International Journal of Computational Intelligence and Informatics, Vol. 4: No. 1, April - June 2014

Adaptive TXOP Allocation Based on DiffServ for QoS Enhancement in IEEE 802.11e WLAN

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***Abstract-* IEEE 802.11e WLAN has provided a new access mechanism called the hybrid coordination function (HCF) for quality-of service (QoS) support[1]. Here, we provide HCF scheduler to allocate transmission opportunities (TXOPs) for the stations. TXOP is the time under which a station can send its burst of data packets to other stations. An station can be either in the good or bad channel state and it can be either in constant bit rate or variable bit rate. In the HCF scheduler, channel interference, busty traffic streaming and packet loss causes insufficiency in the strict periodic TXOP allocation scheme. In this, we propose a mechanism of adaptive TXOP allocation. This method works in accordance with channel and traffic conditions, adaptively to compute. The computation is carried by using Differentiated Service (DiffServ) and prediction, providing more access to the time-bounded multimedia applications such as Voice over IP (VoIP), videoconferencing etc…**

Keywords- IEEE 802.11e, QoS, Transmission Opportunities (TXOPs)

I. INTRODUCTION

IEEE 802.11 Wireless LAN standards describes the physical layer and the Media Access Control (MAC) layer of the network. It defines the Distributed Coordination Function (DCF) and Point Coordination Function (PCF) mechanisms for transmission. DCF is asynchronous, contention based, distributed algorithm mainly used for Adhoc networks. PCF is synchronous, polling based, contention free, centralized algorithm for infrastructure network. In Wireless communication systems the key challenges that must be overcomed is to realize the practical benefits of Quality of Service (QoS) [3].

IEEE 802.11e defines a set of Quality of Service (QoS) enhancements for wireless LAN applications through modifications to the MAC layer. IEEE 802.11e has provided a new access mechanism called the Hybrid Coordination Function (HCF) for QoS support. There are two methods of channel access in HCF namely HCF Controlled Channel Access (HCCA) and Enhanced Distributed Channel Access (EDCA). In EDCA, high-priority traffic has a higher chance to be sent than low-priority traffic. EDCA provides contention-free access to the channel for a period called a Transmit Opportunity (TXOP). In HCCA the interval between two beacon frames is divided into two periods such as Contention Free Period (CFP) and Contention Period (CP). During the CP, all stations function in EDCA, and in CFP send/receive is initiated by Access Point (AP).

II. RELATED WORK

Many works has been reported on the performance of DCF, EDCA and HCCA. Most of the works on EDCA were focused on the AIFS and CW schemes. Xiao [7] proposed a two dimensional Markov chain model for differentiating the CW. Ramaiyan, Kumar, and Altman [8] proposed an analysis model with a fixed point to capture AIFS and CW differentiation and providing a condition for the uniqueness of the fixed point. Many works have been proposed to improve HCCA’s polling efficiency by optimizing its traffic scheduler. Grilo, Macedo and Nunes[9], presents a scheduler in which the common service interval in original HCCA is replaced by various service intervals for different streams of data scheduling.TXOP scheme support service differentiation and also improve the network utilization, thus experiments of this scheme has also received many research efforts recently. Most of the existing TXOP schemes have been developed under the assumption of saturated traffic loads and thus traffic conditions and queuing are not considered. For example, Tinnirello and Choi [11] compared the throughput for different ACK policies in the TXOP scheme under saturated trffic. Li, Ni, and Xiao [12] analyzed the TXOP scheme with the block ACK policy under saturated traffic loads and noisy channel conditions. Xu, Sakurai, and Vu [13] proposed an access delay model for EDCA with the AIFS, CW, and TXOP schemes under saturated conditions. But the realistic network conditions are unsaturated, thus the evaluation of the TXOP scheme should be done under the unsaturated traffic loads. Thus several unsaturated traffic TXOP-based approaches have been reported in the literature. Ksentini et al. [14] proposed an TXOP

ISSN: 2349 - 6363

scheme which considers the traffic flow of the queue and dynamically computes TXOP limit according to the the queue length and AC. However, the TXOP limits for the ACs with video traffic are set to the number of arriving frames between two successful transmission attempts. Liu and Zhao [15] introduced a new TXOP scheme, which takes into account the frame size and the transmission queue length to calculate the TXOP limit for VBR video transmission over the IEEE 802.11e WLANs. All those algorithms did not mitigate the problem and still suffer collisions when overlapping BSSs exist. Moreover, they are of high complexity due to frequent negotiation operations between AP and stations. Distinguished from the existing solutions for the unsaturated traffic issue, we propose a prediction based TXOP scheme that dynamically adjusts the TXOP limits according to the current state of the transmission queue and the frame length. Moreover, we verify the efficacy of this scheme through simulation experiments.

