



Public Safety Communications Research
(PSCR)

Priority, Pre-emption, QoS

Department of Commerce – Boulder Labs

LTE Functionality

- Priority services, the ability to pre-empt users, and Quality of Service are all crucial to a public safety broadband network.
 - LTE as a standard has more control over this, than any other previous wireless broadband technology
- Since most of these features within 3GPP have never been commercially deployed and the way in which public safety will use them is unique – it is crucial to understand what LTE can provide.
- NCS, 3GPP, IETF all have documented QoS at various levels

LTE Access Control & QoS Mechanisms

- Cell Status
- Cell Barring
- Access Classes
- Bearers
 - GBR – Guaranteed Bit Rate
 - MBR- Maximum Bit Rate
 - Non GBR
 - Default
 - Dedicated
- TFT – Traffic Flow Template
 - Uplink
 - Downlink
 - Bearer Level
 - SDF – Service Data Flow Level
- QCI – QoS Class Identifier
- ARP – Allocation Retention Priority
- APN-AMBR – Aggregate Maximum Bit Rate
- UE-AMBR

Access Barring

- Cell Status (Access Barring) and Special Reservations (Access Reserved) control cell selection and reselection procedures.
 - Cell Barring – UE isn't permitted to select/re-select cell, even for emergency calls
 - UE reselects another cell according to specific rules
 - Cell Reserved - Reserve cells for operator activities – maintenance, special events etc.
 - Only specific access classes 11 or 15 allowed for cell selection/re-selection

Access Control

- Access control using access classes:
 - Can be used to prevent devices of commercial users from initiating an RRC connection
 - Can be manually invoked by the LTE network operator on some or all cells to suspend commercial traffic during an overload situation (% basis)
 - Recommendation is to follow commercial practice:
 - Access classes 0 through 9 should be randomly allocated to commercial subscribers on public/private combined networks
 - Access classes 12, 13 and 14 can be used for Public Safety User. 3GPP specifications are :
 - Class 12 – Security Services
 - Class 13 – Public Utilities
 - Class 14 – Emergency Services
 - Access class 11 and 15 are reserved for LTE network administrative use
 - Example is testing a new cell before it is placed into service

Allocation Retention Priority

- ARP is stored in the Subscriber profile (HSS) typically on a per APN basis - not included within the EPS QoS Profile sent to the UE
 - Priority level: 1 – 15
 - Pre-emption capability: determines whether a bearer with a lower ARP priority level should be dropped to free up the required resources
 - Pre-emption vulnerability: determines whether a bearer is applicable for dropping by a pre-emption capable bearer with a higher ARP priority value
- **At every Radio Bearer (RB) setup request** (including HO and RRC connection re-establishment), the eNB Radio Admission Control (RAC) entity will check the current eNB hard limit capacities, which includes factors such as:
 - maximum number of UEs and RBs, number of RBs on GBR
- ARP controls how the eNodeB reacts when when there are insufficient resources to establish the new RB
 - Deny the RB request
 - Preempt an existing RB and accept the new RB request

QCI

- QCI is a scalar that is used as a reference to access node-specific parameters that control bearer level packet forwarding treatment (e.g. scheduling weights, admission thresholds, queue management thresholds, link layer protocol configuration, etc.), and that have been pre-configured by the operator owning the access node (e.g. eNodeB).

Traffic Flow Template

- TFT is set of all packet filters associated with an EPS bearer.
 - A default bearer may or may not be associated with a TFT (based on HSS data) but a dedicated bearer is always associated with a TFT
 - Bearer level QoS is associated with a bearer and all traffic mapped to that will receive same bearer level packet forwarding treatment.
 - A packet filter may be associated with a protocol.
 - A packet filter Identifier shall be used to identify a packet filter.
 - Uplink TFT used by the UE
 - Downlink TFT used by the PDN
- Each EPS bearer is associated with the following bearer level QoS parameters:
 - QoS Class Identifier (QCI);
 - Allocation and Retention Priority (ARP).
- Each GBR bearer is additionally associated with the following bearer level QoS parameters:
 - Guaranteed Bit Rate (GBR);
 - Maximum Bit Rate (MBR).
 - Each APN is associated with an Aggregate Maximum Bit Rate (APN AMBR).
 - Each UE is associated with UE Aggregate Maximum Bit Rate (UE AMBR).

