# Introduction

By: Sudhan Kandel

## What is intelligence?

- The ability to reason
- The ability to understand
- The ability to create
- The ability to learn from experience
- The ability to plan and execute complex tasks

## Human mind

- Can use common sense and past experience for problem solving.
- Can understand natural language processing.
- Can percept environment like see, hear
- Can learn from experiences and acquire knowledge.

# What is Artificial Intelligence?

- Artificial Intelligence is a branch of Science which deals with helping machines to find solutions to complex problems in a more human-like fashion.
- This generally involves taking characteristics from human intelligence and applying them as algorithms in a computer friendly way.
- A more or less flexible or efficient approach can be taken depending on the requirements established, which influences how artificial the intelligent behavior appears.
- “Giving machines ability to perform tasks normally associated with human intelligence.”
- Branch of computer science that aims to create intelligence of machines
- Part of computer science concerned with designing intelligent machines
- Deals with issues like reasoning, problem solving, knowledge representation, planning, natural language processing, perceptron, etc.

## Contd..

- AI is generally associated with Computer Science, but it has many important links with other fields such as Math, Psychology, Cognition, Biology and Philosophy, among many others. Our ability to combine knowledge from all these fields will ultimately benefit our progress in the search of creating an intelligent artificial being.
- Major AI textbook define artificial intelligence as “the study and design of intelligent agents”. Where an intelligent agent is a system that perceives its environment and take actions which maximize its chances of success.

# Acting Humanly: The Turing Test Approach

- proposed by Alan Turing (1950)
- designed to convince the people that whether a particular machine can think or not.
- Involves an interrogator who interacts with one human and one machine. Within the given time the interrogator has to find out which one is human, and which one is machine.
- A computer passes the test if a human interrogator after posing some written questions, cannot tell whether the written response come from human or not.

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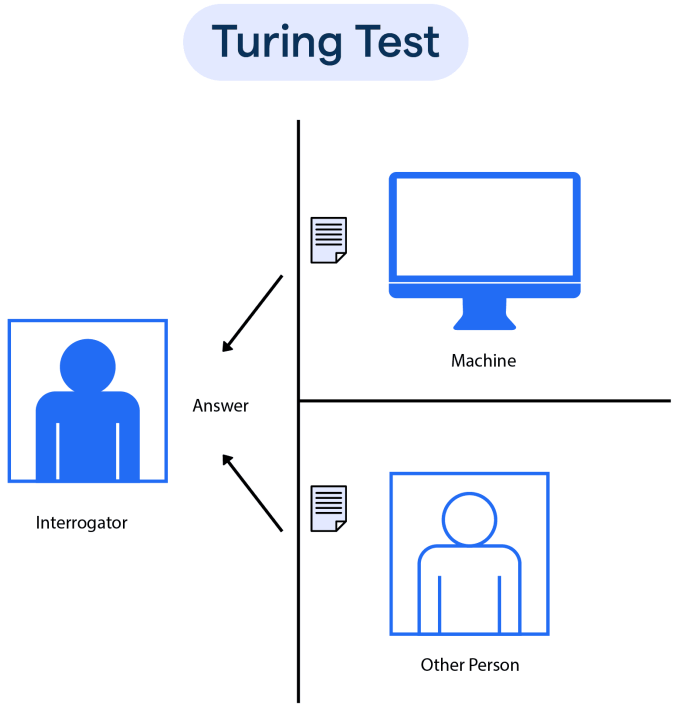


- To pass a turing test, a computer must have following capabilities:
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning
- The total Turing test includes video signals and manipulation capability so that the interrogator can test the subject's perceptual abilities and object manipulation ability. To pass the total Turing test computer must have following additional capabilities:
  - Computer Vision: To perceive objects
  - Robotics: To manipulate objects and move

# Contd..

- Limitations of the Turing Test Approach
  - Turing test avoid the physical interaction with human interrogator.
  - It can not tell any thing about proficiency about the agent.

# Thinking Humanly: Cognitive Modeling Approach

- If we are going to say that a given program thinks like a human, we must have some way of determining how humans think.
- We need to get inside the actual working of human minds. There are these way to do this:
  - Through introspection → Catch our thoughts while they go by
  - Through psychological experiments → Observing a person in action
  - Through brain imaging → Observing the brain in action.
- Once we have precise theory of mind, it is possible to express the theory as a computer program.
- But unfortunately until up to now there is no precise theory about thinking process of human brain. Therefore it is not possible to make the machine that like human brain.

# Think Rationally: The Law of Though approach

- Aristotal was one of the first who attempt to codify the “ right thinking” that is, irrefutable reasoning process.
- He gave syllogism that always yielded correct conclusion when correct premises are given.
- Syllogism is a kind of logical argument that applies deductive reasoning to arrive at a conclusion based on two or more propositions that are assumed to be true.
- For Example:
  - Ram is a man
  - All man are mortal
  - Ram is Mortal

# Acting Rationally: The Rational Agent

- Agent is something that acts Computer agent is expected to have following attributes:
  - Autonomous control
  - Perceiving their environment
  - Persisting over a prolonged period of time
  - Adapting to change
  - Capable of taking on another's goal
- Rational Behavior: Doing the right thing
- The Right Thing: That which is expected to maximize goal achievement, given the available information.
- Rational Agent: is one that acts so as to achieve the best outcome

# Hard vs Soft AI

- **Hard AI:** Hard AI is a type of AI that is designed to replicate human intelligence as closely as possible. This means that hard AI systems are typically designed to be conscious, self-aware, and capable of independent thought. Hard AI is still in its early stages of development, and no fully-functional hard AI systems exist yet. However, there are a number of research projects that are working on developing hard AI, and some experts believe that it is only a matter of time before hard AI systems become a reality.
- **Soft AI:** Soft AI is a type of AI that is designed to solve specific problems, rather than replicate human intelligence. Soft AI systems are typically rule-based or statistical, and they do not have the same level of complexity as hard AI systems. However, soft AI systems are often more efficient and effective at solving specific problems, and they are already being used in a wide range of applications, such as medical diagnosis, financial trading, and customer service.

