A priority scheme for IEEE 802.11 with guaranteeing QoS

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Abstract: In this paper, we proposed the IEEE 802.11 CSMA/CA protocol with the priority scheme. The IEEE 802.11 CSMA/CA protocol is the standard in wireless LAN. We applied the proposed mathod to the aeronautical mobile telecommunication environment. The CSMA/CA protocol has two frames : one is PCF frame for real time service like voice and image and the other DCF frame for contention services like data transmission. Now we proposed the priority scheme that has the different CW region according to the transmitted data. The simmulation results shows the proposed method's performance is improved. Because the collision probability is reduced by allowing the different CW between stations. And the time dalay results show the priority scheme is very appropriated.

1. Introduction

Currently, there two emerging WLAN standards: the European Telecommunication Standards Institute (ETSI) High Performance European Radio LAN (HIPERLAN) and the IEEE 802.11 WLAN. There are also several other proposals under study. Most draft standards cover the physical layer and medium access control (MAC) sublayer of the open systems interconnections (OSI) seven-layer reference model.

In the IEEE 802.11 CSMA/CA protocol, collisions are resolved by a binary exponential backoff algorithm, similar to that used in Ethernet. There are two problems associated with the use of the backoff algorithm.

First, although the algorithm is fair in the long term so that every station has equal access on the average, it is not fair in the short term because it does not give equal access to all the stations competing for the channel. Oftentimes, a station that has just transmitted has a higher chance to access the channel again in the near future. This behavior may cause large variations in inter-channel access delays, an undesirable phenomenon in systems wishing to provide certain qualify of service in access.

And, slots that are more likely to be chosen also are more likely to be chosen twice or more times, in which case a collision would result.

Furthermore, frames in DCF, the basic access method in IEEE 802.11 MAC layer protocol, do not have priorities, and there is no other mechanism to guarantee an access delay bound to the stations. To put it another way, real-time applications like voice or live video transmission may suffer with this protocol. Since the demand for transferring delay-sensitive data in wireless environment is evident from the evolution of new data communication applications, we propose a method to modify the DCF protocol such that station priorities can be supported along with the real time applications in an ad hoc network.

In this paper, by applying CSMA/CA that is the standard in wireless LAN to aeronautical mobile telecommunication, a protocol is aimed at improving a present CSMA performance. Proposed method was intended to adjust backoff algorithm to load state that has a large effect in CSMA/CA, and to fit aeronautical mobile telecommunication environment on a large number of user and a large propagation delay time.

2. Proposed Methods - The Priority Scheme

Basically, CSMA/CA protocol supports that all stations has the same priority. Anytime a station to transmit data access to the channel and generate itself backoff delay time a. A station to transmit data have continuing to descend itself backoff time each Idle time. When backoff time reach to 0, a station transmit data packet. If the transmit error occurs, a station increse the CW(Contention Window) value and generate new backoff delay time. Therefore all stations use the variable random backoff delay for statistics fairness. Show the following equation.

$$\mathit{Backoff\ Delay} = \mathit{INT}(\mathit{CW} \times \mathit{random}()) \times \mathit{SlotTime}$$

CW is an integer between the values of MIB (Management Information Base) attributes aCWmin and aCWmax. random() is pseudo random number between 0 and 1 . This pseudo random number shall have sufficient fractional precision to represent not less than aCWmax discrete values, drawn from a uniform distribution over the half-open interal [0, 1). SlotTime is the value of MIB attribute aSlotTime.

The CW parameter shall take an initial value of aCWmin. The CW shall take the next value in the series(or a higher value) everytime an unsuccessful attempt to transmit an MPDU. The set of CW values shall be sequentially ascending, integer power of 2, minus 1, beginning with a PHY-specific aCWmin value, and continuing up to and including a PHY-specific aCWmax value.

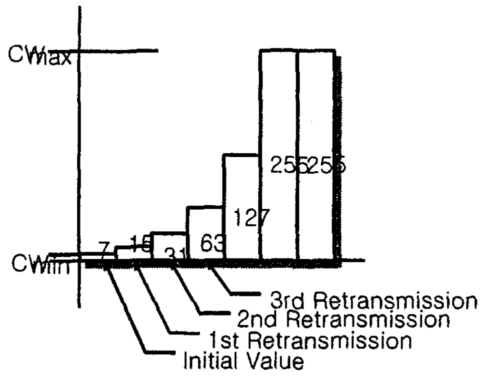

Fig. 1. An Exponential Increase of CW

All stations have the same CW period. This make two problems. First each station have no priority for the generated data packet. And all stations have same CW distribution values, so the probability that a specific CW value is chosen twice or more times is very high. In the high traffic, this make degenerate the system performance. To support priority, we change the backoff algorithm.

