A tutorial report for SENG 609.22
Agent Based Software Engineering
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Mobile Agent Systems

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1. Introduction

With the tremendous developments in information and communication technologies, the information systems are experiencing an exponential growth. In particular, the Internet based World Wide Web (WWW), with its 40 million users in 100 different countries and 8 million host computers. The WWW and information highways will be used for electronic commerce, information retrieval, workflow systems and many other applications. However, the following are the important observations.

- The important characteristics of the Infosphere have hampered the effective use of the Internet. Information available from the Net is unorganized, multimodal and distributed on server sites all over the world.

- The number and variety of data sources and services increase dramatically every day. Furthermore, the availability, type and reliability of information services are constantly changing.

- Information is ambiguous and possibly erroneous due to the dynamic nature of the information sources and potential information updating and maintenance problems.

Therefore, information is becoming harder for a person or machine systems to collect, filter, evaluate, and use in problem solving. As a result, the problem of locating information sources, accessing, filtering and integrating information and coordinating information retrieval and problem-solving efforts of information sources have become very critical. The notation of agents and agent-oriented approaches has emerged to address this challenge.

Mobile agents are executing programs that can migrate from one host to another host in a network.[KG99] More specifically, a mobile agent is an agent that can move at times and places of its own choosing from machine to machine in a heterogeneous network. [GKCR01]

Mobile Agents are autonomous, intelligent programs that move through a network, searching for and interacting with services on the user's behalf. These systems use specialized servers to interpret the agent's behavior and communicate with other servers.
A Mobile Agent has inherent navigational autonomy and can ask to be sent to some other nodes.

Mobile Agents should be able to execute on every machine in a network and the agent code should not have to be installed on every machine the agent could visit. Therefore it becomes popular for mobile Agents to use mobile code systems like Java and the Java virtual machine where classes can be loaded at runtime over the network.

2. Different between mobile code (java applet) and mobile agent

Mobile agents are mobile codes. However not every mobile codes is a mobile agent. Mobile code allows for pushing or pulling code, i.e. procedures or even programs, to remote sites, and for executing the transferred code at these sites. Examples for mobile code systems are Java applets, remote evaluation (Remote Procedure Calls where the procedures are transferred before calling them) or even Postscript files (which are programs that are executed on e.g. printers). Mobile Agents are program instances (or processes) that are capable of moving within the network under their own control. The difference to mobile code lies in the inclusion of state (i.e. data state and execution state). This state can be transported within the mobile agent, whereas mobile code entities are not able to transport state. An active network is a network where the transporting components (i.e. routers) are able to execute arbitrary code. This code is provided in some systems by special network packets (active packets) that can be injected by normal users.

3. Advantages of mobile agent systems

Mobility allows the programmer to easily distribute resource usage throughout the network over time.[BKR99] Mobile agents are autonomous, they can schedule their own computation at a later time at a remote host, avoiding times of congestion. In brief, there are six strengths of mobile agents.

- Conservation of bandwidth. The agent performs the necessary sequence of operations locally. Avoiding intermediate messages and conserving more bandwidth.
- Reduction of total completion time. Mobile agents can share the resource on the network, instead of heavy overloaded server in traditional client-server applications.
However it may not be true for all cases. Not every system is suitable to use agent technology.

- Reduction in latency. The same as total completion time; ideally mobile agent systems should reduce latency when we use them correctly.
- Disconnected operation and mobile computing
- Load balancing
- Dynamic deployment

4. **Mobile Agent Systems**

A mobile agent system provides the execution environment for mobile agents. Sometimes called middleware, mobile agent systems also provide a framework in which mobile agent applications can be developed and managed. There are a lot of frameworks of mobile agent systems existing on internet. There are some famous examples:

- **Aglet** is Java based mobile agent created by IBM. It supports light weight object migration and event-driven. Aglet is built with persistent support.
- **ARA** is a platform for the portable and secure execution of mobile agents in heterogeneous network.
- **Concordia** is a full-featured framework developed at Mitsubishi Electric Information Technology Center America's (MEITCA) Horizon Systems Laboratory. It provides for the development and management of network-efficient mobile agent applications for accessing information anytime, anywhere, and on both wire-based and wireless device supporting Java.
- **D'Agents** is a mobile agent system created at Dartmouth College. The architecture of D'Agents is based on the server model of Telescript and supports a modified version of Tool Command Language (TCL). It also supports JAVA and Scheme.
- **Mole** is the first mobile agent system that has been developed in Java.
- **Tacoma** project focuses on operating system support for agents and how agents can be used to solve problems traditionally addressed by other distributed computing paradigms. An agent in Tacoma is a program can be installed and executed on a remote machine. It supports C, Tcl/Tk, Perl, Python and scheme.
- **Voyager** is a pure Java agent enhanced Object Request Broker (OBR) created by ObjectSpace Company. Voyager supports RMI, CORBA and DCOM architecture to provide stationary client server applications, which make the system very flexible.
5. **Limitations**

Although numerous mobile agent systems now exist, mobile agents are not wildly used in production applications. [GKCR01] There are some reasons for this.

- Agent mobility is most useful in highly dynamic, mobile-computing environments. Such environments are just becoming common with the recent dramatic increase in the number and power of portable computing devices.
- Most existing mobile agent systems are research prototypes. No single system has implemented all of the features needed for robust and efficient operations.
- No applications are required mobile agents. They can be realised by using traditional techniques.
- Few mobile agent applications implement communication with agents from other applications.
- In the mobile agent system, decisions are made throughout the network. Coordination becomes more difficult.
- There is less or no centralized control to mobile agents.
- Security is a major issue. Authentication and authorization are the most popular used security technologies.

6. **Reference:**

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