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The Web service composition based on colored Petri net

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ABSTRACT: An automatic approach to get colored Petri net model of web service composition was put forward in this paper. Each web service composition had its Petri net which described in PNML(Petri net Markup Language) +OWL(Ontology Web Language) ,where PNML part describes the Petri net structure and OWL part shows out their domain ontology definitions (semantic markups) of place elements of the Petri net. Based on the input / output interaction related places elements among web service colored Petri nets, through place fusion operation, merging sub-web service Petri nets, we can get the colored Petri net model of web service composition, this work proposes the necessary precondition for practical application of colored Petri net in the context of service computing.

Keywords: Web service; colored Petri net; PNML; service composition

I. INTRODUCTION

Web services[1] are loosely coupled, cross-platform and open, etc., and it has become an emerging distributed computing model and a new Internet application model. Web services can not only share data, software and hardware resources over the Internet, but also allow interconnection between application systems or heterogeneous software. However, when the user requests more complex functions, a single service because of the need to simplify the application logic can not meet its implementation, so there is a need for a combination of Web services.

At present, the WSDL in Web service description and OWL-S is the most representative; the WSDL description is a kind of the most extensive description of the syntax level, but it has defects of service automatic combination semantic of Web is a huge obstacle; OWL-S is one of the commonly used form of Web service semantic description although, with the semantic information of Web services, but its internal execution less flow information description is not conducive to obtain service internal execution flow information to analyze the nature of the Web service.

Petri net[2] is an important tool for modeling and analysis of asynchronous concurrent systems, and it is widely used in the field of system modeling, analysis and verification, monitoring and fault monitoring, and it made a series of research results, become a hot research field of computer, automation industry direction. As the field of science and information science control in depth, in the actual engineering application, the system is on the formal modeling problem, performance evaluation problem, optimal scheduling problems. By combining the WSDL description, the Petri net model and the semantic ontology effectively, the paper puts forward a method of publishing PNML[3]+OWL[4] services for Web services.

II. COLORED PETRI NETS

Colored Petri nets (Colored Petri Nets, CPN) is a graphical language for modeling and analyzing complex systems.

Colored Petri nets are defined as followed:

Colored Petri net (CPN) is a multivariate group, which is defined as:

$CPN=（\Sigma，P,T,A,N,C,G,E,I）$, the meaning of each letter is defined as followed:

1) Σ is a non empty finite set type, also known as the color sets；
2) $P=\{p_1,p_2,...,p_m\}$ is a finite set of places, m represents the number of places in the system；
3) $T=\{t_1,t_2,...,t_n\}$ is a finite set of transitions，n represents the number of transitions in the system；
4) A is a finite set of arcs, where $P\cap T=P\cap A=T\cap A=\varphi$;

5) N is a finite set of nodes，defined as $N: A \to P \times T \cup T \times P$；

6) C is the function of Colors，defined as $C: P \to \Sigma$；$C(p)$ is called token color is the set of all color library on Tokheim, known as the color is all can make the change of ignition color set.

7) G is the function of guard, defined as $G: T \to$ Expression；

8) E is the function of Arc expression，defined as $E: A \to$ Expression；

9) I is the initialization，defined as $I: P \to$ CloseExpreesion；

Figure 1 shows a simple colored Petri net model:

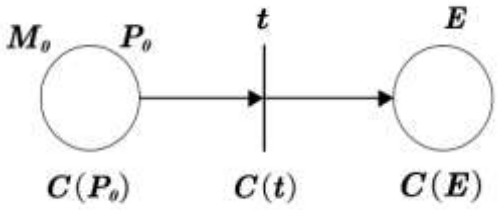

Fig1. colored Petri nets

A CPN can be defined as a multivariate set in order to give a mathematical description and a clear definition.

III. PNML

PNML (Petri Net Markup Language) is based on XML and can it support all Petri net exchange format, which Petri nets is used PNTD (Petri Net Type Definition) is defined to solve the Petri net in the creation and display of the sharing problem of different tools, it was showed as figure 2. Which contains three basic information:

(1) Label: in the XML standard, tags are the most common form of elements, including the following two types: annotations and attributes.

(2) Graphical Information: Petri net is a formal description of the support tools in the Petri net in the XML file, the image information indicates the coordinate relationship between Petri net elements in a graphical interface, the image information is a two-dimensional coordinate.

