White Paper

Long-Term Evolution: Simplify the Migration to 4G Networks

What You Will Learn

With the convergence of the Internet and wireless communications, mobile data services are undergoing tremendous growth. However, the mobile wireless environment has been challenged to keep up with the growth, in part because of limitations on access speed. If mobile operators are to succeed in today's communications landscape, they must continue to focus on the quality of experience for their users.

This paper outlines how mobile operators can prepare their networks to support fourth-generation (4G) broadband services that will improve the user experience and yield new revenue opportunities. Specifically, it addresses the role of Long-Term Evolution (LTE), a Third-Generation Partnership Project (3GPP) standard that provides much greater spectral efficiency than the most advanced 3G networks. Benefits of an LTE network include:

- Simple migration from 2G or 3G to 4G without a complete equipment upgrade - in a single common core platform
- Fast, smooth transition to Evolved Packet Core (EPC), an all-IP core network that supports higher throughput, lower latency, and mobility between 3GPP and non-3GPP radio access technologies
- Core network solution that optimizes backhaul
- Converged mobility and policy management so operators can choose any access technology without a complete overhaul of existing IP core or IP core overlay
- Intelligence in the network to deliver higher-bandwidth multimedia services - interacting with and understanding key elements within the multimedia core

Overview

Designated as a fourth-generation (4G) mobile specification, LTE is designed to provide multimegabit bandwidth, more efficient use of the radio network, latency reduction, and improved mobility. This combination aims to enhance the subscriber's interaction with the network and further accelerate the demand for mobile multimedia services. With wireless broadband, users can more readily access their Internet services, such as online television, video streaming, blogging, social networking, and interactive gaming - all while mobile.

Changes in mobile communications have always been evolutionary, and the deployment of LTE will be the same. It will be a transition from 3G to 4G over a period of several years, as is the case still with the transition from 2G to 3G. As a result, mobile operators must look for strategies and solutions that will enhance their existing 3G networks while addressing their 4G deployment requirements without requiring a complete equipment upgrade.

Specifically, mobile operators need the multimedia core network to be readily upgradable to meet the requirements of the System Architecture Evolution (SAE), the 4G core network architecture of the LTE standard.

Solutions already deployed in the market may include many of the elements required of the 4G network, including integrated intelligence, simplified network architecture, high bandwidth performance capabilities with on-demand scalability, and enhanced mobility. Only solutions capable of supporting multiple functions in a single node through a software upgrade will protect today's investment for tomorrow's network and avoid a costly replacement of the existing systems.

Evolving the Packet Core

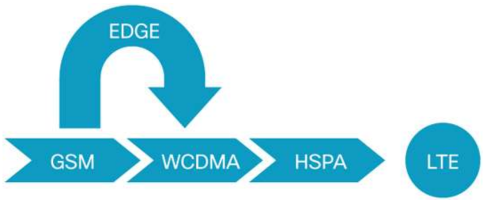
Radio access solutions are a primary consideration of the LTE deployment strategy, because LTE affects the mobile operators' most valued asset: spectrum. As an equally important part of this equation, the multimedia core network will play a central role in enhancing mobility, service control, efficient use of network resources, and a smooth migration from 2G or 3G to 4G. As a result, SAE calls for a transition to a “flat”, all-IP core network, called the Evolved Packet Core (EPC), which features a simplified architecture and open interfaces as defined by the 3GPP standards body. A key EPC goal is to enhance service provisioning while simplifying interworking with non-3GPP mobile networks. The standards promise an all-IP core network with a simplified and flattened architecture that supports higher throughput, lower latency, and mobility between 3GPP (Global System for Mobile Communications [GSM], Universal Mobile Telecommunications Service [UMTS], and LTE) and non-3GPP radio access technologies, including Code Division Multiple Access (CDMA), WiMAX, Wi-Fi, High-Rate Packet Data (HRPD), evolved HRPD (eHRPD), and European Telecommunications Standards Institute (ETSI)-defined Telecoms and Internet Converged Services and Protocols for Advanced Networks (TISPAN) networks.

