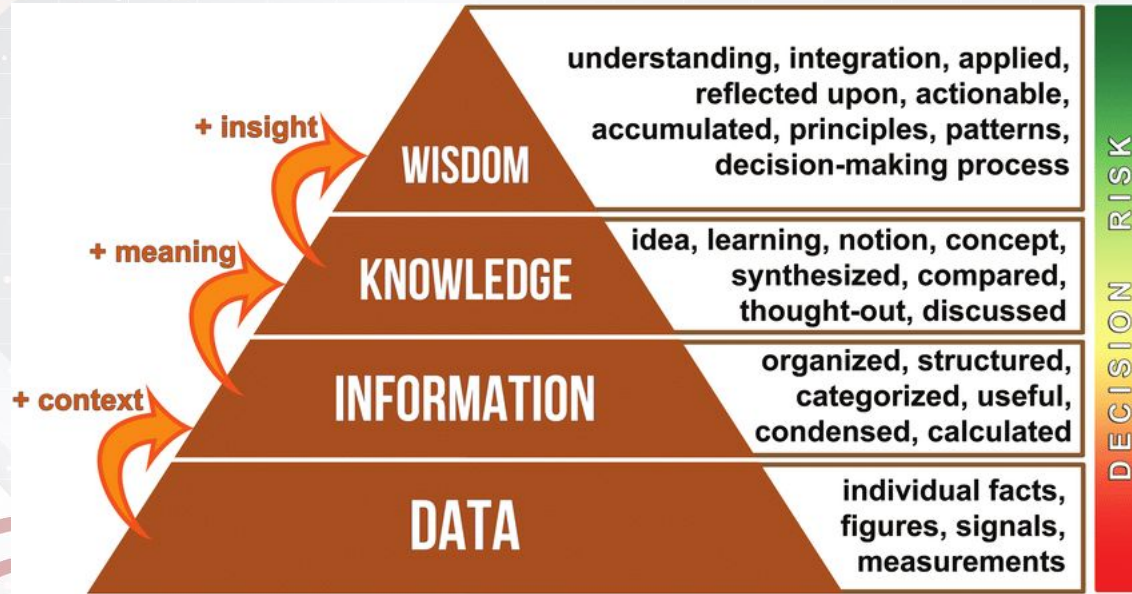# KNOWLEDGE REPRESENTATION

RATNA MUFIDAH, S.Kom., M.Kom.

KNOWLEDGE???

Image source: https://www.dictionary.com/e/wp-content/uploads/2020/01/WisdomvsKnowledge_1000x700_jpg_OHVUvmTo.jpg
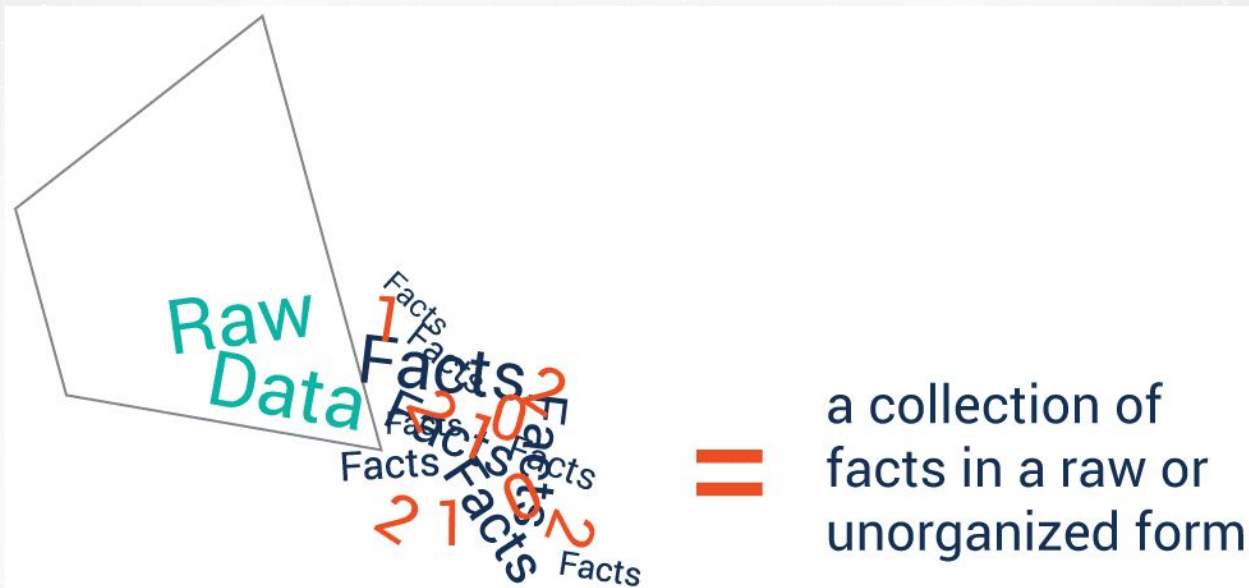
The data-information-knowledge-wisdom (DIKW) hierarchy

- **Wisdom** is the capacity to choose objectives consistent with one's values within a larger social context.
- **Knowledge** is the ability to use information strategically to achieve one's objectives
- **Information** is structured data, which adds meaning to the data and gives it context and significance
- **Data** are the pure and simple facts without any particular structure or organization, the basic atoms of information

