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## Mapping Quality of Service (QoS) Procedures of Proxy Mobile IPv6 (PMIPv6) and WLAN

### Abstract

This document provides guidelines for achieving end-to-end Quality of Service (QoS) in a Proxy Mobile IPv6 (PMIPv6) domain where the access network is based on IEEE 802.11. RFC 7222 describes QoS negotiation between a Mobile Access Gateway (MAG) and Local Mobility Anchor (LMA) in a PMIPv6 mobility domain. The negotiated QoS parameters can be used for QoS policing and marking of packets to enforce QoS differentiation on the path between the MAG and LMA. IEEE 802.11 and Wi-Fi Multimedia - Admission Control (WMM-AC) describe methods for QoS negotiation between a Wi-Fi Station (MN in PMIPv6 terminology) and an Access Point. This document provides a mapping between the above two sets of QoS procedures and the associated QoS parameters. This document is intended to be used as a companion document to RFC 7222 to enable implementation of end-to-end QoS.

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## 1. Introduction

PMIPv6 QoS [1] describes an access-network-independent way to negotiate Quality of Service (QoS) for Proxy Mobile IPv6 (PMIPv6) mobility sessions. IEEE 802.11, Wi-Fi Multimedia (WMM), and Wi-Fi Multimedia - Admission Control (WMM-AC) describe ways to provide QoS for Wi-Fi traffic between the Wi-Fi Station (STA) and Access Point (AP). This document describes how QoS can be implemented in a network where the access network is based on IEEE 802.11 (Wi-Fi). It requires a mapping between QoS procedures and information elements in two segments: 1) the Wi-Fi segment and 2) the PMIPv6 segment. (See Figure 1.) The recommendations here allow for dynamic QoS policy information per Mobile Node (MN) and session to be configured by the IEEE 802.11 access network. PMIPv6 QoS signaling between the Mobile Access Gateway (MAG) and Local Mobility Anchor (LMA) provisions the per-MN QoS policies in the MAG. Further details on policy configuration and the Policy Control Function (PCF) can be found in [1], Section 6.1. In the IEEE 802.11 access network modeled here, the MAG is located at the AP / Wireless LAN Controller (WLC). Figure 1 below provides an overview of the entities and protocols.

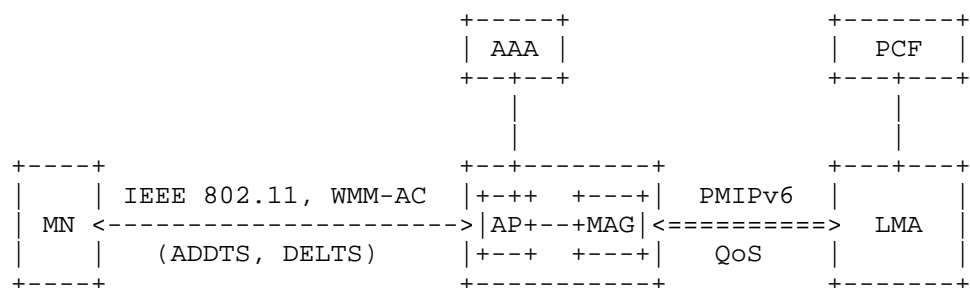


Figure 1: End-to-End QoS in Networks with IEEE 802.11 Access

The MN and Access Point (AP) use IEEE 802.11 QoS mechanisms to set up QoS flows in the Wi-Fi segment. The MAG and LMA set up QoS flows using PMIPv6 QoS procedures. The protocols and mechanisms between the AP and MAG are outside the scope of this document. Some implementations may have the AP and MAG in the same network node. However, this document does not exclude various deployments including those in which the AP and WLC are separate nodes or in which the MAG control and data planes are separate.

The recommendations in this document use IEEE 802.11 QoS and PMIPv6 QoS mechanisms [1]. State machines for QoS policy setup in IEEE 802.11 and PMIPv6 operate differently. Guidelines for installing QoS in the MN using IEEE 802.11 and PMIPv6 segments and for mapping parameters between them are outlined below.

- Procedure Mapping:

PMIPv6-defined procedures for QoS setup, as specified in [1], may be triggered by the LMA or MAG. IEEE 802.11 QoS setup, on the other hand, is always triggered by the MN (IEEE 802.11 QoS Station (QSTA)). The end-to-end QoS setup across these network segments should accommodate QoS that is triggered by the network or by the end user.

- Parameter Mapping:

There is no systematic method of mapping of specific parameters between PMIPv6 QoS parameters and IEEE 802.11 QoS. For example, parameters like Allocation and Retention Priority (AARP) in PMIPv6 QoS have no equivalent in IEEE 802.11.

The primary emphasis of this specification is to handle the interworking between WMM-AC signaling/procedures and PMIPv6 QoS signaling/procedures. When the client does not support WMM-AC, then the AP/MAG uses the connection mapping in Table 2 and DSCP-to-AC mapping as shown in Table 3.

The rest of the document is organized as follows. Section 2 provides an overview of IEEE 802.11 QoS. Section 3 describes a mapping of QoS signaling procedures between IEEE 802.11 and PMIPv6. The mapping of parameters between IEEE 802.11 and PMIPv6 QoS is described in Section 4.

