

Video Coding and Weight Based Scheduling to Enhance QoS in WLAN

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Abstract: Video Transmission over wireless network suffers a lot of discrepancies in Quality of Experience at the end user. Wireless LAN is adopted widely everywhere even at home because of its simpler installation, cheaper, flexible and reliability. A novel approach Dynamic Transmission Opportunity over Weight Based Scheduling (DTWBS) is proposed to transmit video at end user with enhanced QoS. Dynamic bandwidth allocation is performed over measuring the future traffic demands based on the piggybacked requests made by the QoS enabled stations (QSTA) to QoS enabled Access Point (QAP) for the variable bit rate video. Prior to this, H.264 standard video is being coded with a specified fixed Group of Pictures (GOP) having no two keyframes are aligned to occur within 2 seconds. The offered bandwidth from the QAP is categorized to a dynamic percentage of weights based on different class of frames/slices with their significant information. The Scheduler in our proposed scheme polls the more weight video frame/slice which has more significant information followed by a frame/slice with less significant information. Hence, this approach dynamically uses the bandwidth with improved Quality of Experience at the end user without the loss of less significant frames/slices which achieves fairness.

Keywords: H.264, IEEE 802.11e, quality of service, group of pictures, weight based scheduling.

1. Introduction

To eliminate the issues of QoS guarantees in MAC layer IEEE 802.11 standard [2], the working Group E has defined an amendment to the 802.11 MAC- the 802.11e [3]. The 802.11e [3] is standardized with a new Hybrid Co-ordination Function (HCF) that includes two mechanisms: Enhanced Distributed Channel Access (EDCA) and HCF Controlled Channel Access (HCCA). The EDCA is a contention based scheme whereas HCCA is a contention free scheme. As number of stations increase in a QoS enabled Basic Service Set (QBSS), throughput is reduced and larger end – end delay in EDCA. Also it is a differentiated service which does not provide fairness to the low priority traffic. HCCA is a centralized mechanism which is used for parameterized QoS. So it preferred for VBR traffic by requesting some traffic parameters (data rate, delay, jitter, etc) with QoS enabled stations (QSTAs) [4] to QoS enabled Access Point (QAP). This QAP is collocated with the Hybrid Coordinator (HC) which provides a centralized polling scheme. Although HCCA has some ubiquities like it under utilize the channel resources for VBR traffic, higher signaling overhead and implementation complexity.

H.264 [1] standard was developed and is the latest video coding standard of ITU-T Video Coding Experts Group and ISO Moving Picture Experts Group [1]. The major difference between H.264 standard and other existing standards is the motion estimation scheme. In H.264, the motion estimation along with variable block sizes and multiple reference slices greatly reduces the prediction errors. H.264 Video slices are taken for the analysis of video transmission over WLAN. In our proposed scheme the more important I slices are considered as keyframes and these are aligned with a fixed Group of Picture (GOP). The fixed

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GOP alignment is arranged in a way that no two keyframes occur within less than 2 seconds [12]. The future traffic demand for the VBR video is estimated based on this coded video. The bandwidth which is allocated is categorized to a dynamic percentage of weights based on different class of slices with their significant information. The Scheduler in our proposed scheme polls the more weight video frame which has more significant information followed by a frame with less significant information.

The remainder of this paper is organized as follows. Section 2 discusses 802.11e HCCA standard and H.264 standard overview and related works. A new Scheduling algorithm which improves the quality of experience of the video delivered with dynamic & efficient band width utilization is proposed in section 3. The Conclusion and possible future works are described in section 4.

2. Background and Related Work

2.1. Background

H.264 is the latest international video coding standard developed by ITU-IT Video Coding Experts Group along with Moving Picture Experts Group (MPEG) as a joint effort known as JVT (Joint Video Team) and was first published in 2003 [5]. It is also known as MPEG_4 Part 10 or MPEG-4 AVC. The objective of the H.264/AVC project was to provide a good quality video at substantially lower bit rates than the previous methods, without increasing the complexity of the design, which could make it expensive to implement.

