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Agent-based Web Services Integration Model and Tasks Allocation Method

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Abstract: The existing Web services integration systems have three major disadvantages, in order to improve these disadvantages, this study propose extend the traditional contract net model so as to improve its disadvantage in allocating tasks. In the extended model, the tendering tactic is developed based on creditworthiness of task acquaintance and the bid awarded tactic is advanced based on the fuzzy comprehensive evaluation. Hence, it not only guarantees the quality of task fulfillment but also solves the problem of excessive communication in the traditional contract net model.

Key words: Agent, web services integration, contract net, tasks allocation

INTRODUCTION

Presently, the most famous projects in the research of Services integration are SELF-SERV (Benatallah *et al*., 2005), METEOR-S (Abhijit *et al*., 2004) Symphony (Nanda and Karnik, 2003), WebSASE (Basaran *et al*., 2003), etc. However, the major software technology in these existing web service integration modes is still object-oriented technology, which has some limits (Mardiana *et al*., 2011), such as passiveness of objects and single coordinative patterns between objects. So the existing Web services integration systems have three major problems:

- Autonomy, self-adapting and individuality of Web service are insufficient
- Single services integration mode also makes it difficult for Web service to adapt to the dynamic network environment
- Because of the limitation of platform realization technology, the method of constructing integration framework is inflexible and can not guarantee the quality of integration system

In order to solve the problems discussed above, an Agent-based Web services Integration Model (AWSIM) has been developed in one of our studies (Zhang and Ben, 2009). While in this study, the traditional contract net model is extended to realize the allocation of multi-tasks with multi-rounds.

CONTRACT NET-BASED TASKS ALLOCATION

Contract Net is a distributional task-allocation method applied extensively in MAS. However, when dealing with the tendering-bidding activity with multi-rounds, multi-tasks and multi-winning-bidders, many shortcomings are exposed (Wang *et al*., 2008). This study will improve the traditional contract net models from perspectives of the tendering tactic and the bid awarded tactic.

Tasks distribution in AWSIM depends on four types of Agent: task-cooperation Agent, local resource Agent, service execution Agents and mediator Agent. The task-cooperation Agent classifies the tasks according to their functions and allocates them to the local resource Agent in different functional domains. After receiving the task information, the local resource Agent will initiate a task-oriented coordination in its own function domain to choose the best service execution Agent to play the role of manager in the contract net. The service execution Agent as the contractor in contract net is responsible for receiving and executing tasks. The mediator Agent does not participate in the decision process of the distributional task allocation and only play the role of the mediator in charge of the management of the information related to tasks and to Agents. The information related to task, including input and output of the task, the required qualifications, the task finish time and quality, etc., is registered by task-cooperation Agent. The information related to Agents, including the Agent location, utility structure, basic capabilities, capability of behavior execution, etc., is registered by Agents themselves.

THE TENDERING TACTIC BASED ON CREDITWORTHINESS OF TASK ACQUAINTANCE

This study extends the traditional task acquaintance set model by introducing the description of default and proposes the tendering tactic based on creditworthiness

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of task acquaintance. It is a method that manager, by comprehensively evaluating the task acquaintances on their task acquainting degree and default records, chooses some certain ones to send task notification to. This tactic helps to intensify the effectiveness of bids. A extended task acquaintance set is defined by AS = <TC, TI, CN, RE, PD>, where TC represents the class of tasks; TI represents tasks' basic information; CN represents candidate nodes set; RE represents the task acquainting degree of candidate nodes, which is defined as the ratio of accepted tasks in the same class by task execution Agent to the total tasks of the class; PD represents default probability, which indicates whether the task acquaintance complete the accepted task successfully.

Let M denote manager and C denote contractor, so the possible cases of task execution can be described as:

Case 1: M does not terminate a contract and C does not default

Case 2: M does not terminate a contract but C does default

Case 3: M does terminate a contract and C does not default

The indicative function:

$$I_M = \begin{cases} 1, & \text{M does not terminate a contract} \\ 0, & \text{M does terminate a contract} \end{cases}$$

and the indicative function:

$$I_C = \begin{cases} 1, & \text{C does default} \\ 0, & \text{C does not default} \end{cases}$$

are used respectively to describe whether M terminates a contract and whether C defaults.

Let n_{t-1} ($t\geq 1$ and t is an integer) denote the total number of defaults of C in [0, t-1] and let N_{t-1} ($t\geq 1$ and t is an integer) denote the total number of bids awarded to C in [0, t-1]. Thus, the default probability of C can be expressed as:

$$\begin{aligned} PD_t &= (n_{t-1}+I_C)/(N_{t-1}+I_M) \\ &= \begin{cases} n_{t-1}/(N_{t-1}+1), & \text{Case1} \\ (n_{t-1}+1)/(N_{t-1}+1), & \text{Case2}, \quad (t\geq 1) \\ n_{t-1}/N_{t-1}, & \text{Case3} \end{cases} \end{aligned}$$

where, $PD_0 = n_0/N_0$ and the value of n_0 and N_0 can be found in the historic record of task acquaintance set.