### 1.1. Abbreviations

AAA	Authentication, Authorization, and Accounting
AARP	Allocation and Retention Priority
AC	Access Category
ADDS	ADD Traffic Stream
AIFS	Arbitration Inter-Frame Space
ALG	Application Layer Gateway
AMBR	Aggregate Maximum Bit Rate
AP	Access Point
CW	Contention Window
DETS	DElete Traffic Stream
DL	DownLink
DSCP	Differentiated Services Code Point
DPI	Deep Packet Inspection
EDCA	Enhanced Distributed Channel Access
EPC	Evolved Packet Core
GBR	Guaranteed Bit Rate
MAC	Media Access Control
MAG	Mobile Access Gateway

MBR	Maximum Bit Rate
MN	Mobile Node
MSDU	Media Access Control Service Data Unit
PBA	Proxy Binding Acknowledgement
PBU	Proxy Binding Update
PCF	Policy Control Function
PHY	Physical Layer
QCI	QoS Class Identifier
QoS	Quality of Service
QSTA	QoS Station
SIP	Session Initiation Protocol
STA	Station
TC	Traffic Class
TCLAS	Type Classification
TCP	Transmission Control Protocol
TS	Traffic Stream
TSPEC	Traffic Conditioning Specification
UDP	User Datagram Protocol
UL	UpLink
UP	User Priority
WLAN	Wireless Local Area Network
WLC	Wireless Controller
WMM	Wi-Fi MultiMedia
WMM-AC	Wi-Fi MultiMedia Admission Control

## 1.2. Definitions

### Peak Data Rate

In WMM-AC, Peak Data Rate specifies the maximum data rate in bits per second. The Maximum Data Rate does not include the MAC and PHY overheads [4]. Data rate includes the transport of the IP packet and header.

TSPECs for both uplink and downlink may contain Peak Data Rate.

### Mean Data Rate

This is the average data rate in bits per second. The Mean Data Rate does not include the MAC and PHY overheads [4]. Data rate includes the transport of the IP packet and header.

TSPECs for both uplink and downlink must contain the Mean Data Rate.

#### Minimum Data Rate

In WMM-AC, Minimum Data Rate specifies the minimum data rate in bits per second. The Minimum Data Rate does not include the MAC and PHY overheads [4]. Data rate includes the transport of the IP packet and header.

Minimum Data Rate is not used in QoS provisioning as it is described here.

#### QCI

The QoS Class Identifier (QCI) is a scalar parameter that points to standardized characteristics of QoS as opposed to signaling separate parameters for resource type, priority, delay, and loss [8].

#### STA

A station (STA) is a device that has the capability to use the IEEE 802.11 protocol. For example, a station maybe a laptop, a desktop PC, an access point, or a Wi-Fi phone [3].

An STA that implements the QoS facility is a QoS Station (QSTA) [3].

#### TSPEC

The TSPEC element in IEEE 802.11 contains the set of parameters that define the characteristics and QoS expectations of a traffic flow [3].

#### TCLAS

The TCLAS element specifies an element that contains a set of parameters necessary to identify incoming MSDUs (MAC Service Data Units) that belong to a particular TS (Traffic Stream) [3].

## 2. Overview of IEEE 802.11 QoS

IEEE 802.11 defines a way of providing prioritized access for different traffic classes (video, voice, etc.) by a mechanism called EDCA (Enhanced Distributed Channel Access). The levels of priority in EDCA are called access categories (ACs) and there are four levels (in decreasing order of priority): Voice, Video, Best-Effort, and Background. Prioritized access is achieved by using AC-specific values for Contention Window (CW) and Arbitration Inter-Frame Space (AIFS). (Higher-priority categories have smaller values for minimum and maximum CW and AIFS.)

A subset of the QoS mechanisms is defined in WMM -- a Wi-Fi Alliance certification of support for a set of features from an IEEE 802.11e draft (now part of IEEE 802.11). This certification is for both clients and APs and certifies the operation of WMM. WMM is primarily the implementation of the EDCA component of IEEE 802.11e. WMM uses the IEEE 802.1P classification scheme developed by the IEEE (which is now a part of the 802.1D specification). The IEEE 802.1P classification scheme has eight priorities, which WMM maps to four access categories: AC\_BK, AC\_BE, AC\_VI, and AC\_VO. The lack of support in WMM for the TCLAS (used in identifying an IP flow) has an impact on the QoS provisioning. The impact on WMM-based QoS provisioning is described in Sections 3 and 4.

IEEE 802.11 defines the way a (non-AP) STA can request QoS to be reserved for an access category. Correspondingly, the AP can determine whether to admit or deny the request depending on the available resources. Further, the AP may require that Admission Control is mandatory for an access category. In such a case, the STA is expected to use the access category only after being successfully admitted. WMM-AC is a Wi-Fi Alliance certification of support for Admission Control based on a set of features in IEEE 802.11.

The QoS signaling in IEEE 802.11 is initiated by the (non-AP) STA (by sending an ADDTS request). This specification references procedures in IEEE 802.11, WMM, and WMM-AC.

## 3. Mapping QoS Procedures between IEEE 802.11 and PMIPv6

There are two main types of interaction possible to provision QoS for flows that require Admission Control -- one where the MN initiates the QoS request and the network provisions the resources. The second is where the network provisions resources as a result of a PMIPv6 QoS request. In the second scenario, the LMA can push the QoS configuration to the MAG. However, there is no standard way for the AP to initiate a QoS service request to the MN. Recommendations to set up QoS in both these cases are described in this section.

