Knowledge Representation

Module 3

Knowledge

- Knowledge is awareness or familiarity gained by experiences of facts, data, and situations
- Knowledge is a familiarity, awareness, or understanding of someone or something, such as facts (propositional knowledge), skills (procedural knowledge), or objects (acquaintance knowledge).
- knowledge can be acquired in many different ways and from many sources, including but not limited to perception, reason, memory, testimony, scientific inquiry, education, and practice.
- The philosophical study of knowledge is called epistemology.

Different types of knowledge

1. Declarative knowledge
    - also known as descriptive knowledge
    - is to know about something such as concepts, facts, and objects.
    - It is expressed in declarative sentences.
2. Procedural knowledge
    - also known as imperative knowledge
    - type of knowledge which is responsible for knowing how to do something.
    - It can be directly applied to any task and it includes rules, strategies, procedures, agendas, etc.
3. Meta-knowledge
    - Knowledge about the other types of knowledge is called meta-knowledge.

Different types of knowledge

4. Heuristic knowledge
    - knowledge of experts in a field or subject.
    - Heuristic knowledge is a “rule of thumb” knowledge based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.
5. Structural knowledge
    - It describes relationships between various concepts such as kind of, part of, and grouping of something.
    - It describes the relationship that exists between concepts or objects.

Knowledge Representation

- Knowledge representation is a field of artificial intelligence that focuses on designing computer representations that capture information and knowledge about the world that can be used to solve complex problems.
- Knowledge representation is not just storing data into some database, but it also enables an intelligent machine to learn from that knowledge and experiences so that it can behave intelligently like a human.
- A knowledge representation structure (or, knowledge representation system) is a particular set of definitions, rules and procedures for setting up a representation that captures information and knowledge about the world

Desirable properties of knowledge representation systems

1. Representational adequacy -This the ability to represent all kinds of knowledge that are needed in a domain.
2. Inferential adequacy -This is the ability to derive new knowledge from old.
3. Inferential efficiency -This is the ability to incorporate into the knowledge base additional information.
4. Acquisitional efficiency- This is the ability to acquire new knowledge easily.

Some knowledge representation systems

- Frames
- Semantic networks
- Conceptual dependencies
- System based on logic

FRAMES

- A frame is a collection of attributes and possible values that describe some entity in the world.
- A frame system is a collection of frames that are connected to each other by the fact that the value of an attribute in one frame may be another frame.

Frames

A **frame** is essentially a data structure that holds information about an entity or concept, which can include:

1. Slots : Slots are attributes or properties of a frame. They represent the different aspects or characteristics of the frame's concept.

- For a "Person" frame, slots might include:
- **Name:** ”Arathy”
- **Age:** 32
- **Occupation:** ”Teacher”
- **Address:** ”XXX YYY”

2. Facets (Constraints): Constraints or default values that provide additional details or restrictions on the values for the slots.

- *Example:* For the "Age" slot in the "Person" frame:
- **Type:** Integer
- **Range:** 0 to 120
- **Default Value:** 30

3. Default Values

- Default values are predefined values assigned to slots if no specific value is provided. They offer a baseline that can be overridden with more specific information.
- *Example:* In a "Car" frame:
- **Make:** Default value could be "Unknown"
- **Model:** Default value could be "Unknown"
- **Year:** Default value could be the current year

4. Procedures

- Procedures are methods or functions associated with frames that define how the information within the frame should be processed or utilized.
- *Example:* In an "Account" frame:
- **Procedure:** CalculateInterest - A method to compute interest based on the account balance.

- **Frame Name**: Book
    - **Slots**:
        - **Title**: "To Kill a Mockingbird"
        - **Author**: "Harper Lee"
        - **Publication Year**: 1960
        - **ISBN**: "978-0-06-112008-4"
        - **Genre**: "Fiction"
    - **Facets**:
        - **Publication Year**:
            - **Type**: Integer
            - **Range**: 1450 to current year (reasonable range for publication years)
        - **ISBN**:
            - **Format**: 13-digit number
    - **Default Values**:
        - **Genre**: "Unknown" (if not specified)
    - **Procedures**:
        - **CheckAvailability**: A method to check if the book is currently available in the library.
        - **UpdateRecord**: A method to update the book’s record when it is borrowed or returned.

