Agent Synthesis: Partnership and Agreement in Cooperative Mobile Agents

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ABSTRACT

This work focuses on an emerging extension to traditional agent models, called Hierarchical Mobile Agents model, where an agent can contain other agents recursively. The model enables agents to dynamically build a partnership to integrate their services, migrate around and work cooperatively for a long term as an agent compound. This work describes our approach to facilitate development of agents in the model. Our work introduces advanced cooperative behaviors in the model and agreement mechanism for the behaviors. For example, an agent can encapsulate services of agents it contains with an agreement to inhibit direct service provisioning to the outside. Our proposed MAFEH framework enables developers to incorporate simple parameter settings into workflow-based agent control logic, to specify how the agent discovers partner agents, builds agreements with them, and to work cooperatively.

Categories and Subject Descriptors

D.3.3 [**Programming Languages**]: Language Constructs and Features—*frameworks*

General Terms

Languages

Keywords

Agent Framework, Mobile Agents, Coordination, Agreement

1. INTRODUCTION

Agent technologies have attracted widespread attention, oriented toward more autonomy and flexibility in software components. Among them, the mobile agent model considers the ability of agents to migrate from one host to another by themselves, to support various computing paradigms[1]. The Hierarchical Mobile Agent (HMA) model is an emerging extension to traditional agent models, where an agent can migrate into another agent on the same host (or after moving to the same host)[7, 5, 8]. We call the entering agent and accepting agent as a *child* and its *parent*, respectively. When an agent migrates into an agent or a host, it takes all its descendants along. The HMA model thus enables cooperation of multiple mobile agents as a mobile agent compound. In this paper, we refer to the action establishing the parent-child relationship as *synthesis* of agents.

Since the HMA model enables function-migration as well as remote messaging, it can be used for adaptation to limitation in computing/network resources in mobile computing or multimedia processing as the mobile agent model. The HMA model extends the mobile agent model in the sense that agents can maintain their partnership stable for a long term even if the agents migrate around. In addition, the HMA model can be considered as one way to implement SOC (Service-Oriented Computing), where agents can integrate services with published and discoverable interfaces. The Web Service activity has taken a leading part for SOC [2]. The HMA model considers dynamic discovery and coordination of services as well. It additionally enables agents to establish stronger partnerships by keeping service instances as agents, not for one-shot invocation but for long-lasting interaction. With these advantages, the HMA model has been adopted to multimedia applications where agents encapsulate multimedia contents and services, achieving adequate and flexible editing, presentation, and delivery[6, 8].

This paper briefly describes the approach in our proposed MAFEH framework to facilitate development of agents in the HMA model. Detailed description of MAFEH is available in [3]. MAFEH introduces advanced cooperative behaviors in the model and agreement mechanism for the behaviors, such as to make a child's services available only by requesting the parent (encapsulation of a child's services by its parent). MAFEH enables developers to incorporate simple parameter settings into workflow-based agent control logic, in order to control how the agent discovers partner agents, builds agreements with them, and works cooperatively according to the agreements.

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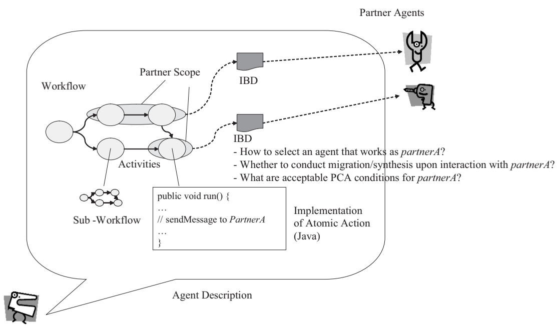

Figure 1: MAFEH Agent Description Model

2. MAFEH FRAMEWORK

MAFEH is a framework for development of agents in the HMA model, including the following two features.

2.1 PCA

Agents can achieve various types of synthesis. For example, suppose an agent encapsulating a video content contains another agent encapsulating an advertisement content as its child. The parent (video agent) may want to encapsulate the child (ad agent) so that the child's services are not directly available from the outside, and advanced usages or access control are achieved by the parent.

Our previous work discussed the needs for such controls and restrictions over a child by its parent[4]. MAFEH considers several controls and restrictions related to primitive functions that should be supported by HMA frameworks, such as messaging and synthesis. MAFEH facilitates agreement on the extent of the controls and restrictions between the agents upon synthesis (*PCA:Parent-Child Agreement*). MAFEH also realizes enforcement of such agreements.

2.2 IBD

Figure 1 illustrates the agent description model of MAFEH. Synthesis-related behaviors, including the behaviors to establish PCAs mentioned above, are added separately as simple parameter settings to the agent control logic (*IBD: Interaction Behavior Description*).

The agent control logic is described as a *workflow*, which connects *activities*, that is, sub-workflows and *atomic actions* (graphs of solid lines in Fig. 1). An atomic action is a unit of execution (computation or interaction with other agents) implemented using Java. This logic specifies how to interact with abstract partners, only whose roles (types) are defined at design time. Discovery and selection of the partners is conducted at runtime according to IBD.

By specifying the agent control logic, a set of activities where interaction with each partner can occur is defined (*partner scope*). The central idea of IBD is to activate synthesis-related behaviors with a partner, i.e. discovery, agreement establishment, and migration/synthesis, according to simple parameter settings when execution enters or exits of the scope of the partner (dashed lines in Fig. 1). Some specifications in IBD are shown below.

How to discovery an adequate agent for the partner, in the case the agent is the requester of the interaction, (currently attribute values used in a query to directory services).

What interaction form to use for the partner. For example, when the agent is the requester of the interaction, it can ask the partner to come to the local host and become its parent. This is done by setting parameters as *interactionType=parent, approach=come.*

Acceptable PCA conditions for the partner. Agents are given conditions for each partner about the extent of controls and restrictions under which they can achieve their expected behavior. We mentioned encapsulation of a child's services by its parent as an example of cooperative behaviors in an agent compound. Intuitively, this is achieved if the parent declares "I want to inhibit inbound/outbound message to/from the child" and the child declares "I can accept such inhibition" in their acceptable PCA conditions. When an agent activates synthesis, it discovers a partner with which it can establish a PCA using simple matching rules.

3. CONCLUSION

This paper has presented our approach to the MAFEH framework where control of agent synthesis is enhanced and made easy. We are presently constructing multimedia applications based on MAFEH, where agents encapsulate multimedia contents and services, and achieve advanced services composed using synthesis as well as remote messaging.

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