(3) Pages and reference node: a carrier picture of the Petri net, which can support Petri net users depicted in a different page, after using the reference point will draw Petri nets together; the form page was varied so that it can be composed of several objects, can also be composed of different pages to form this information to describe the common Petri net..

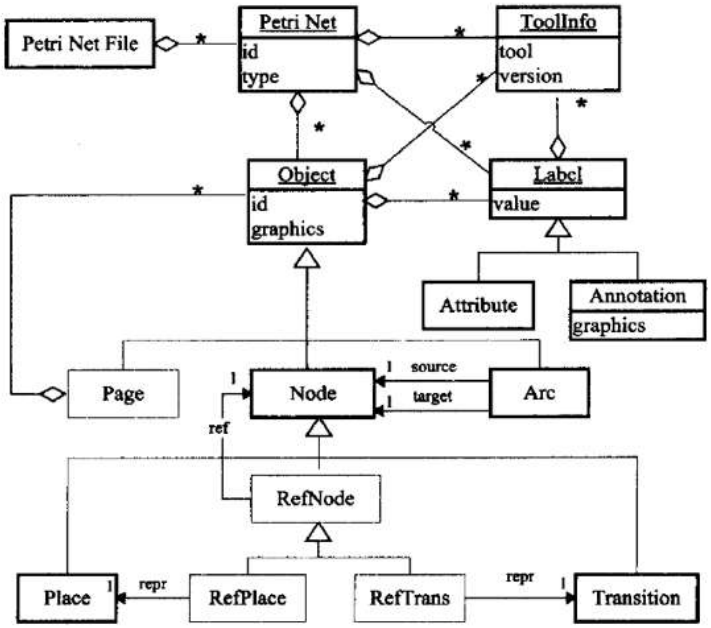

Fig 2. the PNML model

IV. OWL

Ontology (Ontology) is a concept of a philosophical category, recognized as a reflection of ontology in the field of concept or definition set goal is through the collection of relevant knowledge in the field, with the formal content to describe the relationship between words to achieve a common understanding of the domain related knowledge.

OWL (Web Ontology Language) is a description of the net by ontology developed by W3C language, DAML (DARPA , Agent Markup Language, the U.S. Defense advanced research agency design markup language (+OIL) Ontology Inference Layer, ontology inference layer) and improved, so there is a compatibility of the OWL file based on XML language the description and the resource description framework(RDF) to define and describe the Web information. OWL not only has a strong semantic expression ability, but also has the ability to describe the logic of reasoning. OWL can create ontologies by defining properties of different elements, such as object properties, data attributes, and domain properties.

Although PNML solves the shared Petri net in different tools, but is still based on the grammatical level . Petri Ontology will describe Petri net as a single ontology file, but the two are focused on the structure of single Petri net model itself is shared between the different Petri net tools, and did not involve the interoperability between different Petri nets the model, such as the sharing of different Petri net models between synthetic operation, and this is one of the key problems of automatic Petri net model of Web service composition.

V. Web service composition based on colored Petri net

We illustrate the structure of the PNML+ OWL description document for atomic Web services by a simple example.

A simple example of a method and result Petri net, it can be conceived as figure3.

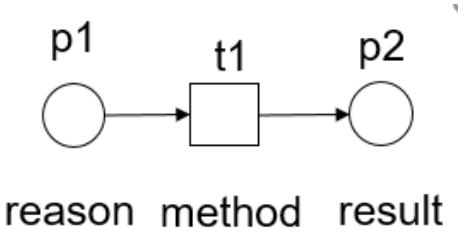

Fig 3. the reason-result petri net

It can be described as PNML by followed figure4.The description of pnml is based on XML, although the pnml description of Petri nets expresses the relationship between the library and the change and flow, but it does not make the net get a good semantics.

```
<? xml version = "1.  0" encoding = " iso-8859-1" standalone = " no" ? >
< pnml xmlns: rdf = " http: / / www.w3.org/2000 /01 / rdf-schema#" >
< owl: imports xmlns: owl = " http: / /127.0.0.1:8080/ ontology / reason-result.owl#" / >
< net id = " Net-One" type = " P / T net>
< place id = " P0" >
< name > < value > reason< / value > < / name >
< initial Marking > < value > 1 < / value > < / initial Marking >
< place id = " P1" >
< name > < value > result < / value > < / name >
< initial Marking > < value > 0 < / value > < / initial Marking >
< transition id = " T1" >
< name > < value > method< / value > < / name >
…
< /net >
< /pnml>
```

