# Dynamic Admission Control Algorithm for WLANs 802.11

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*Abstract*—**Quality of service (QoS) is a key problem in wireless environments where bandwidth is scarce and channel conditions are time varying and sometimes implies highly packet losses. IEEE 802.11b/g/a wireless LAN (WLAN) are the most widely used WLAN standards today, and the IEEE 802.11e QoS enhancement standard exists and introduces QoS support for multimedia applications. This paper presents an admission control algorithm for 802.11e based wireless local area networks . The strengths of our admission control is dynamicity and flexibility of the algorithm, which adapts to the situation of the BSS, like global load, number of best effort AC, and position of QSTA by report of QAP. Thus it achieves higher throughput than other admission control for 802.11 e. The 802.11e standard starves the low priority traffic in case of high load, and leads to higher collision rates, and did not make a good estimate of weight of queues, so there is an unbalance enters the flows with high priorities. A discussion is presented in detail using simulation-based evaluations, with an aim of comparing results of our admission control algorithm, with the 802.11e standard and the FHCF algorithm. Results reveal an improvement of the network load and a decrease of the numberofcollisions.**

Keywords: IEEE 802.11e, WLAN, Quality of Service (QoS), Enhanced Distributed Channell Acces (EDCA), Hybrid Coordination Function Channel Access (HCCA), admission control, Network Simulator (NS)

## I. Introduction

IEEE 802.11 WLAN [1] is the most widely used technology for wireless access to wired Local Area Network (LAN) infrastructure and to Internet. This technology is being adopted and deployed at high rate both in private homes and in enterprise networks. On the other hand, new multimedia applications, like Internet conferencing, IP telephony, and video would use this technology, but their requirements pose critical constraints on Quality-of-Service (QoS) differentiation between different types of traffic in the wireless access network. To satisfy these constraints, the new IEEE 802.11e amendment [2] to the standard was developed, and it has recently be accepted as a new standard. It includes the Enhanced Distributed Channel Access (EDCA), and HCF Controlled Channel Access (HCCA), which introduces four and eight priority for flows, mapped into four classes called Access Categories (AC). But traffic differentiation alone is not sufficient to accommodate appropriate levels of QoS. In addition, some added mechanisms are needed to enforce that the users get their agreed QoS. These mechanisms also ensure that traffic not entitled for network resources is not destroying the quality of the admitted traffic by consuming network resources. The standard 802.11e have proposed an admission control algorithm noted DAC (Distributed Admission Control), very simple, which have been not adopted. So the Admission Control is left to the implementer. The solutions, that have been previously proposed [3-22], still have some drawbacks. In this context, we propose in this paper a new solution. In particular, many proposed admission control mechanims assume that the resources are statically allocated among the used classes involving loss of unutilized resources. To tackle this weakness, our admission control algorithm aims at sharing resources dynamically between the classes. Our paper is organized as follows. The section 2 gives an overview on 802.11e and section 3 describes our admission control algorithm. In section 4, we provide an analysis study based on our obtained simulation results. Section 5 concludes the paper and highlights some future work.

## II. Background

IEEE 802.11e is a standard for QoS improvements of the 802.11 MAC layer, approved by IEEE in july 2005 [2].

### A. *802.11 e*

IEEE 802.11e basically adds priorities. HCF is composed of two access methods: contention-based

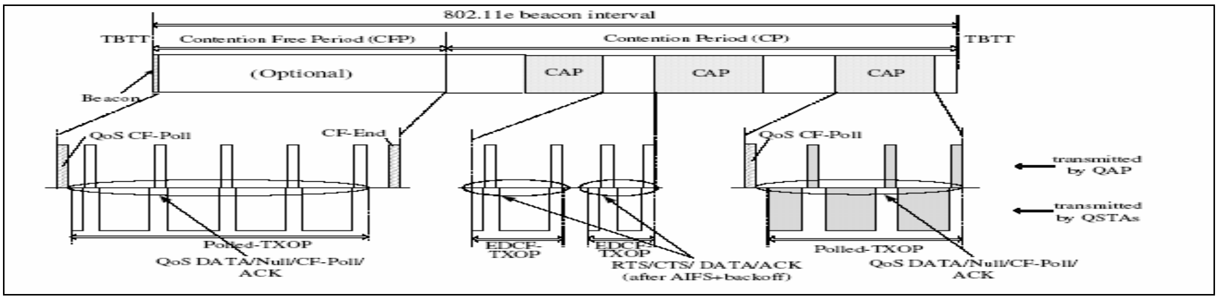



Figure 1. A typical 802.11e HCF beacon interval [2]

