Handling of Voice and Data Services in the Evolved Packet Core

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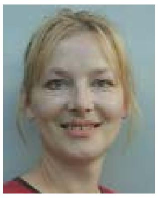

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The new cellular system from the 3GPP is commonly referred to as 'LTE' or '4G'. The system comprises a radio part, called evolved UTRAN (eUTRAN) and a core network part called the Evolved Packet Core. Together these constitute what is called the Evolved Packet System. In addition to supporting eUTRAN, the new all-IP core network includes a large number of new features and enhancements compared to the legacy mobile core networks. The new core network supports GERAN and UTRAN radio accesses and supports interworking with the legacy circuit switched domain. Non-3GPP networks, like Wireless LAN, are also supported, enabling the operator to offload the mobile macro network. Included in the new architecture is also the new policy- and QoS regime, opening for new services and being required to support voice calls in this new all-IP system.

1 Introduction to the Evolved Packet System

The Evolved Packet System (EPS) is a new wireless system standardized by 3GPP [3GPP], which was first introduced in Release 8. This release was finalized late 2008. It is the successor of UMTS and HSPA systems, aiming to fulfill the IMT-Advanced 4G requirements. The Evolved Packet System or 'LTE' will in the early stage of deployment mainly be a system for offering mobile broadband services. The first available terminals are USB-dongles for PCs. Later, handheld terminals supporting voice services will also be introduced.

The first commercial equipment is available already this year. 2010 will however be a year for testing and piloting for many operators. Only a few operators, such as TeliaSonera in Sweden and NetCom in Norway, start commercial offerings this year.

The core network is denoted Evolved Packet Core (EPC), while the radio access network is called evolved UTRAN or simply eUTRAN. However the expression LTE, which was the working title for the radio access network, is now commonly used for the whole system. To support LTE radio access, the new core network is required, but it is possible to upgrade to the new core network without deploying eUTRAN.

The advantage that LTE brings for operators over other competing systems (eg. mobile WiMAX), is that the system is designed to interwork with the legacy systems, enabling the operators to protect their investments in the 2G/3G networks and do a smooth upgrade to the new system.

1.1 Architecture

The Evolved Packet Core is a completely new core network, which in contrast to the 2G/3G systems is purely packet based, also known as 'All-IP'. Despite the fact that the Circuit Switched domain is discontinued in the new core network, interworking with this part of the legacy network is supported for transition purposes. The Serving GPRS support Node (SGSN) known from 2G/3G is kept in the new architecture, in order to support GSM/UMTS radio access.

The new system has a flatter architecture compared to legacy systems. There is no RNC entity anymore, and the MME is a signalling-only entity, similar to 3G Direct Tunnelling in the sense that the user plane and the control plane is split. A simplified system overview is shown in Figure 1.

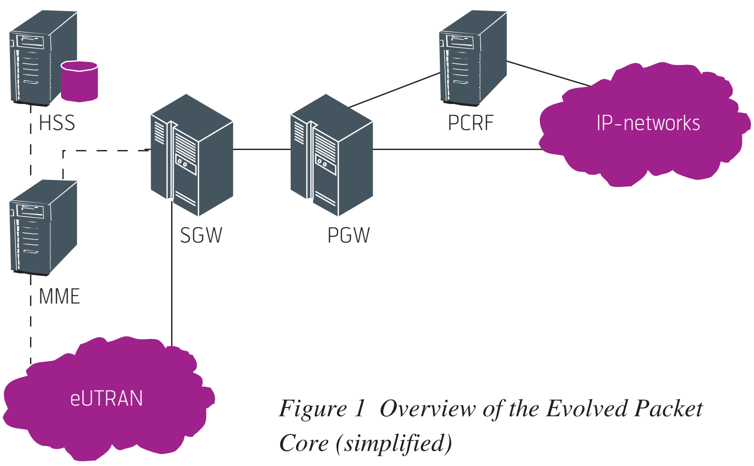

Figure 1 Overview of the Evolved Packet Core (simplified)

The Serving Gateway (denoted SGW in the figure), is the local anchoring point for the user plane, responsible for sending and receiving packets to/from the eNodeB where the terminal resides. This entity interfaces with the PDN-Gateway (denoted PGW in the figure) which acts as a router towards other IP networks, eg. IMS, Internet or others.

