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Modelling and performance analysis of an alternative to IEEE 802.11e Hybrid Control Function

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Abstract: Modern wireless networks are offering a wide range of applications that require the efficient integration of multimedia and traditional data traffic along with QoS provision. The IEEE 802.11e workgroup has standardized a new QoS enhanced access scheme for wireless LANs, namely Hybrid Control Function (HCF). HCF consists of the Enhanced Distributed Channel Access (EDCA) and the Hybrid Control Channel Access (HCCA) protocols which manage to ensure QoS support. However, they exhibit specific weaknesses that limit network performance. This work analyzes an alternative protocol, called Priority Oriented Adaptive Polling (POAP). POAP is an integrated channel access mechanism, is collision free, it employs priorities to differentiate traffic in a proportional way, it provides fairness, and generally supports QoS for all types of multimedia applications, while efficiently serving background data traffic. POAP is compared to HCF in order to examine the wireless network performance when serving integrated traffic.

Keywords: EDCA; HCCA; HCF; IEEE 802.11e; MAC; POAP; QoS; Traffic differentiation; Wireless LANs.

1 Introduction

The development and the rapid evolution of local area networks (LANs) along with the increasing end user requirements for multimedia applications such as voice over IP, video conference and video on demand requires the efficient management of multimedia and background data traffic. In wired networks, the adequacy of the available resources seems capable to provide Quality of Service (QoS), but the characteristics of the wireless links and the scarcity of network resources in WLANs (Wireless LANs) render QoS provision a challenging issue. Furthermore, the mobility concept, adopted in recent WLANs standards, impose further requirements in QoS provision mechanisms. Thus, Medium Access Control (MAC) protocols role is crucial towards this objective.

Medium Access Control (MAC) protocols are responsible for ensuring efficient and fair sharing of the available bandwidth. QoS support is also strongly related with the access control mechanism. For this reason the IEEE 802.11e workgroup [1] has enhanced the legacy 802.11 standard, which is widely adopted, with QoS support mechanism, proposing the HCF scheme. Furthermore, various works proposing MAC protocols with QoS support mechanisms can be found in the literature for different types of networks [3-10]. HCF consists of a contention based protocol (EDCA) and a resource reservation protocol (HCCA). In what follows the main limitations of the HCF scheme are presented. EDCA provides basic QoS support; however, the contention scheme degrades its performance due to high overhead resulting to the inability of serving efficiently multiple flows of different types of traffic. Furthermore, EDCA is not able to guarantee fairness for the contending mobile stations. Additionally, HCCA is unable to assign priorities to packet flows of different types of traffic and it is based on predefined fixed transmission intervals assigned to the requesting stations. Thus, it seems able to provide QoS only to Constant Bit Rate (CBR) multimedia streams. Besides, taking into account, the intense use of the wireless networks for both real-time and conventional delay tolerant data transfers, along with the bandwidth scarcity and the nature of the wireless channel, necessitates the development and use of, a more efficient protocol.

The main contribution of the present work lies on analyzing and extending the Priority Oriented Adaptive Polling (POAP) scheme that was initially presented in [2]. More particularly, in this work all the aspects of its operation are described in detail regarding the polling scheme, the prioritization model, and the station selection mechanism. POAP belongs to the centralized protocols; however, no bandwidth reservation is required. The values of the weights control the behaviour of the protocol’s resource allocation mechanism, thus, in this paper the impact of the weights in the network performance is examined when multiple types of traffic are supported. POAP efficiently supports simultaneous real-time and background traffic, by adapting its operation to different traffic priorities and current network conditions. The QoS supportive MAC protocol is able to distinguish different types of traffic and treat them accordingly. Usually, traffic is prioritized and high priority data is favoured by the access control mechanism. The classification of the traffic considered by this work can be found in [11, 12]. In the analysis provided it is assumed that stations are in range for direct communication, however the case where the Access Point (AP) acts as a packet forwarder could be also used. According to the IEEE 802.11e standard, the access model also provides a Direct Link Protocol (DLP) as an extra feature.

The analysis of the proposed POAP scheme is further extended by providing a complete performance evaluation of the POAP compared to the corresponding IEEE 802.11e MAC protocol, namely HCF. Specifically, apart from the mandatory EDCA scheme, the optional HCCA scheme is also examined. The objective is to study the ability of the POAP protocol to operate as an overall MAC solution, comparing it to the combination of the EDCA general purpose protocol and the HCCA real-time traffic protocol. For this purpose, a hybrid network scenario was employed, which involves legacy data flows handled by EDCA and multimedia flows handled by HCCA. On the contrary, POAP is designed to handle simultaneously all types of traffic in the examined network scenario.

This paper is organized as follows. In Section 2, the IEEE 802.11e HCF medium access control mechanism is presented. POAP is analysed in Section 3, focusing on the polling scheme, the priority model and the station selection algorithm. The network model employed, the simulation scenarios and the numerical results are provided in Section 4. The simulation results demonstrate the performance of POAP under different traffic conditions validating its efficiency compared to the existing HCF scheme. Finally, Section 5 concludes the paper and future research potentials are provided.

2 IEEE 802.11e HCF

The IEEE 802.11 is the dominant standard for WLAN infrastructure deployment, nowadays. The employed MAC protocol does not support QoS, totally. However, some modifications that enhance partial QoS support can be found in [13]. The need for integration of QoS provision mechanisms in modern WLANs has led IEEE to form the 802.11e workgroup. The super-frame of the legacy 802.11 MAC protocol involves the operation of a distributed and a centralized access scheme. The first one is the Distributed Coordination Function (DCF), while the latter is the Point Coordination Function (PCF). IEEE decided to enhance them with advanced features, thus, the new version that corresponds to DCF is the EDCA protocol, while the one corresponding to PCF is the HCCA protocol. Some recent solutions that claim to further improve HCF QoS support can be found in [14-18].

2.1 IEEE 802.11e EDCA

According to EDCA, when a station needs to transmit a packet and the channel is busy, it waits until the medium becomes idle and then defers for an extra time interval, namely Arbitrary Distributed Interframe Space (AIFS). If the channel stays idle for the AIFS interval, the station then initiates the backoff process by selecting a random number of backoff slots from a contention window [1].

An additional RTS/CTS (Request To Send/Clear To Send) mechanism is defined to solve the hidden station problem. This is a usual problem in a wireless environment, which is due to the fact that each mobile station may have a different view of the medium status. The successful exchange of RTS/CTS ensures to a certain extent that the channel has been reserved. This scheme, however, increases significantly the network overhead and does not provide a completely collision-free medium. In EDCA, the QoS support is realized with the introduction of Access Categories (ACs) [1]. In every station, there are four packet buffers corresponding to the four ACs. The eight possible User Priorities (UPs) assigned to the generated traffic are mapped to the four ACs. This way traffic is differentiated. In order to favour higher priority traffic, higher ACs are assigned lower AIFS values and smaller contention windows.

This model provides only minimal QoS. The backoff procedure leads to bandwidth waste and the hidden stations cause collisions despite of the backoff mechanism. The use of the RTS/CTS handshake confines this problem; however, it increases the overhead. Another drawback of EDCA is related to the exponential backoff algorithm, which may not be suitable for QoS sensitive applications. The colliding packets are supposed to be transmitted successfully sooner than any newly contending packets. However, they are penalized by the exponential backoff with a longer waiting time while newly contending packets are given a small waiting time. Exponential backoff may cause variations of throughput and delay under heavy loaded network situations. Furthermore, it has been shown that EDCA can be unfair when stations experience different conditions [19]. Some approaches that enhance EDCA were proposed in [20-22]. An analysis on the performance limits caused by EDCA overhead can be found in [23]. Conclusively, EDCA definitely enhances DCF, however, it is shown in practise that only limited traffic of low QoS demands can be served. It becomes evident that an alternative protocol with higher channel utilization, more efficient QoS support, and fair resource allocation could be possibly applied.

2.2 IEEE 802.11e HCCA

First of all, it should be underlined that HCCA is able to serve exclusively real-time traffic of known characteristics, so that resource reservation can take place. HCCA is based on the use of a Hybrid Coordinator (HC), which decides the Transmission Opportunities (TXOPs) granted to the QoS enhanced stations. The HC, which is responsible for the central control, is actually located at the AP. HCCA operates during dedicated periods of the HCF super-frame.

