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Colored Petri net based techniques for constructing reliable web service composition

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Abstract
In today's scenario, there are many web services around the web. This service has its own limited functionality. A single service can not satisfy the users' requests, so we need to combine these services in a set of services. Web service composition uses certain standard protocol to provide these services such as UDDI, SOAP, and WSDL. Reliability of composite web service which is an important aspect. The analysis of reliability in this scenario is not an easy task. In this paper we have proposed a model named Coloured Petri net based Reliability in Composite Web Service (CPN-RCWS). Using this model we compared the reliability under different state of recovery mechanism.

1. Introduction

The origin of web service composition is due to necessity of user requirement because requirement of user is different. Web Service composition is a set of services that is provided by the service provider. These services is utilized by the customer via standard protocol such as UDDI (Universal, Description, Discovery, and Integration), SOAP, WSDL. In today's scenario there are many web services around the web. These services have its own limited functionality. A single service can not satisfy the user request. So we need to combine these services in a set of services. WSC is a composition of services that is available by the service provider and that services is utilized by the user. WSC uses certain protocol standard to provide these services such as UDDI, SOAP on over HTTP. The reliability of composite web services is defined as the probability that all the tasks involved in the given web service be executed successfully. The proposed model CPN-RCWS is based on the reliability definition and the service provided by a web service has been modeled using coloured Petri nets (CPNs).

1.1Web Service

By Chemaa et al.[1], a Web service is a tuple S = (NameS; Desc; Loc; URL; CS; SGN)
Where -

- NameS is the name of the service used as its unique identifier,
- Desc is the description of provided service. It summarizes what functionalities
  the service offers,
- Loc is the server in which the service is located,
- URL is the invocation of the Web service,
- CS is a set of the component services of the Web service, if CS = {NameS} then S is a basic service, otherwise S is a composite service,
- SGN is the dynamic behavior of the service

1.2 Web Service Selection

The WS selection problem has been extensively studied in the past few years. Previous works have focused on optimizing the selection of WSs for a single activity, while the most recent ones focus on the selection of WSs in order to satisfy the QoS requirements of a workflow (or composite WS).

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1.3 Composite Web Service Reliability

The reliability of a WS refers to the probability that the web service will successfully execute. Several works have been proposed in the literature to derive the reliability of a web service. The reliability of a composite web service can be derived by aggregating the reliabilities of constituent web services based on the occurrence rate of each flow pattern. While a thorough test on a (remote) web service may require intensive interaction between the web service and the test requester [2].

Composite Web Service Reliability ensure that the delivery of services without duplication and fault tolerance. In Web services composition, reliability is an important aspect. The reliability of a services can be defined as the probability of a services that will perform a required function without failure under stated condition for a stated period of time.We need Reliable Web Service Composition due to following reasons:

- For improving better performance,
- System should be made fault tolerant.

1.4 Challenges in reliable web service composition

- Discovering and selection of web services,
- The availability of resources,
- To maintain Quality of Services (QoS),
- Reliability analysis of composite web service.

In this paper we propose a CPN based model CPN-RCWS for modeling and analysis of reliability in composite web service. We also measure the performance of the model. Using CPN, it is possible to investigate the behavior of the modeled system using simulation, to verify properties by means of state space methods and model checking, and to conduct simulation-based performance analysis.

Before simulation of our model we assume that the number of users are 100 and the arrival rate of the users follow exponential distribution i.e., any random number from 1 to 100 of users arrive in a unit of time or send their requests for web service.

We assume that there are 100 number of nodes and each node consists of 10 number of resources. For failure modeling, we assume that any random number subtasks of 100 subtasks running on the executing nodes or processors will face a failure in a unit of time. Here the failure types are of communication, hardware and software.

In simulation set up, we categorized the CPN-RCWS model in two categories.

1.4.1 Local Level Recovery: In this category, the model has local level recovery approach to recover the failure i.e., the recovery will be done on the same node where the failure has occurred.

1.4.2 Replicated Level Recovery: In this category, the model has replicated level recovery to recover the failure i.e., the execution of failed sub tasks will be executed on other nodes instead of the node where the failure has occurred. The Proposed Model is as shown in fig 1.

