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Mapping 802.11 QoS in a PMIPv6 Mobility Domain
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Abstract

This document provides recommendations on procedures and mapping of QoS parameters between 802.11 and PMIPv6. QoS parameters in 802.11 that reserve resources for 802.11 streams should be mapped to PMIP QoS resources for IP sessions and flows. QoS reservation sequences in 802.11 should allow cases where MN initiate resource reservation, as well as cases where the network initiates resource reservation. Additionally, it should be possible for QoS parameters for PMIPv6 flows and mobility sessions to be mapped to 802.11 traffic stream reservations. The sequences and parameters to be mapped to provide a consistent behavior across 802.11 and PMIPv6 QoS are described here.

http://www.ietf.org/shadow.html

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1. Introduction

802.11 networks can currently apply QoS policy by using ALG (Application Level Gateway) to detect an application (e.g. SIP signaling) and then install QoS for the corresponding IP flow on the Wireless LAN Controller (WLC)/ Access Point (AP). However, this is not a general mechanism and would require ALG or detection of application level semantics in the access to install the right QoS.

[PMIP-QoS] describes a application neutral procedure to obtain QoS for PMIPv6 flows and sessions. However, there are differences in parameters and procedures that need to be mapped between PMIPv6 QoS and 802.11. PMIPv6 has the notion of QoS for mobility sessions and flows while in 802.11 these should correspond to QoS for 802.11 data frames. Parameters in 802.11 QoS do not always have a one-to-one correspondence in PMIPv6 QoS. Further, 802.11 and PMIP QoS procedures need to be aligned based on whether QoS setup is triggered by the MN or pushed by the the network, as well as working with WMM or 802.11aa mechanisms.

This document provides information on using PMIPv6 QoS parameters for an MN connection over a 802.11 access network. The recommendations here allow for dynamic QoS policy information per Mobile Node (MN) and session to be configured by the 802.11 access network. PMIPv6 QoS signaling between MAG and LMA provisions the per MN QoS policies in the MAG. In the 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.

```
                                      +--------+          +-------+
                                      |  AAA   |          |  PCF  |
                                      +---+----+          +---+---+
                                          |                   |
                                          |                   |
        +----+                        +---+----+          +---+---+
        |    | 802.11 (WMM, 802.11aa) |        |  PMIPv6  |       |
        | MN <------------------------> AP/WLC <==========>  LMA  |
        |    |     (ADDTS, DELTS)     | (MAG)  |   QoS    |       |
        +----+                        +--------+          +-------+
```

Figure 1: QoS Policy in 802.11 Access

MN and AP/WLC use 802.11 QoS mechanisms to setup admission controlled flows. The AP/WLC is a MAG that requests for QoS policy from the LMA. The MN uses ADDTS (Add Traffic Stream) to setup QoS for a traffic stream between itself and the AP, and DELTS (Delete Traffic Stream) to delete that stream. In WMM [WMM 1.2.0], the AP advertises if admission control is mandatory for an access class. Admission control for best effort or background access classes is not recommended. In addition to WMM capability, 802.11aa allows for AP/WLC to support an ADDTS reservation request to the MN. This makes it simpler to support a PMIPv6 QoS request that is pushed to the AP/WLC.

The parameter mapping recommendations described here support the procedures by which the 3GPP network provisions QoS per application dynamically or during authorization of the Mobile Node (MN). However, the 802.11 procedures described here are not limited to work for just the 3GPP policy provisioning. If PMIPv6 QoS parameters can be provisioned on the MAG via mechanisms defined in [PMIP-QoS], the 802.11 procedures can be applied in general for provisioning OoS in a 802.11 network.

PMIPv6 QoS parameters need to be mapped to 802.11 QoS parameters. In some cases, there is no one-to-one mapping. And in other cases such as bandwidth, the values received in PMIP should be mapped to the right 802.11 parameters. This document provides recommendations to perform QoS mapping between PMIPv6 and 802.11 QoS.

