Mobile Objects and Mobile Agents:
The Future of Distributed Computing?

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Abstract. This paper will lead you into the world of mobile agents, an emerging technology that makes it very much easier to design, implement, and maintain distributed systems. You will find that mobile agents reduce the network traffic, provide an effective means of overcoming network latency, and perhaps most importantly, through their ability to operate asynchronously and autonomously of the process that created them, helps you to construct more robust and fault-tolerant. Read on and let us introduce you to software agents - the mobile as well as the stationary ones. We will explain all the benefits of mobile agents and demonstrate the impact they have on the design of distributed systems before concluding this paper with a brief overview of some contemporary mobile agent systems.

1 What's a Software Agent?

So what is a software agent? Well, what actually constitutes an agent, and how it differs from a normal program, has been heavily debated for several years now. While this debate is by no means over, we more and more often see agents loosely defined as programs that assist people and act on their behalf. This is what we prefer to call the "end-user perspective" of software agents.

**Definition of an Agent (End-User Perspective)**

An agent is a program that assists people and acts on their behalf. Agents function by allowing people to delegate work to them.

While this definition is basically correct, it does not really get under the hood. Agents come in myriad different types and in many settings. They can be found in computer operating systems, networks, databases, and so on. What properties do these agents share that constitute the essence of being an agent?

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1 This paper is based on a chapter of a book by Lange and Oshima entitled *Programming and Deploying Java™ Mobile Agents with Aglets™*, Addison-Wesley, 1998. (ISBN: 0-201-32582-9).
This is not the place to examine the characteristics of the numerous agent systems made available to the public by many research labs. But if you looked at all these systems, you would find that a property shared by all agents is that fact that they live in some environment. They have the ability to interact with their execution environment, and to act asynchronously and autonomously upon it. No one is required either to deliver information to the agent or to consume any of its output. The agent simply acts continuously in pursuit of its own goals.

In contrast to software objects of object-oriented programming, agents are active entities that work according to the so-called Hollywood Principle: "Don't call us, we'll call you!"

**Definition of an Agent (System Perspective)**

An agent is a software object that

- is situated within an execution environment;
- possesses the following mandatory properties:
  - Reactive - senses changes in the environment and acts accordingly to those changes;
  - Autonomous - has control over its own actions;
  - Goal driven - is pro-active;
  - Temporally continuous - is continuously executing;
- and may possess any of the following orthogonal properties:
  - Communicative - able to communicate with other agents;
  - Mobile - can travel from one host to another;
  - Learning - adapts in accordance with previous experience;
  - Believable - appears believable to the end-user.

**2 What's a Mobile Agent?**

Mobility is an orthogonal property of agents. That is, all agents do not necessarily have to be mobile. An agent can just sit there and communicate with the surroundings by conventional means. These include various forms of remote procedure calling and messaging. We call agents that do not or cannot move stationary agents.

**Definition of a Stationary Agent**

A stationary agent executes only on the system where it begins execution. If it needs information that is not on that system, or needs to interact with an agent on a different system, it typically uses a communication mechanism such as remote procedure calling (RPC).

In contrast, a mobile agent is not bound to the system where it begins execution. The mobile agent is free to travel among the hosts in the network. Created in one execution environment, it can transport its state and code with it to another execution environment in the network, where it resumes execution.

By the term "state," we typically understand the agent attribute values that help it determine what to do when it resumes execution at its destination. By the term