

Performance analysis and deployment of VoLTE mechanisms over 3GPP LTE-based networks

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LTE and LTE-A Interworking and Interoperability with 3GPP and non-3GPP Wireless Networks

¹Chris G. Guy, ²Myasar R. Tabany

¹ Prof., School of Systems Engineering, Reading University, Reading, Berkshire, UK

² MSc, Mobile Communications, School of Systems Engineering, Reading University, Reading, Berkshire, UK

¹ c.g.guy@reading.ac.uk, ² m.tabany@pgr.reading.ac.uk

ABSTRACT

This paper provides a high-level overview of E-UTRAN interworking and interoperability with existing Third Generation Partnership Project (3GPP) and non-3GPP wireless networks. E-UTRAN access networks (LTE and LTE-A) are currently the latest technologies for 3GPP evolution specified in Release 8, 9 and beyond. These technologies promise higher throughputs and lower latency while also reducing the cost of delivering the services to fit with subscriber demands. 3GPP offers a direct transition path from the current 3GPP UTRAN/GERAN networks to LTE including seamless handover. E-UTRAN and other wireless networks interworking is an option that allows operators to maximize the life of their existing network components before a complete transition to truly 4G networks. Network convergence, backward compatibility and interpretability are regarded as the next major challenge in the evolution and the integration of mobile wireless communications. In this paper, interworking and interoperability between the E-UTRAN Evolved Packet Core (EPC) architecture and 3GPP, 3GPP2 and IEEE based networks are clearly explained. How the EPC is designed to deliver multimedia and facilitate interworking is also explained. Moreover, the seamless handover needed to perform this interworking efficiently is described briefly. This study showed that interoperability and interworking between existing networks and E-UTRAN are highly recommended as an interim solution before the transition to full 4G. Furthermore, wireless operators have to consider a clear interoperability and interworking plan for their existing networks before making a decision to migrate completely to LTE. Interworking provides not only communication between different wireless networks; in many scenarios it contributes to add technical enhancements to one or both environments.

Keywords: LTE, LTE-A, Interworking architecture, GERAN, UTRAN, Diameter

1. INTRODUCTION

Long Term Evolution (LTE) [1] technology has become the target for most of the wireless operators moving towards Fourth Generation (4G) deployments. As user demand for mobile broadband services continues to rise, LTE and its ability to cost effectively provide very fast, highly responsive mobile data services will become ever more important. According to the Global mobile Suppliers Association (GSA) statistics [2], there are 371 LTE network deployments planned or in progress in 116 countries around the world. By the end of May 2013, GSA anticipates there will be 248 LTE networks. For many operators, LTE represents a significant shift from legacy mobile systems as it is the first all-Internet Protocol (IP) network technology and will impact the way networks are designed, deployed, and managed. LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) and advanced antenna techniques to maximize the efficient use of radio frequency spectrum with a purely Packet Switch (PS) EPC core network. In addition, the transition to IP has enabled LTE to support Quality of Service (QoS) for real time packet data services like VoIP and video conversation. The overall goal of 4G systems is to provide a converged network compatible with the Next Generation Network (NGN). Though the Release 8 version of LTE does not strictly meet the ITU requirements of a 4G system [3,4], its architecture and underlying technologies provide a solid foundation for the Release 10 LTE-Advanced system (LTE-A) [5]. LTE-A meets the full IMT-Advanced requirements and sometimes exceed them, including for example, 8x8 Multiple Input and Multiple Output (MIMO) technology,

Channel Aggregation (CA) up to 100 MHz, and Relay Repeaters (RR). Moreover, it supports a range of self-optimizing, self-healing capabilities that enable the network to execute tasks that in earlier technologies have been carried out manually. On the other hand, there are some cons for LTE and LTE-architecture. For example, Full upgrade is high expensive; new equipments will be needed to be installed which are also suppose to be expensive, any security concerns regarding the network architecture and the user equipments. The high mobility supported by these technologies includes real risks during transfer from home network and servers to someone else's. 3GPP has well established evolutionary networks schemes from 3GPP Release 99 to 3GPP Release 10 LTE-Advanced and in 3GPP Release 8 by introducing LTE as a separate overlay network, wireless operators become able to deploy and test an LTE network separately while minimizing impact to their existing UTRAN/GERAN packet networks and provide service to their subscribers. Nowadays, mobile operators will need to deal with specific challenges associated with LTE, such as interworking and interoperability with legacy 3GPP and non-3GPP wireless networks, ensuring end-to-end high QoS delivery to satisfy the desired end user experience (QoE), Furthermore, an interaction with the IP Multimedia Subsystem (IMS) for the delivery of multimedia services and voice will make sure that LTE will remain competitive for at least the next ten years. The goal of this work is to analyse the interworking and interoperable capabilities and requirements between the E-UTRAN EPC architecture and legacy GERAN (radio access network of GSM/GPRS) / UTRAN (radio access