The protocol defines that every Traffic Stream (TS), which has its own packet buffer, sends a QoS request to the AP. This request contains the Traffic Specifications (TSPECs) of the specific TS. The scheduling of the TXOPs assigned to the different TSs is based on the fact that a TXOP should be long enough to allow the transmission of all the packets generated during a SI in a TS buffer. The mean number of packets (N_{ij}) generated in the TS buffer (j) for a station (i) during a SI is given by:

$$N_{ij} = \left\lceil \frac{\bar{r}_{ij} SI}{M_{ij}} \right\rceil \text{ (1),}$$

where $\bar{r}_{ij}$ is the application mean data rate and M_{ij} is the nominal MSDU size. The TXOP (T_{ij}) is finally calculated as follows:

$$T_{ij} = \max\left(\frac{N_{ij} M_{ij}}{R} + 2SIFS + T_{ACK}, \frac{M_{max}}{R} + 2SIFS + T_{ACK}\right), \text{ (2)}$$

where R is the transmission rate supported by the physical layer and M_{max} is the maximum MSDU size. The time interval 2SIFS + T_{ACK} corresponds to the overhead during a TXOP. Equation (2) guarantees that the TXOP will be long enough for the transmission of at least one packet with maximum size. The total TXOP assigned to a station is the sum of the TXOPs assigned to the different TSs of this station, is obtained by:

$$TXOP_i = \sum_{j=1}^{Fi} T_{ij} \text{ , (3)}$$

where F_i is the number of TSs in station i. The admission control checks for available bandwidth before assigning TXOP to a new TS. The fraction of total time assigned to a station i is: $TXOP_i$ / SI. If the total number of QoS stations that are assigned TXOPs is K, then the scheduler needs to check if the new request of $TXOP_{K+1}$ will keep the fraction of time allocated for TXOPs lower than the maximum fraction of time that can be used:

$$\frac{TXOP_{K+1}}{SI} + \sum_{i=1}^{K} \frac{TXOPi}{SI} \leq \frac{T_{CAPLimit}}{T_{Beacon}} \text{ ,(4)}$$

where $T_{CAPLimit}$ is the maximum duration of HCCA in a beacon interval (T_{Beacon}).

There are some significant drawbacks of the HCCA operation. A major weakness of HCCA is related to the scheduler. Specifically, the allocation of fixed TXOPs leads to inefficient support of Variable Bit Rate (VBR) traffic, because possible sudden increases of the generated bit rate would cause increased delays and packet drops. Moreover, the scheduling algorithm does not take into account prioritized TSs. It just uses the QoS requests in order to assign TXOPs. This means that the traffic is not efficiently differentiated according to the demands for QoS. It can be seen that a new efficient protocol could be proved useful.

3 The POAP Protocol

The motivation for the development of this protocol was the need for an access control protocol which takes advantage of the usual presence of an AP in order to offer services of high quality to end users. The main objective is to efficiently integrate real-time and background traffic, without resource reservation, via the improvement of the basic system feedback. POAP is designed to provide QoS by adapting its operation to the traffic QoS characteristics. The respective algorithm uses this information in order to favour high priority transmissions in a proportional and fair way avoiding the cases where high priority traffic requests from some stations monopolize the medium.

As it is already mentioned, the objective of this work is to examine the POAP protocol as a complete MAC solution capable of QoS provision for wireless LANs that could be considered as a possible alternative of the 802.11e HCF. However, the fundamental components of the POAP protocol could be also considered independently, so that they could be integrated into an existing or on development IEEE network standard. Specifically, the polling-based signalling pattern, the priority assignment concept and the station selection mechanism that are described in this section could be employed separately as parts of a total QoS support network solution.

3.1 The Polling Scheme

The cellular topology is assumed in the analysis of POAP where the AP polls the stations in order to give them permission to transmit. The proposed polling scheme eliminates the collisions and causes low system overhead, while it provides efficient network feedback. The protocol uses the POLL, NO_DATA, and STATUS control packets, with transmission durations t_{POLL}, t_{NO_DATA}, and t_{STATUS}, respectively. A STATUS packet is marked as ACK or NACK according to the specific case. The transmission duration of a DATA packet is t_{DATA} and the propagation delay is t_{PROP_DELAY}. The possible polling events are depicted in Figure 1 and explained below.

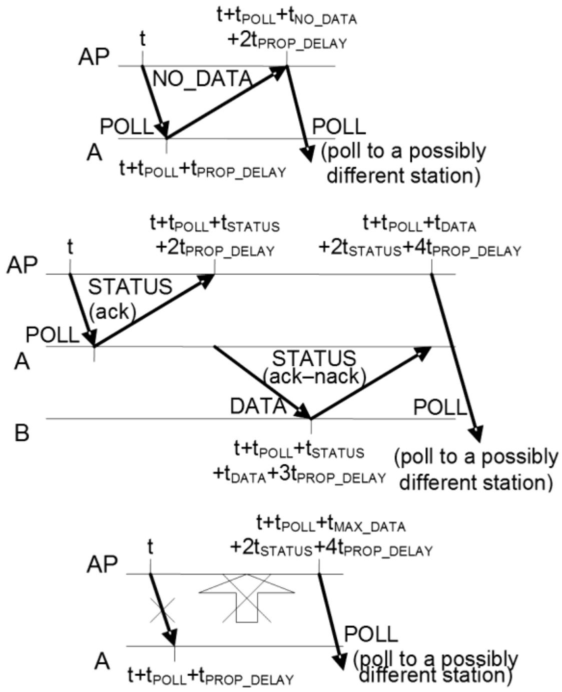


Figure 1: The polling scheme of the POAP protocol.

- Polling a station that has no buffered packets to transmit.

The AP sends POLL to the wireless station at time t and waits for feedback. The station responds with NO_DATA, which is received by the AP at $t+t_{POLL}+t_{NO\_DATA}+2t_{PROP\_DELAY}$. Then, the latter initiates new polling.

- Polling a station that has buffered packets to transmit.

The AP sends POLL to the wireless station at time t and waits for feedback. The station replies with a STATUS packet marked as ACK, which carries the destination address and the size of the following DATA packet. Then, the polled station starts transmitting the DATA packet directly to the destination station. Upon successful reception of the DATA packet, the destination station broadcasts a STATUS packet marked as ACK. Otherwise, if the reception fails but the station has realized that the specific packet is destined to it, it responds with a STATUS packet marked as NACK. The transmission of a NACK is not wasted time, since either way the stations had to wait for a possible ACK. As we will see later, each STATUS packet contains valuable feedback for the AP. The latter can proceed to a new poll at time $t+t_{POLL}+t_{DATA}+2t_{STATUS}+4t_{PROP\_DELAY}$. It should be noticed that we consider variable DATA packet size, thus, t_{DATA} is not constant.

- Polling fails or the AP fails to receive any feedback after polling.

In case the corresponding station does not successfully receive the POLL packet from the AP, the polling procedure fails. The AP has to wait for the maximum polling cycle before proceeding to a new poll, since it has to be certain that it will not collide with a possible ongoing transmission which is not detectable by the AP. When the POLL packet is received successfully by the polled station, but then the AP fails to receive any feedback, that is it cannot detect the following control and data packets, it waits for the maximum polling cycle similarly to the previous case. The duration of the maximum polling cycle is $t_{POLL}+t_{MAX\_DATA}+2t_{STATUS}+4t_{PROP\_DELAY}$, where t_{MAX_DATA} is the transmission duration of the largest allowed DATA packet. At the end of the maximum polling cycle, it is certain that the medium is idle in any event. When such a communication failure occurs, the AP lowers the probability to select this station in the new polling procedure assuming that there is an unreliable link between them. It also has to be mentioned that it is most likely that the AP will eventually receive some feedback either from the polled or the destination station.

It should be noticed that despite the fact that each station is supposed to send a single DATA packet per transmission, it is possible to have multiple successive data packets destined to the same station with total duration no longer than t_{MAX_DATA} and a single block acknowledgement for all these packets. This way, bursty traffic with strict QoS requirements could be more effectively supported.

This polling scheme provides efficient network feedback, low system overhead, and high channel utilization, while it eliminates collisions that may appear. It uses the AP to perform high performance access control without requiring packet relay. The purpose of the control packets is to keep the concerned stations informed about the network status and minimize the idle intervals. The AP needs to monitor the network transmissions so that it can proceed to the next poll right after the completion of a communication. For this reason, it has to be aware of the actual duration of the specific polling cycle. In order to gain this knowledge, the AP just has to successfully detect the NO_DATA packet or the STATUS ACK packet, which contains the duration of the following data transmission, or the DATA packet from the polled station or the STATUS ACK-NACK packet from the destination station. In all these cases, the AP is aware of the polling cycle duration and can proceed to the next poll without wasting any time. Actually, when at a given time the downlink is in good state, then it is most probable that the corresponding uplink will also be in good state at that same time. This means that when a successful reception of the POLL packet is achieved, then it is most probable that the AP will also succeed to obtain the necessary feedback for the current polling cycle.

