Chapter 16

Game Theoretic Analysis for Cooperative Video Transmission over Heterogeneous Devices: Mobile Communication Networks and Wireless Local Area Networks as a Case Study

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ABSTRACT

This chapter presents a mechanism for cooperative video transmission based on game theory for heterogeneous devices during broadcasting. Broadcasting is a multipoint delivery of transmission that sends data from a source to multiple destinations. The terminal is involved in cooperative transmission when the station broadcasts video data. To enhance performance, the heterogeneity and forwarding capabilities should be considered. This work studies power control and allocation in a collaborative transmission based on game theory, which provides an effective strategy when network resources are limited. First, a novel power-allocation model of the base station (BS) based on noncooperative game theory and bidding is presented in this study. Additionally, we also propose a utility function of Signal-to-Noise Ratios (SNRs) along with Signal-to-Interference Ratio (SIRs). Subsequently, based on such noncooperative game theory with a utility function, the model of the power distribution of terminals in cooperative transmission can be built. Experiments on the System-in-the-Loop (SITL) mode in OPNETs have proven the correctness of the designed model and superiority, verifying the effectiveness of the proposed power-control idea.

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INTRODUCTION

Previous studies showed that the resource allocation problem in cooperative networks could be divided into two types - Centralized (Nosratinia & Hunter, 2007; Ng & Yu, 2007) and distributed methods (Alamouti, 1998; Savazzi & Spagnolini, 2007; Laneman & Wornell, 2003; Abdelnasser & Hossain, 2013). Usually, centralized methods considered channel state information. However, such a method is not frequently used since channel conditions are fluctuating, and a large number of video packets are delivered during transmission. Compared with centralized methods, distributed approaches focused only on local information. Hence, the distributed approaches were frequently adopted in the wireless network research. For example, Nosratinia and Hunter (2007) devised a centralized method for maximizing the network bandwidth. Ng and Yu (2007) presented a distributed resource-allocation algorithm for networks of OFDMA (Orthogonal Frequency Division Multiple Access), which was designed for power/bandwidth allocation and the selection for relay nodes. Alamouti (1998) proposed distributive power allocation of multihop transmissions for a single user. (Liu, Tao, & Huang, 2013; Huang, Zhu, Mung, & Poor, 2008) presented a cooperative transmission scheme based on auction mechanisms. Typically, most researchers concentrated only on the power allocation of the terminal while maximizing the network benefit. However, cooperative transmission is important as it can reduce the burden of the base station (BS) and improves power utilization when limited resources are present. In view of this, this chapter studies the power-allocation strategy for terminals to collaboratively transmitting data. That is, video streaming is broadcast to heterogeneous terminals by a base station (BS). Moreover, terminals cooperate with each other during the proposed process. First, terminals are classified into different groups, and each terminal in the same group can co-work with another member while transmitting video streaming. For instance, if the terminals are divided into three parts “A, B, and C” based on three different transmission powers “p_A, p_B, and p_C,” then they can receive video streams from the BS, which broadcasts video streaming with p_A, p_B, or p_C. The members in a group can be further divided into different subgroups. With Scalable Video Coding (SVC), the cooperative transmission process in groups can be described as follows. If the total type of terminals is one, terminals transmit and receive the same video layer. Otherwise, if more than one type exists, then terminals cooperatively transmit different layers. In this study, game theory is used to model and understand the cooperative behavior of mobile users because the related work on Device-to-Device (D2D) communication proved its effectiveness (Song, L., Niyato, D., Han, Z., & Hossain, E., 2014). Song (2014) presented an auction model and a coalitional game-theoretical model. They described advanced research on development of game-theoretical models and introduced many significant challenges for wireless-network resources allocation in D2D data transmission.

As for the Wireless Local Area Networks (WLANs), with the development of wireless network standards and transmission technologies, communications become more efficient and gradually enrich our lives. Besides the advanced wireless communication techniques, recent research focused on video encoding methods. In 2003, H.264 video coding standard was issued by International Telegraph Union — Telecommunication Standardization Sector (ITU-T). As one of the new generation of video coding standards, H.264 coding has its own incomparable superiority. This coding scheme takes advantage of Quality-of-Service (QoS) mechanism in order to preserve the most significant information and to decrease video distortion under congestion conditions (Choudhry, U. I., & Kim, J., 2005). The performance of wireless local network systems is based on the Quality of Service and the Signal-to-Noise Ratio (SNR). QoS is a necessary element for supporting a number of applications which utilize wireless network resources. These applications may be video streaming, voice over IP, video conferencing, etc.
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