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Inter-Operator Mobility with CBRS

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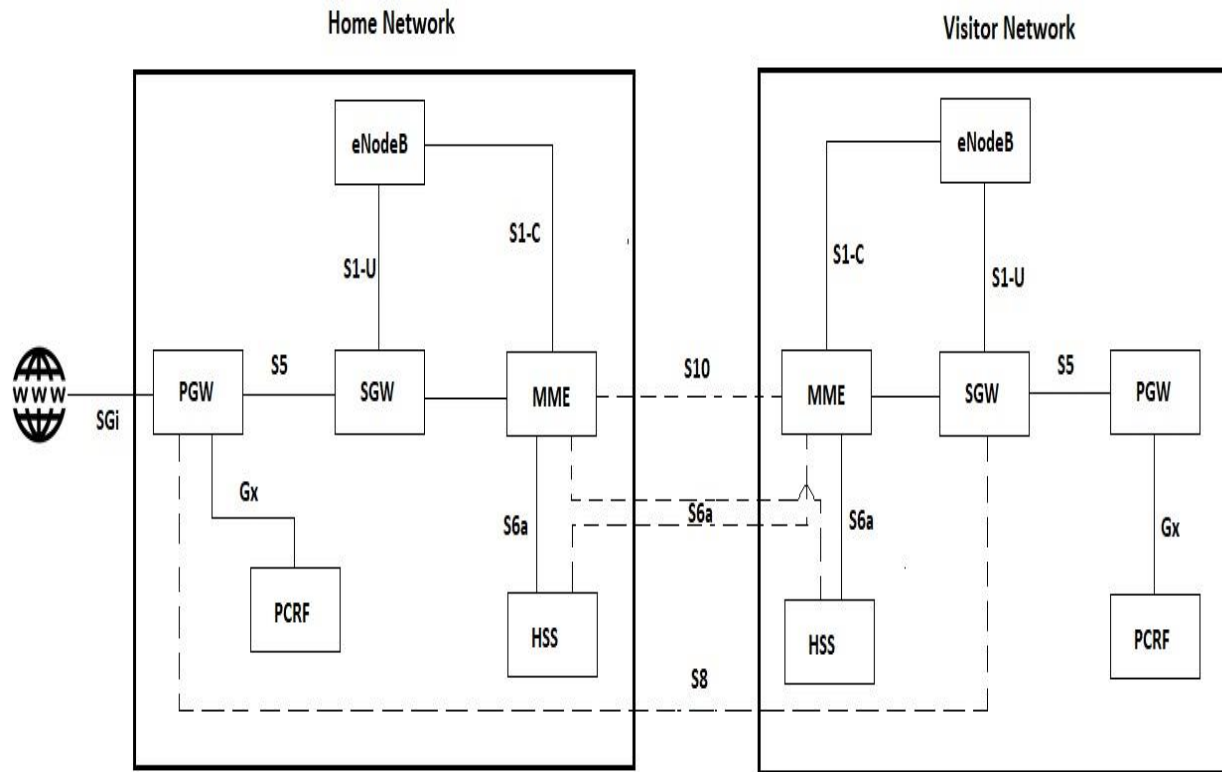
Agenda

- 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:
 - Home Routed (HR)
 - 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)



