A Research on Resource Transaction for Streaming Media Based on Combinatorial Double Auction

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Abstract: Streaming media technology has always been a hot topic in the academic world. A dynamic resource transaction model is proposed to provide flexible services for streaming media systems. Firstly, we analyzed various server attributes of the existing streaming media distribution system, and introduced the time attribute of streaming media, measure the price attribute. Secondly, we simplified the combinatorial double auction model, and then conducted resource transaction in a reasonable and fair way. The feasibility of the model in the streaming media distribution system and the high transaction rate are verified by numerical analysis.

1. Introduction

According to the recently released research report on the audio-visual development of China's Internet in 2017 [1], as of June 2017, the scale of video users in China has reached 565 million, accounting for 75.2% of the total number of Internet users. The first three scenes of video users watching video online are when they are at home, before going to bed, and having lunch [1]. Network video has become the most important way of network entertainment, and the network video service shows a temporal correlation. In some time periods, the number of service requests surges, the streaming media resources are insufficient, and a large number of streaming media resources are idle in other times. The shortage of resources will seriously affect the service quality of streaming media video. Therefore, the streaming media nodes need flexible services to obtain a large amount of resources in peak period and lease out idle resources in low period.

While most of the current resources market model is not applicable to streaming media: first of all, the sensitivity of the streaming media server to time is extremely high [5], while other services not. Secondly, study of resource distribution of trading in the research mostly based on cloud computing platform, and based on the virtual machine [2], but streaming media system should base on the whole node server. Weng chuliang [3] proposed a bidirectional auction pricing algorithm, which is mainly aimed at the characteristics of grid resources, so as to realize the allocation of grid resources. The ways of asking price and bid are very simple, market participant’s income distribution is not very well. Tintin [4] puts forward an adaptive cloud resource auction mechanism, which guarantees the benefits of the seller and the buyer. However, resource transaction allocation mostly takes quantity and price as resource quality, and it based on a single resource research.

To solve above problems, this article put forward a dynamic resource trading model based on streaming media. First, the price attribute and non-price attribute of the streaming media server are normalized and priced, and then the order is made according to the price and the results of previous processing, and the reasonable and fair distribution is made according to the buyer's demand.

2. Streaming media resource transaction model based on combinatorial double auction

2.1 The traditional streaming media resource transaction model based on combinatorial double auction

Combinatorial double auction [6] is a kind of auction that the buyers and sellers will compose types of goods into the different kinds and number of combinations. Compared with other types of way to trade, combinatorial double auction can avoid those trading resources monopoly, satisfy people's diversity demand for service resource. The streaming media resource transaction model based on combinatorial double auction is shown in figure 1.

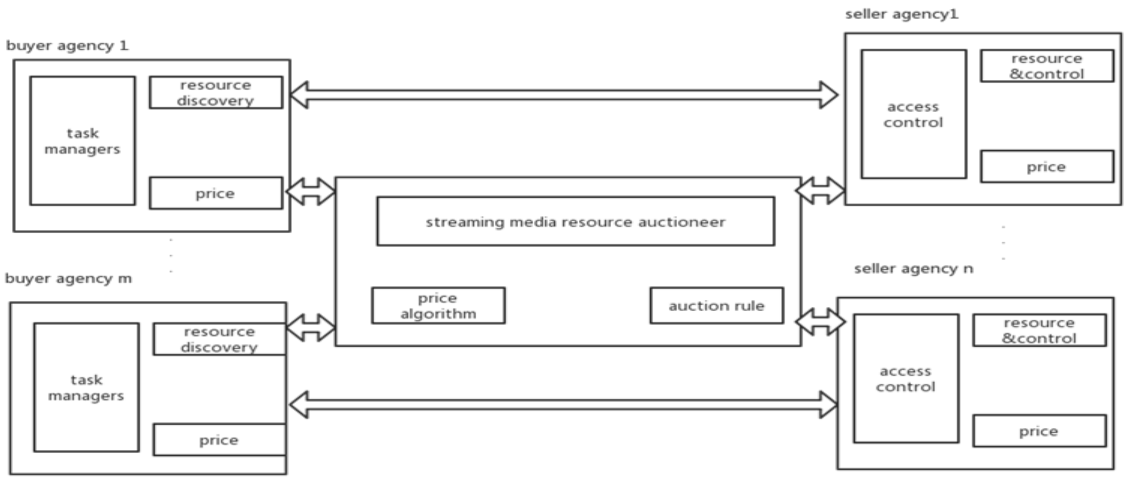

Figure 1. The streaming media resource transaction model based on combinatorial double auction

