Slot and filler structure

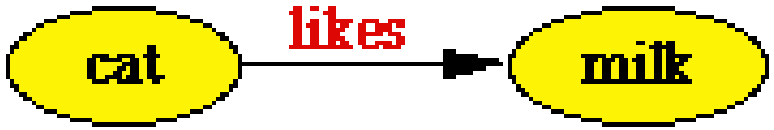
- A device to support property inheritance
  - Isa
  - Instance links
  - Weak and strong slot and filler structure
- Here inheritance is easy because knowledge in slot and filler structure is represented as entities and set of attributes
- Two views are **semantic net** and **frames**
  - They are weak slot and filler structure as they have some limitation.

Semantic net

- Meaning of a concept comes from the ways in which it is connected to other concept
- Semantic network is formalism for representing information about objects, people, concepts and specific relationship between them.
- A semantic network is a structure for representing knowledge as a pattern of interconnected **arcs** and **nodes**. It is a network of labeled nodes and links.

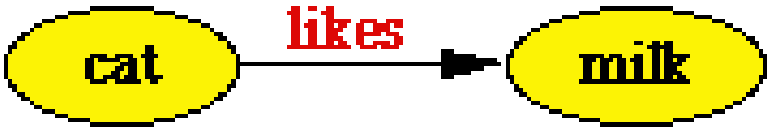
Nodes represent
- Entities
- Attributes
- States
- Events

Arc represent the relationship between nodes and label specify the type of relation that exist

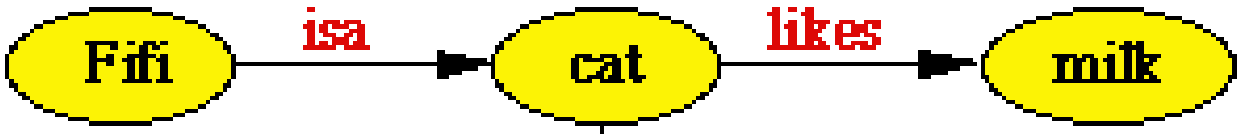


Simple semantic Nets

- Nodes are labeled with names (nouns).
- Arcs are labeled with relationships.



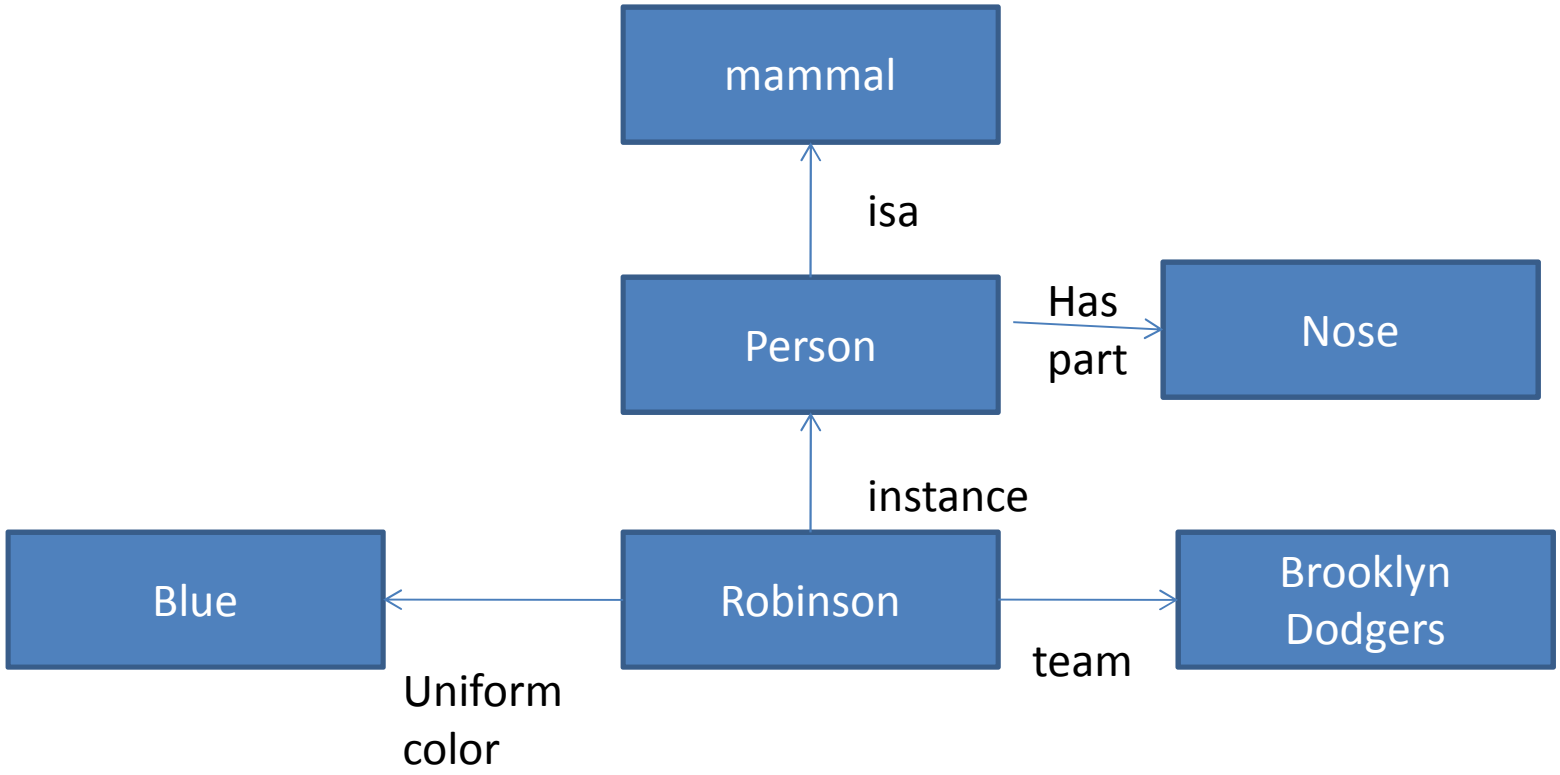
- Special link label "isa" means "is a".
- Show membership or subset relationships



