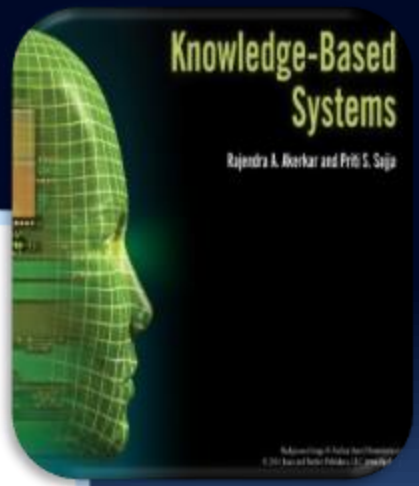

Multi-Agent Systems

Priti Srinivas Sajja

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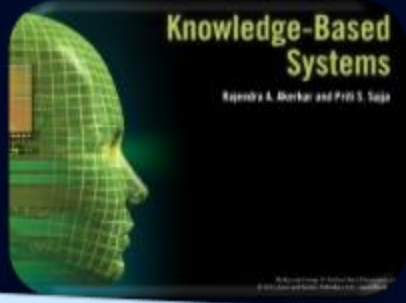
Department of Computer Science
Sardar Patel University

URL: http://pritisajja.info

Multi Agent Systems



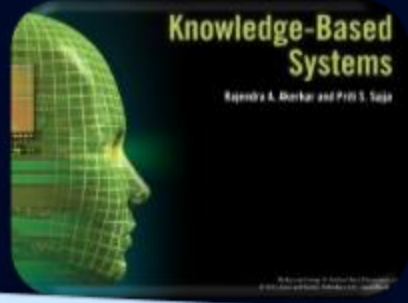
Agent

- Characteristics
- Architecture
- Advantages
- Typology
- Communication
- Objects
- Expert Systems
- MAS

- **An agent is a computational entity that:**
  - Acts on behalf of other entities in an autonomous fashion
  - Performs its actions with some level of proactivity and/or reactiveness
  - Exhibits properties like learning, cooperation, and mobility to a certain extent

- **Software agents (often simply termed agents) are software systems that freely fit the aforementioned criteria and can principally be described as inhabiting computers and networks, assisting users with computer-based tasks.**

Multi Agent Systems



Autonomy

Capability to work autonomously without human intervention. For this purpose, they are supposed to possess necessary skills and enriched with required resources.

Co-operation

In order to complete the tasks, agents must interact with users, the environment, and other agents.

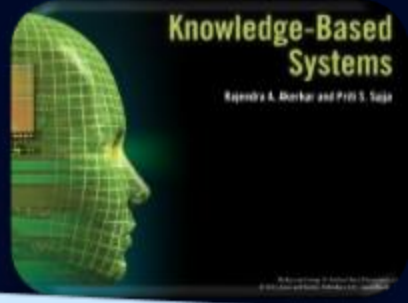
Learning

Agents should be able to learn from the entities with which they interact to complete their tasks.

Reactivity

Agents perceive their environment and respond in a timely fashion to changes enforced by the environment.

Multi Agent Systems



- Agent
- Characteristics
- **Architecture**
- Advantages
- Typology
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- Objects
- Expert Systems
- MAS