The trading model of this paper, it was assumed that an auction process, the number of participants for M = m + n, M a buyer, n. The seller resource properties of n number, N = 4 (memory, CPU, storage space, memory).

Definition 1: use the B_i (S_i, P_i, i) = to compete situation, i was the number.

Definition 2: S_i representative node resources situation, Si = (S_{i1},...S_{ij},...S_{kj});. S_{ij} on behalf of the participant i of j resource properties.

Definition 3: Pi on behalf of the price of the participants i taken to the Si, when Pi is greater than 0, the offer of the buyer, Pi is less than zero, which is resource provider for node's asking price.

Based on combinatorial auction mechanism of transaction model can be described as a streaming media resources:

$$\max \sum_{i=1}^{M} P_i x_i \tag{1}$$

$$(PM) \sum_{i=1}^{M} \frac{x_i * P_i}{|P_i|} = 0 \quad \forall j \in (1, \ldots N) \tag{2}$$

$$x_i \in \{0,1\} \;\; \forall i \in \{1,2,3, \ldots, M\} \tag{3}$$

According to equation (1), it can be seen that the purpose of this general model is to maximize the number of market transactions, and equation (2) ensure that a seller node meets a buyer demand. Formula (3) represents a 0-1 programming model, which reduces the complexity of the whole combinatorial double auction model.

2.2 Streaming media resource transaction model based on combinatorial double auction (SMRCD)

But the price given by the auction participants may be unreasonable, which leads to a very low transaction rate, so we give a pricing mechanism to improve the situation.

We can consider the relationship of each attribute: assign a coefficient to each resource node, and the coefficient is determined by the attribute weight and the adjustment coefficient.

The improvement method is given below:

(1) The buyer and the seller submit each resource node, as well as the attribute types of the resource nodes. This article only considers four categories, as well as the size of each attribute, and its own price P_i.

(2) Prior to the start of the auction, the weight of each resource is given according to the type and size of the attribute and the adjustment factor, and W_{ij} represents the weight of the class j attribute of the participant i.

$$W_{ij} = \frac{s_{ij}}{\sum_{i=1}^{m} s_{ij}/i} * c_{ij} \tag{4}$$

(3) It is assumed that the participants have four kinds of resources, and Sij represents the attributes of the j-type resources owned by the participant i, and which is calculated by the actual situation. The price of the participants can be determined as

$$P_i^{*} = P_i * \sum_{j=1}^{4} W_{ij} /4 \tag{5}$$

c_{ij} is the adjustment parameter, which is divided into three types according to the degree expected by the participants, namely [0.8, 1.0], [1.0, 1.2], [1.2, 1.4].

Tables 1. the adjustment parameter

	0.8-1.0	**1.0-1.2**	**1.2-1.4**
buyer	Not expecting	expecting	Very expecting
seller	expecting	Not expecting	Very undesired

Formula (4) means that the attribute j of a certain node is compared with the average value of the attribute j of the entire resource market, and the degree of expectation of the attribute by the participants.

This pricing strategy considers all the node attributes in the market, prevent buyers and sellers miss the trading opportunities for the information lackness. At the same time, psychological expectation factors of the price of the seller are introduced.

