Review of WLAN Qos Enhancements in MAC Layer to Improve Business Process

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ABSTRACT

A communications network forms the backbone of any successful organization. These networks transport a multitude of applications and data, including high-quality video and delay-sensitive data such as real-time voice. The bandwidth-intensive applications stretch network capabilities and resources, but also complement, add value, and enhance every business process. Networks must provide secure, predictable, measurable, and sometimes guaranteed services.

The objective of this paper is achieving the required Quality of Service (QoS) by managing:

(i) Enhanced distributed channel access (EDCA) and QoS hybrid coordination function (HCF) controlled channel access (HCCA)[7].

(ii) QoS parameters like Delay, delay variation (jitter), bandwidth, and packet loss parameters on a network by having Reliable and Secure Performance Model for Quality of Service enhancements in wireless LAN.

(iii) Use network simulator-2 (NS-2)[10, 11] or other simulator to evaluate the performance of WLAN by using EDCA and HCCA plus admission control mechanism.

Keywords

Simulations, security, Quality-of-Service, QoS routing, ad hoc networks, Performance, Design, Security

1. RESEARCH WORK

IEEE 802.11e-2005 or 802.11e is an approved amendment to the IEEE 802.11 standard that defines a set of Quality of Service enhancements for wireless LAN applications through modifications to the Media Access Control (MAC) layer. The standard is considered of critical importance for delay-sensitive applications, such as Voice over Wireless LAN and streaming multimedia. The amendment has been incorporated into the published IEEE 802.11-2007 standard.

802.11 is an IEEE standard that allows devices such as laptop computers or cellular phones to join a wireless LAN widely used in the home, office and some commercial establishments.

That means one can talk about the issues of wireless Network relating to not only QoS enhancement through MAC but also others such as Security issues or compatibility issues. However we would like to restrict to us to research issues related to secure and reliable QoS only.

2. THE QOS ISSUES

The networks are intended to have wide applicability in many environments that requires its part of QoS. Such as [8 , 9]

- File transfer
- Graphics
- Text processing
- Desktop publishing
- Electronic mail
- Database access
- Transaction processing
- Multimedia
- Office automation
- Process control
- Robotics
- integrated Services (voice, video and data) applications
- Client/server applications

The WLAN networks are intended to support various data devices, such as the following:

Computers

Terminals

Mass storage devices

Printers and plotters

Photocopiers and facsimile machines

Image and video monitors

Wireless terminals

Monitoring and control equipment

Bridges, routers, and gateways

Integrated Services devices, including ISDN terminals and end systems supporting combined voice, video, and data applications

3. WIRED NETWORKS (802)

The first meeting of the IEEE "Local Area Network Standards Committee", Project 802, was held in February of 1980. (The project number, #802, was simply the next number in the sequence being issued by the IEEE for standards projects).

There was originally one LAN standard, with speeds ranging from 1 to 20 Mb/s. It was later divided into a Media or Physical layer (PHY) standard, a Media Access Control (MAC) standard, and a Higher Level Interface (HILI) standard.

The original access method was similar to that for Ethernet and used a passive bus topology. However, by the end of 1980 token access methods were proposed, and a year after there were three different MACs: CSMA/CD, Token Bus, and Token Ring[1 2].

In RECENT years, Wireless local area network (WLAN) technologies have emerged as a fast-growing market. Among the various WLAN technologies available in the market, IEEE 802.11 standard has emerged as the dominating technology and is vastly used in WLANs. Low cost, ease of deployment and mobility support has resulted in the vast popularity of IEEE 802.11 WLANs. They can be easily deployed in hot-spot zones of airports, hotels, stock markets, residence homes and other places. With ever increasing popularity of multimedia applications, people want voice, audio and broadband video services like High definition television (HDTV) through WLAN connections. Unlike the traditional best effort data applications, multimedia applications require quality of service (QoS) support such as guaranteed bandwidth and bounded delay/jitter. As both the medium access control (MAC) layer and the physical (PHY) layer of 802.11[6] are designed for best effort data transmissions, the original 802.11 standard does not take QoS into account. Hence to provide QoS support IEEE 802.11 standard group has specified a new IEEE 802.11e standard. IEEE 802.11e supports QoS by providing differentiated classes of service in the medium access control(MAC) layer, it also enhances the physical layer so that it can delivery time sensitive multimedia traffic, in addition to traditional data packets.

