Supporting Real-Time Multimedia Traffic in a Wireless LANs

論 文
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Abstract

This paper presents a new dynamically adaptable polling scheme for efficient support of real-time traffic over an IEEE 802.11 wireless LAN network. The poll scheduling plays an important role in IEEE 802.11 PCF. However, the current version of the polling list management scheme proposed in the IEEE 802.11 standard is inefficient when a variable number of mobile stations have variable packets to transmit. If Point Coordinator has an exact information on the station status, it is possible to efficiently perform polling. In this paper, we suggest an adaptable polling scheme to meet requirements of the stations. In our scheme, each station transmits packets including a piggyback information to inform that it wants to receive a poll in the next polling duration. Simulation results indicate that our scheme may reduces the packet discard ratio and real-time packet transfer delay.

Keywords : adaptable polling, real-time

Ⅰ. Introduction

Wireless LANs are widely accepted and deployed in public and residential buildings such as classrooms, airports, apartments to support user with mobile terminal. More and more users are accepting wireless LANs as the dominant front-end networking facility to receive online services. With the rapid deployment of wireless LANs, there are growing demands for wireless LANs to provide Quality of Service for real time traffic such as telephony traffic or video traffic. Wireless LANs need to handle fully dynamic real-time traffic loads, which are not evenly distributed over time and location[1]. For example, access points in classrooms expect more intensive traffic demands during lecture hours than at night time; Access points in public libraries are supposed to carry more traffic than those in warehouses[2,3].

IEEE 802.11 wireless LAN standard MAC protocol supports two types of services, PCF and DCF. Asynchronous non-real time traffic is provided by DCF based on Carrier Sense Multiple Access/ Collision Avoidance protocol. Synchronous real-time traffic is served by PCF that implements polling method. Polling-based scheme has some advantages over contention-based scheme in that it is possible to guarantee various QoS requirements to real-time applications. Since real-time traffic is sensitive to delay, and non-real time traffic to error and throughput, proper traffic scheduling algorithm needs to be designed. But it is known that the standard IEEE 802.11 scheme is insufficient to serve real-time traffic since the exhaustive polling method of IEEE 802.11 PCF does not consider traffic characteristics in polling terminals[4].

Noting the difference between performance of DCF and PCF in different traffic scenarios and the fact

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that DCF and PCF coexist in the same access point, we propose a dynamic polling scheme to dynamically adjust the ratio of PCF duration and polling list upon different traffic demands. This polling scheme increases the throughput and the number of real-time connections while maintains real-time traffic quality.

II. IEEE 802.11 wireless LAN network

1. IEEE 802.11

The IEEE 802.11 wireless LAN system has a Basic Service Set which is defined as a group of stations that are under the direct control of a single coordination function i.e., DCF and/or PCF. Each station directly transmits to any other stations in the same BSS. The 802.11 MAC layer protocol provides asynchronous, time-bounded, and contention free access control on a variety of physical layer. These functions are independently provided of the characteristics of the underlying physical layer and/or data rates. The basic access method in the 802.11 MAC protocol is DCF which is known as CSMA/CA. In addition to the DCF, the 802.11 also incorporates an alternative access method known as the PCF - an access method that is similar to "polling" and uses a point coordinator (PC called the AP) to determine which station has the right to transmit. The PCF has been developed for providing real-time services. In this paper, we focus on the PCF, since we are interested in examining the ability of the IEEE 802.11 draft standard to support real-time services[5].

2. PCF Mode

The PCF is built by using the DCF through the use of an access priority mechanism that provides synchronous or asynchronous data frames contention free access to the channel. The PCF access method is derived from the classical Time Division Multiple technique. The PCF relies on the point coordinator to perform polling, enabling polled stations to transmit without contending for the channel. Each station can transmit one data frame upon receiving a polling frame. The access point within each BSS usually performs the function of the point coordinator. The point coordinator determines which station should be polled for data transmissions. Without the uncertain delay caused by collisions, PCF provides bounded delay and is suitable for transmitting data generated by real-time applications.

The CFP repetition interval is used to determine the frequency with which the PCF occurs. The duration of the CFP repetition interval is a manage- able parameter. It is up to the point coordinator to determine how long to operate the CFP during any given repetition interval. The maximum length of the CFP is chosen such that at least one maximum sized IEEE 802.11 data frame, henceforth referred to as a MAC Protocol Data Unit can be transmitted in the contention period. If traffic is very light, the point coordinator may shorten the CFP and provide the remainder of the repetition interval for the DCF. However, the maximum size of the CFP is determined by the manageable parameter CFP_Max_ Duration. The minimum value of CFP_Max_Duration is determined by the time required for the point coordinator to send one data frame to a station, while polling that station, and for the polled station to respond with one data frame.

