Knowledge Representation

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Outline

- Knowledge Representation
- History of KR
- Types of Knowledge
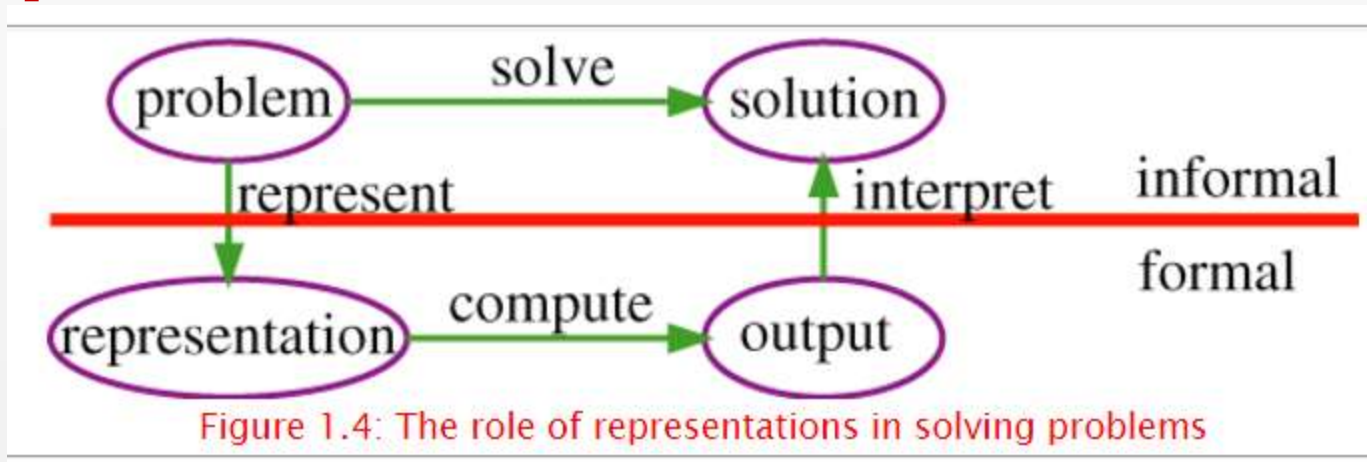- Types of Knowledge Representation

Knowledge Representation

- Typically, a problem to solve or a task to carry out, as well as what constitutes a solution, is only given informally, such as "deliver parcels promptly when they arrive" or "fix whatever is wrong with the electrical system of the house."

- Ref: http://artint.info/html/ArtInt_8.html

Knowledge Representation

- **Knowledge** is the information about a domain that can be used to solve problems in that domain. To solve many problems requires much knowledge, and this knowledge must be represented in the computer. As part of designing a program to solve problems, we must define how the knowledge will be represented.

- A **representation scheme** is the form of the knowledge that is used in an agent.

- A **representation** of some piece of knowledge is the internal representation of the knowledge. A representation scheme specifies the form of the knowledge.

- A **knowledge base** is the representation of all of the knowledge that is stored by an agent.

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Knowledge Representation

Figure 1.4: The role of representations in solving problems

- The general framework for solving problems by computer is given in Figure 1.4. To solve a problem, the designer of a system must

- flesh out the task and determine what constitutes a solution;

- represent the problem in a language with which a computer can reason;