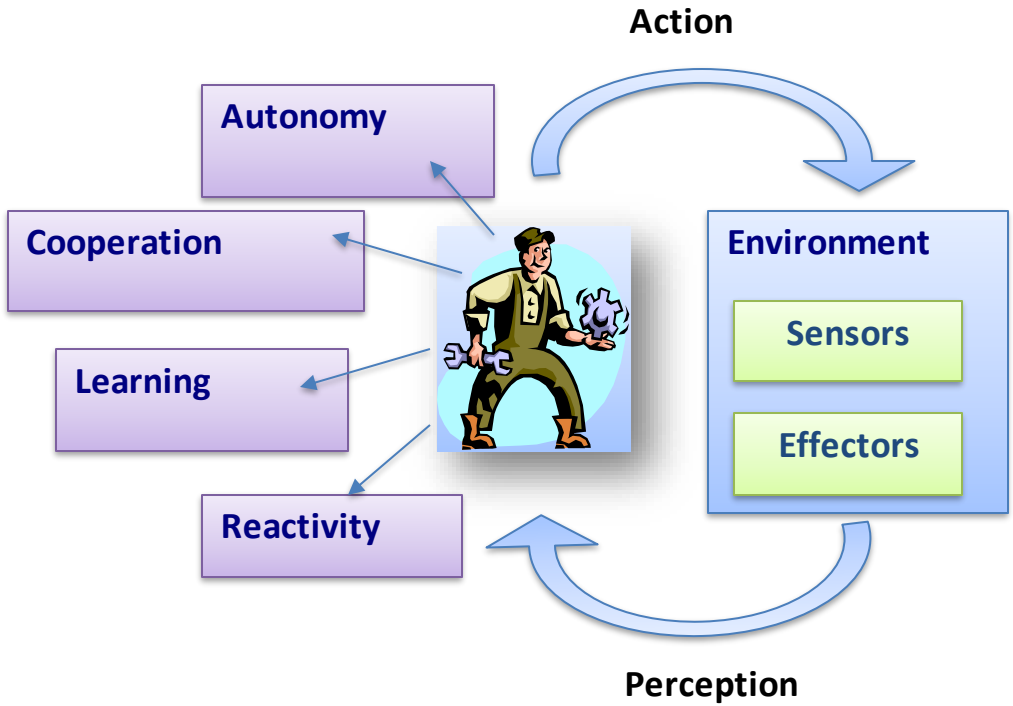

Figure 1: Architecture of an agent

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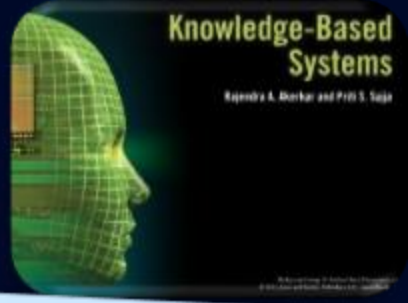
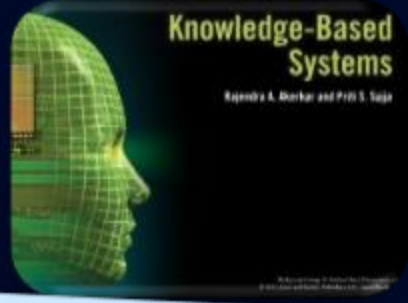
Multi Agent Systems



- They can be used to solve large, complex problems.
- They allow interconnection and interoperation of multiple existing legacy systems.
- They provide solutions to problems where information resources, expertise, and the problem itself are widely distributed.
- They enhance modularity, speed, reliability, flexibility, and reusability in problem solving.
- They lead to research into other issues—for example, understanding interactions among human societies.

Multi Agent Systems



- Agent
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- **Typology**
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Collaborative Agent

