Chapter 17
Dynamic Spectrum Auction and Load Balancing Algorithm in Heterogeneous Network

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ABSTRACT
Mobile communication plays an important role in the future of communication systems. To meet personalized and intelligent requirements, mobile communication has evolved from single wireless cellular network to heterogeneous mobile communication network, including wireless cellular network, wireless local network, and wireless personal network. In the heterogeneous communication system, to entirely fulfill the spectrum resource complementary advantages of such a heterogeneous wireless network, the spectrum resource trade algorithm has attracted tremendous research efforts. In this paper, the advantages and disadvantages of dynamic spectrum allocation and load balancing are discussed and spectrum auction takes the place of spectrum allocation to maximize the operation revenue. The authors design a joint spectrum auction and load balancing algorithm (SALB) based on heterogeneous network environment to develop a more flexible and efficient spectrum management. The simulation result shows that SALB increases the operation profit significantly.

INTRODUCTION
In the past few years, with the development of various radio communication systems such as UMTS, WLAN, DVB, LTE and so on and the rapid grows of the numbers of users, the spectrum resource became limited. The lack of spectrum resource leads to the decreases of the system performance and users’ satisfaction (Leaves, Moessner, & Tafazolli, 2004).

The current method of assigning spectrum to different radio systems is fixed allocation, where the spectrum is divided into non-overlapping blocks and assigned to different radio communication systems (GSM, WLAN, DVD, LTE, etc.). However, fixed spectrum allocation does have disadvantages. For example, if the spectrum is allocated to cope with a certain maximum amount of traffic, called the “busy hour”, this network utilizes its spectrum fully during this time, but it
Dynamic Spectrum Auction and Load Balancing Algorithm in Heterogeneous Network

is underused at all other times. If the spectrum is allocated based on the average amount of traffic, under the circumstance that different radio access networks cover certain areas, traffic various with time and some new radio access technologies approaches the market, some networks are lack of spectrum due to the increasing traffic requirement, and at the mean time, the spectrum of other networks is over enough because of the traffic decrease. With the rapid grows of all kinds of services, e.g., broadcasting, video call, downloading, fixed spectrum allocation scheme is not able to meet the demand for radio spectrum. This is the motivation for a more efficient technique, such as dynamic spectrum allocation (DSA), flexible spectrum management (FSM), spectrum action and spectrum trading.

Dynamic spectrum allocation scheme adjusts spectrum allocation according to different network traffic among some areas, thus the network requirements are met and the traffic QoS is improved.

SPECTRUM ALLOCATION

The spectrum allocation scheme allocates non-overlapping spectrum blocks to different radio access networks (RANs), wherein the widths of the spectrum blocks are fixed which are separated by fixed guard bands. It is called a fixed spectrum allocation (FSA) scheme that a wireless network operator with a license is able to utilize the spectrum blocks of its own. Interference between different wireless communication specifications is avoided and radio spectrum management is simplified when using FSA. But the disadvantages of FSA also exist: first, the demand for spectrum in wireless networks varies with time. For example, most of the wireless communication network allocates spectrum according to the maximum amount of traffic. The spectrum is allocated to cope with the traffic in the “busy hour”. Since FSA is implemented, the spectrum is fully used in the “busy hour” but underused in the other time. This situation often occurs in other services as well. For example, the requirement for the Video-On-Demand (VOD) service is higher after work, but lower during working hours; second, the demand for spectrum varies with locations. As services provided by different wireless access networks in different locations are different, demand for spectrum varies; third, with the development of various wireless communication systems and the growing number of users, spectrum shortages become more and more apparent. System performance and user satisfaction degrade due to the spectrum insufficient. In conclusion, FSA cannot adapt the rapid development of wireless communication environment. In the circumstance that traffic varies with time and locations, FSA cannot achieve high spectrum efficiency. In addition, with the growing demand for wireless mobile multimedia services and the increasing traffic demands, there is an urgent need for a more flexible spectrum allocation. The factors above drive researchers to work on a more flexible and efficient dynamic spectrum allocation (DSA) scheme. Recently, U.S. Department of Trade and Industry in a government white paper about cultural, education, media and sports state that: about to introduce new mechanism to enable communication companies to implement spectrum trading (UK Department of Trade and Industry, UK Department of Culture, Media and Sport, 2000).

IST (Information Society Technologies) DRiVE (Dynamic Radio for IP-services in Vehicular Environments) project funded by European commission aims to explore a method for improving spectrum efficiency and increasing spectrum capacity in a network environment with a variety of wireless communication standards co-exist, wherein the method includes new dynamic spectrum allocation scheme and flow control method (Tonjes, Xu, & Paila, 2000; Ghaheri-Niri, Leaves, Benko, Huschke, & Stahl, 2000).
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