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The Analyzing Method about Behavior Weak Soundness of Web Services based on Open Petri Net

[1,2]Xianwen Fang, [1]Juan Wang and [1]Ke Luo
[1]Department of Information and Computing Science, Anhui University of Science and Technology, Anhui Huainan, 232001, China
[2]Department of Computer Science and Technology, Tongji University, Shanghai, 201804, China

Abstract: At present, the correctness of the composite Web service is very important. The soundness of the composite Web service model was the core of the correctness of the service composition and can be judged by determining whether or not the composite model satisfied the behavior relativity. But the proposed judging algorithm of behavior relativity was feasible only in the case that T-invariant of Petri net model exists. In the paper, in order to realize the correctness analysis of the composite Web service, an algorithm for determining the behavior weak soundness of the composite service was presented based on the theory of the service tree. The method can analyze the correctness effectively, even if in the case that T-invariant of Petri net model didn't exist. Finally the concrete example showed the effectiveness of the proposed method.

Key words: Open petri net, weak soundness, web service, behavior relativity, T-invariant

INTRODUCTION

As a new computational resource configuration in the Internet, Web services played a more and more important role in the field of the electronic commerce, enterprise application integration and so on. Many researchers pointed out that services do not only contain static syntax and semantics but also contain some dynamic behavior attributes, e.g., internal control flow, data flow and interact-ion protocol (Fu *et al.*, 2004). Now the service composition approach becomes mature, so a large number of large-granularity process web service compositions will occur. These services implied business process a logic and the operations offered have some temporal relation (Fang *et al.*, 2009). Hence, it is key to ensure the correctness after compositions except ensuring the correct function of every service.

At present, the correctness of Web service composition was mainly determined by the soundness and the behavior soundness attracts many researchers' attentions. Most of these researches were based on Petri Net, finite state machine or automata theory. Based on the concept of service view (Fang *et al.*, 2010) proposed a formal definition of behavior relativity between services, then presented a Petri net method to qualitatively determine and quantitatively compute behavior compatibility (Foster *et al.*, 2004) translated the service composition into the Finite State Machine (FSM) and used labeled transition system analyzer to analyze FSM model, then analyzed behavior compatibility among services by verifying its safety, live and deadlock property (Fu *et al.*, 2004) modeled service composition Business Process Execution Language (BPEL) description by Guarded automata, used temporal logic to describe the goal attribute which is required to meet the interaction process. Then, translated the model into the Promela specification and used Simple Promela Interpreter (SPIN) model checker to verify whether the model meets goal attribute property and it is a high demand for determining the correctness of Web service composition. Martens (2005) applied the workflow net to model Web services and analyze the service behavior compatibility in the composition by verifying safety, live and deadlock property in the Workflow Net. Based on extended the Martin-Lf's Type Theory (MTT) which supports a type-theoretic formulation of services behavior structured patterns (Yin *et al.*, 2009) proposed the verification on consistency and compatibility of Web services behavior. Fang *et al.* (2011) studied the soundness property form the language viewpoint of the workflow net system. Net language depiction for soundness was presented to reveal the behavior characteristic of this basic property. Furthermore, synchronous composition and combined composition of the workflow net system was studied. Necessary and sufficient conditions were given for soundness preservation whether the two composition

Corresponding Author: Xianwen Fang, Department of Information and Computing Science, Anhui University of Science and Technology, Anhui Huainan, 232001, China

system. This study provided a novel approach to the modeling and analysis for composition in complex WF-net systems. However, it was difficult to determine the soundness property and it was a high demand for determining the correctness of Web service composition. In the study, though discovering the limitation of the method based on behavior relativity to judge the soundness, a decision method of behavior weak soundness was proposed to determine the correctness of composite Web service.

BASIC CONCEPTION

A Web service consists of internal structures that realize a local sub process and an interface to communicate with its environment. So modeling services with the help of Open Petri Net, i.e., a Petri Net with an interface. Then, giving out the definition of OPN.