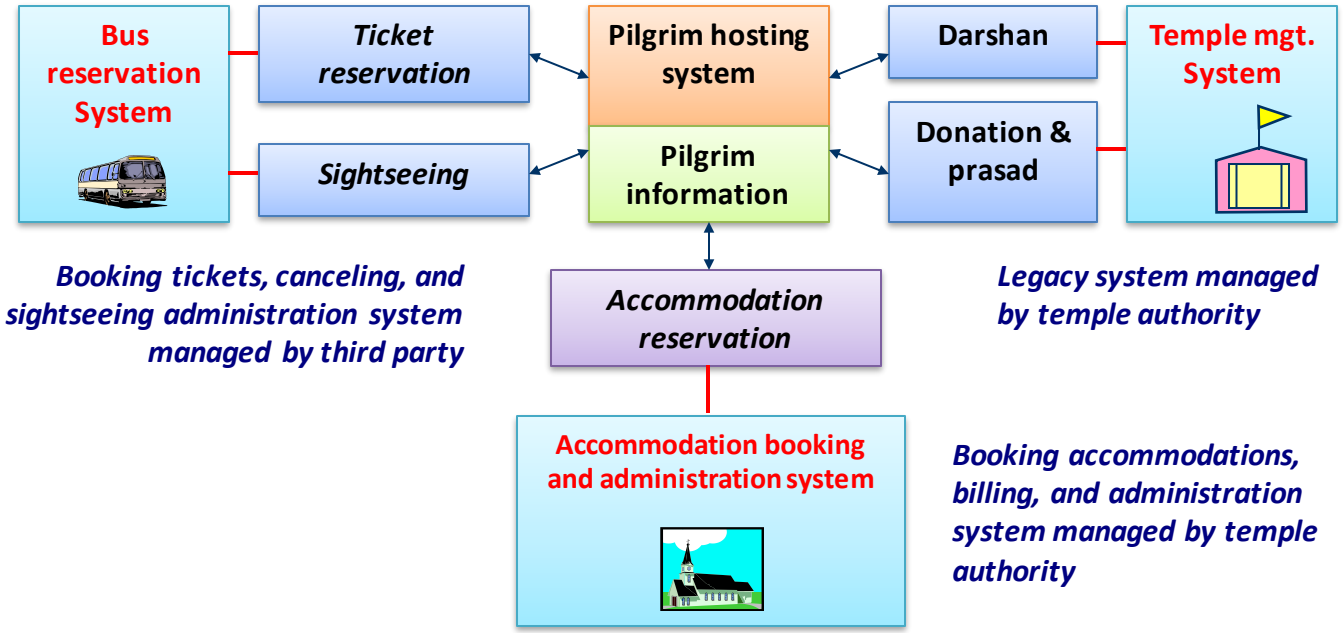

Figure 2: An example of a collaborative agent

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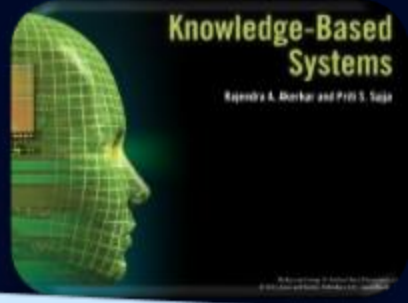
Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- **Typology**
- Communication
- Objects
- Expert Systems
- MAS