As a result, mobile operators are looking for the best multimedia core solutions to deliver an optimum user experience and build an efficient network. Key considerations for the multimedia core network include:

- Integration of intelligence at the access edge: As a greater variety of services and user types cross the mobile network, it is critical to increase network and subscriber intelligence. Through this intelligence, including quality of service (QoS) and policy enforcement, mobile operators will better understand individual users and their transactions and be able to shape the service experience and optimize network efficiency.
- Simplified network topology: In order to deliver the enhanced performance of LTE effectively, the network will need to be simplified and flattened, with a reduction of elements involved in data processing and transport.
- Optimized backhaul: With the introduction of 4G, the transport backhaul is a critical consideration that many are realizing after the fact. It is very important to deploy a core network solution that is flexible enough to offer smooth migration from centralized (longer backhaul) to distributed (shorter backhaul) core network nodes.
- Converged mobility and policy: Maintaining the subscriber session is an important consideration during 4G-to-2G or 4G-to-3G mobility events. Additionally, unified policy management in the network is critical for offering efficient service delivery over mixed 4G and 2G or 3G networks and providing differentiated services and applications with flexible charging and billing options. It is therefore important to deploy a core network based on a single mobility and policy control paradigm.

- Increased performance characteristics: Clearly the intent of LTE is to improve the performance and efficiency of the network. To realize the full potential of LTE, mobile operators must deploy core solutions that can meet the flexible demands generated by increased mobile multimedia services and a growing subscriber base, including increased network capacity requirements. These core solutions also must be able to scale multidimensionally in thousands of call transactions per second, higher numbers of sessions, and significant increase in throughput over a heterogeneous access network.
- Migration from 2G or 3G to 4G: As mobile operators migrate their networks to LTE (Figure 1), they will seek to minimize costs and maximize subscriber usage. These goals will require core solutions that can address 2G and 3G network requirements while being used for 4G network introductions. Operators will want to avoid a complete equipment upgrade while deploying best-in-class solutions based on open standards. Additionally, mobile users will expect a uniform service experience across both networks, with consideration to the bandwidth differences.

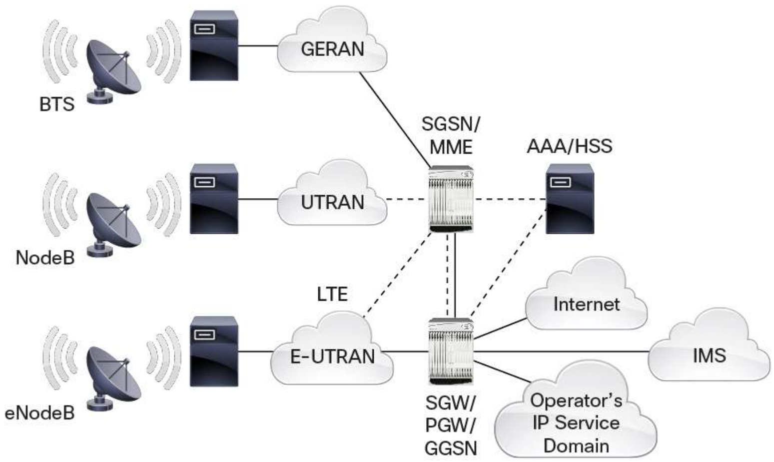
Figure 1. Migration to Wireless Broadband: LTE Is the Next Step on the Migration Path to Wireless Broadband



Although it is likely that the evolution to 4G technologies will take many years, it is imperative for mobile operators to identify the multimedia core elements now that will most effectively migrate them to a 4G network in the future.

Solutions designed for the specific requirements of the next-generation multimedia core network include the capability to support 2G, 3G, and 4G functions in a single platform (Figure 2). These solutions will provide major benefits to mobile operators who want to migrate their networks smoothly, maximize their investments, and offer their customers an exceptional experience.

Figure 2. Integrated Multimedia Core for 2G, 3G, and 4G: As Mobile Operator Evolve to LTE, They Will Benefit from Solutions That Can Integrate 2G, 3G and 4G Functions in a Single Node



Standard Interfaces and Protocols

EPC also supports standard interfaces and open protocols aimed at enabling operators to launch services and applications with Internet speed while also reducing the overall cost per packet through the inherent advantages of going all-IP.

Standardized interfaces and protocols also enable operators to achieve a best-in-class approach with their network infrastructure. By eliminating proprietary protocols, operators can operate an open network that empowers them to select the vendors they deem most qualified to deliver a specific network function without having to worry about interoperability problems.

