Mobile Software Agents: an Overview

Authors : Vu Anh Pham and Ahmed Karmouch
From: University of Ottawa, Ontario

Presented by: Luba Sakharuk

Agenda for the Overview of Mobile Agents

- Abstract
- The Mobile Agent in Telecommunications
- Mobile Agents in Network Management
- A Survey of Mobile Agent Systems
- Mobile Agent Models
- Mobile Agent System Requirements and Design Forces
- Conclusion

ABSTRACT

Mobile Agent is a self-contained and identifiable computer program that can move within the network and act on behalf of the user or another entity

• Proposed to replace the client-server paradigm as a better, more efficient and flexible mode of communication

•Two general goals:
- **•reduction of network traffic**
- **•asynchronous interaction**

•Can be used to implement network management by delegation and to deliver network services

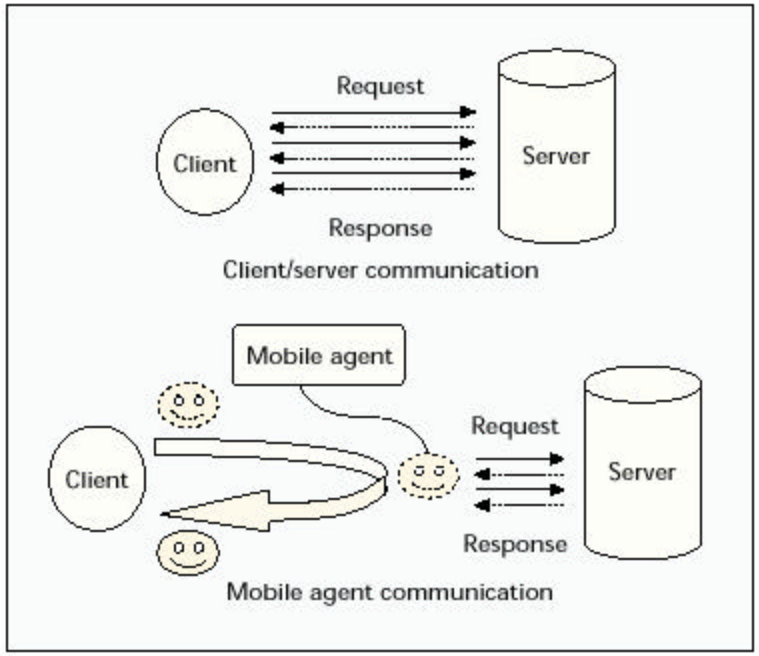


Figure 1. *A mobile agent can optimize network bandwidth usage.*

•Agents can function independent of each other or cooperate to solve problems

ABSTRACT

Issues in the design and implementation of mobile agent system architecture:

- **Agent transfer mechanisms**
- **Naming, addressing, and locating a mobile agent**
- **Control of the mobile agent**
- **Exporting mobile agent states**
- **Mobile agent data transfer**
- **Transparent communication**
- **Security**
- **Secrecy and privacy**
- **Coordination**
- **Communication language**
- **Stability, performance**
- **Scalability**
- **Portability**
- **Resource management and discovery**

Some of these issues have roots in the field of process migration;

others come from artificial intelligence

These 12 have technical connotations

- **Authority -who owns agents and agent resources**
- **Legality -who is responsible for an agent's action**
- **Ethics -in what context should agent be used**

Social issues

Not discussed in the paper

Mobile Agents in Telecommunications

Potential applications of mobile agents in network services and network management:

- **Mobile Agents in Network Services**
- **Mobile Agents in TINA**

TINA - **Telecommunications Information Networking Architecture**

TMN - **Telecommunications Management Network**

IN - **Intelligent Networking**

SCP - **Service Control Points**

SSP - **Service Switching Points**

RPC - **Remote Procedure Call**

SMS - **Service Management Systems**

Mobile Agents in Telecommunications

Mobile Agents in Network Services

- **TMN and IN rely on the traditional client/server paradigms to provide services via centralized nodes known as SCP**
- **During execution of a service, the distributed exchanges known as SSP will ask the SCP for control services so that SSP can carry out processing**
- **SCPs and SSPs communicate via RPC-based protocol - INAP**

To install IN services, specific SMSs will download the necessary IN service components into the IN network elements.

