White Paper

Evolving to LTE: Cisco's Seamless Migration for UMTS Operators

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 is failing to fully meet user expectations, due to limitations on access speed. If mobile operators are to succeed in today's communications landscape, they must address the quality of experience for their users.

This document 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, we will discuss how Cisco can assist Universal Mobile Telecommunications System (UMTS) operators in their move toward Long Term Evolution (LTE), a 3rd Generation Partnership Project (3GPP) standard that represents a significant advance in mobile technology.

With industry-leading mobile infrastructure solutions from Cisco, operators can:

- Gradually transition from second- and third-generation (2G/3G) UMTS to 4G without a comprehensive network upgrade
- Support 2G/3G UMTS and 4G functionality on a single platform
- Meet LTE requirements for increased data rate capacity, reduced latency, and improved spectral efficiency
- Provide transparent roaming between High Speed Packet Access (HSPA) networks and LTE networks
- Take a phased approach to migrating the UMTS/HSPA network to LTE by upgrading the core network to Evolved Packet Core (EPC) elements without an overlay Radio Access Network (RAN)

Overview

Designated as a 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 user's interaction with the network and further increase 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 on the go.

Changes in mobile communications have always been evolutionary, and the deployment of LTE will be the same. It will be a transition from 3G UMTS 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 UMTS networks, while addressing their 4G deployment requirements without involving a "forklift" upgrade.

Cisco® solutions meet the specific needs of the mobile operator's packet core network. Our solutions deliver superior performance in the existing network, while being readily upgradeable to meet the requirements of LTE. Our offerings already 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. Furthermore, Cisco solutions are capable of supporting multiple functions in a single node, allowing a single platform to concurrently act as a 2G/3G and 4G node. All of this functionality is available through a software upgrade, protecting today's investment and eliminating the need for a complete equipment upgrade.

Evolving the Packet Core

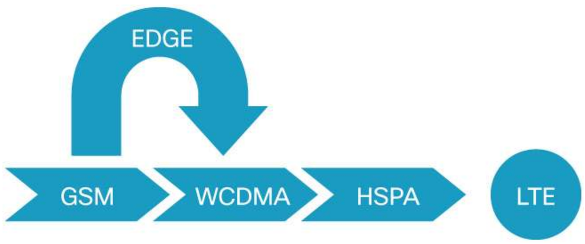
Radio access solutions are a primary consideration of the LTE deployment strategy, as LTE impacts the mobile operators' most valued asset: spectrum. As an equally important part of this equation, the multimedia core network will play a central role in enhancing mobility, service control, efficient use of network resources, and a smooth migration from 2G/3G UMTS to 4G. As a result, LTE calls for a transition to a "flat," all-IP core network with a simplified architecture and open interfaces. This requirement is defined by the System Architecture Evolution or SAE, also known as Evolved Packet Core, which is the 3GPP specification for changes to the core network architecture. A key SAE goal is to enhance service provisioning while simplifying interworking with non-3GPP mobile 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:** To effectively deliver the enhanced performance of LTE, 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 key 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/3G mobility events. Additionally, unified policy management in the network is critical for efficient service delivery over mixed 4G and 2G/3G networks and for 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 increasing network capacity requirements, and being able to scale multidimensionally in thousands of call transactions per second, higher number of sessions, and significant throughput over a heterogeneous access networks.

- **2G/3G UMTS to 4G migration:** As mobile operators migrate their networks to LTE (Figure 1), they will seek to minimize costs and maximize subscriber usage. This will require core solutions that can address 2G/3G network requirements, while at the same time be used for 4G network introductions. Operators will want to avoid a comprehensive 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 of the bandwidth differences.

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



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

Cisco is exceptionally well positioned to address these challenges and assist in the migration to LTE. Our solutions are designed for the specific requirements of the next-generation multimedia core network. As a result, these solutions already address the key considerations listed previously, including the ability to support both 2G/3G and 4G functionality in a single platform. A single node can appear as a 2G/3G node to the 2G/3G radio network and a 4G node to the 4G radio network. This capability provides major benefits to mobile operators that want to smoothly migrate their networks, maximize their investments, and offer an exceptional experience to their customers.

Long Term Evolution Requirements

With specifications nearing completion, the 3GPP is finalizing 4G access and core specifications with the primary goals of increasing bandwidth, improving spectral efficiency, reducing latency, and enabling improved mobility.