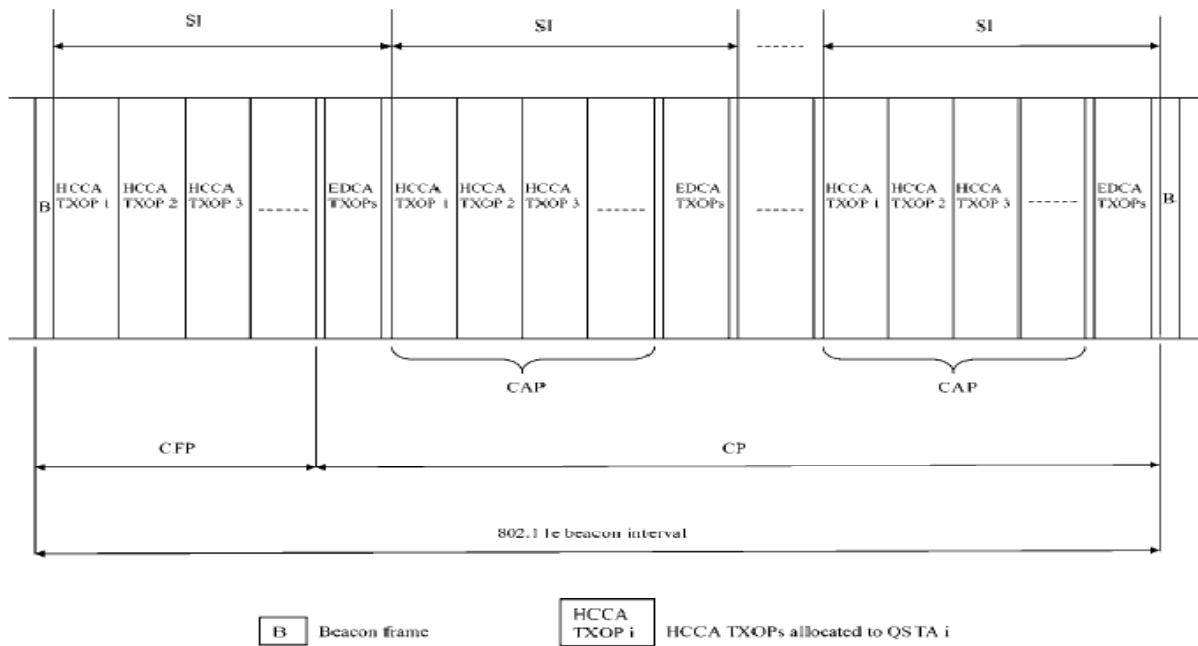


Fig. 1: TXOP allocation with HCF Standard Scheduler

In late 2005, to overcome the QoS liabilities in 802.11 standards, IEEE 802.11e standard was developed, to enhance QoS for LAN applications. It was mainly developed for delay-sensitive applications. This standard makes use of HCF (Hybrid Coordination Function). In HCF, two channel access methods are used: HCF Controlled Channel Access (HCCA) and Enhanced Distributed Channel Access (EDCA). To support parameterised QoS, 802.11e defines the HCCA that can operate during both the contention period (CP) and the optional contention-free period, as illustrated in Fig 1. Controlled access phases (CAPs) are defined as intervals when the HC that usually resided within the QoS-enabled AP (QAP) controls the medium. The HC can initiate a CAP in the CP after the channel has remained idle for at least a PIFS inter-frame space (PIFS) interval by sending a QoS CF-poll frame to allocate HCCA transmission opportunities (TXOPs) to the QSTAs. The HC divides the beacon interval into SIs of equal length and polls QSTAs on a round-robin basis during each SI. To decide the SI, the HC determines the minimum value of all the maximum SIs that are required. It chooses the SI as the highest submultiple of the beacon interval, which is inferior to the

minimum of all the maximum SIs that are required. Subsequently, the HC allocates TXOPs to the different admitted TSs. The number of packets arriving in the TS queue j of the QSTA i during one SI is

$$N_i^j = \left\lceil \frac{\rho_i^j \times SI}{L_i^j} \right\rceil \quad (1)$$

Where ρ_i^j is the mean data rate and L_i^j is the nominal MSDU size. Subsequently, the TXOPs, T_i^j are computed as follows

$$T_i^j = N_i^j \left(\frac{L_i^j}{R} + 2 \times \text{SIFS} + \text{ACK} \right) \quad (2)$$

Where R is the physical layer transmission rate, SIFS the short inter-frame space and ACK the time taken to transmit an acknowledgement packet.