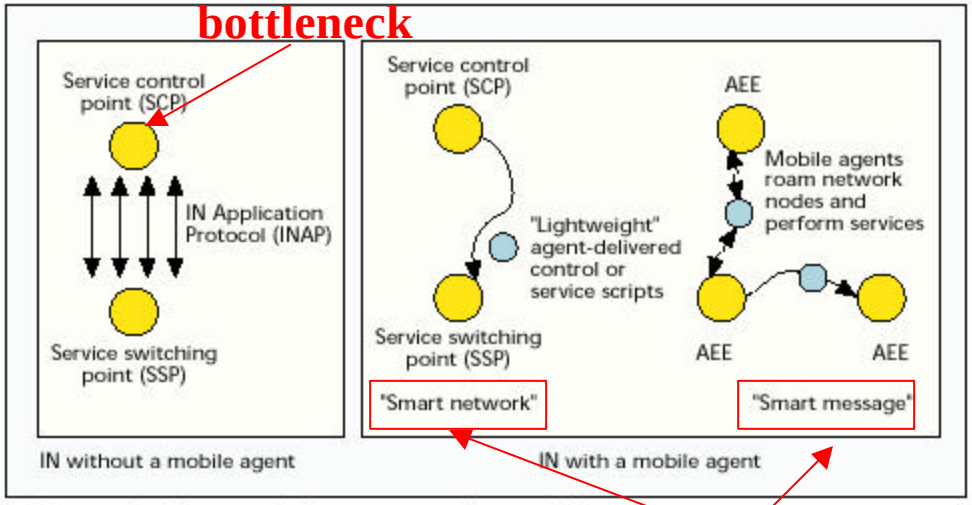
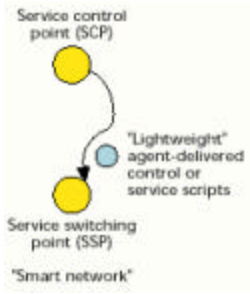


Figure 2. *How a mobile agent can enhance IN services.*

Two general approaches for agent based service architecture

Mobile Agents in Telecommunications

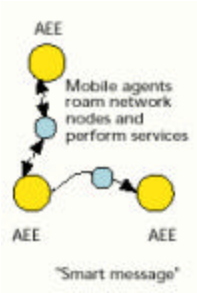
Smart Network



- **Agents are static entities in the network**
- **Able to perform tasks autonomously and asynchronously**
- **Can communicate with other agents and be dynamically configured**
- **Issue is the dynamic downloading and/or exchange of control scripts**
- **Intelligence resides mostly at the network devices**
- **Control scripts can be simple or complex**
- **Represent “lightweight” mobile agents**

Mobile Agents in Telecommunications

Smart Message



- **Agents are mobile entities**
- **Travel between computers/systems to perform tasks**
- **Agents are received and executed in an Agent Execution Environment**
- **Intelligence is partitioned in a balance between the AEE and the agent**
- **The smart message agent can serve as**
  - **an asynchronous message carrier for its owner**
    (retrieve email asynchronously, forward to owner's current location)
  - **as a broker that requests and sets up all requirement for services**
    (establishes a real-time connection for media delivery)
- **Services can be provided instantly, customized, and distributed !!!**
- **However, the approaches aim to replace IN components with mobile agents and are not consistent with IN's goal of centralized service control**
- **If IN moves toward this approach, it would evolve into TINA architecture!!!**

Mobile Agents in Telecommunications

Mobile Agents in TINA

TINA - Telecommunications Information Networking Architecture,

- **Current target architecture for future telecommunications and management services**
- **Considered an evolution from IN and TMN**
- **Allows flexible and transparent distribution of computation objects that are supported by Distributed Processing Environments**
- **The mobile agent concept in not yet part of TINA**
- **TINA-C (consortium) is working to expend the specification to accommodate intelligent and mobile agents**
- **TINA has identified the following agent dimensions:**

-Act on behalf of someone	-Communicating	-Planning
-Persistent	-Reasoning	-Negotiating
-Adaptive	-Environmentally aware	
-Mobile	-Socially aware	

Considerable work to extend DPE to support AEE

Mobile Agents in Network Management

This section elaborates some of the issues in networking management and how mobile agents can help solve them:

- **Network Management Approaches**
- **Mobile-Agent-Based Network Management**

Mobile Agents in Network Management

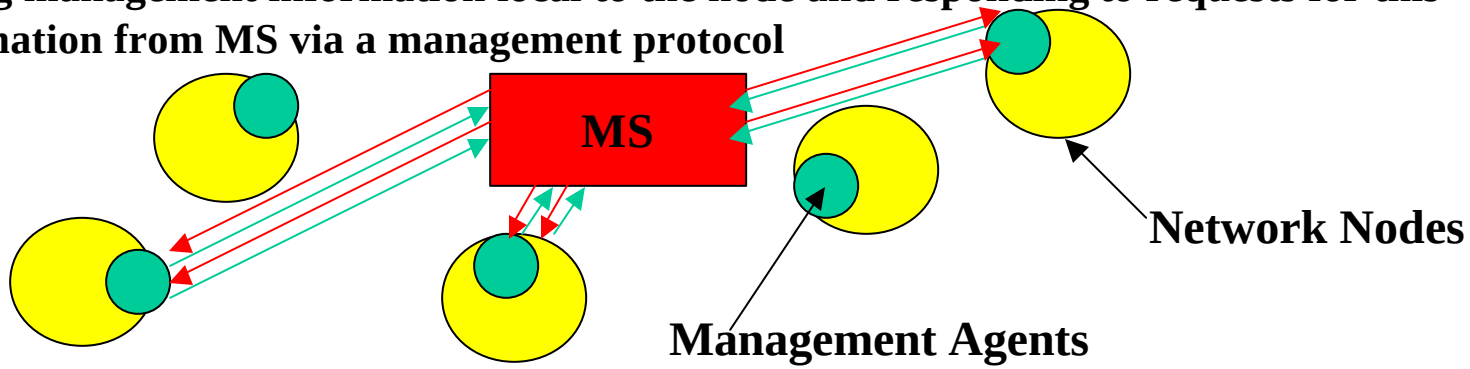
Network Management Approaches

- Most popular approach to manage networks
  - comes from Internet Engineering Task Force
  - based on Simple Network Management Protocol

- Closely related in structure
  - comes from International Organization for Standards
  - based on Common Management Information Protocol
  - for application within Open Systems Interconnection networks

- Both approaches assume the presence of Management Stations that interact with management agents running on network nodes

- The agent in these protocols are computational entities responsible for collecting and storing management information local to the node and responding to requests for this information from MS via a management protocol



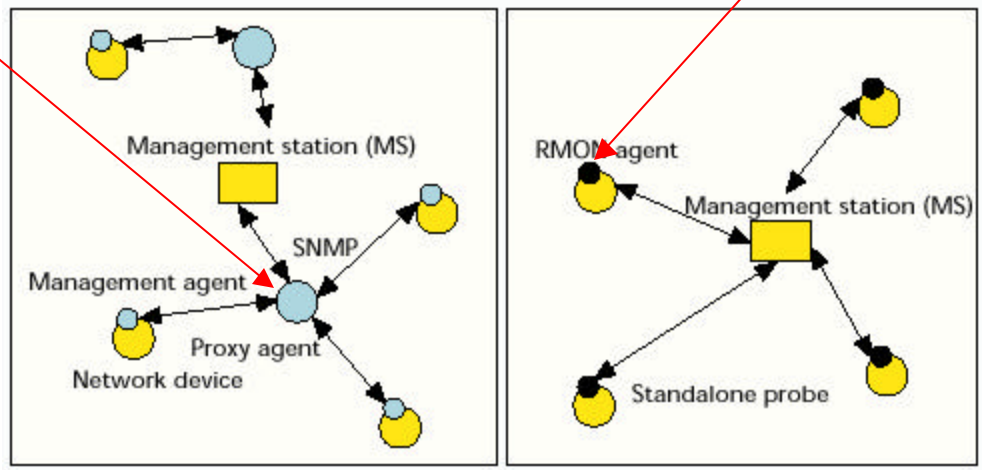
Mobile Agents in Network Management

Network Management Approaches

- **Centralization in Network Management**
  - **limits its scalability,**
  - **leading to poor performance,**
  - **inability to cope with dimensions of the network**

- **IETF and ISO have taken steps to decentralize and relieve the bottleneck around the MS**

