CHAPTER 1

INTRODUCTION

1.1 RESEARCH MOTIVATION

The trend towards communication engineering especially in data exchange had made a revolution in the recent decade. Wireless networks have become increasingly interoperable with each other and with the high-speed wired networks. This reflects a paradigm shift towards new generation of mobile networks where seamless mobility across heterogeneous networks have become fundamental and is referred to as the fourth generation (4G). Future users will always be best connected through different available access networks, when they move from one place to another. For example, a video teleconference can transparently switch from an enterprise Wireless Local Area Network (WLAN) to the traditional cellular environment while driving home as well as to the fixed home network on arrival. In fact, users can access and maintain a seamless connectivity anywhere, anytime. Handovers between the technologies are transparent to users, allowing a simplified and seamless on the move experience. In summary, seamless mobility is enabling a user to accomplish his or her tasks without regard to technology, type of media or device, facilitating freedom of movement while maintaining continuity of application.

This thesis contributes to the evolution of technology convergence by improving different aspects of the inter-system handover management to make seamless mobility a reality. Due to the enormous growth of the industry
and also change in the life style of people, even general communication has become paperless. The transition of mobile transmission from transmitting just voice has progressed to transmission of data and then to voice with added data to the transmission of videos, over the years. The transfer technique is dependant on the bandwidth and the utilization of the network. The traffic and flow rate of the network rely on the parameters which are closely related with the transmission of the information such as signal strength, traffic density of the network, bandwidth etc.

This work deals with mobility management which has included, the nature of the network studied in advance and the availability of the bandwidth through which data transmission is carried out. For the cause of mobility management, the technical factor is the handover. A handover called heterogeneous handover is proposed for the seamless flow of information. Heterogeneous handover is based on the nature of the network, the operational performance, the signal coverage and the strength of the network. In this work, mobility architecture have been proposed dynamically based on the transmission pattern of the devices for the transfer of information. The multilayered network could be any type of network such as backhaul network, WiMax (Worldwide Interoperability for Microwave Access), 3G, WLAN etc. The Heterogeneous handover works on the concept of request-response-information exchange between the networks.

1.2 PROBLEM STATEMENT

To define a Quality of Service (QoS) based architectural framework for Mobility Management, the framework should be based on the existing mobile (node/router) endpoint and access point functionality which will support seamless flow of Information for real-time IP (Internet Protocol) streams across heterogeneous wireless access technology making use of the
Hybrid Mobile IP with routing protocols along with Network Selection and Handover Management.

The first seamless mobility application that has been commercial is the Unlicensed Mobile Access (UMA) solution, allowing seamless handover between cellular and Wi-Fi (Wireless Fidelity) hot-spot for voice call services. However, the UMA technology has some drawbacks (Lee et al 2005). It does not ensure the QoS of the multi-service bearer and the handover between the Universal Mobile Telecommunications Service (UMTS) and WLAN which had not yet been supported. This solution is only suitable for home or SOHO (Small Office and Home Office) subscribers due to the access capacity limitations. Though the intersystem mobility has attracted immense research and development effort from the research community and standardization bodies (Koh et al 2007), the seamless handover has not become a reality due to shortfalls (Christian Makaya et al 2008).

Vertical handover, a term used to indicate the handover between two access nodes of two different technologies, is an issue in heterogeneous networks since each technology has its own mobility management solution. The mobile terminal must be capable of adapting the service content and the communication parameters whenever it changes the access network. The two important performance criteria for the handover design are latency and packet loss. Generally, multimedia application, one of the main services in 4G networks, requires short handover latency, low jitter and no packet loss. Handover in this case has to be achieved seamlessly, which means that handover should be transparent to user’s experience. Users have to be unaware of the handover during the application, meaning that the handover interruption delay should be very minimal (below 50ms) along with a minimum packet loss ratio, so that the service quality is unaffected (tolerant loss ratio differs for different application types).
The need of the user is to have a continuous and quality service, as the user is unaware of which access technology he/she is connected to. In order to support the seamless handover from one technology to another, the access networks involved should be integrated. The interworking between Third Generation Partners Project (3GPP), Third Generation Partnership Project 2 (3GPP2) networks and WLAN networks has been the topic of research. Within the 3GPP/3GPP2 standardization bodies, a collaboration between groups of telecommunication associations to make a globally applicable 3G mobile phone system with specifications within the scope of the International Telecommunication Union (ITU) and International Mobile Telecommunications-2000 (IMT-2000) project is the need of the hour. The UMA solution mentioned above has also been recognized as a 3GPP Generic Access Network (GAN) standard.

