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Collaborative content dissemination based on game theory in multimedia cloud

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ABSTRACT

With the development of multimedia clouding applications and broadband technology, multimedia group communication applications, such as multi-point video conference, major news and events live, internet-on-demand TV, network video monitoring and so on, continue to emerge. However, limited network bandwidth, burst of incoming service requests, and imbalance of content dissemination seem to be the most important factors that affect users' experience. To this end, this paper proposes a collaborative content dissemination method based on game theory in multimedia cloud. In order to obtain the optimal number of service user in each group, integrated utility value of each user is calculated, and the improved particle swarm optimization algorithm is used. Moreover, the matching problem between service users and non-service users is formulated into game theory. In order to avoid the blindness and selfishness of non-service users to choose the service users, an evolutionary game is aimed at achieving the stability by learning the connection from the non-service users. A Stackelberg game is aimed at obtaining optimal pricing policy and bandwidth allocation of service users. The numerous experiment results show that the proposed method can effectively improve users' experience of those who have weak system capabilities, reduce the average time of the content dissemination and decrease the total cost of the multimedia cloud user.

1. Introduction

With the rapid development of multimedia cloud technology, multimedia content dissemination has penetration into all aspects of people's work and life, becomes an important research direction in the field of cloud computing, and has gained the attention of industry and academia. Multimedia services, especially those that provide live video, have been widely focused and applied. The desktop computer is no longer the only source to get live video services but smart devices have also become a popular platform. Since the video broadcast services are sensitive to QoS, these require devices with better performance and network bandwidth [1]. There is a huge challenge for the devices with poor performance and weak network to transmit and deal with video contents. Because of the poor physical properties, low bandwidth and limited battery life, the smart devices may lead to low satisfaction for users on service quality. In addition, many users with the same requirements have the same demand of multimedia services. If users request video services individually from the multimedia cloud center, they need to pay for the same video services they access, which will lead to high cost and low utilization of service content. Therefore, it is quite important to rationally use and allocate service resources in multimedia cloud [2].

Multimedia cloud provides multimedia services. Multimedia content is usually stored by the service providers, and is provided to the user according to the demand [3]. As the number of users in the network increases rapidly, response time of getting service for a large number of users also increases. As a result, service satisfactions cannot be achieved. Moreover, as the multimedia service provides live video, there are the same requirements of live video among the users who have the same requirements. So if several users with close position and with the same live video demand want to obtain video broadcast service from the multimedia service providers concurrently, it will certainly cause a waste of resources and the increase in service cost. For that reason, a collaborative content dissemination method based on game theory is proposed in this paper.

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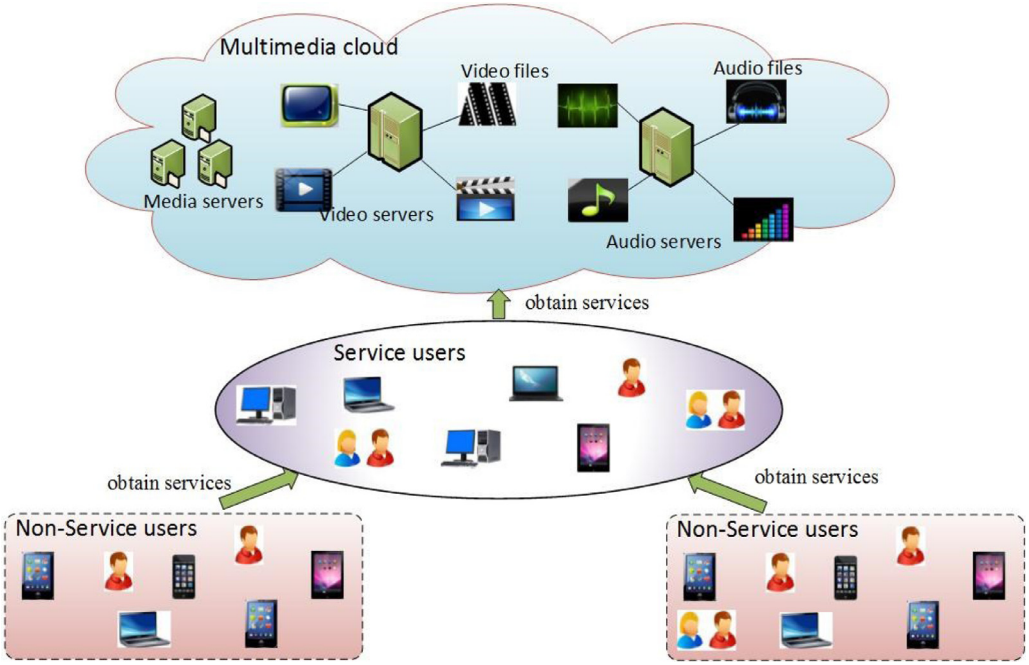