These two logical entities can, and in many deployment scenarios probably will be combined into one physical entity. This combined node is called an SAE

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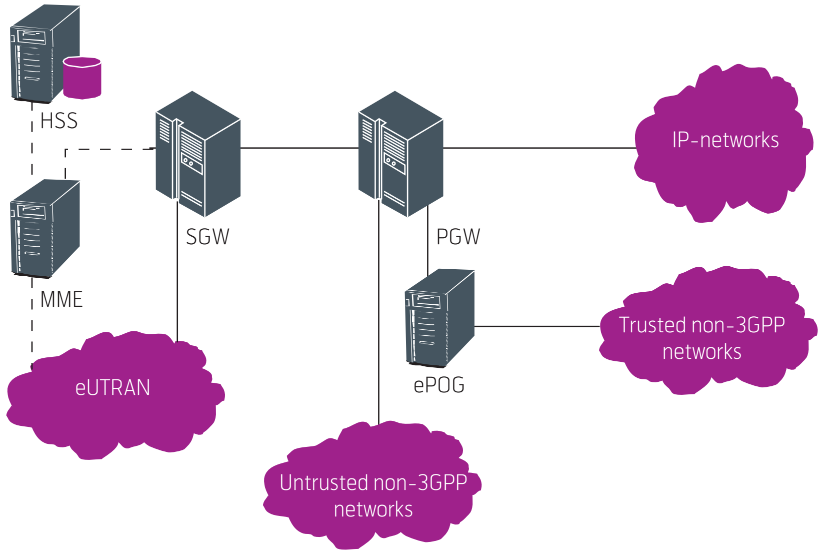

Figure 2 Interworking with non-3GPP access networks

Gateway and is comparable to a GGSN node in the legacy system.

The MME is, as already mentioned, a signalling-only entity, whose main purpose is to manage the terminal's mobility. In addition, it performs authentication, authorization and tracking of the terminal. It can be compared to an SGSN in the UMTS system when 3G Direct Tunnelling[1)] [TS 23.060] is used.

In the Evolved Packet Core, the customer database HLR, as used in GSM- and UMTS systems, is replaced by a new database called HSS (Home Subscriber Server). This is a mandatory network element; hence the old HLR cannot be used in the EPC. The new and enhanced security features also require the SIM card to be replaced by UICC/USIM. This identity module was introduced in 3G, but many operators continued to use the GSM SIM-cards, as this was allowed by the 3G system. For LTE this is no longer possible [Køien].

The PCRF (Policy and Charging Rules Function) is used for Policy and QoS functions in the Evolved Packet System and is an optional part of the architecture. The policy and QoS functions are described in more detail later in this chapter.

1.2 Non-3GPP Access Networks

The EPC supports interworking with non-3GPP access networks, meaning WLAN, WiMAX and others. While the support for WLAN in earlier releases was made as an add-on to the existing system, this support was intended from the beginning of the development of EPS, creating an access agnostic core network.

While mobility in the 3GPP domain (2G/3G/LTE) is based on GTP (GPRS Tunnelling Protocol) as introduced in GPRS [TS 23.060], the mobility management for non-3GPP accesses is based on different flavours of Mobile IP, such as DualStack MIPv6 and ProxyMIP, which originated from the IETF.

An overview of the architecture is shown in Figure 2. It has been defined so-called 'trusted' and 'untrusted' non-3GPP networks. The impact this has on the architecture is that the trusted networks are connected to the PDN Gateway directly, while the untrusted ones are connected via an entity called the ePDG (evolved Packet Data Gateway). This entity performs different functions related to IP addresses, security and mobility.

Whether an access network is regarded trusted or untrusted is solely an operator decision, it is not based on the characteristics of the access network.

While the mobility towards non-3GPP networks in the first release of EPC was non-seamless, seamless handovers to WLAN are now being standardized. This is based on a feature called IP Flow Mobility, which also originated from IETF. Utilizing this functionality the multi-radio terminal can utilize two networks simultaneously to do a 'make-before-break' handover. Furthermore, this functionality can be used to load-balance or utilize the best available network by moving the IP flows between the access networks seamlessly, and choose which IP flow to be transported using which network.

