Developing a Wireless Ad-Hoc Network using MAC Schemes

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Abstract—

A mobile user can connect to a LAN by using a wireless connection which is known as Wireless LAN (WLAN). WLAN uses high frequency waves instead of wire to communicate between nodes. Here signals are of limited range. WLANs combine data connectivity with user mobility, and, through simplified configuration, enable movable LANs. IEEE 802.11 standard provides technical specifications for the wireless interfaces. There are two modes of operations in WLAN.One is the presence of control module often called as based station or IEEE 802.11 calls them access points and the second one is ad hoc or peer-to-peer connectivity. Three basic medium access control (MAC) mechanisms have been defined for IEEE 802.11: the mandatory basic method based on a version of carrier sense multiple access with collision avoidance (CSMA/CA), an optional method avoiding the hidden terminal problem and the third one is a contention-free polling method. The mandatory MAC mechanism and the optional method of IEEE 802.11 are known as distributed coordination function (DCF) whereas the third method is called as point coordination function (PCF). DCF is CSMA/CA with binary exponential backoff algorithm. DCF with optional RTS/CTS scheme in 802.11 MAC protocol avoids the problem of hidden terminals. In this paper, we have studied the 802.11 wireless LAN (WLAN) and the working of DCF in wireless LANs (WLANs).

Keywords— Wireless LAN, medium access control, mobile ad hoc network, distributed coordination function**,** backoff.

INTRODUCTION

Now a day's WLAN is fetching very much attention because WLAN do not need any sort of physical cable. The nodes in WLANs share the same radio broadcast channel.WLAN technologies constitute a fast growing market introducing the flexibility of wireless access into office or home. WLANs are typically restricted in their diameter to buildings, a campus or a single room and are operated by individuals, not by large-scale network providers. The global goal of WLANs is to replace office cabling and, additionally, to introduce a higher flexibility for ad hoc communication, such as emergency group meetings.

Following are the some advantages of WLANs [1]. First one is flexibility. Within radio coverage, nodes can communicate without further restriction. Radio waves can penetrate walls, senders and receivers can be placed anywhere. The second advantage is planning. Only wireless ad-hoc networks allow for communication without previous planning, any wired network needs wiring plans. As long as devices follow the same standard, they can communicate. Third one is design. Wireless networks allow for the design of small, independent devices which can for example be put into a pocket. Cables not only restrict users but also designers of small PDAs, notepads etc. And the last one is robustness. Wireless networks can survive disasters, e.g., earthquakes or users pulling a plug. If the wireless devices survive, people can still communicate. Networks requiring a wired infrastructure will usually break down completely.

WLANs also exhibit several disadvantages [1] like they typically offer lower quality as compared to wired networks. The main reasons for this are the lower bandwidth due to limitations in radio transmission (e.g., only 1–10 Mbit/s user data rate instead of 100–1,000 Mbit/s), higher error rates due to interference (e.g., 10–4 instead of 10–12 for fiber optics), and higher delay/delay variation due to extensive error correction and detection mechanisms. Another disadvantage is that using radio waves for data transmission might interfere with other high-tech equipment, for e.g., in hospitals. Here special precautions have to be taken. Also, open radio interface makes eavesdropping much easier in WLANs.

WLANs can be set up anywhere on demand, but the medium is shared among the communicating nodes. Therefore data transmission is little bit complex in WLANs. Hence there is a need for an access protocol which resolves the contention between the stations trying to access the medium without degrading performance for large networks. The protocol should be efficient, providing high throughput, fairness, less delay and less collision rate in the network.

DCF is the standard MAC scheme which is a distributed scheme designed to support best-effort traffic whereas PCF is centralized scheme in which stations are polled to ensure their service requirements are met. Research has shown that DCF performs reasonably well for transmitting best-effort packets in small-size networks [2].

The rest of the paper is organized as follows. Section II describes the two basic variants of WLANs. Section III describes the operation of DCF. Section IV discusses the various performance parameters of DCF and Section V concludes this paper.

II. VARIANTS OF WLANs

There are two basic variants of wireless networks: infrastructure dependent and infrastructure less.

- Infrastructure dependent:

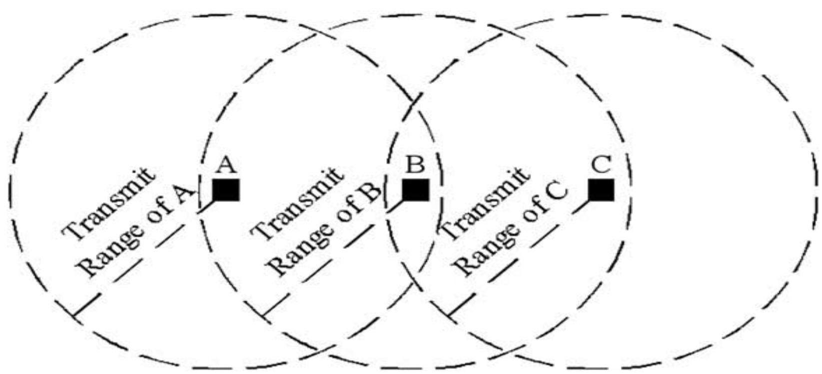
The infrastructure dependent wireless networks consist of a group of stations and a central access point also known as base station. If any node wants to communicate with any other node in the network, it has to communicate through this base station. Thus, they are single-hop wireless networks.

