

Research on the Service Modeling Method of Information Management Software based on the Petri Net Model

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ABSTRACT: *With the continuous development of science and technology, the development of the enterprise also requires the agility of enterprises. At present, SOA is one of the most popular means of achieving enterprise's agility. This article embarks on the Petri net model to study the service modeling method of information management software. Firstly, it introduces service-oriented architecture SOA and the methodology of service modeling SOMA, it has been understood its theoretical basis. Secondly, it expounds the structure and characteristics of Petri net. And then it introduces the PN - SM modeling process and the basic structure of the model. Finally, it draws the conclusion: Petri net is a kind of system model that suitable for describing concurrent characteristic.*

Categories and Subject Descriptors:

I.2.10 [Software Technology]; Information Management Software; **I.4.10 [Computer Applications]**

General Terms:

Petri net, Mapping

Keywords: Petri Net, SOA, SOMA, PN-SM

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1. Introduction

With the needs of the economic development, more and more companies are looking for a suitable software service modeling of information management for the enterprise's development. Therefore, both at home and abroad have a lot of research on this subject.

In 1996, the concept of SOA was first put forward by Gartner, it mainly research the integration of system [1]. Professor Liu Dayou and another people research Web

services modeling and combination method based on the semantic of SROIQB, analyzes IOPE properties of atomic services and control structure of combination process from the atoms services provided by OWL-S and semantic description of combination process. Within the framework of describing logic, for the semantic Web service composition problem, this paper proposes a new method that has enough modeling capabilities and ensure composite reasoning process can be determined [2]; Wu Budan and Jin Zhi study a modeling method that service oriented and all the process reused [3]. Gou Juanqiong and another people research service system modeling method based on multi-layer ontology integration [4]; Ding Yulan and others study a set of SMDA service modeling method, and study its support tools [5]; At present, the study of SOA mainly be classified into the following aspects: theoretical model (reference model, service interface model, formalized description of a service-oriented architecture), service modeling, design, combination, The research of the combination of SOA and business process management (BPM), crossover study of service-oriented architecture, evolution model, simulation validation, the evaluation and testing of SOA, the standard research of neutral SOA, and the application of SOA [6]. Modeling method based on Petri net exists a single mapping between service system and the Petri net, it will affect the flexibility of describing the transformation of service status, the structure of the service model is not well. Facing all these problems, this paper proposes a modeling method PN - SM based on Petri net.

In order to achieve the agility of enterprise, this paper uses a system called SOA. The architecture can achieve the business needs of the enterprise to a great extent and the consistency of IT, it also can reduce the cost of enterprise, it is one of the most popular means of realizing enterprise's agility.

2. Service Modeling of Information Management Software

2.1 Service-oriented architecture SOA

2.1.1 Definition of SOA

In recent years, SOA has gradually become a hot research topic in the field of software engineering, it has obvious advantages in the enterprise's information system integration, distributed software system development, and it is the key technology to deal with the flexible challenge of enterprise's business needs^[7]. At present, there is not a recognized concept about SOA, in this paper, the concept of SOA is: SOA is an architectural style, it combines units that the application program of different functional and service through well-defined interfaces and contracts. Interface is defined by neutral method, it is independent from hardware platform of implementing services, operating system, and made into language, it makes the service of building system can use the unified and standard way to communicate. This characteristic with the neutral interface definition is called loose coupling among services.

2.1.2 Service of SOA

Service is the core of implementing SOA. Service is the basic element of the SOA^[8]. SOA specify a set of entity (service providers, service consumers, service registry, service terms, service broker, and service contract), these entities detailed instructions on how to provide and consume services. These services are interoperable, independent, modular, location clear, loosely coupled and they can find other addresses through the network.

2.1.3 Service specification of SOA

Service specification has three elements, people can choose them according to the modeling type of services:

- (1) **Specify structure:** It defines the operation that can be invoked and the message that destroyed or created by these operations.
- (2) **Specify behavior:** It stands for any expected meaningful agreement or session between service customers and specified service.
- (3) **Specify strategy:** It stands for service strategy and constraints. Strategies may include security, manageability and so on.

2.1.4 Protocol stack of SOA

Functional aspects of service

Transport protocol: It is used to transport service requests from the service users to the service provider, and transmit the service provider's response to the service users.

Communicational protocol: A mechanism after negotiation, through this mechanism, service providers and service consumers can communicate with each other about the content will be requested and will be returned.

Service description: A model after negotiation, it is used to describe what is service, how should call the service,

and successfully invoke what data the service need.