Frame Structure

- Frames can also be more complex, where a frame might include other frames within it. For example, a frame for **Mammal** could be a parent frame, and **Dog** could inherit properties from it.

Dog Frame:

- **Frame Name**: Dog
  - **Slots**:
    - **Breed**: Labrador
    - **Color**: Yellow
    - **Age**: 3 years
    - **Size**: Medium
    - **Legs**: 4 (inherited from the **Mammal** frame)
    - **Can Bark**: Yes

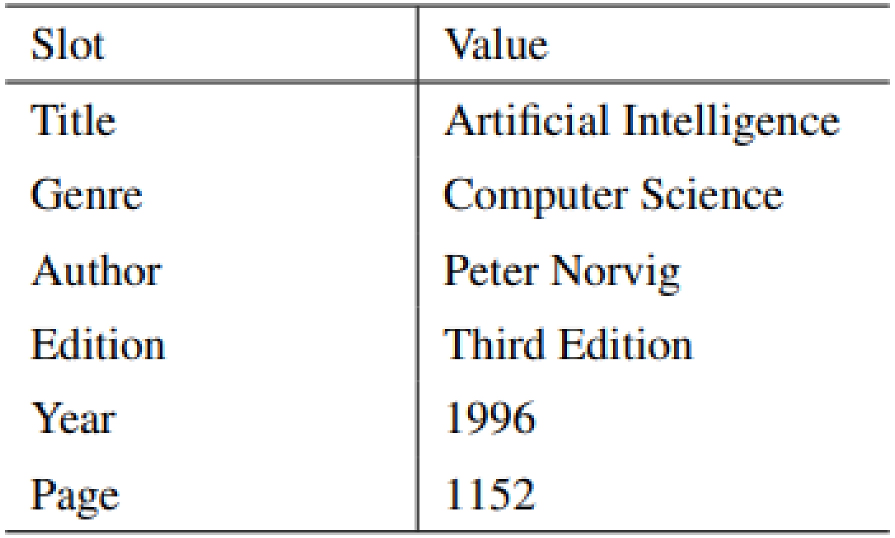
Mammal Frame (Parent frame):

- **Frame Name**: Mammal
  - **Slots**:
    - **Has Fur**: Yes
    - **Warm-Blooded**: Yes
    - **Legs**: 4

- The **Dog** frame inherits the **Has Fur**, **Warm-Blooded**, and **Legs** slots from the **Mammal** frame, meaning we don't need to define these properties again for the dog. This hierarchical relationship allows for **reuse** and **avoidance of redundancy**.

Example

- Frame for a book

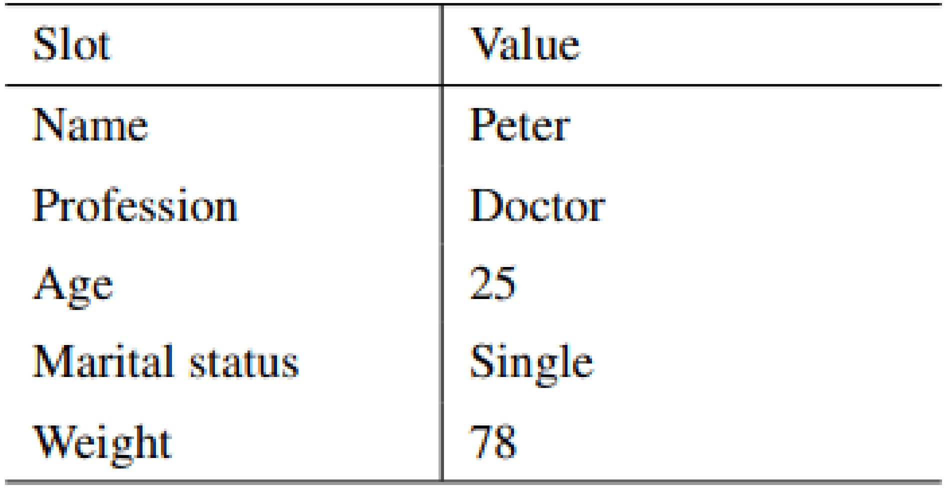


Slot	Value
Title	Artificial Intelligence
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

