Software Agents Theory and Practice

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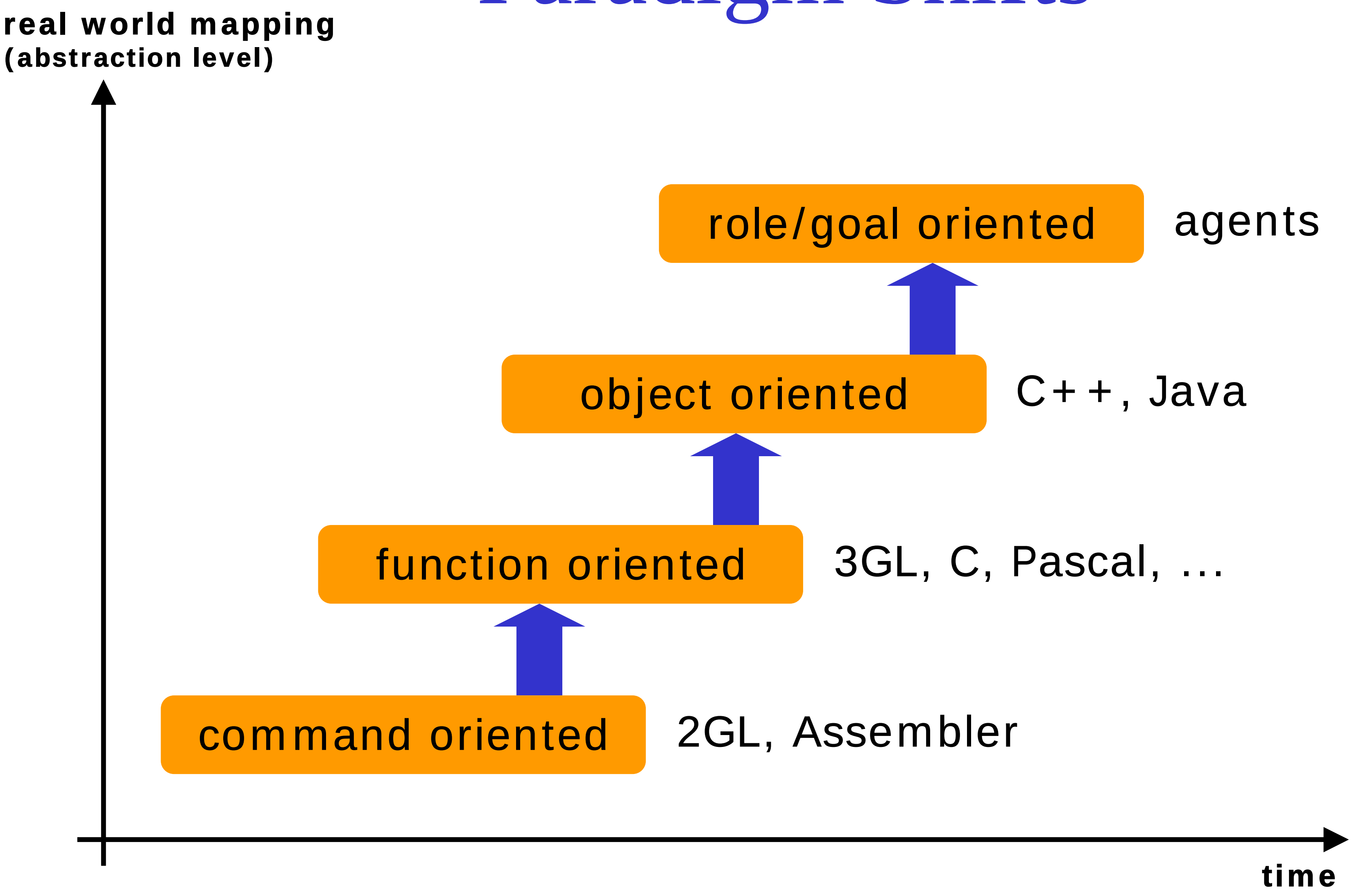
Issues to be discussed

- 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



real world mapping
(abstraction level)

role/goal oriented — agents

object oriented — C++, Java

function oriented — 3GL, C, Pascal, …

command oriented — 2GL, Assembler

time

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

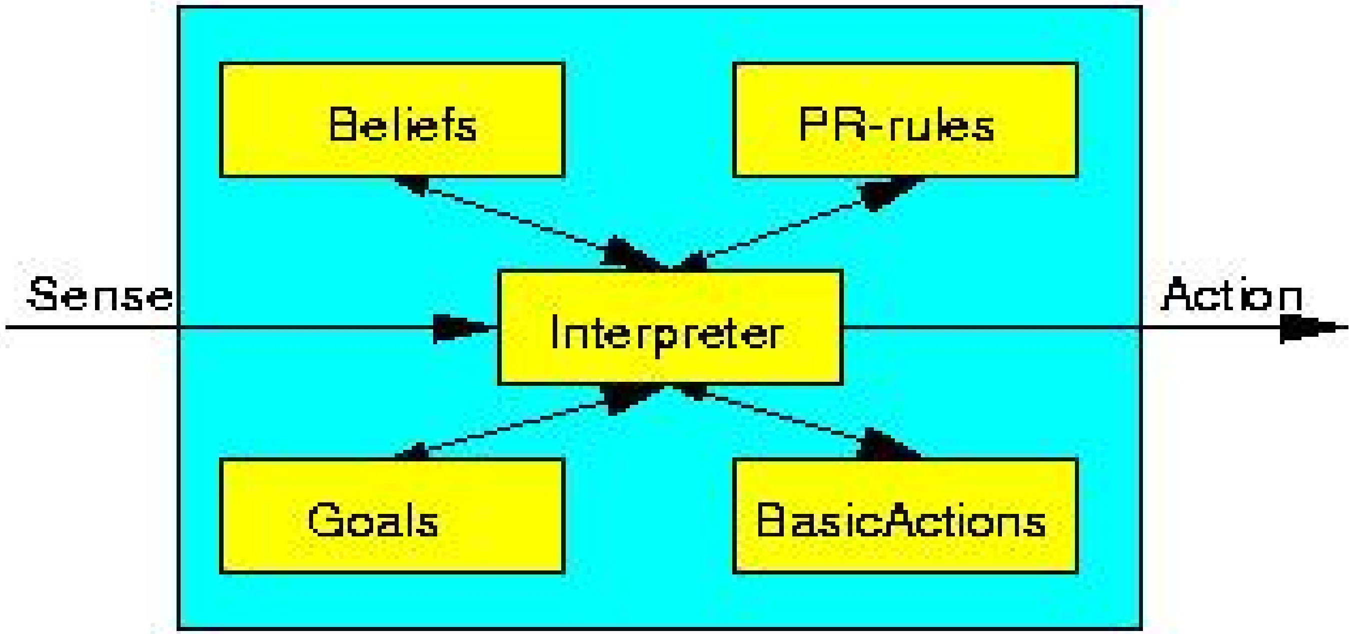
Agent architectures

- 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:**

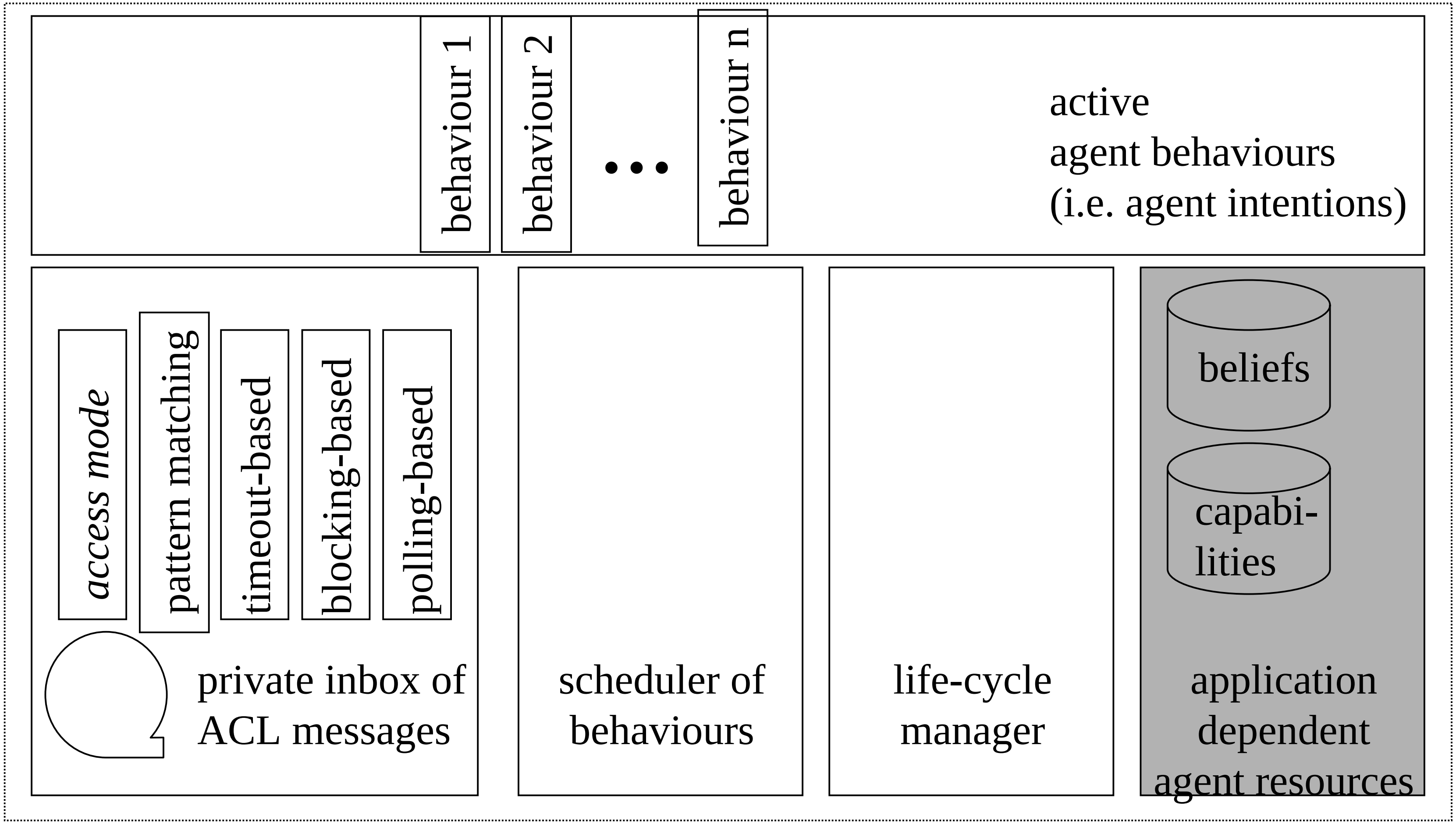
  { at_east(self) **}** WalkWest() **{ NOT** at_east(self) **,** at_west(self) **} ,**
  { at_west(self) **}** WalkEast() **{** at_east(self) **, NOT** at_west(self) **}**
- **BELIEFBASE:**

