Arrival Prediction Based Reservation MAC for the Next Generation WLAN

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Abstract. Wireless Local Area Network (WLAN) has been greatly developed for the last twenty years. Quality of Service (QoS) and Quality of Experience (QoE) in high-dense deployment scenario greatly challenges the next-generation WLAN [1]. To address this challenge, researchers proposed channel reservation mechanism for WLAN, but the premise of channel reservation mechanism is to know the next packets exact arrival time. This assumption is impractical since the next packets arrival time is a stochastic process. In order to solve the above problem, this paper proposes an arrival prediction based channel reservation media access control (MAC) for the next generation WLAN. Simulations show that the protocol can reduce the network collisions generated by concurrency to a certain extent and improve network throughput.

Keywords: WLAN · Prediction · Channel reservation · MAC protocol

1 Introduction

In recent years, the rapid development of wireless communication technology has brought great convenience to our lives. For example, the usual communication tools such as smart phones and Bluetooth headsets rely on wireless communication technology. Wireless communication technology plays a huge role in today's society, and all aspects of our lives are related to wireless communication technology. It can be seen that the wireless network attracts more and more users because of its high flexibility and convenience, which leads to the rapid growth of wireless data traffic worldwide. In the face of such a huge increase in wireless business, countless people in the industry have gone on to research on wireless networks. As a key component of wireless networks, WLAN has received great attention from industry and academics. It is expected that the next-generation WLAN standard IEEE 802.11ax will be officially promulgated in the second half of 2019 [2].

As the number of users continues to increase, so does the need to access wireless networks. The growing distributed wireless network allows users to access the wireless network at any time. In order to make the channel resources in the

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network more fully available, the multiple access technology has long been one of the research hotspots. The WLAN multiple access is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) technology [3]. For example, our most common enhanced distributed channel access access (EDCA) channel method is based on CSMA/CA. A competitive access method with service priority enables high-priority services to achieve higher quality of service. At present, there are four queues in the common EDCA mechanism, which correspond to four kinds of services: voice (VO), video (VI), best effort (BE) and background (BK), and different services enter different queues. Different competition windows and different inter-frame spacing (AIFS) are set for each queue to make the competition priority when accessing the channel [4]. When accessing a channel, there is a different priority when competing. If a site has a service that needs to access the channel, it first randomly selects a backoff value from the backoff window of its own service, and then detects whether the channel is idle. If the channel is idle, it performs a backoff process. Once it is backed off to zero, The data frame is started to be transmitted. If the channel is busy during the backoff process, the backoff does not continue. The current backoff time is suspended, and when the channel becomes idle again, the backoff is resumed. After the data frame is sent, if the destination station successfully receives the data frame, after a period of time, the destination station sends an ACK acknowledgement frame to the source station. If the source station successfully receives the ACK acknowledgement frame, the transmission is Successful, otherwise the transmission fails, and the data frame is retransmitted after waiting for a while. The above is the specific implementation process of the EDCA mechanism. It is characterized by distributed access based on random competition. If there are more users in the network and the traffic is relatively large, these users want to transmit data through CSMA/CA. It is possible to cause multiple users to simultaneously transmit data on the channel, thereby causing mutual transmission and interference between each other, causing conflicts, and data transmission failure [5]. Conflicts and interferences are mainly caused by random competition of stations and competing for shared wireless channels to transmit data [6]. Conflict and interference are important features of WLAN systems, especially for next-generation WLANs for high-density deployment scenarios. The channel reservation technology broadcasts the time of transmitting the next data packet when the current data packet is transmitted, and the neighboring node reasonably avoids the time of the reservation, Thereby alleviating the conflict of the congested channel.

