

CSE3001 - Artificial Intelligence and Machine Learning

**SCHOOL OF CSE & IS,
PRESIDENCY UNIVERSITY,
BANGALORE**



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MODULE 1

Introduction to Artificial Intelligence and Knowledge based systems



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CONTENTS

- Artificial Intelligence
 - Introduction
 - Definitions
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 - Types of Agents, Structure and functions
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- Searching Algorithm in AI
- Conceptual graphs:
- Methods of Logic representation(POL, FOL)



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ARTIFICIAL INTELLIGENCE - INTRODUCTION

- Homo Sapiens : The name is Latin for "*wise man*"
- Philosophy of AI - "*Can a machine think and behave like humans do?*"
- In Simple Words - *Artificial Intelligence is a way of **making a computer, a computer-controlled robot, or a software think intelligently**, in the similar manner the intelligent humans think.*
- **Artificial intelligence (AI)** is an area of computer science that emphasizes the creation of **intelligent** machines that work and react like humans.
- AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.



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What is AI?

Views of AI fall into four categories:

1. **Thinking humanly**
2. **Thinking rationally**
3. **Acting humanly**
4. **Acting rationally**

The textbook advocates "acting rationally"



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What is AI?

Thinking Humanly “The exciting new effort to make computers think ... machines with minds, in the full and literal sense.” “Activities that we associate with human thinking, activities such as decision-making, problem solving, learning...”	Thinking Rationally “The study of mental abilities through the use of computational models.” “The study of the computations that make it possible to perceive, reason and act.”
Acting Humanly “The art of creating machines that perform functions that require intelligence when performed by people.” “The study of how to make computers do things at which, at the moment, people are better.”	Acting Rationally “Computational Intelligence is the study of the design of intelligent agents.” “AI ... is concerned with intelligent behavior in artifacts.”



Thinking humanly: Cognitive Modeling

- If we are going to say that *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 3 ways to do it:

1. Through introspection

Trying to catch our own thoughts as they go

2. Through psychological experiments

Observing a person in action

3. Through brain imaging

Observing the brain in action



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Thinking humanly: Cognitive Modeling

- Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program.
- If the program's input-output behavior matches corresponding human behavior, that is evidence that the program's mechanisms could also be working in humans.



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Thinking Rationally: “Laws of Thought”

- Aristotle: one of the first to attempt to codify “**right thinking**”.
Mathematical representation.
- His **syllogisms** provided patterns for **argument structures** that always yielded correct conclusions when given premises are correct.
- **Example** – Socrates is a man
All men are mortal
Therefore
Socrates is mortal



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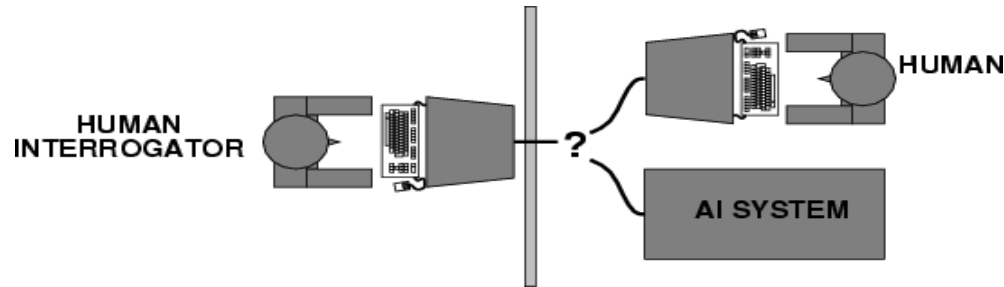
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Acting humanly: Turing Test

- Turing (1950) developed "Computing machinery and intelligence":
- "Can machines think?" ? "Can machines behave intelligently?"
- Operational test for intelligent behavior: **the Imitation Game**



- A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a machine.
- Suggested major components of AI: knowledge, reasoning, language understanding, learning



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Acting humanly: Turing Test

The computer would need to possess the following capabilities:

- **Natural Language Processing:**
To enable it to communicate successfully in English.
- **Knowledge representation:**
To store what it knows or hears.
- **Automated reasoning:**
To use the stored information to answer questions and to draw new conclusions.
- **Computer vision:** To perceive objects.
- **Robotics:** To manipulate objects and move about.



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Acting Rationally: Rational Agent

- An **agent** is an entity that perceives and acts
- A system is rational if it does the “right thing,” given what it knows.
- This course is about designing rational agents
- Rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.
- Abstractly, an agent is a function from percept histories to actions:

$[f: P^* \rightarrow A]$



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Definition of AI

- Existing definitions advocate everything from replicating human intelligence to simply solving knowledge-intensive tasks.

Examples:

“Artificial Intelligence is the design, study and construction of computer programs that behave intelligently.” -- Tom Dean.

“Artificial Intelligence is the enterprise of constructing a physical symbol system that can reliably pass the Turing test.” -- Matt Ginsberg.



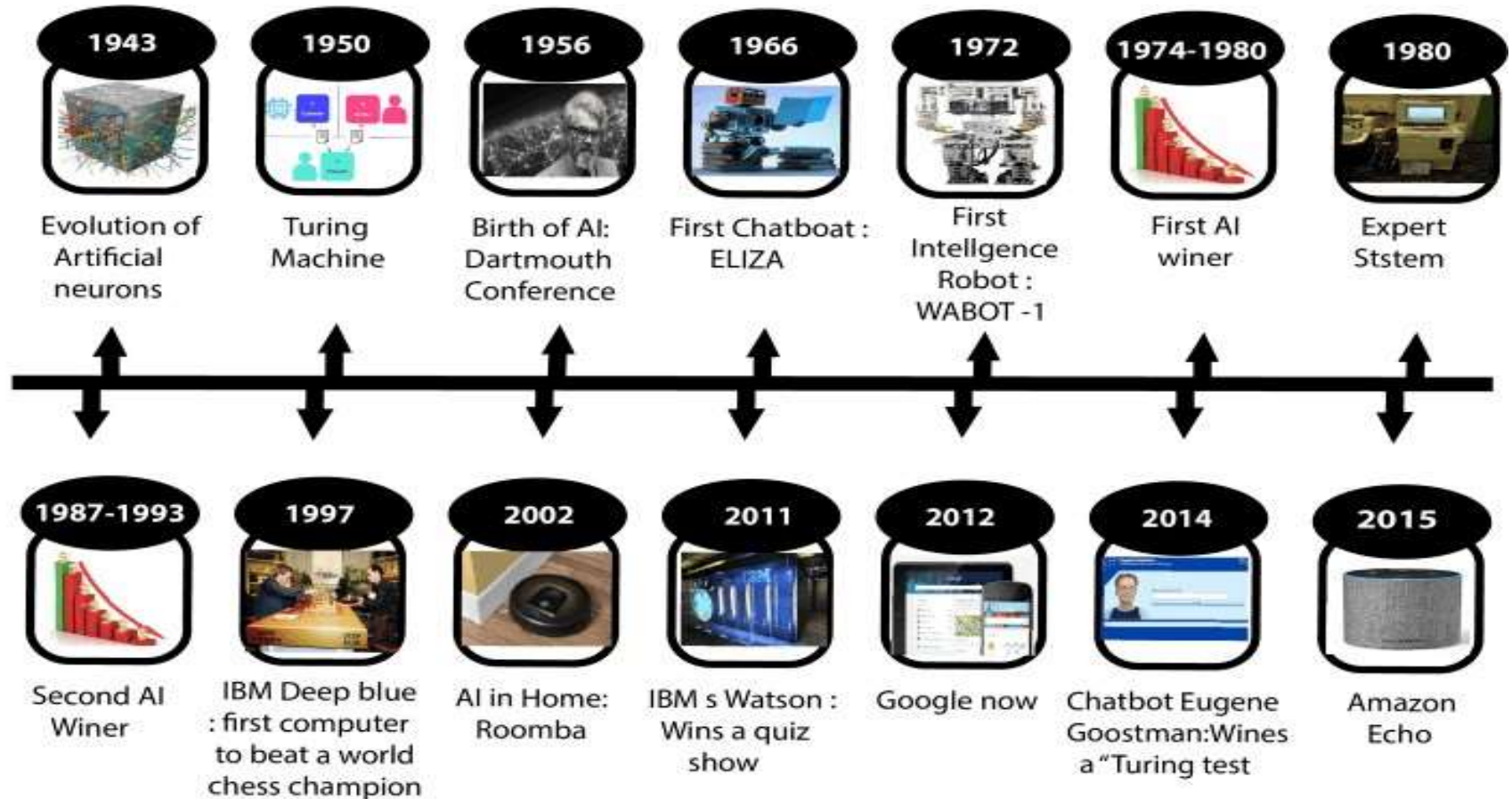
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History of AI



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Applications of AI

- **Deep Blue(chess-playing computer)** defeated the world chess champion Garry Kasparov in 1997
- During the 1991 Gulf War, US forces deployed an **AI logistics planning and scheduling program** that involved up to 50,000 vehicles, cargo, and people
 - Planning – How to use resources?
 - Scheduling – When to use the resources?
- NASA's on-board autonomous planning program controlled the **scheduling of operations for a spacecraft**
- **Google duplex**
- The GPS developed in 1957 by Alan Newell and Hervert Simon, embodied a grandiose vision



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Future Perspective

- (1) Reducing the time and cost of development is a big plan for AI.
 - (2) To develop applications towards strong AI.
 - (3) Allowing students to work collaboratively is another plan from Researchers.
- **Perfect rationality:** the classical notion of rationality in decision theory.
 - **Bounded optimality:** A bounded optimal agent behaves as well as possible given its computational resources.
 - **Game theory** studies decision problems in which the utility of a given action depends not only on changing events in the environment but also on the actions of other agents.



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Major Concerns



TAY



COMPAS - Correctional Offender Management
Profiling for Alternative Sanctions

	HUMANS	COMPAS
Accuracy (overall)	67.0%	65.2%
False positive (black defendants)	37.1%	40.4%
False positive (white defendants)	27.2%	25.4%
False negative (black defendants)	29.2%	30.9%
False negative (white defendants)	40.3%	47.9%



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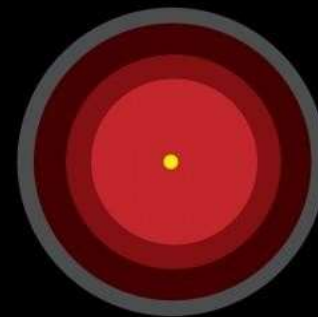
Singularity

Singularity is a hypothetical future point in time at which technological growth becomes uncontrollable and irreversible, resulting in unfathomable changes to human civilization.



THE TECHNOLOGICAL SINGULARITY

MURRAY SHANAHAN



THE MIT PRESS ESSENTIAL KNOWLEDGE SERIES



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AGENTS



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Agents in Artificial Intelligence

- Artificial intelligence is defined as a study of rational agents. A rational agent could be anything which makes decisions, as a person, firm, machine, or software. It carries out an action with the best outcome after considering past and current percepts(agent's perceptual inputs at a given instance). An AI system is composed of an **agent and its environment**. The agents act in their environment.
- The environment may contain other agents. An agent is anything that can be viewed as :
 - perceiving its environment through **sensors** and
 - acting upon that environment through **actuators**



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The Structure of Intelligent 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.
- To understand the structure of Intelligent Agents, we should be familiar with *Architecture* and *Agent Program*. **Architecture** is the machinery that the agent executes on. It is a device with sensors and actuators, for example : a robotic car, a camera, a PC. **Agent program** is an implementation of an agent function. An **agent function** is a map from the percept sequence(history of all that an agent has perceived till date) to an action.



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Agent Terminology

- **Performance Measure of Agent** – It is the criteria, which determines how successful an agent is.
- **Behavior of Agent** – It is the action that agent performs after any given sequence of percepts.
- **Percept** – It is agent's perceptual inputs at a given instance.
- **Percept Sequence** – It is the history of all that an agent has perceived till date.
- **Agent Function** – It is a map from the precept sequence to an action.



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Rationality

- Rationality is nothing but status of being reasonable, sensible, and having good sense of judgment.
- Rationality is concerned with expected actions and results depending upon what the agent has perceived. Performing actions with the aim of obtaining useful information is an important part of rationality.

What is Ideal Rational Agent?

- An ideal rational agent is the one, which is capable of doing expected actions to maximize its performance measure, on the basis of –
- Its percept sequence, built-in knowledge base
- Rationality of an agent depends on the following –
- The **performance measures**, which determine the degree of success.
- Agent's **Percept Sequence** till now. The agent's **prior knowledge about the environment**.



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Rationality

- The **actions** that the agent can carry out.
- A rational agent always performs right action, where the right action means the action that causes the agent to be most successful in the given percept sequence. The problem the agent solves is characterized by Performance Measure, Environment, Actuators, and Sensors (PEAS).



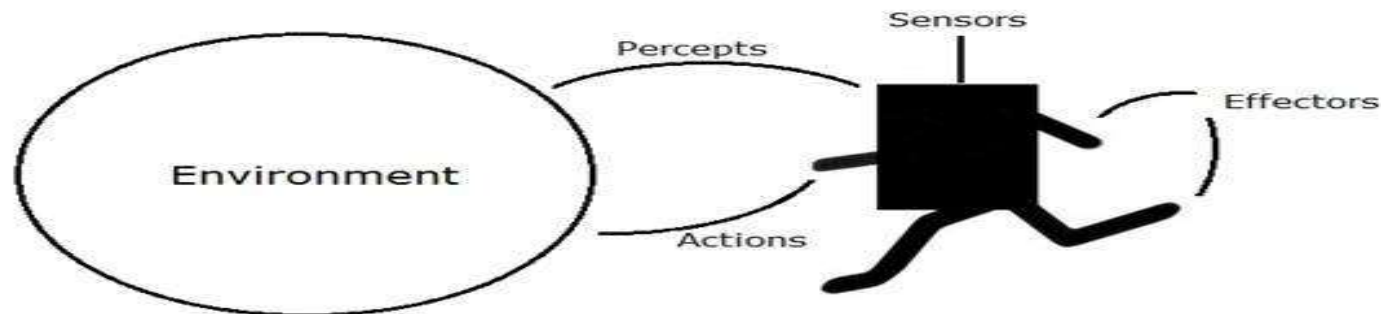
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Examples of Agent Environment:-

- An **agent** is anything that can perceive its environment through **sensors** and acts upon that environment through **effectors**.
- A **human agent** has sensory organs such as eyes, ears, nose, tongue and skin parallel to the sensors, and other organs such as hands, legs, mouth, for effectors.
- A **robotic agent** replaces cameras and infrared range finders for the sensors, and various motors and actuators for effectors.
- A **software agent** has encoded bit strings as its programs and actions.