Then the Streaming Media Resource Trading Model (SMRCD) based on combinatorial double auction can be described as:

$$\max \sum_{i=1}^{M} \{pi * \sum_{j=1}^{4} W_{ij} /4\} * xi \tag{6}$$

$$(PM) \sum_{i=1}^{M} \frac{x_i * P_i}{|P_i|} = 0 \quad \forall j \in (1, \dots N) \tag{7}$$

$$x_i \in \{0,1\} \ \forall i \in \{1,2,3, \dots, M\} \tag{8}$$

$$C_{ij} > 0 \tag{9}$$

2.3 Normalization of streaming media resource attributes [2]

Because each streaming media server performance and the structure has the difference, if the simple according to server node number of tasks to assess its utility is not appropriate. In the assumption in the resource bundle property price is four, CPU frequency, time, disk capacity, network bandwidth, these attributes belong to different types, different criteria, can't simply will be accumulate, their value needs to be normalized processing.

In order to facilitate the calculation of the number of resources with different attribute dimensions, a simple linear weighting method WSA was used in this paper to weight the sum of each attribute. The weight coefficient of each attribute was set as $\omega_i(1 \le i \le k)$, which met the requirement of $0 \le \omega_i \le 1$,$\omega_i=0$ indicates that characters are only interested in this type of resource and do not need other kinds of resources. There is a formula (10) between weight coefficients, in which k=4

$$\sum_{i=1}^{k} \omega_i = 1 \tag{10}$$

The specific normalization formula is (11) and (12) (13) (14) (15).

$$S_1 = \sqrt{(\sum_{i=1}^{s} cpu_i)^2 + (\sum_{i=1}^{s} time)^2 + (\sum_{i=1}^{s} sto_i)^2 + (\sum_{i=1}^{s} bw_i)^2} \tag{11}$$

The result after the normalization of each attribute is

$$cpu1 = \frac{\sum_{i=1}^{s} cpu_i}{S_1} \tag{12}$$

$$time1 = \frac{\sum_{i=1}^{s} time_i}{S_1} \tag{13}$$

$$sto1 = \frac{\sum_{i=1}^{s} sto_i}{S_1} \tag{14}$$

$$bw1 = \frac{\sum_{i=1}^{s} bw_i}{S_1} \tag{15}$$

The above (12)-(15) are used to calculate the weight coefficient of each attribute, as follows:

$$\omega_1 = \frac{cpu_1}{cpu_1 + time_1 + sto_1 + bw_1}$$

$$\omega_2 = \frac{mem_1}{cpu_1 + time_1 + sto_1 + bw_1}$$

$$\omega_3 = \frac{sto_1}{cpu_1 + time_1 + sto_1 + bw_1}$$

$$\omega_4 = \frac{bw}{cpu_1 + time_1 + sto_1 + bw_1} \tag{16}$$

The attribute values of each resource combination can be obtained:

$$Qi=\omega_1 * cpu_i + \omega_2 * time_i + \omega_3 * sto_i + \omega_4 * bw_i \tag{17}$$

3. resource transaction process

3.1 Presuppositions

The assumptions made in this paper are as follows:

Hypothesis 1: participants take maximization of returns as the goal, and there is no collusion between buyers and sellers;

Hypothesis 2: the auctioneer does not charge commission, provides services for free, and no other fees are incurred during the transaction;

Hypothesis 3: nodes are independent from each other and will not affect each other in the process of distribution;

Hypothesis 4: a purchaser can purchase multiple nodes, and a resource node provider can also publish multiple resource node information;

Hypothesis5: after the node starts to perform the distribution task, neither the node provider nor the purchaser can undo the distribution task;

Hypothesis6: during the transaction, the node provider cannot change the node configuration at will.

3.2 Transaction process

Auction rules in resource transaction are the core content of resource transaction. The following is a detailed introduction of the algorithm in this paper. We only consider the situation of oversupply.

(1) k auction participants will send the combination of resources provided or to be auctioned and the bid price to the auctioneer in the form of Gj, and the auctioneer will run (7) to select the participants who maximizes the market transaction income, so that these participants can enter the next stage.

(2) the participants were classified according to the buyer and the seller, the buyer was ranked according to the price from large to small, and the list bl was obtained; the seller was ranked according to the quality attribute from large to small, and the list sl was obtained. Just like figure 2.