QCI Table – TS 23.203

Table 6.1.7: Standardized QCI characteristics

QCI	Resource Type	Priority	Packet Delay Budget (NOTE 1)	Packet Error Loss Rate (NOTE 2)	Example Services
1 (NOTE 3)	GBR	2	100 ms	10^{-2}	Conversational Voice
2 (NOTE 3)		4	150 ms	10^{-3}	Conversational Video (Live Streaming)
3 (NOTE 3)		3	50 ms	10^{-3}	Real Time Gaming
4 (NOTE 3)		5	300 ms	10^{-6}	Non-Conversational Video (Buffered Streaming)
5 (NOTE 3)	Non-GBR	1	100 ms	10^{-6}	IMS Signalling
6 (NOTE 4)		6	300 ms	10^{-6}	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
7 (NOTE 3)		7	100 ms	10^{-3}	Voice, Video (Live Streaming) Interactive Gaming
8 (NOTE 5)		8	300 ms	10^{-6}	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
9 (NOTE 6)		9			

ARP Mapping

Priority	User groups		Non-GBR bearer		GBR bearer		
			Can pre-empt	Vulnerable	Can pre-empt	Vulnerable	
-	-	-					
1			Yes	No	Yes	No	Reserved for Serving Network
2	1 st responder at home (A)		Yes	No	Yes	No	Priority 1 user non video traffic
3	1 st responder at home (B)		Yes	No	Yes	No	Priority 1 user video traffic Priority 2 user non-video traffic
4	1 st responder at home (C)		Yes	No	Yes	No	Priority 2 user video traffic Priority 3 user non-video traffic
5	1 st responder at home (D)	1 st responder visiting (A)	Yes	No	Yes	No	Priority 3 user video traffic Priority 4 user non-video traffic
6	PS support at home (A)	1 st responder visiting (B)	No	Yes	Yes	No	Priority 4 user video traffic Priority 5 user for non video traffic
7			No	Yes	Yes	No	E911
8	PS support at home (B)		No	Yes	Yes	No	GBR Voice Calls (non-PTT)
9	PS support at home (C)		No	Yes	Yes	No	GBR non-voice and IMS signaling
10	PS other (A)	PS support visiting (A)	No	Yes	No	Yes	Regular subscriber general data IMS signaling
11	PS other (B)	PS support visiting (B)	No	Yes	No	Yes	Voice calls
12			No	Yes	No	Yes	Reserved for Serving Network
13			No	Yes	No	Yes	Reserved for Serving Network
14	Commercial user		No	Yes	No	Yes	Priority 1 Commercial Users non-video traffic
15	Commercial user		No	Yes	No	Yes	Priority 1 Commercial Users video traffic Priority 2 Commercial Users non-video traffic

Layer 3 IP Precedence and DSCP

- **IPV4**: The three most significant bits of ToS byte are called IP Precedence.
- **Diffserv**: Six most significant bits of ToS byte are called Diffserv Code Point (DSCP) – remaining two bits are used for flow control
- **EF**: Expedited Forwarding defined in RFC3246. **DSCP 46**
- **AF_xy**: Assured Forwarding defined in RFC 2597
 - where x corresponds to IP precedence value (only 1-4 are used for AF classes) and y corresponds to the drop precedence value (either 1, 2, 3) with the higher value denoting higher likelihood of dropping. **DSCP 10/12/14, 18/20/22, 26/28/30, 34/36/38**
- **CS_x**: Class Selector defined in RFC2474
 - where x corresponds to the IP precedence value (1-7). **DSCP 8,16,32,40,48,56**
- **BE**: Best Effort of Default Marking value (RFC2474). **DSCP 0**