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Types of Agents

- Agents can be grouped into five classes based on their degree of perceived intelligence and capability. All these agents can improve their performance and generate better action over the time. These are given below:
 - Simple Reflex Agent
 - Model-based reflex agent
 - Goal-based agents
 - Utility-based agent
 - Learning agent



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Simple Reflex Agent

- The Simple reflex agents are the simplest agents. These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the fully observable environment.
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.
- The Simple reflex agent works on Condition-action rule, which means it maps the current state to action. Such as a Room Cleaner agent, it works only if there is dirt in the room.
- Problems for the simple reflex agent design approach:
 - They have very limited intelligence
 - They do not have knowledge of non-perceptual parts of the current state
 - Mostly too big to generate and to store also not adaptive to changes in the environment.



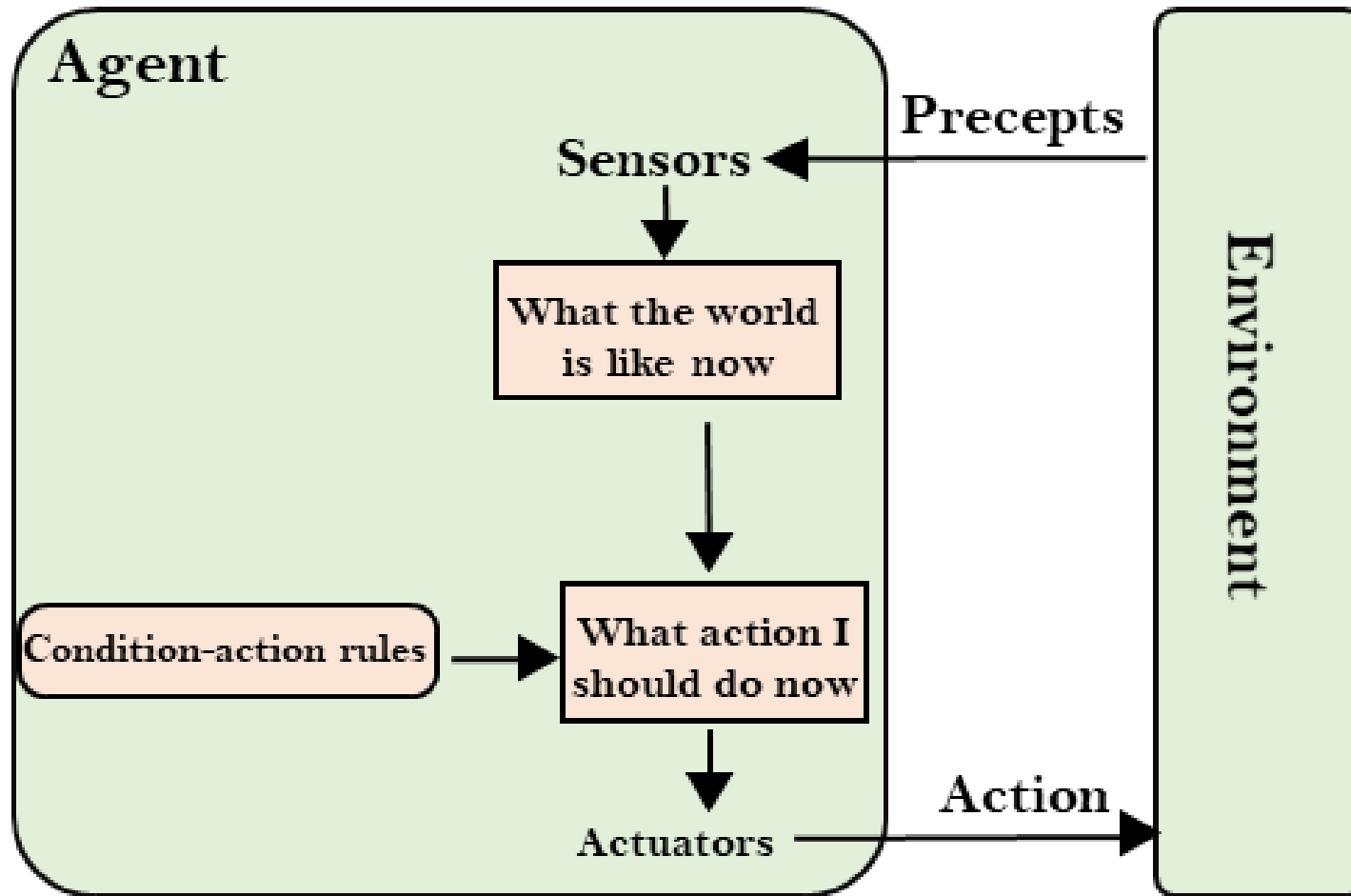
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Simple Reflex Agent

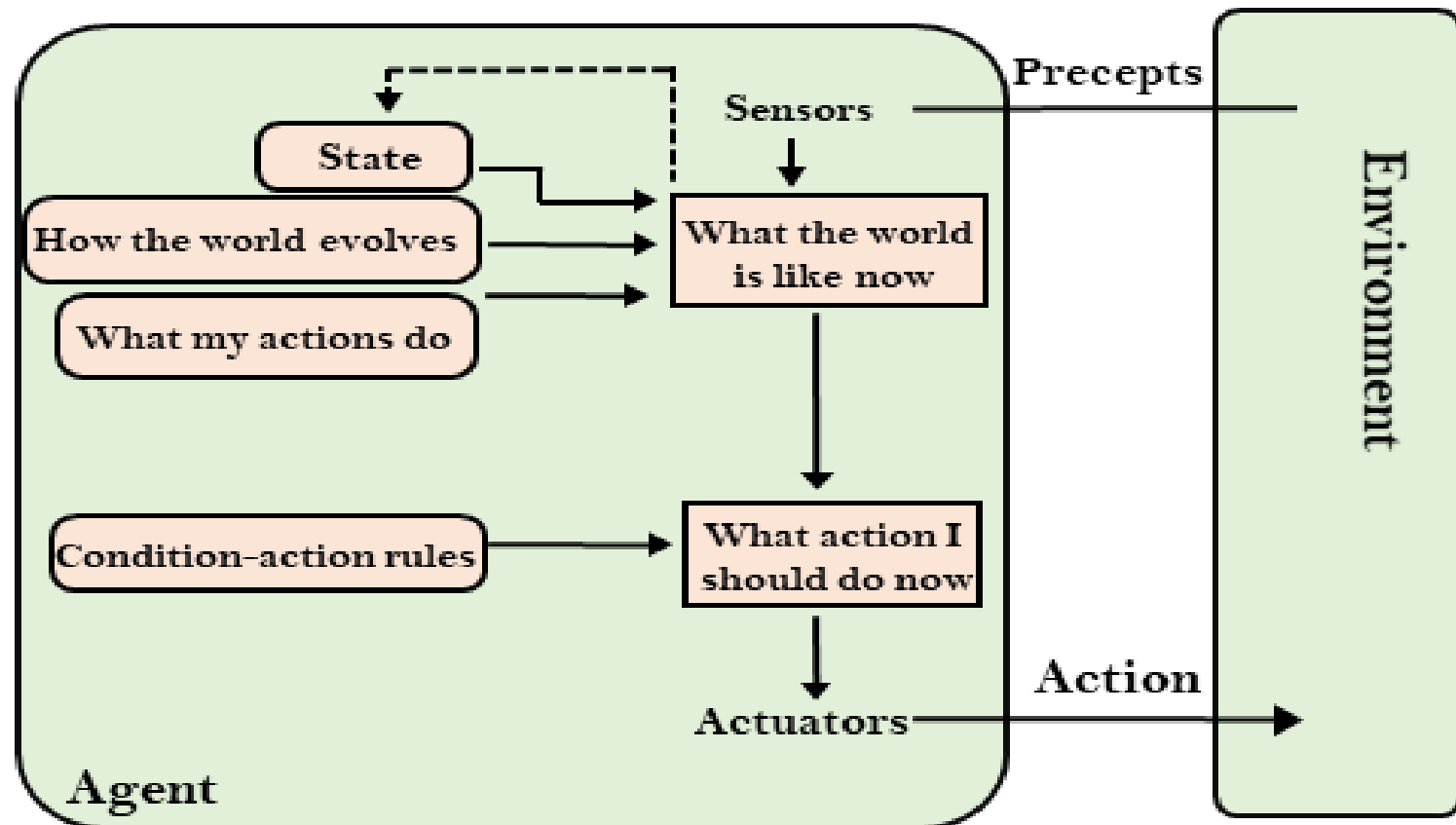


Model-based reflex agent

- The Model-based agent can work in a partially observable environment, and track the situation.
- A model-based agent has two important factors:
 - **Model:** It is knowledge about "how things happen in the world," so it is called a Model-based agent.
 - **Internal State:** It is a representation of the current state based on percept history.
- These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- Updating the agent state requires information about:
 - How the world evolves
 - How the agent's action affects the world.



Model-based reflex agent



Goal-based agents

- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goal.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not. Such considerations of different scenario are called searching and planning, which makes an agent proactive.



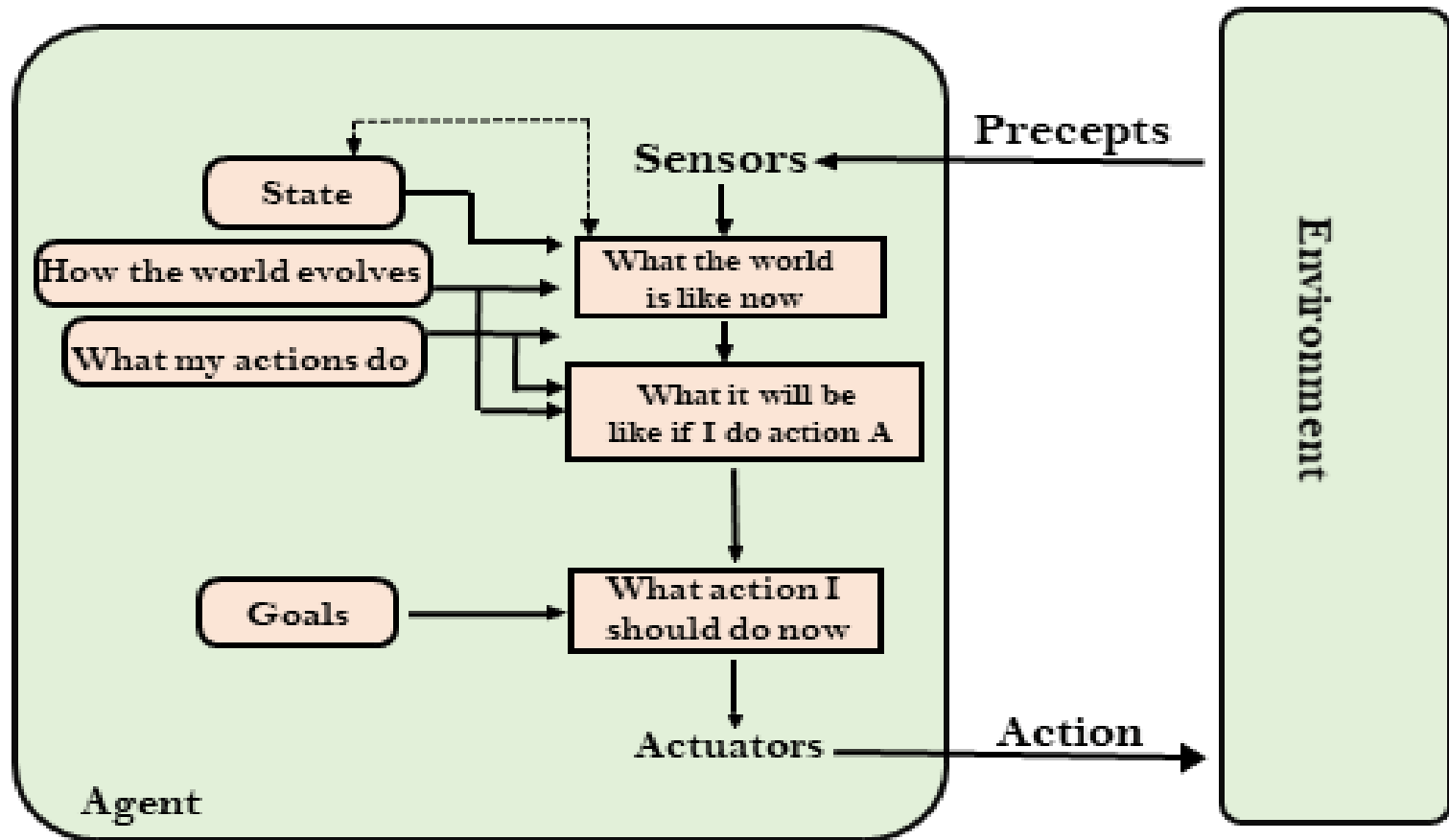
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Goal-based agents



Utility-based agents

- These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.
- Utility-based agent act based not only goals but also the best way to achieve the goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.