[PMIP-QoS] does not explicitly describe how the QoS signaling and QoS sub-options map into corresponding signaling and parameters in the 802.11 access network. This mapping and the procedures in the 802.11 network to setup procedures are the focus of this document. The end-to-end flow spanning 802.11 access and PMIPv6 domain and the QoS parameters in both segments are described here. Thus, it provides a systematic way to map the various QoS parameters available in initial authorization, as well as setup of new sessions (such as a voice/video call). The mapping recommendations allow for proper provisioning and consistent interpretation between the various QoS parameters provided by PMIP QoS, and 802.11.

The rest of the document is organized as follows. Chapter 2 provides an overview of establishing mobility sessions with no admission control. These mechanisms are specified in [PMIP QoS] and outlined here since the mobility session established is the basis for subsequent admission controlled requests for flows. Chapter 3 describes how end to end QoS with 802.11 admission control is achieved. The mapping of parameters between 802.11 and PMIP QoS is described in Chapter 5.

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

Guaranteed Bit Rate (GBR)
GBR in a mobile network defines the guaranteed (reserved) bit rate resources of service data flow on a connection (bearer) [TS23.203].

Maximum Bit Rate (AMBR)
MBR represents the maximum bandwidth of a flow with reservation.

Aggregate Maximum Bit Rate (MBR)
AMBR represents the total bandwidth that all flows of a user is allowed. AMBR does not include flows with reservation.

Allocation Retention Priority (ARP)
ARP is used in the mobile network to determine the order in which resources for a flow may be preempted during severe congestion or other resource limitation. ARP of 1 is the highest priority while 15 is the lowest [TS23.203].

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 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].

1.3. Abbreviations

3GPP	Third Generation Partnership Project
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
PCF	Policy Control Function
PDN-GW	Packet Data Network Gateway
QCI	QoS Class Indicator
QoS	Quality of Service
TCLAS	Type Classification
TSPEC	Traffic Conditioning Spec
WLC	Wireless Controller

2. End-to-End QoS with no Admission Control

PMIPv6 and 802.11 QoS with no admission control is specified in [PMIP QoS]. This section is provided as background here since prior to the establishment of an admission controlled flow, a mobility session as described here is established. IETF (RFC 4594) and GSMA have defined mapping between DSCP and IEEE 802.11 UP (User Priority). The AP/WLC (MAG) should be pre-configured to use the mapping from one of these specifications.

An MN that attempts to connect to a 802.11 network typically authenticates first and may have an authorization profile downloaded. The AP/WLC may use the QoS profile for the MN for policing flows. However, the network can obtain more dynamic policy that corresponds to current mobile network conditions and preferences using PMIP QoS.

```
                          +--------+
      +----+              | AP/WLC |              +-------+
      | MN |              | (MAG)  |              |  LMA  |
      +-+--+              +---+----+              +---+---+
        |                     |                       |
      +-------------------------------------------------------------+
      |           [0] connection setup to mobile network            |
      +-------------------------------------------------------------+
        |                     |                       |
        |                     |  PBU(QoS-i, ALLOC)[1] |
        |                     |---------------------->|  QoS Policy
        |                     |  PBA (QoS-r, NEG) [2] |<--------------->
        |                     |<----------------------|
        |                     |                       |
        |                     |  PBU(QoS-r, ALLOC)[3] |
        |                     |---------------------->|
        |                     |  PBA (QoS-r, RESP)[4] |
        |                     |<----------------------|
        |                     |                       |
```

Figure 2: Default connection setup

[0] MN signals to setup connection. The AP/WLC obtains an authorization profile that includes QoS information, or may have an administratively configured profile with QoS information.

[1] The completion of 802.11 and IP setup serves as a trigger for the MAG (AP/WLC) to request for dynamic QoS parameters. The MAG sends a PBU containing QoS Option with operation code set to ALLOCATE, and DSCP, QoS Attributes set to initially authorized values for the MN’s default connection (QoS-i).