Apart from the elimination of the idle periods so that no bandwidth is wasted, our purpose is also to poll stations that are actually active in a way that QoS is provided. For this reason, the AP needs to be aware of the stations' status while the control overhead is kept low, in order to avoid wasting time at polling inactive stations, favour the high priority traffic and provide fairness. This mechanism is presented in the next subsections.

3.2 Priority Model

POAP adopts the packet priorities concept employed by 802.11e in order to retain compatibility. Specifically, it uses four packet buffers organized in access categories and eight user priorities as it was described in the EDCA section. However, POAP introduces a new method of selecting the packet that is going to be sent.

There are some issues that must be taken into account when choosing which data packet to send. First of all, the priority (access category) of each packet buffer has to be considered, so that high priority traffic is favoured and QoS is provided. Thus, the probability of selecting packets of high priority access categories for transmission should be increased. Furthermore, in order to provide low packet delays, low packet drops due to buffer overflow and some fairness among the ACs, the number of packets contained in each buffer should be taken into account before selecting a packet. Specifically, heavy loaded buffers should have higher probabilities of transmitting packets. Finally, the earlier generated packets must be favoured, so that a form of the FIFO queue discipline is followed.

The introduced packet selection mechanism that takes all the above issues under consideration is depicted in Figure 2. Initially, the existence of buffered packets is examined, otherwise, the polled station replies with a NO_DATA message. Then, for each of the four buffers the normalized priority (P_{PR}) and normalized number of buffered packets (P_B) are estimated. Specifically, it is assumed that the priority of buffer i is equal to p[i]=i+1, so that it is not null for AC[0], then:

$$P_{PR}[i] = p[i] \Big/ \sum_{k=0}^{3} p[k] \,. \quad (5)$$

Also, if b[i] is the number of packets carried by buffer i, then it holds:

$$P_B[i] = b[i] \Big/ \sum_{k=0}^{3} b[k] \,. \quad (6)$$

Note that these two formulas determine the contribution of the traffic priority and the buffer load to the buffer selection probability.

It is necessary that the buffer priority and the number of buffered packets have different contribution to the final buffer selection probability (P). Thus, the weights W_{PR} (default value 6) and W_B (default value 2) are defined for P_{PR} and P_B, respectively. Obviously, when the network configuration aims at extendedly favour high priority traffic, then W_{PR} is set to a higher value compared to W_B, otherwise, if the configuration should be able to efficiently serve highly loaded stations, then the value of W_B is increased. The default values are determined by the significance of the parameters and tests which have shown that when the priority weight is three times higher than the buffer load weight, then the resulted buffer selection probability ensures the combination of efficient traffic differentiation and relatively low packet delays for all the buffers in most network conditions. The values 6 and 2 are used rather than 3 and 1, because value 1 is given to the weight W_T which is going to be introduced in the next subsection. A simulation analysis of the weights' performance impact is provided in Section 4. The non-normalized final probability of selecting a packet from buffer i is given by:

$$\mathrm{P}[i] = \mathrm{W}_{\mathrm{PR}} \times \mathrm{P}_{\mathrm{PR}}[i] + \mathrm{W}_{\mathrm{B}} \times \mathrm{P}_{\mathrm{B}}[i]\,. \quad (7)$$

As it was mentioned above, when W_{PR} is high compared to W_B, it is most probable that a high priority buffer will be chosen for transmission. On the other hand, if W_B is increased, it is more probable to select a packet from a highly loaded buffer. The normalized selection probability is finally equal to:

$$P_N[i] = P[i] \Big/ \sum_{k=0}^{3} P[k]\,. \quad (8)$$

After applying the introduced method of selecting a buffer, the station selects for transmission the earliest generated packet in it.

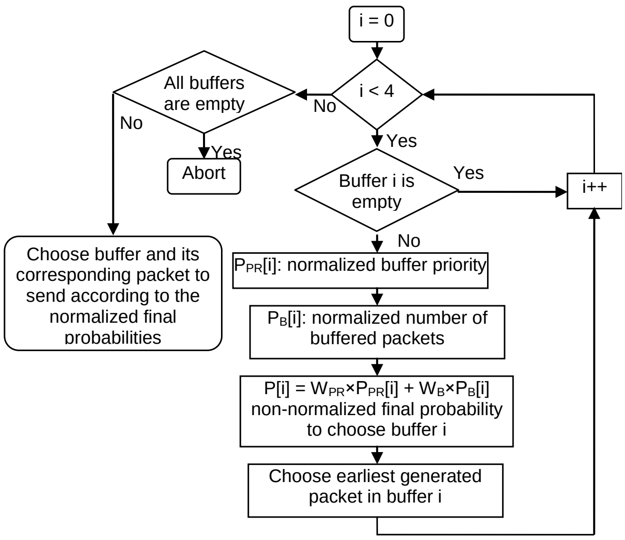


Figure 2: Overview of the packet selection mechanism.

3.3 The Station Selection Mechanism

Before the AP decides which station to poll, it has to be well informed of their buffers' status, in order to make selections that provide QoS and generally high performance. However, this necessary feedback should not cause excessive network overhead. For this reason, we exploit the use of the ACK and NACK messages, which are already useful in the polling scheme. Specifically, apart from the use of the STATUS control packet in acknowledging the packet receptions, it also carries its source station's priority score, which is analyzed below.

According to this modern feedback engine, when a station broadcasts a STATUS packet, it includes its priority score, which is introduced as a metric of the station's buffered traffic status. It depends on the priority of each buffer and the number of packets it contains. The priority score of station j is given by:

$$\mathrm{P_S}[j] = \sum_{k=0}^{3} p[k] \times b[k] \text{. (9)}$$

So, every time a STATUS packet is broadcasted, the AP examines it in order to update the stored priority score of the transmitting station. The introduced priority score formula is based on the concept that a station with more packets in high priority buffers should have proportionally higher transmission probability. Moreover, the exploitation of the control packets and our definition of the priority score introduce an efficient new method of having frequent feedback, which describes the status of every station causing minimal overhead. For example, 14 bits are required to represent maximum priority score equal to 16383, while a highly loaded station with 1000 packets in each buffer is characterized by priority score equal to 10000 (assuming that the priority of buffer i is p[i]=i+1). Finally, these scores are used by the AP to implement an efficient station selection mechanism.

The first factor considered by the selection algorithm is the priority score. Thus, it is most probable to poll a station with high priority traffic and large number of buffered packets, according to the given definition of the priority score. The second factor affecting the AP's decision is the time that has elapsed since the last poll of each station (τ). Specifically, in order to provide fairness and avoid the total exclusion of stations that are inactive for quite long, the stations that have not been polled for a long time are favoured to some degree. Furthermore, the AP, which also participates in the channel contention, is assigned a higher probability of getting access, since it usual plays a central role in the network communications. Lastly, it should be noticed that the AP halves a mobile station's priority score, when it receives no feedback after polling it, assuming the existence of an unreliable link between them.

The flow chart in Figure 3 depicts the operation of the proposed algorithm that returns the station to be polled. Initially, we check if the AP has any buffered packets. If it has not, then it is not included in the station selection procedure. Then, the priority score of each considered station j is normalized, as defined as below:

$$P_P[j] = P_S[j] \Big/ \sum_{l=0}^{M-1} P_S[l] \text{, (10)}$$

where M is the number of stations considered by the algorithm. The time elapsed since its last polling is also normalized as below:

$$P_T[j] = \tau[j] \Big/ \sum_{l=0}^{M-1} \tau[l] \text{. (11)}$$

The non-normalized final probability of polling station j is given by:

$$P_{POLL}[j] = W_{PR} \times P_P[j] + W_T \times P_T[j], \quad (12)$$

where W_T (default value 1) is the weight of the contribution of the P_T factor. It is clear that the priority score has great significance in selecting which station to poll, since our primary objective is to provide QoS. Thus, according to our tests, when the value of the weight W_T is six times lower than the value of W_{PR}, then fairness is provided without degrading the QoS support. Regarding fairness, it is unacceptable to exclude a station that at some point carried low priority score. The proposed method gives this station the chance to be polled, as it might have generated new traffic since its last poll. Obviously, a station that has not been polled for a long time has a high P_T value, so its polling probability increases. A high W_T value would provide extended fairness among stations; however, this way traffic differentiation would fade. If the examined station j is the AP, then its non-normalized final probability of getting channel access is multiplied by the factor W_{AP} (default value 10):

$$P_{POLL}^{AP}[j] = W_{AP}(W_{PR} \times P_P[j] + W_T \times P_T[j]). \quad (13)$$

Thus, the AP is not allowed to monopolize the channel. However, because of its central role in the network, we give it the significant advantage of accessing the channel with ten times higher chances. Lastly, the AP decides which station will be given access according to each one's normalized polling probability, which for station j is obtained by:

$$P_{POLL\_N}[j] = P_{POLL}[j] \Big/ \sum_{l=0}^{M-1} P_{POLL}[l]. \quad (14)$$

This station selection mechanism completes the POAP QoS support.