Semantic network

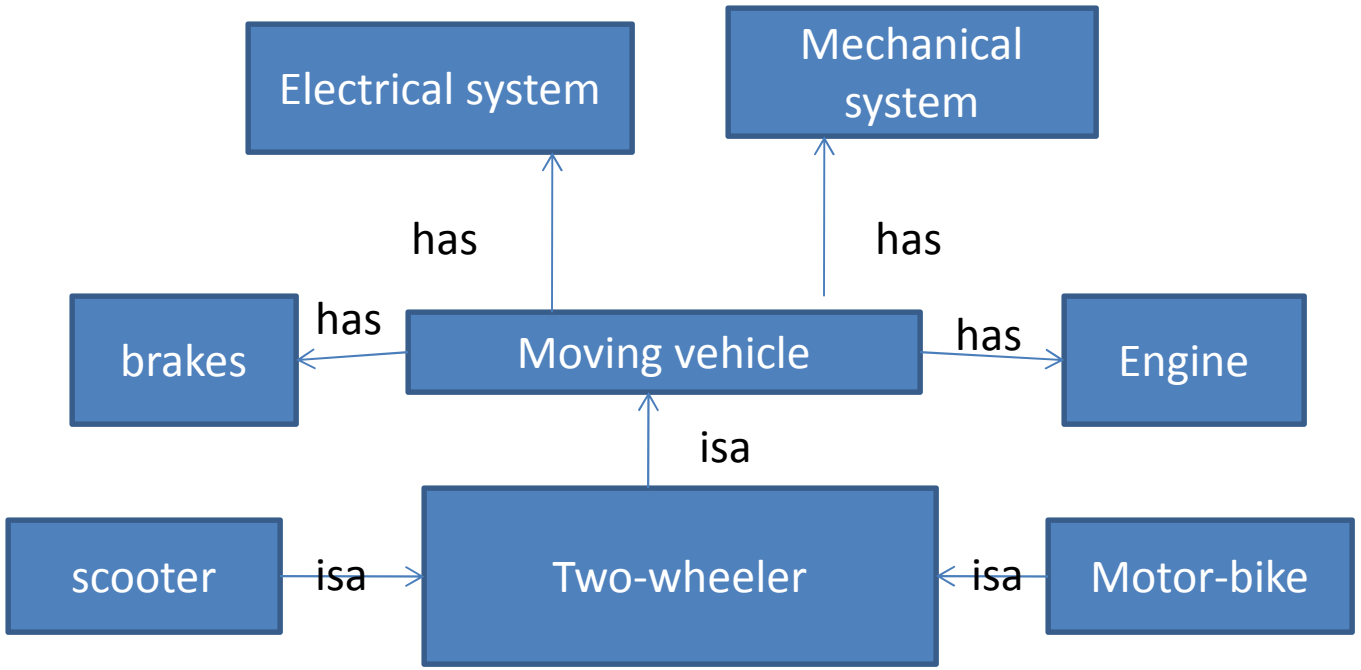
- Semantic networks are representations of **human memory structures**.
  - The cognitive theory underlying semantic networks maintains that human memory is organized semantically
  - that is, according to meaningful relationships between ideas in memory.
- **Arc** generally represent following type of association
  - Hierarchical (**inheritance** eg is-a instance)
  - Property (represent **characteristic** of node eg has-a)
  - Action –related (agent, objects etc)

