

Enabling mobile broadband growth – Evolved Packet Core

Nokia Siemens
Networks



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Enabling mobile broadband growth

In recent there has been a dramatic evolution of terminals, a rapid growth in the availability of laptop data cards, and widespread deployment of high speed networking technologies. These developments have both benefited from, and helped to drive up, the global accessibility of the Internet. Today, wireless networks are seen as a viable alternative to fixed broadband access, leading to huge and continuing growth in mobile data business for communications service providers (CSP).

The growth trend started with High Speed Packet Access (HSPA) network launches and CSPs attracting subscribers with monthly flat fee subscriptions using HSPA dongles for laptops. This business model has allowed mobile CSPs to compete with fixed CSPs with mobile broadband offerings for both the consumer and business segments.

Mobile CSPs can support this growth cost-effectively by deploying more efficient radio network technologies, combined with efficient backhauling, simple network architecture and advanced tools to stay in control of how network resources are used. The benefit for subscribers is better service quality, with increasing bandwidth and lower latency, as well as more opportunities to use innovative services. For CSPs, it all adds up to the ability to build more valuable customer relationships.

Enabling migration from current networks to LTE

3GPP R8 introduces major advances in mobile networks. For the subscriber, it means higher access rates and lower latency on the connection, while for the mobile CSP, Long Term Evolution (LTE) radio technology provides lower cost per transmitted bit thanks to more efficient use of radio network resources. The technology also offers more flexibility in frequency allocation, thanks to the ability to operate LTE networks across a very wide spectrum of frequencies. LTE also minimizes the power consumption of terminals that are used 'always-on'.

3GPP R8 also introduces major advances in the core network that improve service quality and networking efficiency, leading to a better end user experience. GPRS technology has already introduced the always-on concept for subscriber connectivity and 3GPP R8 mandates this ability, with at least one default bearer being always available for all subscribers. This allows fast access to services as well as network initiated services such as terminating voice calls and push e-mail. The connection setup time for person-to-person communication is also minimized with always-on bearers.

Evolved Packet Core (EPC) was designed to support any mobile access technology including LTE, 2G/EDGE, 3G/HSPA, evolved HSPA, CDMA, WiFi and WiMAX and as such serves as a common anchor point for subscribers moving between the different access networks. EPC's ability to support both LTE as well as current access technologies gives CSPs a smooth migration path to LTE/SAE.

As well as providing connectivity between the radio network and the content and service networks, EPC also acts as the policy and charging enforcement point. The mobile gateway is a central point through which all the traffic must travel, making it the natural place to enforce policy and charging rules. This centralized control allows the CSP to enforce preferred business models and stay in control of how network resources are used.

Terminology

A 3GPP project, LTE, has specified Evolved UTRAN (E-UTRAN) radio technology. E-UTRAN is generally referred to as LTE radio.

In order to deploy LTE radio technology, CSPs need to upgrade the Packet Core. A 3GPP project, called Service Architecture Evolution (SAE), has specified Evolved Packet Core (EPC).

E-UTRAN and EPC specifications are included in 3GPP R8. The whole system including both radio and core is referred to as Evolved Packet System (EPS).

EPS technology can be referred to as LTE/SAE.

The demand for cost-effective support of mobile data growth

With circuit switched services, the amount of traffic is directly proportional to CSP revenue. However, as developed markets have reached saturation, CSPs have been forced into fierce competition on voice call tariffs. The consequent fall in voice revenues has been compensated for by improving network efficiency with 3GPP release 4 MSC Server System, which is already leading to cost-effective voice services.

Mobile networks are experiencing a transformation from circuit switched to packet switched technology. Along with this development, the CSP business model is changing from a pure service provider to a service and connectivity provider. In circuit switched mobile networks, services are predominantly provided and controlled by the CSP. Internet access is revolutionizing this business model in packet switched networks, where the CSP provides connectivity and data transport. New methods are also needed to manage the growing volumes of data traffic.

Driving down the cost per transmitted bit

An important business challenge that mobile CSPs are facing is the decoupling of the association between traffic volume and revenues. With revenue growth not keeping pace with the growth in data volumes, the only way for CSPs to retain profitability is to lower the cost per transmitted bit.