The IEEE 802.11e standard introduces the hybrid coordination function (HCF) as the medium access control (MAC) scheme. While backward compatible with DCF and PCF, HCF provides stations with prioritized and parameterized QoS access to the wireless medium. HCF combines aspects of both the contention-based and the contention free access methods, where the contention-based channel access mechanism in HCF is known as the enhanced distributed channel access (EDCA) and its contention free counterpart is known as the HCF controlled channel access(HCCA)[7].The EDCA is an extension of conventional distributed coordination function (DCF). It provides prioritized QoS services which classifies all the traffics destined medium access control (MAC) layer to multiple access categories (ACs) and it differentiate the chance to get a transmission opportunity (TXOP) using unequal channel access parameters. The EDCA is the fundamental and mandatory mechanism of IEEE 802.11e, while HCCA is optional and requires centralized polling and scheduling algorithms to allocate the resources. In this paper, we only consider the EDCA as a channel access scheme.

4. DISTRIBUTED COORDINATION FUNCTION (DCF)

The existing 802.11 protocols use the distributed coordination function (DCF) access method. The DCF protocol, implements a "listen-before talk" scheme, which is based on Carrier Sense Multiple Access (CSMA)[6 7]. A station wishing to use the wireless medium must first listen to check if it is idle. If it is not idle, the station starts a back-off timer with a random back-off interval, based on a predetermined range defined by the network parameters. Each station determines individually when to access the medium. Therefore the decision making process on the medium access is distributed among all stations.

The DCF provides equal opportunity for each device to access the wireless medium, and works well in traditional data applications. Data application users do not notice the fact that they share the wireless medium with others, because these applications are not sensitive to latency and jitter. In contrast, video, gaming and other applications are intolerant to bandwidth fluctuations, resulting in the inadequacy of the fairness-access mechanism provided by DCF.

5. POINT COORDINATION FUNCTION (PCF)

To support time sensitive services, the PCF provides a mechanism for the prioritization of access to the wireless medium, coordinated by one central Point Coordinator (PC) entity usually the AP. PCF medium access has higher priority than medium access based on DCF.

PCF defines a Contention-Free Period (CFP) and a Contention Period (CP) alternating periodically over time. The PCF is used for accessing the medium during the CFP, while the DCF is used during the CP. During the CFP, there is no contention among stations as stations are polled by the central point coordinator for transmission and they do not try to access the medium independently [7].

Due to complexity of the implementation and some technical issues that remained unsolved, PCF didn't find its way into real products resulting in further development of the QoS standards.

6. IEEE 802.11E

The IEEE 802.11e standard introduces the hybrid coordination function (HCF) for QoS support. The HCF defines two medium access mechanisms [8]:

• Contention-based medium access also known as Enhanced Distributed Channel Access (EDCA)

• Controlled medium access (including polling) also known as HCF Controlled Channel Access (HCCA).

There may still be two phases of operation with 802.11e, (i.e., CP and CFP). The EDCA is used in the CP only, while the HCCA is used in both phases. The HCF combines methods of the PCF and DCF. For this reason it is also called Hybrid.

7. EDCA

While in the DCF all stations try to access the wireless medium with the same priority, in EDCA there are four levels of priority or ACs (voice, video, best effort and background)[7 8]. The EDCA parameter set associated with each AC, defines the priority in medium access by setting individual inter-frame spaces, contention windows, and other additional parameters per AC. The mechanism for listening to the medium and the back-off mechanism, to determine the required transmission times, is similar to the mechanism defined by DCF.

However, unlike DCF, the maximum back-off times differ for the various ACs. This means that higher-priority ACs have a shorter maximum back-off time than lower-priority ACs. The shorter maximum back-off time allow the higher-priority AC to gain access to the wireless medium more frequently than the lower-priority AC. Once a device has gained access to the wireless medium, it has the opportunity to continue transmitting for a specified transmission opportunity (TXOP). Applications or packets that share the same AC also have the same maximum back-off time and, hence, the same chance to gain access to the wireless medium. EDCA is fairly simple to implement, but cannot guarantee latency, jitter or bandwidth and has no means to handles several applications with the same priority level.

8. HCCA

HCCA uses another approach to guarantee QoS. Instead of waiting for idle time for transmission and using a back-off mechanism, it relies on a centralized control in the access point (functioning as the HC, Hybrid Coordinator) that can guarantee the time and duration of the transmission for each of the connected stations[7]. Every station that would like to join the network must request permission from the central access point. This request includes a traffic specification that details the QoS required by the station. The access point then determines if it can support the requested QoS specifications and admits or denies the station. The access point maintains a centralized schedule that is based on the all of its registered stations' QoS requirements. The access point then notifies each station when it will have access to the wireless medium. Since this process is managed from a central location, it is guaranteed that the access will be contention-free. As everything is predetermined upon registration, HCCA is able to guarantee bandwidth, jitter and latency, which is otherwise challenging in a mixed data and multimedia environment.