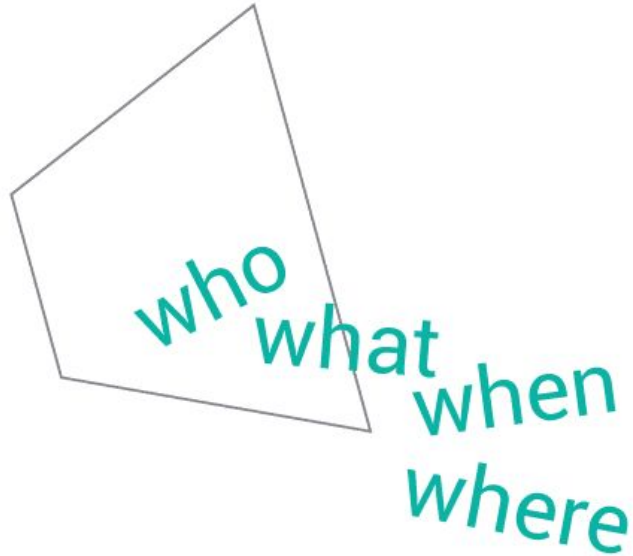(Robert Logan, What is Information?, 2010)

Data

Raw Data

= a collection of facts in a raw or unorganized form

Base building block - Raw **Data**

https://www.ontotext.com/knowledgehub/fundamentals/dikw-pyramid/

Information

who what when where = easier to measure, visualize and analyze data for a specific purpose

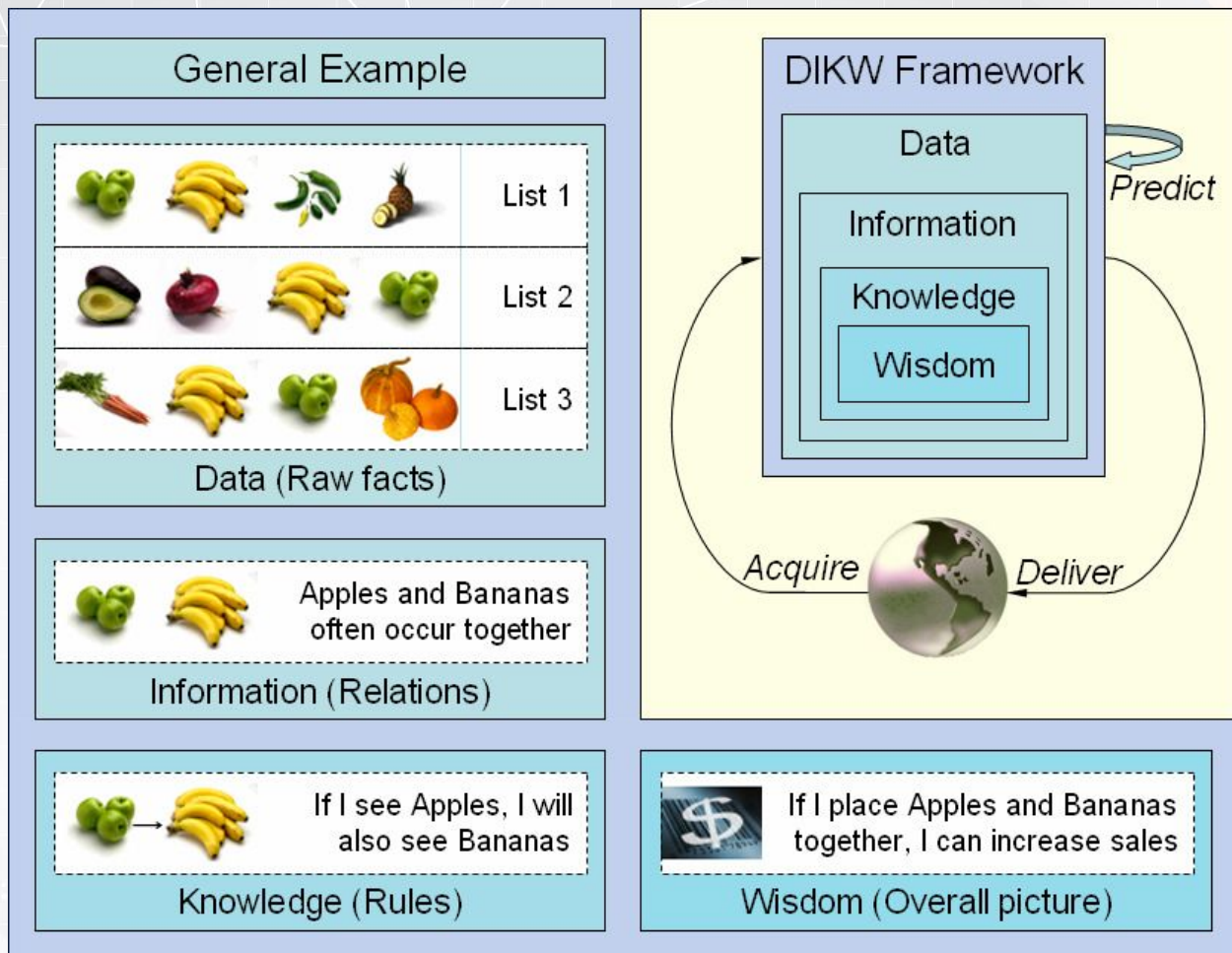Second building block - Derived **Information**

https://www.ontotext.com/knowledgehub/fundamentals/dikw-pyramid/

Knowledge

HOW

pieces of information
pieces of information
pieces of information

connected to other pieces help us understand how to apply information to achieve our goal

Third building block - Relevant **Knowledge**

https://www.ontotext.com/knowledgehub/fundamentals/dikw-pyramid/

Wisdom

why
do
something?
what is best?

