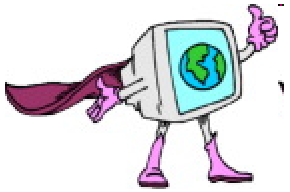
Mehran University of Engineering & Technology, Pakistan

Intelligent Agents

Department of Software Engineering

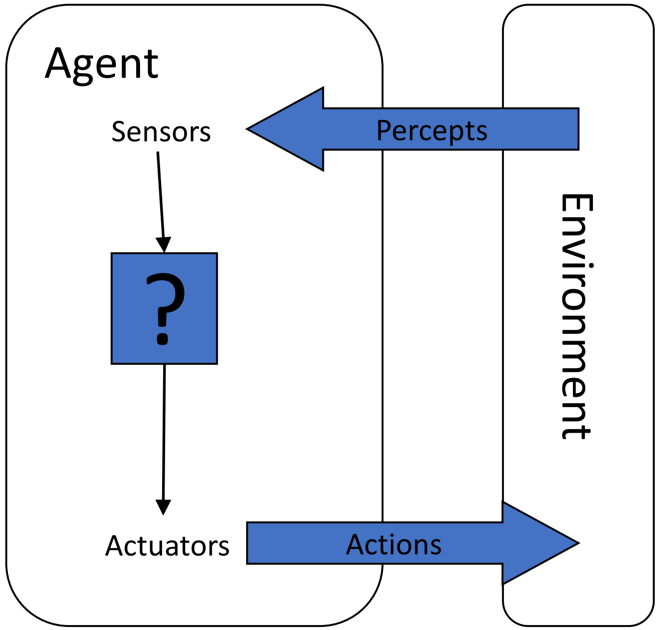


What’s An Agent?

Anything/entity that can be viewed as Perceiving its environment through sensors and Acting upon the environment through effectors.

Examples

- A Human Agent
- A Robotic Agent



Mehran University of Engineering & Technology, Pakistan

What's an Intelligent Agent?

- **"An intelligent agent is an entity capable of combining cognition, perception and action in behaving autonomously, purposively and flexibly in some environment."**

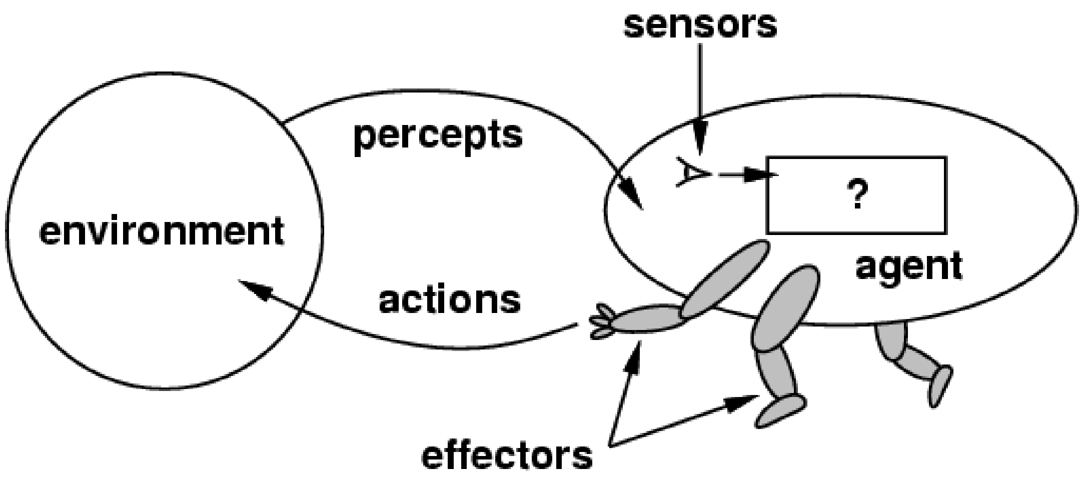
- It **perceives** its environment, **reasons** about its goals, and **acts** upon the environment

Supported by

- Knowledge representation, search, inference, planning, uncertainty, learning, communication….

Department of Software Engineering

Description Of An Intelligent Agent



Main components

– Perception (sensors)

– Reasoning/cognition

– Action (actuators)

- An **intelligent agent** perceives its environment via **sensors** and acts rationally upon that environment with its **effectors**.
- Discrete agents receive **percepts** one at a time, and map them to a sequence of discrete **actions**

PEAS description of an agent – Performance measure, Environment, Actuators, Sensors

PAGE description of an agent – Percepts , Actions, Goals, Environments

Sensors/Percepts and Effectors/Actions

- **Humans**
  - Sensors: Eyes (vision), ears (hearing), skin (touch), tongue (gustation), nose (olfaction), neuromuscular system (proprioception)
  - Percepts:
    - At the lowest level – electrical signals from these sensors
    - After preprocessing – objects in the visual field (location, textures, colors, …), auditory streams (pitch, loudness, direction), …
  - Effectors: limbs, digits, eyes, tongue, …
  - Actions: lift a finger, turn left, walk, run, carry an object, …
- **Robot**
  - Sensors: camera, infrared range finders,
  - Effectors: motors