However, there are still some problems with the HCCA implementation. A major problem is that HCCA lacks the ability to work with a neighbor legacy network. Since the HCCA AP gains the highest priority medium access over any legacy network during both the CFP and CP, it will interfere with a legacy network that does not support HCCA.

9. ADMISSION CONTROL AT THE HC

An IEEE 802.11 network may use admission control to administer policy or regulate the available bandwidth resources. Admission control is also required when a STA desires guarantee on the amount of time that it can access the channel. The HC, which is in the AP, is used to administer admission control in the network. As the QoS facility supports two access mechanisms, there are two distinct admission control mechanisms: one for contention-based access and another for controlled access. Admission control, in general, depends on vendors' implementation of the scheduler, available channel capacity, link conditions, retransmission limits, and the scheduling requirements of a given stream. All of these criteria affect the admissibility of a given stream. If the HC has admitted no streams that require polling, it may not find it necessary to perform the scheduler or related HC functions.

Contention-based admission control procedures

A non-AP STA may support admission control procedures to send frames in the AC where admission control is mandated; but, if it does not support that procedure, it shall use EDCA parameters of a lower priority AC, that does not require admission control. APs shall support admission control procedures, at least to the minimal extent of advertising that admission is not mandatory on its ACs. The AP uses the ACM (admission control mandatory) subfields advertised in the EDCA Parameter Set element to indicate whether admission control is required for each of the ACs. While the CWmin, CWmax, AIFS, TXOP limit parameters may be adjusted over time by the AP, the ACM bit shall be static for the duration of the lifetime of the BSS. An ADDTS Request frame shall be transmitted by a non-AP STA to the HC in order to request admission of traffic in any direction (i.e., uplink, downlink, direct, or bidirectional) employing an AC that requires admission control. The ADDTS Request frame shall contain the UP associated with the traffic and shall indicate EDCA as the access policy. The AP shall associate the received UP of the ADDTS Request frame with the appropriate AC per the UP-to-AC mappings. The non-AP STA may transmit unadmitted traffic for the ACs for which the AP does not require admission control. If a STA desires to send data without admission control using an AC that mandates admission control, the STA shall use EDCA parameters that correspond to a lower priority and do not require admission control. All ACs with priority higher than that of an AC with an ACM flag equal to 1 should have the ACM flag set to 1.

10. PROCEDURES AT THE AP

Response frame that may be to accept or deny the request.

On receipt of an ADDTS Request frame from a non-AP STA, the AP shall make a determination about whether to

a) Accept the request, or

b) Deny the request.

The algorithm used by the AP to make this determination is a local matter. If the AP decides to accept the request, the AP shall also derive the medium time from the information conveyed in the TSPEC element in the ADDTS Request frame. The AP may use any algorithm in deriving the medium time, but K.2.2 provides a procedure that may be used. Having made such a determination, the AP shall transmit a TSPEC (traffic specification) element to the requesting non-AP STA contained in an ADDTS Response frame. If the AP is accepting the request, the Medium Time field shall be specified.

11. PROCEDURE AT NON-AP STAS

Each EDCAF shall maintain two variables: admitted_time and used_time.

The admitted_time and used_time shall be set to 0 at the time of (re)association. The non-AP STA may subsequently decide to explicitly request medium time for the AC that is associated with the specified priority. In order to make such a request, the non-AP STA shall transmit a TSPEC element contained in an ADDTS Request frame with the following fields specified (i.e., nonzero): Nominal MSDU Size, Mean Data Rate, Minimum PHY Rate, Inactivity Interval, and Surplus Bandwidth Allowance. The Medium Time field is not used in the request frame and shall be set to 0.

On receipt of a TSPEC element contained in a ADDTS Response frame indicating that the request has been accepted, the non-AP STA shall recompute the admitted_time for the specified EDCAF as follows:

admitted_time=admitted_time+ dot11EDCAAveragingPeriod * (medium time of TSPEC).

The non-AP STA may choose to tear down the explicit request at any time. For the teardown of an explicit admission, the non-AP STA shall transmit a DELTS frame containing the TSID and direction that specify the TSPEC to the AP. If the non-AP STA sends or receives a DELTS frame, it shall recompute the admitted_time for the specified

EDCAF as follows:

admitted_time=admitted_time– dot11EDCAAveragingPeriod * (medium time of TSPEC).

