Mapping DiffServ to MAC differentiation for IEEE 802.11e

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Abstract

In Internet, the user's traffic crosses several domains. More and more the users want end-to-end quality of service (QoS). So it's necessary to have differentiation mechanisms in the access networks where the bottlenecks are often located. In this paper, we propose a global quality of service management applied to DiffServ environments and IEEE 802.11e wireless networks.
We analyze the essential basis for DiffServ in order to ensure an optimal differentiation. Then we evaluate solutions of QoS introduction into the 802.11e network. We finish by a study of mapping solution between DiffServ and QoS mechanisms for IEEE 802.11e wireless networks.

I. Introduction

The IEEE 802.11 Wireless LAN (WLAN) has become a prevailing broadband wireless technology in recent years providing internet service.
As broadband Internet access becomes pervasive, many multimedia applications such as VoIP, AOD and VOD have been deployed via Internet Service Providers (ISPs).
Today, the IEEE 802.11 WLAN is considered a "wireless Ethernet" by virtue of its best effort service provisioning based on Ethernet-like medium access control (MAC) protocol and up to 54 Mbps transmissions rates. However, the 802.11 WLAN is also evolving to support QoS currently, and a new QoS enabled MAC called IEEE 802.11e is emerging. In order to maintain a required Qos for particular applications, IEEE 802.11e enables priority for multimedia traffic. For these applications to work properly, the end-to-end QoS should be provided. IEEE 802.11e WLAN and DiffServ architecture have QoS limitations. In order to improve QoS provided by IEEE802.11e wireless network, in this paper, we consider an end-to-end QoS architecture which is based on mapping DiffServ to MAC differentiation.

II. IEEE 802.11e

In IEEE 802.11, there's no effective mechanism to prioritize video and voice traffics. As a result, the 802.11e task group is currently refining the 802.11 MAC (Medium Access Layer) to improve QoS for better support of audio and video (such as MPEG-2) applications [2].
Because 802.11e falls within the MAC layer, it will be common to all 802.11 PHYs and be backward compatible with existing 802.11 wireless LANs. In addition, you should be able to upgrade your existing 802.11 access points to comply with 802.11e through relatively simple firmware upgrades once they are available [2].

Enhanced Distributed Coordination Function (EDCF):

The goal of EDCF is to provide a distributed access mechanism to support service differentiation. EDCF introduces the concept of access categories (ACs), which are variants of the DCF access mechanism. The IEEE 802.11e draft currently specifies four defaults ACs. The four defaults ACs, are listed in Table I, in which a physical layer IEEE 802.11is adopted [2].

Acess Category AC	CWmin	CWmax	AIFSN	TXOP-limit 802.11b
AC-BK (3)	31	1023	7	0
AC-VI (1)	15	31	2	6. 016 ms
AC-VO (0)	7	15	2	3. 264 ms

Table 1. EDCF Parameters

Different ACs, use different values of arbitration interframe space duration (AIFSD), CW_{min}, and CW_{max}. Traffic classes with smaller values of CW_{min} and CW_{max} have higher priorities. Furthermore, different interframe spaces can be used by different traffic classes. DCF Interframe space (DIFS) is substituted for the AIFSD. AIFSD is at least a duration of short interframe space (SIFS) plus a slot time and can be enlarged individually by different traffic classes. Let the length of a slot time is noted by δ. AIFSD can be computed as the following:

$$AIFSD = SIFS + AIFS * aSlotTime \quad (1)$$

AIFSD is determined by AIFS and traffic classes with smaller values of AIFS have higher priorities.

The values of AIFS[AC], CWmin[AC], and CWmax[AC], which are referred to as the EDCF parameters, can be determined and announced by the access point (AP) via beacon frames, which are transmitted periodically, say every 100 msec typically. Basically, the smaller AIFS [AC] and CWmin [AC], the shorter the channel access delay, and hence the more bandwidth share for a given traffic conditions. These parameters can be used in order to differentiate the channel access among different priority traffic [2].