- use the computer to compute an output, which is an answer

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Knowledge Representation

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History of KR
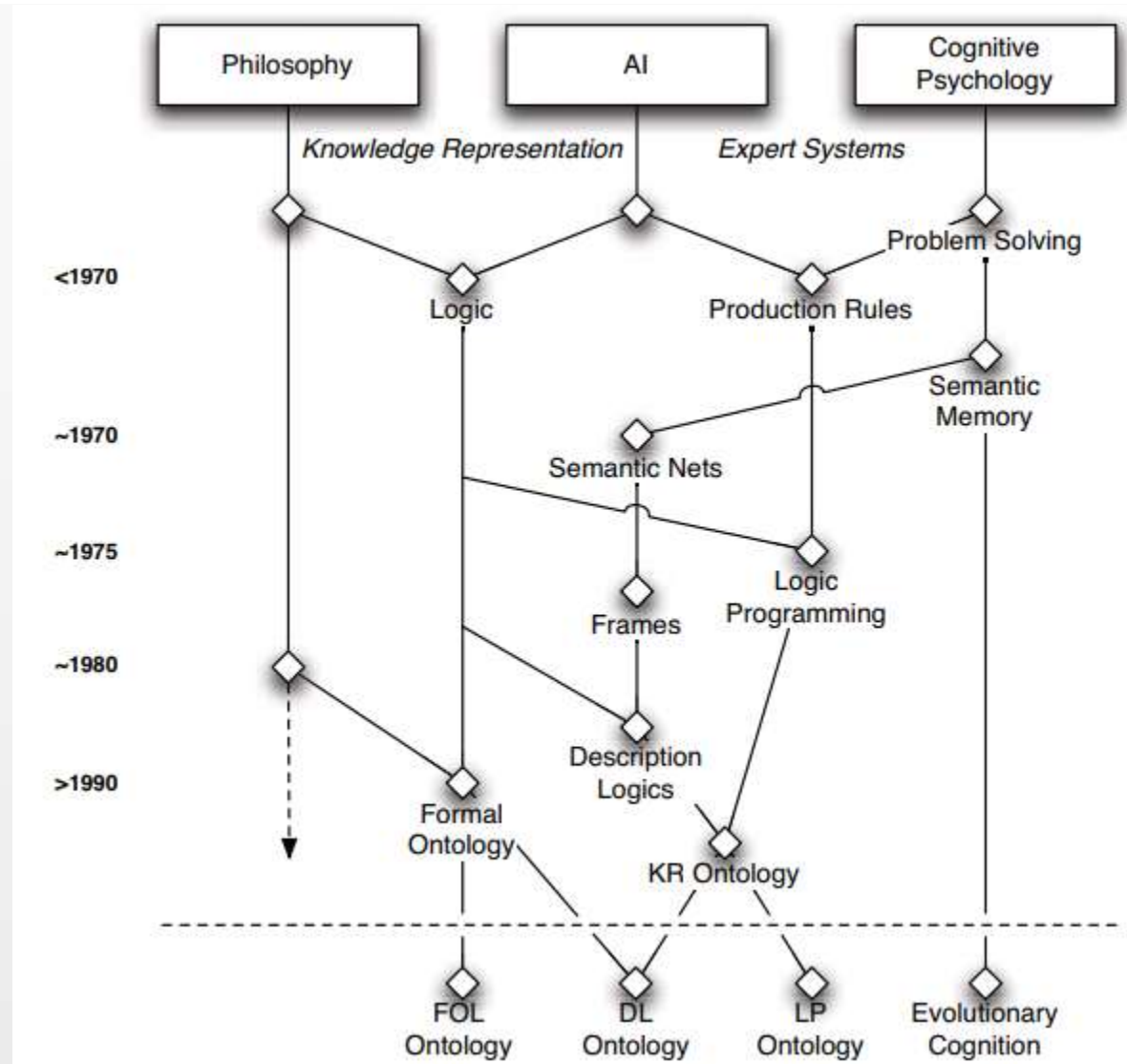
Types of Knowledge

- Factual or Declarative Knowledge

- Procedural Knowledge

- Meta- Knowledge

- Heuristic Knowledge

- Structural Knowledge

- Inexact and Uncertain Knowledge

- Commonsense Knowledge

- Ontological Knowledge

Factual or Declarative Knowledge

- explains what things are

- is concepts, objects, facts

- is knowing about something

- e.g., the dogs eats meat or a dog has a tail.

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Procedural Knowledge

- explains how things work for example what the dog needs to do in order to eat,

- rules, strategies, agendas, procedures.

