An Abstract Model for Service Compositions Based on Agents^{*}

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Abstract. This paper presents an abstract model for service compositions based on agents. The model is based on distributed Abstract State Machine and tallies with Universal Plug and Play (UPnP) architecture standard. In the abstract model, the composition of services can be viewed as a union of agents. This model can be used to depict a number of Web Service applications, and as an instance, the paper presents a BPEL Abstract Machine.

1 Introduction

This paper presents an abstract model for service compositions. The abstract model constructs the whole service compositions system as a collection of communicating agent subsystems. Each subsystem's communication structure is analogous in the essence. The model is open and has a Universal Plug and Play (UPnP) architecture [7]. We set up the model with distributed Abstract State Machine, and give some descriptions to BPEL (Business Process Execution Language for Web Services) [6].

2 Abstract State Machines

We first define the notion of Abstract State Machines. For more details, we refer to the Lipari-Guide [4] and the ASM 1997 Guide [5]. An *Abstract State Machine* (ASM) is a tuple $(\Sigma, \Phi_{Init}, Trans)$ where Σ is a signature, Φ_{Init} is a set of Σ -formulas (the *initial conditions*), and $Trans$ is a finite set of *transition rules*. The set of *states* is the set $Alg(\Sigma)$ of Σ -algebras; $\llbracket \cdot \rrbracket_q$ denotes the interpretation function of symbols of Σ in Σ -algebra q . A state q is *initial* iff q is a model of Φ_{Init} in the sense of logic, denoted as $q \models \Phi_{Init}$. In this article, we use ordered partial Σ -algebras.

For the service compositions' purpose, we introduce A *distributed ASM* (DASM) involves a collection of *agents* [3]. Agents are represented in global states as well. They are elements of a dynamically universe *Agent* that may

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grow and shrink. Intuitively, a run can be seen as the common part of histories of the same computation recorded by various observers.

3 Service Compositions Based on Agents

Research in the Web Service model is a hot area. In our abstract model, Web Service infrastructure can be divided into three layers: the Service Requestor Layer, the Middle Agent Layer, and the Service Layer [1]. Moreover, in this system, the Agent category has three subcategories: the *Service Requestor Agent* (SRA), the *Service Provide Agent* (SPA), and the *Coordination Agent* (COA). Among these subcategories, the agents are flexible and can transform their roles in the Web Service context, so the whole composition system is a Universal Plug and Play (UPnP) architecture [7].

Fig. 1. Agent-based service compositions framework

The agent-based service compositions framework is presented on Fig. 1. In the model, there are three basic operations: (1) $agent_1 \circ agent_2$: it represents a composite service that performs the service $agent_1$ followed by the service $agent_2$, i.e., $\circ$ is an operator of *sequence*. (2) $agent_1 + agent_2$: it represents a composite service that behaves as either service $agent_1$ or service $agent_2$. Once one of them executes its operation the other service is discarded, i.e., $+$ is an operator of *choice*. (3) $agent_1 \parallel agent_2$: it represents a composite service that performs the services $agent_1$ and $agent_2$ independently, i.e., $\parallel$ is an operator of *concurrency*.

4 Service Compositions Abstract Machine

Based on DASM, we can present a BPEL Abstract Machine. The BPEL (Business Process Execution Language for Web Services) builds on top of WSDL (and indirectly also on SOAP) effectively introducing a stateful interaction model that allows to exchange sequences of messages between business partners (i.e. Web

Fig. 2. High-level structure of the BPEL model

services) [6]. A BPEL document abstractly defines a Web service consisting of a collection of business *process* instances. A process instance maintains a continuous interaction with the external world (i.e., the communication network) through two interface components, called *inbox manager* and *outbox manager* [2], as shown in Fig. 2.

domain AGENT $\equiv$ INBOX_MANAGER $\cup$ OUTBOX_MANAGER $\cup$ PROCESS
 $\cup$ ACTIVITY_AGENT $\cup$ HANDLER_AGENT

In the initial DASM state, there are only three DASM agents: the *inbox manager*, the *outbox manager* and a *dummy process*.

domain MESSAGE

inboxSpace: INBOX_MANAGER $\rightarrow$ MESSAGE-set

InboxManagerProgram $\equiv$

```

if inboxSpace(self)  $\neq \phi$  then
  choose  $p \in$  PROCESS,  $m \in$  inboxSpace(self)
    with match( $p, m$ ) and waiting( $p$ )
    Assign_Message( $p, m$ )
  if  $p =$  dummyProcess then
    new newdummy : PROCESS
    dummyProcess = newdummy
  
```

In general, a BPEL program combines two different types of activities: basic activities and structured activities.

RUNNING_AGENT $\equiv$ PROCESS $\cup$ ACTIVITY_AGENT

startedExecution: PROCESS $\rightarrow$ BOOLEAN

suspended: RUNNING_AGENT $\rightarrow$ BOOLEAN

ProcessProgram $\equiv$

```

if  $\neg$ suspended(self) then
  if  $\neg$ startedExecution(self) then
    startedExecution(self) := true
    suspended(self) := true
  else
    stop self
  else
    Execute_Activity(activity(self))
  
```

ReceiveMode: RUNNING_AGENT $\rightarrow$ BOOLEAN

waitingForMessage: PROCESS $\rightarrow$ (RUNNING_AGENT, ACTIVITY)-set

Execute_Receive(activity: RECEIVE) $\equiv$

```

let inputDescriptor = (self, activity)
if  $\neg$ receiveMode(self) then
  
```

```

receiveMode(self) := true
add inputDescriptor to waitingSet
else
  if inputDescriptor  $\notin$  waitingSet then
    receiveMode(self) := false
    suspended(self) := false
    where waitingSet = waitingForMessage(rootProcess(self))

```

A basic agent executes a single activity. Thus, its program is very similar to a process agent.

```

BasicAgentPROGRAM  $\equiv$ 
  if  $\neg$ suspended(self) and  $\neg$ startedExecution(self) then
    startedExecution(self) := true
    suspended(self) := true
  if suspended(self) then
    Execute_Activity(baseActivity(self))
  if  $\neg$ suspended(self) and startedExecution(self) then
    remove self from compositionAgentSet(parentAgent(self))
  stop self

```

5 Conclusions

In this paper, we introduce a distributed ASM (DASM) involves a collection of agents, then provide an abstract service architecture based on agents, which is open and universal. As an application, the paper presents a BPEL Abstract Machine. The proposed hierarchical abstract framework enhances the intelligibility and integrality of the business process. The future work of the model will focus on the complicated business interactions in the service.

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