A Multicast polling Scheme for Idle Station in IEEE 802.11 Wireless Networks

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Abstract

IEEE 802.11 Point Coordination Function (PCF) mode is defined to support time bounded traffic, such as VoIP in wireless LANs. The poll scheduling plays an important role in IEEE 802.11 PCF mode operation. This paper proposed a Multicast Polling Scheme to increase the performance of wireless LANs. Moreover, we proposed a polling schedule scheme for our proposed multipoll to serve real-time traffic. The results show that the proposed mechanism is more efficient than the original IEEE 802.11 PCF.

Keywords: Multicast polling, polling schedule, IEEE 802.11 PCF

1. INTRODUCTION

Mobile communication devices like Laptop and PDAs become more and more popular. Especially, the number of WLANs in public facilities like railway stations, official buildings and airports increases rapidly, not talking into account all the small private "home" WLANs [1].

WLANs are widely accepted and deployed in private sites and hot-spot commercial areas to support user with terminal mobility. With the rapid deployment of WLANs, there are growing demands for WLANs to provide Quality of Service (QoS) for real time service such as Voice over Internet Protocol (VoIP). For a sufficient speech quality, the mouth-to-ear delay must be kept small and should be released of jitter/delay at the receiver.

A IEEE 802.11 PCF mode addresses one issue; empty poll problem which happens when the AP polls to stations in silence state. Eustathia Ziouva and Theodore Antonakipoulos proposed a scheme called Cyclic Shift and Station Removal Polling process (CSSR) in which the AP's polling list temporarily removes stations that enter silence state [2]. However, when it leaves silence state, its voice packet may be discarded in the next round because it does not receive a poll in the maximum allowable delay. O.Sharon and E. Altman proposed an Efficient Polling MAC Scheme in which stations are separated into two groups, active group and idle group, according to whether there are any pending data ready to be sent. a station in active group and a station in the idle group can simultaneously respond to the polling from the PC by using signals of different strengths. However, this approach does not work well in overlapping BSSs [3][4].

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This paper propose a dynamically adaptive polling scheme for support of voice communications and avoid unnecessary polling over an IEEE 802.11 Wireless LAN.

The remainder of this paper is organized as follows. In Section 2, we briefly describe the DCF and PCF operation
and section 3 presents the Multicast Polling Scheme. In section 4, we evaluate the performance of the proposed scheme deriving the packet discard ratio and maximum number of real-time stations handled by PCF. Finally, section 5 conclude in this paper.

2. IEEE 802.11 MAC PROTOCOL

2.1.Basic DCF

A coordinator function shares the medium among the stations, i.e., decides when a station can send data. The DCF is a distributed algorithm, where all stations run the algorithm. The basic DCF is Carrier Sense Multiple Access with Collision Avoidance. Carrier sensing is done through physical and virtual mechanisms. A station senses the medium to check if another station is transmitting in by distributing reservation information with RTS/CTS changes. If the medium were to remain medium becomes busy during the DIFS time interval, the backoff procedure is enabled. Similarly, backoff is enabled if the medium were found busy when sensing for the first time. [5]

When the backoff is invoked, the station waits till the current transmission is over. After the end of the current transmission, the station waits for a DIFS. Once the medium was detected, the station performs an additional backoff wait before actual transmission. The backoff timer is set to some randomly chosen value. If the medium is free throughout the backoff interval and the timer expires, the frame is transmitted. If the medium becomes busy during this interval, the timer is frozen at its current value but not reset. The station waits for the medium to become free, waits for an DIFS, and performs the backoff wait again, reducing the timer. This process continues till the backoff timer finally expires and the station transmits the frame. When a station receives a DATA frame, it waits for a SIFS (Short IFS) duration and transmits an ACK to the sender. There is no carrier sensing or backing off ACK frames. The sender retransmits if no ACK is received within a specified duration.

2.2. PCF

PCF is a centralized, polling-based access mechanism which requires the presence of an AP that acts as Point Coordinator (PC). In the PCF mode, time is divided into CFPR intervals. Each CFPR interval consists of a contention period where DCF is used and a contention-free period (CFP) where PCF is used. The CFP is started by a beacon frame sent by the PC using DCF. The CFP may vary from CFPR interval to CFPR interval, as the base station has to contend for the medium. Once CFP starts, the PC polls each station in its polling list (the high priority stations) when they can access the medium. To ensure that no DCF stations are able to interrupt this mode of operation, the inter frame space between PCF data frames (PIFS) is shorter than the DIFS. To prevent starvation of stations that are not allowed to send during the CFP, there must always be room for at least one maximum length frame to be sent during the contention period. [5]