1.3 Policy and QoS Regime

Policy and QoS means the mechanisms available to differentiate traffic based on traffic type, operator policy, user preference and subscription. These features and the network entities to realize them are not mandatory; most early LTE networks will probably be deployed without them.

[1)] *Direct Tunnel is a feature for UMTS, introduced in Release 7. It enables the user plane to bypass the SGSN, making it a signalling-only entity. This will offload the SGSN.*

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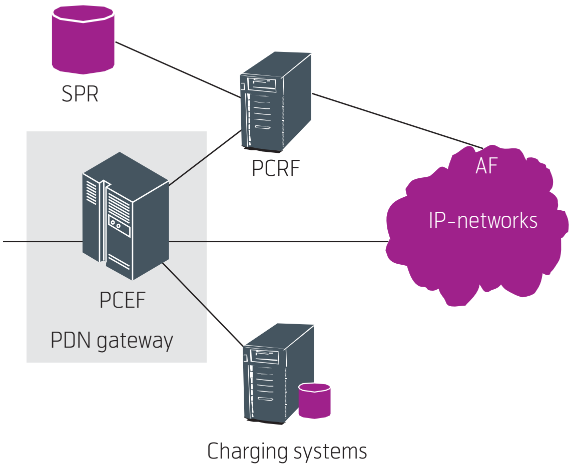

Figure 3 Policy and charging architecture

The policy and QoS regime in the Evolved Packet Core are more advanced and more sophisticated compared to what was specified in legacy systems.

In general, QoS is used to differentiate traffic. While some types of traffic have strict demands when it comes to eg. delay (like voice calls), other types of traffic can handle a larger amount of delay without degrading the quality (like email). For this reason it is necessary to give packets belonging to certain services higher priority and other packets lower priority.

Different mechanisms are specified to ensure proper quality of service in LTE. These are designed to work on a per-bearer-basis. These mechanisms apply to the radio network, specifically the scheduler in the base station, but this section will focus on the core network aspects. In addition to the default bearer (meaning best effort), there are specified dedicated bearers with guaranteed and non-guaranteed bit rate, called GBR and non-GBR bearers.

Nine different QoS classes exist, with their corresponding QoS Class Identifier (QCI). These state the characteristic of the stream when it comes to priority, packet delay budget and packet loss rate. Based on these characteristics, different packets will be treated differently in the core network nodes, and the QoS properties are mapped to the available QoS mechanisms on the transport network to the base stations (eg. DiffServ [DiffServ]).

The PCRF is the 'heart' of the policy system in the wireless system. It communicates with the PCEF (Policy and Charging Enforcement Function) in the PDN Gateway, the SPR (Subscription Profile Repository) and the AF (Application Function). The AF can be a third party application server or belonging to the operator's IP Services. The policy architecture is shown in Figure 3.

The PCRF includes policy control decision and charging control functionalities, deciding how different service data flows shall be treated in the PDN Gateway. The decisions can be based on the user's subscription, time of day, or request from the AF. The PCEF in the Gateway will enforce the decisions from the PCRF by the use of packet filtering. This can be realized by the use of DPI (Deep Packet Inspection). The PCEF further interworks with the charging systems, enabling charging based on volume, time, event or other parameters.

2 Services

Mobile broadband is clearly the main motivation for an operator to deploy LTE, but narrowband services like voice still have to be supported. With high-bandwidth mobile broadband, new service possibilities arise, enabling new revenue opportunities for the operator. More advanced services may be offered and voice can be bundled together with other services to offer richer communication services, such as video conferencing, text applications or other multimedia type of services.

2.1 Mobile Broadband Services

While the new radio access network can provide a bandwidth that is better than legacy systems by an order of magnitude, the new core network can be used not only to support the new radio network, but also legacy mobile networks and so-called non-3GPP access networks, eg. WLAN.

This allows the operator to combine the different access networks to provide a superior user experience in a cost effective manner. The principle known as 'Always Best Connected' can now become a reality. The user can always utilize the network which is best suited at any given time.

