Chapter 3

4G Access Network Architecture

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ABSTRACT

Although all-IP networking is the ultimate goal of 4G wireless networks, 3G LTE and WiMAX systems have designed semi all-IP network architectures for efficient radio resource and mobility management. These semi all-IP networks separate layer 2 and layer 3 handoff operations by grouping many base stations (BSs) as a subnet, thus alleviating handoff, while the pure all-IP networks provide a simple network platform at the cost of high handoff overhead. The authors compare the semi all-IP networks to the pure all-IP networks, and provide an overview to WiMAX access service networks and 3G LTE backhaul networks. They then present advanced architectures that support efficient radio resource and mobility management. First, they present a semi hierarchical cellular system with a super BS that behaves like a normal BS as well as a supervisor over other BSs within the group. They further extend this model to a system that combines multiple access techniques of OFDMA and FH-OFDMA with microcells and macrocells. Also, to alleviate the handoff latency, a dual-linked BS model is presented in order to support seamless handoff. Finally, as an integrated approach to supporting diverse QoS requirements, the authors consider an IP-triggered resource allocation strategy (ITRAS) that exploits IntServ and DiffServ of the network layer to interwork with channel allocation and multiple access of MAC and PHY layers, respectively. These cross layer approaches shed light on designing a QoS support model in a 4G network that cannot be handled properly by a single layer based approach.

DOI: 10.4018/978-1-61520-674-2.ch003
1. INTRODUCTION

Fourth-generation (4G) networks are expected to deploy a simplified network architecture based on all-IP (ITU-R, 2003). The scenario of all-IP networking will alleviate the problem of third-generation (3G) access networks such as WCDMA and cdma2000, where there are many protocols to cover their complicated backhaul networks. While these 3G networks basically have evolved from a circuit-switched cellular network, 4G networks are expected to become an all-IP based packet-switched system where packets traverse across an access network and a backbone network without any protocol conversion. To set a goal for 4G networks, International Mobile Telecommunications (IMT) has defined IMT-Advanced of which requirements for supported data rates are 100 Mbps and 1 Gbps for high mobility and low mobility, respectively (ITU-R, 2007). Alongside this effort, proposals such as IEEE 802.16m and 3G LTE (Long-Term Evolution) Advanced are on the table to develop new systems towards 4G networks.

These proposals, despite the importance of all-IP networking, may not adopt pure all-IP due to some issues in terms of radio resource management (RRM) and mobility management. The all-IP scenario may enforce each base station (BS) to trigger the change of an IP address, when a mobile station (MS) switches its serving BS. In reality, it is known that changing an IP address incurs a too long delay to provide a seamless service for the MS (Yokota et al, 2002). Therefore, a semi all-IP network is considered, where changing an IP address is not executed within a subnet (i.e., a group of BSs).

In this chapter, we describe the difficulty in deploying all-IP networks for cellular systems by comparing pure all-IP and semi all-IP networks, and provide an overview of existing network architectures such as WiMAX and 3G networks. We then present advanced network architectures that solve the problems of existing network architectures. Finally, an IP-triggered resource allocation strategy is described.

2. OVERVIEW OF WIRELESS NETWORK ARCHITECTURES

A. All-IP Cellular Networks

In existing cellular networks, an access network consists of many entities for supporting radio resource management and mobility management. For example, in 2G GSM/GPRS networks, the base station subsystem (BSS) consists of the base transceiver system (BTS) that handles the physical layer and the base station controller (BSC) that

Figure 1. An example of protocol stacks in GSM systems
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