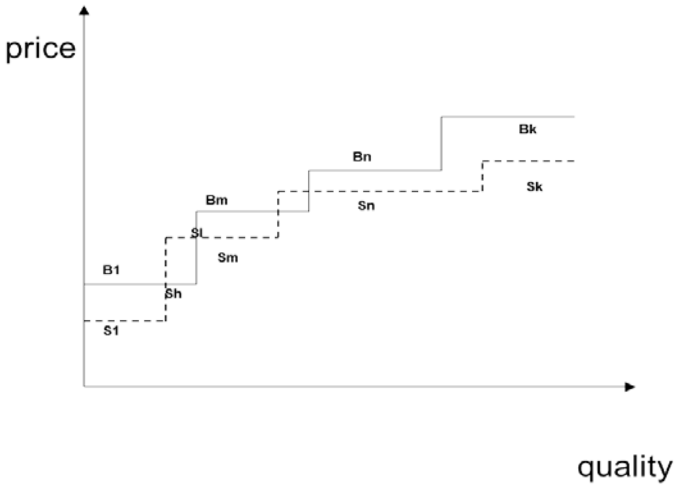

Figure 2. list bl and sl

(3) Delete the buyer's price is lower than the seller's price, while the seller's quality attribute is higher than the buyer's quality attribute. Just like figure 3.

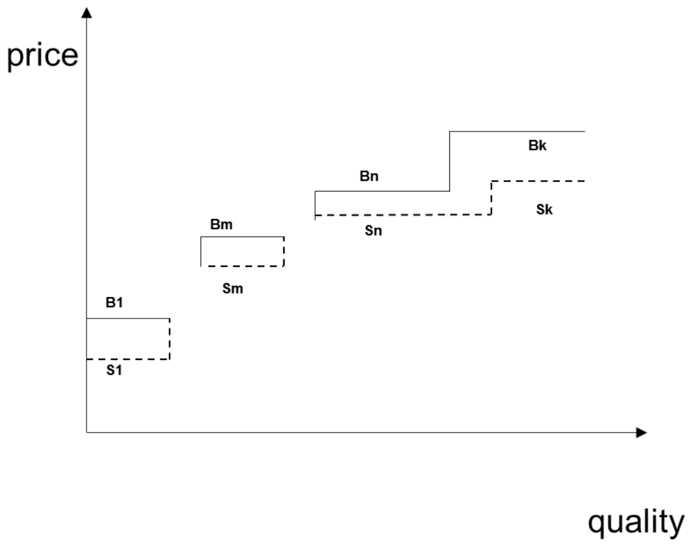

Figure 3. The seller's quality attribute is higher than the buyer's quality attribute

(4) Execute the resource transaction according to the order in the kl of the buyer list one by one until all the buyer traders have finished processing or the time of this round of transaction is up.

(5) The auctioneer shall send the auction results to both parties, and start the streaming media access and conduct, and charge fees after the completion of the task.

4. Experiment

In order to verify the effectiveness of pricing and price adjustment and the validity of the model, matlab was used for simulation verification. The parameters are set as follows, the buyer's price belongs to (u1, u2), and is evenly distributed within the range. The asking price of the resource provider is evenly distributed in the range (s1, s2). Among them, s1<u1, s2<u2, to avoid the seller's price is higher than the buyer's quotation.

Table 2. Simulation parameter list

Symbol	Meaning	Meaning
(u1,u2)	Buyer's price range	(5,20)
(s1,s2)	Seller's price range	(4,16)
C_i	CPU property settings	(2,12)
M_i	Storage property settings	(1000GB, 2000GB)
R_i	Memory property setting	(8GB, 16GB)
B_i	Bandwidth property setting	(100MB/s, 300MB/s)
N	Number of participants	(100,300,500 ......)

The SMRCD will be verified from the following four aspects:

1) The SMRCD model is applicable to the node trading market for streaming media.

2) Market average return: The value of the objective function $\max \sum_{i=1}^{M} P_i x_i$ divided by the total number of people.

3) Turnover rate: The ratio of the total number of buyers and sellers who have successfully traded to the total number of buyers and sellers entering the auction.