This request is for QoS of all flows of a connectivity session of the MN and includes DSCP, Per-MN-Agg-Max-DL-Bit-Rate, Per-MN-Agg-Max-UL-Bit-Rate, Per-Session-Agg-Max-DL-Bit-Rate, Per-Session-Agg-Max-UL-Bit-Rate and Allocation-Retention-Priority fields derived from the MN initial authorization profile. The Traffic Selector field should not be present.

[2] The LMA queries the policy server and obtains a response. The policy server may grant the QoS requested or may change the QoS levels based on network or other dynamic conditions (QoS-r in figure). This example assumes that the LMA cannot provide the QoS requested by the MAG.

The LMA sets the operational code to NEGOTIATE and responds with downgraded parameters for DSCP, Per-MN-Agg-Max-DL-Bit-Rate, Per-MN-Agg-Max-UL-Bit-Rate, Per-Session-Agg-Max-DL-Bit-Rate, Per-

Session-Agg-Max-UL-Bit-Rate and Allocation-Retention-Priority. The Traffic Selector field is not present since the provisioning applies to the entire PMIPv6 connectivity session.

[3] The MAG receives the downgraded QoS and sends a revised PBU with the QoS options that the LMA is prepared to offer. The operational code is set to ALLOCATE.

[4] The LMA can accept the requested QoS. The LMA sends a PBA message with the revised QoS options and operational code set to RESPONSE.

The new QoS values will be used by the MAG to police flows of the MN and will supercede earlier (or initially) provisioned QoS values. MAG polices session flows to not exceed Per-Session-Agg-Max-DL-Bit-Rate, Per-Session-Agg-Max-UL-Bit-Rate. If there are multiple sessions, the total bandwidth should not exceed Per-MN-Agg-Max-DL-Bit-Rate, Per-MN-Agg-Max-UL-Bit-Rate.

3. End-to-End QoS with Admission Control

This section outlines a few use cases to illustrate how parameters and mapping are applied for flows that require admission control. These cases illustrate the various provisioning sequences and mechanisms. It is not intended to be exhaustive.

The general procedure here is that a flow that requires admission control is part of a PMIPv6 connectivity session. QoS options for the overall session are provisioned as described in section 2. As a result of some application layer signaling, specific flows of the application may require admission controlled QoS which can be provisioned on a per flow basis.

There are two main types of interaction possible to provision QoS for flows that require admission control - one case is 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 some out of band signaling (like application signaling). In the second scenario, if the MN supports 802.11aa, the network can push the QoS configuration to the MN. If the MN only supports WMM QoS, then MN requests for QoS for the 802.11 segment and the MAG provisions based on QoS already provisioned for the MN. These three cases are described in sections 3.1 - 3.3.

In each of the sequences, QoS parameters need to be mapped between 802.11 and PMIPv6. The table below provides an overview of the mapping for establishing QoS for an admission controlled flow.

Further details of the parameters and mappings are provided in section 4.

MN <--> AP/WLC(802.11)	AP/WLC(MAG) <--> LMA PMIPv6
(TCLAS) TCP/UDP IP (TCLAS) User Priority	Traffic Selector (IP flow) DSCP
(TSPEC)Minimum Data Rate, DL (TSPEC)Minimum Data Rate, UL (TSPEC)Mean Data Rate UL/DL (TSPEC)Peak Data Rate, DL (TSPEC)Peak Data Rate, UL	Guaranteed-DL-Bit-Rate Guaranteed-UL-Bit-Rate - Aggregate-Max-DL-Bit-Rate Aggregate-Max-UL-Bit-Rate