Definition 1: A 3-tuple N = (P, T; F) is called Petri Net (Murata, 1989), where:

- $P \cup T \neq \phi$
- $P \cup T = \phi$
- $F \subseteq ((P \times T) \cup (T \times P))$
- $dom (F) \cup cod (F) = P \cup T$
- $dom (F) = \{x \in P \cup T \mid \exists y \in P \cup T: (x, y) \in F\}$
- $cod (F) = \{x \in P \cup T \mid \exists y \in P \cup T: (x, y) \in F\}$

Definition 2: An Open Petri Net is a 7-tuple N = (P, I, O, T, F, i, f) (Lohmann *et al*., 2007) where:

- $(P \cup I \cup O, T, F)$ is a Petri net
- ρ is a set of internal places; T is a set of transitions; F is a set of flow relations
- t is a set of input places and $\cdot I = \phi$; O is a set of output places and $\cdot O = \phi$
- t is the initial marking
- f is the final marking and f is a deadlock

We call the set $I \cup O$ the interface places of the OPN. Note that the initial and final markings cannot mark interface places.

As the open Petri net has interface places, termination depends on the communication partners of the net. Still, the aims are to express that at least the service disregarding the communication is modeled in a proper way. Therefore, by considering weak soundness, i.e. soundness without considering the communication which can be seen as generalization of the soundness concept of workflow nets.

Definition 3: An OPN N is called weak sound, if and only if:

- For any marking $\forall m \in R(N, i_N)$ holds $S(N): m \xrightarrow{*} f_N$ i.e., the final marking f_N is reachable
- For any marking $\forall m \in R(N, i_N)$, such that $m \geq f_N$ holds $m = f_N$

Two OPNs can by be composed fusing interface places with the same name. Next, we give the condition of two OPNs composed and their composition.

Definition 4: Two OPNs A and B are composable if and only if they do not share any internal places, input places and output places, i.e., $(P_A \cup P_A \cup O_A \cup T_A) \cap (P_B \cup P_B \cup O_B \cup T_B) = (I_A \cap O_B) \cup (O_A \cap I_B)$ hold (Aalst *et al*., 2009)

Definition 5: Let A and B be two OPNs (Aalst *et al*., 2009). Their composition is an OPN $A \oplus B$ = (P, I, O, Y, F, i, f) defined by:

- $P = P_A \cup P_B \cup (I_A \cap O_B) \cup (I_B \cap O_A)$
- $I = (I_A \backslash O_B) \cup (I_B \backslash O_A)$
- $O = (O_A \backslash I_B) \cup (O_B \backslash I_A)$
- $T = T_A \cup T_B$
- $F = F_A \cup F_B$
- $i = i_A \cup i_B$
- $f = f_A \cup f_B$

PROBLEM ANALYZING

At present, if two Petri nets which are sound have behavior relativity, they will be sound after composition (Van der Aalst *et al*., 2008). Therefore, the soundness was mainly determined by judging the behavior relativity of the service composition model. Behavior relativity was a good behavior interactive relation. It showed that two components do not change their behavior after interaction and reached the requirement of software composition. Next we give out the decision algorithm for behavior relativity (Fang *et al*., 2010).

Algorithm 1: Behavior relativity decision: $PN_i = (P_i, T_i, F_i, M_{0i})$ is two Petri nets, $PN = PN_1 O_T PN_2$ and $\Delta = T_1 \cap T_2$. X_{ij} ($j_i = 1, 2,..., q_i$; I = 1, 2) are all of the minimal T-invariant and $X_{iji}^{\Delta} = \Gamma_{ti \to \Delta} (X_{iji})$ are the non-zero projection vectors of the minimal T-invariant:

- Compute the relational matrices of PN_1 and PN_2
- Compute the T-invariant and the minimal T-invariant of PN_1 and PN_2, i.e., X_{iji} ($j_i = 1, 2,..., q_i$; i = 1, 2)