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network of UMTS-based technologies W-CDMA and HSPA) and provide seamless mobility through non-3GPP wireless accesses such as WiMAX, cdma2000® EV-DO. Taking into consideration many heterogeneous networks constraints with regard to different data rates, handover procedures, billing strategies and authentication which are fundamentally different between these wireless networks. The rest of this paper is organized as follows. Section II gives a description of the LTE-EPC core network with the role of IMS and evolved Packet Data Gateway (ePDG) in the interworking architecture briefly. Section III describes the LTE interworking requirements and explains and analyses the LTE interworking with different wireless networks. Section IV introduces the LTE interoperability with 3GPP and non-3GPP wireless networks and Section V concludes the work.

2. THE LTE-EPC ARCHITECTURE

The LTE consists of two networks: the E-UTRAN and the EPC [6]. The result is a flat system characterized by its simplicity, a non-hierarchical structure for increased scalability and efficiency, and a design optimized to support real time IP-based services, higher data rates, and lower latency. Moreover, support for interworking with several wireless access technologies is provided. The EPC is a flat all-IP system consisting of six nodes: The Mobility Management Entity (MME), the Serving Gateway (S-GW), the Packet Data Network Gateway (P-GW), the Home Subscriber Server (HSS), the Policy and Charging Control Function (PCRF) and the evolved Packet Data Gateway (ePDG). It allows for interconnections to legacy 3GPP technologies via the S-GW and to non-3GPP technologies via the PDN-GW to ensure Inter-technology handover and roaming. The migration from GSM/UMTS to LTE is great step because these networks are fundamentally different, and this includes a migration from Circuit Switch (CS) based networks to all-IP purely PS networks.

2.1 The Role of Diameter Protocol in the Interworking Process

The design of the Diameter protocol was initiated by the 3GPP to be used for their IMS [7]. Diameter is a type of Authentication, Authorization and Accounting (AAA) protocol. LTE uses the Diameter protocol as a signalling protocol; operators usually use it to provide a seamless handover, which results in better user experience across different networks. Diameter helps in LTE interworking with a legacy networks, signalling conversion from Diameter to SS7/MAP includes scenarios such as roaming between LTE and UTRAN/GERAN networks, security handover and HLR subscriber authentication. However, the interworking of LTE and legacy elements, protocols and interfaces require the right kind of connectivity to guarantee a smooth transition and to deliver the promised cost reductions. Standard bodies such as 3GPP and GSMA have defined the InterWorking Function (IWF) (Fig. 1) [8] that specifies Diameter to SS7/MAP and vice versa for interworking. The IWF of Diameter/SS7-MAP solution enables seamless connection of LTE elements,

interfaces and protocols to legacy SS7, thereby delivering cost savings on the reuse of legacy elements by converting the Diameter (S6a, S6d, S13, Gy) to SS7 (Gr, Gf, Ge) during the handover and roaming scenarios. The IWF serves as a translator between Diameter messages and Mobile Application Part (MAP) messages and maps these messages to their final destination according to a session mapping table between Diameter and MAP.