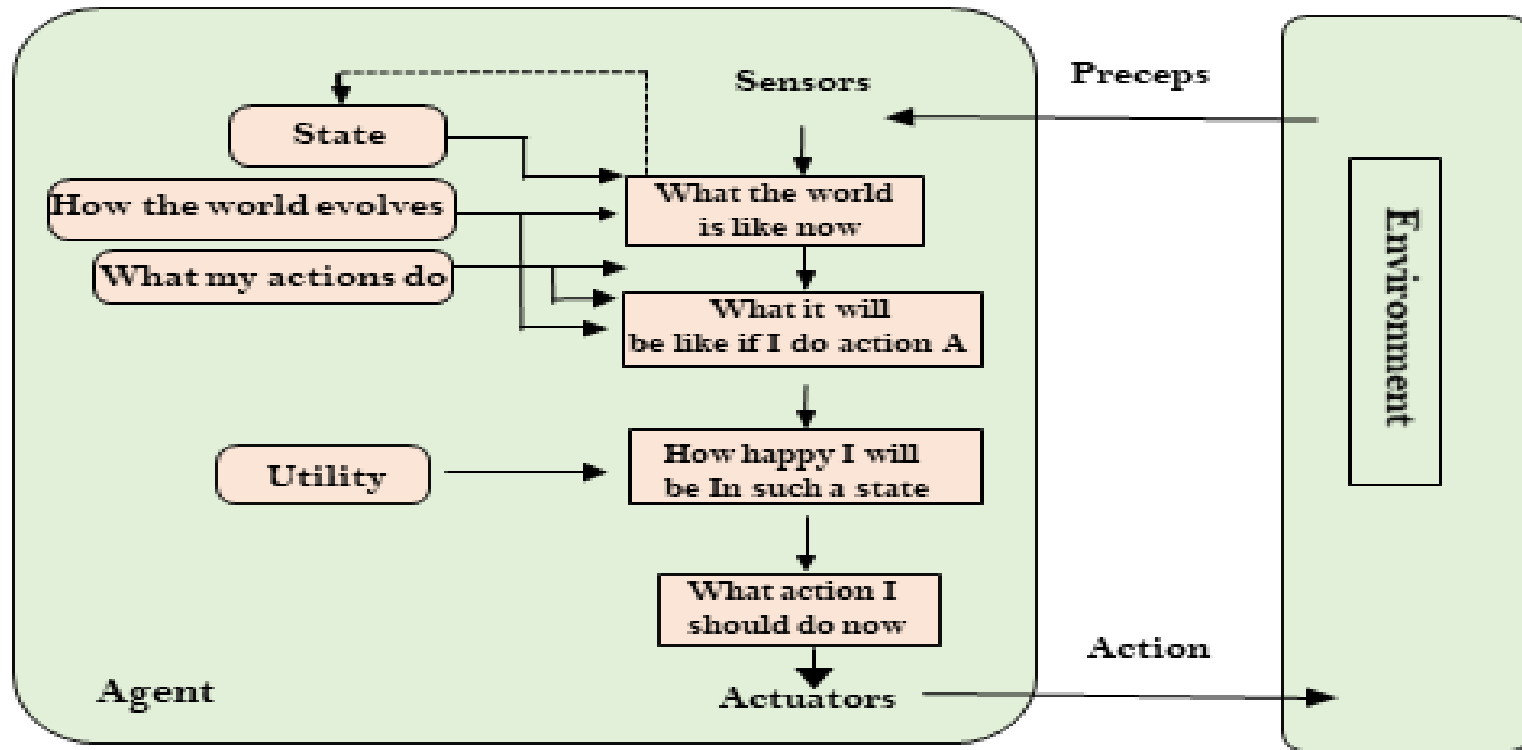
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Utility-based agents

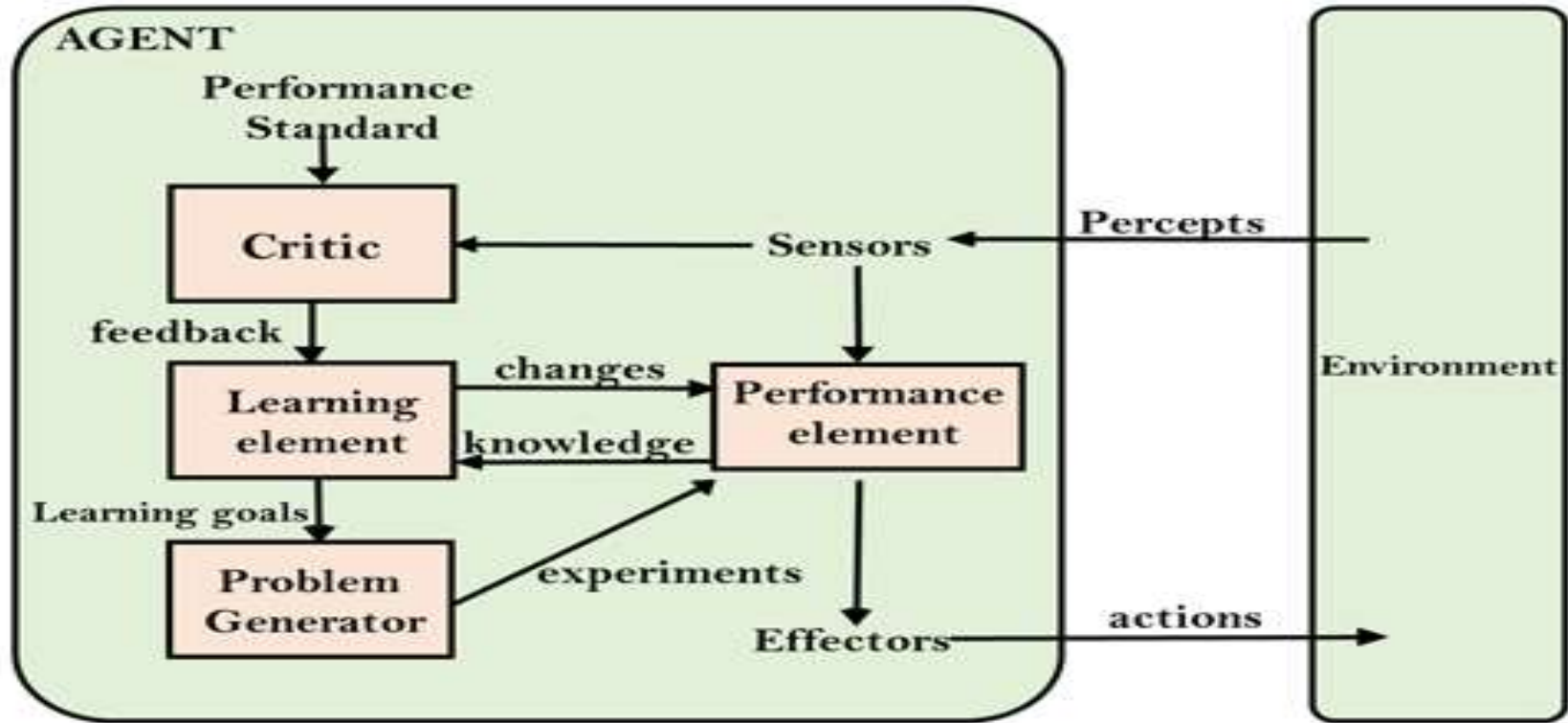


Learning Agents

- A learning agent in AI is the type of agent that can learn from its past experiences, or it has learning capabilities.
- It starts to act with basic knowledge and then is able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
 - **Learning element:** It is responsible for making improvements by learning from the environment
 - **Critic:** The learning element takes feedback from the critic which describes that how well the agent is doing with respect to a fixed performance standard.
 - **Performance element:** It is responsible for selecting external action
 - **Problem generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.
- Hence, learning agents are able to learn, analyze performance, and look for new ways to improve performance.



Learning Agents



AGENTS AND ENVIRONMENT

- Some programs operate in the entirely **artificial environment** confined to keyboard input, database, computer file systems and character output on a screen.
- In contrast, some software agents (software robots or soft bots) exist in rich, unlimited soft bots domains. The simulator has a **very detailed, complex environment**.
- The most famous **artificial environment** is the **Turing Test environment**, in which one real and other artificial agents are tested on equal ground.
- The success of an intelligent behavior of a system can be measured with Turing Test.
- Two persons and a machine to be evaluated participate in the test. Out of the two persons, one plays the role of the tester. Each of them sits in different rooms. The tester is unaware of who is machine and who is a human.



Properties/Features of Environment

- Discrete / Continuous
- Observable / Partially Observable
- Static / Dynamic
- Single agent / Multiple agents
- Accessible / Inaccessible
- Deterministic / Non-deterministic
- Episodic / Non-episodic



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KNOWLEDGE REPRESENTATION



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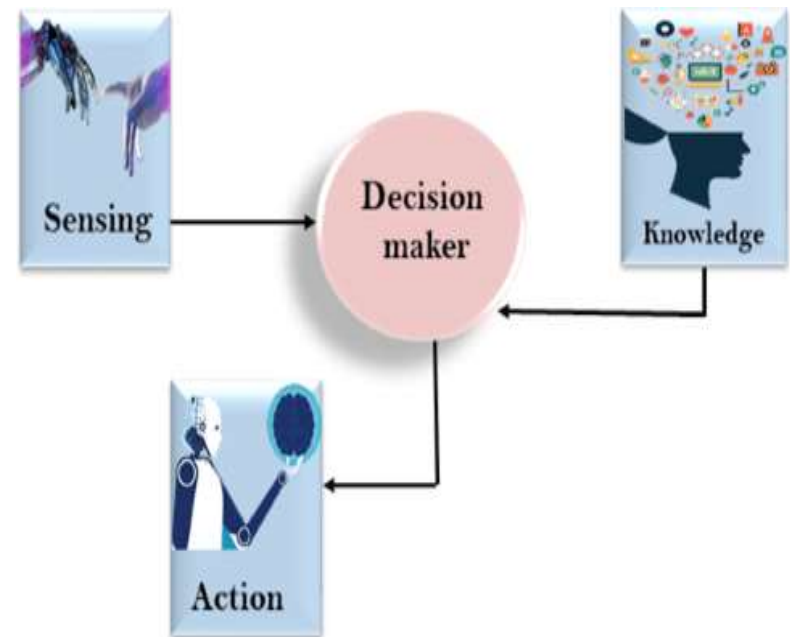
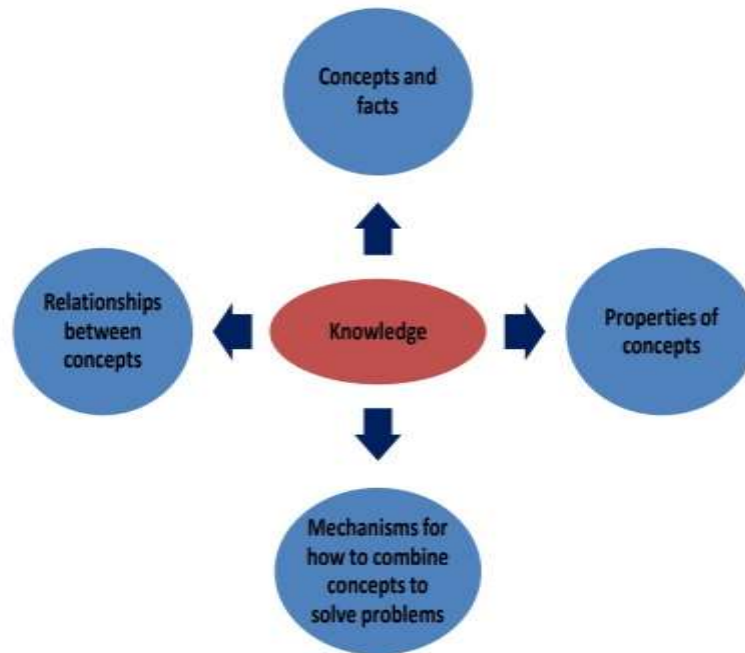
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Introduction to knowledge

- Knowledge is the sort of information that people use to solve problems.
- **Knowledge is having familiarity with the language, concepts, procedures, rules, ideas, places, customs, facts, and associations.**
- Knowledge is understanding of a subject area.



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Knowledge

- Definition and Importance of Knowledge
- Knowledge-Based Systems
- Knowledge Organization
- Representation of Knowledge
 - Logic
 - Associative Networks
 - Frame Structures
 - Conceptual graphs



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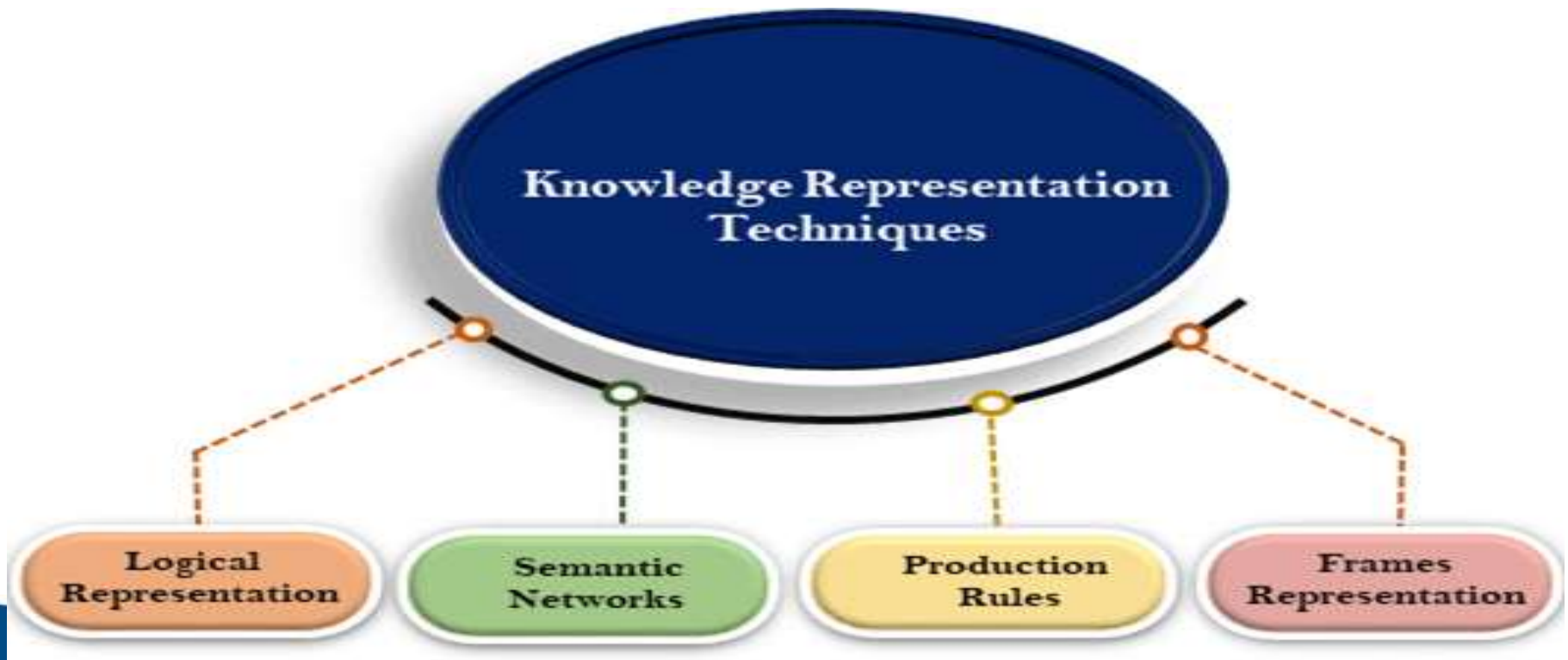


- Difference between data, information and knowledge:
 - Data: Primitive verifiable facts. Example: name of novels available in a library.
 - Information: Analyzed data. Example: The novel that is frequently asked by the members of library is “Harry Potter and the Chamber of Secrets”.
 - Knowledge: Analyzed information that is often used for further information deduction. Example: Since the librarian knows the name of the novel that is frequently asked by members, s/he will ask for more copies of the novel the next time s/he places an order.



Introduction to Knowledge Representation (KR)

- The method used to encode knowledge in an KBS's Knowledge base
- The field of AI dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks



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Why do we need Knowledge Representation?