- Is knowing How to do something

- e.g. if dog hungry -> find food, then chew food, then swallow, then find more food if still hungry.
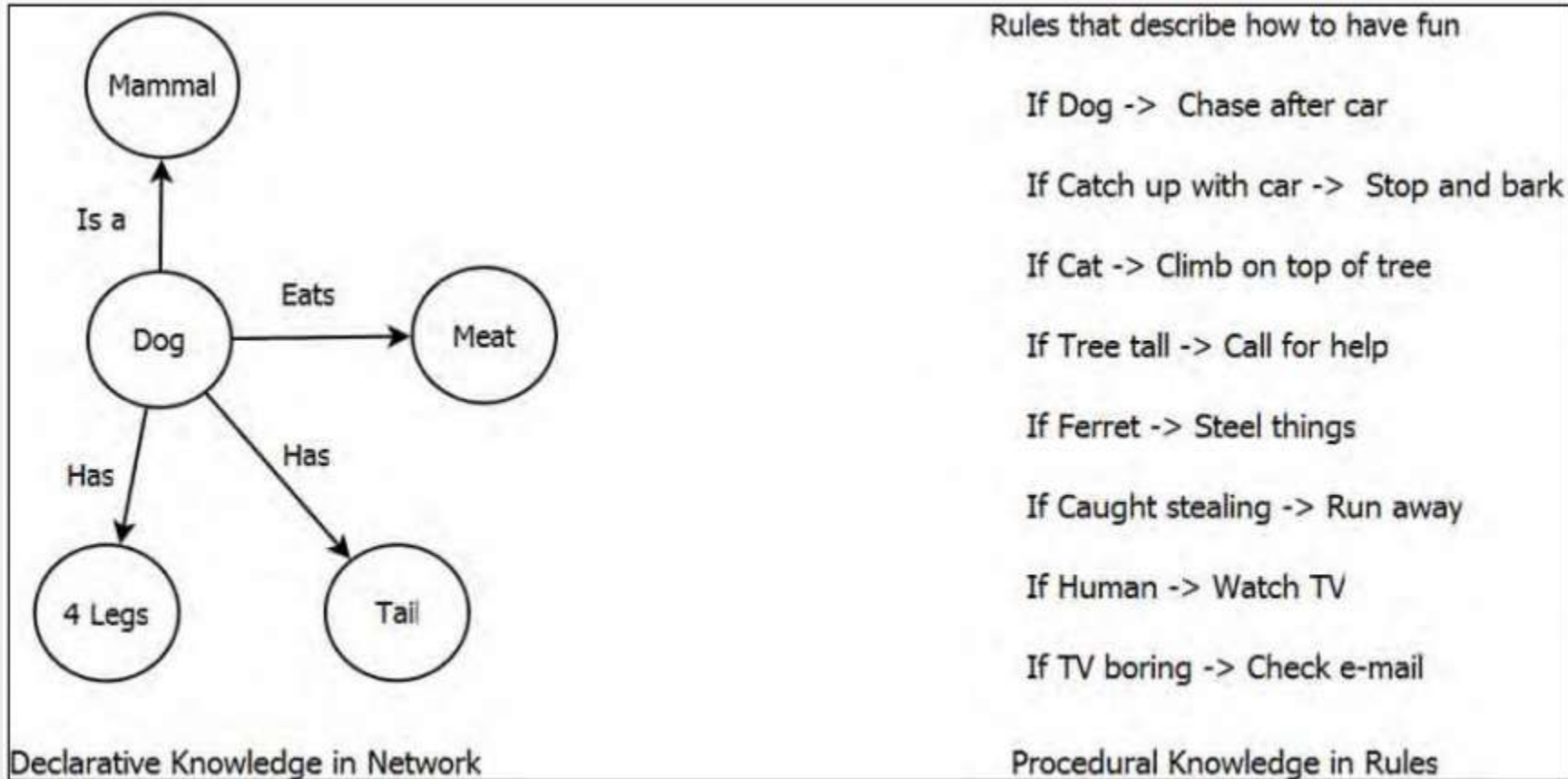
Types of Knowledge

Rules that describe how to have fun

If Dog -> Chase after car

If Catch up with car -> Stop and bark

If Cat -> Climb on top of tree

If Tree tall -> Call for help

If Ferret -> Steel things

If Caught stealing -> Run away

If Human -> Watch TV

If TV boring -> Check e-mail

Declarative Knowledge in Network

Procedural Knowledge in Rules

Fig. 2. Example of declarative and procedural knowledge.

