Chapter 10
Planning Based Service Composition

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ABSTRACT

Planning is a problem solving technique where knowledge about available actions and their consequences is used to identify a sequence of actions, which, when applied in a given initial state, reach a desired goal. Planning technology has been employed in a variety of application domains including robotics, process planning, Web-based information gathering, and spacecraft mission control. Over the past decade, applicability of planning technology to the service composition problem, the process of constructing flexible, and complex services from atomic ones have been progressively explored.

This chapter presents how automated service composition can be considered as a planning problem. Furthermore it identifies the following three specific technical requirements for planning systems in order to handle service composition problem: (1) richness of domain description, (2) control constructs for assembling complex actions, and (3) a mechanism for plan optimization. This chapter illustrates a number of existing planning systems and discusses their applicability to automated service composition. The chapter then describes a service composition framework, based on a forward chaining planner, and how the abstract plan is instantiated into an executable service. Finally, the chapter discusses future research directions in planning based service composition.

1. INTRODUCTION

With the evolution of the Web and introduction of Web service technology, as a popular way of developing distributed applications, service composition has gained considerable attention to support business-to-business or enterprise application integration. This approach has been applied in a number of domains ranging from travel planning (S. McIlraith & Son, 2002), dining

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and entertainment booking services (Dale & Ceccaroni, 2002; Ponnekanti & Fox, 2002), content and news conversion services (Sabou, Richards, & Splunter, 2003), to managing supply-chain operations (Zeng et al., 2003), an agent based mobile e-Health system for emergency medical assistance task management (Klusch and Gerber, 2006), and automating IT processes in the telecommunications domain (Agarwal et.al, 2005).

The ultimate promise of Web services, as atomic components that enable dynamic and adaptive e-business solutions calls for mechanisms is to facilitate the integration of their complex interactions into composite added value services. The development of the high-level, semantic languages for abstract description of an atomic and complex service has opened the space for automated service composition.

In the most general sense, service composition methodologies can be categorized into approaches that are based on the following underlying technology: constraint based systems, verification of artifact-based workflows, operations research concepts, weakest pre-conditions in formal verification and synthesis and AI planning.

Early works on service composition have employed scripting and coordination languages (Gelernter & Carriero, 1992), rule-based systems (Ponnekanti & Fox, 2002), planning (Wu, Sirin, Hendler, Nau, & Parsia, 2003), situation calculus (Berardi, Calvanese, Giacomo, & Mecella, 2003), data view integration (Thakkar et al., 2003), and integer programming (Zeng et al., 2004).

Logic-based approaches include reduction of the service composition problem to satisfiability in logic of programs (Berardi et al., 2003) such as Propositional Dynamic Logic (PDL).

More recent work (Patrizi, 2008) applies Linear Time Logic synthesis, based on model checking of game structures. Another set of logic-bases approaches exploits the formal notion of simulation (Berardi et al, 2008, where composite service request is represented using a finite deterministic transition model. Furthermore, simulation is used to compute all the possible compositions at the same time, and thereby delaying the choice of the executable composite service.

Fritz et al. (Fritz, Hull and Su, 2009), consider the service composition as the automated workflow construction problem. They present the concept of business-artifacts, which encapsulates the data of a business entity, as well as the specification of its lifecycle, capturing how the artifacts evolve as they move through a workflow resulting from execution of services. This method captures the behavior of a composite service in a general-purpose workflow schema that can be used for all possible inputs, allowing for more flexiblity in scheduling the services based on various optimization parameters.

The service composition methodologies vary in their ability to represent and model non-functional properties of the service, to verify the correctness of the composite service, to automate the process of service composition fully, and to gracefully scale as the number of atomic services increases.

This chapter further discusses applicability and challenges in employing AI Planning as a core mechanism for assembling a composite service. AI Planning allows for a composition request to be expressed in terms of goal conditions that specify a set of constraints and preferences. By explicitly declaring services as processes in terms of their inputs, outputs, reconditions and effects, this chapter shows how to employ goal-oriented inferencing from planning technology for service composition.

Service composition requires a number of sophisticated facilities in the planning system, so that goal and application domain models are realistic, complete and comprehensive. This chapter examines several features that planning systems should support.

Koehler et al. (Koehler & Srivastava, 2003) identified several open issues in planning-based service composition. Firstly, conventional plans are sequences of actions. Modeling service interaction requires control structures involving loops,

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