White Paper

Top 10 Considerations for a Successful 4G LTE Evolved Packet Core Deployment

As 1800 MHz has emerged as the main band for Long-Term Evolution (LTE) network deployments (LTE1800), LTE is going strong, with almost 100 million net additions in the past year, according to the GSA September 5, 2013 LTE Market Summary report. At the time of the report, 213 commercial networks had been deployed in 81 countries; GSA forecasts 260 commercial LTE networks in 93 countries by the end of 2013. One of the key network elements in this growth is an evolved packet core (EPC) that is elastic and scalable, with built-in inline services and intra-chassis virtualization. The EPC provides the network intelligence for communications services providers to offer rich-media services and applications. When integrated with context-aware analytics and policy, it is foundational to provide innovative, revenue-generating services and new business models.

LTE is an IP-based wireless technology that is driving a major network transformation as the traditional circuit-based applications and services migrate to an all-IP network. Mobile broadband networks are being designed to support new value-added services and applications that are either enabled or optimized by the communication services provider. With the massive growth in traffic from smartphones and other mobile devices, the multimedia packet core network has become critical to providing a superior user experience and monetizing these new services and applications.

This paper explores the following 10 priorities as key considerations in migrating the network to LTE for communication services providers seeking a competitive advantage, especially those that are planning an LTE deployment in an ecosystem comprising 2G, 3G, and future 4G wireless technologies. Communication services providers planning an LTE deployment will need to offer multitechnology devices with networks that allow mobility and service continuity between Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), Universal Mobile Telecommunications System (UMTS), and LTE.

- An open evolved packet core (EPC)
- Deployment flexibility and network optimization
- Control plane intelligence, scalability, and signaling
- Session-state and subscriber management
- Policy and charging control with integrated intelligence
- Voice-grade reliability
- Security
- Reporting, monitoring, accounting, and charging
- Roaming
- Multimedia services

Background

The 3rd Generation Partnership Project (3GPP) Release 8 standard specifies the 4G Evolved Packet System (EPS), which includes the Evolved Universal Terrestrial Radio Access Network (E-UTRAN, also known as the LTE RAN) and the EPC. The EPS is designed to provide high data rates and low latency using a flat, all-IP network architecture. It is standardized to provide all services, including mobile broadband data, high-quality voice, and multimedia services. While 3G networks are fundamentally all IP from the packet-switched domain perspective, the 4G networks have begun the transition of circuit traffic to an all-IP network.

The EPC is the next-generation multimedia core network for 4G access and is required to deploy LTE radio technology. It also provides optimized access for 2G, 3G, non-3GPP, and potentially even fixed access networks. Due to the sizable investment required to roll out LTE radio access, the wireless industry tends to lower the priority of the packet core, leaving the EPC exposed to mediocrity, last-minute shortcuts, and a lack of standards-based **interoperability testing** (IOTs), among other issues. However, the business factors influencing emerging LTE radio access affect the EPC just as much, including fast and efficient introduction of new multimedia services and applications, lower overall cost through intelligence and optimization, and session/subscriber management.

In addition, while the EPC involves the smallest percentage of overall spending by communication services providers for wireless infrastructure, it provides the greatest potential impact on overall network profitability through the generation of new services and cost savings. These are achieved through the creation of an intelligent EPC network, as opposed to providing a “bit pipe” transport utility network. Incremental investment in an intelligent 4G EPC allows communication services providers to monetize the network by creating new services and lowering the overall cost of the core and backhaul network.

As you plan your LTE/EPC networks, there are many unique challenges and considerations to analyze when deciding your architecture, deployment strategy, and vendors.

Since not all EPC networks are the same, and your goals with LTE/EPC are unique, addressing potential challenges will help you work through the many aspects of evolving to and deploying an LTE/EPC network.

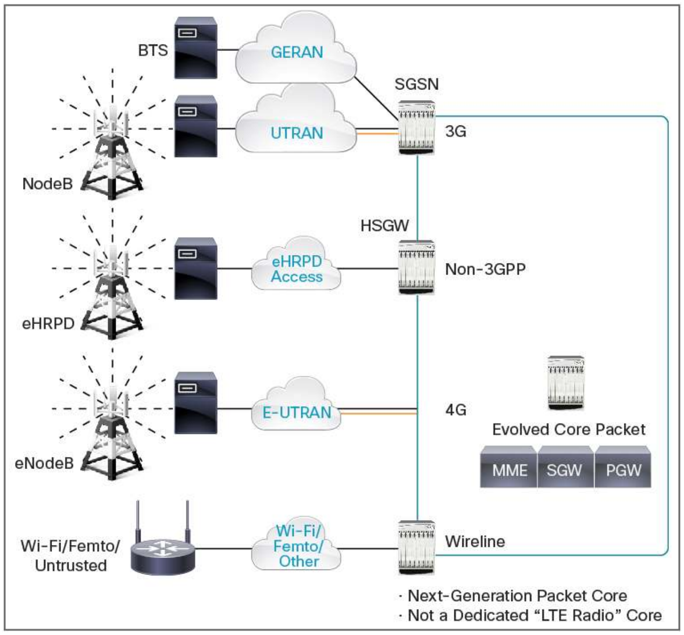
An Open Evolved Packet Core

The industry tends to couple the LTE radio (the E-UTRAN) and the EPC, and communication services providers tend to buy the EPC from macro radio vendors. However, the EPC is being standardized as the core network for all access mechanisms, including LTE, 2G, 3G, non-3GPP, and even wireline networks.