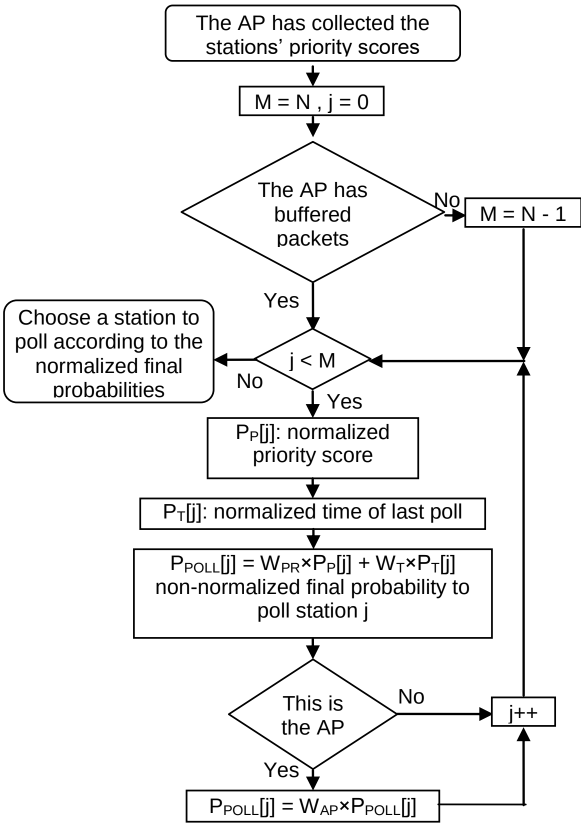


Figure 3: Overview of the station selection mechanism, where N is the total number of stations including the AP.

3.4 Special Points Review

In the previous subsections the algorithms that define the operation of the POAP protocol are described. In this section certain points of the POAP analysis are further analysed to improve the description of the proposed scheme. First of all, it has to be explained that P (that concerns the packet selection algorithm) and P_{POLL} – P^{AP}_{POLL} (that concern the station selection algorithm) are non-normalized probabilities, which means that their values are relative, so they don't range from 0 to 1 and cannot stand on their own. The normalized probabilities which get values ranging between 0 and 1 are P_N (that concerns the packet selection algorithm) and P_{POLL_N} (that concerns the station selection algorithm). These are finally calculated based on the former non-normalized values.

It should be clarified that in the POAP polling scheme, once a station gets permission to transmit via the received POLL control packet, it is free to transmit data for a maximum duration of the predefined t_{MAX_DATA} interval. In this network configuration we assume the transmission of one DATA packet each time an active station is successfully polled, however, as it is already mentioned, a station could transmit multiple consecutive DATA packets, as long as the total transmission duration is kept below t_{MAX_DATA} and all the packets are of the same priority. Of course, in this case, a block-type acknowledgement would be used.

The concept is based on the flexibility of the scheme that allows the transmission of variable-length data frames. However, according to the station selection mechanism, given that stations A and B carry the same amount of buffered packets of the same priority and the same time that has elapsed since the last poll, they will have the same probabilities to be polled, but if B transmits larger data frames, then it will eventually use more bandwidth than A. Nevertheless, it should be considered that a station with more and smaller buffered packets enjoys higher polling probabilities than a station with less and larger buffered packets, achieving a tradeoff till a certain extent.

It should be also noticed that POAP is a QoS aware protocol without employing a resource reservation mechanism for resource requests thus it does not provide strict QoS guarantees. If for example in POAP VBR real-time traffic is served (similarly to the video flows in the following network scenario), then the AP can be informed of the sender’s increased or decreased requirements based on its priority score that is regularly broadcasted via the STATUS control packets. In this manner, the AP provides each time the respective resources, considering also the other stations’ bandwidth requirements.

4 Performance Evaluation

4.1 Simulation Environment

The performance of POAP has been evaluated under different traffic load conditions. Moreover, extensive simulations were performed employing a simulation developed in C++ to validate the performance of the proposed scheme and compared it with the HCF. The physical layer protocol adopted for the simulated WLAN is the 802.11g [24]. POAP and HCF are simulated in order to be compared and evaluated. At this point, it should be made clear that the objective of this work is to present the POAP protocol as a complete solution that could be considered as a possible alternative to the standardized HCF scheme of the IEEE 802.11e, in contrast to the various proposed HCF improvement techniques.

In the developed simulator, the condition of any wireless link was modelled using a finite-state machine with three states [25, 26]. Moreover, the links among the AP and the stations are considered to be more reliable than the inter-station links, because the range of the AP is usually greater than the mobile stations’ range, its emitted signal is usually stronger and its default position is in the centre of the cell. The network parameters’ were set according to the specifications of the 802.11e standard.

Specifically, the states adopted in our link error model are the following:

1. State G denotes that the wireless link is in a relatively “clean” condition and is characterized by a small BER (Bit Error Rate), which is given by the parameter G_BER.

2. State B denotes that the wireless link is in a condition characterized by increased BER, which is given by the parameter B_BER.

3. State H denotes that the pair of communication stations is out of range (hidden stations).

We assume that the background noise is the same for all stations; hence, the principle of reciprocity stands for the condition of any wireless link. Therefore, for any two stations A and B, the BER of the link from A to B and the BER of the link from B to A are the same. The time spent by a link in states G, B, and H is exponentially distributed, but with different average values, given by the parameters TG, TB, TH, respectively. The status of a link probabilistically changes between the three states. When a link is in state G and its status is about to change, the link transits either to state H, with probability given by the parameter Ph, or to state B, with transition probability $1 - $ Ph. When a link is in state B and its status is about to change, the link transits either to state H, with probability given by the parameter Ph, or to state G, with transition probability $1 - $ Ph. Finally, when a link spent its time in state H, it transits either to state G or B, with the same probability (0.5). It can be easily seen that by setting the parameter Ph to zero, a fully connected network topology can be assumed, whereas for values of P_h greater than zero, the effect of the well-known “hidden station” problem on protocol performance can be studied.

In the considered network topology, it stands for the inter-station links: TG = 3 s, TB = 1 s, TH = 0.5 s, G_BER = 0, B_BER = 0.00001, Ph = 0.05. Similarly, for the more reliable AP-station links it stands: TG_AP = 6 s, TB_AP = 0.5 s, TH_AP = 0.25 s, G_BER_AP = 0, B_BER_AP = 0.000001, Ph_AP = 0.01. The BERs are assumed to be resulted after the application of the standard’s predefined coding techniques.

The medium bit rate is 36 Mb/s supported by the typical Extended Rate PHY – Orthogonal Frequency Division Multiplex (ERP-OFDM) technique, the signal propagation delay is 0.0005 ms corresponding to distances among the stations of 150 m, and the maximum allowed packet size is 10 KB. It should be mentioned that the transmission adaptation mechanism (according to link quality) was not modelled by our simulator, since it has no influence on the comparative behaviour of medium access control defined by POAP and HCF.

Regarding the simulation engine, the random number generator used by our simulator is a classic multiplicative congruential random number generator with period 2^{32} provided by ANSI C. The simulation results presented in this section are produced by a statistical analysis based on the “sequential simulation” method [27] where simulations are performed until the relative statistical error of the estimated mean value falls below an acceptable threshold.

4.2 Simulation Scenario

The performance of the proposed scheme is examined under variable traffic load. The traffic load considered is based on a combination of multimedia, high priority and low priority background traffic flows. The traffic mixture assumed is able to model traffic load conditions in WLANs with multiple services support as shown in Figure 4. The simulation duration is 60 sec and every communication of the terminal with the AP that corresponds to a different service lasts 30 sec also a new traffic flow is added every second. 15 different WLAN topologies are simulated, starting from the case of 2 wireless stations and finally reaching to the case of 30 stations with a step of 2. Thus, results for 8 to 120 one-way traffic flows are deduced. The results regarding the POAP weights analysis are derived from the simulation of a 30-station network which is considered as the most demanding scenario.