Converged Mobility and Policy Management

In 2G and 3G networks, diverse schemes were used for mobility management within and across the access technology boundary. So, an operator choosing to deploy 2G access technology of one kind and 3G access technology of a different kind had to deploy two divergent mobility management schemes in the same network. This necessity caused serious problems, and, more importantly, impeded rapid deployment of some access technologies. EPC is an attempt to address this divergent mobility management problem.

With a single comprehensive architecture, EPC supports all access technologies, including 2G, 3G, and 4G, from all standards-defining organizations. The basis of this convergence is the use of an IETF-defined mobility management protocol such as Proxy Mobile IPv6 (PMIPv6). If an operator wants to deploy any access technology with an EPC, a single mobility management protocol such as PMIPv6 is all that is required. This reality is a significant step toward building a single common IP core for future access technologies with seamless mobility. It gives operators the freedom to choose any access technology without having to worry about a complete overhaul of their existing IP core or an IP core overlay.

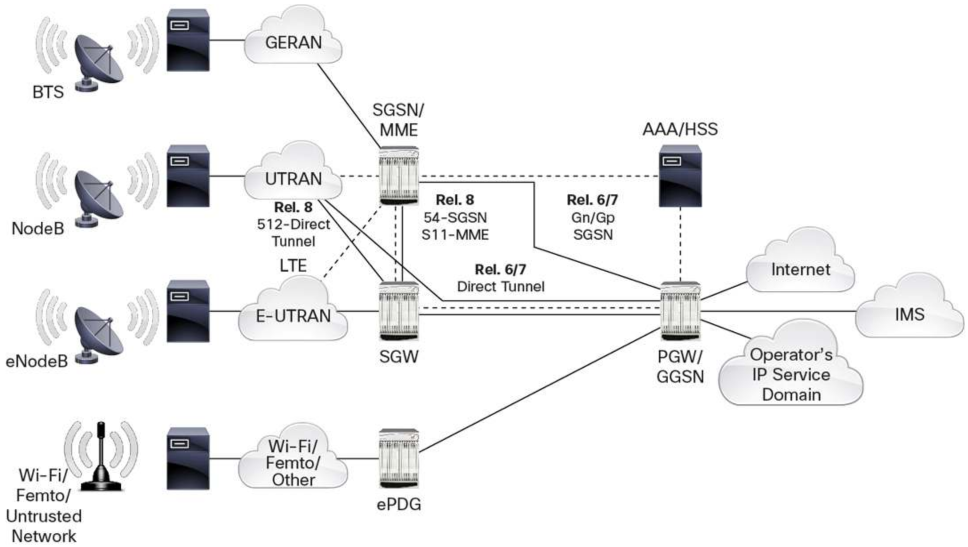
Common Core Platform

The benefits of an EPC highlight the growing importance of a common packet core across multiple access technologies. As many operators transition from disparate 3G specifications (Universal Mobile Telecommunications Service [UMTS] and Code Division Multiple Access 2000 [CDMA2000]) to LTE and EPC, there is the potential for significant network simplification and cost savings, as well as greater efficiencies within the core network.

Integrating EPC Network Functions

The EPC specifications call out the Mobility Management Entity (MME), Serving Gateway (SGW), and Packet Data Network Gateway (PGW) as specific network functions, but do not define them as separate nodes in the network. In keeping with the simpler and flatter architecture intentions, these three functions can logically be integrated into one node (Figure 3). However, a solution that is capable of this integration and can deliver the benefits of such integration is necessary.

Figure 3. Combining Network Functions Into a Single Carrier-Class Platform: Support for Multiple Network Technologies and the Corresponding Multimedia Core Network Functions in a Multiaccess, Multiservice Environment



For instance, the MME, SGW, and PGW can be combined into one carrier-class platform. By collapsing these functions, operators could reduce the signaling overhead, distribute session management, and use the control and user plane capabilities of the carrier-class node.

Alternatively, an operator could deploy the MME separate from the combined SGW and PGW, resulting in reduced signaling overhead (S5 and S8 would be internal), fewer hops on the bearer path, less backhaul, reduced signaling on the S7 interface, and a lower session requirement for the PGW. This setup also provides for a single location for policy enforcement and charging data generation.

Additionally, colocation of 2G and 3G Serving GPRS Support Nodes (SGSNs) with the MME will significantly reduce signaling and context transfer overhead. This colocation will also be critical to 2G, 3G, and 4G mobility and session management. The advantage of integrating or collapsing functional elements into one carrier-class node is paramount to the goals of simplifying and flattening the network while also reducing latency.