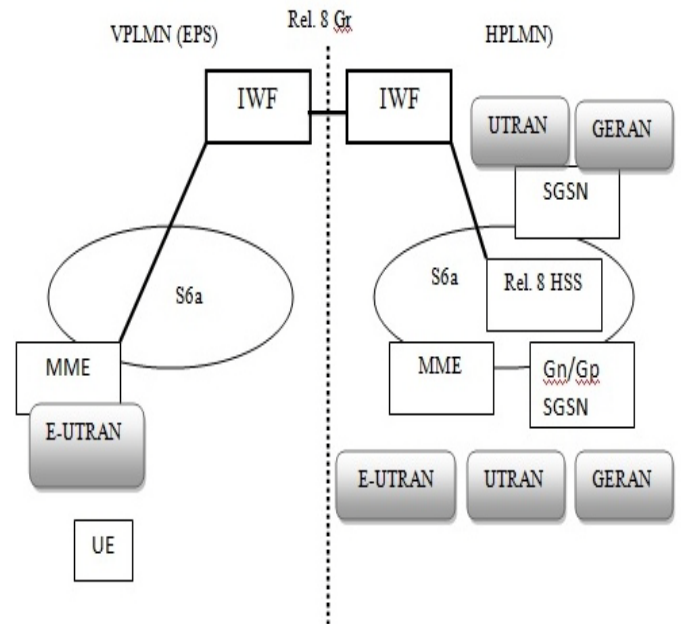


Fig 1: Architecture for IWF Scenario three network deployment: visited EPS with E-UTRAN only, home EPS with E-UTRAN and UTRAN/GERAN and Pre Rel8 UMTS/GPRS- Source 3GPP

2.2 The Role of IMS in the Interworking Process

3GPP developed a complete service network system for mobile networks, called IP Multimedia Subsystem (IMS) in Release 5 [9]. After that, many development and enhancement have been made to the IMS in term of interworking with other wireless networks in 3GPP Release 6 and beyond. IMS is a full Session Initiation Protocol (SIP) based control architecture that includes charging, billing and bandwidth management. As such, it defines its own formal interfaces with the IETF for any protocol extensions. Mobile operators will count on LTE to implement cost-effective network changes as preparation for IMS. The interworking between UTRAN/GERAN and LTE can enhance the system capacity for voice calls by utilizing IMS network capabilities. However, IMS was designed to support the IP6 address space but most of the 3GPP and non-3GPP networks only support the IP4 address space. In this case, IMS requires additional functions to deal with IP4 such as an IMS Translation Gateway (IMS-TrGW), an IMS Application Level Gateway (IMS-ALG) - IMS Access Gateway (IMS-AGW) [22]. These functions helps IMS to interwork with other non-IMS, different protocol stacks and IP address space wireless networks by providing transcending, IP4-IP6 media flow interworking and

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security, bandwidth control etc.. However, these functionalities may be not available in early IMS deployments.

2.3 The Role of ePDG in the Interworking Process

ePDG [10] is important node in the EPC architecture which is responsible for interworking between the EPC and untrusted non-3GPP networks (Fig. 2) that require secure access, such as Wi-Fi and femtocells. It will authenticate the UE with the 3GPP AAA server during tunnel establishment using the Extensible Authentication Protocol (EAP)/ AKA. The ePDG provides the local IP address.

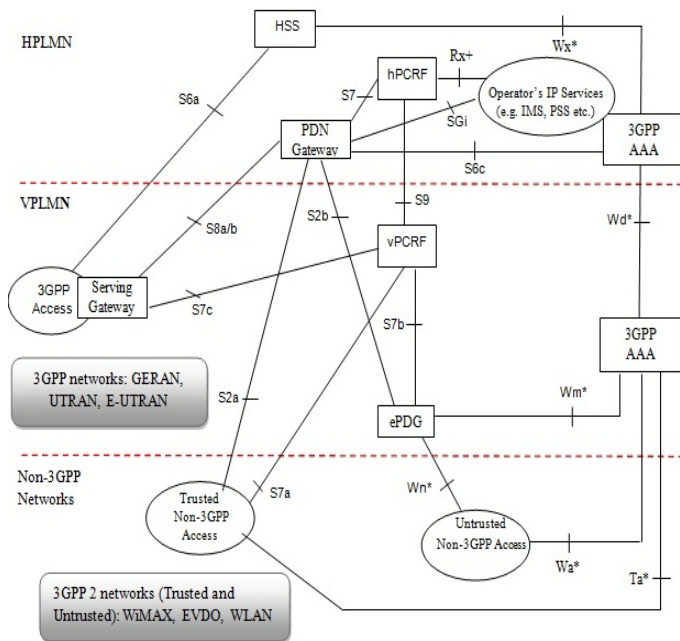


Fig 2: Architecture for E-UTRAN (LTE/LTE-A) Interworking with 3GPP and non-3GPP (Trusted and untrusted networks) (Roaming Scenario) - Source 3GPP

2.4 Backward Compatibility

Backward compatibility is an important characteristic of 3GPP standards, allowing phased upgrades and a choice of evolution paths for operators, for example, HSPA is backward compatible with W-CDMA systems, allowing operators to maximize returns from their W-CDMA investments. LTE and LTE-A are backward compatible with non-3GPP as well as 3GPP technologies [11], also there are backward and forward (for LTE) between themselves. Their ability to interwork with legacy and new networks, and the seamless integration of Internet applications will drive the convergence between fixed and mobile systems and facilitate new types of services. LTE has opened a new era with the transition from circuit switched approaches for voice traffic to a fully PS model. A key attraction of LTE for mobile operators is its inherent spectral flexibility through its variable carrier bandwidth. It can be deployed in many different frequency bands with minimal changes to the radio interface. The EPC has a network architecture

which simplifies connectivity with 3GPP and 3GPP2 technologies as well as IEEE based and fixed line broadband networks. This raises the possibility of migration from cdma2000® to LTE.

