Soft Semantic Web Services Agent

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Abstract – **Web services play an active role in the business integration and other fields such as bioinformatics. Current Web services technologies such as WSDL, UDDI, BPEL4WS and BSML are not semantic-oriented. Several proposals have been proposed to develop Semantic Web services to facilitate the discovery of relevant Web services [1][8]. In our vision, with the mature of Semantic Web services technologies, there will be a lot of public or private Semantic Web services Registries based on specific ontologies. These Registries may provide a lot of similar Web services. So how to provide the high quality of service (QoS) Semantic Web services for specific domain using these Registries will be a challenge task. Different domains have different requirements of QoS, it is impractical to use classical mathematical modeling methods to evaluate the QoS of Semantic Web services. In this paper, we propose a framework called Soft Semantic Web services Agent (SSWSA) for providing high QoS Semantic Web services using soft computing methodology. And we will use fuzzy neural network with GA learning algorithm as our study case. Simulation result shows that the SSWSA could handle fuzzy and uncertain QoS metrics effectively.**

I. INTRODUCTION

Web services are playing more and more important role in e-business application integration and other fields such as bioinformatics. So it is crucial to provide and invoke the high quality of service (QoS) Web services for the success of both service providers and service consumers. Unfortunately, current Web services technologies such as WSDL, UDDI, ebXML, XLANG, WSFL, BPEL4WS and BSML are not semantic-oriented that means they do not provide semantic information—implicit semantics of service requestor and service designer about Web services during the publishing, discovery and invocation processes.

Several projects are undergoing to try to add semantics to the Web services framework. DAML-S from DAML Services Coalition [1] uses DAML+OIL based ontology for describing Web services. The latest draft release [5] of DAML-S uses WSDL in conjunction with DAML-S for Web service description. METEOR-S from LSDIS Lab in the Computer Science Department of the University of Georgia [8] follows the approach to relate concepts in WSDL to DAML+OIL ontologies in Web service description and then provide an interface to UDDI that allows querying based on ontological concepts.

In our vision, with the mature of Semantic Web services technologies, there will be a lot of public or private Registries for hosting and querying Semantic Web services based on specific ontologies. Just as today's situation, there are many public and private UDDI Registries hosting a lot of similar Web services with different QoS. For example, XEMBL, BQS and OmniGene. We think the QoS of Semantic Web services should cover both functional and non-functional properties. Functional properties include the input, output, conditionaloutput, precondition, accesscondition and effect of service. These functional properties can be characterized as the capability of the service [1]. Mon-functional properties include the availability, accessibility, integrity, performance, reliability, regulatory, security, response time and cost.

Several matchmaking schemes have been proposed to match the service requestor's requirement with service provider's advertisement [7][8][14[15]. Here we must be aware that on the one hand, the degree of capability matching and non-functional properties are all fuzzy and on the other hand, different, domains have different requirements on non-functional properties. It is difficult to use classical mathematical modeling methods to evaluate the whole QoS. Although there are several QoS models [3] existing, they are not suitable for the case in this paper.

In this paper, we propose a framework called Soft Semantic Web services Agent (SSWSA) to provide the high QoS Semantic Web services based on specific ontology such as gnome. The SSWSA itself is Semantic Web sercice. The SSWSA comprises of six components: specific ontology based Semantic Web services Registries crawler (SOBSWSRC), specific ontology based Semantic Web services repository (SOBSWSR), specific ontology based Semantic Web services inquiry server (SOBSWSIS), specific ontology based Semantic Web services publish server (SOBSWSPS), soft Semantic Web services agent communication server (SSWSACS) and intelligent inference engine (IIE). The core of SSWSA is intelligent inference engine. It uses soft computing methodology to evaluate the whole QoS (both functional and non-functional properties) of Sematnic Web services. In this paper, we use several specific ontology based Semantic Web services for bioinformatics and fuzzy neural network with GA algorithm as our study to show the flexibility and reliability of soft computing methodology for handling fuzzy and uncertain linguistic information. For example, capability of service is fuzzy. It is unreasonable to use crisp value to describe it. So we can use several linguistic variables such as low or a little bit low and a little bit high or high to express the concept of capability of service.