Fig. 1. Application scenario of collaborative content dissemination in multimedia cloud.

The basic idea of the collaborative content dissemination method is as follows: multimedia cloud users who have the close locations and the same multimedia services demands are connected to form the user groups. Parts of users are selected as service user for obtaining multimedia contents from the multimedia cloud, and the others are regarded as non-service users for obtaining multimedia contents from service users. In this situation, it is not necessary that all the users request multimedia contents from the multimedia cloud center. And the local communication capacity of the users can be well utilized. As a result, multimedia contents can be reused, the cost of multimedia cloud users can be reduced and users' experience of those who have weak system capabilities can be improved. The application scenario of collaborative content dissemination in multimedia cloud is shown in Fig. 1.

Collaborative content distribution can solve the problems of the limited bandwidth, substantial user visits and server dissemination imbalance of the user content acquisition. However, the following issues existed in collaborative content dissemination should be addressed [4,5]: (1) the number of selected service users significantly affects the system performance. Too many service users will result in higher cost of user service, while too few service users can increase the service time and cause network congestion in the group, which will greatly degrade non-service users' experience. So service user selection criteria and quantity determination mechanism are necessary; (2) the optimal matching between the service users and non-service users has considered the blindness and selfishness features of multimedia cloud users.

In this paper, aiming at reducing the resource cost and cutting down the service response time during multimedia content dissemination process, we study collaborative content distribution method, the main contribution and innovations of this paper are as follows:

(1) In order to obtain the optimal service user number in each location-based multimedia user group, the method could calculate and sort integrated utility value of each user, and then the improved particle swarm optimization algorithm is used to calculate service user number.
(2) A matching strategy based on game theory for content dissemination is proposed to realize the matching between service users and non-service users. In order to avoid the blindness and selfishness of non-service users to choose the service users, an evolutionary game is aimed at achieving the stability by learning the connection from the non-service users. A Stackelberg game is aimed at obtaining optimal pricing and bandwidth strategy of service users.
(3) The collaborative content dissemination method based on game theory in multimedia cloud is realized. The numerous experiment results show that the proposed method can effectively improve users' experience of those who have a weak system capabilities, reduce the average time of the content dissemination and depress the total cost of the multimedia cloud user.

The rest of the paper is organized as follows: Section 2 reviews related works. Section 3 describes the collaborative content dissemination method based on game theory in multimedia cloud. Section 4 is the implementations of the proposed algorithms. Section 5 is the analysis and the summing-up of the experiment. Finally, Section 6 is the conclusion of the paper.

2. Related work

In multimedia cloud, content dissemination strategies have become a hot research topic in recent years [6]. For meeting the demands of independent and self-interested users, both conventional content dissemination strategies and economic approaches, such as game theory, are studied in existing literature.

2.1. Applications of game theory for content dissemination

The game theory is widely applied to content dissemination and resource allocation in multimedia services. Nan et al. [7] proposed an efficient multimedia distribution approach taking advantage of live-streaming social networks to deliver the media services from the cloud to both desktop and wireless end users, this approach allows bandwidth limited mobile users to acquire live mul-

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