Chapter 8
Game Theory for Wireless Network Resource Management

ABSTRACT

Computer network bandwidth can be viewed as a limited resource. The users on the network compete for that resource. Their competition can be simulated using game theory models. No centralized regulation of network usage is possible because of the diverse ownership of network resources. Therefore, the problem is of ensuring the fair sharing of network resources. If a centralized system could be developed which would govern the use of the shared resources, each user would get an assigned network usage time or bandwidth, thereby limiting each person's usage of network resources to his or her fair share. As of yet, however, such a system remains an impossibility, making the situation of sharing network resources a competitive game between the users of the network and decreasing everyone's utility. This chapter explores this competitive game.

INTRODUCTION

Radio spectrum generally refers to radio channel (i.e., frequency band, time slot, channel access code) and transmission power. Usually, radio spectrum is a renewable resource that is finite in any instant of time but through its different dimensions of use: space, time, frequency and bandwidth, can be distributed to many users simultaneously. The process of distributing radio spectrum to users is radio resource management (Niyato, & Hossain, 2007). Nowadays, game theory can be used to design and analyze radio resource allocation protocols and corresponding network dynamics. In this chapter, we outline the game theory based radio resource management models.

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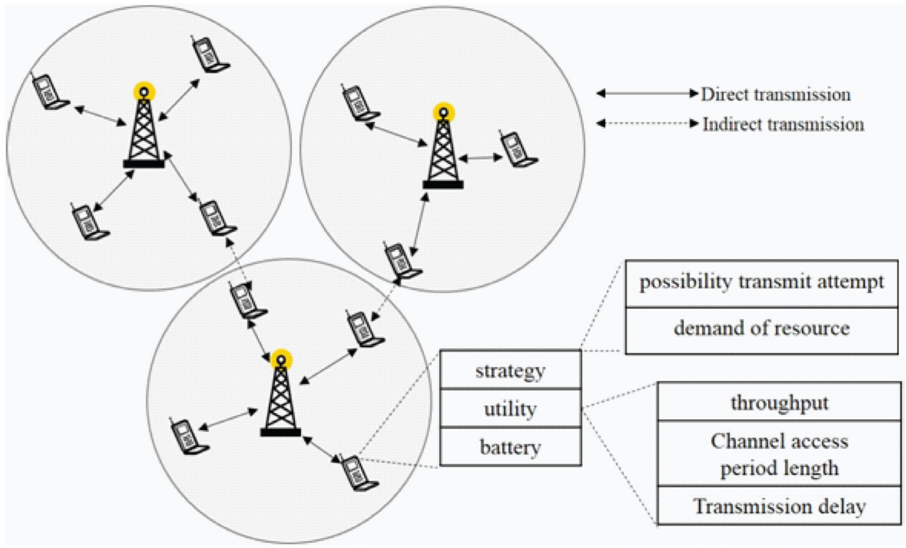
GAME MODELS FOR WLAN RESOURCE MANAGEMENT

In 2004, Altman et al., proposed a non-cooperative game model for optimal random channel access in s Local Area Network (WLAN) (Altman, Borkar, & Kherani, 2004) (Figure 1). In this game model, the players are the nodes in the network, and the strategy of each player is the probability of a transmission attempt if there is a packet in the queue. The player's utility is defined as the payoff due to successful packet transmission. To achieve the Nash equilibrium of channel access, a distributed algorithm was proposed considering the constraint on battery power at the mobile node (Niyato, 2007). Another game model for WLANs

Figure 1. WLAN resource management



was proposed to support the QoS requirements (Berlemann, Hiertz, Walke, & Mangold, 2005). This game was designed as a radio resource sharing game among multiple wireless networks. In this game, the players are the different wireless networks, the strategy of each player corresponds to demand for resource allocation, and the payoff is obtained based on throughput, channel access period length, and transmission delay. Nash equilibrium is considered as the solution of the game in a bargaining domain (Niyato, 2007). For channel access in WLAN, another non-cooperative repeated game was formulated for CSMA/CA-based MAC protocol (Tan, & Guttag, 2005). The players of this game are the mobile nodes, and the strategy of each player is the data rate and average payload size. The payoff of each player is the achievable throughput. It was observed that the Nash equilibrium of this game cannot achieve the highest system throughput. However, by guaranteeing fair long-term channel access for each player, the total throughput achieved by all the nodes can be maximized (Niyato, 2007), (Tan, 2005).

Admission Control Game for WLAN

Recently, a variety of types of traffic must be accommodated in future WLAN environments. Therefore, a new distributed MAC function has been developed to support service differentiation (Kuo, Wu, & Chen, 2004). Besides, high speed WLAN environments are also expected to provide wireless Internet services in hot spots. Since there are usually multiple service providers competing for providing wireless network access in hot spots, mobile users are free to choose their own service providers. For a specific service provider, more flows are admitted to transmit in its coverage range, more revenue is gained. However, admitting many flows may make the wireless medium overloaded and degrade the QoS satisfactions of ongoing flows. Therefore, some mobile users may leave the current service provider and subscribe to wireless network access with another service provider. Under this competitive environment, an admission control game was formulated as a non zero-sum and non-cooperative game. As a solution, a Nash equilibrium was obtained (Kuo, 2004). Based on the game, a service provider not

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