Table 6.1: A frame for a book

Example

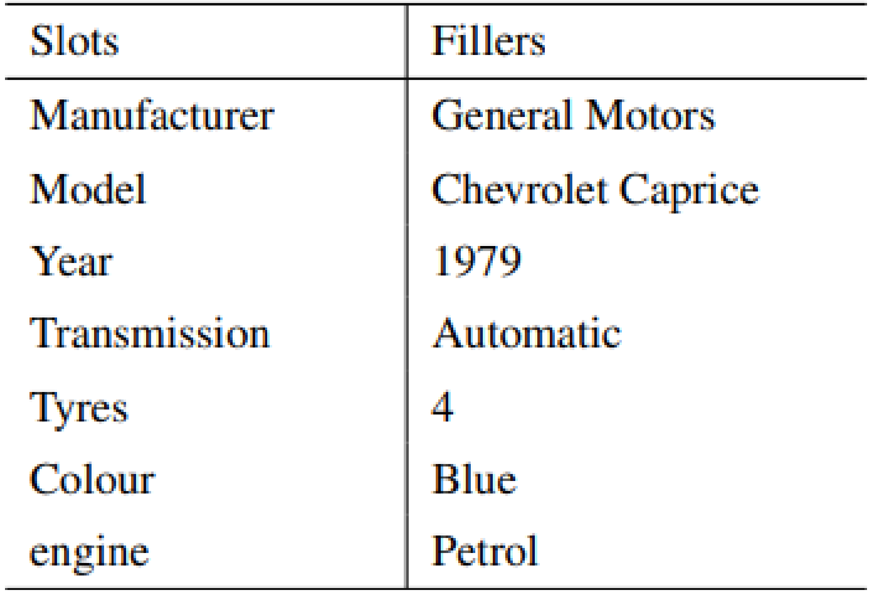
- frame representation of the statement: “Peter is a doctor as a profession, and his age is 25. He is single and his weight is 78.”