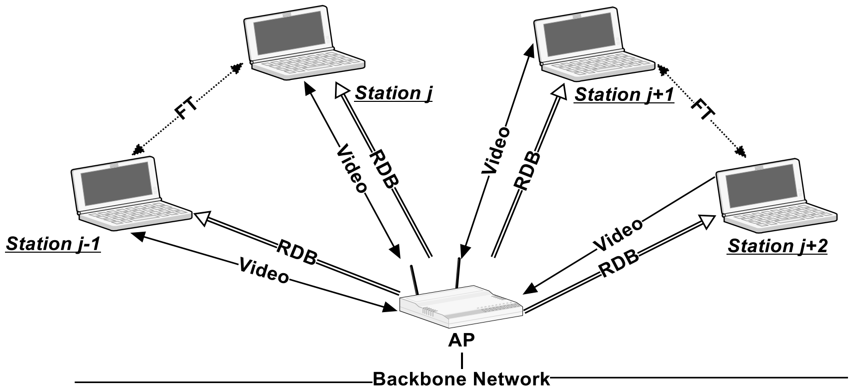


Figure 4: The network topology of the simulation scenario.

The characteristics of different types of traffic load, employed in the simulation scenario are provided in the following Table 1.

Table 1: Characteristics of Traffic Load Types Supported in the Simulation Scenario

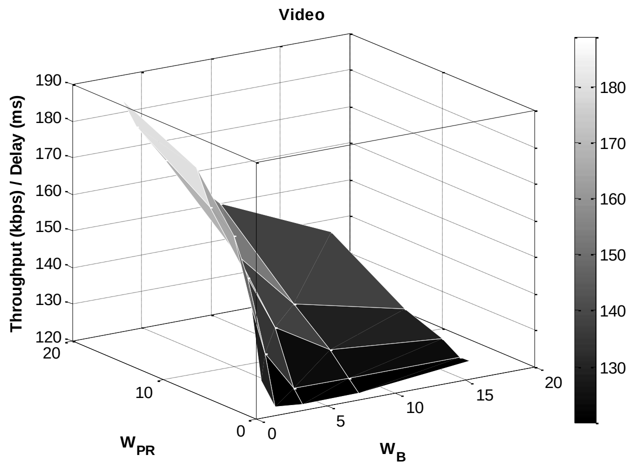
Traffic Type	Coding	Packet Data Size (bytes)	Packet Interarrival Time (ms)	Data Bit Rate (kbps)	Packet Delay Bound (ms)	User Priority
Video	H.261 [CIF]	Expo. [40-2048] Mean: 1320	Expo. Mean: 13	~800 (VBR)	100	5
Remote DB	-	1500	Expo. Mean: 60	~200 (VBR)	1000	3
File Transfer	-	1500	Expo. Mean: 15	~800 (VBR)	60000	0

4.3 Simulation Results

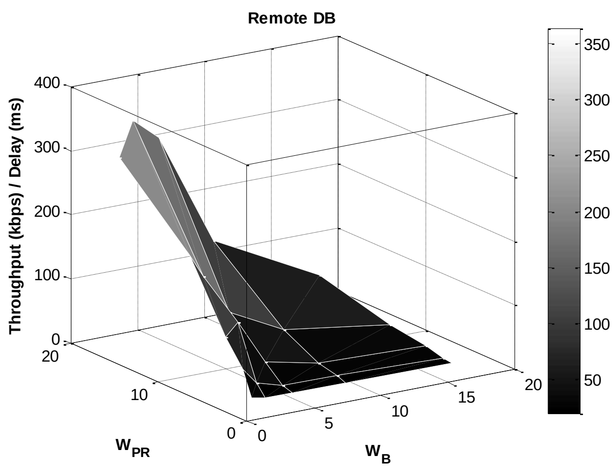
4.3.1 Simulation analysis of the POAP weights

Based on the simulation scenario described above, the impact of POAP weights on the network performance is examined. Specifically, the simulated network consists of 30 mobile stations and the traffic characteristics were provided in Table 1. In order to perform this analysis, the ratio of throughput to packet delay is calculated for different weights values as an index of the network performance. To enhance the interpretation of the results, it should be noted that as the ratio increases the network performance is increased. The performance of the proposed scheme is evaluated for three different types of traffic and results are obtained for different values of the weights W_B and W_{PR}. The weight W_T was kept constant and equal to 1, since if W_T was set at a value higher than W_B or W_{PR} traffic differentiation would not be possible (as it has been explained W_T is related to fairness). In Figure 5, three 3D graphs are demonstrated, where the ratio of throughput to packet delay is plotted versus W_B and W_{PR} (as a two-variable function), regarding the three different types of traffic (video, remote database, file transfer).

a)



b)



c)

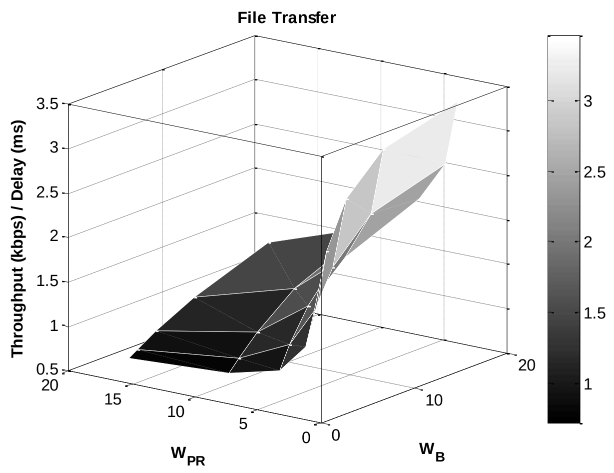


Figure 5: Ratio of traffic throughput to packet delay as a function of the POAP weights WB and WPR for a) video, b) remote database, and c) file transfer traffic.

As explained above, W_B and W_{PR} weights denote the performance level of each traffic type, depending on traffic load differentiation as confirmed by the simulation results. Therefore, high priority traffic is expected to exhibit better performance when W_{PR} value is high, while traffic of high load is expected to exhibit better performance when W_B is increased.

As it can be seen in Table 1, relatively, video traffic is assigned high priority and exhibits high data bit rate, consequently. Figure 5a shows that video performance increases when W_{PR} increases and it softly decreases when W_B increases (W_{PR} has a greater influence than W_B according to the proposed selection algorithms). Similarly, remote database traffic is assigned high priority and exhibits low data bit rate, thus, Figure 5b shows that remote database performance increases when W_{PR} increases and it sharply decreases when W_B increases. Finally, file transfer traffic is assigned low priority and exhibits high data bit rate, so as it can be seen in Figure 5c, file transfer performance sharply decreases when W_{PR} increases and it increases when W_B increases.

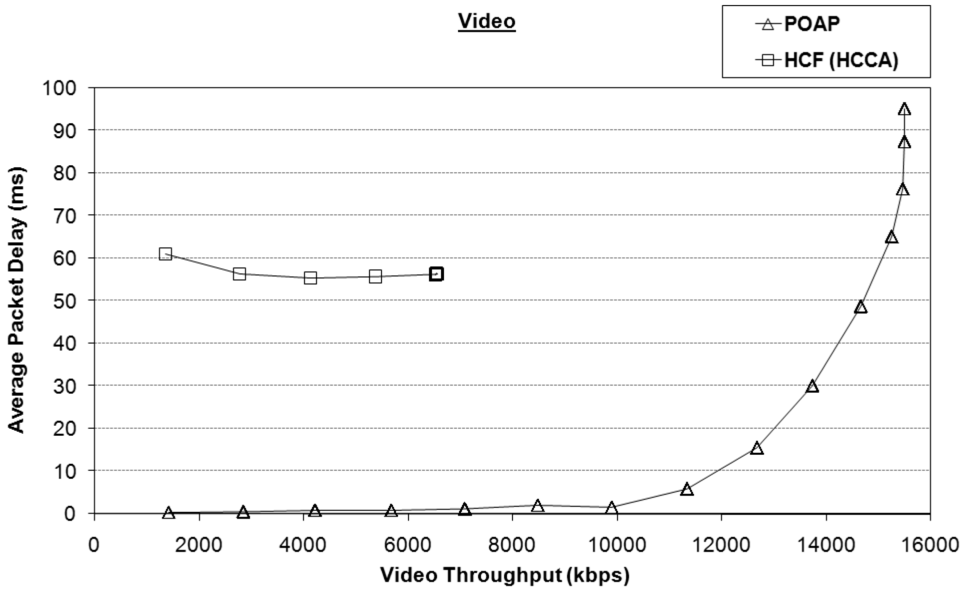
Based on the analysis provided and by taking into account the impact of each weight on the proposed algorithms, the need for QoS support and the necessity to simultaneously serve mixed traffic flows of different priorities, the default values for the POAP weights are obtained.

