WHITE PAPER

Evolved Packet Core Testing

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Introduction

The drastic speed increase associated with LTE – 20 times faster than UMTS – will forever change the way in which mobile services are used. Not only this will spur development of rich new broadband services, but the increased capacity will trigger the deployment of new handset features, including higher screen resolution and better battery technologies. Ubiquitous services, such as SMS and MMS, will accelerate their inclusion of real-time photos and video. LTE will bring the mobile browsing experience to an all new level, similar to wired network experiences, allowing greater interaction with social networking, sites such as Facebook and MySpace.

Service providers will require their network to support a variety of applications not traditionally seen on mobile phones, including web surfing, streaming video, peer-to-peer networking, and machine-to-machine communications that will consume large amounts of bandwidth for longer durations.

The drastic speed increase associated with LTE – 20 times faster than UMTS – will forever change the way in which mobile services are used.

Smartphones, now more computers than phones, will become more attractive when paired with an apparently unlimited LTE bandwidth. Smartphones have already created nightmares scenarios for carriers who are seeing increased backhaul traffic, the need to regulate the traffic flows, and the need to monetize new services. For example, downloading a YouTube video uses 100x more bandwidth than voice, and the average iPhone uses 400 Mb of data per month. LTE will be available not only for smartphones, but also for notebooks, ultra-portables, cameras, camcorders, mobile broadband routers and other devices that would benefit from mobile broadband.

LTE is moving forward to meet key 4G capacity requirements by providing peak downlink rates of 300Mbit/s or more when used with multiple antennas. The LTE infrastructure is designed to be as simple as possible to deploy and operate, while being flexible enough to adapt to frequency band constraints.

The number of worldwide LTE subscribers is expected to exceed 72 million by 2013, largely split between the Asia Pacific and North American regions. NTT DoCoMo, KDDI, Verizon Wireless, and AT&T are expected to deploy LTE technology during this time frame. Europe will be expected to lag due to its deployment of HSPA+ in the interim between HSPA and LTE, as shown in Figure 1.

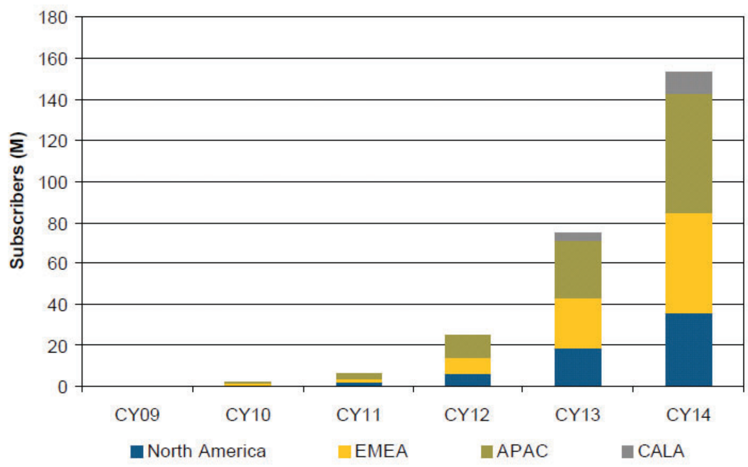

Figure 1 Worldwide LTE Equipment Revenue Forecast
(Source: Infonetics, Infrastructure and Subscribers, March 2010)

The expected monthly HSPA+ and LTE bandwidth usage will increase twenty folds from 2009 to 2014. In a recent survey by Cantab Wireless, U.S. operators estimated that by 2013 LTE will be available to 95% of the U.S. population.

In order to maintain profitability in a climate of ever-increasing backhaul network costs, operators need to move beyond a flat data rate model. In Japan, for example, networks typically carry a mix of 60% data and 40% voice. Only 40% of revenue comes from data, however. Carriers are actively developing enhanced pricing models, including fair usage (pay as you consume) policies.

If all roads lead to LTE, carriers are taking different paths to get there. Approximately 72% of the Americas today use GSM. Many GSM-based carriers, such as AT&T, will first move to HSPA (7.2Mbps), then to HSPA+ (21Mbps) and then to LTE (100+ Mbps). LEAP (Cricket), a CDMA2000 network, will move first to EV-DO and then to LTE. Metro PCS is expected to deploy LTE using Ericsson's infrastructure and Samsung for handset. Rogers, T-Mobile and Telstra have already begun trials of HSPA+. T-Mobile is expected to deploy HSPA+ in 2010.

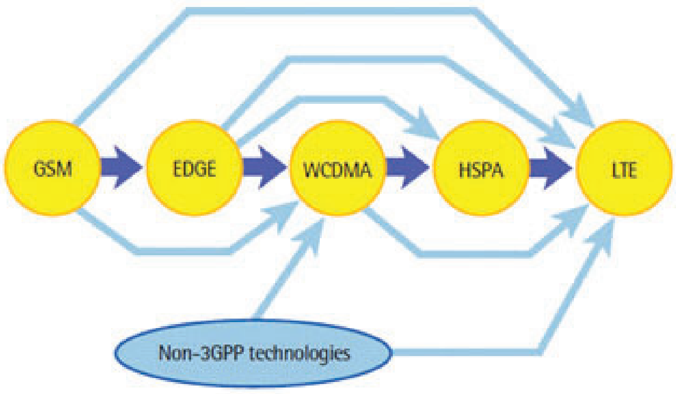

Figure 2 Upgrade Paths to LTE
(Source: UMTS Forum, Towards Global Mobile Broadband, 2008)

In order to maintain profitability in a climate of ever-increasing backhaul network costs, operators need to move beyond a flat data rate model.

