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Mapping PMIPv6 QoS Procedures with WLAN QoS procedures
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Abstract

This document provides guidelines for achieving end to end QoS in a PMIPv6 domain where the access network is based on IEEE 802.11. RFC 7222 describes QoS negotiation between a MAG and 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 802.11-2012, WMM-AC describes 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

[RFC 7222] describes an access network independent way to negotiate QoS for PMIPv6 mobility sessions. IEEE 802.11, WMM, WMM-AC describes ways to provide QoS for Wi-Fi traffic between the STA and AP. This document describes how QoS can be implemented in a network where the access network is based on IEEE 802.11 (Wi-Fi). This requires a mapping between QoS procedures and information elements in two segments 1) Wi-Fi segment and 2) 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 MAG and LMA provisions the per MN QoS policies in the MAG. In the IEEE 802.11 access network modeled here, the MAG is located at the Access Point (AP)/ Wireless LAN Controller (WLC). Figure 1 below provides an overview of the entities and protocols.

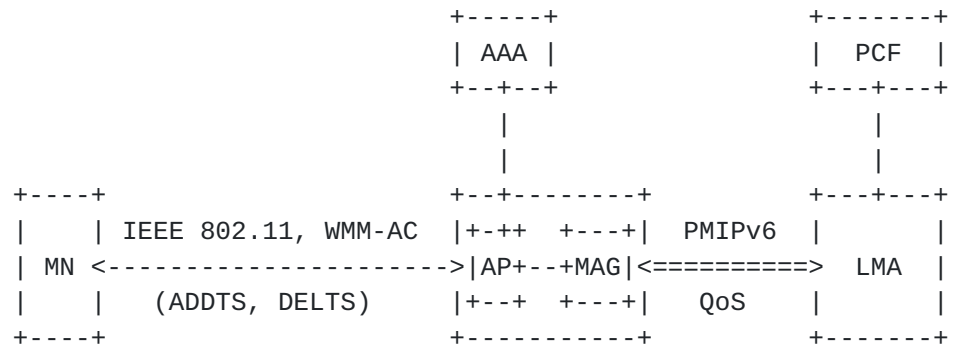

Figure 1: End-to-End QoS in Networks with IEEE 802.11 Access

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

The recommendations in this document for IEEE 802.11 accesses supplement RFC 7222 specifically as outlined below.

- Procedure Mapping:
  PMIPv6 defined procedures for QoS setup maybe triggered by the LMA or MAG. IEEE 802.11 QoS setup on the other hand is always triggered by the MN (IEEE 802.11 QSTA). The end-to-end QoS setup across these network segments should accommodate both network triggered and end-user triggered QoS.

- 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 ARP in PMIPv6 QoS have no equivalent in IEEE 802.11.

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. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

1.2. Definitions

Peak Data Rate
: In WMM, Peak Data Rate specifies the maximum data rate in bits per second. The Maximum Data Rate does not include the MAC and PHY overheads [WMM 1.2.0].

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 [WMM1.2.0]

Minimum Data Rate
: In WMM, Minimum Data Rate specifies the minimum data rate in bits per second. The Minimum Data Rate does not include the MAC and PHY overheads [WMM 1.2.0].

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

TCLAS
: The TCLAS element specifies an element that contains a set of parameters necessary to identify incoming MSDU (MAC Service Data Unit) that belong to a particular TS (Traffic Stream) [802.11-2012].

1.3. Abbreviations

AAA Authentication Authorization Accounting

AMBR	Aggregate Maximum Bit Rate
ARP	Allocation and Retention Priority
AP	Access Point
DSCP	Differentiated Services Code Point
EPC	Enhanced Packet Core
GBR	Guaranteed Bit Rate
MAG	Mobility Access Gateway
MBR	Maximum Bit Rate
MN	Mobile Node
QCI	QoS Class Indicator
QoS	Quality of Service
TCLAS	Type Classification
TSPEC	Traffic Conditioning Spec
WLC	Wireless Controller

2. Overview of IEEE 802.11 QoS

IEEE 802.11-2012 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): Voice, Video, Best-Effort, Background. The prioritized access is achieved by using access category specific values for contention window (CW) and arbitration inter frame service (AIFS). (Higher priority categories have smaller values for minimum and maximum CW and AIFS.). WMM is a Wi-Fi Alliance certification of support for a set of features from an 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 802.11e. WMM uses the 802.1P classification scheme developed by the IEEE (which is now a part of the 802.1D specification). The 802.1P classification scheme has eight priorities, which WMM maps to four access categories: AC_BK, AC_BE, AC_VI, and AC_VO.