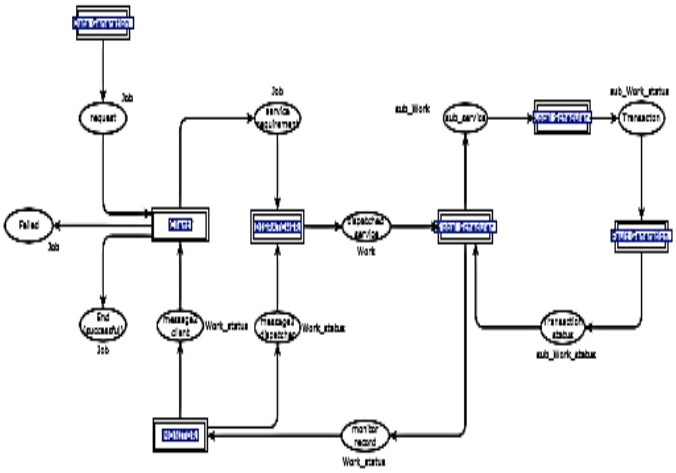

Fig. 1: CPN-RCWS

2. Review on the Development of Web Service Composition

Chemaa et al. [1](2012) studied that Web services are modular, self-describing, self contained and loosely coupled applications, which intercommunicate via message exchange. The composition of web services is a topic that attracts the interest of researchers. They proposed an expressive object-oriented Petri net based algebra that succeeded in the complex composition of Web services.

Fan et al. [3] studied that service composition is an important mean for integrating the individual web services to create new value added systems to satisfy complex requirements. However, it is challenging to guarantee the reliability of service composition in a distributed, dynamic and complex environment. The authors proposed a Petri net approach to constructing the reliable service composition.

Hamadi and Benatallah [4] studied that there is an important challenge to integrate web services to create new value-added Web services. Therefore, there is a need for modeling techniques and tools for reliable Web service composition. In this paper, the authors proposed a Petri net-based algebra, used to model control flows, as a necessary constituent of reliable Web service composition process. This algebra is expressive enough to capture the semantics of complex Web service combinations.

In the article by Zhang et al. [5], a model based coloured Petri net (CPN) to provide semantic support for web service composition has been proposed, and the reliability and maintainability of composite services are improved. The composite constructs in the model are sequence, concurrent, choice, loop and replace. The web service is formally defined by a CPN. A closed composing algebra is defined to obtain a framework which enables declarative composition of web services. Availability, confidentiality, and integrity of composite service are analyzed within the framework of the model based CPN.

According to Feng et al. [6], the emergence of Web services opens a new way of Web application design and development. It has led to more interest into Web service composition, which is an active area of research. The formidable problem of efficient and effective composition of existing Web services is the subject of much current attention. The study of modeling is one of the most important parts and a key layer of Web service composition. Therefore, there is a need for modeling techniques and tools for reliable Web services composition. They proposed a method using an Advanced Object-Oriented Petri Net (AOOPN) to model and evaluate the process of Web services composition. This method is expressive enough to capture the semantics of complex Web services combinations.

In a paper, Liu et al. [7] has proposed a novel way of modeling Web services using semantic graph transformations. Each operation supported by a Web service is associated with a semantic annotation that describes the input and output messages using RDF graph patterns. The terms used in these patterns are defined in OWL ontology's that describe the application domain. A key difference between our model and existing semantic Web service models like OWLS is that it describes the inputs and outputs in terms of instance-based graph patterns, rather than in terms of concepts. This allows associating a rich set of constraints on the input and output data in terms of relations between instances. They also proposed a composition model for Web service operations, that described the conditions for composing services into work flows. The composition model included the notion of semantic propagation, i.e. the semantic description of the output message of an operation depends on the semantics of the input message. They developed a planner that used this model to compose services, automatically. The planner used DLP reasoning to aid plan search. They presented performance results for the planner.

Deng et al. [8] presented a Petri net based framework called G-Net for the modular design of complex information systems. The motivation of this framework is to integrate Petri net theory with a modular, object oriented approach for the specification and prototyping of complex software systems. We use the client/server example to illustrate the G-Net specification of distributed systems, and how such a specification can be translated into a Predicate/Transition net for formal analysis. The differences between G-Net and hierarchical Petri net, as well as some limitations of the transformation technique, are then discussed.