Wisdom is knowledge applied in action

The top of the DIKW hierarchy - Guiding **Wisdom**

https://www.ontotext.com/knowledgehub/fundamentals/dikw-pyramid/

Schumaker, Robert P. . Knowledge Acquisition, Delivery and Prediction Through Text Mining. 2007

Knowledge Types

Procedural knowledge

Knowledge that focuses on how we do things?

for example,

1. Knowledge of how to wash clothes using a machine

2. Knowledge of how to make coffee

3. Knowledge of how to treat coughing

Knowledge Types

Declarative knowledge

Knowledge that shows data or facts about something

Knowledge that answers the question whether something is true or false

for example,

1. Tomatoes are red and round in shape.

2. A car has four tires

3. The earth rotates around the sun in a certain time

Knowledge Types

Tacit knowledge

Knowledge that is difficult to understand because it has a personal quality is a combination of cognitive knowledge and technical expertise

Tacit knowledge is generally acquired through experience, independent learning, and is influenced by beliefs, perspectives, and values.

for example,

1. How to pedal a bicycle

2. How to move our hands

3. How to close our eyes

Knowledge Representation

- **Knowledge representation** is intended to capture the important properties of the problem and make information accessible to problem-solving procedures.

- Representational language must be able to make a programmer able to express knowledge to get a solution to a problem.

The Characteristics of Knowledge Representation Model

- **Must be programmed in a programming language**, and the results are stored in memory.

- Designed **to be used in the reasoning process**.

- A knowledge representation model is a **data structure** that can be manipulated by inference and search engines for pattern-finding activities.

- Capture the **important properties of the problem**.

- Make information **accessible for troubleshooting procedures**.

Knowledge Representation Types

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Knowledge Representation Types

- **Logical representation** uses formal logical expressions to represent knowledge.

- **Procedural representation** describes knowledge as a set of instructions.

- **Network representation** captures knowledge as a graph where the nodes describe objects or concepts in the problem at hand.

- **Structured representation**aims to expand the network, such as script, frame, and object.

1. Logical Representation

- Logic can be used to represent simple facts

- The logical representation consists of propositional logic and predicate logic.
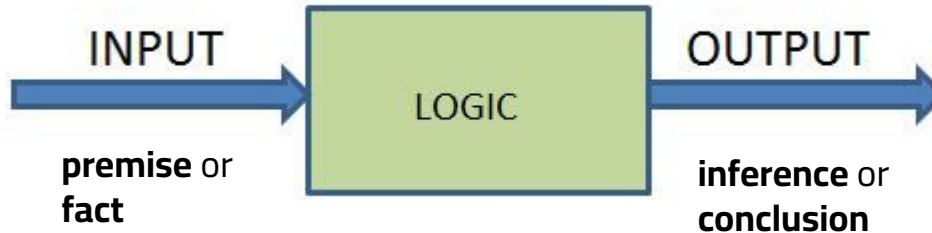
INPUT → LOGIC → OUTPUT

premise or **fact**

inference or **conclusion**

Logical Representation – Propositional Logic

- A proposition is a sentence, written in a language, that has a truth value (i. e. , it is true or false) in a world.

- The logical representation consists of propositional logic and predicate logic.

- A proposition is built from atomic propositions using logical connectives.

- An atomic proposition, (or atom), is a Symbol that starts with a lower-case letter.

- An atom is something that is true or false. For example:

  - sunny

  - ai_is_fun

Logical Representation – Propositional Logic

- A proposition is a sentence, written in a language, that has a truth value (i. e. , it is true or false) in a world.

- Propositional logic is logic that only has true or false values.

- A proposition is built from atomic propositions using logical connectives.

- An atomic proposition, (or atom), is a Symbol that starts with a lower-case letter.

- An atom is something that is true or false. For example:
  - sunny
  - ai_is_fun

Logical Representation – Propositional Logic

SYMBOL	NAME	FUNCTION	TRANSLATION
~	tilde	negation	*"it is not the case that"*
&	ampersand	conjunction	*"and"*
∨	wedge	disjunction	*"or"*
→	arrow	conditional	*"If...then..."*
↔	double-arrow	biconditional	*"If and only if"*

A	B	~B	A & B	A ∨ B	A→B	A↔B
T	T	F	T	T	T	T
T	F	T	F	T	F	F
F	T	F	F	T	T	F
F	F	T	F	F	T	T

Logical Representation – Propositional Logic

Example: Translating English Sentences into logical statements
(https://www.geeksforgeeks.org/discrete-mathematics-applications-of-propositional-logic/)

Given a sentence "**You can purchase this book if you have \$20 or \$10 and a discount coupon**." Now, this is a bit complex to be understood at once. So we translate this into a logical expression that will make it simple to understand.