Table 1. Priority Table

Priority	Backoff algorithm	Latency
Priority 1	$\lfloor random()\cdot 2^{3+i} \rfloor$	0.62
Priority 2	$2^6 + \lfloor random()\cdot 2^{i} \rfloor$	0.19
Priority 3	$2^7 + \lfloor random()\cdot 2^{i} \rfloor$	0.19

To support priority, we change the backoff time generation function to $\lfloor random()\cdot 2^{3+i} \rfloor$ for first priority stations, $2^6 + \lfloor random()\cdot 2^{i} \rfloor$ for second priority stations and $2^7 + \lfloor random()\cdot 2^{i} \rfloor$ for third priority stations, This technique *divides the random backoff time into three parts:* $0 \sim 2^{3+i}-1$, $2^6 + 2^{3+i} \sim 2^{3+i}-1$ and $2^7 + 2^{3+i} \sim 2^{3+i}-1$. The higher priority stations use the former and the lower priority stations use the latter. Please note that dividing the backoff time in more detail can support more levels of priorities. Low priority stations still have to generate a longer backoff time even when no high priority stations want to transmit. Fortunately, the Slot_Time used in IEEE 802.11 standard is relatively small when compared to the other frame formats, so delay is tolerable.

The proposed backoff algorithm procedures follows:

1. When packet generated , give the priority for packet.
2. In the first stage, set the backoff delay time by using Priority Table
3. In the case of Busy state, maintain the backoff delay time
4. In the case of Idle state, decrease the backoff delay time
5. When backoff delay reach to 0, transmit a packet
6. When error occurs, increase CW value two times by using Priority Table and retransmit packet.

So the CW occupy region for priority is divided to three regions. Show the following Fig. 2.

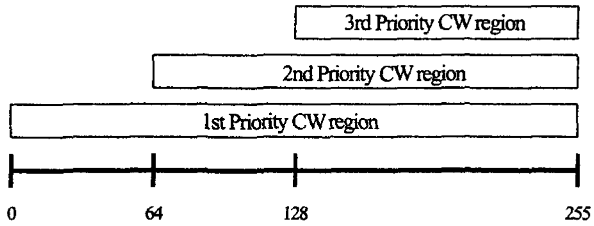

Fig. 2. The CW occupy region for Priority

3. Performance Analysis

Following CSMA/CA, when a station has a packet to transmit, it has to wait until channel idle for a period of time called IFS. After channel idle for IFS, it uses a random number generator to set a random backoff time. In the coming slots, the station decreases its backoff time by one if it finds channel idle. In case channel is found busy, the backoff time counting should be frozen till channel being idle for IFS again. In addition, a station transmits an acknowledgement after receiving without error. The whole transmission mechanism is shown in following Fig. 3.

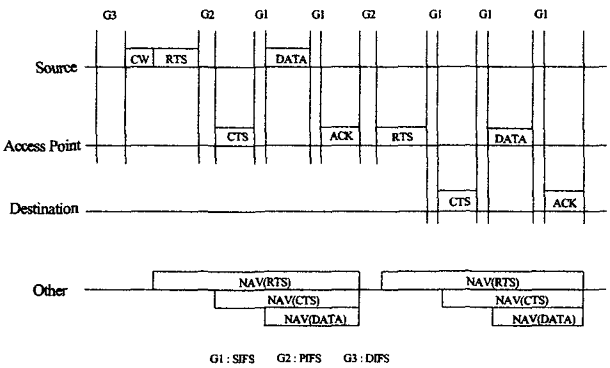

Fig. 3. IEEE802.11 transmission mechanism

In our 2-D finite state Markov chain, it is clear that we have only one class hence it is an ergodic system. Therefore we could calculate out stationary probabilities $\pi(S)$. Also we could calculate the average holding time H(S) and successful transmission probability $P_{SUC}(S)$. Define *Packet_Time* to be the length of a packet hence we could have a throughput formula as:

$$Throughput = \frac{\sum_{all\_state\_S} \pi(S)\cdot P_{SUC}(S)\cdot Packet\_Time}{\sum_{al\_state\_S} \pi(S)\cdot H(S)}$$

4. Simulation & Results

We have carried out simulations to evaluate the IEEE 802.11 CSMA/CA protocol with the priority scheme. Performance is evaluated by the number of contention slots to resolve the use of the channel and the inter-channel access delay by the same station.

The following Fig.4a, 4b show the CW attempt number comparing to the basic CSMA/CA and the CSMA/CA with priority scheme. The CSMA/CA with priority scheme have the wider CW values than the basic methods. This result show that the priority scheme assigned the different CW region for priority. So the priority scheme has the efficient load adaptive ability.

