A Negotiation Model Based on Multi-agent System under Cloud Computing

Jian Chen, Xinwei Han, Guorui Jiang
The Economics and Management School,
Beijing University of Technology
Beijing, China
emails: {cjmpw@163.com, jianggr@bjut.edu.cn, hanxinwei@bjut.edu.cn}

Abstract-**With the development of cloud computing, the amount of data processing and the ability of information sharing in e-commerce are increasing. Negotiation based on multi-agent is an essential approach to accomplish e-commerce. How to make the negotiation based on multi-agent to adapt to the change brought by cloud computing is an important problem. By considering the degree of market competition pressure, negotiation time, opponent's negotiation historical information under cloud computing, the paper constructs a negotiation model. Finally, the negotiation model's effectiveness is verified by simulation experiment on CloudSim.**

Keywords-Negotiation; Multi-agent System; Cloud Computing; Negotiation Framework; Negotiation Model.

I. INTRODUCTION

The emergence of cloud computing represents the arrival of new era of the Internet. Under the circumstance of cloud computing, the methods of requiring information and communication and so on have changed. In cloud computing, all kinds of resources on the Internet could be packaged into service. The packaged resources could supply limitless resource services for requesters [1]. The advantage of cloud computing is that the platform combines enormous resources and could supply variable resources based on actual requirements of users [2]. For suppliers, the process of supplying cloud resource to users is a process of service trade in nature. Negotiation holds an important position in service trade. With the rapid development of Distributed Artificial Intelligence, Multi-agent systems and Autonomy-Oriented Computing, lots of researchers devoted into the research of multi-agent based negotiation [3]. According to the theoretical basis, the multi-agent based negotiation includes negotiations based on game theory [4][5], negotiations based on heuristic [6][7], and negotiations based on argumentation [8][9].

The multi-agent based negotiation has good abilities of distribution and autonomy, it is suitable for the trade under the circumstance of cloud computing especially for cloud resource trade. There have been some researchers who investigated the multi-agent based negotiation under the circumstance of cloud computing. Multi-agent based negotiation under the circumstance of cloud computing has been concerned by researchers [10][11]. There are two markets in cloud computing, i.e., cloud service market between users and service intermediaries, and resource market between service intermediaries and cloud suppliers, and proposed a negotiation mechanism to accomplish dynamic SLA (Service Level Agreement) negotiation in cloud computing [10]. The supply-demand relationship under cloud resource allocation was modeled by game theory [12]. Distributed negotiation mechanism was proposed for leasing contracts between cloud suppliers and users [13]. Under the market of cloud computing, negotiation would proceed successfully by take good advantage of resource-level information. Then, the negotiation would promote the accomplishment of business targets. Consequently, a negotiation model based on non-addition utility function is proposed to promote the business trade under cloud computing [14]. Service level agreement should be established to resolve the conflicts of participates' different preferences for cloud service. A multi-issue negotiation mechanism is established to resolve the multi-issue negotiation for price, time and service quality under cloud computing. Moreover, corresponding negotiation agreement is established [15]. During the process of cloud resource allocation, the resource suppliers and users are all self-interest agents. The amount of suppliers' resource and the requirement of customers are changing consistently. Facing with these problems, a distribute negotiation mechanism is proposed. While using this mechanism, supplier agent and customer agent could negotiate according to contract price and penal sum. The agents could adapt to the changing environment. Then, the negotiation's accomplishment will promote the cloud resource allocation [16]. The cloud resource suppliers provide large amount of cloud resource to customers according to customers' requirements on IaaS layer. A negotiation mechanism of decision making for cloud resource allocation is proposed by extending the current appointment arithmetic [17].

However, current multi-agent based negotiation under the circumstance of cloud computing mainly used the existing multi-agent based negotiation theory, and aiming at maximizing the economic benefits for users and suppliers. They ignored the influencing factors during the negotiation process, such as degree of competition, time of negotiation, historical information of trade and so on. Moreover, current research mainly used static negotiation process, which may cause the waste of resource and may be lack of interaction between cloud resource suppliers and users.

Based on the above analysis, the article designs a multi-agent based negotiation model under the circumstance of cloud computing. Firstly, the negotiation framework under the circumstances of cloud computing is constructed. Intermediary agent is added to the framework to filter the resource. Secondly, considering the degree of market competition pressure, negotiation time, opponent's negotiation historical information during the negotiation, the multi-agent based negotiation model under cloud computing is established. Thirdly, the negotiation model's effectiveness is verified by simulation experiment. Finally, we summarize our work and propose our future work.

 ISBN: 978-1-61208-346-9

II. MULTI-AGENT BASED NEGOTIATION FRAMEWORK AND WORKFLOW UNDER THE CIRCUMSTANCE OF CLOUD COMPUTING

In this section, we will design a negotiation framework under cloud computing and construct a negotiation workflow correspondingly.

A. Negotiation Framework

The framework of multi-agent based negotiation under the circumstance of cloud computing is designed as showed in Figure 1:

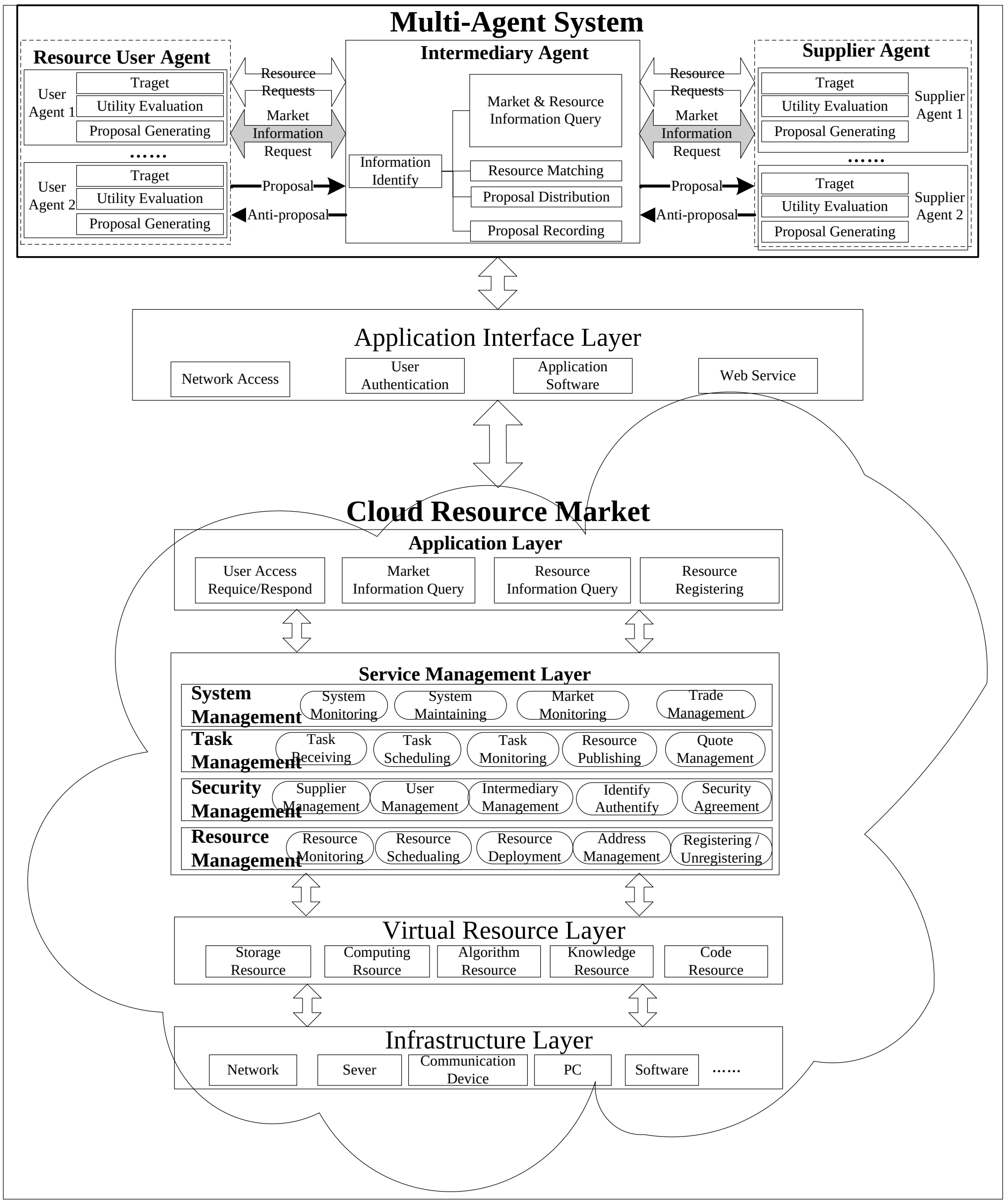


Figure 1. Multi-agent based negotiation framework under the circumstances of cloud computing.

The negotiation framework contains 3 components:multi-agent system, application interface layer and cloud resource market. Multi-agent system is the platform for the service trade, agents represent resource user, resource supplier and intermediary. Application interface connect the multi-agent system to cloud resource market. Cloud resource market contains all the resources used for service trade. The detailed description of the 3 components are introduced as bellow:

1) Multi-agent System

a) Resource Use Agent and Resource Supply Agent

Resource use agents and resource supply agents are the main participants of Multi-agent negotiation, who possess different targets, get information through intermediary agent, and negotiate with opponent agents. Resource supply agents possess the resource in the cloud computing market.

b) Intermediary Agent

In order to improve the efficiency of matching users' requirements to resources, we add intermediary agent to the negotiation framework. The intermediary agent is a third party in cloud computing market which is trusted by participants of cloud resource trade. It interacts with cloud resource market through application interface layer to get market information.

2) Application Interface Layer

The intermediary agent in multi-agent system connects with cloud resource market through application interface layer. The application interface layer supplies web service, user authentication, application software and so on to intermediary agent.

3) Cloud Resource Market

Cloud resources are stored in cloud resource market Which mainly contains infrastructure layer, virtual resource layer, service management layer and application layer. The relationship of the layers and the layers' components are shown in Figure 1.

B. Workflow of Multi-agent Based Negotiation

We construct workflow of automated negotiation (shown in Figure 2) based on Figure 1. As intermediary agent is an important part for connection, we also introduce it in this section.

1) Workflow

The workflow of Multi-agent negotiation is shown in Figure 2.

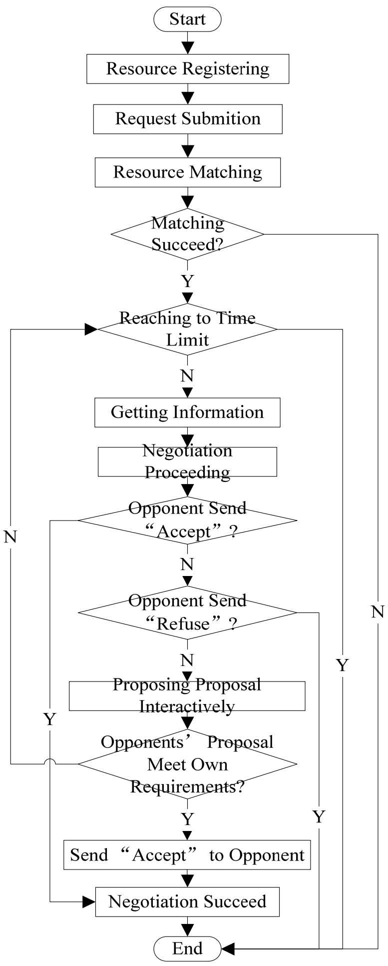


Figure 2. Workflow of multi-agent negotiation under the circumstance of cloud computing.

