ABSTRACT

A Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes communicating through wireless channels without any existing network infrastructure or centralized administration. We start with the Multiple Access Collision Avoidance (MACA) protocol first which uses an RTS-CTS-DATA packet exchange and invokes binary exponential backoff procedure upon hearing a collision or whenever the channel is not idle. Based on the packet-level simulations and various performances and design issues in MACA protocols, a new protocol Multiple Access Collision Avoidance By Invitation (MACA-BI) was designed. Many medium-access control (MAC) protocols for wireless networks proposed or implemented to date are based on collision avoidance handshakes between sender and receiver. In this paper a study on the bandwidth utilization and efficiency between MACA and MACA-BI medium access protocol has been studied in order to determine their performance and behavior. MACA is a sender-initiated protocol while MACA-BI is the receiver initiated protocol. MACA-BI is more robust than MACA to problems such as protocol failures (control packet collision and corruption) and finite turn-around time.

Keywords

MACA, MACA-BI, Bandwidth, RTS, CTS.

1. INTRODUCTION

An ad hoc network is a temporary network formed by a collection of dynamic nodes in the absence of an existing network infrastructure or a centralized administration. In this network, the mobile nodes communicate with each other using multi hop wireless links. Due to the flexibility, ad hoc network can be organized in such a place where wiring or cost of infrastructure is prohibitive. Mobile ad hoc networking (MANET) group had been formed within IETF to improvise a routing platform for IP-based protocols in ad hoc networks. MANETs allow a cluster of few hundred nodes to create an autonomous system and provide mutual connectivity. Each node operates on end systems and also on nodes that forward packets. The main application of mobile ad hoc network is in emergency rescue operation and battlefields [1]. The nodes in MANET can move freely and hence the topology changes arbitrarily and frequently at unpredictable times. Since the radio channel of each node is shared with all its neighbor nodes so it causes the remaining bandwidth of each node is relative to the scheduling policy of the adopted MAC layer.

Contention-based protocols basically do not have any bandwidth reservation mechanisms. All ready nodes contend for the channel simultaneously, and the winning node gains access to the channel. Since nodes are not guaranteed bandwidth, these protocols are normally not used for transmitting real life traffic, which requires QoS guarantees from the system. This paper therefore is a study to show how the protocols utilize bandwidth and are efficient and affect the QoS. MACA or Multiple Access Collision Avoidance Protocol was proposed by Karn and was proposed due to shortcomings of CSMA protocols when used for wireless protocols [4]. MACA-by Invitation on other hand is a receiver initiated MAC protocol. The rest of the paper is organized as follows. Section II discusses the approaches for bandwidth allocation in wireless adhoc network. Section III recalls the MACA protocol and focuses on the effect of bandwidth utilization of MACA. Section IV focuses on MACA-BI and the effect of bandwidth in MACA-BI followed by section V deals with quality of services and section VI deals with comparison between MACA and MACA-BI. Sections VII and VIII gives the conclusion and references respectively.

1. BANDWIDTH ALLOCATION IN WIRELESS ADHOC NETWORK

Ad hoc networks have been proposed for situations where it is not practical or affordable to set up fixed network
Due to the infrastructure-less nature of ad hoc networks, all network functions have to be performed by the participating users [2]. However, users with limited bandwidth and battery resources might be reluctant to forward data packets for other users, unless there is an additional mechanism in place to give users an incentive to provide this service. Here we consider pricing as a means to stimulate cooperation in an ad hoc network. In particular, we assume that users can charge other users for forwarding their data packets. We study how users set their prices for forwarding packets, and focus in this paper that how much bandwidth they allocate for relaying data packets for other users [5]. When bandwidth and battery resources are scarce in an ad hoc network, then users might not volunteer to forward packets for other users as these impacts the ability to transmit their own traffic. To model this situation, we associate with each user a cost which consists of the following three components: bandwidth, battery cost, and interference cost. When a user has limited transmission resources, then relaying packets for other users will incur a bandwidth cost as it reduces the bandwidth available to the user to transmit its own traffic. Relaying packets for other users will also drain the battery and incur a battery cost. Finally, interference between users who transmit at the same time instant can cause bit errors and packet loss [6-12].