Example



Semantic Network

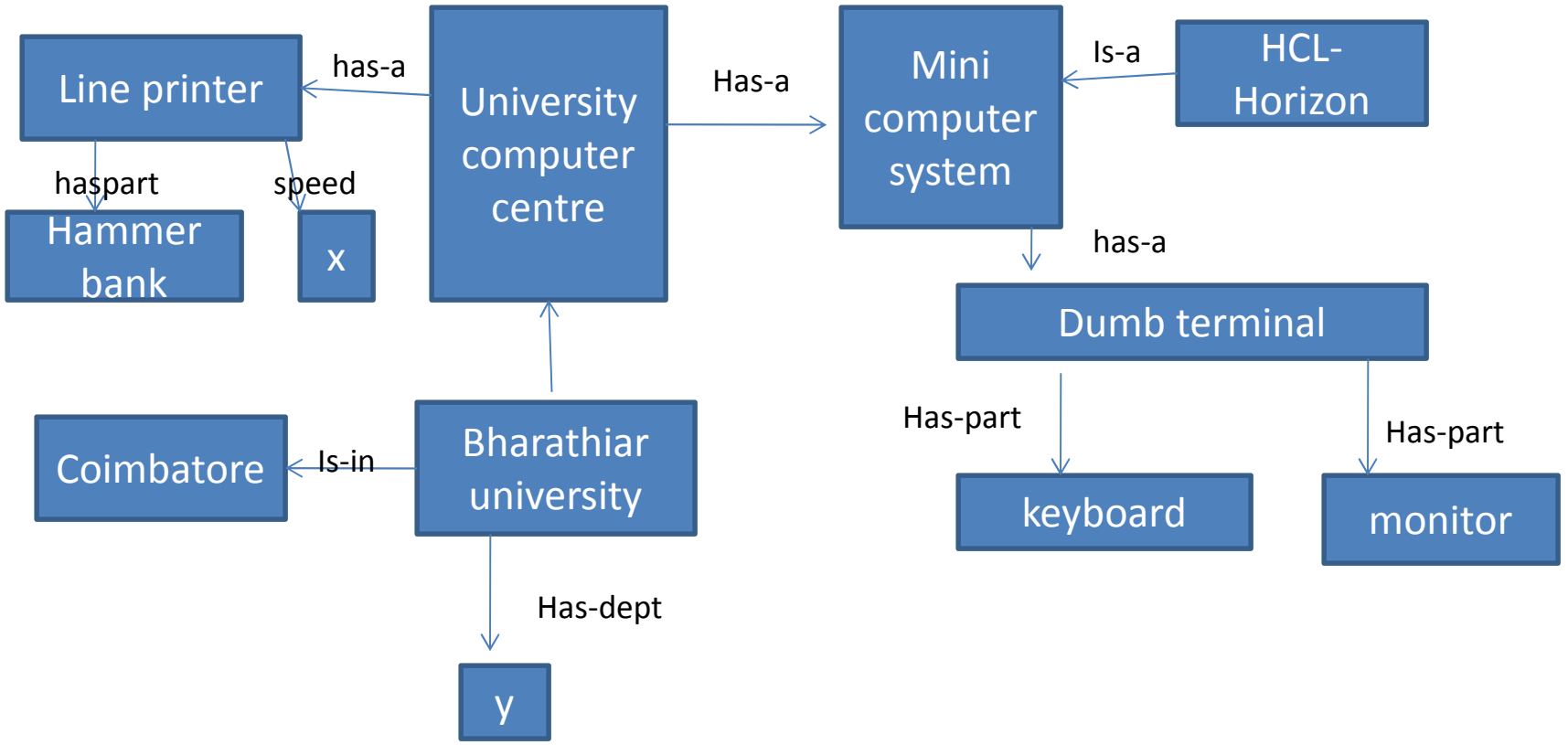
Semantic net example



Deduce : scooter is two wheeler and is a moving vehicle

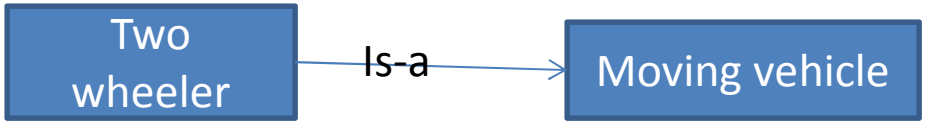
Semantic net

Representation of variables is also possible

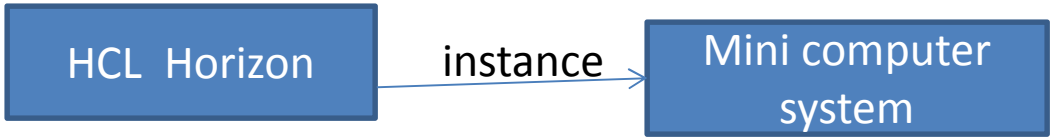


Semantic Net

- There are two types of nodes
  - Generic nodes
  - Individual or Instances nodes
- Generic node is a very general



- Individual Node

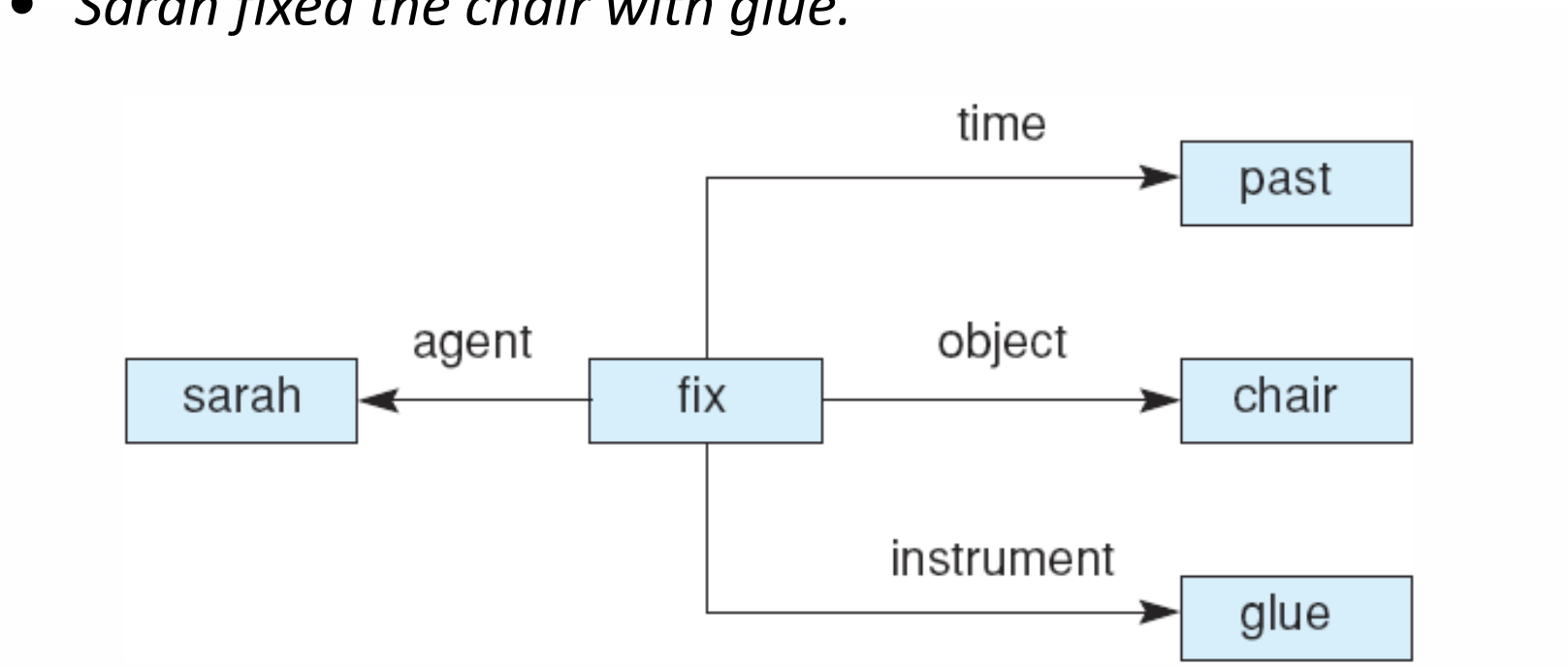


Property of is-a

- Is-a link
  - Is hierarchical in nature
  - Inheritance
- Reasoning with semantic net
  - Specify the start node
  - Traverse the other node using links
  - Till final node is reached
- What is the speed of the line printer?

Verb analysis
(action based)

