Intelligent Agents & Multi-Agent Systems

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Intelligent Agent: what is about?

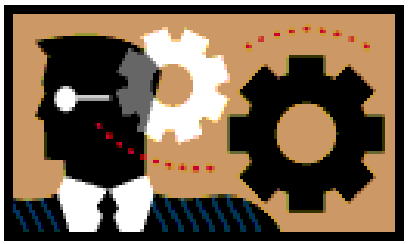
- An "intelligent" software
- A robot

An intelligent agent is characterized by…

- **Cognitive level** (reactive, deliberative, hybrid)
- **Autonomy** (complete to fully controlable)
- **Proactiveness**
- **Capabilities** (what she can do)
- **Sociability** (cooperative to antagonistic)

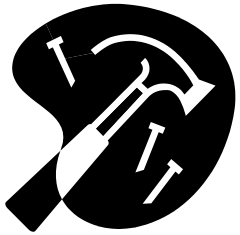
What she can do then?

- Reasoning



- But also

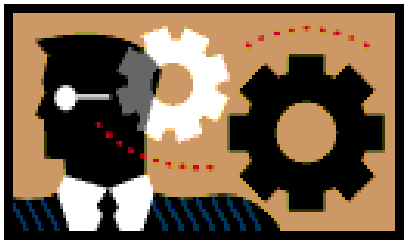
- Acting
  - Alone

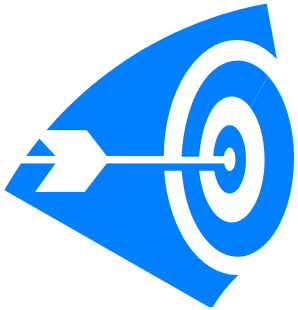


  - With other agents

Agent as an individual computational entity

But reasoning for what?





Choosing a goal

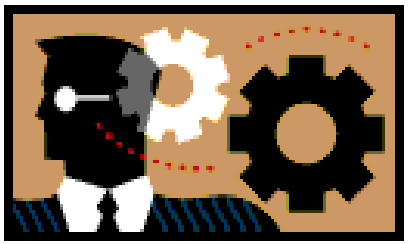
Building a plan for achieving a task

Executing a task for achieving a goal

Agent as an individual computational entity

Reasoning for what?