IEEE 802.11 also defines a way a (non-AP) STA can request QoS 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 AC 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 802.11-2012 is initiated by the (non-AP) STA (by sending an ADDTS request). This specification references procedures in IEEE 802.11-2012, WMM and WMM-AC.

3. Mapping QoS Signaling 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 PMIP QoS request. In the second scenario, the LMA can push the QoS configuration to the MAG. However, there are no standards defined way for the AP to initiate a QoS service request to the MN. Recommendations to setup QoS in both these cases are described in this section.

3.1. MN Initiated QoS Service Request

3.1.1. MN Initiated QoS Service 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 PMIPv6 PBU/PBA sequence with QoS options with the LMA. Details of the QoS provisioning for the flow are described below.

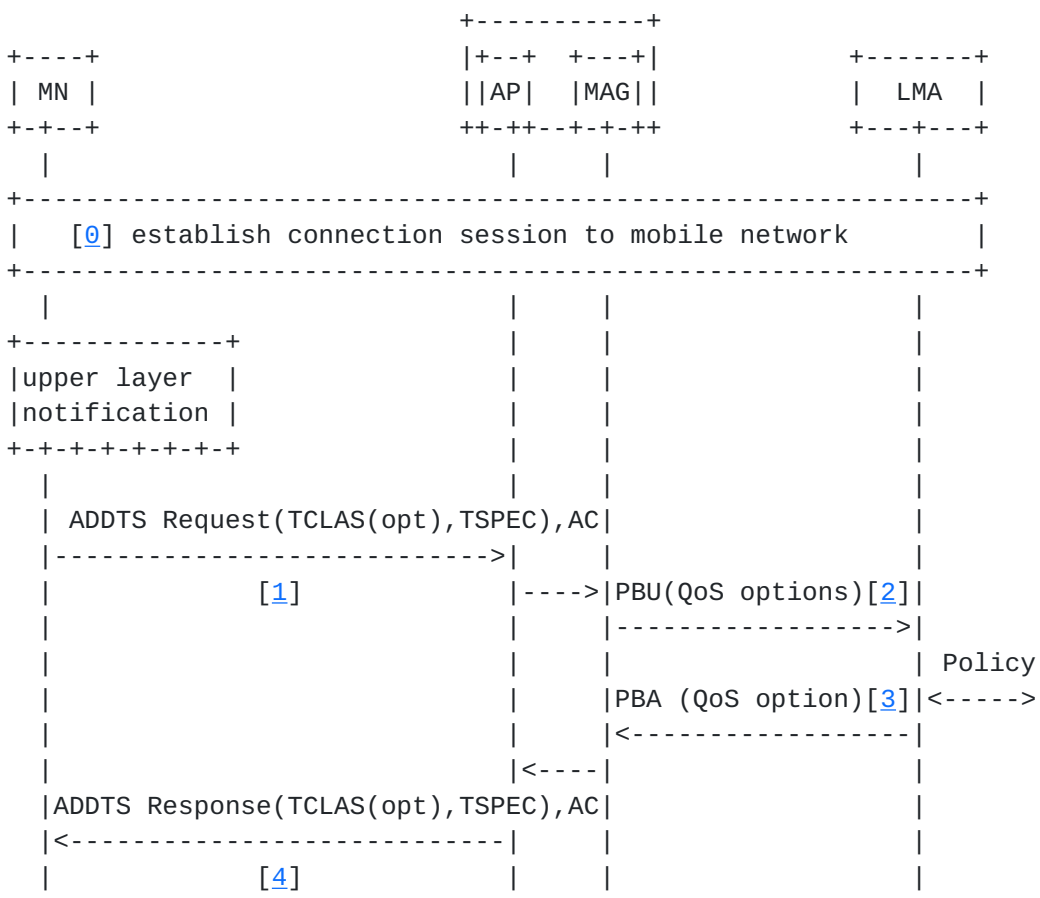

Figure 2: MN initiated QoS service request

[0] The MN establishes a connectivity session as described in [RFC 7222], section 3.1, MAG-initiated QoS service request, steps 1-4. At this point, a connection with PMIPv6 tunnel is established to the LMA. This allows the MN to start application level signaling.

[1] The trigger for 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).