Let a, b, c, and d represent the sentences "You can purchase this book.", "You have \$20.", "You have \$10.", and "You have a discount coupon." respectively. Then the given sentence can be translated to (b ∨ (c ∧ d) -> a, which simply means that "if you either have \$20 or \$10, along with a discount coupon, then you can purchase the book."

Logical Representation – Predicate Logic

- **Predicate logic** is an extension of Propositional logic**.**
- **Predicate logic** adds the concept of predicates and quantifiers to better capture the meaning of statements that cannot be adequately expressed by propositional logic**.**
  (https://www.geeksforgeeks.org/mathematic-logic-predicates-quantifiers/)
- **Example**:
  There are the following facts:

  >   Ana is a woman : A
  >   Bela is a woman : B
  >   Cindy is a woman: C
  >   Dea is a woman : D

- If the five facts mentioned above are stated in propositional logic, there will be a waste where several statements with the same predicate will be made in different propositions.
- So that the above statement can be expressed in the form of predicate logic as follows:
  a woman(x(Ana, Bela, Cindy, Dea))

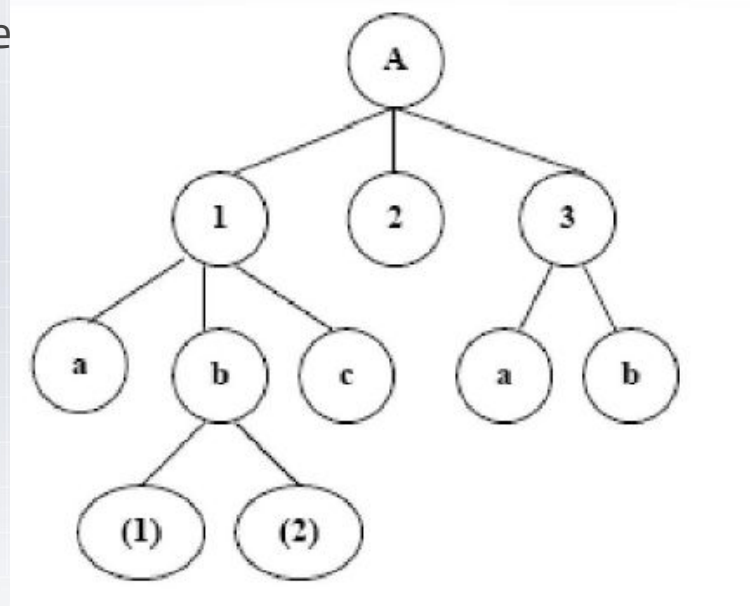# Logical Representation – Predicate Logic

- **Example**:
  There are the following facts:
  Diana is the mother of Beno.

  Predicate logic: Mother (Diana, Beno)

2. Tree

- **A tree** is a simple structure of knowledge representation.
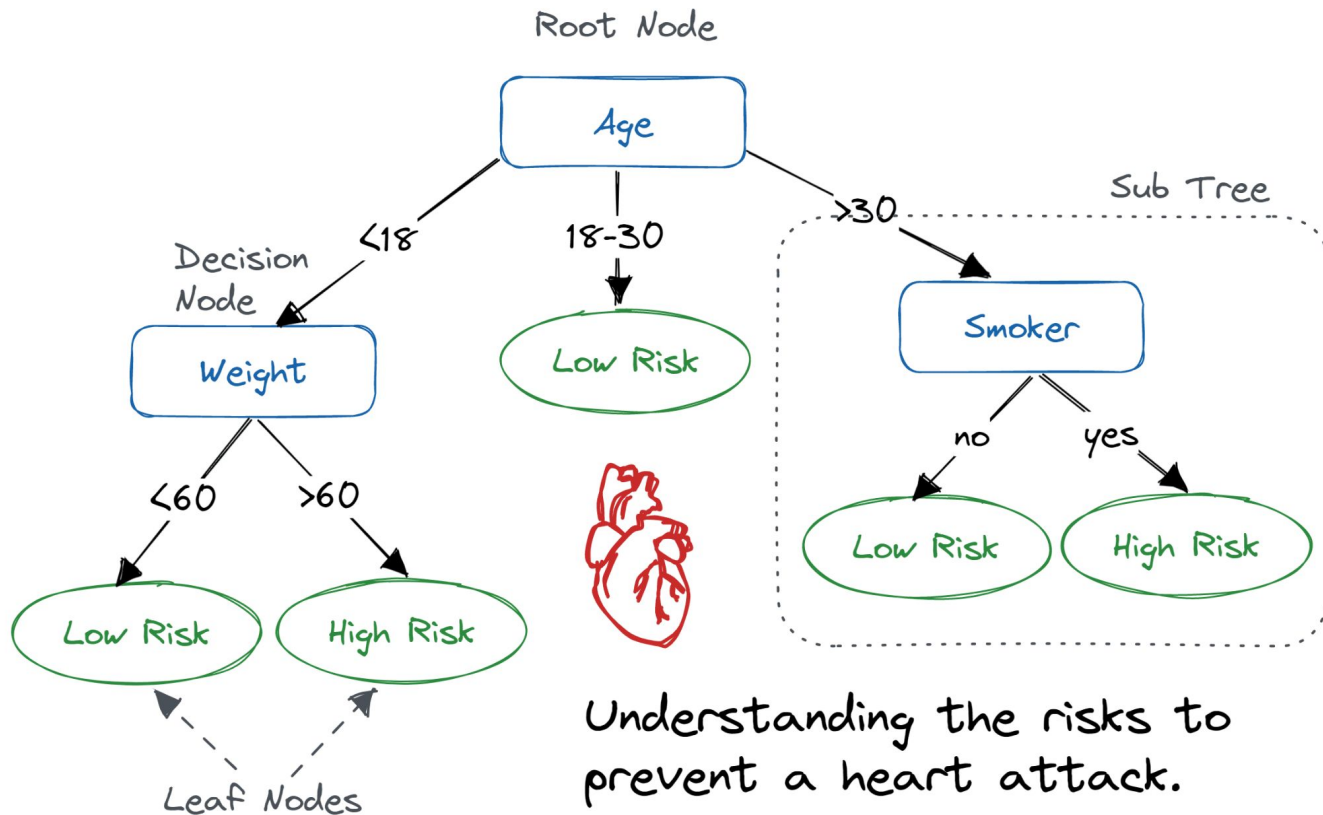
- **A tree** is a hierarchical graphic structure