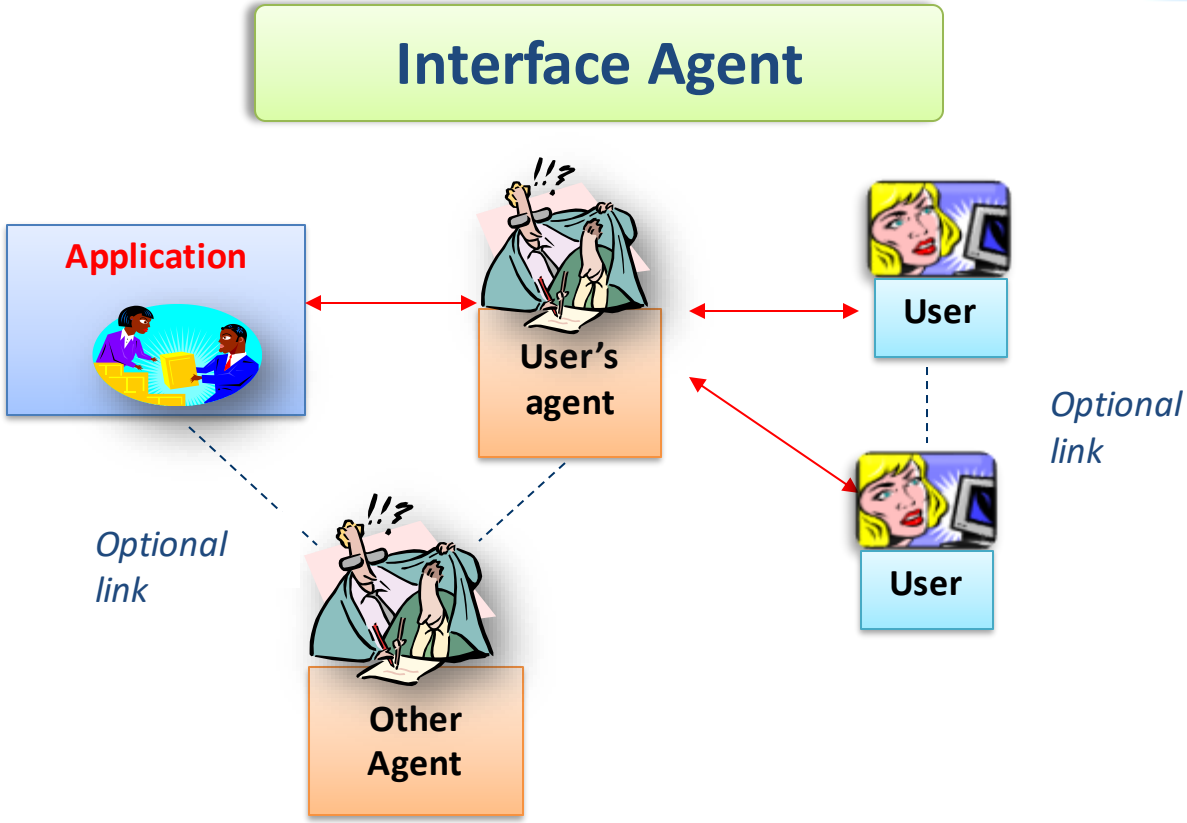
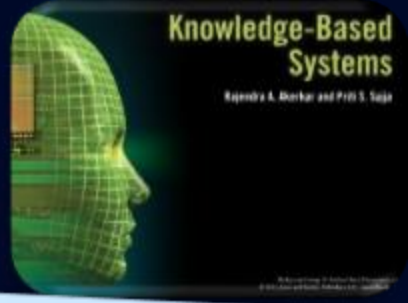


Figure 3: An example of an interface agent

Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- **Typology**
- Communication
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- Expert Systems
- MAS

Mobile Agent

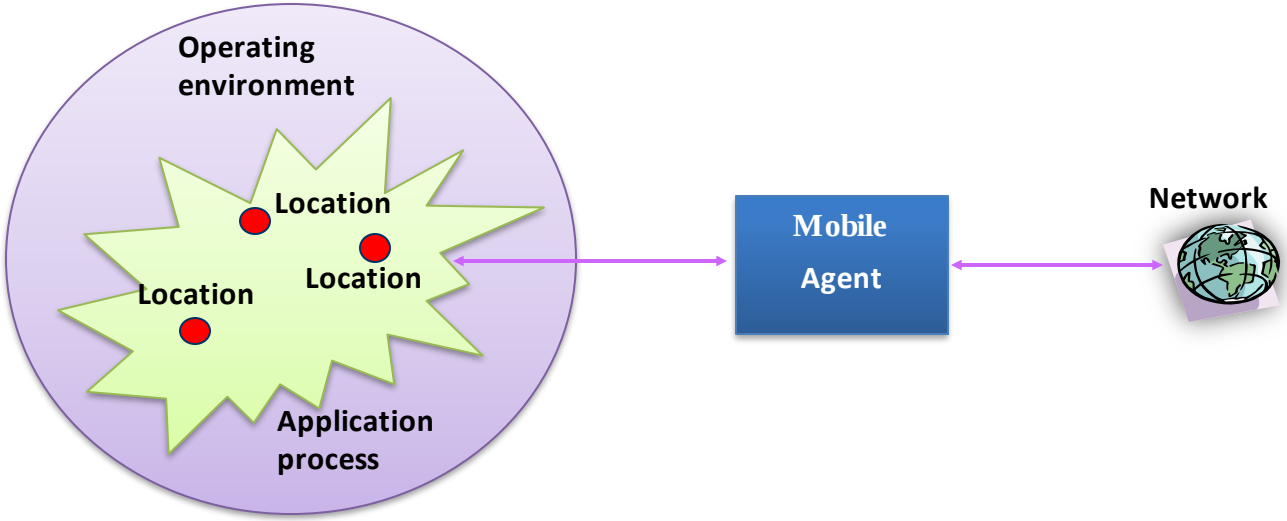
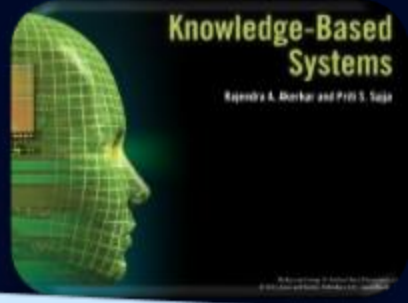


