LTE Evolved Packet System Architecture

Alcatel·Lucent

LTE COMES IN TWO FLAVORS – FDD AND TDD

FDD

BAND	IDENTIFIER	FREQUENCIES (MHz)
1	IMT Core Band	1920-1980/2110-2170
2	US PCS (A-F)	1850-1910/1930-1990
3	GSM 1800	1710-1785/1805-1880
4	AWS (US & Other)	1710-1755/2110-2155
5	850 (Cellular)	824-849/869-894
6	850 (Japan #1)	830-840/875-885
7	IMT Extension	2500-2570/2620-2690
8	GSM 900	880-915/925-960
9	1700 (Japan)	1750-1785/1845-1880
10	3G Americas	1710-1770/2110-2170
11	1500 (Japan #1)	1428-1448/1476-1496
12	US L700 (A,B,C)	698-716/728-746
13	US U700 (C)	777-787/746-756
14	U U700 (Pub Safety, D)	788-798/758-768
17	US L700 (B,C)	704-716/734-746
18	850 (Japan #2)	815-830/860-875
19	850 (Japan #3)	830-845/875-890
20	Digital Dividend	832-862/791-821
21	1500 (Japan #2)	1448-1463/1496-1511
23	MSS	2000-2020/2180-2200
24	MSS	1626.5-1660.5/1525-1559
25	US PCS 1900 (A-G)	1850-1915/1930-1995

TDD

BAND	IDENTIFIER	FREQUENCIES (MHz)
33	TDD 2000	1900-1920
34	Europe	2010-2025
35	TDD 1900	1850-1910
36	AWS (US & Other)	1930-1990
37	PCS CenterGap	1910-1930
38	IMT Extension Center Gap - EMEA	2570-2620
39	China TDD	1880-1920
40	2.3 TDD	2300-2400
41	ISM Coexistence	2496-2690
42	UMTS/LTE 3500	3400-3600
43	UMTS/LTE 3500	3600-3800

LTE BASIC NODES AND INTERFACES

MOBILITY MANAGEMENT ENTITY (MME) FUNCTIONS
- Non-Access Stratum (NAS) signaling (attachment, bearer setup/deletion)
- NAS signaling security
- Signaling for mobility between 3GPP access networks (S3)
- Idle mode user equipment reachability
- Tracking Area list management
- PDN gateway and serving gateway selection
- MME selection for handoffs with MME change
- Roaming - S6a to home subscriber server (HSS)
- Authentication
- Bearer management functions including dedicated bearer establishment
- Support for Earthquake and Tsunami Warning System (ETWS) message transmission
- Alcatel-Lucent 9471 MME

USER EQUIPMENT (UE) FUNCTIONS
- Contains the Universal Subscriber Identity Module (USIM) which holds authentication information
- Supports services and applications
- Monitors radios and conveys performance to the Evolved Node B (eNB) channel quality indicator (CQI)
- Supports LTE uplink and downlink air interface
- Maps upstream traffic into traffic classes that are defined by upstream traffic flow templates

EVOLVED NODE B (ENB) FUNCTIONS
- Radio resource management: radio bearer control, radio admission control, connection mobility control, uplink/downlink scheduling
- IP header compression and ciphering of user data stream
- Mobility management entity (MME) selection
- Forwarding uplink data to serving gateway
- Paging
- Scheduling and transmission of broadcast information, originated from the mobility management entity (MME) or operations and maintenance (O&M)
- Measurement and measurement reporting configuration for mobility and scheduling
- Scheduling and transmission of Earthquake and Tsunami Warning System (ETWS) messages, originated from the MME

HOME SUBSCRIBER SERVER (HSS)
- Storage of subscriber data
- Enhanced Presence Service (EPS) QoS subscriber profile
- Roaming restrictions list
- Accessible Access Point Names (APNs)
- Address of current serving mobility management entity (MME)
- Current Tracking Area (TA) of user equipment (UE)
- Authentication vectors and security keys per UE
- Alcatel-Lucent 8650 Subscriber Data Manager
- Provide subscriber policies using Sp interface to PCRF

POLICY AND CHARGING RULES FUNCTION (PCRF)
- Interfaces with application functions such as the proxy-call session control function (P-CSCF) or other policy enabled applications
- Interfaces with the PDN gateway to convey policy decisions to it
- Decides how services shall be treated in the PDN gateway in accordance with a user subscriber policy
- Alcatel-Lucent 5780 DSC