### 3.1. MN-Initiated QoS Service Request

#### 3.1.1. MN-Initiated QoS Reservation Request

This procedure outlines the case where the MN is configured to start the QoS signaling. In this case, the MN sends an ADDTS request indicating the QoS required for the flow. The AP/MAG obtains the corresponding level of QoS to be granted to the flow by using the PMIPv6 PBU/PBA sequence that contains the QoS options exchanged with the LMA. Details of the QoS provisioning for the flow are provided below.

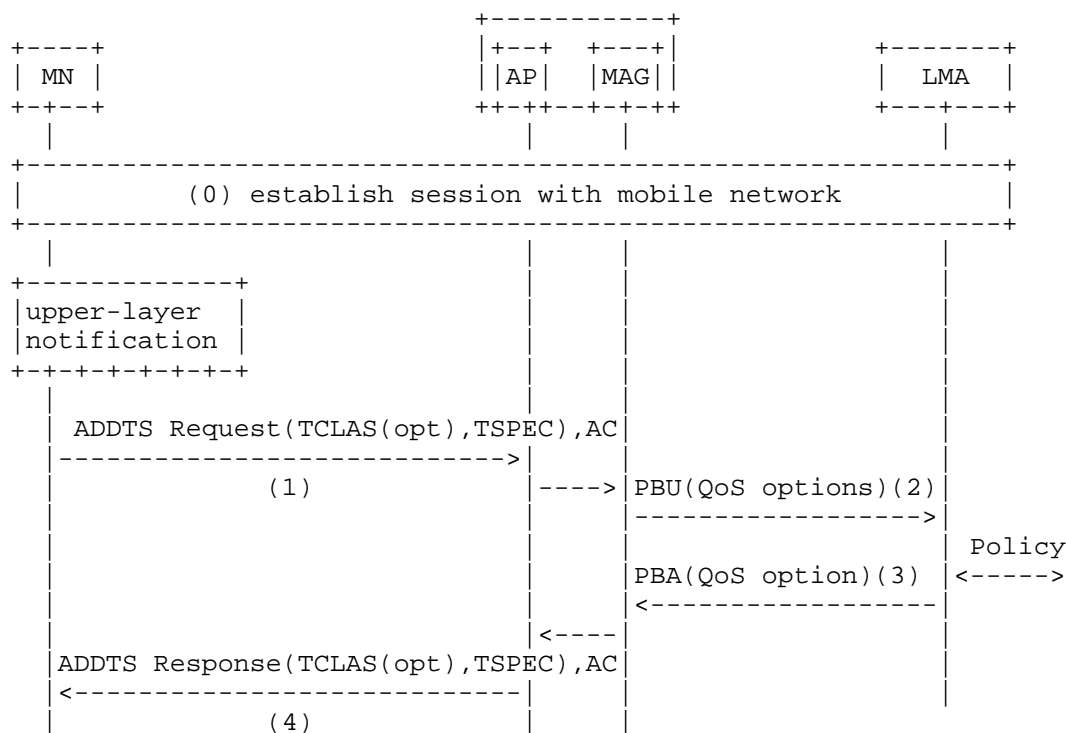


Figure 2: MS-Initiated QoS Service Request

In the use case shown in Figure 2, the MN initiates the QoS service request.

- (0) The MN establishes a session as described in steps 1-4 of Use Case 2 (MAG-Initiated QoS Service Request) in Section 3.1 of [1]. At this point, a connection with a PMIPv6 tunnel is established to the LMA. This allows the MN to start application-level signaling.



- (1) The trigger for the MN to request QoS is an upper-layer notification. This may be the result of end-to-end application signaling and setup procedures (e.g., SIP [10]).

Since the MN is configured to start QoS signaling, it sends an ADDTS request with TSPEC and TCLAS identifying the flow for which QoS is requested.

It should be noted that WMM-AC specifications do not contain TCLAS. When TCLAS is not present, there is no direct way to derive flow-specific attributes like Traffic Selector in PMIPv6. In this case, functionality to derive IP flow details from information in upper-layer protocols (e.g., SIP [10]) and associate them with a subsequent QoS request may be used. This is not described further here, but it may be functionality in an Application Layer Gateway (ALG) or Deep Packet Inspection (DPI). It should be noted that an ALG or DPI can increase the complexity of the AP/MAG implementation and affect its scalability. If no TCLAS is derived, the reservation applies to all flows of the MN. Parameter mapping in this case is shown in Table 2.

- (2) If there are sufficient resources at the AP/WLC to satisfy the request, the MAG sends a PBU with QoS options, Operational Code ALLOCATE, and the Traffic Selector identifying the flow. The Traffic Selector is derived from the TCLAS to identify the flow requesting QoS. IEEE 802.11 QoS parameters in TSPEC are mapped to PMIPv6 parameters. The mapping of TCLAS to PMIPv6 is shown in Table 1. TSPEC parameter mapping is shown in Table 4.

If TCLAS is not present (when WMM-AC is used), TCLAS may be derived from information in upper-layer protocols (as described in step 1) and populated in the Traffic Selector. If TCLAS cannot be derived, the Traffic Selector field is not included in the QoS options.