  at_west(self)
- **GOALBASE:**

  patrol()
- **RULEBASE:**

  patrol() ← at_east(self) | WalkWest() ; patrol() ,
  patrol() ← at_west(self) | WalkEast() ; patrol() .

JADE agents



behaviour 1

behaviour 2

• • •

behaviour n

active
agent behaviours
(i.e. agent intentions)

access mode

pattern matching

timeout-based

blocking-based

polling-based

private inbox of
ACL messages

scheduler of
behaviours

life-cycle
manager

beliefs

capabi-
lities

application
dependent
agent resources

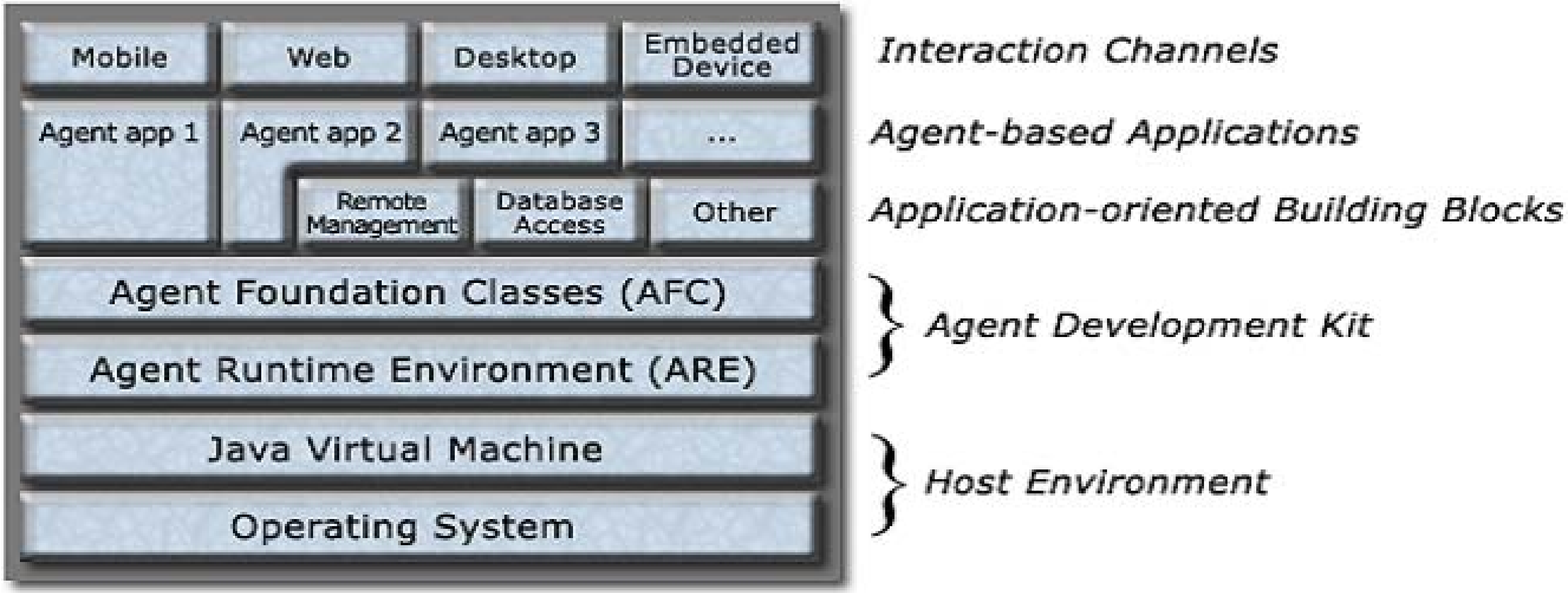
The JADE framework includes a library of interaction protocols
and generic agent behaviours, that must be customized for the specific
application needs in order to create the agent capabilities

JADE library of
interaction
protocols
and of generic
agent behaviours

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



Mobile | Web | Desktop | Embedded Device — *Interaction Channels*

Agent app 1 | Agent app 2 | Agent app 3 | ... — *Agent-based Applications*

Remote Management | Database Access | Other — *Application-oriented Building Blocks*

Agent Foundation Classes (AFC)

Agent Runtime Environment (ARE)

Agent Development Kit

Java Virtual Machine

Operating System

Host Environment

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

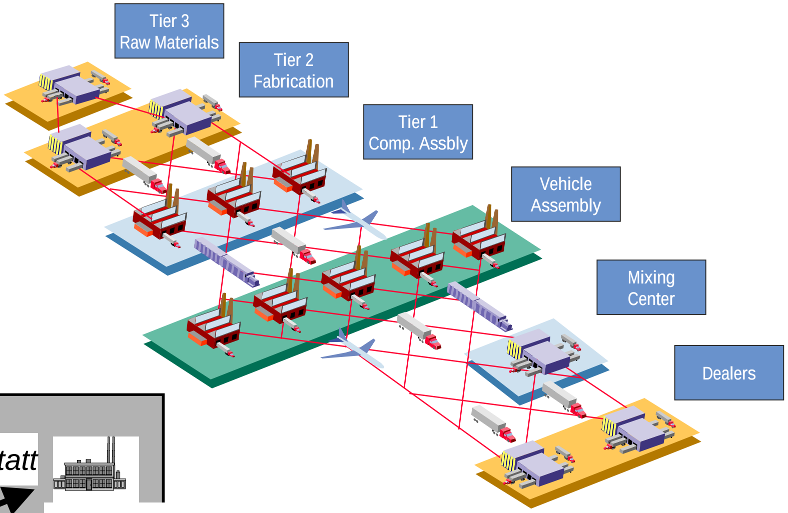
Industrial applications (I)

Manufacturing at Daimler Benz

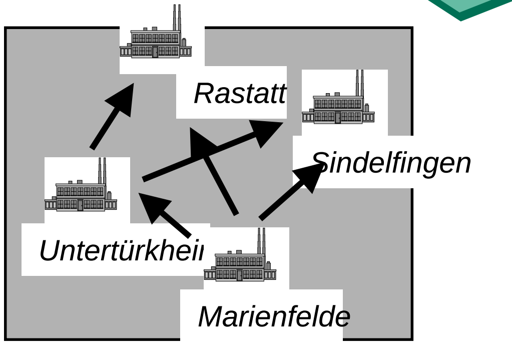
Manufacturing and supply nets
Daimler Benz