The LTE specifications call for peak data rates of 150 Mbps downlink with 2x2 multiple-input multiple-output (MIMO) and 75 Mbps uplink with 1x2 MIMO over 20-MHz channels in frequency-division duplexing (FDD) mode. This increased capacity is set to arrive as existing 3G networks begin to strain under the dramatic increases in the use of bandwidth-intensive applications, long-duration services, and signaling overhead.

Latency is another issue addressed by the LTE standards. Transition times in the control plane are designed to be between 50 and 100 milliseconds (ms), depending upon the state of the session (dormant to active). The user plane will also have reduced latency with less than 5 ms in unload condition from a small IP packet.

Spectrum efficiency will also be improved and the radio architecture simplified. This will be achieved through a single element called the Evolved Node-B (eNodeB) that is packet-based, reduces “single points of failure,” supports end-to-end QoS, and has an optimized bearer plane with a reduced number of hops.

Mobility is also an extremely important factor. As specified, the radio network will be optimized for higher performance and seamless handoff between multiple access technologies.

Aside from the improvements made on the access portion of the network, the most dramatic and important changes will be in the packet core.

System Architecture Evolution

SAE/EPC specifies the network architecture in 3GPP 4G core networks. SAE/EPC promises an all-IP core network with a simplified and flattened architecture that supports higher throughput, lower latency, and mobility between 3GPP (GSM, 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 ETSI-defined Telecommunications and Internet converged Services and Protocols for Advanced Networks (TISPAN) networks.

Standard Interfaces and Protocols

SAE/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 all-IP networks.

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 issues.

Converged Mobility and Policy Management

In 2G/3G networks, diverse schemes were used for mobility management within the access technology boundary and across the access technology boundary. So an operator choosing to deploy a 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 caused serious issues, and more importantly, impeded rapid deployment of some access technologies. 3GPP SAE/EPC is an attempt to address this issue.

With a single comprehensive architecture, SAE/EPC supports all access technologies: 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 a 3GPP SAE/EPC core, a single mobility management protocol such as PMIPv6 is all the operator needs. This is a significant step toward building a single common IP core for future access technologies with superior mobility. Operators have 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.

Evolution of the Packet Core

The benefits of SAE/EPC highlight the growing importance of a common packet core across multiple access technologies. As many operators transition from disparate 3G specifications (UMTS and CDMA2000) to LTE/SAE, there is the potential for significant network simplification and cost savings, as well as greater efficiencies within the core network.

Integrating SAE Core Network Functions

The SAE specifications call out the Mobility Management Entity (MME), Serving Gateway (SGW), and Packet Data Network (PDN) 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 (Figure 3), these three functions can logically be integrated into one node. However, this will require a solution that is capable of this integration and can deliver the benefits of such integration. Figure 2 shows a Cisco Solution Mobile Network Deployment

Example, where the direct tunnel approach is used as an option to gain core network efficiency for user plane traffic.

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 take advantage of 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/Gx interface, and lower session requirement for the PGW. This also provides for a single location for policy enforcement and charging data generation. Additionally, colocation of 2G/3G Serving GPRS Support Nodes (SGSNs) with the MME will reduce signaling and context transfer overhead significantly. This colocation will also be key to 2G/3G and 4G mobility and session management.

The integration of both 2G/3G and 4G core network functions (Figure 3) is an ideal solution for operator's seeking to achieve capital and operational efficiencies along their upgrade path. For example, a single node acting as a colocated SGSN+MME and a node acting as a colocated GGSN+SGW+PGW can serve both the 2G/3G network and 4G network. At the same time, Cisco's solution offers the flexibility to decouple functions when the network traffic and density grows. With substantial 2G/3G core investments already in place, operator's can ease their 4G evolution by gradually converting existing 2G/3G systems into combined 2G/3G/4G systems, and ultimately 4G only. This integrated solution will also simplify 2G/3G to 4G roaming capabilities. Optionally, operator's can deploy combined 2G/3G/4G systems for all new growth as the capacity on 2G/3G networks is reached.