- (3) The LMA obtains the authorized QoS for the flow and responds to the MAG with Operational Code set to RESPONSE. Mapping of PMIPv6 to IEEE 802.11 TCLAS is shown in Table 1, and mapping of TSPEC parameters is shown in Table 4.

Reserved bandwidth for flows is calculated separately from the non-reserved session bandwidth. The Traffic Selector identifies the flow for which the QoS reservations are made.

If the LMA offers downgraded QoS values to the MAG, it should send a PBU to the LMA with Operational Code set to DE-ALLOCATE. (The LMA would respond with PBA to confirm completion of the request.)

- (4) The AP/MAG provisions the corresponding QoS and replies with ADDTS Response containing authorized QoS in TSPEC, the flow identification in TSPEC, and ResultCode set to SUCCESS.

The AP polices these flows according to the QoS provisioning.

In step 3, if the LMA sends a downgraded QoS or a PBA message with status code CANNOT\_MEET\_QOS\_SERVICE\_REQUEST (179), then the AP should respond to the MN with ADDTS Response and ResultCode set as follows:

- for downgraded QoS from LMA, ResultCode is set to REJECTED\_WITH\_SUGGESTED\_CHANGES. Downgraded QoS values from LMA are mapped to TSPEC as per Table 4. This is still a rejection, but the MN may revise the QoS to a lower level and repeat this sequence if the application can adapt.
- if LMA cannot meet the QoS service request, ResultCode is set to TCLAS\_RESOURCES\_EXHAUSTED.

Either REJECTED\_WITH\_SUGGESTED\_CHANGES or TCLAS\_RESOURCES\_EXHAUSTED results in the rejection of the QoS reservation, but it does not cause the removal of the session itself.

### 3.1.2. MN-Initiated QoS De-allocation Request

QoS resources reserved for a session are released on completion of the session. When the application session completes, the LMA or the MN may signal for the release of resources. In the use case shown in Figure 3, the MN initiates the release of QoS resources.

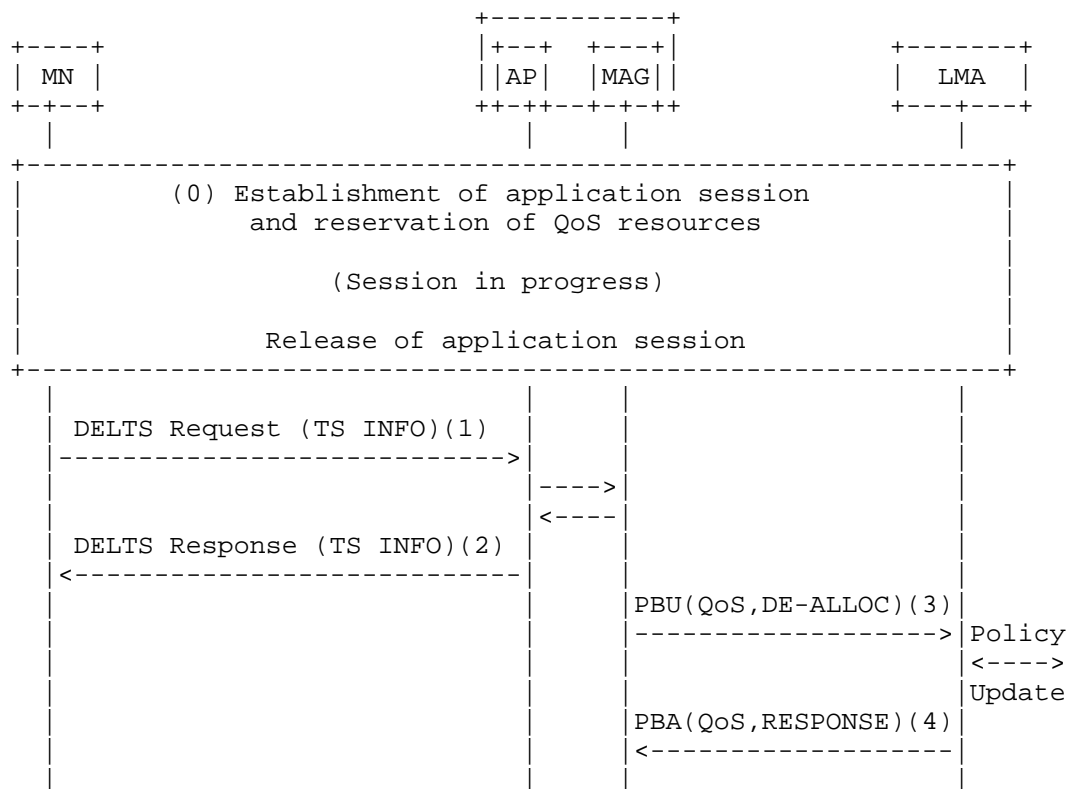


Figure 3: MN-Initiated QoS Resource Release

- (0) The MN establishes and reserves QoS resources. When the application session terminates, the MN prepares to release QoS resources.
- (1) The MN releases its own internal resources and sends a DELTS Request to the AP with TS (Traffic Stream) INFO.
- (2) The AP receives the DELTS request, releases local resources, and responds to the MN with a DELTS response.

- (3) The MAG initiates a PBU, with the Operational Code set to DE-ALLOCATE, and with the Traffic Selector constructed from TCLAS and PMIPv6 QoS parameters from TSPEC.