The “open” EPC allows the communication services providers to realize a truly converged packet core supporting all access technologies (Figure 1). Planning for the EPC must consider how all of these access networks enter the core, interwork with legacy systems, maintain seamless mobility, and provide consistent and optimized services.

For example, it is possible to migrate the 2G/3G core network to the EPC after the EPC is deployed to support LTE radios. It is also possible to migrate the 2G/3G core network to the EPC before or at the same time that the LTE radios are deployed, using a Serving GPRS Support Node (SGSN) S4 or HRPD Serving Gateway (HSGW) for evolved High Rate Packet Data (eHRPD) networks. You cannot wait for the deployment of LTE radios to evolve the packet core. The preparation and planning for the EPC network must be done together with the 3G network.

Figure 1. The Open Evolved Packet Core



Deployment Flexibility and Network Optimization

One of the key deployment considerations is the location of each of the EPC functions, both initially and over time. Each communication services provider has unique requirements; therefore, no single deployment model will suit all operators. A 3G UMTS communication services provider will differ significantly from a Code Division Multiple Access (CDMA) communication services providers, small communication services providers will differ from large ones, wireline from wireless, and there will be a clear dependency on the equipment that has already been deployed.

Key considerations include:

- Do I start with an overlay?
- Do I use a distributed or centralized architecture?
- What do I do with existing nodes when subscribers migrate off of 3G?
- Is my EPC platform ready to support 2G/3G from day one?
- Does my 2G/3G platform evolve to 4G/LTE?
- Can I minimize the cost of the bearer and/or signaling?
- Do I deploy an all-in-one solution?
- With my requirements and strategy, how do I differentiate my network and services and quickly reach the market?

Integration of Functions

A key optimization and deployment consideration is integration (or co-location) of multiple core functions on a single platform. Options to consider are the integration of discrete 4G functions as well as the integration of 2G/3G, 4G, and/or non-3GPP core network functions to achieve capital and operational efficiencies along the upgrade path. For example, a single node acting as a co-located SGSN plus Mobility Management Entity (MME), and a node acting as a colocated Gateway GPRS Support Node (GGSN) plus Serving Gateway (SGW) plus Packet Data Network Gateway (PGW) can serve both the 2G/3G network and the 4G network.

The integration of functions simplifies the network topology, makes it easier to manage, and provides service uniformity. The reduction in “box” count could also lower capital expenditures (CapEx) and operational expenses (OpEx) and also eliminate external servers, load balancers, interfaces, and related management equipment.

The following are some of the more common integration options:

- **MME and SGSN**: When EPC is deployed for 4G and requires mobility with an existing 2G/3G network, the EPC MME will interact with the SGSNs to perform mobility management. The signaling load between the MME and SGSN can be significant as the network grows. As separate nodes, both generate signaling traffic toward external nodes such as the Home Subscriber Server (HSS) and Mobile Switching Center (MSC). In an integrated SGSN/MME, signaling functions can be internalized, eliminating heavy signaling traffic between the two functions and external nodes. Additionally, performance and capacity utilization are substantially improved, reducing costs by up to 30 percent over separate elements.
- **MME, SGSN, and SGW**: Additional performance and cost improvements are possible if the SGW is combined with the MME and SGSN. This could improve transaction performance by up to 80 percent over separate elements.
- **SGW and PGW**: The flexibility to split PGW functionality and colocate SGW and PGW functionality allows traffic to be offloaded from the network closer to the customer, eliminating backhaul costs for a large portion of traffic. In addition, this integration could lower CapEx and OpEx, as it takes fewer physical nodes to deploy and maintain, and the software and hardware utilization of the physical node will be better in many cases, compared to separate nodes. Typical cost savings with this option range between 25 and 35 percent for a distributed deployment model, primarily from core network backhaul savings. In the separate model, there is always some redundancy and leftover capacity in each node, not to mention the duplication of common functions.

Call Localization, Internet Offload, and Local Breakout

Deployment flexibility must extend beyond specific functions in specific locations. Flexibility is also needed for individual applications, subscribers, services, and call flows. Local breakout of media is important in the management of bearer traffic. For example, it may make economic sense in some networks to offload Internet traffic locally at the wireless edge. This reduces the backhaul overload and cost between the edge and the core for traffic that is not adding a significant contribution to revenue.

Other traffic that does add to profitability - for example, “walled garden” services such as video on demand (VoD) or gaming - can be sent to a centralized location that supports and enables the higher-revenue-generating services.

Similarly, since the majority of voice traffic remains local to a regional aggregation point, voice can be localized by “hair-pinning” within the same regional aggregation point where the SGW and the distributed PGWs are deployed.

To enable these types of services requires the flexibility to support the PGW functionality in two different physical locations - distributed and centralized - for different applications potentially from the same subscriber, based on the destination.

Optimized Core Network Backhaul

The sheer volume of the aggregated throughput to backhaul all user data from a local or regional aggregation cluster with SGWs to centralized data centers with PGWs will be expensive in many scenarios. Support for call localization, Internet offload, and local breakout can significantly reduce the core network backhaul.

Deployment Architectures

One of the key considerations in EPC is the deployment architecture (Table 1). The majority of 3G core deployments use a centralized architecture in which a centralized GGSN serves multiple SGSNs at distributed locations. The EPC, with many of the considerations already described, opens the door to revisit deployment architectures, including:

- **Centralized bearer/distributed control**: The traditional 3G architecture expanded to 4G, where the PGW is located at a centralized location and the MME and SGW are distributed.
- **Centralized control/distributed bearer**: A scenario in which the PGW and SGW are distributed and the MME is located at a centralized location.
- **Completely centralized**: An architecture in which all of the EPC functions are centralized.
- **Completely distributed**: An architecture in which all of the EPC functions are distributed and generally deployed together.