Fig 4. the PNML description of the reason-result petri net

In order to enhance the semantics of Petri net expression, owl is used to describe the semantics of place and transition in the original description of pnml only in PNML+OWL. It can be described as PNML+OWL by followed figure 5.

```
<? xml version = "1.  0" encoding = " iso-8859-1" standalone = " no" ? >
< pnml xmlns: rdf = " http: / / www.w3.org/2000 /01 / rdf-schema#" >
< owl: imports xmlns: owl = " http: / /127.0.0.1:8080/ ontology / reason-result.owl#" / >
< net id = " Net-One" type = " P / T net>
< place id = " P0" >
< name > < value > reason< / value > < / name >
< initial Marking > < value > 1 < / value > < / initial Marking >
< place: owl
xmlns: place = http: / /127.0.0.1: 8080 / ontology / reason-result.owl#rdf:
ID = "reason" / >
< / place >
< place id = " P1" >
< name > < value > result < / value > < / name >
< initial Marking > < value > 0 < / value > < / initial Marking >
< place: owl
xmlns: place = "http: / /127.0.0.1:8080 /ontology/reason-result.owl#"rdf:ID = "result"/>
< / place >
< transition id = " T1" >
< name > < value > method< / value > < / name >
…
< /net >
< /pnml>
```

Fig 5. the PNML+OWL description of the reason-result petri net

This is a normal petri net and PNML+OWL description, but in dealing with complex situations, the petri net can't meet the requirements. Now it can use colored petri nets. Here is the example as figure 6. And it can be descriped by PNML as figure 7.It can be seen that the colored Petri net has a much more color than the ordinary Petri net. From Figure 7, you can see that the token has three colors, one for the blue, one for the default black, one for the red, by pnml , The pnml + owl method is used not only to semantically describe its place and transition, but also to semantize its color, as shown in Fig 8.

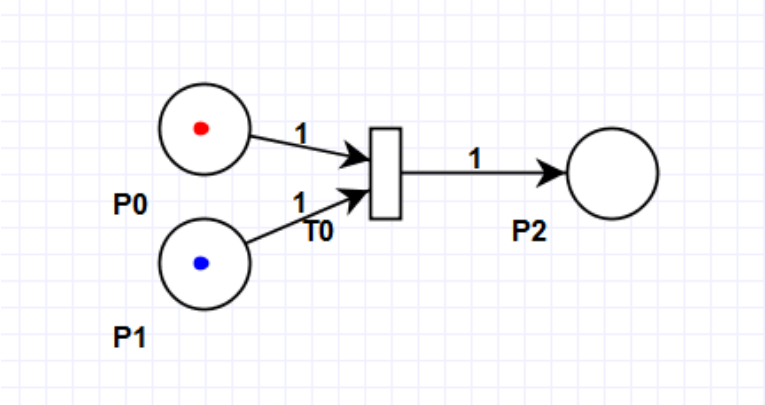

Fig 6. Colored petri nets

```
<?xml version="1.0" encoding="ISO-8859-1"?><pnml>
<net id="Net-One" type="P/T net">
 <tokenclass id="blue" enabled="true" red="0" green="0" blue="255"/>
 <tokenclass id="Default" enabled="true" red="0" green="0" blue="0"/>
 <tokenclass id="red" enabled="true" red="255" green="0" blue="0"/>
<place id="P0">
<name>
 <value>P0</value>
</name>
<initialMarking>
 <value>Default,0,red,1,blue,0</value>
</place>
<place id="P1">
<name>
 <value>P1</value>
</name>
<initialMarking>
 <value>Default,0,red,0,blue,1</value>
</initialMarking>
</place>
<place id="P2">
<name>
 <value>P2</value>
</name>
<initialMarking>
 <value>Default,0,red,0,blue,0</value>
</initialMarking>
</place>
<transition id="T0">
<name>
 <value>T0</value>
</name>
</transition>
<arc id="P0 to T0" source="P0" target="T0">
</arc>
<arc id="P1 to T0" source="P1" target="T0">
</arc>
<arc id="T0 to P2" source="T0" target="P2">
</arc>
</net>
</pnml>
```

Fig7. the PNML description of colored petri nets.

Fig 8. the PNML+OWL description of colored petri nets.

VI. CONCLUSION

In this paper, a web service composition method based on colored Petri nets is given. The comparison of pnml description and pnml + owl description method can be used to understand the necessity and superiority of owl for semantics. Due to the limitation of ordinary Petri net, the method of pnml + owl is proposed, which has a great influence on the web service.

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