Objective

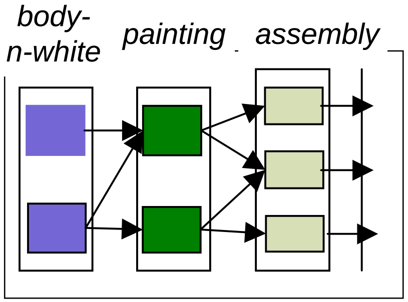
improve manufacturing and supply processes



inter-organizational supply net

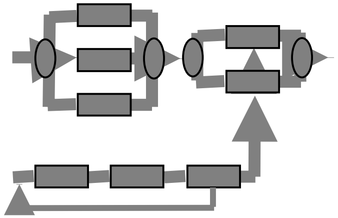


plant network



vehicle assembly plant

production lines



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

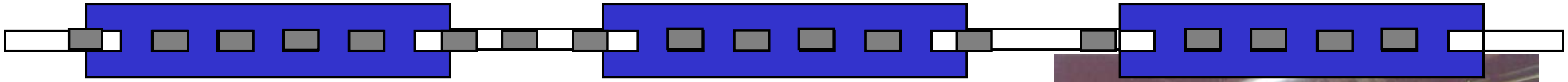
New manufacturing requirements

➔ **product flexibility**

➔ **volume scalability**

➔ **robustness**

Production 2000+: Flexible and robust production system

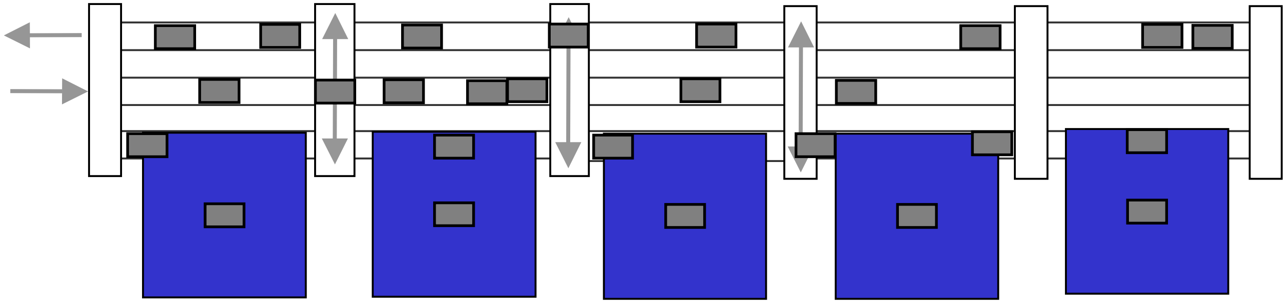


Disadvantages of transfer lines

- dedicated machines
- rigid material flow

