ATIS-1000079

National Security Emergency Preparedness Next Generation Network Priority Service (NS/EP NGN-PS): Transport Level Packet Marking and Packet Scheduling

TECHNICAL REPORT

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ATIS-1000079, *National Security Emergency Preparedness Next Generation Network Priority Service (NS/EP NGN-PS): Transport Level Packet Marking and Packet Scheduling*

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ATIS Technical Report on

National Security Emergency Preparedness Next Generation Network Priority Service (NS/EP NGN-PS): Transport Level Packet Marking and Packet Scheduling

Alliance for Telecommunications Industry Solutions

Approved December 20, 2018

Abstract

This Technical Report provides guidance on how the Long Term Evolution (LTE) Allocation Retention Priority (ARP) parameter is used for transport level packet marking and packet scheduling in support of National Security Emergency Preparedness Next Generation Priority Service (NS/EP NGN-PS).

Foreword

The Alliance for Telecommunications Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The Packet Technologies and Systems Committee (PTSC) develops and recommends standards and technical reports related to services, architectures, and signaling, in addition to related subjects under consideration in other North American and international standards bodies. PTSC coordinates and develops standards and technical reports relevant to telecommunications networks in the U.S., reviews and prepares contributions on such matters for submission to U.S. ITU-T and U.S. ITU-T Study Groups or other standards organizations, and review for acceptability or per contra the positions of other countries in related standards development and takes or recommends appropriate actions.

The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages. The word *may* denotes an optional capability that could augment the standard. The standard is fully functional without the incorporation of this optional capability.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PTSC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, PTSC, which was responsible for its development, had the following leadership:

M. Dolly, PTSC Chair (AT&T)

V. Shaikh, PTSC Vice Chair (Vencore Labs)

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1 Scope, Purpose, & Application

This Technical Report (TR) describes support of National Security/Emergency Preparedness Next Generation Priority Services (NS/EP NGN-PS) based on updated 3GPP features allowing use of the Quality of Service (QoS) Class Identifier (QCI) and Allocation Retention Priority (ARP) parameters for:

1. Transport Level Packet Marking (e.g., to set DiffServ Code Point value for priority traffic), and
2. Packet Scheduling (e.g., to determine the relative priority of Service Data Flows (SDFs) and which packet to serve when the QCI Packet Delay Budget (PDB) can no longer be met for one or more SDF aggregates across all UEs).

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[FCC 47 CFR § 64 Appendix B]	FCC Title 47 Telecommunication Appendix B to Part 64; Priority Access Service (PAS) for National Security and Emergency Preparedness (NSEP)[1]
[ATIS-1000057]	ATIS-1000057, Service Requirements for Emergency Telecommunications Service (ETS) in Next Generation Network.[2]
[ATIS-1000065]	ATIS-1000065, Emergency Telecommunications Service (ETS) Evolved Packet Core (EPC) Network Element Requirements.[2]
[ATIS-1000066]	ATIS-1000066, Emergency Telecommunications Service (ETS) Network Element Requirements for IMS-based Next Generation Network (NGN) Phase 2.
[TS 22.153]	3GPP TS 22.153, Multimedia Priority Service.[3]
[TS 23.203]	3GPP TS 23.203, Policy and charging control architecture.3
[TS 23.401]	3GPP TS 23.401, General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.[3]
[RFC 3260]	IETF RFC 3260, New Terminology and Clarifications for Diffserv.[4]
[RFC 5865]	IETF RFC 5865, A Differentiated Services Code Point (DSCP) for Capacity-Admitted Traffic.[4]

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[1] This document is available from the Electronic Code of Federal Regulations (eCFR) at < https://www.ecfr.gov/ >.

[2] This document is available from ATIS at < https://www.atis.org/docstore/default.aspx >.

[3] This document is available from the Third Generation Partnership Project (3GPP) at < http://www.3gpp.org/specifications >.

[4] This document is available from the Internet Engineering Task Force (IETF). < http://www.ietf.org >.

3 Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < http://www.atis.org/glossary >.

3.1 Definitions

NS/EP NGN Priority Services (NS/EP NGN-PS) [ATIS-100057]: are the evolution of legacy GETS and WPS to achieve continuity in the packet-switched NGN, and to leverage the NGN to offer new features and priority multimedia services.

3.2 Acronyms & Abbreviations

3GPP	3rd Generation Partnership Project
ARP	Allocation, Retention, Priority
ATIS	Alliance for Telecommunications Industry Solutions
DRMP	Diameter Routing Message Priority
DSCP	Differentiated Services Code Point
EPC	Evolved Packet Core
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GETS	Government Emergency Telecommunications Service
LTE	Long-Term Evolution
NGN	Next Generation Network
NS/EP	National Security / Emergency Preparedness
QCI	QoS Class Identifier
QoS	Quality of Service
RAN	Radio Access Network
SDF	Service Data Flow
WPS	Wireless Priority Service

4 Overview

4.1 Transport Level Packet Marking

4.1.1 Background

Prior to Release 14, 3GPP specifications indicated that the transport level packet marking is determined solely based on the Quality of Service (QoS) Class Identifier (QCI) value established for a particular bearer. This resulted in the inability to differentiate priority traffic and restricted the ability to provide priority transport treatment for NS/EP NGN-PS. The 3GPP Release 14 specifications were modified to remove this restriction. Specifically, 3GPP Release 14 specifications were modified to allow the QCI and optionally the Allocation Retention Priority (ARP) priority level to be used to determine the Differentiated Services (DiffServ) Code Point (DSCP value or other transport specific information element. This allows the transport level packet marking, e.g., DSCP, to be set properly for priority traffic, based on the QCI and ARP priority level of the associated EPS bearer. The 3GPP Release 14 option for determining the transport level packet marking based on the QCI and ARP priority level needs to be

specified as a mandatory feature for National Security / Emergency Preparedness Next Generation Priority Services (NS/EP NGN-PS).