3. LTE INTERWORKING REQUIREMENTS

There are many requirements for interworking that need to be taken into consideration, driven by the constraints which have been mentioned before. The user expects to receive the same service level in both network environments, before and after interworking. The main requirements for LTE are firstly mobility support between two different networks, and the user needs to notify of service derogation during handover [13] [14]. Secondly, partnership or roaming agreements between an LTE network operator and any other network operator should give the user the same benefits (e.g. data rate, QoS) as if the interworking was handled within one network operator. Furthermore, a billing system between roaming partners must be handled. Finally, the subscriber database is also important and could either be shared or be separate for the two networks but sharing the subscribers' security association. The subscriber database could be a HLR/HSS (3GPP terminology) or an AAA server (IETF terminology).

3.1 The LTE-IEEE Based Networks Interworking

3.1.1 LTE –Wi MAX Interworking

Mobile Wi MAX using IEEE802.16e has excellent capabilities in regard to supporting high data rates, the essential QoS and mobility ability, in addition to offering a wide area of coverage. Interworking between this technology and LTE (Fig. 3) is considered as significant towards developing the 4G networks. 3GPP and mobile WiMAX access are integrated through the EPC; the 3GPP side uses S-GW for supporting this interworking while WiMAX uses P-GW for the same reason. The SGSN in the legacy network connects to the S-GW. A new entity in EPC called the Access Network Discovery Support Function (ANDSF) is used to help E-UTRAN discover the target access [12]. Since the mobile WiMAX and the LTE networks have different protocol architectures and QoS support mechanisms [15], protocol adaptation is required for their interworking. For example, with a Layer 2 approach, adaptation would be required in the Medium Access Control (MAC) layer for the WiMAX Base Station (BS) and LTE eNodeB. With a Layer 3 approach, the adaptation would be performed at the IP layer, and an LTE user would interact only with the corresponding LTE S-GW. This Layer 3 approach is preferred for WiMAX/LTE interworking, since LTE S-GW can fully control bandwidth allocation among the LTE users. The S-GW in LTE is responsible for the protocol adaptation up to the IP layer; modifications of LTE User Equipment (UE) and the WiMAX BS are not required. A new architecture deployed between these two new technologies will result in benefits to both mobile operators and subscribers. The interworking will provide high data rates, better performance and additional features

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and services to the subscribers in both wireless networks. The required LTE access network may be owned either by the WiMAX operator or by any other party, which then requires proper rules and Service Level Agreements (SLAs) set up for smooth interworking on the basis of business and roaming agreements between the LTE and mobile WiMAX operators. The interworking architecture is required to support automatic selection of the appropriate network, based on Mobile Terminal (MT) preferences. The main requirements for interworking that need to be taken into consideration are the requirements which are given Section II. The Mobility Management (MM) procedure should provide a mechanism to

minimize the service interruption time and support service continuity in addition to minimizing the impact on the legacy systems (GERAN, UTRAN) and the UE using the S14 interface. There are important interfaces to complete the interworking between the two wireless networks. For example S2a and S2c which are used to control and provide mobility with WiMAX because WiMAX is considered from the 3GPP point of view as a trusted non-3GPP wireless network. The S101 interface also plays an important role by connecting the LTE-MME with the WiMAX Access Service Network (ASN).

