Chapter 16
Game Paradigm for Wired Networks

ABSTRACT

There are a great number of situations in which a many agent system self-organizes by coordinating individual actions. Such coordination is usually achieved by agents with partial information about the system, and in some cases optimizing utility functions that conflict with each other. A similar situation is found in many network situations. An example of a frustrated multi-agent system is given by the evolutionary minority game in which many players have to make a binary choice and the winning option is the one made by the minority. In evolutionary minority game, players make decisions by evaluating the performance of their strategies from past experience, and hence, they can adapt. The players have access to global information, which is in turn generated by the actions of the agents themselves. As the game progresses, non-trivial fluctuations arise in the agents' collective decisions – these can be understood in terms of the dynamical formation of crowds consisting of agents using correlated strategies. This chapter explores the game paradigm for wired networks.

EVOLUTIONARY MINORITY GAME BASED CONGESTION CONTROL (*EMGCC*) SCHEME FOR WIRED NETWORKS

Telecommunication technology advances in the past decade have brought networking to another level in terms of reliability and link speeds. However, existing transmission control protocols do not provide satisfactory performance due to their inefficient congestion control mechanisms. Recently, S. Kim proposed a new Evolutionary Minority Game based Congestion Control (*EMGCC*) scheme to provide QoS provisioning while ensuring bandwidth efficiency. Based on the evolutionary minority game model, the *EMGCC* scheme adaptively controls the packet transmission to converge a desirable network equilibrium. For the efficient network management, the evolutionary minority game approach is dynamic and flexible that can adaptively respond to current network conditions.

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Development Motivation

Nowadays, the continuing growth of multimedia traffic raises the important issue of how to efficiently utilize network bandwidth. In addition, network systems should support widely different and diversified multimedia data services. Different data services require diverse Quality of Service (QoS). Usually heterogeneous multimedia data can be categorized into two classes according to the required QoS: class I (real time) and class II (non-real time). Class I data has a higher priority than class II data, so a multimedia network should take into account the prioritization among different multimedia traffic services. For the service differentiation, QoS provisioning strategy plays a crucial role (Mahapatra, Anand, & Agrawal, 2006). Therefore, the future network system is expected to provide a comprehensive solution where multimedia services can be delivered to the user with a satisfactory high data rate, premium quality and high security (Tao, & Yu, 2011), (Shaii, Ismail, Jais, & Manan, 2008).

Due to the shared nature of network bandwidth, all network users contend for medium access. If the traffic exceeds a network capacity, network congestion occurs. When congestion occurs, packets are dropped either because of collision or buffer overflow; it seriously penalizes the network throughput and coverage fidelity. In order to fully utilize the network bandwidth and effectively maximize the network performance, we have to control the traffic flow (Kutsuna & Fujita, 2011). Various congestion control algorithms have been developed to satisfy service requirements while maximizing network efficiency at the same time. However, due to the complexity of network structures, the nature of supported services, and the variety of involved dynamic parameters, the design of effective congestion control algorithms is a challenging problem (Shaii, 2008).

In network systems, a number of intelligent nodes interact with each other and make control decisions individually without centralized coordination. To understand the behavior of self-regarding nodes, game theory has some attractive features (Shang, 2007), (Araujo & Lamb, 2004). Today, game theory is a sort of unified field theory for the rational side of social science, where 'social' is interpreted broadly, to include human as well as non-human players such as computers or network nodes. Therefore, game theory can describe the possibility to react to the actions of the other network nodes and analyze the situations of conflict and cooperation. However, classical game theory makes the assumption that game players are perfectly rational. In this assumption, each player must have knowledge of all relevant aspects of the environment, and enough computational power to choose the best strategy. However, this supposition is too strong to implement in the real world game player. Many studies have suggested that game players have very limited information and often do not behave in a perfect rational way. Therefore, for the practical game operation, players should be modeled with bounded rationality; bounded rational players have limits in their abilities to make their decisions (Shang, 2007), (Araujo, 2004).

In 1997, Challet and Zhang proposed a game model called Minority Game (MG) to study the effects of bounded rationality (Kutsuna, 2011). MG is a repeated coordination game where players use a number of different strategies in order to join one of the two available groups, and those who belong to the minority group are rewarded. Recently, MG models have been extended widely. The Evolutionary Minority Game (EMG) is regarded as a paradigmatic model of the evolutionary version of MG game. It allows players dynamically to adapt their strategy according to their past experiences (Shang, 2007). In the last few years, EMG has attracted considerable attentions and has been investigated extensively in many engineering fields (Araujo, 2004).

Motivated by the above discussion, the *EMGCC* scheme has been developed based on the EMG model. In the *EMGCC* scheme, sender nodes (i.e.,