

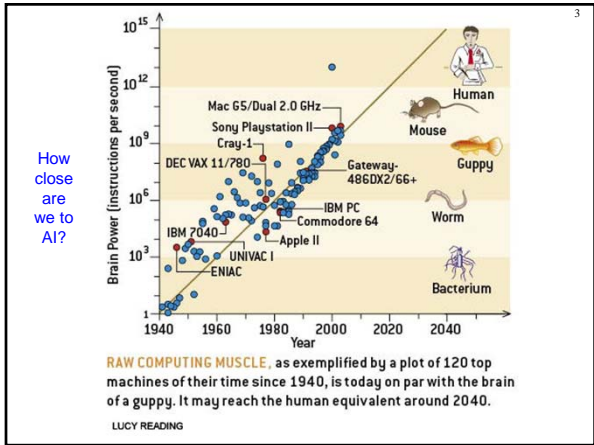
**Intelligent Autonomous Agents**  
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**Lecture #1- Introduction**

- Computing power and trends
- Simple autonomous agent
- Characteristics of agents
- Differences between agents and other systems
- Typology of agents
- Related disciplines
- Reference – Ch. 1 & 2, papers



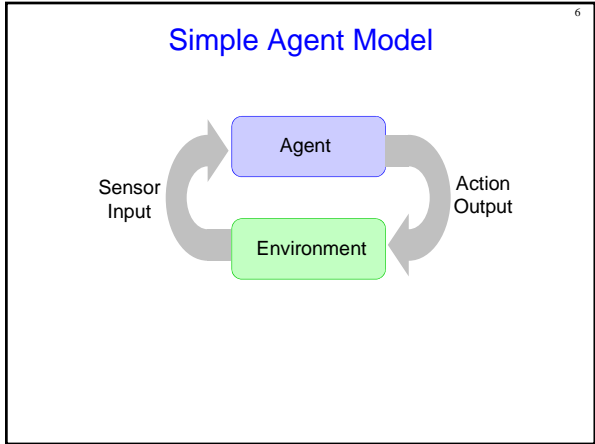
**Computing Trends**

- **Ubiquity** → mobility, pervasiveness, deep integration into all-day-life
- **Interconnection** → distributed systems, web services, grid computing, global computing
- **Intelligence** → growing complexity of tasks, (including AI but not necessarily) ...
- **Delegation** → changing information culture, computer systems take responsibility
- **Human-Orientation** → GUIs, IDEs, personalization, context aware computing,...

**Software Advances**

Programming has progressed through:

1. sub-routines
2. procedures & functions
3. abstract data types
4. objects
5. to *agents*



## Agent Characteristics

“Simple agents” (not intelligent)

- thermostat;
- UNIX daemon (e.g., biff).

*An intelligent agent is a computer system capable of flexible autonomous action in some environment.*

By *flexible*, we mean

- *reactive*
- *pro-active*
- *social*

## Reactivity

- If a program’s environment is guaranteed to be fixed, the program need never worry about its own success or failure — program just executes blindly.
- Example of *fixed environment*: compiler.
- The real world is not like that: things change, information is incomplete. Many (most?) *interesting environments are dynamic*.
- Software is hard to build for dynamic domains: program must take into account the possibility of failure — ask itself whether it is worth executing!
- A *reactive* system is one that maintains an ongoing interaction with its environment, and responds to changes that occur in it (in time for the response to be useful).

## Proactiveness

- Reacting to an environment is easy (e.g., stimulus response rules).
- But we generally want agents to *do things for us*
- Hence **goal directed behavior**
- Pro-activeness = generating and attempting to achieve goals; not driven solely by events; taking the initiative
- Recognizing opportunities

## Social Ability

- The *real world is a multi-agent environment*: we cannot go around attempting to achieve goals without taking others into account.
- Some goals can only be achieved with the cooperation of others.
- Similarly for many computer environments: witness the Internet.
- *Social ability* in agents is the ability to *interact* with other agents (and possibly humans) *via some kind of agent-communication language*, and perhaps cooperate with others.

## Other Agent Properties

Some agents have one or more of the following:

- *mobility*: the ability of an agent to move around an electronic network (code moves between computers);
- *veracity*: an agent will not knowingly communicate false information;
- *benevolence*: agents do not have conflicting goals, and that every agent will therefore always try to do what is asked of it;
- *rationality*: agent will act in order to achieve its goals, and will not act in such a way as to prevent its goals being achieved — at least insofar as its beliefs permit;
- *learning/adaptation*: agents improve performance over time.