Table 1: 802.11 - PMIPv6 QoS Parameter Mapping

3.1. Case A: MN Initiates QoS Request

During an MN flow setup that requires admission control in the 802.11 network, QoS parameters for the flow needs to be provisioned. This procedure outlines the case where the MN is configured (e.g. in SIM) to start the QoS signaling. In this case, the MN sends an ADDTS request indicating the QoS required for the flow. The AP/WLC (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.

```
                                 +--------+
      +----+                     | AP/WLC |          +-------+
      | MN |                     | (MAG)  |          |  LMA  |
      +-+--+                     +---+----+          +---+---+
        |                            |                   |
      +---------------------------------------------------------+
      |   [0] establish connection session to mobile network       |
      +---------------------------------------------------------+
        |                            |                   |
      +-------------+                |                   |
      |upper layer  |                |                   |
      |notification |                |                   |
      +-+-+-+-+-+-+-+                |                   |
        |                            |                   |
        | ADDTS Request (TCLAS,TSPEC) |                  |
        |--------------------------->| PBU(QoS options)[2] |
        |             [1]            |------------------->| QoS Policy
        |                            |PBA (QoS option) [3] |<--------->
        | ADDTS Response(TCLAS,TSPEC) |<-------------------|
        |<---------------------------|                   |
        |             [4]            |                   |
```

Figure 3: MN initiated QoS setup

[0] The MN has a best effort connectivity session as described in section 2. This allows the MN to perform application level signaling and setup.

[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)

If the MN is configured to start QoS signaling, the MN sends an ADDTS request with TSPEC and TCLAS identifying the flow for which QoS is requested. The TSPECs for both uplink and downlink in this request should contain the Minimum Data Rate and Peak Data Rate .

[2] If there are sufficient resources at the AP/WLC to satisfy the request, the MAG (AP/WLC 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. 802.11 QoS parameters in TSPEC are mapped to PMIPv6 parameters. The mapping of TCLAS and TSPEC parameters to PMIPv6 is shown in Table 1.

[3] The LMA obtains the authorized QoS for the flow and responds to the MAG with operational code set to RESPONSE. Mapping of PMIPv6

parameters to 802.11 TSPEC and TCLAS is shown in Table 1.

In networks like 3GPP, the 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/WLC (MAG) provisions the corresponding QoS and replies with ADDTS Response containing authorized QoS in TSPEC and flow identification in TSPEC.

The AP/WLC polices these flows according to the QoS provisioning.

3.2. Case B: Network Initiates QoS Signaling (802.11aa based)

In some cases (e.g. LTE/SAE), the policy server in the network may be configured to initiate the policy reservation request for a flow. This use case illustrates how an MN and 802.11 network that support 802.11aa can provision QoS to flows of the MN that when the policy server pushes the reservation request.

```
                             +--------+
  +----+                     | AP/WLC |         +-------+
  | MN |                     | (MAG)  |         |  LMA  |
  +-+--+                     +---+----+         +---+---+
    |                            |                  |
  +-----------------------------------------------------------------+
  |   [0] establish connection session to mobile network            |
  +-----------------------------------------------------------------+
    |                            |                  |
    |                            |                  | Policy update
    |                            |UPN(QoS option)[2]|<-------------
    | ADDTS Reserve Request      |<-----------------|       [1]
    |         (TCLAS, TSPEC)[3]  |                  |
    |<---------------------------|                  |
    | ADDTS Reserve Response     |                  |
    |         (TCLAS, TSPEC)[4]  |                  |
    |--------------------------->|                  |
    |                            |UPA(QoS option)[5]|
    |                            |----------------->|
    |                            |                  |
```

Figure 4: Network initiated QoS setup with 802.11aa

[0] The MN sets up best effort connectivity session as described in Case A. 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] LMA sends PMIP UPN (Update Notification) to the MAG with QoS parameters for the flow for which the LMA reserved resources in step [1]. In UPN, the operational code in 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. In networks like 3GPP, the reserved bandwidth for flows are accounted separately from the non-reserved session bandwidth.

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

PMIPv6 parameters are mapped to TCLAS and TSPEC as shown in Table 1.

If there are insufficient resources at the AP/WLC, the MAG will not send and ADDTS message and will continue processing of step [5].

[4] MN accepts the QoS reserved in the network and replies with ADDTS Reserve Response.