Based on traffic forecasts from eg. Cisco [Cisco], the global mobile data traffic will grow exponentially the next years. Figure 4 shows a Compound Annual Growth Rate (CAGR) of 131%; the traffic increases 66 times from 2008 to 2013. At the same time, the trend is that mobile broadband now is becoming flat-rate.

For the operator it will therefore be beneficial to carry the user traffic in best suited and less costly network. Often this will mean to offload traffic to WLAN when available. With the new core network, the operator is given the tools to do this.

Mobile broadband services have traditionally been best effort only. With the introduction of Evolved Packet Core, advanced mechanisms for QoS may be

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introduced opening up for differentiating on service quality. The operator may then offer premium services with high quality, and can add on to the price compared to best effort type of services. To some extent mechanisms for differentiation of traffic were available in HSPA networks as well, but operators have not utilized these to a large extent. How to avoid LTE becoming yet another bit pipe is something operators need to focus on in the years to come.

Most services available over the Internet are designed for best effort bearers and work well that way. Customers are also used to internet-based services being free to use. To sell a differentiated service, the operator will most probably need to have a business relationship with some kind of content provider. One example of such can be a content provider providing high quality real-time video that can utilize a better service. Non-realtime services can use buffering and therefore do not benefit from priority to the same extent.

Priority can also be offered to a third party conference system like Microsoft Livemeeting, where companies using that service might be willing to pay for differentiation. The operator would then have to accept revenue sharing with the content/service provider. However, considering this, care must be taken by the operator not to cannibalize on its own services, eg. by giving priority to a third party voice service, the use of operator's voice services could easily decrease.

2.2 Handling of Future Voice Services

Voice services, both fixed and mobile, have traditionally been Circuit Switched (CS). In the cellular networks voice has been separated from the data by utilizing one CS domain and one Packet Switched (PS) domain. However, as described in the first section of this article, the Evolved Packet System does not include a Circuit Switched domain like the legacy systems, and therefore new ways of handling voice are required.

Different techniques exist to support voice over LTE, but what they all have in common is that the voice service will be based on Voice over IP (VoIP). VoIP has been around for quite a while, however mainly for fixed networks. During the mid-2000s small fixed-VoIP companies started to emerge in Scandinavia following the growing ADSL penetration, offering voice calls at a much lower rate than the ISDN/POTS subscriptions. In Norway the number of fixed VoIP subscriptions is now 28% of the total fixed subscriptions [PT09].

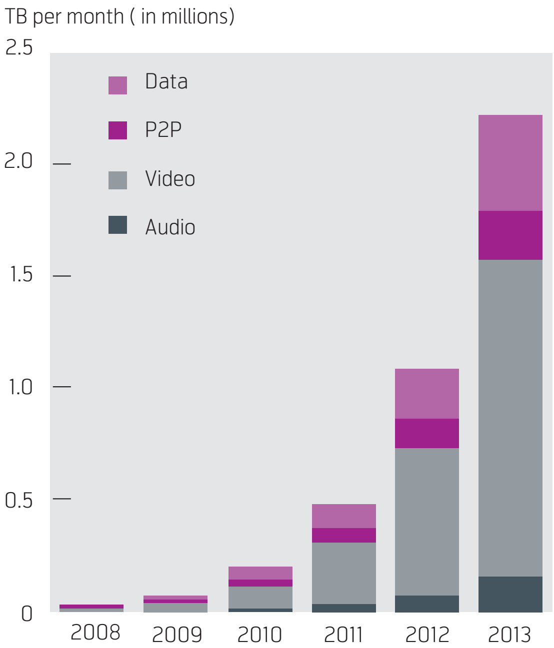

Figure 4 Global Mobile IP Traffic Will Grow at a CAGR of 131% [Cisco]

In the coming years mobile voice calls will start to be migrated to VoIP as well. While best-effort can be acceptable when using fixed broadband like ADSL, this is not necessarily the case when using a broadband radio access. For an operator to migrate the voice services to the PS Domain, it is crucial to be able to offer 'carrier grade' voice quality, meaning at least the same quality as experienced using legacy circuit switched voice. For that reason, different techniques have been specified to enhance the VoIP quality over best effort. Using the dedicated bearer with guaranteed bit rate and the appropriate QoS class as described earlier, voice will be prioritized over other traffic in the radio- and core network. To set up this bearer, dynamic policy control is required. This is realized using the Policy and Charging Rules Function (PCRF). The standardized long-term solution to handle VoIP over LTE radio access is known as 3GPP IMS MultiMedia Telephony and is based on IMS (IP Multimedia Subsystem) [IMS].