Although the reference scheduler is easy to implement, it has some limitations in satisfying the QoS requirements for diverse applications. The reason is that the HC always allocates a fixed amount of TXOPs according to the mean data rate and the average frame size. This is more appropriate for CBR traffic because the bandwidth requirement is fixed and the required bandwidth has to be reserved for a CBR flow at the call setup time. With respect to VBR traffic, this will lead to the low utilisation of the reserved bandwidth or to packet loss (intolerable delay / jitter), as the granted fixed capacity cannot cope with the unexpected increase in the instantaneous bandwidth requirement

2.2. Related work

To improve the performance of a Standard Scheduler, several scheduling schemes have been proposed by various researchers.

Fairness among all types of traffic such as data, bulk data, voice & video by sacrificing throughput [6] when compared with the standard scheduler. Dynamic Bandwidth allocation is achieved for variable bit rate traffic [4] by measuring the required amount of bandwidth for future traffic demands by piggybacking but the author does not consider the starvation of low priority traffic. A class based queuing mechanism was introduced to provide fairness in WLAN [7] but the maximum bandwidth allocated to a class is fixed and it is not possible for any class to acquire more bandwidth than the maximum allocated bandwidth even if there is unused bandwidth available in other classes.

A simple earliest deadline first scheduling discipline used to address the issues of MPEG video services over 802.11e HCF [8], but the characteristics of MPEG video is not considered. Another scheduling scheme uses queue length estimation to tune the resource allocation for VBR services [9], this estimation is based on unreal assumption that transmission rate of VBR follows a Gaussian distribution & therefore it cannot accurately predict the requested resources. The characteristics of H.264 video stream delivery is implemented through cross layer interaction in EDCA mechanism [10] [11] but not adopted using HCCA centralized channel access mechanism defined for parameterized QoS.

3. Dynamic Transmission Opportunity over Weight Based Scheduling

In this section we present the proposed algorithm to improve QoS of the H.264 video delivered over WLAN, names, Dynamic TXOP over Weight Based Scheduling (DTWBS). We introduce a coding which keeps the keyframes aligned not to appear less than 2 seconds, bandwidth measured for the future demand VBR traffic, & with this bandwidth is categorized into different percentage of weights being assigned for H.264 video slices. Basically our approach is divided into three modules, Video Coding, Dynamic BW measurement and Weight Based Scheduling.

3.1. Video coding

In H.264, IDR and non-IDR I frames have different meaning. IDRs (Instantaneous Decoding Refresh) are ‘traditional’ I-frames the way they were known in previous standards. An IDR i-frame allows subsequent frames reference itself and the frames after it, thus marking a closed GOP. This behavior resets the decoder completely and thus guarantees reliable seeking. A non IDR I frame can be understood as an intra-coded P-frame, they can be referenced by preceding B-frames, which improves picture quality (especially in high

motion scenes) and reduces I-frames flicker effect by smoothing the P-to-I frame transition. The side effect of non-IDR frames that they can reduce seeking precision or increase decoder start-up time.

The bitrates at IDR keyframe intervals must be carefully considered. This interval affects the seeking performance, decoder playback start-up time, recovery time from network errors, and overall picture quality.

It is suggested to keep the keyframe interval at a static distance of no less than 2 seconds for short form content and no less than 3 seconds for long form content, across all bitrates. If keyframes are spaced closer than 2 seconds, resulting response is going to be better for heuristic bit rate changes, but video quality will suffer. Keyframes are much larger than intermediate frames. If the keyframe rate is taken from one every 2 seconds to one every 1 second, the data rate is nearly doubled if everything else is held constant. The goal is to provide a file at a given download bitrate, thus not all elements can be held constant. Instead, the video quality must be reduced proportionately, to get the data rate down. So increasing the keyframe rate reduces the video quality.

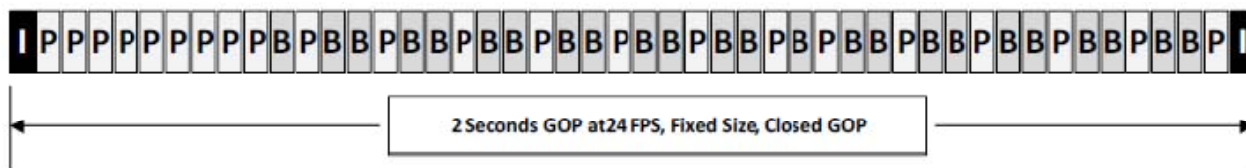


Fig. 2: Keyframe in a fixed GOP

In other words, going from 1 to 2 second keyframe interval will mean that almost 2x the bitrate is available for quality improvement, and going from a 2 to a 3 second keyframe interval gives another 50% and so on. The alignment of the keyframe in a fixed GOP with 2 seconds interval is shown in fig 2.