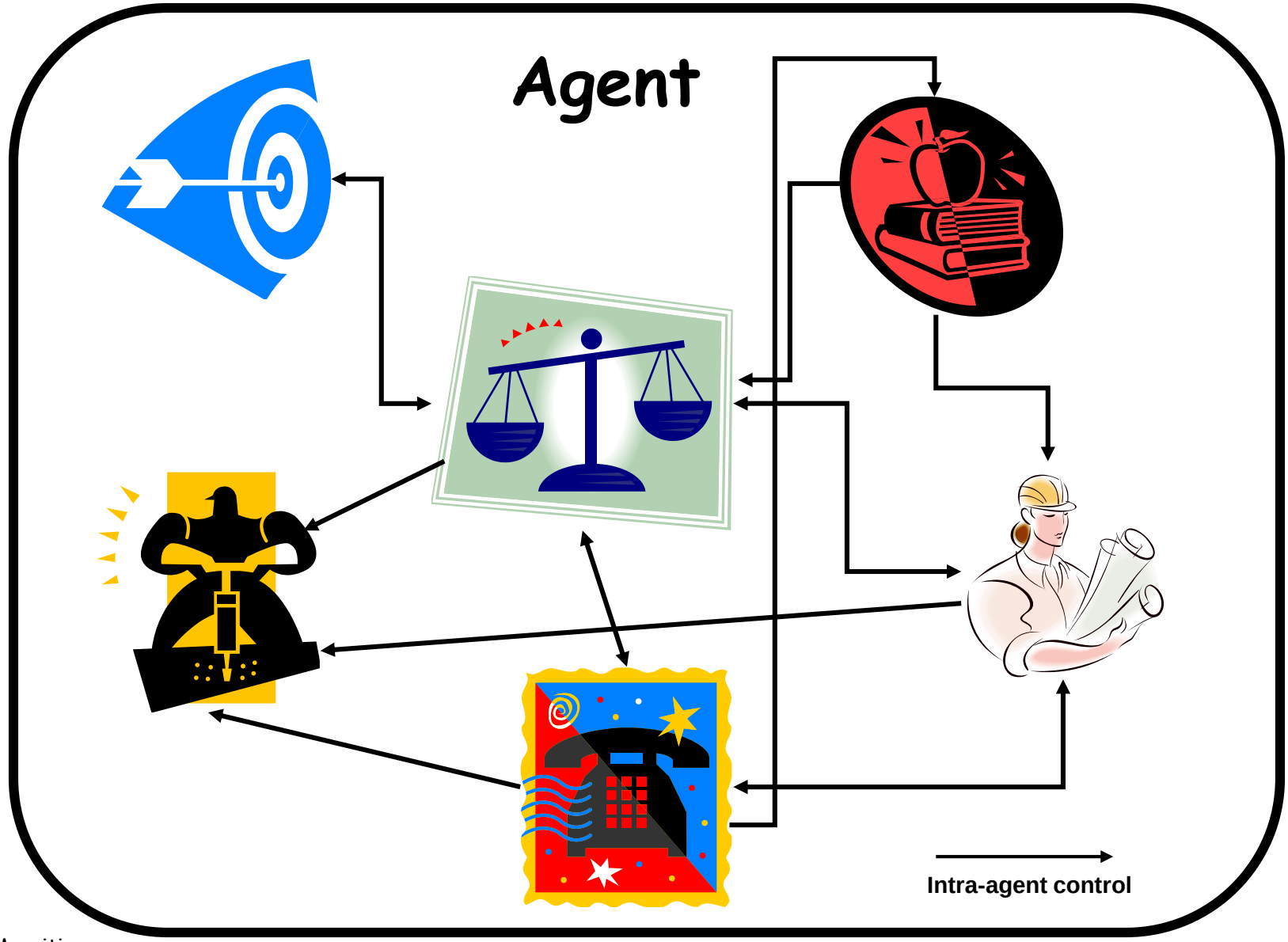
Learning



Making a decision

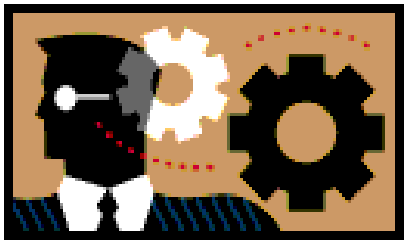
Communicating

Agent as an individual computational entity



Agent as a social entity

Reasoning for what?



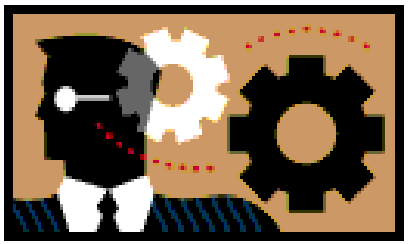
Coordinating a task

Assisting another agent or a human user

Planning and executing a task with another agent

Agent as a social entity

Reasoning for what?