# Foundation of AI

- Here are the key foundational points of AI:

1. **Mathematics**
    1. Linear Algebra
    2. Probability and Statistics
    3. Calculus
    4. Graph Theory
2. **Logic and Reasoning**
    1. Propositional and Predicate Logic
    2. Boolean Algebra
    3. Automated Theorem Proving

# Contd..

3. **Algorithms and Data Structures**
    1. Search Algorithms (DFS, BFS, A*)
    2. Sorting and Hashing
    3. Optimization Algorithms
4. **Machine Learning**
    1. Supervised Learning
    2. Unsupervised Learning
    3. Reinforcement Learning
    4. Deep Learning

# Contd..

**4. Cognitive Science and Neuroscience**

1. Artificial Neural Networks
2. Cognitive Models
3. Psychology and Linguistics

5. **Computer Science**

1. Programming Languages (Python, Lisp, etc.)
2. Software Engineering
3. Data Management

6. **Philosophy and Ethics**

1. Philosophical Foundations
2. Ethical Considerations

## Contd..

### 7. Robotics

1. Perception (Computer Vision, Sensors)
2. Motion and Control
3. Autonomy

### 8. Natural Language Processing (NLP)

1. Language Understanding
2. Text and Speech Processing

# Applications of AI

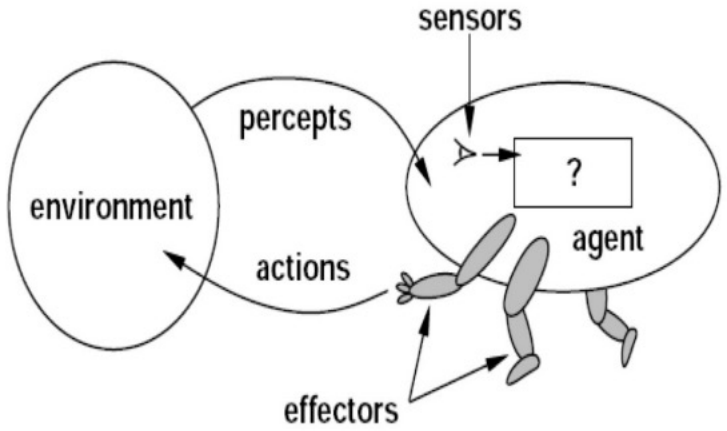
Some of the applications of AI as follow:

- Autonomous planning and Scheduling
- Game Playing
- Autonomous Control
- Diagnosis
- Logistic Planning
- Robotics
- Speech Re-cognition
- Spam Filtering
- Machine Translation

# Agent

- An agent is anything that perceives its environment through sensors and acts upon that environment through actuator.
- Its action can change environment through different states.
- The sensors act as input device and actuators act as output device.
- The percept is complete set of inputs at a given time.
- It has agent program that decides the best action to be taken based upon current percept.
- The mapping between percept and its action is done by function.
- The agent function is a mathematical function that maps a sequence of perceptions into action.
- The function is implemented as the agent program.

- For eg: a human agent has eyes, ear and other organs as sensors and legs, hands etc as an actuators.
- A robotic agent might have camera as sensor and motors as actuators.



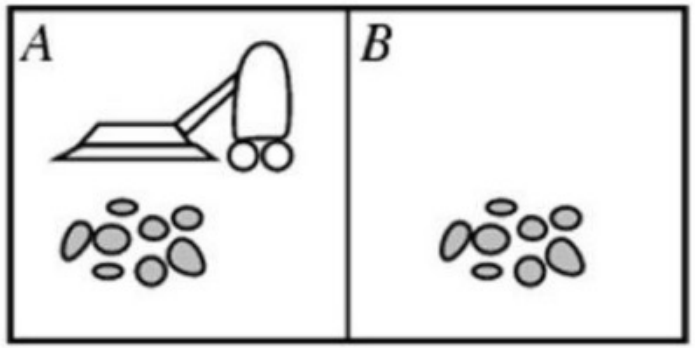
# Sensor, Percept, Effector and Actions

**Human**

- **Sensors:** eyes(vision), skin(touch), nose(smell), ears(hearing)
- **Percepts:**
  - At the lowest level: Signals from the sensors
  - After preprocessing: Visual (location, texture, color, direction), Auditory (pitch, loudness)
- **Effectors:** legs, hands, eyes, head
- **Actions:** lift finger, walk, talk, run, carry an object
- Percepts and actions need to be defined carefully at different levels of abstraction

# Vacuum Cleaner World

- **Percepts:**
  Location and status,
  e.g., [A,Dirty]
- **Actions:**
  Left, Right, Suck, NoOp




Example vacuum agent program:

**function Vacuum-Agent**([location,status]) returns an action

- *if* status = Dirty *then* return Suck
- *else if* location = A *then* return Right
- *else if* location = B *then* return Left

# Example of agent

**A human Agent**

- Has eyes, ear and other organs for sensors and hands, legs, mouth and other body parts for actuators.