4.3.2 Simulation comparison of POAP and HCF

Extensive network simulations were performed to evaluate the capability of the two protocols (POAP and HCF) to handle simultaneously three different traffic load types: multimedia, high priority data, and low priority data traffic. The most indicative metrics of the network performance such as the average packet end-to-end delay, the loss rate, and the achieved throughput were considered for the performance evaluation of these schemes. The packet loss rate results from the number of packet drops occurred due to expiration of the packet lifetime or buffer overflow. Since the adopted buffer size is 1 Mbyte, the overwhelming majority of video packet drops are caused by the expiration of their lifetime, the remote database traffic packet drops are due both to lifetime expiration and buffer overflow, while the file transfer packet drops are due to buffer overflow. According to the described simulation environment, the number of stations increases in each topology examined, thus, the number of traffic flows and the overall load also increase. Regarding the HCF configuration, the default values of all parameters were used since different types of traffic are integrated. In HCF, the video traffic is handled as traffic streams by the HCCA protocol, while traditional data traffic is handled by EDCA.

The results regarding video traffic are presented in Figure 6. Specifically, in Figure 6a the average packet delay depending on the video throughput is depicted while in Figure 6b the packet loss rate is plotted as a function of video load. Note that if the generated video data bits are equal to g, the produced video control bits are equal to c, and the total simulation time is s, then the considered video load (in terms of rate) is equal to $(g + c)/s$. Following the same approach the video throughput is estimated using the successfully transmitted bits. Similar calculations are performed for the other types of traffic. As already mentioned, video traffic is handled by HCCA in the HCF scheme. It can be seen that POAP achieves significantly higher throughput (~16 Mbps) than HCF (~7 Mbps) and lower packet delay for throughput values lower than 15 Mbps. Regarding packet loss rate, POAP achieves fewer losses than HCF for load lower than 13 Mbps. Note that the maximum video throughput and the maximum video load are the same for the HCF scheme. This is due to the fact that HCCA is a resource reservation protocol that allows a traffic stream to initiate transmissions only when enough resources can be allocated to so that QoS is guaranteed. This method allows HCCA to perform steadily, however, it imposes a strict maximum performance limit. On the other hand, the POAP medium control algorithms try to efficiently serve all the video traffic offered to the network, taking into account its priority and the corresponding load. For high load, the exhibited packet loss rate is probably unacceptable; however, POAP generally seems to perform better.

a)



b)

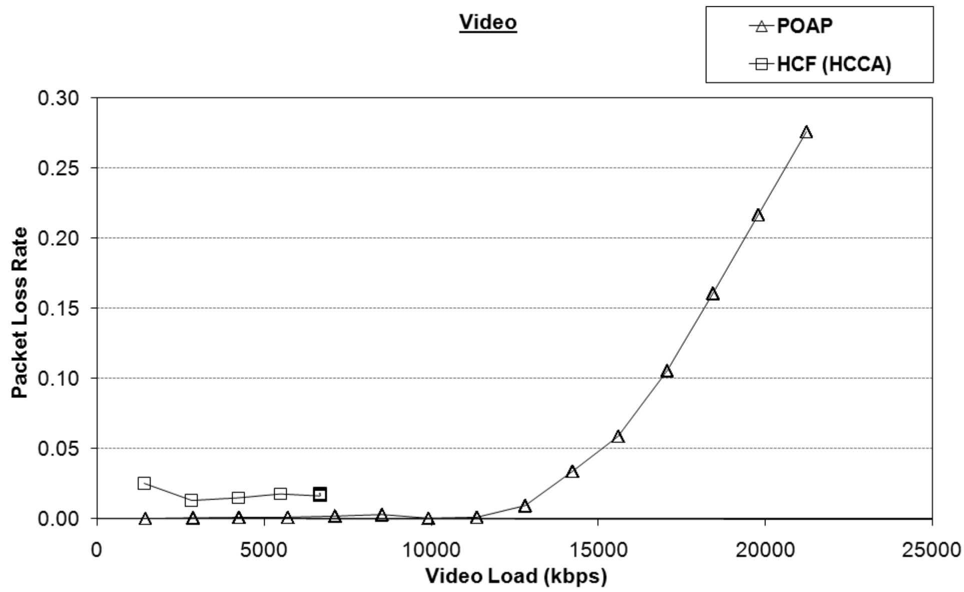


Figure 6: Video Traffic: a) Average Packet Delay versus Video Throughput and b) Packet Loss Rate versus Video Load, in POAP and HCF (EDCA).

In Figure 7 the results concerning the remote database traffic are presented. It is demonstrated that POAP performs significantly better than HCF when dealing with high priority data traffic. It is reminded that remote database traffic is handled by the EDCA protocol in the HCF scheme. In Figure 7a, it can be observed that POAP achieves significantly lower packet delay than HCF, especially for high throughput values, while it exhibits approximately 16% higher maximum throughput. Furthermore, as can be seen in Figure 7b, POAP manages to minimize packet losses, while HCF suffers from increased packet loss rate for load higher than 1.5 Mbps. This behaviour of HCF is due to the fact that EDCA causes large waiting intervals and extended network overhead, when traffic load increases. Thus, the efficient POAP feedback engine, the introduced priority score and the proposed packet-station selection algorithms manage to ensure higher performance when serving high priority data traffic in an integrated scenario. Specifically, the remote database traffic, which is assigned higher priority than typical background traffic and is characterized by relatively low bit rate, is favoured to such a degree by POAP so that it performs absolutely satisfactorily, while the other types of traffic are not degraded.