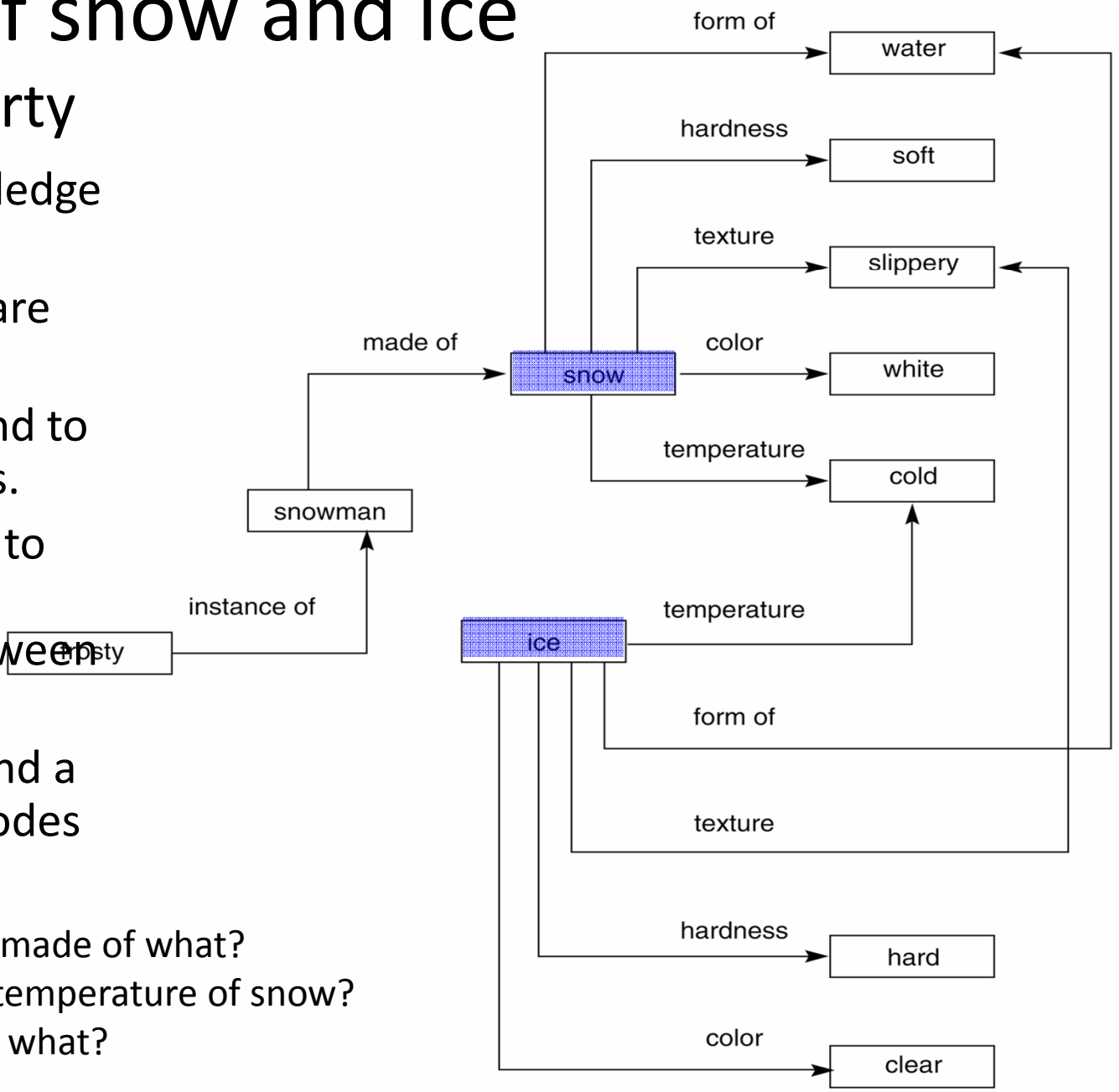
- Verb-oriented approach
- Links define the roles of nouns/phrases in the action of the sentence
- Case relationships: agent, object, instrument, location, time, etc.
- *Sarah fixed the chair with glue.*



Concepts of snow and ice

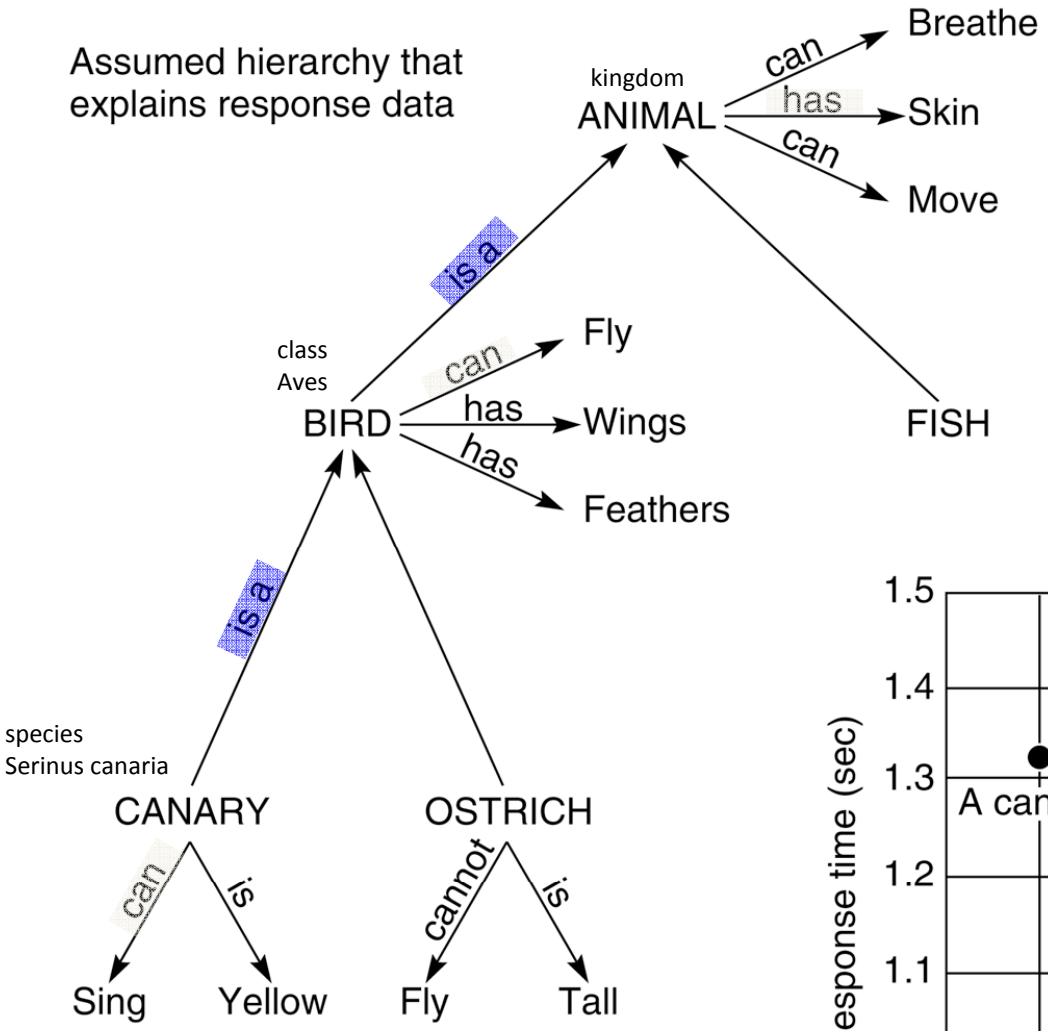
Property

- Represent knowledge as a graph.
- Nodes and arcs are labeled.
- Nodes correspond to facts or concepts.
- Arcs correspond to relations or associations between concepts
- Inference is to find a path between nodes