Table 1. Potential Deployment Architectures

Deployment Architectures	Centralized Functions	Distributed Functions
Completely centralized	SGSN + GGSN MME + SGW + PGW	
Completely distributed		MME + SGSN + GGSN SGW + PGW
Centralized bearer/distributed control (traditional 3G)	SGW + PGW + GGSN	MME + SGSN
Centralized control/distributed bearer	MME	PGW + SGW

One of the main considerations is the variation over time of the deployment architecture. The first steps toward evolving the existing 2G/3G mobile packet core will be to provide initial EPC functional capabilities. Scaling and densification of the EPC will be required at a later stage (generally three to four years after initial deployment), as the rollout of LTE coverage progresses and subscriber numbers increase. Depending on the operator requirements, the architecture may vary between initial deployment and densification.

Some additional considerations for choosing the optimal architecture for your network include:

- Does one architecture fit your entire infrastructure or all of your properties?
- Does the platform support multiple deployment options?
- Can existing platforms be redeployed and reconfigured as different functions during the evolution of the network from initial rollout to densification?
- Is colocation of functions supported, including 3G and 4G functions?

Considerations in the Evolution to LTE

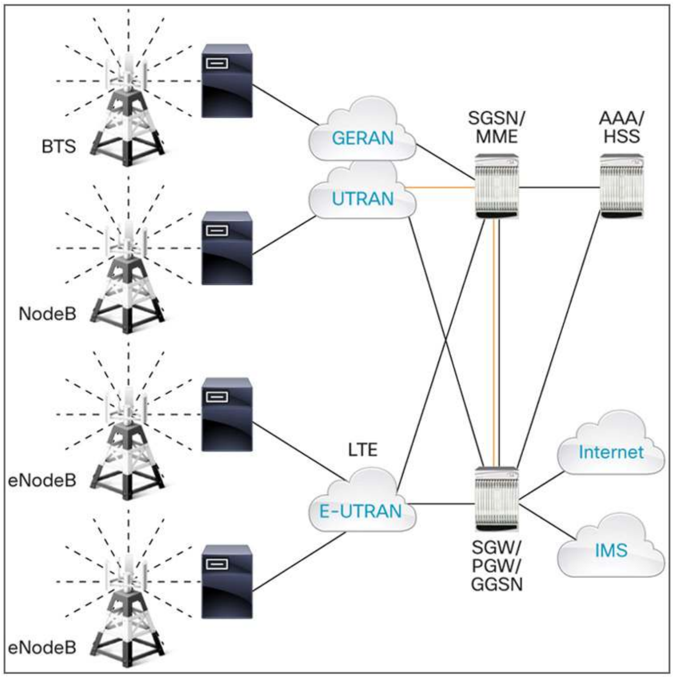
Communication services provider migration strategies in the evolution to LTE/EPC can be classified into three main categories:

1. Data-only services on LTE
2. Data-only services on LTE with 2G/3G voice
3. Voice and data services on LTE

To mitigate the risks of their LTE deployments, communication services providers may incorporate one or more of these strategies at different times. Therefore, the three migration strategies are not diametric to one another, but rather build upon their predecessor(s).

For example, a critical decision is whether the EPC is initially an overlay network just for LTE access or whether it integrates LTE plus 3G networks. The integrated approach is possible from day one, if desired (Figure 2). An example of the integrated approach would be the deployment of MME and/or SGW capabilities in regionally distributed nodes co-located with the existing SGSN. The PGW capabilities could be in a more centralized location with the GGSN, or an integrated SGW and PGW could be provided in a distributed node. **Note:** Other integration options exist that depend on the chosen architecture. These strategies will need an IP Multimedia Subsystem (IMS) to provide voice over IP (VoIP) on LTE.

Figure 2. Integration of 2G/3G and 4G Functions in a Single Node, Providing Separate Access Through a Common Core



Evolution considerations for an integrated approach include:

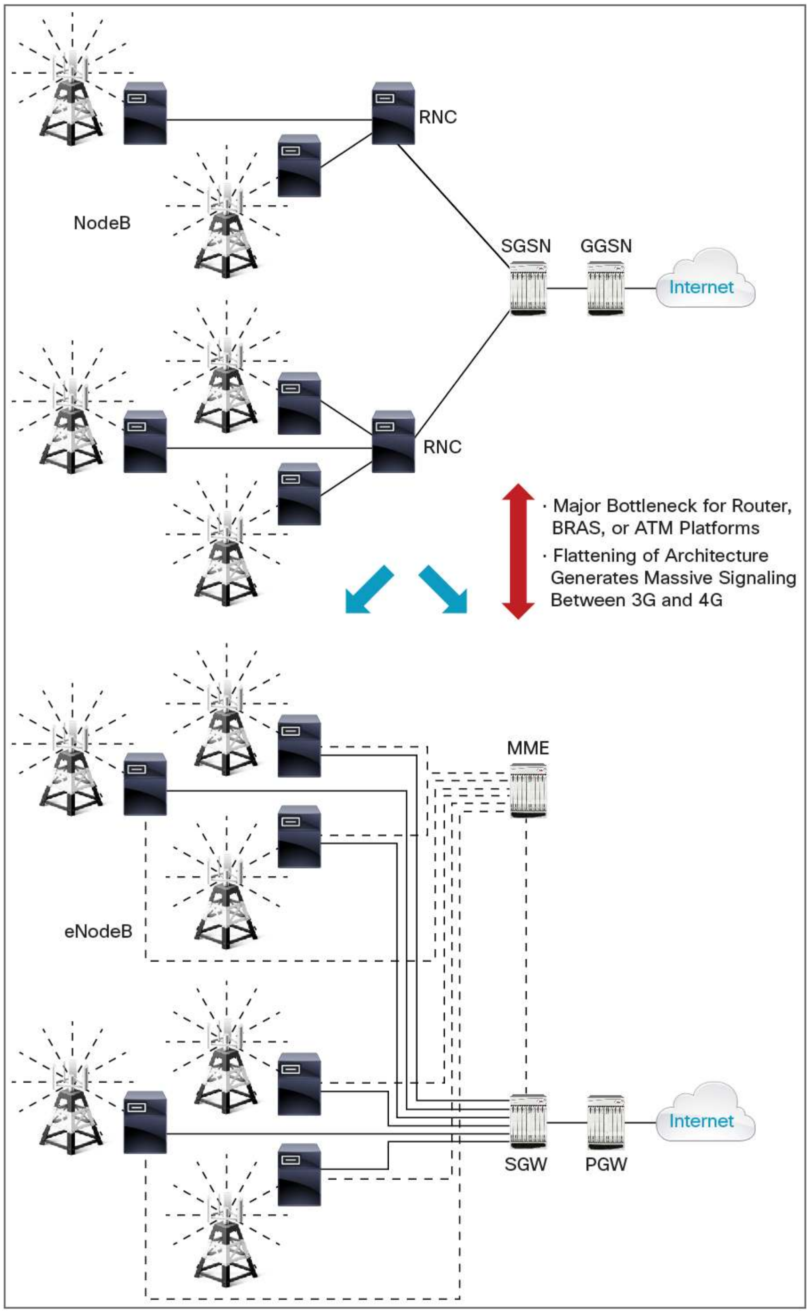
- Does your existing 3G network support a software upgrade to 4G functions?
- Have you analyzed the optimization you can achieve by integrating functions when migrating from 3G to 4G and growing 4G networks?
- Did you know that colocation of SGSN/MME minimizes intertechnology mobility signaling by 30 percent?
- Does the platform chosen for 3G scale to support the capacity required for 4G?

Another potential near-term deployment model is a complete EPC overlay with separate functional elements handling LTE connections. This approach may mitigate some risk and allow slow migration to EPC.

Considerations for these deployments include:

- How will handover support be provided between 2G/3G and 4G?
- Will end customers be happy if their common applications - FTP, email, HTTP, and YouTube - do not have seamless service mobility?
- Are the existing platforms ready for the performance challenges of separate elements?
- If an overlay is chosen, does the solution support eventual migration of 2G/3G and non-3GPP access to the EPC?

Figure 3. 3G RAN RNC Capabilities Are Distributed Among eNodeB, MME, and SGW in LTE



Control Plane Intelligence, Scalability, and Signaling

With the flattening of the radio network, LTE brings multiple challenges to signaling. The MME and SGW are bound to have a massive load of transactions per second. The elimination of a node equivalent to the RFSS Network Controller (RNC) in the LTE radio network hierarchy increases the signaling requirements, as the eNodeBs are connected directly to the MME (Figure 3). This means the MME will be handling significantly greater signaling loads than a typical SGSN, including paging requests to all eNodeBs and exposure to all inter-eNodeB mobility events, in addition to network-attached storage (NAS) signaling ciphering and integrity protection.

Finally, the MME and SGW have to handle an extremely large number of idle/active transitions. Since radio resources are expensive, the eNodeBs attempt to transition calls to idle as quickly as possible. This is not a major issue in current 3G networks, because many 3G applications are not typically "always on." This will also affect the SGSNs that are providing mobility with 4G elements.

Potential ways to address the signaling challenge include improving the signaling performance of platforms and adding flexibility in both the SGSN and MME. The SGSN will experience a massive increase in signaling that may require platforms that support large signaling capacity.

In addition to scalability, a great deal of optimization can be achieved by collapsing the signaling plane entities - the MME and SGSN - into a single platform, which:

- Reduces the session-maintenance burden by making the session context a shared resource between SGSN and MME, reducing the number of transactions by up to 30 percent. If the SGW is integrated as well, the reduction increases to as high as 80 percent.
- Reduces signaling latency between SGSN and MME by internalizing communication.
- Reduces the HSS and MSC server signaling hit by showing a single interface to these entities.

Finally, considerations when looking specifically at the MME include:

- Is it a highly scalable architecture and carrier-class platform?
- Does it support 1: N platform redundancy?
- Is it a high-capacity platform across sessions, bearers, eNodeBs, and SGWs?
- Does it support high transaction rates - attaches, activations, tracking area updates (TAUs), handoffs, and paging?
- Does it support congestion management, load sharing, and MME pooling?
- Is there support for legacy interfaces to HSS and other legacy elements?
- Does it support intelligent signaling heuristics, such as paging optimizations to minimize latency?
- Does it support heuristics to select the optimal PGW for call localization and local breakout?
- Can it determine whether the SGW or the PGW is overloaded, causing a new call failure? An intelligent MME can determine which element failed and can redeploy resources to connect the call.
- Does it support congestion-based load balancing in the MME to optimize traffic into the SGW?
- Does the MME solution use self-organizing network (SON) capabilities, both for the radio and the core network?
- Does the MME provide the intelligence to dynamically optimize the topology of the operator's network based on usage patterns to reduce latency and backhaul costs?