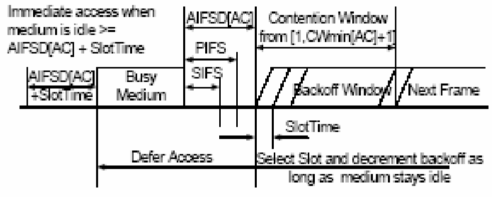

Figure 1. IEEE 802.11e EDCF channel access

In EDCF, data packets are delivered through multiple backoff instances within one mobile station. A single mobile station may implement up to 4 transmission queues and each transmission queue uses a specific AC for contending the channel access, as illustrated in Fig. 1. Each queue within the mobile station contends for the channel access and independently starts its backoff procedure depending on its associated AC. Each queue performs as virtual terminal.

If the backoff time counters of two or more parallel queues within a single mobile station reach zero at the same time, an internal scheduler will resolve the internal collision.

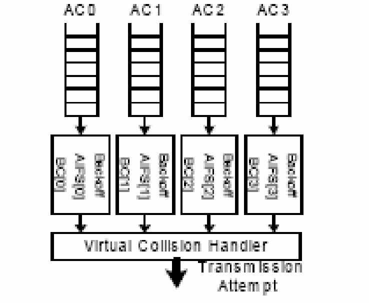

Figure2. Four Access Categories (ACs) for EDCF

Mapping priorities to ACs is defined in the table below:

Service	Access category	Priority
Voice	AC_VO	0
Vidéo	AC_VI	1
Data	AC_BK	3

Table2. Priority to access category mappings

III. Quality of service in the backbone network with DiffServ

Two different Internet QoS models have been proposed by the Internet Engineering Task Force (IETF): integrated services (IntServ) and differentiated services (DiffServ) [1]. In IntServ, network nodes classify incoming packets, and network resources are explicitly identified and reserved. In DiffServ, instead of explicit reservation, traffic is differentiated into a set of classes for scalability, and network nodes provide priority-based treatment according to these classes. In this article we focus on DiffServ in order to provide consistent end-to-end QoS behavior. However, DiffServ itself lacks a simple and scalable bandwidth resource management scheme for a mobile environment.

Differentiated services [1] are a policy-based approach to QoS support in the Internet, where traffic entering a particular network is classified into different classes. Classes are assigned to different behavior aggregates. DiffServ uses the DiffServ code point (DSCP) field in an IP packet header, which determines the service type of the data traffic by specifying a per-hop behavior (PHB) for that packet [1]. Packets marked into the same PHB class experience similar forwarding behavior in the core nodes. PHBs are actually implemented by means of buffer management and packet scheduling mechanisms in the core nodes. For service differentiation for individual or aggregated flows, a meter measures the sending rate of a flow, and a marker sets the DSCP fields of packets in the flow at the edges of the network. A dropper discards packets of different flows according to the DSCP fields and the current load with various dropping precedence policies [1] in the core of the network.

Several PHB group approaches have been introduced, but expedited forwarding (EF) and assured forwarding (AF) PHBs are currently considered to allow delay and bandwidth differentiation.

An EF flow, which has high priority and needs bandwidth and delay assurances, is based on User Datagram Protocol (UDP) traffic and is non adapted. EF service thus requires admission control to prevent resource starvation of lower-priority traffic classes. Meanwhile, an AF flow, which is based on TCP traffic, would be to consume a fraction of the available bandwidth. AF service also requires buffer management mechanisms to control its effect on TCP traffic under congestion.

IV. Mapping DiffServ to MAC differentiation

From the overall network service perspective, QoS should provide end-to-end traffic control so that users' applications can be properly served according to the allowable quality requirements such as latency, jitters and packet loss rate. To comply with the service quality requirements, user level traffic of the applications should coordinate QoS traffic control with transport level QoS at the network interfaces [3].

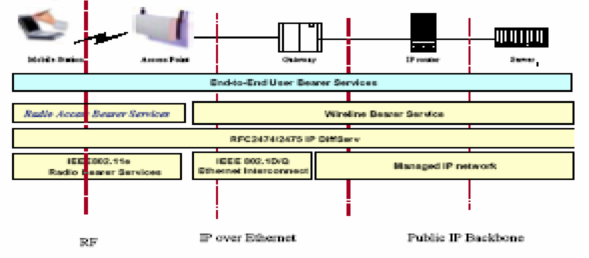

Figure 3. End-to-end QoS network structures

As illustrated in Fig. 3, the user traffic QoS specifies end-to-end network traffic delay, jitter and policing. Since most data service accessing remote servers carries user traffic through multiple heterogeneous networking environments, the user level QoS should be decomposed into each network interface segment as follows:

(a) *Radio Access network* [3]: air interface between mobile station (STA) and access point (AP) defined by IEEE 802.11e.