4.1.2 Problem Description

Prior to Release 14, 3GPP specifications indicated that the transport level packet marking is determined solely based on the QCI value established for a particular bearer. Since NS/EP NGN-PS traffic uses the same QCI as used for comparable non-priority traffic (e.g., QCI value '1' for "Conversational Voice" and QCI value '2' for "Conversational Video"), this mechanism does not allow NS/EP NGN-PS traffic to use a different transport level packet marking than used for non-priority traffic.

4.2 Packet Scheduling

4.2.1 Background

Prior to Release 15, 3GPP specifications indicated that packet scheduling priority is determined primarily based on the QCI Packet Delay Budget (PDB) associated with the Service Data Flow (SDF). The QCI Priority Level plays a secondary role in such a way that if the target set by the PDB can no longer be met for one or more SDF aggregate(s) across all UEs that have sufficient radio channel quality then the QCI Priority level is used as follows: in this case a scheduler meets the PDB of an SDF aggregate on QCI Priority level N in preference to meeting the PDB of SDF aggregates on next QCI Priority level greater than N, until the priority N SDF aggregate's GBR (in case of a GBR SDF aggregate) has been satisfied. The ARP is precluded from being used for the scheduling of individual packets. 3GPP Release 15 specifications were modified to take into account the different ARP priority levels in addition to QCI Priority Level of the different traffic flows when the QCI PDB is not sufficient to determine which packet to serve. However, 3GPP specifications do not mandate specific implementation that requires the ARP to be compared across different QCI priority levels to determine the relative priority of packet scheduling. The 3GPP agreement to allow the use of QCI and ARP priority level for packet scheduling needs to be specified as a mandatory feature for NS/EP NGN-PS.

4.2.2 Problem Description

This clause discusses problems with 3GPP Release 12, 13, and 14 specifications in context of support of NS/EP NGN-PS.

The QCIs for NS/EP voice and NS/EP video are tied to GSMA IR.92 and IR.94 respectively. Release 12 introduced new QCIs with a higher scheduling priority than QCI=1.

The eNodeB scheduling was based on the PDB associated with a QCI and then (when the PDB targets are not satisfied) based on the Priority Level associated with the QCI (i.e., the ARP Priority Level was not included in the scheduler behavior prior to Release 15). Consequently, some precautionary guidance regarding NS/EP NGN-PS Voice and NS/EP NGN-PS Video is required for Release 12, 13, and 14 systems. Similarly, NS/EP NGN-PS data also faces a risk for Release 12, 13, and 14 as a number of QCIs with higher priority than that used for NS/EP NGN-PS data have been defined.

Beginning in Release 15, the ARP Priority Level was added as a parameter that can influence the scheduler priority.

5 QoS Parameters

The following parameters are relevant in influencing transport level packet marking and the packet scheduling behavior (e.g., scheduling weights, admission thresholds, queue management thresholds, link layer protocol configuration, etc.).

The service level (i.e., per SDF or per SDF aggregate) QoS parameters are QCI, ARP, GBR, and MBR. Each Service Data Flow (SDF) is associated with one and only one QCI. For the same IP-CAN session multiple SDFs with the same QCI and ARP can be treated as a single traffic aggregate which is referred to as an SDF aggregate. An SDF is a special case of an SDF aggregate.

5.1 QCI

The QCI is one of the node specific parameters that controls packet forwarding treatment (e.g., scheduling weights, admission thresholds, queue management thresholds, link layer protocol configuration, etc.) that has been pre-configured by the operator owning the node (e.g., eNodeB). QCI is associated with the following QoS characteristics:

- Resource Type (GBR or Non-GBR);

- Priority Level;

- Packet Delay Budget;

- Packet Error Loss Rate;

- Maximum Burst Size (for some GBR QCIs);

- Data rate Averaging Window (for some GBR QCIs).

The Resource Type determines if dedicated network resources related to a service or bearer level Guaranteed Bit Rate (GBR) value are permanently allocated (e.g., by an admission control function in a radio base station). GBR SDF aggregates are therefore typically authorized "on demand" which requires dynamic policy and charging control. A Non GBR SDF aggregate can be pre-authorized through static policy and charging control. GBRs and non-GBRs are assigned different pool of resources and therefore, don't normally compete for resources.

The Packet Delay Budget (PDB) defines an upper bound for the time that a packet can be delayed between the UE and the PCEF. The purpose of the PDB is to support the configuration of scheduling and link layer functions (e.g., the setting of scheduling priority weights and Hybrid Automatic Repeat Request (HARQ) target operating points). Scheduling between different SDF aggregates is primarily based on the PDB. Except for delay critical GBRs (QCIs 82 and 83), the PDB is interpreted as a maximum delay with a confidence level of 98 percent.

Every QCI (GBR and Non-GBR) is associated with a Priority level. The lowest Priority level value corresponds to the highest Priority. The Priority level is used to differentiate between SDF aggregates of the same UE, and it is also used to differentiate between SDF aggregates from different UEs.

The Packet Error Loss Rate (PELR) defines an upper bound for the rate of packets (e.g., IP packets) that have been processed by the sender of a link layer protocol (e.g., RLC in E-UTRAN) but that are not successfully delivered by the corresponding receiver to the upper layer (e.g., PDCP in E-UTRAN). Thus, the PELR defines an upper bound for a rate of non-congestion related packet losses. The purpose of the PELR is to allow for appropriate link layer protocol configurations (e.g., RLC and HARQ in E-UTRAN).

The Maximum Burst Size, if defined for the QCI, is the amount of data which the RAN is expected to deliver within the part of the Packet Delay Budget allocated to the link between the UE and the radio base station. If more data is transmitted from the application, the PDB can be exceeded.

The Data Rate Averaging Window, if defined for the QCI, is the 'sliding window' duration over which the GBR and MBR are calculated (e.g., in the (R)AN, PDN-GW, and UE).

Among the above characteristics, PDB and Priority Level influence the packet forwarding treatment.