- Unlike human mind, computers cannot acquire and represent knowledge by themselves.
- It is complicated to machine process a knowledge represented in natural language.
- Human knowledge is of different types.
- Knowledge manipulation involves:
 - Knowledge acquisition: gathering, structuring and organizing knowledge.
 - Knowledge storing: putting the knowledge into computer.
 - Knowledge retrieval: getting the knowledge when needed.
 - Reasoning: gives conclusion, inference or explanation.



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Knowledge Representation Schemas

<ul style="list-style-type: none">• Logical schemas<ul style="list-style-type: none">- First-order logic- Higher-order logic	<ul style="list-style-type: none">• Network schemas<ul style="list-style-type: none">- Semantic networks- Conceptual graphs
<ul style="list-style-type: none">• Procedural schemas<ul style="list-style-type: none">- Rule-based systems	<ul style="list-style-type: none">• Structural schemas<ul style="list-style-type: none">- Frames- Scripts



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Common Techniques/Issues of KR

- Object – Attribute – Value Triplets (O-A-V)
- Rules
- Semantic Networks
- Frames
- Logic



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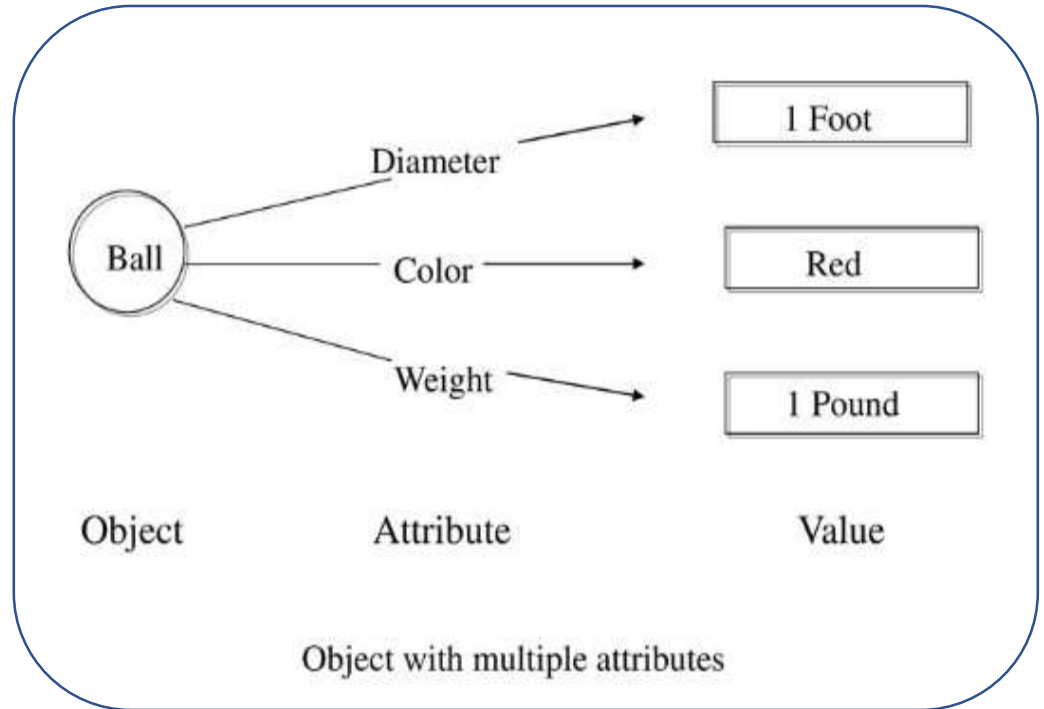
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Object – Attribute – Value Triplets (O-A-V)

- *The Ball is round in shape*
 - **Object:** Ball
 - **Attribute:** Shape
 - **Value:** Red



Rules

- **Rule:** A knowledge structure that relates some known information to other information that can be concluded or inferred
- A rule describes how to solve a problem
- Expert systems employing rules are called rule-based expert systems



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Structure of Rule

The rules structure logically connects one or more **antecedents** also called **premises** contained in the **IF** part, to one or more **consequents** also called **conclusions** contained in the **THEN** part.

IF The ball's color is red
THEN I like the ball

If the balls color is red then we can infer that I like the ball



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Working Memory

- Expert systems employing rules are called rule-based expert systems
- System matches the IF portion of the rules with facts contained in the working memory
- When a match is confirmed, the rule *fires* and its THEN statements are added to the working memory
- The new statements added to the working memory can also cause other rules to fire



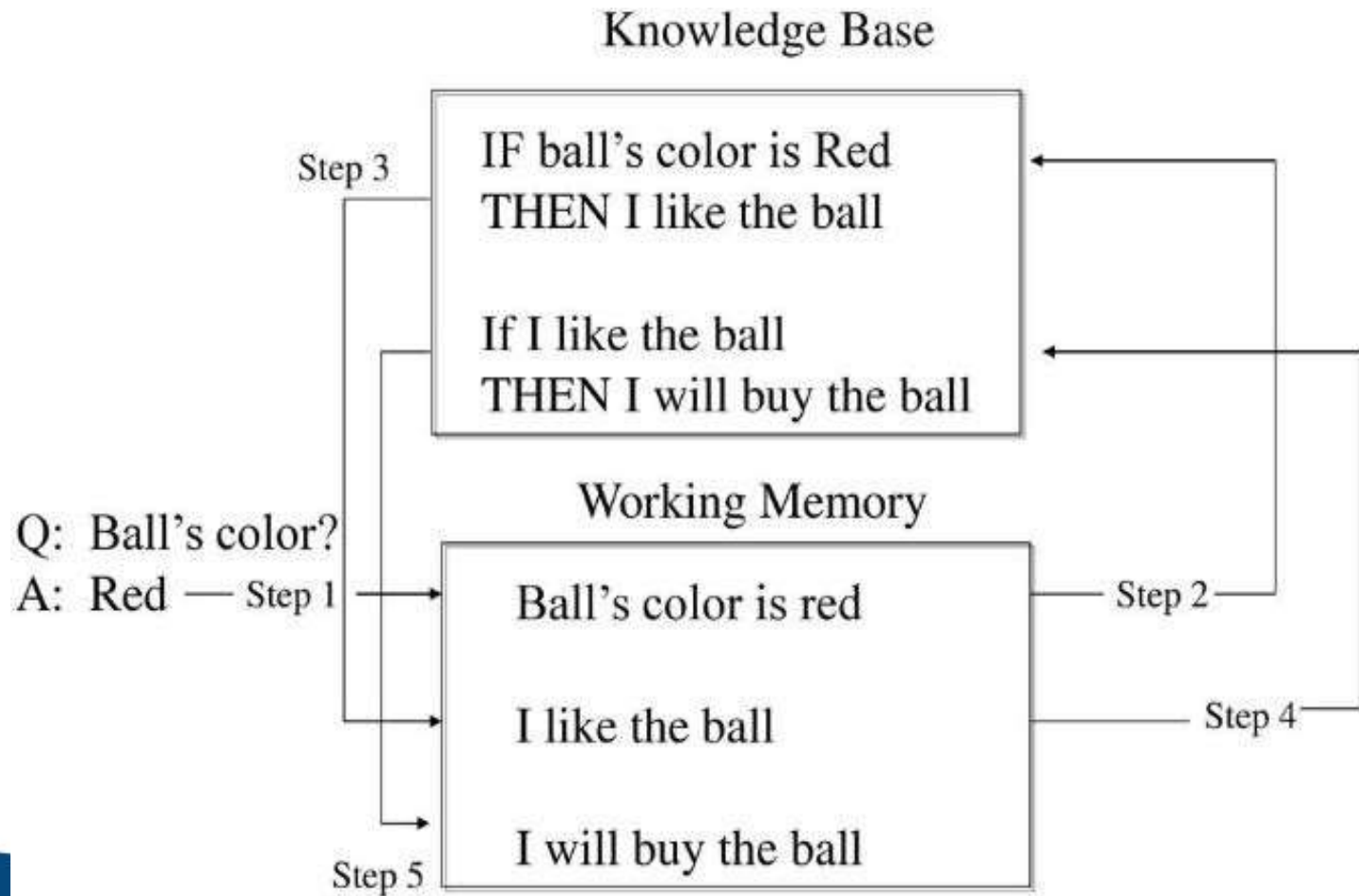
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Inference Engine



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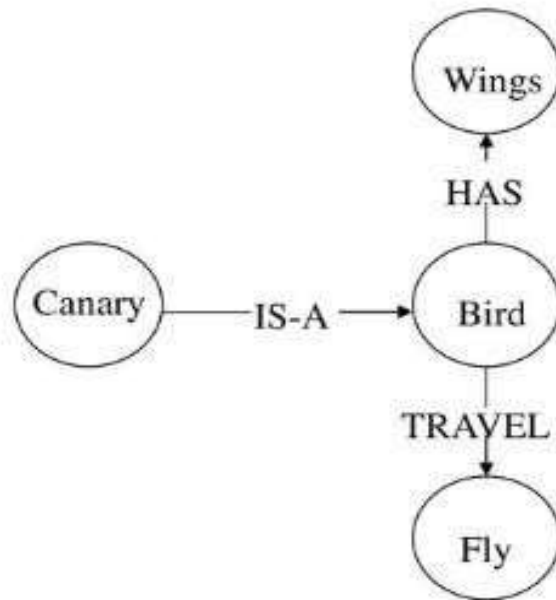
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Semantic Networks

DEFINITION: Semantic Network - A method of knowledge representation using a graph made up of nodes and arcs where the nodes represent objects and the arcs the relationships between the objects



IS-A (Canary, Bird)

Semantic network of a bird



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Draw a Semantic Network

“Every human, animal and bird is living thing who breathe and eat. All birds can fly. All man and woman are humans who have two legs. Cat is an animal and has a fur. All animals have skin and can move. Giraffe is an animal who is tall and has long legs. Parrot is a bird and is green in color”.

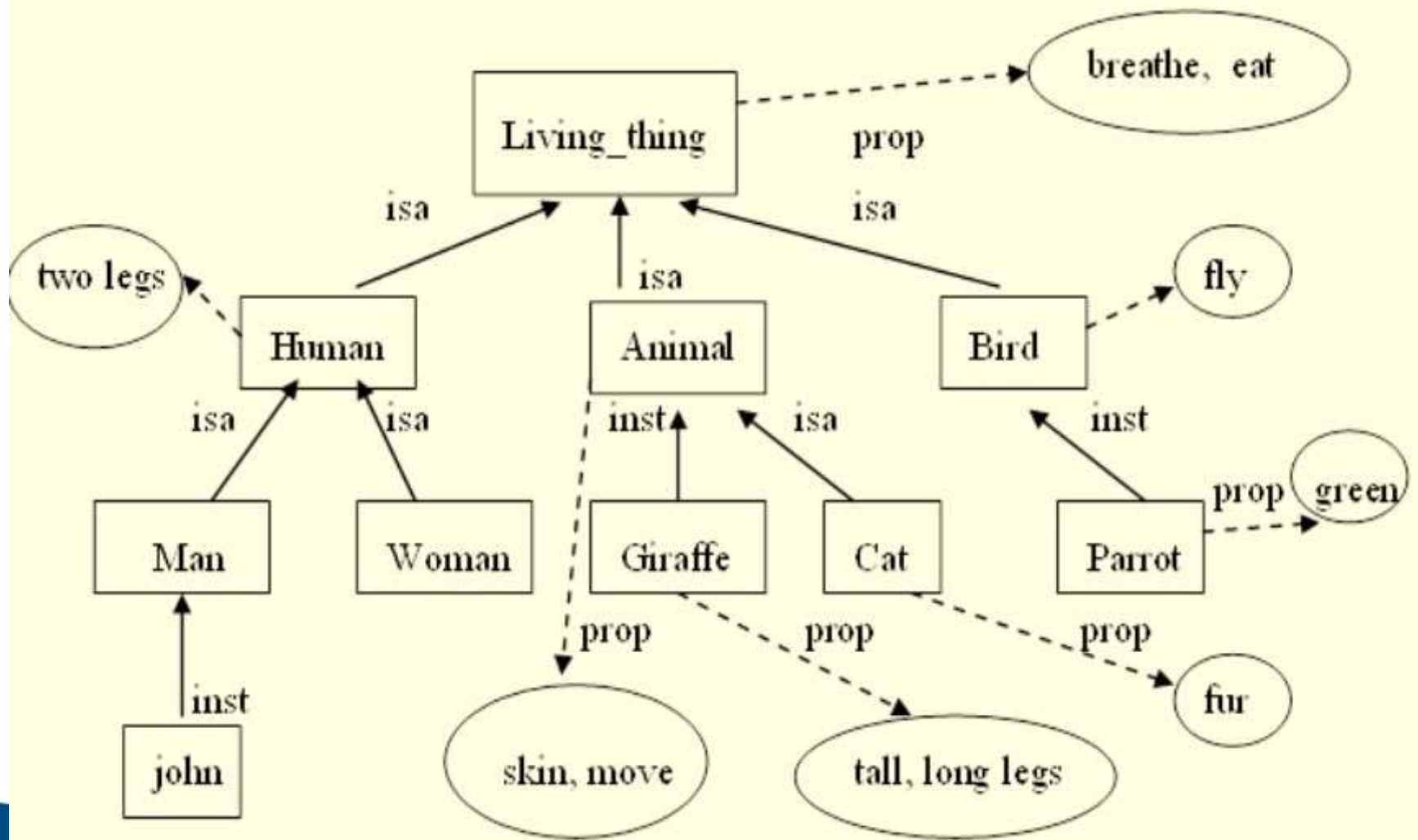


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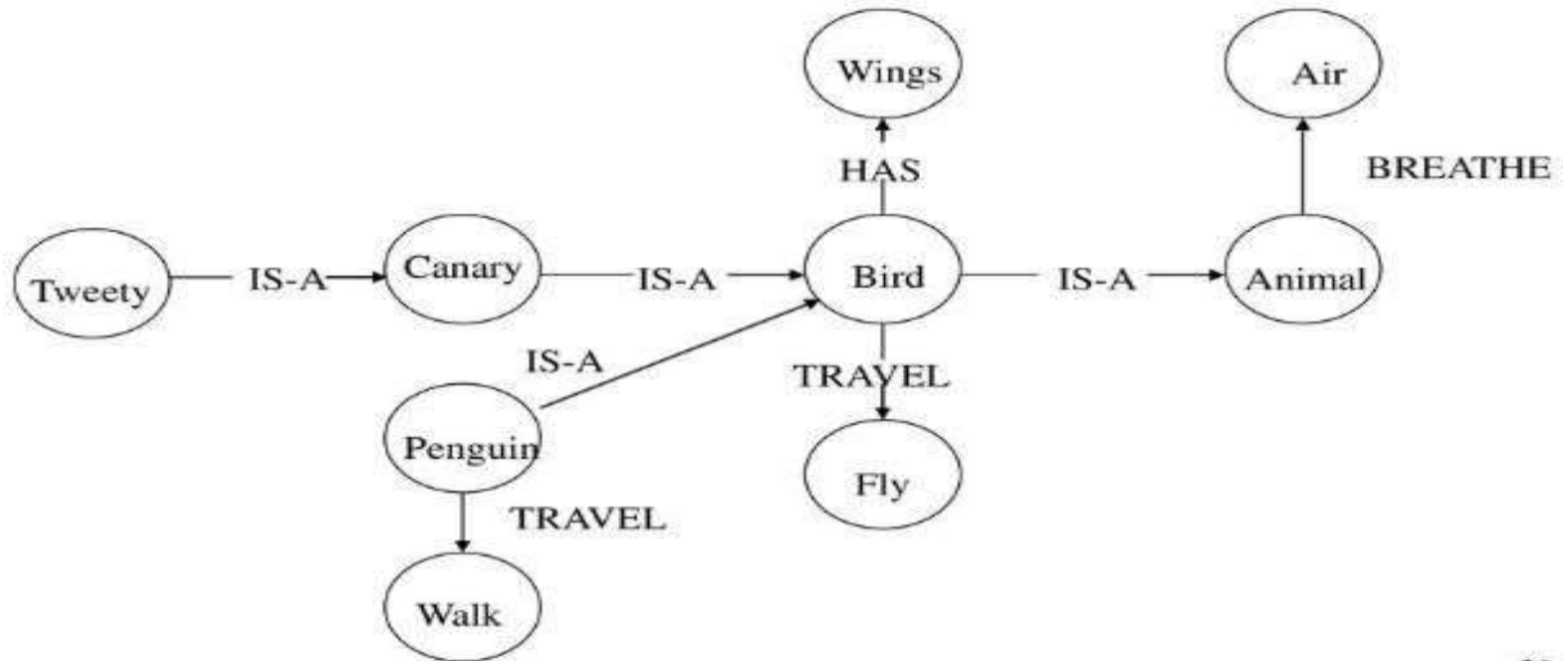
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Semantic Networks

You can add a new object node by 1) a similar object, 2) a more specific object, or (3) a more general object.



