ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2015

Seamless Mobility Management in Next Generation Hybrid Networks

Suhas G K, Dr. D. Jayaramaiah

M.Tech, Dept of ISE, The Oxford College of Engineering, Bangalore, India.

HOD, Department of ISE, The Oxford College of Engineering, Bangalore, India

ABSTRACT: In this review paper, the mechanisms of interoperability between Long-Term Evolution (LTE) and mobile WIMAX networks are introduced. LTE and WiMAX are emerging wireless access technologies of next generation mobile networks, where making the mobile users interoperating LTE and WiMAX smoothly with service continuity is the major concern. Effective and efficient Multimedia services such as Voice and Video services can be provided to mobile users with reduced Delay and Packet drops. The parameters such as Handover delay for voice and video services and number of packets dropped in downlink and uplink are obtained.

KEYWORDS: LTE, WiMAX, HandOver, Multimedia services, Seamless mobility.

I. INTRODUCTION

With rapid developments in the field of Mobile communication and wireless access technologies across different generations of networks, the mobile user has to be given the best services without any interruptions. The fast-changing mobile landscape and convergence in all aspects of telecommunications, interoperability is important for any technology to succeed. Operators and consumers both benefit from interoperability in terms of cost effectiveness, enhanced features, location independence and ease of use [1,2].

The main challenges of seamless mobility is the availability of efficient horizontal and vertical handovers (HHO, VHO). The handover which occurs between two networks using the same technology is called horizontal handover (HHO), for example WiMAX-to-WiMAX or LTE-to-LTE handovers [3], whereas the handover happening between different technologies is called vertical handover (VHO), for example LTE-to-WiMAX handover or vice versa [4].

LTE advanced [5] and mobile WIMAX [6] are measured as the strongest two candidates of 4G systems. LTE and mobile WiMAX have many similarity but also some major differences, e.g. in the air interface used in the uplink (SC-FDMA and OFDMA respectively) and in the length of their sub frames (1msec. and 5 msecs. respectively). WIMAX possesses independent RAN to enable seamless interoperability with 3GPP (LTE) networks and existing IP operator core network. WIMAX can offer 70 Mbps peak data rate depending on spectrum allocation. LTE is able to offer more than 300 Mbps peak data rate downstream.

4G systems present new challenges and requirements in terms of spectrum limitations, architecture scalability and reliability or broad service abilities. Both next generation telecommunication networks meet these challenges with similar approaches. As LTE, WiMAX uses OFDMA for the wireless connection to its subscribers. In addition, the WiMAX network is based on a flat all-IP architecture.

II. CHARACTERISTICS OF LTE AND WIMAX

Long Term Evolution – LTE also known as “Evolved UTRA and UTRAN”, which is a 4G radio access technology intended to increase the capacity and speed of mobile phone enabling greater bandwidth flexibility, modulation and access schemes. In general, the LTE standards define two types of inter-technology mobility are :

- Inter-RAT (Radio Access Technology) mobility: The Mobility between LTE and earlier 3GPP technologies.

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- Inter-Technology mobility: The Mobility between LTE and non-3GPP technologies.

Inter-technology mobility is the key feature of smooth handover, which eventually results in interoperability. Seamless handover is one of the obligatory issues of interoperability. In LTE there are three types of handovers:

- Intra-LTE: The Handover happens within the current LTE nodes (intra-MME and Intra-SGW)
- Inter-LTE: The Handover happens toward the other LTE nodes (inter-MME and Inter-SGW)
- Inter-RAT: The Handover happens between different radio technology networks, for example GSM/UMTS and UMTS. All the special and differentiating characteristics of LTE are summarized in Table 1.

A flat architecture is substantial to realize the main targets of LTE development. Hence this flat architecture require less nodes, which lead to lower delays and a higher reliability. Therefore 3GPP LTE Release 8 introduces only three different types of nodes. As prior telecommunication networks LTE divides these nodes into two different planes.
The SAE GW (System Architecture Evolution Gateway) operates in the user plane (UP), whereas the MME (Mobility Management Entity) is used in the control plane (CP). The eNodeB provides functionality in both planes.

