Introduction: What are the agents?

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Definitions of agents

- The concept of agent has been used to describe many kinds of features, e.g.:
  - Carrying out tasks at a given time
  - Combining many information resources
  - Implementing distributed artificial intelligence
  - Acting as an intelligent assistant in user interfaces
  - Ability to transfer an entity between computers
  - A believable graphic figure
  - Ability to understand an agent communication language
First direction of definitions

- Taking into account the great amount of applications that we call as agents no general definition can be based on the similarities of implementation, architecture, or underlying theory.

- The problem: definition as an individual opinion
  - One person’s **intelligent agent** may be another’s **smart object**
  - A **smart object** today may be a **dull program** tomorrow
  - Expectations and the point of view are central
First direction of definitions

American Heritage Dictionary:

agent

“one that acts or has the power or authority to act... or represent another”

“means by which something is done or caused; instrument”
What is an agent?

“By *software agent*, we mean a computer program that behaves in a manner analogous to a human agent, such as a travel agent or an insurance agent.” [Etzioni and Weld, 1995]
First direction of definitions

An agent program carries out a task in favor of someone who has delegated it.

- To avoid tedious description of tasks we want agents to be proactive, able to infer our goals.
- The agents should have knowledge of task domain and the user.
**First direction of definitions**

*software agent* is a software entity which functions continuously and autonomously in a particular environment, often inhabited by other agents and processes [Shoham, 1997]

*software agent*: an umbrella term that covers a range of other more specific and limited agent types [Nwana, 1996]
Intelligent software agents are defined as being a software program that can perform specific tasks for a user and possesses a degree of intelligence that permits it to perform parts of its tasks autonomously and to interact with its environment in a useful manner.
What is an agent? [Brenner et al., 1998]

- An agent acts on behalf of its master within its environment, and carries out tasks without the user actively participating in the task.
  - A software agent is like a travel agent, but acts in a different environment. (no offence here, folks)
  - The greatest problem is the level of artificial intelligence, even though we can achieve accurate results in a specific area.
The environment of an agent

- Human users
  - sensing
- Information sources
  - file system
  - databases
  - network/Internet
- Other agents
What is an agent: classification

- Franklin and Graesser: Is it an Agent or just a Program?: A Taxonomy of Autonomous Agents
  [http://www.msci.memphis.edu/~franklin/AgentProg.html](http://www.msci.memphis.edu/~franklin/AgentProg.html)

*Autonomous Agents*
- Biological Agents
- Robotic Agents
- Computational Agents
  - Software Agents
  - Artificial Life Agents
- Task-specific Agents
- Entertainment Agents
- Viruses
Agents by Franklin ja Graesser

An autonomous agent is a system situated within and as a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future.

- Humans and animals are “high-end” agents, but also a thermostat or bacteria fit in this definition.
- The definition requires temporal continuity and that the agent belongs to some environment that it can have an effect on; these requirements make a lot of ordinary programs not to fit in.
Features of agents

- **reactive**: responds in a timely fashion to changes in the environment
- **autonomous**: exercises control over its own actions
- **goal-oriented**: does not simply act in response to the environment
- **temporally continuous**: is a continuously running process
- **communicative**: communicates with other agents, perhaps including people
- **learning**: changes its behavior based on its previous experience
- **mobile**: able to transport itself from one machine to another
- **flexible**: all actions are not scripted
- **character**: believable personality and emotional state
Expected features of agents

- Autonomy, initiative
  - Goal-oriented: high-level goals
  - Cooperation abilities
  - Flexibility: many ways for carrying out operations
  - Environment-aware
- Temporally continuous process
- Personality
- Communicating ability
  - With other agents and humans
- Adaptability, learning
- Mobility
Features of agents [Brenner et al., 1998]

Agent
- autonomy
- mobility
- reasoning & learning
- proactivity
- goal-orientation
- communication
- character
- cooperation
- coordination

Environment
Features of agents

- Intra-agent and inter-agent features
  - reactivity
  - proactivity
  - goal-orientation
  - reasoning & learning
  - autonomy
  - mobility
  - communication
  - cooperation
  - character
An agent model [Nwana, 1996]

- Smart agents
- Collaborative agents
- Learn
- Collaborative learning agents
- Cooperate
- Interface agents
- Autonomous
Is an agent intelligent?

- The word **intelligent** is used in a very broad sense when talking of software agents.
  - Some people associate the word with any autonomous process. However, this is not enough to call them as intelligent agents.
  - In order to call an agent as an intelligent agent it has to be able to react on changing environment.
  - Often, however, already very elementary reasoning is described as intelligent behavior.
  - A large knowledge base does not make an agent intelligent but knowledgeable; many still call this as intelligence when agents are concerned.
Agents

- Agents
  - Carry out tasks independently on behalf of their client or master
    - a travel agent (human)
    - a planerary crawler (robot)
    - a web spider (software)
  - Require a certain amount of “intelligence” to carry out their tasks
    - Where is the line? Autonomy?
  - Are interacting with their environment
[Nwana et al., 1996]