Mata- Knowledge

- knowledge about other types of knowledge

- Example: bibliographic data, catalogue of books

- May be used to reveal patterns in research, relationship between researchers and identify contradictory results

Heuristic Knowledge

- rules of thumb based on previous experience, awareness of approaches that are likely to work but which are not guaranteed.

- Example: Knowledge about the web navigation habits of an individual

- An educated guess for example, about the search needs of a person

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Structure Knowledge

- rule sets, concept relationships, concept-to-object relationships.

- Is basic to problem solving

- Describes relationships between concepts like kind of, part of and groupings.

- Example: Mango is a kind of fruit. Fruit is a kind of crop. Crop information is part of agricultural knowledge.

Inexact and Uncertain Knowledge

- probabilities, uncertain facts – rules – relationships – evidence.

- Characterizes situations in which information is imprecise, unavailable, incomplete, random or ambiguous

- Example: Rumors about something or someone, terms like 'little', 'too much', 'warm', 'more or less' etc.

Commonsense Knowledge

- default propositions, approximate concepts and theories, general hierarchies and analogies.

- Denotes vast amount of human knowledge about the world that cannot be stated in precise theories

- Collection of facts and information that an ordinary person is expected to know

- Example: The shape and color of an apple, knowledge about human emotions, reflexes etc

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Ontological Knowledge

- concepts, relationships between concepts, axioms, constraints

- Describes the categories of things in a domain

- Example: Ontological knowledge about crop diseases contains concepts like crop, disease, symptoms and management

- Overlaps with other categories of knowledge like declarative and structural

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Types of Knowledge Representaion
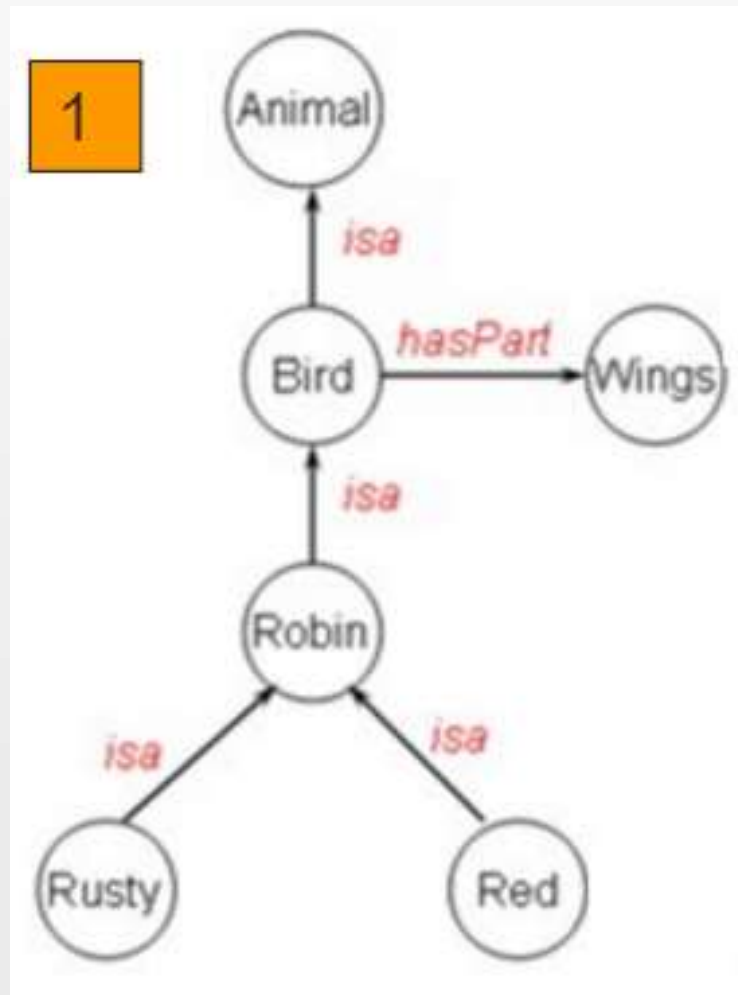
- Semantic Network

- Frame

- Script

- Conceptual Graph

Semantic Network

- A useful way to represent relationship between knowledge that is similar to an important feature of human memory with large number of relationships.