Channel reservation protocol is divided into synchronous channel reservation and asynchronous channel reservation. As is shown in Fig. 1. Synchronization requires strict time synchronization. It divides the time into periodic frames, and then divides each frame into time-slots of equal length. At the beginning of each time slot, the nodes are allowed to compete to obtain channel access. Right, then this node can reserve the channel usage rights of the subsequent slots. The asynchronous mode does not need to divide the time slot, and the reservation of the next transmission time period is performed by the current node data transmission process. This paper adopts the asynchronous channel reservation method to design the protocol.

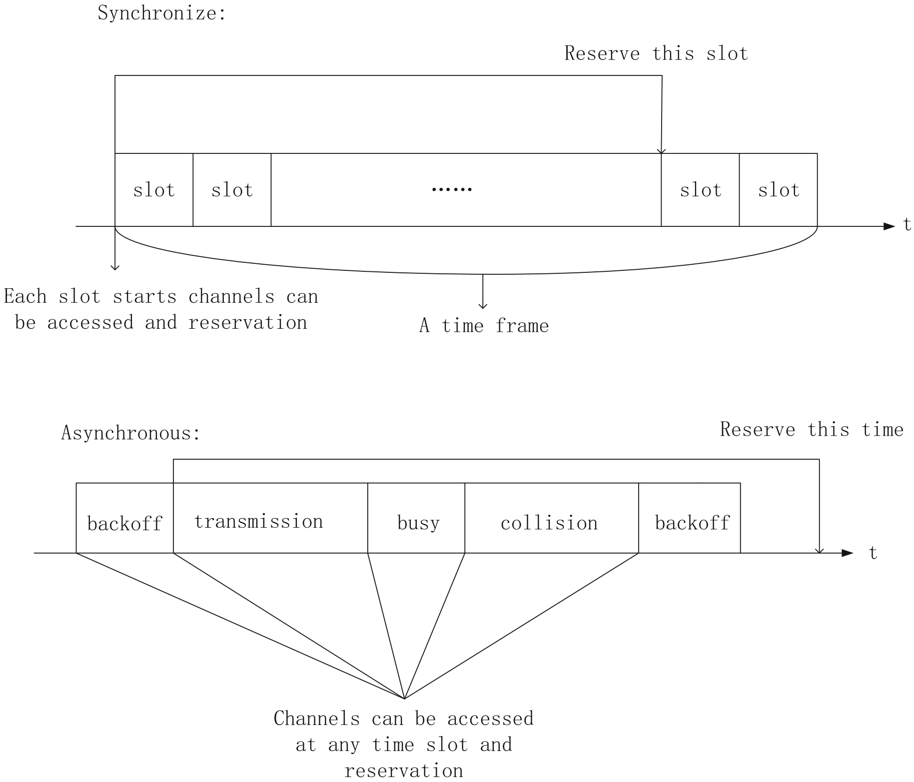

Fig. 1. The difference between synchronous and asynchronous reservation MAC protocol.

At present, there have been many researches on the channel reservation mechanism, such as A channel reservation based multi-channel MAC protocol with serial cooperation for the next Generation WLAN [7], this article focuses on two aspects of capabilities, one is cooperative relay, the other is channel reservation, will These two aspects are skillfully combined to mitigate link collisions. Such as A Cooperative Channel Reservation MAC Protocol with Adaptive Power Control and Carrier Sensing [8], the article will The time resource and space resources of the channel are used together. The main work is to do two aspects. One is to calculate the channel reservation time period, and the other is to adjust the channel reservation space. The former is calculated according to the periodicity of the real-time service, and the latter is Using a combination of power control and carrier sense, this protocol improves QOS for real-time traffic. There are many other studies as shown in the references [9–13]. Various studies have given various solutions for the channel reservation mechanism, but their premise is to know when the next data packet is transmitted, and this assumption is too strong, because the next packet is a random process. Predicting the arrival of the next data packet based on current and historical data packet arrivals is a problem worth studying, which can be done using fitting or machine learning methods, which is not the focus of this paper. This article focuses on how to design a subscription MAC protocol in case the future data packet prediction is not completely accurate. The work done in this paper is to design a reservation MAC protocol for the case that the next data packet arrival prediction is not completely accurate. The core idea is to predict the interval of the next packet arrival based on a prediction accuracy P. The simulation proves that the designed protocol can achieve the effect of throughput improvement and conflict reduction. The chapter structure of this paper is as follows: Sect. 2 introduces the Motivation of this article. Sect. 3 describes the specific design of the protocol. Sect. 4 simulation design and implementation. Sect. 5 Conclusions and future work.