①Requests submitting:under the circumstance of cloud computing, resource use agents submit their requests to intermediary agent, and intermediary agent gets resource information from cloud resource market through application interface layer.

②Resource Matching:the intermediary agent matches the users' requests to the resource information and sends results to negotiators.

③Getting Information:the matched agents get market information and opponent's proposal history through intermediary agent.

④Negotiation proceeding:participants of negotiation send proposal to opponents. When agent gets the proposal that meets its requirement, negotiation succeed. Otherwise, negotiation proceeds until reaching to the time limit.

If negotiator could not get expected result within the negotiation time limit, the negotiation fails.

2) Function of Intermediary Agent

Under circumstance of cloud computing, in order to improve the efficiency of matching the requests and resource information, we use intermediary agent to match the requests to resource information rapidly. The matching of users' requests to cloud resource information includes three steps:selecting, evaluating and recommendation.

a) To select. The resources use agents submit resource requests to intermediary agent. Intermediary agent acquires service information from cloud resource market and compares the requests with resource information, then selects the resource that match to users' requests.

b) To evaluate. Because there are lots of elements can be evaluated, we only analyze price for the convenience of research. Let F_k represents the resource that matched successfully, k is the serial number of F_k and *U* represents the utility of F_k 's price.

$$U(F_k) = (P_{c_{max}} - P_{p_{min}}) / P_{c_{max}} \tag{1}$$

$P_{c_{max}}$ is the user's maximum price to accept; $P_{p_{min}}$ is the minimum price that supplier could accept. If $P_{c_{max}} << P_{p_{min}}$, it means $P_{c_{max}}$ is far below $P_{p_{min}}$, there is no space to negotiation for user and supplier. If $P_{c_{max}} \to P_{p_{min}}$, then $U(F_k) \to 0$, which means $P_{c_{max}}$ is nearly to $P_{p_{min}}$, the space for negotiation is small. If $P_{p_{min}} \to 0$, then $U(F_k) \to 1$,which means the gap between $P_{c_{max}}$ and $P_{p_{min}}$ is very large, the negotiation space is large. Intermediary agent should evaluate the value of F_k.

c) To recommend. Resource use agents and supply agents should set γ $(0<\gamma<1)$, which is the minimum $U(F_k)$. The intermediary agent uses the minimum $U(F_k)$ to select an appropriate F_k :①If $U(F_k) < \gamma$, relieve the match; ②If all $U(F_k)$ is bigger than γ, relieve the match of minimum $U(F_k)$. Then, the intermediary agent sends the results to the negotiators.

 ISBN: 978-1-61208-346-9

III. NEGOTIATION MODEL BASED ON COMPETITION-TIME-HISTORY

During negotiation under the circumstance of cloud computing, resource use agents and resource supply agents are affected by some influencing factors. The pressure of market competition, negotiation time, opponent's historical information may be the most main factors. We combine the influencing factors under cloud computing circumstance and construct the multi-agent based negotiation model.

A. Formal Description of Negotiation Model

The negotiation model can be described as following:

$$M=<A,\ T,\ U,\ m_t,\ n_t,\ H,\ S>$$

In the model,

A :Set of Agents, A={Resource Use Agents, Resource Supply Agents, Intermediary Agent}.

T :Negotiation time limit, $T=<T_r,\ T_p>$.

U :Set of Agents' price utility function, $U=<U_r,\ U_p>$. Users' price utility function is $U_r = \frac{P_{r_{\max}} - P_{p_t}}{P_{r_{\max}} - P_{r_{\min}}}$, resource suppliers' price utility function is $U_p = \frac{P_{p_{\max}} - P_{r_t}}{P_{p_{\max}} - P_{p_{\min}}}$. The negotiators decide whether to accept opponent's proposal by the utility function.

m_t :No. of competitors in t, gained through intermediary agent. t is the negotiation round.

n_t :No. of opponents in t, gained through intermediary agent. t is the negotiation round.

H :Opponent's historical information of proposals in negotiation gained from intermediary agent. $H=<H_{r_j},\ H_{p_j}>$. $j \geq 1$, j is the length of proposal history

S :Negotiation strategy agent uses during negotiation.

During each round of negotiations, the elements in the above model would be updated. During the negotiation model, the pressure of market competition is decided by m_t and n_t, the negotiation time is decided by T, the opponent's historical information is decided by H. The specific connotation of three elements is introduced as bellow.

B. The Three Influencing Factors of Negotiation

1) Pressure of Market Competition

The pressure of market competition should be evaluated in time during negotiation. The evaluation function of competition pressure is defined as:

$$C(m_t, n_t) = 1 - \left(\frac{m_t - 1}{m_t}\right)^{n_t} \tag{2}$$

The agent could get the market information through intermediary agent. Through analysis, we know that if competition pressure $C(m_t, n_t)$ is bigger, the probability of agent being considered as the best opponent is bigger, then the probability of reaching good results is bigger and the agent's competitiveness is bigger. So the environment is advantage for agent and the agent should make smaller concession. Otherwise, the agent should make bigger concession.

When only consider the pressure of market competition, the cloud resource use agent's proposal in the next round is:

$$\begin{aligned} P_{r_{t+1}} &= P_{r_t} + f^{c\text{-user}}(m_t, n_t) \\ &= P_{r_t} + (1 - C(m_t, n_t))(P_{r_{\max}} - P_{r_t}) \end{aligned} \tag{3}$$

P_{r_t} and $P_{r_{t+1}}$ is the agent's proposal at t and t+1, $f^{c-\text{user}}$ is the agent's function based on the pressure of market competition. $P_{r_{\max}}$ is the maximum price that resource use agent could accept.

