Chapter 3

Resource Allocation in Heterogeneous Wireless Networks

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ABSTRACT

The advent of heterogeneous broadband wireless access networks (BWANs) has been to support the ever-increasing cellular networks’ data requirements by increasing capacity, spectrum efficiency, and network coverage. The focus of this chapter is to discuss the implementation details (i.e., architecture and network components), issues associated with heterogeneous BWANs (i.e., handovers, network selection, and base station placement), and also the various resource allocation schemes (i.e., shared resource allocation in split handover and inter-RAT self-organizing networks) that can improve the performance of the system by maximizing the network capacity.

INTRODUCTION

Emergence of BWAN as a popular alternative to the wire-line access infrastructure is primarily associated with steady increase in data rate support and has inherent advantages, such as: easy scalability; ease of use in the end system; and low deployment and maintenance cost. According to Dahlman et al. (2008), the 4th generation (4G) BWAN, like LTE-A (long term evolution-advanced) and WiMAX-Mobile (world-wide interoperability for microwave access-mobile), have a maximum data rate of approximately 1 Gbps in downlink and 300Mbps in uplink as per the IMT-Advanced (international mobile telecommunications-advanced) specification. According to the data published by Ericsson (2018) and Cisco (2017), the mobile broadband data traffic has been increasing exponentially every year and the increase was nearly 18-fold over the past five years. Traffic forecast update by Cisco (2017) also projects an increase in mobile devices and connections to 11.6 billion and a 24 percent increase in network connection speeds by 2021. Latouche et al. (2013) has suggested value-added services (based on end-user information and user

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identification) and industry “coopetation” (simultaneous cooperation and competition between service providers) as feasible solutions for the predicted mobile data explosion. Mobile data offloading (such as Wi-Fi offloading) is a cost-effective solution for delivering cellular network data that eases network congestion, provides seamless connectivity, and offers higher bandwidth to end-users.

The future heterogeneous network would efficiently and effectively integrate the prevailing heterogeneities as discussed by Chan et al. (2011), such as: communication modalities, channel types, technology generations, protocol types, and QoS requirements. To address dynamic, distributed, and unpredictable nature of these networks, they need to have self-organisation properties that range from self-configuration during startup, to self-adaptation to dynamic changes in operating environment, to self-healing in presence of failures and losses, as has been discussed by Razzaque et al. (2010). Among the standardization groups in this domain, are next generation mobile networks (NGMN) alliance that aims to bring affordable mobile broadband services to the LTE and LTE-A end users and Small Cell Forum/Femto Forum that works towards adoption of small cell technologies to improve coverage, capacity, and services delivered by mobile networks.

Heterogeneous Networks have proved their worth in 3G/4G cellular systems and because of the innumerable advantages associated with them, they will play a big role in future 5G networks as well. In 3G and 4G cellular networks the aim of BS densification is to improve the wireless transmission rate in partial regions and to cover the dark spots arising due to various natural and artificial obstacles, as discussed by Ge et. al. (2016).

The prominent need to enhance network capacity, throughput and users’ quality of service (QoS) has led to the advent of heterogeneous next generation networks, comprising of different RAN (radio access networks) connected to a single core network. Implementing these networks, while ensuring high data rates in the wireless environment, poses certain resource allocation challenges such as: positioning the base station (BS) transceiver, handovers and network selection etc. In this chapter, we discuss: the architecture of heterogeneous BWAN; the issues associated with their implementation such as handover, network selection and BS placement; shared resource allocation solution to maximize the users capacity; and the idea of self-organizing network (SON) based inter-RAT (radio access technology) MRO (mobility robustness optimization).

ARCHITECTURE

Heterogeneous network (het-net) architecture is a prominent low-cost approach where an operator can exploit the different BWANs to provide additional areal capacity gain, indoor coverage improvement, and improved quality of service (QoS) in the network, as per Yeh et al. (2011).

Deployment Scenarios

Multitier Architecture Network Components

A heterogeneous BWAN architecture consisting of hierarchical multitier multiple radio access technologies (RAT) deployments is shown in Figure 1. This multitier deployment improves capacity and coverage by enabling dense reuse of the spectrum and enhancing link quality. The role of tiers and the larger and smaller footprint devices is examined as follows: