Abstract—Nowadays, searching for web services can be done through accessing from UDDI which is widely available. Most of the searches are functioned by the use of keywords without understanding the meaning of them. This causes users inability to access to the semantic web service, none of the users can identify whether the required web services are still active, and they cannot expect for the quality of those web services. As a result, this study is aimed to 1) collect the web service on weather forecast from many providers, 2) design the knowledge base of web service by using Ontology and RAP-RDF API to create the user interface of web service, 3) select the qualified web service based on four aspects includes; 1) response time 2) availability 3) reliability, and 4) cost. The results of this study help the users to search through the qualified semantic web service.

Index Terms—Web service, web service selection, quality of service, ontology.

I. INTRODUCTION

Web service searching today is carried out by accessing UDDI [1] that exists abundantly in different providers scattering on the internet. However, UDDI service searches are functioned by using keywords which sometimes provides results that don't satisfy needs of users. Obviously, there is a lack of service data definition or ability to do a semantic web service search functional, for example, when a keyword "Weather Forecast" is input, search engines will not be able to displayed all results because some web services are named "Weather Prediction" (both weather prediction and weather forecast are related because of the meaning and they appear in the same type of web services). Moreover, how can we realize which web services provide the best quality when response time, availability, reliability, and cost are concerned.

Thus, this research has proposed semantic web search pattern applied from ontology principles which generate ability to recognize words relate to input word as a set of concept definition. Ontology application also provides other required abilities to identify and store service data definitions for web services with practical meanings in order to facilitate searching performance that actually responds the needs of users. This research also proposes three key areas of 1) knowledge base development from ontology application to identify definitions, relations, and structures of web services via Web Ontology Language (OWL) by selecting weather forecasting web services as a model, 2) steps in selecting best qualified web services, 3) user interface design that displays detected web services as a results list ranked by quality scores.

II. THEORY AND RELATED LITERATURE

A. Web Service

Web service [2] is the technology that enables the different software developed from different language can be work together through using XML [3]. The XML is the language for software communication through using protocol HTTP and others standards. Web service employed WSDL [4] language to explain the pattern and service. Using web service in nowadays is in the pattern of SOAP [5] according to the traditional standard or the REST method [6] which is very simple under the OASIS and W3C units which control the quality and architecture of web service.

B. Ontology

Ontology is the regulation of concept which tries to describe the concept of domain or scope of interest of something inside that domain. It can classify the information and connect the relationship of that information through the symbol such as class, instance, relationship, property, and rule. Moreover, the ontology is able to manage information such as share, reuse, and inheritance. Adapting ontology is one of many ways in sharing and differentiating information from database. It can also help computer understand the meaning of words which is very useful, because searching by using ontology focusing on meaning not keywords or synonym which made the search very fast and accurate.

C. Web Service Searching

In currently, searching in web service is the searching through the UDDI, because the UDDI is the system that the web service providers come to register and announce their services. The search from UDDI is the value comparison between the characteristic that request by the users and the characteristic offer by the providers as announced in the UDDI standard. The standard UDDI consists of two aspects which are: 1) UDDI API which operates to search for the service and to storage the information into database, and 2) UDDI Database which storages the service and business information about the registration of the web service providers in the UDDI. Almost of the search from UDDI is the use of keywords without the consideration of meaning of words, this made the search through web service cannot find from meaning of words.

D. The Study of Liangzhao Zeng et al. [7]

This research is about the use of principle of quality of service (QoS) in selecting service concerning 5 qualifications...
which are: execution path, execution duration, reliability, availability, and reputation, while the pattern of web service integration used the state chart as the process of integration and communication. Moreover, the Direct Acyclic Graph (DAG) was used to show the direction and plan of operation, while the Simple Additive Weighting (SAW) was used in the selection process.

E. The Study of Piya Suwannopas and Twittie Senivongse [8]

This research presented new method of using OWL-S process model for web service search which can explain the interior process help users search for the web service having some desired details. The integration of service will be based on flexible ontology integration and the regulation of duty behavior and the process flow of web service. The structure of control in the process flow which interests this study is the process having the structure of order, multifunction, decision, and repetition. Moreover, this study also presented that search service architecture using process base and also developed the connector to help search for web service to improve the effectiveness of searching.

F. The Study of Winai Saman et al. [9]

This study presented the methods of searching on web service based on meaning by proposed the addition of data of quality of service in UDDI standard using ontology. Moreover, this study also presented the procedures of search based on quality through the use of OWL file, the use of RDQL language which was designed to search through the ontology form OWL file for searching, the method of comparison data of quality of service from the UDDI registered providers with the data of quality which required by users. This comparison is based on the scores from searching service and the weight value using parameters including time of operation, the ratio of the ability of service, and the cost of service.

III. METHODOLOGY

A. The Preparation and Collection of Web Service Information

This study collected various web services information from many UDDIs and the five most popular web services of weather forecast for the experiment in this study were shown in the Table I below:

<table>
<thead>
<tr>
<th>ID</th>
<th>Web Service Name</th>
<th>WSDL Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS1</td>
<td>Global Weather</td>
<td><a href="http://www.webservicex.net/global/weather.asmx?wsdl">http://www.webservicex.net/global/weather.asmx?wsdl</a></td>
</tr>
</tbody>
</table>

B. Design the Knowledge Base of Web Service Using Ontology

This step is the design the knowledge base of web service which describes the structure of relationship of data which developed through the Protégé and the results were explained in Fig. 1 as follow:

The Fig. 1 consists of Class, Data, Type Prototype, and Object Prototype as explained in the Table II below:
The selection of appropriate web service of each service depends on the score, the details of the evaluation of four factors, and the calculation of the quality of web service which explained below:

1) Response time was measured from to the time since the users send their requests to service sever until it was responded which can be calculated from the following equation:

\[ T = \frac{\sum_{i=1}^{n} (T_i - T_s)}{n} \]

When
\[ T \] is average response time measuring in millisecond.
\[ T_s \] refers to the for getting information measuring in millisecond.
\[ RT \] is the probability value of the average response time.

2) Availability was measured by the mean ratio of the whole of times that the users can access the service successfully in the specific period measuring in millisecond.

\[ A = \frac{N_{suc}}{N_{all}} \]

When
\[ A \] is the availability.
\[ N_{suc} \] refers to the mean of the whole of times that the users can access the service successfully in the specific period measuring in millisecond.
\[ N_{all} \] means the whole of time that the users use to request for the service in the specific period measuring in millisecond.

3) Reliability was measured from the ratio of all of the times that the users request for the service successfully divided by the all of the times that the users request for the service in specific time which can be calculated from the following equation:

\[ R = \frac{T_{suc}}{T_{all}} \]

When
\[ R \] is the reliability.
\[ T_{suc} \] refers to all of the times that the users request for the service successfully in the specific time.
\[ T_{all} \] means all of the times that the users request for the service in specific time.

For instance, the users requested for services four times in the specific time and but three of them are successfully, while the remaining one is failed. So, the reliability is ¾ or 0.75.

4) Cost referred to the cost of service measuring from the rate of service charge of the service providers in the same group which can be calculated from the following equation:

\[ C = 1 - \frac{P}{\sum P_i} \]

When
\[ C \] is the probability of the cost service charge.
\[ P \] refers to the rate of the service charge.
\[ \sum P_i \] means the sum of the rate of service charge of all of

C. The Factors in the Selection of Web Services

The methods of appropriate web service selection could be done by considering the following four factors:

1) Response Time which refers to the time since the users send their requests to service sever until it was responded.

2) Availability which means that the showing of available status of web service which the users can use calculating from each response time that the users can use according to the specified range of time.

3) Reliability which is the level of ability in providing service of web service showing through the ratio of the usage time of successfully web service.

4) Cost which refers to the cost in requesting for using web service from some providers.

D. The Evaluation of Web Service Selection

The selection of appropriate web service of each service depends on the score, the details of the evaluation of four factors, and the calculation of the quality of web service which explained below:

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Web Services</td>
<td>Class</td>
<td>Class for web service</td>
</tr>
<tr>
<td>2</td>
<td>Web Service Type</td>
<td>Class</td>
<td>Class for information of type of web service</td>
</tr>
<tr>
<td>3</td>
<td>Services</td>
<td>Class</td>
<td>Class for information of the operation of web service</td>
</tr>
<tr>
<td>4</td>
<td>Group</td>
<td>Class</td>
<td>Class for the information of group of web service</td>
</tr>
<tr>
<td>5</td>
<td>skos:Concept</td>
<td>Class</td>
<td>Class of information of terms</td>
</tr>
<tr>
<td>6</td>
<td>WSDL_Location</td>
<td>Data type</td>
<td>The constant indicated value showing the address of web service</td>
</tr>
<tr>
<td>7</td>
<td>URL</td>
<td>Data type</td>
<td>The constant indicated value showing URL</td>
</tr>
<tr>
<td>8</td>
<td>Owner</td>
<td>Data type</td>
<td>The constant indicated value showing names of provider</td>
</tr>
<tr>
<td>9</td>
<td>Cost</td>
<td>Data type</td>
<td>The constant indicated value showing cost</td>
</tr>
<tr>
<td>10</td>
<td>Input</td>
<td>Data type</td>
<td>The constant indicated value showing input information</td>
</tr>
<tr>
<td>11</td>
<td>InputDataTest</td>
<td>Data type</td>
<td>The constant indicated value showing input information for testing</td>
</tr>
<tr>
<td>12</td>
<td>Output</td>
<td>Data type</td>
<td>The constant indicated value showing the outcome information</td>
</tr>
<tr>
<td>13</td>
<td>hasWebService</td>
<td>Object</td>
<td>Showing the relationship between class:group and class:web service on the amount of web service in each group</td>
</tr>
<tr>
<td>14</td>
<td>hasService</td>
<td>Object</td>
<td>Showing the relationship between class:web service and class:web service on the service in each service</td>
</tr>
<tr>
<td>15</td>
<td>hasTerms</td>
<td>Object</td>
<td>Showing the relationship between class:group and class:skos:concept on the amount of related words</td>
</tr>
<tr>
<td>16</td>
<td>hasServiceTest</td>
<td>Object</td>
<td>Showing the relationship between class:web service and class:service on the use of service for testing</td>
</tr>
<tr>
<td>17</td>
<td>hasWS</td>
<td>Object</td>
<td>Showing the relationship between class:services and class:web service on the web service in each service</td>
</tr>
<tr>
<td>18</td>
<td>hasWS_Type</td>
<td>Object</td>
<td>Showing the relationship between class:web service and class:web service type on the type of service</td>
</tr>
</tbody>
</table>
service providers.

