# The Role of 3GPP's Evolved Packet Core in the Build-out of the Mobile Internet

Until recently, the mobile world has focused on circuit-switched voice as the primary application. We are now seeing a tremendous acceleration in the adoption of mobile broadband services. Depending on the location, the increase in mobile data traffic ranges from 300 to 800 percent a year in 2008.

The factors driving this transition include powerful new devices, high-speed mobile networks optimized for IP transport, and compelling applications like Facebook, Google Earth, Flickr, and Cisco WebExTM Connect, to name just a few. Flat-rate billing plans are also an important factor.

With industry forecasts calling for as much as a hundredfold increase in data traffic over the next five years, operators face all sorts of challenges in scaling their networks in a cost-effective manner. This paper focuses on the role that the Evolved Packet System (EPS) and more specifically the Evolved Packet Core (EPC) will play in meeting the scaling requirements of the Mobile Internet.

The key components of the EPS are the evolved Universal Mobile Telecommunications Service (UMTS) terrestrial Radio Access Network (RAN), abbreviated as E-UTRAN, and the Evolved Packet Core (EPC). The E-UTRAN is also known as LTE (the long-term evolution of 3G) and is based on Orthogonal Frequency Division Multiple Access (OFDMA) radio access technology that has been highly optimized for packet traffic. The EPC is an all-IP, end-to-end architecture for supporting mobile access networks.EPS has been standardized by the Third-Generation Partnership Project (3GPP) as part of Release 8.

### 3GPP Release 8 EPC Architecture

The 3GPP Evolved Packet System is divided into a radio access network known as the E-UTRAN and a core network known as the EPC.The E-UTRAN consists of eNodeBs, which provide the radio interface toward the user equipment. The eNodeBs are interconnected with each other via the IP-based X2 interface and toward the Evolved Packet Core (EPC) via the IP-based S1 interfaces. The detailed requirements for the E-UTRAN radio interface and radio access network are captured in 3GPP specification TR 25.913. The requirements include the following:

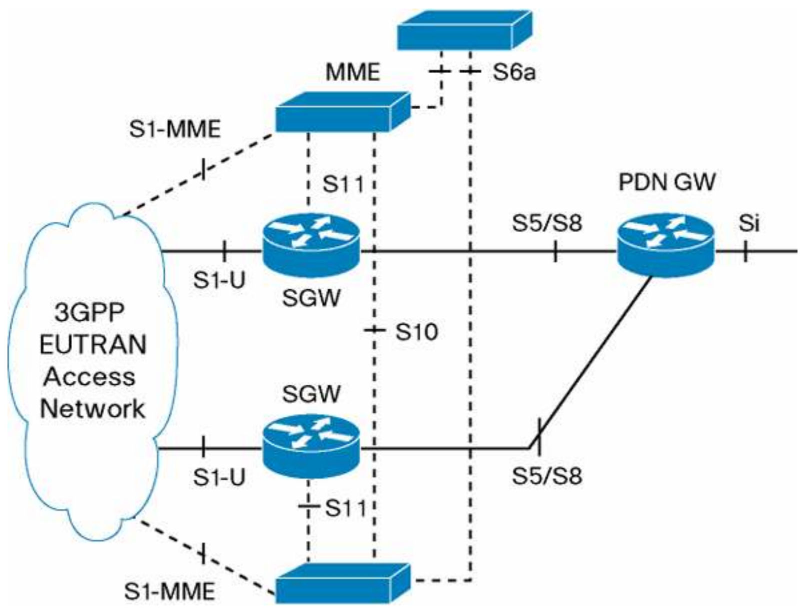
- 100 Mbps downlink and 50 Mbps uplink peak data rates
- Low control-plane latency (less than 50 ms from idle to active)
- Low user-plane latency (less than 5 ms for small IP packets)
- Support for inter-working with existing 3GPP and non-3GPP specified systems
- Reduced CapEx and OpEx

The EPC (shown in Figure 1) can be broadly described as an evolution of the legacy core network functions and procedures defined for UTRAN access, with the notable exception that the EPC defines a clear separation between control plane and user plane functions. The EPC comprises three core functional elements:

- **Serving Gateway (SGW):** The SGW is a local mobility anchor for E-UTRAN mobility, switching packets between the S5/S8 interface and the General Radio Packet System (GPRS) Tunneling Protocol (GTP)-based S1-U interface for mobiles in connected mode. For mobiles in idle mode, the SGW is responsible for terminating the down-link data path and when down-link data is received, buffering the data and triggering a paging procedure by signaling the Mobility Management Entity (MME) over the S11 interface.
- **Mobility Management Entity (MME):** The MME is the control-plane function for E-UTRAN access. It is responsible for authentication and critical management for mobile devices as well as for tracking and paging procedures for mobiles in idle mode. The MME authorizes bearer activation/deactivation including SGW and Packet Data Network (PDN) gateway selection.
- **Packet Data Network Gateway (PDN GW):** The PDN GW is the permanent IP point-of-attachment for access via the E-UTRAN. The PDN GW performs IP policy and charging enforcement on packet flows to and from mobile devices. The same access point name (APN) concepts from the UTRAN PS core network apply, allowing a mobile device to have simultaneous connectivity to multiple PDNs.

**Figure 1.** 3GPP Release 8 Evolved Packet Core




Since this is an all-IP system, authentication and authorization based on legacy Mobile Application Part/ Signaling System 7 (MAP/SS7) has been replaced with an S6a approach based on the Diameter Protocol.

The S11 interface is used to decompose the control and user plane functions between the MME and SGW. The S10 interface is used for context transfer operations, although the frequency of context transfer will be reduced as the mutli-homing capability of S1-MME should allow a single MME/SGW to handle control and user plane functions for a mobile device as it moves within the E-UTRAN.

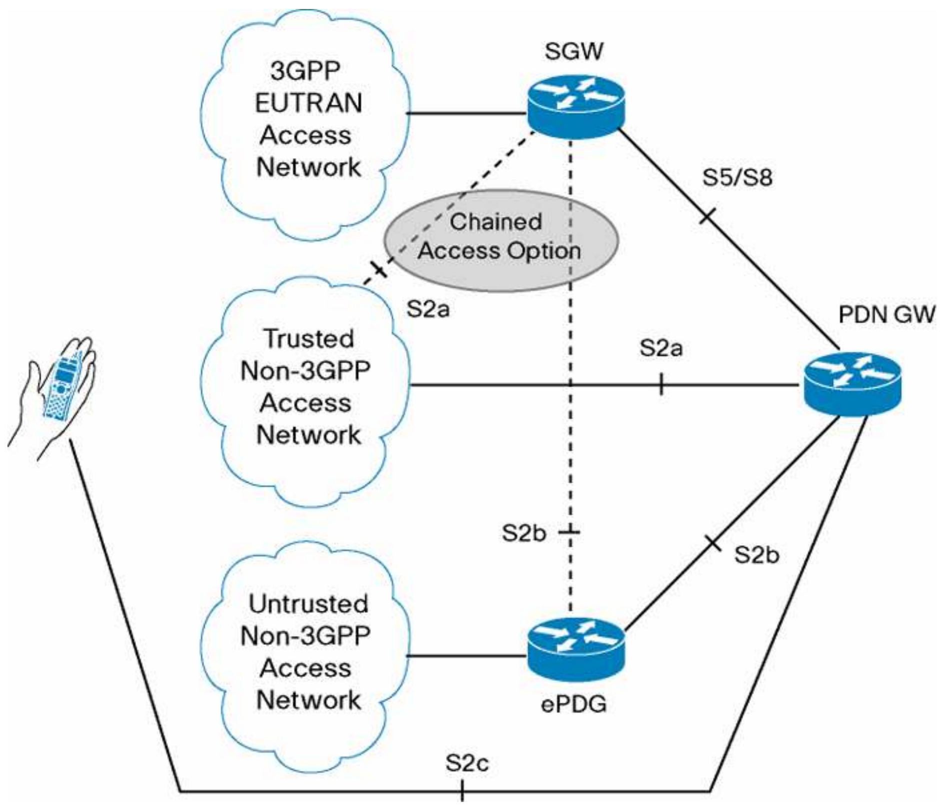
Both S10 and S11 are based on GTP-C and require a new set of features compared to legacy GTP-C functionality. Rather than simply extend GTPv1-C, the EPC uses a new version of GTP for the control plane, version 2.