5.2 Allocation and Retention Priority

The QoS parameter ARP contains information about the priority level, the pre-emption capability and the pre-emption vulnerability. The priority level defines the relative importance of a resource request. This allows deciding whether a bearer establishment or modification request can be accepted or needs to be rejected in case of resource limitations (typically used for admission control of GBR traffic). It can also be used to decide which existing bearers to pre-empt during resource limitations. The ARP priority level can be used in addition to the QCI to determine the transport level packet marking, e.g., to set the DSCP value of the associated EPS bearer.

The eNodeB can be configured to use the ARP priority level in addition to QCI priority level to control the packet forwarding treatment for SDFs having high priority ARPs.

> NOTE: In the context of determining the DSCP value or scheduling priority, QCI in the document refers to the QCI Priority Level.

The range of the ARP priority level is 1 to 15 with 1 as the highest level of priority. The pre-emption capability information defines whether a service data flow can get resources that were already assigned to another service data flow with a lower priority level. The pre-emption vulnerability information defines whether a service data flow can lose the resources assigned to it in order to admit a service data flow with higher priority level. The pre-emption capability and the pre-emption vulnerability can be either set to 'yes' or 'no'.

The ARP priority levels 1-8 are assigned to resources for services that are authorized to receive prioritized treatment within an operator domain (i.e., that are authorized by the serving network). This ensures that future releases could use ARP priority levels 1-8 to indicate e.g., emergency and other priority services within an operator domain in a backward compatible manner. The ARP priority levels 9-15 can be assigned to resources that are authorized by the home network and thus applicable when a UE is roaming. This does not prevent the use of ARP priority levels 1-8 in roaming situation in case appropriate roaming agreements exist that ensure a compatible use of these priority levels.

5.3 GBR

The GBR denotes the guaranteed bit rate that may be expected to be provided by a GBR QoS Flow.

5.4 MBR

The MBR limits the maximum bit rate that may be expected to be provided by a GBR QoS Flow (e.g., excess traffic may get discarded by a rate shaping function).

5.5 Establishment Cause

The "Establishment Cause" IE is a field in the "RRCConnectionRequest" message that includes highPriorityAccess as one of the enumerated values. The encoding of the "Establishment Cause" IE in the S1-AP "Initial UE Message" message is the same as that of the "Establishment Cause" IE in the RRC "RRCConnectionRequest" message.

An Establishment Cause marked as "highPriorityAccess" indicates that the access request is originated from a UE operating as AC 11-15. NS/EP NGN PS subscribed UEs are assigned to Access Class (AC) 14. Therefore, NS/EP NGN-PS subscribed UEs set "highPriorityAccess" marking while making an access. The presence of highPriorityAccess may be used to set DSCP marking by the eNodeB and the MME before the QCI and ARP of the bearer are known.

6 Transport Level Packet Marking

6.1 Procedures

This clause describes procedures used to support transport level packet marking for NS/EP NGN-PS traffic.

Priority treatment for an FE that has "per hop behavior" queues that support both NS/EP NGN-PS and other public (non-NS/EP NGN-PS) traffic is accomplished using Differentiated Services (DiffServ) Code Point (DSCP). In this case, the Service Provider provisions and configures these queues so that NS/EP NGN PS traffic is the last traffic to be shed from these queues (e.g., NS/EP NGN-PS traffic is assigned a low drop probability DSCP while public traffic is assigned a medium or high drop probability DSCP). Once an FE is made aware of the need to mark the DSCP, packets are marked with appropriate DSCP that will give priority to NS/EP traffic over public traffic.

QCI and ARP are two key parameters that are used to determine the DSCP value. Establishment Cause may also be used to determine if a different DSCP value should be used. Other parameters (e.g., Establishment Cause,

Diameter Routing Message Priority (DRMP), SIP Resource Priority Header (RPH), eMLPP) may also be used to determine if a different DSCP value should be used and are outside the scope of this document.

Once the FE meets the conditions to mark the DSCP for NS/EP during a procedure (e.g., Attach, Call Origination, Call Termination, etc.), the FE handles all subsequent packets for this procedure with priority and marks all subsequent outgoing packets for this procedure with the DSCP configured for NS/EP. It is possible that the Establishment Cause condition is met first and a DSCP value based on that Establishment Cause is chosen and later in the procedure, the ARP/QCI condition is met that requires a different DSCP value. In that case, the ARP/QCI condition overrides the Establishment Cause condition for the rest of the procedure and the DSCP value corresponding to ARP/QCI will be used to mark the packets.
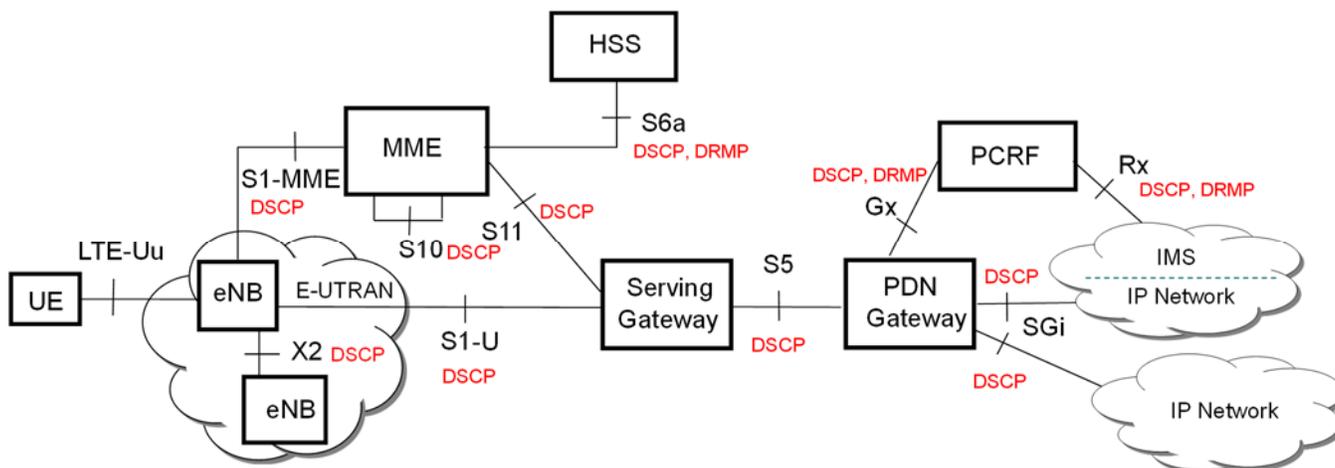

Figure 6.1 – EPS Architecture

Figure 6.1 shows the EPS architecture (non-roaming) and the interfaces where DSCP and DRMP marking appropriate for NS/EP may be included.