Associative Networks

- Semantic networks consist of **nodes**, **links (edges)** and **link labels**.
- **nodes** appear as circles or ellipses or rectangles to represent objects such as physical objects, concepts or situations.
- **Links** appear as arrows to express the relationships between objects.
- **link labels** specify particular relations.
- As nodes are associated with other nodes semantic nets are also referred to as **Associative Networks**.
- Semantic Networks, Frames and Scripts are sometimes called as **Associative Networks**.



Associative Networks

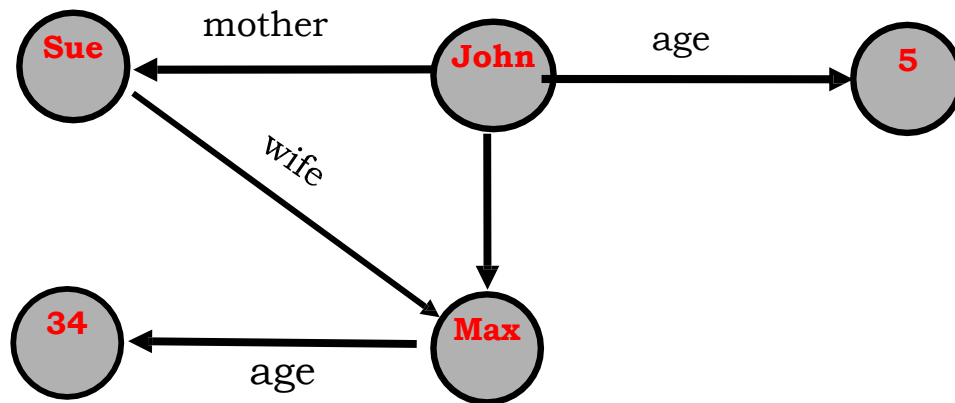
Example :

mother(john, sue)

age(john,5)

wife(sue,max)

age(max,34)



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Associative Networks

- It's defined as various kinds of links between the **concepts**.
 - “**has-part**” or **aggregation**.
 - “**is-a**” or **specialization**.More specialized depending on domain.
- It typically also includes **Inheritance** and some kind of procedural attachment.

Example :

- Tom is a Bird.
- Bird is a Animal.
- Bird has part Wings.



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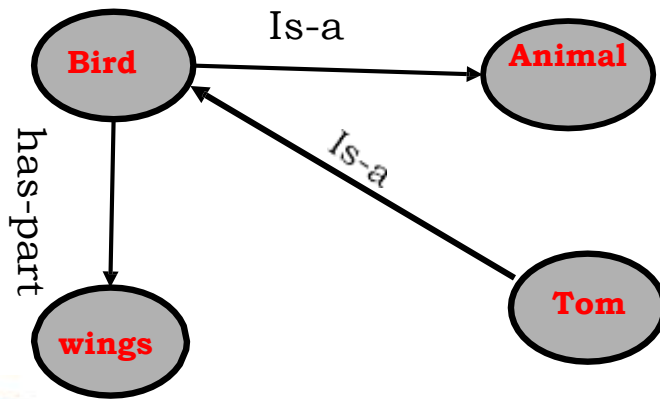
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Associative Networks

Example: Tom is a Bird. Bird is a Animal. Bird has part Wings.



- The ISA (**is-a**) or AKO (a-kind-of) relation is often used to link instances to classes, classes to super classes
- Some links (e.g. **has Part**) are inherited along ISA paths.
- The semantics of a semantic net can be relatively informal or very formal – often defined at the implementation level



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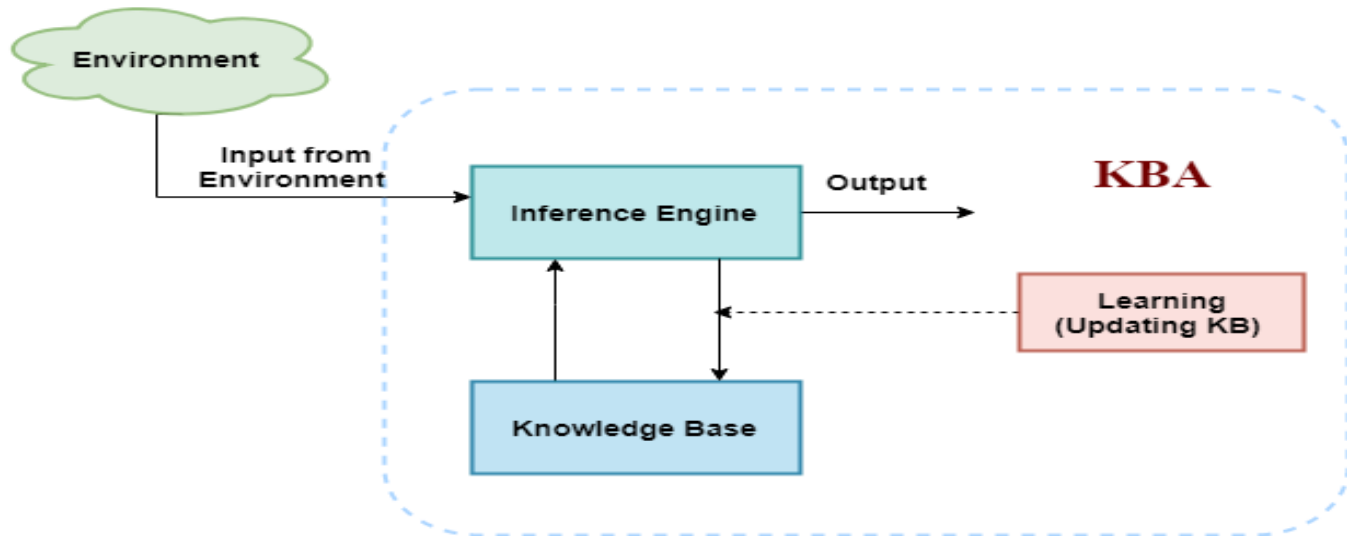


Knowledge-based agent and its Structure

- Knowledge-based agents are those agents who have the capability of maintaining an internal state of knowledge, reason over that knowledge, update their knowledge after observations and take actions. These agents can represent the world with some formal representation and act intelligently.
- Knowledge-based agents are composed of two main parts:
 - **Knowledge-base and**
 - **Inference system.**
- A knowledge-based agent must able to do the following:
 - An agent should be able to represent states, actions, etc.
 - An agent Should be able to incorporate new percepts
 - An agent can update and deduce the internal representation of the world. An agent can deduce appropriate actions.



The Structure of knowledge-based agent:



- The knowledge-based agent (KBA) take input from the environment by perceiving the environment.
- The input is taken by the inference engine of the agent and which also communicate with KB to decide as per the knowledge store in KB.
- The learning element of KBA regularly updates the KB by learning new knowledge.



- **Knowledge base:** Knowledge-base is a central component of a knowledge-based agent, it is also known as KB. It is a collection of sentences (here 'sentence' is a technical term and it is not identical to sentence in English). These sentences are expressed in a language which is called a knowledge representation language. The Knowledge-base of KBA stores fact about the world.
- **Inference system:**
 - Inference means deriving new sentences from old. Inference system allows us to add a new sentence to the knowledge base. A sentence is a proposition about the world. Inference system applies logical rules to the KB to deduce new information.
 - Inference system generates new facts so that an agent can update the KB. An inference system works mainly in two rules which are given as:
 - **Forward chaining**
 - **Backward chaining**

- Operations Performed by KBA
- **Following are three operations which are performed by KBA in order to show the intelligent behavior:**
 - **TELL:** This operation tells the knowledge base what it perceives from the environment.
 - **ASK:** This operation asks the knowledge base what action it should perform.
 - **Perform:** It performs the selected action.



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Knowledge Based Systems (KBS)

- A Knowledge-based system(KBS) is a computer program that reasons and uses a knowledge base to solve complex problems.
- A system which is built around a knowledge base. i.e. a collection of knowledge, taken from a human, and stored in such a way that the system can reason with it.
- Uses AI to solve problems within a specialized domain that ordinarily requires human expertise.
- Uses Heuristic (cause and effect) rather than algorithms.
- E.g.
 - Expert Systems
 - Clinical decision-support systems
 - MYCIN, for example, was an early knowledge-based system created to help doctors diagnose diseases



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KBS Examples

- **Expert Systems**

- One in which the knowledge, stored in the knowledge base, has been taken from an expert in some particular field.
- **Expert systems** are designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as if-then rules rather than through conventional procedural code.
- Therefore, an expert system can, to a certain extent, act as a substitute for the expert from whom the knowledge was taken.

- **Clinical decision-support systems**

- MYCIN, for example, was an early knowledge-based system created to help doctors diagnose diseases.



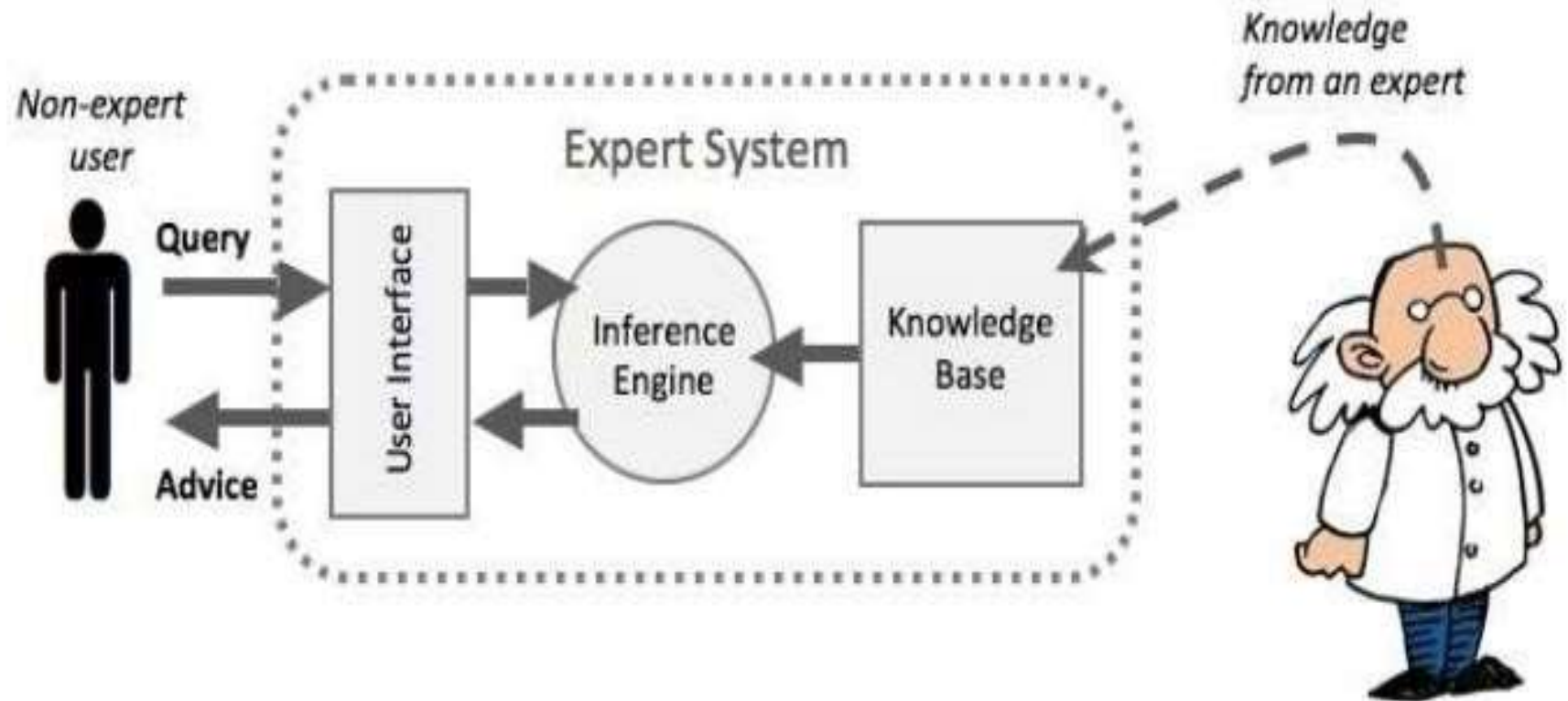
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KBS Architecture