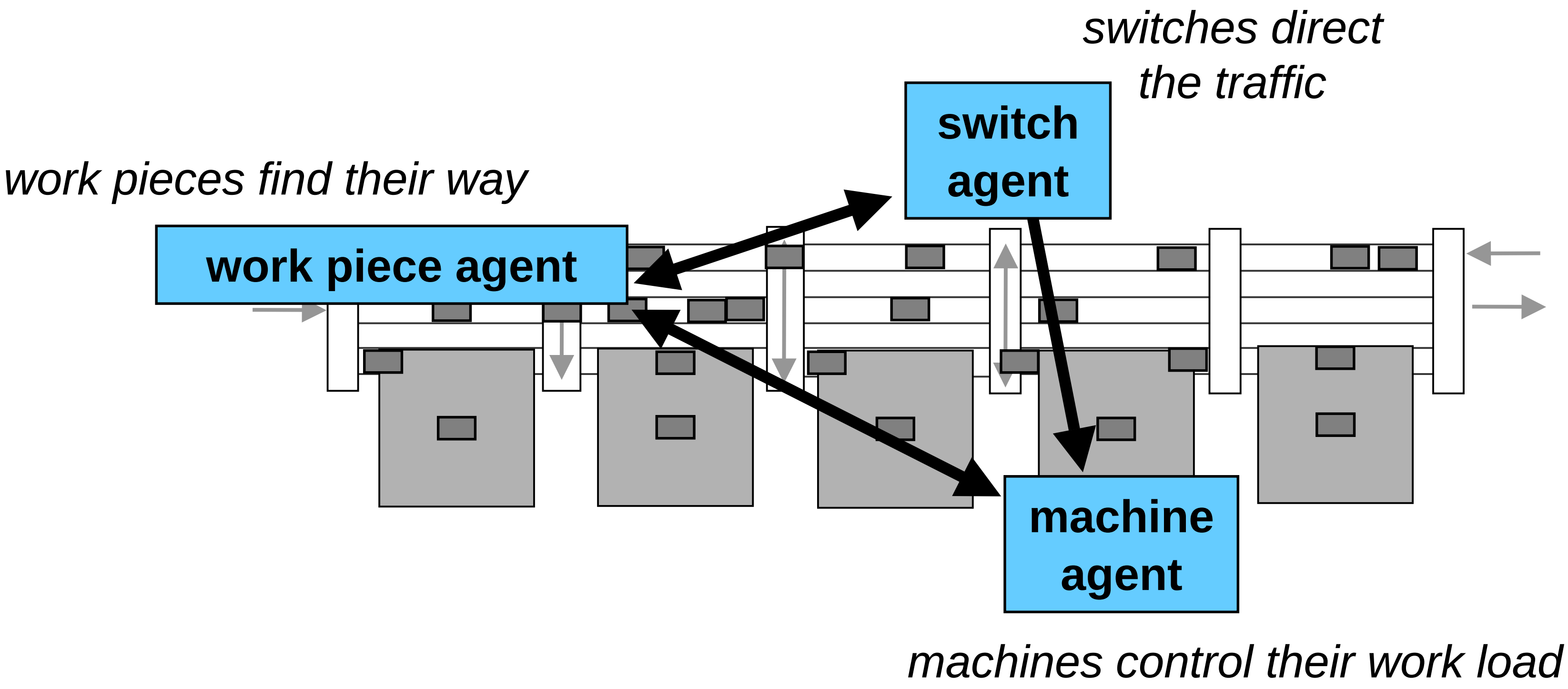
introduce more hardware flexibility

flexible transportation system



flexible machine

Production 2000+: An agent-based control system



switches direct the traffic

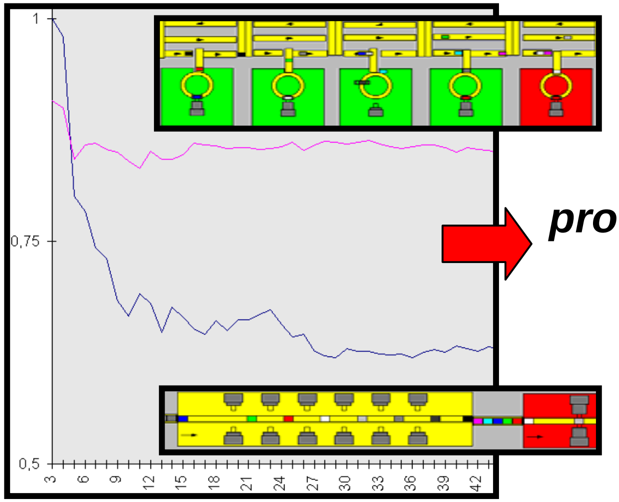
work pieces find their way

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

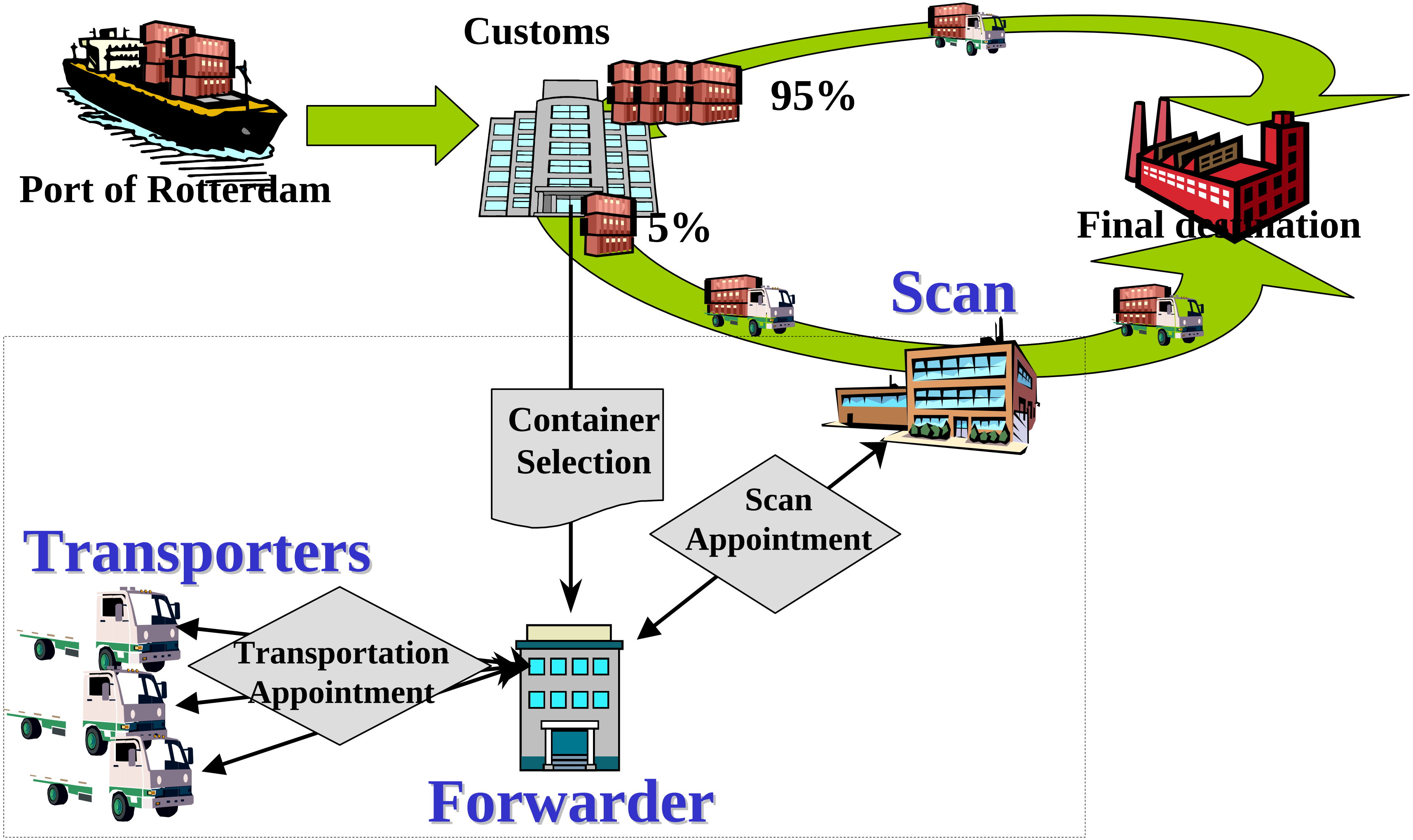
Schneider Electric

Industrial applications (II)

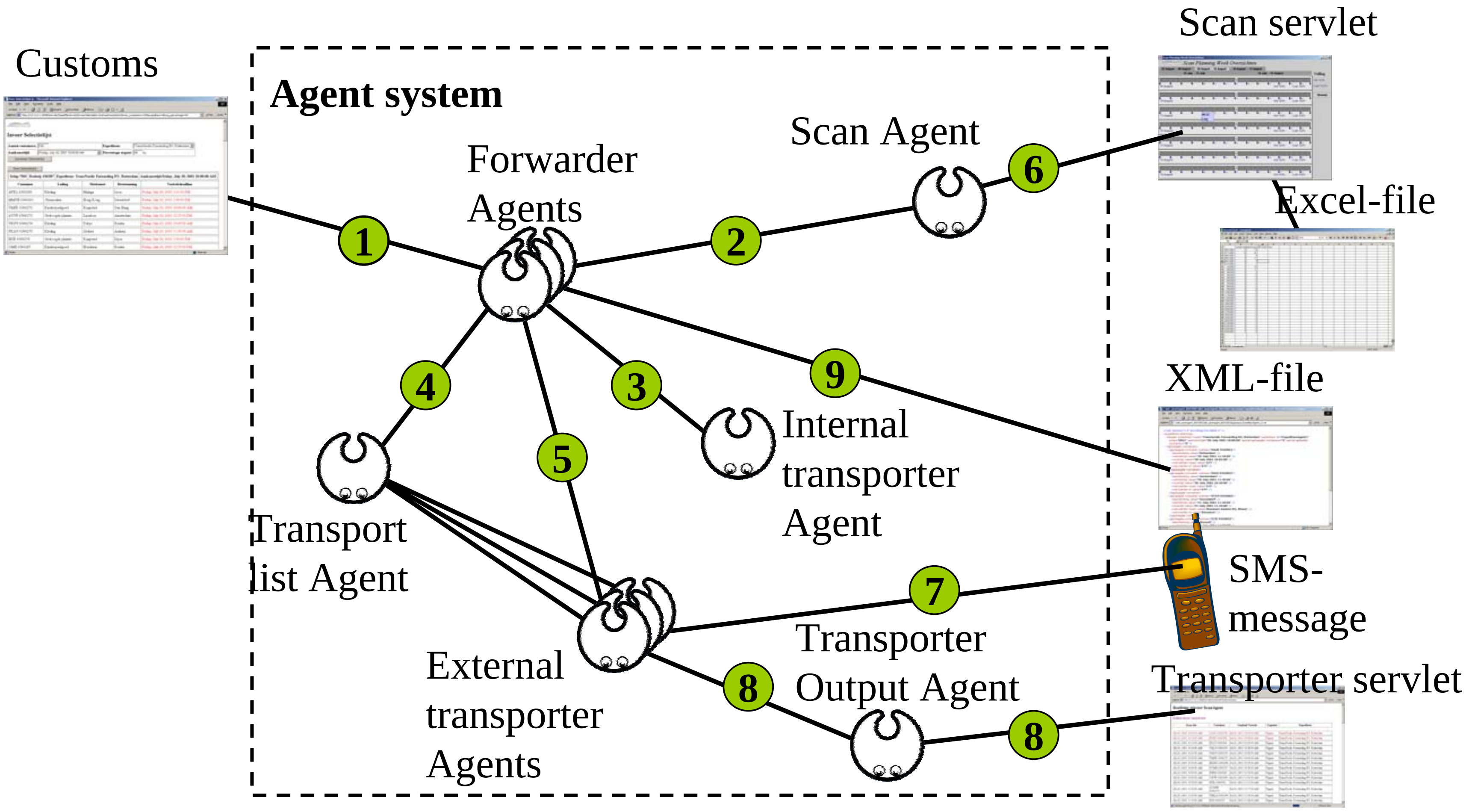
Container transport in Rotterdam

Tryllian

Container scanning



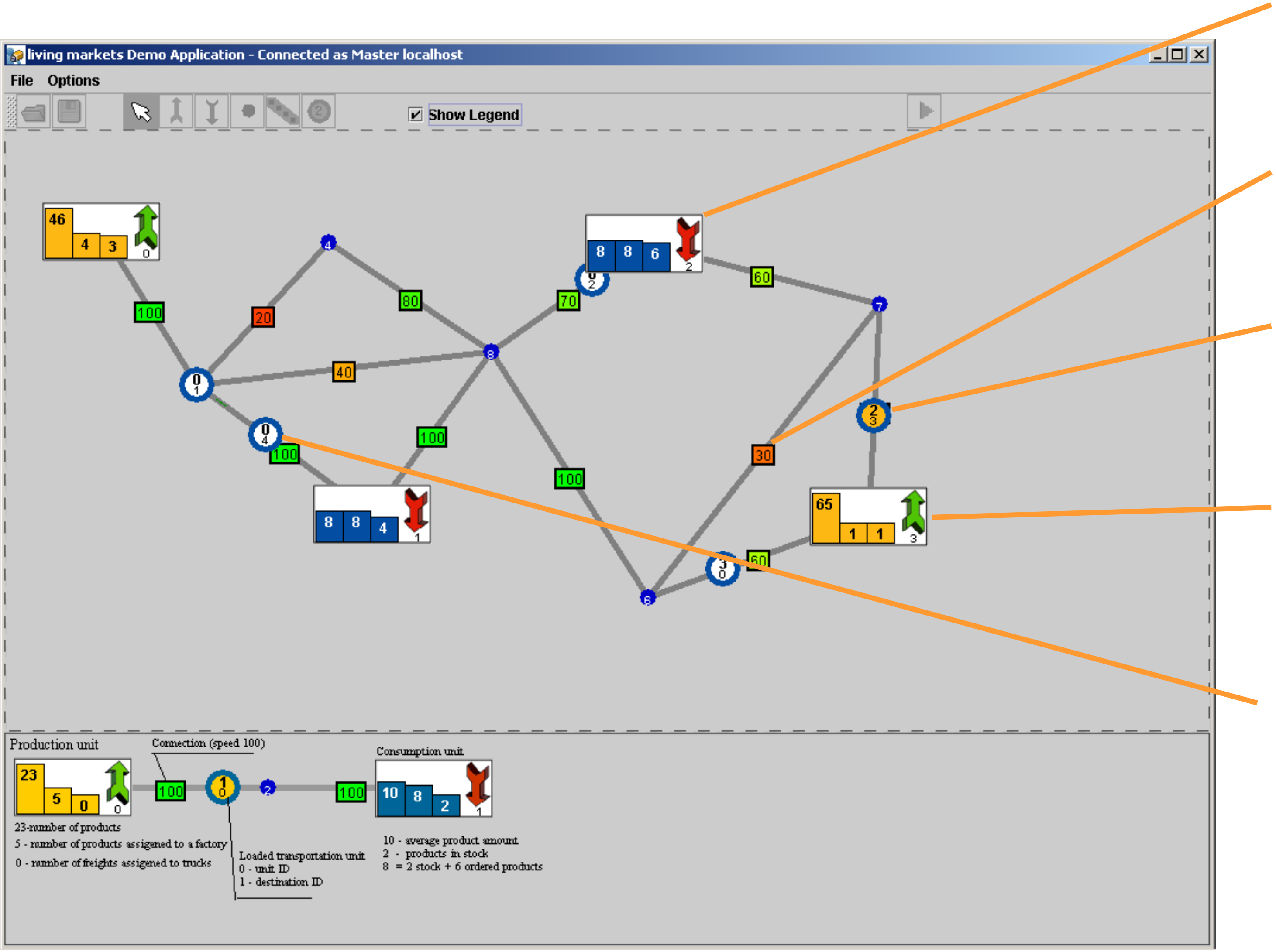
System overview



Industrial applications (III)