[5] The MAG (AP/WLC) replies with UPA confirming the acceptance of QoS options and operational code set to RESPONSE. The AP/WLC police flows based on the new QoS.

If there are insufficient resources at the AP/WLC, the MAG sends a response with UPA status code set to CANNOT_MEET_QOS_SERVICE_REQUEST.

3.3. Case C: Hybrid (Network Initiated for PMIP, MN initiated in 802.11)

This use case outlines a scenario where an MN attaches to the 802.11

and then obtains services in the mobile network. When the MN attaches, PMIP signaling between the MAG and LMA establishes mobile connection and related QoS. Subsequently, the MN starts an application that requires dedicated bandwidth resources and signals that using TSPEC/ADDTS request. The details of this sequence are described below.

```
                         +--------+
   +----+                | AP/WLC |          +-------+
   | MN |                | (MAG)  |          |  LMA  |
   +-+--+                +---+----+          +---+---+
     |                       |                   |
     |                       |                   |
   +-----------------------------------------------------------------+
   |   [0] establish connection session to mobile network           |
   +-----------------------------------------------------------------+
     |                       |                   |  Policy update
     |                       | UPN(QoS option)[2] |<--------------
     |                       |<------------------|       [1]
   +-------------+           | UPA(QoS option)[3] |
   |upper layer  |           |------------------>|
   |notification |           |                   |
   +-+-+-+-+-+-+-+           |                   |
     |                       |                   |
     | ADDTS Request(TSPEC)[4] |                 |
     |----------------------->|                  |
     | ADDTS Response(TSPEC)[5]|                 |
     |<-----------------------|                  |
     |                       |                   |
```

Figure 5: Network initiated QoS setup with WMM

[0] The MN sets up best effort connectivity session as described in Case A. 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] LMA sends PMIP UPN (Update Notification) to the MAG with QoS option operational code set to ALLOCATE and QoS parameters for which the LMA reserved resources in step [1]. In UPN, the Traffic selector field in QoS Option 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. In networks like 3GPP, the reserved bandwidth for flows are accounted separately from the non-reserved session bandwidth. This is indicated by using the Traffic Selector in PMIPv6 QoS.

[3] If there are sufficient resources to satisfy the request, the MAG (AP/WLC) replies with UPA confirming the acceptance of QoS options and operation code set to RESPONSE. If there are insufficient resources at the AP/WLC, the MAG may send a response with UPA status code set to CANNOT_MEET_QOS_SERVICE_REQUEST.

The AP/WLC can police flows based on the new QoS. However, the AP/WLC does not initiate QoS reservation signaling on 802.11 because either it or the MN does not support 802.11aa.

[4] 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)

The MN sends an ADDTS request with TSPEC and TCLAS identifying the flow for which QoS is requested. The TSPECs for both uplink and downlink in this request should contain the Minimum Data Rate and Peak Data Rate. The MAG maps PMIPv6 parameters obtained earlier as shown in Table 1.

If the MN supports only WMM QoS, TCLAS is not sent. The AP/WLC may identify the flow based on connection signaling (e.g. 3GPP 23.402, WCS), most recent updates from PMIP QoS (i.e. that in message [3] above), or some combination thereof.

[5] The AP/WLC (MAG) provisions the corresponding QoS and replies with ADDTS Response containing authorized QoS in TSPEC.

The AP/WLC (MAG) may revise the offer to the MN based on PMIPv6 QoS reservation.