- 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

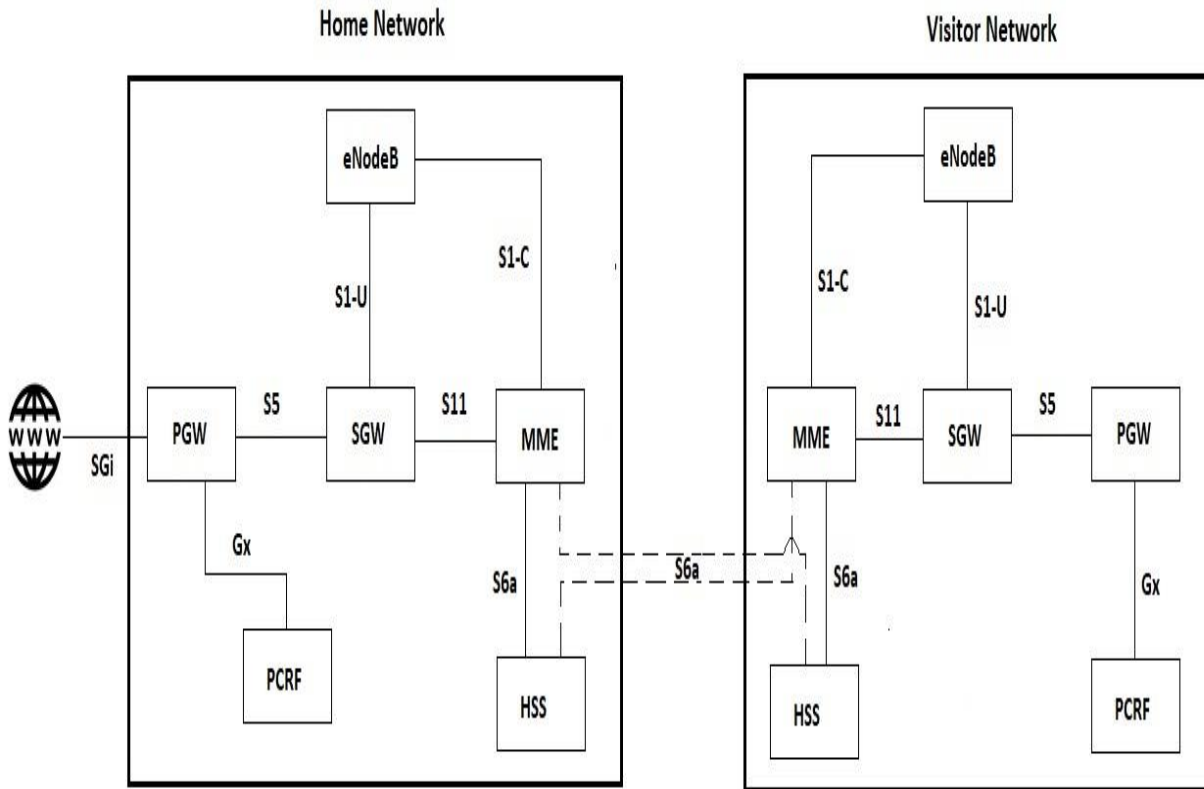
Pros:

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

Cons:

- High dependency on MNO
- Increased latency

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 re-direction 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