Percepts and actions need to be carefully defined, possibly at different levels of abstraction

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Possible Properties

- Agents are **autonomous** – they act on behalf of the user
- Agents can **adapt** to changes in the environment
- Agents don't only act **reactively**, but sometimes also **proactively**
- Agents have **social ability** – they communicate with the user, the system, and other agents as required
- Agents also **cooperate** with other agents to carry out more complex tasks than they themselves can handle
- Agents **migrate** from one system to another to access remote resources or even to meet other agents

PAGE Description

Agent Type	Percepts	Actions	Goals	Environment
Medical diagnosis system	Symptoms, findings, patient's answers	Questions, tests, treatments	Healthy patient, minimize costs	Patient, hospital
Satellite image analysis system	Pixels of varying intensity, color	Print a categorization of scene	Correct categorization	Images from orbiting satellite
Part-picking robot	Pixels of varying intensity	Pick up parts and sort into bins	Place parts in correct bins	Conveyor belt with parts
Refinery controller	Temperature, pressure readings	Open, close valves; adjust temperature	Maximize purity, yield, safety	Refinery
Interactive English tutor	Typed words	Print exercises, suggestions, corrections	Maximize student's score on test	Set of students

Rationality

Rational = "Does the right thing" in a particular situation

– ***Maximize expected performance (not actual performance)***

- An ideal **RATIONAL AGENT** should, for each possible percept sequence, do whatever actions will maximize its expected performance measure based on
  (1) the percept sequence, and
  (2) its built-in and acquired knowledge.
- It Maximizes the likelihood of success, given its information

– How is "the right thing" chosen?

- ♦ Possible actions (from which to choose)
- ♦ Percept sequence (current and past)
- ♦ Knowledge (static or modifiable)
- ♦ Performance measure (*wrt* goals – defines success)

AI is about building RATIONAL AGENT.

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Basic Agent Types

1. **Table-driven agents**
   - Use a percept sequence/action table in memory to find the next action. They are implemented by a (large) ***lookup table***.
2. **Simple reflex agents**
   - Are based on ***condition-action rules***, implemented with an appropriate production system. They are stateless devices which do not have memory of past world states.
3. **Agents with memory**
   - Have ***internal state***, which is used to keep track of past states of the world.
4. **Agents with goals**
   - Are agents that, in addition to state information, have ***goal information*** that describes desirable situations. Agents of this kind take future events into consideration.
5. **Utility-based agents**
   - Base their decisions on ***classic axiomatic utility theory*** in order to act rationally.