Tree – Decision Tree

A **decision tree** is a flowchart-like tree structure where an internal node represents a feature(or attribute), the branch represents a decision rule, and each leaf node represents the outcome.

Tree – Decision Tree

3. Semantic Network

A **semantic network** is a knowledge structure that depicts how concepts are related to one another and illustrates how they interconnect.

Semantic networks are knowledge representation schemes involving nodes and links (arcs or arrows) between nodes. The nodes represent objects or concepts and the links represent relations between nodes.

This representation consist of mainly three types of relations:

- IS-A relation (Inheritance)
- Kind-of/ is-part relation
- HAVE/HAS relation

Semantic Network

- **Example**:

  Following are some statements which we need to represent in the form of nodes and arcs.
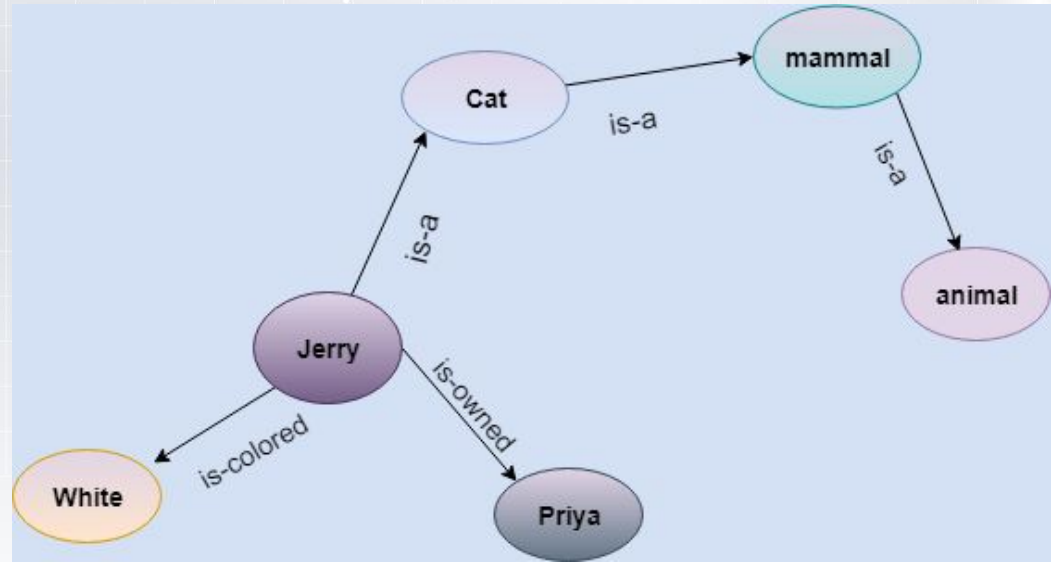
  Statements:
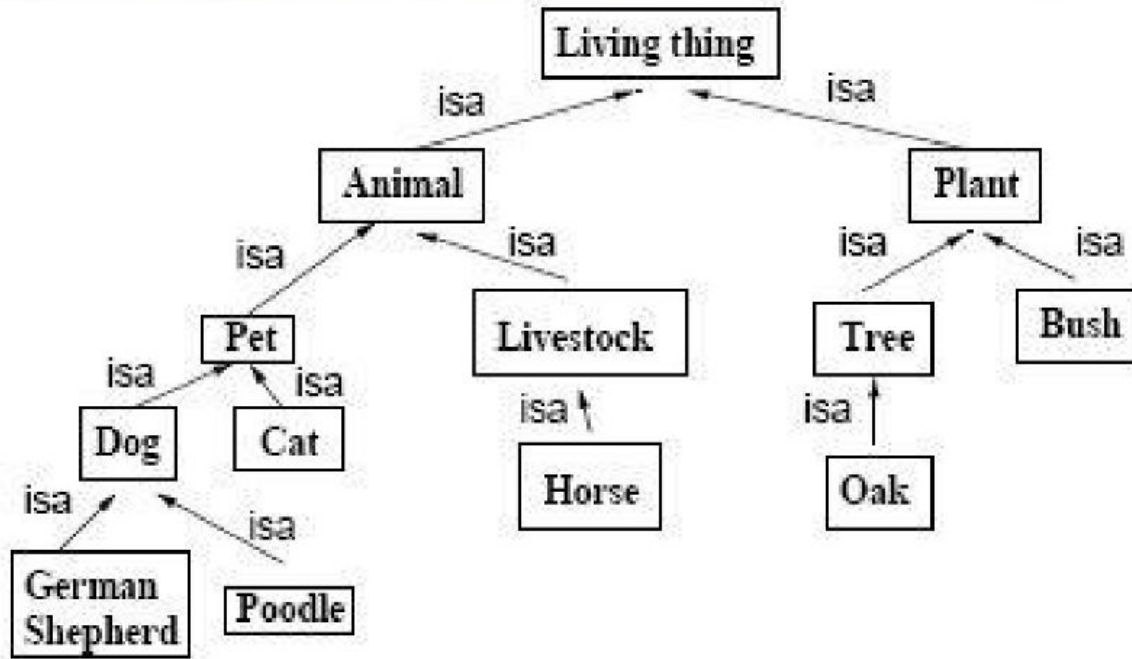
  Jerry is a cat.
  Jerry is a mammal
  Jerry is owned by Priya.
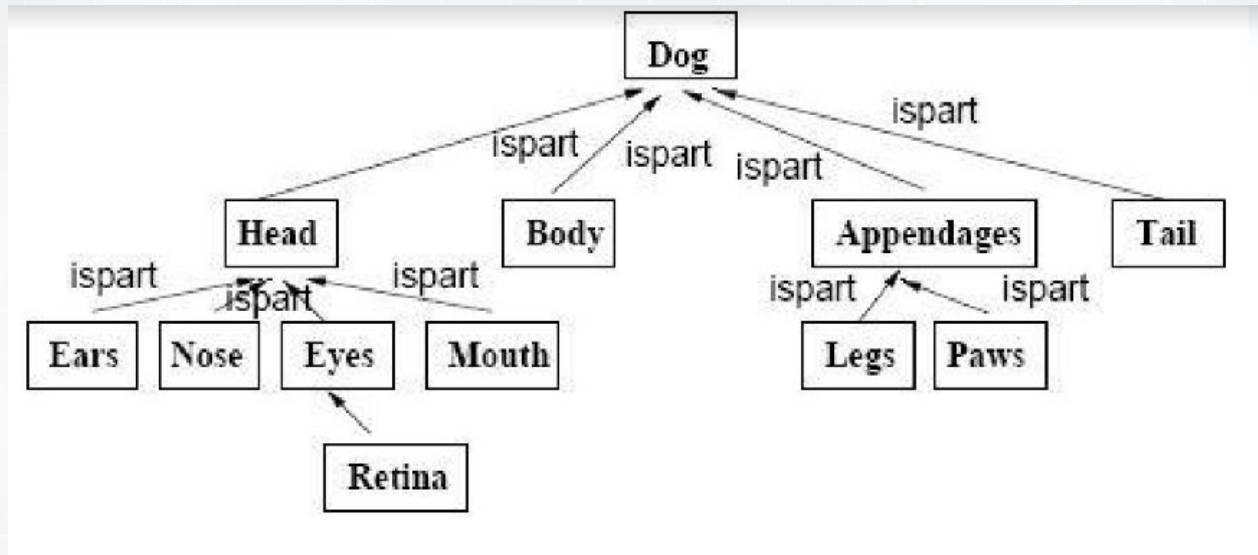 Jerry is brown colored.
  All Mammals are animal.