Figure 4: Workflow for a mobile agent

Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- **Typology**
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- MAS

Information Agent

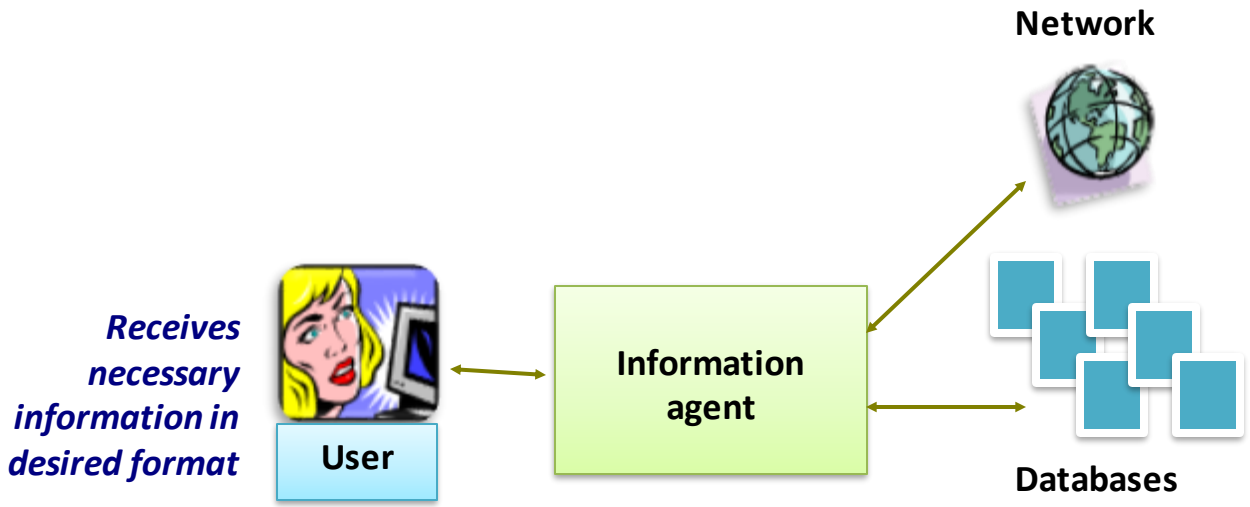
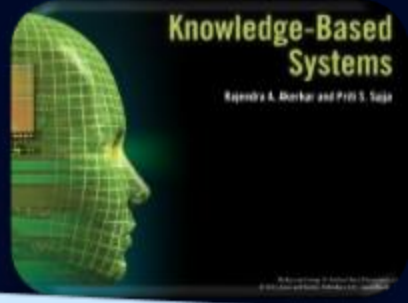