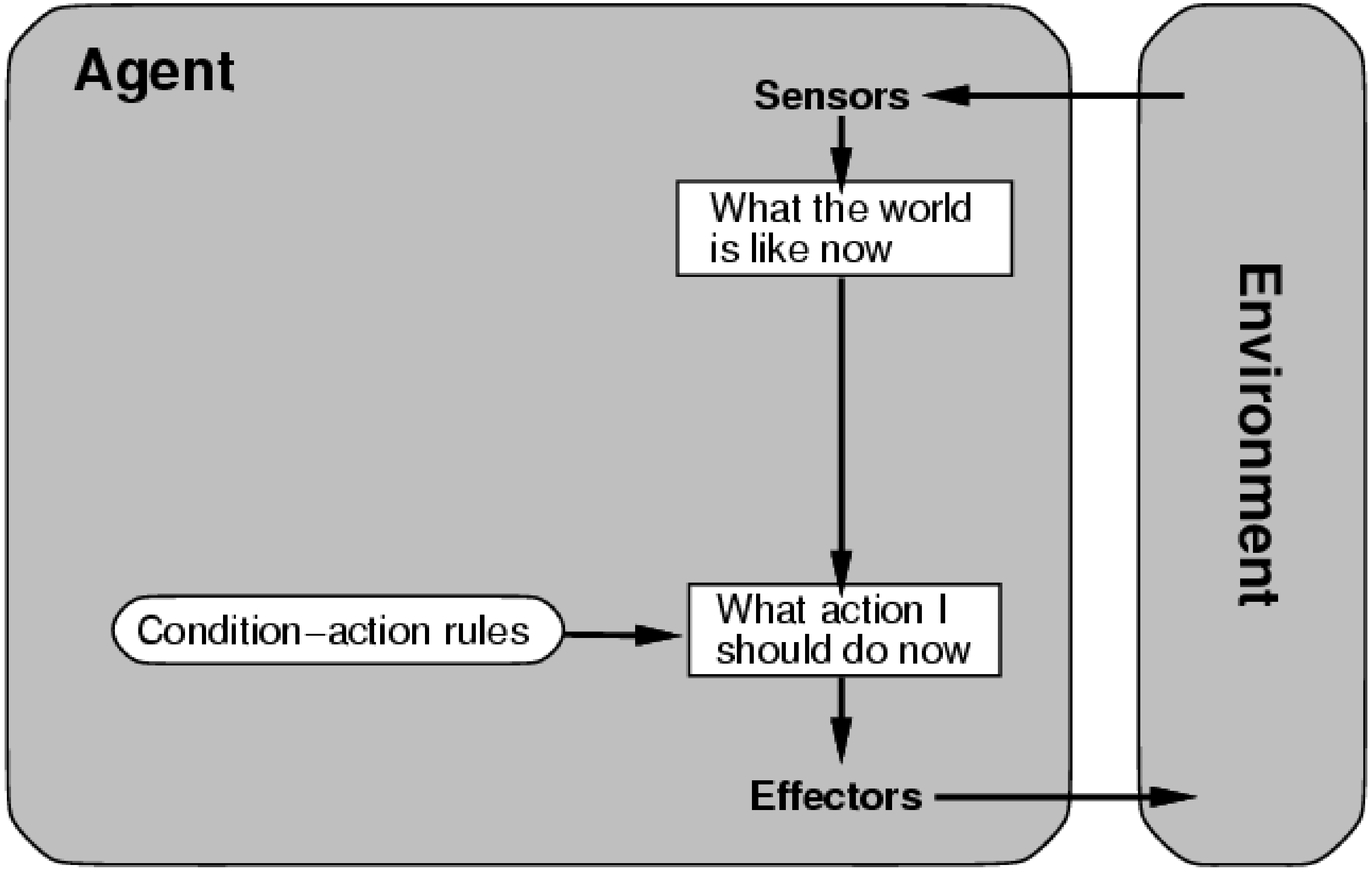
Table-driven agents

- **Table lookup** of percept-action pairs mapping from every possible perceived state to the optimal action for that state
- **Problems**
  - Too big to generate and to store (Chess has about 10^{120} states)
  - No knowledge of non-perceptual parts of the current state
  - Not adaptive to changes in the environment; requires entire table to be updated if changes occur
  - Looping: Can't make actions conditional on previous actions/states.

Simple reflex agents

- **Rule-based reasoning** to map from percepts to optimal action; each rule handles a collection of perceived states
- **Problems**
  - Still usually too big to generate and to store
  - Still no knowledge of non-perceptual parts of state
  - Still not adaptive to changes in the environment; requires collection of rules to be updated if changes occur
  - Still can't make actions conditional on previous state