(b) *Ethernet LAN*: Ethernet between AP and Gateway terminating subnet traffic including traffic through other MAC bridges [3]. 802.1D/Q defines the QoS mechanisms, which can be used in the Ethernet LAN.

(c) *Managed IP WAN* [3]: The IP WAN is normally managed by Service Level Agreement (SLA). User traffic's DiffServ parameters can be directly reflected into the IP routers to be prioritized over other traffic.

In the wireless network, STA performs the packet classification and conditioning in the network layer and forwards the packet to the AP. As illustrated in Fig.3, a STA should map QoS in IP layer to the 802.11e. In STA supporting DiffServ and 802.11e, the DSCP value should be mapped to the TCID placed in 802.11e MAC QoS Control field. Table 3, depicts an example of mapping DSCP to TCID. DSCP values are recommended by standards [4][5]. According to the traffic control structure, two QoS architectures can be considered as follows: Direct mapped QoS between DSCP and TCID.

Traffic class	Exemple	DSCP	TCID
Class1	VoIP	(101)xxx for EF	0
Class2	Video	(100)xxx (AF4x)	1
Class3	Best Effort	(010)xxx (AF2x)	2
Class4	Data	(000)000	3

Table 3. QoS mapping table DSCP to TCID

This architecture uses hierarchical architecture from PHB to the 802.11e Prioritized QoS. The DiffServ engine is a logical entity that performs packet classification and conditioning in the network layer. As illustrated in Fig. 4, when the IP packets arrive at the DiffServ engine, called Traffic Conditioner (TC), which consists of Classifier, Meter, Marker and Shaper/Dropper, they are classified, marked into DSCP values, and shaped in accordance with the priority of the DSCP values. When DiffServ TC completes the traffic shaping, it encapsulates IP packets into 802.11e MAC frames, and forwards them to 802.11e priority queues in accordance with the TCID values. For example, as shown in Fig. 4, when the IP packets arrive at DiffServ TC in order of DSCP values, AF4, AF2, EF and default, they are shaped to EF, AF4, AF2 and default according to the priority. After completing the traffic shaping, IP packets are encapsulated in 802.11e MAC frame and placed into the 802.11e priority queue.

In this architecture, since IP packets are policed and shaped in the network layer, traffic control can support full range of DiffServ QoS as well as 802.11e. This enables the network system to manage accurate end-to-end QoS traffic control required by user applications.

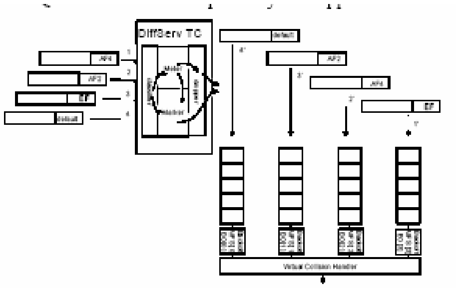

Figure 4. Combined QoS of DiffServ and 802.11e

V. Simulation Results

We validate our models by using the Ns-2 simulator. The values of parameters used in the simulative model are summarized in Table 4. In this validation, each class-k packet has constant packet payload size, as shown in Table 4. We have three common applications (data, video, and voice applications) and each one is associated with default AC specified in the IEEE 802.11e draft. Data, video, and voice applications are associated with AC_3, AC_1 and AC_0 respectively for acquiring channel access. The values of parameters are assigned in the IEEE 802.11draft [6].

Class Traffic/	Priority	Access Category (AC)	Packet size (octets)	Throughput (Kbps)
Voice	0	AC_VO	500	400
Video/	1	AC_VI	500	400
Data/	3	AC_BK	500	400

Table 4. Simulation parameters

In the mapping model, we have three mobile stations. These three mobile stations perform data, video, and voice applications, respectively, to a base station that's connected to a backbone network.

