PROCESS INTEGRATION FOR SERVICE ORIENTED NETWORKED APPLICATIONS

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Abstract: With the development of information, the paradigm in distributed networked applications is shifting towards Service Oriented Architecture, which has some good quality of louse coupled, reused, opened and integrated attributes. Single service can only satisfy some certain requirement, only large scale of integration can solve the conflicts between demands and supply. It involves three layers' integration, the bottom data integration, the middle process integration and the uppermost architecture integration. The paper mainly focuses on the middle process integration. The paper makes use of object Petri net language to construct five meta-models of sequence, alternative, parallel, arbitrary sequence, and iteration operations and studies some characteristics of these meta-models. On the basis of the above analysis, we make further research on process integration methods and models. Finally, process integration algorithm and analysis are made, which verifies the improvement of process analysis and implementation efficiency.

1 INTRODUCTION

As the development of information technology and software architecture, Service Oriented Architecture (SOA) has been paid more and more attention. The paradigm in distributed networked applications is shifting towards Service Oriented Architecture where services play as basic elements. SOA has some good quality of louse coupled, reused, opened and integrated attributes. However, users' requirements become more and more complicated, and single service can not satisfy the needs any more. Service integration is needed to realize complicated business requirement.

Service integration is a process that existed services are dynamically discovered under certain rules, and are organized as a large service or system, to satisfy users' complicated needs and improve the software productivity. With the growing number of alternative services that provide the same functionality but differ in quality parameters, and the business process becomes more and more complicated, service integration is not just concerned with the services themselves. Service integration contains the bottom data integration, the middle process integration and the uppermost architecture integration. In recent years, some simple process integration applications have been used widely by many service vendors such as airline companies and hotels to satisfy their customers' various demands and improve their profits.

It is more desirable if the whole process can be determined in advance. Some research on Markov process and Petri Net workflow is partially similar to process integration, which gives us some instructive inspiration. Only considering the bottom data integration without the high level process integration is not a practical solution for service oriented applications. The process integration paradigm and its realization provide a promising solution for the

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seamless integration of service oriented applications to create new value-added services.

The rest of this paper is organized as follows. Section 2 introduces the framework of integration for service oriented networked applications. Section 3 proposes the process integration based on object Petri net. In Section 4, we will discuss the related work. Finally, Section 5 draws the conclusion and future work.

2 FRAMEWORK INTEGRATION FOR SERVICE ORIENTED NETWORKED APPLICATIONS

Service oriented networked applications has become more and more popular. To study architecture integration hierarchy structure is of great necessity for the inner process integration.

2.1 Overall Integration Framework

Lots of systems have adopted service oriented architecture as a novel solution to high efficiently implement on the net. SOA has the excellent characteristics of louse-coupled, reused, opened and integrated attributes, which has the special kinds of data structure, process construction and top-level architecture. Now the popular data structure for service oriented networked applications is based on XML schema. In the middle level, the process modeling and construction are the basic mechanism to fulfill the function of the systems. On the top level, the system architecture is the blue print governing the system design, implementation and evolution over time..

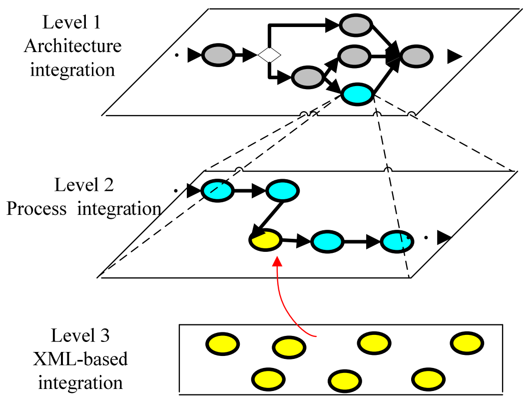

Figure 1: The overall integration framework.

The overall integration framework is depicted in Fig 1. The third level is the fundament data layer, which depicts the XML-based schema, and is involved with XML-based data integration. The second level is the process layer, which depicts the process modeling and is involved with process integration mechanism. And the first level is concerned with architecture integration for service oriented networked systems.

Certainly, the all three layers are not isolated by each other; and the successful operation of each layer is dependent on the support and restriction of other two layers. For example, the process integration should consider the specific data structure and realized manner. Different data structure determines the upper algorithm and integrated method. On the other hand, the process integration should also consider the framework of the system. Because each bottom detail is carried out under the constraints of the system architecture. Some conflict and inconsistency will result in the communication congestion and difficulty, even the whole system redesign and reconstuction.

