

# “ Mobile Agents ”

Intelligent Assistants on the Internet

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**A software agent is an intelligent program that acts as a user’s personal assistant. Software agents endowed with the property of mobility are called mobile agents. Mobile agents perform a user’s task by migrating and executing on several hosts connected to the network.**

## Introduction

An agent is defined as “a person whose job is to act for, or manage the affairs of, other people”. In the context of computers, software agents refer to programs that perform certain tasks on behalf of the user. Imagine that you want to go on a trip to a new holiday destination. You contact your travel agent program and describe your preferences and your constraints (such as how much money you are willing to spend, when you want to travel, etc.).

The travel agent program suggests where you can spend your holidays after consulting several information sources such as tourist guides and flight schedules and verifying the availability of airline tickets and hotel rooms. When you confirm your destination, the program books the flight tickets and reserves the hotel rooms for you. Thus the software agent acts as your personal assistant.

Software agents have the following properties, which distinguish them from other programs:

### Intelligence:

Software agents employ techniques from the field of artificial intelligence, which empower them with a fair degree of intelligence and common sense. For example, the travel agent program should realize that people generally do not prefer travelling by flights that depart or arrive at the airport late in the night and the agent should avoid booking tickets on such flights. The travel agent program should be smart enough to bargain and arrange the trip so that the overall expenditure for the trip is as low as possible without compromising on the user’s preferences.

### Autonomy:

The agents themselves decide the sequence of actions to be performed to achieve the user's task. This autonomy enables agents to operate without requiring human intervention. Once the specifications are given to the travel agent, it should be able to proceed on its own to arrange the trip for the user without requiring the user to constantly monitor the agent.

### Responsiveness:

Agents perceive their environment (which may be the Internet, a collection of other agents, etc.) and respond in a timely fashion to changes that occur in it. At the same time, agents should not simply act in response to their environment; they should be able to exhibit opportunistic, goal-oriented behavior and take the initiative when appropriate.

### Communicative Ability:

Software agents should provide a user-friendly interface so that the user can easily interact with the agent. Agents are social entities and often communicate and collaborate with one another in order to complete their tasks. For example, the travel agent program of one user must be able to communicate with other travel agents to find out about hotels which customers disliked and avoid such hotels.

### Adaptability:

Agents learn about the user's behavior and adapt themselves to suit the user. Consider a search agent that retrieves information for the user from the Internet. The search agent should be able to learn about the type of information the user is interested in and adapt it to deliver only the relevant information to the user.

Software agents can be classified as *static agents* and *mobile agents*. Static agents achieve their goal by executing on a single machine. On the other hand, mobile agents migrate from one computer to another in the network and execute on several machines. Mobility increases the functionality of the mobile agent and allows the mobile agent to perform tasks beyond the scope of static agents. For example, a travel agent program may visit several hosts such as an airline reservation system, a hotel resources host, etc. in order to achieve its function. This eliminates the need to have all the relevant databases on one host.

- *A mobile agent consists of the program code and the program execution state.*

## Working of Mobile Agents

A mobile agent consists of the program code and the program execution state (the current values of variables, next instruction to be executed, etc.). Initially a mobile agent resides on a computer called the home machine. The agent is then dispatched to execute on a remote computer called a mobile agent host (a mobile agent host is also called mobile agent platform or mobile agent server). When a mobile agent is dispatched the entire code of the mobile agent and the execution state of the mobile agent is transferred to the host. The host provides a suitable execution environment for the mobile agent to execute. The mobile agent uses resources (CPU, memory, etc.) of the host to perform its task. After completing its task on the host, the mobile agent migrates to another computer. Since the state information is also transferred to the host, mobile agents can resume the execution of the code from where they left off in the previous host instead of having to restart execution from the beginning. This continues until the mobile agent returns to its home machine after completing execution on the last machine in its itinerary.

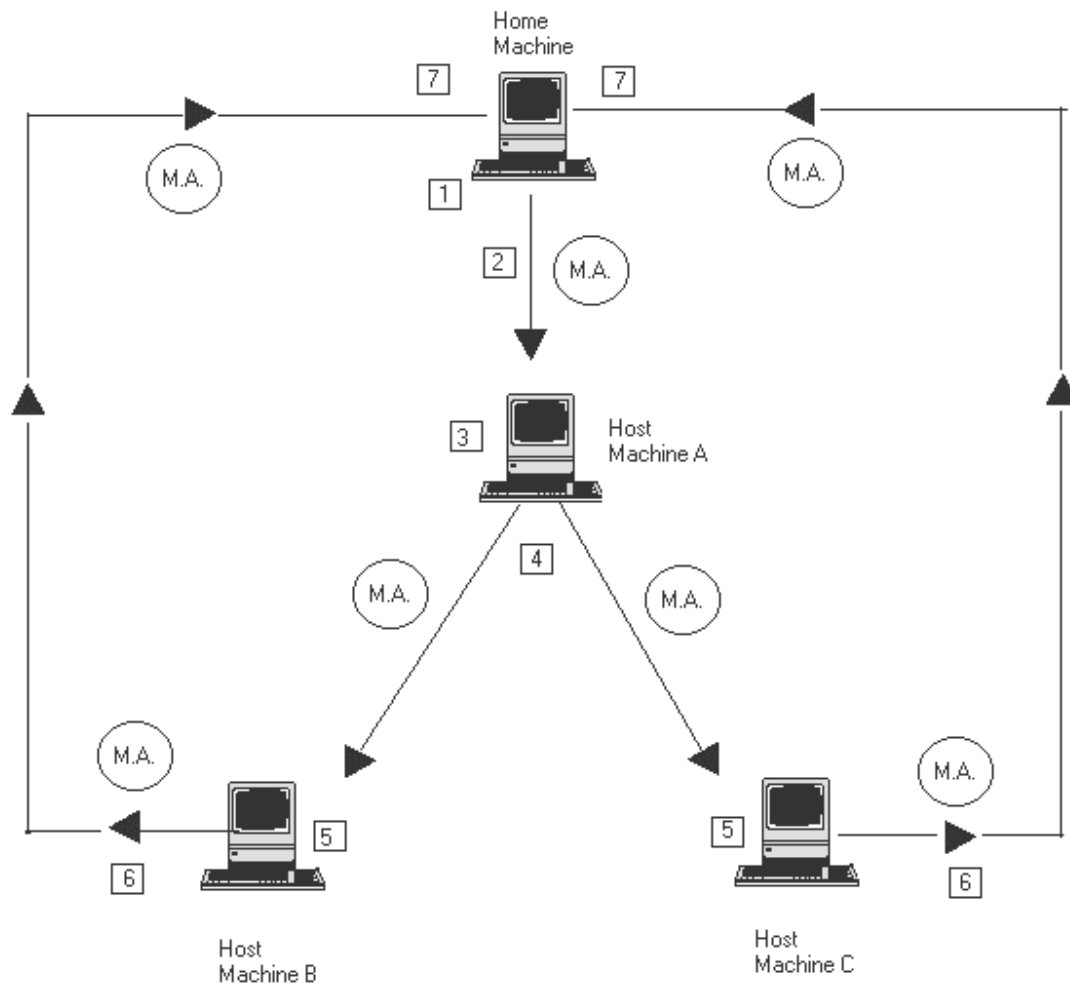
- *The mobile agent uses resources (CPU, memory etc.) of the host to perform its task.*

