Agent Mobility

Overview

mobile agents
    and mobile computing

technical issues
    agent languages, distributed execution, environment, security

multi-agent systems
    cooperation between agents to solve a task
Mobile Agents

emphasis on electronic agents

purpose
release the user from mundane tasks

approach
utilize autonomous, mobile programs ("agents")

advantages
dealing with information overload, increased efficiency, better results

problems
new technology, loss of control, security

mobility is clearly important for autonomous robots, but the emphasis here is on software agents
Mobile Computing

vs. mobile agents

mobile computing equipment
laptops, hand-held computers

usage
not stationary, but usually off-line (not connected to other computers or networks)

limitations
activities requiring network access

potential solution
mobile agents perform the requested activities while the user is off-line, and report the results when the user reconnects
Distributed Applications

execution of subtasks on different machines

distributed programming

distribution-aware implementation

distributed operating systems

provide essential services like task allocation, load balancing, remote procedure calls, ...

network services

communication, synchronization

transportation infrastructure

LAN, WAN, Internet, Intranet

provides the physical interconnection between the agent’s starting and end points
Mobile Code Systems

*general architecture*

**user interface**

communication between agent and user

**agent execution environment**

“living space” for agents on computers

**services**

local and mobility services

basic functions provided for the execution and movement of agents
Mobility Services

main obstacle to pervasive use of mobile agents

generic mobility module
provides most of the support various types of mobile agents need
good for agent designers
difficult to implement
somewhat rigid: extensions need to be compatible with the full module, and changes may affect the infrastructure as a whole

minimal mobility modules
specific modules for different types of agents
provide only the minimum support needed
good for infrastructure providers
development more difficult for agent
designers
more flexible: extensions can be
implemented on top of minimal services
Agent Implementation Languages

cross-platform execution

platform independent
often converted into an abstract
instruction set (virtual machine), such as
Java, Tcl, Telescript

standard set of services
libraries, CGI, ActiveX, SOAP

user interface
generic user interface capabilities
Java AWT/Swing, Tcl/Tk
Host Security

**is it a virus or an agent?**

**alien code problem**
remote host has to execute unknown code

**authentication**
agents must carry identification and authentication information
possibly third-party certification

**“padded cell” security**
isolation layer between the code to be executed and the sensitive parts of the system

**permissions**
access restrictions for certain activities and types of agents

some of these measures are not technical, but organizational
Agent Security

is the agent safe out there?

internal workings

should not be fully accessible to foreign hosts

valuables

agents may carry electronic cash, copyrighted materials, important data,

agents must be protected from robbery

shared resources

agents may be prevented from utilizing resources by other careless, greedy, or malicious agents

destruction

agents’ lives must be protected

accidents or deliberate destruction
Agent and Resource Identification

Who are you?

agent identification
agents must be identifiable and distinguishable from one another
owner, origins of an agent

resource identification
uniform way to identify and access agent-specific resources
independent of the underlying platform

inter-agent communication
arrangement of meetings between agents
exchange of information

name space conventions
uniform or at least compatible naming schemes for agents and resources
Resource Control

competition for scarce resources
    CPU time, memory, data base access,
    network connections, bandwidth, ...

permissions and restrictions
    priorities for agents
    restrictions on operations

remunerations
    agents pay for the utilization of resources

consumption limits
    agents have only a certain amount of
    currency to spend on resources

complex and difficult task, but very important
Programming Support

**program development**

specific requirements and constraints due to the mobile and distributed nature platform-independence, behavior in systems under load, vulnerability

**program execution**

the agent’s execution may be temporally and spatially inaccessible to the owner monitoring, exception handling, incomplete execution

**remote control**

steering of an agent’s activities cancellation of a task, modification, requests from hosts visited by the agent
Efficiency

costs of code mobility
preparation, packaging, transfer of an agent
authentication, setup of the environment, execution of the agent’s code

niches for agents
in the near future, agents may be restricted to specific applications: more complex than client-server or Web-based applications, but limited by infrastructure, complexity

scalability
worldwide use may imply millions of agents
popular services may be hit by thousands
of agents simultaneously