Session-State and Subscriber Management

While mobile networks use IP for transport, a mobile-enabled multimedia EPC is about subscriber and session management (Table 2). When planning and selecting the EPC infrastructure, are you considering all the implications of building a session-state-aware, subscriber-aware, service-aware, access-technology-aware, and location-aware network? The requirements for these networks are very different from those of existing IP transport-based networks using traditional IP routers that are not designed and optimized for subscriber and session management.

With a subscriber session management system, unique applications can be launched on a per-subscriber or per-session basis if the platform supports attributes such as:

- Location-aware policy decisions
- Time-of-day policy enforcement, based on a subscriber's time zone, for example
- Dedicated quality-of-service (QoS) bearers
- Advanced flow-level interception
- Localization of bearers for optimized transport, such as local breakout, based on visibility into user equipment (UE) subscription and session state
- Intelligent use of subscriber information with firewall (if embedded), to identify charge violators, for example
- Ability to automatically adapt QoS for ongoing sessions after handover between different networks, such as LTE and UMTS or Wi-Fi/small cell and LTE in a heterogeneous networks (HetNets) environment

Table 2. Comparison Between Subscriber Session Management Platform and Transport Plane Platform

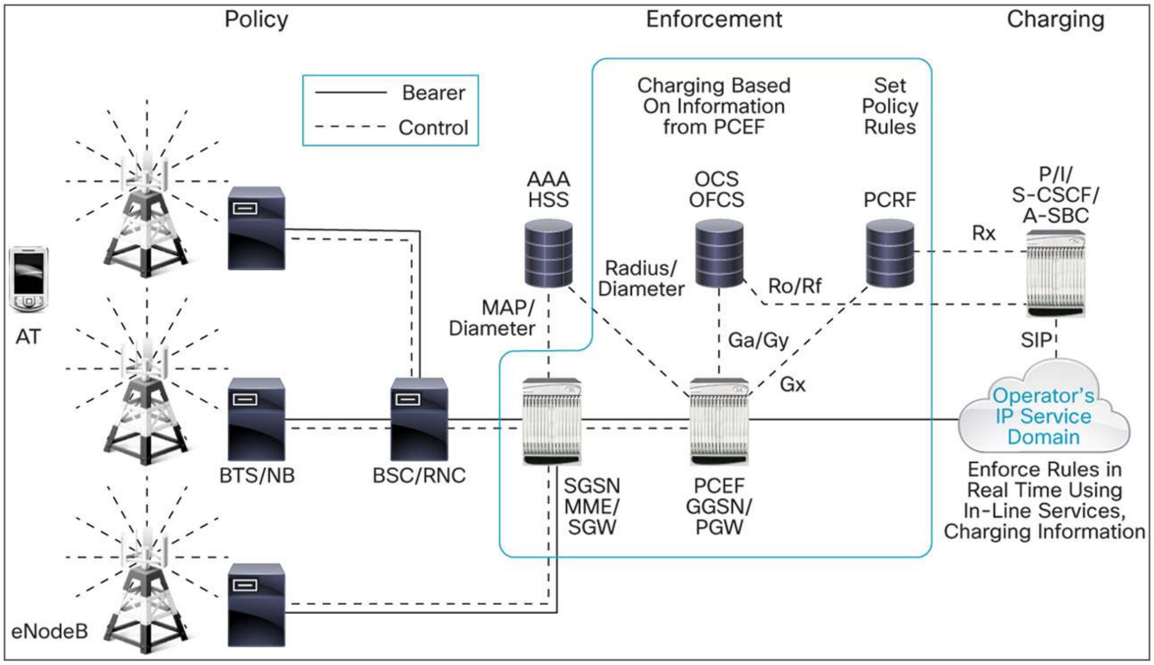
	Subscriber Session Management Platform	Transport Plane Platform
Transaction processing	• High subscriber session count processing • Mobility management • Session policy enforcement • Session security	• Routing computations • Network policy enforcement • Network security
Memory	• Large subscriber session counts	• Large routing table • Internet routing table size degrades performance
Routing and switching	• Layers 3 through 7 • Application/session routing	• Layers 1 through 3 • Network routing

Policy and Charging Control with Integrated Intelligence

Mobile operators are recognizing the unmistakable reality that bandwidth, along with CapEx and OpEx, is increasing much faster than revenue. They must work to control skyrocketing bandwidth growth through network resource management and also introduce next-generation, personalized services such as live streaming video, games, rich content, music, IPTV, VoIP, and video-enabled phone calling. These services involve differing levels of bandwidth, latency tolerance, and data-flow treatment. In addition, communication services providers are looking for solutions that monitor, observe, and analyze network and traffic conditions in real time, while having the intelligence to modify policies if required.

These challenges are driving the development and standardization of policy and charging control (PCC) solutions that assure the proper allocation of network resources based on what the subscriber has purchased and what the network can deliver (Figure 4). This means providing a superior mobile multimedia offering optimized for the operator network and meeting the performance objectives of the service offerings. Intelligent policy solutions enable the creation of an intelligent EPC network, as opposed to a "bit pipe" transport utility network.

Figure 4. Policy and Charging Control Solution



The three key capabilities required for a standard PCC solution are policy, enforcement, and charging, including the following functions:

- Policy and charging enforcement function (PCEF)
- Policy and charging rules function (PCRF)
- Charging through online and offline charging systems

The PCEF is specified by 3GPP as being part of the EPC PGW. The PCC solution must consider both predefined and dynamic PCC rules controlled by the PCRF over a standard Gx interface, as well as full quota management for both prepaid and postpaid subscribers over a standard Gy interface. For multimedia services, the solution should support a standard northbound Rx interface into service application nodes, including VoIP and IMS networks.