Therefore, the creditworthiness can be calculated by $Cr_{t+1} = (1-PD_t)\times RE_t$, ($t\geq 1$ and t is an integer).

However, the task acquaintance set only includes some service execution agents of total. If the tender is only confined to the task acquaintance set, some agents with strong competitiveness in the external side of the set will lose the chance to participate in the task allocation. Such a case will limit the performance of task fulfillment.

FUZZY COMPREHENSIVE EVALUATION BASED BID AWARDED TACTIC

The bid awarded tactic is based on the Fuzzy Comprehensive Evaluation. It is a method that the manager develops the set of factors and the set of evaluations that influencing the award of bid in accordance to the features of the allocated tasks and the negotiation target. Then the candidate contractors will be rated according to the results from fuzzy comprehensive evaluation and thus the best task executor will be chosen. The Fuzzy Comprehensive Evaluation based bid awarded tactic includes five steps, they are:

Step 1: Develop the set of evaluating factors which are given by the capabilities of agent and are used to choose the winning bidder. The set of factors is denoted by $U = \{u_1, u_2, u_3\}$, where u_1, u_2, u_3, respectively represents Agent's utility structure, its basic capabilities and its capability of behavior execution

Step 2: Establish the set of evaluating results. It includes all possible ratings of evaluations on bidders, i.e., good, average(medium) and bad. Thus, the set of evaluating result can be denoted as $V = \{v_1, v_2, v_3\}$, where v_1, v_2 and v_3 is good, medium(average) and bad

Step 3: Constructing the fuzzy matrix. By the fuzzy comprehensive evaluation, the fuzzy matrix is defined as:

$$R = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix}$$

where, each row denotes a fuzzy sub-set, e.g., $\{r_{i1}, r_{i2}, r_{i3}\}$ is the fuzzy sub-set of the ith evaluating factor and thus r_{ij} is the ith evaluating factor's membership grade to the jth evaluation rating, e.g., r_{11} is the first evaluating factor's membership grade to the rating of good. The membership grade is given by a linear membership function defined as follows: (1) According to each evaluating factor's features, set three threshold values-good, average(medium) and bad -as the criteria to calculate its membership grade. For instance, the threshold values of the ith evaluating factor is denoted as S_{i1}, S_{i2} and S_{i3}. (2) By the requirement of tendering document, each agent must provide its own value of each evaluating factor when participating in the bid. Suppose that its value of the ith evaluating factor u_i is x_i. (3) Its membership grades are calculated as follows:

$$r_{i1} = u_i(v_1) = \begin{cases} 1 & x_i \geq s_{i1} \\ \dfrac{x_i - s_{i2}}{s_{i1} - s_{i2}} & s_{i2} < x_i < s_{i1} \\ 0 & s_{i3} < x_i \leq s_{i2} \\ 0 & x_i \leq s_{i3} \end{cases},$$

$$r_{i2} = u_i(v_2) = \begin{cases} 0 & x_i \geq s_{i1} \\ \dfrac{s_{i1} - x_i}{s_{i1} - s_{i2}} & s_{i2} < x_i < s_{i1} \\ \dfrac{x_i - s_{i3}}{s_{i2} - s_{i3}} & s_{i3} < x_i \leq s_{i2} \\ 0 & x_i \leq s_{i3} \end{cases},$$

$$r_{i3} = u_i(v_3) = \begin{cases} 0 & x_i \geq s_{i1} \\ 0 & s_{i2} < x_i < s_{i1} \\ \dfrac{s_{i2} - x_i}{s_{i2} - s_{i3}} & s_{i3} < x_i \leq s_{i2} \\ 1 & x_i \leq s_{i3} \end{cases}$$

Step 4: Set the weight of each evaluating factor. Because each evaluating factor reflects a different execution capability, it needs to set the weight to each evaluating factor, especially when the purpose of choosing the winning bidder and the final target of task execution change. Denote the weight of the ith evaluating factor u_i by ω_i and $\sum_{i=1}^{n} \omega_i = 1$. The vector of weights is expressed as A (ω_1, ω_2, ω_3)

- **Step 5:** Calculate the fuzzy comprehensive value

$$S = AR = (\omega_1, \omega_2, \omega_3) \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix} = (s_1, s_2, s_3)$$

According to the final values S (s_1, s_2, s_3), each agent can be evaluated and the bid will be awarded to the agent with the highest membership grade in the rating of good.