2.1.5 SOMA methodology

The whole name of SOMA is Called the Service-Oriented Modeling Architecture, it is modeling and architecture that service oriented. SOMA realizes analysis and design of service according to analyzing business fields, business processes, business goals, the analysis of the existing system, the whole process is divided into three stages, find service, service specifications, service implementation.

2.2 Petri net

2.2.1 Introduction of Petri net

Petri net is a tool of graph theory, and it is suitable for dynamic system modeling for the discrete event, it is widely used in manufacturing system, computer systems, communicational systems modeling and analysis.

2.2.2 Characteristics of Petri net

It describes system through using graph, it makes the complex system become visualization, it is helpful to understand. Petri net can be established layered, it is easy to describe the distributed hierarchical system. It has a rigorous mathematical theory, it can analyze all kinds of running characteristic of manufacturing system. It can not only describe the static characteristics of manufacturing systems, but also can describe the dynamic characteristics. It can describe the data flow and logistics of internal system. It can describe the system's concurrency, competitive, and so on. And it can describe complex systems are prone to combined explosion, it is bad for system's optimization.

3. The PN-SM modeling process and the basic structure of the model

3.1 Service modeling process of PN-SM

Service system modeling is one of the research focus of service science, it carries on the modular design in the field of business, and keeps the dynamic consistency with information system, it needs to solve the adaptability of components, multi-granularity and social factors modeling, and other issues. The definition of Petri net is shown by strict mathematical analysis and intuitive, visual graphs, it can also provide a lot of system description method and the system behavior analysis technology, it is very suitable for modeling needs in the workflow. At present, many scholars at home and abroad are researching on service composition modeling method based on Petri net. Using the migration in Petri net to express the operation of the service, library expresses the situation of service, the arc of library and migration express the causal relationship among state; On the contrary, the literature [8] regards the library mapping in the Petri net as a service. Many studies have shown that there are the following two problems exist in the previous research of service modeling method based on Petri net:

- (1) Differential structure of service model. The simple model structure, level without division, unable to meet the

demands of different levels view of different levels of staffs who are make development and design.

(2) The single mapping between service system and the Petri net. According to the process of SOMA service modeling method, this paper proposes a service modeling method PN - SM based on Petri net. This method can establish a layered service model, and can establish the transformation between different hierarchical model; This method does not belong to describing language and implementing technology, its application scope is broad, and can guide service system development. PN - SM service modeling is dependent on the main frame of the general service modeling method, this paper constructs service modeling method process suitable for the field of information management software based on the SOMA service modeling method process, according to the classification rules of the service and principles of service design and combined with Petri net. This paper defines the process of PN - SM service modeling as shown in figure 1.

$p1 . p2 . p3$

are the continuation of three service status. Service1 and service 2 are two order service. The solid dot in library $p1$ is control token, flower heart dot is data token. In the whole process, control flow and data flow are completely represented and passed.

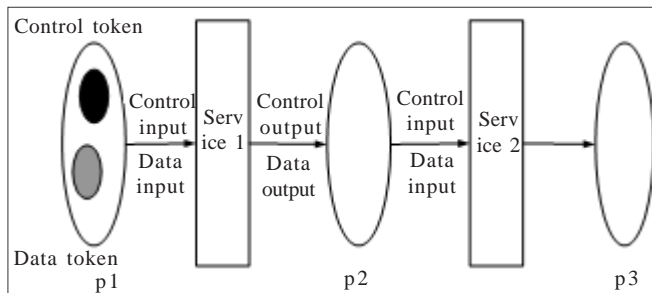


Figure 1. PN - SM service modeling process

3.2 The structural model of PN-SM

PN-SM service model is a service process, it is used to describe the logical relationship among various services. In this article, the model is improved based on previous modeling experience, it emphasizes the parallel relationship between the control flow and data flow, the hierarchical structure diagram as shown in figure 2.

4. The PN-SM service modeling experiment

4.1 Put forward hypothesis

We assume that a Petri net represents a service behavior, contains an import library (that is, a library has not incoming arc) and an output library (that is, a library has not outgoing arc). Has a Petri net with an input library that receiving information and an output library that can send a message, it will be conducive to the service synthesis, analysis and testing of certain properties (such as accessibility, deadlocks, activity, etc.). At any time, Web services can be in one of the following condition:

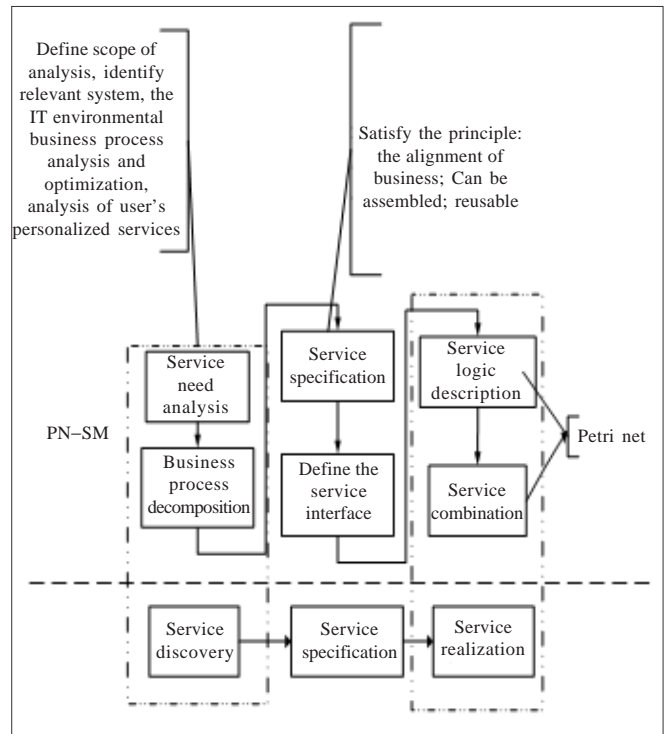


Figure 2. Nonhierarchical structural model of PN - SM

Not instantiated, ready, running, suspended, completed. When the Web service is in the ready state, which means that a token is in the appropriate import library, however, when it is in the completed status means that there is a corresponding tag that stands for output location.

4.2 Set up the mapping between service system and the Petri net

Establish a mapping between service system and colored Petri net, and improve it, make it become a more complete service system, and formally describe it. Definition: Service System, $SS = (K, P, T, F, C, G, E, I, o)$, among them:

(1) K is the set which is not empty and limited types, also known as color set, is used to express data types that involved in service.

(2) $N = (P, T, F)$ is the structure of Petri net; That meets: it is the finite set of libraries, express the state of a service.

(3) T is the finite set of migration, it expresses that execute services, in the service flow chart, simply equate it to the service itself.

(4) $F \in (P \times T) \cup (T \times P)$ is a finite set of the arc, it expresses causal conversion relations between the service status and service operations, meets:

$$P \cap T = P \cap F = T \cap F = \phi$$

(5) C is color function, it is defined as: $C: P \rightarrow K$. It maps every library to a data type $C(P)$, each token in library P the must have a value that belongs to data type .

(6) G is the guard function, defines the relationship that the migration T to the expression, meet:

$$\forall t \in T: [Type(G(t)) = B \wedge Type(Var(G(t))) \subseteq K]$$

That guard function G migrates every map to a BOOL expression, which all variable data types belong to K . When we use the graphic representation of colored Petri net express the service system, if the value of the guard expression is true all the time, we will omit it.

(7) E is arc expression function. It defines the relationship between directed arc F and the expression, it meets:

$$\forall fF : [Type(E(f)) = C(P) \wedge Type(Var(E(f))) \subseteq K]$$

(8) I is import library, expresses the set of beginning library service, satisfy:

$$I = \{X \in P \cup T | (X, I) \in F\} = \phi$$

(9) O is the output library, expresses the library collection of the end of service, meet:

$$O = \{X \in P \cup T | (O, X) \in F\} = \phi$$

4.3 Combination and operation of basic service model

4.3.1 set up the order service operation model

Using $S_1 \Theta S_2$ expresses service sequential pattern, when after executing S_1 , then S_2 . Figure 4 shows that after completing activity, it will produce a integer control data d for its output library; Then S_2 binds the control data, enters the ready state, waiting for their corresponding actuator to complete.

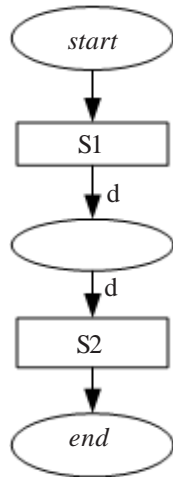


Figure 3. Sequential Pattern

4.3.2 Establish iterative service operation model

μ_n is iterative operators. It is a unary operator. As shown in figure 4. Prepositive and the subsequent state of the service S in figure are respectively pre and post library, μ_n represents the service S makes iterative operation, the operating times is n .