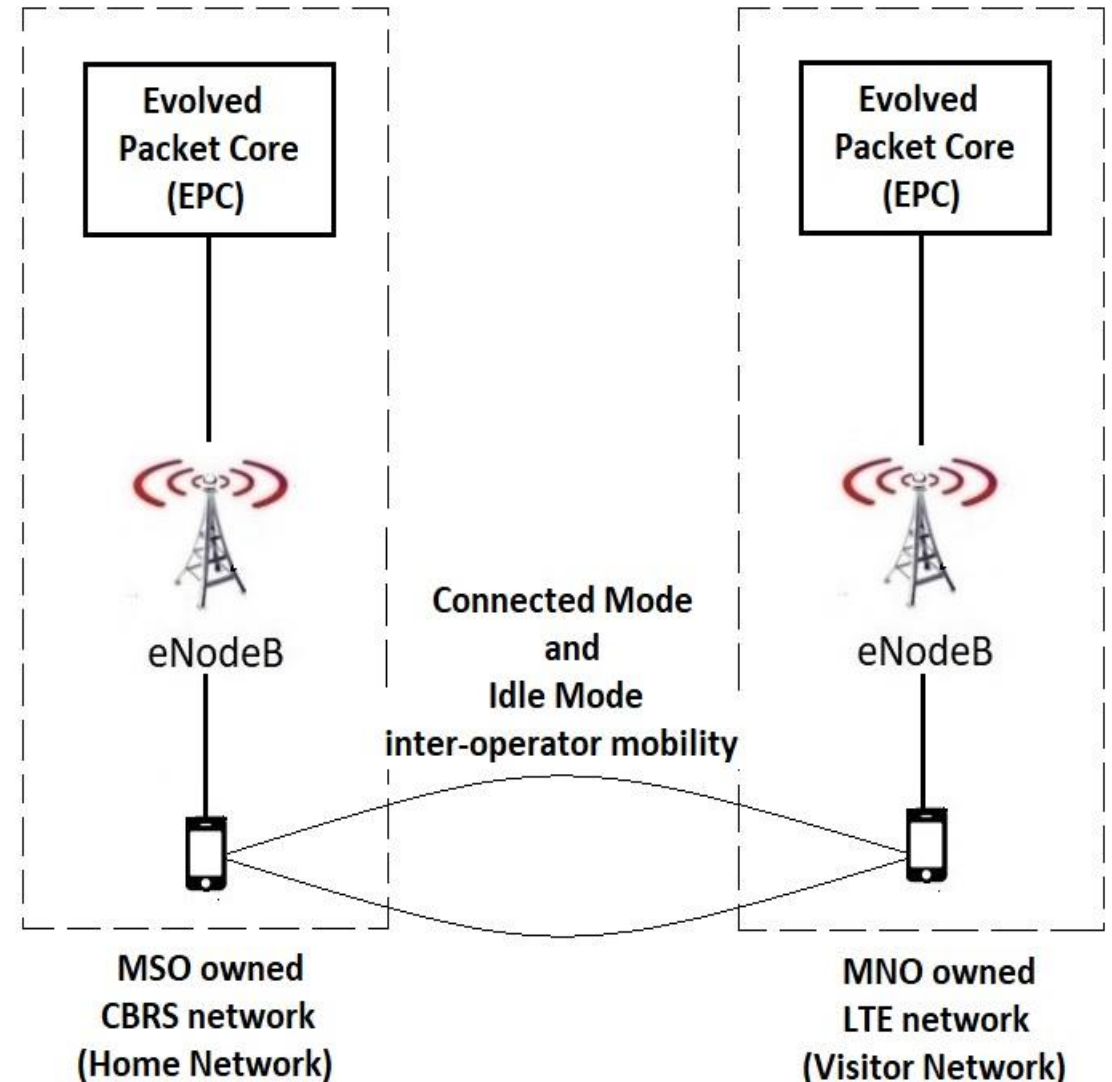
- LTE Evolved Packet Cores (EPCs)
- LTE eNodeBs (ENBs)
- End User Device

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:
 - Event A1 - Triggered when serving cell becomes better than a threshold
 - Event A2 - Triggered when serving cell becomes worse than a threshold
 - Event A3 - Triggered when a neighboring cell becomes better than the serving cell by an offset
 - Event A4 - Triggered when a neighboring cell becomes better than a threshold
 - 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 $\text{Thresh}(x, \text{high})$ 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
 - $S(\text{serving cell}, x) < \text{Thresh}(\text{serving}, \text{low})$
where $\text{Thresh}(\text{serving}, \text{low})$ 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 $\text{Thresh}(x, \text{low})$ 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