LTE seems the inevitable evolutionary target. Getting there,however, won't be without its hurdles. Although LTE brings an essential simplification to a pure IP network, it does not immediately address the migration of key services such as SMS and voice, and a long list of circuit switch (CS) domain services. Voice calls in LTE, for example, are specified to be SIP-based IMS calls. This creates a problem, not only in term of complexity and cost, but also during LTE to 3G mobility, since VoIP calls are not supported by in all 2G/3G networks. In order to maintain the same quality of service and service level, various approaches have been proposed. The two main ones are:

- Circuit switched fall back (CSFB), where the mobile terminal is forced off the LTE network onto 2G/3G for voice calls, and
- Circuit switch-over-packet, as in the voice over LTE via GAN (VoLGA) initiative, where circuit-switch domain services are offered over LTE using the generic access network (GAN) standard.

The recent voice over LTE (VoLTE) forum announcement gives credibility to the IMS-based solution.It is based on standards developed by the One Voice Initiative, an international collaboration between more than 40 operators and vendors including AT&T, Verizon Wireless, Nokia and Alcatel-Lucent. The One Voice Initiative was formed to support a single, IMS-based voice solution for 4G networks. The GSM Association (GSMA), who backs the initiative, said that it will spearhead the development of domestic and international roaming technology for LTE networks. Work on the GSMA's roaming technology project is expected to be completed by the first quarter of 2011.

Some operators see VoLTE at least 3-5 years out, with LTE and the EPC initially addressing video and data traffic exclusively.

Evolved Packet Core

Architecture

The LTE architecture defines the Evolved Packet System (EPS) as a combination of the LTE access system (radio part) and an IP-based core network, the Evolved Packet Core (EPC).

The radio access part consists of a mesh network of radio base stations, evolved Node B (eNode B), while the EPC is an all-IP mobile core network for LTE, allowing the convergence of packet-based real-time and non-real-time services. LTE and EPC were specified by the 3GPP Release 8 standard, which was finalized in March 2009.

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All EPS transactions are IP-based: from the mobile handsets, over eNode Bs, across the EPC, and throughout the application domain, for both IMS and non-IMS. The EPC is a multi-access core IP-based network that enables operators to deploy and operate one common packet core network for 3GPP radio access (LTE, 3G, and 2G) and non-3GPP radio access (HRPD, WLAN, and WiMAX), and fixed access (Ethernet, DSL, cable and fiber).

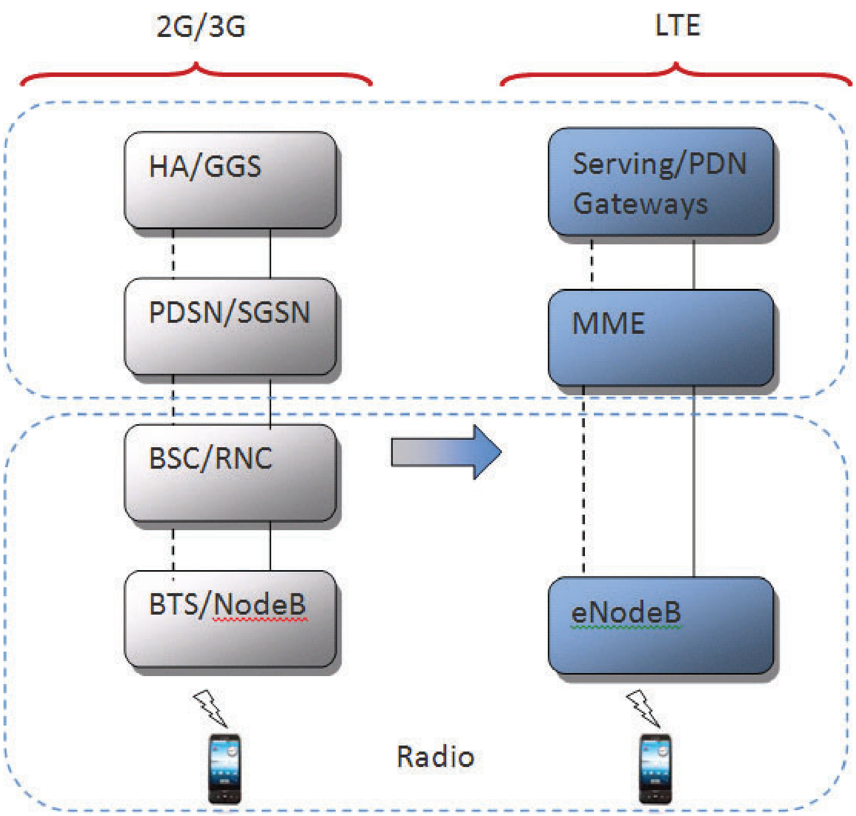

Figure 3 Architecture changes from 2G/3G to LTE/EPC

The EPC is defined around three paradigms: mobility, policy management, and security.

