AN ADAPTIVE POLLING SCHEME FOR IEEE 802.11 WIRELESS LAN

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Abstract: The point coordination function of IEEE 802.11 is defined to support time bounded traffic in wireless LANs. However, current WLAN standard does not consider the traffic characteristics such as time bound traffic, null poll, and priority. In the case of time bounded traffic, PCF must evolve to support degrees of priority. In this paper, we proposed an adaptive polling scheme to increase the performance of wireless LANs. Moreover, we focused to a polling schedule to serve voice traffic. The simulation results show that the proposed scheme is more efficient than using only standards.

Key words: WLAN, IEEE 802.11, Polling, PCF, Real-time

1. INTRODUCTION

The dramatic increasing of wireless devices has recently generated a lot of interest in wireless networks that support multimedia services, such as streaming video and audio that has critical quality of service requirements such latency, jitter and bandwidth [6].

IEEE802.11 WLAN standard protocol supports two kinds of access methods: distributed coordination function and PCF [1]. The DCF is designed for asynchronous data transmission by using CSMA/CA (carrier sense multiple access with collision avoidance) and must be implemented in all stations. On the other hand, the PCF is a polling-based scheme which is mainly intended for transmission of real-time traffic. This access method is optional and is based on polling controlled by a PC (point coordinator). Currently, the polling mechanism for IEEE 802.11 PCF mode is based on the round robin principle which polls every station in sequence regardless of whether it has packets to transmit or not. Real-time applications are characterized by QoS parameters such as delay, jitter, etc [8]. These applications generally have higher priority than non-real time traffic and hence they are allocated a significant portion of the bandwidth.

In our knowledge, since the round robin polling scheme does not consider traffic characteristics in each station, the PCF suffers from performance degradation such as delay since empty poll which a happen when the AP polls to stations in silence state [2, 3]. However, current WLAN standard does not consider the traffic characteristics such as time bound traffic, null poll, and priority. In the case of time bounded traffic, PCF must evolve into support priority and to reduce packet drop due to buffer overflow, traffic to the bottleneck node must be controlled. This can be achieved by decrease of the number of polling.

In this paper, we proposed dynamically adaptive polling scheme that reducing the unnecessary polling overhead for service real-time data in IEEE 802.11 WLAN efficiently. Thus, our scheme is to increase the bandwidth effectively without losing fairness at the MAC layer in wireless local area networks.

The remainder of this paper is organized as follows. In Section 2, we briefly describe the related works. In section 3 presents an adaptive 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 concluded in this paper.

2. RELATED WORKS

This section briefly summarizes the some of the features of the 802.11 WLAN sub-layer with the emphasis on the PCF mode of operation.

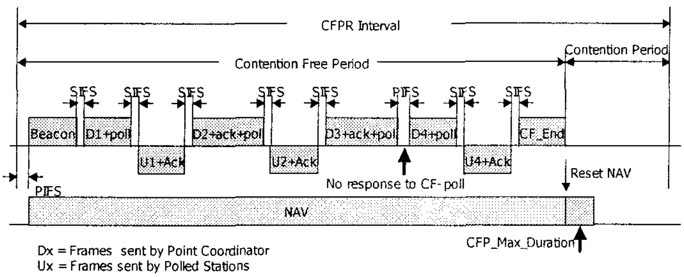

Figure 2. Example of PCF frame transfer

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 defer or during the next contention period. A PC [1] polls the stations in a round-robin fashion. A polled station always responds to the received a poll. If there is no pending transmission, the intended station responds to a null frame without payload. This frame is called empty poll. In the PCF mechanism, prior to all stations polling, if the *CFP_Max Duration* terminates, next polling sequence resumed at a station not called station. If transmission failed, the station retransmits the frame after delay or during the next contention period.

If contention traffic from the previous repetition interval carries over into the current interval, the *CFP_Max Duration* may be shortened. Also, if a station lasts longer than the remaining contention periods, the PC has to defer the start of its real time traffic transmission until the medium becomes free for a PIFS. This is because of bandwidth of shared medium. Therefore, recently, bandwidth has been a major design goal for wireless LAN.