**A Robotic Agent**

- Might have cameras and infrared range finders for sensors and various motors for actuators.

**A Software Agent**

- Receives keywords, file contents, and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files and sending network packets.

# Properties of the agent

- An agent is just something that act. Of courses, all computer programs do something, but computer agent are expected to do more:
  - Operate autonomously
  - Perceive and react to their environment.
  - Pro active
  - Capable of taking on another's goal
  - They are persistent over a prolonged time period.
  - Adapt to change

# Environment

- The first step to design a rational agent is the specification of its task environment.
- Task environment are essentially the ‘Problems’ to which rational agent are the ’Solutions’.
- Generally, task environment are specified by using the following four parameter
  - Performance
  - Environment
  - Actuators
  - Sensors
- Therefore, task environment is also called PEAS description of the environment.

# Properties of environment

- Fully observable versus partially observable
- Single agent versus multi-agent
- Deterministic versus stochastic
- Episodic versus Sequential
- Static versus Dynamic
- Discrete versus Continuous
- Known versus Unknown

# Fully observable versus Partially Observable

- If an agent's sensors give it access to the complete state of the environment at each point in time, then we say that the task environment is fully observable.

  For example: Chess Playing

- An Environment might be partially observable because of noisy and inaccurate sensors.
  - For example: a Vacuum agent with only a local dirt sensor cannot tell whether there is dirt in other squares.

# Single agent vs Multi-agent

- Single-agent systems are often used in scenarios where the environment is relatively simple and the task can be accomplished by a single autonomous entity, such as in many robotics applications or game playing agents.
  - Example: Chess-playing AI
- Multi-agent systems find applications in areas such as decentralized control systems, decentralized marketplaces, traffic management, and negotiation scenarios.
  - Example: Traffic Management System
- In summary, the choice between single-agent and multi-agent systems depends on factors such as the complexity of the environment, the need for coordination and collaboration, scalability requirements, and the desired level of robustness and adaptability.

# Deterministic vs Stocastic

If the next state of the environment is completely detemined by the current state and the action executed by the agent, then we say the environment is deterministic; otherwise; it is stocastic.

The simple vacuum world is deterministic where as the taxi driving is clearly stocastic in this sense, because one can never predict the behavior of traffic exactly.

# Episodic versus sequential

- In episodic environment, the choice of action in each episode depends only on the episod iteself i.e., the next episode does not depend on the actions taken in previous episodes.

  For example an agent that has to spot defective parts on an assembly line bases each decision on the current part, regardless of previous decisions; moreover, the current decision doesn't affect whether the next part is defective.

- In sequential environment, on the other hand, the current decision could affect all future decisions.

  For example: Chess and taxi driving are sequential

## Static Versus Dynamic

- If the environment can change while an agent is deliberating, then the environment is dynamic for that agent; otherwise, it is static.
- Static environment are easy to deal with because the agent need not keep looking at the world while it is deciding on an action, nor need it worry about the passage of time

  For example: Crossword Puzzles are Static
- Dynamic environments, on the otherhand, are continuosly asking the agent what it want to do; if it hasn't decided yet, that counts as deciding to do nothing.

  For example: Taxi driving is dynamic because the other cars and the taxi itself keep moving while the driving algorithm think about what to do next.

# Discrete versus Continous

- The discrete/continuous distinction can be applied to the state of the environment to the way time is handled and to the percept and actions of the agent.
  - for example, a discrete-state environment such as a chess game has a finite number of distinct states.
  - Example of continuous state environment includes Taxi driving: the speed and location of the taxi sweep throufh a range of continuous values and fo so smoothly over time.

# Known versus Unknown

- This distinction refers not to the environment itself but to the aget's state of knowledge about the environment.
- In a known environment, the outcomes for all actions are given.
- Obviously, if the environment is unknown, the agent will have to learn how it works in order to make good decisions.

## The Structure of the agents

- *Agent's structure can be viewed as :*
  - *Agent= Architecture + Agent Program*
- *Architecture=The machinery that an agent executes on.*
- *Agent Program= an Implementation of an agent function*

# Contd..

- Agents are grouped into five classes based on their degree of perceived intelligence and capability
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents
  - Learning agents

# Contd..

**Simplex Reflex Agent**

- Simple reflex agent act only on the basis of the current percept, ignoring the rest of the percept history.

  For example: Vacuum Cleaner Agent

- First of all, the simple reflex agent perceives the percepts from the environment and the agent intercept input to generate an abstract state description of the current state from the percept.
- This generated state description is then matched against the condition part the rules in the rule set.
- Then it act according to a first rule whose condition matches the current state, as defined by the percept.