In many aspects, the EPC represents a radical change from previous mobile network generations:

- **Departure from the circuit-switched domain**: The technology used to carry voice in LTE is VoIP. In the core, the EPC treats voice as just one of many IP-based network applications. However, the EPC must provide outstanding packet performance in order to maintain the same voice quality that was previously delivered over dedicated channels. It is important to remember that voice and SMS services are still a significant share of operator revenues.
- **Evolved wireless broadband:** LTE must deliver a quality of experience (QoE) equal to or better than that of wireline broadband networks. This requires a major update for existing mobile packet switches that are designed to provide best-efforts, low-speed web browsing and SMS.
- **Mobility as a part of the core network**: LTE moves the mobility management responsibilities previously performed by the RNC and Node B/BTS into the EPC under control of the mobility management entity (MME). As a consequence, MME control plane handling capacity must be significantly more compare to that of the SGSN or PDSN. The MME must not only manage LTE traffic, but also ensure interworking with legacy 2G/3G mobile systems.
- **Top-notch end-to-end QoS**: LTE must provide advanced end-to-end QoS management and enforcement in order to deliver new media-rich, low-latency, real-time services, while ensuring scalability in terms of users, services and data sessions. Advanced packet processing techniques such as deep packet inspection (DPI) are required.
- **Policy management and enforcement:** LTE service management and control is provided through the policy and charging rules function (PCRF). PCRF dynamically controls and manages all data sessions and provides appropriate interfaces for charging and billing systems, as well enabling new business models.

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The EPC not only provides a simpler, flatter, and cheaper network infrastructure, but also adheres to new, stringent LTE requirements for high bandwidth, reduced latency, and 2G/3G interoperability.

EPC Requirements

The EPC not only provides a simpler, flatter, and cheaper network infrastructure, but also adheres to new, stringent LTE requirements for high bandwidth, reduced latency, and 2G/3G interoperability. Therefore, the enforcement of control of quality of service (QoS)-related parameters, such as jitter and delay, is critical. This will allow the EPS to support a TDM-like deterministic behavior for delivery of real-time, performance-sensitive services, such as voice and video.

The EPS must be a high-performance, high-capacity, all-IP core network in order to aggregate many eNode Bs with significantly increased peak data rates – up to 300 Mbps downlink per sector when operating at 20 MHz with 4x4 MIMO.

Load requirements will vary depending on several factors, including:

- Number of sectors used. A typical configuration will range from 3 to 6 sectors.
- Number of UEs per sector and their relative velocities, since higher speeds lend themselves to increased transmission errors.
- Radio conditions.
- Types of voice, video, and data applications used by each UE. Some chatty applications, such as instant messaging, tend to keep the signaling level of the radio fairly busy with large numbers of short transactions, although they present a light load for the core.

The EPC must also match LTE latency and QoS requirements by providing superior real-time and media-rich services with improved QoE. The EPC increases network performance by using a streamlined IP architecture in which the control and data planes are separated at the edge of the core network. Data connections from eNode Bs traverse EPC gateways, while user mobility is addressed by the MME.

Figure 4 shows the EPC as a core part of the all-IP environment of LTE.

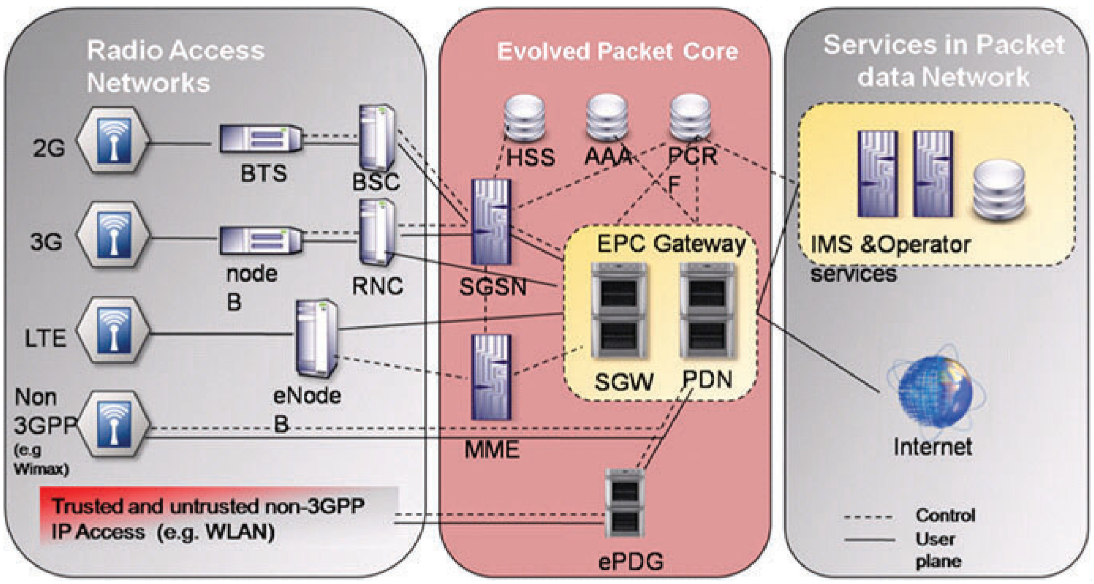

Figure 4. Simplified view of the EPS

EPC Components

Although the EPC is composed of a number of components that provide IP connectivity for multiple access technologies, the key node elements are:

- Serving Gateway (SGW)
- Packet Data Network (PDN) Gateway (GW)
- Mobility Management Entity (MME)
- Policy and Charging Rules Function (PCRF)