Semantic Network – IS-A relation

Semantic Network – is-part-relation

Semantic Network – relation

Fernandez, Hector Beck and David F. Nettleton. Identification and Extraction of Memes represented as Semantic Networks from Free Text Online Forums.2015
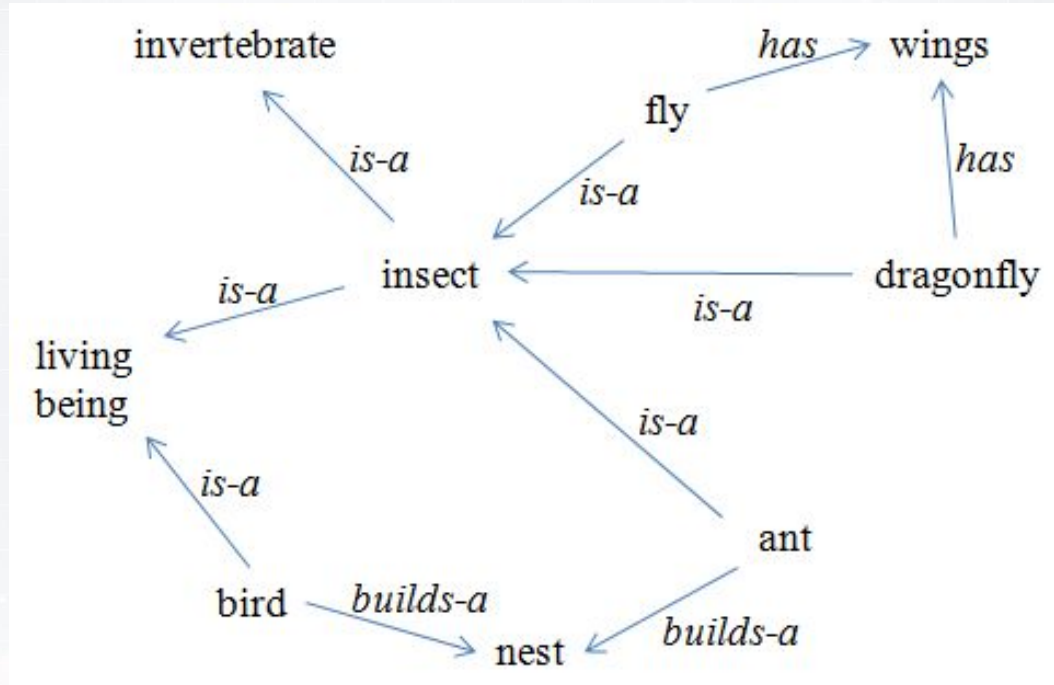
4. Frame

