Modeling and Analysis for Grid Service Cooperative Scheduling Based on Petri Nets*

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Abstract. As the complexity of application system for enterprises, an important challenge is to dynamically schedule and integrate the heterogeneous and distributed services or activities to work cooperatively and efficiently. An effective technology to resolve the problem is grid service. A grid service built on both grid computing and web services technologies is an extended Web service. An application system for enterprises is a grid service composition that consists of a collection of grid services related by data and control flow. Therefore, there is a need for modeling and analyzing techniques and tools for reliable and effective grid service composition. The Petri net based method is an idea approach. In this paper, we use a colored dynamic timed Petri net (CDTPN) to model the grid service composition. The definition of CDTPN for grid service and an algorithm to construct a composite service are proposed. We give a definition of reachable service graph and an algorithm for constructing the reachable service graph of CDTPN. Finally, we discuss the correctness and effectiveness of the grid service composition by analyzing the reachable service graph.

Keywords: grid service, composition, dynamic timed Petri net, performance analysis

1 Introduction

As the development of Internet and World Wide Web, many organizations are rushing to put their core business competencies on the Internet to survive the massive competition created by new online economy [1]. An important challenge is to dynamically schedule and integrate the heterogeneous and distributed services or activities to work cooperatively and efficiently. An effective technology to resolve the problem is grid service. A grid service built on both grid computing and web services technologies is an extended Web service [2]. Grid computing is becoming a mainstream technology

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for large-scale distributed resource sharing and system integration [3]. Grid applications for service-based systems are usually not based on a single service, but are rather composed of several services working together in an application specific manner. As the complexity of application system for enterprises, an important challenge is to dynamically schedule and integrate the heterogeneous and distributed services to work cooperatively and efficiently. Therefore, there is a need for modeling and analyzing techniques and tools for reliable grid service composition because of dynamic and complex service composition process.

Petri nets are promising tools for modeling and analysis information processing systems that are characterized as being concurrent, parallel and distributed [9,10,11]. Many researchers model and analyze Web service using Petri Nets, since they are well suited for capturing flows in web services, for modeling the distributed nature of web services, for representing methods in a web service and for reasoning about the correctness of the flows [1,4-7]. The existing approaches have difficulties in modeling and analyzing dynamic and complex grid service composition process, so we propose a colored dynamic timed Petri Net (CDTPN) model for grid service composition, which is an extended timed Petri-net model. In CDTPN, the time delay of transition is a function of execution time of a service instead of time constant, which is convenient for modeling and analyzing dynamic performance of grid service composition.

The rest of this paper is organized as follows. The concepts of Petri nets related to this paper are reviewed in section 2. In section 3, we present CDTPN model of grid service and give the algorithm for four basic structures of grid service composition workflow. In section 4, we propose a definition of reachable service graph, give algorithms for constructing the reachable service graph of CDTPN and discuss the correctness and performance of the grid service composition by analyzing the reachable service graph. Section 5 presents a case study of public services in a city. We conclude the paper in section 6.

2 Concepts of Petri Nets Related to the Paper

In this section, we simply review some concepts of Petri nets related to this paper. For the details of the definitions, the reader can see references [8,9,10].

Definition 1[8]**.** A Petri Net is a bipartite directed graph represented by a three-tuple $PN = (P,T;F,M_0)$, where,

$P=\{p_1,p_2\ldots p_n,\}$ is a finite set of place nodes;

$T=\{t_1,t_2,\ldots t_m\}$ is a finite set of transition nodes;

$P\cap T=\varphi$, $P\cup T\neq\varphi$;

$F= P\times T\cup T\times P$ is a finite set of directed arcs from P to T and T to P, where directed arcs from P to T are called input arcs, directed arcs from T to P are called output arcs;

$M_0 : P\rightarrow N$ is called an initial marking.

Let $PN = ((P,T;F,M_0)$ be a Petri net. For $x\in P\cup T$,

$x\bullet=\{y\in P\cup T|(y,x)\in F\}$ and

$\bullet x=\{y\in P\cup T|(x,y)\in F\}$