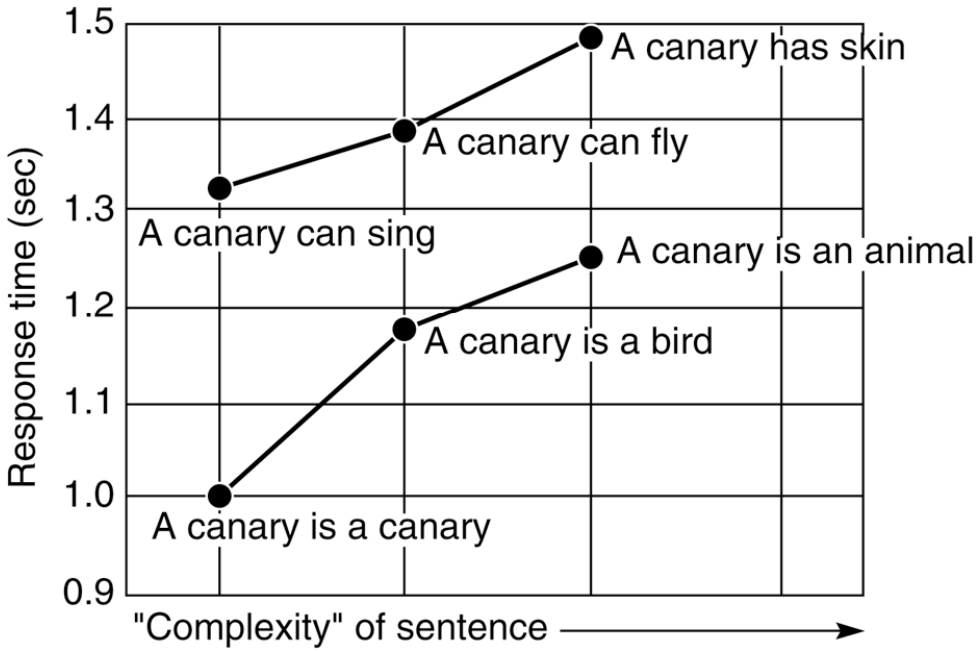


Snowman is made of what?
What is the temperature of snow?
Water forms what?

Semantic net: hierarchy



Psychological experiment shows that our brains organize knowledge hierarchically



Is a canary a bird?
Can it fly?

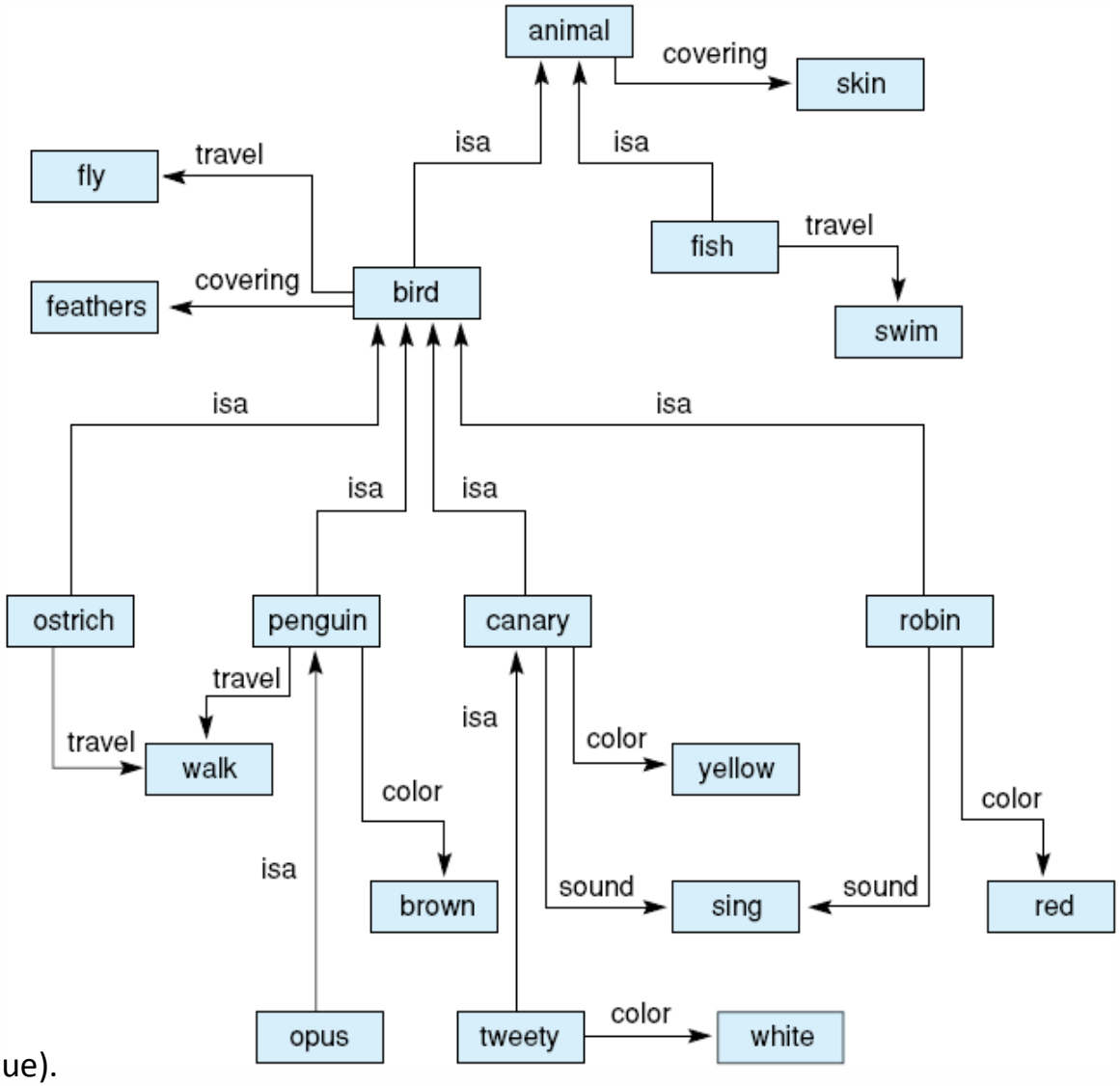
Prolog implementation

```
isa(canary,bird).
isa(ostrich,bird).
isa(bird,animal).
isa(opus,penguin).
isa(robin,bird).
isa(penguin,bird).
isa(fish,animal).
isa(tweety,canary).

hasprop(animal,cover,skin).
hasprop(fish,travel,swim).
hasprop(bird,travel,fly).
hasprop(bird,cover,feathers).
hasprop(ostrich,travel,walk).
hasprop(robin,color,red).
hasprop(penguin,color,brown).
hasprop(penguin,travel,walk).
hasprop(canary,color,yellow).
hasprop(canary,sound,sing).
hasprop(tweety,color,white).

hasproperty(Object,Property,Value) :-
        hasprop(Object,Property,Value).
%Inheritance
hasproperty(Object,Property,Value) :-
        isa(Object,Parent),
        hasproperty(Parent,Property,Value).
```

```
?- hasproperty(penguin,cover,X).
X = feathers ;
X = skin ;
No
```



Inferences in semantic networks

- Inference along associational links
- Find relationships between pairs of words
  - What is the **uniform color** of **Brooklyn Doger** team?
- Search graphs outward from each word in a breath-first fashion
- Search for a common concept or intersection node
- The path between the two given words passing by this intersection node is the relationship being looked for

Representing Nonbinary Predicates

- **Unary Predicates** can be rewritten as binary ones.