Integrating PCEF and DPI into the PGW

Integration of the PCEF into the PGW is accomplished through deep packet inspection (DPI) and integrated intelligent services, which integrate appropriate services or applications into the bearer-plane traffic at the mobile gateway inline. This technology not only provides the ability to detect appropriate traffic from Layers 3 through 7, through shallow and deep packet inspection, but also provides the enforcement function (PCEF) of the subscriber management solution.

DPI with Cisco In-Line Services simplifies the network through integrated functions and services, simpler manageability and control, fewer points of configuration, and consolidated accounting and billing (Table 3). The integration of DPI with In-Line Services allows you to manage your network and services per subscriber and even per application - all in real time - and also allows you to eliminate external lower-reliability elements with optimal integrated DPI performance. Managing these services with subscriber and session awareness enables you to grow the services only across the subscribers that need the service.

By being fully integrated with the PGW, the PCEF has full access to mobility management and subscriber session management events, enabling policy actions to be made based on the full complement of subscriber events.

As you choose an intelligent EPC solution, the following are some considerations when integrating DPI and policy enforcement into the PGW:

- Does it meet 3GPP R7 and R8 standards for PCC and PCEF?
- Does the solution provide services that enable you to monetize services and applications in the Mobile 2.0 world?
- How many times does the packet have to be “cracked” through the DPI engine for multiple services?
- Will the network be session, application, and subscriber aware?
- Is the solution simple and easy to manage, or does it require external hardware, servers, load balancers, interfaces, or related management equipment?
- Are the accounting and billing consolidated and accurate?
- How many hops do packets require to go through the solution?
- Are the PCRF, PCEF, and charging tightly integrated?
- Does the solution include multimedia integration?
- Does the vendor have experience with integrated platforms?
- Is the complete solution reliable?

Voice-Grade Reliability

Mobile operators succeed when they deliver an experience that meets or exceeds the expectations of their subscribers. A key consideration to achieving this success is, of course, the availability of the network and its services. The elements within the mobile network are the backbone of an operator's business. As a result, the design of the network must take into account the availability and robustness of both the network and the services being offered. For example, a typical router design manages IP flows, not subscriber sessions. So if the router fails, the IP flow is rerouted, dropping the subscriber session and requiring that it be reestablished and, most importantly, losing the billing information in the process.

Obviously, reliability translates into greater revenue and customer retention. For example, many operators use external systems for billing to correlate user names with IP addresses and billing information. If these products are not designed with stateful reliability, the end-to-end billing solution has lower reliability because of these “weak link” systems. This results in lost data and lost revenue.

Table 3. Accounting Functionality

Network Function	Accounting and Charging
Serving Gateway (SGW)	Accounting information for each UE
	Data transmitted through uplink and downlink
	Type of traffic per packet data network (PDN)
Packet Data Network Gateway (PGW)	Charging functionality for each user device
	Support for flow-based online and offline charging

Some of the key considerations for platform design are:

- Are subscriber sessions always maintained, even during a failure?
- Are sessions recovered rapidly in case of interruption?
- Is all billing information maintained in the event of a failure?
- Is the reliability of the end-to-end solution sufficient, or are there some weaker links that could cause service issues?
- Is the platform designed for no revenue loss due to any single link or node failure?

Security

Mobile operators realize the importance of expanding service offerings to address the home, enterprise, and hotspot markets. In addition, due to LTE radio challenges, many operators are considering deploying radios in nontraditional locations, such as in buildings, on poles, or in other less secure areas. To lower the cost of deploying radios, many operators are considering sharing radio locations. The EPC can be used as the packet core for unsecured access networks, such as Wi-Fi or femtocells that use fixed broadband networks.

While security has always been a top priority in mobile networks, these emerging new access networks and deployment scenarios require even stronger security.

Some of the EPC security considerations include:

- What is the IP Security (IPsec) scalability, including number of tunnels, tunnel setup rates, and throughput?
- Is LTE access backhaul security supported?
- Have you considered security across multiple access applications - LTE, WLAN, and femtocell - in the open EPC?
- Does the platform support evolved Packet Data Gateway (ePDG) functionality?
- Does the security solution scale to support a large number of base stations or home base stations?
- Does the solution support enterprise VPN functions such as Layer 2 Tunneling Protocol (L2TP), IPsec, and Mobile IP?

LTE Access Backhaul Security

A key challenge for operators when deploying LTE will be ensuring the security of user data. Within the 3G packet-switched domain, ciphering of NAS signaling and user data is performed within the RNC (and for 2G within the SGSN). As both RNC and SGSN are typically physically located with the mobile operator's secure core data center, this prevents a customer's data from being wiretapped over the air interface or between the core data center and the NodeB (or base station for 2G).

Within the EPC, ciphering of NAS signaling is performed within the MME, maintaining the security (as per 2G/3G) of NAS signaling between the core data center and UE. However, ciphering of user data within the LTE is performed within the eNodeB. This presents a security risk for user-plane data between the SGW deployed in a secure site and the remote eNodeBs, because unciphered user data may be wiretapped within the backhaul network or at the eNodeB S1-U interface (there is a particular risk from deployments that are relatively physically unsecured, such as in-building eNodeBs), and also creates the potential for eNodeB and SGW attacks (such as denial of service) performed by a device at the eNodeB site or within the access backhaul site masquerading as an eNodeB or SGW.

The security risks just described can be addressed through IPsec ciphering of the S1-U interface between SGW and eNodeB by enabling IPsec functions within the SGW. An IPsec encapsulating security payload (ESP) can encrypt and integrity-protect 100 percent of the user-plane traffic with minimal impact on signaling and throughput capacity.

