Distributed Service Discovery Algorithm Based on Ant Colony Algorithm

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***Abstract*—UDDI is a universal description, discovery and integration protocol. As a public registry of Web service, it is designed to store information about each company and its service. Traditional centralized service discovery structure of UDDI service registration center does not apply to large-scale service discovery. When all the services register to a center, the service bottleneck, failure of single point and the poor scalability defects will occur. In addition, traditional service matching mechanisms are mainly based on keywords method which lacks of semantic description and makes the service publisher and demanders cannot reach a common semantic understanding. This will lead to the problems of semantic conflicts and low accuracy that seriously affects the precision and recall of service matching. To address these shortcomings of the centralized service discovery structure of UDDI, we propose a distributed semantic service registration center which is in the construction of loosely coupled P2P network enabled the progressive massive search. In the P2P distributed network, there can be a large number of nodes to store the registration information which is suitable for large-scale service because of the adaptivity, scalability and good fault tolerance characteristics. In order to reduce the number of concurrent transmitted packets, the advanced ant colony algorithm is introduced to forward packets by probabilistic choice. The results comparison with the traditional algorithm is given through the simulation experiments and it has shown that the proposed method has good performance for the distributed service discovery**

***Index Terms*—UDDI, P2P distributed network, Semantic, Ant colony algorithm**

I. Introduction

The emergence of e-commerce is an important change of combining business and the information technology together. At the same time, the service-oriented is another breakthrough which provides a variety of opportunities to find new customers, supply flow and new service for business entities [1-3]. Web service architecture is accomplished through a series of open protocols and specifications. The most important three protocols are SOAP (service-oriented architecture), WSDL (Web Service Definition Language) and UDDI (universal description, discovery and integration). UDDI is the key technologies for service publishing. It provides universal description, discovery and integration of Web service and the Web service lookup operation can be implemented with the combination of UDDI and WSDL. The core components of UDDI is the UDDI business registry,which describe the business entities and their Web service in XML file. The information provided by the UDDI business registration consists of three parts of the white, yellow and green pages respectively [4-7].

Traditional UDDI service registry center utilizes the centralized service discovery model where all service is concentrated in one server. The lookup method of this structure is simple and the speed is relative fast. However, the drawbacks are the existence of a single point of failure, performance bottlenecks, and not suitable for large-scale service discovery [8-11]. On the other hand, UDDI service description is commonly in form of the WSDL documents that does not support non-functional semantic description and attributes of service quality, which is not suitable for the semantic extension of service description [12-16]. Requirements of service demanders cannot be well described in the WSDL documents and it only supports simple keyword comparison for the technical details as well.

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To overcome the disadvantages of the centralized structure of UDDI, the P2P distributed network is proposed in many researches [17, 18]. In the P2P network, there can be a large number of nodes storing the registration information and it is suitable for large-scale service due to the adaptivity, scalability and good fault tolerance characteristics. However, information searching algorithm of the fully distributed unstructured P2P network has certain blindness due to the low routing efficiency and poor scalability. For large-scale distributed service, the service discovery efficiency is not very high. The current solutions are of the following aspects. METEOR-S proposed the creation of a shared ontology [19]. Each UDDI service registration center in the P2P network maps the registered service on it to one or more ontology concepts and then use the shared ontology to organize the P2P topology. Chen etc. proposed to use DNS to manage P2P nodes[20]. However, these proposed methods are mostly tightly coupled.

As a capable language that can express the service capabilities, adopting semantic description for service registry architecture can provide good intelligence [21, 22]. Registration center of UDDI service introduces semantic annotations so that services and ontology concepts can be associated together. Utilizing ontology concept identifications which are already associated with Web service in the semantic routing table so that it is not to deal with the UDDI server but the service on UDDI server when conducting the route searching processes. At the same time, the concept ID and server ID are bundled in the routing table can solve the problem of mapping between service and servers.

In this paper, an improved distributed service discovery algorithm based on agent and the ant colony algorithm was proposed for the Internet on the basis of constructing the semantic routing. For the service discovery mechanisms in the P2P network, ontology-based knowledge was introduced for publishing and discovering the web services in the service registry. Concepts and relations in ontology were superimposed to the network to construct the service request routing to improve the service discovery and query capabilities. Through the analysis of Comparative experiments with the Spay and Wait protocol, the proposed algorithm has shown better performance in many aspects.

The article is organized as follows. Section 2 provides the main theory of the advanced semantic routing method based on ant colony algorithm. The evaluation results are illustrated in section 3 by comparing the proposed algorithm with the Spay and Wait protocol. Section 4 is our concluding remarks.