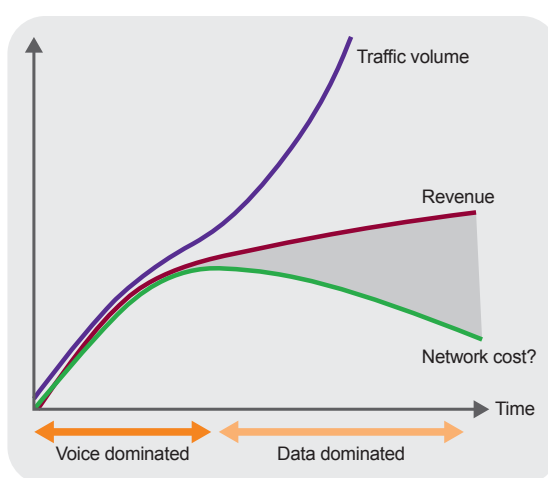


Figure 1. The gap between mobile traffic growth and revenue growth is expanding. The challenge is: how to shape the network OPEX curve according to the revenues, not the traffic.

Even though most capital and operational expenditures are due to the radio and transmission networks, there is also room for optimization in the core network. Examples of improvements that can be introduced in today's networks are deploying all-IP interfaces with the radio network and introducing Direct Tunnel in 3G networks. Mobile CSPs are currently forced to maintain parallel networks for voice and data services and considerable savings are expected when all services can be offered over a single, IP based network technology.

Enabling service evolution

LTE/SAE is designed to support all CSP services, including data, high quality voice and multimedia. Current packet switched mobile networks have been designed to accommodate user initiated communications. If services and applications are to enable facilities such as person-to-person communication, the network and terminals must support 'always-on' sessions, allowing subscribers to be continuously reachable for incoming calls. Always-on sessions are also needed for machine-to-machine applications.

For the packet core, always-on sessions mean increasing demand for higher subscriber density. Together with the 3GPP R8 flat architecture, where all the mobility transactions are directly visible to the core network, the signaling performance of the core network elements must also be carefully considered.

Traffic patterns in mobile networks are evolving. The original assumption for mobile data services was that the CSP provides the services and access to corporate intranets. Currently, mobile data subscriptions, particularly HSPA, are mostly used for both open Internet access and company intranet access.

Staying in control of traffic growth

LTE radio technology will allow increasing amounts of traffic to be transmitted over the network, increasing the CSP's need to stay in control of traffic. Better technology is allowing the development of new applications and services, many of which the CSP will need to treat differently to ensure users get the best possible service quality. Prioritized treatment is particularly important for premium services such as CSP VoIP and other high quality real-time services.

In current 2G/3G and CDMA broadband networks, there is already an urgent need to deploy online usage control to service access. A typical example are fair usage policies that are applied to set limits to the maximum access speed that the subscriber is allowed to retrieve from the network and to limit the maximum amount of data consumed during the subscription period.

3GPP R8 Evolved Packet Core unifies mobile networks

Evolved Packet Core plays an essential role in unifying mobile networks, offering interoperability between LTE and existing wireless access technologies. With these capabilities, it offers smooth transition to 3GPP R8 architecture and technology, independent of the access technologies currently deployed in CSP networks.

Evolved Packet System to carry all services

3GPP R8 specifies Evolved Packet System (EPS) as a flat all-IP network architecture that is ready to carry all CSP services, from mobile broadband data to high quality voice and multimedia. EPC links the wireless access networks to the service and content networks. In this position, it is the natural point to enforce charging and traffic treatment policies to allow the CSP to stay in control of how network resources are used.

Evolved Packet Core is required to support the LTE radio network, subscriber mobility and to offer interoperability between LTE and other CSP access networks. Handovers between LTE and other networks must be supported and service continuity must be ensured. 3GPP R8 specifies optimized interworking between LTE and other 3GPP accesses and CDMA to minimize handover times.