The cloud resource supply agent's proposal in the next round is:

$$\begin{aligned} P_{p_{t+1}} &= P_{p_t} - f^{c\text{-supplier}}(m_t, n_t) \\ &= P_{p_t} - (1 - C(m_t, n_t))(P_{p_t} - P_{p_{\min}}) \end{aligned} \tag{4}$$

P_{p_t} and $P_{p_{t+1}}$ is the agent's proposal at t and t+1, $f^{c-\text{supplier}}$ is the cloud resource supply agent's function based on the pressure of market competition. $P_{p_{\min}}$ is the minimum price that resource supply agent could accept.

2) Time

Time limit is usually set during negotiation, negotiators usually take different concession as the time goes. The different concession based on time is summarized and the time constraint equation is proposed [18]:

$$k_t = [1 - (t/T)^{\lambda}]k_0 \tag{5}$$

k_0 denotes the gap between cloud resource use agent and cloud resource supply agent at initial time. k_t the gap between cloud resource use agent and cloud resource supply agent at time t, $t \leq T$. λ is the nonnegative time factor, it affects degree of concession, and is preset by negotiators and not changes during negotiation.

From (5), k_{t+1} at time t+1 is:

$$k_{t+1} = \frac{1 - [(t+1)/T]^{\lambda}}{1 - (t/T)^{\lambda}} k_t \tag{6}$$

Suppose the function of time as

$$T(t, t+1, T, \lambda) = \frac{k_{t+1}}{k_t} = \frac{1 - [(t+1)/T]^{\lambda}}{1 - (t/T)^{\lambda}} \tag{7}$$

where $T(t, t+1, T, \lambda) < 1$. The bigger $T(t,t+1,T,\lambda)$ would be, the gap between the user's proposal and supplier's proposal would be bigger, the probability of reaching negotiation success would be smaller, in that case, the agent should make bigger concession. When only consider time during negotiation, the cloud resource use agent's proposal in the next round is :

$$P_{r_{t+1}} = P_{r_t} + f^{t\text{-user}}(t) = P_{r_t} + T(t, t+1, T, \lambda)(P_{r_{\max}} - P_{r_t}) \tag{8}$$

$f^{t\text{-user}}(t)$ is the resource use agent's function based on time.

The cloud resource supply agent's proposal in the next round is:

$$P_{p_{t+1}} = P_{p_t} - f^{t\text{-supplier}}(t) = P_{p_t} - T(t, t+1, T, \lambda)(P_{p_t} - P_{p_{\min}}) \tag{9}$$

$f^{t\text{-supplier}}(t)$ is the resource supply agent's function based on time.

3) Opponent's historical information

Negotiation opponent's proposals during negotiation have some characteristics. If negotiators could take advantage of these characteristics, the negotiation would be advantage for them.

Suppose H_{a_j} is agent *a*'s negotiation history that contains the proposal in previous negotiation $< P_{a_1}, P_{a_2}, \ldots, P_{a_j} >$. P_{a_j} is the proposal that agent *a* proposed in round *j*. According to opponent's historical information, we could divide opponent's concession into absolute minimum concession, absolute average concession, absolute maximum concession and relative average concession. All of them can be described as bellow.

a) Absolute Average Concession

$$\Delta_1^a = (last(H_{a_j}) - first(H_{a_j})) / len(H_{a_j}) \quad (10)$$

where $last(H_{a_j})$ is the last proposal in H_{a_j}, $first(H_{a_j})$ is the first proposal in H_{a_j}. $len(H_{a_j})$ is the length of H_{a_j}.

b) Absolute Minimum Concession

$$\Delta_2^a = \min |P_{a_j} - P_{a_{j-2}}|, 2 < j \le len(H_{a_j}) \quad (11)$$

c) Relative Average Concession

$$\Delta_3^a = |P_{a_j} - P_{a_{j-2k}}| / k, 1 \le j - 2k \le j \le len(H_{a_j}) \quad (12)$$

d) Absolute Maximum Concession

$$\Delta_4^a = \max |P_{a_j} - P_{a_{j-2}}|, 2 < j \le len(H_{a_j}) \quad (13)$$

Agent could get opponent's negotiation historical information from intermediary agent. When considering opponent's behaviors, agent's proposal in next round is:

$$P_{a_{j+1}} = P_{a_j} + f^b(H_{b_j}) \quad (14)$$

$f^b(H_{b_j})$ is the function agent *a* whose opponent is agent *b*. H_{b_j} is the negotiation history of agent *b*. The function based on opponent's historical information of could resource use agents and supply agents are $f^{b-\text{user}}(H_{p_j})$ and $f^{b-\text{supplier}}(H_{r_j})$. H_{p_j} is the history of supplier and H_{r_j} is the history of user

$$f^{b\text{-user}}(H_{p_j}) \in \{\Delta_1^p, \Delta_2^p, \Delta_3^p, \Delta_4^p\} \quad (15)$$

$$f^{b-\text{supplier}}(H_{r_j}) \in \{\Delta_1^r, \Delta_2^r, \Delta_3^r, \Delta_4^r\} \quad (16)$$

C. Proposal Generating Based on COMPETITION -TIME-HISTORY

We combine the weighted influencing factors to generate new proposals by summation. Agents in the negotiation could decide each factor's weight by themselves. The weight reflects agent's preferences to each factor. When using the above negotiation model to negotiate, agent could generate new proposal as the following:

a) Colud resource use agent's proposal generating

$$P_{r_{t+1}} = P_{r_t} + \omega_1 f^{c-\text{user}}(m_t, n_t) + \omega_2 f^{t\text{-user}}(t) + \omega_3 f^{b-\text{user}}(H_{r_j}) \quad (17)$$

where P_{r_t} and $P_{r_{t+1}}$ represent the use agent's proposal at *t* and *t*+1. ω_i is resource use agent's preference to the *i*th influencing factor, and $\sum_{i=1}^{3} \omega_i = 1$.

b) Colud resource supply agent's proposal generating

$$P_{p_{t+1}} = P_{p_t} - [\omega_1 f^{c-\text{supplier}}(m_t, n_t) + \omega_2 f^{t-\text{supplier}}(t) + \omega_3 f^{b-\text{supplier}}(H_{p_j})] \quad (18)$$

where P_{r_t} and $P_{r_{t+1}}$ represent the supply agent's proposal at *t* and *t*+1. ω_i denotes resource supply agent's preference to the *i*th influencing factor, and $\sum_{i=1}^{3} \omega_i = 1$.

