SVC Based Multiple Access Protocol with QoS Guarantee for Next Generation WLAN (Invited Paper)

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Abstract. With the increasing in demand for video traffic, video service has been becoming more and more diversified. Scaled video coding (SVC) has become one of the most common video code technology to meet the requirements of different video service types. Therefore, SVC based video users quality of service (QoS) guarantee is one of the most basic problems of the network, but there are few studies focusing on the SVC based video users QoS guarantee protocol for the next generation wireless location access network (WLAN). This paper proposes SVC based media access control (MAC) protocol with QoS guarantee for next generation WLAN, referred to as QoS-SVC. If there are some residual sub-channels resource after the first channel contention, the protocol offers another opportunity, named second random contention, for the video users both collided and successful in the first random contention phase and enables them to transmit their data in the residual sub-channels. The simulation results show that the throughput adopting QoS-SVC is improved by 154%, compared with non-second random contention access (Non-SRCA) protocol.

Keywords: SVC · WLAN · QoS · MAC

1 Introduction

With the increasing development of mobile Internet service and the growing prosperity of intelligent terminals, the ability of terminal continues to increase. The people's demand for mobile data shows a trend of explosive growth, especially the increasing in demand for video streaming traffic. From a global perspective, the video traffic in 2014 has accounted for 80% of the wireless network [1].

The wide popularization of video applications makes the video traffic diversified, such as video-on-demand, video conferencing, and video surveillance, coupled with the diversity of the network and the terminal, so the diversity of video traffic is the most basic feature. In order to deal with this feature to meet the needs of different video services, scaled video coding (SVC) has been generated.

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It is a video stream that can be divided into a number of layers by the code technology such as in resolution, quality and the frame rate domain, and then the video traffic can be encoded into a basic layer and multiple enhancement layers. SVC as an extension of the H.264 standard is an approved standard, known as H.264-SVC [2].

In recent years, The widespread use of wireless network has promoted the rapid development of Internet of things(IoT), more and more of IoT and WLAN combination of applications in our real life, and now the emergence of Internet of Things is seen as the third wave of information technology. The development of WLAN and the popularity of mobile smart terminals has made the trend that the way watching the network video gradually moves to the mobile side. So both industry and academic dedicated to researching the key technologies of next generation WLAN. As early as March 2014, the IEEE standards committee formally approved the project authorization request (PAR) and established the IEEE 802.11ax working group. This working group clearly proposed to guarantee the video traffic QoS is one of the important goals of the next generation WLAN in PAR [3].

In order to be able to guarantee the QoS of the video traffic and improve the efficiency of multiple access control (MAC), IEEE 802.11ax standard draft has accepted OFDMA as a key technology currently in the next generation WLAN. That is the introduction of concurrent access and concurrent transmission. In recent years, OFDMA based MAC in next generation WLAN has been a number of researches. Our laboratory the MAC protocol based on OFDMA for the next generation WLAN has been proposed, referred to OMAX [4]. This protocol dramatically improves throughput and MAC efficiency. The other MAC protocol based on OFMDA for QoS guarantee has been recently proposed by our laboratory, referred to redundant accession (RA) OFDMA [5]. This protocol introduces the difference of service type in the access phase, and the video traffic adopts the redundant access mechanism (randomly selects multiple sub-channels to transmit request to frames (RTS)), so that increases video traffic access success probability. However, redundant access to video traffic increases the collision probability of system and is unfair to the background traffic.

For the existing research, the two problems of the QoS guarantee of the video streaming traffic are non-SVC based coding and poor fairness. This paper proposes the QoS-SVC MAC protocol. After all the traffic nodes have finished first random content access, the access point (AP) allocates channel resource for access successful nodes according to their bandwidth requirements. If there are residual sub-channels after allocation, allowing video traffic nodes, including video nodes of collision and successful access in first random content access, make second random content access for transmitting their data in the residual sub-channels after allocation. The simulation results show that the QoS-SVC proposed in this paper can guarantee the fairness and improve the video traffic throughput by 154% compared with the Non-SRCA protocol.