5) The calculation for the quality value of service of the web service was done through the weighted equation calculating from the combination of quality value of services in four factors including response time, availability, reliability, and cost which can be through the following equation:

\[
QoS_{Si} = \sum_{x \in V} W_x \cdot QoS_{Si,x}
\]

Where

- \(QoS_{Si}\) is the quality value of the service of web service \(Si\)
- \(QoS_{Si,x}\) refers to the quality value of the service on factor \(x\) of web service \(Si\)
- \(W_x\) means the weighted value which the users define for the quality of factor \(x\) by mean of \(\sum_{x \in V} W_x = 1\)
- \(V\) is set of factor used to specify the quality of service of web service by mean of \(V = \{\text{Response time, Availability, Reliability, Cost}\}\)

IV. EXPERIMENTAL RESULTS

After designing the knowledge base of web service using ontology, the formula for calculating for factors using in selecting the quality of web service, and create the software using PHP language, the operational testing was presented as follow:

Fig. 2 showed the first page of the system showing searching form of web service. In this case, the searching words “Weather Forecast” were filled out and then press the “Search” button.

Fig. 3 showed the results of searching through the words “Weather Forecast” which revealed that there were five related web services which each one consisted of the information namely ID, WSDL Location, Cost, Operation Name, Input, Service Test, Input Test, and Input Data Test. Moreover, when pressing the “Continue” button, the results were shown as illustrated below:

Fig. 4 presented the example of results of the response of sever providing web service of ID which was WeatherForecast5 by requesting for ten times. This also showed that total of time and average time as well.

Fig. 5 showed the score of five web services in 5 aspects separating into four factors including Response time, Availability, Reliability, and Cost which the users can specify the weight in each factor according to the appropriateness from 1 to 5. The most important factor will be scored as 5. After pressing the “Continue” button, the system will calculate to find out the quality score of service as presented in the Fig. 6 below:

Fig. 6 presented the quality of service score of five web services ordering from highest scores.

Table III presented the information of score of quality of
service of web service. The results revealed that web service with ID which are “WeatherForecast4” had the highest score as 0.92, while the “WeatherForecast5”, the “WeatherForecast3”, the “WeatherForecast1”, and “WeatherForecast2” had the score of 0.88, 0.76, 0.29, and 0.15 respectively.

<table>
<thead>
<tr>
<th>ID</th>
<th>Factor 1 (Response time)</th>
<th>Factor 2 (Reliability)</th>
<th>Factor 3 (Availability)</th>
<th>Factor 4 (Cost)</th>
<th>QoS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS4</td>
<td>0.72</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.92</td>
</tr>
<tr>
<td>WS5</td>
<td>0.74</td>
<td>1.00</td>
<td>1.00</td>
<td>0.85</td>
<td>0.88</td>
</tr>
<tr>
<td>WS3</td>
<td>0.54</td>
<td>1.00</td>
<td>1.00</td>
<td>0.65</td>
<td>0.76</td>
</tr>
<tr>
<td>WS1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.29</td>
</tr>
<tr>
<td>WS2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.50</td>
<td>0.15</td>
</tr>
</tbody>
</table>

V. CONCLUSION

This research proposes a knowledge base development by applying ontology to verify meaning, relation, and structure of web services via Web Ontology Language (OWL) with weather forecasting web service providers as a case study. It designs steps in selecting qualified web services according to Response Time, Availability, Reliability, and Cost with score ranking included. Although, the required web services contain no words which matches to keyword input, this ontology application can practically access to details or meaning relations of the related web services. It can reduce unnecessary or irrelevant search results. This can decrease complexity and confusion in data searching. Moreover, these proposed steps in selecting qualified web services can also be used to calculate related factors to identify quality of service.

Ekkachai Naenudorn is a PhD student at the School of Information Technology, Suranaree University of Technology, Thailand. Currently he is lecturer at the Mahasarakham Business School, Mahasarakham University, Thailand. He completed his MSc in Information Technology from the Khon Kaen University, Thailand in 2006. His research areas include web service and semantic searching.

Suphakit Niwattanakul is a lecturer at the School of Information Technology, Suranaree University of Technology, Thailand. He received his PhD in computer science from the University of La Rochelle, France in 2008. His current research is about Semantic Web technologies applied to information extraction and retrieval system.

REFERENCES