Slot	Value
Name	Peter
Profession	Doctor
Age	25
Marital status	Single
Weight	78

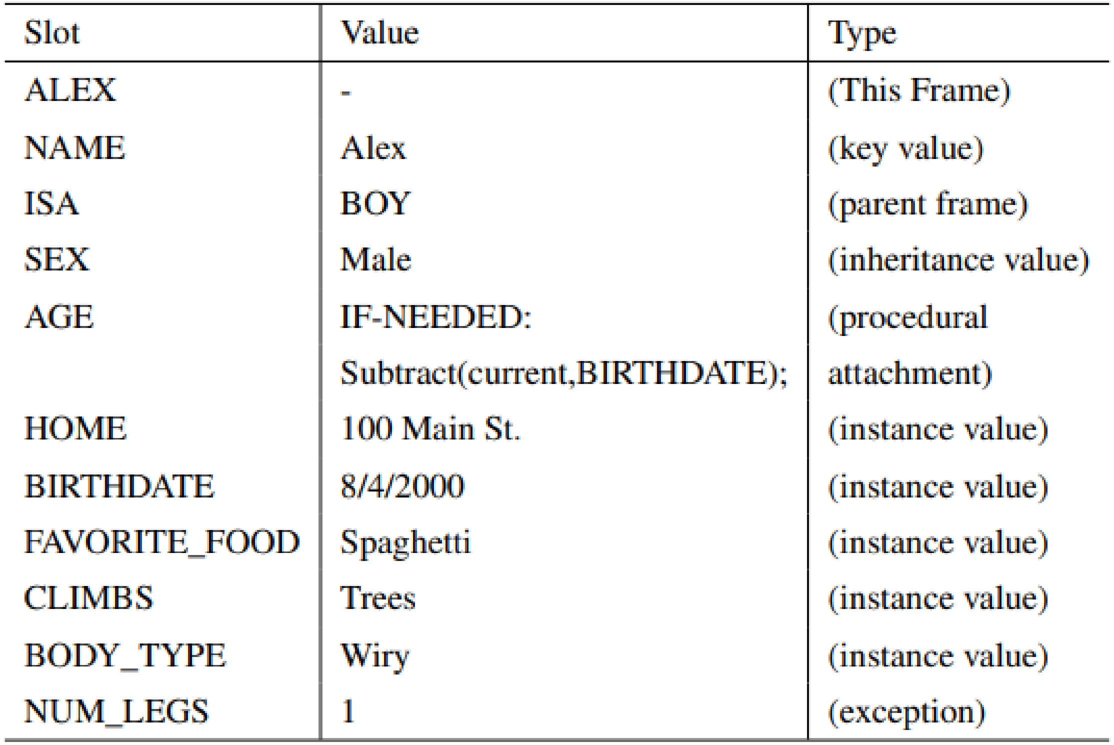
Example

- Frame for a car



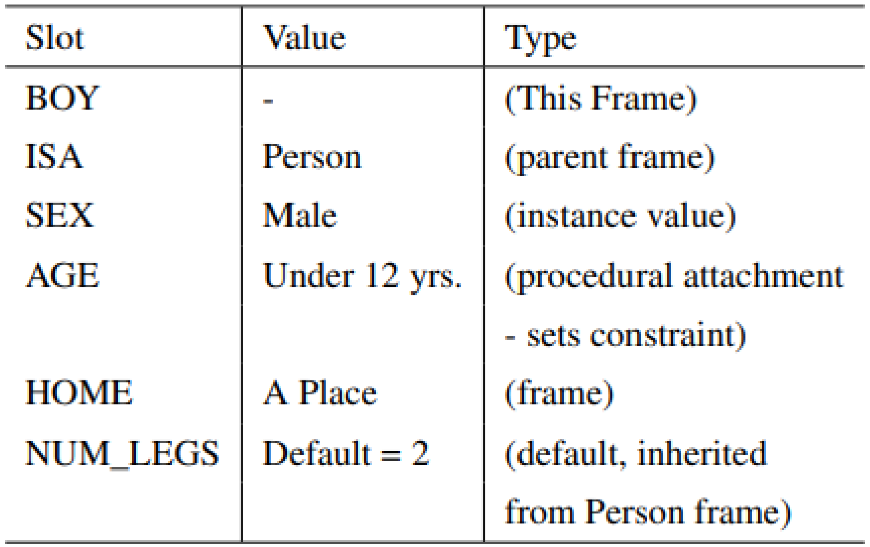
Slots	Fillers
Manufacturer	General Motors
Model	Chevrolet Caprice
Year	1979
Transmission	Automatic
Tyres	4
Colour	Blue
engine	Petrol

- a frame with name ALEX



Slot	Value	Type
ALEX	-	(This Frame)
NAME	Alex	(key value)
ISA	BOY	(parent frame)
SEX	Male	(inheritance value)
AGE	IF-NEEDED: Subtract(current,BIRTHDATE);	(procedural attachment)
HOME	100 Main St.	(instance value)
BIRTHDATE	8/4/2000	(instance value)
FAVORITE_FOOD	Spaghetti	(instance value)
CLIMBS	Trees	(instance value)
BODY_TYPE	Wiry	(instance value)
NUM_LEGS	1	(exception)

- The parent frame BOY of the frame named ALEX



Slot	Value	Type
BOY	-	(This Frame)
ISA	Person	(parent frame)
SEX	Male	(instance value)
AGE	Under 12 yrs.	(procedural attachment - sets constraint)
HOME	A Place	(frame)
NUM_LEGS	Default = 2	(default, inherited from Person frame)

Advantages of using Frames

Modularity and Reusability:

- Frames allow for the modular representation of knowledge, so you can easily update and reuse knowledge components. For example, changing the properties of a **Mammal** frame automatically affects all derived frames (e.g., **Dog**, **Cat**).