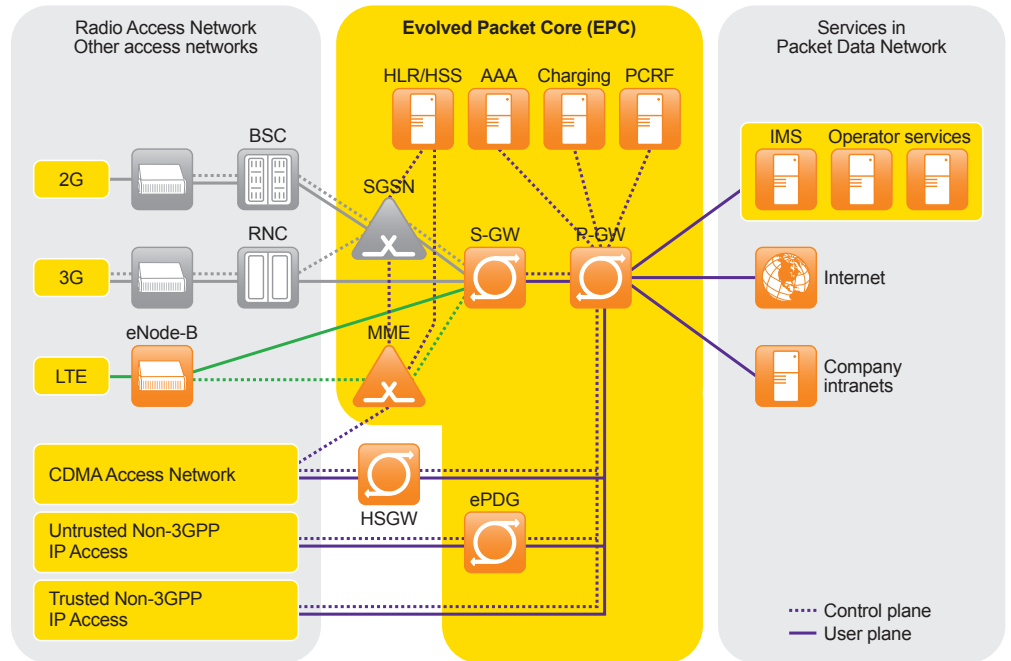


Figure 2. 3GPP R8 architecture.

3GPP R8 architecture

3GPP R8 architecture is simpler than current R7 architecture. The most important difference is that the R8 network is an all-IP network where all services are provided over IP based connections. However, interoperability with current circuit switched networks is provided to ensure, for example, voice call continuity. Interoperability with existing packet switched networks is also specified, allowing subscribers to move easily between different access networks.

Simplifications are introduced by implementing the radio network functionality in a single node, the evolved Node-B. Traffic flows are separated in the core network user plane and control plane, allowing a more flexible network architecture. The user plane data is carried from

the eNode-B directly to the S/P-GW. To handle control plane traffic, EPC introduces a Mobility Management Entity (MME) that takes the role of SGSN as a dedicated control plane element, taking care of such things as session and mobility management.

The Serving Gateway (S-GW) and Packet Data Network Gateway (P-GW) together take the role of the current GGSN. These functions can be implemented in one or two separate network elements. S-GW acts as a user plane anchor for mobility between the 2G/3G access system and LTE access system. P-GW acts as mobility anchor for all accesses and as a gateway towards the Internet, company intranets and CSP services. It acts as a centralized control point for policy enforcement, packet filtering and charging.

Solutions to match the needs of evolution steps

CSP networks need to be upgraded to LTE/SAE in smooth steps that ensure service continuity for subscribers. This evolution towards Evolved Packet Core can be started today.

Introducing EPC in the CSP network

Introducing EPC in a CSP network can be performed in steps while taking advantage of the synergies with 3GPP R7 architecture.

Leveraging the synergies with 3GPP R7

3GPP R8 is a logical progression from earlier 3GPP releases and allows existing 3GPP CSPs to take advantage of the synergies with their existing networks. For HSPA CSPs, 3GPP R7 already specifies separation of user plane and control plane handling. Deploying Direct Tunnel to carry the user plane traffic directly from the radio network to the GGSN, CSPs can save up to 30 % of OPEX costs, mainly due to transmission network savings. With R7 Direct Tunnel, the network architecture is already aligned with 3GPP release 8 architecture that mandates user plane and control plane separation for LTE networks.