In the last few years, many researchers actively explored advanced bandwidth reuse approaches for wireless LAN. A set of related research issues needs to be addressed before our approach called as adaptive polling scheme which is technically feasible and economically practical.

In [2, 3, 4] scheme, in the case of real time traffic, the existence of transmission delay and packet discard by empty poll is not assumed in order to decrease transmission delay. However, our adaptive polling scheme predicts an adaptive (optimal) priority for the current transmission, based on queue sizes in each station. Most of the known wireless MAC protocols are not specifically designed to support multimedia traffic QoS such as transmission delay, which severely impairs the system performance, can be averaged out.

Eustathia et al. [2] 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. 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 et al. [4] 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.

In contrast, our polling scheme, each station has a priority and AP multi-polls in each station, which is dynamically assigned by the PC based on the queue size of each station.

3. AN ADAPTIVE POLLING SCHEME

3.1 Overview

IEEE 802.11 PCF mode has been addressed many issues, very important one of these issues which is empty poll problem, this is happens during polling to stations under the silence state. For example, if any station leaves silence state, voice packet of the idle station may be discarded in the ongoing next round, since excess maximum delay for receiving a poll.

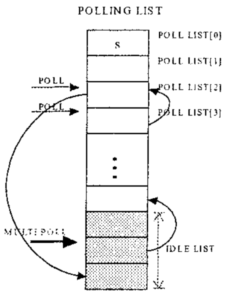

Figure 2. The polling list used for the re-setup

Therefore, an adaptive polling scheme for avoidance null-poll without transmitting delay is an important challenge to serve real-time traffic. When large frames are transmitted in a noisy channel, they accumulate bit errors that triggers retransmissions. These retransmissions consume valuable bandwidth and degrade the efficiency of the entire system. Thus, an adaptive polling scheme achieves two benefits: 1) the priority of a frame is guaranteed; and 2) avoid to waste bandwidth, which increases the throughput of the system. Fig. 2 shows basic operation of adaptive multicast polling list re-setup.

3.2 Management of Polling List

In this section, we propose an adaptive polling scheme in the IEEE 802.11 PCF to reduce polling overhead. It is occur because of managing the polling list based on the amount of packets at each station. A station with many data is expected to having a higher priority. For each intended station, its priority is given depending on an amount of payload, which is dynamically assigned by the PC based on the queue size of each station. The PC received a packet which includes the information of queue size and an amount of payload of each station. At this time, idle stations without data are assigned the lowest priority level. and then at one time they will be received a multicast poll instead of separated poll. For that reasons, a number of empty poll can be reduced as many as the number of idle stations, since using a multicast poll.

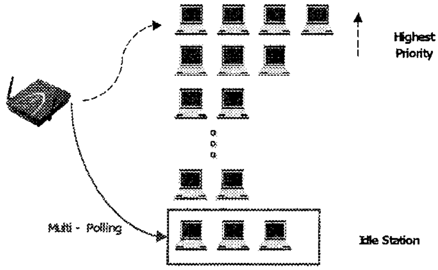

Figure 3. Multi-polling illustration

When an idle station receives the poll frame, it can transmit its packet after a designated constant time. We use silence detection mechanism to avoid empty-poll of the silence terminals.

Fig. 3 shows the illustration of the multi-polling. Frequently, any station within silence period will to be less polled. The use of silence detection can increase the number of voice stations supported by the network. The PC transmits sequentially a poll frame to each station based-on polling priority of polling list, and then the PC receives queue length information by a poll-feedback. Using poll-feedback, the PC allows priority to stations based on the queue length. In the Fig.4, we will describe how node determines that its priority given own.

3.3 An Adaptive Multicast Polling Scheme

We now describe an adaptive multicast polling scheme for idle station to avoid empty polling. As discussed above, the main objective of this scheme is to reduce delay depending on an empty poll and packet loss due to buffer overflow, as well as maintain the network bandwidth.