Inheritance:

- The inheritance mechanism makes it easy to model hierarchical relationships between concepts, where more specific concepts can inherit properties from more general ones.

Flexibility:

- Frames can be extended with new slots, facets, and values as needed. This makes them adaptable to evolving knowledge bases or systems.

Support for Default Values:

- The ability to provide default values for slots helps handle incomplete or uncertain information effectively.

Structured Representation:

- The frame-based approach provides a structured and human-readable format for representing knowledge, making it easier to understand and maintain.

Applications of Frame-based representation

- **Expert Systems**: Frames are often used in expert systems to model domain knowledge, where each frame represents an entity or concept in a domain (e.g., medical diagnosis, legal advice).
- **Natural Language Processing (NLP)**: Frames can represent syntactic or semantic structures in language understanding, where concepts and their relationships are organized in frames.
- **Robotics and AI**: In robotics, frames can represent objects or actions, helping robots make decisions based on predefined knowledge.
- **Ontologies and Knowledge Graphs**: In ontology development, frames can help model concepts and relationships in a formal, standardized way.

Frame Languages

- A frame language is a technology used for knowledge representation in artificial intelligence.
- One of the first general purpose frame languages was **KRL** (Knowledge Representation Language).
- The most influential early Frame languages was **KL-ONE**.
- **Loom, F-Logic, Cycl** etc are other Frame languages

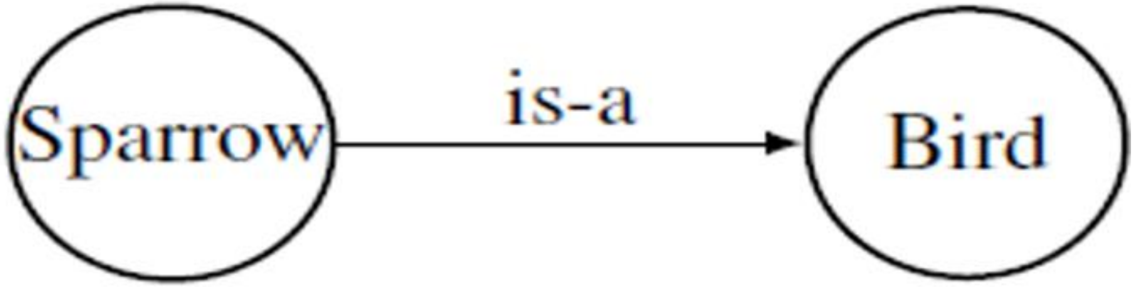
Semantic Network

- A semantic network is a graph constructed from a set of vertices (or nodes) and a set of directed and labelled edges.
- The vertices or nodes represent concepts or objects, and the edges represent relations between the nodes

