Software Agents
Theory and Practice

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Issues to be discussed

- Software agents?
- Definition of software agents
- Theory and architecture of agents
- Multi-agent systems
- Building Agents
- Applications (general)
- Agents and Information Management
- Applications
- Current developments
Software agents?

• Development metaphor
  – Software Engineering
  – Methodology

• Technology
  – agent theory
  – agent architectures
  – agent languages
Paradigm Shifts

role/goal oriented
agents
C++, Java

object oriented
3GL, C, Pascal, ...

function oriented

command oriented
2GL, Assembler

time

real world mapping
(abstraction level)
Definition of agents (weak notion)

- Autonomous
- Pro-active
- Reactive
- Social ability
Definition of agents (strong notion)

- Belief
- Desire
- Intentions
- Goals
- Knowledge
- Obligations
Other possible attributes

- Rationality
- Veracity
- Mobility
- Learning capacity
- Cooperativeness
Theory of agents

• Represent mental attitudes
  – knowledge, belief, goals, etc.

• Reason about mental attitudes

• Plan actions

• “Observe” changes

• Update mental attitudes
From Theory to Architecture

- How to use the theory in architecture of agents:
  - Only for representation of attitudes
  - As formal specification of agent implementation
  - Also use the logical inferencing of logic in deliberative agent architecture
Agent architectures

• Deliberative agents
  – BDI agents (mostly theory)
  – planning agents (IRMA)

• Reactive agents
  – Brooks’ subsumption architecture

• Hybrid agents
  – Interrap
Building Agents

1. Agent Oriented Programming (e.g. 3APL)
   • Close to agent theory, but far from industrial use

2. Based on Java components (e.g. Jade)
   • More robust, but build intelligence yourself in Java

3. Based on robust infrastructure (e.g. Tryllian ADK)
   • Industry standard systems (robust, efficient, scalable), but no intelligence
3APL agents (I)
3APL agents (II)

- **PROGRAM** "patrol_agent.3apl"
- **CAPABILITIES:**
  - \{ at\_east(self) \} WalkWest() \{ NOT at\_east(self), at\_west(self) \},
  - \{ at\_west(self) \} WalkEast() \{ at\_east(self), NOT at\_west(self) \}
- **BELIEFBASE:**
  - at\_west(self)
- **GOALBASE:**
  - patrol()
- **RULEBASE:**
  - \begin{align*}
    & \text{patrol()} \leftarrow \text{at\_east(self)} \mid \text{WalkWest()} ; \text{patrol()} , \\
    & \text{patrol()} \leftarrow \text{at\_west(self)} \mid \text{WalkEast()} ; \text{patrol}().
  \end{align*}
The JADE framework includes a library of interaction protocols and generic agent behaviours, that must be customized for the specific application needs in order to create the agent capabilities.
Tryllian ADK (I)

• The *Agent Foundation Classes* (AFC) providing tools, libraries, building blocks and examples for building Agent Based Applications
• The *Agent Runtime Environment* (ARE) a “habitat” for hosting agents developed using the AFC
• *Agent Management Tools* for managing agents on a server
Tryllian ADK (II)
System Architecture
From Agents to Multi-Agent Systems

• Agent communication
• Agent societies
  – realise there are other agents
  – use other agents for your actions
• Collective plans, goals, etc.
• MAS vs. Autonomous agents
Some General Application Areas:

1. **Industrial applications**
   - manufacturing
   - process control
   - telecommunications
   - transportation systems

2. **Electronic Commerce**
   - electronic markets/auctions
   - buying agents (e.g. Jango, shopbot, etc.)