2 Motivation

2.1 Principle of Channel Reservatio

In order to solve the problem of multiple access in the wireless network, the channel reservation mechanism should come out. The channel reservation technique enables the wireless communication link to achieve reliable access to the use of channel resources. The basic principle is to make reservations before using the channel resources. In the traditional CSMA/CA random competition access mechanism, a node needs to complete a series of signaling interactions before sending a data frame, such as channel idle detection, performing a backoff procedure, etc., But access technology based on channel reservation will essentially change the randomness of channel access. Its core idea is that when the node successfully accesses the channel through the CSMA/CA mechanism for the first time, it notifies the neighbor node of the time when the node uses the channel for the next time, and makes an appointment for the channel usage right in advance. when other node know the reservation time of this node and When the reservation time arrives, Other nodes do not participate in channel competition. When the reservation time arrives, this node can access the channel directly and send data in the appointed time period without competing with other nodes for channel usage.

2.2 This Article Motivation

The flow chart of traditional EDCA access channel is shown in Fig. 2. The solid line in the figure is the data normally transmitted and the dotted line is the interference received.

It can be seen that this random competitive access mode will cause multiple users to compete for access rights to the channel at the same time in the case of more users and larger traffic, thus causing transmission interference and transmission failure. This conflict is particularly serious in the case of the deployment of high-density neighbourhoods. However, this kind of conflict can be well avoided by introducing channel reservation mechanism, as shown in Fig. 3.

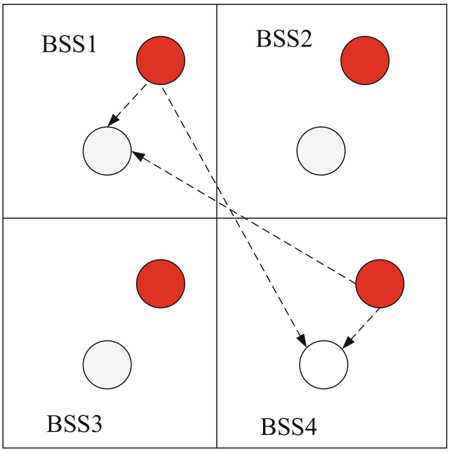

Fig. 2. Conflict occurs when users compete for the channel at the same time.

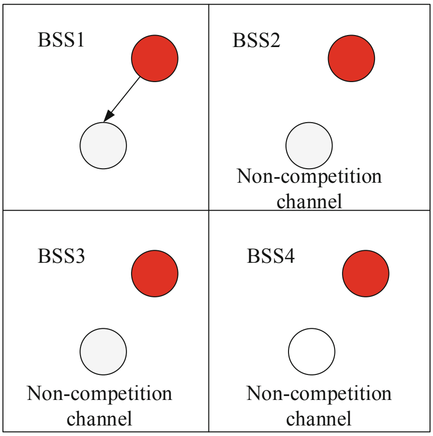

Fig. 3. Reservation mechanism avoids neighbor nodes competing to the channel at the same time.

During the period of reserved time, other nodes do not participate in the competition of the channel, so the node can obtain the right to use the channel and transmit data directly in the reserved time period. Many previous studies have designed reservation mechanism protocols on the premise of knowing when the next data packet will arrive. This paper first predicts when the next data packet will arrive. After the predicted time is obtained, the channel usage right at this predicted time will be reserved. In the appointed time period, the neighbor node will not generate the node. Interference. In order to reduce link conflicts and improve network performance.