2.2 XML-based Integration

XML has become the de-facto standard format for representing structured amd semi-structured data among various applications and databases on the Web. The Document Type Definition (DTD) or W3C XML Schema definition language (WXS) can be used to define the standard schema which describes the syntax and structure of XML documents. XML schema is a formalized description language, which uses lots of announcement sentence to ensure the standardization. Here we just give a simple entity integration example based on XML.

```
   <? xml version='1.0' ?>
   <! DOCTYPE a SYSTEM "keyvalue.txt"[
    <! ENTITY % key "Coke" > <! ENTITY
% value "Good">
    <! ENTITY % key "Tea" > <! ENTITY %
value "Delicious">
   ]>
   <a>&Coke;</a>
   <a>&Tea;</a>
```

The fundamental data integration is foundation stone to study integration field The XML-based integration is not so easy just like the above codes. We should consider the data storage manner, data accessing interface, syntax and semantic confliction, and so on. Because of the standard description manner of XML, the integration of data layer becomes much easier than some other data structure.

2.3 Architecture Integration

As the definition of DoD Architecture Framework, Architecture is the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time. The architecture is involved with all the upper design and lower detail realization, so the architecture integration is much more complicated not only for the service oriented systems, but also for other various systems. By the methods of process reconstruction, function optimization, and structure reconstruction, architecture integration will establish an integrative platform.

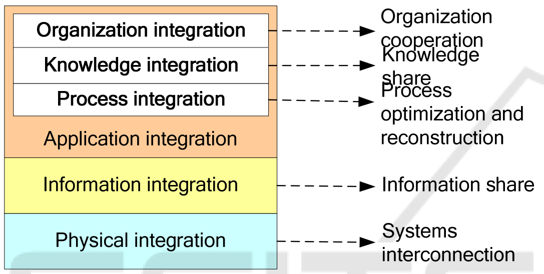

Figure 2: The common architecture integration structure.

Fig 2 depicts the common architecture integration structure, which contains three research fields: physical integration, information integration and application integration. Thereinto, the application integration is the hot research field and can be subdivided into organization integration, knowledge integration and process integration. The paper mainly focuses on the process integration in the application layer. On the other hand, SOA has been proven to be a flexible and extensible architecture for designing and realizing industry solutions and networked applications. The process integration in such a specific architeture should be paid more emphases to the process cooperation, redundancy elimination and overall optimization, and so on.

3 PROCESS INTEGRATION BASED ON OBJECT PETRI NET

A multitude and diversity of networked applications appear on the net.To hunt for a flexible and efficient process integration method is of great help to save network resources and improve service quality.

3.1 Object Petri Net (OPN)

Petri Net is a kind of modeling tool which is fit for describing and analyzing discrete dynamic system, especially parallel system.

The information carried by Place, Transition and Token in Petri Net is not rich, and is short of semantic description function. The space explosion problem of Petri Net limits the modeling and analysis ability for large systems. In order to satisfy the requirement of modeling and simulation of C4ISR systems, Object Petri Net Modeling Simulation Environment is developed by the C4ISR key lab of National University of Defense Technology. The Object Petri Net Description Language (OPDL) is designed. The service description, arithmetic operator analysis, process integration and modeling simulation in the paper are based on OPN and OPMSE.

Definition 1 The service OPN formalized description is an eight-tuples $cpS=(P,T,SubS,IP,OP,F,M_0,C)$:

1) P is the place set of service state, T is the set of Transition, $SubOBJ$ is the set of sub service objects.

2) IP is the set of service input ports, OP is the set of service output ports. The input and output interfaces are divided into two kinds: interior input port IIP, exterior input port OIP, interior output port IOP, exterior output port OOP. The objects interact with their sub service objects by IIP and IOP, and interact with exterior users and simulation environment by OIP and OOP.

$SIP(N)$ and $SOP(N)$ denote the sets of exterior input ports and output ports of all sub objects,

$SIP(N)=\bigcup_{obj\in SubOBJ(N)} OIP(obj)$,

$SOP(N)=\bigcup_{obj\in SubOBJ(N)} OOP(obj)$.

3) F is a flow relation in service composition,

$$F\subseteq P\times T\cup T\times P\cup IIP\times T\cup T\times IOP\cup OIP\times T\cup T\times OOP$$
.

4) $M_0:(P\cup IIP\cup IOP\cup OIP\cup OOP)\rightarrow(0,1,2,...)$ is the initial mark, and represents the state mark.