Figure 2. Cisco Solution Mobile Network Deployment Example

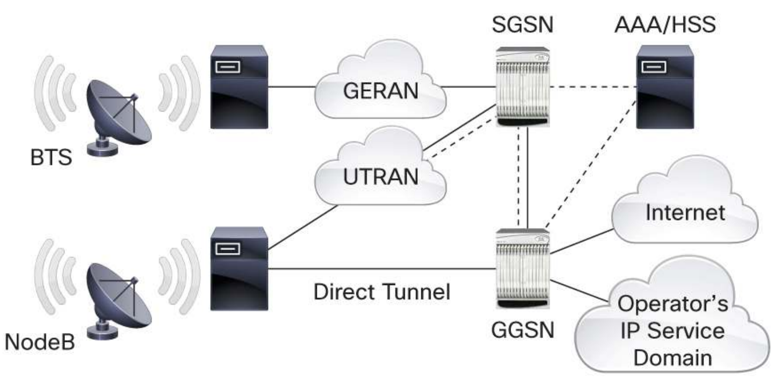
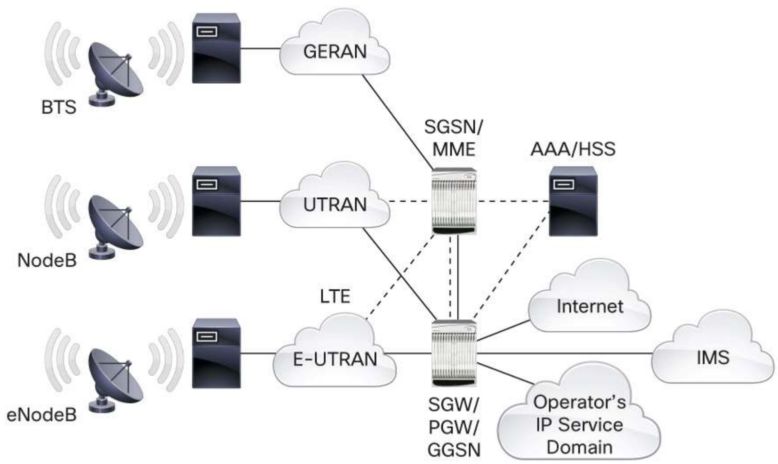


Figure 3. Integrating 2G/3G and 4G Functions in a Single Node

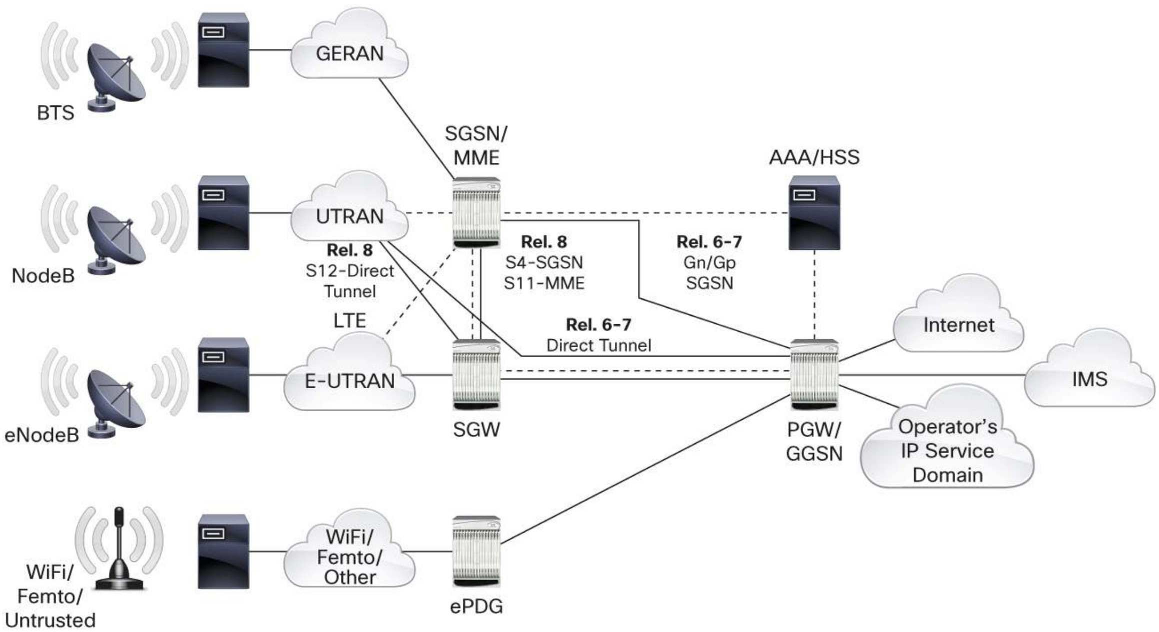


The advantage of integrating or collapsing functional elements into one carrier-class node is paramount to the goals of simplifying and flattening the network while also reducing latency.