Table-driven/Reflex agent architecture

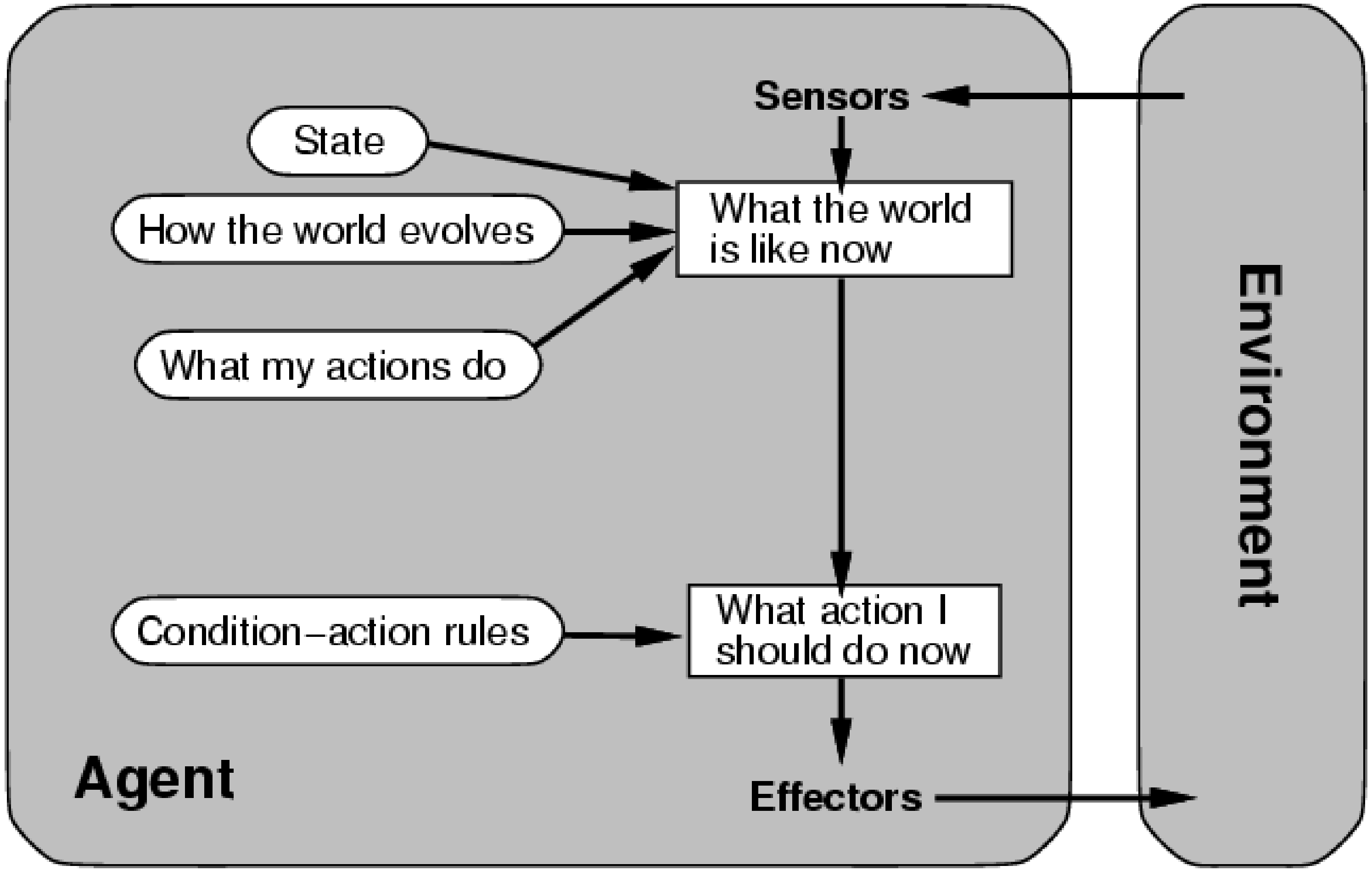


Agents with Memory

- Encode “internal state” of the world to remember the past as contained in earlier percepts.
- Needed because sensors do not usually give the entire state of the world at each input, so perception of the environment is captured over time. “State” is used to encode different "world states" that generate the same immediate percept.
- Requires ability to represent change in the world; one possibility is to represent just the latest state, but then can’t reason about hypothetical courses of action.
- Example: Rodney Brooks’s Subsumption Architecture.