User Plane and Control Plane separation considerably simplifies network design decisions, making it easier for the CSP to adapt to growth in both subscribers and traffic. LTE networks are introduced for mobile broadband and early adopters of the services can be expected to be high volume subscribers. An exception

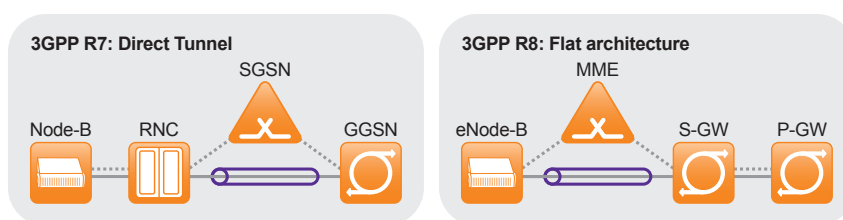


Figure 3. Direct Tunnel and 3GPP R8 flat architecture.

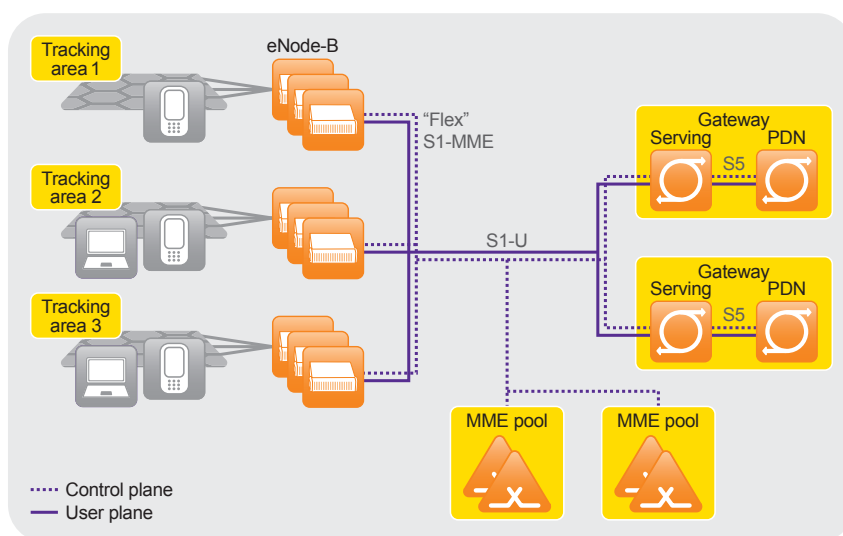



Figure 4. S1 Flex interface for MME pooling with geographical redundancy.

occurs in 2G networks where Control Plane and User Plane traffic flows are tightly coupled. This sets some limitations to aligning the 2G and LTE network architectures, as the 2G SGSN is always forced to handle the user plane traffic.

CSPs introducing 3GPP R8 and LTE are also able to benefit from the all-IP networking synergies. Upgrading interfaces to IP, especially deploying

Gb and Iu interfaces over IP, allows the transport network technology to be unified and prepared for the all-IP 3GPP R8. The existing SGSN pooling concept, multipoint Gb/Iu, currently deployed in 2G/3G networks, is also specified in 3GPP R8 for LTE via MME pooling over the S1 interface.



In current 2G/3G networks, the common factors of 2G and 3G technologies are used in both control and gateway deployments. As 2G traffic volumes are modest compared to HSPA and LTE traffic volumes, decisions on network optimization should always be driven by these bandwidth intensive technologies. In other words, the synergy benefits of 3G and LTE technologies outweigh the benefits of combined control for 2G and 3G. 2G, 3G and LTE consume equal amounts of control capacity per supported bearer but HSPA and LTE can carry considerably larger traffic volumes. Because of this, network expansions will concentrate on 3G/HSPA and LTE technologies.

EPC as overlay versus upgrade deployment

The key motivation for introducing 3GPP R8 EPC is the possibility of introducing LTE radio technology. EPC is, however, specified to be backwards compatible and can also be applied to serve existing 2G/3G networks. It also supports interoperability with CDMA and other non-3GPP networks.

The two key alternatives for EPC deployment are introducing the MME and S/P-GW functionalities as software upgrades to the existing packet core platforms or to deploy the functionalities on stand-alone platforms in an overlay type setup. As 3GPP R8 introduces major changes and improvements to the packet core network, it is beneficial, at least in the early phases of technology introduction, to apply EPC in isolation from the existing packet core to keep the main production system intact. The introduction of EPC

is also a logical time to introduce next generation packet core nodes to meet the increased requirements in traffic volumes, signaling and subscription handling.

LTE sets new requirements on the packet core. On the control side, these include adapting to the flat architecture where MME acts as a dedicated control element. It also includes the ability to support a considerable increase in mobility management transactions when the CSP's primary voice service is migrated from a circuit switched network to LTE.