Our scheme can be expressed in an example of the management for polling list shown in Fig, 4. The arrow mark with small circle indicates multicast poll and general poll without circle, respectively. In Fig. 4, S_A, S_b, S_c, and S_d represents its station *A, B, C,* and *D*. The rectangular indicate pending packet. The multi column boxes represent polling list. The PHY show the sequence of packet transmission in physical layer.

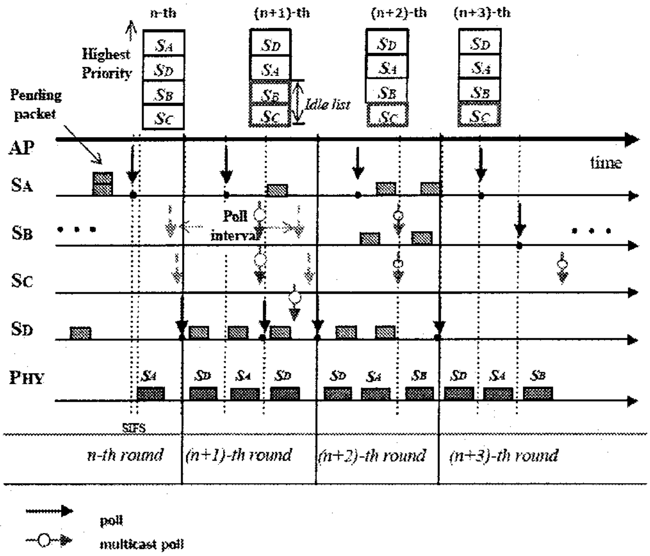

Figure 4. An example of the management for polling list

First, in the n*th* PCF round, S_B and S_C enter silence state following packet generation interval and have no more data to send (that is, because of 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 (n+1)*th* round which will receive the multi-poll. If the idle station group has no data to send, it still leaves the idle station group.

```
PROCEDURE AP_POLLSEND (i) {
  for each station i in current round
   for (i = 0; i < n; i++)
    if poll was sent by AP
      return STA_POLLFEEDBACK()
}
PROCEDURE STA_POLLFEEDBACK( queue_length , i) {
   for each station i in current round
     for (i =0; i < n; i++)
       if queue_length_i is not empty
         AP        queue_length of the pollable STA
}
PROCEDURE UPDATE_PRIORITY(i, poll_list[]) {
   if queue_length_i > queue_length_i-1
      poll_list[n]         station_i
      poll_list[n+1]       station_i+1
   else queue_length is empty || poll_interval > packet generation interval
      idle list group        pollable STA
```

Figure 5. Basic operation of multicast polling scheme

In the (n+1)*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. 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. At time (n+2)*th*, S_b can transmit its packet. In other hand, S_c is remained idle station status. In the Fig. 5 shows an algorithm of basic operation of multicast polling scheme.

4. ANALYSIS AND SIMULATION RESULTS

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. Fig. 6 shows the simulation model.

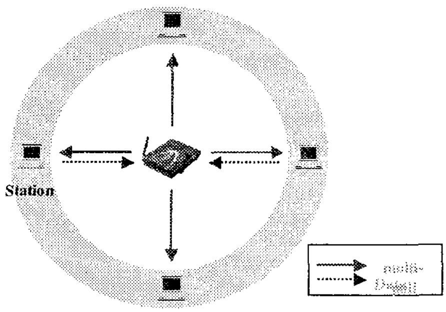

Figure 6. Simulation model

We consider on/off model of voice traffic. In the simulation, we assume that a voice packet is generated by exponential distribution [7]. While the previous packet has been transmitted, the older packet is discarded since a new packet is generated. 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.