3.4. Case D: Network Initiated Release

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.

```
                       +--------+
      +----+           | AP/WLC |         +-------+
      | MN |           | (MAG)  |         |  LMA  |
      +-+--+           +---+----+         +---+---+
        |                  |                  |
      +---------------------------------------------------------------+
      |         [0] Establishment of application session              |
      |              and reservation of QoS resources                 |
      |                                                               |
      |                   ( Session in progress)                      |
      |                                                               |
      |                Release of application session                 |
      +---------------------------------------------------------------+
        |                  |                  | Policy update
        |                  |UPN(QoSx,DE-ALLOC)[2]<---------------
        |                  |<-----------------|       [1]
        |                  |UPA(QoSx,RESPONSE)[3]
        |                  |----------------->|
        | DELTS Request    |                  |
        |       (TS INFO)[4]                  |
        |<-----------------|                  |
        | DELTS Response   |                  |
        |       (TS INFO)[5]                  |
        |----------------->|                  |
        |                  |                  |
```

Figure 6: Network 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 - Traffic Selector field 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. AP/WLC derives the corresponding 802.11 Traffic Stream from the PMIPv6 Traffic Selector. The AP sends a DELTS Request

with TS INFO identifying the reseravtion.

[5] MN sends DELTS Response confirming release.

Since the MN has completed the session, it may send a DELTS to explicitly request release QoS resources at AP. If the AP and MN are 802.11aa capable, the release of resources may also be signaled to the MN.

3.5. Case E: MN Initiated Release

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.

```
                       +--------+
  +----+               | AP/WLC |          +-------+
  | MN |               | (MAG)  |          |  LMA  |
  +-+--+               +---+----+          +---+---+
    |                      |                   |
  +------------------------------------------------------------+
  |         [0] Establishment of application session           |
  |              and reservation of QoS resources              |
  |                                                            |
  |                  ( Session in progress)                    |
  |                                                            |
  |               Release of application session               |
  +------------------------------------------------------------+
    |                      |                   |
    | DELTS Request        |                   |
    |       (TS INFO)[1]   |                   |
    |--------------------->|                   |
    | DELTS Response       |                   |
    |       (TS INFO)[2]   |                   |
    |<---------------------|                   |
    |                      |PBU(QoSx,DE-ALLOC)[3]
    |                      |------------------>| Policy Update
    |                      |PBA(QoSx,RESPONSE)[4]<------------>
    |                      |<------------------|
    |                      |                   |
```

Figure 6: Network 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 MN prepares to release QoS resources.

[1] MN releases its own internal resources and sends a DELTS Request to the AP/WLC with TS (Traffic Stream) INFO.

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

[3] AP/WLC (MAG) initiates a PBU with Traffic Selector constructed from TCLAS and PMIPv6 QoS parameters from TSPEC (QoSx) as shown in Table 1.

[4] LMA receives the PBU, releases local resources and informs policy server. The LMA then responds with a PBA.

3.6. Service Guarantees in 802.11

The GBR - Guaranteed Bit Rate in mobile networks are used to request and commit resources in the network for providing the bandwidth requested. In 802.11 networks, a random backoff timer based on the access class only provides priority access to a shared medium. These mappings and recommendations allow the AP to schedule resources in a fair manner based on subscribed QoS and application request/policy server interaction.

However, there are no guaranteed or committed resources in the 802.11 network - only prioritization that gives better opportunity for frames to compete for a shared medium.

It should also be noted that unlike mobile networks which inform the MN about QoS for established or modified connections (bearers), there is no means for an MN in 802.11 networks to find out the QoS that a policy server requests to be granted. Thus, the application in MN should make its determination to downgrade a request based on SDP and media parameters to downgrade to a lower quality.

4. Mapping of QoS Parameters

This section outlines the handling of QoS parameters between 802.11 and PMIP QoS. 802.11 QoS reservations are made for an MN’s data frames. PMIP QoS provisioning on the other hand is for IP sessions and flows. Parameters in PMIP QoS and 802.11 also need to be mapped according to the recommendations below.

4.1 Connection Mapping

TSPEC in 802.11 is used to reserve QoS for a traffic stream (MN MAC, TS(Traffic Stream) id). The QoS reservation is for 802.11 frames associated with an MN's MAC address. TCLAS element with Classifier 1 (TCP/UDP Parameters) should be used to identify a flow. The flow definition should use the specification in [PMIP-QoS] Traffic Selector. Thus, there is a one-to-one mapping between the TCLAS defined flow and that in Traffic Selector.