5) $C\subseteq IOP\times SIP\cup SOP\times IIP\cup SOP\times SIP$ is link relation.

In Fig 3, the numbers in Place and Port denote initial mark, called Token number. A pane with crewel in the middle denotes object. A concentric cirque denotes input port. A cirque embedded a triangle denotes output port. Here $S0$ denotes a switch. A switch is lighted when it receives a token, but it doesn't set each place a token. First the switch executes an act function and finishes the distribution. According to the designed token type in the channel, the token is distributed to appropriate place.

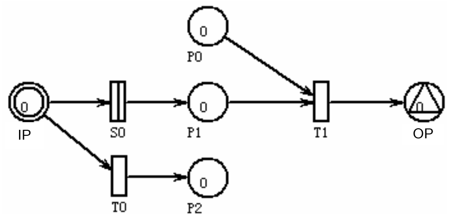

Figure 3: Object Petri Net example.

There are five kinds of functions in the object Petri Net modeling simulation environment designed by National University of Defense Technology. The according relation is depicted in table 1. The function is written by VBScript, which extends the element attribute and strengthen the support of modeling simulation. In this paper we mainly use act function in switch and event handing function in place.

Table 1: The relation of functions and elements in OPMSE.

Function Type	Obj-ect	Pla-ce	Trans-ition	Swi-tch	Arc	Port
Instantiation	Y					
EventHanding		Y	Y	Y		Y
Act			Y	Y		
Delay			Y	Y		
Predication			Y	Y		

3.2 Process Integration Meta-model

According to process integration requirement, we define five kinds of meta-models based on the description of OPN. The sequence operation definition is shown below, which can realize the sequence operation in the process integration.

Definition 2 sequence operation: Service $S = S_1 \perp S_2 = (P, T, SubS, IP, OP, F, M_0, C)$, $\perp$ is the sequence operator of service composition. Here $S_1 = (P_1, T_1, SubS_1, IP_1, OP_1, F_1, M_{10}, C_1)$,

$S_2 = (P_2, T_2, SubS_2, IP_2, OP_2, F_2, M_{20}, C_2)$, depicted in Fig 4:

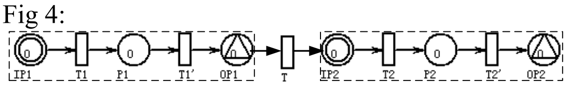

Figure 4: Service sequence operation.

- $P = P_1 \cup P_2$;
- $T = T_1 \cup T_2 \cup \{t\}$;
- $SubS = SubS_1 \cup SubS_2 \cup \{cpS_1, cpS_2\}$;
- $IP = IP_1$;
- $OP = OP_2$;
- $F \subseteq F_1 \cup F_2 \cup \{(OP_1, t), (t, IP_2)\}$;
- $M_0 = M_{10} \times M_{20}$;
- $C \subseteq C_1 \cup C_2 \cup OP_1 \times IP_2$;

Table 2 expresses the five kinds of meta-models for process integration., which are sequence, parallel, alternative, arbitrary sequence, iteration operations. They can fulfill the according function like their names' expressions.

Table 2: Five meta-models and the arithmetic operators.

Meta-models	Expr-ession	Arithmetic operator
sequence operation	$\perp$	$S = S_1 \perp S_2 = (P, T, SubS, IP, OP, F, M_0, C)$
parallel operation	$\parallel$	$S = S_1 \parallel S_2 = (P, T, SubS, IP, OP, F, M_0, C)$
alternative operation	$\oplus$	$S = S_1 \oplus S_2 = (P, T, SubS, IP, OP, F, M_0, C)$
arbitrary sequence	Θ	$S = S_1 \Theta S_2 = (P, T, SubS, IP, OP, F, M_0, C)$
iteration operation	μ	$S = \mu S_1 = (P, T, SubS, IP, OP, F, M_0, C)$

According to the above five meta-models, we can get more complicated arithmetic operators. Table 3 shows some deductive arithmetic operators from five basic meta-models. For arithmetic operator (1), the three services S_1, S_2, S_3, $S = (S_1 \perp S_2) \perp S_3$, $S' = S_1 \perp (S_2 \perp S_3)$, the inputs are all IP_1, the outputs' end marks are all $M_e(OP_3)$, So we can get $cpS = cpS'$. In the same way, the other arithmetic operators can be proofed.