Depending on if the NS/EP subscriber is using an NS/EP NGN-PS-subscribed UE or a public UE, the stage where the bearers are assigned NS/EP-specific ARP is different and therefore, the stage where the packets are marked for NS/EP-specific DSCP value is different.

An NS/EP NGN-PS subscribed UE after the completion of Attach procedure is usually allocated an ARP appropriate for NS/EP for the default bearer and IMS signaling bearer. This capability is known as advance priority and plays a key role in an NS/EP user with an NS/EP NGN-PS-subscribed UE getting priority treatment while initiating a call and before the network can determine if the attempted call is an NS/EP call or not. The packets transported on default and IMS signaling bearers have DSCP value(s) marked appropriate for NS/EP whether the signaling traffic is for NS/EP or not. If this capability is not available, an NS/EP call made from an NS/EP NGN-PS-subscribed UE will get DSCP priority marking for signaling traffic only after the network detects the call as an NS/EP call. For a call initiated from an NS/EP NGN-PS-subscribed UE, the media bearer is assigned an NS/EP-specific ARP only if the call is determined as an NS/EP call. Therefore, the DSCP value for media packets are marked for priority only for media traffic belonging to an NS/EP call.

If an NS/EP NGN-PS-subscribed UE does not have advance priority, the default and IMS signaling bearers are not assigned with an ARP belonging to NS/EP at the time of Attach to the network. When an NS/EP call is initiated by such UEs, once the initiation is determined to be for an NS/EP call the ARP for the default and IMS signaling bearers are upgraded and the FEs start marking signaling packets with appropriate DSCP values only after the ARP is upgraded.

The procedures for an NS/EP NGN-PS-subscribed UE (with advance priority) and when FEs become aware of the conditions that mandate setting of DSCP appropriate for NS/EP are described in the following sub-clauses.

6

6.1.1 Attach

The Attach Procedure for an NS/EP NGN-PS subscribed UE for non-Roaming scenario is shown in Figure 6.2. The ARP and QCIs to be assigned for the default bearer and IMS Signaling bearer are stored in the HSS and also configured in PCRF.
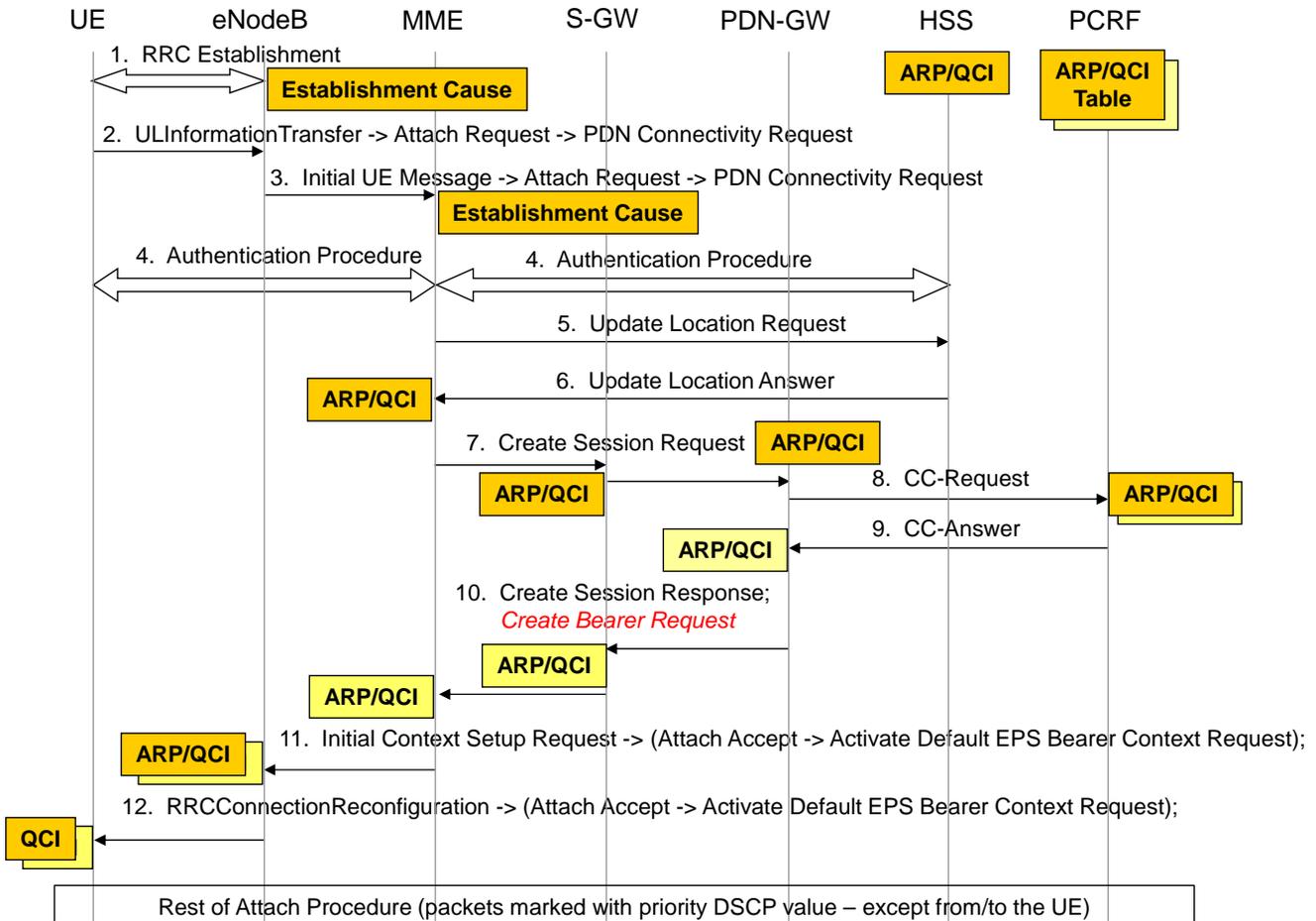