Managing transportation
Living Systems

MAS for transport management



living markets Demo Application - Connected as Master localhost

Production unit

Connection (speed 100)

Consumption unit

23-number of products

5 - number of products assigened to a factory

0 - number of freights assigened to trucks

Loaded transportation unit
0 - unit ID
1 - destination ID

10 - average product amount
2 - products in stock
8 = 2 stock + 6 ordered products

consumption units (store)

connections with varying speed (road)

transportation units (truck)

production units (factory)

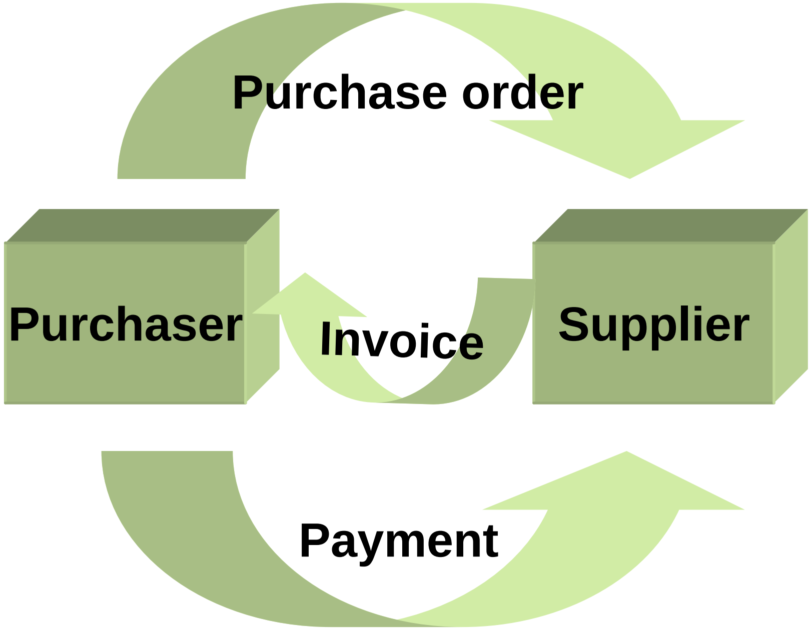
trucks inform each other about slow traffic

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:

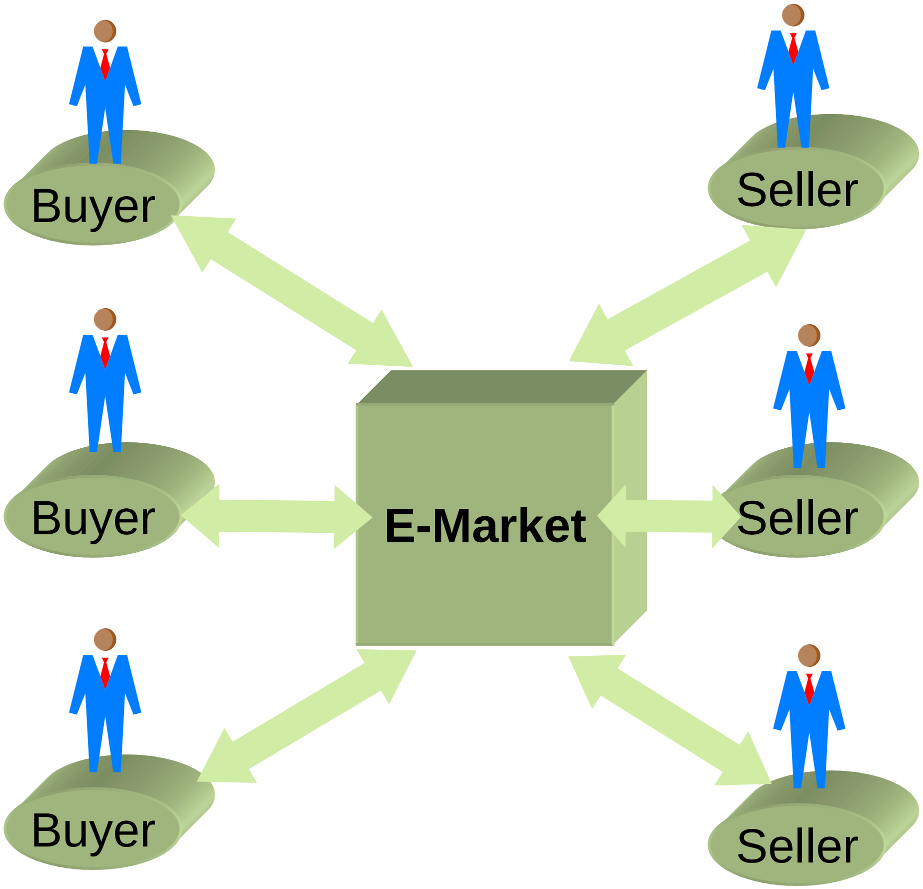
Reduced paperwork, faster transactions, easy to automate.

Disadvantages:

Lock-in to small number of business partners.

Electronic Markets

Many potential trading partners meet and negotiate at an internet site.



Advantages:

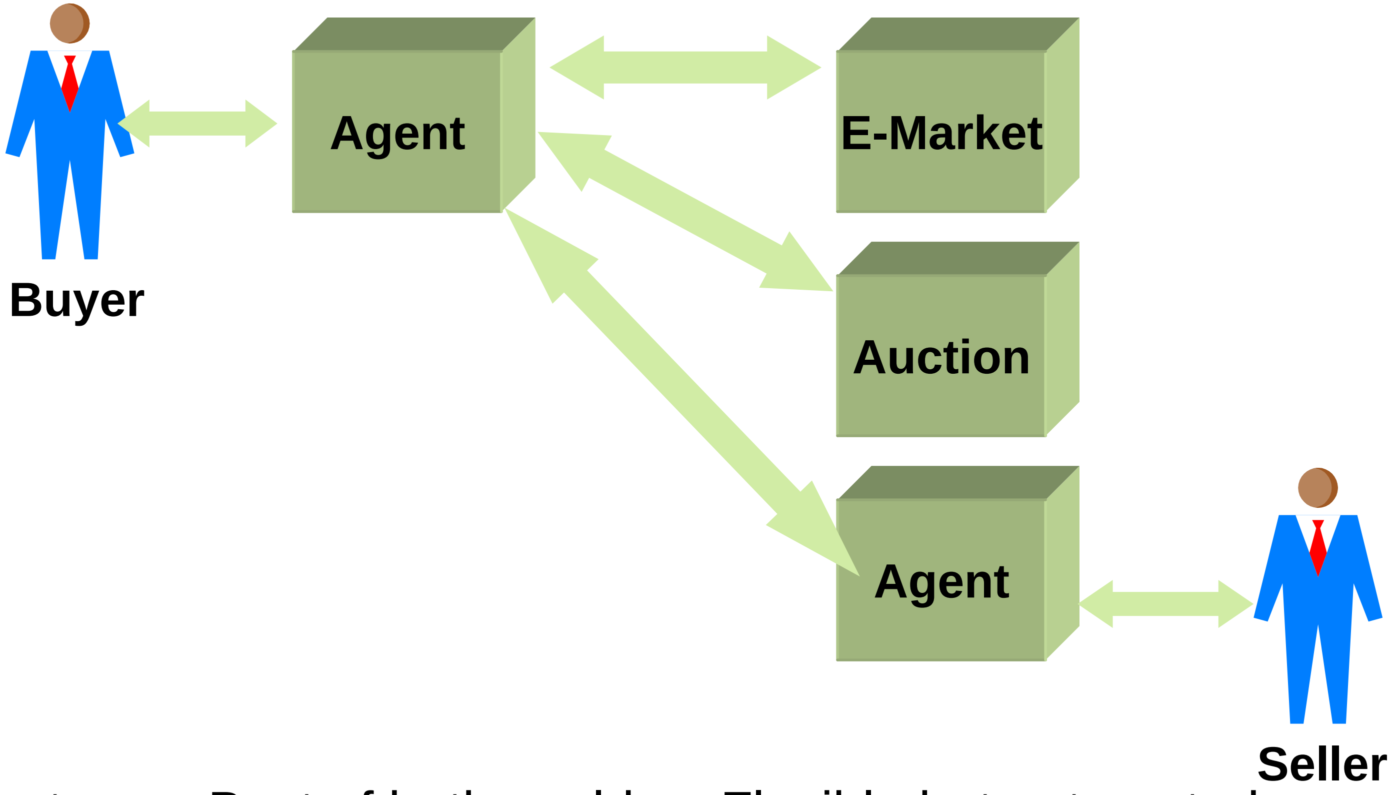
Very flexible. More competition, leading to better deals.

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.