The paper is organized as follow. In section II, we present the necessary background of Semantic Web services and soft computing methodology. Section III provides the details of architecture of the SSWSA. Section IV gives the design of fuzzy neural network with GA algorithm. Section V provides the simulation results. And finally, in section VI, we conclude this paper and give the future direction.

II. BACKGROUND

In this section, we will give a brief overview of the background knowledge related to this paper.

A. Semantic Web Services

Currently, the Web is just a collection of documents which are human readable but not machine understandable. In order to remedy this disadvantage, the concept of Semantic Web is proposed to add semantics to the Web to facilitate the information finding, extracting, representing, interpreting and maintaining. There are many Semantic Web technologies available today such as: RDF, RDFS, SHOE, DAML-ONT, OIL, DAML+OIL, DAML-L and OWL [13]. On the other hand, industry proposes the Web services to transform the Web from "passive state" – repository of static documents to "positive state" – repository of dynamic services. Unfortunately, the Web services standards such as WSDL, UDDI, XLANG, WSFL, ebXML and BPEL4WS are all not semantic-oriented. They are awkward for service discovery, invocation and composition [8]. So it is natural to combine the Semantic Web with Web services, the so-called Semantic Web services. Several projects have been initiated to design the framework for Semantic Web services such as DAML-S [1] and METEOR-S [8].

B. Soft Computing Methodology

According to Zadeh [11] "Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation." The principal constituents of soft computing are fuzzy logic, neural networks and genetic algorithms. More and more technologies will join into the soft computing framework in near future. Fuzzy logic is primarily concerned with handling imprecision; neural computing focuses on simulating human being's learning process; genetic algorithms simulate the natural selection and evolutionary processes to do randomized global search. Each component of soft computing is complementary to each other. Using combination of several technologies such as fuzzy-neural system will generally get better solution.

III. ARCHITECTURE OF SSWSA

The Soft Semantic Web services Agent (SSWSA) can provide high QoS Semantic Web services based on specific ontology. SSWSA uses centralized client/server architecture. But itself can also be implemented as a Semantic Web service. The SSWSA comprises of six components: specific ontology based Semantic Web services Registries crawler (SOBSWSRC), specific ontology based Semantic Web services repository (SOBSWSR), specific ontology based Semantic Web services inquiry server (SOBSWSIS), specific ontology based semantic Web services publish server (SOBSWSPS), soft Semantic Web services agent communication server (SSWSACS) and intelligent inference engine (IIE). The high level architecture of SSWSA is shown in Figure 1.

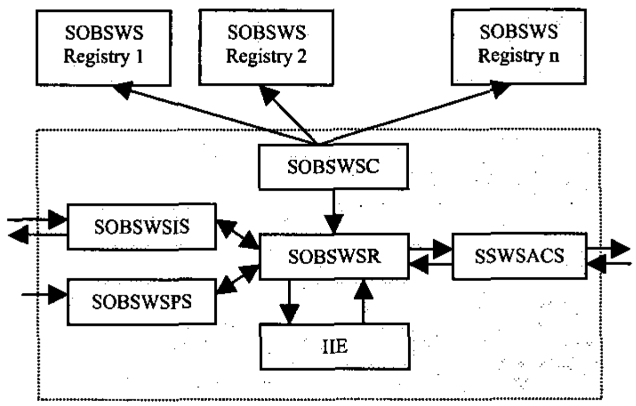

Fig. 1. Architecture of SSWSA

A. SOBSWSRC

The specific ontology based Semantic Web services Registries crawler (SOBSWSRC) will access many public or private specific ontology based Semantic Web services Registries such as semantics-oriented UDDI for gnome to fetch the service profiles and store them in specific ontology based Semantic Web services Repository (SOBSWSR).

B. SOBSWSR

The specific ontology based Semantic Web services Repository (SOBSWSR) will store the service profiles which are fetched by SOBSWSRC and Semantic Web services which are published by services provider through the SOBSWSPS.