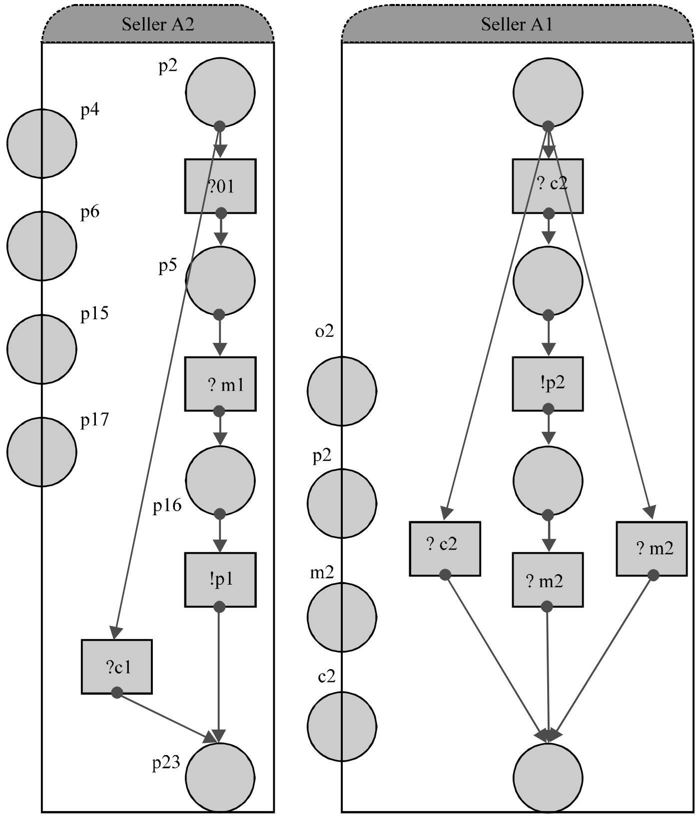

Fig. 1: Two different sellers

- Compute the projection vector $X_{iji}^{\Delta} = \Gamma_{ti \to \Delta} X_{iji}$, ($j_i$ =1, 2..., q_i, i = 1, 2)
- Determine whether every vector can be linear represented by the other vectors
- Based on the definition, the decision method is given as follows:
    - If there exists $\exists X_{iji}^{\Delta}$, $j_i \in$ {1, 2,..., q_i} and it can be linear represented by $X^{\Delta}_{3-ij_{3-i}}, j_{3-i} \in \{1, 2, \cdots, 1_{3-i}\}, i = 1 \vee 2$, we call it Be ($PN_1$), Be ($PN_2$), i.e., they satisfy the consistent behavior relativity

The algorithm need the existence of T-invariant but some Petri net do not have T-invariant. For example, Fig. 1 showed the OPNs of two different sellers. Both sellers do their business in different ways but they are linked together via a common broker-shown in Fig. 2. After Seller 1 has got the order (via channel o1), he waits for the money (channel m1) and send the requested product, afterwards (channel p). Seller 2 sends the product immediately after he has received the order. In case he received the money first, he would not send the product at all. Both sellers will terminate their process, if they received the signal to cancel (via channel c1 or c2).

We can compute the relational matrix A1 of the Seller 1 OPN model which is:

$$A = \begin{pmatrix} -1 & 1 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & -1 & 1 \\ -1 & 0 & 0 & 1 \end{pmatrix}$$

Then we compute the T-invariant and we find that the T-invariant do not exist. Therefore, the algorithm cannot be used to determine whether A1 and A2 satisfy the behavior relativity.

Next, we have a research on the case that the T-invariant does not exist.

THE ANALYZING METHOD ABOUT BEHAVIOR WEAK SOUNDNESS OF WEB SERVICES BASED ON OPEN PETRI NET

In the study, we use other methods to solve the problem that the T-invariant does not exist. Based on the service tree and its properties, the paper proposes a decision algorithm for weak soundness of Web service composition. First we introduce some basic concepts of service tree.

Definition 5: Let $A_1, \ldots, A_n$ be pairwise composable OPNs (Aalst *et al*., 2009). Let c {2,...n}→{1,...n-1} be such that:

$\forall i \in \{2,\ldots n\}$: c (i)<i

$\forall i \le i < j \le n$: $i = c(j) \Rightarrow I_{Aj} \cap O_{Aj} \ne \theta \vee O_{Ai} \cap I_{Aj} \ne \theta$

$\forall i \le i < j \le n$: $i \ne c(j) \Rightarrow I_{Aj} \cap O_{Aj} = \theta \vee O_{Ai} \cap I_{Aj} = \theta$

Definition 6: Let A and B be two composable OPNs. Condition $\Omega_{A,B}$ holds if and only if (Aalst *et al*., 2009):

$$\forall m \in R(A \oplus B), \sigma \in (T_A)^*: (A : m|P_A \xrightarrow{\sigma} f)$$
$$\Rightarrow (\exists \tilde{\sigma} \in (T_A \cup T_B)^*: (A \oplus B : m \xrightarrow{\tilde{\sigma}} f_A + f_B)$$
$$\wedge \tilde{\sigma} | T_A = \sigma$$

Here, T* is represented as the closure of T, $P \xrightarrow{\sigma} f$ is represented as the P reach to f though the transition sequences σ.