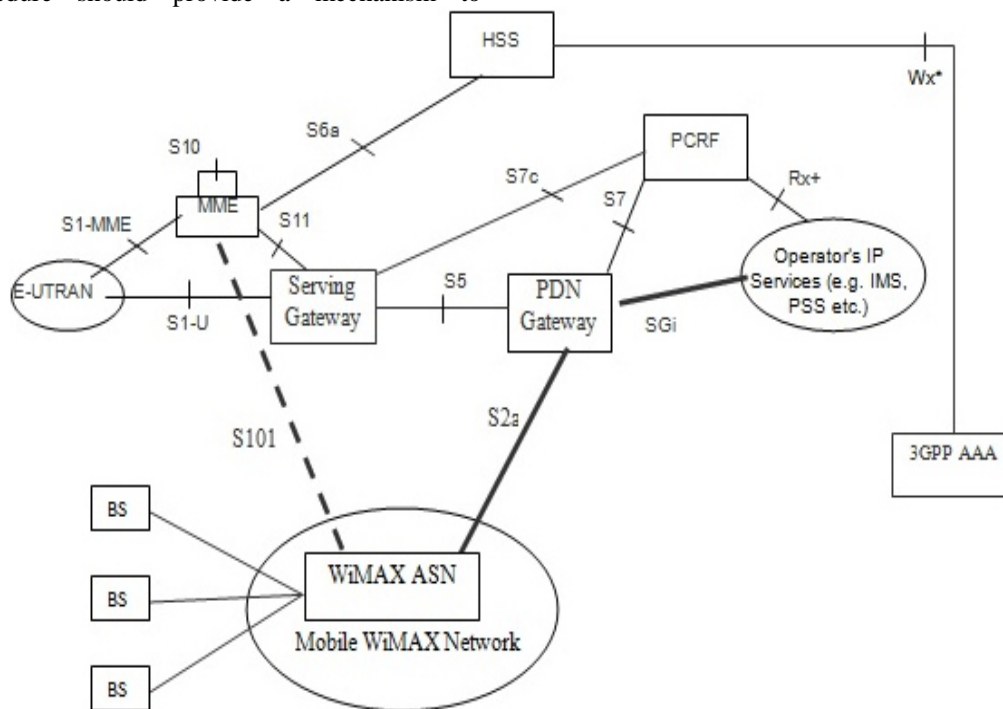


Fig 3: Architecture for E-UTRAN Interworking and Handover with Mobile WiMAX- Source 3GPP

3.1.2 LTE –WLAN Interworking

3GPP firstly developed an IMS-based network interworking mechanism with WLAN in 3GPP Release 6. The interworking of LTE and WLAN is very important to make wireless multimedia and other high data rate services a reality for mobile subscribers. A multimedia LTE/WLAN terminal can access high-bandwidth data services where WLAN coverage is offered, while accessing wide area networks using LTE in other places. To make multi-access solutions effective, we need an integrated solution to provide seamless mobility between these access technologies, allowing continuity of existing sessions. LTE/WLAN integration promises to offer these capabilities seamlessly. The 3GPP has defined an interworking architecture between LTE and non-3GPP, classifying the non-3GPP as trusted and untrusted networks. In the context of LTE/WLAN interworking, the 3GPP considers the WLAN as an untrusted network since it is using unlicensed radio spectrum. This is why when integrating these two technologies, more functional entities have to be added in order to enforce the security mechanism between them. The network elements added to

the WLAN network are a WLAN Access Gateway (WAG) and a Packet Data Gateway (PDG) [17]. WAG allows a visited LTE network to generate charging information for users accessing via the WLAN access network, in the roaming case. The WAG filters out packets based on unencrypted information in the packets. PDG accepts or rejects the requested WLAN access point name (W-APN) according to the decision made by the 3GPP AAA Server. The PDG basically behaves as a Gateway GPRS Support Node (GGSN) for WLAN users. It can use Wi-Fi hotspots to help the interworking between LTE and WLAN [16]. In this case, the interworking can provide better security and mobility but the mobile operators have to invest in a large number of Wi-Fi hotspots, to ensure a good user experience. The UE accesses the P-GW directly through the operator owned Wi-Fi hotspot using the S2a interface. The UE accesses the P-GW through the ePDG using the SWn (toward non-3GPP network) and S2b interfaces. The UE has to setup a secure tunnel with the ePDG through the untrusted WLAN network over the SWu interface (toward the UE).

Note that in the roaming scenario the ePDG resides in the VPLMN.

4. LTE-3GPP BASED NETWORKS INTERWORKING

Most existing cellular operators are likely to phase-in LTE over a period of time with initial deployments being made in areas of high demand, such as urban cores. Service continuity, mobility, handover and roaming between LTE and existing pre-Release 8 3GPP networks are critical to obtain a seamless user experience.