C. SOBSWSRC

The specific ontology based Semantic Web services Inquiry Server (SOBSWSIS) will provide two kinds of interfaces: one is the programmatic API to other agents; another is the human-readable. The SOBSWSIS transforms the service request profile into standard format and does matchmaking operation to calculate the capability of Semantic Web services stored in the SOBSWSR.

D. SOBSWSPS

The specific ontology based Semantic Web services Publish Server (SOBSWSPS) will provide the API for service providers to publish their specific ontology based Semantic Web services into the SOBSWSR.

E. SSWSACS

The soft Semantic Web services Agent Communication Server (SSWSACS) will use certain communication protocol such as KQML and SOAP to communicate with other SSWSAs. For example, if the SSWSA could not find the appropriate Semantic Web services requested by the service requesters, it will transfer the request to other SSWSAs through the SSWSACS.

F. IIE

The Intelligent Inference Engine (IIE) will use soft computing methodology to calculate the QoS of the Semantic Web services.

IV. DESIGN OF FUZZY NEURAL NETWORK WITH GA ALGORITHM

A schematic diagram of the four-layered fuzzy neural network (FNN) is shown in Figure 2. Nodes in layer one are input nodes representing input linguistic variables. Nodes in layer two are membership nodes. Each membership node is responsible for mapping an input linguistic variable into a possibility distribution for that variable. The rule nodes reside in layer three. The last layer contains the output variable nodes [4].

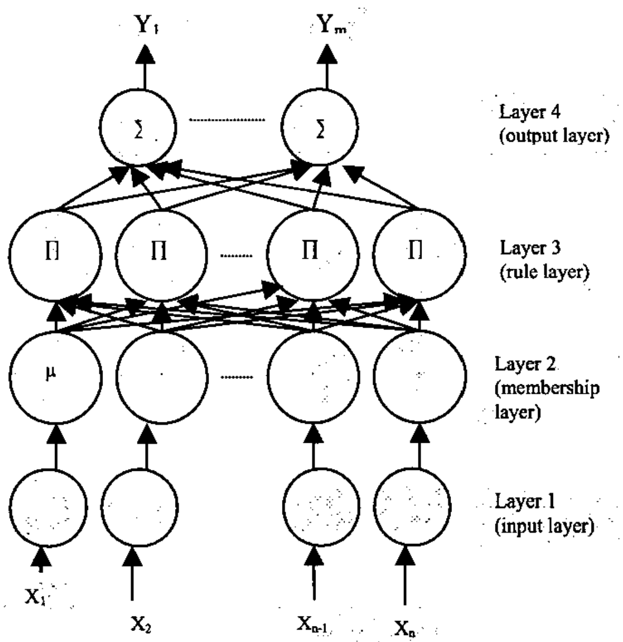

Fig. 2. Schematic diagram of FNN

As we mentioned before, metrics of QoS of Semantic Web services are multidimensional. For illustration of specific ontology based Semantic Web services for bioinformatics, we decide to use capability, response time and trustworthiness as our inputs and QoS as output. The fuzzy logic system (FLS) is based on TSK model.

A. Design of Fuzzy Input Sets

Let x represent capability, y represent response time and z represent trustworthiness. We scale capability, response time and trustworthiness to [0, 10] respectively. The graphical representation s of membership functions of x, y, z are shown in Figure 3.

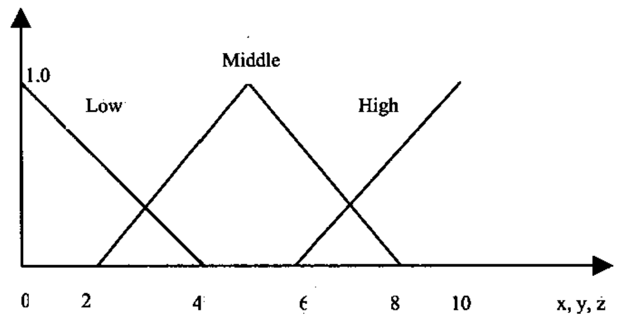

Fig. 3. Membership Functions of Inputs

B. Design of Fuzzy Rule Base

Here, we design the fuzzy rule base based on TSK model. Fuzzy rule is the form shown below:

If x is I_1 and y is I_2 and z is I_3 THEN

O is $a_{i,1} * x + a_{i,2} * y + a_{i,3} * z + a_{i,4}$.

where I_1, I_2 and I_3 in {low, middle, high}, I in [1, 27].