Figure 6.2 – Attach Procedure

During the Attach procedure, the NS/EP NGN-PS-subscribed UE sets the Establishment Cause to highPriorityAccess in the RRC Connection Request message. The eNodeB includes the Establishment Cause in the Initial UE Message to the MME. If the eNodeB is provisioned to set a priority DSCP value when the Establishment Cause indicates highPriorityAccess, the eNodeB sets the DSCP value for priority handling from this point for packets exchanged with the MME, though the actual ARP/QCI is still not known to the eNodeB. Similarly, if the MME is provisioned to set a priority DSCP value when the Establishment Cause indicates highPriorityAccess the MME sets the DSCP value and the DRMP to reflect priority appropriate for NS/EP. Once the MME gets the ARP/QCI from the HSS during the Attach procedure (in the Update Location Answer), the MME conveys the ARP/QCI to the eNodeB. The MME and the eNodeB update the DSCP (and DRMP for applicable interfaces) to NS/EP-assigned values based on the ARP/QCI for the remaining interactions with other FEs. Similarly, the S-GW, PDN-GW and the PCRF get the ARP/QCI as a result of the message exchanges and these FEs once they acquire QCI/ARP set the DSCP values accordingly for all subsequent packets sent by these FEs.

For an NS/EP NGN-PS-subscribed UE without advance priority, the eNodeB and the MME, if configured, may set appropriate DSCP marking based on the Establishment Cause included in the RRC Connection Request message. The eNodeB and the MME cannot mark DSCP values based on ARP/QCI.

For public UEs, packets exchanged between FEs are not marked with any priority DSCP value nor get any priority handling.

6.1.2 Tracking Area Update (TAU)

For an NS/EP NGN-PS-subscribed UE performing TAU without MME change, the eNodeB may set DSCP values, if configured, based on the Establishment Cause. The MME already has the context of the UE that includes the QCI/ARP and sets the DSCP and DRMP accordingly. Therefore, the MME sets DSCP and DRMP values appropriate for NS/EP in the packets sent to the HSS. The HSS sets the same DSCP and DRMP values in the packets sent to the MME. The MME sets the appropriate DSCP in the TAU Accept message and passes the ARP/QCI to the eNodeB. The eNodeB sets the DSCP value appropriate for NS/EP for the remaining outgoing packets sent to the MME.

For an NS/EP NGN-PS-subscribed UE performing TAU with MME change, the eNodeB and the new MME may set DSCP values, if configured, based on the Establishment Cause until the new MME gets the UE context from the old MME. Once the new MME gets the ARP/QCI, the MME sets the DSCP values based on the ARP/QCI. If the other FEs (S-GW and PGW) haven't changed, they already have the ARP/QCI associated with the UE and use them to set the DSCP value for the interaction with other FEs.

When the S-GW also changes, the first message from the new MME to the new S-GW conveys the ARP/QCI and from this point onwards the S-GW sets the DSCP value based on ARP/QCI.

For an NS/EP NGN-PS-subscribed UE without advance priority, the eNodeB and the MME, if configured, may set appropriate DSCP marking based on the Establishment Cause included in the RRC Connection Request message. The eNodeB and the MME cannot mark DSCP values based on ARP/QCI.

For public UEs, packets exchanged between FEs are not marked with any priority DSCP value nor get any priority handling.