3 Protocol Description

3.1 Introduction of Core Ideas

This protocol is mainly aimed at packet-by-packet transmission, does not use frame aggregation and can not accurately grasp when the next data packet arrives. First, we need to predict the arrival time of the next data packet. Then after knowing this prediction time, we design the corresponding channel reservation MAC protocol. Its goal is to reduce the interference and collision caused by neighbor nodes, and weaken the need to know the next one. On the premise of the arrival time of data packets, the performance of this protocol is compared with that of the channel reservation MAC protocol without prediction.

3.2 Protocol Process Design

The MAC protocol process designed in this paper is as follows:

(1) First, the arrival time of the next data packet is predicted, that is, the interval at which the next data packet arrives is predicted immediately after the current data packet arrives. The specific implementation is as follows: The prediction accuracy is defined as $p(0 \leq p \leq 1)$, where $p = 1$ represents that the prediction is completely accurate, and $p = 0$ represents that the prediction is completely inaccurate. Assume that the interval of the next packet is subject to Truncated Normal Distribution, and the mean is Δ. When $p = 1$ represents variance $= 0$, it is similar to the impulse function; when $p = 0$ represents variance $= \infty$, that is, similar to the continuous Gaussian white noise distribution. Thereby, the generation timing of the next packet can be determined based on this distribution.

(2) The node transmits the data packet and sends the predicted packet interval Δ of the next data packet. If a data packet arrives before the $\Delta + \delta$ time, the data packet is sent out at the time of $\Delta + \delta$; otherwise, the data packet is not sent.

(3) Other nodes do not send packets at the time of $\Delta + \delta$ (pre-ordering packets must be guaranteed to end), and if the packet of the reserved node is not heard, the channel can be contending.

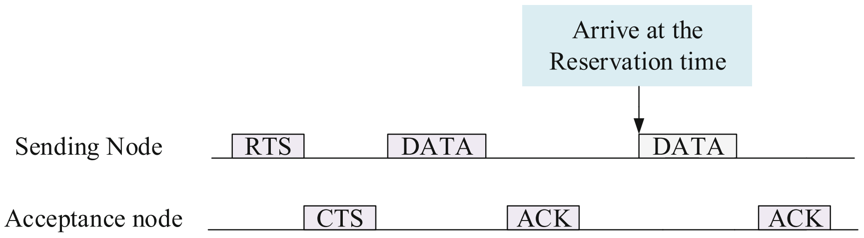

Fig. 4. Reservation mechanism protocol process.

The process is as shown in the following Fig. 4. When the transmitting node has a service request and the transmitting node first contends to the channel, it predicts the arrival time of the next data packet. The transmitting node performs the current data transmission, and carries the predicted time of arrival of the next service in the transmitted data packet, that is, the time of the next use of the channel. When the predicted time comes, I directly send the data packet.

3.3 Frame Format Design

Because it is necessary to carry the information of the reservation time when the node sends the data packet, in order to support this condition, this paper adds a 1-byte information bit in the MAC header to store the reservation information. The modified MAC frame format is designed as follows (Fig. 5):

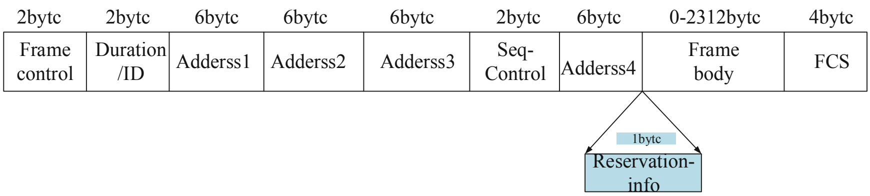

Fig. 5. Frame format.