The main contributions of this paper are given as follows:

(1) This paper proposes the QoS-SVC MAC protocol. It guarantees the video users QoS while taking into account the fairness of the low priority user. As far as we know, the MAC protocol proposed QoS-SVC is the first SVC based QoS guarantee for the next generation WLAN, which guarantees the fairness of low priority user and video user's QoS.
(2) Through establishing ns-2 simulation platform, the simulation results show that the video users throughput is improved by 154% compared with Non-SRCA protocol.

2 System Model

This protocol's scenario is based on the basic service set (BSS) of the next generation WLAN to study the QoS guarantee of uplink video streaming traffic. As shown in Fig. 1, in the BSS, there are m uplink video nodes and k uplink background users. Based on the OFDMA mechanism, the dividing sub-channel method is maintained on the AP side. The 20 MHz full channel of the traditional WLAN adopts the fixed division method and divides the whole channel bandwidth into N sub-channels. As the video service will occupy a large part of data in the future wireless network, so we divide the users into two categories: video streaming traffic and background traffic. The video stream traffic corresponds to the real-time constant bit rate (CBR) service which has strict transmission delay. Background traffic corresponds to non-real-time service which generates from the Poisson distribution and requires low QoS that tolerates a certain transmission delay. Of course, the basic idea in this paper can be easily extended to more traffic types. As the uplink access and transmission to the MAC design of next generation WLAN is more challenging, so this protocol is mainly concerned with uplink access and transmission.

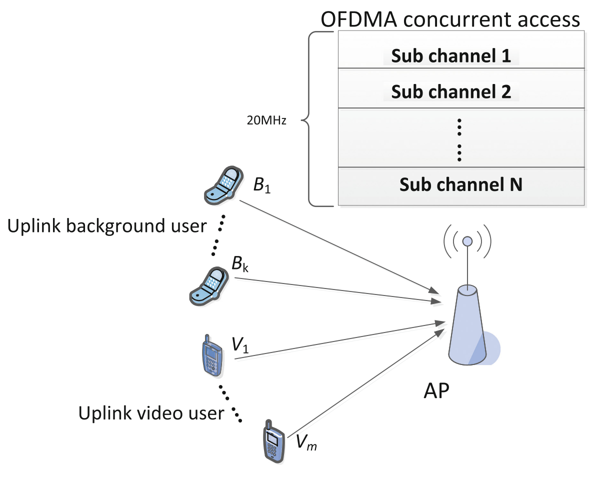

Fig. 1. Network scenario

3 SVC-QoS Protocol Design

This protocol idea isn't introducing additional overhead. It can not only guarantee the video user's QoS requirements, but also make low priority user to have fair transmission opportunities. The basic idea of the protocol design is to guarantee the video user's QoS requirements by introducing the second random contention, allowing both the access successful video users and the collision video users in the first random contention to independently randomly select sub-channels from residual sub-channels after allocation to send their data. As the first random content access phase does not distinguish traffic type, low-priority users and video users have equal access opportunities, to guarantee the fairness.

As shown in Fig. 2, the protocol is divided into three phases, i.e., the first random content access phase, the resource allocation phase and the second random content access and data transmission phase.

