Activity Sequence Modes for Web Services and Verifications

CHEN Bo, YUAN Qingneng, LIU Zhiqi

Department of Computer Engineering, Guangxi University of Technology, Liuzhou 545006, Guangxi, China

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Abstract: Behavior requirement expression and its satisfiability verification for composite Web services is one of the ongoing issues in service computing. In this paper, the concept of behavior specifications based on activity sequence is proposed to express one kind of behavioral requirements for composite Web services. Its basic element is activity sequence. The method to express such behavioral requirements by behavioral modes is presented. Five behavioral modes used in this method are adopted. Through mapping modes to Labeled Transition Systems (LTSs), these modes are encoded with exact operation semantics. Then, the sufficient and necessary conditions as well as the checking algorithm for satisfiability of behavioral modes are given. Finally, an example analysis is presented. The result indicates that the behavioral requirements based on activity sequence are more suitable for the case of composite Web service than those based on activity or scenario. The behavioral modes expressions are concise and the satisfiability checking is effective by the given algorithm.

Keywords: Web service; activity sequence; behavior mode; mode satisfiability

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0 Introduction

Formal verification of satisfiability of specific behavioral requirements of users for composite Web services is a hot research issue in service computing, including behavioral modeling, behavioral requirements expressions, and behavioral satisfiability verification. Most of the existing works primarily focused on behavioral modeling[1-4]. Behavioral requirements were simply expressed by traditional temporal logic LTL, CTL, etc.,[1,2] or graphic tools MSC, UML, etc.[3,4] The elements in these expressions are activity and scenario, respectively. Pistore et al[5] and Rouached et al[6] made some exploration in behavioral requirements expressions with Formal Troops and event calculus. However, in essence, their basic elements are still activities.

In fact, many basic elements of behavioral requirements are activity sequence/activity chains. An activity sequence is a finite activity tuple of one execution of a composite Web service, in which all activities are sequentially occurred. An activity chain is an activity sequence whose activities occurred one by one. The granularities of these expressions are larger than activity and smaller than scenario. Activity chain and their satisfiability checking were researched[7]. In this paper, the expressions of behavioral requirements and the behavioral modes based on activity sequence will be studied.

1 Basic Concepts of Activity Sequence and An Example

1.1 Definition of Activity Sequence

The basic activity of a composite Web service can
be expressed below[7].

Definition 1  CS is a set of subservices of a composite Web service. Act, is the set of activities of service s, where s ∈ CS. Act = ∪ {aᵢ | aᵢ ∈ Actᵢ, s ∈ CS} is the set of activities of a composite Web service. aᵢ can be denoted as aᵢ in short.

Definition 2  Let Q = (a₁, ..., aᵦ) be a sequence, where aᵢ ∈ Act, 1 ≤ i ≤ k. If the order of aᵢ in Q accords with the occurrence order of aᵢ in some execution of service s, then call Q an activity sequence of service s.

A trace of service s is a special activity sequence that all its activities equal to the set of all activities of one execution of services s, denoted by σ = (σ₁, ..., σᵦ), where the number of activities may be finite or infinite. Specially, a composite service can be regarded as a service and has its traces.

1.2 Behavioral Modes Based on Activity Sequence

Definition 3  Q and σ are, respectively, an activity sequence and a trace of service s. If there is a subsequence of σ, σᵢ = (σᵢ₁, ..., σᵦᵢ), which satisfies σᵢ = Q, Q exists in σ, denoted by Q EX σ. If Q EX σ holds for any σ of service s, Q exists globally and is formally written as Q EX Globally.

Definition 4  Let σᵢ = (σᵢ₁, ..., σᵦᵢ) be any subsequence of σ. If σᵢ ≠ Q, then Q is absence in σ, denoted by Q AB σ. If for any trace σ of service s, Q AB σ holds, Q is absent globally and is formally written as Q AB Globally.

Q may occur in σ many times. The earliest occurrence is focused here.

Definition 5  F(Q, σ) = (σ₀₁, σ₀₂, ..., σ₀ₙ) is the earliest occurrence of Q in σ.

Definition 6  If an activity sequence Q and an activity a satisfy that when Q EX σ for any trace σ of service s, it must be a EX σ and F(a, σ) < F(Q, σ), then call the occurrence of a the precondition of the occurrence of Q and is formally written as a PR Q.

Definition 7  If activity sequence Q and activity a satisfy that when Q EX σ and a EX σ for any trace σ of service s, it must lead to occurrence of a in σ and F(Q, σ) < F(a, σ), then call a response to Q and is formally written as a RE Q.

Definition 8  If activity sequence Q and activity a satisfy that when Q EX σ and a EX σ for any trace σ of service s, then F(Q, σ) = (σ₀₁, σ₀₂, ..., σ₀ₙ). Q < F(a, σ) < Q, call a Plugin Q and is formally written as a PL Q.

1.3 An Example of Composite Services

Example: BookProvider (BP) and ExpressDelivery (ED) are two existing Web services that provide book purchase and express delivery service, respectively. NetworkBook (NB) is a composite Web service of BP and ED providing integrated network book purchase function for client. An interaction scenario of NB with other services is shown in Fig. 1. Some behavioral specifications are listed below: (1) The service must start to invoke book filter for a specific category of books. (2) Once the book filtration finished, no book price sort service will be executed. (3) That the service provides deliveries offers must be the precondition of invocation of book filtration. (4) After the client replies nack for the offer, the service must not provide another offer. (5) The service will invoke delivery filter during the execution of book filtration.

The behavior specification above is expressed in the activity sequence modes shown in Table 1.

<table>
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<tr>
<th>Client</th>
<th>NB</th>
<th>BP</th>
<th>ED</th>
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<td>Invoke[offers_next]C</td>
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Fig. 1 Interaction scenario of NB and other services.