When an 802.11 QoS reservation is complete, it is identified by a Traffic Stream (TS) identifier. This corresponds to the flow in PMIPv6 Traffic Selector, and identified in TCLAS. For releasing QoS resources identified by a PMIPv6 Traffic selector, the AP/WLC uses the above relationship to determine the corresponding TS identifier to be sent in the DELTS request.

If the MN or AP/WLC is not able to convey TCLAS, the AP/WLC should use out of band methods to determine the IP flow for which QoS is requested. This includes correlation with connection signaling protocols (e.g. 3GPP 23.402 WCS) and Traffic Selector in most recent PMIP QoS updates.

4.2. QoS Class

Table 1 contains a mapping between Access Class (WMM AC) and 802.1D in 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 802.11 TSPEC and PMIP 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 data packets with DSCP and 802.1D UP corresponding to the application and the subscribed policy or authorization. The AP/WLC polices sessions and flows based on these values and the QoS policy for the MN.

For QoS reservations, TSPEC use WMM AC values and PMIP QoS uses corresponding DSCP values in Traffic Selector. 802.11 QoS Access Class AC_VO, AC_VI are used for QoS reservations. AC_BE, AC_BK should not be used in reservations.

4.3. Bandwidth

There are bandwidth parameters that need to be mapped for admission controlled flows and others for non-admission controlled flows.

Non-Admission Controlled Flows:

Flows and sessions that do not need QoS reservation have no need for equivalent mapping for 802.11. These sessions and flows are policed by the AP/WLC to ensure that QoS policy obtained initially (during MN authorization) or dynamically over PMIP QoS is not exceeded by the MN.

All connection sessions of the MN should not in total exceed Per-MN-Agg-Max-DL-Bit-Rate and Per-MN-Agg-Max-UL-Bit-Rate in the downlink and uplink directions respectively. The non-admission controlled flows of a single connectivity session of an MN should not exceed Per-Session-Agg-Max-DL-Bit-Rate and Per-Session-Agg-Max-UL-Bit-Rate in the downlink and uplink directions respectively.

Admission Controlled Flows:

For flows that require reservation, the 802.11 Minimum Data Rate should be equal to Guaranteed Bit Rate (GBR). If the MN requests Minimum Data Rate in ADDTS greater than GBR, then AP/WLC should reject the admission request in ADDTS Response.

MN <--> AP/WLC(802.11)	AP/WLC(MAG) <--> LMA PMIPv6
Minimum Data Rate, DL	Guaranteed-DL-Bit-Rate
Minimum Data Rate, UL	Guaranteed-UL-Bit-Rate
Mean Data Rate UL/DL	[a]
Peak Data Rate, DL	Aggregate-Max-DL-Bit-Rate
Peak Data Rate, UL	Aggregate-Max-UL-Bit-Rate

NOTE[a] AP/WLC may derive Mean Data Rate from Minimum and Maximum Data Rates. There is no equivalent parameter in PMIP QoS.

Table 3: Bandwidth Parameters for Admission Controlled Flows

During the QoS reservation procedure, if the MN requests Minimum Data Rate, or other parameters in excess of values authorized in PMIP QoS, the AP/WLC should deny the request in ADDTS Response. Bandwidth of admission controlled flows are policed according to the mappings in Table 2.

4.4. Preemption Priority

Mobile networks with resource reservation configure ARP (Allocation Retention Priority) during authorization and it is obtained in [PMIP QoS]. There is no corresponding configuration in 802.11 QoS. However, the AP/WLC may use ARP to determine priority during call setup and vulnerability to release of reserved QoS resources.

Parameter Allocation-Retention-Priority and sub fields of Priority, Preemption-Capability and Preemption-Vulnerability are used as defined in [PMIP-QoS].

When a new ADDTS request for reservation of QoS resources arrives, if there is sufficient free resources, the AP/WLC proceeds to allocate it. If there are insufficient resources, the AP/WLC may preempt existing calls based on the Preemption-Capability of the new call and Preemption-Vulnerability of established calls.