On the gateway side, LTE and mobile broadband in general demands support for increasing traffic volumes.

With flat architecture, the gateway also plays a part in subscriber mobility transactions, while introducing more options in network topology. Another factor is that different services set different requirements on the network topology. Despite the majority of services being provided from the Internet, CSPs still need to stay in control of how network resources are used. The importance of both static and dynamic policy control is increasing in line with the rising usage of real-time services. Subscription types can be differentiated by enforcing policies governing bandwidth usage and charging.

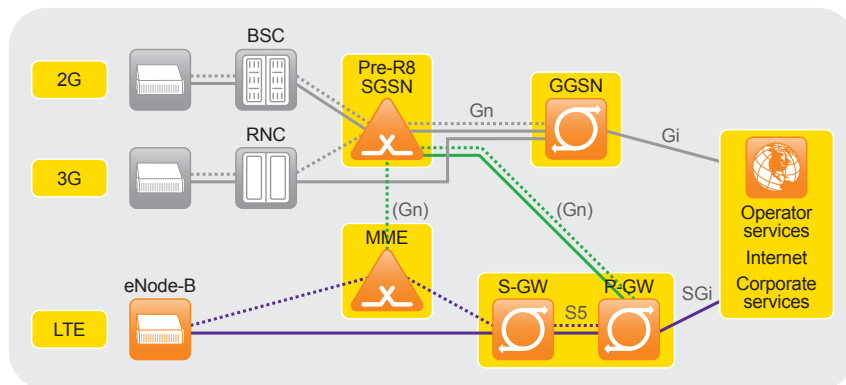


Figure 5. EPC deployed as overlay on top of existing 2G/3G network.

Stepwise migration to 3GPP R8 EPC

The key functions of the Packet Core network are to support subscriber mobility, to provide connectivity between the radio access network and the service networks and to serve as a centralized control point to enforce CSP business policies. 3GPP R8 allows CSPs to migrate from their existing Packet Core to EPC in smooth steps, ensuring the subscribers see no major disruptions as their network evolves.

EPC introduction with minimum changes to the existing pre-R8 Packet Core

Deploying EPC as an overlay allows LTE to be introduced with minimum changes to the existing pre-R8 Packet Core. According to 3GPP R8, the P-GW supports in-built GGSN functionality including Gn interface support. The Gn interface can also be applied between 2G/3G SGSN and a stand-alone MME element to support handovers between 2G/3G networks and LTE. In handovers between the access technologies, EPS bearers are mapped 1:1 to 2G/3G PDP contexts and vice versa.

As P-GW is the anchoring point for LTE subscribers, independently of which access network they use, connectivity must also be provided between 2G and 3G access networks and the P-GW.

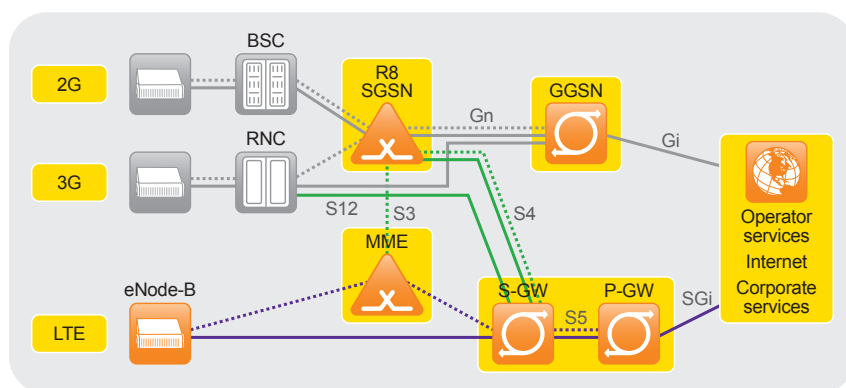


Figure 6. Upgrading existing 2G/3G network with 3GPP R8 interfaces.

Upgrading Packet Core to R8 level

3GPP introduces new interfaces between the network elements. Known as S interfaces, they form the basis of new feature development and improvements in 3GPP from R8 onwards. An example of the improvements is deploying GPRS Tunneling Protocol version 2 (GTPv2) in control plane signaling. In order to keep the 2G/3G packet core network aligned with the development, the G-interfaces must be upgraded to S-interfaces. For the 2G/3G SGSN, this means software upgrades to support the S3 interface with the MME and the S4 interface with S-GW.