Reporting, Monitoring, Accounting, and Charging

Session, application, and network knowledge are critical components necessary to provide a superior service experience to customers. This powerful information can be used to provide a comprehensive, consistent set of statistics and reports.

- Do you have access to and can you utilize all the available session, application, and network information in the EPC - a unified service management capability?
- Can the same information be used to modify policies either manually or dynamically to provide a better service experience to the customer?
- Can you collect real-time service information, including information from Layers 1 through 7 plus real-time tracing and troubleshooting information?

In the EPC, accounting functionality is provided by the SGW and the PGW. The SGW collects accounting information for each UE, including the amount of data transmitted in both the uplink and downlink direction and information about the type of traffic per PDN. The PGW provides charging functionality for each UE and supports flow-based online and offline charging based on local configuration and interaction with the online and offline charging systems.

Some of the EPC accounting and charging considerations include:

- How accurate and consolidated is the network’s accounting and charging architecture?
- Do you have revenue leakage?
- Does your accounting and charging solution allow you to monetize the full value of your network while offering a compelling range of services?
- Does the charging capability in the EPC provide visibility into subscriber behavior through in-depth examination of services, sessions, and applications, or does it just count packets?

This unique understanding is the key to tiered and detailed billing schemes based on how mobile subscribers use their devices. Now mobile operators can meet the complex and processing-intensive accounting challenges required for next-generation network deployments, based on the following criteria:

- Time: Minutes used, peak/off-peak, in-network/out-of-network
- Volume: Packet amount, number of bytes, etc.
- Content: Destination, email, application, game, etc.

- Event: Messaging, video downloads, etc.
- Destination: Prepaid, reverse billing, browsing in-network or out-of-network, URLs
- Application: Video, VoIP, instant messaging

Roaming (GTP and PMIPv6, DSMIPv6, MIPv4)

In the standardization of LTE and the EPC, 3GPP specifies mobility protocols from both traditional 3GPP networks and non-3GPP networks - GPRS Tunneling Protocol (GTP) and Proxy Mobile IPv6 (PMIPv6), Dual Stack Mobile IPv6 (DSMIPv6), and Mobile IPv4 (MIPv4).

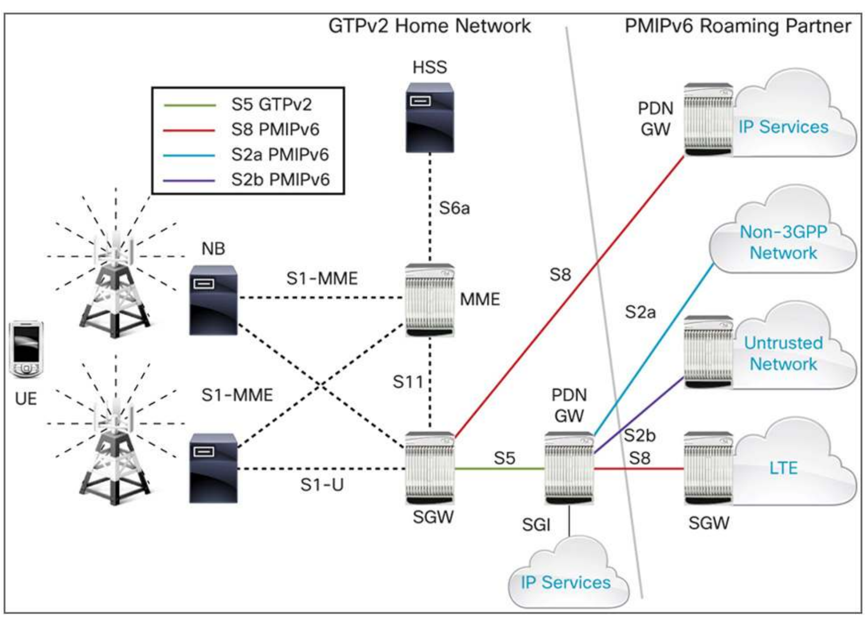
The Mobile IP-based protocols will typically be used for connectivity to non-3GPP networks, such as CDMA, Wi-Fi, and femtocell. The design of the EPC core must consider subscriber roaming to other LTE networks, as well as non-3GPP accesses. The selected core vendor must have expertise in both GTP and these Mobile IP-based protocols, but consideration also must be made toward supporting both technologies within a single platform to minimize complexity and cost.

A GTP-based operator should be able to roam with a PMIPv6-based operator without the cost and complexity of deploying PMIP to and from GTP conversion devices or different SGW (PMIPv6 and GTP) variants. The early implementation of the PMIPv6-based S2a and S2b interfaces will enable interworking for home-routed traffic for an outbound roamer that connects over a non-3GPP network or an untrusted network.

Figure 5 depicts roaming scenarios for a GTP-based operator (that has the ability to support PMIPv6) with a PMIPv6-only network. The following are some considerations related to this approach:

- Are the EPC nodes ready to support all types of roaming arrangements?
- Can home network subscribers roam outbound to PMIPv6 network providers?
- Are roaming home network subscribers served by non-3GPP networks, such as eHRPD or WLAN?
- Are roaming-partner visiting subscribers able to roam inbound to GTP and PMIPv6-based network operators?