Example

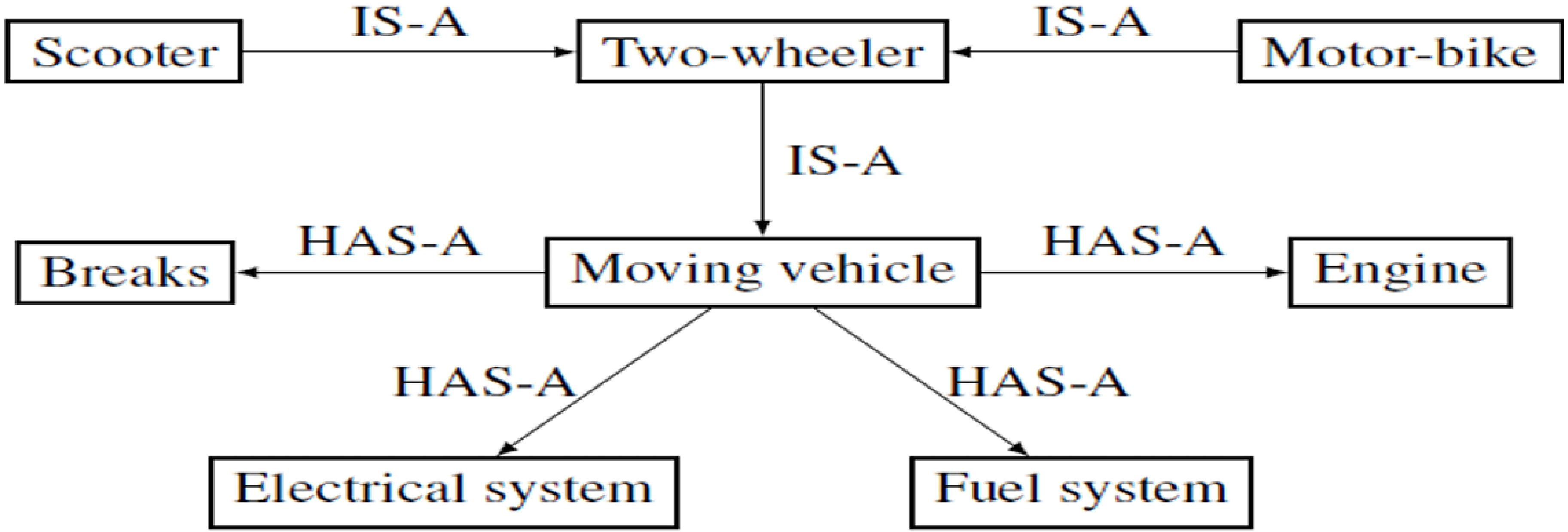
- Consider the knowledge contained in the following sentence: S: “Sparrow is a bird.”

- There are two concepts in the sentence, namely, “Sparrow” and “Bird”. The relation between these concepts is indicated by “is a”. We represent the two concepts by two nodes in a graph and the relation between them by a directed edge with the label “is-a”.This is the semantic network representation of the knowledge contained in S.



Example

- Motorbike is a two wheeler.
- Scooter is a two wheeler.
- Twowheeler is a moving vehicle.
- Movingvehicle has a brake.
- Movingvehicle has a engine.
- Movingvehicle has electrical system.
- Movingvehicle has fuel system.

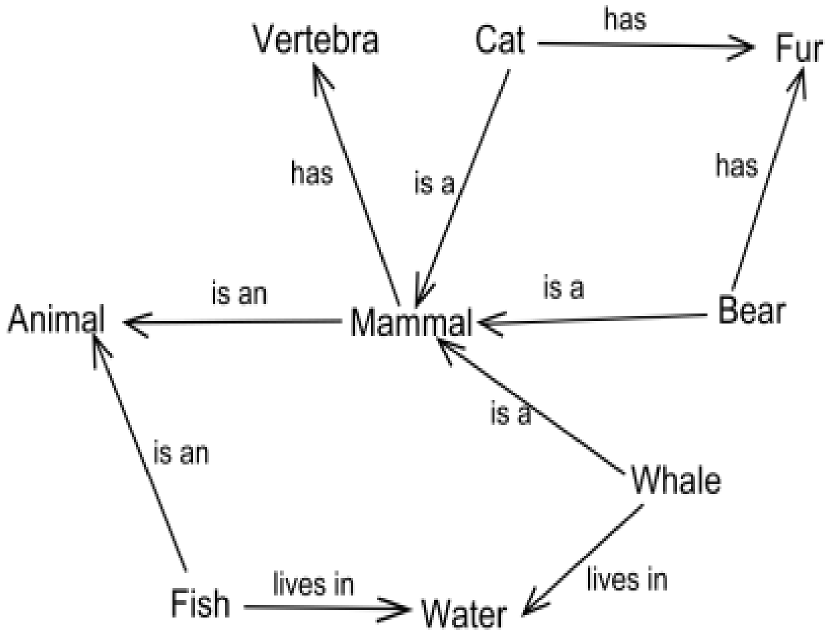

Scooter
IS-A
Two-wheeler
IS-A
Motor-bike
IS-A
Breaks
HAS-A
Moving vehicle
HAS-A
Engine
HAS-A
HAS-A
Electrical system
Fuel system