Figure 5: Workflow for an information agent

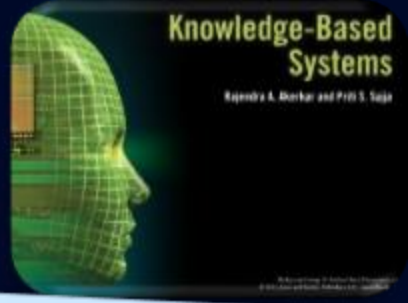
Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- **Typology**
- Communication
- Objects
- Expert Systems
- MAS

Figure 6: Structure of an intelligent agent

Multi Agent Systems

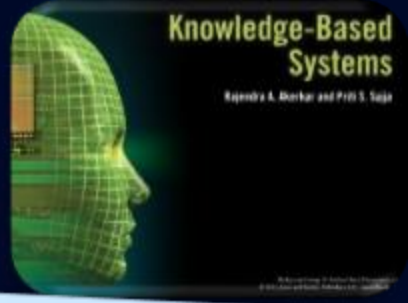


- Agent
- Characteristics
- Architecture
- Advantages
- **Typology**
- Communication
- Objects
- Expert Systems
- MAS

Hybrid Agent

- **A hybrid agent combines two or more agent categories.**
- **For example, an agent facilitating effective information searching from large databases and providing communication through a well-designed, natural-language interface is a hybrid agent because it encompasses the methodologies of an information agent as well as an interface agent.**
- **Such hybrid agents can be placed at the upper level of the agent hierarchy and hence, become application specific.**

Multi Agent Systems



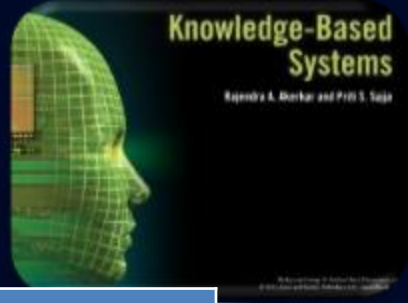
Knowledge Query and Manipulation Language (KQML) Block

(A query about the price of a share)

```
(ask-one
:content “price (Infosys, [?price])”
:receiver stock-server
:language LPROLOG
:ontology NYSE-TICKS)

(ask-all
:content "price(Infosys, [?price, ?time])"
:receiver stock-server
:language standard_prolog
:ontology NYSE-TICKS)
```

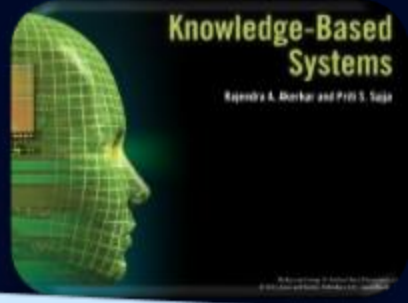
Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- Typology
- Communication
- **Agent & Objects**
- Expert Systems
- MAS

	Objects	Agents
Autonomy	Method invocation	Society interaction
Learning	Programmed	Inference
Co-operative	Restricted through Access Modifiers	More co-operative
Mobility	No	Yes
Reactivity	Reactive on Instructions (Object behaviour is static and always expected to be executed)	Can be Proactive (Object behaviour is dynamic and can refuse to perform given action)
Organization	Central	Distributed
Creation	Liberally created and destroyed	Created in predefined environment only and controls its own behaviour
Control	With system (glass box)	With agent itself (black box)
Execution	Synchronous	Asynchronous and parallel