Theorem 1: Let A1, A2,..., An be a service tree with root A1 and tree function c. Further, let A1 be weak sound and for 2 = i = n, $\Pi_{Ai,Ac(i)}$ holds. Then A1 ⊕...⊕ is weak sound.

Based on the theory, we give the weak soundness decision algorithm.

Decision Algorithm 2: Weak soundness.
Input: $A_1, \ldots A_n$ are service components.
Output: Decision Result.

(1) First, the components are modeled by OPNs. Then, if A1,...An are pairwise composable, go into
(2) Else algorithm terminates
(3) If A1 satisfies weak soundness, then continue step (3); else algorithm terminates
(4) Determine whether A1,...An can form service tree, i.e., c {2,...n}→{1,...n-1}, whether c satisfies the three conditions: $\forall i \in \{2,\ldots n\}$: c (I)<i, $\forall 1 \ge o < j \le n$: $i = c(j) \Rightarrow I_{Ai} \cap O_{Aj} \ne \theta \vee O_{Ai} \cap I_{Aj} \ne \theta$ and $\forall 1 \le i < j \le n$: $i \ne c(j) \Rightarrow I_{Ai} \cap O_{Aj} \ne \theta \vee O_{Ai} \cap I_{Aj} \ne \theta$. If they can, then continue step (4); else algorithm terminates;
(5) Based on Theorem 1, determine whether when $2 \le i \le n$, $A_i + A_{c(i)} \ge A_{c(i)}$ holds. If so, then continue step (5); else algorithm terminates
(6) A1 ⊕...⊕are weakly sound and algorithm terminates

EXAMPLE ANALYZING

In order to verify the validity of our method, we use Fig. 1, 2 to analyze.

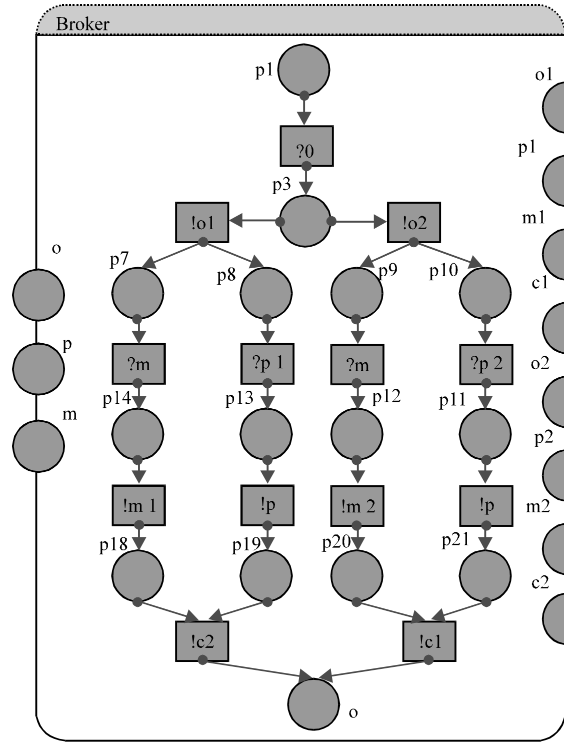

Fig. 2: One common broker

First, A1, A2, A3 can form service tree, because c: {2, 3}→{2, 1} exists, $I_{A1} \cap O_{A3} = \phi$ and $O_{A1} \cap O_{A3} = \phi$ and $O_{A1} \cap I_{A3} = \phi$ hold. Then, it is obvious that A1 is weak sound. So we compose A1 and A2 and we can get the reachable marking set R $(A_1 \oplus A_2)$, where:

$$R(A_1 \oplus A_2) = \left\{ \begin{array}{l} M_i(110\cdots0), M_1(0110\cdots0), M_2(010100110\cdots0), \\ M_3(00001011\cdots0), \\ M_4(000010000000110\cdots0), M_5(000010000000101001\cdots0), \\ M_f(0\cdots11) \\ M_6(0000010000001001010\cdots1), M_7(0\cdots0110001), \\ M_{11}(0\cdots01001101) \\ M_9(010000000011\cdots0), M_{10}(010\cdots1100), \\ M_8(0100000011\cdots0) \end{array} \right\}$$

For $\sigma = \{?m1, !p1\} \in (T_{A1})^*: (A_1 : M_4|_{P_{A1}} \xrightarrow{\sigma} f_{A1}) \Rightarrow \exists\tilde{\sigma} = \{!m1, ?m1, !p1, !p, !c2\}$ makes $M_4 \xrightarrow{\tilde{\sigma}} f_{A1} + f_{A2}$ and $\tilde{\sigma}|_{T_{A1}} = \{?m1, !p1\} = \sigma$ hold.