Mehran University of Engineering & Technology, Pakistan

Architecture for an Agent with memory



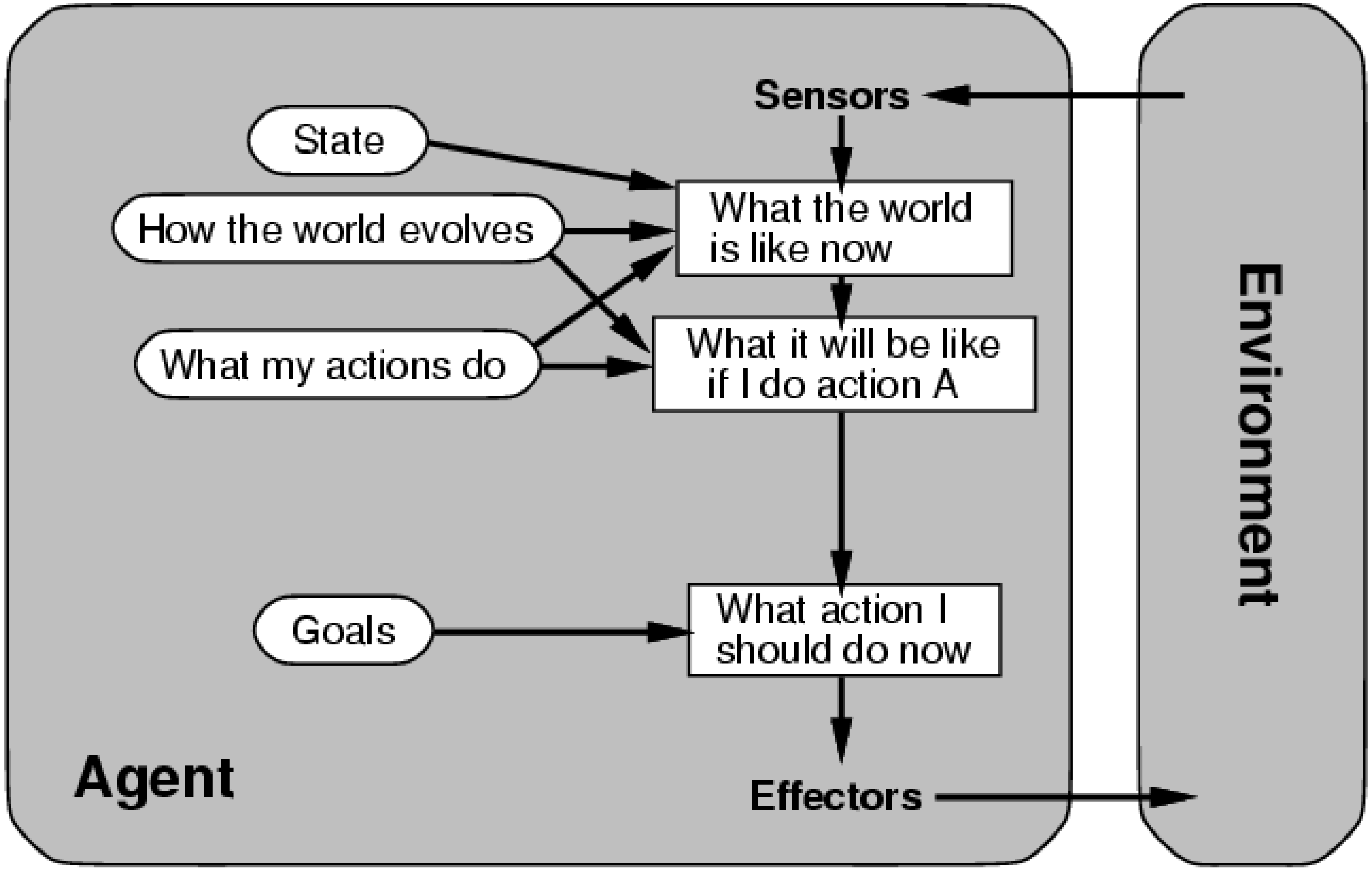
Department of Software Engineering

Goal-based agents

- Choose actions so as to achieve a (given or computed) goal.
- A goal is a description of a desirable situation.
- Keeping track of the current state is often not enough – need to add goals to decide which situations are good
- **Deliberative** instead of **reactive**.
- May have to consider long sequences of possible actions before deciding if goal is achieved – involves consideration of the future, ***"what will happen if I do...?"***

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Architecture for goal-based agent



Dr. Isma F. Siddiqui (isma.farah@faculty.muet.edu.pk)

Utility-based Agents

"When there are multiple possible alternatives,

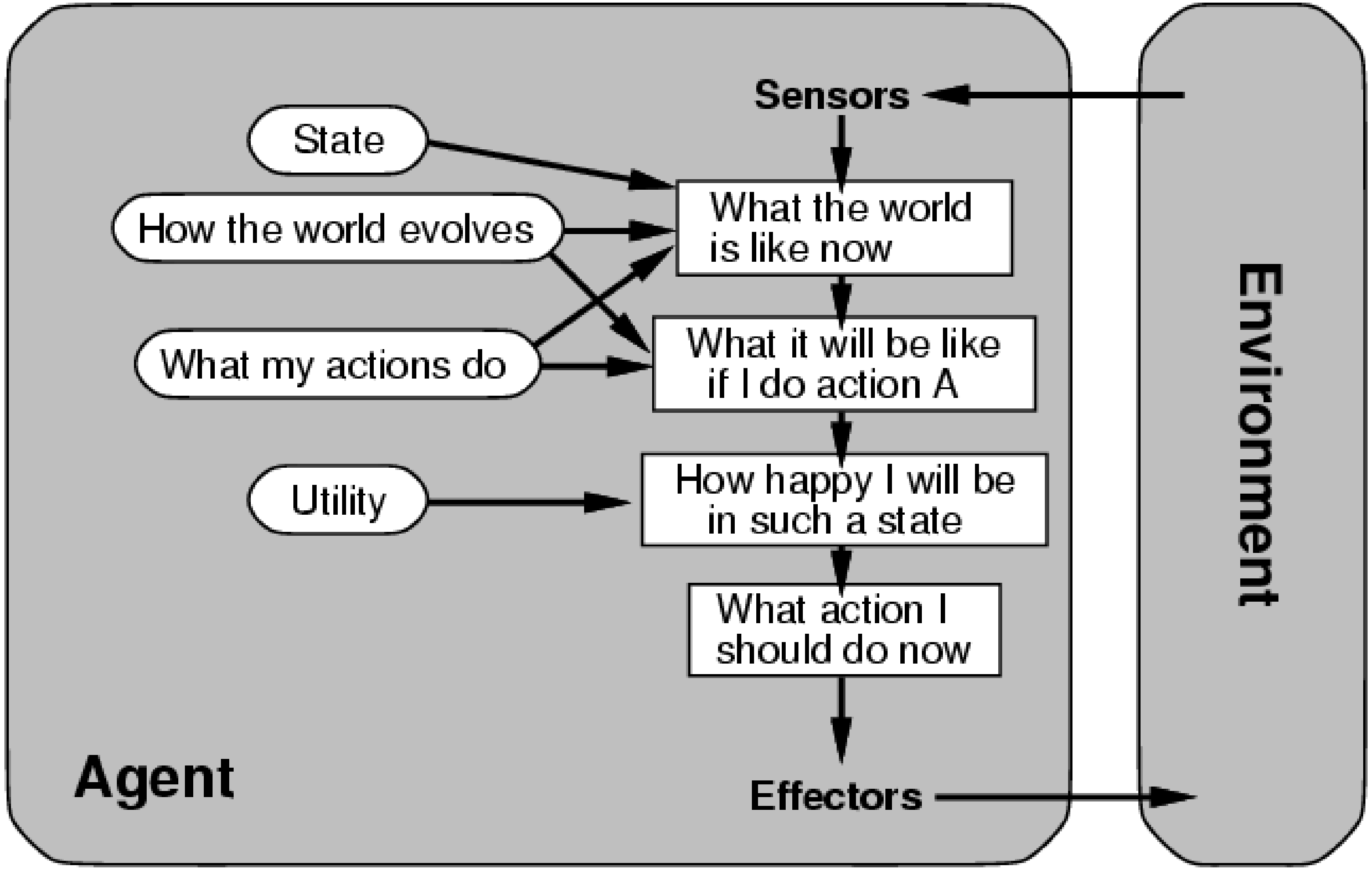
how to decide which one is best?"