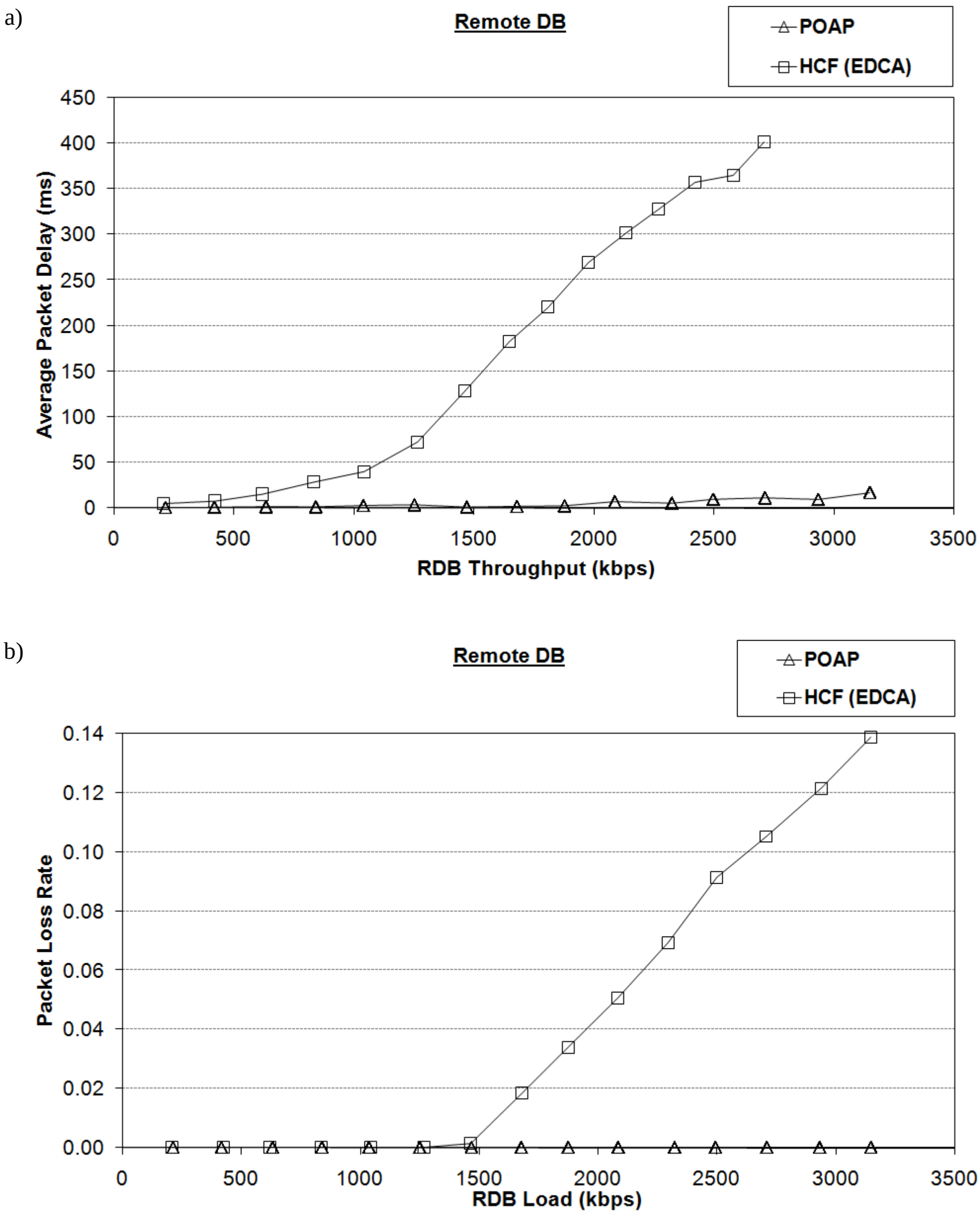
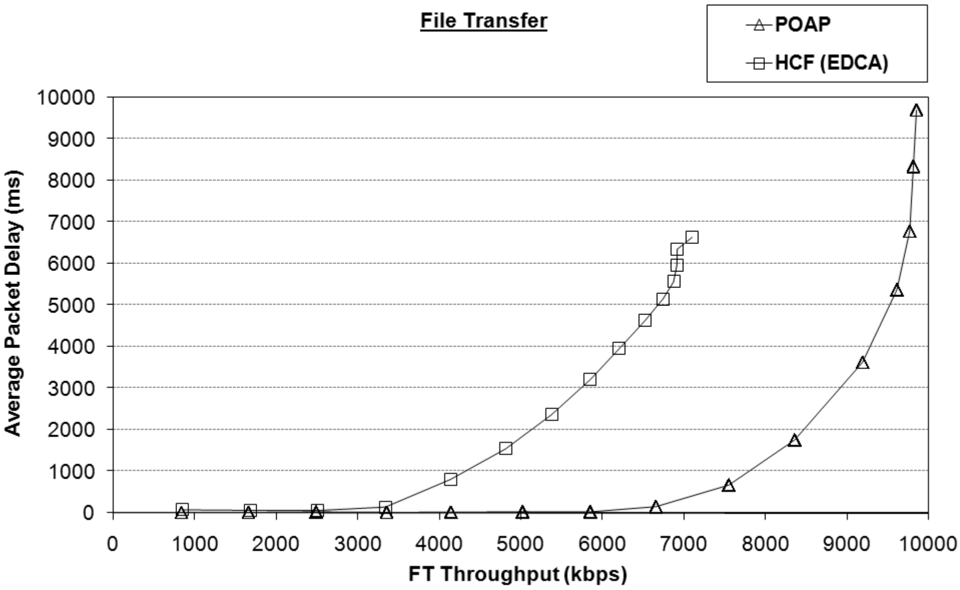


Figure 7: Remote DB Traffic: a) Average Packet Delay versus Remote DB Throughput, and b) Packet Loss Rate versus Remote DB Load, in POAP and HCF (EDCA).

Regarding file transfer traffic, in Figure 8, it becomes evident that POAP can efficiently support bandwidth demanding background transmissions the same time it provides QoS for high priority communications. In the HCF scheme, file transfers are handled by the EDCA protocol. In Figure 8a, it is shown that POAP achieves about 39% higher maximum throughput and up to 40 times lower packet delay than HCF for the same throughput values. File transfer packet loss rate is depicted in Figure 8b. The graph reveals that POAP exhibits lower packet loss rate than HCF for load higher than 7 Mbps and lower than 12 Mbps. When the load is quite low, then both protocols keep file transfer packet loss rate close to zero. On the other hand, in heavy load conditions, HCF exhibits slightly lower loss rate than POAP. Although, POAP can serve adequately both low and high priority traffic providing QoS support under any traffic load conditions.

a)



b)

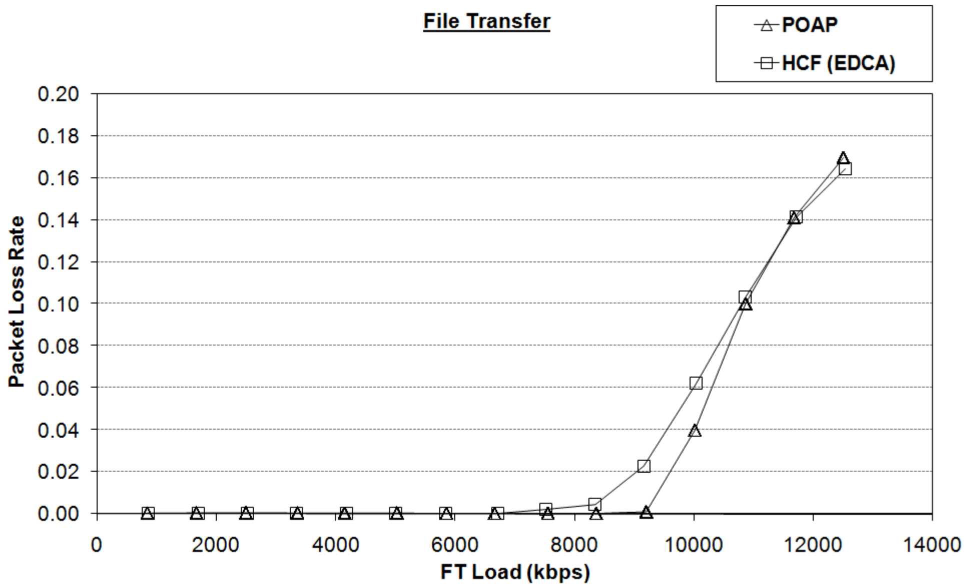


Figure 8: File Transfer Traffic: a) Average Packet Delay versus File Transfer Throughput, and b) Packet Loss Rate versus File Transfer Load, in POAP and HCF (EDCA).

In Figure 9, a 3D graph of the average bit delay and loss rate versus the total throughput, for the whole offered traffic is plotted. It can be deduced that HCF exhibits steady performance until total throughput value reaches 15 Mbps, while the behaviour of POAP is steady even when the total throughput exceeds 20 Mbps. Furthermore, the average bit delay and the bit loss rate of POAP are significantly lower than HCF for the same throughput values and the maximum achieved total throughput is almost 5 Mbps higher than HCF. Specifically, the increased bit loss rate exhibited by HCF is mainly due to its difficulty in supporting high priority traditional data traffic under increasing traffic load conditions. Moreover, the high file transfer packet delays cause increased delays in HCF. Furthermore, HCF exhibits limited maximum throughput for all types of traffic. On the other hand, the access scheme of POAP manages to significantly limit the performance degradation appeared at increased load conditions. Conclusively, POAP saturation is more difficult than HCF.

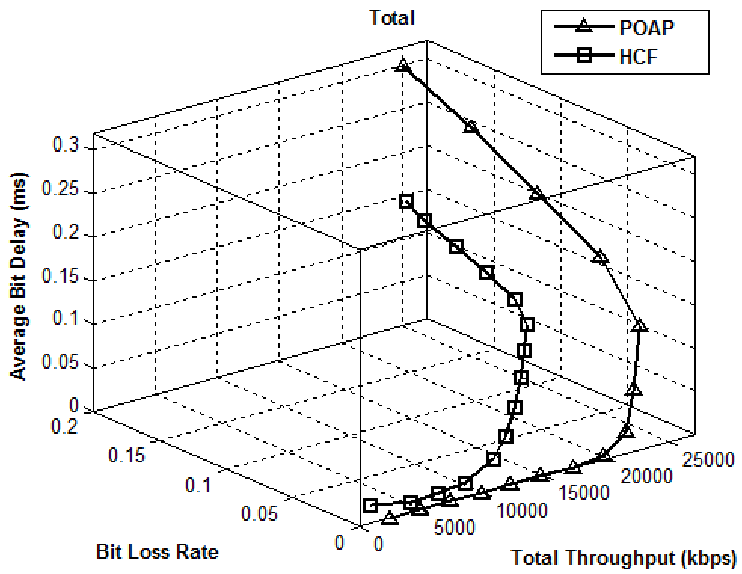


Figure 9: Total Traffic: The average bit delay and the bit loss rate versus the total throughput in POAP and HCF.

