Multiagent Systems:
Local Decisions vs. Global Coherence

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Some episodes from Seinfeld …

- http://www.youtube.com/watch?v=e64nHicE1bY&feature=related

- http://www.youtube.com/watch?v=dSZYsyrP3Co

- http://www.youtube.com/watch?v=vZwnSrAvfrI
    - 0:18 – 0:54

What is an agent?

- An agent is an entity that takes sensory input from its environment, makes **autonomous** decisions, and carries out actions that affect the environment
  - A thermostat is an agent
  - A calculator is *not* an agent
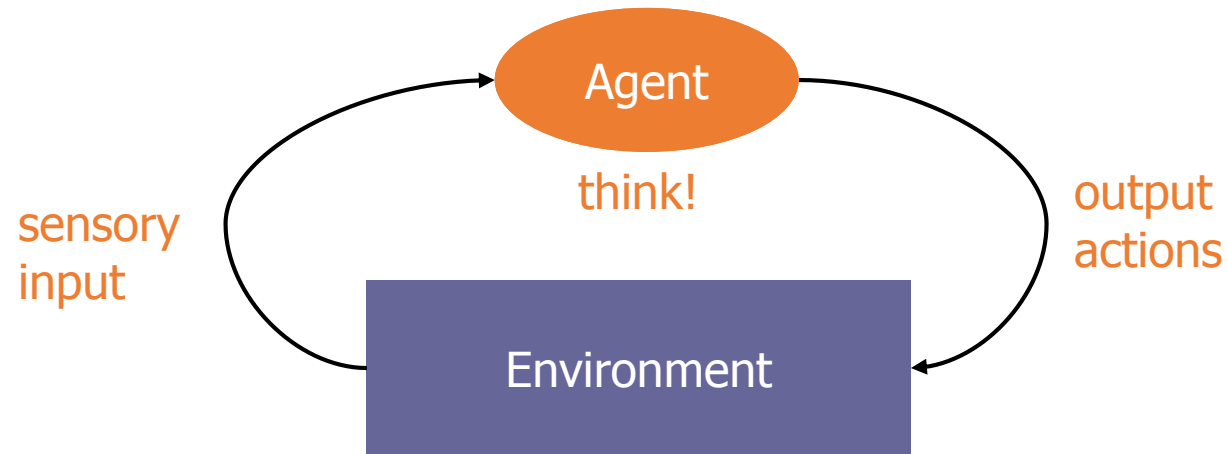
What is an Intelligent Agent?

- An intelligent agent is one that is capable of flexible autonomous actions in order to meet its design objectives, where **flexibility** means:

    - Reactivity: agents are able to perceive their environment, and respond in a timely fashion to changes that occur in order to satisfy their design objectives

    - Pro-activeness: agents are able to exhibit goal-directed behavior by taking the initiative in order to satisfy their design objectives

    - Social ability: agents are capable of interacting with other agents (and possibly humans) in order to satisfy their design objectives

(Wooldridge and Jennings 1995)

What is an Intelligent Agent? 2

- An intelligent agent is one that is capable of learning

> **The acquisition of new knowledge and motor and cognitive skills and the incorporation of the acquired knowledge and skills in future system activities, provided that this acquisition and incorporation is conducted by the system itself and leads to an improvement in its performance.**

- Agents that learn are intelligent
- Not all agents are intelligent!

Agent Environment

- Inaccessible vs. accessible
  - Incomplete vs. complete data
- Deterministic vs. non-deterministic
  - Certainty vs. uncertainty
- Episodic vs. non-episodic
  - Each episode is independent or not
- Static vs. dynamic
  - Remain unchanged except by the performance of actions by the agent?
- Discrete vs. continuous
  - "Chess game" vs. "taxi driving"

Why Use Agents?

- If the system to be built or modeled has, during the execution of the system:
  - Incomplete data
  - Uncertainty in the assessment/interaction of its environment
  - Inter-dependent episodes of events
  - No full control over the events in the environment
  - An "open world", instead of a "closed world"
- In other words, agents are used when you need to build a system that is adaptive to an uncertain, dynamic, and at times unexpected environment (think: *Complex Systems*)
  - So you can make full use of the **autonomous** property of an agent

Why Use A Multiagent System?

- A multiagent system is a system where multiple agents complete a task (or solve a problem) better when interacting with each other
  - Direct or Indirect communication, Observation
  - Coordination, Collaboration, Competition too!
  - Distributed Control, Scalability, Flexibility
- *Example*: A group of basketball players who do not observe or communicate with each other is not a team—simply a group of individual agents

Local Decisions vs. Global Coherence

- Agents making local decisions have high autonomy
  - Less reliant on other agents: flexible (think reactive, pro-active, social)
  - Local neighborhood: efficient, scalable
  - No explicit global control
  - May lead to unexpected, "chaotic" results due to lack of coordination
    - Local optima

- A multiagent system should strive for global coherence
  - How well a system behave as a unit

Emergent Behaviors and Self-Organization

- Whether and how do global coherent behaviors emerge?
  - What factors influence such process and how?
  - Which actors' decisions influence such process and how?

- How do actors (or agents) organize themselves?
  - What environmental stimuli cause them to push/pull and how?
  - How do actors adapt themselves and evolve in the environment?

Tradeoff: Local Autonomy vs. Global Coherence

High Coherence

DESIRABLE

- Emergent behaviors can be analyzed for their patterns
- Self-organized steady states can be analyzed for their processes
- Local reasoning policies can be investigated
- ...

NOT DESIRABLE

Low Coherence

Low Autonomy   High Autonomy