The CFP may be shortened as illustrated in Fig 1 if DCF traffic from the previous repetition interval carries over into the current interval. For example, if a station with non real-time traffic starts transmission just before a superframe and lasts longer than the remaining contention period, the point coordinator has to defer the start of its real-time traffic transmission until the medium becomes free for a PIFS. The maximum delay that can be incurred is the time it takes to transmit a maximum MPDU and ACK.

3. Polling List

Only the stations in the polling list maintained by the point coordinator are eligible to receive polls. When a station joins a BSS, it can ask to be appended to the polling list by sending the Association Request frame with the CF Pollable subfield set to be

TRUE. If a station is not in the polling list at the beginning, it also can send Reassociation Request frame to do that. If a station is in the polling list initially but it doesn't want to be polled late, it can send Reassociation Request frame to the point coordinator. Accordingly, the point coordinator will remove the station from the polling list.

This paper assumes that there are two way traffics between the point coordinator and station. Traffic from the point coordinator to stations and traffic from a station to the point coordinator or other stations are called outbound traffic and inbound traffic namely. The point coordinator may use CFP to transmit broadcast or multicast frames. We only consider the poll scheduling for inbound traffic.

4. PCF Access Method

Once the CFP has begun the Ap senses the medium and if idle waits a PIFS by setting this timer the normal timeout method is used. Then a beacon is sent out. Then the Ap after timeToTxBeacon+SIFS transmits either a poll or a poll+data. If a poll is sent then the state of the Ap is set to TxPoll and the timer is set to waitForAck and if a response is not received within this time the Ap will poll the next STA. On reception of this poll the STA checks the buffer for a packet and if there is none an Ack is sent (state TxAck).

If the STA has data to sent then a Data+Ack will be sent. When the Ap receives a Data+Ack (state TxDataAck) it will send a piggybacked Ack in the next frame. If the Ap has a packet to send to a polling STA next in the list a poll+data frame is sent (state TxPollData timer waitForAck). If the Ap detects that the time left is below minDataTx + timeToTxEnd than an end frame is sent.

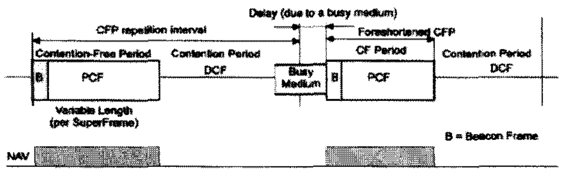

Fig 1. 802.11 operation for PCF and DCF access methods in the same BSS

Ⅲ. New polling scheme

We consider a BSS network that employs PCF and DCF functions using a time-sharing mechanism. When PCF is used, the network is in a CFP and the stations do not compete for transmitting their frames. Each CFP begins with a Beacon frame transmission and alternates with the CP. The PC generates its Beacon frame at predetermined time instants, which are defined by the CFP Repetition Interval parameter and determine the so-called Target Beacon Transmission Time . The length of CFP is based on the available traffic and the size of the polling list. The PC may terminate any CFP round at or before a maximum duration, called the CFPmax Duration. The actual duration of CFP and CP may vary and all timing parameters that determine the coexistence of PCF and DCF are contained in the Beacon frame.

Each real-time service station desires to make a request to the Point Coordinator and if the request is accepted by the PC, the requested station is placed on the PC's polling list. When the CFP starts, the PC sends a CF-Poll to the first station in the polling list. This station sends its real-time packet, no later than SIFS time after receiving the CF-Poll from the PC and the PC waits a PIFS interval following the ACK frame, before polling the next station in the polling list. If the polled station has no frame to send, the response shall be a NULL frame. The PC terminates the CFP with a CF-END frame. A real-time service packet is transmitted per time when the station is being polled by the PC.

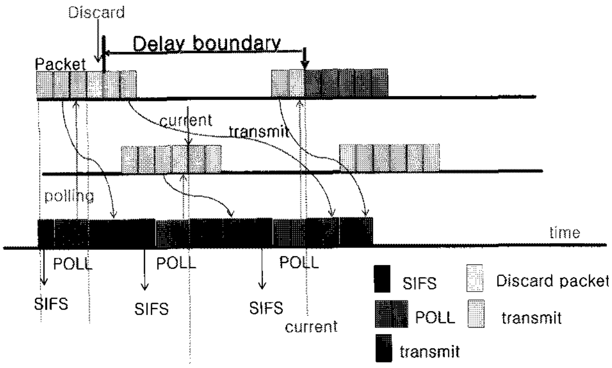

Fig 2. Proposed polling scheme

Table 1. System parameters

Parameter	Value
Channel rate	11Mbps
Slot	40us
SIFS	20us
PIFS	40us
DIFS	30us
CFP repetition interval	10ms
CFPmaxDuration	30ms

Therefore, in order to spread the rejection rate to all pollable stations in the network and by exploiting the characteristics of the real-time traffic model, we propose a new polling scheme in figure 2.

The basic functionality of this dynamically adaptable polling scheme is the following.

At the beginning of each PCF round, the PC polls the first station on its polling list. The PC maintains information of each polling list which are a packet generation time and a queue length.