### Non-3GPP Access

Although the EPC architecture for E-UTRAN access can be broadly seen as an evolution of the current UTRAN PS core network, with the serving GPRS support mode (SGSN) being decomposed into MME and SGW elements, the revolutionary aspect of the EPC relates to how non-3GPP access networks have been accommodated. Previous attempts to integrate non-3GPP access networks have resulted in the I-WLAN architecture where all such networks were deemed untrusted, requiring an overlay of IPsec from the mobile device to a Packet Data Gateway (PDG) in the 3GPP core network. In contrast, the EPC supports trusted non-3GPP access networks, as shown in Figure 2, obviating the need for an IPsec overlay in such scenarios. The S2 mobility interfaces are used to support non-3GPP access networks, where:

- **S2a:** Is based on Proxy Mobile IP (PMIP) v6 (RFC 5213). To enable access via legacy trusted non-3GPP access networks (for example, CDMA2000 based networks), S2a also supports Client MIPv4 in FA mode.
- **S2b:** Is based on PMIPv6 and can be seen as an evolution of the TTG concept. In this case an evolved Packet Data Gateway (ePDG) tunnel switches packets between IPsec and PMIPv6 tunnels.
- **S2c**: Is based on Client Mobile IP using Dual Stack MIPv6 (DSMIPv6) as specified in RFC 4877.

**Figure 2.** Non-3GPP EPC Access




As Figure 2 illustrates, EPC has given the mobile industry the first opportunity to provide a converged packet core network, capable of supporting all-IP E-UTRAN access via GTP-based S1, legacy CDMA2000 access via MIPv4-based S2a, and WiMAX Release 1.5 access via PMIPv6-based S2a.