4.1 LTE –UTRAN/GERAN Interworking

Many of the wireless operators have existing UTRAN/GERAN networks and they want to keep them prior to fully upgrading to LTE. They prefer to interwork their networks with LTE network so LTE will be an overlay in their current architecture. So MMEs and the EPC gateways need to develop the pre-Release 8 signalling and bearer interfaces, acting like the existing SGSNs and GGSNs, to support handover between the networks. In the case of using Direct Tunneling, then an additional interface is required from the P-GW to the RNC without connecting to the SGSN. The bearer path connecting the E-UTRAN and UTRAN networks (Fig. 4) is between the P-GW and the SGSN.

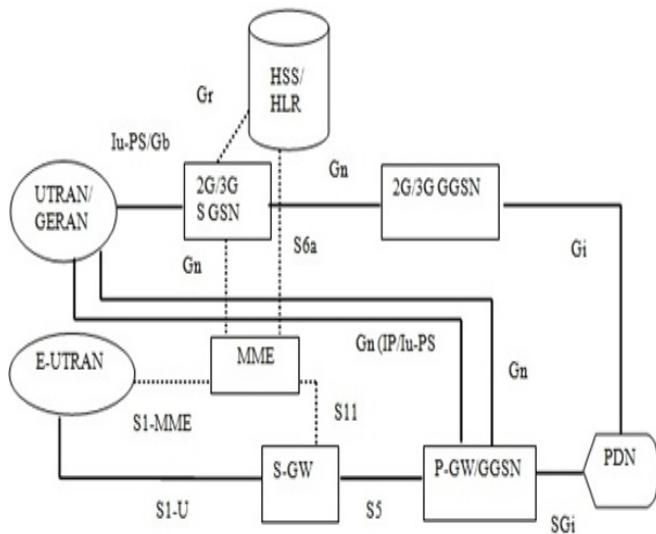


Fig 4: Architecture for E-UTRAN Interworking with GERAN/UTRAN (Pre-Release 8)-Source 3GPP

There is no change required for WCDMA in this interworking, the LTE-EPC starts a handover with the existing network and looks like Inter-SGSN relocation. The key interfaces involved in this Inter-RAT handover are: the Gn signalling interface between the source MME and the target SGSN, the enhanced Gr authentication interface between the target SGSN and the HSS/HLR, the S6a interface from the HSS/HLR to the MME, the signalling interface between the target SGSN and the source P-GW (Gn/Gp) [18], and the Direct Tunnel User

Plane interface between the target RNC and the source P-GW (Gn/Gp). All of the Gn/GP interfaces utilize GTP. Separate EPS bearers for IPv4 and IPv6 addressing are recommended for the pre-Release 8 W-CDMA network so that both can be maintained when handover occurs. The handover mechanisms between an LTE network and a pre-Release 8, GERAN A/Gb network are very similar to the above Inter-RAT E-UTRAN to UTRAN procedures, since the Gn/Gp SGSN is used to facilitate the handover in both packet networks. From the GERAN network perspective; the I-RAT handover appears as Inter-SGSN relocation with the source eNodeB assuming the role of the source RNC, the MME assuming the role of the “old” SGSN, and the P-GW acting as the GGSN. As before in the preparation phase, the source eNodeB determines that a handover to the GERAN A/Gb mode network is required. As with the previous option, this interworking requires no changes to the existing UTRAN/GERAN networks and the preparation phase and execution phases of the handover procedures are very similar. Finally, the option of adding a LTE overlay network onto a Release 8 network provides the best user experience with seamless mobility across all three radio technologies.

5. LTE-3GPP2 BASED NETWORKS INTERWORKING

5.1 LTE –HRPD/ EV-DO Interworking

Seamless transition between 3GPP2 based cdma2000® and LTE is required to provide interworking between them. This interworking provides current subscribers in 3GPP2 based cdma2000® more new features. Here, in order to make the interworking between cdma2000® High Rate Packet Data (HRPD) and LTE, many interfaces are introduced such as S101, S103, and S2a [12] to realize the interworking between them (Fig. 5). The Packet Data Serving Node (PDSN) is split into HRPD Serving Gate Way (HS-GW) and PDN-GW. Following is a brief description of the new required interfaces [13]:

- S103: A bearer interface between EPC S-GW and HS-GW, which is used to forward the downlink data, minimizing the packet loss during the transfer from LTE to HRPD.
- S101: A signaling interface between MME and HRPD AN, which allows a UE to tunnel HRPD air interface signaling over the LTE system to make preregistration and exchange handover signaling messages with the target system before the actual handover.
- S2a: An interface between PDN-GW and HS-GW, which provides control and mobility support for the user plane. HRPD enables Inter-technology handover between LTE and EV-DO networks based on HRPD. It also enables roaming for LTE subscribers on EV-DO networks and enables common applications to be used across EV-DO and LTE Access.