- Nodes represent objects, concepts, situations

- Edges represent relationships

- Typically, "IS_A" and "AKO" (A Kind Of) relations are used between knowledge. But Can be specified by the designer

Semantic Network

Frame

- Introduced by Marvin Minsky in 1974

- It extends semantic network to provide a more structured way of representing a knowledge base.

- It stores properties, values, methods and relevant information of object.

- Frame supports class hierarchies applied in object oriented concept.

- Each frame has:
  - A name
  - A Slot which stores information like specific value, default value, inherited value, a pointer to another frame (superclass or subclass)

Frame
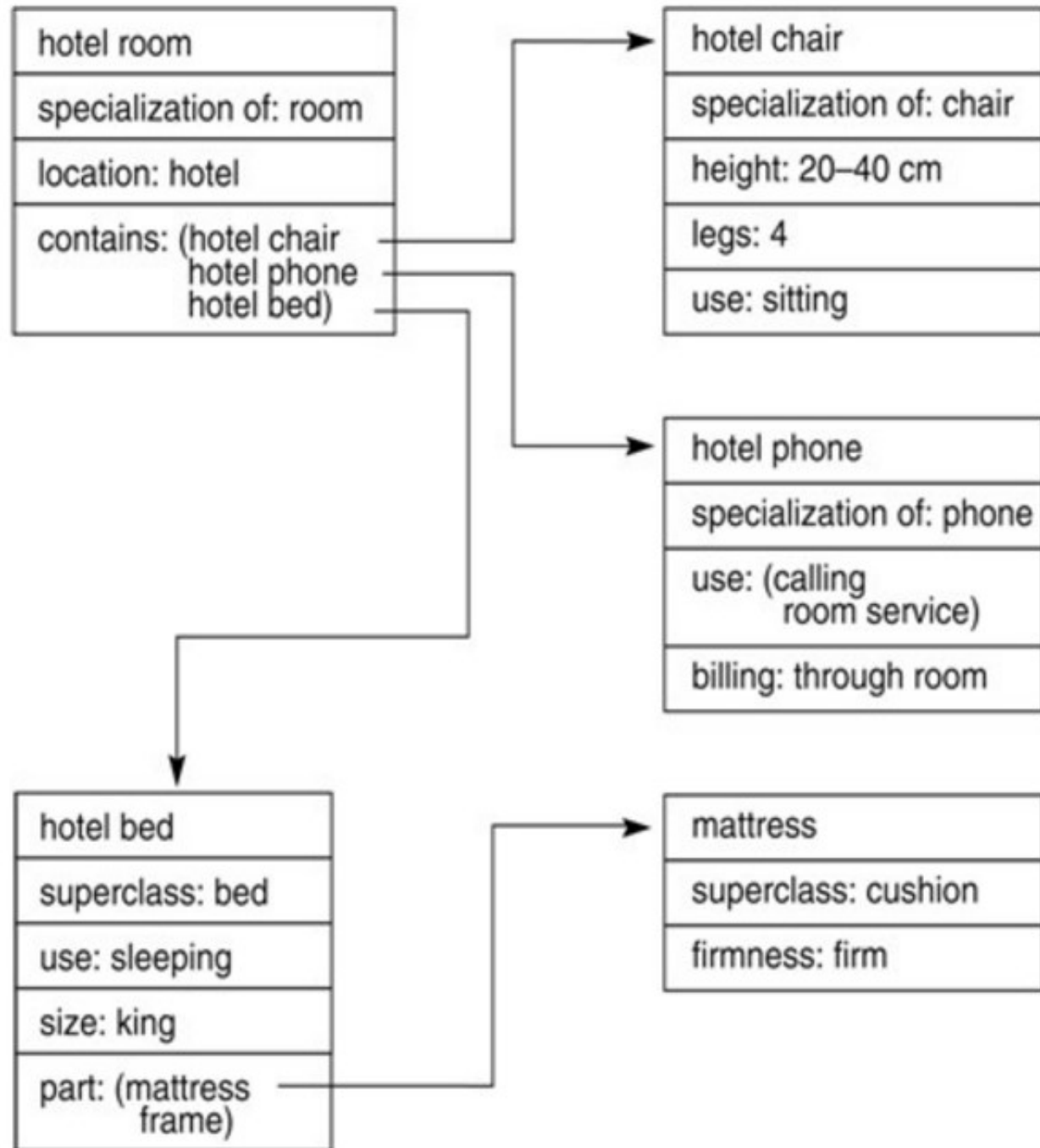
Frame
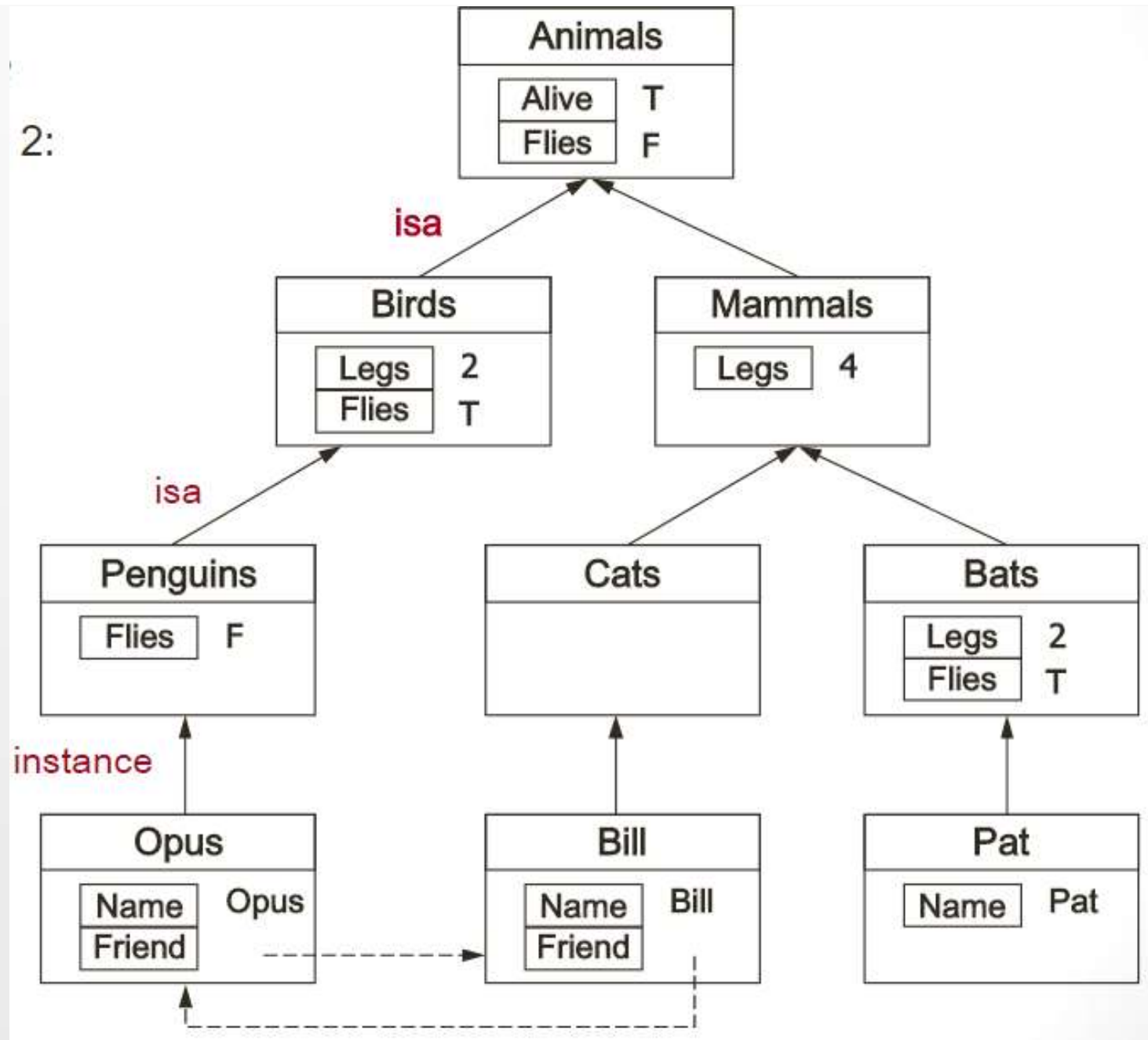
Script