channel access (called EDCA) and controlled channel access mechanisms (HCCA). One main feature of HCF is to introduce four access category (AC) queues and eight traffic stream (TS) queues at MAC layer. When a frame arrives at MAC layer, it is tagged with a traffic priority identifier (TID) according to its QoS requirements. This can take the values from 0 to 15. The frames with TID values from 0 to 7 are mapped into four AC queues using EDCA access rule. On the other hand, frames with TID values from 8 to 15 are mapped into eight TS queues using HCF controlled channel access rule. The reason of separating TS queues from AC queues is to support strict parameterized QoS at TS queues while prioritized QoS is supported at AC queues.

*B. Enhanced Distributed Coordi Function*

EDCA is designed for the contention-based prioritized QoS support. In EDCA, each QoS-enhanced STA (QSTA) has 4 queues (ACs), to support 8 user priorities (UPs). Therefore, one or more UPs are mapped to the same AC queue. This comes from the observation that usually eight kinds of applications do not transmit frames simultaneously, and using less ACs than UPs reduces the MAC layer overheads. Each AC queue works as an independent Distributed Corrdination function (DCF) station (STA) and uses its own backoff parameters.

*C. HCF controlled channel access*

The HCF controlled channel access mechanism (HCCA) is designed for the parameterized QoS support, which combines the advantages of Point Coordination Function (PCF) and Distributed Coordination Function (DCF). HCCA can start the controlled channel access mechanism in both (Contention-Free Period) CFP and (Contention Period) CP intervals, whereas PCF is only allowed in CFP. Fig 1 is an example of typical 802.11e beacon interval, which is composed of alternated modes of optional CFP and CP. During the CP, a new contention-free period named Controlled Access Phase (CAP) is introduced. CAPs are several intervals during which frames are transmitted using HCCA. HCCA can start a CAP by sending downlink QoS-frames or QoS CP-Poll frames to allocate polled-TXOP (transmission opportunity) to different QSTAs after the medium remains idle for at least PIFS (PCF InterFrame Space) interval. Then the remaining time of the CP can be used by EDCA. This flexible contention-free scheme makes PCF and CFP useless and thus optional in the 802.11e standard. By using CAP, the HCF beacon interval size can be independent of targeted delay bounds of multimedia applications. For example, in order to support audio traffic with a maximum latency of 20 millisecond (ms) using PCF, the beacon interval should be no more than 20 ms since the fixed portion of CP forces the audio traffic to wait for the next poll. On the other hand, the HCCA can increase the polling frequency by initiating CAP at any time, thus guarantee the delay bound with any size of beacon interval. So there is no need to reduce the beacon interval size that increases the overheads [2].

## III. Our New Admi Control Algorithm : Physical Rate and Contention Window based admission control (PRCW)

After study several recherches about QoS of 802.11 wlan, we note that, all the algorithms [3-14] have disadvantages that we will evict in our new algorithm of admission control. The ideas that we retained are as follows:

The idea given in [9], which consists of changing parameters [AIFSN,CWmin and CWmax] of best effort flows, for decreasing collisions, is valid and very interesting, so we think that it is an efficient way to protect QoS flows from best effort flows, and to allow to reduce then number of collisions.

But, we do this only after the case when the throughput of network is higher or equal to 70% of the maximum throughput of the network, and only if the number of best effort flows exceeds a threshold (=number of active stations/3). This is, because in all reference algorithms, they show that the degradation of QoS starts at this load. So we increase AIFSN [best effort flow], CWmin and CWmax only at 70% of load of network, to prevent starvations of best effort flows, and so we increase rate utilization of channel. We also use the current rate transmission of QSTAs, according to their positions, instead of the minimum rate transmission used by standard 802.11e, for calculate the load of network and derived the TXOPi necessary for all the stations, with i=1 to number of active stations. For example, in the case of using the 802.11g physical layer, we assume that:

- if the position p of the station from the QAP $<=$ 5 meters then Throughput of station D=36Mbps;
- if $5<p<10$ meters then D=11Mbps;
- otherwise D=6Mbps.