6.1.3 Service Request Procedure

When a UE that is attached to the EPC, but is CM-IDLE wants to send a NAS message, uplink data or respond to Paging, the UE initiates a Service Request procedure to move to CM-CONNECTED. The Service Request Procedure for an NS/EP NGN-PS subscribed UE is shown in Figure 6.3. The ARPs and QCIs to be assigned to NS/EP NGN-PS bearers are configured in the MME and the PCRF.
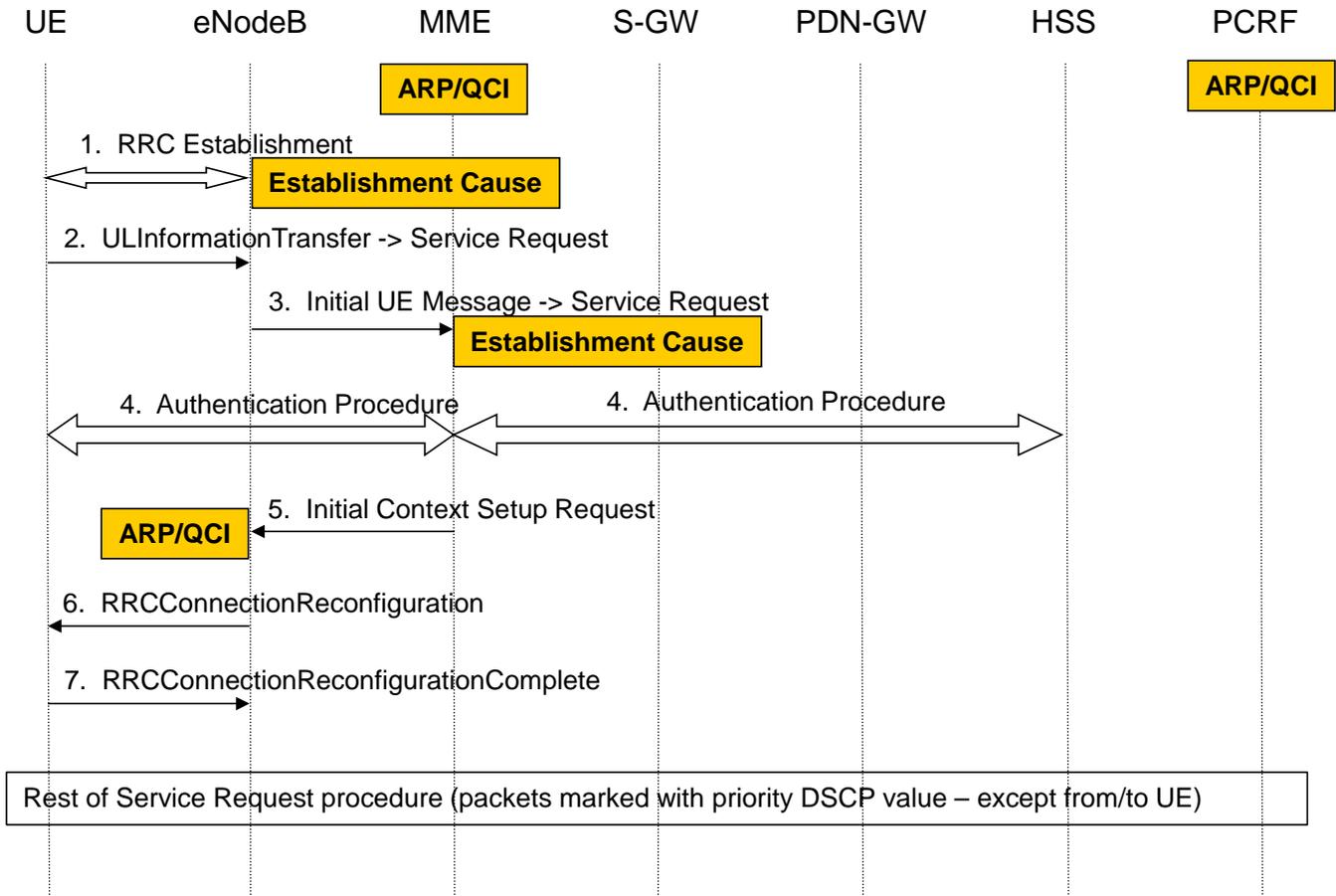
Figure 6.3 – Service Request Procedure

During the Service Request procedure, the NS/EP NGN-PS-subscribed UE sets the Establishment Cause to highPriorityAccess in the RRC Connection Request message. The eNodeB includes the Establishment Cause in the Initial UE Message that encapsulates the Service Request to the MME. The eNodeB, if provisioned to set a priority DSCP value when the Establishment Cause indicates highPriorityAccess, sets the DSCP value for priority handling for packets sent to the MME, though the actual ARP/QCI is still not known to the eNodeB. The MME, based on the stored context for the UE, identifies that the default bearer is assigned an ARP belonging to NS/EP. The eNodeB upon receiving the ARP/QCI in the Initial Context Setup Request from the MME sets the DSCP value configured for QCI/ARP in all subsequent outgoing packets to all FEs. The MME sets the DSCP value configured for the ARP/QCI in all subsequent outgoing packets to all FEs. In addition, the MME and the HSS set the DRMP value configured for the ARP/QCI in all subsequent packets between them.

For an NS/EP NGN-PS-subscribed UE without advance priority the eNodeB and the MME, if configured, may set appropriate DSCP marking based on the Establishment Cause included in the RRC Connection Request message. The eNodeB and the MME cannot mark DSCP values based on ARP/QCI.

For public UEs, packets exchanged between FEs are not marked with any priority DSCP value nor get any priority handling.

6.1.4 Mobile Origination

For a UE that is RRC and CM-IDLE, the Mobile Origination starts with an RRC Connection Establishment followed by Service Request procedure. DSCP/DRMP markings for packets during this stage are as described in the Service Request procedure in 6.1.3. The IMS Signaling bearer of an NS/EP NGN-PS subscribed UE is assigned an ARP

belonging to NS/EP. Therefore, all IP packets carrying SIP messages have DSCP marking based on the ARP/QCI of the IMS Signaling bearer.

The PCRF initiates media bearer establishment upon receiving the final service information from the P-CSCF. The ARP/QCI of the media bearer is assigned by the PCRF based on the service information (MPS-Identifier AVP, Reservation-Priority AVP) received from the P-CSCF. The ARP/QCI is conveyed from the PCRF to PDN-GW to S-GW to MME to the eNodeB. For packets exchanged between the P-CSCF and the PCRF, the DSCP and DRMP markings are based on the MPS-Identifier AVP and the Reservation-Priority AVP. For packets exchanged between other FEs (PCRF, PDN-GW, S-GW, MME and eNodeB), the DSCP markings are based on the ARP/QCI assigned to the media bearer. The PDN-GW and the PCRF set DRMP markings also based on the ARP/QCI. Once the media bearer has been established, all packets sent over the media bearer are marked with a DSCP value based on the ARP/QCI of the media bearer.

For an NS/EP NGN-PS subscribed UE without advance priority, the DSCP marking for the packets carrying the SIP INVITE do not have any priority until the NS/EP NGN-PS call is detected by the P-CSCF. Once the P-CSCF identifies the call as NS/EP, it initiates a message exchange with the PCRF providing the service information (MPS-Identifier AVP and Reservation-Priority AVP) and all the subsequent SIP signaling packets include a SIP Resource Priority Header (RPH) for NS/EP NGN-PS and are marked with DSCP value selected for priority services. The ARP of the default bearer and IMS Signaling bearer is updated and in that process the ARP is passed from the PCRF to PDN-GW to S-GW to MME to the eNodeB. Once an FE becomes aware that the ARP belongs to NS/EP all further outgoing packets from that FE are marked with a priority DSCP value. Once the IMS Signaling bearer has been modified for NS/EP ARP, all packets sent over the IMS Signaling bearer are marked with a DSCP value based on the ARP/QCI of the IMS Signaling bearer. For media bearer, the procedure for marking DSCP is the same as described above.