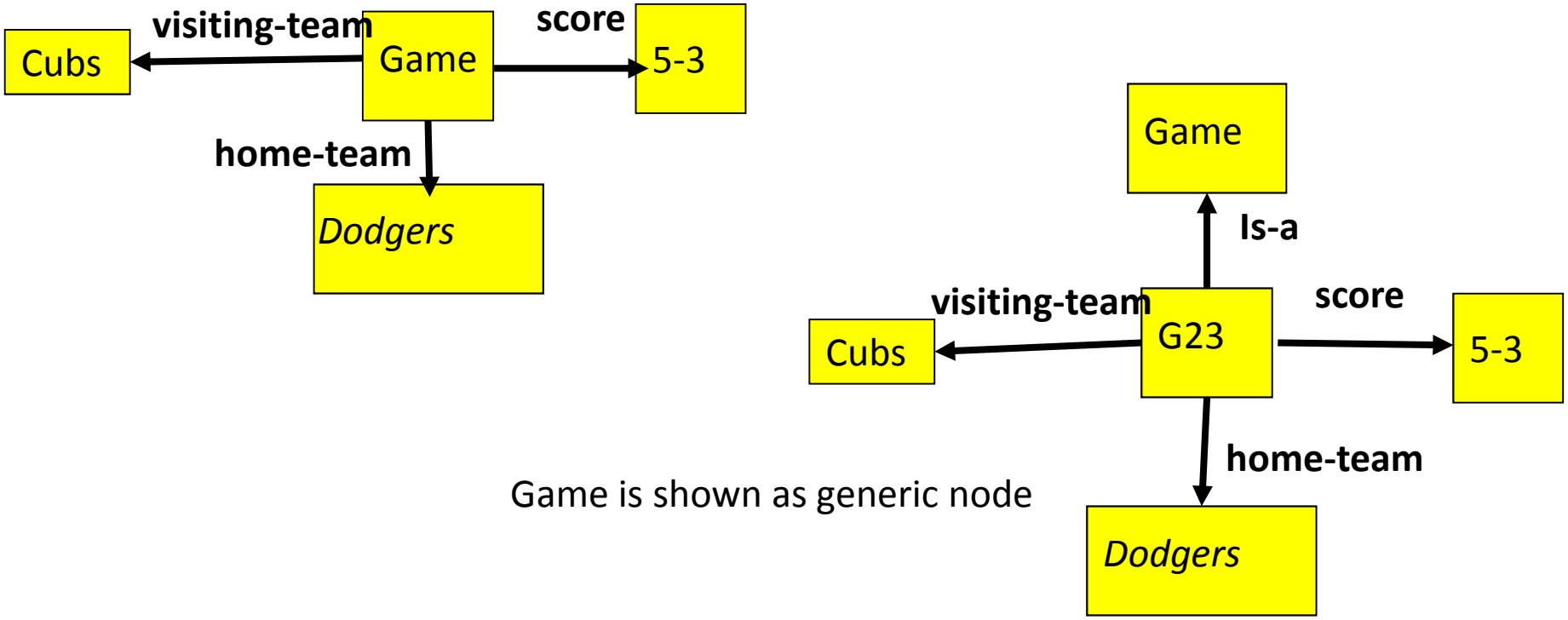
man(*Marcus*)

could be rewritten as

instance(Marcus,Man)

Representing Nonbinary Predicates cont.

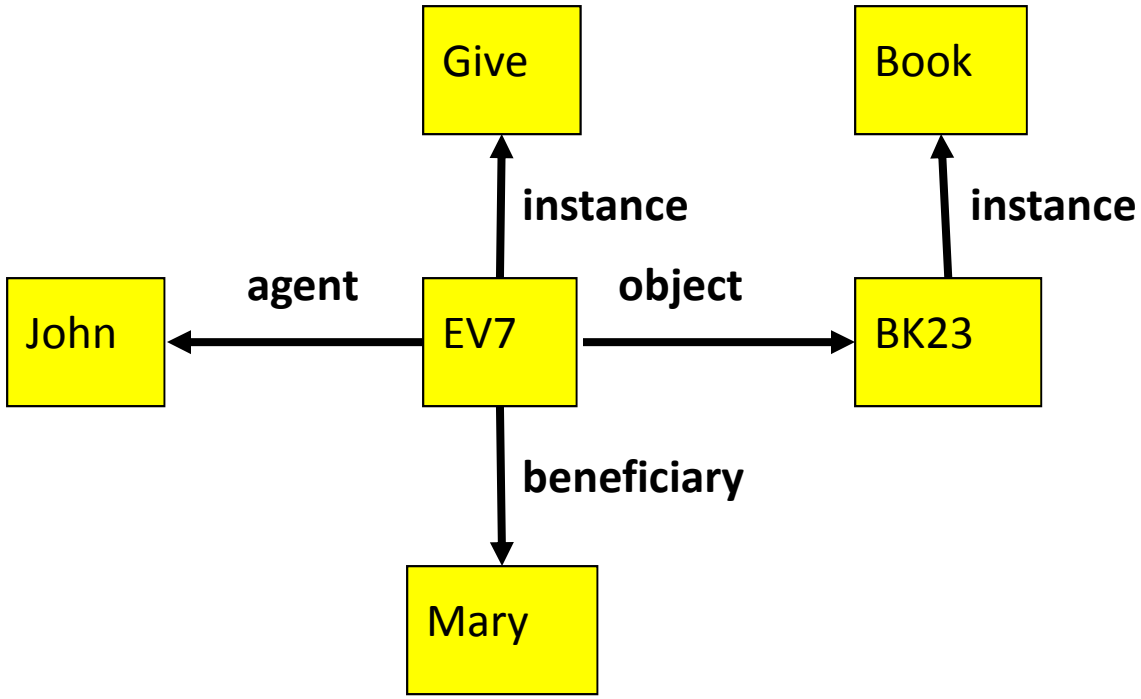
- N-Place Predicates *score(Cubs,Dodgers,5-3)*becomes



Game is shown as generic node

A Semantic Net Representing a Sentence

"John gave the book to Mary."