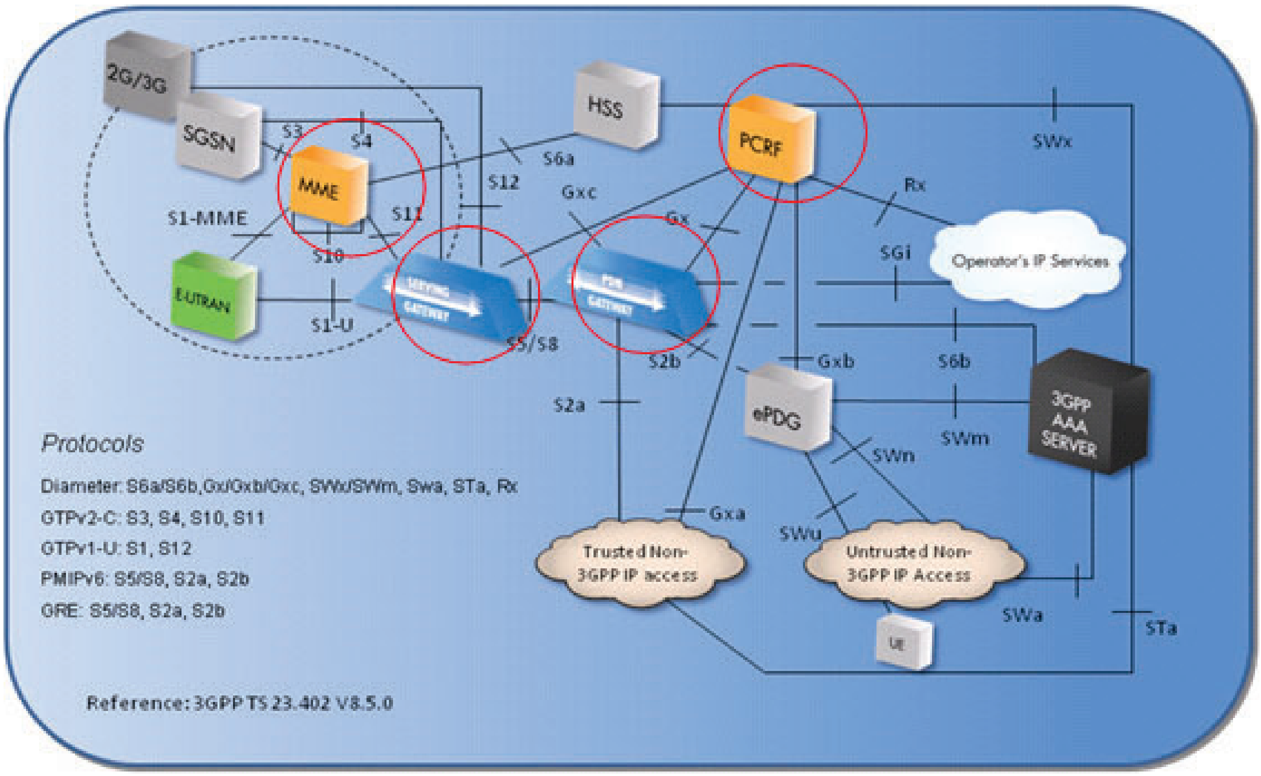

Figure 5. EPC reference diagram

Serving Gateway

The SGW is a user-plane node providing data paths between eNode Bs and the PDN gateway. One of the essential functionality of the SGW, beside routing and forwarding packets, is as a local mobility anchor point for inter-eNode B handovers as well as managing mobility between LTE and 2G/GSM and 3G/UMTS networks. The SGW also provides charging for user equipment, PDN, and service classes.

The SGW is connected to the PDN-GW via the S5 interface, which can support two distinct protocols, either the GPRS tunneling protocol (GTP) or the proxy mobile IPv6 (PMIPv6) protocol. When using PMIP, the SGW also has a direct connection with the PCRF via the Gxc interface to supplement the lack of event reporting not available in the PMIPv6 protocol. PMIPv6 maintains IP connectivity instead of a requiring an EPS bearer. The EPS bearer goes from the UE to the PDN-GW with appropriate QoS.

Packet Data Network Gateway

The PDN-GW is the termination point of the packet data interface. It provides the anchoring function for sessions with external packet data networks. A critical function of the PDN-GW is enforcement of per-user-based packet filtering, allowing gating and rate enforcement policies as well as service level charging.

User-plane LTE traffic is carried over service data flows (SDFs), which are aggregated over a set of virtual connections that match a specific filter policy or template. SDFs are in turn carried over EPS bearers. An EPS bearer uniquely identifies data flows that receive a common QoS treatment between a UE and a PDN GW.

Mobility Management Entity

The MME has a key role in the handling of mobile users. It performs the signaling and control functions that manage the mobile users' access to LTE, assigns network resources, and manages mobility states that support roaming, paging, and handovers. The MME oversees all control plane functions related to subscriber and session management.

Additionally, the MME performs the inter-core network node signaling for mobility between 3GPP access networks and provides bearer management control functions to establish the bearer paths that the mobile user will use.

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The MME supports the following functions:

- **Security procedures**: End-user authentication as well as initiation and negotiation of ciphering and integrity protection algorithms.
- **Terminal-to-network session handling**: All signaling procedures used to set up packet data context and negotiate associated parameters, such as QoS.
- **Idle terminal location management**: The tracking area update process used to enable the network to join terminals for incoming sessions.

An MME typically manages thousands of eNode Bs – one of the key differences between 2G/3G networks based on RNC/SGSN platforms.

Policy and Charging Rules Function

Defined in 3GPP Release 7 as the union of the policy decision function (PDF) and the charging rules functions (CRF), the PCRF was further enhanced in Release 8 by broadening the scope of the policy and charging control (PCC) functionality to ease non-3GPP access to the network, for example for Wi-Fi or fixed IP broadband access.