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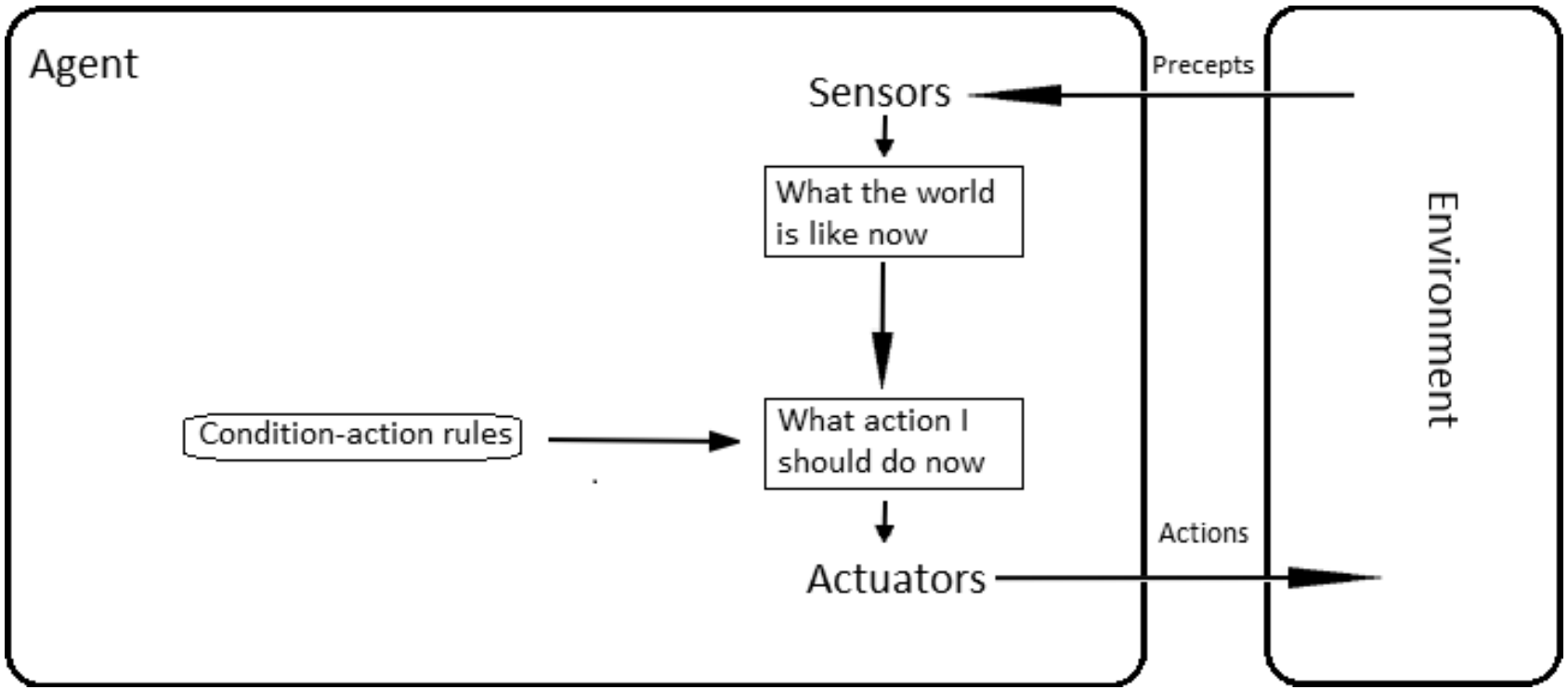
Agent
Sensors
What the world is like now
Condition-action rules
What action I should do now
Actuators
Precepts
Actions
Environment

# Contd..

- **Characteristics**
  - Simple, but very limited intelligence.
  - The simple reflex agent work only if the environment is fully observable. Even a , little bit of unobservability can cause serious trouble.
  - Lacking history, easily get stuck in infinite loops.

# Contd..

- **Advantages of Simple Reflex Agents:**
  1. **Efficiency in Decision-Making:** Simple reflex agents quickly respond to inputs based on pre-defined rules, making them efficient in scenarios where immediate responses are necessary.
  2. **Simplicity in Design:** Their rule-based approach simplifies the design and implementation, requiring less computation and memory, which is ideal for straightforward tasks.
  3. **Reliability in Static Environments:** They perform well in predictable, static environments where the conditions remain consistent over time, as they rely solely on current sensor inputs.

# Contd..

- **Disadvantages of Simple Reflex Agents:**
  1. **Lack of Memory:** Simple reflex agents have no memory of past actions or states, limiting their ability to adapt to environments where history or context is necessary for effective decision-making.
  2. **Inability to Handle Complex Tasks:** They struggle with complex or dynamic environments because they lack the ability to plan, predict outcomes, or handle conditional dependencies.
  3. **Limited Adaptability:** Without learning capabilities, simple reflex agents cannot improve or modify their behavior based on experience, making them unsuitable for tasks requiring adaptation.

# Contd..

***Model based Reflex Agent***

- *Maintain a internal state to keep track of part of world it can not see now.*
- *Internal state is based on percept history and keeps two kinds of knowledges:*
  - *How the world evolves independently of the agent*
  - *How the agent's own actions affect the world*
- *Then it combines current percept with the old internal state to generate the updated description of the current state.*
- *It then choose an action in the same way as reflex agent.*

