

Mobility and Management Support for Mobile Agents

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1. ABSTRACT

In this paper, we investigate the related issues of constructing a mobile computing environment based on mobile agents. We then propose an open infrastructure that enables co-operation among the components to carry out the assigned tasks. An implementation of the infrastructure is then described with the implementation issues discussed. A unique feature of the infrastructure and the implementation is the management support of mobile agents in such environments

1.1 Keywords

Agents, Mobility, Management, infrastructure

2. INTRODUCTION

Mobile agents [3] are shown to be promising in addressing many issues in mobile computing. In this approach, an agent, which is composed of code and data, is submitted by a mobile user and can navigate autonomously through heterogeneous networks. The agent is capable of interacting with servers or other agents, moving to another server while carrying the intermediate results, and resuming execution when it reaches the destination. After the agent is submitted, the mobile user can be disconnected from the network. With this approach, the mobile user is decoupled from the servers in the sense that instead of getting intermediate results many times, the mobile user interacts with the network only when it submits the agent and when the agent returns with results.

Despite the advantages provided by the mobile agents, to make a mobile agent service network commercially viable, a high quality and cost-effective agent mobility management system must be in place. In this paper, we examine the issues in designing and implementing a mobile agent infrastructure for mobile computing environments. We also provide a Java-based implementation as a prototype of the infrastructure. It supports agent execution environment, agent transport protocol, agent-agent interaction, and agent management functions.

3. THE INFRASTRUCTURE

In this section, we propose an open mobile agent infrastructure, with the focus on the network transport and agent management, to support mobile computing. The infrastructure is

depicted in Fig. 1. Note that the components in the infrastructure are "LOGICAL" entities, i.e., their physical locations might be implementation-dependent. The infrastructure is open in the sense that no proprietary protocols are used and anyone who are interested in the infrastructure can participate in using or providing services.

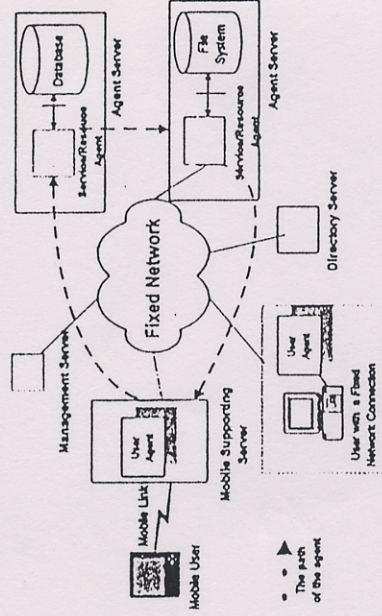


Figure 1. The Infrastructure of a Mobile Agent System

3.1 Entities in the Infrastructure

The major entities in the infrastructure are:

- 1. User Agent:** Created by the Mobile Supporting Server when a mobile user submits a request for services. The user agent will first query the Directory Server to obtain the location information of the Agent Server where the requested services could be fulfilled. It then constructs an itinerary according to the obtained information and move to the servers.
- 2. Agent Server:** The Agent Server provides the resources needed for the mobile agents to carry out their assigned tasks.
- 3. Mobile Supporting Server:** It is an Agent Server that compensates the limited capacity of the mobile computers and the unreliable, slow mobile link between the fixed network and the mobile user. The Mobile Supporting Server accepts the request from the mobile user and invokes an instance of the user agent on behalf of the mobile user to carry out the requests.
- 4. Directory Server:** It serves as a "bulletin board" where the Service/Resource Agents advertise the services/resources

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they provide. It offers the agent server the functions of *register* and *deregister* the services they provide.

5. Management Server: The Management Server holds the status of the mobile agents and responds to the queries and commands from the user in order to report the status of the agents and apply management controls to the submitted agents. The management functions include *suspend*, *terminate*, *resume*, *cancel*, *report*, etc.

6. Service/Resource Agent: It is the stationary agent in the Agent Server, where the services or resources are provided. When the Agent Server first comes to service, or when there is a status change, the agent communicates the changes to the Directory Server.

3.2 Related Issues

For the infrastructure to be feasible in providing the needed services to mobile users, some issues need to be addressed. The issues and their possible solutions are summarized as follows.

- **Transport protocol for Mobile Agents:** A transport mechanism is needed for the mobile agents to move the agents to their destinations. The management functions provided by ATP [1] are not complete and have some room for improvement. (In our prototype implementation, we implemented a version of ATP with our own extensions.)

- **Management Functions:** The management server needs to hold the status of the mobile agents and to provide some control functions to the user. The functions it needs to provide are as follows.

- a. **Agent Location:** How to locate an agent in a service network?
- b. **Agent Status Report:** How to find out effectively the status of agents.
- c. **Agent Control:** How to apply control functions to the target mobile agents?

In addition, possible control actions that should be provided are:

- **Launch:** Request the creation of a mobile agent.
- **Dispatch:** Send a mobile agent to another Agent Server.
- **Fetch:** Retrieve agent-related information from another Agent Server.
- **Terminate:** Stop the execution of a mobile agent and release the resource held by the agent.
- **Suspend:** Suspend the execution of a mobile agent until a resume message is received.
- **Resume:** Resume the execution of a suspended agent.
- **Retract:** Remove an agent from its current context and move it into the context from which the retraction was requested.
- **Report:** Continue the execution of the mobile agent but send back the intermediate results currently available.

With the aforementioned management functions, the mo-

bile agent can be in one of the following states: **Running**, **Suspended Stopped**, **Aborted**, and **completed**.

- **Information Abstraction and Filtering:** To prevent the mobile computer being overwhelmed by the information retrieved.
- **Protocols for Wireless Links:** to overcome the weak connectivity between the mobile user and the wired network.

4. IMPLEMENTATION OF THE INFRASTRUCTURE

The prototype of the infrastructure is implemented in Java. A screen shot of the Management Server providing management functions to the user is shown in Fig. 2.

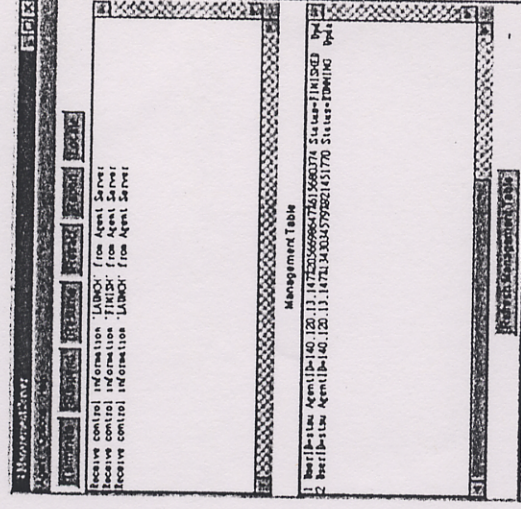


Figure 2. A Screen Shot of the Management Server.

5. CONCLUSION

Mobile agents are very suitable for mobile computing environments as they allow asynchronous operations, consume less bandwidth, help compensate the limited power of mobile devices. Although there are some effort in the literature in providing mobility to software agents, we argue that management supports should be in place before the mobile agents become commercially viable. In this paper, we have proposed an open infrastructure that offers not only mobility but also management support for software agents in mobile computing environments.

6. ACKNOWLEDGMENTS

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