IMS is an access independent system that works towards different access types, eg. fixed network, UMTS, GSM, LTE, WLAN, etc. It consists of a service layer with interfaces towards application servers or service platforms, and a session control layer dealing with integration towards underlying access networks. Two essential features are required when IMS is used for VoIP; that is IMS Centralized Services (ICS) [ICS] and Single-Radio Voice Call Continuity (SR-VCC) [SRVCC].

In an early phase of LTE deployment, the coverage will be limited, and continuous eUTRAN coverage

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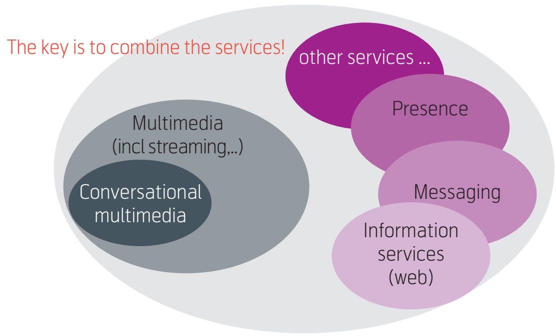

Figure 5 IMS used to combine services

will probably not be seen for many years. For that reason, service continuity for voice has to be implemented for users moving between LTE and 2G/3G coverage.

Single Radio-VCC is the mechanism which handles handover from packet-based accesses, eg. LTE and HSPA, to 2G/3G Circuit Switched for calls that are anchored in the IMS. The SR-VCC procedure uses IMS for call control and requires support of IMS Centralized Services. ICS enables CS connections to be incorporated in IMS sessions in a consistent way. ICS is needed to support supplementary services such as Call Hold and Call Wait, and can also be considered as a replacement of legacy IN functionality.

IMS has existed for several years in specifications, but is still lacking a large footprint. Operators are hesitant to install IMS at the same time as they are rolling out a new core and radio access network; nevertheless they want to offer voice services to LTE terminals.

For that reason operators plan to use other solutions, depending on the old Circuit Switched network. While CS Fallback [CSFB] only uses the eUTRAN for paging and handles the actual call using Circuit Switched 2G/3G, the solution from the VoLGA Forum [VoLGA] uses the LTE Packet Switched domain for the radio part, while the CS part of the network handles the call in the core. It is however expected that all operators will eventually migrate their voice services to IMS, and that the CS-dependent solutions can be regarded as intermediate.

Figure 6 RCS implementation

Lately, a new initiative has arisen called ‘One Voice’. This initiative does not aim to create a new standard, but instead make a ‘profile’, a subset of the existing IMS-based standards for VoIP. A large number of features and different options are specified in the IMS documents, making roaming and interworking between operators challenging. One Voice has a large number of supporters, making it a promising solution for the long term voice solution. Lately the GSM Association (GSMA) [GSMA] has undertaken the responsibility for One Voice, which will probably create even more momentum for this initiative.

2.3 Utilizing IMS and LTE for Enriched Services

The development towards All-IP is creating new opportunities for the telecom industry. More advanced voice services may be offered with packet switched technology. IP technology may be used to bundle together voice with other services to offer richer communication services, such as conferencing or multimedia type of services. Voice can be offered together with video and text applications over packet switched networks in a cost efficient way.

IP Multimedia Subsystem (IMS) is required for the standardized way of handling voice calls in LTE and to support voice handovers to legacy networks, but it will also be an enabler for this type of enriched applications. IMS is being deployed now in some operator networks. This can pave the way for new service offerings. With IMS the user is able to combine several media in one session, eg. text, video and voice, into a multimedia session.