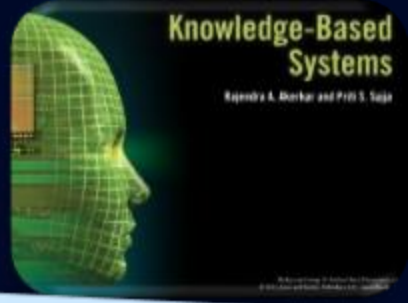
Multi Agent Systems



Similarity among objects and agents

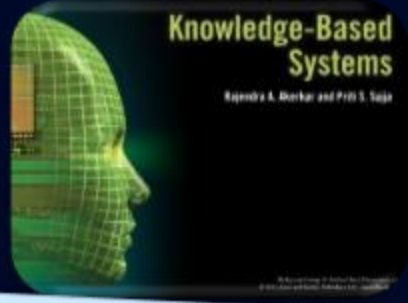
1. Both use **modular programming** approach.
2. Both have their **own internal parameter**.
3. Both **interact** with their surrounding elements.
4. Both uses **encapsulation** and information hiding.
5. Both **do not know** everything about their system.

Multi Agent Systems



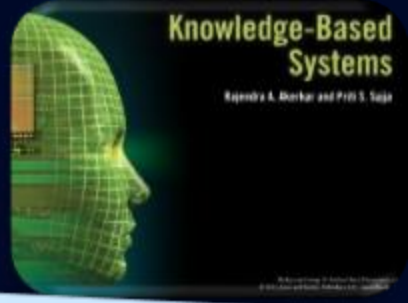
	Agents	Expert Systems
Execution Environment	Required agent execution platform	No environment needed
Behaviour	Can be proactive and reactive	Not generally capable of pro-active and reactive behaviour
Sociality	Equipped with social ability	Not generally equipped with social ability
Co-operation	Agents are co-operative	ES can not co-operate with other ES

Multi Agent Systems



- A multi agent system is comprised of several intelligent agents working together toward a goal or completion of a task.
- It is a loosely coupled network of problem-solving entities that work together to find answers to problems that are beyond the capacity of any individual problem-solving entity.
- This system is called for when complex problems require the services of multiple agents with diverse capabilities and needs.
- Besides multiple agents, a multi agent system (MAS) does the following:
  - Provides an environment for the agents
  - Sets the relationships between the entities
  - Provides a platform for a set of operations that can be performed by the agents

Multi Agent Systems



- Agent
- Characteristics
- Architecture
- Advantages
- Typology
- Communication
- Objects
- Expert Systems
- **MAS Architecture**

