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

approache

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 (policies)

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
- example: URI (uniform resource identifier) in XML

inter-agent communication

- communication protocol
- communication language
- arrangement of (virtual) 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, modificaiton, 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