- Infrastructure less:

Infrastructure less wireless network is also known as mobile ad hoc network (MANET). MANETs are defined as that category of wireless networks which uses multi-hop radio relaying and are capable of operating without the need of any fixed infrastructure. Thus a MANET is a group of nodes in which the nodes can directly communicate with those nodes which fall within their radio waves range. Wireless mesh networks and wireless sensor networks are specific examples of ad hoc wireless networks.

MANETs faces a problem known as hidden terminals, shown in Fig. 1. It refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of each other (sender), but are within the transmission range of the receiver. Collision occurs when both nodes (senders) transmit packets at the same time without knowing about the transmission of each other, i.e., both the senders are hidden from each other.

The absence of the central base station in MANET makes the routing, complex as compared to the infrastructure dependent ones. In infrastructure dependent WLANs the presence of base station simplifies routing and resource management, as the routing decisions are made in centralized manner with more information about the destination node. But in ad hoc WLANs, the routing and resource management are done in a distributed manner in



which all nodes coordinate to enable communication among themselves. It means if a node doesn't falls within the radio range of other node, still they can communicate with each other through intermediate nodes. Thus, in MANET each node acts as both a network host for transmitting and receiving data and a network router for routing packets from other nodes. This requires the mobile nodes to be more intelligent. Hence the mobile nodes in ad hoc wireless networks are more complex than their counterparts in infrastructure dependent networks.

A third variant of WLANs is the hybrid wireless networks in which we combine both the above explained variants of WLANs.

Due to the absence of wires in WLANs for communication the protocols used in wired network cannot be directly used in WLANs. The access protocols for WLANs needs to be a little bit different. The basic MAC protocol defined for WLAN is the DCF. Its operation is described in the next section.

OPERATION OF DCF

The contention-based access mechanism that is adopted in the IEEE 802.11 standard is the DCF. This section describes the operation of DCF as a MAC scheme. In DCF, a successful frame transmission cycle consists of the transmission of a data frame followed by the reception of the corresponding ACK frame by the source station from the receiving station (Fig.2). A transmission cycle may also include one or more collisions.

The DCF operates as follows. Before transmitting a data frame, the sending station senses the medium for a time period of an interframe space (IFS) that is defined for each class of frames (DIFS for data frames). If the medium is idle for DIFS, the station initiates the transmission. Otherwise, the station proceeds to follow a two-step procedure. First, the station waits until the medium becomes idle and then defers for a time period of DIFS. If the medium remains idle throughout the DIFS, the station proceeds to the second step in which it enters the contention phase. In this phase CW is initialized to a value, CWmin, which depends on the physical layer. Then, the station sets a timer known as backoff timer to a value that is uniformly chosen from the contention window (CW) interval i.e., from [0, CW]. After that, the station reduces its backoff timer by one unit (slot time) following the elapse of an idle time slot. If the medium is found to be busy during any of the time slots, the station freezes its backoff timer and resumes it after detecting the medium to be idle for another DIFS time. The purpose of the second step is to reduce the chance of a collision between stations that are transmitting data frames. The backoff time is calculated as follows:

BackoffTime = random() x SlotTime where, random() function randomly chooses a value from the range of the CW and SlotTime is the length of one slot.

At time when the backoff timer reaches zero, the station is allowed to transmit its packet. It may be possible that two or more stations’ backoff timer reaches zero at the same time, then the transmitted frames won’t be received correctly and the sending stations will not receive the ACK frames. In this case, the colliding stations will double their CW until it reaches the maximum value, CWmax. Whereas, in the case of a successful packet transmission, the destination station defers for a short IFS (SIFS) and then sends back an ACK packet. The transmitting station then resets its CW to the minimum defined initial value (CWmin). This two-way handshaking technique for the packet transmission is called basic access mechanism.