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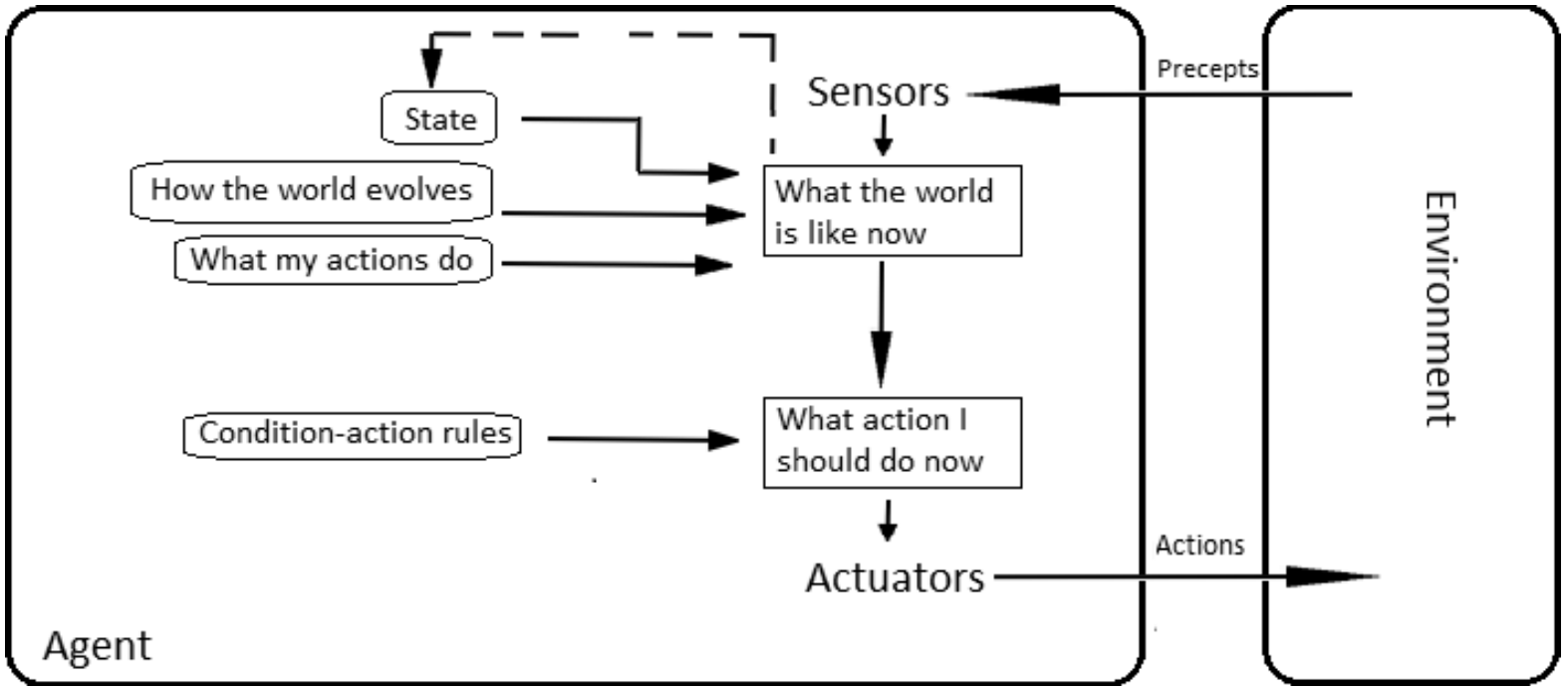
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# Contd..

## Characteristics

- **Internal State Representation:** Unlike simple reflex agents, model-based agents maintain an internal state that reflects aspects of the world that may not be immediately observable, allowing them to "remember" or infer information.
- **World Model:** They possess a model of the environment that helps them predict how the world changes in response to their actions. This model-based understanding allows them to handle partially observable environments.
- **Decision-Making Based on State and Model:** Decisions are made by consulting the internal model and current state, allowing the agent to respond more intelligently in complex situations.

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## Advantages of Model-Based Reflex Agents:

1. **Handles Partially Observable Environments:** With an internal state and model, these agents can make informed decisions even when all information is not directly observable, making them useful in complex environments.
2. **Improved Problem-Solving Ability:** The model-based approach enables better decision-making by simulating outcomes based on the model, which allows for more nuanced and informed responses to changing conditions.
3. **Greater Flexibility:** These agents can adjust to changes in the environment over time, as they continually update their internal state, making them more adaptable than simple reflex agents.

# Contd..

**Disadvantages of Model-Based Reflex Agents:**

1. **Increased Complexity:** The internal model and state tracking add computational complexity and require more memory and processing resources compared to simpler agents.
2. **Requires Accurate Environment Model:** The effectiveness of the agent heavily depends on the accuracy of its model. If the model does not accurately represent the environment, the agent's performance may degrade significantly.
3. **Higher Development Cost and Effort:** Designing and implementing a model-based agent is more time-consuming and complex, as it involves creating an effective model of the environment and maintaining an updated internal state.

# Contd..

***Goal Based Agent***

- *Goal based agent further expand on the capabilities of the model based agents, by using "goal" information.*
- *Goal information describes situations that are desirable. This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state.*
- *It is more flexible because the knowledge that supports its decisions is represented explicitly and can be modified.*