- A goal specifies a crude distinction between a happy and unhappy state, but often need a more general performance measure that describes "degree of happiness."
- Utility function **U: State $\rightarrow$ Real** indicating a measure of success or happiness when at a given state.
- Allows decisions comparing choice between conflicting goals, and choice between likelihood of success and importance of goal (if achievement is uncertain).

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Mehran University of Engineering & Technology, Pakistan

Architecture for Utility-Based Agent



Department of Software Engineering

Example:
Automated taxi driving system

- **Percepts**: Video, sonar, speedometer, odometer, engine sensors, keyboard input, microphone, GPS, …
- **Actions**: Steer, accelerate, brake, horn, speak/display, …
- **Goals**: Maintain safety, reach destination, maximize profits (fuel, tire wear), obey laws, provide passenger comfort, …
- **Environment**: Urban streets, freeways, traffic, pedestrians, weather, customers, …
- **Different aspects of driving may require different types of agent programs!**

Possible Properties (revision)

- Agents are **autonomous** – they act on behalf of the user
- Agents can **adapt** to changes in the environment
- Agents don't only act **reactively**, but sometimes also **proactively**
- Agents have **social ability** – they communicate with the user, the system, and other agents as required
- Agents also **cooperate** with other agents to carry out more complex tasks than they themselves can handle
- Agents **migrate** from one system to another to access remote resources or even to meet other agents

Autonomy of an Agent

- A system is autonomous to the extent that its own behavior is determined by its own experience.

- Therefore, a system is not autonomous if it is guided by its designer according to a priori decisions.

- An autonomous agent can always say “no”.

- To survive, agents must have:
  - Enough built-in knowledge to survive.
  - The ability to learn.

- Extremes
  - No autonomy – ignores environment/data
  - Complete autonomy – must act randomly/no program
- Example: baby learning to crawl
- Ideal: design agents to have some autonomy
  - Possibly become more autonomous with experience

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

The Structure of Agents

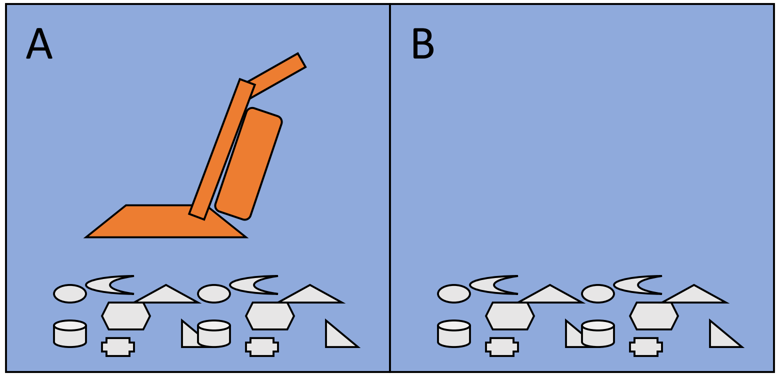
- Agent = Architecture + Program

- Basic algorithm for a rational agent
  - While (true) do
    - Get percept from sensors into memory
    - Determine best action based on memory
    - Record action in memory
    - Perform action

- Most AI programs are a variation of this theme

Agents and Environments

- Example: Vacuum Cleaner World
  - Two locations: squares A and B
  - Perceives what square it is in
  - Perceives if there is dirt in the current square
  - Actions
    - move left
    - move right
    - suck up the dirt
    - do nothing



Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Agents and Environments

- Agent Function: Vacuum Cleaner World
  - If the current square is dirty, then suck, otherwise move to the other square

- But what is the right way to fill out the table?
  - is the agent
    - good or bad
    - intelligent or stupid
  - can it be implemented in a small program?

