

## Chapter III

# Realizability Analysis of Top-Down Web Service Composition Specifications

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### Abstract

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*A conversation protocol specifies the desired global behaviors of a Web service composition in a top-down fashion. Before implementing a conversation protocol, its realizability has to be determined—that is, can a bottom-up Web service composition be synthesized so that it generates exactly the same set of conversations as specified by the protocol? This chapter presents three sufficient conditions to restrict control flows of a conversation protocol for achieving realizability. The model is further extended to include data semantics of Web services into consideration. To overcome the state-space explosion problem, symbolic analysis techniques are used for improving the accuracy of analysis. The realizability analysis can effectively reduce the complexity of verifying Web services with asynchronous communication.*

## Introduction

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To construct a mission-critical Web service composition (also called “composite Web service”) is a very challenging task, as any design or implementation fault could lead to great losses. Recently, automated verification and testing of Web services have attracted attention in both academia and industry (Bultan, Fu, Hull, & Su, 2003; Foster, Uchitel, Magee, & Kramer, 2003; Narayanan, & McIlraith, 2003; Betin-Can, Bultan, & Fu, 2005; Canfora & Di Penta, 2006). However, before any automatic verification technique can be applied, a formal model must be defined to describe behaviors of Web services. This chapter presents a top-down specification approach called “conversation protocol” and studies the realizability problem of conversation protocols. It is an extension of the work by Fu, Bultan, and Su (2004c, 2005b) and covers other results by Fu et al. (2003, 2004a, 2004b, 2004d, 2004e, 2005a) in the area.

## Background

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In general, there are two different ways of specifying a Web service composition: (1) the bottom-up approach, favored by many industry standards such as WSDL (W3C, 2001), in which each participant of the composition is specified first and then the composed system is studied; and (2) the top-down approach, such as Message Sequence Charts (ITU-T, 1994), conversation policies (Hanson, Nandi, & Kumaran, 2002a), WSCI (W3C, 2002), and WSCL (Banerji et al., 2002), in which the set of desired message exchange patterns is specified first and detailed specification of peer implementation is left blank.

In this chapter we concentrate on the top-down specification approach due to its simplicity and the potential benefits in verification complexity (Bultan et al., 2003). One natural idea for top-down specification of Web services is to use finite state machines (FSAs) to represent some aspects of the global composition process. The state machines can involve two parties (Hanson, Nandi, & Levine, 2002b) or multi-parties (Bultan et al., 2003), and may describe the global composition process directly (Hanson et al., 2002b) or may specify its local views (Banerji et al., 2002).

A top-down conversation protocol must be realized by a bottom-up Web service composition. In studying the composition behaviors, asynchrony usually complicates analyses. Asynchronous communication is one of the benefits provided by the Web service technique. It is supported by many industry platforms such as Java Message service (Sun, n.d.) and Microsoft Message Queuing service (Microsoft, n.d.). In an asynchronous communication environment, the receiver of a message does not have to synchronize its action with the send action by the sender. However, asyn-

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