Using the S3 interface makes intersystem mobility between LTE and 2G/3G networks more flexible. This allows bearer management according to 3GPP R8, including Dual Stack Bearer (IPv4/IPv6) support and EPS QoS support. The full set of R8 features, including local mobility anchoring for roaming users, minimizes the signaling load for the home network.

Towards a fully integrated R8 network

In the integrated scenario, all accesses including 2G/3G accesses use a common gateway, the 3GPP R8 S/P-GW.

With Direct Tunnel and S4 interface, the 3G SGSN is very tightly aligned with Evolved Packet Core architecture and can provide synergies when deployed in the same physical network element as the MME. According to 3GPP specifications, the handling of user plane and control plane traffic is tightly coupled in 2G SGSN and Direct Tunnel type optimization is not possible. This limits the synergy benefits that can be attained by deploying 2G SGSN in the same physical node as the MME. Many CSPs may find it best to continue using their existing SGSN for 2G traffic handling.

The common Gateway for 2G, 3G and LTE provides obvious synergies, yet the CSP may decide to upgrade existing GGSN to allow service access to LTE subscribers. In this scenario, low bandwidth services such as WAP browsing and MMS would remain in the existing GGSN, whereas high volume services such as Internet and corporate intranet access would be migrated to the S-GW/P-GW that also allows service access for 2G/3G subscribers.

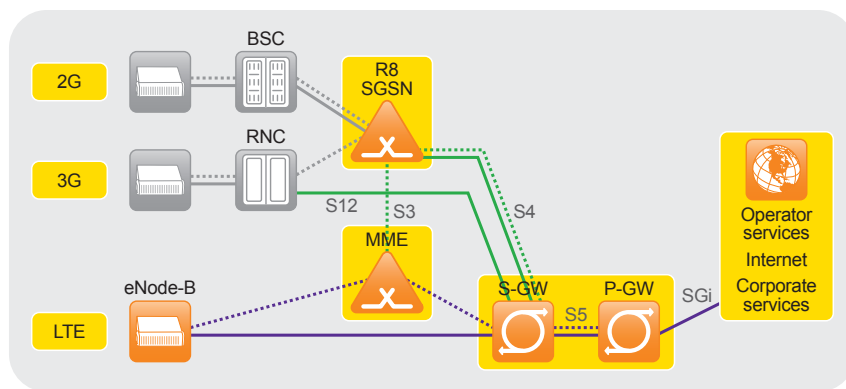


Figure 7. Common gateway for all 3GPP accesses.

Continuous support for services


LTE/EPC is designed to support all services, including the CSP's primary voice service. In order to achieve this, EPC bearers are always-on, allowing fast call setup and ensuring subscribers are always available for incoming calls. LTE radio interface provides more efficient radio usage for VoIP via maximized terminal battery lifetime and minimized latency. The flat architecture contributes to the optimized path for user plane traffic and minimal latency.

Ensuring continuity for voice service

Today, a CSP's primary voice service is provided over the Circuit Switched network. Primary in this context refers to the voice service that the user gets when picking up a mobile phone and dialing a number. The CSP may offer a secondary voice service comparable to Internet based VoIP services.

In an early phase of LTE deployment, the most commonly available terminals will probably be data cards for laptops. For this kind of terminal, the secondary voice service is offered with VoIP clients. When handheld LTE terminals become available, subscribers will expect the primary voice service to be available. The short to mid-term solution to provide CSP primary voice service to LTE subscribers is Circuit Switched Fall Back (CSFB), which is specified in 3GPP R8.

In the CSFB scenario, the end user terminal is simultaneously attached to both the EPS (MME) and CS (MSC) domain. When the user initiates or receives a voice call, the UE is moved from LTE to the 2G/3G CS network before the call is set up. The procedure is standardized in 3GPP R8.



Later, as LTE radio coverage increases, it becomes possible to consider offering the CSP primary voice service over the LTE network. LTE/SAE networks can support high quality voice, through:

- always-on connectivity allowing short connection setup times
- minimum latency on the transmission path and
- Quality of Service (QoS) management for both the voice media and associated Session Initiation Protocol (SIP) signaling.