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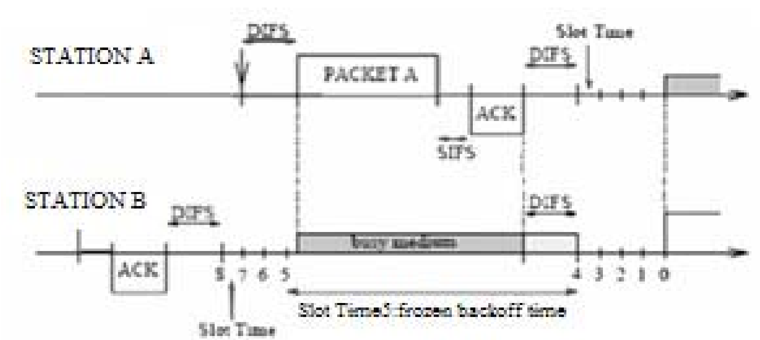
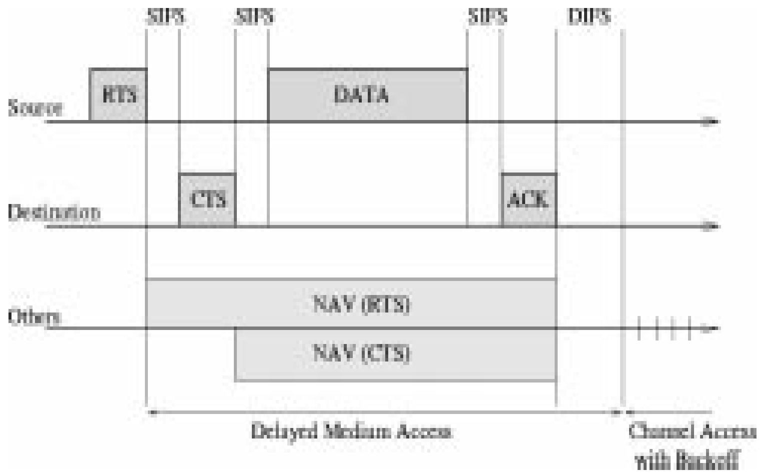


DCF defines an optional four- way handshaking technique for a packet transmission. This mechanism, known as RTS/CTS, is shown in Fig. 3. A station that has a packet to transmit, waits until the channel is sensed idle for a DIFS, follows the backoff rules explained above, and then, instead of the packet, it first transmits a special short frame called request to send (RTS). When the receiving station detects an RTS frame, if its not busy, it responds, after a SIFS, with a clear to send (CTS) frame. The transmitting station is allowed to transmit its packet only if the CTS frame is correctly received.

The frames RTS and CTS carry the information of the length of the packet to be transmitted. This information can be read by any listening station, which is then able to update a network allocation vector (NAV) containing the information of the period of time in which the channel will remain busy. Due to this the station will not try to transmit any packet during this period. Therefore, when a station is hidden from either the transmitting or the receiving station, by detecting just one frame among the RTS and CTS frames, it can suitably delay further transmission, and thus avoid collision. This resolves the hidden terminal problem. The RTS/CTS mechanism is very effective in terms of system performance, especially when large packets are considered, as it reduces the length of the frames involved in the contention process. In fact, in the assumption of perfect channel sensing by every station, collision may occur only when two (or more) packets are transmitted within the same slot time. If both transmitting stations employ the RTS/CTS mechanism, collision occurs only on the RTS frames,



and it is early detected by the transmitting stations by the lack of CTS responses. This four-way handshaking mechanism is used when the size of the packet to transmit is larger than the RTS threshold (RT) value.

IV. **PERFORMANCE METRICS OF DCF**

Performance of the basic access method strongly depends on the system parameters, mainly minimum contention window and number of stations in the WLAN. On the other hand, performance is only marginally dependent on the system parameters when the RTS/CTS mechanism is considered. RTS/CTS scheme has the ability to cope with hidden terminals; hence this access method avoids collision at the receiver end.

The throughput of the basic access scheme strongly depends on the number of stations in the network. The greater is the network size; the lower is the throughput and vice-versa. DCF performs well with small limited number of stations, but its performance degrades significantly with an increase in the number of stations. Delay is also small for normal traffic, whereas it may be large with busy traffic conditions. Finally, if we consider the fairness of DCF, it doesn't have a high fairness in the short-term, although its fairness increases as the stations contend for longer periods.

V. CONCLUSION

This paper presented a study on WLANs and its two basic variants. After that we describe the operation of IEEE 802.11's basic MAC mechanism i.e., DCF. DCF which uses CSMA/CA and binary slotted exponential backoff, is the basis of the IEEE 802.11 WLAN MAC protocols**.** We also describe an optional method known as RTS/CTS mechanism. It has been seen that the basic access mechanism with RTS/CTS scheme helps in avoiding the collision at the receiver end.

The RTS/CTS mechanism has proven its superiority in most of the cases. When the capability of the RTS/CTS scheme to cope with hidden terminals is accounted, we conclude that this method should be used in the majority of the practical cases. We also presented the various performance parameters of DCF which says that the DCF performs really well with small sized networks, but it degrades as network size grows.

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