IV. EXPERIMENT AND RESULTS

CloudSim is a cloud computing simulator developed by research group in the University of Melbourne. The simulator aims at simulating constructing the infrastructure of cloud computing and comparing difference service scheduling and allocation strategies. By this way, CloudSim could control the resources in cloud computing.

A. Targets of Experiment

In cloud computing market, the resource users want to solve their problems by lower cost, while service suppliers want to get more profit by supplying resources. Consequently, the process of cloud resource allocation is a process of service trade in nature. As negotiation holds an important position in service trade, cloud resource allocation is a good field to apply negotiation. Moreover, negotiation could improve the cloud resource allocation's flexibility, interaction and autonomy.

During simulation experiment on CloudSim, we apply the negotiation model proposed in this paper by modifying the class of VmAllocationPolicy in CloudSim. By comparing with the default resource allocation method and negotiation strategy based on time in CloudSim, we could verify the effectiveness of negotiation and the effectiveness of proposed negotiation model.

B. Experimental Parameters Setting

Hardware environment setting:Intel Core 1.86GHz CPU, 2GB RAM, 160G Hard Disk. Software environment setting:operating system is windows XP, development tools are Java 1.7.0, Eclipse 3.2 and CloudSim 3.0.

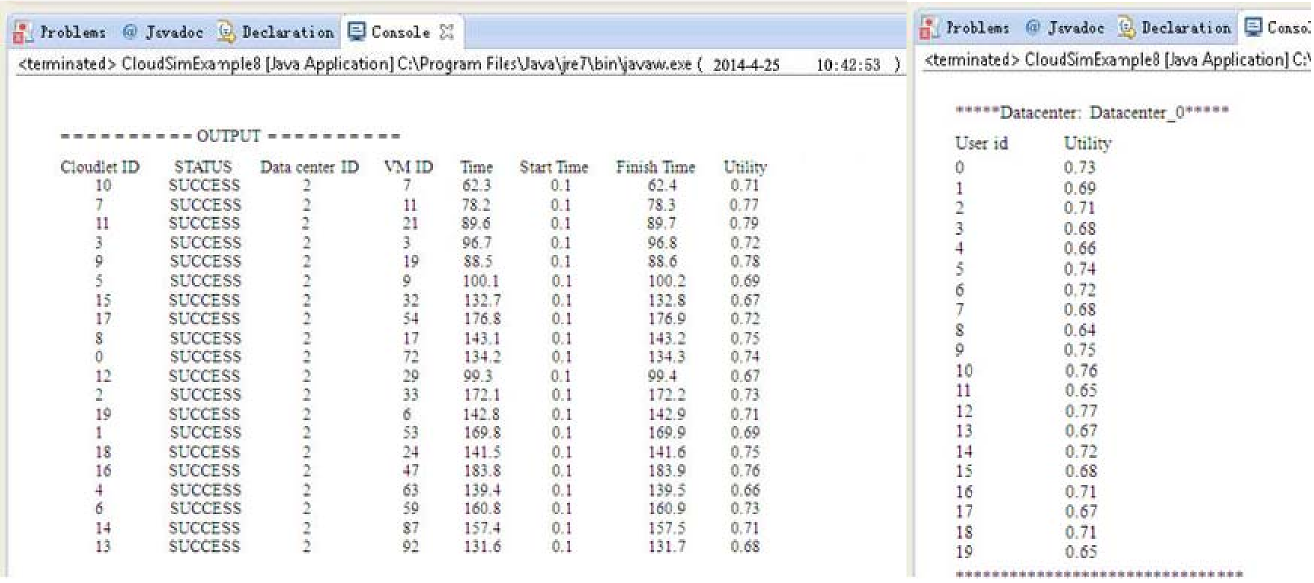
Environment settings of CloudSim:the number of virtual machine's CPU pick up 1or 2 randomly. The CPU's capability of processing is 200MIPS-400MIPS. 1G RAM. Network bandwidth is 2M/s-4M/s. Hard disk is 2G-4G.

During experiment, we assume that cloud resource users only request storage resource and virtual nodes only supply storage resource. The experiment will simulate how virtual nodes which are on a same data center deal with 20 tasks. Each task represents a user's request (that means there are 20 cloud resource users during experiment). Each virtual node represents a cloud resource supplier and there are 100 virtual nodes on a data center during experiment. The data center will use default method and the proposed negotiation model to allocate the cloud resource. We will verify the advantage of proposed negotiation model through comparison.

During experiment, the cloud resource users' expected price will choose from [10,60] randomly and reserved price will choose from [200,250] randomly. Virtual nodes' expected price will choose from [200,250] randomly and reserve price will choose from [10,60] randomly. The price utility of resource users and suppliers for selecting targets is 0.1. Time strategy is chosen from 1/3, 1.0 and 3.0 randomly. The maximum negotiation round is 20. Other attributes is the default value of CloudSim.

C. *Results*

The experiment results are shown in Figure 3-5.We will analyze the experiment results from the angle of users and suppliers.