When subscribers leave the LTE radio network coverage area, the active voice sessions must be handed over to another access network. If the CSP is already providing VoIP over HSPA service, the sessions can be handed over to the HSPA network.

For cases where the voice session is handed over from LTE VoIP to CS voice, 3GPP R8 specifies the so called Single Radio Voice Call Continuity (SRVCC) scenario. SRVCC is one directional, only allowing switching the current voice call from LTE to 2G/3G CS radio. The procedure of handing over a voice session to 2G/3G CS voice is standardized in 3GPP Rel-8.

Simultaneous voice and data sessions can be supported during handovers in a 3G network when the multi-RAB is enabled and in a 2G network when Dual Transfer Mode is enabled in both CSFB and SRVCC scenarios.

The ultimate aim is an all-IP network where IP Multimedia Subsystem (IMS) is the 3GPP standardized connectivity control machinery for voice and multimedia sessions.

Supporting messaging and WAP

WAP and Multimedia Messaging Service (MMS) are pure data services and can be supported today in LTE networks. For SMS there are two options:

- CS fallback based solution where the SMSs are sent and received between UE and MSC over an EPS network so that MME tunnels SMS over LTE and uses an SG interface with the MSC.
- Generic SMS over IP solution where IMS provides SMS support and EPS provides a bearer for SMS transfer.

Policy enforcement to manage growth

Evolved Packet Core has an essential role to play in keeping the CSP in control of network resources use by enforcing its policies. Policies are applied to enforce differentiation between subscribers and between services. An example of a subscription based differentiation is controlling the maximum access speed that the subscriber is able to retrieve from the network. When high quality real-time services, in particular CSP primary voice, are to be offered in the network, policies must be applied to guarantee the necessary bandwidth and minimum transmission delay for these data flows.

CSP tools to enforce policies include allowing, limiting or denying traffic flows according to the selected policy and applying charging control. The Quality of Service (QoS) level can also be differentiated based on the service or application accessed.

Policy control architecture

According to 3GPP R8, the Policy and Charging Rules Function (PCRF) acts as a centralized point to control policy and charging. PCRF provides the rules for the Policy and Charging Enforcement Function (PCEF), which resides in the mobile Gateway.

The benefits of deploying centralized policy enforcement in mobile networks are widely recognized, in particular because this strategy minimizes the number of network elements and thus also the OPEX costs. Traffic detection functionality is implemented in the gateway element together with all policy enforcement capabilities, in order to simplify network architecture and management.

Charging

Charging is an essential tool in enforcing CSP business models. When migrating the network from 2G/3G to LTE it is essential that continuity of the existing business models is supported for both packet switched and circuit switched services. In practice, this means supporting similar charging models independently of the deployed access technology.

Online charging control is generally deployed for both prepaid and postpaid subscriptions and the need to support this remains valid in EPC. By deploying online charging control for prepaid subscribers, the CSP can minimize fraud in service usage. Use cases for online charging control for postpaid users include companies that want to set limits on how much use their employees make of data services.

Flow based charging is generally applied in current 2G/3G networks and will also have applications in LTE networks. Examples are applying time based charging for VoIP calls and differentiating the charging of CSP provided services.

Enforcing fair use policies

Fair use policies allow the CSP to control the usage of network resources, ensuring fair sharing of available capacity among the subscribers. Fair use policies can be implemented by, for example, setting limits to the maximum access speeds and the maximum amount of data that the subscriber is allowed to consume during the subscription period. With automated interactive user dialogs, the CSP can encourage usage and sell more aspects and features to the subscriber.

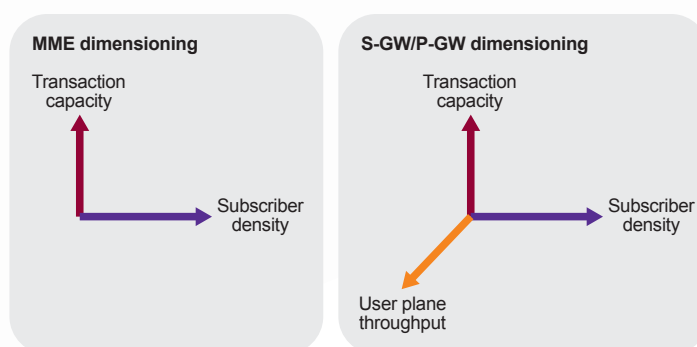


Figure 8. Dimensioning diagrams for MME and GW.