Our algorithm operates as follows:

✓ At QAP side : The QAP scheduler is simple and the same that used by the standard 802.11e, as long as the load of network is less than 70%. It will first calculate the number of frames which will arrive during the interval beacon for each flow of all stations, by using formula:

$$TXOPij = \frac{\text{interval beacon [s]*average size of frame for flow j[bit]}}{\text{interarrival time of flow j[s]*rate transmi of station [bps]}}$$

After it calculate the necessary TXOPi for the active station i

$$TXOPi = \sum_{j=1}^{\text{Active flows}} TXOPij$$

New flow K+1 is accepted if

$$\frac{TXOP_{k+1}}{SI} + \sum_{i=1}^{k} \frac{TXOPi}{SI} <= \frac{T_{CAPLimit}}{T_{Beacon}}$$

where *TCAPLimit* is the maximum duration bound of HCCA and *TBeacon* represents the length of a beacon interval. But if the new flow accepted is not CBR traffic, but VBR, so the number of frames that will arrive at queues may be different of the number calculated by the QAP, and thus we will have a lot of packets dropped. So we propose to use the idea given by [15,16]. If the number of dropped packets >=threshold (10% ), the QAP will recalculate the TXOPi of stations, that have not use all its precedent TXOPs, and redistribute it to stations that have used all their precedent TXOPs.

We will also use the real speed of transmission of the stations,if we know that in the standard, allocation of the TXOPi is based on minimal speed of transmission of stations (that is not the case in reality, the stations can adapt their speeds as function of their positions by report of QAP). So we integrate this functionality in our simulations.

After, we will always calculate the number of collisions and if it greater than a threshold value (5% for example),we decrease the number of stations which transmit data, for maintaining the QoS of existing audio, and video flows, without starlaving data flows. And at all time, if the number of collisions is less than a threshold, we authorize the recovery of data transmission.

- ✓ At QSTA side:The scheduler of stations redistributes the extra of gained TXOP, between the flows which have size of queues longer than what it have been communicated to the QAP.

## IV. Simulation Results

### *A. Simulation model*

Different simulation have been conducted to compare the performance of our algorithm PRCW with performance of FHCF and HCCA. So we take the same parameters (see Table 1 and 2) for the three algorithms, except for values of data contention windows of PRCW wich will vary.We have used a topology of 19 stations, with one AP,without moving.The scenario uses 6 audio ,6 video VBR and 6 video CBR communications between stations in order to analyze the QoS of each trafic flow.

The thresholds value for data contention window have been changed until we find the best value (if number of data flows >total flows/3) then we increase the Cwmin =Cwmin*2

Table 1. Flows parameters

| Parameters | Audio | Vidéo CBR | Vidéo VBR | Data |
|---|---|---|---|---|
| Cwmin | 7 | 15 | 15 | 31 |
| Cwmax | 15 | 31 | 31 | 1023 |
| AIFSN | 2 | 2 | 2 | 2 |
| Packet Size (Bytes) | 160 | 800 | 660 | 1600 |
| Packet Interval (ms) | 20 | 2 | 26.4 | 12.5 |
| Sending Rate (KB/s) | 8 | 400 | 25 | 128 |
| MaxSI(ms) | 50 | 50 | 100 | - |

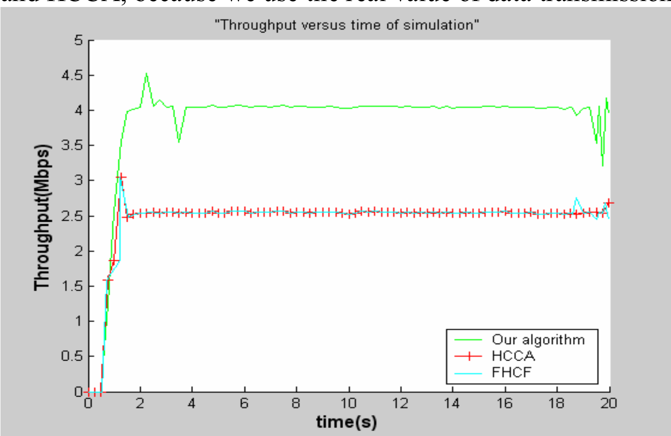
Table 2. Network parameters

| | | | |
|---|---|---|---|
| **SIFS** | **16µs** | **MAC header** | **28bytes** |
| **DIFS** | 34µs | PLCP header length | 4µs |
| **ACK size** | 14bytes | Preamble length | 20µs |
| **PHY rate** | 36Mbps | 802.11Mac Header Data Frame Length in byte | 30 |
| **Slot time** | 9µs | Short and Long Retry Limit | 7 , 4 |