For a public UE making an NS/EP NGN-PS call, the DSCP marking for the packets carrying the SIP INVITE do not have any priority until the NS/EP NGN-PS call is detected by the P-CSCF. The bearer modification for default and IMS Signaling bearer and DSCP marking are the same as that for an NS/EP NGN-PS-subscribed UE without advance priority except that the P-CSCF identifies the call setup based on GETS-AN number. However, the media bearer is set up with normal priority ARP and therefore, the media packets are not marked with DSCP priority until the user credentials are received and the user is authenticated as a service user and the media bearer ARP is upgraded to a value that belongs to NS/EP. Once the media bearer is updated all the media packets are marked with priority DSCP.

6.1.5 Mobile Termination

For an NS/EP NGN-PS subscribed UE, since the ARP of the default bearer and IMS Signaling bearer belongs to NS/EP, all signaling packets, whether the call is NS/EP or not are marked with priority DSCP. The media bearer packets for a normal call will not have any priority DSCP marking. When P-CSCF identifies received INVITE is for as an NS/EP call (based on RPH), the P-CSCF conveys service information to the PCRF and all the subsequent SIP signaling packets include a SIP Resource Priority Header (RPH) for NS/EP and are marked with the DSCP value selected for priority services. The ARP/QCI of the media bearer is assigned by the PCRF based on the service information (MPS-Identifier, Reservation-Priority AVP) received from the P-CSCF. The ARP/QCI is conveyed from the PCRF to PDN-GW to S-GW to MME to the eNodeB as part of media bearer establishment. For packets exchanged between the P-CSCF and the PCRF, the DSCP and DRMP markings are based on the MPS-Identifier AVP and the Reservation-Priority AVP. For packets exchanged between other FEs (PCRF, PDN-GW, S-GW, MME and eNodeB), the DSCP markings are based on the ARP/QCI assigned to the media bearer. The PDN-GW and the PCRF set DRMP markings also based on the ARP/QCI. Once the media bearer has been established, all packets sent over the media bearer are marked with a DSCP value based on the ARP/QCI of the media bearer.

NS/EP Mobile Termination to an NS/EP NGN-PS subscribed UE without advance priority, when the P-CSCF (based on RPH) identifies the termination as an NS/EP call conveys the service information (MPS-Identifier AVP and Reservation-Priority AVP) to the PCRF and all the subsequent SIP signaling packets include a SIP Resource Priority Header (RPH) for NS/EP and are marked with the DSCP value selected for priority services. The PCRF initiates modifying the ARP of the default bearer and IMS Signaling bearer. Signaling to modify the default and IMS Signaling bearer is done with priority DSCP marking as the ARP is conveyed to the FEs as part of bearer modification. Once the IMS Signaling bearer has been updated, all the FEs forwarding packets for IMS Signaling are marked with priority DSCP. The ARP/QCI of the media bearer is assigned by the PCRF based on the service information (MPS-

Identifier, Reservation-Priority AVP) received from the P-CSCF. The ARP/QCI is conveyed from the PCRF to PDN-GW to S-GW to MME to the eNodeB. For packets exchanged between the P-CSCF and the PCRF, the DSCP and DRMP markings are based on the MPS-Identifier AVP and the Reservation-Priority AVP. For packets exchanged between other FEs (PCRF, PDN-GW, S-GW, MME and eNodeB), the DSCP markings are based on the ARP/QCI assigned to the media bearer. The PDN-GW and the PCRF set DRMP markings also based on the ARP/QCI. Once the media bearer has been established, all packets sent over the media bearer are marked with a DSCP value based on the ARP/QCI of the media bearer.

For Mobile Termination to a public user, the procedures for detecting that the call is for NS/EP and priority marking for DSCP/DRMP are similar to that for an NS/EP NGN-PS subscribed UE without advance priority.

6.1.6 Summary

The eNodeB and the MME may be configured to mark packets with priority DSCP when the received message includes Establishment Cause set to highPriorityAccess.

All FEs (eNodeB, MME, S-GW, PDN-GW, and PCRF) are configured to mark packets with priority DSCP based on QCI and NS/EP ARP.

If more than one DSCP value is allocated for NS/EP NGN-PS, for the eNodeB and the MME, the DSCP marking based on Establishment Cause will have a lower priority DSCP value than the DSCP marking based on ARP/QCI

During any procedure (Attach, TAU, Service Request, Bearer Modification, Bearer Establishment, Call Origination, Call Termination), once an FE detects priority marking condition (Establishment Cause, ARP/QCI, SIP RPH, MPS-Identifier AVP/Reservation-Priority AVP) all further outgoing packets from that FE will be marked with appropriate priority DSCP value.

Over any interface that supports SCTP (e.g., S1-MME), the Establishment Cause or QCI + ARP may be used to derive the appropriate priority of SCTP association and the priority of the SCTP association is used to determine the DSCP marking.

Over Diameter interfaces (Rx, Gx, S6a) and for any procedure (Attach, TAU, Service Request, Bearer Modification, Bearer Establishment, Call Origination, Call Termination), once the PCRF, P-CSCF, or the HSS detects priority marking condition (SIP RPH, MPS-Identifier AVP/Reservation-Priority AVP, or ARP/QCI) all further outgoing packets from that FE will be marked with appropriate DRMP value. The DRMP AVP may be used to set the DSCP marking for transport of the associated Diameter message.

6.2 Solution Considerations

This clause will provide guidance as to how the DSCP marking based on ARP and QCI is used to support transport level packet forwarding for NS/EP NGN-PS traffic.

Each FE marks the packets belonging to NS/EP with the DSCP selected for priority services as described in clause 6.1. Once a packet has been marked with a DSCP, subsequent FEs retain the DSCP marking for the packets while forwarding. During normal traffic situations, an FE will be able to admit, process and forward all packets in a timely fashion. During traffic overload, an FE may not be able to admit, process and forward all packets in a timely fashion that may result in exceeding the target delay budget for the FE. Each FE by following the guidelines specified in RFC 5865 for admitting packets and processing and forwarding an admitted packet, the NS/EP NGN-PS packets with higher priority DSCP will get priority over non-NS/EP NGN-PS traffic.