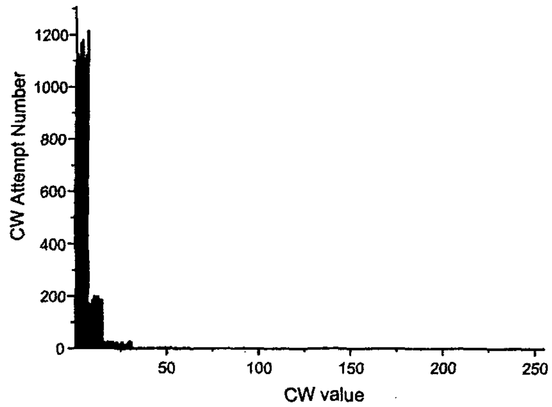

Fig. 4a. The Basic CSMA/CA

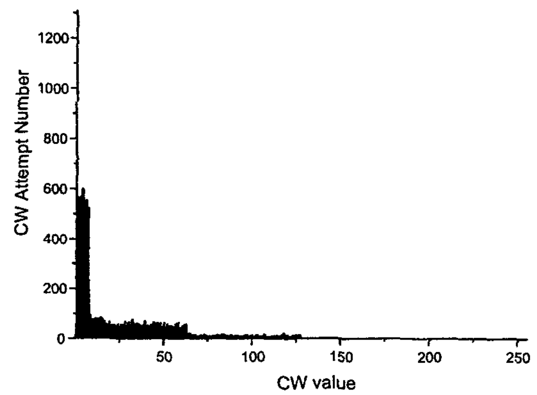

Fig. 4b. The CSMA/CA with priority scheme

Fig. 5 shows throughput as protocol mathods. Now we compares with five mathods : Pure-ALOHA, non-persistent CSMA, CSMA/CD, CSMA/CA and CSMA/CA with priority scheme.

The proposed method' s performance is better than the IEEE 802.11 CSMA/CA, specially more stable in the high traffic load. Also, comparing to non-persistent CSMA that has been used in AMC, the proposed method has the higher throughput performance. Because the collision probability is reduced by allowing the different CW between stations.

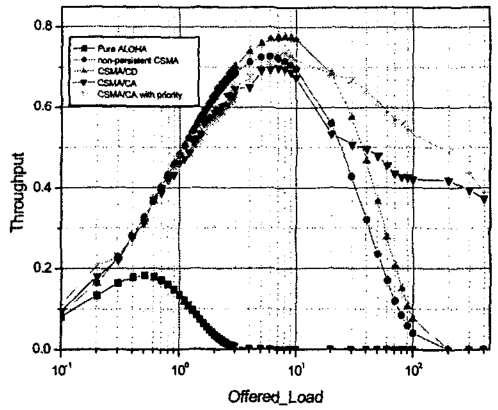

Fig. 5. Throughput as Protocol mathods

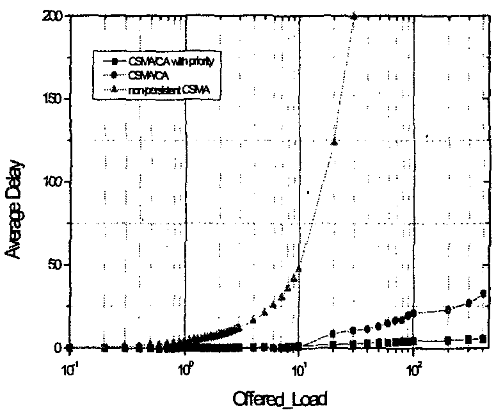

Fig. 6. Time Delay as Protocol mathods

Fig. 6 displays time delay as protocol mathods. Now we compare the CSMA/CA with priority scheme to non-persistent CSMA and CSMA/CA. The CSMA/CA with priority scheme has the lower transmission time delay than other methods.

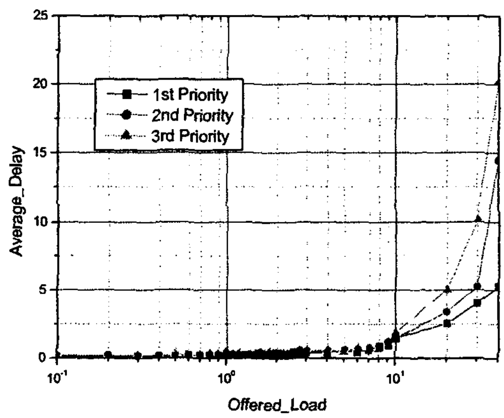

Fig. 7. Time Delay as Prioritys

Fig. 7 shows the time delay as priority. The first priority' time delay increase slowly by the offered load increasing. But The second and third priority' time delay increase rapidly by the offered load increasing. So in the environment of high traffic, the higher priority, the lower time delay. The priority scheme operates properly in the network.

5. Conclusions

In this paper, we have descrived the design and performance evaluation of the IEEE 802.11 CSMA/CA with priority scheme in the one-cell scenarios. Our simulation' s results have confirmed that the IEEE 802.11 CSMA/CA protocol with the priority scheme is an efficient scalable and fair protocol.

The proposed method have the wider CW values than the basic method. The simulation results show the priority scheme has the efficient load adaptive ability.

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