4 Simulation and Results

On the simulation platform supporting the key technologies of IEEE 802.11ax, the protocol algorithm proposed in this paper is simulated and implemented. Through the writing of the MAC layer code related functions and the simulation scenario configuration, the following simulation results are obtained, and the performance of the protocol is evaluated by the result. In the process of simulation, the EDCA mechanism is used as the basis for simulation comparison with the proposed scheme.

4.1 Simulation Scenario Configuration

Simulation scenario configuration:

- Simulation topology: Configure the cell of 1*2.
- a cell with a side length: 15 m.
- Number of STAs per cell: randomly assign a STA.
- The packet size: 1500 Bytes.
- the maximum transmission time of the data packet: Cancel RTS/CTS, 0.000236 s.
- Simulation duration: 5 s.
- Service MCS: MCS9.

4.2 Performance Analysis

Through simulation, the average DCF chart of the processing delay of each packet is shown in Fig. 6:

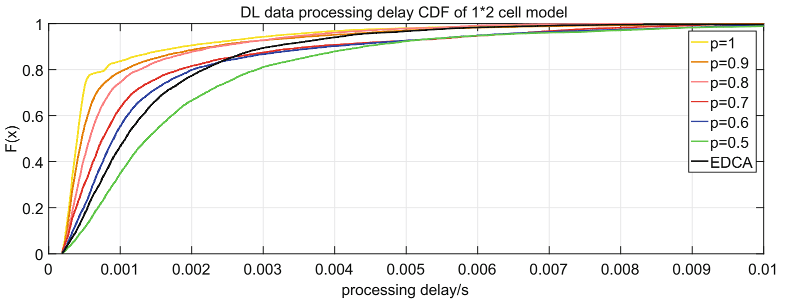

Fig. 6. The prediction is completely accurate.

The predicted probabilities are 1, 0.9, 0.8, 0.7, and 0.6, respectively. The average processing delay of each packet is less than that of EDCA, that is, its performance is better than EDCA.

Change the prediction accuracy P, which is 1 (predictive accuracy), 0.9, 0.8, 0.7, 0.6, 0.5, and count the average throughput of each packet. Compared with EDCA, the result is shown in Fig. 7:

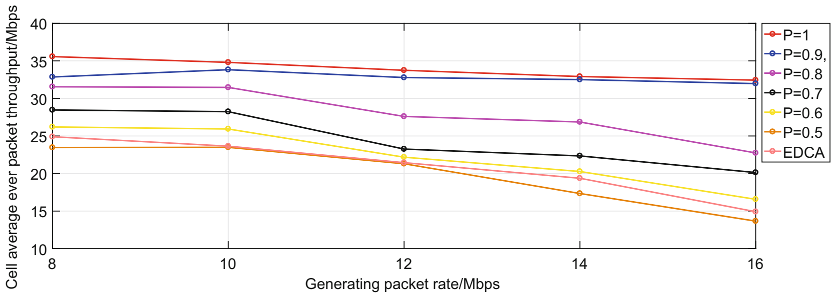

Fig. 7. Performance with different prediction accuracy.

It can be seen that at different service rates, the average throughput of each packet is calculated, P = 1 is greater than P = 0.9 is greater than P = 0.8 is greater than P = 0.7 is greater than P = 0.6 is greater than the EDCA mechanism, indicating the prediction accuracy. When the ratio is greater than or equal to 0.6, the performance of this prediction algorithm is better than that of the EDCA mechanism. When P = 0.5, its performance is the same as or better than that of EDCA, and the result is in line with expectations.

5 Conclusion and Future Works

This paper proposes a channel reservation MAC protocol based on prediction, which is used to make channel reservations. Compared with the EDCA mechanism, the join reservation mechanism reduces the link collision and reduces the packet loss rate. The prediction is added so that the reservation mechanism can still proceed without being able to accurately grasp when the next data packet arrives. The simulation results show that this protocol has certain advantages in some specific situations. However, this paper studies the case of packet without packet aggregation. In future research, we can continue to consider how to perform prediction and reservation in the case of packet aggregation.

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