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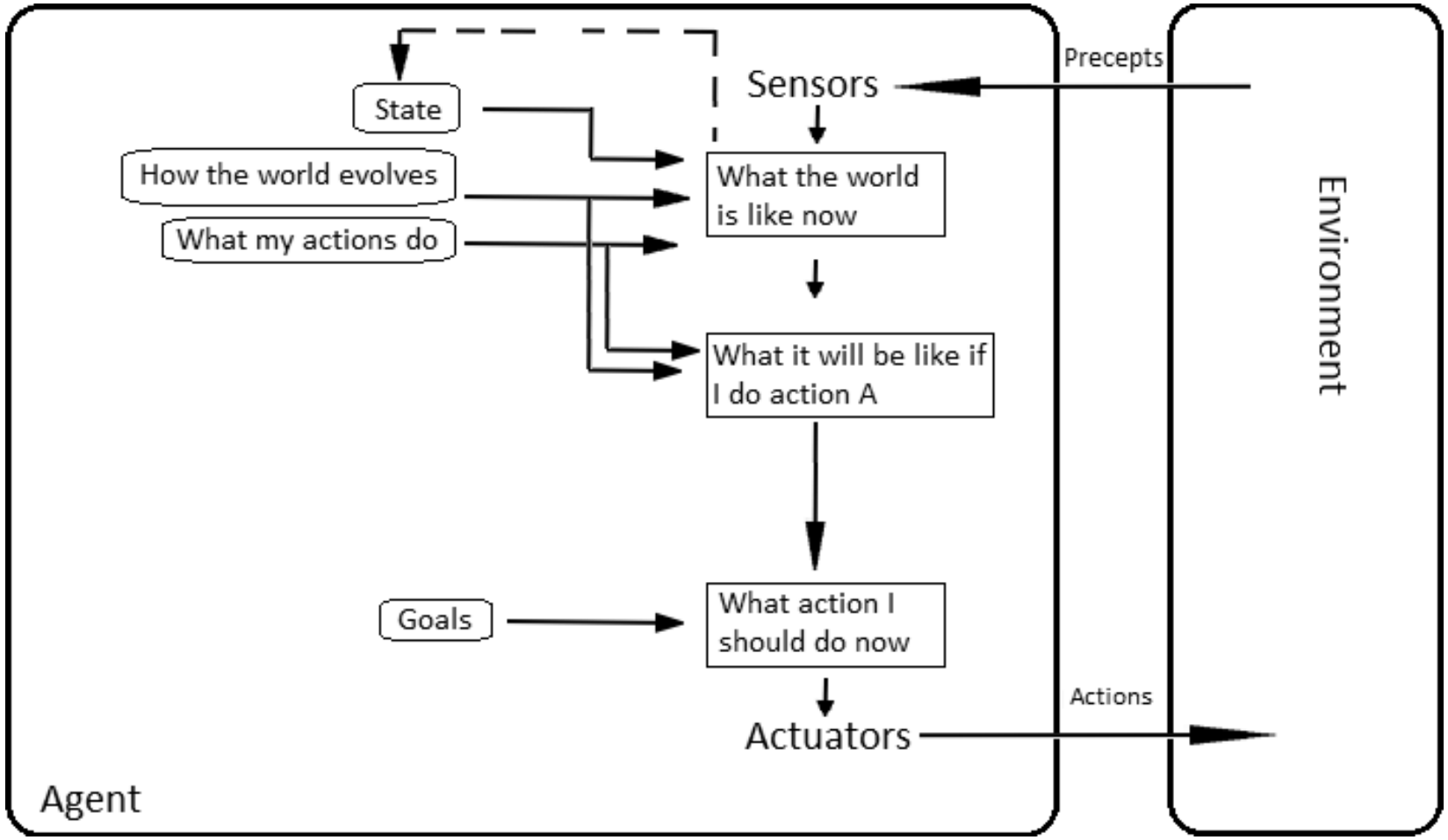
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Actions
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Environment

# Contd..

**Characteristics of Goal-Based Agents:**

1. **Goal-Oriented Behavior:** Goal-based agents make decisions by considering future states and choosing actions that help achieve a specific objective, rather than simply reacting to the current state.
2. **Planning and Search Capabilities:** These agents often use planning or search algorithms to evaluate sequences of actions that will lead to the desired goal, allowing them to operate effectively in complex and dynamic environments.
3. **Decision-Making Based on Goals and Environment Model:** They combine their goals with an internal model of the environment to choose actions, making them capable of handling more challenging tasks than reflex-based agents.

# Contd..

## Advantages of Goal-Based Agents:

1. **Enhanced Problem-Solving Abilities:** By focusing on goals and outcomes, these agents can tackle complex tasks, make strategic decisions, and handle situations where achieving long-term objectives is essential.
2. **Flexibility in Decision-Making:** They can adapt their behavior as goals or priorities change, allowing them to respond to dynamic environments and shifting objectives.
3. **Improved Efficiency in Complex Environments:** Goal-based agents can plan ahead, optimizing their actions to minimize effort and resources while achieving the desired outcome.

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- **Disadvantages of Goal-Based Agents:**
  1. **High Computational Cost:** Goal-based reasoning and planning can be computationally intensive, especially in large or highly dynamic environments, which may limit performance and speed.
  2. **Complexity in Goal Definition:** Setting up appropriate goals and designing the planning algorithms can be complex and challenging, requiring substantial development effort and expertise.
  3. **Dependency on Accurate Environment Models:** The agent's effectiveness depends on an accurate model of the environment. Inaccurate models or unforeseen changes in the environment can lead to suboptimal or even incorrect behavior.

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**Utility Based Agent**

- Goal Based agent only distinguish between goal states and non-goal states.
- It is possible to define a measure of how desirable a particular state is this measure can be obtained through the use of a utility function which maps a state to a measure of the utility of the state.
- A more general performance (for example, speed and safety) measure should allow a comparison of different world states according to exactly how happy they would make the agent. The term utility can be used to describe how ”Happy” agent is.