EXPERIMENT

In the experiment, the performance of each type of manager in various environments will be tested. The manager firstly notifies the contractors the major requirements of task including execution cost and time. After receiving the notification, each contractor undertakes different tactic to bid. Then, the manager chooses a contractor to execute the task by his own tactic of evaluating the bidding documents. The data in each experiment is randomly generated and there are five contractors but belonging to different types in each experiment:

- **First experiment:** five contractors are all cooperative agents. Fig. 1(a, b) show, there are little difference in task execution costs and negotiation time in processing the same number of tasks between the

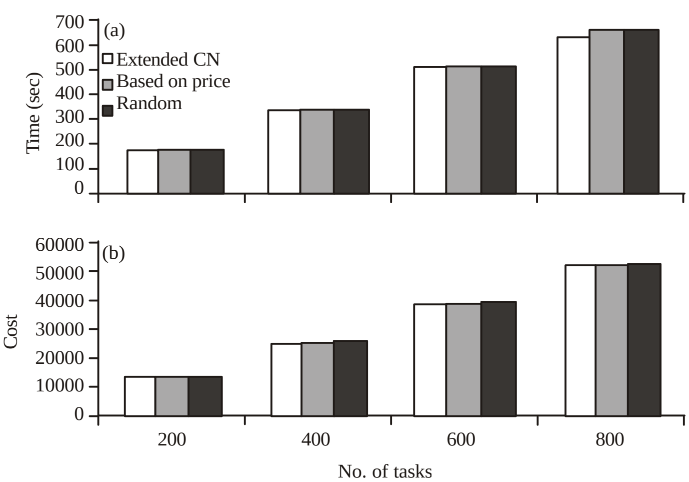

Fig. 1(a-b): In cooperative environment (a) Negotiation time and (b) Task execution cost

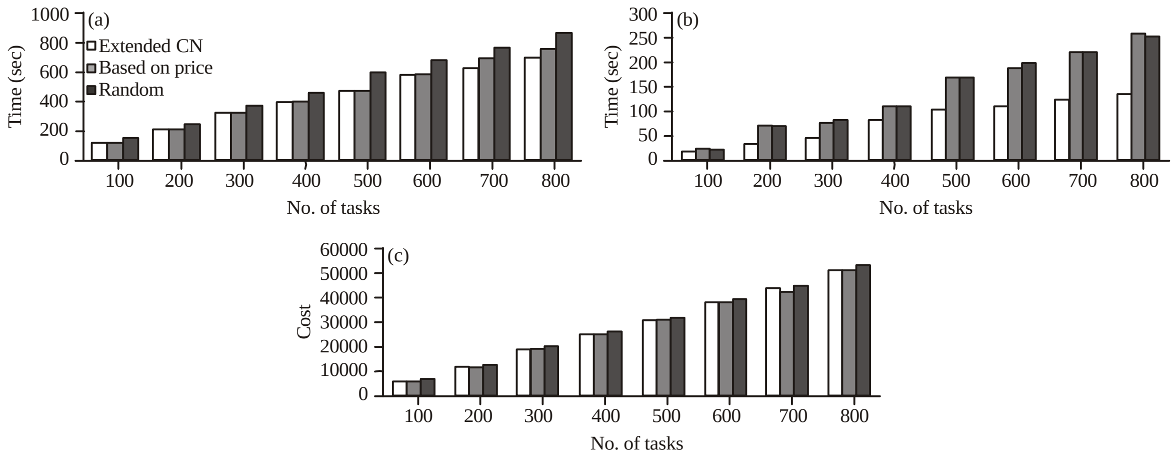

Fig. 2(a-c): In non-cooperation environment, (a) Negotiation time, (b) Added negotiations and (c) Task execution cost

extended contract net model and price based model in the cooperative environment. But both of them perform better than the tactic of choosing in random

- **Second experiment:** five contractors are all self-centered agents. Figure 2a shows, in the non-cooperative environment, the manager using the extended contract net model boasts the least task execution cost and negotiation time among the threes. Figure 2b shows, the tasks allocation method based on the extended contract net decreases the number of negotiations. In addition, with increase of the tasks, this advantage is more obvious. From the Fig. 2c, the cost in the extended contract net based tactic is the second highest but the excessive fee is still in the acceptable range

CONCLUSION

In order to more efficiently realize the tasks allocation in the process of Web Services integration, this study extends the traditional contract net model so as to improve its disadvantage in allocating tasks. From the experiments above, the tasks allocation tactic based on the extended contract net is feasible. In particular, when dealing with a large number of tasks, this tactic not only guarantees the quality of task execution but also cuts the number of negotiations and thus elevates performance of the system.

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