Architecture for Optimized Handover between CDMA (EV-DO/1X) and LTE

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Content

- Common Network Architecture
- Nature of Terminal and Handoff
- Optimized Handoff Requirements
- The architecture for CDMA-LTE Inter-technology HO
- Standards Status
Introduction

- Areas to considered for Inter-technology Interworking and Handoff:
  - Core Network Architecture
  - Radio Capability of the Hybrid terminal
  - Handoff Control: Network or Terminal
  - Intersystem functionalities: Loose and Tight Coupling
  - Service continuity across network boundaries
  - Ability to make measurements in target system
Core Network Architecture

- The Interworking architecture must cover:
  - Mobility
  - Authentication / Security
  - Policy and Charging
  - Fixed / Mobile convergence

- Current agreed architectures
  - HRPD-LTE: based on 3GPP Evolved Packet Core (EPC) (agreed in 3GPP and 3GPP2)
  - HRPD-UMB: based on 3GPP2 Converged Access Core (CAN)
  - WiMAX-HRPD: based on “commonalities” between 3GPP2 & WiMAX NWG

A common reference architecture should accommodate performance requirements and deployment models for the all technology pairings.
3GPP Evolved Packet Core
(Example of Roaming Arch in TS 23.402)

Note: Interfaces for CDMA-LTE Optimized Handoff are not shown here
23.402 Architecture Legend

- Trusted non-3GPP IP access
  - Assumes that IPsec tunnel between UE and Evolved Packet Core (EPC) is not required because the access has its own internal security mechanisms (e.g. privacy, integrity protection, key management, etc) that can be “trusted” (e.g. HRPD or WiMAX ASN)

- Non-trusted non-3GPP IP access
  - Assumes that IPsec tunnel between UE and EPC is required in order to make it trusted (e.g. I-WLAN with ePDG)

- Whether a non-3GPP access is Trusted on Non-trusted is an operator's decision i.e. it is NOT an intrinsic feature of the access technology

- Non-3GPP accesses may be anchored in the PDN GW or in Serving GW

- Access authentication: SWa/STa - SWd - SWx

- Tunnel authentication: SWm - SWd - SWx

- Network-based mobility (Proxy MIP): S2a, S2b, S5

- Gx, Gxa, Gxb, Gxc – Diameter interfaces for QoS/PCC signalling

- Host-based mobility (DSMIPv6): S2c

- DSMIPv6 authentication: S6b
Radio Capability of Hybrid Terminals

- **Dual Radio: Dual Rx/ Dual Tx**
  - Increasing terminal complexity/cost/interference
  - Reducing HO solution complexity

- **Single Radio: Dual Radio Rx/ Single Radio Tx**
  - Reducing terminal complexity/cost/interference
  - Increasing HO solution complexity

- **Single Radio: Single Radio Rx / Single Radio Tx**

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LTE-CDMA interworking is optimized for single Rx terminals, also allowing dual Rx/ dual Tx devices
Handoff Control: Network or Terminal Triggering

• Network Triggered:
  • Target selection (in the network) may be enhanced with additional parameters to finely tune the handoff criteria.
  • Network can be tuned to trigger handoff based on highly granular information (e.g. aggressive handoff regimen depending on deployment circumstances)

• Mobile Triggered:
  • The mobile makes the HO decision, potentially with assistance from the network.
    • Network push
    • Network receives measurement information.
  • The degree of network assistance (i.e. what information is provided) will determine the performance of the handoff

LTE-CDMA interworking is optimized for Network controlled HO
Inter-system Functionalities

Loose coupling
a) “Break Before Make”
  • Little or no inter-system functionalities
    • UE-centric L3 mobility based on (P)MIP
  • Resources are released in the source system prior to Handover execution
    • Service break is significant

b) “Dual-radio MBB”
  • Resources in target system are obtained prior to HO execution directly over target radio interface - “seamless mobility”
    • Requires dual radio capability, simultaneous transmit.
  • Requires inter-system functionalities
    • Network-controlled; L3 mobility based on (P)MIP

Tight coupling
“Make Before Break”
  • Requires inter-system functionalities
    • Ability to configure and report measurements of the target system

“Network-controlled”
  • Inter-system interface for establishing resources in target system prior to HO execution
  • Possibility of data forwarding
  • Suitable for single radio devices, but also applicable to dual radio devices
Requirements for CDMA-LTE Mobility and HO
(3GPP2 S.R0129 and 3GPP TS 22.278)

- The system shall support voice service continuity from LTE to CDMA2000 1X Revision A.
- The system shall support bidirectional service continuity between CDMA2000 HRPD (1xEV-DO) Revision A and LTE for best effort and real-time applications.
- The system shall support terminals with single radio and dual radio solutions.
- The solution should minimize the coupling between the LTE and the 3GPP2 accesses (e.g. by using transparent signaling through the source system) allowing independent protocol evolution in each access.
- The solutions shall be based on the principles of network controlled radio access mobility.
- Impact on service quality, e.g. Quality of Service (QoS), interruption times should be minimized.
Architecture for LTE-HRPD Optimised Handovers

S101: Enables interactions between EPS and HRPD access to allow for pre-registration and handover signalling with the target system