Table 1: Features of LTE

Features	Description
OFDMA for DL	To achieve high peak data rates
SC-OFDMA for UL	To achieve high peak to average ratio(PAR)
Bandwidth	Better channel bandwidth
Spectral efficiency	Increased Spectral Efficiency
Modulation	64QAM
Duplexing	Both TDD and FDD profiles
Access Network	Flexible
UE	Simplify Rx design in UE for high-speed data
Antenna Type	MIMO UL & DL
Interference	Overcome Multi-path Interference
Link Capacity	Increased Link Capacity
Flat IP	To support voice in the packet domain
Latency	Low Latency
Interoperability	Flexible
Mobility	Inter-technology Mobility, MobileIP based IP Mobility
Transport	Backhaul based on IP / MPLS transport
Applications	Ensuring Applications at lower cost like *Peer to peer application requiring high throughput *Online gaming *Fits with IMS, VoIP, SIP

WiMAX is the hottest broadband wireless technology. WiMAX systems are estimated to deliver broadband access services to residential and enterprise customers in an economical way. WiMax is a standardized wireless version of Ethernet intended primarily as an alternative to wire technologies (such as Cable Modems, DSL and T1/E1 links) to provide broadband access to customer premises. WiMAX is an industry trade organization formed by leading communications, component and equipment companies to promote and certify compatibility and interoperability of broadband wireless access equipment that conforms to the IEEE 802.16 and ETSI HIPERMAN standards.

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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Vol. 3, Issue 4, April 2015

WiMAX would operate similar to WiFi but at higher speeds over greater distances and for a greater number of users. WiMAX has the ability to provide service even in areas that are difficult for wired infrastructure to reach and the ability to overcome the physical limitations of traditional wired infrastructure.

Mobile WiMAX defines only the MAC (Media Access Control) and the PHY (Physical) layer protocols. This covers among other things functions for network selection, mobility support, QoS signaling and management or power management. However, IEEE 802.16 does not have any support for a further End-to-End architecture. Therefore the WiMAX Forum [15], which ratifies the standards, set up the Network Working Group (NWG) that worked beyond IEEE 802.16 and developed the WiMAX End-to-End Network Architecture. There are certain similarities between the LTE architecture and the WiMAX architecture. As in LTE the WiMAX network architecture is an all-IP approach. As figure 5 shows, the high level WiMAX Network Reference Model (WiMAX NRM) differentiates between Network Access Providers (NAPs) and Network Service Providers (NSPs). A NAP provides radio access infrastructure. Whereas, the NSP provides IP connectivity and services to subscribers. The basic architecture consists of three logical entities.

III. RELATED WORK

A. *Initial Network Selection(INS):*

In this section, an approach is developed for INS of one of the following two interoperating networks: the LTE network as cellular wide area coverage and the WIMAX network as Wireless Medium Area coverage Network (WMAN). This approach, a basic element of interoperability process between these two heterogeneous networks, is based on cost function criteria and covers all possible selection key factors.

The basic INS key factors are defined as follows:

- Terminal Type Factor: Laptop is better served by the WIMAX network than the LTE since laptops have a high probability of use in accessing Wireless systems as they replace workstations in office environments and are equipped with wireless access points that enable wireless access in general.
- Speed Factor: The two networks are differently adapted to user speed; the WIMAX network is adapted for speeds from 0 up to 100 Km/h where the LTE network is adapted for speeds from 0 up to around 350 Km/h [12].
- Network Connection History Factor: If one network's history shows significant number of connection failure for the current user or previous users due to some shortcoming or unstable circumstances then the user is preferred to join the other network.
- Traffic Load Factor: The user should be assigned to the network which has free resources. This is achieved if the selected network load is less than a predefined threshold. The goal is to achieve traffic balance between the two networks.