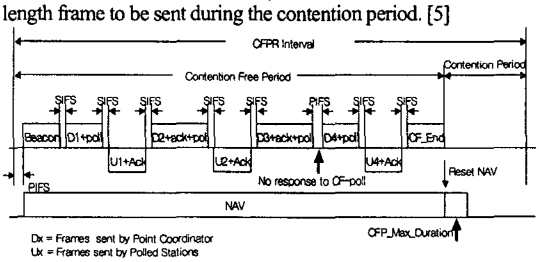

Fig. 1. Example of PCF frame transfer

The PC polls the stations in a round-robin fashion. A polled station always responds to a poll. If there is no pending transmission, the response is a null frame containing no payload. If the CFP terminates before all stations have been polled, the polling list is resumed at the next station in following CFP cycle. A typical medium access sequence during PCF is shown in Fig. 1. A station being polled is allowed to transmit a data frame. In case of an unsuccessful transmission, the station retransmits the frame after being repelled or during the next contention period.

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3. PROPOSED MULTICAST POLLING SCHEME

In this section, we propose an adaptive polling scheme for IEEE 802.11 PCF to reduce polling overheads by managing the polling list based on the amount of queued data, that is, the number of packets waiting to be transmitted at each station. A Station with more queued data is expected to have a higher priority. Each pollable station is given a priority, which is dynamically assigned by the PC based on the queue size of each station. The priority of each station is updated by the PC using the poll-feedback information from each station. At this time, idle stations which have no data to be transmitted are assigned the lowest priority level, and they are to receive a multicast poll instead of separate poll for each station. In other words, idle stations are multi-polled by a single poll frame at the same time.

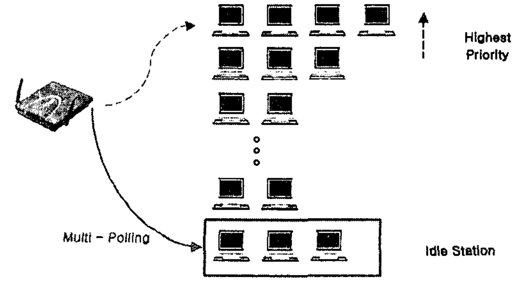

Fig. 2. Station lists with different priorities

We can reduce amount of empty polls by using a multicast poll to the idle stations group. When an idle station receives the poll frame, it can transmit its packet after a constant time respectively. In this way, we can consider that the polling list is conceptually split into station lists with different priorities. All stations with the same priority are placed in the same list, as illustrated in Fig. 2.

We use silence detection mechanism to avoid polling voice terminals which are in silence state.

Fig. 3 shows an example of the polling list. The use of silence detection can increase the number of voice stations supported by the network since those stations within silence periods will be polled less frequently. The PC transmits a poll frame to each station sequentially beginning from the top of the polling list, then PC receives queue length information by a poll-feedback. Using poll-feedback, the PC gives priority to stations based on the queue length.

First, assuming S_D transmits its packet in the (n+1)-th PCF round, the PC gives the highest priority to S_D in the next PCF round since its queue is the longest of all stations. In the (n+1)-th PCF round, S_B and S_C enter silence state following packet generation interval and have no more data to send (that is, the poll interval is longer than the packet generation interval), then S_B and S_C are added to the idle station group in the next PCF round which will receive the multi-poll . If any of the idle station group has no data to send, it leaves the idle station group. In the (n+2)-th PCF round, S_B leaves the idle station group because it has a packet to be sent when receiving the multi-poll at the same time.

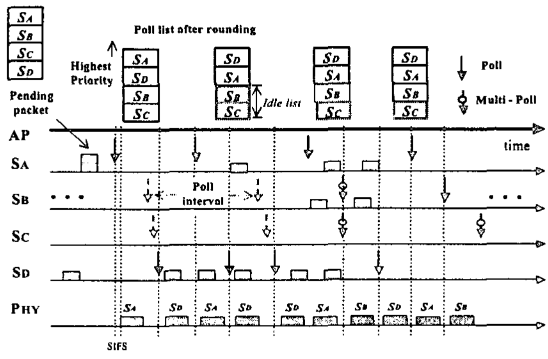

Fig. 3. An example of the management for polling list.