Percept Sequence	**Action**
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Characterizing a Task Environment

- Must first specify the setting for intelligent agent design.
- **PEAS: Performance measure, Environment, Actuators, Sensors**
- **Example:** the task of designing a self-driving car
  - **Performance measure**
    - **Safe, fast, legal, comfortable trip**
  - **Environment**
    - **Roads, other traffic, pedestrians**
  - **Actuators**
    - **Steering wheel, accelerator, brake, signal, horn**
  - **Sensors**
    - **Cameras, LIDAR (light/radar), speedometer, GPS, odometer engine sensors, keyboard**

Properties of Environments

1. Observability:

- If an agent's sensors give it access to the complete state of the environment needed to choose an action, the environment is **Fully Observable**, agent doesn't keep track of the other changes in the environment. E.g., chess.
- In **Partially observable** environment, only the related states and features are accessed and observed. E.g., Bridge Game.

2. Determinism:

- An environment is **Deterministic** if the next state of the environment is completely determined by the current state of the environment and the action of the agent. E.g., Image Analysis System.
- In a **Stochastic** environment, there are multiple, unpredictable outcomes
- A partially observable, deterministic environment will appear stochastic to the agent.

Mehran University of Engineering & Technology, Pakistan

Properties of Environments

3. Episodicity:

- An **Episodic** environment means that subsequent episodes do not depend on what actions occurred in previous episodes.
- In a **Sequential** environment, the agent engages in a series of connected episodes. Such environments do not require the agent to plan ahead.

4. Dynamism:

- A **Static** environment does not change while the agent is thinking.
- The passage of time as an agent deliberates is irrelevant. The agent doesn't need to observe the world during deliberation.
- A **Dynamic** environment changes over time independent of the actions by the agent, timely action is required to make effective action.

Department of Software Engineering

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Properties of Environments

5. Continuity:

- If the number of distinct percepts and actions is limited, the environment is **Discrete**, otherwise it is **Continuous**.

6. Presence of Other Agents:

- If the environment contains **Multi-Agents**, the agent needs to be concerned about strategic, game-theoretic aspects of the environment (for either cooperative *or* competitive agents)
- Most engineering environments works with **Single Agent** properties, whereas most social and economic systems get their complexity from the interactions of (more or less) rational agents.

Mehran University of Engineering & Technology, Pakistan

Characteristics of Environments

	Fully observable?	Deterministic?	Episodic?	Static?	Discrete?	Single agent?
Solitaire	No	Yes	Yes	Yes	Yes	Yes
Backgammon	Yes	No	No	Yes	Yes	No
Taxi driving	No	No	No	No	No	No
Internet shopping	No	No	No	No	Yes	No
Medical diagnosis	**No**	**No**	**No**	**No**	**No**	**Yes**

→ Lots of real-world domains fall into the hardest case!

Department of Software Engineering
Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Intelligent Agents Examples:
Data mining agent

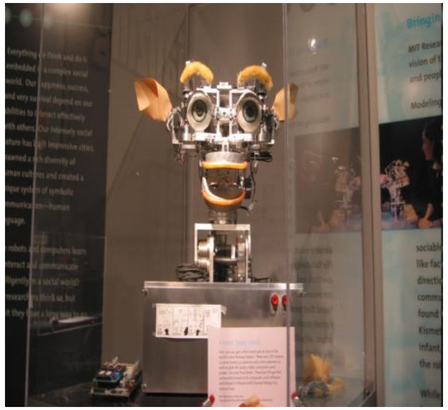
- A ***software program*** built for the primary purpose of finding information efficiently.
- It is a type of ***intelligent agent*** that:
  - Operates in a ***data warehouse*** and does the actual dirty work involved in finding sometimes less than obvious relationships between different pieces of data.
- It ***detects*** **major trend changes**, as well as detect **new pertinent information**.
- If a **new information is found**, the agent attempts to ***alert*** the end-user of the new information.
- **For example:**
  - A corporation may develop ***an agent to analyze economic trends***.
  - If agent ***detects*** that consumers are **becoming more conservative**, it will ***alert*** management of the change.
  - With this information in hand, management can **better plan on how to produce, market and sell product**.