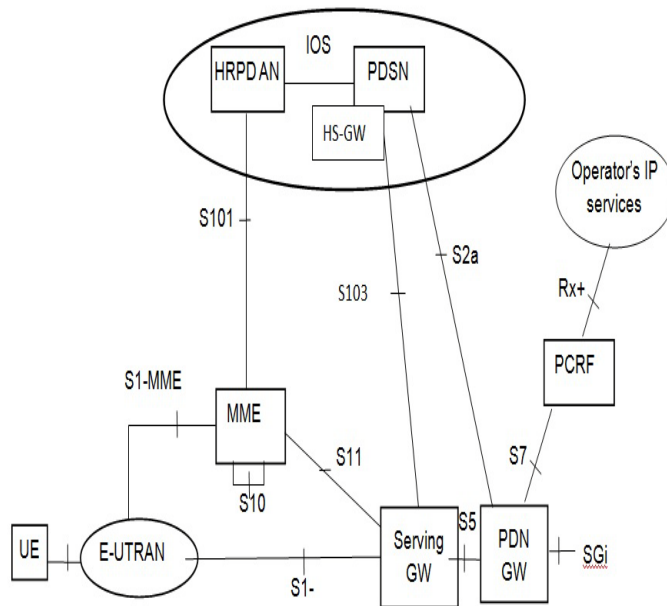


Fig 5: Architecture for E-UTRAN-HRPD Interworking and Mobility- Source 3GPP

6. LTE INTEROPERABILITY

Interoperability provides end to end solutions, enhanced features and cost effectiveness, by interconnecting components of different networks together. Networks operators and subscribers both benefit from interoperability. Moreover, interoperability can offer network providers with the possibility to switch between alternative wireless accesses networks [21]. This feature provides the capability to automatically roam onto a visited network, have access, and share appropriate information or services as authorized. The early mobile generations such as 1G, 2G do not provide this feature. The E-UTRAN provides high interoperability with other wireless networks such as 3GPP UTRAN/GERAN and non-3GPP wireless networks. These networks can integrate with LTE network through some standardized interfaces for example, S1-MME, S1-U and SGi. These interfaces allow E-UTRAN to connect with Serving GPRS Support Node (SGSN) in case of 3GPP and PDSN in case of 3GPP2. The P-GW serves as a mobile anchor for interworking with non-3GPP technology such as cdma2000® and WiMAX. It uses the Mobile Internet Protocol (MIP) to support Inter-technology mobility between LTE and Wi-Fi and also between EV-DO and WiMAX. As a result, subscribers from one network should be able to seamlessly roam for voice, SMS and data to another network. This utilizes IP in its most completed form with converged voice and data capabilities as a way of providing interoperability between different generations of wireless communication and Inter-technology mobility using LTE.

6.1 LTE Handover and Inter-technology Mobility

Inter-technology Mobility is important in LTE to provide high interoperability with other wireless networks. It supports seamless connection and handover between LTE and 3GPP legacy as well as non-3GPP wireless networks. There are two main types of Inter-technology Mobility [13]: Inter-Rat mobility which is the mobility between LTE and different Radio Access Technology (RAT) 3GPP technologies. The other one is Inter-technology Mobility between LTE and non-3GPP networks. LTE provide three handover possibilities, The Intra-LTE handover which happens inside the current LTE nodes using X2 or S1 interfaces such as intra-MME and Intra-SGW handover; the Inter-LTE handover which happens between one of the LTE nodes towards other LTE nodes using S1 interface such as Inter-MME and Inter-SGW; And the Inter-RAT handover between different Radio Access Technology networks (RATs), for example UTRAN/GERAN and LTE [13].

6.2 E-UTRAN-UTRAN/GERAN Interoperability, the role of Idle state Signaling Reduction (ISR)

E-UTRAN interoperability with legacy UTRAN/GERAN results in extending their life. It is provided through supporting the signalling and connection between SIP in the E-UTRAN side with SS7 in the UTRAN/GERAN side. PS-domain handover between E-UTRAN and UTRAN/GERAN should be supported also. Here the new mandatory mechanism called Idle state Signalling Reduction (ISR) which allows the UE to remain simultaneous by registered in an UTRAN/GERAN Routing Area (RA) and an E-UTRAN Tracking Area (TA) list [19]. This case usually happens when the ISR feature is activated in the UE and the UE attaches and registers in one of the networks and then moves to another (e.g. E-UTRAN to UTRAN/GERAN or vice versa). Consequently, there is no need to perform the TAU or RAU procedure frequently. In the LTE-legacy Inter-RAT handover, the source e-NodeB connects to the MME and SGW while the target RNC connects to the SGSN and SGW; both the source and target S-GW connect to the same P-GW. This procedure is divided into Preparation and Execution. In the Preparation phase, resources are reserved in the target network. While in the Execution phase, the UE is handed over to the target network from the source network.