DSCP Mapping to QCI, ARP and PS Apps

Expedited Forwarding		
DSCP Name	DSCP Value	RFC Standard
EF	46	RFC3246

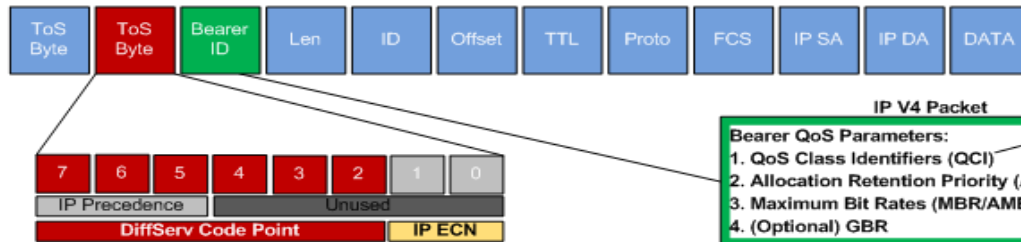
Assured Forwarding					
Drop	Class 1	Class 2	Class 3	Class 4	RFC Standard
Low	AF11 / DSCP 10	AF21/ DSCP 18	AF31/ DSCP 26	AF41/ DSCP 34	RFC 2597
Medium	AF12 / DSCP 12	AF22/ DSCP 20	AF32/ DSCP 28	AF42/ DSCP 36	RFC 2597
High	AF13 / DSCP 14	AF23/ DSCP 22	AF33/ DSCP 30	AF43/ DSCP 38	RFC 2597

Class Selector		
DSCP Name	DSCP Value	RFC Standard
CS 7	56	RFC 2474
CS 6	48	RFC 2474
CS 5	40	RFC 2474
CS 4	32	RFC 2474
CS 3	24	RFC 2474
CS 2	16	RFC 2474
CS 1	8	RFC 2474
CS 0	0 (Best Effort)	RFC 2474

QCI, ARP to DSCP Mapping				
QCI	*ARP	QoS Level	Traffic Class	Public Safety Apps
QCI 1	1-15	Platinum	Conversational	Voice – PTT, telephony
QCI 2	1-15	Gold	Streaming	Video – Surveillance video, In-car Streaming
QCI 6	1-15	Silver	Interactive	Interactive - Web, CAD, GIS, Database and Records
QCI 8 QCI 9	1-15	Bronze	Background	Best Effort - Email, SMS, MMS, Alert Notifications