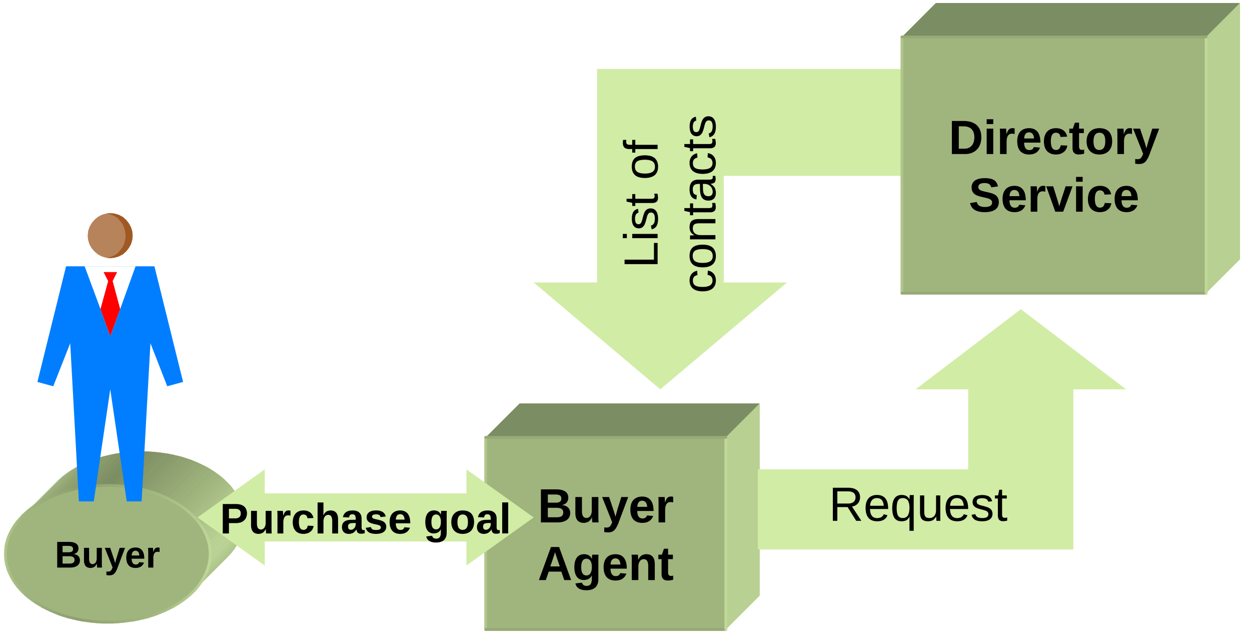
Advantages: Best of both worlds – Flexible but automated.

Disadvantages: Technology not yet widely accepted.