3.2. Dynamic bandwidth measurement

It is discussed in [4], reserving a certain amount of bandwidth and dynamically allocating this bandwidth for the remaining part of the VBR portion will improve the QoS for compressed digital video. Accordingly a dynamic bandwidth measurement scheme is proposed, that reserves a certain amount of VBR video requirement during a call setup time. At each Service Interval (SI) the HC allocates this reserved part to the video stream. Requested bandwidth for the remaining VBR portion of the video stream will be sent along with the transmitted data. The requested bandwidth is allocated for the video stream through HC by processing the piggybacked requests.

The proposed scheme is explained in Fig 3. The HC polls the QSTA with a TXOP which is lesser than the required bandwidth of the first data unit video slice with overhead SIFS and ACK. The QSTA transmits a portion of 1 video frame as 1(a) also transmits the piggybacked requests for 1(b) & 2. Now the QSTA is allocated with the remaining bandwidth and the QSTA transmits the remaining portion of VBR and again the request made for the next portion of VBR.

A dynamic allocation has to be provided for the video stream, since the VBR video exhibits rate variability. So TXOPs of all QSTAs are periodically monitored and adjusted dynamically according to the required TXOP with the following measurements [4]. (1) assigned_bw (n), which represents the bandwidth allocated to the video stream during nth SI. (2) Unused_bw (n), which indicates the unused portion of the assigned_bw (n). (3) txop_request (n), which is the amount of traffic demand sent through piggybacked requests. Initially QAP computes the assigned_bw (n+1) based on the assumptions made in [4]. From the assumptions it is illustrated that reserving bandwidth in the current and previous SI can be used to estimate the demanded bandwidth for the next beacon interval.

3.3. Weight based scheduling

A different weight adjustment algorithm is proposed in [6], which is used for the allocated bandwidth from the QAP to QSTA. This allocated bandwidth is differentiated according to the different classes of TSID value range from 8 through 15 of HCCA assigned in the layer above MAC. Each video slice can be assigned

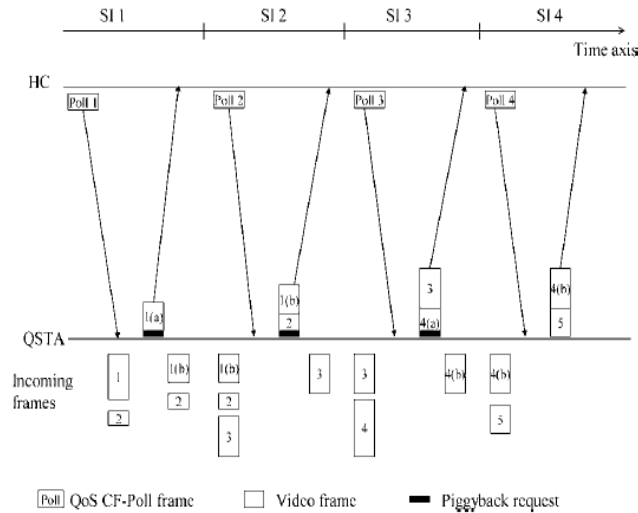


Fig. 3: Dynamic Bandwidth Measurement

Table. 1: Classification and Bandwidth allocation

TSID	Class	Type of Video Slice	Initial Weight
8	1	B Slice	10 %
9			
10	2	P Slice	20 %
11			
12	3	I Slice	30 %
13			
14	4	Parameter Set information	40 %
15			

a weight as a percentage of the total bandwidth as shown in Table 1. The weight adjustment algorithm can dynamically change the weights according to the algorithm proposed in [6].

4. Conclusion

In this paper, we have proposed a method of dynamic allocation of bandwidth with weight adjustment scheduling which improves the network utilization. The bandwidth is efficiently utilized and the throughput of the network is improved without any loss of video slices. Fairness is maintained between the less significance information of B and P Slices without keeping them idle for more than two MSI. A different encoding method is implemented in which the keyframes are not aligned to occur within 2 seconds, this is due to the change in bit rates. Possible future works of calculating the bandwidth measurements by QSTAs can be extended.

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