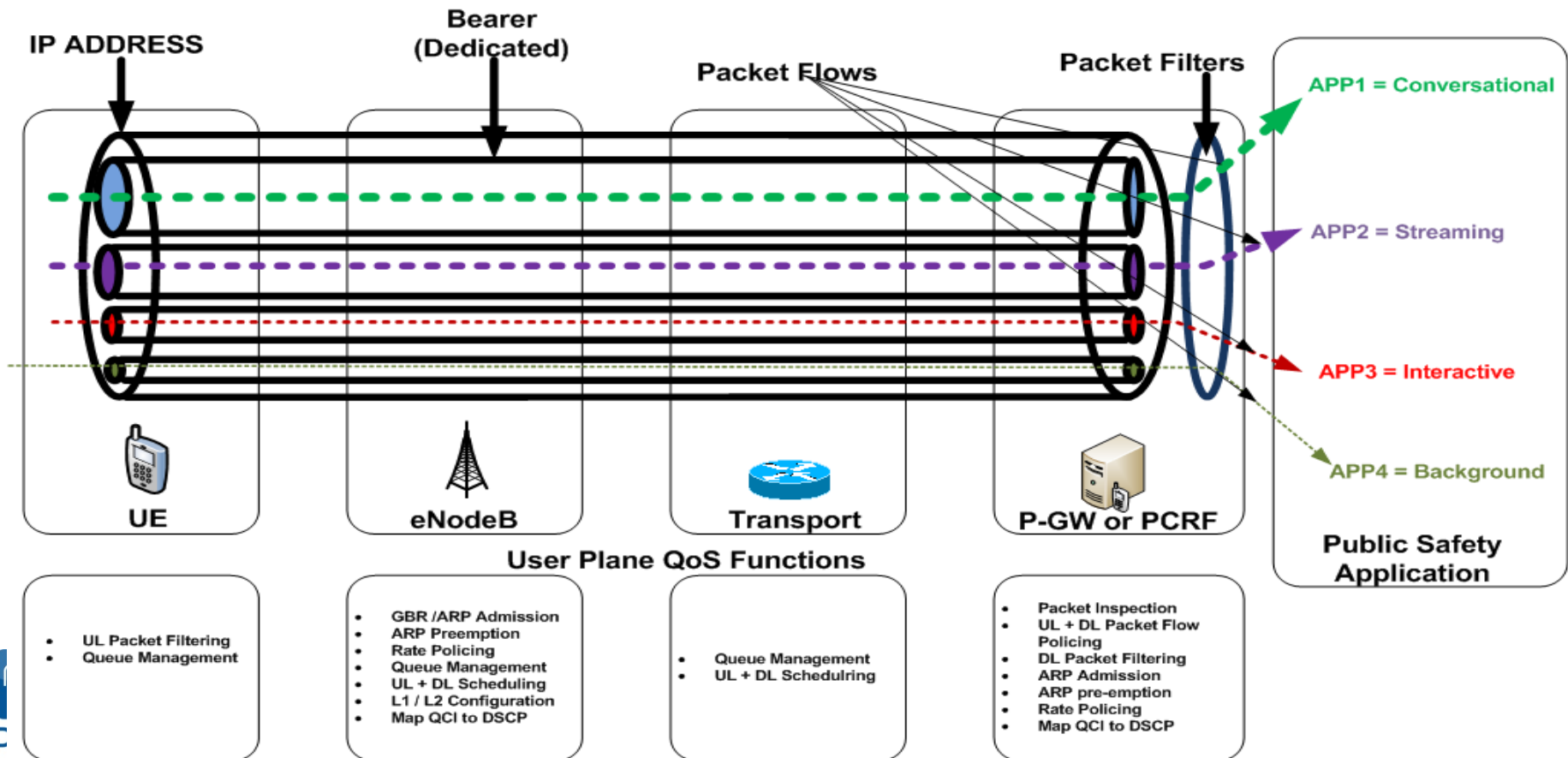
* ARP value still needs to be defined.

QoS Mapping



3GPP TS 23.203

- GBR QCI 1 = Conversational Voice
- GBR QCI 2 = Conversational Video (Live Streaming)
- GBR QCI 3 = Real Time Gaming
- GBR QCI 4 = Non-Conversational Video (Buffered Streaming)
- Non-GBR QCI 5 = IMS Signaling
- Non-GBR QCI 6 = TCP Based (e.g. www, email, chat, ftp, sharing)
- Non-GBR QCI 7 = Voice, Video (Live Streaming)
- Non-GBR QCI 8/9 = TCP Based (e.g. www, email, chat, ftp, sharing)



Demo Network Implementations

- Design network to support full End-to-End QoS
- Start with Best effort data (start simple ...):
 - Map default bearer to QCI 8 or 9 [in HSS subscriber profile]
 - Investigate use Aggregate Maximum Bit Rate (AMBR) [in HSS subscriber profile] to create different levels of Best Effort Service
- Support use of QoS bearers
 - Determine overall QoS mapping possible in Release 8
 - Develop test cases
 - Requires PCRF and Rx interface to Application Servers

Discussion

- How can we accomplish meeting public safety's QoS goals? Does our template meet those needs?
- What parts are available?
 - Access Control
 - Access Barring
 - Allocation Retention Priority
 - Traffic Flow Template
- When will they be available?

Working Group

- We will send around a sign up sheet

Questions?