6.3 Interoperability between WiMAX and E-UTRAN

Interoperability between E-UTRAN (LTE and LTE-A) and WiMAX is very important. They complement each other; both of them are Fourth Generation (4G) candidates. Moreover, the WiMAX core network is IP based and that helps to interconnect easily with other IP based core networks like LTE and LTE-A. Furthermore, WiMAX supports IMS and this gives it more flexibility to interconnect with E-UTRAN and its core network EPC easily. These similarities in characteristics give the whole interconnecting between these two wireless networks many benefits. This is in terms of roaming and other services provided to the end user. WiMAX can interconnect with LTE-TDD and LTE-

FDD as well, although the TDD in both cases is not same. This is the reason why frame synchronisation is required during deployment of the overall process [21]. There are two methods for WiMAX networks to interwork (Fig. 6) and provide interoperability with other wireless networks such as LTE [20]:

- **Loose Coupling Architecture:** WIMAX-GW and LTE- MME are connected indirectly using an external IP network. This type of architecture allows for WiMAX deployment gradually with little impact and modification to the LTE network. It also provides flexibility and independence for each network. However, this architecture increases handover latency between the two wireless networks.
- **Tight Coupling Architecture:** WIMAX and LTE are connected as one LTE radio access network. The major benefit from this architecture is to reduce the handover latency between the two wireless networks.

It is highly recommended for the seamless interoperability between any heterogeneous networks to use an efficient network selection mechanism. This can help user to choose a suitable network which support their required QoS.

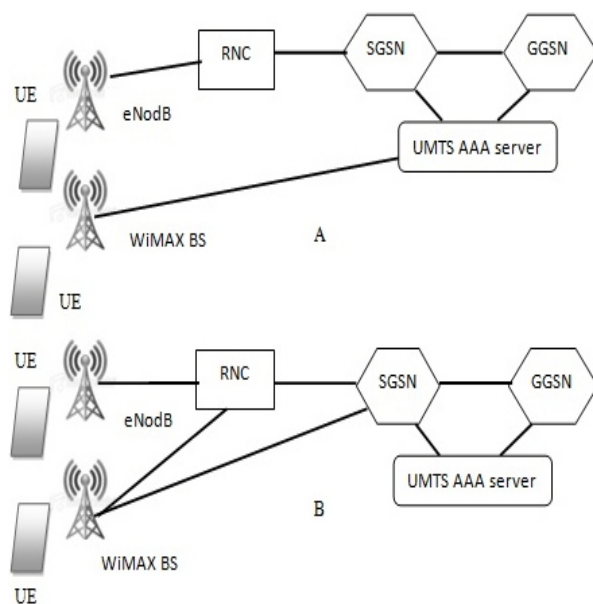


Fig 6: Architecture for Loose coupling Vs Tight coupling in Mobile WiMAX [23]

7. CONCLUSIONS

This paper has presented a study on the interworking and interoperability between LTE/LTE-A, 3GPP and non-3GPP wireless mobile networks. The study has been focused on the role of LTE-EPC architecture and its interfaces to provide seamless interworking and handover. As wireless operators begin the process of evolving their existing 2G, 3G and other networks to LTE, a new all-IP EPC will be required to support the

network and to deliver the performance and QoE and provide required connection flexibility. With this transition to LTE, interoperability and interworking with the existing wireless mobile networks will be required so that seamless handover occur can across the wireless operators own networks as well as when LTE services roam across both trusted and untrusted networks. Deploying IMS with LTE in addition to ePDG and SIP based control architectures on broadband wireless IP-based LTE is a natural fit for the EPC to support interoperability and interworking with the legacy wireless accesses. Interworking mechanisms are of prime importance to achieve ubiquitous access and seamless mobility in heterogeneous wireless networks and help them shorten the time needed to bring new applications to profitability. The study showed that interoperability and interworking between existing networks and LTE/LTE-A is indispensable while wireless operators plan to move their existing networks completely to 4G.

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