Time-Based Web Service Composition

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ABSTRACT

This article describes how incorporating temporal constraints in web service composition results in more complex models and makes the verification of temporal consistency during the modeling and execution crucial. This article proposes a model named H-Service-Net based on the time petri net model to control and manage temporal consistency; the model also supports time constraints and exception handling. First, this approach proposes a modular approach for modeling composition using Extend Time Unit System, Allen’s interval algebra, and comparison operators in a time petri net model to consider all types of temporal constraints. Subsequently, this article presents algorithms on checking temporal consistency and mechanism for exception handling and validating the system in an implementation tool (H-Service-Editor) based on the proposed approach that uses BizTalk Server 2013 to evaluate the implementation of temporal constraints and timeout exception handling. Finally, an exhaustive performance experiment is presented to assess the scalability of the authors’ approach.

KEYWORDS

Exception Handling, Petri Net, Temporal Constraints, Web Services Composition

1. INTRODUCTION

With the continuous growth of web services through the World Wide web and the increase in composite web services that must satisfy the end user, time constraints in web service composition have become a relevant issue.

A web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically web Services Description Language (WSDL)). Other systems interact with the web service in a manner prescribed by its description using Simple Object Access Protocol (SOAP) messages, typically conveyed using HyperText Transfer Protocol (HTTP) with an Extensible Markup Language (XML) serialization in conjunction with other web-related standards (Booth et al., 2014).

In a web service composition system, autonomous web services perform various activities together to accomplish a common task. The success of this task often depends on the right synchronization. To improve the capacity of this system, time constraints are incorporated to the services for their synchronization. Each temporal constraint of each atomic service in the same composition may conflict with each other. For that reason, it is essential to check temporal consistency between atomic services.

Temporal consistency is crucial as time constraints must be respected. All business experts agree on the fact that time is a key asset for business processes as violating time constraints may lead to critical situations such as budget losses. There is a fundamental need to describe time properties in service composition because time constraints are manifested in several scenarios and provide pertinent
advantages in either business-to-business (B2B) scenario, enterprise application integration (EAI) scenario, E-government scenario, E-healthcare scenario, or mobile service (M-service). For example, E-healthcare comprises different services such as medical laboratories, clinics, and social security, and all such services must be performed according to a set of temporal constraints as per their duration and delays. Time constraints will help doctors in the diagnosis and treatment of diseases. A doctor may require an analysis at a specific time. Similarly, medical tests can only be provided after a given period. In addition, in E-commerce, a client must pay within 48 hours after his/her reservation. Time is also an essential element in medical web service such as treatment duration and other details related to the disease, for example, the pain lasting for three days, a history of hypertension two years ago, respiratory infection for the last four to five days, etc.

Respect temporal deadlines and overcome temporal contradictions and conflicts play a crucial role in web service composition, which is subject to delay errors (response time), network failure, and many other exceptions. However, less attention has been given to following temporal constraints in service composition systems.

Each web service has its own specific time constraint. Moreover, web service resources come from different sources with different local time constraints. The major objective is to ensure that the defined time constraints are consistent when they are combined with the composition.

Our goal is to find a model that respects local and relative temporal constraints of different services and conforms to the global temporal constraints of composition at design time, and then, at run time. Our major objectives are the implementation of a modeling and verification tool of temporal constraints in a web service composition, the extension of the Hierarchical service Net model (H-Service-Net) to consider all types of time constraints (absolute, relative, local, global, etc.), and allowing exception handling in the H-Service-Net model. The verification of time consistency is clearly a very important task. Using a service that has time inconsistency will only lead to the wastage of resources. The first step that must precede the web service composition is the analysis of temporal consistency. This type of analysis can be used to determine whether composite services are totally consistent, partially consistent, or temporally inconsistent. The important goal here is to determine the time inconsistency at design time and avoid using the system for temporal exception handling.

This article presents the definition of a formal model that supports the necessary abstractions such as time constraints and exception handling. The content of this article is organized as follows: Section 2 presents some related works. Section 3 describes the originality of our approach. Section 4 presents definitions and preliminaries. Section 5 presents our model named “H-Service-Net”; it is illustrated with an example. Section 6 describe the set of time constraint in H-Service-Net model. Section 7 provides solutions to temporal violations by exception processing. Section 8 describes a dedicated editor named H-Service-Editor. Section 9 evaluates the approach and shows the experiment results. Finally, Section 10 concludes the paper.

2. RELATED WORK

Constraint-based Web service composition is a dynamic research issue in recent years and attracts many researchers from both academia and industry. For this issue, several approaches have been proposed to resolve this problem.

In order to find best service that satisfy user’s constraint solution in (Mallayya, Ramachandran, & Viswanathan, 2015) ranking algorithms are used to describe user constraint and QoS requirements. During composition of service solution of (Deng, Huang, Wu, & Wu, 2016) consider both temporal constraints and QoS constraints using constraints-based service filtering process. Population-based algorithm is proposed to select atomic services affected in composition. In order to validate temporal constraint at runtime (Liang & Du, 2016) proposes a queueing network and adjusts temporal inconsistency using temporal adjustment model with linear programming (LP). Improved Cased Based Reasoning is used to predicate the QoS value of candidate web services in (Liu, Jia, Xue,
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