Different Types of Semantic Network

- Definitional
- Propositional
- Implicational
- Executable
- Learning
- hybrid types

Definitional Network

- Represent hierarchical relationships, often used in taxonomies or ontologies.
- They define concepts by their relationships to more general or more specific concepts.
- supports the rule of *inheritance* for copying properties defined for a supertype to all of its subtypes
- *In a definitional network, "Dog" might be defined as a type of "Mammal," which is in turn a type of "Animal."*



Assertional networks

- Represent specific facts or assertions about individual instances of concepts.
- also known as propositional semantic networks are designed to represent assertions or proposition
- They often describe properties or attributes of specific entities.
- *An assertional network might represent the fact that "Rex is a Dog" and "Rex has Brown Fur."*

Implicational Network

- Focus on representing logical implications between concepts
- They are used to infer new knowledge from existing relationships.
- *If "All Dogs are Mammals" and "Rex is a Dog," an implicational network can infer that "Rex is a Mammal."*

Executable networks

- Represent procedural knowledge, where the relationships include actions or sequences.
- *An executable network might represent the steps in a recipe, such as "Add Water to Pot" followed by "Boil Water."*

Learning Network

- Dynamic and evolve as the AI system learns new information
- They update relationships and nodes based on new data or experiences.
- The new knowledge may change the old network by adding and deleting nodes and arcs or by modifying numerical values, called *weights*, associated with the nodes and arcs.
- In a learning network, an AI might update its understanding of "Dog" as it encounters new breeds or characteristics.

Hybrid Network

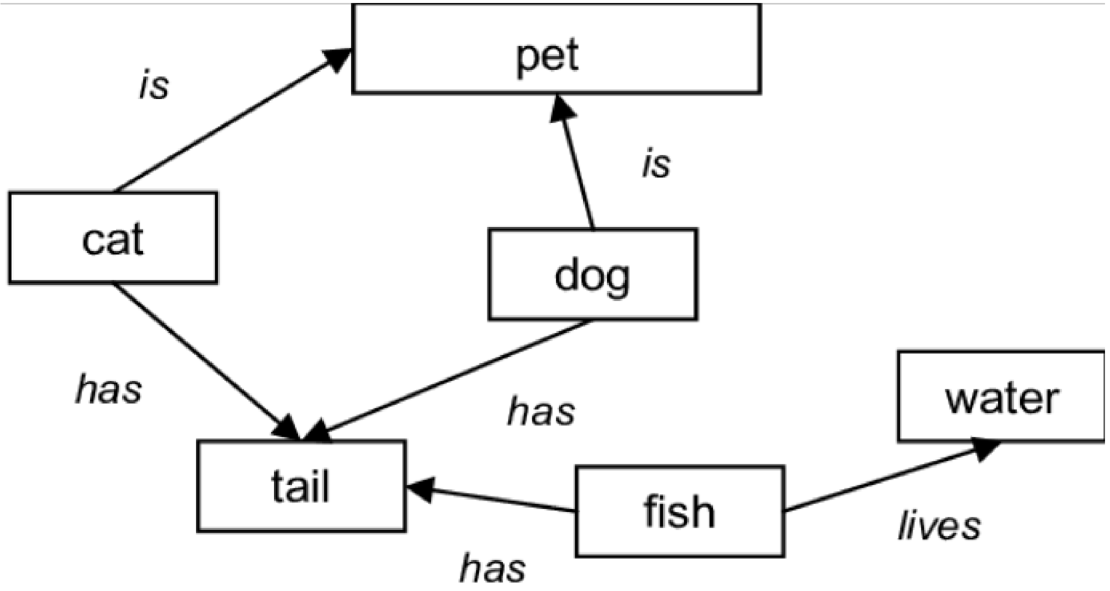
- Hybrid networks combine elements from two or more of the above types, allowing for more complex and versatile representations of knowledge.
- A hybrid network might integrate definitional and assertional aspects, representing both the general concept of "Dog" and specific instances like "Rex."

