Agenda

• Introduction
• 3GPP-based network implementations for inter-operator mobility
• Inter-operator mobility testing at CableLabs
• Alternate implementations
• Inter-operator mobility with CBRS demo
• Q&A
Introduction

• New entrants, including Multiple Service Operators (MSOs) are looking to offer mobile services with Citizens Broadband Radio Service (CBRS)

• MSOs may need Multiple Network Operators’ (MNOs’) network to provide coverage outside CBRS network coverage

• Inter-operator mobility, as defined by 3GPP, has two variants:
  o Home Routed (HR)
  o Local Break Out (LBO)

• 3GPP-defined network implementations require operators to share roaming interfaces and configure mobility parameters

• CableLabs conducted testing to analyze benefits and tradeoffs of both 3GPP defined network implementations

• Alternate implementations are being investigated that do not need interface sharing or mobility configuration
3GPP-Defined Home Routed (HR)

Pros:
- Seamless mobility in connected mode
- Easier policy enforcement with charging and billing functionality

Cons:
- High dependency on MNO
- Increased latency

- User traffic serviced by the home network, giving more control over the subscriber’s traffic when roaming
- Sharing of S6a, S8 and S10 interface
- Trigger connected mode mobility with Inter Freq Inter PLMN S1 Handover
- Trigger idle mode mobility with cell re-selection
- Preferred when the visitor network provider is not reliable enough to service the home network subscriber’s data
3GPP-Defined Local Break Out (LBO)

- User traffic serviced by the visitor network
- Sharing of only S6a interface
- Trigger connected mode mobility with blind cell redirection while moving from MSO to MNO and fresh attach while moving from MNO to MSO
- Trigger idle mode mobility with cell re-selection while moving from MSO to MNO and using HPPLMN search period while moving from MNO to MSO
- Preferred when there is a trusted relationship between the two operators

**Pros:**
- More efficient routing in terms of bandwidth and latency
- Less dependency on MNO network

**Cons:**
- No seamless connected mode mobility
- Voice will be a concern if MSO decides to provide both data and voice services
Inter-Operator Mobility Test Equipment and Setup

Network components

- LTE Evolved Packet Cores (EPCs)
- LTE eNodeBs (ENBs)
- End User Device

Subscriber Identification Module (SIM) configuration

- Extended PLMN (EHPLMN)
- Home PLMN (HPLMN)/Visitor PLMN (VPLMN)

Testing Details

- Handover and cell re-selection procedures tested multiple times (10) to validate the repeatability of the test results
- All the triggers were based on Reference Signal Received Power (RSRP) thresholds
Connected Mode Mobility Triggers

• Connected mode handover performed when the device has an active data or voice session

• Different triggers for intra LTE connected mode handovers include:
  o Event A1 - Triggered when serving cell becomes better than a threshold
  o Event A2 - Triggered when serving cell becomes worse than a threshold
  o Event A3 - Triggered when a neighboring cell becomes better than the serving cell by an offset
  o Event A4 - Triggered when a neighboring cell becomes better than a threshold
  o Event A5 - Triggered when serving cell becomes worse than threshold-1 and neighboring cell becomes better than threshold-2

• For HR, testing was conducted with Event A2 and Event A5 to reduce the risk for the device to ping-pong (i.e., move back and forth) between the source and target cell

• For LBO, testing was conducted with blind cell redirection using Event A2 while moving from MSO to MNO network
Idle Mode Mobility Triggers

- Idle mode cell re-selection performed when the device has no active data or voice session

- Trigger for idle mode cell re-selection with HR when moving from a lower priority cell to a higher priority cell
  - $S_{\text{non-serving cell, } x} > \text{Thresh} (x, \text{high})$
  - where Thresh $(x, \text{high})$ is the absolute threshold used with higher priority cells broadcasted in SIB 5
  - and $S_{\text{non-serving cell, } x}$ is the recorded RSRP value of non-serving cell

- Triggers for idle mode cell re-selection with HR when moving from a higher priority cell to a lower priority cell
  - $S_{\text{serving cell, } x} < \text{Thresh} (\text{serving, low})$
  - where Thresh $(\text{serving, low})$ is the absolute threshold applied to serving cell used with lower priority cells broadcasted in SIB 3
  - and $S_{\text{serving cell, } x}$ is the recorded RSRP value of serving cell
  - $S_{\text{non-serving cell, } x} > \text{Thresh} (x, \text{low})$
  - where Thresh $(x, \text{low})$ is the absolute threshold applied to neighbor cell used with lower priority cells broadcasted in SIB 5

- Trigger for idle mode cell re-selection in LBO while moving from MNO to MSO network
  - Higher Priority PLMN (HPPLMN) Search Period – Default value of 6min as defined by 3GPP standard
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Alternate Solutions to Network-Based Triggers
Device Mobility Control with External Server

- Device mobility controlled using an external server to avoid significant changes on network

- Solution creates a logical tunnel between an external server and an application embedded on the UE

- Embedded application integrated with the connection manager within the UE to override the inherent chipset and device algorithm

- Reachability to the external server using either MSO owned Wi-Fi network, MSO owned CBRS network or MNO owned LTE network

- External server and client exchange information for MSOs to control the mobility policies for specific user(s)
Dual SIM Implementation Enhancements

- Traditional phones can connect to a single operator network while dual SIM phones can connect to multiple operators.

- Dual SIM dual standby (DSDS) allows devices to connect simultaneously to two networks by time sharing a single transceiver.

- Scope to improve DSDS implementations to make devices smart to switch between the networks avoiding interface sharing and mobility parameter configuration.
Inter-Operator Mobility with CBRS Demo

- With introduction of CBRS, operators investigating different ways to perform inter-operator mobility

- Demo showcases inter-operator mobility in connected mode with Inter Freq Inter PLMN S1 HO using:
  - Citizens Broadband Radio Service Device (CBSD) operating in Band 43 and an LTE eNodeB operating in Band 41
  - Each eNodeB is connected to a different virtualized evolved packet core (vEPC)
  - Each eNodeB is configured with connected and idle mode mobility parameters

- CBSD and LTE eNodeB are backhauled using DOCSIS with a cable modem (CM) and cable modem termination system (CMTS) between the eNodeB and vEPC
Questions?