A **frame** is a record like structure which consists of a collection of attributes and its values to describe an entity in the world.

Frames are the AI data structure which divides knowledge into substructures by representing stereotypes situations.

Frame consists of a collection of slots and slot values. These slots may be of any type and sizes. Slots have names and values which are called facets.

Frame

Each piece of information about a particular frame is held in a **slot**. The information can contain:

- **Facts or Data**
  - Values (called facets)
- **Procedures** (also called procedural attachments)
  - IF-NEEDED: deferred evaluation
  - IF-ADDED: updates linked information
- **Default Values**
  - For Data
  - For Procedures
- **Other Frames or Subframes**

Frame

Facets: The various aspects of a slot is known as Facets.

Facets are features of frames which enable us to put constraints on the frames. Example: IF-NEEDED facts are called when data of any particular slot is needed.

A **frame** may consist of any number of slots, and a slot may include any number of facets and facets may have any number of values.

A **frame** is also known as slot-filter knowledge representation in artificial intelligence.

Frame

Alkrimi, Jameela et al. Review of Artificial Intelligence.2013
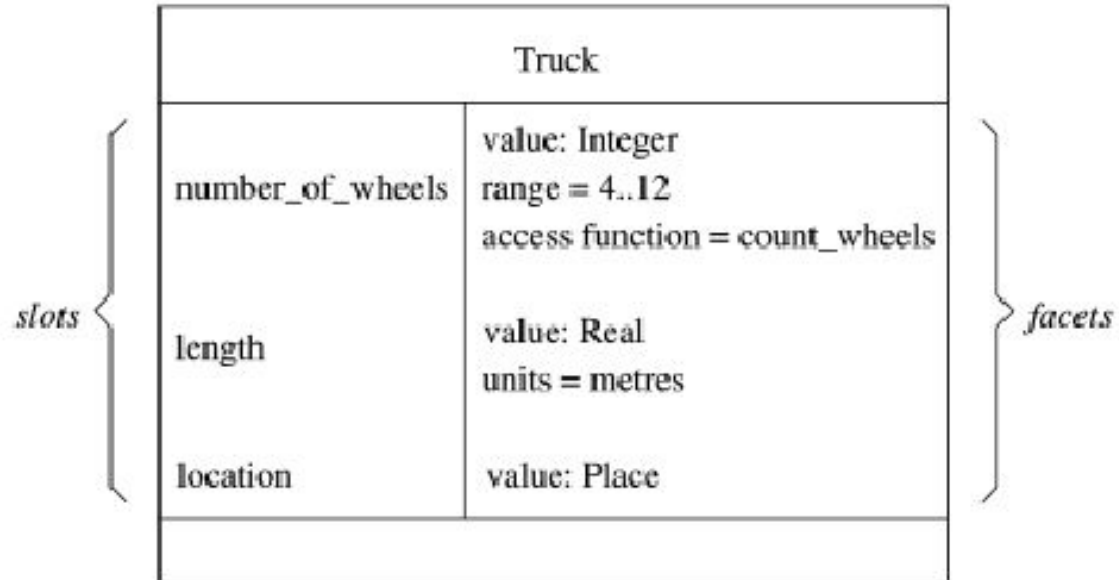
Frame

Example: 1

Let's take an example of **a frame for a book** (https://www.javatpoint.com/ai-techniques-of-knowledge-representation)

Slots	Filters
Title	Artificial Intelligence
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

Frame

Part of the Frame Description of a Hotel Room
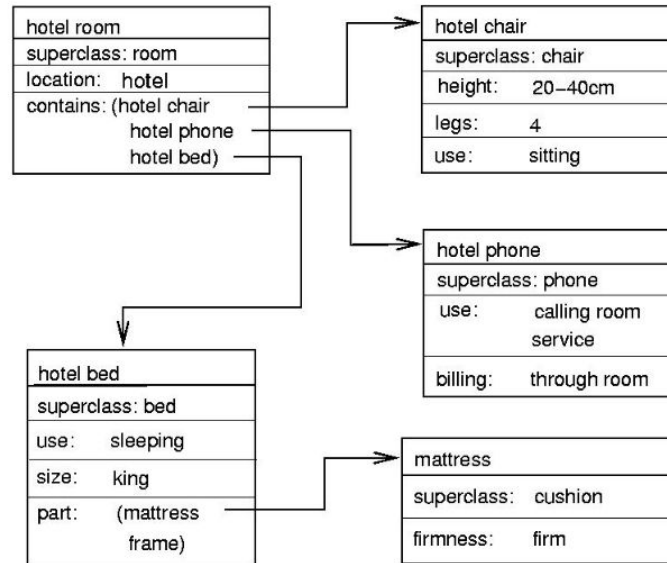
5. Script

A **script** is a structured representation describing a stereotyped sequence of events in a particular context.