(a) The SMRCD model applies to the node trading market

SMRCD provides a definition of the resource requirements of both parties. This definition can clearly describe the attribute requirements of nodes. This is the basis for applying the SMRCD model to the node trading market.

Secondly, the node trading market for streaming media is dynamically changing. Pricing and price adjustment strategies describe this change and adjust the price.

The SMRCD model can auction nodes and provide trading strategies and adapt to dynamic changes in node trade market. So the SMRCD model can be applied to the node trading market for streaming media.

(b) Impact on turnover rate

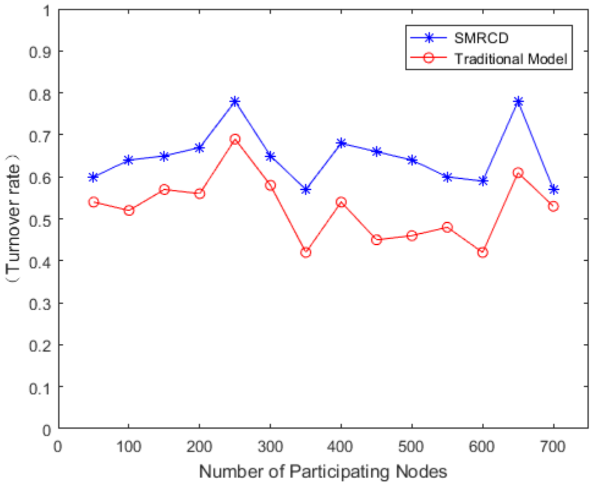

Figure 4. Comparison of transaction rates between SMRCD and traditional models

The experiment sets the participant size to 50, 100, 150, 200, 250... 700, respectively, in which the number of buyers and sellers is half, and the node parameters and price parameters are set according to the parameter list. The experimental results are shown in the figure4

It can be seen from experiments that the SMRCD model has a higher turnover rate than the traditional model. Because the SMRCD model sets a pricing strategy, it is clear that the pricing adjustment strategy is effective. SMRCD effectively increases the transaction rate of the buying and selling nodes, and basically maintains above 0.6. However, the turnover rate does not increase linearly with the number of people. We adjust the experimental parameters in addition to the number and price and attributes. Obviously the price and attributes may affect the transaction rate.

(c) Market average income

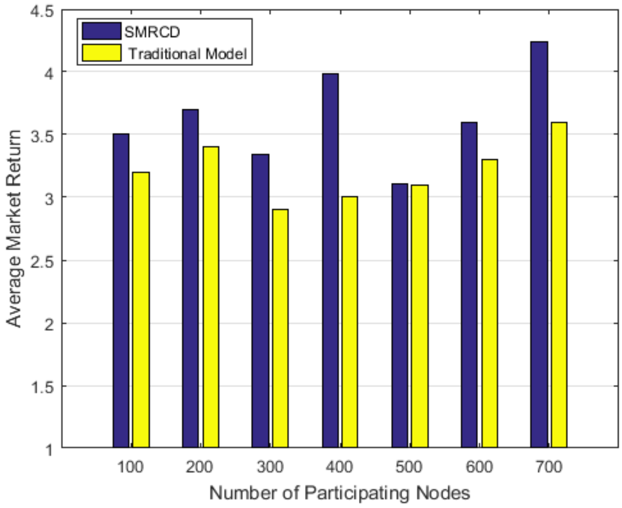

Figure 5. Average income from traditional models and SMRCD

In order to determine the maximum market return for comparing SMRCD with traditional models, we set the same number of participants and compare their average market returns. Through experiments, it can be concluded that SMRCD can get a higher average return on market income. In other words, SMRCD effectively improves the maximum market profit compared to the traditional model.

Acknowledgments

In this paper, the combinatorial double auction is introduced into the streaming media domain. On this basis, a practical and effective method of resource allocation and attribute measurement is proposed. In the next step, the server attributes and characteristics of each stage of the streaming media system will be divided into more specific areas, the resources will be classified in a more detailed way, and the resources will be allocated more fairly to further improve the service quality of streaming media.

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