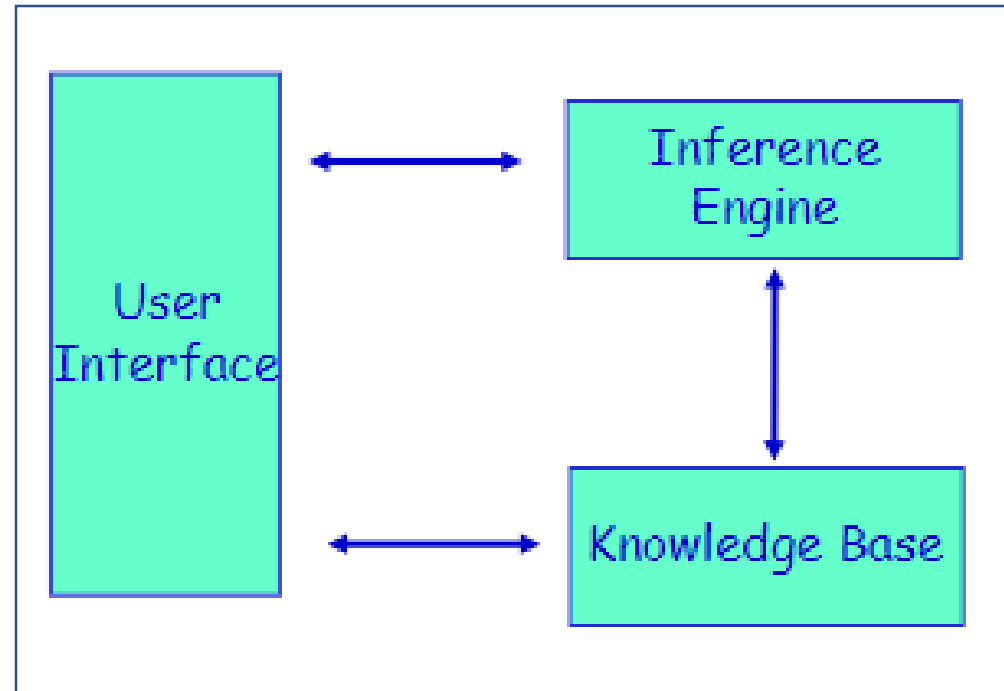
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KBS Architecture

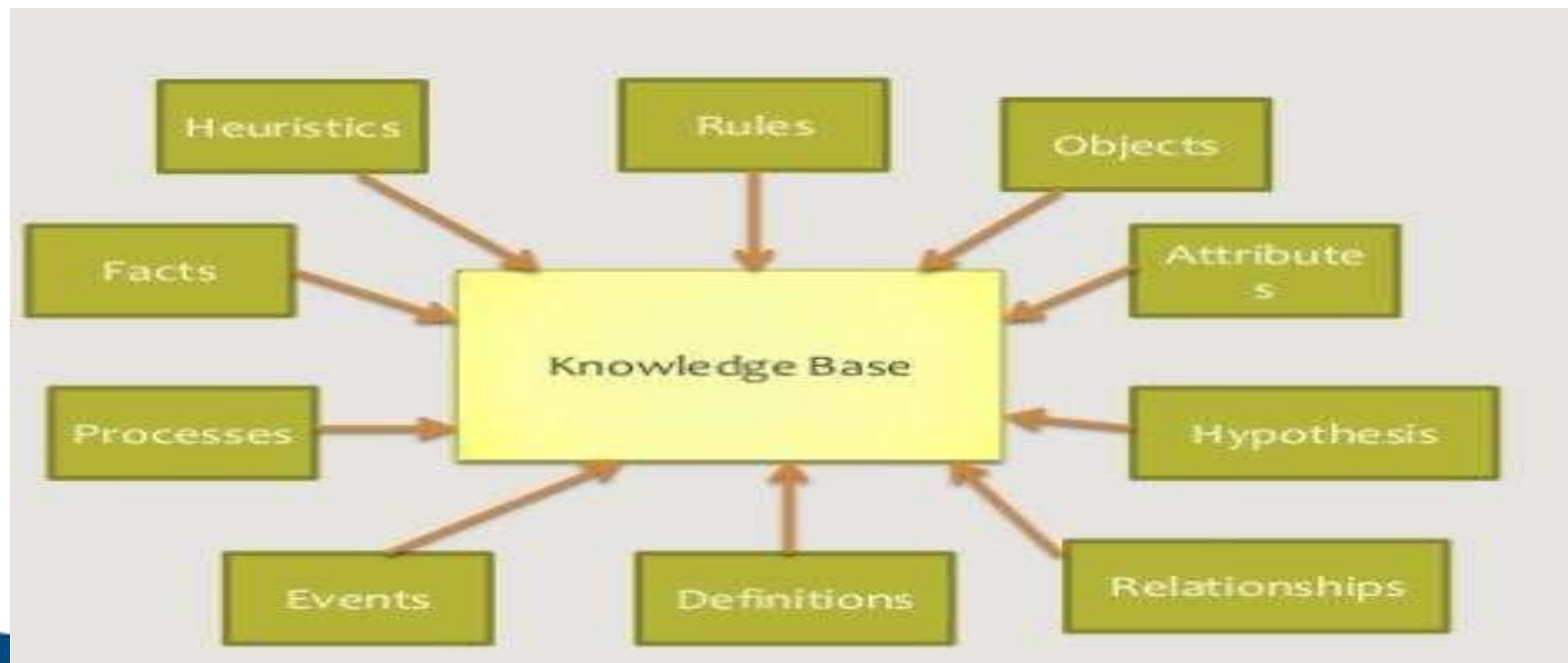
- **User Interface**
 - Enables the user to communicate with KBS



KBS Architecture

KBS = Knowledge-Base + Inference Engine

- Knowledge Base



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Knowledge base System

Storing knowledge inside the program

```
#include<stdio.h> int
```

```
main()
```

```
{
```

```
char dob="20/08/1992";
```

```
.....
```

```
.....
```

```
}
```

#Knowledge

Instead write the dob in text file and access the date of birth from the text file

Text file: dob.txt

20/08/1992



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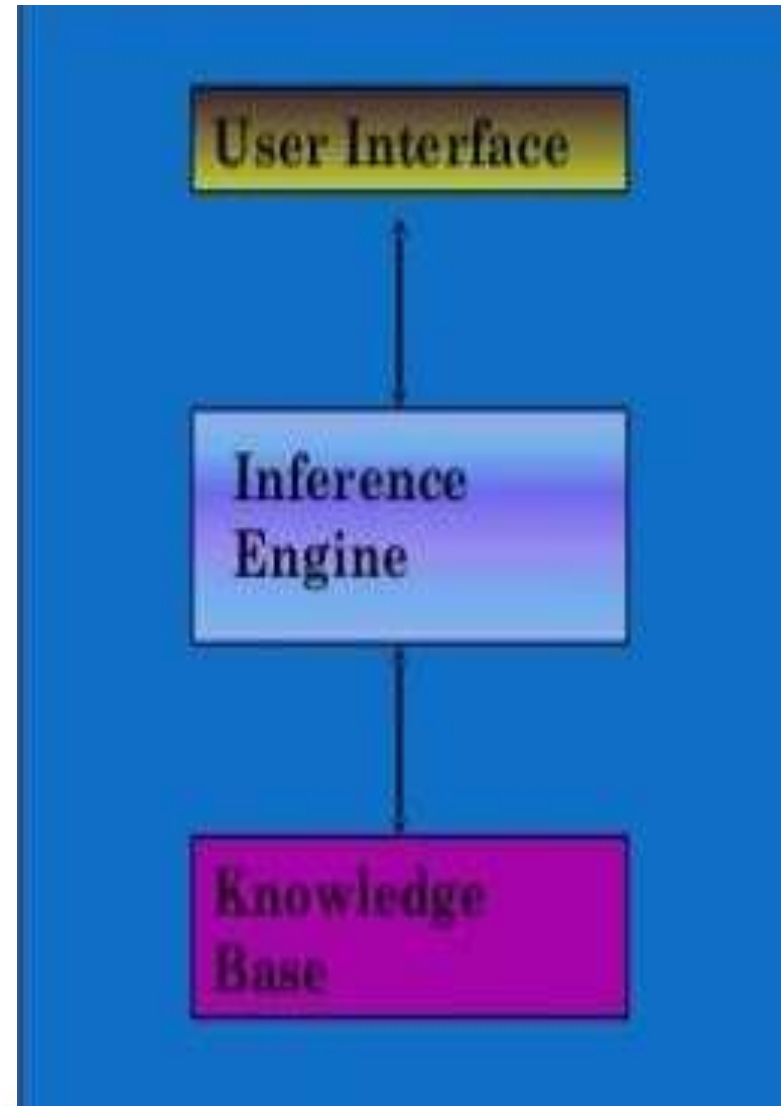
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KBS Architecture continued

- **Inference Engine :**
 - Tries to derive answers from knowledge base.
 - Brain of KBS that provides a methodology for reasoning about the information in the knowledge base and for formulating conclusions.



Example 1 for AI system:

Gender Identification Problem

- Male and female names have some distinctive characteristics.
- Names ending in *a*, *e* and *i* are likely to be female.
- Names ending in *k*, *n*, *r*, *s* and *t* are likely to be male.

Input File: male.txt

Amit
Prasan
Ashok
Ankit
Amar
Chetan
Shashank
Sumant

Input File: female.txt

Reshma
Akshata
Vani
Sita
Bhavani
Lalita
Ankita
Harika

Output: Predict the Gender for the following names:

- Karan
- Sameera



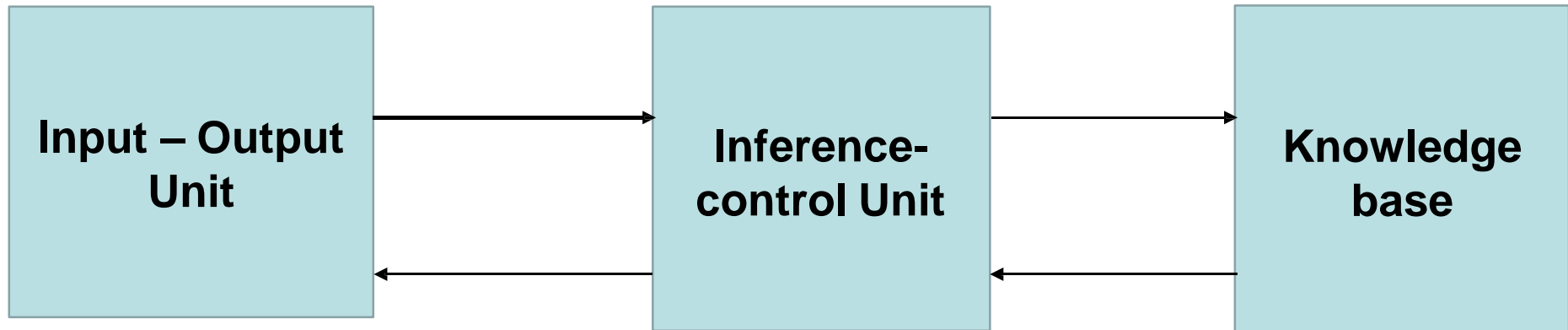
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Architecture of AI Components of Knowledge base System



Input-output: male.txt and female.txt

Knowledge base:

From the last character in the name identification of gender is possible.

Inference-control Unit: AI Algorithm Implementation – Programs

Example: Naïve Bayes Algorithm, Decision Tree Algorithm



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List of Common Algorithms:

- Naive Bayes
- Decision Trees
- Linear Regression
- Support Vector Machines (SVM)
- Neural Networks



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Example 2 for AI system: Movie Rating

Airlift Movie rating – Reviews

(Movie site, Facebook, Blog)

Post - How is Airlift Movie?

Comments from the people who watched movie -

- Airlift Movie is nice.
- It's boring.
- Yesterday I went to the movie. I enjoyed it.
- Superb.



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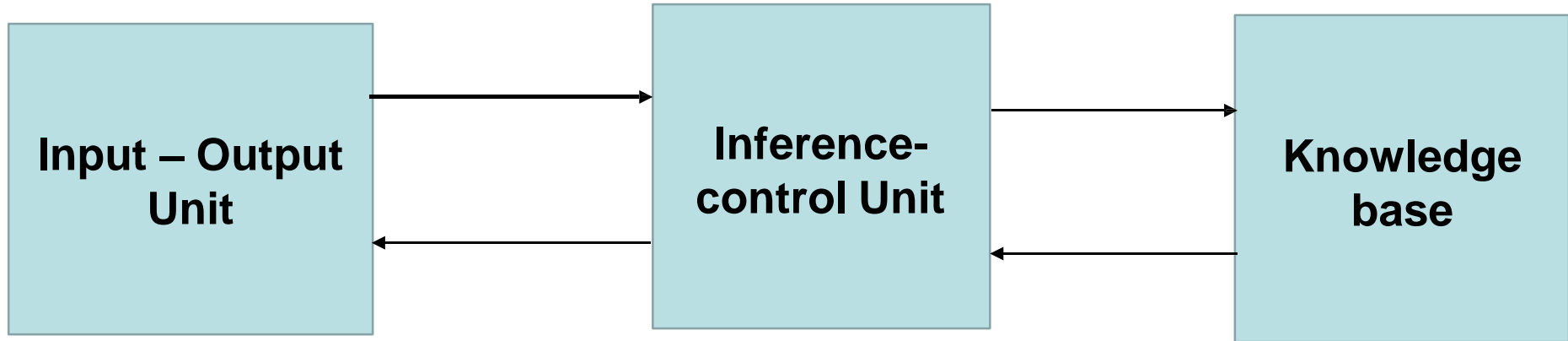
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Architecture of AI

Components of Knowledge base System



Input-output: Facebook, twitter and movie site comments about the movie.

Knowledge base: Contains the **positive**, **negative** and **neutral** keywords (Dictionary).

Inference-control Unit: AI Algorithm Implementation – Programs

Example: NLP Algorithms, Naïve Bayes Algorithm, Support Vector Machines



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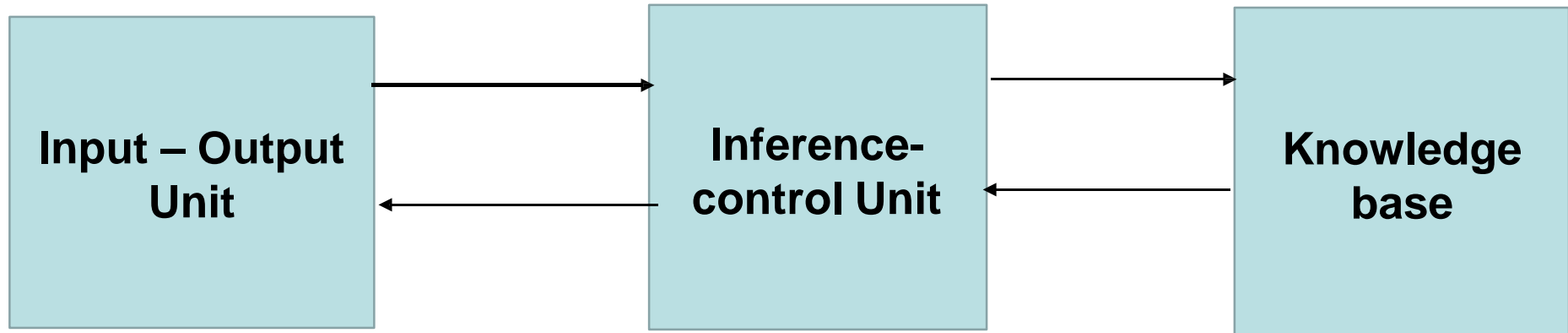
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Architecture of AI

Components of Knowledge base System



- Knowledge-based systems – get the power from expert knowledge that has been coded into facts, heuristics, and procedures.
- The knowledge is stored in knowledge base separate from the control and inference components.
- This makes possible to add new knowledge or refine existing knowledge without recompiling the control and inference programs.