SERVING GATEWAY (S-GW)
- Local mobility anchor for inter-evolved Node B (eNB) handover
- Mobility anchor for inter-third-generation partnership project (3GPP) mobility
- Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) idle-mode downlink packet buffering and initiation of network triggered service request procedure
- Lawful intercept
- Packet routing/forwarding
- Transport level packet marking (uplinking and downlinking)
- Accounting on user and Quality of Service (QoS) class identifier granularity for inter-operator charging
- Uplink and downlink charging per user equipment, packet data node (PDN), and QoS class identifier (for roaming with home routed traffic)
- Alcatel-Lucent 7750 Service Router

PDN GATEWAY (P-GW)
- PDN gateway
- Per-user packet filtering
- Lawful intercept
- User equipment (UE) IP address allocation
- Transport level packet marking for downlinking
- Uplink/downlink service level charging, gating, and rate enforcement
- Downlink rate enforcement based on aggregate maximum bit rate (AMBR)
- Alcatel-Lucent 7750 Service Router

S1-mobility management entity (MME): used for signaling between the Evolved Node B (eNB) and the MME

S1-U: defines user plane between eNB and serving gateways

S10: used by MMEs to support MME changes

X2: used to support intra-MME handoff with no packet loss

S11: used by the MME to control path switching and bearer establishment in the serving gateway and PDN gateway

S6a: used by the MME to retrieve subscriber data from home subscriber server (HSS)

S5: a signaling interface for establishing bearers between the serving gateway and the PDN gateway or between serving gateways, for serving gateway changes (GTPv2). It also supports the user plane for bearers (GTPv1). Note there is a PMIPv6 version of the S5.

S11: used by the MME to control path switching and bearer establishment in the serving gateway and PDN gateway

Gx: used by the PCRF to convey policy enforcement to the P-GW, and also used to retrieve traffic flow data.

SGi: the interface into the IP PDN. This is where the IP visibility into the UE IP address(es) is exposed.

S8: analogous to the S5 except that it is used in roaming scenarios.

Rx: used by application functions, such as the IMS P-CSCF, to convey policy data to the PCRF.

VOICE AND SMS INTERWORKING OPTIONS

IMS – INDUSTRY-STANDARD SERVICE ARCHITECTURE

APPLICATIONS
Voice Call Continuity
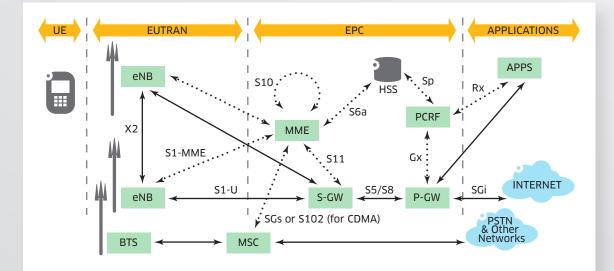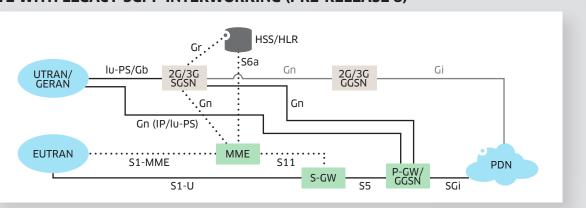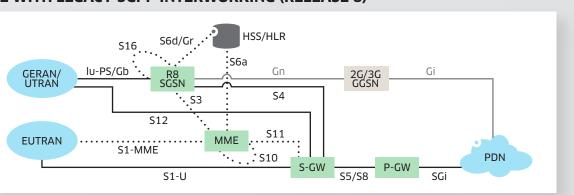Telephony
Presence
SMS/IM
Voice Mail

- IMS architecture is described in TS 23.228
- IMS supports VoIP on EV-DO, HSPA+ and LTE
- Single Radio Voice Call Continuity (SRVCC) IMS supports optimized handoff of calls between VoIP domains and wireless circuit domains using the Voice Call Continuity (VCC) application server (TS 23.216)
- IMS centralized services (ICS) (TS 23.292) and service centralization and continuity (SCC) (TS 23.237) enable IMS services for user equipment in the circuit-switched domain

CIRCUIT SWITCHED FALL BACK (CSFB)