- A structured representation describing a stereotyped sequence of events related to a particular context introduced by Roger Schank in 1977.

- They are used in natural language understanding to understand specific situation.

- Components of script:
  - Entry condition: condition that must be true for the scripts to be valid
  - Results: facts that become true once the script is completed.
  - Props: secondary things that support the script.
  - Roles: actions that individual participants perform.
  - Scenes: there are many scenes in a script. Each one represents a specific temporal aspect of the script.

Script

A script for the process ....."Going to a restaurant to have a meal"

```
SCRIPT
Name: RESTAURANT
Roles: Customer, Waiter, Cook, Cashier
Entry condition: Customer is hungry
Props: Food, table, money, menu, tip
Events:
 1/ Customer enters restaurant
 2/ Customer goes to table
 3/ Waiter brings menu
 4/ Customer orders food
 5/ Waiter brings food
 6/ Customer eats food
 ...
10/ Customer leaves restaurant

Main concept: 6
Results: Customer not hungry,
         Customer has less money,
         Restaurant has more money
```
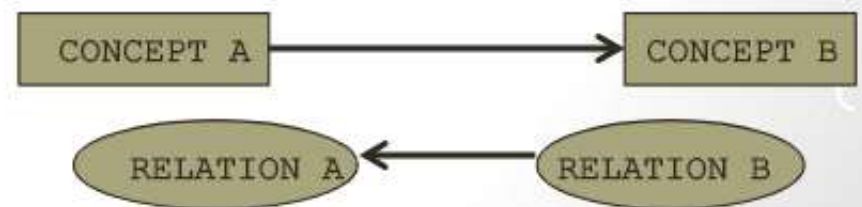
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Conceptual Graph

- Is finite, connected bipartite graph or bigraph.

- A bipartite graph is a graph in which the set of nodes can be partitioned in two disjoint sets.

- There are two type of node in the CG:
  - Concept: the knowledge / fact / action
  - Relation: the type of relationship between 2 concepts.

- Rule in CG:
  - There are **NO** arcs between a concept and another concept, and no arcs between a relation and another relation. All arcs either go from a concept to a relation or from a relation to a concept.