  - **complex notification agents (ISO)**
  - **proxy agent (SNMP v2, IETF)**
  - **remote monitoring (RMON, IETF)**

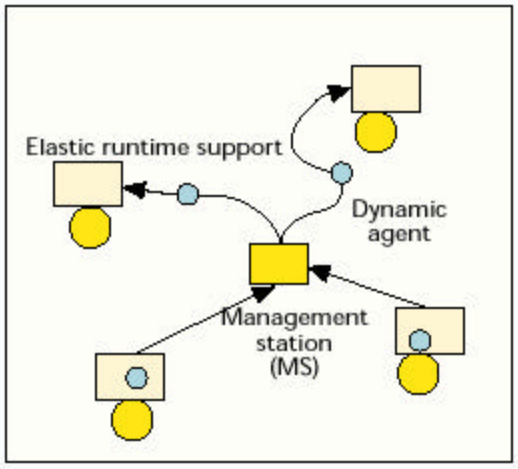


Mobile Agents in Network Management

Network Management Approaches

Clean design for decentralization is the Management By Delegation approach

- **There is still a management protocol and agents**
- **Elastic process runtime support is assumed to be present at each device**
- **In SNMP &CMIP, the MS computes & sends results to device via client/server msgs**
- **MS in MBD packs a task to agents and sends it to be executed at the devices**



(c) Management by delegation

Executions would be asynchronous, freeing MS to perform other tasks

Large portion of the functionality of MS would be delegated to devices

Mobile Agents in Network Management

Mobile-Agent-Based Network Management

- The research field of mobile agents in network management is still young
- Projects such as Hitachi, MAGNA, and NEC have posted homepages
- BUT, little technical information is available
- All project have a similar scope of using in-house mobile agent architecture to provide telecommunications services and management
- Another term for the mobile agent, mobile code paradigm
- Decentralization of network management services can be implemented using one or a combination of three design paradigms:

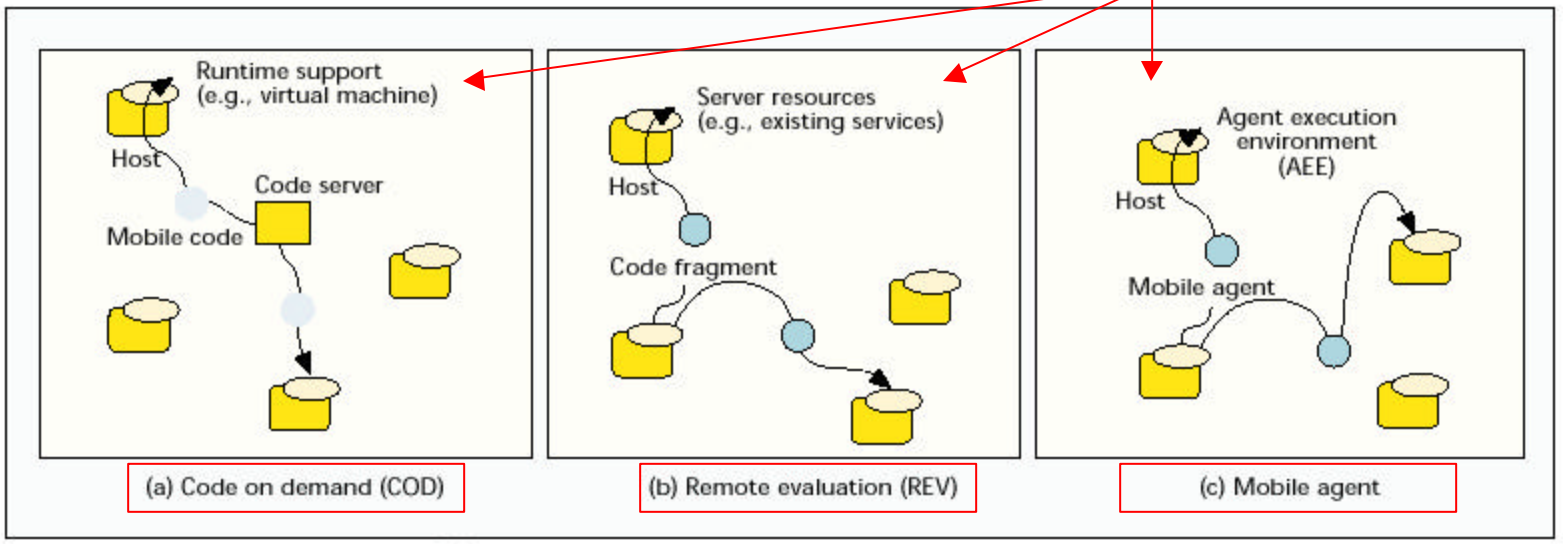
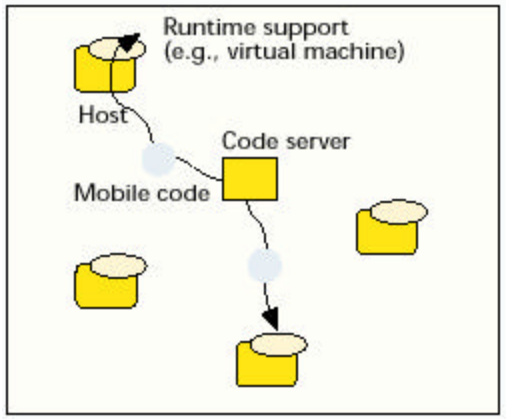