- CSFB is defined in TS 23.272
- Dual mode 2G/3G and LTE user equipment is registered in the 2G/3G circuit domain but is tuned and connected to the LTE/EPC network
- Voice calls come into the mobile switching center (MSC)
- The MSC alerts the user equipment of incoming voice calls through the serving gateway interface, mobility management entity (MME) and LTE. Note the S102 is used in the event the MSC is 3GPP2 (CDMA)
- The user equipment retunes and reconnects to the 2G/3G carrier and accepts calls
- LTE data session is either suspended or is handed to W-CDMA (if applicable - not shown above)
- SGs interface can also deliver SMS traffic to the user equipment when in LTE mode
- Alignment of tracking areas between 3G and LTE provide optimal fall back timing

BEARER ARCHITECTURE

EPS BEARER (36.300, CLAUSE 13.1)
- Evolved packet system (EPS) bearer (36.300, clause 13.1):
- An EPS bearer is an end-to-end tunnel defined to a specific QoS
  - A default bearer is defined at the user equipment initial attach; radio resources are removed if the user equipment goes idle
  - A dedicated bearer is created using signaling for specific services
- The QoS model is built on the EPS bearer which has four parameters associated to it:
  - QoS class identifier (QCI) is an integer which provides an index into a table providing forwarding treatment for that bearer (in terms of latency and packet loss)
  - Allocation and retention priority (ARP) is used by the scheduler to provide preemption priority in case of contention
  - Guaranteed Bit Rate (GBR): separately for both downlinks and uplinks. Note an EPS-bearer can be non-GBR
  - Aggregate Maximum Bit Rate (AMBR) specifies downlink and uplink bit rates for an aggregate EPS bearer
- Service data flows (SDF) are specific packet flows identified by quintuple and associated to a service requiring special treatment
- SDFs are mapped into EPS bearers at the user equipment (for uplinks) and at the PDN gateway (for downlinks) using a set of filter rules called traffic flow templates (TFT).

LTE POLICY CONTROL AND CHARGING

Gxc (PMIPv6 S5 only)

PCRF (TS 23.203)
- Policy rule
  - Applies a filter (TFT) to map SDFs to EPS bearers
  - Provides charging instructions
- Extremely flexible model
  - Dynamic policy control
  - Policy push: User equipment <> application signaling determines which SDFs to use and what policy rule to install using the PCRF on the PDN gateway
  - Policy pull: The gateway detects an event which triggers notification to the PCRF to download a policy rule
  - Pre-defined policy rules
  - Roaming support, other AN support
- Charging functions in PCRF
  - Charging correlation: binds uplink traffic (per SDF) to IMS signaling layer (useful for volume metering, for example)
- Charging in PDN gateway and serving gateway (for roamers)
  - Per SDF statistics collection based on charging rules provided by the PCRF
  - Online charging through diameter credit control (Gz)
  - Offline charging (Gy)
- Other PDN gateway functions
  - Gate control: allows or disallows SDF
  - Flow policing
  - Marking flows
  - Metering
  - Application awareness through DPI
- Bearer binding and event reporting function (BBERF)
  - Bearer binding is the generic procedure for associating a bearer in the access to a SDF
  - TS 23.402 and 23.203 defines bearer binding and event reporting function (BBERF) to support situations where a direct policy interface is needed.

INTERFACE	PURPOSE	PROTOCOL	REFERENCE
Gx/Sd	Policy control	Diameter/SCTP	TS 29.212
Gxa and Gxc	BBERF as defined in TS 23.402	Diameter/SCTP	TS 29.212
Rx	Application function to PCRF	Diameter/SCTP	TS 29.214
S9	Roaming interconnect for PCRF	Diameter/SCTP	TS 29.215
Sh	Retrieving per subscriber policy data	Diameter/SCTP	TS 29.329
Gy/Ro	On-line charging	Diameter/SCTP	TS 32.299
Rf	Off-line charging	Diameter/SCTP	TS 32.299
Ga	Off-line charging	GTP	TS 32.295
Gz	Flow based Off-line charging	Rf or Ga	TS 32.251
Sy	OSC data usage threshold crossing notification	Diameter/SCTP	TS 29.219

LTE INTERWORKING OPTIONS

LTE WITH LEGACY 3GPP INTERWORKING (PRE-RELEASE 8)

TS 23.401, ANNEX D
Utilizes new LTE elements to emulate legacy elements for interworking
- Mobility management entity (MME) supports Gn/Gp interfaces (TS 23.060) for the control plane (based on GTPv1)
- PDN gateway needs to support Gn/Gp interfaces (TS 23.060) for the control and user planes. PDN gateway also acts as a GGSN and common anchor for evolved packet core (EPC) bearers and packet data protocol (PDP) contexts.