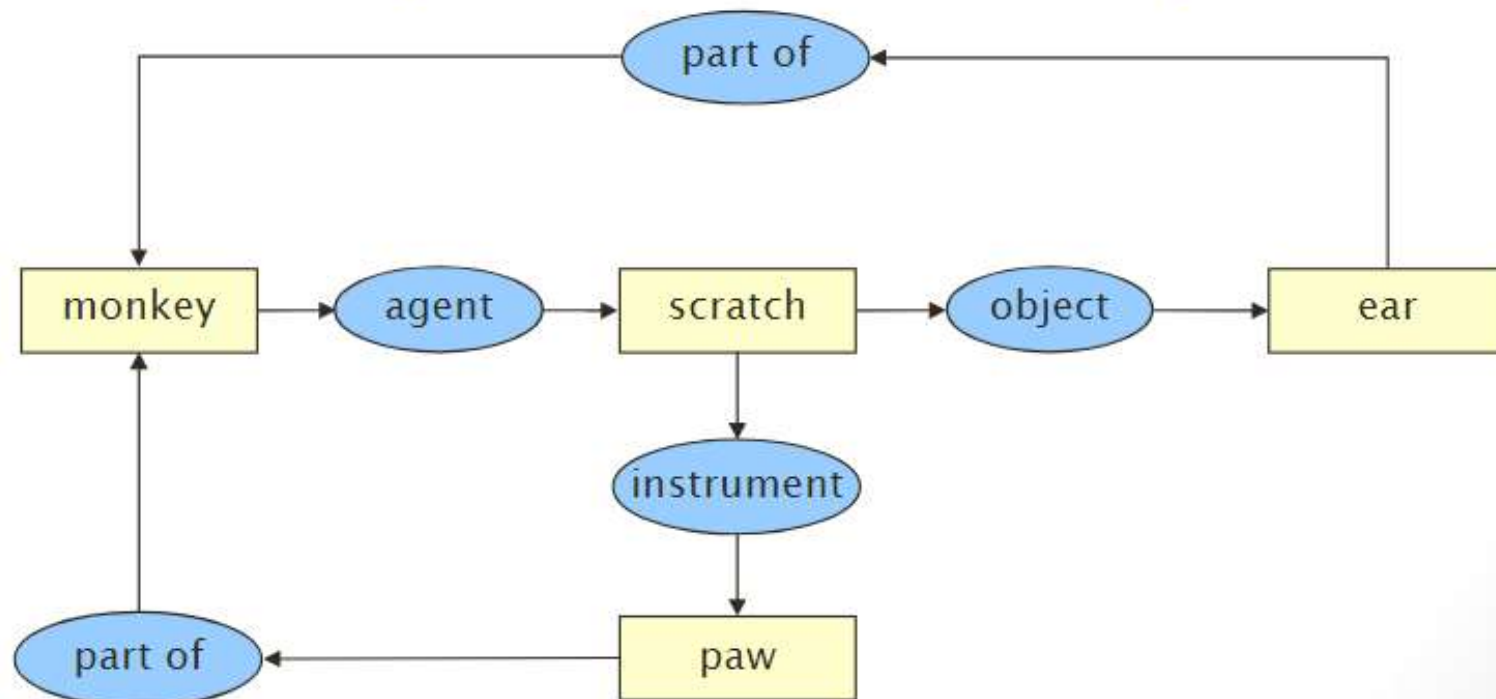Valid CG

Invalid CG

Conceptual Graph

A dog is brown

dog → color → brown

A cat is on the mat

cat → on → mat

A monkey scratch its ear with a paw

monkey → agent → scratch → object → ear

part of

scratch → instrument → paw

part of

Conceptual Graph

A cat is grey

Cat: X → color → grey

General concept CG is referring to a particular but unknown instance.

A cat named Abu is grey

Cat: Abu → color → grey

Cat → color → grey

Cat → name → "Abu"
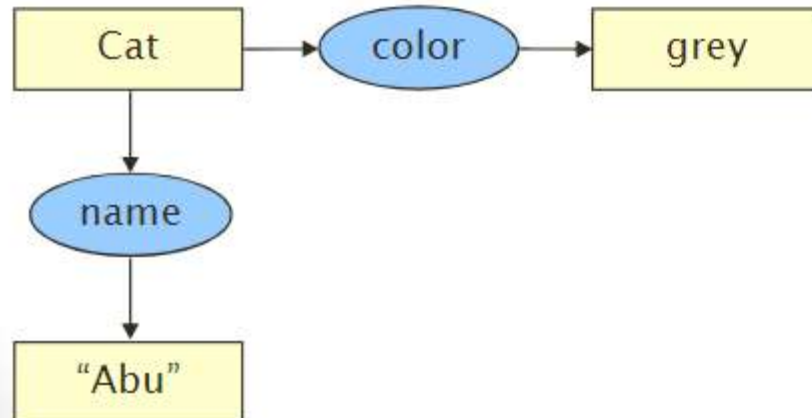
Specific concept CG is referring to a particular and known instance.

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