Problems Javadoc Declaration Console

<terminated> CloudSimExample8 [Java Application] C:\Program Files\Java\jre7\bin\javaw.exe (2014-4-25 10:42:53)

========== OUTPUT ==========

Cloudlet ID	STATUS	Data center ID	VM ID	Time	Start Time	Finish Time	Utility
10	SUCCESS	2	7	62.3	0.1	62.4	0.71
7	SUCCESS	2	11	78.2	0.1	78.3	0.77
11	SUCCESS	2	21	89.6	0.1	89.7	0.79
3	SUCCESS	2	3	96.7	0.1	96.8	0.72
9	SUCCESS	2	19	88.5	0.1	88.6	0.78
5	SUCCESS	2	9	100.1	0.1	100.2	0.69
15	SUCCESS	2	32	132.7	0.1	132.8	0.67
17	SUCCESS	2	54	176.8	0.1	176.9	0.72
8	SUCCESS	2	17	143.1	0.1	143.2	0.75
0	SUCCESS	2	72	134.2	0.1	134.3	0.74
12	SUCCESS	2	29	99.3	0.1	99.4	0.67
2	SUCCESS	2	33	172.1	0.1	172.2	0.73
19	SUCCESS	2	6	142.8	0.1	142.9	0.71
1	SUCCESS	2	53	169.8	0.1	169.9	0.69
18	SUCCESS	2	24	141.5	0.1	141.6	0.75
16	SUCCESS	2	47	183.8	0.1	183.9	0.76
4	SUCCESS	2	63	139.4	0.1	139.5	0.66
6	SUCCESS	2	59	160.8	0.1	160.9	0.73
14	SUCCESS	2	87	157.4	0.1	157.5	0.71
13	SUCCESS	2	92	131.6	0.1	131.7	0.68

Problems Javadoc Declaration Conso

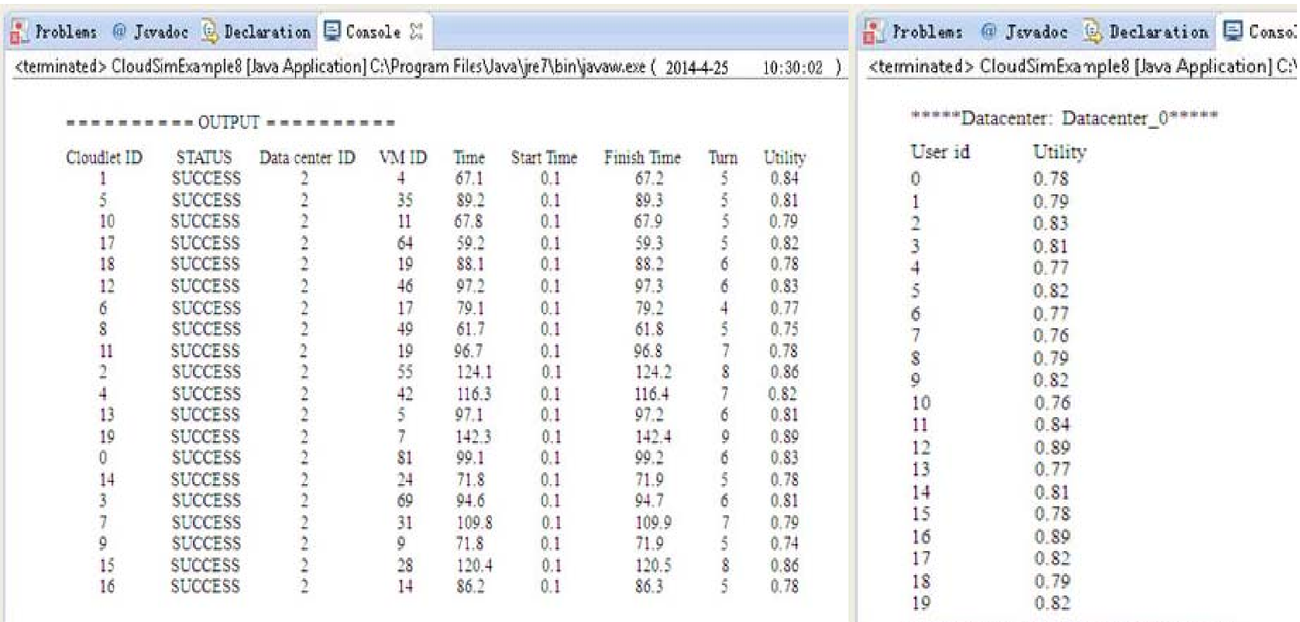
<terminated> CloudSimExample8 [Java Application] C:\

*****Datacenter: Datacenter_0*****

User id	Utility
0	0.73
1	0.69
2	0.71
3	0.68
4	0.66
5	0.74
6	0.72
7	0.68
8	0.64
9	0.75
10	0.76
11	0.65
12	0.77
13	0.67
14	0.72
15	0.68
16	0.71
17	0.67
18	0.71
19	0.65

****

Figure 3. Results of cloud resource allocation using CloudSim default method



Problems Javadoc Declaration Console

<terminated> CloudSimExample8 [Java Application] C:\Program Files\Java\jre7\bin\javaw.exe (2014-4-25 10:30:02)

========== OUTPUT ==========

Cloudlet ID	STATUS	Data center ID	VM ID	Time	Start Time	Finish Time	Turn	Utility
1	SUCCESS	2	4	67.1	0.1	67.2	5	0.84
5	SUCCESS	2	35	89.2	0.1	89.3	5	0.81
10	SUCCESS	2	11	67.8	0.1	67.9	5	0.79
17	SUCCESS	2	64	59.2	0.1	59.3	5	0.82
18	SUCCESS	2	19	88.1	0.1	88.2	6	0.78
12	SUCCESS	2	46	97.2	0.1	97.3	6	0.83
6	SUCCESS	2	17	79.1	0.1	79.2	4	0.77
8	SUCCESS	2	49	61.7	0.1	61.8	5	0.75
11	SUCCESS	2	19	96.7	0.1	96.8	7	0.78
2	SUCCESS	2	55	124.1	0.1	124.2	8	0.86
4	SUCCESS	2	42	116.3	0.1	116.4	7	0.82
13	SUCCESS	2	5	97.1	0.1	97.2	6	0.81
19	SUCCESS	2	7	142.3	0.1	142.4	9	0.89
0	SUCCESS	2	81	99.1	0.1	99.2	6	0.83
14	SUCCESS	2	24	71.8	0.1	71.9	5	0.78
3	SUCCESS	2	69	94.6	0.1	94.7	6	0.81
7	SUCCESS	2	31	109.8	0.1	109.9	7	0.79
9	SUCCESS	2	9	71.8	0.1	71.9	5	0.74
15	SUCCESS	2	28	120.4	0.1	120.5	8	0.86
16	SUCCESS	2	14	86.2	0.1	86.3	5	0.78