Figure 4. *Mobile code paradigms [5].*

Mobile Agents in Network Management

COD

- **Similar in concept to the use of mobile agent**
- **Proposed to allow dynamic configuration and functionality of network devices**
- **The ISO approach (CMIP) is amenable to this kind of application**



(a) Code on demand (COD)

- **Management agent in the IRTF approach (SNMP) is too rigid to be considered for implementing COD**

Mobile Agents in Network Management

REV

•Small code fragment is moved to the devices where it is allowed to invoke other codes to complete the service

•This approach subsumes MBD, because MBD has fixed functionality (only distribution is implemented)

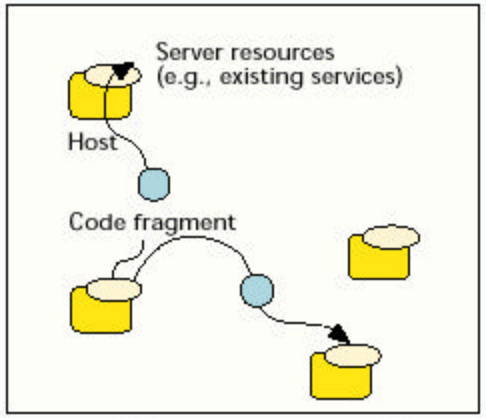
•REV also provides the benefit of dynamic configuration change obtained with COD.

EX:

•the manager can pack a series of commands to be sent by an REV mechanism

•these commands then invoke and execute built-in functionalities at the device

•one such functionality is the search for routing table entry now being carried out in the MS



(b) Remote evaluation (REV)

Mobile Agents in Network Management

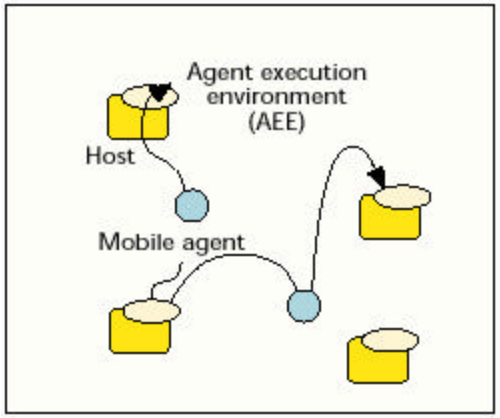
Mobile Agent

•**Sufficient intelligence of the agent allows it to travel from node to node to collect information and carry out device control tasks**