In the 3GPP policy and charging control model, the policy and charging enforcement function (PCEF) is the generic name for the functional entity that supports service data flow detection, policy enforcement and flow-based charging. This functionality is the responsibility of the PDN-GW, which hosts the rules sent by the PCRF using the Gx interface.

At the application level, i.e. within IMS, the PCRF also communicates with the proxy call charging session control function (P-CSCF), providing support for applications that require dynamic policy and/or charging control via the Rx interface.

QoS in the EPS

The network components that implement EPS-QoS control are the EPS bearer between the PDN-GW and the UE, and the Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) radio access bearer (E-RAB) between the S-GW and the UE. Each packet flow, called a service data flow (SDF), ensures that the same EPS bearer receives identical bearer-level packet forwarding treatment and is assigned the same QoS class. Separate bearers are requires to provision different packet forwarding treatments to different packet flows.

Each QoS class and UE IP address combination requires a separate bearer, and each UE IP address is associated with a single access point name (APN). The APN is a reference used to identify a PDN to which the UE may connect. The APN itself is a name that may be used in a DNS query to resolve the IP address of the appropriate PDN-GW. One bearer, known as the default bearer, remains established throughout the lifetime of the PDN connection. Additional EPS bearers, known as dedicated bearers, may be associated with the same APN but with different QoS classes, and are also associated with the same UE IP address. A single UE may connect to multiple APNs and hence may be assigned multiple UE IP addresses.

The EPS supports two types of bearer: guaranteed bit rate (GBR) and non-guaranteed bit rate (non-GBR). A GBR bearer is permanently assigned network resources at the time of its establishment or modification by the admission control functions resident in the EPS, e.g., the eNode B. Provided that the traffic carried over a GBR bearer conforms to the QoS assigned to it, congestion related packet losses are usually rare. Congestion related packet losses on a non-GBR bearer are to be unexpected.

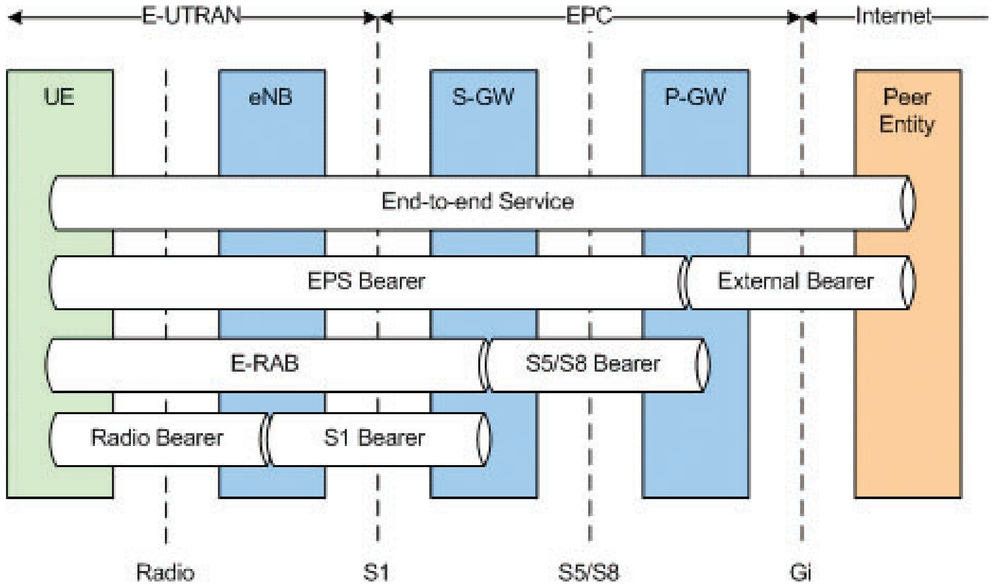

Figure 6 EPS Bearer Service Architecture

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EPC Testing Challenges and Strategies

The radical evolution of the EPC, compared to previous generations' mobile core networks, presents a number of testing related challenges .

LTE's eNode B significantly increases radio spectrum efficiency. This results in greater system capacity and performance, requiring the EPC to provide higher throughput and lower latency over the all-IP network architecture, while maintaining a high quality of experience. Existing 2G/3G mobile cores networks designed for low-speed and best efforts data could not have coped with these requirements.

The following are key aspects of the EPC that must be validated before any LTE deployment:

Mobile Backhaul and Core Network Validation

The radical evolution of the EPC, compared to previous generations' mobile core networks, presents a number of testing related challenges .

The proliferation of smart phones, PDAs, and other mobile communication devices, along with ever increasing bandwidth-intensive mobile data applications, has placed heavy strains on mobile backhaul networks worldwide. Simultaneously, mobile network operators have come to expect high performance with carrier-class reliability from cell site backhaul links that are low cost, scalable, and offer a clear migration path from legacy telephony standards (TDM-Time Division Multiplexing), to new highly-scalable all-IP packet-based data transport technology.