Figures below show throughput, packet loss and delay results related to EDCF and mapping solutions.

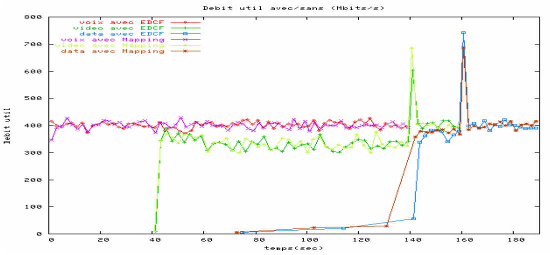

Figure 5. Throughput with/without mapping

Figure 6. Packet loss with/without mapping

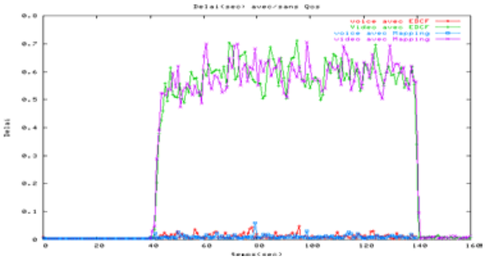

Figure 7. Delay with/without mapping

Fig. 5 shows the throughputs of three flows without and with mapping. We observe that without mapping the throughput of data flows is less than with mapping. Especially, when more voice flows are added. When voice trafic is stopped, we observe that the throughput is more improved with mapping.

Fig 6 shows the packets loss of three flows with and without mapping. We observe that with mapping packet loss of data flows is less than with EDCF.

Fig 7 shows delay of voice and video flows with and without mapping, where the delay is defined as the time interval from the time when a frame arrives at the front of the queue to the time when it is received by the receiver. We observe that voice's delay is improved with mapping more than with EDCF. Video delay is more perfect with mapping. The figure shows that the delays with mapping are much better than delays with EDCF in terms of protection and guarantee of quality of service.

However, in wireless local network where medium is equitably divided between stations, which are in the same BSS, all packets have even the same probability to reach the channel. Conversely, when only MAC differentiation service is used to control the access to the bond, priority packages can be delayed by less priority packages inside the same node. In this case, less priority packages can wait more time to reach the medium. Consequently, priority packages are still penalized in their access to the medium.

VI. Summary and Conclusions

We have analysed a solution introducing the quality of service into the wireless local network. This solution is based on using DifServ model, in order to improve the performances of less priority flows.

This paper has presented an end-to-end network QoS architecture engaged with IEEE 802.11e MAC, which is an emerging QoS standard accompanying with the IEEE 802.11 Wireless Local Area Network (WLAN) standard. Each transport level QoS scheme is presented with associated network interfaces, including DiffServ in network and 802.11e in link layer. End-to-End QoS architecture can be defined with minimal coordination amongst QoS traffic parameters such as DSCP in DiffServ, TCID in 802.11e MAC.

Acronymes

AOD	Data
VOD	Video
EDCF	Enhanced Distributed Coordination Function
WLAN	Wireless Local Area Network
IP	Internet Protocol
VoIP	Voice over IP
DCF	Distributed Coordination Function
TCID	Traffic Category Identifier
TCP	Transmission Control Protocol
UDP	User Datagramme Protocol
WAN	Wide Area Network
BSS	Basic Service Set
MAC	Medium Access Control

References

[1] RFC 2475, *An Architecture for Differentiated Services*, December 1998.

[2] Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-speed Physical Layer in the 5GHz Band, IEEE Std 802.11a-1999, Sep. 1999.

[3] Collaborative QoS Architecture between DiffServ and 802.11e Wireless LAN, Seyong Park, Kyungtae Kim, Doug C. Kim, Sunghyun Choi+, Sangjin Hong

[4] RFC 2598, An Expedited Forwarding PHB, June 1999.

[5] RFC 2597, Assured Forwarding PHB Group, June 1999.

[6] Couplage de services différenciés pour une QoS de bout en bout, Ibrahima NIANG, Hossam AFIFI, Dominique SERET.