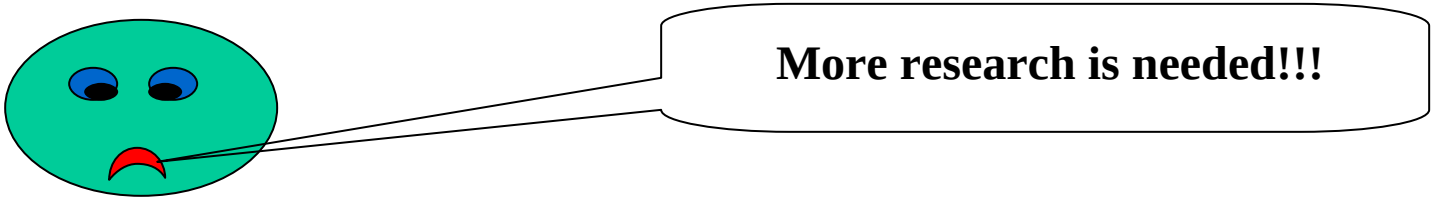
•**Two drawbacks:**

-how to define an agent's intelligence

-complexity which may increase the agent' size



(c) Mobile agent



A Survey of Mobile Agent Systems

In general, there are three targets for Mobile Agent (MA) system design and implementation:

- **Using or creating a specialized language**
  - **-language features provide the requirements of MA systems**
- **As operating system (OS) services or extensions**
  - **-implements MA system requirements as OS extensions to take advantage of existing OS features**
- **As application software**
  - **-builds MA systems as specialized application software that runs on top of an OS to provide MA functionalities**

A Survey of Mobile Agent Systems

Nine Projects Chosen for the discussion:

- **Aglet from IBM**
- **Agent Tcl from Dartmouth College**
- **Agents for Remote Access (ARA) from University of Kaiserslautern**
- **Concordia from Horizon Systems Laboratory, Mitsubishi Company**
- **Mole from the Institute for Parallel and Distributed Computer Systems**
- **Odyssey from General Magic**
- **TACOMA from Cornell Univercity**
- **Voyager from ObjectSpace**
- **Secure and High Performance Mobile Agent Infrastructure (SHIP-MAI) from the Multimedia and Mobile Agent Research Laboratory, University of Ottawa**

Mobile Agent Models

Summary of Mobile Agents Models

- **MA systems consists of**
  - **Java class libraries**
    (Aglet, Concordia, Voyager, Odyssey, Mole, and SHIP-MAI)
  - **Scripting language systems with interpreter and runtime support**
    (ARA, Agent Tcl)
  - **OS services accessible via a scripting language**
    (TACOMA)
- **Aglet, Concordia, Odyssey, and Mole can be qualified as experimental application frameworks**
- **Voyager is a current (was in 1998) commercial product that advocates itself as agent-enhanced middleware**

Mobile Agent Models

Summary of Mobile Agents Models cont.

- **ARA and Agent Tcl are called "strongly mobile systems"**

- **Compared to external classes such as in systems based on Java, there is tighter integration of mobility as a language feature**

- **Conceptually, all approaches are similar**

- **MA is considered a special application that requires two parts:**
  - **-the mobile part (MA)**
  - **-a host part that reside on a computing device such as network node**

- **There is also a service point or location concept that serves as a mediator between the MA and the services offered (called static agent in some cases)**

Mobile Agent System Requirements and Design Forces

- **The environment in which MA must function theoretically can be either uniform or heterogeneous**

- **Although an MA system can be build with a single computing platform, such a system would have limited scope and usefulness**

- **Current MA system assume that the operating environment is heterogeneous**

- **First consideration in the design, how do deal with platform heterogeneity**

- **Second issue, how to guarantee certain security levels to protect:**

    - **agent form the host**
    - **host from the agent**
    - **agents form each other**
    - **hosts form each other**

- **There are adequate solutions to satisfy the heterogeneity constraint**

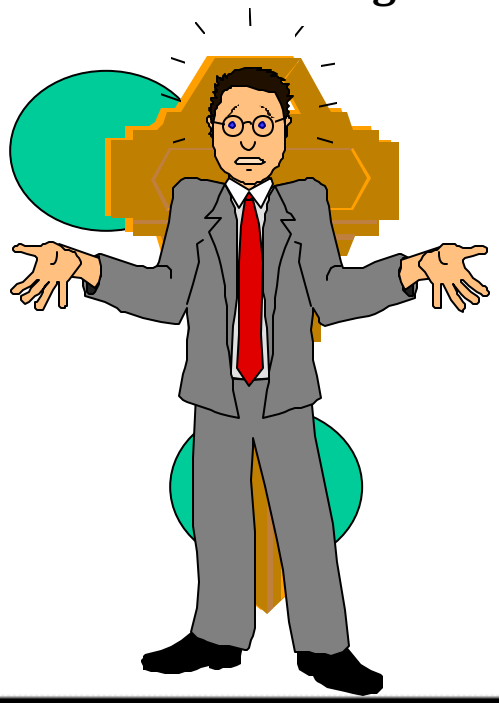
- **Only limited solutions are available to deal with security constraints**