Perkusich and De Figueiredo [9] studied that for specifying, designing and analyzing complex systems, it is necessary to adopt a modular or compositional methodology. So that the methodology can allow the designer the ability to verify local logical and timing properties of individual modules or components in the system, and also can allow the verification of the correct behavior of interacting components. They introduced a modular logical and timing analysis methodology for a kind of high level Petri nets named G-Nets, that can be applied for complex software systems.

The paper by Genrich and Lautenbach [10] presented a high-level Petri net model of concurrent systems called predicate /transition-nets (PrT-nets). Its places represent variable properties of, or relations between, individuals; they are predicates with variable extension. The transitions represent classes of elementary changes of those extensions. The model is introduced on the basis of a simple example from resource management. The central part of the paper is devoted to linear-algebraic techniques for verifying invariant assertions, yielding a calculus of S-invariants for PrT-nets. Finally, these modelling and analysis techniques are applied to a scheme for organizing a distributed data base taken from literature.

According to Fan et al. [11], service composition is an effective way to achieve value-added service, which has found wide application in various areas. Security design at architecture level is critical to achieve high assurance for these applications. However, most security design techniques for service composition were in ad hoc fashion and fell short in precise notations. This paper proposes a formal aspect-oriented approach to designing and analyzing secure service composition.

Fugini et al. [12] studied that Web service composition can be adopted to integrate information systems as complex composed processes. While interfaces of services are known at composition time, the quality of the composed process may depend on the ability of component services to react to unforeseen situations, such as data quality problems and coordination problems. They proposed an approach to analyze the quality of composed services using fault injection techniques, by inspecting the reaction to injected faults in

the composed process to assess its quality in terms of fault tolerance capabilities.

Bhiri et al. [13] studied that one of the main challenges to encounter Web services is how to ensure reliable compositions. They presented an approach that starts from a composite service effective executions to improve its reliability. Basically, they proposed a set of mining techniques to discover its model and its transactional behavior from an event based log. Then, based on this mining step, they used a set of rules to improve its recovery mechanisms.

In research related to the modeling of web service composition, several initiatives have been taken with the intention to provide platforms and languages that will allow easy integration and analysis of heterogeneous system. Some service model like BPEL4WS and DAMLS are focussed on representing service composition where flow of process and bindings between services known as priory Bucchiarone and Gnesi[14]; Rao and Su (2005)[15]; Dustdar and Schreiner (2005)[16].

Hamadi and Benatallah [4](2003) proposed an elementary petri net model for web service composition in which data types cannot be distinguishable. Yu-Yue and Jian-Qing [17] proposed CP net model for web service composition where services compositions chain can not

be generated automatically without predefined composition. Zhang et al. [18] proposed a model named CPWSC where availability, confidentiality, and integrity of composite web service were analyzed. Fan et al. [3] proposed petri net model based on efficient strategy for constructing the reliable service composition. But none of the above research focuses on the reliability analysis modeling of composite web service which is a challenge.

3.CPN Based Reliability In Composite Web Service

In this paper we propose a CPN based Reliability in Composite Web Service (CPN-RCWS).

We compared the reliability of composite web services between local level recovery and replicated level recovery.

3.1 Local Level Recovery: It is a sort of fault tolerance mechanism where failed service is recovered on the concept that the failed subtask of the service will be again rescheduled the same node for execution. But the problem in this approach is that there is no possibility of successful execution as the node is failure prone node. The benefit in this approach is that the communication overhead is minimum.

3.2 Replicated Level Recovery: In this type of fault tolerance approach, the failed task of service is replicated to other nodes to resume the execution after failure occurs. The benefit in this approach is that the probability of success of service execution of web service is higher than in

local level recovery. The disadvantage in this approach is that the communication overhead exceeds and thus the cost increases.

4.Conclusions

The reliability of composite web services is defined as the probability that all the tasks involved in the given web service be executed successfully. The proposed model CPN-RCWS is based on the reliability definition and the service provided by a web service has been modeled using coloured Petri nets (CPNs). When we compared the reliability among the different categories of the model, it was analyzed that the services have different values of reliability. The composite web service having local recovery also had the lowest value of reliability. The composite web service having replicated recovery had the highest value of reliability.

In the future, the same approach is planned to analyze the reliability, availability and dependability of composite web service empirically.

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