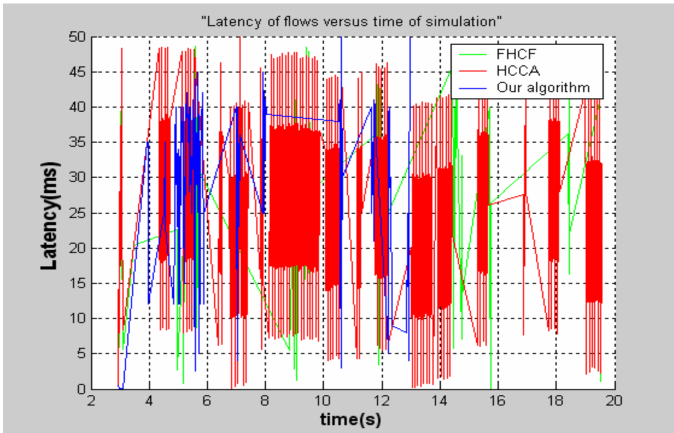
## *B. Performance analysis*

The main performance parameters for voice traffic are well known: voice packet transfer delay, delay variation and packet loss [11]. In order to preserve the end-user perceived voice quality, commonly accepted maximum values for these parameters in an end-to-end connection over an IP based network are 150 ms for the one-way delay, a few milliseconds for the delay variation, and 3% packet loss [11]. However, because the WLAN represents only the last hop of an end-to-end connection, we have chosen to select more stringent values. Accordingly, we consider 50 ms as a maximum acceptable value for the one-way voice transfer delay over the WLAN. As for the video performance, note that widely deployed adaptive algorithms can be assumed to be used at the receiving side, thus mitigating effects of possible high latency and jitter values for video packets. For this reason, such flows are in general not as delay-sensitive as interactive video streams, such as real-time video-conferencing, can be. However, even adaptive algorithm are useless in case of strong throughput degradation. For this reason, when evaluating the simulation results, we concentrate more on throughput guarantee for video applications, instead of their delay performance, especially for the high-quality video case. Algorithms FHCF and PRCW satisfie correctly the requirements of QoS flows, but PRCW performs better than FHCF. For exemple in Fig 2a we notice that the total throughput of network is greater for PRCW than for FHCF and HCCA, because we use the real value of data transmission instead of the minimum value. The number of collision (Fig 2k) is less for PRCW than for the two other algorithms. The channel utilisation (Fig 2l) of PRCW is better than the two other, because PRCW reacts for congestion by increasing CWmin of data flows. Fig 2b shows that with the three algorithm, the maximum latency of audio flows is bounded by the selected SI (equal to 50*ms*),but our algorithm performs better. In Fig 2j, we notice that for FHCF and HCCA, between zero and 1.5 s, the CBR video latency exceed 160ms while the maxSI must be equal to 50ms, except for our algorithm. Whereas for HCCA, some flows may not meet their QoS requirements. For example, the delays of the VBR flows are completely uncontrolled (see Fig 2e) because the queue lengths increase dramatically during some time period. Note that the maximum delay of HCCA can be controlled if *TXOPs* are allocated according to the maximum transmission rate of the VBR flows. In this case, fewer flows with HCCA than with PRCW and FHCF can be accepted.

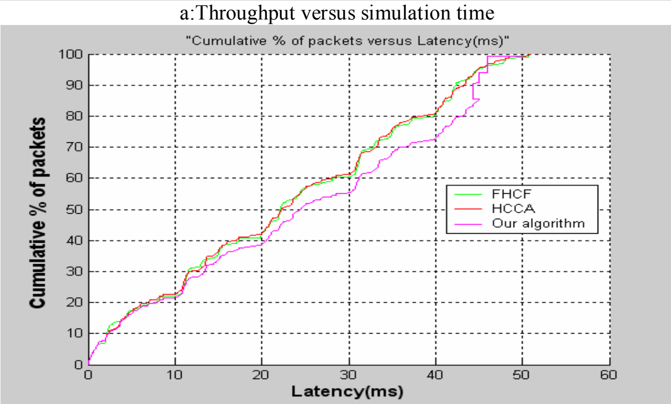
Fig 2d,f and i show that the video and audio flows have their requirements of throughput satisfied, 400 Kbps for CBR flow, 8 Kbps for audio flow and 25 Kbps for VBR flow by FHCF, but beter performed by PRCW algorithm, but we notice that HCCA do not satisfy the VBR throughput flow, wich is a sensible parameter. Fig 2c,g and h show that PRCW performs better than the other algorithms.