The PC updates polling list when the PC receives the polled packet that includes the time when the next packet generates and whether it is existed in queue length of delay jitter boundary. This information are included in reserve part in duration field.

Each station, it sends it's requirement state during next CFP when station received poll.

The next CFP_Max_Duration depends on the polling list's state.

At the beginning of next CFP round, the polling starts the next polling list.

During a PCF round, the PC sequentially polls the stations according to the current polling list. In each round, the PC marks polling information on its polling list when it receives polled packet from each station. The PC shifts its list by one position for its start point and then determines the polling list for the next PCF round. All stations are sequentially served according to their position on the polling list. If the last station is polled and CFP_Max_Duration is remained, the PC repeats the same procedure. This procedure decreases real-time packet discard and guarantees small and bounded delays.

Table 2. Real-time traffic parameters

Parameter	CBR Voice	VBR video
Mean bit rate	32 Kbps	240Kbps
Packet length	500 octets	1000 octets
Generation model	On OFF	Constant
Max packet delay	60ms	100ms

Ⅳ. Simulation

We describe the simulation setup and results in this section. We compare the basic round-based polling scheme with the adaptive polling scheme proposed in this paper.

1. Simulation models and measurements

We measure the polling schedule on real-time traffic through simulations. 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.

Two traffic models are considered and the traffic parameters are presented in Table 2.

CBR voice traffic: The voice traffic is modeled as a two state Markov process with talk and silence states. The duration of these two states is assumed to be exponentially distributed with parameters 1s and 1.35s, respectively .

VBR video traffic: The video traffic is modeled as a multiple state model where a state generates a continuous bit stream for certain bolding duration. The bit rate values of different states are obtained from a truncated exponential distribution with a minimum and a maximum bit rates[4].

The following two metrics are chosen to evaluate the performance of round robin scheduling scheme and a new scheduling scheme.

Packet delay: the time duration for a packet from entering the local queue to the beginning of successful transmission[6].

Packet dropped ratio: The fraction of discussed packets caused by transmission failures or violation the delay bound.

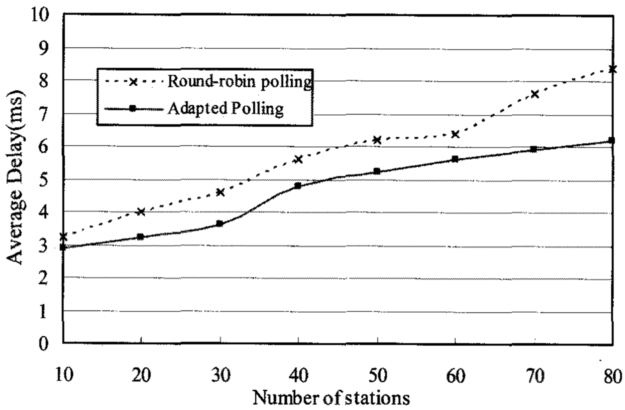

Fig 3. Packet transfer delay

2. Simulation results

Fig 3 shows the effect of changing the number of stations in the simulation on the performance of the average transfer delay. The average delay is increased as the number of the node increases. The average delay of proposed scheme is shorter than the original IEEE 802.11 scheme, since the proposed scheme can reduce the amount of the empty polls.

In Figure 4, we see that the 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 means the remaining time in the delay boundary between a station and the PC instead of end-to-end delay between two communicating stations. The discard ratio for real-time traffic using the proposed scheme stays low.

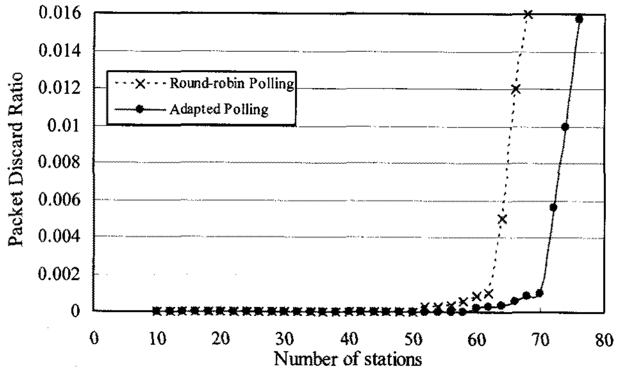

Fig 4. Packet dropped ratio

Ⅴ. Conclusion

In this paper, we propose an adaptive polling scheme to serve real-time traffic with bounded delay requirements. The proposed scheme can increase the performance over that of the round-robin polling scheme.

The proposed polling schedule can support real-time services like audio and video communications in wireless LANs. The performance evaluations show that scheduling model can fulfill the delay requirements and decrement of the packet dropped probability. In the future, we will consider a mechanism to serve the polling requirement on the flow's priority or emergency level. Also we will implement our proposed scheme into hot-spot area.

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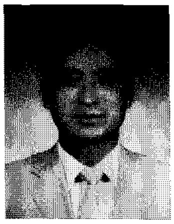

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