

Designing Service-Based Cooperative Systems

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INTRODUCTION

The connectivity generated by the Internet is opening opportunities for services composition. As a consequence, organizations are forming online alliances in order to deliver integrated value-added services. However, due to the lack of methodologies and tools, the development of such composite services across organizations is usually ad hoc and raises a number of issues, especially in the identification, composition, and orchestration of services. The objective of this article is to propose a goal-driven approach to understand the needs of different organizations for a new added-value composite service, and to model the cooperative process supporting this service provision in a declarative, goal-driven manner. The goal model called a map is then used for service elicitation, composition, and orchestration. The article presents the approach and illustrates it with a distance learning cooperative service.

BACKGROUND

Web standards and distributed technologies and platforms allow the development of new business paradigms such as *virtual organizations* and *virtual enterprises* (Georgakopoulos, 1999). Within such paradigms, different organizations pool together their services to offer more composite added-value services made easily accessible through network technologies and the Internet.

The support for such new paradigms is offered by cooperative applications. By using an approach based on interorganizational business-process coordination, the cooperation between organizations is obtained by sharing, composing, and orchestrating services across networks. Such services, usually referred to as *e-services* or *Web services* (Casati & Shan, 2001), are exported from the different organizations involved in the cooperative application. Such an e-service corresponds to a semantically well-defined functionality that allows users and applications to access and perform tasks offered by back-end business applications. Then, the cooperative application consists of a set of distributed applications that integrate

the e-services offered by the participating organizations. Such integration raises some interesting points regarding service identification and composition.

A composition of e-services addresses the situation when a client request cannot be satisfied by available e-services but by a composite e-service, obtained by combining a set of available component e-services. Composition involves two different issues. The first issue is related to the elicitation of the composite service itself and the identification of e-services that will enter into this composition. Whereas this first issue is requirements driven, the second issue relates to the means to express the coordination between the various component e-services of the composite service. The former is referred to as composition whereas the latter is referred to as orchestration.

Several recent works address the second issue. In Casati, Georgakopoulos, and Shan (2001), an e-service that performs the coordination of e-services is considered a meta e-service, referred to as a composite e-service that can be invoked by clients. In Fauvet, Dumas, Benatallah, and Paik (2001), a composite e-service is modeled as an activity diagram, and its enactment is carried out through the coordination of different state coordinators in a decentralized way through peer-to-peer interactions. In Mecella, Presicce, and Pernici (2002), the orchestration of e-services is addressed by means of petri nets. In Bultan, Fu, Hull, and Su (2003), an e-service is modeled as a meal machine processing a queue of input messages into output messages. Finally, in Shegalov, Gillmann, and Weikum (2001), the coordination of e-services is obtained by an enactment engine interpreting process schemas modeled as state charts.

The first issue still remains largely unexplored. However, Hull, Benedikt, Christophides, and Su (2003) propose to classify composition into three categories: (a) the peer-to-peer approach, in which the individual e-services are equal, (b) the mediated approach, based on a hub and spoke topology, in which one service is given the role of process mediator, and (c) the brokered approach, where process control is centralized but data can pass between e-services. In Aiello et al. (2002), a way of composing e-services is presented based on planning under uncer-

tainty and constraint-satisfaction techniques, and a request language, to be used for specifying client goals, is proposed. In Fauvet et al. (2001), an approach to model service composition is introduced in which a composite service is defined as an aggregation of other composite and elementary services, whose dependencies are described through a state chart. Finally, in Yang and Papazoglou (2002), the issue of service composition is addressed in the context of Web components as a way for creating composite Web services by reusing, specializing, and extending existing ones.

Despite these attempts, an overall approach for eliciting, distributing, and orchestrating e-services into cooperative applications is still lacking. There is undoubtedly a need for a methodological approach toward service composition and cooperative application development.

Based on this observation of the current state of the art, our position is that the interorganizational composition of services should be tackled in a requirements-driven manner. In this article, we introduce a requirements-centric approach to understand the needs of different organizations that want to develop a cooperative information system implying service composition. We propose to use a goal-driven approach to (a) elicit functional requirements for a cooperative interorganizational process, (b) identify services that should be provided by each organization, and (c) design the coordination between those services to achieve the purpose of the cooperative process. The article presents the approach and illustrates it with an e-learning cooperative application.

MODELING THE COOPERATIVE PROCESS WITH MAPS

In this section, we introduce the map representation formalism (Rolland & Prakash, 2000) to model a process in goal and strategy terms, and illustrate the use of a map to model the cooperative process to provide distance learning in a virtual university. The map formalism has been practically validated in a number of large professional projects such as the FUSE project to model the business processes in the financial branch of Renault (Nurcan, Etien, Kaabi, Zoukar, & Rolland 2004), the ELEKTRA (Electrical Knowledge for Transforming Applications) project to conduct a change project (Nurcan & Rolland, 1999), and for the alignment of an Enterprise Resource Planning (ERP) functionality to the needs of Société Nationale des Chemins de Français (SNCF) (the French national railways company; Zoukar & Salinesi, 2004).

Introducing the Map

A map is a labeled, directed graph (Figure 1) with intentions as nodes, and strategies as edges between intentions. The directed nature of the graph shows which intentions can follow another. An edge enters a node if its strategy can be used to achieve the corresponding intention. Since there can be multiple edges entering a node, the map is capable of representing the many strategies that can be used for achieving an intention.

An intention is a goal to be achieved by the performance of the process. Each map has two special intentions, start and stop, to respectively start and end the process.

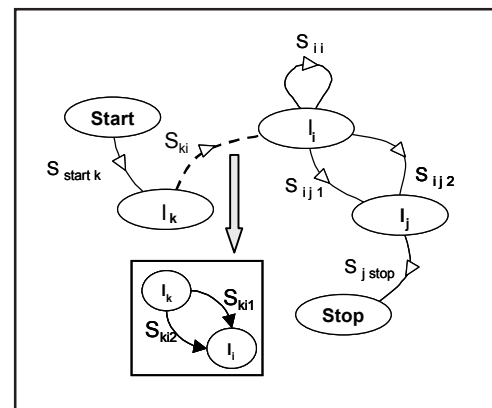
A strategy is an approach, a manner to achieve an intention.

A section is the key element of a map. It is a triplet $\langle I_i, I_j, S_{ij} \rangle$ and represents a way to achieve the target intention I_j from the source intention I_i following the strategy S_{ij} . The strategy S_{ij} characterizes the flow from the source intention I_i to the target intention I_j , and the way I_j can be achieved once I_i has been achieved. Thus, each section of the map captures the condition to achieve an intention and the specific manner in which the process associated with the target intention can be performed.

It can be noticed that in general, a map comprises several paths from start to stop. This is due to the fact that (a) there might be several threads between a couple of intentions and (b) different combinations of sections can form different paths between two nonadjacent intentions.

Several strategies between a couple of intentions are usually related by an and/or relationship, with one or several of the set being applicable in a given situation. In cases of an exclusive *or* relationship, it is possible to bundle the set of alternative strategies as shown in Figure

Figure 1. A map



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