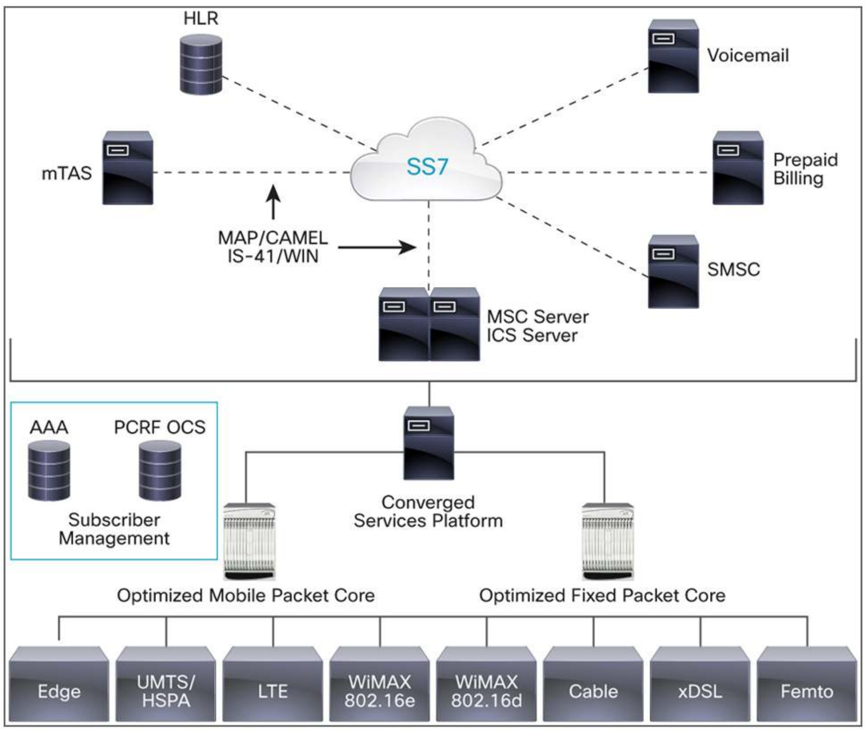
Figure 5. Roaming Support Between a GTP S5/S8-Based Network and a PMIPv6-Based Roaming Partner



Multimedia Services

One of the biggest disruptions in the mobile industry is the movement to an open, IP-based architecture designed to deliver converged voice, data, and multimedia services (Figure 6). The emerging mobile packet technologies, High Speed Packet Access (HSPA) and LTE, provide an all-IP infrastructure from the mobile device, whether it is a handset, smartphone, data card, or other emerging intelligent device. With all-IP networks, the door is open to providing the traditional circuit-based services, including voice and video, over the packet infrastructure.

Figure 6. SIP/IMS Multimedia Architecture



The migration from circuit-based voice to packet voice and multimedia services is a key consideration in the deployment of an EPC solution. Operators must consider how to migrate and deploy an infrastructure that enables the immediate introduction of a full suite of SIP-based services that provide subscribers with a rich service experience, including video, VoIP, Push to Talk over Cellular (PoC), IPTV, presence, instant messaging, and many others.

Some of the key considerations for the integration of multimedia services with LTE and the EPC are:

- Can the existing circuit-switched network for voice be used after the EPC is deployed?
- How are you planning to support legacy interfaces required for legacy circuit domain services such as SMS?
- How will existing services transition to IMS?
- When is the appropriate time to migrate to IMS, and what elements are required?
- What types of services can be added on top of voice?
- How do femtocells fit into this evolution?

CS Fallback

While SIP/IMS is considered the future for voice and multimedia services, some operators are considering transitional approaches for voice services that do not rely on deploying an IMS core. One such approach is circuit switch (CS) fallback, which allows the network to fall back to the circuit-switched network from the LTE network when a voice call arrives. This approach requires the MME to interface with the MSC. The SGs interface has been designed to allow this interworking but requires a change to the MSC. One option is to allow the MME to interwork with the MSC using the existing Gs interface, requiring no changes to the MSC.

IMS Evolution

In an IMS-based solution, SIP-based applications connect through the packet data infrastructure to a SIP/IMS core. For services that connect to another SIP device on the network, the service remains totally in the SIP domain. For calls that are sent to a non-VoIP network, the signaling portion of the call passes through a convergence server (an SIP application server) that connects to a standard SS7 network. The functions of the IMS core infrastructure include Telephony Application Server (TAS), SIP Proxy/Registrar, Call Session Control Function (CSCF), and Access Border Gateway (A-BG).

IMS evolution considerations include:

- Does the solution support the evolution to IMS with minimal impact on the overall network?
- Does the solution allow development of applications that blend voice, video, data, messaging, and presence?
- Can new services or features be added to a network without changing the network infrastructure?
- Can you add new revenue-generating services that remain under your control, for example, a presence-based server plus an integrated instant messaging (IM) server?
- Does the core support integration of multiple functions into a single platform - for example, integrating the PGW and CSCF to enable call localization closer to the edge?
- Does the solution support traditional mobile VoIP and integration of femtocell access?
- Does the solution support roaming and interworking between VoIP networks and existing circuit networks, including SIP to Mobile Application Part (MAP) interworking and Service Centralization and Continuity Control (SCC)?

Summary

The deployment of LTE is another step in the evolution of mobile broadband networks. While the deployment of 4G radio access networks receives considerable attention, the multimedia core network has emerged as a critical element in the delivery of next-generation mobile broadband services. As such, mobile operators are looking for solutions that can address today's requirements while positioning them for future technologies. EPC, although often identified as an LTE-only mobility management core, was designed from its inception with the mandate that it support all types of network access, and provide device and service mobility across all networks. The EPC has defined the connectivity, security, and expansion capabilities of the next-generation mobility core.

For More Information

For more information, please visit http://www.cisco.com/go/mobileinternet.

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