3. **Business Process Management**

4. **Information Management**
   - information gathering
   - information filtering
Industrial applications (I)

Manufacturing at Daimler Benz
Manufacturing and supply nets
Daimler Benz

Objective
improve manufacturing and supply processes

inter-organizational supply net

plant network

vehicle assembly plant

production lines

body-n-white painting assembly

Tier 3 Raw Materials
Tier 2 Fabrication
Tier 1 Comp. Asbly
Vehicle Assembly
Mixing Center
Dealers
Motivation: *Business trends*

Growing surplus of industrial capacity and globalization lead to

- shorter product life-cycles
- reduced time-to-market
- increased product variety
- volatile demand
- reduced investment costs

*New manufacturing requirements*

- product flexibility
- volume scalability
- robustness
Production 2000+: Flexible and robust production system

Disadvantages of transfer lines

- dedicated machines
- rigid material flow

introduce more hardware flexibility

flexible transportation system

flexible
machine
Production 2000+: An agent-based control system

work pieces find their way

switches direct the traffic

work piece agent

switch agent

machine agent

machines control their work load

Control forces:
- work pieces push themselves
- machines limit work-in-process
Production 2000+: *Field test*

*productivity increase at least 10%*

by-pass to existing transfer line
Container scanning

Port of Rotterdam

Final destination

Transporters

Forwarder

Customs

Container Selection

Scan Appointment

Transportation Appointment

5%
System overview

Agent system

1. Customs
2. Forwarder Agents
3. Internal transporter Agent
4. Transport list Agent
5. External transporter Agents
6. Scan Agent
7. Transporter Output Agent
8. Transporter servlet
9. XML-file

Scan servlet
Excel-file
SMS-message
Industrial applications (III)

Managing transportation

Living Systems
MAS for transport management

- Consumption units (store)
- Connections with varying speed (road)
- Transportation units (truck)
- Production units (factory)
- Trucks inform each other about slow traffic
Electronic Commerce (I)

Electronic Markets and Auctions
Hewlett Packard
Electronic Data Interchange (EDI)

Business Partners electronically exchange trading documents in a pre-arranged format.

**Advantages:**
Reduced paperwork, faster transactions, easy to automate.

**Disadvantages:**
Lock-in to small number of business partners.
Many potential trading partners meet and negotiate at an internet site.

**Advantages:**
Very flexible. More competition, leading to better deals.

**Disadvantages:**
Not automated, so slower and more labour-intensive than EDI.
Agent-Mediated Electronic Commerce

Agents represent buyers and sellers, and can participate in many Electronic markets.

Advantages: Best of both worlds – Flexible but automated.

Disadvantages: Technology not yet widely accepted.
The Stages of E-Commerce

- Matchmaking
- Negotiation
- Contracting
- Contract Fulfilment
Matchmaking

Buyer

Purchase goal

Buyer Agent

Request

Directory Service

List of contacts
Contracting
Contract Fulfilment

Payment

Service delivery

Buyer Agent

Seller Agent

Buyer

Seller
Electronic Commerce (II)

Research competition:
Trading Agent Competition

www.sics.se/tac/
Information Management

1. Theoretical architecture
2. Examples from Practice
General MAS Architecture for Information Management
The User interface agent
Information Management

Gathering tourist information

DFKI
Intelligent Web Services

**Consumer**
- buys
  - Information
  - Goods
  - Services

**Netbot**
- Intelligent Parallel Retrieval
- Information Extraction and Summarization
- Personalized Presentation
- Matchmaking
- Teleshopping Assistance
- Telemarketing Assistance
- Translation Services
- Data Mining Services

**Provider**
- sells
  - Information
  - Goods
  - Services

**Web Sites**

**Knowledge about:**
- Usage Patterns
- User Models
- Consumer Profiles

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AiA: Information Integration for Virtual Webpages

- PAN Travel Agent Andi
- Car Route Planner
- Yahoo Weather Server
- Yahoo News Server
- Hotel Guide
- Gault Millau Restaurant Guide
Information Management

Remote system and data management

Tryllian
Overview

- Network discovery
- Remote software installation
- Database discovery
- Data retrieval
- Upgrade Agent functionality dynamically
Architecture
Agent research and practice

• AgentLink: Network of excellence
  – Research groups in agents
  – www.agentlink.org
• Agent Cities: Network for deploying agent applications
  – www.agentcities.org
• FIPA: foundation for agent standards
  – www.fipa.org
Conclusions

• Agents are here to stay!
• Agents are NOT simple
• Difference between theory and implementation
• Useful in complex domains:
  – Inter-organizational applications
  – Internet applications
  – Distributed applications
• Agents have a high potential
• Agents are increasingly used in practice