2. MACA (MULTIPLE ACCESS COLLISION AVOIDANCE) PROTOCOL

The MACA access collision avoidance protocol as an alternative to the carrier sense multiple access (CSMA) protocols used in wired networks. In CSMA protocol, the sender first senses the channel for the carrier signal. If the carrier is present it retries after a random period of time [7]. Otherwise, it transmits the packet. CSMA senses the state of the channel only at the transmitter. CSMA does not overcome the hidden node problem. In a typical ad hoc Wireless network, the transmitter and receiver may not be near each other all the time. The main goal of MACA protocol is to overcome hidden & exposed terminal problems [4]. The new idea of MACA is basically: Reserve the channel before sending data packet. Minimize the cost of collision i.e. control packet is much smaller than data packet. MACA does not make use Hidden and exposed terminals abound on simplex packet radio channels, and this makes them very different from Local talk and most other types of local area networks. When hidden terminals exist, lack of carrier doesn't always mean it's OK to transmit. Conversely, when exposed terminals exist, presence of carrier doesn't always mean that it's bad to transmit. The key to collision avoidance is the effect that RTS and CTS packets have on the other stations on the channel. When a station overhears an RTS addressed to another station, it inhibits its own transmitter long enough for the addressed station to respond with CTS [9-10].

A. MACA Packet Transmission

MACA does not make use of carrier-sensing for channel access. It uses two additional signaling packets: the request-to-send (RTS) packet and the clear-to-send (CTS) packet. When a node wants to transmit a data packet, it first transmits an RTS packet. The receiver node, on receiving the RTS packet, if it is ready to receive data packet transmits a CTS packet. Once the sender receives the CTS packet without any error, it starts transmitting the data packet [1-4]. This can be shown in the following figure 1.

![Figure 1: Packet Transmission in MACA](image)

IV.

3. MACA-BI (MULTIPLE ACCESS COLLISION AVOIDANCE-BY INVITATION) PROTOCOL

To reduce, in part, the turn-around overhead, we propose a simpler version of MACA with only a two-way handshake (Multiple Access with Collision Avoidance By Invitation, MACA-BI). A node ready to transmit, instead of “acquiring” the floor (Floor Acquisition Multiple Access, FAMA) [3], waits for a “prepared” floor (Floor Prepared Multiple Access, FPMA). That is, it waits for an “invitation” by the intended receiver in the form of an RTR (Ready to Receive) control packet. The “two pass” handshake of MACA-BI is shown in Figure 2. If a node does not have the exact knowledge of packet arrival times at destination node. Rather, it estimates the average arrival rate. Assuming that each data packet carries the information about the backlog in the transmitter, i.e. number of packets and their lengths, the average rate and future backlog can be easily estimated at the destination node. Thus, the destination node predicts the backlog at the sender node. We examine the various MACA-BI protocol states that occur in a simple 6 node hidden terminal configuration, and identify possible collisions [11]. Accounting for symmetry, there are only three possible combinations of neighbours which are represented by each of three rows. The RTR packets may collide at some nodes. Two types of RTR collision are possible: direct collision between nodes within hearing distance (due to carrier sense failure) and, indirect collision between nodes hidden from each other and transmitting to a common neighbour.
A. MACA-BI Packet Transmission

In MACA-BI the receiver node initiates data transmission by transmitting a ready to receive (RTR) control packet to the sender. If it is ready to transmit, the sender node responds by sending a data packet. Thus data transmission in MACA-BI occurs through a two way handshake mechanism [1-3].

4. QUALITY OF SERVICE

Quality of service (QoS) is the performance level of a service offered by the network to the user. The goal of QoS provisioning is to achieve a more deterministic network behavior, so that information carried by the network can be better delivered and network resources can be better utilized. A network or a service provider can offer different kinds of services to the users. Here, a service can be characterized by a set of measurable pre-specified service requirements such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate. After accepting a service request from the user, the network has to ensure that service requirements of the user’s flow are met, as per the agreement, throughout the duration of the flow [2].