Dimensioning an Evolved Packet Core network

Evolved Packet Core dimensioning is fundamentally different from dimensioning a traditional 2G/3G GPRS network. 3GPP R8 mandates a flat architecture that causes a number of changes in the process of network dimensioning. MME dimensioning is simplified, as it is a pure control element dimensioned according to subscribers and transactions without the user plane traffic burden. With 3GPP R7, the same simplification can be achieved in current 3G networks.

As eNode-Bs are directly connected to the gateway in the user plane, all the mobility transaction events are directly visible to the gateway. The number of transactions will dramatically increase with the introduction of LTE where all the attached subscribers always have at least one active EPS bearer. With dedicated control and gateway elements, CSPs can adapt to the changes in usage patterns and traffic load in the network.

The key gateway dimensioning parameters are:

- throughput in Gbit/s to support non-real-time services and packets per second to support real-time services
- number of subscribers to allow high subscriber density
- number of transactions per second to support subscriber mobility

All these dimensions must be supported simultaneously and must scale independently of each other.

Nokia Siemens Networks is an end-to-end LTE/SAE vendor

Nokia Siemens Networks LTE/SAE offering covers the whole end-to-end system including E-UTRAN radio network, Evolved Packet Core, transport and backbone solutions, charging and subscription data management solutions as well as network management and services to design, build and operate the networks.

For Evolved Packet Core networks, we offer the MME and S-GW/P-GW functionalities on next generation Advance TCA (ATCA) platforms. We see the introduction of Evolved Packet Core as a timely development to upgrade the Packet Core elements to meet future needs. We also support a smooth evolution option to upgrade our current SGSN and Flexi ISN elements to 3GPP R8 with software.

Evolved Packet Core mandates MME as a dedicated control plane element. As the leading vendor for 3GPP R7 Direct Tunnel and having initiated it in 3GPP standardization, we were the first vendor to implement it. With the largest number of implementations in live CSP networks, we have gained a solid understanding and experience in implementing flat architecture networks, both of which are reflected in our EPC offering.

Rapidly increasing data volumes in mobile networks, the pressure to reduce the cost per transmitted bit and the prospect of eventually offering all services including voice over LTE/SAE networks are encouraging CSPs to exploit the greater efficiency of LTE. Such a key transformational shift requires a solution that ensures a high-quality end-user experience at an optimal cost.

Nokia Siemens Networks, with the largest customer base world wide, deep insights in packet core technology implementation and a driving role in 3GPP standardization, as well as close co-operation with Nokia, has a comprehensive, end-to-end view of LTE.

Conclusion

Evolution of terminals and networking technology coupled with Internet access as a global phenomenon are allowing advanced CSPs to report dramatic growth in mobile data usage. None of these three alone could have set off the boom in data services usage but the combination of all three have been fundamental to its growth.

3GPP R8 and LTE/SAE form a unifying evolutionary step for all existing mobile networks including 3GPP and 3GPP2 networks, as well as WiFi and WiMAX networks. EPC has an essential role in supporting the LTE radio network and in maximizing the return on investment made in the network. It is the link between existing networks and LTE, supporting subscriber mobility with service continuity across different network technologies. Serving as a centralized aggregation point for the traffic flows, the EPC is a natural policy enforcement point that allows the CSP to stay in control of network resource usage.

The key components of EPC are MME and S/P-GW. 3GPP R8 architecture allows the MME to be dedicated to handling control functions, essentially for supporting subscriber mobility transactions in the network. The Gateway must be designed to take into account the increased data volume and packet processing requirements, high subscriber density and the need to support mobility transactions in the flat architecture.

Introducing EPC in CSP networks is best performed in steps. By deploying a Direct Tunnel solution, CSPs can start migrating their networks towards 3GPP R8 architecture today. In the initial phase of EPC deployment, the MME and S/P-GW functionalities are implemented with an overlay solution, leaving the existing production network intact. Interoperability with the existing 2G/3G network can be introduced without any upgrades to the existing system. In the following phases, the 2G/3G network elements can be upgraded to 3GPP R8 level. The eventual target is a 3GPP R8 common core network where all accesses are served by a common gateway.

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