There are totally 27 fuzzy rules. The $a_{i,j}$'s are consequent parameters which will be obtained by training phase of FNN using GA algorithm.

C. Design of Defuzzifier

Suppose, for certain input x, y and z, there are m fuzzy rules fired. To calculate firing strength of jth rule, we use below formula:

$$W^j = \mu_x(x) * \mu_y(y) * \mu_z(z) \quad (1)$$

So the output is:

$$o = \sum_{j=1,\dots,m} W^j*(a_{j,1}*x + a_{j,2}*y + a_{j,3}*z + a_{j,4}) / (\sum_{j=1,\dots,m} W^j) \quad (2)$$

D. Design of Genetic Algorithm

GA is a model of machine learning which derives its behavior from a metaphor of the processes of *evolution* in nature. This is done by the creation within a machine of a *population of individuals* represented by *chromosomes*. Here we use real-coded scheme. Given the range of parameters (coefficients of linear equations in TSK model), the system uses the derivate-free random search-GA to learn to find the near optimal solution by the fitness function through the training data.

1) *Chromosome*: the genes of each chromosome are 81 real numbers (there are 81 parameters in fuzzy rule base) which are initially generated randomly in the given range. So each chromosome is a vector of 81 real numbers.

2) Fitnesss function: The fitness function is define as

$$E = 1/2\sum_{i=1,\ldots,m} (d_i - o_i)^2 \quad (3)$$

3) Elitism: The tournament selection is used in the elitism process.

4) Crossower: The system will randomly select the two parents among the population and then randomly select the number of cross points and simply exchanges the corresponding genes among these two parents to generate new generation.

5) Mutation: For each individual in the population, the system will randomly select the genes in the chromosome and replace them with randomly generated real number in the given range.

VI. SIMULATION

There are two phases for applying fuzzy neural network (FNN): training and predicting. In training phase, we use 168 data entries as training data set. Each entry consists of three inputs and one expected output. We tune the performance of the system by adjusting number of population, generation and probability of crossover and mutation. Table I gives the part of prediction result with several parameters for output o.

TABLE I PREDICTION RESULT OF FNN.

X	Y	Z	Desired Output	Real Output o
0	0	0	0	0.0
2	0	4	0	1.35
4	2	6	0	0.63
6	2	2	3	2.89
7	5	0	3	2.4
8	0	8	4	2.66
9	9	4	2	3.3
10	0	6	7	5.4

In Table I, NO. OF GENERATION = 1000000, NO. OF POPULATION = 1000, PROBABILITY OF CROSSOVER = 0.7, PROBABILITY OF MUTATION = 0.1. From the Table I, we could see the maximum error of training result is 1.6. The total prediction error for 168 entries is 25%. By our observation, designing reasonable fuzzy membership functions and choosing reasonable training data set which is based on specific application domain can reduce the prediction error a lot.

VI. CONCLUSIONS

In this paper, we discuss the design of Soft Semantic Web services Agent (SSWSA). The SSWSA could be used in World Wide Web (WWW), P2P and Grid infrastructure. The SSWSA is flexible and extensible. With the evolution of soft computing, more and more technologies can be integrated into SSWSA. We use specific ontology based Semantic Web services for bioinformatics and fuzzy neural network with genetic algorithm as our study case. The training time is short and training result is satisfactory. The SSWSA will return the desired Semantic Web services based on the QoS of Semantic Web services. In the future, we will implement the SSWSA with the mature of Semantic Web services technologies, and apply it to semantic Web-based bioinformatics applications.

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