If the AP/WLC determines that an established flow with reserved resources should be released, the AP/WLC should inform the MN using ADDTS (802.11aa) and signal the LMA with a revised QoS reservation in PBU/PBA.

5. Security Considerations

This document describes mapping of 3GPP QoS profile and parameters to IEEE 802.11 QoS parameters. No security concerns are expected as a result of using this mapping.

6. IANA Considerations

No IANA assignment of parameters are required in this document.

7. References

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Appendix A: QoS in 802.11, PMIPv6 and 3GPP Networks

A.1. QoS in IEEE 802.11 Networks

IEEE 802.11-2012 [802.11-2012] provides an enhancement of the MAC layer in 802.11 networks to support QoS--EDCA (Enhanced Distributed Channel Access). EDCA uses a contention based channel access method to provide differentiated, distributed access using eight different UPs (User Priorities). EDCA also defines four access categories (AC) that provide support for the delivery of traffic. In EDCA, the random back-off timer and arbitration inter-frame space is adjusted according to the QoS priority. Frames with higher priority AC have shorter random back-off timers and arbitration inter-frame spaces. Thus, there is a better chance for higher priority frames to be transmitted. The Wi-Fi Alliance has created a specification referred to as WMM (Wi-Fi Multimedia) based on above.

The MN uses ADDTS (Add Traffic Specs) to setup QoS for a traffic stream between itself and the AP, and DELTS to delete that stream. In WMM [WMM 1.2.0], the AP advertises if admission control is mandatory for an access class. Admission control for best effort or background access classes is not recommended. The Wi-Fi Alliance has created a specification referred to as WMM-AC (Wi-Fi Multimedia Admission Control) based on the above.

A.2. QoS in PMIPv6 Mobility domain

[PMIP-QoS] defines a mobility option that can be used by the mobility entities in the Proxy Mobile IPv6 domain to exchange Quality of Service parameters associated with an MN’s IP flows. Using the QoS option, the local mobility anchor and the mobile access gateway can exchange available QoS attributes and associated values. QoS attributes include node and mobile session Aggregate Maximum Bit Rate (AMBR) for upstream and downstream, Guaranteed Bit Rate (GBR) for upstream and downstream, Maximum Bit Rate (MBR) for upstream and downstream and the Allocation Retention Priority (ARP).

[PMIP-QoS] does not explicitly describe how the QoS signaling and QoS sub-options map into corresponding signaling and parameters in the 802.11 access network. This mapping and the procedures in the 802.11 network to setup procedures are the focus of this document. The end-to-end flow spanning 802.11 access and PMIPv6 domain and the QoS parameters in both segments are described in subsequent sections.

A.3. QoS in 3GPP Networks

3GPP has standardized QoS for EPC (Enhanced Packet Core) from Release 8 [TS 23.107]. 3GPP QoS policy configuration defines access agnostic QoS parameters that can be used to provide service differentiation in multi vendor and operator deployments. The concept of a bearer is used as the basic construct for which the same QoS treatment is applied for uplink and downlink packet flows between the MN (host) and gateway [TS23.402]. A bearer may have more than one packet filter associated and this is called a Traffic Flow Template (TFT). The IP five tuple (IP source address, port, IP destination, port, protocol) identifies a flow.

The access agnostic QoS parameters associated with each bearer are QCI (QoS Class Identifier), ARP (Allocation and Retention Priority), MBR (Maximum Bit Rate) and optionally GBR (Guaranteed Bit Rate). QCI is a scalar that defines packet forwarding criteria in the network. Mapping of QCI values to DSCP is well understood and GSMA has defined standard means of mapping between these scalars [GSMA-IR34].

The use cases in subsequent sections use 3GPP policy along with PMIP QoS for provisioning of QoS in the 802.11 network. However, this is exemplary and alternative policy architectures may be used in practice.