4. SIMULATION

The system parameters for the simulation environment are listed in Table 1 as specified in the IEEE 802.11b standard. To simplify the simulation, the radio link propagation delay is assumed zero with no transmission errors. We consider on/off model of voice traffic. In the simulation, we assume that the voice stations use Pulse Code Modulation (PCM) voice coding at 64kbps and a voice packet is generated every CFPR interval. If a new packet is generated before the previous packet has been transmitted, the older packet is discarded. In this model, the talk spurt period over silence period is 1.0 sec and 1.35 sec, respectively. The frame length of real-time traffic is set to 200 bytes considering the overheads of upper layer protocols.

Table 1. System parameters for simulation

Symbol	Meanings	Value
R	Channel rate	11Mbps
CW_{min}	Minimum contention window	31
CW_{max}	Maximum contention window	1023
T_S	Slot time	20us
T_{SIFS}	SIFS time	10us
T_{PIFS}	PIFS time	30us
T_{DIFS}	DIFS time	50us
T_{Rep}	CFP repletion interval	30ms
T_{MaxCFP}	CFP_Max_Duration	28ms

Table 2. Parameter for voice traffic

Symbol	Meanings	Value
D_{MAX}	Maximum allowable delay	35ms
T_I	Packet generation interval	25ms
L_{MPDU}	Frame length	200byte

The parameters for the real-time traffic are summarized in Table 2. The maximum delay between a station and the point coordinator, Dmax is set by 35ms as in [6]. Namely, real-time packets are discarded if their waiting time exceeds 35ms. The CFP_Max_Duration is set to 28ms considering the maximum size of MPDU.

The experiments in Fig. 4 show the effect of changing the number of stations in the simulation on the performance of the average transfer delay. The average delay increase as the number of the node increases. The average delay of proposed scheme is shorter than the original IEEE 802.11 scheme because the proposed scheme can reduce the amount of the empty polls.

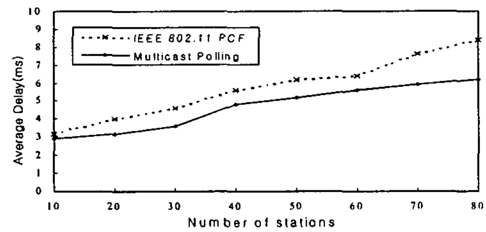

Fig. 4. Average delay according to number of stations

In Fig. 5, we see that the performance advantage of the proposed scheme for the packet discard ratio is more apparent. To reflect the end-to-end delay bound of real-time traffic, the remaining due which represents the remaining time to the service deadline between a station and the point coordinator is considered instead of end-to-end delay between two communicating stations. The discard ratio for real-time traffic using the proposed scheme stayed low. The maximum delay between a station and the point coordinator is set by 35ms as in [6].

In Fig. 6, we see that the maximum number of supported stations in the network increases as the CFPR interval is increased. This is due to the reduction of delay and packet discard ratio with our scheme. Fig. 7 presents the throughput with the proposed scheme. This figure indicates that our scheme may offer a higher throughput than the original polling scheme.

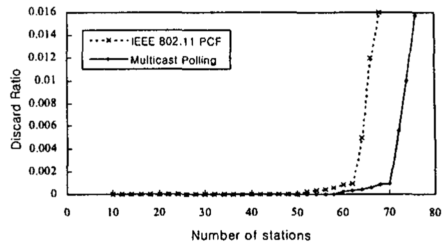

Fig. 5. Discard ratio according to number of stations

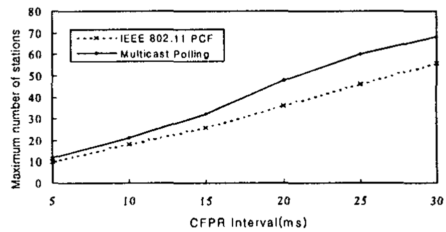

Fig. 6. Maximum number of station according to CFPR interval

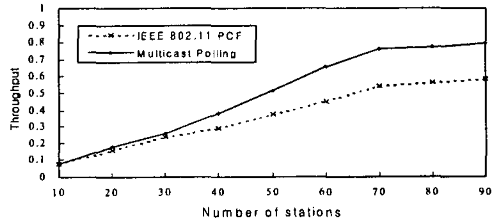

Fig. 7. Throughput according to number of stations

5. CONCLUSION AND FURTURE WORK

To reduce the amount of empty polls in IEEE 802.11 PCF mode operation, this paper proposed a multicast poll scheme. Multicast poll scheme spreads a poll to the silence station group at the same time. It use silence detection to increase the number of the supported stations. Simulation studies revealed that our scheme could improve the average delay and packet discard ratio by preventing serious empty poll.

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