- The first wave (1970’s – 1980’s)
  - Distributed AI research, symbolic models
  - Inter-agent communication, task distributing, coordination and cooperation, negotiating conflicts etc.
- The second wave (1990’s – 2000’s)
  - A broad scale of agents from dumb to semi-intelligent
  - The main emphasis has moved from reasoning to doing
Types of agents

- Problem solving ability
  - A **reactive agent** reacts on outside events
  - An **intentional agent** can adapt its function based on its goals and beliefs, and can plan and execute its tasks
  - A **social agent** knows the other agents well and uses them to help in its task
Agent types [Brenner et al., 1998]

![Diagram of agent types]

- Intelligent agents
  - Human agents (e.g. travel agent)
  - Hardware agents (e.g. robot)
  - Software agents
    - Information agents
    - Cooperation agents
    - Transaction agents
Agent types [Brenner et al., 1998]

- **Information agents**
  - Support the search of information on the web and other distributed systems
  - Tasks: retrieving information, parsing information, filtering information, presenting information

- **Cooperation agents**
  - Solve difficult problems by cooperating with the other actors, as other agents, humans and the environment
  - Require an agent communication protocol

- **Transaction agents**
  - I.e., in eCommerce
The classification of agents

(Brenner et al.): three axes

- intelligence
  - reactivity
  - proactivity
  - reasoning & learning
  - character
  - cooperation
  - autonomy

- mobility
  - autonomy
  - mobility

- amount of agents
  - interaction
  - cooperation
  - communication
Classification (Brenner et al.)
Information Agents
Information Agents

- Support the user in information search and filtering
  - Information search
  - Information filtering
  - Information observing
  - Guidance (help systems)
Search engine types

- Simple search engines
  - AltaVista, WebCrawler, Excite, HotBot, InfoSeek, OpenText, Lycos
  - spider + database + simple user interface

- Meta search engines
  - MetaCrawler, MetaGer, SavvySearch
  - A sort of user interface agent, but very simple

- Personalized search engines
  - Adapt to the preferences of the user
  - User profiles
Guide agents

- **Web Browser Intelligence**
  - A local proxy that helps the user

- **Letizia**
  - A centralized proxy that helps the user
Cooperation Agents

- Number of agents
- Degree of intelligence
- Mobility

Multi-agent system
Single agent
Stationary
Mobile
Simple
Complex
Cooperation Agents

- Can solve even complex problems in cooperation with other users and agents
  - Entertainment agents
  - Groupware and collaboration agents
  - Network management agents

- By definition these are some kind of multi-agent systems
Entertainment agents

- **Firefly**
  - Based on personal user profiles, recommend for example music

- **OpenSesame**
  - Based on user profiles and active observing
Groupware agents

- MAXIMS
  - The email agents of many users exchange information among themselves

- Butterfly
  - Tracks thousands of newsgroups and recommends interesting ones to its users

- Let’s Browse
  - Guide the browsing of one user based on the browsing behavior of the other users
Transaction Agents
Transaction Agents

- Observing and carrying out different transactions
  - eCommerce: ordering, paying
  - Controlling manufacturing processes
  - ...

Bargain agents

- eCommerce search agents aim at helping in Web-based commerce
  - The agent finds out where a specific product can be bought
  - The agents compares prices and makes recommendations
  - The agent orders the product (if it is allowed...)
- Agents as intermediate brokers can meet in an electronic marketplace and negotiate on prices and terms of bargain
eCommerce Agents

- BargainFinder
- BargainBot
- PDA@Shop
- Classified Warehouse
- Jango
- Kasbah
(A sort of) Conclusion

- The concept of *agent* is associated with many different kinds of software and hardware systems. Still, we found that there are similarities in many different definitions of agents.
  - Unfortunately, still, the meaning of the word “agent” depends heavily on who is speaking.
The architecture of agent systems depends heavily on the style and purpose of specific agent systems. Next we discuss briefly the following:

- The internal model of agents: deliberative and reactive agents
- Agent cooperation: individual agents and distributed agent systems
- Ways of distribution: stationary and mobile agents
The internal model of agents

- Deliberative agents
  - based on artificial intelligence techniques
  - complex
  - good results, but slow systems

- Reactive agents
  - simpler than deliberative agents
  - fast
  - react on outside events
Agent cooperation

- Individual agents
  - usually for smaller tasks
  - when the task is handled by the user’s personal computer
  - when distribution does not give any benefits

- Distributed agent systems
  - usually for more demanding tasks
  - when the task is handled by several computers
  - when distribution makes processing more efficient by cutting down network traffic or by speeding up processing (making use of parallel processing)
Distributed agent systems

- Distributed stationary agents
  - when handling the task is beneficial using several computers
  - when one agent can accomplish all its subtasks in one computer
  - when the group of computers is initially known

- Mobile agents
  - when the group of computers is not completely known
  - when there are so many computers that it is not rational to run the agent in them all the time
  - when resources of the computers need to be spared
Distributed agents
Mobile agents

Server n → Server 2 → Server 1 → Browser etc. → Server 3 → Server 4

migration → result
Open questions

- Who is legally responsible for the actions of agents?
- How many tasks and which tasks the users want to delegate to agents?
- How much can we trust in agents?
- How to protect ourselves from erroneously working agents?
- ...

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