## The life cycle of a mobile agent

1. The mobile agent is *created* in the Home Machine.
2. The mobile agent is *dispatched* to the Host Machine A for execution.
3. The agent executes on Host Machine A.
4. After execution the agent is *cloned* to create two copies. One copy is dispatched to Host Machine B and the other is dispatched to Host Machine C.
5. The cloned copies execute on their respective hosts.
6. After execution, Host Machine B and C send the mobile agent Received by them back to the Home Machine.
7. The Home Machine *retracts* the agents and the data brought by the agents is analyzed. The agents are then *disposed*.

From this we observe that a mobile agent experiences the following events in its life cycle:

**Creation:** A brand new agent is born and its state is initialized.



**Figure 1. The life cycle of a mobile agent.**

**Dispatch:** An agent travels to a new host.

**Cloning:** A twin agent is born and the current state of the original is duplicated in the clone.

**Deactivation:** An agent is put to sleep and its state is stored on a disk of the host.

**Activation:** A deactivated agent is brought back to life and its state is restored from disk.

**Retraction:** An agent is brought back from a remote host along with its state to the home machine.

**Disposal:** An agent is terminated and its state is lost forever.

## Advantages of Mobile Agents

***Reduction in Network Load*** Mobile agents are dispatched to the remote hosts containing the data. The agents perform the computations at the remote hosts and return back with the results.

***Overcome Network Latency*** Mobile agents can be directly dispatched from the central controller (home machine) in the manufacturing plant for example to the real time systems.

***Protocol Encapsulation*** The mobile agent code can encapsulate the protocol. When a protocol is upgraded, only the mobile agent has to be altered.

***Asynchronous and Autonomous Execution*** The mobile agent executes autonomously without the intervention of the home machine. The home machine can reconnect at a later time and collect the agent if it's disconnected.

***Fault Tolerance*** If a host is being shut down, all agents executing on that machine will be warned and given time to dispatch themselves and continue their operation on another host in the network.

## Disadvantages of Mobile Agents

The main drawback of mobile agents is the security risk involved in using mobile agents. Security risks in a mobile computing environment are twofold. Firstly a malicious mobile agent can damage a host. For example a virus can be disguised as a mobile agent and distributed in the network causing damage to the host machines that execute the agent. On the other hand a malicious host can tamper with the functioning of the mobile agent.

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## Applications of Mobile Agents

Although no universally used application (normally called killer application) has been developed for them, mobile agents are suitable for the following applications.

***Parallel Computing:*** Solving a complex problem on a single computer takes a lot of time. To overcome this, mobile agents can be written to solve the problem. These agents migrate to computers on the network, which have the required resources and use them to solve the problem in parallel thereby reducing the time required to solve the problem.

***Data Collection:*** Consider a case wherein, data from many clients has to be processed. In the traditional client-server model, all the clients have to send their data to the server for processing resulting in high network traffic. Instead mobile agents can be sent to the individual clients to process data and send back results to the server, thereby reducing the network load.

***E-commerce:*** Mobile agents can travel to different trading sites and help to locate the most appropriate deal, negotiate the deal and even finalize business transactions on behalf of their owners. A mobile agent can be programmed to bid in an online auction on behalf of the user. The user himself need not be online during the auction.

***Mobile Computing:*** Wireless Internet access is likely to stay slow and expensive. Power consumption of wireless devices and high connection fee deter users from staying online while some complicated query is handled on behalf of the user. Users can dispatch a mobile agent, which embodies their queries, and log off, and the results can be picked up at a later time.

## Conclusions

Distributed computing involving several computers in a network can be achieved using message passing or remote procedure calls (RPC). The recently developed mobile agent technology adds a new dimension to distributed computing.

Experts suggest that mobile agents will be used in many Internet applications in the years to come. However there still exist many technical hurdles that need to be tackled, the most important of them being security. Only when security issues are properly addressed, will the mobile agent technology be widely accepted.