B. *Inter Network Handover(INH):*

INH between LTE and WIMAX networks based on a simplified cost function evaluation. The cost function covers all possible handover key factors. The basic internetwork handover key factors are presented for a specific coexisting deployment scenario of the two networks. The cost function for INH decision and the metrics needed for performance evaluation are also produced.

The basic key factors needed to make the decision for triggering the internetwork handover (INH) between the WIMAX and LTE networks are introduced. The CF is the summation of weight values, each assigned to one of the key factors. INH is triggered if the CF exceeds a pre-defined threshold (INH-threshold). INH requests are rank ordered in a priority queue according to their CFs' values. The effects of each factor and weight assignment are discussed in details as following:

- Carrier-to-Interference ratio (C/I) factor: The C/I is the factor considered to assess the signal quality of the user. The interference considered consists of thermal noise, intrasystem (intra and inter-cell) interference.
- Speed factor. The two networks are differently adapted to user speed are WiMAX and LTE users.

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International Journal of Innovative Research in Computer and Communication Engineering

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C. *Vertical Handover Mechanism:*

The handover is process which allows the mobile users to continue their ongoing sessions even when they are moving across heterogeneous networks without any service interruptions.
If the serving base station and destination base station during handover process are of similar wireless access technologies, then it is called as Horizontal Handover and if the serving and destination base station during handover process are of different wireless access technologies, then such a handover is called as vertical handoff. The Vertical Handover process will generally have three important phases :

- Handover Information collection
  - In this Phase, all the required information for Vertical Handover process is collected which includes users and network preference criteria.
- Handover Decision
  - In this Phase, the best RAT available will be selected and information will passed onto handover execution phase.
- Handover Execution
  - In this Phase, the active session for the subscriber will be maintained and continued on the new RAT once the resources of old RAT is released.

IV. SEAMLESS MOBILITY – REQUIREMENTS AND CHALLENGES

Towards seamless mobility in the cellular world, where mobile professionals today and eventually all consumers in the future would like to communicate and be able to do their routine business anytime, anywhere. The real demand for ubiquitous connectivity between a wide variety of mobile devices and access technologies, which include Wireless Wide-Area Networks (WWANs) and Wireless Local- Area Networks (WLANs). Roaming and communications among these technologies are therefore "must-haves" for seamless mobility to occur.

The new generation of wireless networks is intended to provide accessing information anywhere, anytime, with a seamless connection to a wide range of information and services, and receiving a large volume of information, data, images, video, and so on. The future network infrastructures will consist of a set of various networks using IP as a common protocol so that users are in control to choose every application and environment. Figure 1 demonstrates the seamless connectivity of the future Communication Networks.

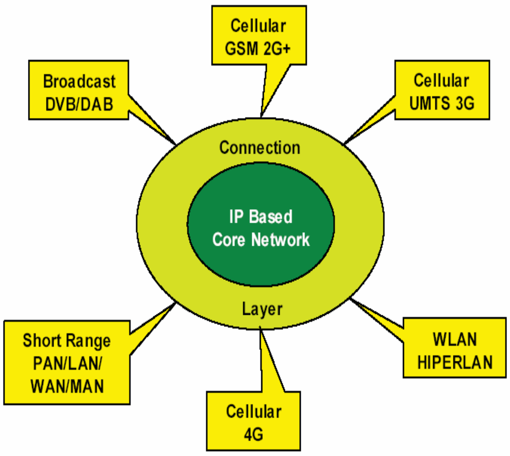

Fig 1: Seamless Connectivity of Communication Networks

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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Vol. 3, Issue 4, April 2015

Seamless Mobility is the result of extensive primary and secondary research on a variety of industry participants including cellular service providers, equipment suppliers, Internet Service Providers (ISPs), electronic component manufacturers, and software providers, among others. Studies have been made to exploit the potential as well as to overcome the shortcomings of 3G, and demonstrate how service providers can take advantage of WLAN deployments. Technology drivers and obstacles that must be addressed to achieve growth in the WLAN market—such as roaming, security, seamless authentication, handovers, and billing, —are also important.