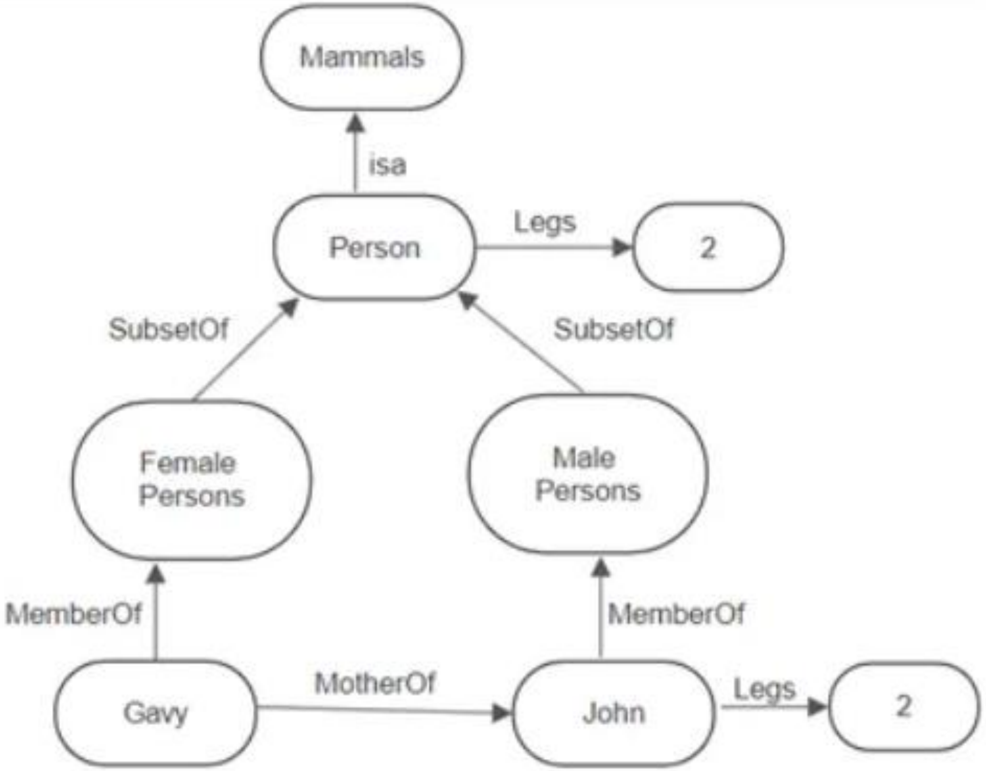
Advantages of semantic network

- **Intuitive Representation**: Semantic networks provide a clear and intuitive way to represent knowledge, making it easier for both humans and machines to understand complex relationships.
- **Flexibility**: They can represent various types of relationships and are flexible enough to be applied across different domains and applications.
- **Support for Reasoning**: Semantic networks facilitate reasoning by enabling AI systems to infer new knowledge based on existing relationships.

Limitations of semantic network

- **Scalability**: As the number of concepts and relationships increases, semantic networks can become complex and difficult to manage.
- **Ambiguity**: Representing ambiguous or unclear relationships can be challenging, leading to potential misinterpretations by the AI system.
- **Computational Complexity**: Complex networks with numerous relationships can require significant computational resources to process and reason about.


pet
is
is
cat
dog
has
has
water
tail
fish
lives
has


Mammals
isa
Person
Legs
2
SubsetOf
SubsetOf
Female Persons
Male Persons
MemberOf
MemberOf
Gavy
MotherOf
John
Legs
2