Convergence of 3G and 4G Core Networks

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

Figure 4. Combining Multiple Core Network Functions for Greater Efficiency



The Cisco Difference

Cisco brings a history of innovative solutions that already meet many of the requirements of LTE and SAE, such as integrated intelligence, simplified network architecture, high bandwidth performance capabilities, and enhanced mobility.

Additionally, mobile operators will benefit from solutions that can provide 2G/3G functionality now and evolve to 4G functionality later. Cisco's solutions are capable of supporting 2G/3G today, and through software upgrades these solutions are designed to support 4G functionality when LTE networks are deployed. Furthermore, they are capable of supporting multiple functions in a single node. This allows a single platform to concurrently act as a 2G/3G and 4G node, providing a true evolution path.

With an adaptable solution, Cisco does not require operators to perform complete equipment upgrades when evolving to 4G. Cisco's existing systems - whether deployed as SGSN, GGSN, or PDG - are designed to be integrated with or upgraded to the 4G functional elements - MME, SGW, PGW, and 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. This allows functional elements to shape and manage bandwidth, while interacting with applications to a very fine degree and delivering the QoS required. Cisco's solution does this through its session intelligence that uses deep packet inspection technology, service steering, and intelligent traffic control to dynamically monitor and control sessions on a per-subscriber/per-flow basis.

Our solution's interaction with and understanding of key elements within the multimedia call - devices, applications, transport mechanisms, and policies - assists in the service-creation process by:

- Providing intelligent QoS control based on service type, user profile, and business policy
- Extending visibility of the access technology type in the SAE nodes; the PGW can automatically adapt QoS for ongoing sessions, for example when the user equipment performs a handover between LTE and UMTS
- Providing a greater degree of information granularity and flexibility for billing, network planning, and usage trend analysis
- 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

Architecture Philosophy

The LTE/SAE architecture calls for the separation of the signaling/control and bearer planes into different functional elements (as previously outlined). Cisco brings a high level of expertise in call control and packet forwarding within a multimedia core network. With the elastic architecture designed into the Evolved Packet Core coupled with the purpose-built hardware and software, the platform is able to scale multidimensionally in transaction, sessions, and throughput over a heterogeneous access network. Figure 5 specifies one of the key aspects of our architectural design philosophy, auto-sizing, showing the elastic nature of the packet core network.

Our multimedia core platforms use a distributed architecture that combines high-performance processing, significant memory, and a powerful switch fabric to more intelligently and reliably handle mobile sessions. The architecture can be deployed in various network topolgies. This reduces traffic-flow inefficiencies, diminishes latency, and accelerates call setup time and handoffs.

Figure 5. Elastic Architecture: Auto-sizing with Normal Traffic

Figure 6 shows these software functions, including SGW/PGW or GGSN at the user plane; MME or SGSN at the signaling/control plane; and DPI, IPsec, NAT/FW, PCRF, etc., at the services plane. The functions constantly grow and shrink to effectively respond to different types of demands, and they have the ability to allocate compute, memory, and storage resources from a common pool when needed. Depending on time of day, location, policy, and analytics, the functions also release the resources back to the common pool when not needed to address the unpredictable demand of 4G LTE traffic

How can the Cisco elastic packet core network do this? The capacity is based on the interplay of the Cisco StarOS and purpose-built hardware with the following core tenets:

- Scalability
- Flexibility
- Adaptability
- Intelligence

The benefits are lower TCO, significant OpEx and CapEx savings through optimization, and facilitating the generation of new revenues through monetization. ACG Research analyzed the total cost of ownership of meeting operators' evolving requirements in the mobile multimedia packet core for the Cisco ASR 5500 Series and a leading competitor's solution. The analysis found that the ASR 5500 has 47 percent lower five-year cumulative TCO than the competitor's solution; CapEx is 51 percent lower, and OpEx is 32 percent lower. The primary source of the cost advantage of the ASR 5500 is that it delivers the required throughput and functionality using 65 percent fewer chassis.