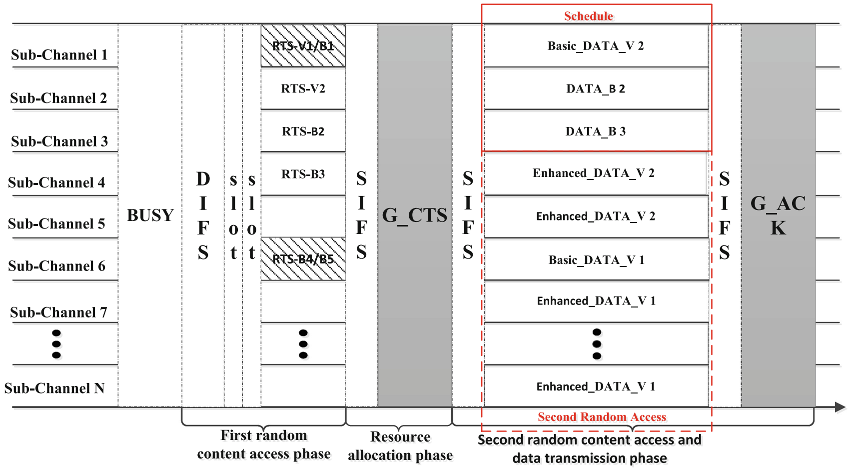

Fig. 2. SVC-QoS MAC protocol

3.1 First Random Content Access Phase

When the node has data to send, it must perform the backoff process same as traditional distributed coordination function (DCF). In order to ensure forward compatibility, this protocol uses the full channel sensing mechanism. That is the user considers the channel is idle if and only if all sub-channels are idle. As long as a sub-channel is busy, full channel would busy, so all users are pending in the backoff process. When the full channel is idle lasting for distributed inter-frame spacing (DIFS) duration, all nodes randomly select a number from (0 contention window (CW)) as backoff value, and begin to backoff. To improve the backoff efficiency, this protocol adopts time-frequency two-dimensional fast backoff mechanism. When the backoff has finished, user randomly selects a sub-channel to send the RTS frame for access. From the access process, it can be seen that the first content access doesn't distinguish traffic type, so all users have the same access opportunities in this stage and thus guarantee the fairness.

The first random content access phase as show in Fig. 2, V1, V2 and B1–B5 have finished backoff, each node independently randomly selects a sub-channel to transmit the RTS frame for channel access.

3.2 Resource Allocation Phase

As the video users using the SVC, so the video users bandwidth requirement is divided into the bandwidth requirement of basic layer data, expressed as m and the bandwidth requirement of enhancement layer data, expressed as Δm. The background users bandwidth requirement is fixed, expressed k. In order to serve more video users and guarantee more video users QoS, AP allocates m sub-channels for the access successful video users to only meet their basic bandwidth requirement. After the channel allocation is finished, the AP generates the group clear to send (G-CTS) piggybacking the sub-channel allocation result. The follow-up protocol process for this phase is the same as the OMAX protocol [4] and RA-OFDMA [5] proposed by this laboratory.

In order to describe the convenience, it is assumed that the video users basic bandwidth requirement $m = 1$, enhanced bandwidth requirement $\Delta m = 2$, and the background user's fixed bandwidth requirement $k = 1$. Other channel allocation algorithms are also suitable for the protocol framework proposed in this paper. Figure 2 reveals AP correctly received the RTS frames of V2, B2, B3, these nodes access the channel successfully. The AP allocates sub-channel 1 to V2 to meet its basic bandwidth requirement, and allocates sub-channel 2 and sub-channel 3 to B2 and B3 respectively, and piggybacks the sub-channel allocation result to the G-CTS frame. However, V1 and B1 select the same sub-channel 1 to send RTS frame, so collision occurs. B4 and B5 also collide as the same reason. So the AP can not receive their RTS frames, i.e., V1, B1, B4 and B5 fail in accessing the channel.

In order to guarantee the video user's QoS, the video users, include successful accession and collision in the first random content access, are allowed to make the second random content access in the residual sub-channel after allocation.

3.3 Second Random Content Access and Data Transmission Phase

The background node of successful access transmites data using allocated sub-channels according to the indication in the G-CTS frame. For the video users of the first random content access successful, the AP only allocates the bandwidth requirements for transmitting the basic layer data. So these video users use allocated channel by the indication in the G-CTS frame to send the basic layer data after the short inter frame space (SIFS) duration, and makes second random content access by randomly selecting Δm sub-channels from residual after allocation to send the enhancement layer data at the same time. The failed video users of the first random content access makes second random content access by randomly selecting $m + \Delta m$ sub-channels from residual after allocation to send the basic layer and enhancement layer data.

As show in Fig. 2, B2 and B3 send data using sub-channel 2 and sub-channel 3 respectively according to the indication in the G-CTS frame. V2 of access successful send basic layer data using sub-channel 1 according to the indication of G-CTS, and makes the second random content access. V2 randomly selects sub-channel 1 and the sub-channel 5 from residual sub-channels after allocation to transmit the enhancement layer data. The failed video user V1 of the first random content access, makes the second random access by randomly selecting sub-channel 6, sub-channel 7 and sub-channel N from residual sub-channels after allocation to transmit the basic layer data and enhancement layer data.