When TCLAS is not present, the MAG should de-allocate all flows with the same access category as indicated in the DELTS Request. In the typical case, if the client does not support TCLAS and only MN-initiated QoS Service requests are supported, then the MAG will have at most one QoS Service request per access category.

- (4) LMA receives the PBU and releases local resources. The LMA then responds with a PBA.

It should be noted that steps 3 and 4 can proceed independently of the DELTS Response (step 2).

### 3.2. LMA-Initiated QoS Service Request

#### 3.2.1. LMA-Initiated QoS Reservation Request

This section describes the case when the QoS service request is initiated by the LMA. For example, an application such as voice may request the network to initiate configuration of additional QoS policy as in [8], Section 7.4.2. In the current WLAN specifications, there is no standard-defined way for the AP to initiate a QoS service request to the MN. As a result, when the MAG receives a QoS request from the LMA, it does not have any standard mechanisms to initiate any QoS requests to the MN over the access network. Given this, the PMIPv6 QoS service requests and any potential WLAN service requests (such as described in Section 3.1) are handled asynchronously.

The PMIPv6 QoS service requests and WLAN QoS service request could still be coordinated to provide an end-to-end QoS. If the MAG receives an Update Notification (UPN) request from the LMA to reserve QoS resources for which it has no corresponding QoS request from the MN, the MAG may, in consultation with the AP, provision a policy that can grant a subsequent QoS request from the MN. If the MN initiates QoS procedures after the completion of PMIPv6 QoS procedures, the AP/MAG can ensure consistency between the QoS resources in the access network and QoS resources between the MAG and LMA.

For example, if the MN is requesting a mean data rate of  $x$  Mbps, the AP and MAG can ensure that the rate can be supported on the network between MAG and LMA based on previous PMIPv6 QoS procedures. If the MN subsequently requests data rates of  $x$  Mbps or less, the AP can accept a request based on the earlier PMIPv6 QoS provisioning. For the case where there is a mismatch, i.e., the network does not

support the x Mbps, then either the MAG should renegotiate the QoS resource and ask for increased QoS resources or the AP should reject the QoS request.

### 3.2.2. Discussion on QoS Request Handling with IEEE 802.11aa

The network-initiated QoS service request scenario poses some challenges outlined here. IEEE 802.11 does not provide any mechanisms for the AP to initiate a QoS request. As a result, the AP/MAG cannot explicitly make any reservations in response to a QoS reservation request made using UPN. IEEE 802.11aa [5] (which is an amendment to IEEE 802.11) has a mechanism that enables the AP to ask the client to reserve QoS for a traffic stream. It does this via the ADDTS Reserve Request. The ADDTS Reserve Request contains a TSPEC, an optional TCLAS, and a mandatory stream identifier. The specification does not describe how the AP would obtain such a stream identifier. As a result, there needs to be a new higher-layer protocol defined that is understood by the MN and AP and that provides a common stream identifier to both ends. Alternately, the IEEE 802.11aa specification could be modified to make the usage optional. When (or if) the stream identifier is made optional, the TCLAS can provide information about the traffic stream.

Appendix A outlines a protocol sequence with PMIPv6 UPN / Update Notification Acknowledgement (UPA) if the above IEEE 802.11aa issues can be resolved.

### 3.2.3. LMA-Initiated QoS De-allocation Request

QoS resources reserved for a session are released on completion of the session. When the application session completes, the LMA or the MN may signal for the release of resources. In this use case, the network initiates the release of QoS resources.