With the introduction of the eNode B, the IP-based mobile backhaul architecture is likely to see a mix of access technologies aggregated over a common packet switched network, introducing potential impairments on new aggregation devices. The following are key areas that must be validated:

- **Layer 2 and 3.** Various network and transport level options can be used, since 3GPP does not mandate any specific configuration. For example MPLS, VPNs, or L2TP can be used for transport. A solid multi-technology validation of transport layers is required at the initial deployment phase and as new access types are introduced.
- **IPv6 deployment**. IPv6 is mandated for LTE, but the reality is that most of the existing components and networks will use IPv4. As a result, close coordination with IPv4 nodes and possible dual IPv4/IPv6 stacks systems will be deployed. Mobile devices will likely support IPv4 and IPv6 and connect concurrently to IPv4/IPv6 packet data networks. Therefore, IPv4/v6 integration testing should not be neglected.
- **IP routing**. Network addressing can be challenging in large IP domains. MMEs will support thousands of eNode Bs deployed across numerous private, semi-private or public networks. Random and systematic addressability tests are required in the EPC.

Device and Interfaces

The EPC utilizes a significant number of core nodes and network devices, including routers, switches, servers, firewalls, and DNS, AAA, and Diameter servers, that interoperate over well-defined interfaces. At an early stage of EPC testing core nodes should be tested for functionality, including negative testing, in isolation mode, i.e. surrounded by various simulators on its interfaces. Multi-protocol solutions are required to wrap-around the device under test in order to create realistic scenarios. The following are key areas that must be validated:

- **Complexity**. EPC connectivity with 2G/3G and non-3GPP type accesses (WLAN, WiMAX, etc.) can potentially require a large number of test scenarios in order to obtain realistic functional coverage. Complete coverage is not feasible and is often best approached through the use of pre-built core scenarios that can be adapted using scripting tools.
- **Protocol breadth.** Even though many interfaces use the same protocol, many variances of the protocol are required in order to test EPC. Diameter, for instance, is used on more than 12 different EPC interfaces, each using a different extension set.
- **Customization**. With LTE/EPC already gearing up for Releases 9 and 10, the need to support early protocol releases and custom variants is indispensible.

From functional to load testing. Following functional testing, migration to load/stress testing will be required.

Voice and Mobility

LTE will likely be deployed in small islands in a sea of existing 2G/3G networks. It is essential that call continuity is validated, physically as well as at the service level. The following are key areas that must be validated:

- Voice over LTE. There is currently no clearly defined path for portability of legacy services – such as voice and SMS services – to the EPC. The standardization body for the EPC, the 3GPP, is proposing the exclusive use of IMS- and VoIP-based technologies, but most existing networks do not support VoIP, and many telephony services do not yet supported IMS.
- Other options have been proposed, such as circuit switch fall back, and the VoLGA initiative. Since the market has not yet declared a clear winner, it is important that the three primary options be tested: CS fall back options via the SGs interfaces, VoLGA support, and the 3GPP SIP migration.
- 2G/3G Mobility. Interaction between 2G/3G or CDMA and LTE will be required from day one. Mobility involves more than handovers. It is important that the impact of idle mobile users on the core network be validated while registering to LTE tracking areas and 3G routing areas, often concurrently, when the network is under stress.

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Capacity and Performance

With thousands of eNode Bs potentially carrying from 1 to 3Gbps peak data throughput of traffic each, the bandwidth capacity in the EPC could be quickly consumed, creating congestion. Behavioral monitoring of a network under stress is critical, since 99% of all network failures occur only under peak usage. The following are key areas that must be validated:

- **High throughput.** 10GE or even 40GE Ethernet might be used in addition to large numbers of 1 GE Ethernet ports on a typical EPC network. Capacity tests must plan for scalability by taking into consideration the use of large numbers of 1GE physical ports concurrent with 10GE ports while testing the SGW. Performance tests must be conducted for user traffic as well as for signaling traffic.
- **S1-Flex coordination**. The S1 interface's flex feature enables traffic load sharing across the SGWs and MMEs serving a local E-UTRAN. This feature increases resiliency through geographic diversity and provides load-balancing to regulate congestion. Additionally, if an eNode B is shared between PLMNs, addressability and security are essential functions that need to be validated.
- **Centralized vs. distributed network architecture for MME, SGW and PGW deployment**. Various nodes in the EPC can be combined into a single platform, depending on the equipment manufacturer. Each possible combination must be validated, but this can be daunting. Focus should be placed on the interoperability interfaces of the various vendors' equipment under high traffic conditions.
- **Media**. A typical LTE mobile user will concurrently run many types of applications, including voice, texting, video viewing, and e-mail. Triple-play simulation is required at the PDN level to fully validate gating and policy control effects. A large number of IP applications will be required for testing. The ability to replay recorded traffic and the ability to route any IP traffic to the device under test is essential.

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Measurements

Measurements are essential to assess the quality and performance of the EPC. They must be rich, flexible, visual, complete, and represent an accurate real-time view of the network or device under test. The following are key areas that must be validated:

- **Quality of Service (QoS)**. The quality of service, expressed in jitter, latency, packets dropped, and other measurements, is a key performance indicator in an all-IP network. QoS testing measures the degradation of a guaranteed bit rate flow, such as a voice call, when a sudden data surge occurs. QoS imbalances should be measured on a per service data flow, per-subscriber, and node level basis using triple-play and video-rich traffic.
- **Quality of Experience (QoE)**. QoE tests validate the perceived quality of a voice or video stream. Based on well-established standards, QoE tests are essential to assess the overall quality of the network from the user's view, and they are especially effective as end-to-end measurements conducted between mobile equipment and the edge of the IP core network.
- **Deep Packet Inspection (DPI).** DPI is a cornerstone capability of the PDN-GW, since QoS enforcement is performed by inspecting and regulating ingress and egress traffic. Using DPI to simulate PDN behavior and to observe and report traffic violations, the EPC can certify service level agreements (SLAs). Triple-play and video-rich traffic is essential for testing node functions that enforce QoS, such as DPI.