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SEARCH ALGORITHM IN AI



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SEARCH ALGORITHM TERMINOLOGIES

- **Search:** Searching is a step by step procedure to solve a search-problem in a given search space. A search problem can have three main factors:
 - Search Space:** Search space represents a set of possible solutions, which a system may have.
 - Start State:** It is a state from where agent begins **the search**.
 - Goal test:** It is a function which observe the current state and returns whether the goal state is achieved or not.
- Search tree:** A tree representation of search problem is called Search tree. The root of the search tree is the root node which is corresponding to the initial state.
- Actions:** It gives the description of all the available actions to the agent.
- Transition model:** A description of what each action do, can be represented as a transition model.
- Path Cost:** It is a function which assigns a numeric cost to each path.
- Solution:** It is an action sequence which leads from the start node to the goal node.
- Optimal Solution:** If a solution has the lowest cost among all solutions.

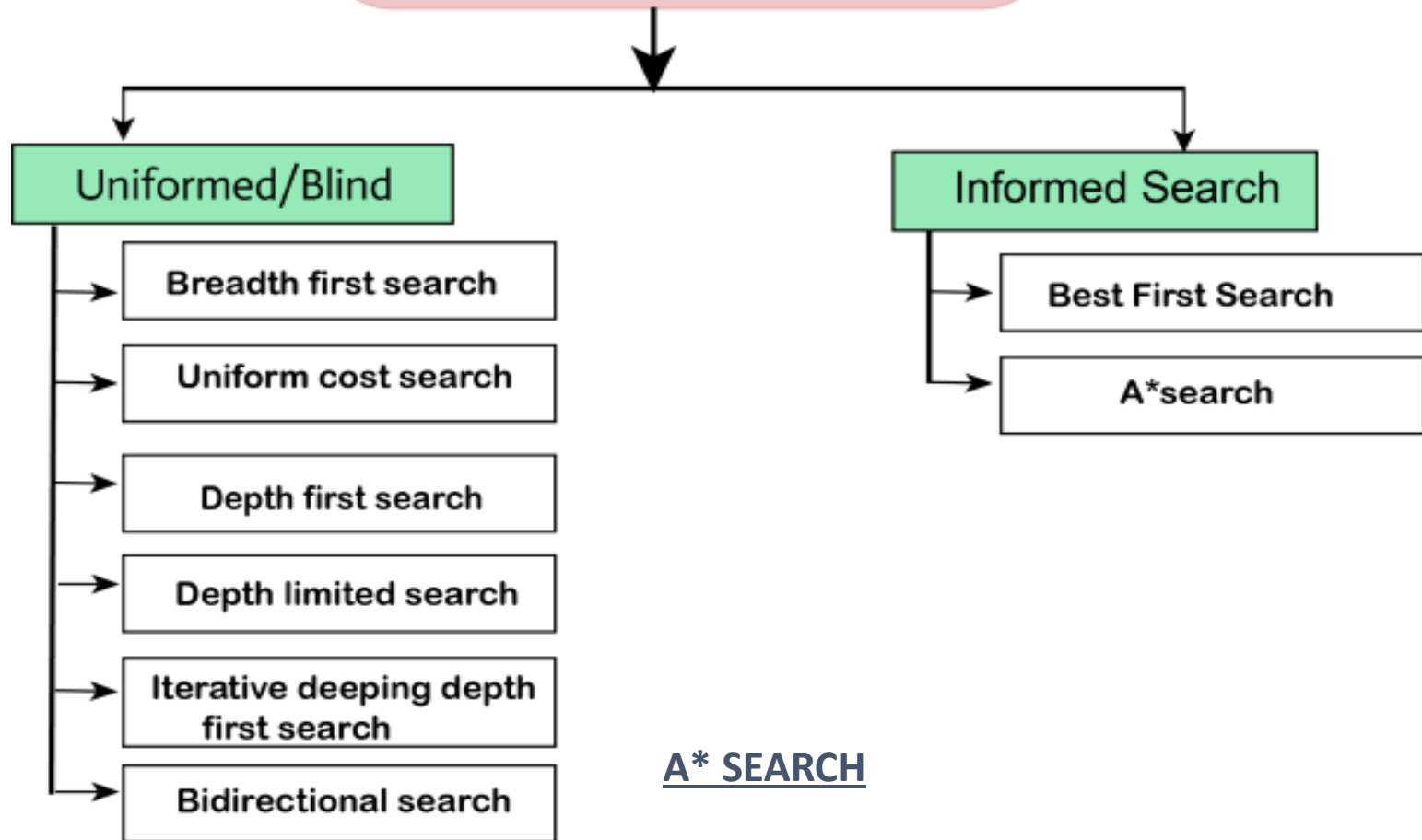


PROPERTIES OF SEARCH ALGORITHM

- **Completeness:** A search algorithm is said to be complete if it guarantees to return a solution if at least any solution exists for any random input.
- **Optimality:** If a solution found for an algorithm is guaranteed to be the best solution (lowest path cost) among all other solutions, then such a solution for is said to be an optimal solution.
- **Time Complexity:** Time complexity is a measure of time for an algorithm to complete its task.
- **Space Complexity:** It is the maximum storage space required at any point during the search, as the complexity of the problem.



Search Algorithm



A* SEARCH

<https://www.youtube.com/watch?v=tvAh0JZF2YE>



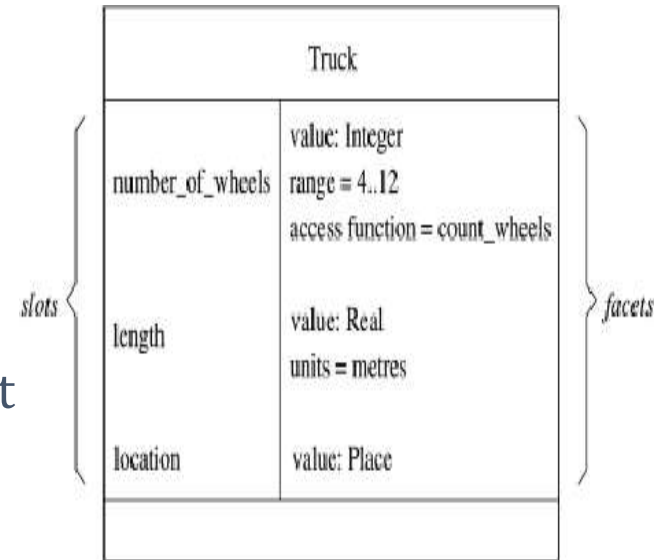
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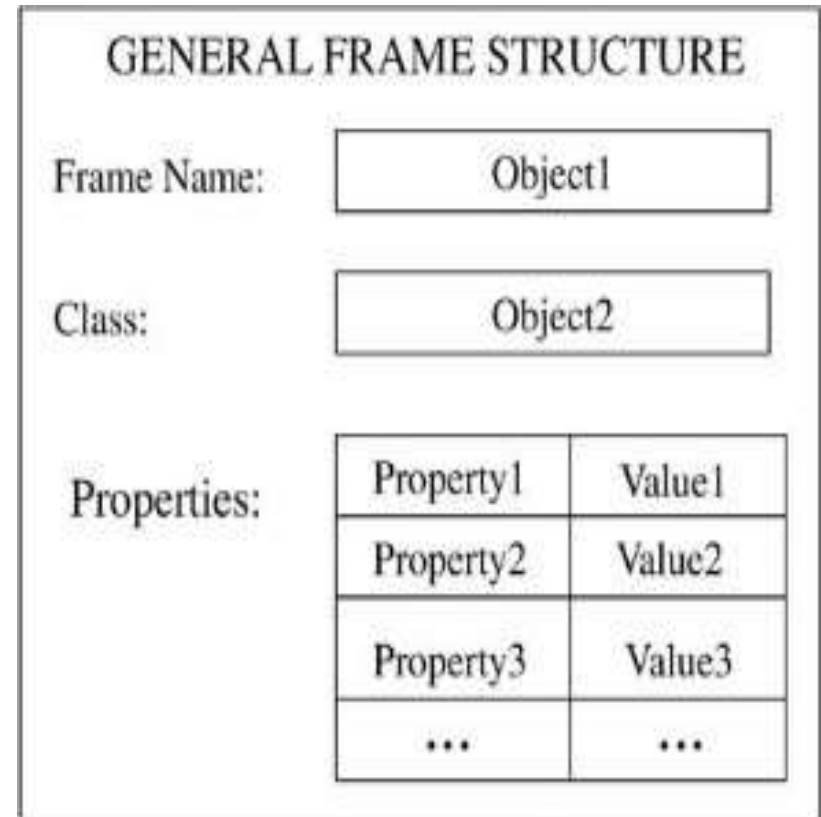
FRAME STRUCTURES

- Semantic networks morphed into Frame representation Languages in the '70s and '80s.
- A frame is a lot like the notion of an object in OOP, but has more meta-data.
- Represents related knowledge about a subject
- A frame has a set of slots.
- A slot represents a relation to another frame (or value). A slot has one or more facets.
- A facet represents some aspect of the relation. Facet : A slot in a frame holds more than a value

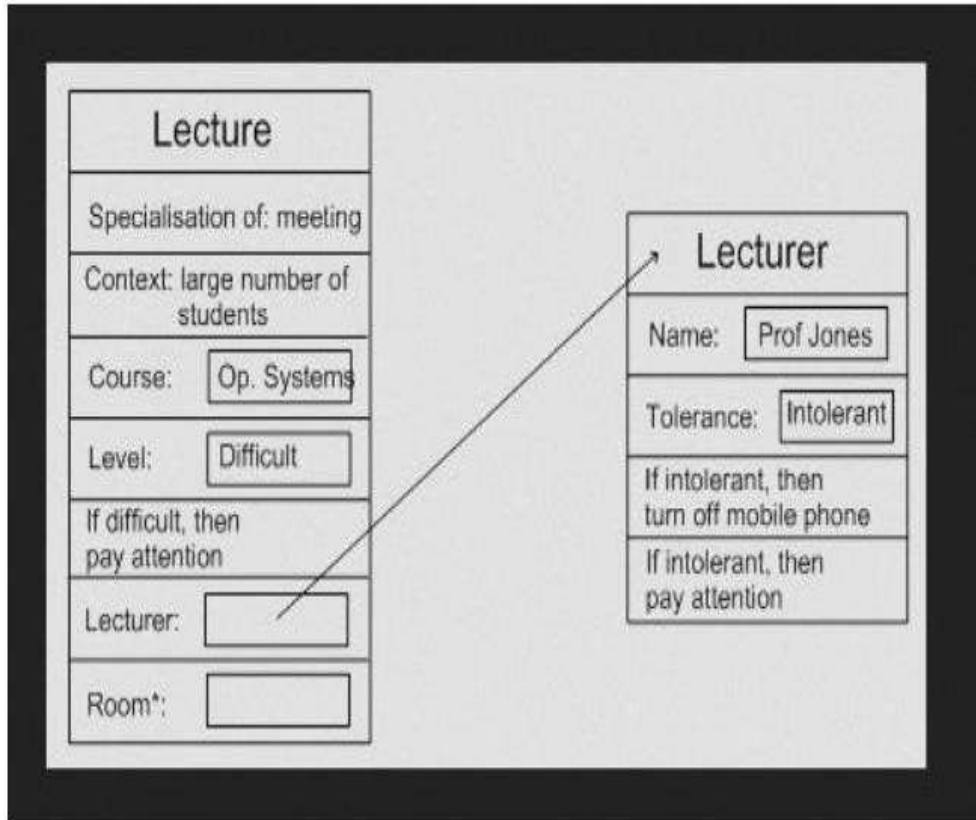


Frame

- A data structure for representing stereotypical knowledge of some concept
- A frame is a collection of attributes and associated values that describe some entity in the world.
- Frames are general record like structures which consist of a collection of slots and slot values.



FRAME STRUCTURES



Example :

- (Jones)
- (Profession (Value Lecturer))
- (Age (Value 25))
- (City (Value Yelahanka))
- (State (Value Karnataka))

* Note : value is a Keyword.



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Class Frame

A class frame represents the general characteristics of some set of common objects.

Frame Name:	Bird	
Properties:	Color	Unknown
	Eats	Worms
	No._Wings	2
	Flies	True
	Hungry	Unknown
	Activity	Unknown



Instance Frame

Instance Frame describes a specific instance of a class frame. The frame inherits both properties and property values from the class.

Frame Name:	Tweety	
Class:	Bird	
Properties:	Color	Yellow
	Eats	Worms
	No._Wings	1
	Flies	False
	Hungry	Unknown
	Activity	Unknown
	Lives	Cage



CLASS FRAME

Frame Name

Bird

Properties

Color	unknown
Eats	Worms
#wings	2
Flies	true
Hungry	unknown
Activity	unknown

INSTANCE FRAME

Frame Name

Tweety

Properties

Color	yellow
Eats	worms
#wings	1
Flies	False
Hungry	unknown
Activity	unknown



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Conceptual Graphs

- **Conceptual graph**
 - A finite, connected, bipartite graph.
 - No arc labels, instead the conceptual relation nodes represent relations between concepts
 - Concepts are represented as boxes and conceptual relations as ellipses
 - Nodes
 - **Concept Nodes – box nodes**
 - Concrete concepts:
 - » These concepts are characterized by our ability to form an image of them in our minds.
 - » cat, telephone, classroom
 - » Concrete concepts include generic concepts such as cat or book along with concepts of
specific cats and books



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Abstract objects:

- » Abstract Concepts that do not correspond to images in our minds
- » love, beauty, loyalty
- **Conceptual Relation Nodes – ellipse nodes**
 - – Relations involving one or more concepts
 - – **Some special relation nodes, namely, agent, recipient, object, experiencer, are used to link a subject and the verb**
 - – Arity – number of box nodes linked to



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Conceptual Graphs

- Example :



Flies is a 1-ary relation.