## Two Key Goals

1. How do we **build** agents capable of *independent, autonomous action* to successfully *carry out tasks* we delegate to them?
2. How do we **build** agents capable of *interacting* (cooperating, coordinating, negotiating) *with other agents* while *performing tasks* delegated to them.  
What if the **other agents cannot be assumed to share the same interests/goals?**



### Definitions of Agents

- No single, common definition for concept **Agent**  
Example: learning ability (adaptability): May not be desired in e.g. flight control system.
- Wooldridge: An agent is a **computer system** that is **situated** in some environment, and that is capable of interacting in this environment in order to meet its objectives
- **Mobility** is sometimes required : (in real or virtual environments), **Veracity** (Agent will not communicate wrong information), **Benevolence** (no conflicts, fulfillment of all goals will be tried)
- **goal orientation** is sometimes called **Rationality**

### Software and Robotic Agents

### Software Agent Typology

### Collaborative Agents

- Cooperation + autonomy
- BDI (beliefs, desires and intentions) (+ obligations)
- several motivations
  - problems too large for a single agent
  - for the interconnecting and interoperation of multiple existing systems
  - for distributed problems
  - to enhance modularity, speed, reliability, flexibility and reusability at the Kn level
- eg. Electric Elves, CMU's Pleiades system (task agents and infoagents, KQML+e-mail), ADEPT, MII, ARCHON, etc.

### Interface Agents

- Observing and imitating the user
- Receiving positive and negative feedback from the user – build a user profile
- Receiving explicit instructions from the user
- Asking other agents for advice
- Learning and using learned knowledge, negotiate with other agents, extend to more interesting areas such as entertainments
- eg. scheduling meetings, assistance in web browsing, remembrance, news agents, matchmaking (buyer and seller), classifying ads service, etc.

### Mobile Agents

- Reduce communication costs, adv. when limited local resources, easier coordination, asynchronous computing, free market trading service, flexible distributed computing, etc.
- Eg. Telescript architecture
  - Telescript is an interpreted object-oriented and remote programming language
  - Telescript engine (telescript API and OS) sends off and accept mobile agents.
- Java, Agent-Tcl, Safe-Tcl, etc.
- Transportation, authentication, secrecy, security, cash, performance issue for too many mobile agents, interoperability, brokering/directory services, service communication

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### Information/Internet Agents

- Drowning in data, but starved of information
- Managing, manipulating or collating information from many distributed sources
- Searching and indexing
- Using a host of Internet management tools such as Spiders (a Spider is an indexer able to search the WWW, depth-first, and store the topology of the WWW in a DBMS and the full index of URLs) and search engines in order to gather the information
- Eg, softbots

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### Hybrid Agents

- Union of the benefits of agents of several different philosophies
- Eg. InteRRap (deliberative + reactive), TouringMachines (dynamic + rational + mobile), Hayes-Roth's integrated architecture, PRS (procedural reasoning system), CIRCA

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### Heterogeneous Agent System

- An integrated set-up of at least two or more agents which belong to two or more different agent classes
- Eg. PACT

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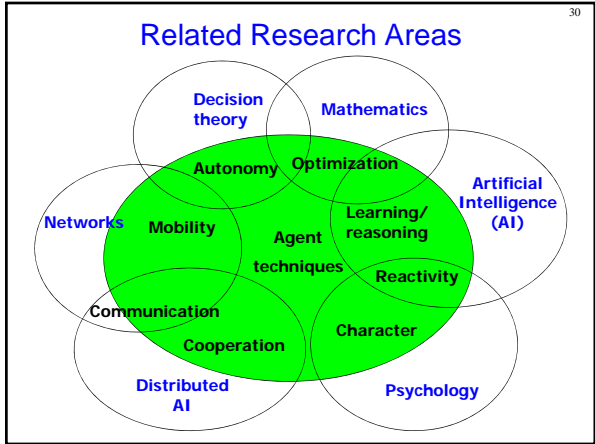
### Agents and Objects

- Are agents just objects by another name?
- Objects:
  - encapsulates some state;
  - communicates via message passing;
  - has methods, corresponding to operations that may be performed on this state.
- Agents are more complicated

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### Main differences

- Agents are autonomous
  - agents embody stronger notion of autonomy than objects, and in particular, they decide for themselves whether or not to perform an action on request from another agent
- Agents are smart
  - capable of flexible (reactive, pro-active, social) behavior, and the standard object model has nothing to say about such types of behavior
- Agents are active
  - a multi-agent system is inherently multi-threaded, in that each agent is assumed to have at least one thread of active control.




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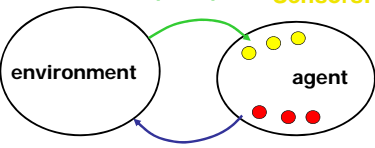
### What is an Autonomous Agent?

**Interacts with its environment**

1. can **sense** its environment
2. make **decisions**, and
3. take **action**



percepts    **Sensors: eyes, sonar, ...**



actions    **Effectors: hands, motors, ...**

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### Summary

- Introduction to the field of autonomous agents
- References
  - Chapters 1 & 2 in Wooldridge text
  - Chapter 2 in AIMA
  - Prologue, Chapter 1 in Weiss text