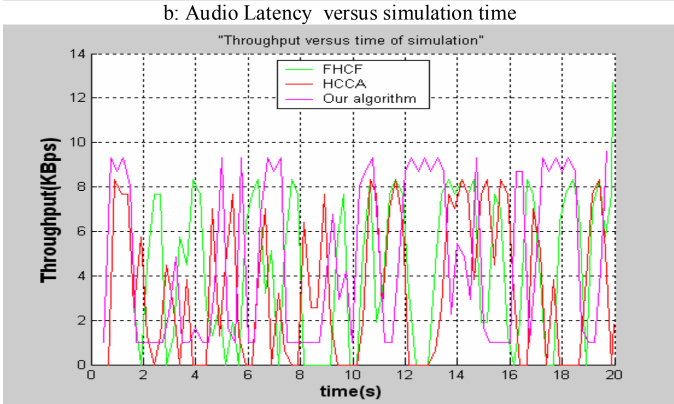

a:Throughput versus simulation time



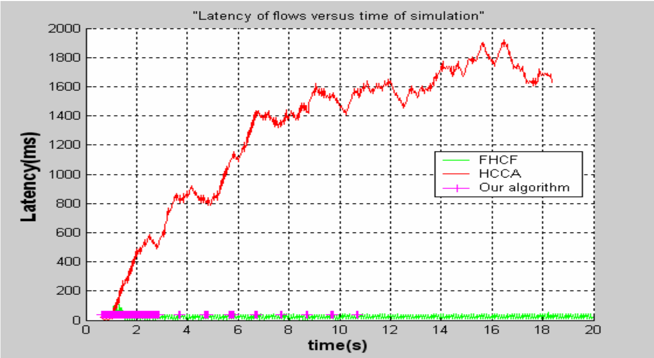

b: Audio Latency versus simulation time



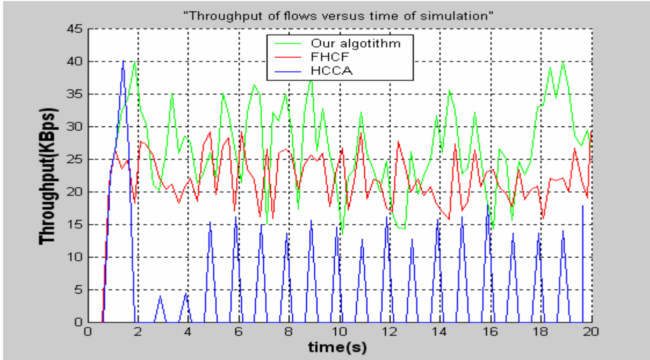

c: Audio Cumulative sum of packets versus latency



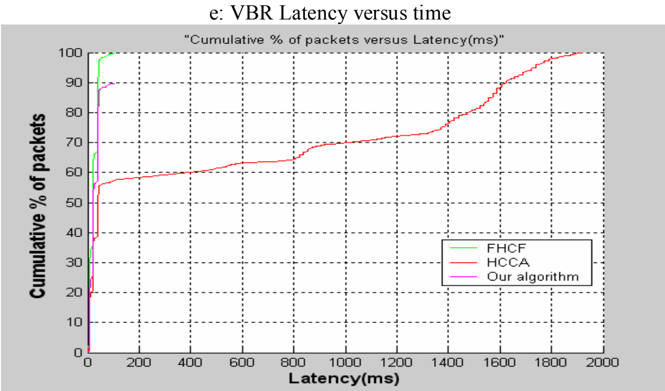

d: Audio Throughput versus simulation time



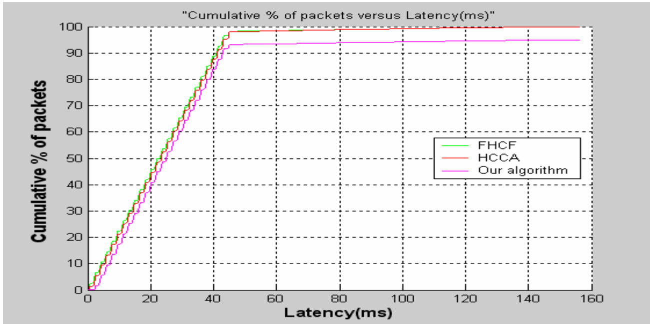

e: VBR Latency versus time



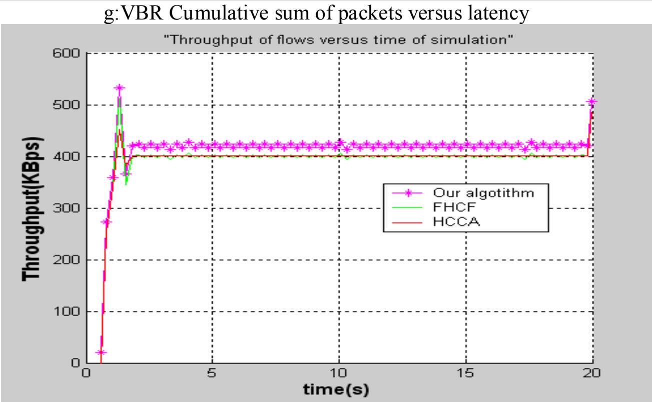

f: VBR Throughput versus time



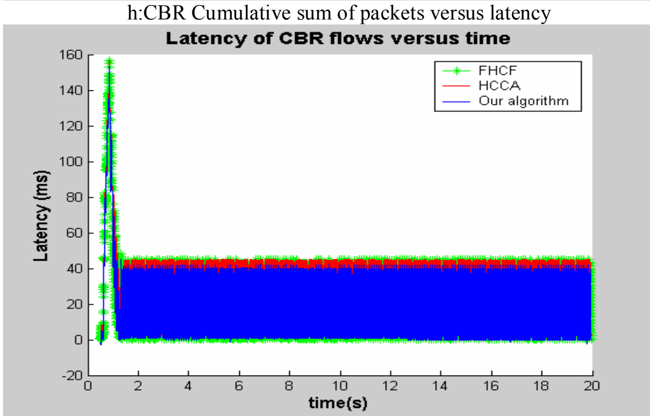

g:VBR Cumulative sum of packets versus latency



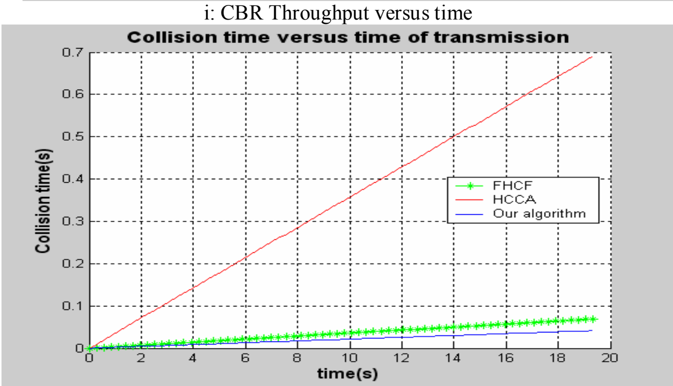

h:CBR Cumulative sum of packets versus latency



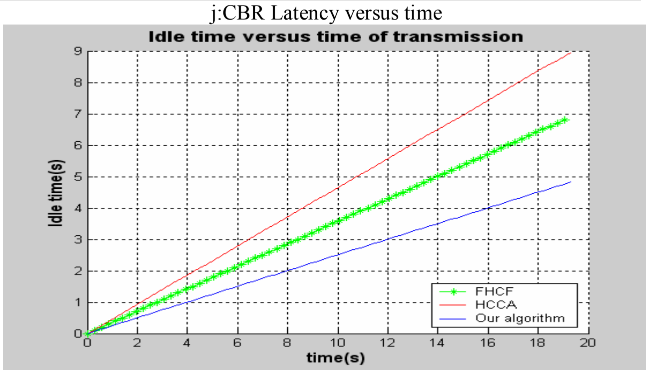

i: CBR Throughput versus time




j:CBR Latency versus time




k:Collision time versus time of transmi




l:Idle time versus time of transmission

Figure 2. Simulation results

## V. CONCLUSION

In this paper, we propose a Class Based Dynamic Admission Control Algorithm for 802.11 WLAN called PRCW that aims at guaranteeing QoS requirements of multimedia flows. We have illustrated through simulation investigation that our algorithm performs better than FHCF and HCCA algorithms in terms of audio and video flows QoS parameters. Moreover, the number of collisions is decreased, so the channel is efficiently utilized. For future work, we intend to test our algorith with ad hoc network, and do an implementation to confirm his performances.

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