### EPC Macro-Mobility and Quality-of-Service Classification

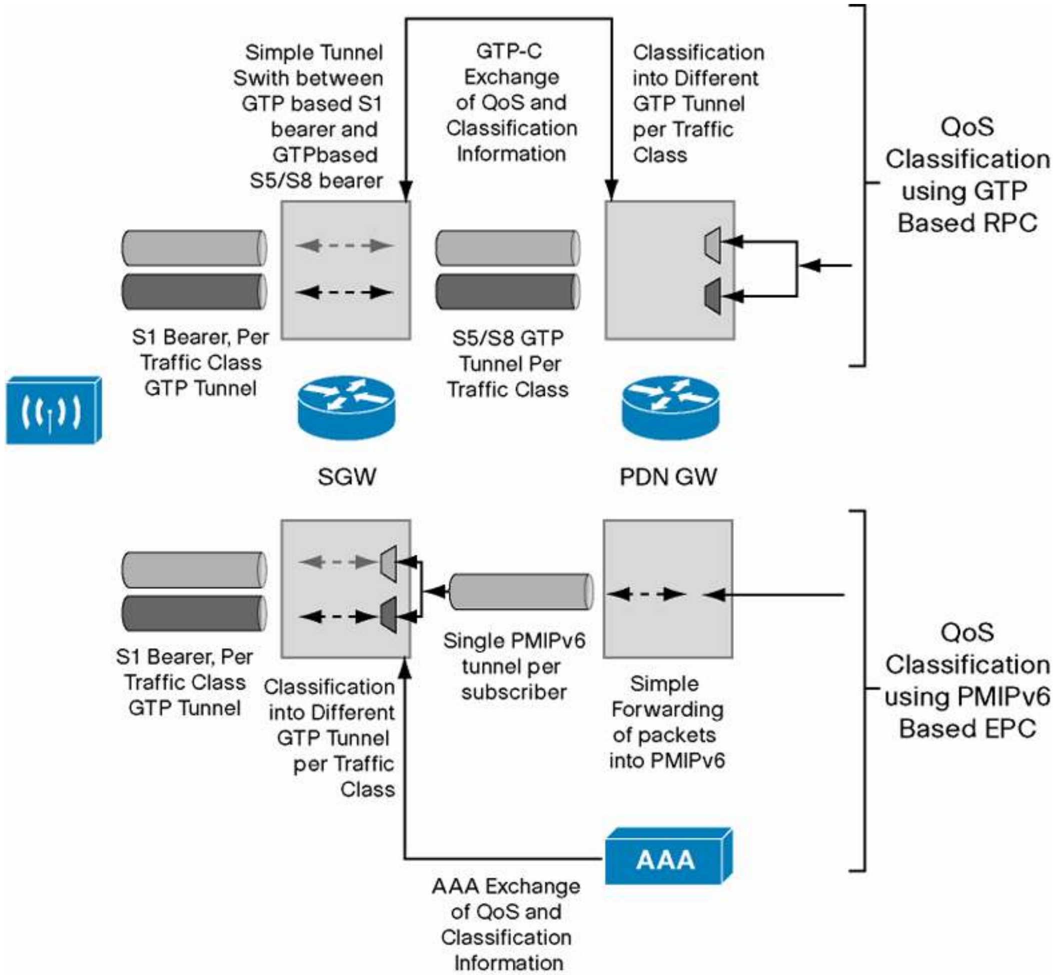
With a legacy in GTP-based roaming interfaces, 3GPP has naturally defined GTP-based S5 and S8 interfaces between the SGW and the PDN GW, using GTPv1 for the user plane and GTPv2 for the control plane. Using the chained access option shown in Figure 2, the same GTP-based S5/S8 can be used to support non-3GPP access networks. Instead of such a GTP-based evolution, several companies within 3GPP preferred an architecture where the protocols between its core network elements were based on IETF defined protocols – in other words having an option to use either GTP or PMIPv6 across the S5 and S8 reference points. As a consequence, 3GPP agreed to define both GTP and PMIPv6 variants for the S5 and S8 interfaces.

The next critical question concerned the functional decomposition for the GTP and PMIP variants. When using a GTP-based core network, the PDN GW acts as the macro-mobility anchor and includes the functionality to support multiple PDP contexts per user as well as the associated downlink classification capability in order to map downlink packets into different PDP contexts. Although this architecture could be realized with PMIPv6 (for example, using different GRE keys to represent the different secondary tunnels), such an architecture is at odds with both CDMA2000 and WiMAX core networks, which assume a single mobility tunnel between the macro-mobility and micro-mobility anchors, with downlink traffic classification being implemented at the micro-mobility anchor.

Consequently, when PMIPv6 has been defined by 3GPP for the S8 and S5 interfaces, a different functional decomposition is used between the SGW and PDN GW to allow a single PMIPv6 tunnel between these elements. Figure 3 compares GTP- and PMIPv6-based EPC architectures. As you can see, in order to deliver an end-to-end differentiated quality-of-service (QoS) architecture for the PMIPv6-based core network, an out-of-band, authentication, authorization, and accounting (AAA)-based policy interface is used to deliver the classification information to the SGW and the binding of flows to radio bearers is performed by the SGW, not the PDN GW.

**Figure 3.** Radio Access Bearer Binding for GTP- and PMIPv6-based EPC




## Cisco's EPC Strategy

Cisco will be developing both Serving and PDN gateway’s for LTE RAN deployments.These gateways will provide the capacity required for LTE deployments and will be compatible with base stations from the major RAN vendors.

### Cisco 3G Mobile Internet Product Line

Cisco currently delivers high-performance, intelligent packet gateways for all the major radio access technologies (GERAN, UTRAN, iDEN, CDMA2000, and WiMAX), as well as mobile services gateways for content charging, policing, filtering, and traffic monitoring.Of special note is the Cisco® Mobile IP Home Agent, which can support mobility across different radio access technologies.