Voice was the driver for second-generation mobile and has been a considerable success. Today, video and TV services are driving forward third generation (3G) deployment. And in the future, low cost, high-speed data will drive forward the fourth generation (4G) as short-range communication emerges. Service and application ubiquity, with a high degree of personalization and synchronization between various user appliances, will be another driver. At the same time, it is probable that the radio access network will evolve from a centralized architecture to a distributed one.

The seamless connectivity – issues are based on the developing trends of mobile communication, next generation wireless networks will have broader bandwidth, higher data rate, and smoother and quicker handoff and will focus on ensuring seamless service across a multitude of wireless systems and networks.

V. INTEROPERABILITY TECHNIQUE

This section briefly explains about the interoperability technique used i.e. IP multimedia subsystems and the various methodologies used to reduce handover delay during the handover process whenever a mobile user is moving around heterogeneous networks. [7]

1. IP Multimedia Subsystem (IMS)

IMS is an emerging architectural framework based on SIP protocol, for offering multimedia services and VoIP services. IMS network consists of application layer to provide the end user with service controls and required services. Control layer is responsible for delivery of control signals and connectivity or transport layer for transporting different types of information such as voice, data and multimedia streams. [7]

IMS Components: The IMS core network predominantly consists of many nodes such as HSS (Home Subscriber Server), SLF (Subscriber Location Function), CSCF (Call/Session Control Function), P-CSCF (Proxy-CSCF), S-CSCF (Serving-CSCF), I-CSCF (Interrogating-CSCF), ECSCF (Emergency-CSCF), IMS-MG (IMS-Media Gateway), etc. [17] - [20].

IMS Registration and Session Initiation: IMS-level registration is the procedure which is used to authorize the user to access the IMS network and use the IMS services. It is done after IP connectivity for the signaling that has been gained from the access network and the application level registration can be initiated after the registration to the access is performed. IMS-level registration is accomplished by a SIP REGISTER request and the user is considered to be always roaming [17]-[20].

2.Home Subscriber Server (HSS)

HSS is main data storage for all user information such as unique identity, registration information and service-triggering. It performs authentication and authorization of the user and provides information about the mobile users physical location. [7]

3.Application Server (AS)

AS executes services and interfaces with the SCSCF using Session Initiation Protocol. [7]

4.The Call Session Control Functions (CSCF)

SIP signaling in the IMS is processed by a SIP server called Call Session Control Function (CSCF). The three types of CSCFs are; Proxy Call Session Control Function (P-CSCF), Interrogating Call Session Control Function (I-CSCF) and Serving Call Session Control Function (S-CSCF). [4]

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5. Media Resource Function (MRF)

MRF performs multi-party call, multimedia conferencing, tones and announcement functionalities. The Media Resource Function communicates with the S-CSCF for service validation of multiparty or multimedia sessions. [7]

6. Media Resource Function Controller (MRFC)

The MRFC performs processing of media streams through corresponding Media Resource Function Processor.[7]

7. Media Gateway Control Function (MGCF)

The Media Gateway Control Function communicates with CSCF through SIP to control media channels for connection in a Media Gateway Function. [7]

VI. RQUIREMENTS OF HANDOFF MECHANISM

1**. Bandwidth** : Bandwidth is a measure of the width of the range of frequencies. It is the difference between the upper and lower frequencies in a contiguous set of frequencies. In order to provide seamless handoff for Quality of service (QoS) in wireless environment, there is need to manage bandwidth requirement of mobile node during movement. Bandwidth is generally known as the link capacity in a network. Higher offered bandwidth ensures lower call dropping and call blocking probabilities, hence higher throughput [15].Bandwidth handling should be an integral part of any of the handoff technique.

