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

<table>
<thead>
<tr>
<th>Priority</th>
<th>User groups</th>
<th>Non-GBR bearer</th>
<th>GBR bearer</th>
<th>Vulnerable</th>
<th>Pre-empt</th>
<th>Vulnerable</th>
<th>Pre-empt</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Reserved for Serving Network</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1st responder at home (A)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Priority 1 user non video traffic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 3        | 1st responder at home (B) | Yes | No | Yes | No | Priority 1 user video traffic  
  Priority 2 user non-video traffic |
| 4        | 1st responder at home (C) | Yes | No | Yes | No | Priority 2 user video traffic  
  Priority 3 user non-video traffic |
| 5        | 1st responder at home (D) | Yes | No | Yes | No | Priority 3 user video traffic  
  Priority 4 user non-video traffic |
| 6        | PS support at home (A) | 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) | No | Yes | No | Yes | Regular subscriber general data  
  IMS signaling |
| 11       | PS other (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**
- **AFxy**: 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**
- **CSx**: 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 | 1-15 | Bronze | Background | Best Effort - Email, SMS, MMS, Alert Notifications

* ARP value still needs to be defined.
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?
• We will send around a sign up sheet
Questions?