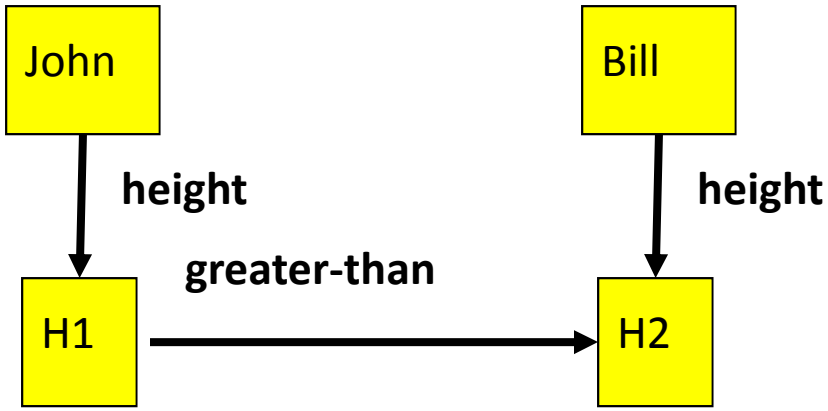


Some Important Distinctions

First try:

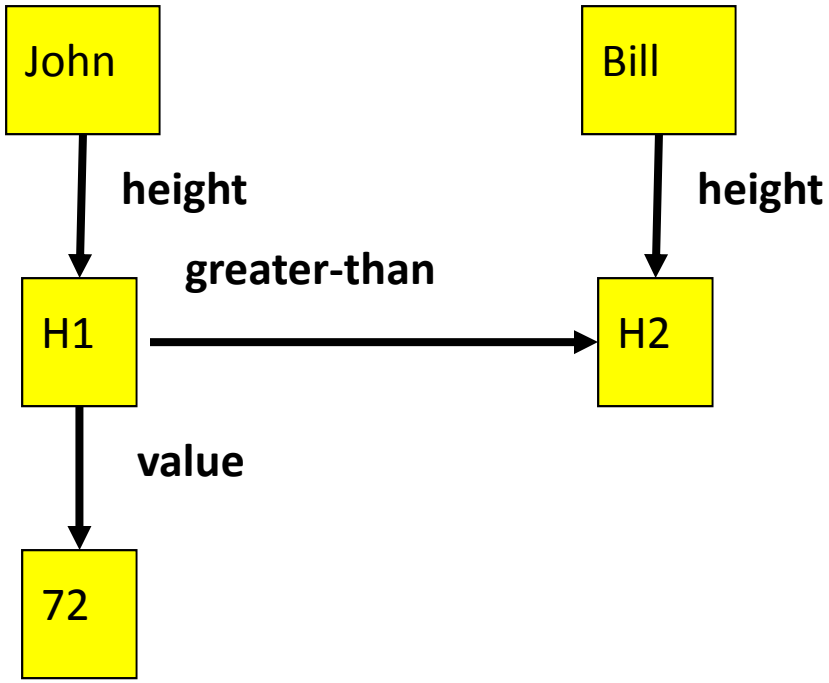
John is tall

Second try: John is taller than Bill



Some Important Distinctions cont.

Third try:

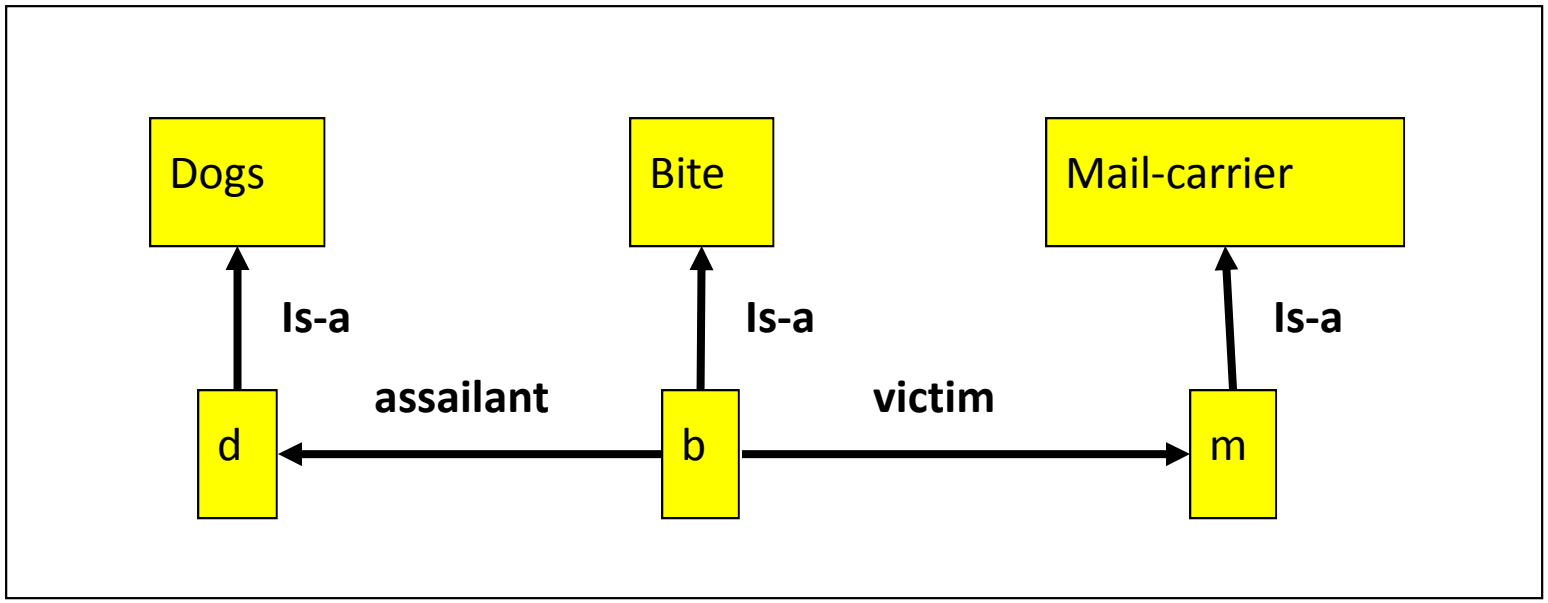


Partition Semantic Net

- Can represent simple quantified expression
- By partitioning semantic net into set of spaces
- Each of these spaces correspond to scope of one or more variables
- Eg All dog bit a mail carrier