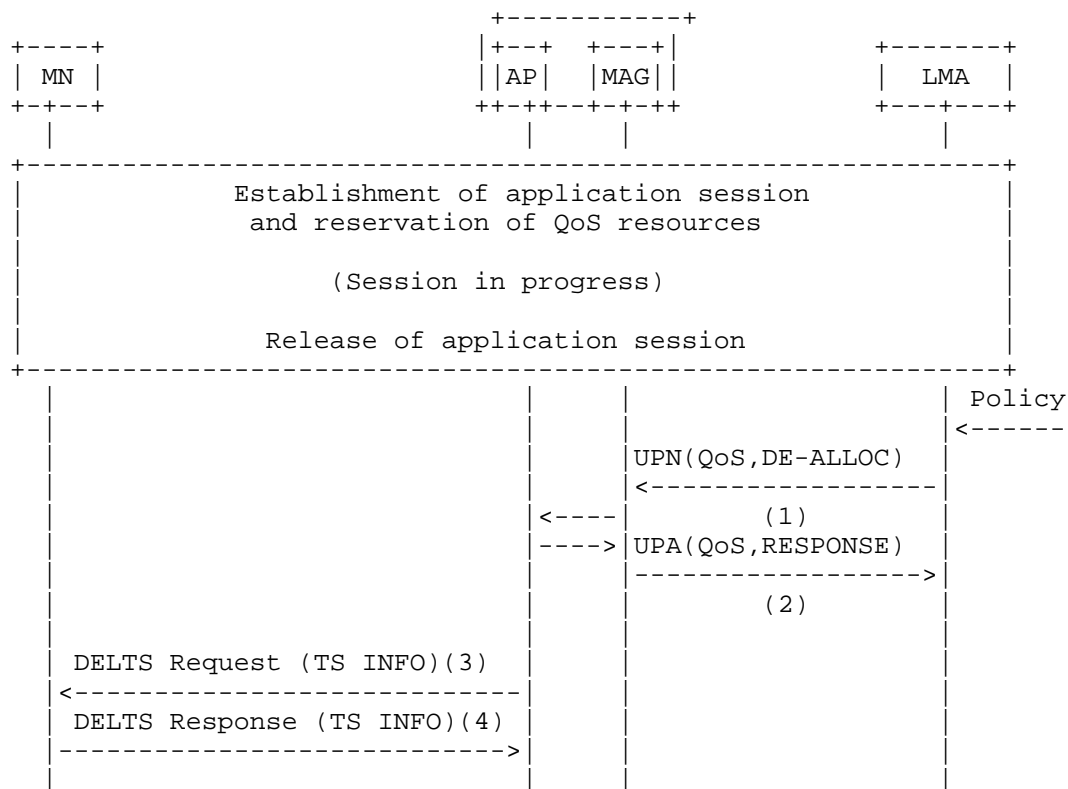


Figure 4: LMA-Initiated QoS Resource Release

In the use case shown in Figure 4, the network initiates the release of QoS resources. When the application session terminates, the LMA receives notification of that event. The LMA releases local QoS resources associated with the flow and initiates signaling to release QoS resources in the network.

- (1) The LMA sends a UPN with QoS options identifying the flow for which QoS resources are to be released and Operational Code set to DE-ALLOCATE. No additional LMA QoS parameters are sent.

- (2) The MAG replies with a UPA confirming the acceptance and Operational Code set to RESPONSE.
- (3) The AP/WLC (MAG) releases local QoS resources associated with the flow. The AP derives the corresponding access category from the Traffic Class (TC) field provided in the QoS option. In addition, if the AP supports TCLAS and the QoS option contains a Traffic Selector field, then the AP shall map the Traffic Selector into a TCLAS element. In the case where the AP does not support TCLAS (for example, an AP compliant with WMM-AC), then the AP shall only use the access category. The AP sends a DELTS Request with TS INFO identifying the reservation.
- (4) The MN sends DELTS Response confirming release.

It should be noted that steps 3 and 4 can proceed independently of the UPA (step 2).

#### 4. Mapping between IEEE 802.11 QoS and PMIPv6 QoS Parameters

##### 4.1. Connection Parameters

TSPEC in IEEE 802.11 is used to reserve QoS for a traffic stream (MN MAC, TS ID). The IEEE 802.11 QoS reservation is for IEEE 802.11 frames associated with an MN's MAC address.

The TCLAS element with Classifier 1 (TCP/UDP Parameters) is used to identify a PMIPv6 QoS flow. We should note that WMM-AC procedures do not support TCLAS. When TCLAS is present, a one-to-one mapping between the TCLAS-defined flow and the Traffic Selector is given below.

QoS reservations in IEEE 802.11 are made for a traffic stream (identified in TCLAS) and correspond to PMIPv6 QoS session parameters (identified by the Traffic Selector). PMIPv6 QoS [1] specifies that when QoS-Traffic-Selector is included along with the per-session bandwidth attributes described in Section 4.3 below, the attributes apply at a per-session level.

+-----+-----+	
MN <--> AP (IEEE 802.11)	MAG <--> LMA (PMIPv6)
+-----+-----+	
(TCLAS Classifier 1)TCP/UDP IP	Traffic Selector (IP flow)
(TCLAS Classifier 1) DSCP	Traffic Class (TC)
+-----+-----+	

Table 1: IEEE 802.11 - PMIPv6 QoS Connection Mapping

If the MN or AP is not able to convey flow parameters in TCLAS, the QoS reservation request in IEEE 802.11 is derived as shown in Table 2.

MN <--> AP (WMM)	MAG <--> LMA (PMIPv6)
(no IP flow parameter/TCLAS)	(a) applies to all flows (b) derived out-of-band
User Priority (802.1D)	Traffic Class (TC) (derived using Table 3)

Table 2: WMM - PMIPv6 QoS Connection Mapping

When WMM [4] is used, and TCLAS is not present to specify IP flow, one of two options apply for the MAG - LMA (PMIPv6) segment:

- (a) Bandwidth parameters described in Section 4.3 apply to all flows of the MN. This is not a preferred mode of operation if the LMA performs reservation for a single flow, e.g., a voice flow identified by an IP 5-tuple.
- (b) The IP flow for which the MN requests reservation is derived out-of-band. For example, the AP/MAG observes application-level signaling (e.g., SIP [10]) or session-level signaling (e.g., 3GPP WLCP (WLAN Control Protocol) [7]), associates subsequent ADDTS requests using heuristics, and then derives the IP flow / Traffic Selector field.

#### 4.2. QoS Class

Table 3 contains a mapping between access category (AC) and IEEE 802.1D User Priority (UP) tag in IEEE 802.11 frames, and DSCP in IP data packets. The table also provides the mapping between AC and DSCP for use in IEEE 802.11 TSPEC and PMIPv6 QoS (Traffic Class). Mapping of QCI to DSCP uses the tables in [6].