III. PROPOSED SYSTEM

HCF scheduler is introduced to take the QoS requirements of admitted flows into account and allocate transmission opportunities (TXOPs). Abhinav Arora, Sung-Guk Yoon, Young-June Choi and Saewoong Bahk propose a mechanism of adaptive TXOP allocation [4]. The scheduling decisions are made by an existing scheduler. The new scheduler allocates TXOP to the stations (STA) scheduled by the existing scheduler. To ensure fairness, it introduces the term lag, which is the difference between the service that session should receive and the service that it has received. In the IEEE 802.11e standard, an STA is required to have a predefined limit up to the maximum TXOP that can be allocated. Huabing Liu, Yun Zhao proposes a method which comprises buffering at least one frame for a particular access class (AC) [6]. The method comprising:

- buffering at least one frame form every access class in the transmission queues;
- perform contention-based mechanism to access the wireless medium;
- computing the size of a frame in the transmission queue;
- predicting the size of the future frame expected

We propose a mechanism of adaptive TXOP allocation. The data are classified into different AC providing at least one frame for a particular AC. This method works in accordance with channel and traffic conditions, adaptively to compute. The larger time bounded data will have a small TXOP, where as small time bound data have larger TXOP.

ADAPTIVE TXOP

TXOP is described as the time needed to transmit all the packets that arrive during an Service Interval (SI) in a Traffic stream (TS) queue at the minimum rate R. If Ni is the number of packets of mean length Li that arrive in SI with the mean rate ρ for TS i, we have

$$N_i = [\frac{\mathrm{SI}*\rho}{\mathrm{L}}] , \quad (1)$$

where i= 1, . . . , n.

Then

$$\mathrm{TXOP}_i = \mathrm{N_i}(\frac{\mathrm{L_i}}{\mathrm{R}} + 2.\mathrm{SIFS} + \mathrm{ACK}) \quad (2)$$

where i=1,…,n

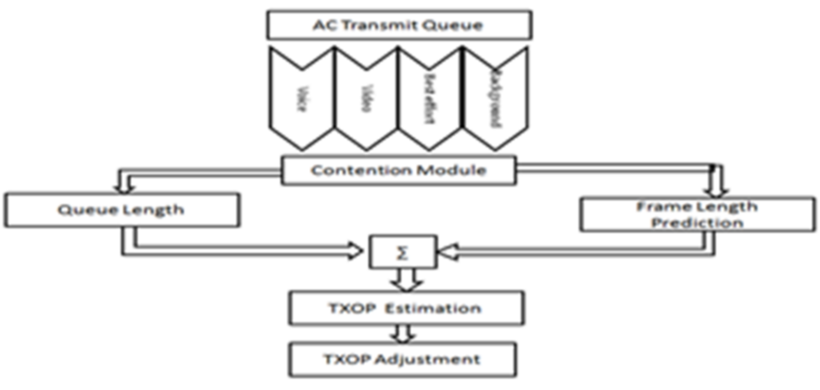

Figure 1: Adaptive TXIO estimation mechanism

The scheduling decisions are made by an existing scheduler. The new scheduler modifies TXOP to the stations (STA). The main components of the scheduler is a lead/lag counter for each session that indicates whether the session is leading or lagging and to make a lagging session compensated at the expense of leading sessions. It also predicts the channel state for every backlogged session. The lagging sessions have higher priority to receive additional services for their compensation.

TXOP PREDICTION FOR FUTURE FRAME

The prediction of TXOP duration for at least one future frame is done by predicting the size of frames based on frame type. The MAC layer time value may include TXOP. It comprises of summing up the size of one frame in the transmission queue and the size future frame predicted and translating it into an estimated transmission time. The method includes accounting for transmission overhead time.

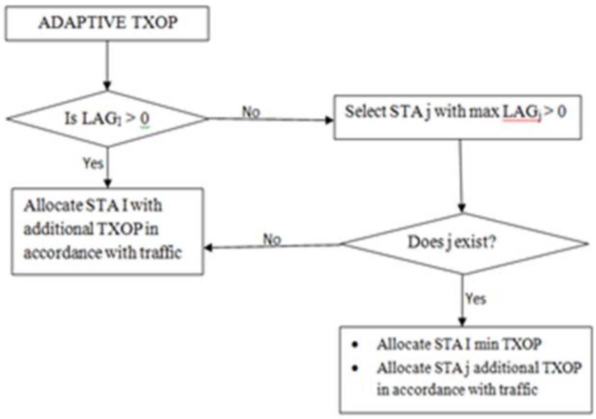

Figure 2: Adaptive TXOP

IV. SIMULATION AND RESULT

To characterize the behavior of our adaptive TXOP allocation scheme, we conducted extensive simulation experiments and compared our algorithm with existing scheduler like adaptive Grilo and reference scheduler [4]. We implemented the proposed scheduler by using Network Simulator 2 (ns-2) [10] with the implementation code of the IEEE 802.11e/D12.0 MAC layer [1, 12]. We designed our simulation model to have only one TS per STA. We adopt the IEEE 802.11a PHY layer for the simulations, and Table I summarizes the MAC parameters.