Under heavy loaded network conditions, high delays and loss rates are observed for both POAP and HCF schemes, since the objective of our simulations is to study their performance under various networks conditions. Thus, it was certainly expected that under extreme traffic conditions both protocols would not perform satisfactory. However, the presented simulation scenario provides us a broad aspect of the protocols performance. Besides, the simulation results demonstrate the superiority of the proposed POAP scheme adopted in the WLANs.

5 Conclusion

In this study, the Priority Oriented Adaptive Polling protocol for WLANs is analyzed. The main purpose of POAP is to provide efficiently QoS to integrated delay non tolerant and background traffic. For the analysis presented, a cellular topology is assumed, where the AP polls the stations to control transmissions, resulting in a collision free medium. For this reason, a new technique was developed, which differentiates traffic taking into account packet priorities via an appropriate prioritization mechanism. The proposed technique is able to provide valuable feedback to the APs regarding the status of the stations' traffic, by exploiting the control packets in the proposed polling model. This gathered information offers to the AP improved decision making capabilities for granting channel access to different requests. Finally, the performance of POAP is evaluated in comparison to the HCF via simulations under various network scenarios to validate its performance.

The simulation results indicate that POAP achieves significantly improved performance compared to the HCF in terms of channel utilization, packet delay - loss rate and throughput.

In fact, POAP could be further extended through the integration of an appropriate resource reservation mechanism leading to a powerful tool for guaranteed QoS provision in WLANs.

References

1. IEEE 802.11e WG, IEEE Standard for Information Technology--Telecommunications and Information Exchange Between Systems--LAN/MAN Specific Requirements--Part 11 Wireless Medium Access Control and Physical Layer specifications, Amendment 8: Medium Access Control Quality of Service Enhancements, 2005.
2. T. D. Lagkas, G. I. Papadimitriou, P. Nicopolitidis, and A. S. Pomportsis, "A Novel Method of Serving Multimedia and Background Traffic in Wireless LANs," IEEE Transactions on Vehicular Technology, vol. 57, no. 5, pp. 3263-3267, 2008.
3. I. Chlamtac, M. Conti, and J. J. N. Liu, "Mobile ad hoc networking: imperatives and challenges," Elsevier Ad Hoc Networks, vol. 1, no. 1, pp. 13-64, 2003.
4. T. Issariyakul, E. Hossain, and D. I. Kim, "Medium access control protocols for wireless mobile ad hoc networks: issues and approaches," Wiley Journal of Wireless Communication and Mobile Computing, vol. 3, no. 8, pp. 935-958, 2003.
5. J. Sanchez, R. Martinez, and M. W. Marcellin, "A survey of MAC protocols proposed for Wireless ATM," IEEE Network Magazine, vol. 11, no. 6, pp. 52-62, 1997.
6. T. D. Lagkas, G. I. Papadimitriou, and A. S. Pomportsis, "QAP: A QoS supportive Adaptive Polling Protocol for Wireless LANs," Elsevier Computer Communications, vol. 29, no. 5, pp. 618-633, 2006.
7. T. D. Lagkas, G. I. Papadimitriou, and A. S. Pomportsis, "SQAP: A Simple QoS supportive Adaptive Polling Protocol for Wireless LANs," Elsevier Computer Communications, vol. 29, no. 8, pp. 934-937, 2006.
8. T. D. Lagkas, G. I. Papadimitriou, P. Nicopolitidis, and A. S. Pomportsis, "A New Approach to the Design of MAC protocols for Wireless LANs: Combining QoS Guarantee with Power Saving," IEEE Communications Letters, vol. 10, no. 7, pp. 537-539, 2006.
9. T. D. Lagkas, G. I. Papadimitriou, P. Nicopolitidis, and A. S. Pomportsis, "Priority Oriented Adaptive Control with QoS Guarantee for Wireless LANs," IEEE Transactions on Vehicular Technology, vol. 56, no. 4, pp. 1761-1772, 2008.
10. G. I. Papadimitriou, T. D. Lagkas, A. S. Pomportsis, "HIPERSIM: A Sense Range Distinctive Simulation Environment for HiperLAN Systems. Simulation," SAGE Transactions of The Society for Modelling and Simulation International, vol. 79, no. 8, pp. 462-481, 2003.
11. I. F. Akyildiz, J. McNair, L. Carrasco, and R. Puigjaner, R. "Medium Access Control Protocols for Multimedia Traffic in Wireless Networks," IEEE Network Magazine, vol. 13, no. 4, pp. 39-47, 1999.

12. A. Chandra, V. Gumalla, and J. O. Limb, “Wireless Medium Access Control Protocols,” IEEE Communications Surveys and Tutorials, vol. 3, no. 2, pp. 2-15, 2000.

13. Q. Ni, L. Romdhani, and T. Turletti, “A Survey of QoS Enhancements for IEEE 802.11 Wireless LAN,” Wiley Journal of Wireless Communication and Mobile Computing, vol. 4, no. 5, pp. 547-566, 2004.

14. G. Boggia, P. Camarda, L. A. Grieco, and S. Mascolo, “Feedback-Based Control for Providing Real-Time Services With the 802.11e MAC,” IEEE/ACM Transactions on Networking, vol. 15, no. 2, pp. 323-333, 2007.

15. R. J. Haines, T. Lewis, J. Coon, and N. Fanning, “Non-linear optimization of IEEE 802.11e super-frame configuration,” in Proceedings of 63rd IEEE Vehicular Technology Conference 2006, vol. 3, pp. 1211–1215, 2006.

16. Q. Zhao, and D. H.K. Tsang, “An Equal-Spacing-Based Design for QoS Guarantee in IEEE 802.11e HCCA Wireless Networks,” IEEE Transactions on Mobile Computing, vol. 7, no. 12, pp. 1474-1490, 2008.

17. P. Larcheri and R. Lo Cigno, “Scheduling in 802.11e: Open-loop or closed-loop?” in Proceedings of WONS 2006, Les Menuires, France, pp. 114–122, 2006.

18. A. Iera, G. Ruggeri, and D. Tripodi, “Providing throughput guarantees in 802.11e WLAN through a dynamic priority assignment mechanism,” Springer Wireless Personal Communications, vol. 34, no. 1-2, pp. 109–125, 2005.

19. D. Pong, and T. Moors, “Fairness and capacity trade-off in IEEE 802.11 WLANs,” in Proceedings of 29th Annual IEEE International Conference on Local Computer Networks 2004, pp. 310-317, 2004.

20. A. Hamidian and U. Korner, “An Enhancement to the IEEE 802.11e EDCA Providing QoS Guarantees,” Springer Telecommunication Systems, vol. 31, no. 2-3, pp. 195-212, 2006.

21. Y. Ge, J. C. Hou, and S. Choi, “An analytic study of tuning systems parameters in IEEE 802.11e enhanced distributed channel access,” Elsevier Computer Networks, vol. 51, no. 8, pp. 1955-1980, 2007.

22. S. Shankar S. and M. Van der Schaar, “Performance analysis of video transmission over IEEE 802.11a/e WLANs,” IEEE Transactions on Vehicular Technology, vol. 56, no. 4, pp. 2346-2362, 2007.

23. S. C. Wang and A. Helmy, “Performance Limits and Analysis of Contention-based IEEE 802.11 MAC,” in Proceedings of 31st Annual IEEE Conference on Local Computer Networks 2006, pp. 418-425, 2006.

24. IEEE 802.11g WG, International Standard for Information Technology – Telecommunications and Information Exchange between systems-Local and metropolitan area networks-Specific Requirements - Part 11:Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, Amendment 4: Further Higher Data Rate Extension in the 2.4GHz Band, 2003.

25. E. Gilbert, “Capacity of a burst noise channel,” Bell Syst. Tech. J., vol. 39, pp.1253-1265, 1960.

26. M. Zorzi, R. R. Rao, and L. B. Milstein, "On the accuracy of a first-order Markov model for data transmission on fading channels," in Proceedings of ICUPC 1995, pp. 211-215, 1995.
27. K. Pawlikowski, H. D. J. Jeong, and J. S. R. Lee, "On Credibility of Simulation Studies of Telecommunication Networks," IEEE Communications Magazine, vol. 40, no. 1, pp. 132-139, 2002.

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