

Chapter 108

Abstract Service for Cyber Physical Service Composition

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ABSTRACT

The collaboration of cyber physical systems poses many real-world challenges, such as knowledge restriction, resource contention, and communication limitation. Service oriented architecture has been proven effective in solving interoperability issues in the software engineering field. The semantic web service helps to automate service discovery and integration with semantic information. This chapter models cyber physical system functionalities as services to solve the collaboration problem using semantic web services. We extend the existing OWL-S framework to address the natures of the cyber physical systems and their functionalities, which are different from software systems and their functionalities. We also present a case study to illustrate our approach.

INTRODUCTION

A cyber physical system (CPS) has strong computational capabilities and can operate autonomously to accomplish difficult tasks. The cyber physical space is composed of a large number of cyber physical systems collaborating with each other. Given the strong capability of an individual cyber physical system, a cyber physical space may provide powerful services and functionalities. How-

ever, it is common that a CPS receives multiple tasks and chooses to accomplish only one of them. If more than one CPS chooses to accomplish the same task and temporarily ignores others tasks, multiple resources are suspended to perform one task causing other tasks to be postponed. In such situations, resources are wasted and the overall performance of the cyber physical space is impacted. To avoid such scenario, there must be an efficient mechanism that manages the collaboration among

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cyber physical systems. Such mechanism is essential in optimizing collaboration, which has a direct influence on the power of the cyber physical space, and it is able to maximize the potential of a cyber physical space.

The objective of the efficient collaboration of cyber physical systems is to achieve an optimal decision making strategy so that as many tasks can be accomplished as possible by the cyber physical systems through collaboration. The collaboration problem of cyber physical systems poses several real-world challenges. First, a CPS has local knowledge instead of global knowledge. Second, a CPS has its own social network, i.e., a CPS has communication link to a limited number of other CPSs instead of all CPSs. Third, a CPS is smart enough to respond to a scenario, i.e., it is able to make a decision according to its current knowledge of the world and its capability. Therefore, given a task, a CPS communicates with accessible CPSs and makes a decision autonomously.

Service-oriented architecture (SOA) emerged as a solution for business and software integration by wrapping business processes as services with standard policies. The SOA-based methods provide solutions to the modeling, composition, and management of services. Their application in industry has proven their effectiveness in improving the interoperability between software applications. Recent advances on semantic web service techniques promote the usage of semantic information in automating services discovery and composition. These techniques may greatly help solve the collaboration problem in cyber physical space. Presenting cyber physical system functionalities as services helps modularize the CPS and deal with the CPS collaboration with the service composition approaches. However, SOA-based approaches are not readily applicable to the cyber physical space because of several distinctions in nature between the cyber physical space and the traditional business processes realized by software applications.

First, the existence of more than one CPS of the same model makes it common the existence of multiple CPS services with the same set of characteristics. This distinction calls for the idea of abstract services, a single description for multiple CPS services of the same kind but not grounded to any physical system. Second, the availability and performance of CPS service is highly dependent on the operational status, the resource usage, and the physical environment of its CPS provider. Such distinction demands the ontology of CPS, its operational status, and its properties, which complements the service ontology in facilitating service composition and CPS collaboration. The dynamic evaluation of CPS service availability and performance also requires the description of the context of CPS.

The problem of CPS service composition and coordination requires an appropriate model that is capable of presenting CPS functionalities as services as well as describing the context around CPSs. Without such model, a service oriented approach may not be properly applied in CPS. This chapter presents an extension of the SOA model. More specifically, the extension is based on the semantic web service model, OWL-S, which is a SOA model for describing the interfaces of services syntactically and semantically. The extension addresses the abstract service, resource contention, physical constraint, and context requirement issues. The difference between abstract services/processes, and concrete services/processes is that the former are not grounded to any CPS and the latter have a concrete CPS owner. Such differentiation is especially useful under the local knowledge and limited accessibility constraints. For example, a CPS that knows how to decompose a given tasks but does not know which concrete CPSs provide the required services is able to use the abstract service during the task decomposition and workflow development. Modeling the properties, context, and status of CPSs and automatic processing the model is a necessary step in the SOA-based approach to dynamic CPS service composition.

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