An LTE-capable device that also supports 2G/3G will access APNs through the PDN gateway, which serves as the mobility anchor for the legacy third-generation partnership project (3GPP)

LTE WITH LEGACY 3GPP INTERWORKING (RELEASE 8)

RELEASE 8 METHOD OF INTERWORKING (TS 23.401, CLAUSE 5.5.2)
The release 8 method of inter-radio access technology (IRAT) interworking relies on using:
- New S3 and S4 interfaces, modeled on the S5 and S10 interfaces used for S1 based handover, to support signaling and user plane requirements
  - A serving GPRS support node (SGSN) that uses the new interface is called an S3/S4 SGSN
- A serving gateway as a mobility anchor for intra-3GPP mobility
  - Mobility management entity (MME) <> SGSN handovers support call flows similar to the basic S1-based handover with MME change (also described in TS 23.401)

Advantages of R8 interworking
- Offers a highly scalable solution that leverages new evolved packet core (EPC) elements for a variety of 3GPP access options (HSPA+, other 2G/3G)
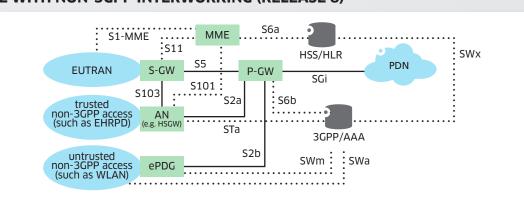- Compatible with 3G direct tunnel approach (3G DT terminated on a serving gateway)
- Supports Idle Mode Signaling Reduction (ISR)

LTE WITH NON-3GPP INTERWORKING (RELEASE 8)

INTERWORKING WITH NON-3GPP ACCESS NETWORKS (TS 23.402)
Fundamental goal: Achieve mobility with IP address preservation when user equipment selects a non-3GPP access

Access types:
- Trusted non-3GPP access – WiMAX and Enhanced High Rate Packet Data (EHRPD) operated by the same provider as LTE
  - The operator has authenticated users to the access network
  - The operator has implemented sufficient safeguards to mitigate potential attacks
- Untrusted non-3GPP access – third-party WLAN access (home or business) hot spot
  - The operator requires separate authentication procedures
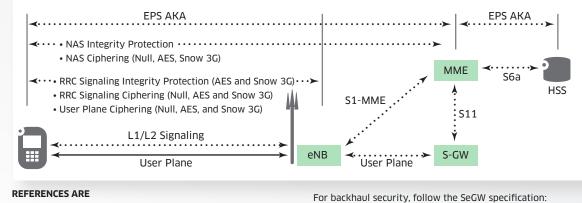 - Example: WLAN access from a third party (home or business) hot spot

Basics:
- The PDN gateway is a mobility anchor for non-3GPP access and supports PMIPv6 Local Mobility Anchor (LMA) functions
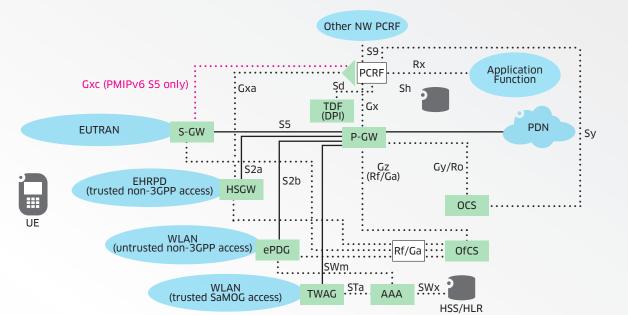- The serving gateway (in the case of PMIPv6 S5/S8) supports mobile access gateway (MAG) functions
- The Access Network (AN) - HRPD Serving Gateway (HSGW) (for EHRPD) or evolved packet data gateway (ePDG) - supports PMIPv6 (RFC 5123)
- Other options such as client MIP, dual-stack MIP and others are supported in TS 23.402
- S101 and S103 can optimize the handoff from LTE to HRPD with no packet loss and quicker handoff completion

LTE SECURITY

- NAS Integrity Protection
- NAS Ciphering (Null, AES, Snow 3G)
- RRC Signaling Integrity Protection (AES and Snow 3G)
- RRC Signaling Ciphering (Null, AES and Snow 3G)
- User Plane Ciphering (Null, AES, and Snow 3G)

REFERENCES ARE
- TS 33.401: SAE Security Architecture
- TS 24.301: NAS Protocol
- TS 36.323: PDCP Specification

For backhaul security, follow the SeGW specification: TS 33.210 / TS 33.310