Multiple Accesses with Collision Avoidance (MACA) is a slotted media access control protocol used in wireless LAN data transmission to avoid collisions caused by the hidden station problem and to simplify exposed station problem. This MACA protocol is not fully solve the hidden node and exposed terminal problem and nothing is done regarding receiver blocked problem. In typical sender-initiated protocols, the sending node needs to switch to receive mode (to get CTS) immediately after transmitting the RTS. Each such exchange of control packets adds to turnaround time, reducing the overall throughput. MACA-BI is a receiver-initiated protocol and it reduces the number of such control packet exchanges. Instead of a sender waiting to gain access to the channel, MACA-BI requires a receiver to request the sender to send the data, by using a Ready-To-Receive (RTR) packet instead of the RTS and the CTS packets. Therefore, it is a two way exchange (RTR-DATA) as against the three-way exchange (RTS-CTS-DATA) of MACA [4-8]. The algorithm proposed by the authors piggybacks the information regarding packet queue length and data arrival rate at the sender in the data packet. When the receiver receives this data, it is able to predict the backlog in the transmitter and send further RTR packets accordingly. There is a provision for a transmitter to send an RTS packet if its input buffer overflows. In such a case, the system reverts to MACA. The MACA-BI scheme works efficiently in networks with predictable traffic pattern. However, if the traffic is bursty, the performance degrades to that of MACA [3].

5. COMPARING MACA AND MACA-BI IN CASE OF DIRECT/INDIRECT COLLISION

The investigation on direct and indirect collision for MACA & MACA-BI has been carried out in [13]. The channel is assumed to be symmetric (i.e. if A hears B, B hears A) as in all other MACA protocols.

Figure 3: MACA v/s MACA-BI direct collision

Further, the control packets can be corrupted by noise, direct collision between two nodes (due to non zero propagation delays) and indirect collision of two control transmissions (due to hidden terminals). It is shown that MACA-BI is more robust than MACA to protocol failures [3-4]. The analysis is done in two parts direct collision and indirect collision neglecting noise corruption. Figure 3 reports all direct collision situation in a three node configuration with nodes A and B within transmission range of each other [13]. Node C is a common neighbour.

Figure 4: MACA v/s MACA-BI indirect collision

There are three situations of direct control packet collision in MACA, i.e. RTS v/s RTS, CTS v/s RTS, CTS v/s CTS,
versus only one possible direct collision in MACA-BI, i.e.
RTR v/s RTR. Fig. 4 [13] reports only the starting states and reports indirect collisions caused by the hidden terminal problem [13]. In the MACA protocol RTS v/s RTS and RTS v/s CTS collisions produce only inefficiency (not data failure) wasting one or two cycles in handshake. CTS vs CTS may interfere with data receptions at A and B. MACA-BI produces three danger situations of the same type but it has fewer efficiency situations as MACA-BI restarts the handshake: it wastes only at most one cycle. In the case of indirect control packet collision, MACA-BI has one danger situation less than MACA, and only one situation of inefficiency. The protocol may fail also because of control packet corruption due to channel noise, fading etc. In this respect, MACA is more vulnerable than MACA-BI since it requires twice as many control packets. The preliminary conclusion of this qualitative analysis (which has been verified via simulation in [13]) is that dropping a pass in the handshake does not increase the number of collision situations and does not affect the functionality of the MACA mechanism.

6. CONCLUSION

In this paper we have performed a study of the MACA and MACA-BI protocols for ad hoc networks and analyze the effect of bandwidth utilization and its efficiency. The need for the RTS packet is eliminated in MACA-BI, and it reduces the overhead for each packet transmission and simplifying the implementation, yet preserving the data collision free property of MACA. As a result, MACA-BI is more robust to failures such as hidden terminal collision, direct collision or noise corruption. The efficiency of MACA-BI in high speed wireless networks with steady traffic, and show its superiority to existing MACA type schemes.

7. REFERENCES


