks. Their characteristics such as the contention free medium access and the reduced collision rate are very interesting for MANETs. In this paper we provide a comparative analysis of these protocols and the major issues encountered in designing such protocols. Particularly, we analyze the effects of mobility on the performance of reservation MAC protocols. We also compare these protocols with the IEEE802.11e standard.

In order to face the limited bandwidth issue in MANETs, MAC protocols should ensure high bandwidth utilization, and reduce bandwidth wasting.

The rest of this paper is organized as follows. In section 2, we give an overview of the IEEE 802.11e standard and reservation MAC protocols. In section 3 we highlight the major challenges and limitations of reservation MAC protocols. In section 4 we give a performance evaluation of reservation MAC protocols. Section 5 gives our conclusions.

BACKGROUND AND RELATED WORK

Channel access protocols in MANETs can be classified into two categories: contention-based and reservation-based protocols. Contention-based protocols are non-deterministic and nodes compete to get access to the wireless channel. The IEEE 802.11 is the most known example of contention-based protocols.

The IEEE 802.11 (IEEE Std. 802.11, 1999) standard is considered as the de-facto MAC protocol for wireless networks. The DCF mode is based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). It uses two mechanisms to avoid collision: the physical carrier sensing and the virtual carrier sensing. The physical carrier sensing is used to detect the presence of signal on the common physical channel. The virtual carrier sensing uses the duration field of the MAC frame header to indicate the duration during which a node will reserve the channel.

DATA transmission in DCF is accomplished following the RTS/CTS/DATA/ACK handshake. A station which has a DATA packet to send waits the channel to be idle for the duration of DIFS (DCF Inter Frame Space). If the channel lasts idle for DIFS, the station transmits an RTS packet. Otherwise, the station enters in a backoff period, by choosing a backoff timer uniformly distributed in [0, CW], where CW is the Contention Window (CW) size. The backoff timer is decremented for each idle time-slot. The station transmits its RTS packet when the backoff timer expires. When the receiver receives successfully the RTS packet, it waits for SIFS (Short InterFrame Space) before replaying with a CTS packet. Both the RTS and CTS packets contain the Duration field which is used in order to prevent neighbours from
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