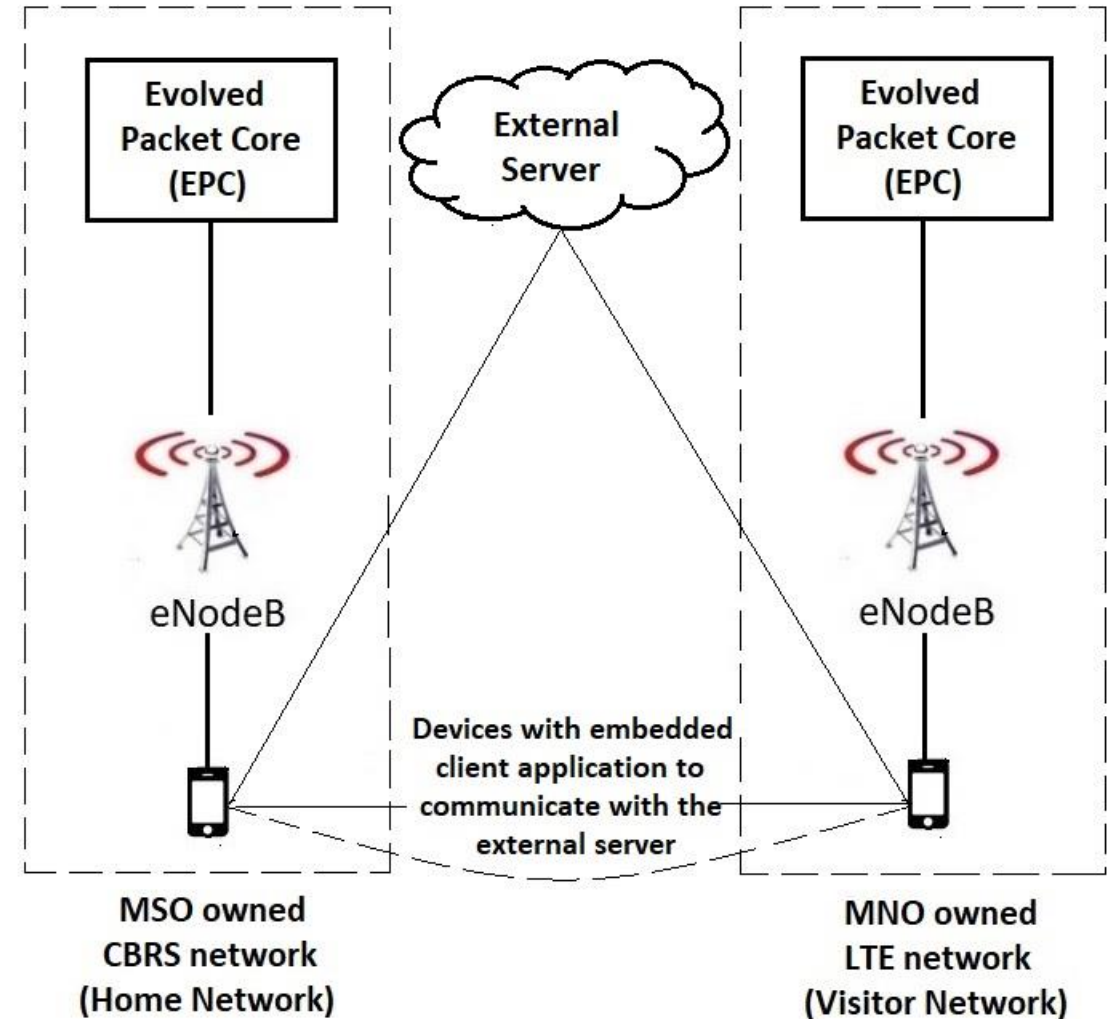
3GPP Network Implementations Analysis

Comparison Metric	Network Implementations	
	Home Routed (HR)	Local Break Out (LBO)
Shared Interfaces	More (S6a, S8 and S10)	Less (S6a)
Mobility Configuration needed on MNO network	Yes	No
Mobility Triggers	Connected Mode: S1 handover Idle Mode: Cell re-selection	Connected Mode: Blind re-direction (MSO to MNO) & radio link failure with re-attach (MNO to MSO) Idle Mode: Higher Priority PLMN (HPPLMN) Search Period
Network Transition Time	Connected Mode: 500-600msec Idle Mode: 100-200msec	Connected Mode: 500-700msec (MSO to MNO); 800-900msec (MNO to MSO) Idle Mode: 100-200msec (MSO to MNO); 6min (MNO to MSO)
Connected Mode Mobility	Seamless Handover via S10	Service Disruption without S10
Key Benefit	Seamless connected mode mobility	Less dependency on MNO
Tradeoff	More dependency on MNO	Non-seamless connected mode mobility