Cisco’s mobile gateways have been successfully deployed by more than 100 mobile operators worldwide, and their capabilities are constantly evolving to align with the latest mobile network requirements.Capabilities that have been added over the years include support for direct tunnel, a new 3GPP technique for optimizing performance in High-Speed Packet Access (HSPA) networks.This optimization is enabled by tunneling directly from the radio network controller (RNC) to the GGSN without the payload having to transit an SGSN.By helping to eliminate the congestion that the SGSN can cause, this optimization improves performance in a very noticeable way.

Cisco is also helping operators address the scaling challenges that come with the Mobile Internet by building our gateways on the Services and Application Module for IP (SAMI) platform.The module runs inside the Cisco 7600 Series Router.Independent testing by Current Analysis has shown that a Cisco 7613 Router with nine SAMI modules can deliver performance in excess of 50 Gbps (running the Content Services Gateway Code).All our gateways have now moved onto the SAMI module.We will be developing both the Serving and PDN gateways to also run on this module. What's more, any SAMI module installed in the field can be upgraded to support EPC functionality with a simple load of new software.SAMI running inside the Cisco 7600 Series Router is the **only** shipping LTE-ready gateway in the industry.

While our initial EPC solution will be 7600 based, we plan to move our gateway functions onto other routing platforms.This platform flexibility will open more deployment options for mobile operators and lower the overall operations, administration, maintenance, and provisioning (OAM&P) by minimizing the number of different platforms in the network.We will use the Cisco Quantum Flow Processor (QFP) for user plane processing across all implementations. The operating system will be Cisco IOS® XE Software, thereby enabling us to take advantage of the considerable investment and development already done for our existing mobile gateways products, while gaining useful features such as OS modularity, containment, support for parallel programming, and so on. Management of the EPC products will be integrated with the existing router management.Management features include configuration management, fault management, performance management and measurement, logging, tracing, troubleshooting, diagnostics, and MIBs.

### Carrier-Class Focus

With the increasing importance and reliance on the IP network infrastructure, the EPC must be carrier class. To that end, our EPC products will support In-Service Software Upgrade (ISSU) and 99.999 percent reliability. Reliability is provided by the use of redundant hardware and stateful local session redundancy. Stateful remote session redundancy (geographic redundancy) is supported as well.Both local and geo-redundancy use a 1+1 redundancy model with a hot standby in order to support a fast switchover in the event of a failure (less than one second in the case of local redundancy). Use of either redundancy model is optional.

### Flexible Deployment Models

The EPC can be deployed in a variety of different ways, including:

- The centralized model, in which PDN GWs, SGWs, and possibly other elements such as the MMEs are located in a few central sites
- The distributed model, in which PDN GWs, SGWs, and so on are located in a relatively large number of sites (generally more than 50).
- The regionalized model, where PDN GWs, SGWs, and so on located in a limited number of regional sites (typically more than two but less than 50)

### Software Capabilities

- By building on the most popular routers in the industry, we are able to use the full breath of our enormous R&D investment in software and hardware.We will also be able to take advantage of many of the mobile specific software capabilities found in today's gateways.

- Our existing products are deployed in a wide range of networks today. By basing our EPC products on the existing code base, we gain the significant benefits of product maturity and stability.
- Our software provides unparalleled performance on our current hardware platform. Our nearest competitor's entire chassis performance today matches only that of a single Cisco service blade.

In terms of technology understanding and thought leadership, Cisco's expertise and operational experience with IP-based networks and features is unparalleled. With IP as the base for the EPC, we believe that Cisco is the best possible vendor to help service providers with the network evolution to IP.

## Conclusion

With the rise of the Mobile Internet, IP capabilities are coming front and center for many operators.3GPP has responded to this trend with an all-IP core network called the EPC and new packet-optimized airlink technologies like E-UTRAN (otherwise known as LTE). Cisco will play a major role in the Mobile Internet build-out by providing a range of IP infrastructure technology including gateways design for EPC, RAN backhaul solutions, IP/MPLS core backbones, cell-site routers, and much more.In addition to providing the basic technology, Cisco has expertise in all things IP and a worldwide footprint to aid our clients as they continue their build-out of the Mobile Internet.

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