LTE together with the new core network (EPC) handles high capacity, broadband type of services, for instance multimedia services such as video conferencing together with streaming and downloading in the background. Streaming of several movies over LTE/EPC at the same time has been tested with good results.

The Rich Communication Suite (RCS) initiative in GSMA is working with the objective of launching successful rich communication services. RCS is utilizing IMS for offering new/enriched services. Today, consumers are experiencing the power and the promise of enriched communication. Services and applications that have been introduced are buddy lists showing dynamically changing status and on-line capabilities. Different messaging options and possi-

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bilities of adding contents are just a few examples of this richer communication experience. Consumers may take for granted that these capabilities are available not only on a PC.

The following areas have been identified as being part of the RCS today:

- Enriched Call
- Enhanced Messaging
- Enhanced Phonebook

The introduction of enriched services opens up for new business opportunities and new revenue streams for an operator.

3 Benefits from the New Core Network

As described, the Evolved Packet Core is required in order to support LTE radio access, and this fact will probably be the main motivation for operators to upgrade their existing core network, along with the need for more capacity. There is however a number of features in EPC enabling the operator to create new revenues, save costs and offer a better experience to the user.

As the usage of mobile broadband increases, while the revenues are decreasing, cost effective solutions are required. Therefore the opportunity to offload the macro network will probably also be an important motivation for the operator to upgrade to the Evolved Packet Core. In this way the operator will be able to offer a good mobile broadband service while maintaining a sustainable business model. While offloading to WLAN networks was included in the standards already in release 6, the release 8 core network is the first to support this kind of interworking in a truly integrated way.

To direct the traffic to the best suited network, a feature called ANDSF (Access Network Discovery Selection Function) is introduced. Utilizing this functionality, the terminal can be notified about alternate available networks, without the demand for constant searching in the terminal, saving radio resources and battery life. The choice of access network can be based on both operator policy and user preference, or a combination of these. Combined with IP Flow Mobility and seamless offload to WLAN, this gives the operator powerful tools to create a cost-effective mobile broadband solution.

Introducing EPC – which is called an access agnostic core network, and IMS – which has been access agnostic since the beginning – this is an important step towards the idea of 'one core', meaning a common core network for *all* accesses. From the beginning it will be possible to attach WLAN, WiMAX and different cellular networks to the EPC, while using IMS to handle voice. Using IMS for call-control will also provide handover for the voice call when the terminal is moving between the different access networks. Using IMS, also fixed VoIP can be handled in the same core network using the same user database.

With the quality of service mechanisms including dynamic policy control in place in order to support VoIP services, these QoS functions can be combined with Deep Packet Inspection (DPI) functionality to prioritize, block or throttle different services and users, also depending on time of day and location, and even the access network used. This can enable the operator to save costs by throttling heavy traffic at the most busy hours/cells while ensuring that all users get their fair share of the resources. One example of a possible policy is that the operator can accept Peer-to-Peer (P2P) traffic only when the subscriber is using WLAN or using the macro cellular network outside of the busy hours, and in other situations block or throttle it.

In many markets the operator will not be allowed to block traffic, but throttling to ensure fair usage will in most cases be accepted. The operator's latitude in this context will be limited by regulations in the actual market and current subscriber contracts.

4 Summary/Conclusive Remarks

The Evolved Packet Core is a new and enhanced mobile core network which is required to support LTE radio access, but also brings a large number of new features that the operator can utilize. The EPC is all-IP, meaning that there is no longer a Circuit Switched domain, demanding new solutions for the legacy CS services such as voice.

The access-agnostic nature of EPC can be used to enhance the user experience and to create cost-effective mobile broadband solutions for the operator utilizing the enhanced offloading and traffic-steering possibilities. Using IMS, voice calls can be conducted using the IP-network and new, enriched services can be offered to the customers, creating possible new revenues for the operator.

In this new wireless system the QoS and policy mechanisms are more advanced and more sophisticated than what is known from the legacy systems. These are required to offer carrier grade voice services over the PS domain, while they also create new opportunities and possibly new revenues for the operator.

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In summary, the Evolved Packet Core can bring new revenue streams and lower costs for the operator and enhanced experiences for the users.

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