II. Algorithms

A. Figures and Tables

The basis of the algorithm is to construct the semantic routing table. The identifications of a routing table on the regular network are constituted by IP addresses, while the semantic routing table consists of the identifications of the concepts from the ontology knowledge base. Semantic routing table is shown in Table 1. Concept represents the concept in the ontology which is associated with the specific service. Next hop represents the next server of the local server which leads to reach the server where the concept Ci is located. Hop count is on behalf of the total number of the hops to the destination server when node Nj serves as the next hop. Pheromone represents the pheromone left by the ants.

TABLE 1:
THE SEMANTIC ROUTING TABLE

Concept	Next hop	Hop count	Pheromone
Ci	Nj	m	phi
Ci	Nk	n	ph**j**
Cj	Ni	k	phk
Ck	Nj	…	…
…	…	…	…

B. Improve the Ant Colony Algorithm

It has the advantage of high convergence rate and has attracted a lot of scholars engaged in the study of the theory and application of it.

Ant colony algorithm is a kind of modern swarm intelligence algorithm inspired by the behavior of ants foraging process. It has the advantage of high convergence rate. In the ant colony algorithm, each path has the distribution of ant pheromone. Note that the pheromone is a kind of special chemical odor left on the path in the process of ants moving.

P2P service discovery is not to find a target node, but to find all nodes where the target services locate as much as possible. Therefore, this paper proposed an advanced protocol algorithm (ASW) based on the Spray and Wait protocol and ant colony algorithm.

In the proposed algorithm, packets transmitted by the P2P service discovery agent are corresponding to the ants. The agent searches for the appropriate service agent based on semantic routing table, which means to search for the ontology concepts associated with the appropriate services. The concepts of qualifying the searching conditions in the routing table may be multiple and the pheromone will be the basis for probability of selecting. When found the appropriate service, the agent will update the routing tables and pheromone along the path, through which the semantic routing table can be dynamically maintained. A service may correspond to more than one ontology concept and the searching algorithm is applicable.

C. Routing

The delivery of messages is represented by the ant walking. First, the agent queries the ontology concept ID associated with the services to be searched in the routing table. If there is no appropriate ID, k nodes will be randomly selected for packet forwarding. If multiple concept IDs are filtered out, the probability of reaching the target node according to the routing list will be calculated according to the pheromone. The probability selection formula is as follows.

$$p_{ij}^{k}=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}[1/d_{ij}]^{\beta}}{\sum\limits_{s\in allowed_k}[\tau_{is}(t)]^{\alpha}[1/d_{is}]^{\beta}} & j\in allowed_k(i)\\ 0 & \text{Others}\end{cases} \quad (1)$$

p_{ij}^{k} is the probability value under the condition that the k-th ant at the i-th node sets the j-th node as the destination; $\tau_{ij}(t)$ is the pheromone dispersed on the path of the i-th and j-th node at time t; $allowed_k(i)$ is the non-visited nodes when the k-th ant is at the i-th node; the distribution of α and β represents the degree of importance for pheromone and visibility.

The greater $\tau_{ij}(t)$ is and the shorter the distance between node i and node j is, the probability of the path ij being selected will be greater.

K nodes around will be selected to transmit the package according to the value of p_{ij}^{k}.

D. Update of the Pheromone

After finding the target service, the agent needs to update the density of the pheromone on the passing paths as the routing basis of other agents. $\tau_{ij}(t)$ will be updated at each iteration, as shown in the formula below.

$$\tau_{ij}(t+\triangle t)\leftarrow\sum_{k=1}^{m}\triangle\tau_{ij}^{k} \quad (2)$$

M is the number of ants and $\triangle\tau_{ij}^{k}$ is the incremental of the pheromone at the k-th interation. The calucation formular of $\triangle\tau_{ij}^{k}$ is as follows.

$$\triangle\tau_{ij}^{k}=\begin{cases}\dfrac{Q}{L_k} & if\,(i,j)\in tour\ \ done\ \ by\ \ ant\ \ k\\ 0 & otherwise\end{cases} \quad (3)$$

Lk is the total length of paths after the k-th ant completing travelling around. Q is a constant to control the increasing speed of $\triangle\tau_{ij}^{k}$.