2. **Power Consumption** : In Wimax and LTE networks, there is need to find ways to improve energy efficiency. Power is not always consumed by user terminal but also attributed to base station equipments. Power is also consumed during mobile switching or handoffs. During handoff, frequent interface activation can cause arises in network discovery because unnecessary interface activation can increase power consumption.

3. **Network Throughput** : Network throughput refers to the average data rate of successful data or message delivery over a specific communications link. Network throughput is measured in bits per second (bps). As network throughput is considered in dynamic metrics for making decision of VHO, it is one the important requirement to be considered for the VHO.

4. **Handoff Latency** : Handover of calls between two BS is encountered frequently and the delay can occur during the process of handoffs. This delay is known as handoff latency. A good handoff decision model should consider Handoff latency factor and the handoff latency should be minimized. Many proposed handoff decision models have tried to minimize the handoff latency by incorporating this factor in their handoff decision models. Handoff Latencies affect the service quality of many applications of mobile users. It is essential to consider handoff latency while designing any handoff technique. It is also important to incorporate power consumption factor during handoff decision.

5. **Network Cost** : A multi criteria algorithm for handoff should also consider the network cost factor. The cost is to be minimized during VHO in wireless networks. The new call arrival rates and handoff call arrival rates can be analyzed using cost function. Therefore, network selection cost is important in handoff decisions.

6. **Received Signal strength (RSS)** :The performance of a wireless network connection depends in part on signal strength. Between a mobile node (MN) and access point (AP), the wireless signal strength in each direction determines the total amount of network bandwidth available along with that connection. RSS [15] depicts the power present in a received signal. A signal must be strong enough between base station and mobile unit to maintain signal quality at receiver. The RSS should not be below a certain threshold in a network during handoff and VHO includes three sequential steps as discussed earlier in this paper, namely handoff initiation, handoff decision and handoff execution.

7. **Velocity:** Velocity of the host should also be considered during handoff decision. Because of the overlaid architecture of heterogeneous networks, handing off to an embedded network, having small cell area, when travelling at high speeds is discouraged since a handoff back to the original network would occur very shortly afterwards [15]. However, it was stated that the capability and bit error rate can also be considered during vertical handoff.

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VII. CONCLUSION

LTE is considered as the basis of next generation mobile Internet. LTE Standards accommodate the use of Mobile Internet Protocol (MIP) to support inter-technology mobility between LTE and other generations. To achieve interoperability across LTE and WiMAX to ensure uninterrupted multimedia services to the mobile users even when they are moving at varying speeds with lower Handover delays and reduced packet drops. LTE should support various mobile speeds from low to a high vehicular speed. The higher speed will cause more frequent handover, therefore handover performance will be more critical at these speeds, and especially for real time services.

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BIOGRAPHY

Mr. Suhas G K a Student of Information Science and Engineering Department at The Oxford College of Engineering-Bangalore, affiliated to VTU pursuing M.Tech in Computer Networking and Engineering. He received his Bachelors of Engineering in Computer science and Engineering from SJC Institute of Technology-Chickaballapur affiliated to VTU. He is currently working as a research assistant under the guidance of **Dr.D.Jayaramaiah.** His research interests are Next Generation Mobile Networks and Information Security.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2015

Dr.D.Jayaramaiah an Alumni of IIT-Delhi with thirty five years of experience in Telecom, Software, IT industry and R&D at Defence Labs has been actively involved with state of art technology development application software development. Earlier he was head R&D of L&T InfoTech, Bangalore Division. Currently he is heading Information Science and Engineering Department at The Oxford College of Engineering-Bangalore, affiliated to VTU. His research interests are Next Generation Mobile Networks, Mobile Agent Technology and Network Management Systems. He is a Fellow of the IETE and Senior Member CSI and senior member PMI-USA. He has presented Seventeen Research Papers at various International Conferences organized by IEEE, World Wireless Congress, 3GMF, 4GMF and IASTED**.**