Despite discussions about the competition between Worldwide Interoperability for Microwave Access (WiMAX) and cellular networks, WiMAX is keen to cooperate by interworking with 3GPP/3GPP2 networks to provide the maximum value to operators allowing them to reach as many customers as possible to provide better quality of service. Since WiMAX is different from WLAN in terms of radio coverage, quality of service, capacity and security, the 3GPP-WiMAX interworking needs more research (Harju et al 2004). The interworking architecture of different technologies should create minimal changes to the existing infrastructure. In addition, most of the existing interworking solutions deal with the integration between two access networks deployed by the same operator or by two coordinated operators.

An approach to facilitate a secure and seamless interworking and roaming in multi-operator environment has not yet been addressed (Ian et al 2004). The user expects, future networks to offer more customized services at higher quality levels. Ease of use and ability to control their services
according to their preferences has become the desire of the user. With the increasing capabilities in devices, the question as to whether the user’s terminal can control and manage the handover across different access technologies arises. Delegating the handover control to the mobile terminal would offer a solution to the user’s need. However, such a terminal-controlled handover requires an interworking architecture, where the mobility management becomes a service independent access network operator domain.

An intelligent access network selection in the terminal is required to aid users to select the best access network. The network selection rely upon different access network characteristics, different constraints on terminal capabilities, the mobility management policy, the user’s contexts and user preferences. An efficient and pragmatic solution is required to solve trade-offs within the multi-criteria selection problem in heterogeneous networks. The fact that the mobile terminal is equipped with one reconfigurable interface or multiple radio interfaces should be taken into account when designing the vertical handover procedure. The determination of the right handover triggering instant is difficult in heterogeneous networks since many criteria (not only the link quality) should be taken into account in the decision algorithm. If the handover is initiated too early, the ping-pong handover (Yuh Shyan et al 2006) problem may occur. The ping-pong effect causes instability and service performance degradation. If the handover is initiated too late, mobile terminals may not have enough time for making handover, which leads to connection drop. Despite using different optimization techniques (Yi hua et al 2007) to determine the appropriate handover triggering instant, the interruption may still be present. The handover interruption time is very critical for real-time applications, particularly for streaming services. The seamless video-on-demand streaming in wireless networks for mobile users is a challenging task, which is addressed in this thesis.
1.3 OBJECTIVES

Existing technology concentrates on seamless mobility only in homogeneous environment, which in turn is under the control of the service providers and concentrate only on intra-system mobility. Keeping this in consideration, this thesis aims to address the different facets of the inter-system mobility management, whose objectives are as follows;

1. To create the interworking architecture between Universal Mobile Telecommunications Service (UMTS) and WiMAX to support seamless handover.

2. To frame a handover decision before moving out of the serving cell coverage by providing a sufficient overlap area between adjacent cells.

3. To design a Roaming Interworking Intermediary (RII) platform which supports all combinations of different radio technologies in a multi-operator environment which will support secured roaming and seamless mobility across two independent access networks and also aims to investigate the role of user terminals in the inter-system mobility management.

4. To enable a complete terminal-controlled handover procedure, for the coordination within mobility management architecture to provide a seamless terminal-controlled vertical handover.

5. To balance the traffic load across the integrated networks is a challenge which leads to best utilization of the pooled resources and there by improve the user satisfaction level, which is related to the mobility management, since it involves the user’s network selection and the network-controlled vertical handover enforcement.
1.4 METHODOLOGY

The inter-system handover is a process involving the management of network entities and end-user terminals. In order to satisfy the objectives outlined above, two different visions, one from user terminal side and the other from network side, are employed to approach the inter-system mobility management issue. In the user-controlled vision, end-users are not anymore passive to enjoy services offered by their network operators. They can use their smart terminals to take over the control of the inter-system mobility management across multi-homing networks (or open access networks) as well as to handle handover optimizations to ensure the seamless services. This part contributes to the migration trend from the network-centricity towards terminal-centricity. The second approach, addresses the important role of the network control in the inter-system mobility management and the handover optimizations. With a global view on user requests, its load values, available resources, roaming agreements with interworked networks, the network can also control the handover to ensure the seamless mobility for mobile users.