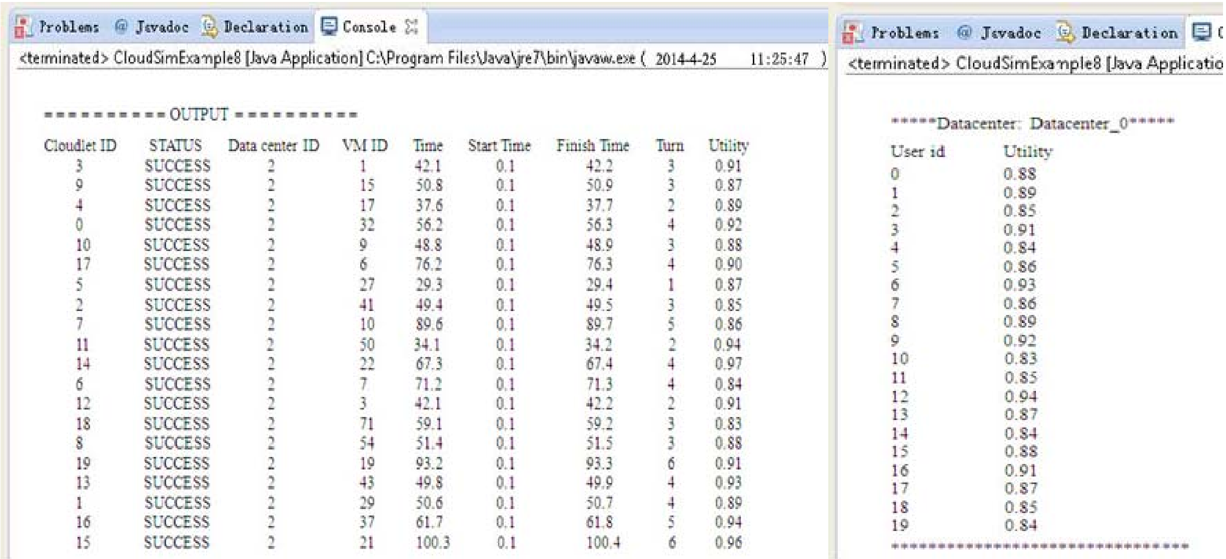
Problems Javadoc Declaration Conso

<terminated> CloudSimExample8 [Java Application] C:\

*****Datacenter: Datacenter_0*****

User id	Utility
0	0.78
1	0.79
2	0.83
3	0.81
4	0.77
5	0.82
6	0.77
7	0.76
8	0.79
9	0.82
10	0.76
11	0.84
12	0.89
13	0.77
14	0.81
15	0.78
16	0.89
17	0.82
18	0.79
19	0.82

Figure 4. Results of cloud resource allocation using negotiation strategy based on time


Problems @ Javadoc Declaration Console

<terminated> CloudSimExample8 [Java Application] C:\Program Files\Java\jre7\bin\javaw.exe (2014-4-25 11:25:47)

========== OUTPUT ==========

Cloudlet ID	STATUS	Data center ID	VM ID	Time	Start Time	Finish Time	Turn	Utility
3	SUCCESS	2	1	42.1	0.1	42.2	3	0.91
9	SUCCESS	2	15	50.8	0.1	50.9	3	0.87
4	SUCCESS	2	17	37.6	0.1	37.7	2	0.89
0	SUCCESS	2	32	56.2	0.1	56.3	4	0.92
10	SUCCESS	2	9	48.8	0.1	48.9	3	0.88
17	SUCCESS	2	6	76.2	0.1	76.3	4	0.90
5	SUCCESS	2	27	29.3	0.1	29.4	1	0.87
2	SUCCESS	2	41	49.4	0.1	49.5	3	0.85
7	SUCCESS	2	10	89.6	0.1	89.7	5	0.86
11	SUCCESS	2	50	34.1	0.1	34.2	2	0.94
14	SUCCESS	2	22	67.3	0.1	67.4	4	0.97
6	SUCCESS	2	7	71.2	0.1	71.3	4	0.84
12	SUCCESS	2	3	42.1	0.1	42.2	2	0.91
18	SUCCESS	2	71	59.1	0.1	59.2	3	0.83
8	SUCCESS	2	54	51.4	0.1	51.5	3	0.88
19	SUCCESS	2	19	93.2	0.1	93.3	6	0.91
13	SUCCESS	2	43	49.8	0.1	49.9	4	0.93
1	SUCCESS	2	29	50.6	0.1	50.7	4	0.89
16	SUCCESS	2	37	61.7	0.1	61.8	5	0.94
15	SUCCESS	2	21	100.3	0.1	100.4	6	0.96

Problems @ Javadoc Declaration

<terminated> CloudSimExample8 [Java Applicatio

*****Datacenter: Datacenter_0*****

User id	Utility
0	0.88
1	0.89
2	0.85
3	0.91
4	0.84
5	0.86
6	0.93
7	0.86
8	0.89
9	0.92
10	0.83
11	0.85
12	0.94
13	0.87
14	0.84
15	0.88
16	0.91
17	0.87
18	0.85
19	0.84

****

Figure 5. Results of cloud resource allocation using negotiation model based on competition-time-history

When using the CloudSim's default method to allocate resources, the average negotiation time is 130.035ms, the suppliers' average utility is 0.7215 and the users' average utility is 0.6995. When using the negotiation strategy based on time, the average negotiation time is 91.98ms, the suppliers' average utility is 0.807, the users' average utility is 0.8055 and the average negotiation rounds is 6. While CloudSim using the proposed negotiation model to allocate resources, the average allocating time is 58.04ms, the suppliers' average utility is 0.8975, the users' average utility is 0.8755 and the average negotiation rounds is 3.55.