4 Performance Evaluation

4.1 Simulation Configuration

This paper uses the network simulation software NS2 to establish the simulation platform. The simulation scenario is as follows: nodes are randomly distributed in 10 m $*$ 10 m network, AP is located in the geometric center of the network. The single simulation time is 50 s, and the final result is the average of 5 simulation results. In the simulation, since the 20 MHz full channel is divided into nine sub-channels in the draft 802.11ax protocol, the number of sub-channels is also set to nine. The number of video node is fixedly set to 5, and the number of background nodes starts from 5 to 50. The other network parameters are set as shown in Table 1.

Table 1. Parameters

Parameters	Value
$CW_{\min}$	15
$CW_{\max}$	127
$DIFS$	34 µs
$SIFS$	16 µs
$Slot$	9 µs
Whole channel bandwidth	20 MHz
Basic bandwidth	1*subchannel*
Enhanced bandwidth	2*subchannes*
Packet size	1500*Bytes*
Control packet PHY rate	6 Mbps
DATA packet PHY rate	54 Mbps

4.2 Simulation Results

Define the total amount of load that is sent by the video node in the network per unit time for the video traffic throughput. As shown in Fig. 3, because video traffic nodes are allowed to make second random content access to randomly select some sub-channels from residual sub-channels after allocation for transmitting packet data, the throughput of video traffic is higher than the Non-SRCA protocol.

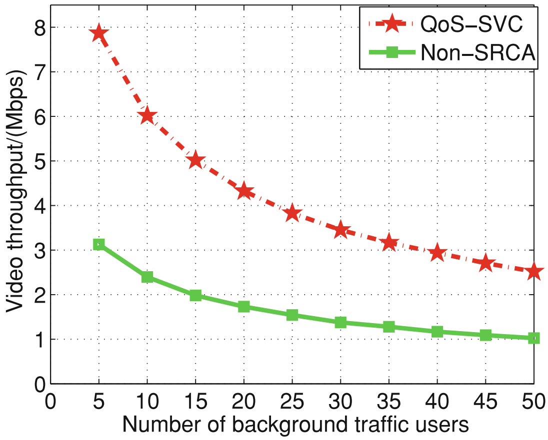

Fig. 3. Video traffic throughput versus the number of background traffic users.

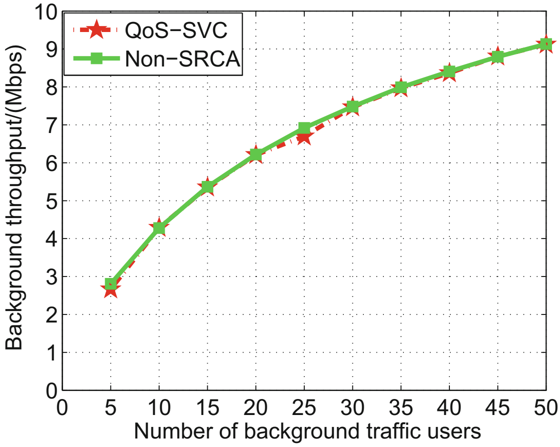

Fig. 4. Background traffic throughput versus the number of background traffic users.

Define the total amount of load that is sent by the background node in the network per unit time for the background traffic throughput. As shown in Fig. 4, the background throughput increases as the number of background nodes increase. We can see that the two curves coincide, so the QoS-SVC protocol proposed in this paper can provide the same fairness as the Non-SRCA protocol.

5 Conclusion

Aiming at solving the problem of SVC based guarantee video users' QoS in the next generation WLAN, this paper proposes the QoS-SVC MAC protocol. The protocol allows video users which access the channel successfully and unsuccessfully in first random content access phase to make second random content access for transmitting their data in residual sub-channels after allocation. The simulation results show that QoS-SVC video users' throughput is improved by 154% compared with Non-SRCA protocol. Follow-up research will be in the multi-channels scenario to further guarantee the video traffic users QoS.

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