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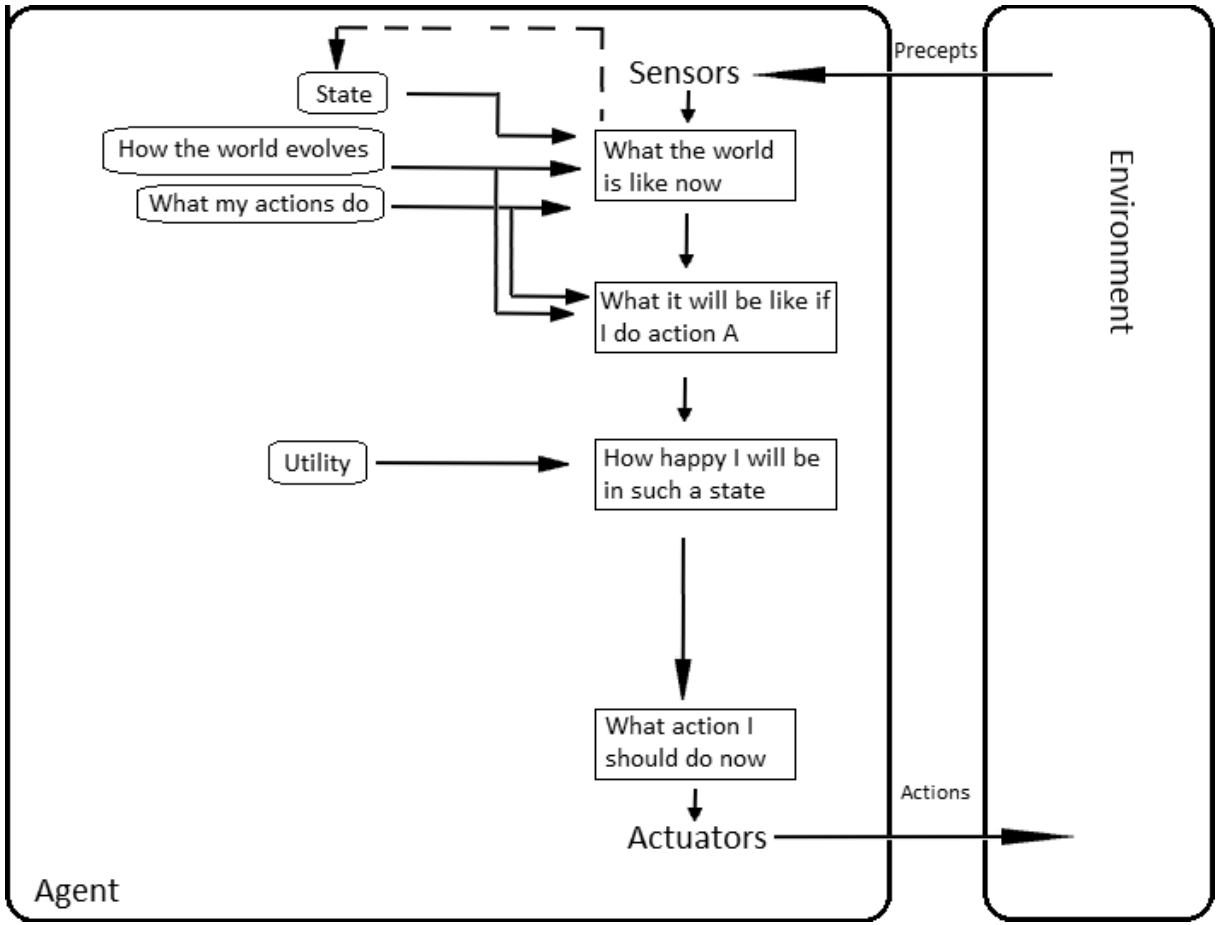
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Actuators
Actions
Agent
Environment

# Contd..

## Characteristics of Utility-Based Agents:

1. **Utility Measurement:** Utility-based agents evaluate actions based on a utility function, which assigns a numerical value to potential outcomes, representing their desirability. This allows them to choose actions that maximize their overall utility.
2. **Balancing Multiple Goals:** These agents prioritize among conflicting goals by selecting actions that maximize utility, making them capable of handling complex environments where trade-offs are required.
3. **Adaptive Decision-Making:** Utility-based agents can make context-sensitive decisions, adjusting their actions based on changing conditions and priorities to optimize outcomes according to their utility function.

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## Advantages of Utility-Based Agents:

1. **High Flexibility and Adaptability:** By using a utility function, these agents can make nuanced decisions in dynamic environments, adjusting their actions to maximize the expected utility under varying conditions.
2. **Effective in Complex and Uncertain Environments:** Utility-based agents handle uncertainty and conflicting goals well, as they can weigh different possible actions based on the expected outcomes, allowing for sophisticated decision-making.
3. **Capability to Optimize Outcomes:** They can prioritize actions that yield the highest utility, leading to more efficient and effective performance, particularly in scenarios where multiple objectives must be balanced.

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## Disadvantages of Utility-Based Agents:

1. **Complex Utility Function Design:** Developing an appropriate utility function is challenging, as it must accurately capture the agent's goals and preferences, which can require significant expertise and fine-tuning.
2. **High Computational Demand:** Calculating the utility for each possible action, especially in complex environments, can be computationally expensive and time-consuming, potentially limiting the agent's responsiveness.
3. **Potentially Overly Complex Decision-Making:** The use of utility functions can lead to overly complex or redundant decision-making processes, which may be unnecessary for simpler tasks or highly structured environments.