Assuming the ratio of PCF duration within a super-frames, r, throughput of an adaptive polling scheme is approximately as follows,

$$r * F_p(n) + (1-r) * F_d(n) \tag{1}$$

Actually r can be dynamically modified by changing priority re-setup, *CFP_Duration*. For any given n, we want to set appropriate *CFP_Duration* to maximize the total throughput, as shown below [3].

$$Th = \lfloor r \mid Max\{r * F_p(n) + (1-r) * F_d(n)\} \rfloor \quad (2)$$

, where F_d is generally throughput, this parameter is function of n, denoted as F_d (n) and F_p is a function of the total number of associated stations T, the number of current active stations n, and r shown re-try limit.

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_{PIFS}	*PIFS time*	30us
T_{Rep}	*CFP repletion interval*	30ms
T_{MaxCFP}	*CFP_Max_Duration*	28ms

The parameters for the real-time traffic are summarized in TABLE 2. The maximum delay between a station and the point coordinator, D_{max} is set by 35ms [6, 7]. 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.

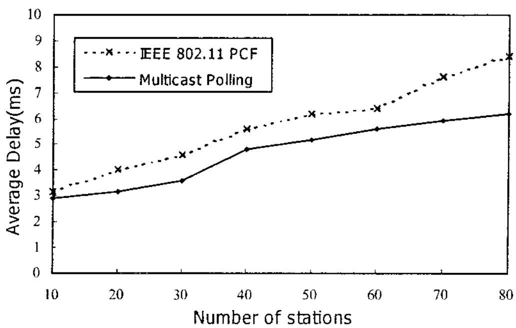

Figure 7. Average delay according to number of stations

In Fig. 7, the simulation shows the effects of changing the number of stations versus the average delay. If the number of node increases, the entire average delay 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.

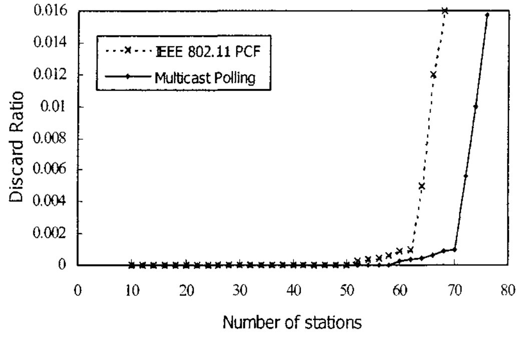

Figure 8. Discard ratio according to number of stations

In Fig. 8, we see that the performance of the proposed scheme for the packet discard ratio. Reflecting the end-to-end delay bound of real-time traffic, remaining time to service deadline between a station and the point coordinator is considered which is 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 [6].

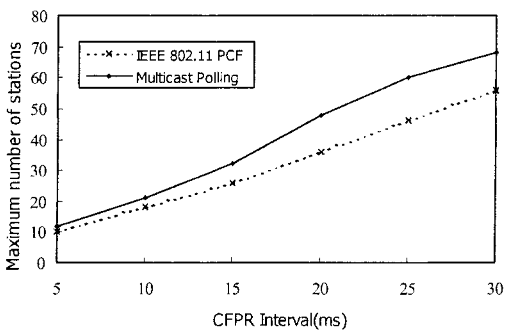

Figure 9. Maximum number of station according to CFPR interval

In Fig. 9, we see that the maximum number of supported stations, while the CFPR interval is increased. This is due to the reduction of delay and packet discard ratio with our scheme. Fig. 10 shows an increase of throughput of the proposed scheme in the same simulation setting.

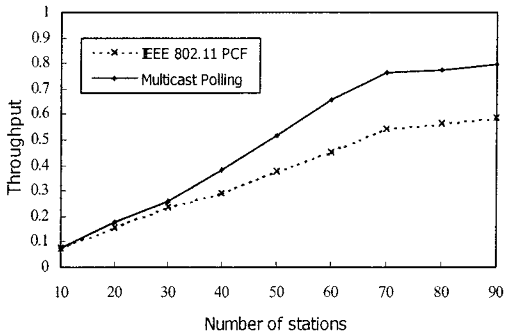

Figure 10. Throughput according to number of stations

5. CONCLUSION

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

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