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, the PMIPv6 QoS shall not contain any flow specific attributes like Traffic Selector. Thus, with WMM-AC, only a single reservation per access category (AC) is possible.

The TSPECs for both uplink and downlink in this request should contain the Mean Data Rate and and may contain Peak Data Rate.

[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 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 3.

[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, TSPEC parameters in Table 3.

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

[4] The AP/MAG provisions the corresponding QoS and replies with ADDTS Response containing authorized QoS in TSPEC and flow identification in TSPEC.

The AP polices these flows according to the QoS provisioning.

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 policy server, or the MN may signal for the release of resources. In this use case, the network initiates the release of QoS resources.

Figure 3: Network 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] MN releases its own internal resources and sends a DELTS Request to the AP with TS (Traffic Stream) INFO.

[2] AP receives the DELTS request, releases local resources and responds to MN with a DELTS response.

[3] MAG initiates a PBU with Traffic Selector constructed from TCLAS and PMIPv6 QoS parameters from TSPEC (QoSx).

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

request per access category (AC).
[4] LMA receives the PBU, releases local resources and informs policy server. The LMA then responds with a PBA.

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 (see RFC 7222 for further details). In the current WLAN specifications, there are no standards 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 cannot 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 MN initiates WMM-AC 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-LMA based on previous PMIPv6 QoS procedures. If the MN subsequently requests for data rates of x Mbps or less, the AP can accept it 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 re-negotiate the QoS resource and ask for increased QoS resources or the AP should reject the QoS request.

3.2.2. 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 policy server, or the MN may signal for the release of resources. In this use case, the network initiates the release of QoS resources.

Figure 5: LMA initiated QoS resource release

[0] The MN establishes and reserves QoS resources as in use cases A, B or C.
When the application session terminates, the policy server receives notification that the session has terminated.

[1] LMA receives a policy update indicating that QoS for flow (QoSx) should be released. The LMA releases local resources associated with the flow.

[2] LMA sends a UPN with QoS options identifying the flow for which QoS resources are to be released, and operation code set to DE-ALLOCATE. No additional LMA QoS parameters are sent.

[3] MAG replies with UPA confirming the acceptance and operation code set to RESPONSE.

[4] AP/WLC (MAG) releases local QoS resources associated with the flow. The AP derives the corresponding Access Category from the

DSCP 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 a WMM-AC compliant AP) then the AP shall only use the Access Category. The AP sends a DELTS Request with TS INFO identifying the reservation.

[5] MN sends DELTS Response confirming release.

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(Traffic Stream) 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.

MN <--> AP(IEEE 802.11)	MAG <--> LMA (PMIPv6)
(TCLAS) TCP/UDP IP	Traffic Selector (IP flow)
(TCLAS) |User Priority	DSCP

Table 1: IEEE 802.11 - PMIPv6 QoS Connection mapping

If the MN or AP is not able to convey flow parameters in TCLAS, the AP should use out of band methods to determine the IP flow for which QoS is requested. This may include higher level connection setup signaling (e.g., WCS in [TS23.402]).

4.2 QoS Class

Table 2 contains a mapping between Access Class (WMM AC) and 802.1D in IEEE 802.11 frames, and DSCP in IP data packets. The table also provides the mapping between Access Class (WMM AC) and DSCP for use in IEEE 802.11 TSPEC and PMIPV6 QoS reservations.

QCI	DSCP	802.1D UP	WMM 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(EE)	0 AC_BE	interactive gaming
8	AF11	1(BE)	0 AC_BE	web access
9	BE	0(BK)	1 AC_BK	e-mail

Table 2: QoS Mapping between QCI/DSCP, 802.1D UP, WMM AC

The MN tags all data packets with DSCP and 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 Selector. IEEE 802.11 QoS Access Class AC_VO, AC_VI are used for QoS reservations. AC_BE, 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 DSCP / access category (AC). 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 PMIP QoS are shown in Table 3.

Table 3 shows the mapping of bandwidth parameters.

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 3: Bandwidth Parameters for Admission Controlled Flows

In PMIPV6 QoS, services using a sending rate smaller than or equal to Guaranteed Bit Rate (GBR) can in general assume that congestion related packet drops will not occur [TS 23.203]. 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 [WMM 1.2.0] 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.

IEEE 802.11 TSPEC requests do not require all fields to be completed. [WMM 1.2.0] 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 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. No security concerns need to be addressed as a result of this mapping.

6. IANA Considerations

No IANA assignment of parameters are required.

7. Acknowledgements

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