QCI	DSCP	802.1D UP	AC	Example Services
1	EF	6(VO)	3 AC_VO	conversational voice
2	EF	6(VO)	3 AC_VO	conversational video
3	EF	6(VO)	3 AC_VO	real-time gaming
4	AF41	5(VI)	2 AC_VI	buffered streaming
5	AF31	4(CL)	2 AC_VI	signaling
6	AF32	4(CL)	2 AC_VI	buffered streaming
7	AF21	3(EF)	0 AC_BE	interactive gaming
8	AF11	1(BE)	0 AC_BE	web access
9	BE	0(BK)	1 AC_BK	email

Table 3: QoS Mapping between QCI/DSCP, 802.1D UP, AC

The MN tags all data packets with DSCP and IEEE 802.1D UP corresponding to the application and the subscribed policy or authorization. The AP polices sessions and flows based on the configured QoS policy values for the MN.

For QoS reservations, TSPEC uses WMM-AC values and PMIPv6 QoS uses corresponding DSCP values in Traffic Class (TC). IEEE 802.11 QoS Access Category AC\_VO and AC\_VI are used for QoS reservations. AC\_BE and AC\_BK should not be used in reservations.

When WMM-AC specifications that do not contain TCLAS are used, it is only possible to have one reservation per Traffic Class / access category. PMIPv6 QoS will not contain any flow-specific attributes like Traffic Selector.

#### 4.3. Bandwidth

Bandwidth parameters that need to be mapped between IEEE 802.11 and PMIPv6 QoS are shown in Table 4.

MN <--> AP(IEEE 802.11)	MAG <--> LMA (PMIPv6)
Mean Data Rate, DL	Guaranteed-DL-Bit-Rate
Mean Data Rate, UL	Guaranteed-UL-Bit-Rate
Peak Data Rate, DL	Aggregate-Max-DL-Bit-Rate
Peak Data Rate, UL	Aggregate-Max-UL-Bit-Rate

Table 4: Bandwidth Parameters for Admission-Controlled Flows

In PMIPv6 QoS [1], services using a sending rate smaller than or equal to the Guaranteed Bit Rate (GBR) can assume, in general, that congestion-related packet drops will not occur [8]. If the rate offered by the service exceeds this threshold, there are no guarantees provided. IEEE 802.11 radio networks do not offer such a guarantee, but [4] notes that the application (service) requirements are captured in TSPEC by the MSDU (MAC Service Data Unit) and Mean Data Rate. The TSPEC should contain Mean Data Rate, and it is recommended that it be mapped to the GBR parameters, Guaranteed-DL-Bit-Rate and Guaranteed-UL-Bit-Rate in PMIPv6 QoS [1].

IEEE 802.11 TSPEC requests do not require all fields to be completed. [4] specifies a list of TSPEC parameters that are required in the specification. Peak Data Rate is not required in WMM; however, for MNs and APs that are capable of specifying the Peak Data Rate, it should be mapped to MBR (Maximum Bit Rate) in PMIPv6 QoS. The AP should use the MBR parameters Aggregate-Max-DL-Bit-Rate and Aggregate-Max-UL-Bit-Rate to police these flows on the backhaul segment between MAG and LMA.

During the QoS reservation procedure, if the MN requests Mean Data Rate, or Peak Data Rate in excess of values authorized in PMIPv6 QoS, the AP should deny the request in an ADDTS response. The AP may set the reject cause code to REJECTED\_WITH\_SUGGESTED\_CHANGES and send a revised TSPEC with Mean Data Rate and Peak Data Rate set to acceptable GBR and MBR, respectively, in PMIPv6 QoS.

## 5. Security Considerations

This document describes mapping of PMIPv6 QoS parameters to IEEE 802.11 QoS parameters. Thus, the security in the WLAN and PMIPv6 signaling segments and the functional entities that map the two protocols need to be considered. IEEE 802.11 [3] provides the means to secure management frames that are used for ADDTS and DELTS. The PMIPv6 specification [9] recommends using IPsec and IKEv2 to secure protocol messages. The security of the node(s) that implement the QoS mapping functionality should be considered in actual deployments.

The QoS mappings themselves do not introduce additional security concerns.

## 6. References

### 6.1. Normative References

- [1] Liebsch, M., Seite, P., Yokota, H., Korhonen, J., and S. Gundavelli, "Quality-of-Service Option for Proxy Mobile IPv6", RFC 7222, DOI 10.17487/RFC7222, May 2014, <<http://www.rfc-editor.org/info/rfc7222>>.
- [2] Krishnan, S., Gundavelli, S., Liebsch, M., Yokota, H., and J. Korhonen, "Update Notifications for Proxy Mobile IPv6", RFC 7077, DOI 10.17487/RFC7077, November 2013, <<http://www.rfc-editor.org/info/rfc7077>>.

### 6.2. Informative References

- [3] IEEE, "IEEE 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", IEEE Standard 802.11.
- [4] Wi-Fi Alliance, "Wi-Fi Multimedia Technical Specification (with WMM-Power Save and WMM-Admission Control)", Version 1.2.0, May 2012.
- [5] IEEE, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, Amendment 2: MAC Enhancements for Robust Audio Video Streaming", IEEE 802.11aa.
- [6] 3GPP, "Guidelines for IPX Provider networks (Previously Inter-Service Provider IP Backbone Guidelines)", GSMA Official Document IR.34 v11.0, November 2014, <<http://www.gsma.com/newsroom/wp-content/uploads/IR.34-v11.0.pdf>>.
- [7] 3GPP, "Technical Specification Group Core Network and Services; Wireless LAN control plane protocols for trusted WLAN access to EPC; Stage 3 (Release 12)", 3GPP TS 23.244 12.1.0, December 2014, <[http://www.3gpp.org/ftp/specs/archive/24\\_series/24.244/](http://www.3gpp.org/ftp/specs/archive/24_series/24.244/)>.
- [8] 3GPP, "Technical Specification Group Services and System Aspects; Policy and Charging Control Architecture (Release 13)", 3GPP TS 23.203 13.2.0, December 2014, <[http://www.3gpp.org/ftp/specs/archive/23\\_series/23.203/](http://www.3gpp.org/ftp/specs/archive/23_series/23.203/)>.

