Mobile Agents

Haiping Xu
Computer Science Department
The University of Illinois at Chicago

Introduction

- The term agent comes from greek “agein”, which means to drive or to lead.
- Today the term agent denotes something that producing an effect, e.g., drying agent, a shipping agent.
- It is suitable to describe current trends in computer science: active instruments (to which work can be delegated) vs. passive tools.
- The term agent in computer science refers to software agent.
Space of Software Agents

Current Researches on Agents

- Do not exploit all the capabilities classified by these three dimensions.
- Multi-agent systems (MAS)
  - Execute a given task.
  - Use distributed but static agents.
  - Collaborate and cooperate in an intelligent manner.
- Mobile agents (MA)
  - Model agent mobility and agent coordination.
  - Assume very limited or even no intelligence.
Evolution of the Mobile Agent Paradigm

Client \(\xrightarrow{\text{parameter (data)}}\) Server \(\xrightarrow{\text{results (data)}}\) RPC

Client \(\xrightarrow{\text{procedure (code)}}\) Server \(\xrightarrow{\text{results (data)}}\) Remote Evaluation

Server-1 \(\xrightarrow{\text{1. agent dispatch}}\) Client \(\xrightarrow{\text{agent (code + data + state)}}\) Server-2

Server-2 \(\xrightarrow{\text{2. agent migration}}\) Server-3 \(\xrightarrow{\text{3. agent migration}}\)

Server-3 \(\xrightarrow{\text{4. agent migration}}\) Server-1

Degrees of Mobility

Transport of code + data: constants

Migration of code + data: parameter

Migration of code + data + state: manual state encoding

Mobility: Code Mobility

Remote Execution

Code on Demand

Weak Migration

Strong Migration

Agent Mobility
Why Mobile Agents?

- **Software-Distribution on Demand**
  - Easy to transport code and install packages automatically.
  - Code mobility simplify the management of an existing structure.

- **Reduction of Communication Costs**
  - The number of interactions.
  - The amount of data communicated over the network.

- **Asynchronous Tasks**
  - Asynchronous processing of requests.
  - Mobile device can be disconnected and reconnected.

- **Scalability Due to Dynamic Deployment**
  - A hierarchy of mobile agents can be set up.
  - The structure of agent hierarchy can change dynamically.
A Mobile Agent System

Examples of Mobile Agent Systems

- **Mole (University of Stuttgart)**
  - First Java-based of a mobile agent system.
  - Use Java as the agent programming as well as the implementation language.

- **Aglets (IBM)**
  - An aglet is a mobile java object and corresponds to mobile agents.
  - Support synchronous and asynchronous message passing.
  - Agent mobility is implemented by weak migration.
Examples of Mobile Agent Systems (continue)

- **Agent Tcl (Dartmouth College)**
  - An extension of the Tool Command Language (Tcl), which is a scripting language on UNIX.
  - Implements strong mobility.

- **MARS (Univ. of Modena and Reggio Emilia)**
  - An architecture for mobile agent coordination.
  - Based on a reactive tuple space model.
  - The tuple space is programmable.

The MARS Architecture
Academic Research Work

• Model agent mobility (physical vs. logical)
  – Distributed join-calculus: an extension of $\pi$-calculus that introduce the explicit notions of named localities and distributed failure.
  – Mobile UNITY: a programming notation that captures the notion of mobility and transient interaction among mobile nodes.
  – MobiS: an extended version of PoliS, which is a specification language based multiple tuple spaces.
  – LIME: a middleware based on tuple spaces.

(continue)

• Model agent communication
  – Knowledge Query Manipulation Language (KQML)
  – Foundation for Intelligent Physical Agents (FIPA)
  – Mobile Agent System Interoperability Facility (MASIF)

• Model agent coordination
  – Inter-agent coordination vs. agent-environment coordination.
  – Example: context-dependent coordination in MARS.
Challenges

- Security
  - Four areas: (1) inter-agent security (2) agent-host security (3) inter-host security (4) hosts and unauthorized third party.
  - Agent-host security:
    - Protect hosts from malicious (visiting) agents.
    - Protect agents from malicious hosts.

Challenges (continue)

Is it safe to use Mobile Agents?
What are the Security Threats?

- Rogue Agent
  - Agent against Platform
  - Agent against Agent

- Malicious Host
  - Platform against Agent
  - Other entities against Both

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Challenges (continue)

- Control structures
  - Primitives: create, clone, and terminate agents.
  - To terminate agents is more complicated in the context of a hierarchy of agents.
- Transactional support
  - To guarantee that the agent is performed exactly once, independent of communication and node failures.
  - Upon failure, agent states must be made recoverable.

My Current Research Work

- Proposed a general model for intelligent software agents.
  - Explicitly model asynchronous message passing.
  - Introduce inheritance mechanism into agent-oriented software design.
  - Exercise behavioral analysis and verification.
- Model intelligent mobile agents (IMA).
  - Introduce mobility into agent-oriented software model.
  - Provide a framework for intelligent mobile agent.
References


Website for Mobile Agent Systems

- Mole (University of Stuttgart)  
  – http://mole.informatik.uni-stuttgart.de/

- Aglets (IBM)  

- Agent Tcl (Dartmouth College)  
  – http://agent.cs.dartmouth.edu/

- MARS (Univ. of Modena and Reggio Emilia)  
  – http://sirio.dsi.unimo.it/_MOON/MARS/index.html