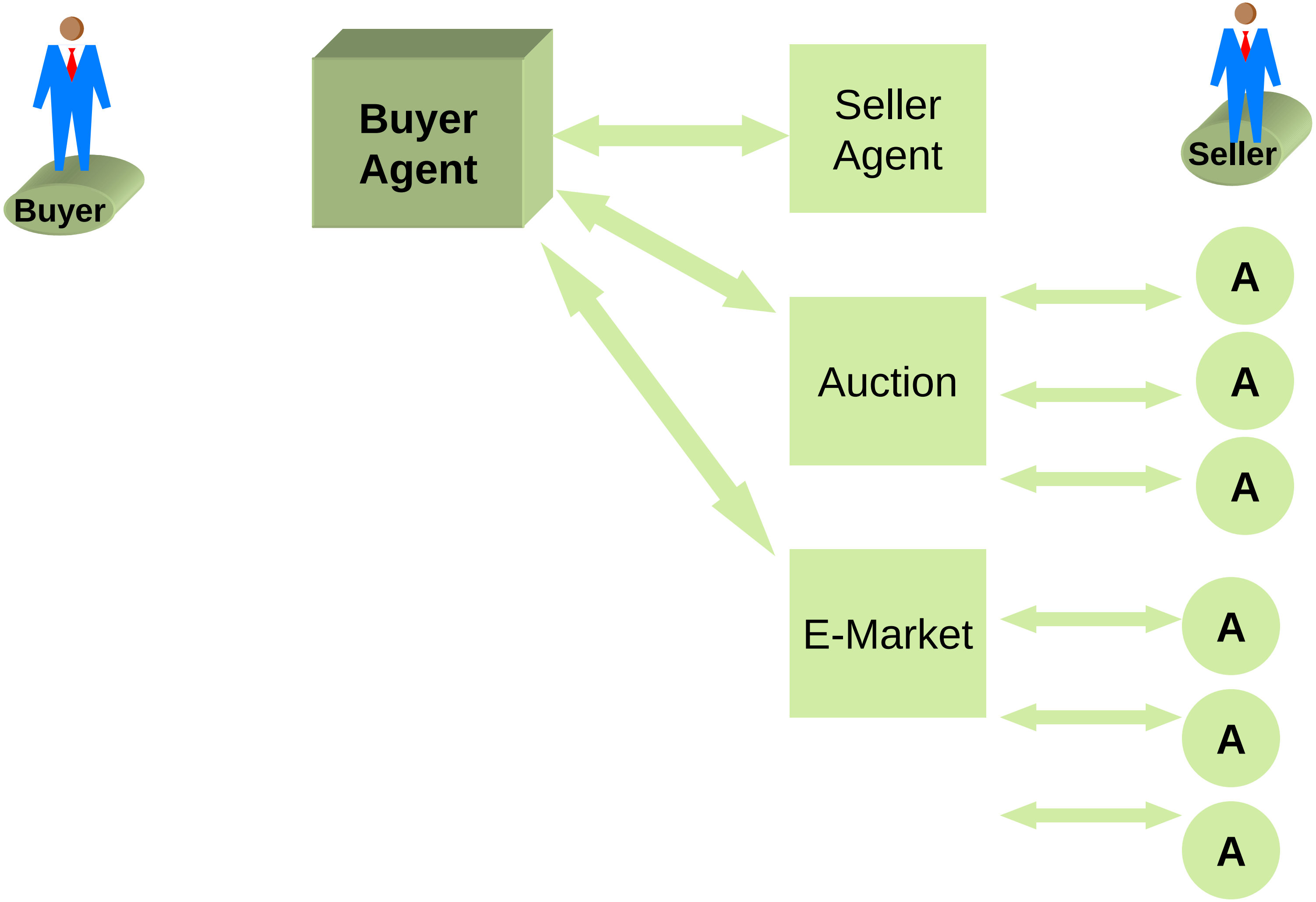
The Stages of E-Commerce

- Matchmaking
- Negotiation
- Contracting
- Contract Fulfilment

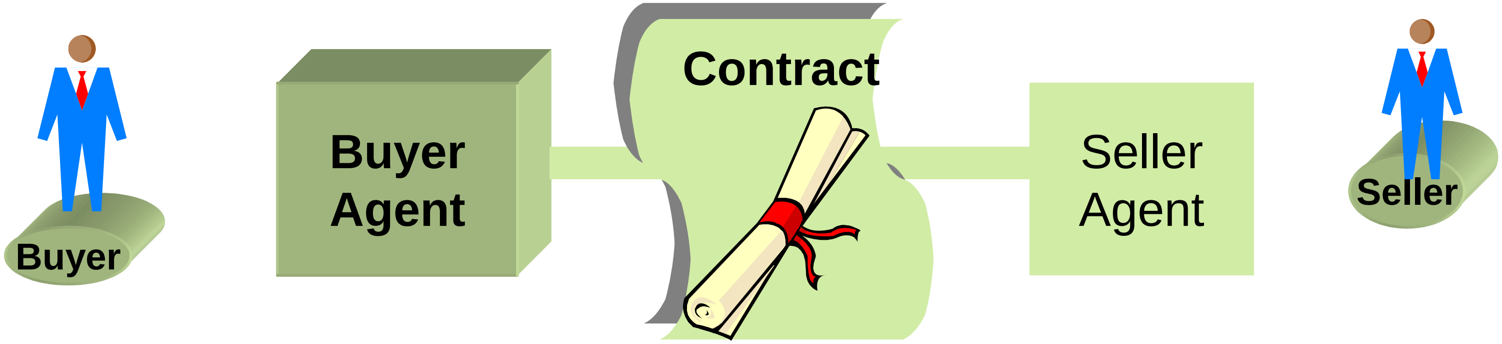
Matchmaking



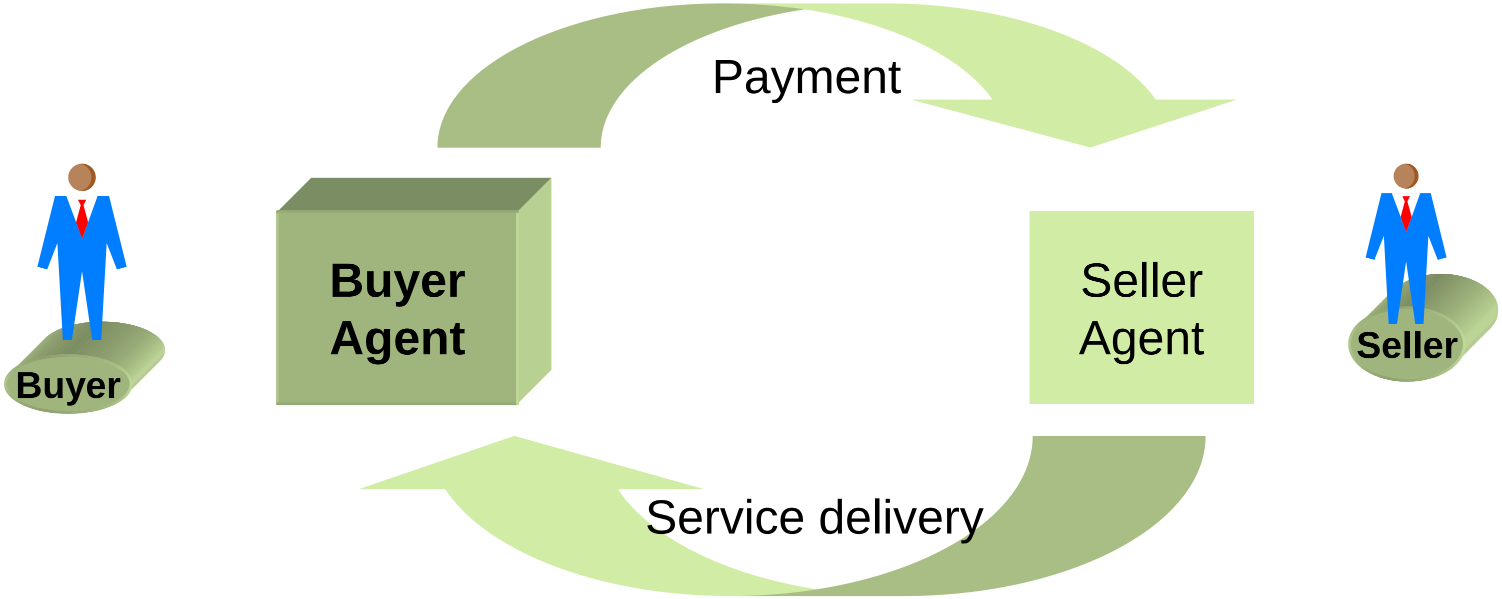
Negotiation



Contracting



Contract Fulfilment



Electronic Commerce (II)

Research competition:

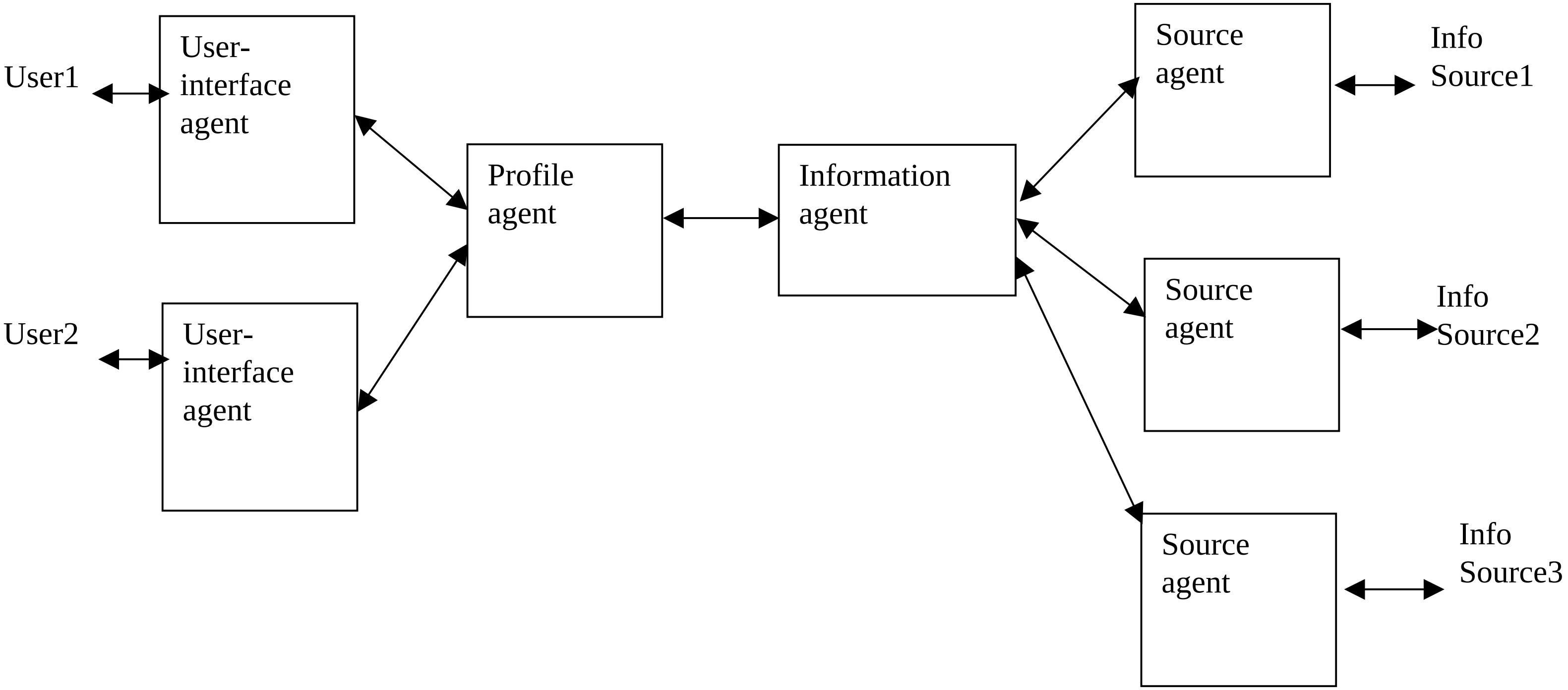
Trading Agent Competition

www.sics.se/tac/

Information Management

1. Theoretical architecture
2. Examples from Practice

General MAS Architecture for Information Management



User1

User-interface agent

User2

User-interface agent

Profile agent

Information agent

Source agent

Info Source1

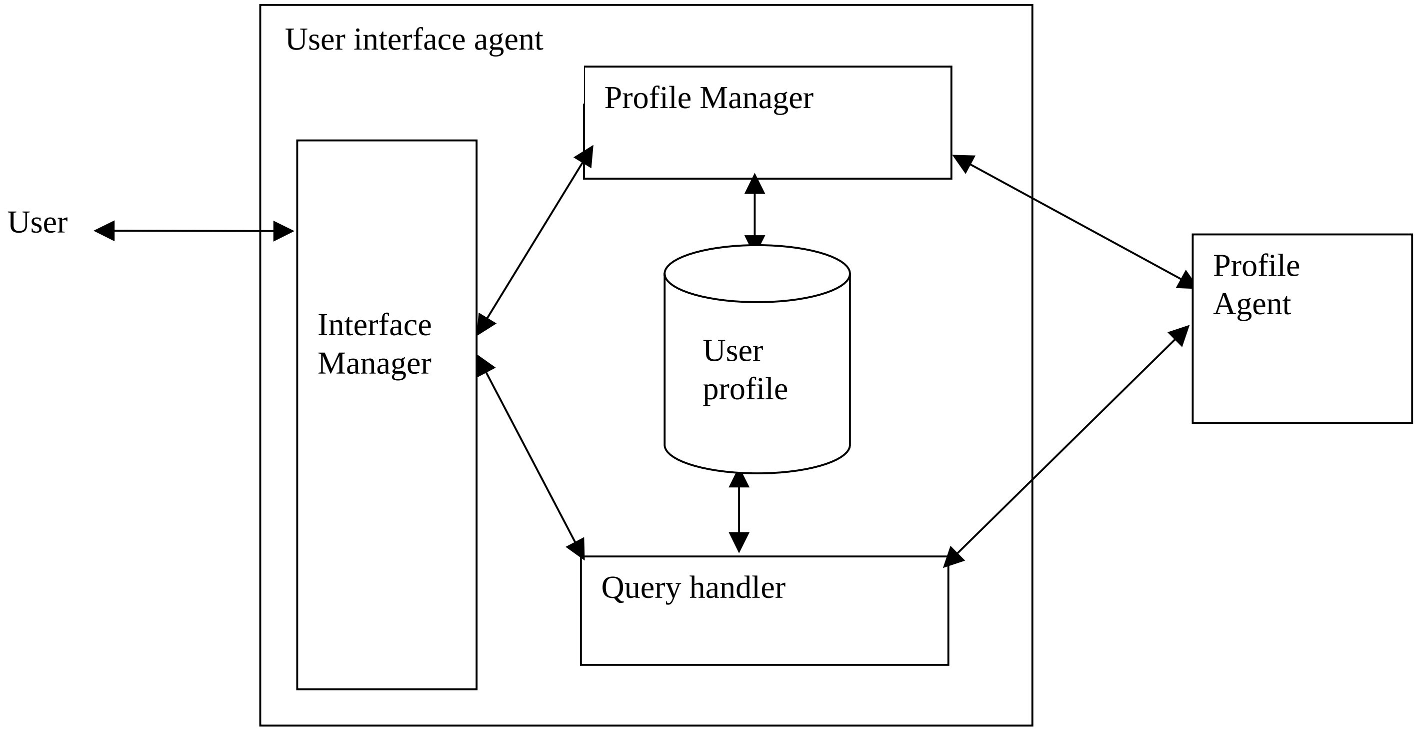
Source agent

Info Source2

Source agent

Info Source3

The User interface agent

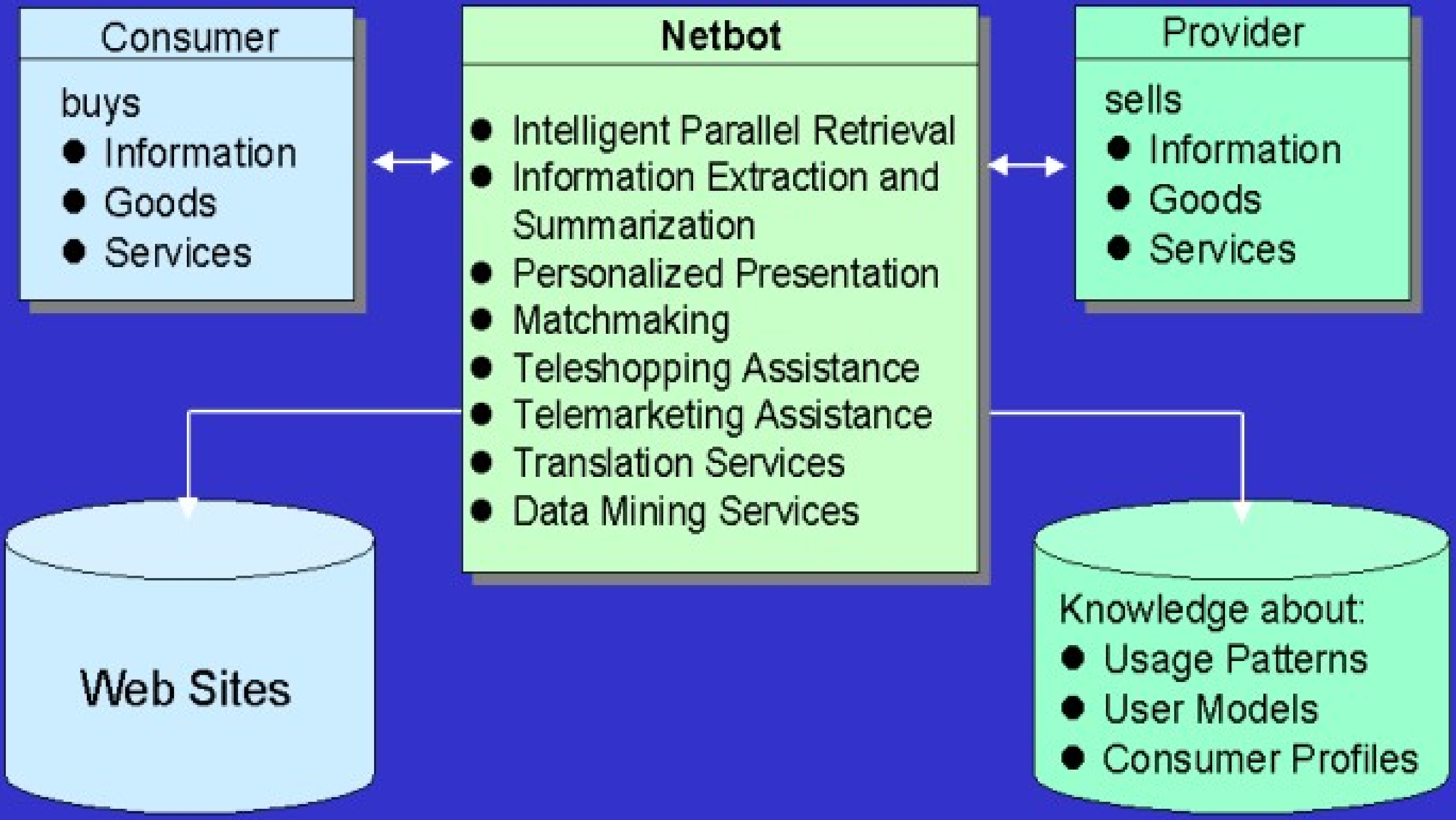


Information Management

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

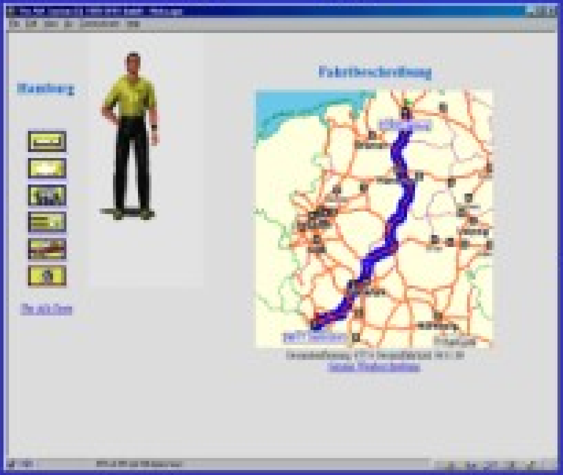
Knowledge about:
- Usage Patterns
- User Models
- Consumer Profiles

AiA: Information Integration for Virtual Webpages

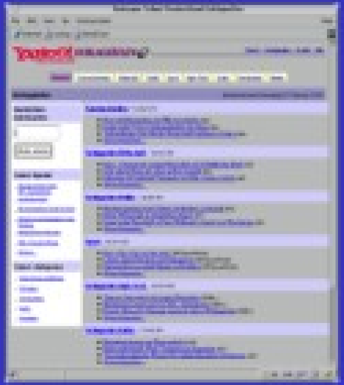
PAN Travel Agent Andi

Car Route Planner

Yahoo
Weather
Server



Yahoo
News
Server



Hotel
Guide

Gault Millau
Restaurant
Guide

Information Management

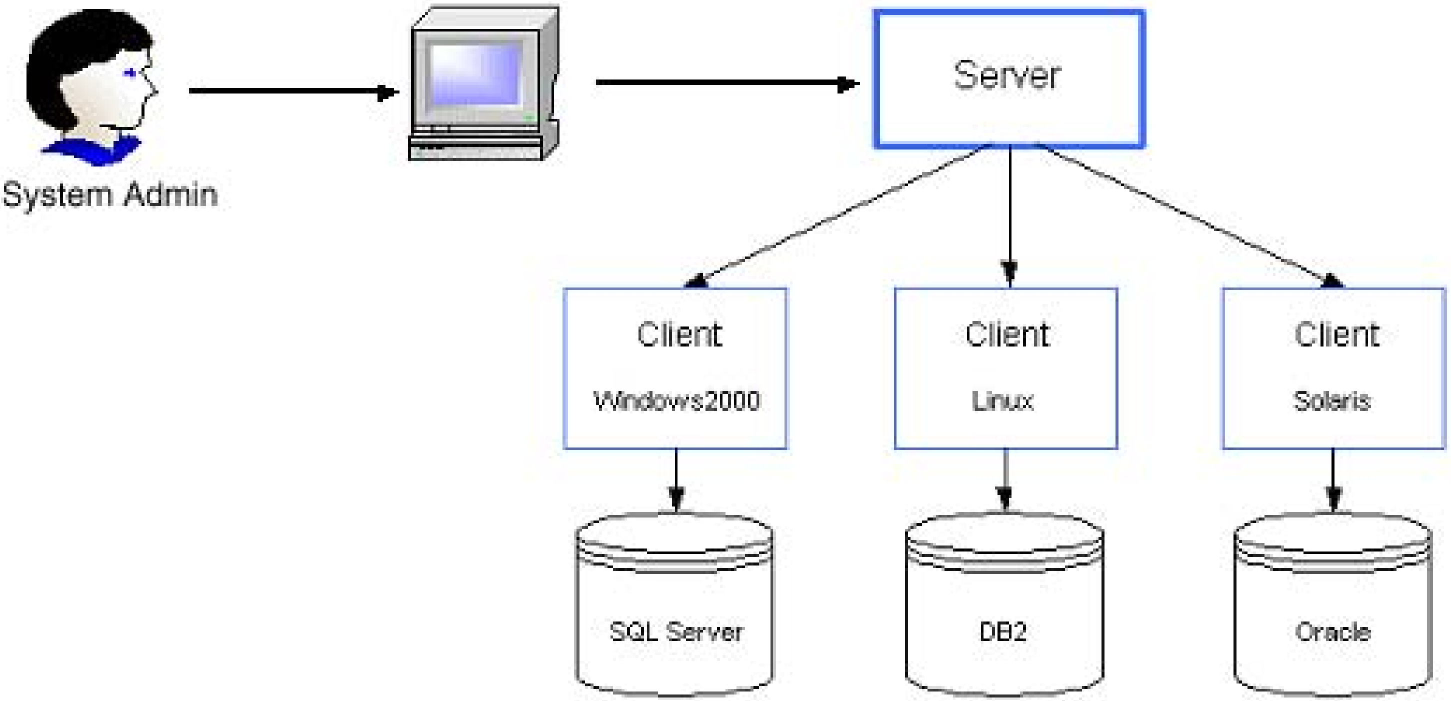
Remote system and data management

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