To describe the behavior at the non-AP STA, two parameters are defined. The parameter used_time signifies the amount of time used, in units of 32 µs, by the non-AP STA in dot11EDCAAveragingPeriod. The parameter admitted_time is the medium time allowed by the AP, in units of 32 µs, in dot11EDCA-AveragingPeriod. The non-AP STA shall update the value of used_time:

a) At dot11EDCAAveragingPeriod second intervals

used_time = max((used_time – admitted_time), 0)

b) After each successful or unsuccessful MPDU (re)transmission attempt,

used_time = used_time + MPDUExchangeTime

The MPDUExchangeTime equals the time required to transmit the MPDU sequence. For the case of an MPDU transmitted with Normal Ack policy and without RTS/CTS protection, this equals the time required to transmit the MPDU plus the time required to transmit the expected response frame plus one SIFS. If the used_time value reaches or exceeds the admitted_time value, the corresponding EDCAF shall no longer transmit using the EDCA parameters for that AC as specified in the QoS Parameter Set element. However, a non-AP STA may choose to temporarily replace the EDCA parameters for that EDCAF with those specified for an AC of lower priority, if no admission control is required for those ACs.If, for example, a non-AP STA has made and had accepted an explicit admission for a TS and the channel conditions subsequently worsen, possibly including a change in PHY data rate so that it requires more time to send the same data, the non-AP STA may make a request for more admitted_time to the AP and at the same time downgrade the EDCA parameters for that AC for short intervals in order to send some of the traffic at the admitted priority and some at the unadmitted priority, while waiting for a response to the admission request.[7]

12. CONTROLLED-ACCESS ADMISSION CONTROL

The schedule management of the admitted HCCA streams by the HC. When the HC provides controlled channel access to non-AP STAs, it is responsible for granting or denying polling service to a TS based on the parameters in the associated TSPEC. If the TS is admitted, the HC is responsible for scheduling channel access to this TS based on the negotiated TSPEC parameters. The HC should not initiate a modification of TSPEC parameters of an admitted TS unless requested by the STA. The HC should not tear down a TS unless explicitly requested by the STA or at the expiry of the inactivity timer. The polling service based on admitted TS provides a "guaranteed channel access" from the scheduler in order to have its QoS requirements met. This is an achievable goal when the WM operates free of external interference (such as operation within the channel by other technologies and co-channel overlapping BSS interference). The nature of wireless communications may preclude absolute guarantees to satisfy QoS requirements. However, in a controlled environment (e.g., no interference), the behavior of the scheduler can be observed and verified to be compliant to meet the service schedule.

The normative behavior of the scheduler is as follows:

The scheduler shall be implemented so that, under controlled operating conditions, all STAs with admitted TS are offered TXOPs that satisfy the service schedule.

Specifically, if a TS is admitted by the HC, then the scheduler shall service the non-AP STA during an SP. An SP is a contiguous time during which a set of one or more downlink unicast frames and/orone or more polled TXOPs are granted to the STA. An SP starts at fixed intervals of time specified in Service Interval field. The first SP starts when the lower order 4 octets of the TSF timer equals the value specified in Service Start_Time Additionally, the minimum TXOP duration shall be at least the time to transmit one maximum MSDU size successfully at the minimum PHY rate specified in the TSPEC. If maximum MSDU size is not specified in the TSPEC, then the minimum TXOP duration shall be at least the time to transmit one nominal MSDU size successfully at the minimum PHY rate. The vendors are free to implement any optimized algorithms, such as reducing the polling overheads, increasing the TXOP duration, etc., within the parameters of the transmitted schedule.

13. CONCLUSION

In this paper we have presented the MAC layer QoS mechanisms provided in IEEE 802.11e standard for WLAN. The MAC layer QOS mechanism make the 802.11e standard a very powerful platform to support QoS in WLANs for real time applications. Among the various coordinate functions such as EDCA and HCCA the survey compares the 802.11e's contentions free medium access method the EDCA cannot provide any QoS guarantee.

The HCCA is a centralized control mechanism; it is applicable to infrastructure mode. It provides a deterministic QoS performance for applications with admission control, while EDCA only provide statistical QoS performance. This is due to HCCA is contention free and EDCA is contentions based. The admission control in EDCA can be used to both Infrastructure and ad hoc mode. In a mixed HCCA and EDCA scenario it is very challenging to tradeoff between EDCA and HCCA. The aim in future work will be to further compare HCCA and EDCA and determine which one will be the best requirement to obtain the required QoS.

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