- **Subscriber modeling.** Subscriber modeling emulates the mix, volume, and variability of mobile user communities. It is only by using rich traffic profiles, including video, file transfer, instant messaging, email, bitorrent, etc, that the EPC core network can be fully tested.

Service, security and environmental issues

The following are key areas that must be validated:

- **IMS Integration.** LTE has been designed with IMS in mind. VoIP calls in LTE are designed to use IMS in conformance with 3GPP standards. QoS rules and policies are distributed to the PDN-GW from the PCRF, triggered from the IMS (P-CSCF) via the SIP message exchange. Tight test integration between the EPC and IMS is necessary.
- **End-to-end security for data and control plane.** Integrity protection and ciphering are sometimes required, strongly suggested, or optional depending on the interface and network configuration. Testing tools must support the validation and monitoring of secured data used for signaling or on the user plane.
- **Charging**. LTE charging occurs mostly in the PDN-GW and SGW. Interfaces have been defined for offline and online charging. A crucial EPC charging test involves checks and balances between the generated traffic trigger events and the measured charging events.
- **Energy consumption**. Energy consumption is becoming an issue, not only to be environmentally friendly, but to minimize OPEX. Energy measurements that correlate to the amount of work performed are essential.

Ixia Test Solutions

Ixia provides a complete set of test solutions for use in wireless testing. Ixia's test solutions are end-to-end from the wireless edge to the Internet core. Ixia's platforms and test applications, including IxCatapult, IxLoad, IxNetwork, and IxANVL are used to test individual devices, subsystems or entire networks.

LTE Network Testing

Ixia tests LTE radio access and EPC network components both independently and in combination. Figure 7 depicts the emulation environment used to test eNode B elements.

Ixia's physical network interfaces emulate all of the components that surround an eNode B in a live network.

Ixia's test solutions are end-to-end from the wireless edge to the Internet core.

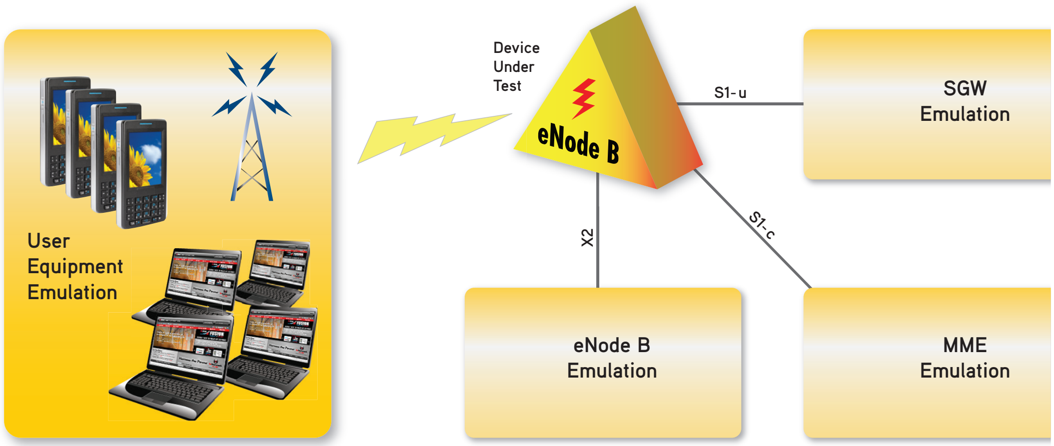

Figure 7. Ixia eNode B Testing

Ixia's UE emulation includes:

- **Multi-UE emulation.** Hundreds of emulated users per sector, with 6-sector support test any eNode B at its maximum capacity and complexity. With 2x2 MIMO, up to 125 Mbps of download traffic can be generated and verified.
- **Full Uu interface support with associated protocols.** PHY, MAC, RLC, PDCP, RRD and NAS protocols through available encoders and decoders, state machines and procedure libraries.
- **Uu simulation**. Includes support for 5, 10 and 20 MHz channels, 2x2 MIMO, in-cable CPRI v3.0/4.0, and RF over LTE frequency bands I-XIV.
- **Simulation of real-world scenarios.** Register and de-register, handover with inter-eNode B, intra-eNode B and IRAT, as well as interoperability with UTRAN, GERAN, CDMA2000 and IMS.

The three key devices in the EPC – the MME, SGW, and PDN-GW – are similarly tested by emulating all interconnected devices.

Device	Simulations
eNode B	eNode B, MME, SGW, UE
MME	HSS, eNode B, SGW, MME
SGW	MME, eNode B, PDN-GW
PDN-GW	SGW, PCRF, Network
Network	UE, IP Core

Table 1. IxCatapult Wireless Device Simulations

UMTS and IMS

Ixia offers a complete UMTS functional and load testing portfolio using high speed downlink/uplink packet access (HSDPA/HSUPA). Full protocol stack testing of the lub interface with HSPA and HSPA+ is available for functional testing, with additional flexibility for lower layer protocol analysis. Ixia test systems deliver the industry's highest load test capacity systems, enhanced with advanced traffic generators that effectively stress and verify UMTS terrestrial radio access network (UTRAN) and core network components. The network components that can be tested include the node B, UE, radio network controller (RNC), and GPRS support nodes.

Ixia offers a complete UMTS functional and load testing portfolio using high speed downlink/uplink packet access (HSDPA/HSUPA).