For $\sigma = \{?m1, !p1\} \in (T_{A1})^*: (A_1 : M_5|_{P_{A1}} \xrightarrow{\sigma} f_{A1}) \Rightarrow \exists\tilde{\sigma} = \{?m1, !p1, !p, !c2\}, \tilde{\sigma} \in (T_{A1} \cup T_{A2})^*$, makes $M_5 \xrightarrow{\tilde{\sigma}} f_{A1} + f_{A2}$ and $\tilde{\sigma}|_{T_{A1}} = \{?m1, !p1\} = \sigma$ hold.

For $M_{10}, \sigma = \{?c1\} \in (T_{A1})^*: (A_1 : M_{10}|_{P_{A1}} \xrightarrow{\sigma} f_{A1}) \Rightarrow \exists\tilde{\sigma} = \{?c1, !c1\} \in (T_{A1} \cup T_{A2})^*$, makes $M_{10} \xrightarrow{\tilde{\sigma}} f_{A1} + f_{A2}$ and $\tilde{\sigma}|_{T_{A1}} = \{?c1\} = \sigma$ hold.

The other marking also satisfy the condition, i.e., ΩA_1, A_2 holds, So $A_1 \oplus A_2$ is weak sound and $A_1 \oplus A_2 \oplus A_3$ satisfies weak soundness.

CONCLUSION

At present, the correctness of Web service composition is mainly determined by the soundness but the requirement of soundness decision method is high, so the paper researches on behavior weak soundness of Web service composition. Now we mainly determine the soundness by determining the behavior relativity of the service composition model. If two Petri net models are soundness and they satisfy the consistent behavior relativity, then their composite petri net model is also soundness. The method requires the existence of T-invariant but not every Petri net has T-invariant. Therefore, the paper proposes the weak soundness decision algorithm on the basis of service tree and its properties.

Future work mainly contains two aspects: 1) the behavior weak soundness. In the paper, we consider that the interfaces do not affect the process but in the fact, their influences cannot be ignored; 2) the method the paper proposes can only be applied when services satisfy the condition of service tree, hence we need to research more general method to adapt more types of service composition.

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REFERENCES

Aalst, W.M., K.M. Hee, P. Massuthe, N. Sidorova and J.M. Werf, 2009. Compositional service trees. Proceedings of the 30th International Conference on Applications and Theory of Petri Nets, (ATPN'09), Springer-Verlag Berlin, Heidelberg, Germany, pp: 283-302.

Fang, X., C. Jiang and X. Fan, 2009. Independent global constraints-aware web service composition optimization. Inform. Technol. J., 8: 181-187.

Fang, X., C. Jiang and X. Fan, 2010. Behavior-aware trustworthiness study of networked software. Int. J. Comput. Intell. Syst., 3: 542-552.

Fang, X.W., C.J. Jiang, Z.X. Yin and X.Q. Fan, 2011. The trustworthiness analyzing of interacting business process based on the induction information. Comput. Sci. Inform. Syst., 8: 843-867.

Foster, H., S. Uchitel, J. Magee and J. Kramer, 2004. Compatibility verification for web service choreography. Proceedings of the IEEE International Conference on Web Services, June 6-9, San Diego, California, pp: 738-741.

Fu, X., T. Bultan and J.W. Su, 2004. Analysis of interacting BPEL web services. Proceedings of the 13th International Conference on World Wide Web, May 17-20, 2004, New York, USA., pp: 621-630.

Lohmann, N., P. Massuthe and K. Wolf, 2007. Operating guidelines for finite-state services. Comput. Sci., 1: 321-341.

Martens, A., 2005. On compatibility of web service. Petri Net Newslett., 65: 12-20.

Murata, T., 1989. Petri nets: Properties, analysis and applications. Proc. IEEE, 77: 541-580.

Van der Aalst, W.M.P., M. Dumas, C. Ouyang, A. Rozinat and E. Verbeek, 2008. Conformance checking of service behavior. ACM Trans. Internet Technol., 8: 13-30.

Yin, Y.Y., Y. Li, S.G. Deng and J.W. Yin, 2009. Determining on consistency and compatibility of web services behavior. Acta Electron. Sin., 37: 433-438.