Convergence of 3G and 4G Core Networks

The concept of collapsing EPC functions can be taken a step further (Figure 3). The move to LTE will be an evolution, meaning many 3G, 2.5G, and even 2G networks - whether 3GPP or 3GPP2 - will remain operational for many years to come. Mobile operators can seize this opportunity to combine EPC functions with GPRS and UMTS functions (3GPP GGSN, and SGSN), easing network migration, reducing signaling overhead, enhancing resource usage by sharing common session data storage, and improving mobility between 2G or 3G and 4G access systems. Most importantly, operators have the potential to achieve this goal without a complete system upgrade by using their existing 3G deployed base. Using their existing base results in dramatic capital and operational savings and reduces risk involved in adding new, unproven access technology.

Easing the Migration

Innovative solutions currently deployed around the globe already meet many of the requirements of LTE and EPC, such as integrated intelligence, simplified network architecture, high bandwidth performance capabilities, and

EPC Network Functions

EPC defines a series of new network functions that flatten the architecture by reducing the number of nodes in the network. Decreases in capital and operational expenditures should occur, followed by a reduction in the overall cost per megabyte of traffic running over the EPC, and better network performance.

- **Mobility Management Entity (MME):** The MME resides in the control plane and manages states (attach, detach, idle, RAN mobility), authentication, paging, mobility with 3GPP 2G and 3G nodes (SGSN), roaming, and other bearer management functions.
- **Serving Gateway (SGW):** The SGW sits in the user plane where it forwards and routes packets to and from the eNodeB and Packet Data Network Gateway (PGW). The SGW also serves as the local mobility anchor for inter-eNodeB handover and roaming between two 3GPP systems.
- **Packet Data Network Gateway (PGW):** The PGW (sometimes called the PDN Gateway) acts as the interface between the LTE network and Packet Data Networks (PDNs), such as the Internet or SIP-based IMS networks (fixed and mobile). The PGW is the mobility anchor point for intra-3GPP access system mobility and for mobility between 3GPP and non-3GPP access systems. The function is responsible for IP address allocation, charging, deep packet inspection, lawful intercept, policy enforcement, and other services.
- **Evolved Packet Data Gateway (ePDG):** The ePDG is the primary element responsible for interworking between the EPC and untrusted non-3GPP networks, such as a wireless LAN. The ePDG uses Proxy Mobile IPv6 (PMIPv6) to interact with the PGW when the User Equipment (UE) is in an untrusted non-3GPP system. The ePDG is involved in the Policy and Charging Enforcement Function (PCEF), meaning it manages QoS, flow-based charging data generation, gating, deep packet inspection, and other functions.

enhanced mobility. Some solutions are capable of supporting 2G and 3G today on a single platform, and through software upgrades can support 4G functions when LTE networks are deployed.

Mobile operators will benefit from solutions that can provide 2G and 3G functions now and evolve to 4G functions later without replacing costly systems and equipment that will still be needed to support legacy networks while subscribers transition to the new network.

Whether existing systems are deployed as SGSN, Gateway GPRS Support Node (GGSN), Packet Data Serving Node (PDSN), Cisco® Mobile Wireless Home Agent, or other gateway functions, they must be designed to be integrated with or upgraded to the 4G functional elements - MME, SGW, PGW, and Cisco Evolved Packet Data Gateway (ePDG) - through a simple software upgrade.

Intelligence in the Network

Key to creating and delivering high-bandwidth multimedia services in 2G, 3G, and 4G networks - and meeting subscriber demand - is the capability to recognize different traffic flows, thereby allowing functional elements to shape and manage bandwidth while interacting with applications to a very fine degree and delivering the quality of service required. This goal is achieved through session intelligence that uses deep packet inspection technology, service steering, and intelligent traffic control to dynamically monitor and control sessions on a per-subscriber and per-flow basis.

The interaction with and understanding of key elements within the multimedia call - devices, applications, transport mechanisms, and policies - requires:

- Sharing information with external application servers that perform value-added processing
- Exploiting user-specific attributes to launch unique applications on a per-subscriber basis
- Extending mobility management information to non–mobility-aware applications
- Enabling policy, charging, and QoS features

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