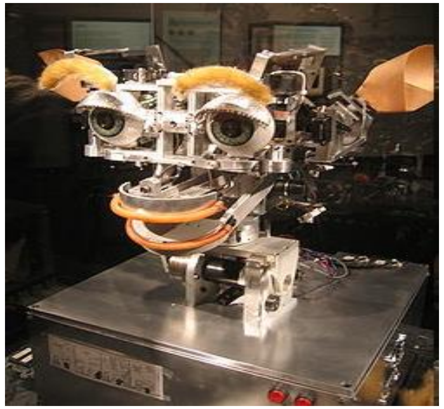
Soft Bots Types

- **Search Bots**
  - Meta search bots, Newsgroup search bots...
- **Shopping Bots**
  - Shop bots, Auction bots, Stock bots,...
- **Tracking Bots**
  - Web monitoring bots, News bots,...
- **Artificial Life Bots**
  - All the Chatterbots, Personal assistants,...
- **Web Development bots**
  - File sharing bots, Download managers,...
- **Download Bots**
  - Referencing bots, Site management bots,...
- **Surf Bots**
  - Pop-up killer bots, Privacy bots,...
- **Games Bots**

Kismet Robot

- **Kismet** is a robot made in the late 1990s at MIT with auditory, visual and expressive systems intended to participate in human social interaction and to demonstrate simulated human emotion and appearance.
- In order for Kismet to properly interact with human beings, it contains input devices that give it auditory, visual, and awareness abilities.
- Kismet simulates emotion through various facial expressions, vocalizations, and movement.
- Facial expressions are created through movements of the ears, eyebrows, eyelids, lips, jaw, and head.

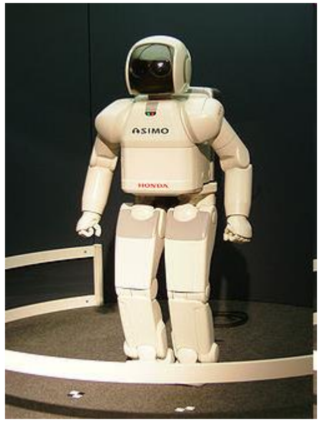




Kismet now resides at the MIT Museum in Cambridge, Massachusetts

ASIMO (Advanced Step in Innovative Mobility) Robot

- **ASIMO** is humanoid robot created by Honda Motor Company at Japan.
- Standing at 3 feet 11 inches and weighing 52 kilograms, the robot resembles a small astronaut wearing a backpack and can walk or run on two feet at speeds upto 6 km/h .



<u>Recognition technology</u>

- With 2000's ASIMO model Honda added many features that enable ASIMO to interact better with humans. These features fall under 5 categories:

1. Recognition of moving objects

2. Recognition of postures and gestures

3. Environment recognition

4. Distinguishing sounds

5. Facial recognition

Dr. Isma F. Siddiqui *(isma.farah@faculty.muet.edu.pk)*

Nao Robot

Specifications	
Height	57 cm
Weight	5 kg
Degrees of freedom	21 to 25[1]
Communication	Wi-Fi / USB
CPU	AMD Geode 500 Mhz
RAM	256 MB SDRAM
Storage	1 GB flash memory
Operating system	Linux
Power	LiPo battery

- **Nao** is an autonomous, programmable and medium-sized Humanoid robot, developed by the French company Aldebaran Robotics, located in Paris.
- This little robot was presented to the public late 2006.
- Since August 15, 2007, Nao has become a feature of the Robocup, which describes itself as the World Cup of Robotics, replacing the robot dog **Aibo** Sony in the Standard Platform League.

Mehran University of Engineering & Technology, Pakistan

Summary

- An **Agent** perceives and acts in an environment, has an architecture, and is implemented by an agent program.
- An **Ideal agent** always chooses the action which maximizes its expected performance, given its percept sequence so far.
- An **Autonomous agent** uses its own experience rather than built-in knowledge of the environment by the designer.
- An **Agent program** maps from percept to action and updates its internal state.
    - **Reflex agents** respond immediately to percepts.
    - **Goal-based agents** act in order to achieve their goal(s).
    - **Utility-based agents** maximize their own utility function.
- **Representing knowledge** is important for successful agent design.
- The most challenging environments are partially observable, stochastic, sequential, dynamic, and continuous, and contain multiple intelligent agents.

Department of Software Engineering

Mehran University of Engineering & Technology, Pakistan

Home Task #1

1. Explain Turing Test and its scenario
2. Search about ELIZA, MYCIN and DENDRAL and describe each in own words. Block diagrams are mandatory (as per your perception)
3. List down the State space for tictactoe or sliding tile puzzle or both in your way of knowledge representation.
4. Study about Human Neural Network. Identify why Human neurons are good conductor of electricity and how they are passing electric signals in between?

Department of Software Engineering

Mehran University of Engineering & Technology, Pakistan

Homework 2

1. Describe four useful advantages and disadvantages of artificial intelligence in your own words.
2. Write a case study example of How AI works in your own words.
3. What procedure will you be adopting if you are assigned a designation of interviewer and have to identify a machine through Turing test?
4. State your own example of an agent in an environment in your own words (Pairwise same submission if needed – mention your 2nd team member on your file)

Department of Software Engineering