Figure 6. Elastic Architecture: Auto-sizing on Signaling, Bearer, and Services Traffic

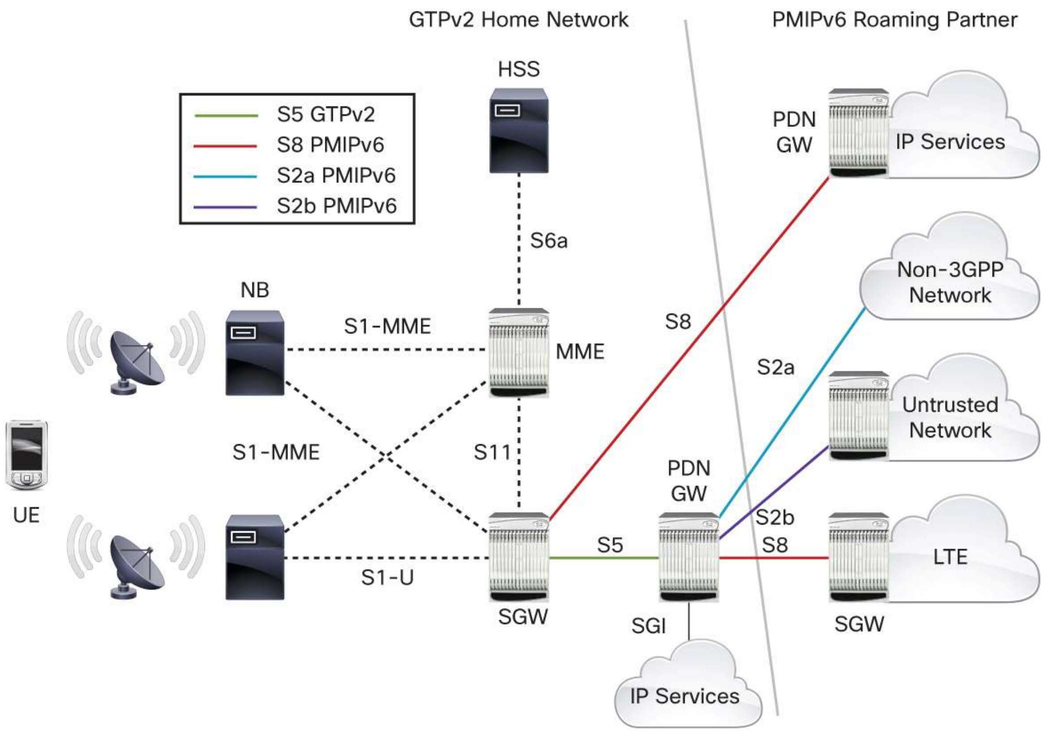
Standards Initiatives

As a market leader in multimedia core networking, Cisco has taken an active role in developing 3GPP, 3GPP2, WiMAX, IETF, and NGMN standards to help ensure the SAE standard contains the requirements that allow operators to select the best-in-class solutions to deliver a true, carrier-class wireless broadband network. As an example, Cisco is the key contributor, co-author, and strong advocate of the core mobility management protocol in

SAE PMIPv6. Cisco is also harnessing its extensive expertise in multitechnology interoperability in taking a leading role in formulating interworking requirements among access technologies, including eHRPD, WiMAX, and LTE.

Cisco made significant contributions to 3GPP SAE for defining procedures for handovers between access technologies using multiple types of mobility management schemes and combinations of access technologies (Figure 7). Cisco is also the primary contributor to the NGMN Alliance's converged mobility initiative in Project 5. Cisco continues to lead development of IETF standards that are essential to fulfill the promise of 3GPP SAE in the areas of mobility management; optimized handover; fast handover; transition scenario handling; and authentication, authorization, and accounting (AAA).

Figure 7. Roaming Support Between GTP S5/S8-Based Network and PMIP6-Based Roaming Partner



For More Information

For more information about how Cisco can help you migrate to an LTE mobile network, please visit http://www.cisco.com/go/mobileinternet.

For more information about network evolution, see:

- 3GPP Americas white paper: "UMTS Evolution from 3GPP Release 7 to Release 8 HSPA and SAE/LTE," December 2007
- Qualcomm white paper: "Evolved Packet System (EPS): An Overview of 3GPP's Network Evolution," December 2007

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