7 Packet Scheduling

7.1 Procedures

This clause will identify and reference the applicable 3GPP procedures.

The eNodeB in the EPS is responsible for scheduling packets belonging to the same UE as well as packets belonging to different UEs. The eNodeB schedules the packets belonging to a service data flow (SDF) to meet the

packet delay budget (PDB) associated with the SDF. Under normal traffic situations, the eNodeB is able to meet the packet delay budget associated with the traffic belonging to different SDFs.

Every QCI (GBR and Non-GBR) is associated with a Priority level (TS 23.203 Table 6.1.7). The lowest Priority level value corresponds to the highest Priority. The Priority levels are used to differentiate between SDF aggregates of the same UE, and are also be used to differentiate between SDF aggregates from different UEs. Via its QCI an SDF aggregate is associated with a Priority level and a PDB. In addition, every SDF is also associated with an ARP. The ARP includes a Priority Level which is also used to determine the priority of SDFs at the time of congestion. Scheduling between different SDF aggregates is primarily based on the PDB. If the target set by the PDB can no longer be met for one or more SDF aggregate(s) across all UEs that have sufficient radio channel quality, then the QCI Priority level and the ARP Priority Level are used to differentiate between SDF aggregates.

7.2 Solution Considerations

This clause will provide guidance how ARP and QCI are used to support NS/EP NGN-PS based on [FCC 47 CFR § 64 Appendix B].

The eNodeB schedules packets belonging to different SDFs as follows:

- As packets arrive, the eNodeB places the packets in the queue for the scheduler in the same order as arriving packets.
- Each packet is monitored for its PDB. If the target PDB can no longer be met for one or more packets, packets associated with ARP Priority Level N are given priority over packets with ARP Priority Level N+1.
- If there are multiple packets belonging to the same ARP Priority Level, then the scheduler gives priority based on QCI Priority Level within the same ARP as follows: in this case a scheduler meets the PDB of an SDF aggregate on QCI Priority level N in preference to meeting the PDB of SDF aggregates on next QCI Priority level greater than N, until the priority N SDF aggregate's GBR (in case of a GBR SDF aggregate) has been satisfied.

8 Conclusions and Recommendations

8.1 Conclusions

By various FEs marking packets with a DSCP assigned for priority services based on QCI and ARP as described in clause 6.1, NS/EP NGN-PS packets get forwarding priority over non-NS/EP NGN-PS traffic. Similarly, when the eNodeB cannot meet the target PDB for one or more SDF aggregate(s) within a UE and across all UEs that have sufficient radio channel quality, the scheduler in the eNodeB takes the ARP and QCI into account and gives priority handling to NS/EP NGN-PS traffic.

8.2 Recommendations

The eNodeB and the MME may be configured to mark packets with a DSCP assigned for priority services when the received message includes an Establishment Cause set to the highPriorityAccess value. Once the eNodeB and the MME become aware of the QCI and ARP associated with the packets, then the eNodeB and MME are to be configured to mark packets with a DSCP assigned for priority services. If more than one DSCP value is allocated for NS/EP NGN-PS, the DSCP marking based on Establishment Cause will have a lower priority DSCP value than the DSCP marking based on ARP/QCI.

All FEs (eNodeB, MME, S-GW, PDN-GW, and PCRF) should be configured to mark packets with the DSCP associated with priority services based on the QCI and NS/EP NGN-PS ARP.

During any NAS procedure (Attach, TAU, Service Request, Network-triggered Service Request, EPS Bearer Modification, EPS Bearer Establishment) or SIP procedure (Call Origination, Call Termination), once an FE detects a condition which warrants priority marking (Establishment Cause, ARP/QCI, SIP RPH, MPS-Identifier AVP/Reservation-Priority AVP) all further outgoing packets from that FE should be marked with the appropriate DSCP value.

Over Diameter interfaces (Rx, Gx, S6a) and for any procedure (Attach, TAU, Service Request, Network-triggered Service Request, Bearer Modification, Bearer Establishment), or SIP procedure (Call Origination, Network-triggered Service Request), once the PCRF, P-CSCF, or the HSS detects a condition which warrants priority marking (SIP RPH, MPS-Identifier AVP/Reservation-Priority AVP, or ARP/QCI) all further outgoing packets from that FE should be marked with appropriate DRMP value.

Table 8.1 provides a summary of how DSCP marking over various interfaces is based on ARP, QCI and other parameters. The interfaces where QCI and ARP directly or indirectly influence DSCP marking are shown in bold red font.

Table 8.1 - Method for Marking DSCP

Method for marking DSCP	Applicable interfaces
ARP + QCI	**X2, S1-U, S5, S8, S10, SGi**
ARP + QCI →SCTP Association	**S1-MME**
ARP + QCI → GTPC Message Priority	**S5, S8, S10, S11**
ARP + QCI → DRMP	**Gx, Gxx, Rx, S9**
Establishment Cause	S10
Establishment Cause → SCTP Association	S1-MME
Establishment Cause → DRMP	S6a
MPS-ID/Reservation Priority → DRMP	Rx
SIP-RPH	Gm
Dialed Digits	Gm
No DSCP marking	Uu

NOTE 1: The DSCP can be used on other interfaces not shown in this report (e.g., for CSFB to GERAN/UTRAN, for support of Legacy SMS, etc.)

NOTE 2: This table does not include mapping of the priority information elements at an FE. Such mapping information can be found in [ATIS-1000065] and [ATIS-1000066], respectively.

Each FE should follow the guidelines specified in [RFC 5865] for admitting packets and processing and forwarding an admitted packet to ensure that the NS/EP packets with higher priority DSCP will get priority over non-NS/EP traffic.

If the eNodeB cannot meet the target PDB for one or more SDF aggregates within that UE or across all UEs, then the eNodeB should use the ARP Priority Level first and then the QCI Priority Level to determine the relative priority of packets for admission, processing, and scheduling.