- [9] Gundavelli, S., Ed., Leung, K., Devarapalli, V., Chowdhury, K., and B. Patil, "Proxy Mobile IPv6", RFC 5213, DOI 10.17487/RFC5213, August 2008, <<http://www.rfc-editor.org/info/rfc5213>>.
- [10] Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, DOI 10.17487/RFC3261, June 2002, <<http://www.rfc-editor.org/info/rfc3261>>.

## Appendix A. LMA-Initiated QoS Service Flow with IEEE 802.11aa

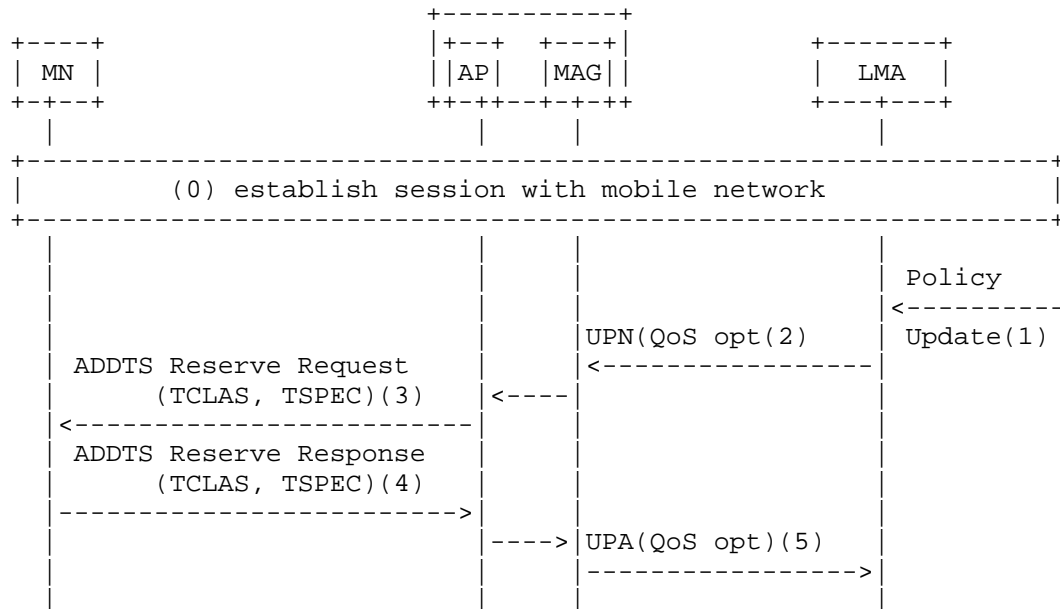


Figure 5: LMA-Initiated QoS Service Request with 802.11aa

In the use case shown in Figure 5, the LMA initiates the QoS service request and IEEE 802.11aa is used to set up the QoS reservation in the Wi-Fi segment.

- (0) The MN sets up a best-effort session. This allows the MN to perform application-level signaling and setup.
- (1) The policy server sends a QoS reservation request to the LMA. This is usually sent in response to an application that requests the policy server for higher QoS for some of its flows.

The LMA reserves resources for the flow requested.

- (2) The LMA sends a PMIPv6 UPN (Update Notification) [2], as outlined in Section 3.2.1, to the MAG with Notification Reason set to QOS\_SERVICE\_REQUEST and Acknowledgement Requested flag set to 1. The Operational Code in the QoS option is set to ALLOCATE, and the Traffic Selector identifies the flow for QoS.

The LMA QoS parameters include Guaranteed-DL-Bit-Rate/Guaranteed-UL-Bit-Rate and Aggregate-Max-DL-Bit-Rate/Aggregate-Max-UL-Bit-Rate for the flow. The reserved bandwidth for flows is calculated separately from the non-reserved session bandwidth.

- (3) If there are sufficient resources to satisfy the request, the AP/MAG sends an ADDTS Reserve Request (IEEE 802.11aa) specifying the QoS reserved for the traffic stream, including the TSPEC and TCLAS elements mapped from the PMIPv6 QoS Traffic Selector to identify the flow.

PMIPv6 parameters are mapped to TCLAS (Table 1) and TSPEC (Table 4). If there are insufficient resources at the AP/WLC, the MAG will not send an ADDTS message and will continue the processing of step 5.

The higher-level stream identifier in IEEE 802.11aa should be encoded as discussed in Section 3.2.2.

- (4) MN accepts the QoS reserved in the network and replies with ADDTS Reserve Response.
- (5) The MAG (AP/WLC) replies with a UPA confirming the acceptance of QoS options and Operational Code set to RESPONSE. The AP/WLC polices flows based on the new QoS.

If there are insufficient resources at the AP in step 3, the MAG sends a response with UPA status code set to CANNOT\_MEET\_QOS\_SERVICE\_REQUEST (130).

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