TABLE1 RESULTS OF EXPERIMENT

	Default Method of CloudSim	*Negotiation Strategy based on Time*	*Negotiation Model based on COMPETITION-TIME- HISTORY*
Average Time/ms	130.035	91.98	58.04
Suppliers' Average Utility	0.7215	0.807	0.8975
Users' Average Utility	0.6995	0.8055	0.8755
Average Negotiation Round /turn	/	6	3.55

Through Table 1, we could see that under cloud computing, while CloudSim uses negotiation strategy based on time, cloud resource allocation would use less time, resource users and suppliers will get higher utility. This means negotiation is more effective than CloudSim default method in cloud resource allocation.

While comparing with the negotiation strategy based on time during cloud resource allocation, the proposed negotiation model based on competition-time-history proposed could shorten the resource allocation time and improve the final effectiveness. Consequently, we could hold the view that negotiation is suitable for cloud resource allocation, the proposed negotiation model is better than traditional negotiation methods.

V. CONCLUSION AND FUTURE WORK

The paper designed the multi-agent based negotiation framework under the circumstance of cloud computing. The intermediary agent could shorten the negotiation time and enhance the success rate of negotiation. The multi-agent based negotiation model based on competition-time-history proposed in the paper considers multiple influencing factors during negotiation, and generates reasonable proposal according to current market by combining all the factors. Finally, the negotiation model was applied to the ResourceAllocation of CloudSim and accomplish cloud resource allocation in the simulation experiments. Simulation experiment proved that the proposed negotiation model could applied to cloud resource well and could get higher effectiveness. With the development of cloud computing and the rapid increase of information technology, negotiation under cloud computing will face more problems such as credit problems, scheduling problems. We will consider how to resolve these problems in the future.

ACKNOWLEDGMENTS

The work in this paper is supported by the National Natural Science Foundation of China (71371018) and the Social Science Fund of Beijing-13JDJGB037.

Corresponding Author: Guorui Jiang, Email: jianggr@bjut.edu.cn

REFERENCES

[1] X. Zheng, P. Martin, and K. Brohman, Cloud service negotiation:concession vs. tradeoff approaches[C]. Proceedings of the 2012 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (ccgrid 2012). IEEE Computer Society, 2012, pp. 515-522.

[2] K. Chen and W. M. Zheng, Cloud computing:system instances and current research[J]. Journal of Software, 20(5). 2009, pp. 1337-1348.

[3] M. He, N. R. Jennings, and H. F. Leung, On agent-mediated electronic commerce[J]. Knowledge and Data Engineering, IEEE Transactions on, 15(4). 2003, pp. 985-1003.

[4] J. S. Rosenschein and Zlotkin, Rules of encounter:design

conventions for automated negotiation among computers [M]. Cambridge MA:MIT Press,1994.

[5] N. R. Jennings, K. Sycara, and M. Wooldrige, A roadmap of agent research and development [J].Autonomous Agents and Multi- Agent Systems, 1.1998, pp. 275- 306.

[6] I. Rahwan, S. Liz, and N. R. Jennings, A methodology for designing heuristic agent negotiation strategies [J]. Applied Artificial Intelligence, 21(6). 2007, pp. 489-527.

[7] T. D. Nguyen and N. R. Jennings, A heuristic model of concurrent bilateral negotiations in incomplete information settings [C]. Proc 18th Int Joint Conf on AI, Acapulco, Mexico, 2003, pp. 1467- 1469.

[8] S. D. Ramchurn, C. Sierra, and L. Godo, Negotiating using rewards[J]. Artificial Intelligence, 171(10). 2007, pp. 805-837.

[9] G. Zhang, G. R. Jiang, and T. Y. Huang, Cognition model of argumentation-based multi-Agent business negotiation[J]. Computer Engineering, 37(1). 2011, pp. 28-31, 33.

[10] K. M. Sim, Towards complex negotiation for cloud economy[J]. Advances in Grid and Pervasive Computing, 2010, pp. 395-406.

[11] S. Son and K. M. Sim, A price-and-time-slot-negotiation mechanism for cloud service reservations[J]. Transactions on Systems, Man, and Cybernetics, 42(3). 2012, pp. 713-728.

[12] G. Wei, A. V. Vasilakos, Y. Zheng, and N. Xiong, A game-theoretic method of fair resource allocation for cloud computing services[J]. The Journal of Supercomputing, 54(2). 2009, pp. 1-18.

[13] D. Sun, G. Chang, C. Wang, Y. Xiong, and X. Wang, Efficient nash equilibrium based cloud resource allocation by using a continuous double auction[C]//Computer Design and Applications (ICCDA), 2010 International Conference on. IEEE, 1. 2010, pp. 94-99.

[14] M. Macias and J. Guitart, Using resource-level information into nonadditive negotiation models for cloud market environments[C]//Network Operations and Management Symposium (NOMS), 2010, pp. 325-332.

[15] S. Son, K. M. Sim, A negotiation mechanism that facilitates the price-timeslot-QoS negotiation for establishing SLAs of cloud service reservation[M]//Networked Digital Technologies. Springer Berlin Heidelberg, 2011, pp. 432-446.

[16] B. An, V. Lesser, and D. Irwin, Automated negotiation with decommitment for dynamic resource allocation in cloud computing[C]//Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems: International Foundation for Autonomous Agents and Multiagent Systems, 1. 2010, pp. 981-988.

[17] J. Akhani, S. Chuadhary, and G. Somani, Negotiation for resource allocation in iaas cloud[C]//Proceedings of the Fourth Annual ACM Bangalore Conference, 2011.

[18] P. Faratin, C. Sierra, and N. R. Jennings， Negotiation decision functions for autonomous agents [J]. Robotics and Autonomous Systems, 24(3-4). 1998, pp. 159-182.