Table 3: Some deductive arithmetic operators from five basic metamodels.

$$(S_1 \perp S_2) \perp S_3 = S_1 \perp (S_2 \perp S_3) \quad (1)$$

$$(S_1 \parallel S_2) \parallel S_3 = S_1 \parallel (S_2 \parallel S_3) \quad (2)$$

$$(S_1 \oplus S_2) \oplus S_3 = S_1 \oplus (S_2 \oplus S_3) \quad (3)$$

$$S_1 \oplus S_2 = S_2 \oplus S_1 \quad (4)$$

$$(S_1 \oplus S_2) \perp S_3 = (S_1 \perp S_3) \oplus (S_2 \perp S_3) \quad (5)$$

$$(S_1 \oplus S_2) \parallel S_3 = (S_1 \parallel S_3) \oplus (S_2 \parallel S_3) \quad (6)$$

$$S_1 \Theta S_2 = (S_1 \perp S_2) \oplus (S_2 \perp S_1) \quad (7)$$

$$\mu S_1 = \overbrace{S_1 \perp S_1 \ldots \perp S_1 \perp S_1}^{\mu} \quad (8)$$

3.3 Process Integration Algorithm

By making use of OPN methods and tools, we get the formalized description of service and process.To study the input, output, control and Mechanism of process integration for service oriented networked applications, we can comprehend the integration schema more clearly. The ICOM of process integration is depicted in Fig 5.

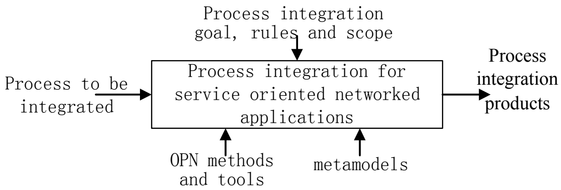

Figure 5: The ICOM of process integration.

Service oriented applications are based on the XML data schema, and standard architecture description. Then we studies the five basic meta-models based on OPN and their arithmetic operators. In algorithm 1, we will introduce an algorithm to do the process integration.

Algorithm 1: Process Integration Algorithm

```
   Require: Candidate process,
Requirements
   1. Input the candidate process set,
then create the according requirement
space
   2. Analyze the candidate process by
integration meta-models to produce the
basic elements and mutual relation.
   3. Analyze the rules and constraints
of the requirement to produce the
formalized restriction.
   4. Under the rules of overall
architecture, reconstruct the basic
elements of candidate process
   5. For the desired process
integration, eliminate redundancy and
optimize the whole process
   6. Process integration is done.
```

According to Algorithm 1, we could divide the candidate process into basic elements, and reconstruct the process integration, then eliminate redundancy and optimize the whole process, finally reach successful process integration.

4 RELATED WORK

Mayerl etc. present an approach how demands on applications can be derived from service management processes as extensions of traditional management processes. To extend traditional management applications with additional service management applications they propose an integration based on a service-oriented architecture.

Hentrich etc. introduce a pattern language that deals with process modeling, execution, and integration. Its main goal is to help solution architects, as well as process and service designers, to master the challenges in designing a stable and evolvable process-driven SOA.

To synthesize existing IT resources and make them integrated and cooperative to gain maximum benefit, Jing Bo etc. put forward an architecture for business process orchestration and integration based on the philosophy of service-oriented architecture. According to the architecture proposed, a platform was implemented using service-oriented technology. Real-world application shows that the platform can meet the current industry needs well.

Kong.Jaehyun etc. introduce a methodology that uses event-driven service technology and active rule processing for business process integration of ubiquitous enterprises. The event-driven approach to business process integration can supplement the service-oriented enterprise architecture by facilitating real-time event processing and distributed service coordination.

Shah, Vikas S etc. introduce an RT-ECM architecture framework illustrating most prominent technical challenges during establishment of business process perceptive integration and time sensitive content flow management. Real-time content management engines, business process engines, and service provisioning are at the centre of presented framework.

5 CONCLUSIONS AND FUTURE WORK

According to the characteristic of service oriented networked applications, the paper studies the overall integration framework, which can be divided into three layers. We make some discussions about the fundamental XML-based integration and the uppermost architecture integration. The core of the paper mainly focuses on the middle process integration. We make use of object Petri net language to construct five meta-models of sequence, alternative, parallel, arbitrary sequence, and iteration operations and study some characteristics of these meta-models. On the basis of the above analysis, we make further research on process integration methods and models. Finally, process integration algorithm and analysis are made, which verifies the improvement of process analysis and implementation efficiency

In the future, we will continue to focus on the fields of the middle process integration and the upper architecture integration. Improving the efficiency of process integration, studying the uppermost architecture integration, and the design and realization of prototype system are three research aspects.

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