TABLE I. IEEE 802.11A MAC PARAMETERS

PHYSICAL PARAMETERS	VALUE
aSlotTime	9µs
Beacon Interval	100ms
aFragmentation Threshold	1024 octets
aRTS Threshold	500 octets
SIFS	16 µs
PIFS	25 µs
DIFS	34µs
aShortRetryLimit	7
aLongRetryLimit	7
dot11DefaultCPTXOPLimit	300 0µs
dot11CAPRate	21 µs
dot11CAPMax	8000 µs
CAP timer update time	5120 µs

We have measured throughput, utilization, medium access delay, queuing delay, jitter, retransmission attempts. The measurements were done when there are four types of traffic such as VoIP, video, best-effort (BE) traffic and background. VoIP traffic has the highest priority, and background data traffic has the lowest priority.

The medium access delay for the various nodes operating in the adaptive TXOP mechanism [4] was computed figure 3. It is then computed for the proposed method of adaptive TXOP with service differentiation and prediction figure 4. For most of the nodes the proposed method provides lesser delay in case of different access classes. In some cases the background data access class of the proposed method may have higher delay than existing schedulers for Adaptive TXOP.

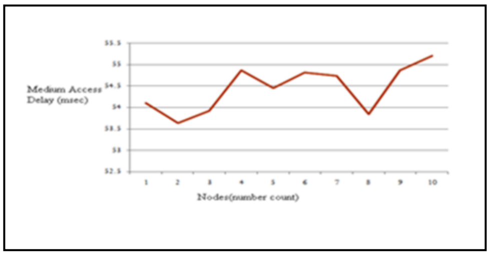

Figure 3: Medium Access Delay of various nodes with Adaptive TXOP

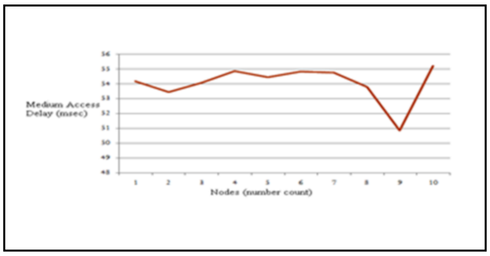

Figure 4: Medium Access Delay of various nodes with service differentiated Adaptive TXOP

To further extend the result analysis another QoS parameter, retransmission attempts are taken into account. The results are compared for the two systems in figure 5 and figure 6.

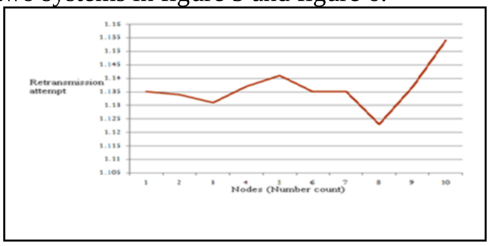

Figure 5: Retransmission attempt for various nodes with adaptive TXOP

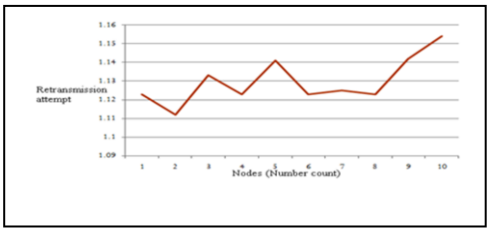

Figure 6: Retransmission attempt for various node of service differentitaded Adaptive TXOP

The table II shows the performance improvement showcase for the proposed methodology. The average of the medium access delay and retransmission attempts are computed for various nodes for both the existing scheduler for Adaptive TXOP and with the mechanism of differentiated service and predictive future frame and the results are compared to find the proposed mechanism is better than existing schedulers for Adaptive TXOP but we aim in improving the performance of the time bounded voice and video data. The adaptive algorithm improves delay around ~3% on average. The adaptive algorithm adjusts very well to the channel. The average delay of our adaptive algorithm is lower than that of the existing algorithms when a rate is high, by enabling TXOP lending when the channel becomes worse and get more TXOPs when the channel gets better.

TABLE II. PERFORMANCE IMPROVEMENT OF THE PROPOSED ADAPTIVE TXOP

	Average Medium Access Delay (msec)	**Average Retransmission Attempts**
Adaptive TXOP	54.444	1.1362
Adaptive TXOP with service differentiation and prediction	54.038	1.1299

V. CONCLUSION AND FUTURE WORK

The paper proposed a mechanism for adaptive TXOP allocation which exploits the channel trffic condition and used it estimate and predict values to compute the TXOP. However the node of background data access class with less traffic and frames find less opportunity compared to that of other access classes.

As a future work the access classes can be broadly classified and the other QoS parameters can be accommodated for fair estimation

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