Ixia's IMS test solutions offer the protocol breadth, stack depth, and traffic/signaling capacity required to stress and verify IMS network elements. Test cases and configurations can be constructed for any of the primary IMS functional areas: core network, interworking elements, and application servers.

Extensive protocol support is included to test all key IMS areas, including authentication, call session control, security, charging, and quality of service. Complex lower layer protocol analysis, essential for IMS testing, is likewise supported. PESQ support is provided for voice analysis. Ixia's multi-user, multi-protocol, multi-technology platform facilitates simultaneous testing of mobile users, application servers and their services, and the PSTN. High performance load testing is easily accomplished.

Realistic Subscriber Modeling

Control and user plane testing facilities must stress test components to ensure proper operation under load, and determine realistic capacities.

Bit and block error rate testing (BERT/BLERT) are used for bit level data pattern testing of all interfaces. For higher layer testing, a wide variety of protocols are available:

- Multiple media streams per UE – RTP, UDP, and TCP.
- Multiple voice and audio encoders – AMR NB/WB, G.711, G.726, G.729, H.261, H.263, MPEG-2, and MPEG-4.
- IPv4 and IPv6 with IPSec, TLS, and ROHC.
- SIP and SDP simulation and analysis.

All types of traffic are available on a per-call basis. Ixia offers the highest flexibility and volume of triple-play traffic in the industry. A wide variety of protocols are emulated, both from the client and server side. Device and network measurements are performed on a per-call or aggregated basis, and include:

- Network characterization: packet loss, jitter, latency, and throughput
- Audio: PESQ
- Video: Telchemy VQmon®, VQA
- Stateful traffic such as HTTP, FTP, IMAP, and POP
- Quality of service and quality of experience

The deployment of LTE wireless networks and the required interoperability with legacy technologies will unleash a level of unprecedented complexity.

Conclusion

The deployment of LTE wireless networks and the required interoperability with legacy technologies will unleash a level of unprecedented complexity. Legacy technologies need to seamlessly interact with newer technologies in order for service providers to deploy networks that not only attract subscribers, but limit maintenance and upkeep costs.

Alongside LTE development is the evolution of the core architecture, called the evolved packet core (EPC), which maximizes data throughput while minimizing latency and network complexity.

The EPC is the all IP-mobile core network for LTE, allowing the convergence of packet-based real-time and non-real-time services. Ixia has taken leadership in convergence testing as the first company to cover LTE/EPC testing from the handset to the IP core.

In order to guarantee a smooth integration to LTE, operators and networks manufacturers will be best served by selecting test tools for all mobile network elements, from layer 2 through layer 7, providing complete end-to-end testing from the wireless edge to the IP core network.

Acronym Soup

2G	Second generation (wireless networks)
3G	Third generation (wireless networks)
AAA	Authentication, authorization and accounting
BGCF	Breakout gateway control function
BSC	Base station controller
BTS	Base transceiver station
3GPP	Third Generation Partnership Project
BERT	Bit error rate testing
BGCF	Breakout control function
BLERT	Block error rate testing
BSC	Base station controller
BTS	Base transceiver station
CDMA	Code division multiple access
CDMA2000	Hybrid 2.5G / 3G CDMA
CPRI	Common public radio interface
CS	Circuit switched
DHCP	Dynamic host control protocol
DNS	Dynamic naming system
DPI	Deep packet inspection
DUT	Device under test
eNode B	Evolved node B
EPC	Evolved packet core
E-UTRAN	Evolved UMTS terrestrial radio access network
GERAN	GSM EDGE radio access network
GGSN	Gateway GRPS support node
GMSC	Gateway mobile switching center
GPRS	General packet radio service
GSM	Global system for mobile communications
HSDPA	High speed downlink packet access
HSPA	High-speed packet access
HSPA+	Evolved high-speed packet access
HSS	Home subscriber service
HSUPA	High speed uplink packet access
I-CSCF	Interrogating call session control function
IM-MGW	IP multimedia media gateway
IMS	IP multimedia subsystem
IPSec	IP security

IRAT	Inter-radio access technology
LTE	Long term evolution
MAP	Mobile application part
MGCF	Media gateway controller function
MGW	Media gateway
MIMO	Multiple-input, multiple-output
MME	Mobility management entity
MRFC	Multimedia resource function controller
MRFP	Multimedia resource function processor
MSC	Mobile switching center
P-CSCF	Proxy call session control function
PCRF	Policy and charging rules function
PDF	Policy decision function
PESQ	Perceptual evaluation of speech quality
PDN	Packet data network
PDN-GW	Packet data network gateway
PHY	Physical layer
QoE	Quality of experience
QoS	Quality of service
RF	Radio frequency
RLC	Radio link control
ROHC	Robust header compression
RNC	Radio network controller
RTP	Real-time transport protocol
S-CSCF	Serving call session control function
SDP	Session description protocol
SGSN	GPRS support node
SGW	Serving gateway (EPC) or signaling gateway (IMS)
SIP	Session initiation protocol
SLF	Subscriber location function
TCP	Transmission control protocol
TEM	Telecommunications equipment manufacturers
TLS	Transport layer security
UMTS	Universal mobile telecommunications system
VQA	Voice quality assessment
W-CDMA	Wideband code division multiple access
UDP	User datagram protocol
UE	User equipment

UTRAN	UMTS terrestrial radio access network
VOLGA	Voice over LTE via Generic Access
VOLTE	Voice over LTE

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