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)



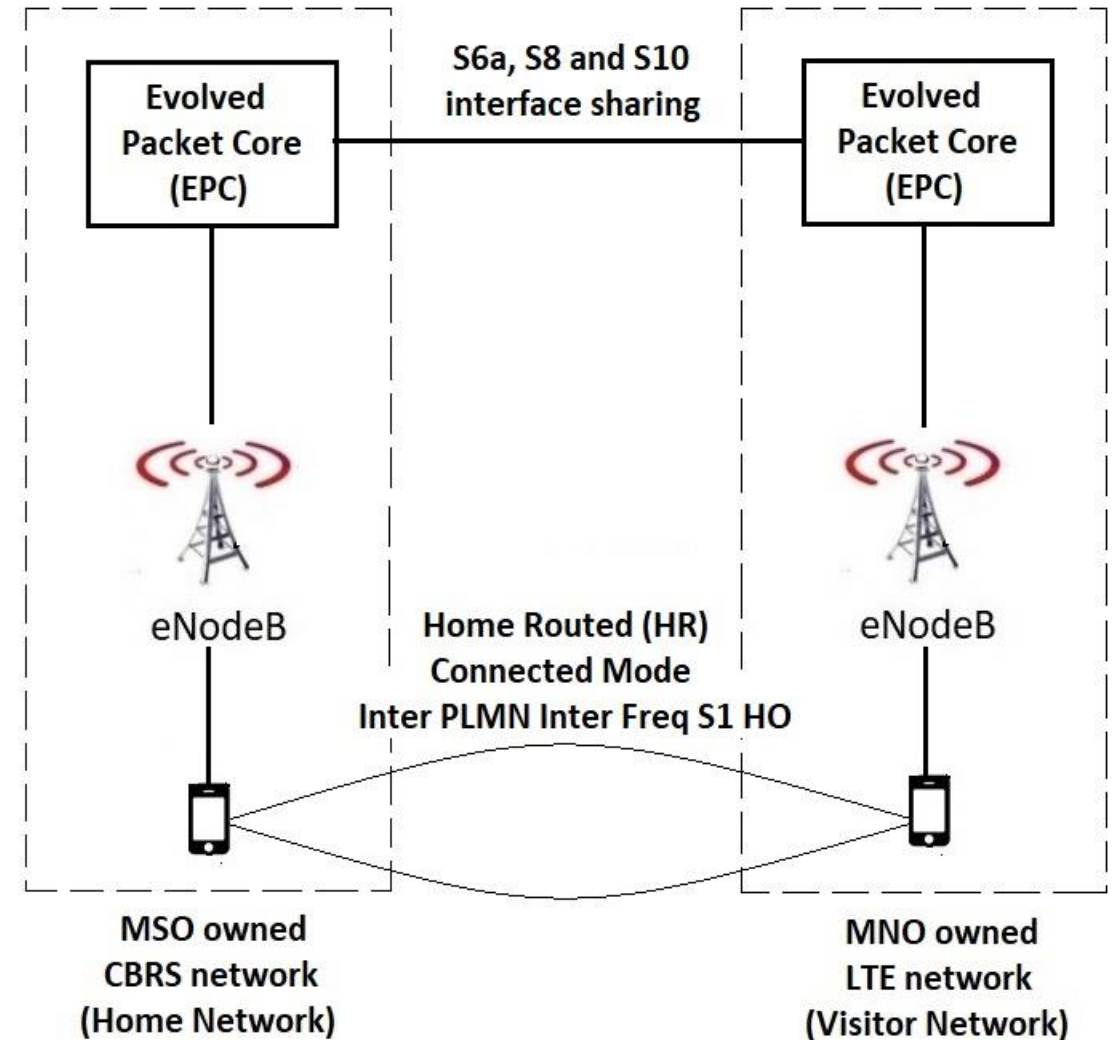
Dual SIM Implementation Enhancements



- 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?