S103: Data forwarding interface
LTE-HRPD(EV-DO) Optimised Handovers - Principles

• Inspired from the A21 interface defined for HRPD=>CDMA2000 1X voice call continuity
• Terminal interacts directly with target system (LTE or HRPD) to perform handover preparation
• Source system provides “tunnelling” capability (S101) for terminal to interact with target system
• In the LTE=>HRPD direction there are two distinct steps
  • 1) Pre-registration: when conditions are such that a handover to HRPD may be required, the source system provides the UE with sufficient information to perform pre-registration with the target HRPD access and core network, over the S101 tunnelling interface
  • 2) HO execution: if conditions subsequently warrant that a handover should occur, the handover signalling will also be performed over the S101 tunnelling interface, whereas data forwarding takes place on S103
• Similar logic applies in the HRPD=>LTE direction, except that the – pre-registration also triggers the HO execution
LTE => HRPD optimised handover (pre-registration)

1. Attached to E-UTRAN (UE has acquired IPv4 address or IPv6 prefix)

2. Decision to pre-register with HRPD

3. HRPD Session Establishment

4. Device Authentication (A12)

5. Main A10* Connection Setup

6a. HRPD User Authentication

6b. Authentication

6c. HSGW caches Subscriber Profile, default APN, NAI, etc.

6d. Gateway Control Session Establishment / Ack
(QoS Policy Rules – S7a)

7. Establish Flows (TFT, QoS)

At this point, all HRPD context and IP context has been established. If changes are necessary in these contexts, e.g., due to mobility events, then steps 8 - 10 may be executed to perform context updates.

8. HRPD Session Maintenance

9. IP context maintenance

10. Gateway Control Request / Ack
(QoS Policy Rules – S7a)
LTE => HRPD optimised handover (HO execution)

1a. Decision to handover to HRPD

1b. HRPD Conn. Req.

1c. S101 (HRPD Conn. Req., P-GW Address(es), GRE Key(s))

2a. A11 1st RQ (P-GW Address(es), GRE Key(s))

2b. A11 1st RRP (HSGW Address, GRE Key)

3. S101 (HRPD TCA, HSGW Address, GRE Key)

4a. Create forwarding tunnel (HSGW Address, GRE Key)

4b. HRPD TCA

5. Indirect data forwarding over S103-U (optional)

6a. UE acquires HRPD Radio

6b. HRPC TCC

7a. A11 1st RQ (Active Start)

7b. A11 1st RRP

8a. Proxy Binding Update

8b. Proxy Binding Update Ack (UE IPv4 address or IPv6 prefix)

8c. Modify IP-CAN Session Ack

9. IP Packets Flowing

10. 3GPP EPS Resource Release

0. Attached to E-UTRAN (UE has preregistered on HRPD)
Voice continuity with the legacy CS Domain: LTE to CDMA2000 CS HO

- EPC/LTE is Packet Switched (PS) only system
- Voice continuity between LTE and CDMA2000 Circuit Switched (CS) domain requires a transformation of a VoIP (on IMS) call into CS session and vice versa
- Requirement is that there should be minimum impact on the CS domain
- The solution to the problem falls in the Voice Call Continuity (VCC) with “single radio hybrid terminal” category
  - VCC = Voice Call Continuity between CS domain and IMS
  - Because of the similarities with 3GPP2 VCC and 3GPP Rel-7 VCC, the problem is referred to as Single Radio VCC
  - Single Radio VCC for LTE-CDMA2000 is specified in 3GPP TS 23.216
SR-VCC Architecture for CDMA2000 CS

- Based on the A21 solution in 3GPP2 A.S0008-C
  - While attached to EUTRAN, the UE initiates tunnelled establishment of the CS access leg (via Uu - S1-MME – S102 – A1)
  - After handover to CDMA2000, the LTE access behaves as if the UE has went out of coverage i.e. it performs the S1 release procedure and considers the UE to be in IDLE state

- 3GPP mostly specifies the transport of A21 messages over S102
Status of LTE-CDMA Interworking Standards in 3GPP

- 3GPP RAN activities
  - Stage 2 is Completed in 2007/12
    - Approved TR and CR for Stage 2.
    - Meets the aggressive schedule set by operators
  - Stage 3 started in 2008/01
    - Modified LTE work item approved in 2007/12
    - Ensures CDMA-LTE as part of LTE release 8
    - Steady Progress in RAN2,3,4

  - Both LTE ➔ HRPD and HRPD ➔ LTE call flows are in normative text

- SA2 TS23.216 is the SR-VCC specification, including CDMA2000 – E-UTRAN mobility (based on CDMA A21 solution)

- 3GPP CT work for Stage 3s has started. CDMA related TSs identified.
  - Dec 2008 target completion
Status of LTE-CDMA Interworking Standards in 3GPP2

• 3GPP2 TSG-C activities
  • Stage 2 contributions are approved (baseline is being developed)
  • Agreement and/or discussion on CDMA aspect of interworking: unicast/broadcast parameters, MEID, HRPD protocol termination, etc.

• 3GPP2 TSG-A activities (A.S0022)
  • Stage 2 approved
  • Stage 3 development in progress

• 3GPP2 TSG-X activities (X.P0057)
  • Architecture and HRPD Serving Gateway (HSGW) functionality (Stage 2) approved
  • Stage 3 development in progress
  • 4Q 08 Publication
Thank You

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