1.5 MAJOR CONTRIBUTIONS

1. Analysis of network-layer metrics in gateway selection and handover decision, based on latency and packet loss,

2. Utility-based access network selection, relies on access network characteristics, terminal capabilities, mobility management policy, user’s content and user preferences,

3. A user-centric access network selection scheme, to facilitate a secure, seamless interworking and roaming in multioperator environment,

4. An adaptive handover initiation threshold to ensure seamless mobility,
5. An adaptive pre-buffering policy to maintain the media content in the buffer for seamless streaming,
6. Flow mobility control in heterogeneous networks,
7. A loose-coupling interworking architecture between UMTS and WiMAX systems,
8. A scheme for inter-system measurement using an Software Defined Radio (SDR) enabled terminal,
9. A required minimum cell overlap for seamless handover in a UMTS/WiMAX system,
10. An intermediary platform for interworking and roaming between different access networks in a multi-operator environment,

1.6 THESIS OUTLINE

Chapter 1: Introduction This chapter outlines the motivation and the scope of the work.

Chapter 2: Foundation of Mobility Management in 4G Wireless Heterogeneous Networks In Chapter 2, the evolution of wireless mobile communication systems with a view to adopting the technology convergence as the core of the 4G concept is reviewed. The motivations of the 4G networks are briefly identified. It also addresses the main interworking architecture approaches proposed in the literature and in the standardization activities. The basic handover procedure and existing mobility management solutions are then reviewed and discussed. This chapter gives an overview of the active research initiatives in the area of mobility management in
heterogeneous networks and identifies the challenges behind the provisioning of seamless services during mobility.

**Chapter 3: Related Work** The chapter 3, presents related work in the areas of mobility management, wireless networks, global connectivity, multihoming and routing in wireless networks. It highlights current research challenges, reflects and comments on the solutions.

**Chapter 4: System Model** Chapter 4, reviews the existing utility models including the single-criterion utility form and aggregate utility form used in access network selection and resource management problems. The limitations of the existing models are unveiled. The utility theory is studied and proposes new single-criterion and multi-criteria utility forms to best capture user satisfaction and sensitivity in varying access network characteristics.

It also proposes a terminal-controlled mobility management framework. The solution is devoted to mobile devices equipped with multiple radio interfaces. The proposed mobility management consists of a policy-based power-saving interface management coupled with a user-centric network selection solution, an adaptive handover initiation algorithm and a handover execution. It gives a complete solution from the architecture design to handover signaling exchanges and seamlessness optimization techniques.

This chapter addresses seamless media streaming during horizontal and vertical handovers in heterogeneous networks. The solution is based on the terminal-controlled pre-buffering adjustment policy, running at the terminal side to maintain the appropriate amount of media content in the buffer. A practical handover prediction scheme is proposed to assist the right pre-buffering boosting decision.
Chapter 5: Proposed Mobility Management Scheme: Interworking Architecture Design

Chapter 5 addresses the proposed UMTS-WiMAX interworking architecture and the corresponding handover sequence charts. Second, an RII functional entity to facilitate the interworking and roaming in a multi-operator environment is also proposed. The solution allows a secured and seamless handover across two access networks of two independent operators.

Inter-system Measurement and Required Cell Overlap: Chapter 5 addresses two important conditions for seamless handover between UMTS and WiMAX systems: inter-system measurement and required cell overlap. It also investigates the possibility to make the UMTS-WiMAX inter-system measurement through a single reconfigurable radio interface terminal without affecting on-going sessions. We analyze the minimum cell overlap required to support seamless handovers between two adjacent cells within the same technology or different technologies in the UMTS-WiMAX networks.

Load Balancing over Heterogeneous Wireless Packet Networks: Chapter 5 highlights the limitations of the existing load balancing approaches and then addresses a new load balancing algorithm. The main contribution in this Chapter is to define a new load metric and a new balancing objective which makes it possible to reconsider the load balancing problem as a classic optimization problem. The proposed approach aims to hide the heterogeneity of different access technologies from the load balancing process.