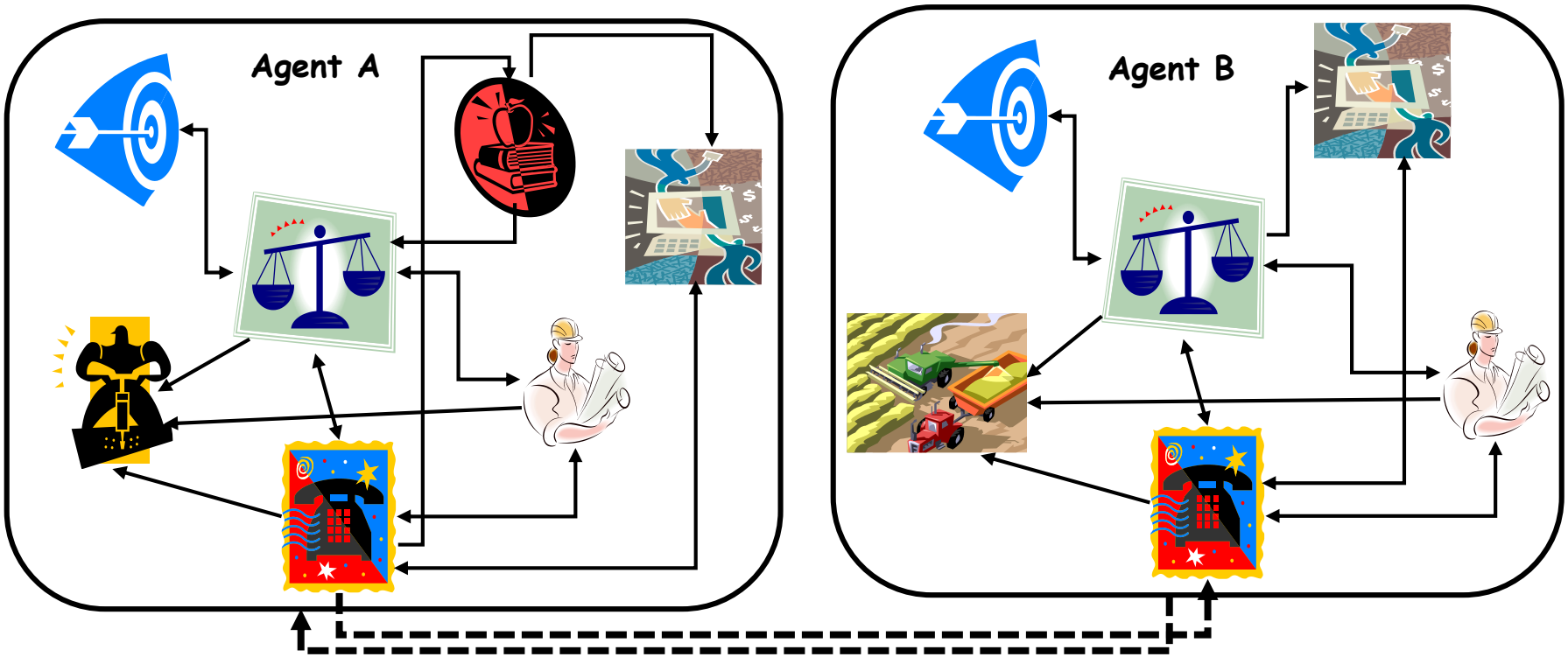


Negotiating (e.g. on the Internet)

Informing another agent or a human user

Making a dialogue with another agent

Multi-Agent Systems (MAS)



Symbolic AI* & MAS**

- Symbolic representation and modeling of
  - Knowledge of agents
  - Reasoning of agents
  - Interaction among agents

  } **Explainability**

- Software engineering methodologies (e.g. GAIA, Tropos, INGENIAS, ASEME) and platforms (e.g. JADE, madKit, JACK) for system development (Agent Oriented Software Engineering)

*** 1956-: (John McCarthy, Marvin Minsky, Herbert Simon, Allen Newell)**
****1985-:**

Different kinds of Knowledge

- Factual knowledge (concrete, verifiable information about the world)
  Ex. Today is Thursday
- Defeasible knowledge (knowledge that it's not universally true)
  Ex. Birds can fly
- Probabilistic knowledge
  Ex. There is a good chance that tomorrow it will be nice weather
- Fuzzy knowledge
  Ex. Nice weather

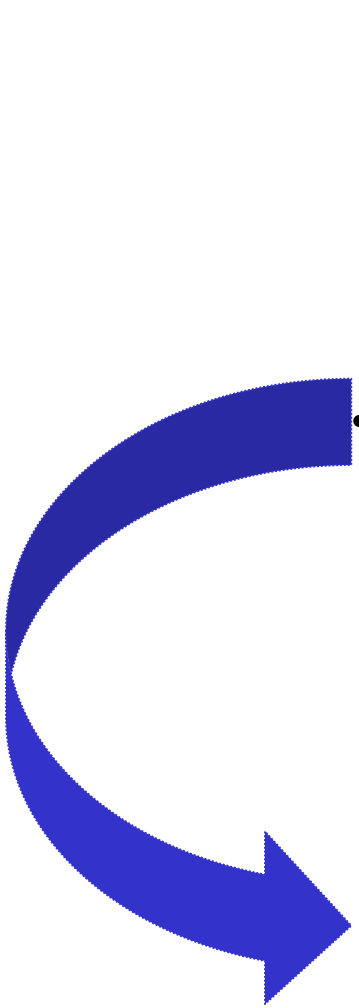
} Uncertain knowledge

- Incomplete knowledge (modeling what is unknown, assumed, or hypothetical)
- Conflicting knowledge (managing contradictions)
- Dialectical knowledge (representing arguments and counterarguments)
- Mental states (representing beliefs, desires, intentions, preferences)
- Procedural knowledge (e.g. representing actions and plans)

→ Declarative **(what we know)** vs Proceduaral knowledge **(how to do)**

Reasoning

Various forms of formal reasoning



Deduction (drawing logically certain conclusions from general rules)

Abduction (inferring the most likely explanation for a set of observations)

Induction (inferring general principles from specific observations)

Non-monotonic reasoning (conclusions can be withdrawn in light of new evidence e.g. computational argumentation)

Case-based reasoning (use of similarity)

Approximate reasoning (use of fuzzy logic, Bayesian networks,….)

Planning and temporal reasoning (reasoning about actions, goals and temporal constraints)

……

Explainable AI

Ability to design autonomous AI agents capable of producing reasoning traces and the data that supports them

Interaction

How to enable multiple autonomous computational entities (i.e. agents) to act collectively—either ***cooperatively*** to achieve shared goals or ***individually*** to fulfill objectives on behalf of human users

COORDINATION

Negotiation (enable interacting agents to resolve conflicts and arrive at a mutually acceptable agreement)

Collaboration (enable several agents to coordinate their actions to achieve common goals more effectively than working individually)

Multi-Agent (or Distributed) Planning (enable several agents to independently develop and coordinate their plans to achieve individual or shared goals, ensuring global consistency

through → *Communication* (enable the exchange of information or knowledge between agents to coordinate their actions)

Symbolic AI & LLMs

Hybrid approach for Agents and MAS

- Generating formal language code from natural language
- Interaction between LLMs and formal reasoners
- LLMs supporting inter-agent communication
- LLMs for modeling intra-agent control