Scripts are used to organize events in knowledge bases.

https://www.cs.jhu.edu/~phi/ai/slides/lecture-knowledge-representation.pdf

Script

A **script** is composed of several components

- **Entry conditions** that must be true for the script to be called

- **Results or facts** that are true once the script has terminated

- **Props** or the "things" that make up the content of the script

- **Roles** are the actions that the individual participants perform

- **Scenes** which present temporal aspects of the script

Script

Canonical Example: Restaurant Visit 31

- Objects: tables, menu, food, check, money, ...

- Roles: customer, waiter, cook, cashier, owner, ...

- Entry conditions: customer hungry, customer has money

- Results: customer not hungry, customer has less money, owner more money, ...

- Scenes

  - Scene 1: Entering
    * customer enters restaurant
    * customers looks at tables
    * customer decides where to sit
    * ...
  - Scene 2: Ordering
    * waiter brings menu
    * ...
  - ...

Script

Script Actions

Describing a script a special symbols of actions are used:

Symbol	Meaning	Example
ATRANS	transfer a relationship	*give*
PTRANS	transfer physical location of an object	*go*
PROPEL	apply physical force to an object	*push*
MOVE	move body part by owner	*kick*
GRASP	grab an object by an actor	*grasp*
INGEST	ingest an object by an animal	*eat*
EXPEL	expel from an animal's body	*cry*
MTRANS	transfer mental information	*tell*
MBUILD	mentally make new information	*decide*
CONC	conceptualize or think about an idea	*think*
SPEAK	produce sound	*say*
ATTEND	focus sense organ	*listen*

Script

Detailed Script

33

Script Restaurant

Props
- Tables
- Menu
- F = Food
- Check
- Money

Roles
- P = Customer
- O = Waiter
- V = Cook
- K = Cashier
- S = Owner

Entry conditions
- P is hungry
- P has money

Results
- P has less money
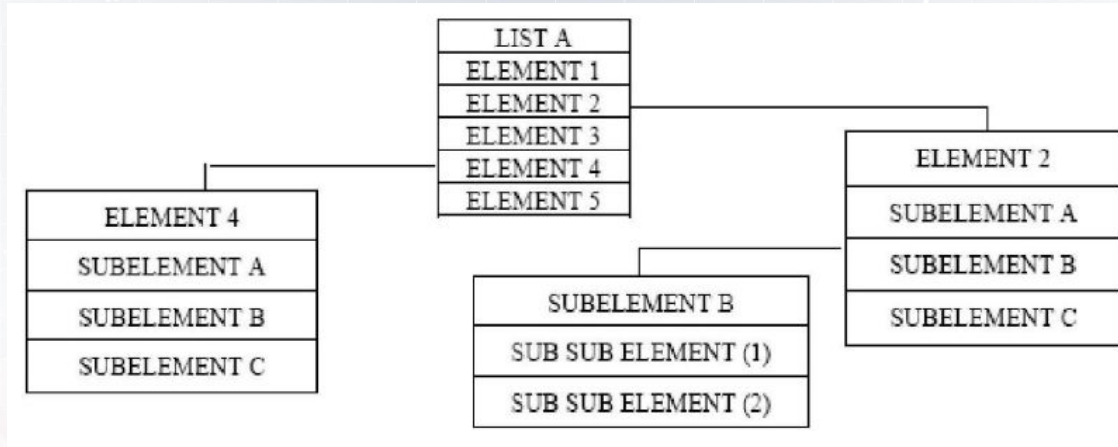- P is not hungry
- P is pleased
- (optional)
- S has more money

Scene 1: Entering
P PTRANS P into restaurant
P ATTEND eyes to tables
P MBUILD where to sit
P PTRANS P to table
P MOVE P to sitting position

Scene 2: Ordering
(Menu on table)   (S asks for menu)
O brings menu   S MTRANS signal to O
P PTRANS menu to P   O PTRANS O to table
                         P MTRANS "need menu" to O
                         O PTRANS O to menu

          O PTRANS O to table
          O ATRANS menu to P

P MTRANS food list to P
* P MBUILD choice of F
P MTRANS signal to O
O PTRANS O to table
P MTRANS 'I want F' to O

                    O PTRANS O to V
                    O MTRANS (ATRANS F) to V

V MTRANS 'no F' to O
O PTRANS O to P
O MTRANS 'no F' to P   V DO (prepare F script)
(go back to *) or   to Scene 3
(go to Scene 4 at no pay path)

Scene 3: Eating
V ATRANS F to O
O ATRANS F to P
P INGEST F

Option: Return to Scene 2 to order
more; otherwise, go to Scene 4

Scene 4: Exiting
          P MTRANS to O
              (O ATRANS check to P)

          O MOVE write check
          O PTRANS O to P
          O ATRANS check to P
          P ATRANS tip to O
          P PTRANS P to K
          P ATRANS money to K
          P PTRANS P to out of restaurant

No pay path

Schank un Abelson, 1977

6. List

Lists are a simple structure for knowledge representation

Lists are used for groups of objects that are grouped, categorized, or combined..

THANKS!

See You