# Contd..

***Learning Agent***

- *A learning agent can be divided into four conceptual components*
  - *Learning element, Which is responsible for making improvements.*
  - *Performance element, Which is responsible for selecting external actions i.e., it takes in percepts and decides on actions.*
  - *The learning element uses feedback from the "Critic" on how the agent is doing and determines how the performance element should be modified to do better in the future.*
  - *The last component of the learning agent is the "Problem Generator" It is responsible for suggesting actions that will lead to new and informative experiences.*

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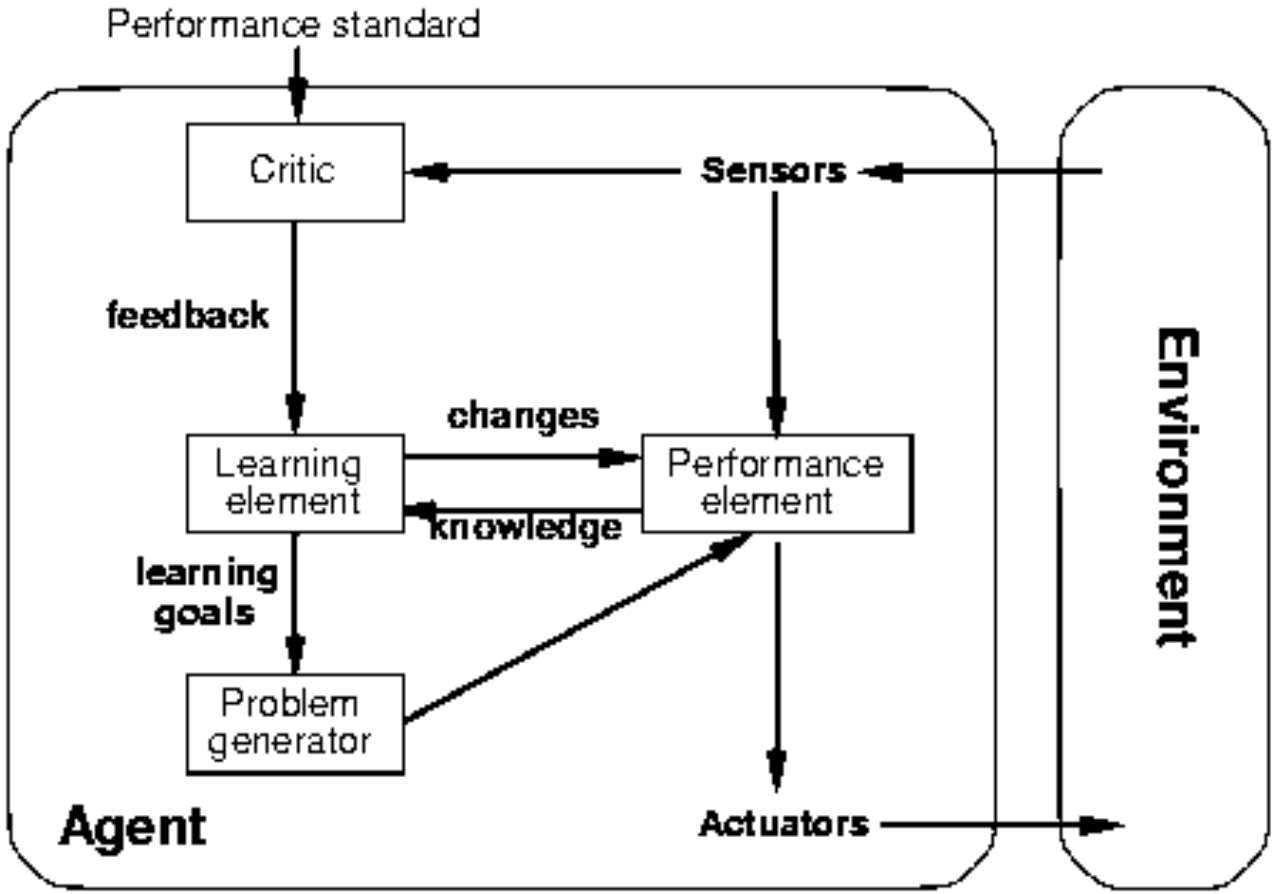
Performance standard
Critic
Sensors
feedback
changes
Learning element
Performance element
knowledge
learning goals
Problem generator
Agent
Actuators
Environment

# Contd..

## Characteristics of Learning Agents:

1. **Capability to Learn from Experience:** Learning agents improve their performance over time by learning from past actions and outcomes, adjusting their behavior based on acquired knowledge.
2. **Four Component Structure:** Learning agents typically have a learning element (to improve behavior), a performance element (to make decisions), a critic (to provide feedback on performance), and a problem generator (to suggest actions to explore new knowledge).
3. **Adaptability in Dynamic Environments:** These agents are highly adaptable, continually updating their knowledge and strategies, making them suitable for unpredictable or changing environments.

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## Advantages of Learning Agents:

1. **Improves Performance Over Time:** By learning from experience, these agents become more efficient and effective, adapting to new tasks or changes in the environment without the need for manual reprogramming.
2. **Handles Complex and Dynamic Environments:** Learning agents are well-suited for complex tasks where static knowledge is insufficient, as they can adapt to unforeseen situations and evolve their strategies.
3. **Reduces Long-Term Development Effort:** With learning capabilities, these agents can independently improve and optimize their behavior, potentially reducing the need for frequent updates and adjustments.

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## Disadvantages of Learning Agents:

1. **High Computational and Resource Requirements:** Learning, especially in real-time or complex environments, can be computationally expensive and may require substantial processing power and memory.
2. **Risk of Suboptimal Learning:** Without proper guidance or feedback, learning agents may develop suboptimal strategies, especially in environments where exploration is limited or reinforcement signals are sparse or delayed.
3. **Complexity in Designing Learning Mechanisms:** Developing an effective learning mechanism and feedback system can be challenging, as it must balance exploration with exploitation and ensure that the agent learns in a way that aligns with the desired outcomes.

## Applications of the agents

- *Intelligent agents are applied as automated online assistants, where they function to perceive the needs of customers in order to perform individualized customer service.*
- *Such an agent may basically consist of a dialog system, as well an expert system to provide specific expertise to the user.*
- *They can also be used to optimize coordination of human group online.*

# Thank You