Chapter 9
Game-Based Approach for Network Routing Applications

ABSTRACT

Traditionally, routing is the process of selecting best paths in a network. Recently, the term routing is much better described as simply forwarding. Routing is performed for many kinds of networks, including the telephone network, electronic data networks, and transportation networks. In a more narrow sense of the term, routing is often contrasted with bridging in its assumption that network addresses are structured and that similar addresses imply proximity within the network. Nowadays, routing has become the dominant form of addressing on the Internet, and bridging is still widely used within localized environments. This chapter explores routing.

COOPERATIVE GAME THEORETIC ONLINE ROUTING *(CGOR)* SCHEME

During wireless network operations, a widely used performance issue is energy efficiency. Along with the energy efficiency, another desirable property is load balancing. Recently, S. Kim proposed a new integrated routing scheme (Kim, 2010); it is composed of path setup and packet distribution algorithms. Due to the online self-adjustment technique, the path setup algorithm can adaptively estimate link costs and establish routing paths. Based on the *Shapley Value* approach, the developed packet distribution algorithm can provide a fair and efficient solution for the packet forwarding problem. Under widely different and diversified network situations, this collaborative approach can offer a well-balanced network performance. The most important novelties of the *CGOR* scheme are its flexibility, adaptability and responsiveness to current traffic conditions.

Development Motivation

Recently, the explosive growth of new communication services and the widespread proliferation of multimedia data have necessitated the development for an efficient network management system. Traditionally, network management refers to the activities, methods, procedures, and tools that pertain to the operation, administration, maintenance, and provisioning of networked systems. Usually, network management is concerned with configuring resources in the network to support a

DOI: 10.4018/978-1-4666-6050-2.ch009

given service and to achieve greater internal efficiencies (Mahapatra, Anand, & Agrawal, 2006).

With the advance of wireless communication technology, low-cost and powerful wireless transceivers are widely used in mobile applications. Therefore, wireless/mobile networking is one of the strongest growth areas of communication technology today. For efficient wireless network operations, routing is very important; network performance is strongly related to routing algorithms. Therefore, much effort has been made trying to find adaptive network routing protocols (Zafar, Harle, Andonovic, & Khawaja, 2009).

To design an adaptive routing algorithm in wireless networks, several issues must be considered. Due to the limited energy supply of wireless device, energy is extremely valuable and scarce resource. Therefore, an efficient energy management strategy becomes a key factor in enhancing wireless network performance. Therefore, the main challenge in wireless networks is to use energy as efficiently as possible (Younis, Youssef, & Arisha, 2002). Another network management issue is load balancing. In computer science, load balancing is a technique to spread work between many computers, processes, hard disks or other resources in order to get optimal resource utilization and decrease computing time. In wireless networks, the meaning of load balancing is to ease out the heavy traffic load in a specific node or link by using multiple routing routes. With load balancing concept, routing packet can be evenly distributed in redundant communications links, which can prolong the network system lifetime from considering the load-sharing service (Huang, Ku, & Kung, 2009).

For efficient network management, control decisions must be dynamically adjustable to current situation. However, the future traffic patterns are generally not known. Furthermore, the fact that traffic patterns can vary dramatically over short periods of time makes the problem more challenging. Therefore, these decisions have to be made in real time, and without the knowledge of future traffic requests at the decision time. Online algorithms are natural candidates for the design of efficient routing schemes in networks (Azar, 1998). An algorithm employing online computations is called an online algorithm. The term 'online computation problem' refers to decision problems where decisions must be made in real time based on past events without securing information about the future. In online computation, an algorithm must produce a sequence of decisions that will have an impact on the final quality of its overall performance. Formally, many online problems can be described as follows. An online algorithm $\mathcal{A}$ is presented with a request sequence $\sigma = \sigma(1), \sigma(2), \ldots, \sigma(m)$. The algorithm $\mathcal{A}$ has to serve each request online, i.e., without knowledge of future requests. More precisely, when serving request $\sigma(t)$, $1 \le t \le m$, the algorithm does not know any request $\sigma(t')$ with $t' > t$. Serving requests incurs cost, and the goal is to serve the entire request sequence so that the total cost is as small as possible. This setting can also be regarded as a request-answer game (Azar, 1998).

Online algorithms are a natural topic of interest in many disciplines such as computer science, economics, and operations research. Online algorithms have been implicitly and explicitly studied for last several decades in the context of scheduling, optimization, data structures, and other computational topics. Many computational problems are intrinsically online in that they require immediate decisions to be made in real time. Paging in a virtual memory system is perhaps the most studied of such computational problems. Routing in communication networks is another obvious application. Decision making in the field of finance is another obvious area of interest (Azar, 1998).

Motivated by the above discussion, online algorithms (Kim, & Varshney, 2004) are natural candidates for the design of efficient routing schemes in wireless networks. Offline algorithms are unrealizable for the network management because it needs full knowledge of the future for