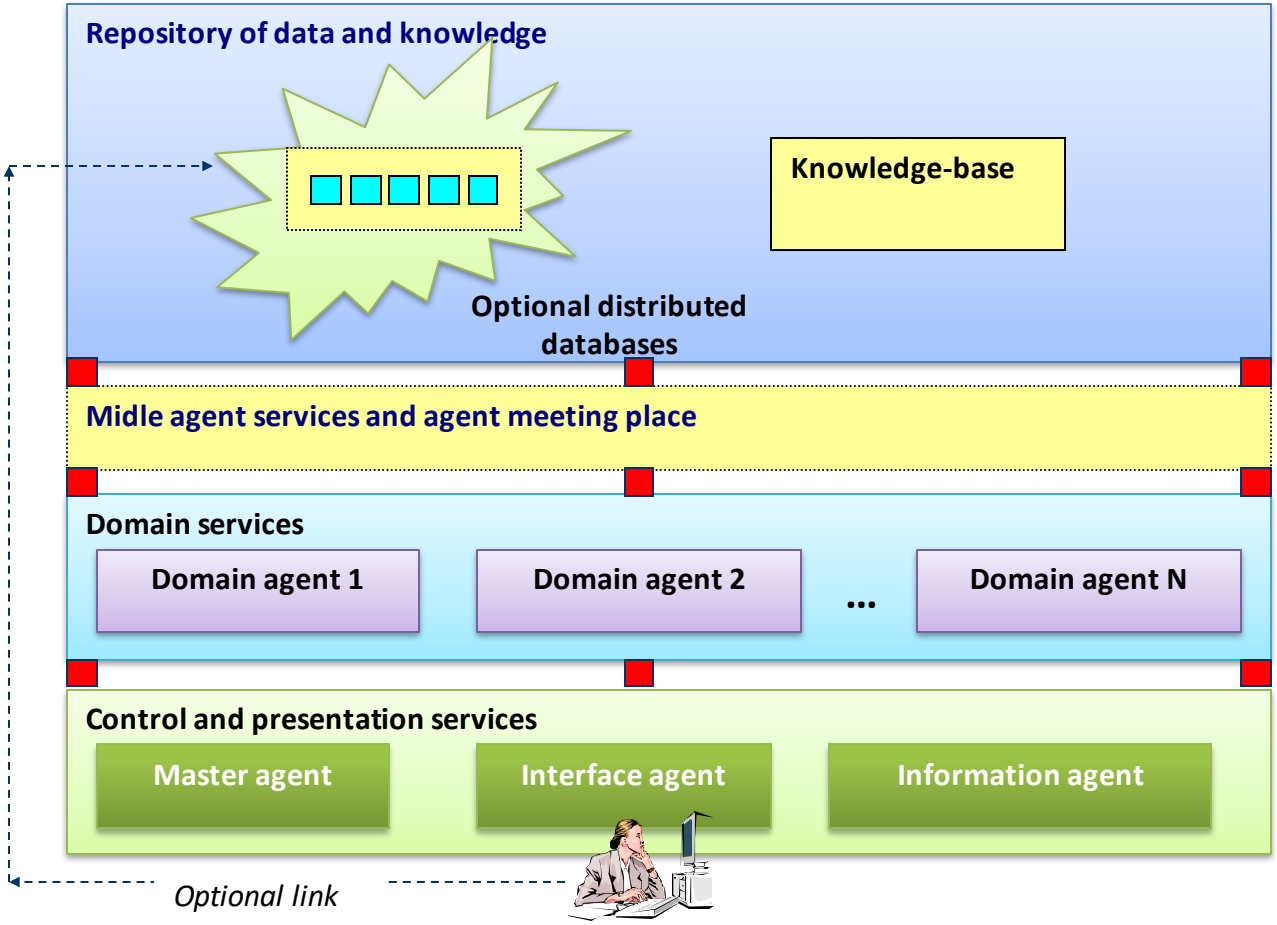
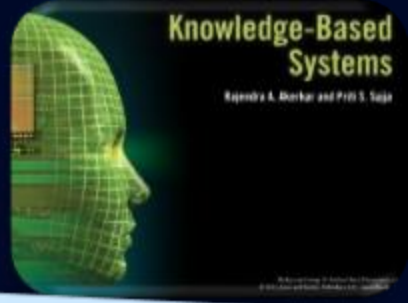


Figure 7: Layered architecture of generic multi agent system

Multi Agent Systems



- Agent
- Character
- Architecture
- Advantages
- Typology
- Communication
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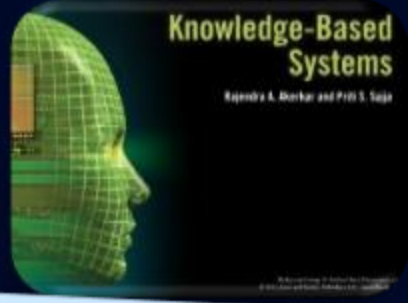
- MAS

Research Directions

- Intelligent agent designs
- Learning in a multi agent system
- Analysis and design methodology for multi agent system development
- Agent communication, specification, and/or programming languages
- Agent protocols and standards
- Agents for a Semantic Web for automatic processing of data
- Agents for information retrieval and data mining
- Supporting agents for Web services and service-oriented computing
- Agents serving as middleware for grid computing
- Knowledge management agents for an organization
- Agents for E-commerce
- Query and interface agent for business applications
- Agents for a personal assistance system

Multi Agent Systems



- Agent
- Characteristics
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Recommended Text Book

"Knowledge-based systems"

Rajendra Akerkar and Priti Srinivas Sajja
Jones & Bartlett Publishers, Sudbury, MA, USA