At the same time, pheromone on each route of the routing table regularly volatilizes. The pheromone will volatile to none if haven't been update for a long time which means the services associated with ontology concepts of the target node may be canceled or the target node has exited the network. The pheromone evaporation formula is as follows.

$$\tau_{ij}(t+\triangle t)\leftarrow\rho\tau_{ij}(t)\text{, Where }\rho\in(0,1). \quad (4)$$

E. Life Time Control

In order to control the packets (ants) roaming around network, a life cycle TTL is set for every packet. When a packet is produced, TTL of it is set to an initial value and it decreases by1 when forwarded once only if the next node is not the destination. If the next node is the target node, then TTL stays unchanged. These measures are conducive to the messages (ants) to search more service. When TTL is 0, the ants automatically die.

F. Maintaining the Semantics Routing Table

In the beginning, when each server node is registered to the P2P network, the ontology concepts which are associated with the local server should be broadcasted to the neighbors to construct the initiate routing table. Every concept forms a routing entry. The next hop is the local server and the number of the hop is 1. The pheromone is set to the initiate pheromone value. After the ants roaming and finding the target node where target service located, the update process including the hops, next hop and the pheromone will be adopted.

III. Experiment

The simulator ONE is utilized to provide the opportunity network environment. The parameter settings for the ant colony algorithm are as follows. Alpha which stands for the importance degree of pheromone is 1. Beta which stands for the importance degree of the heuristic factor is 5. Q which is the pheromone increasing strength coefficient is 100. Rho which is the pheromone evaporation coefficient is 0.5. The Simulation duration is set to 200s, 300s and 500s.

For the protocol need to select k rounding nodes as the next hop target nodes, we set k=1, k=3 and k=6 to during the experimental measures respectively. The comparative experiment was done by comparing with the Spay and Wait protocol (SW) marked as SW.

The results analysis was done by collecting the simulation performance reports. The number of the sending packets is shown in Table2.

Table 2:

Confluence of the arriving rates for the sending packages

time	0.2	0.3	0.5
k=6	28	48	73
SW	6	10	17
k=3	26	38	65
k=1	1	1	3

According to Table 2, Figure 1 can be made. From the figure, the number of the sending packets increases in turn of k=1, k=3 and k=6 when utilizing the proposed routing algorithm based on ant colony algorithm, While the number of packets produced by the SW algorithm is between the number of k = 1 and k = 3.

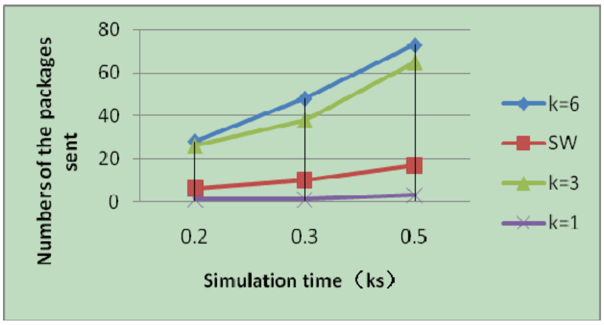

Figure 1: Confluence of the arriving rates for the sending packages

The number of messages reaching the destination is shown in Table 3.

TABLE 3:
CONFLUENCE OF THE NUMBER OF MESSAGES REACHING THE DESTINATION

time	0.2	0.3	0.5
k=6	3	7	11
SW	6	10	17
k=3	3	5	8
k=1	1	1	3

Figure 2 can be made according to Table 3. From the figure, the number of the messages reaching the destination increases in turn of k=1, k=3 and k=6 when utilizing the proposed routing algorithm based on ant colony algorithm. The number of packets reaching the destinations produced by the SW algorithm is the most.

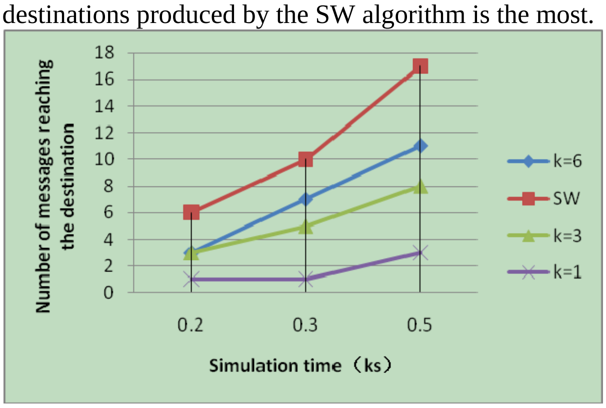

Figure 2: Confluence of the number of messages reaching the destination

The arrival rates of the packets are shown in Table 4.