Mobile Agent System Requirements and Design Forces

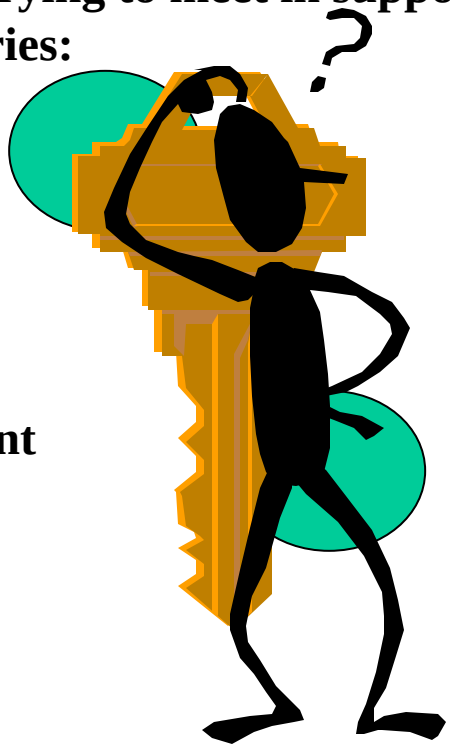
•**Remaining considerations in the design would be:**

-how to deal with resource allocation and discovery
-how to identify and control agents
-how to handle scalability

•**The requirements current MA systems are trying to meet in supporting MA execution generally fall into nine categories:**



- **Security**
- **Portability**
- **Mobility**
- **Communication**
- **Resource Management**
- **Resource discovery**
- **Identification**
- **Control**
- **Data Management**



Conclusion

Mobile agent system	Security	Portability	Mobility	Communication	Resource management
Aglet	Limited, sandbox model	Java	Aglet Transfer Protocol	Event, message object	Java
Agent Tcl	Limited, sandbox model	Support multiple language interpreters	Multiple protocol	RPC	Yes
ARA	Limited, sandbox model	Support multiple language interpreters	Multiple protocol	RPC	Yes
Concordia	Limited, sandbox model and secure channel	Java	Socket and Java serialization	Event, group	Yes, via the queue server
Mole	Basic Java	Java	Enhanced Java model with code server	Event	Java
Odyssey	Basic Java	Java	Java RMI, CORBA IIOP, DCOM	Event	Java
TACOMA	Limited, uses firewall agent	None	TCP	Folder object	Operating system
SHIP-MAI	Sandbox model, secure channel, policy, access control	Java	Java object serialization	Event, group, room object, Java syntax for method call	Planned
Voyager	Limited, sandbox model, secure channel	Java	Java object serialization, reflection	Distributed event (VoyagerSpace), Java syntax for method call	Java

Table 1. *A summary of moble agent system features.*

Conclusion

Mobile agent	Resource discovery system	Identification	Control	Data management	Case study in telecommunication
Aglet	None, user-implemented	Yes, via globally unique number sequence	Yes‹	None, user-implemented	None so far
Agent Tcl	Limited	N/A	N/A	Yes, in core	Yes
ARA	Limited	N/A	N/A	Yes, in core	None so far
Concordia	None, user-implemented	N/A	Yes	Yes, but limited	None so far
Mole	None, user-implemented	DNS	Yes	N/A	None so far
Odyssey	None, user-implemented	N/A	Yes	None, user-implemented	None so far
TACOMA	None, user-implemented	N/A	Yes	None, user-implemented	None so far
SHIP-MAI	Planned	Yes, use globally unique number sequence	Yes	Yes	Yes, in mobility management and information delivery
Voyager	None, user-implemented	Yes, use globally unique number sequence, alias, federated naming directory service	Yes	Persistent interface	Yes, but details not publicly available

Table 1(continued). *Summary of mobile agent systems features.*

Conclusion

•**The mobile agent paradigm proposes bringing the requesting client closer to the source to reduce traffic**

•**Decentralization of network design is important to cope with growth in demand for services and pressure for more efficient network management**

Conclusion

THE END