4.3.3 Establish concurrent service operation model

Concurrent operation is expressed as the operator sign $// c$, it represents the parallel relationship among two services, there is no restriction among them. The logic relation of concurrent service can be described with partial order: Assuming S is a set of service, $<$ is a binary operator sign, acting on the X :

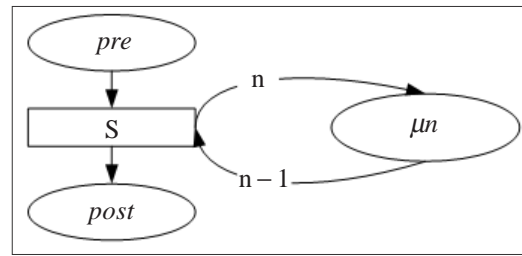


Figure 4. Iterative model

(1) $x, y : (x, y) \in < \rightarrow x, y \in X$;

(2) $x, y, z \in X : (x, y) \in < \wedge (y, z) \in < \rightarrow x, y \in X \in <$;

(3) $x \in X : (x, x) <$ at this moment, we call it $SPO(x, <)$. If service $x, y : (x, y \in X) \wedge \neg(x < y) \wedge \neg(y < x)$, then we call it concurrent service xS_COy . In the workflow process, a single control thread split into multiple control threads can be parallel executed, it makes some activities can be implemented at the same time or in any order, at this moment it needs to introduce the parallel branch mode. Figure 5 shows the two examples that two activities can be executed in parallel after performing activities.

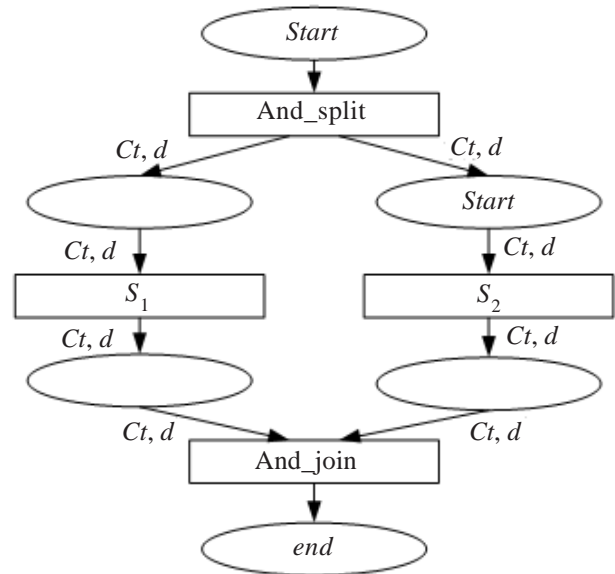


Figure 5. Parallel branches model

4.3.4 Establish select service operation model

In service modeling process, there is a choice model in the service relationship, that is, make a decision according to the condition of above state, or service flow to the service, or to another service, it is impossible to flow simultaneously, we call this kind of circumstance choice model. Operating sign of Select service operation mode is \oplus , it is a binary operating sign, it means that the service flow only can go through S_1 or S_2 , that is $S_1 \oplus S_2$. Figure 6 shows an example of two alternative branches (S_1 and S_2) are selected simply:

If the control or data signals delivered by above state is equal to C , then service process choose to go through S_1 , instead, choose S_2 . If any one activity of S_1 or S_2 is executed, then the next activity can enter the ready state.

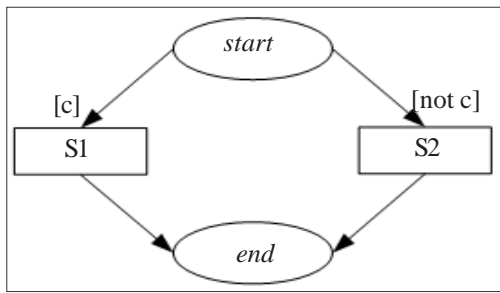


Figure 6. Choice model

4.4 Result analysis

Through the above experiment can conclude that the PN - SM service model is a clear expression that through using the logic operation relationship between Petri nets and service system, service and service composition. It need to build a one-to-one mapping relationship of corresponding elements between Petri net and service system, and make it has convenient, flexible model structure. Representing the service model based on Petri net need to create a accurate element mapping between service system and Petri nets, it shows that the symbols and pictorial in Petri net respectively represent which elements in the service system.

5. Conclusion

Through Petri model, this paper puts forward the service-oriented architecture SOA, describes the SOMA, let the reader know more about the service specifications and performance of SOA. And it puts forward a kind of service modeling method PN - SM based on Petri net, accurately and flexibly describe service model and service composition logic. Through introducing PN - SM modeling process and the basic structure of the model, and the service composition relationship among them, let the reader understand that PN - SM is a supplement of SOA, it has a guiding role for the development of the service

system. Finally it concludes that the Petri net is a model that suitable for describing concurrent system. This study can't go more in-depth due to the limit time, if next time there is an opportunity, this article will further improve the theoretical model; It will Further make a research on service discovery, service code algorithm; And it will put forward the effective method of the simulation and validation of service model.

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