TABLE 4:
CONFLUENCE OF THE ARRIVAL RATES OF THE SENDING PACKETS

time	0.2	0.3	0.5
k=6	0.5	0.7	0.6471
SW	1	1	1
k=3	0.5	0.5	0.4706
k=1	0.1667	0.1	0.1765

Figure 3 is made according to Table 4. It can be found that the arrival rates of the sending packets increases in turn of k=1, k=3 and k=6 when utilizing the proposed routing algorithm based on ant colony algorithm. The arrival rate of the sending packets produced by the SW algorithm is the greatest.

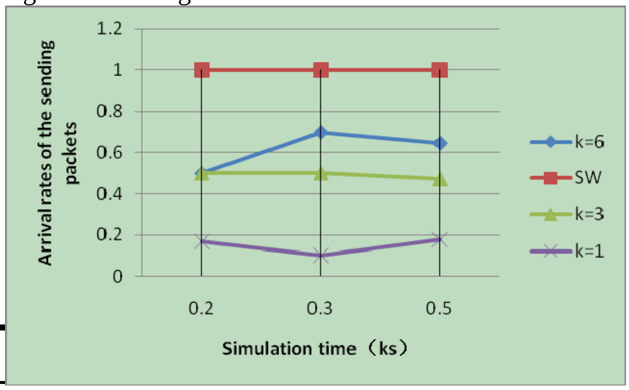

Figure 3: Confluence of the arrival rates of the sending packets

The average delay is shown in Table 5.

TABLE 5:
CONFLUENCE OF THE AVERAGE DELAY

time	0.2	0.3	0.5
k=6	8.5333	12.3857	16
SW	4.2667	3.83	3.4824
k=3	7.2333	8.38	7.2625
k=1	2.7	2.7	2.6333

Figure 4 can be made according to Table 5. It can be found that the average delay increases in turn of k=1, k=3 and k=6 for the proposed routing algorithm based on ant colony algorithm. The average delay produced by the SW algorithm is between the results of k=1 and k=3.

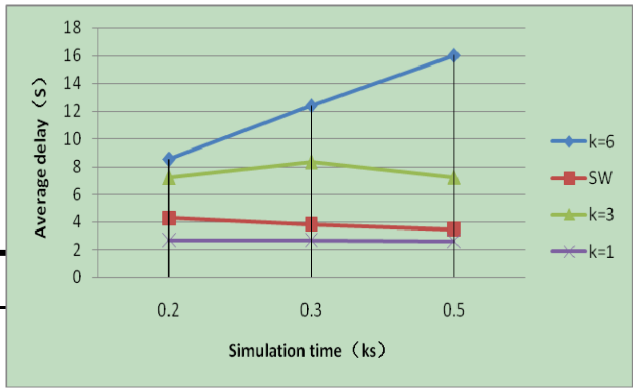

Figure 4: Confluence of the average delay

The return rate is shown in Table 6.

TABLE 6:
CONFLUENCE OF THE RETURN RATE

time	0.2	0.3	0.5
k=6	0.2	0.8	0.8
k=3	0	0.2	0.8
k=1	0	0.2	0.2
SW	0.6	0.6	0.6

Figure 5 can be made according to the Table 6. It can be found that the return rate increases in turn of k=1, k=3 and k=6 for the proposed routing algorithm based on ant colony algorithm. The return rate produced by the SW algorithm mostly does not change with the simulation time.

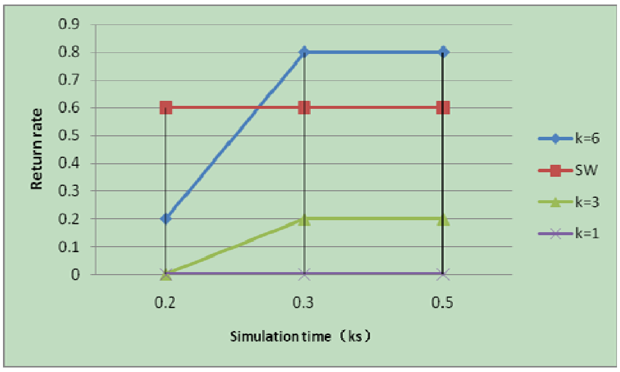

Figure 5: Confluence of the return rate

IV. CONCLUSIONS

On the basis of the semantic routing algorithms, this study proposes a novel distributed service discovery algorithm based on the ant colony algorithm by introducing the probability selection mechanism. The messages choose the next hop by the probabilistic choice in accordance with the distribution of the pheromone. Through the simulation procedures, the proposed algorithm has shown the superiority at the return rate of messages and so on, compared with traditional SW protocol.

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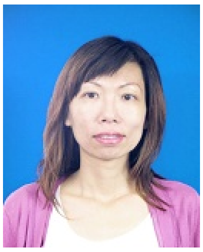

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