Color is a 2-ary relation.



Parents is a 3-ary relation.



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Conceptual Graphs

- **Example:**

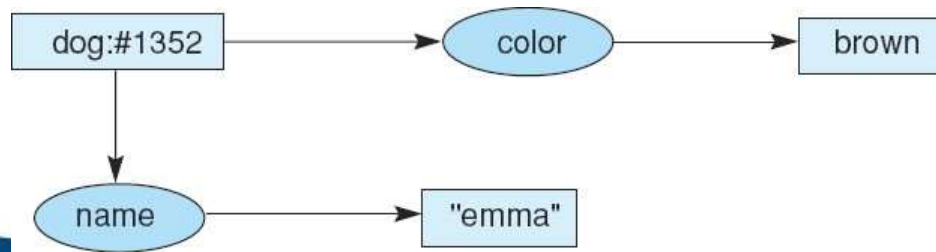
Conceptual graph indicating that the dog named Emma is brown.



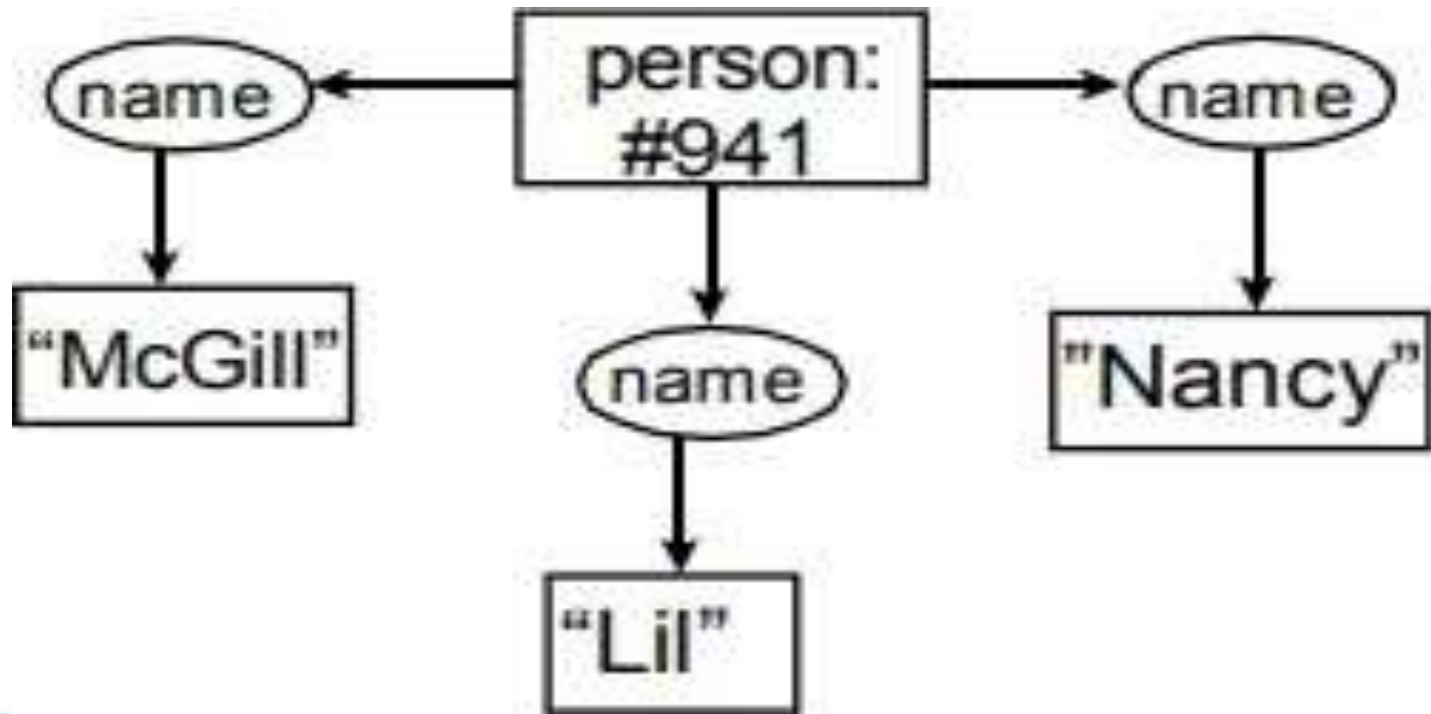
Conceptual graph indicating that a particular (but unnamed) dog is brown.



Conceptual graph indicating that a dog named Emma is brown.



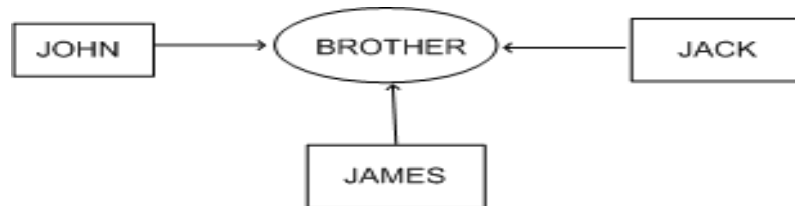
Example: Her name was McGill and she called herself Lil, but everyone knew her as Nancy



Conceptual Graphs

- **Example:**

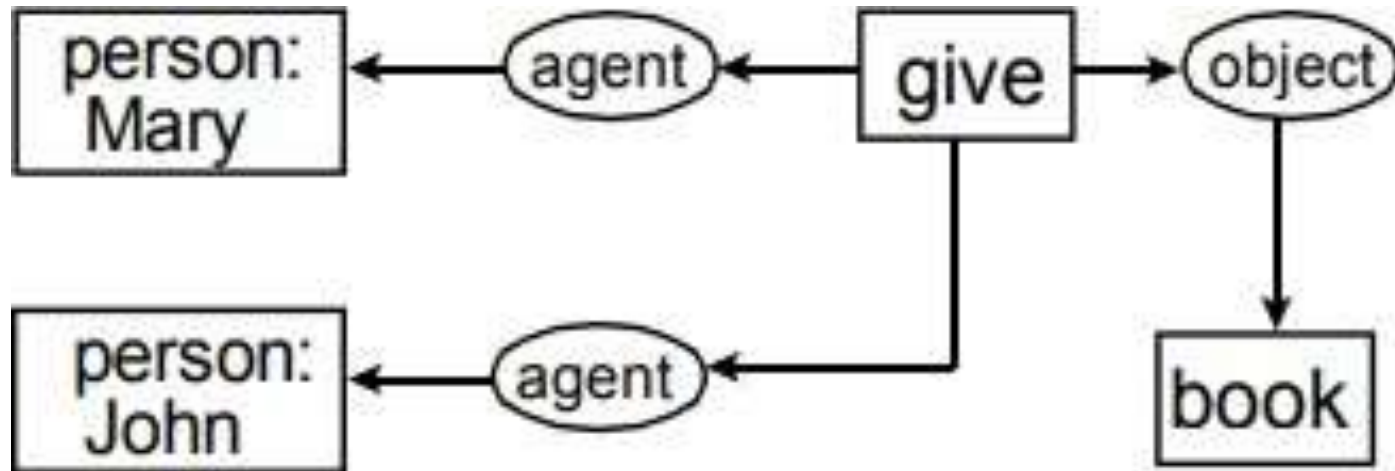
Each graph represents a single proposition.



- **Advantage:**
 - Single relationship between multiple concepts is easily representable.

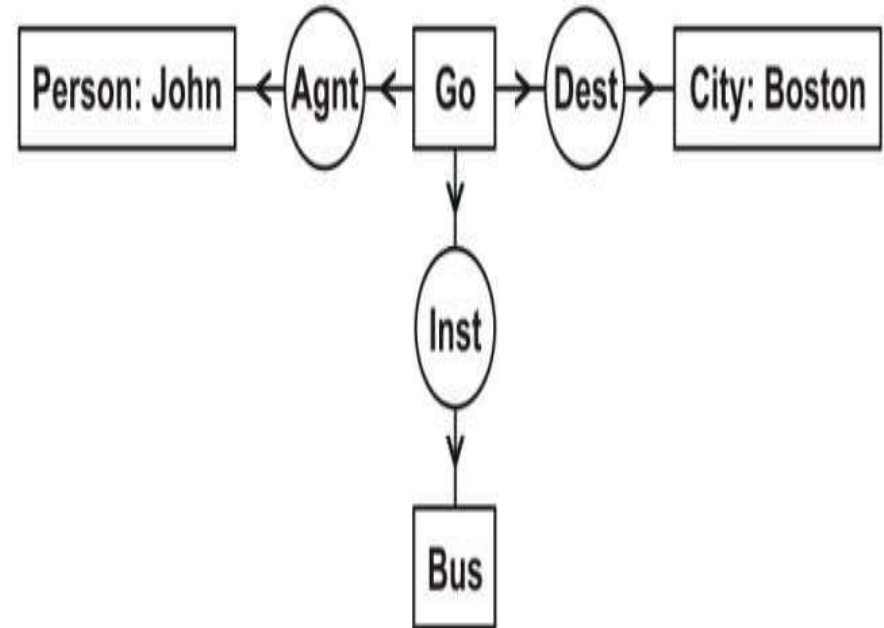


Example: Mary gave John the book

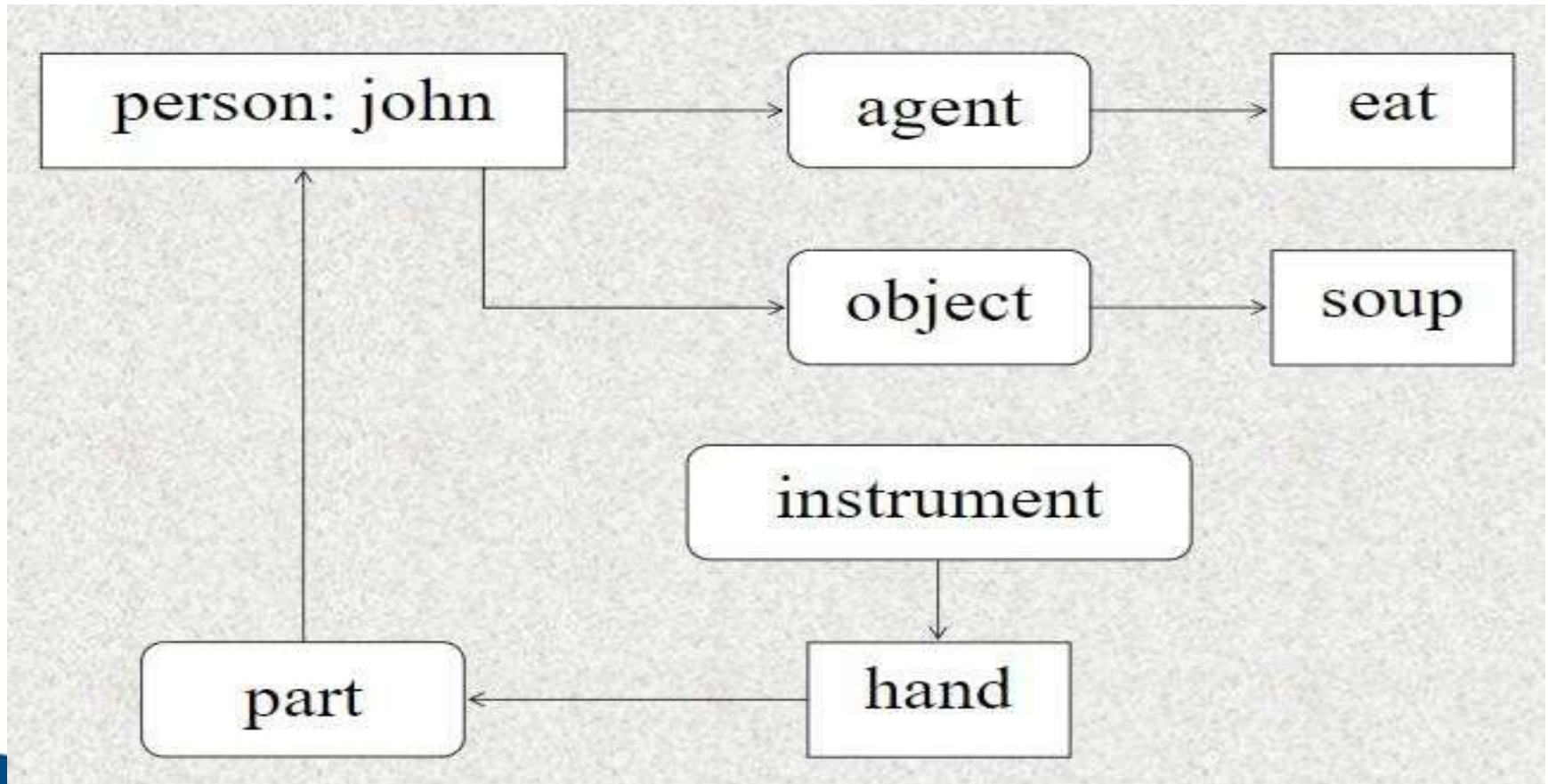


Example: John is going to Boston by bus

- Each of the four concepts has a type label, which represents the type of entity the concept refers to: **Person**, **Go**, **Boston**, or **Bus**.
- Two of the concepts have names, which identify the referent: John or Boston.
- Each of the three conceptual relations has a type label that represents the type of relation: agent (Agnt), destination (Dest), or instrument (Inst).
- The CG as a whole indicates that the person John is the agent of some instance of going, the city Boston is the destination, and a bus is the instrument.

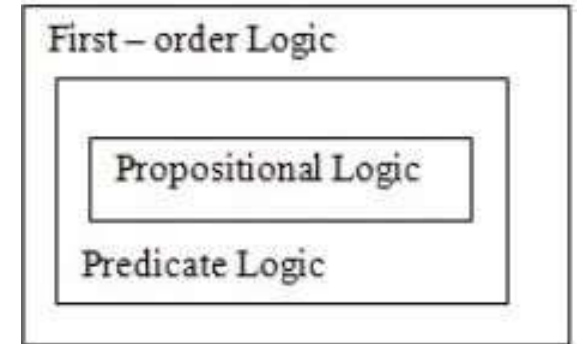


Example: John agent eat object soup instrument hand part



Logic

- Logic is the oldest form of knowledge representation in a computer
- One most often linked to intelligent systems are **propositional logic** and **predicate calculus**
- Techniques use symbols to represent knowledge
- Operators applied to the symbols produce logical reasoning
- A logic is a formal language, with precisely defined syntax and semantics, which supports sound inference.
- Different logics exist, which allow you to represent different kinds of things, and which allow more or less efficient inference.



THANK YOU



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