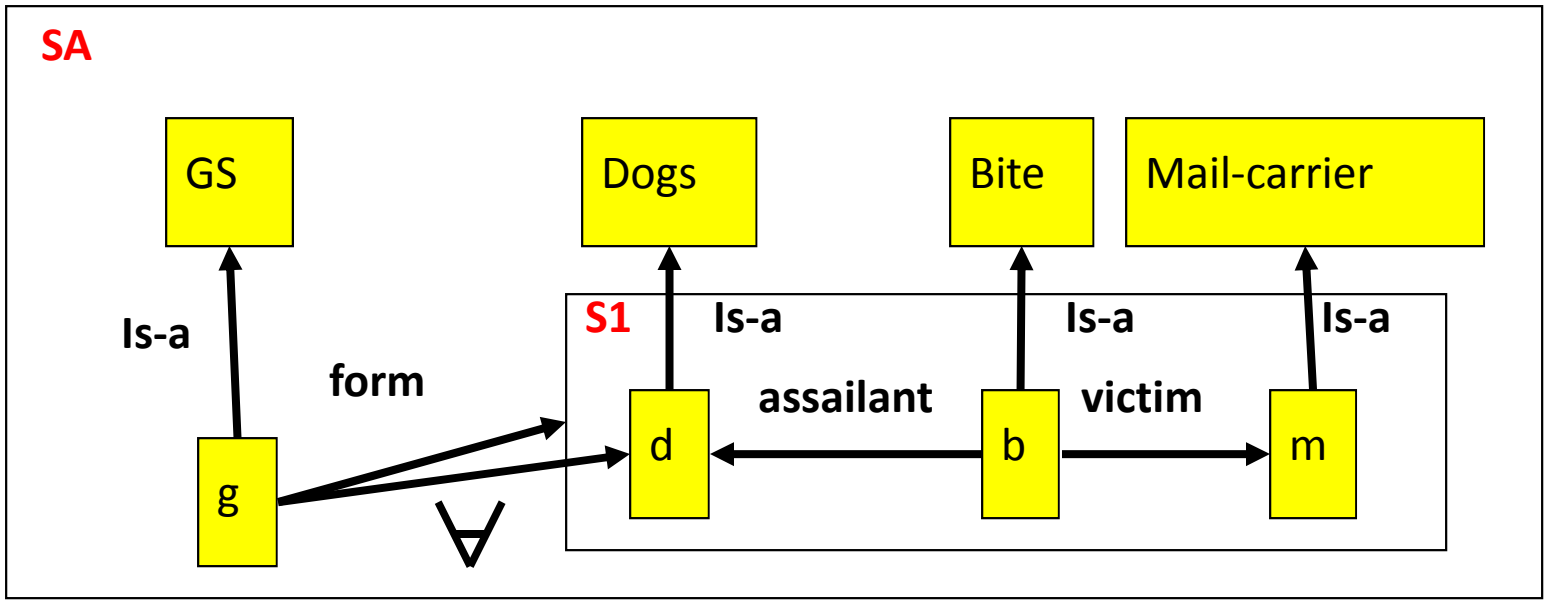
Partitioned Semantic Nets

a) The dog bit the mail carrier.



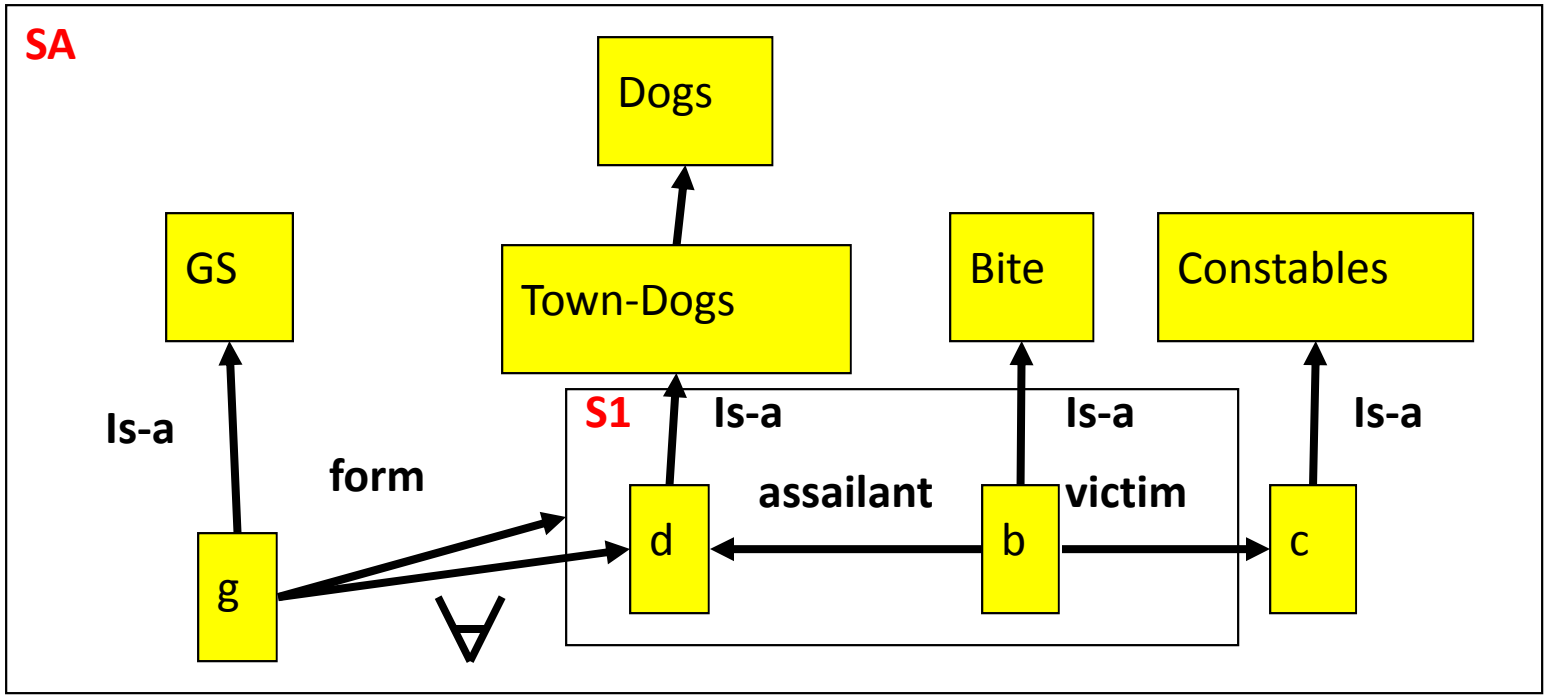
Partitioned Semantic Nets cont.

b) Every dog has bitten a mail carrier.



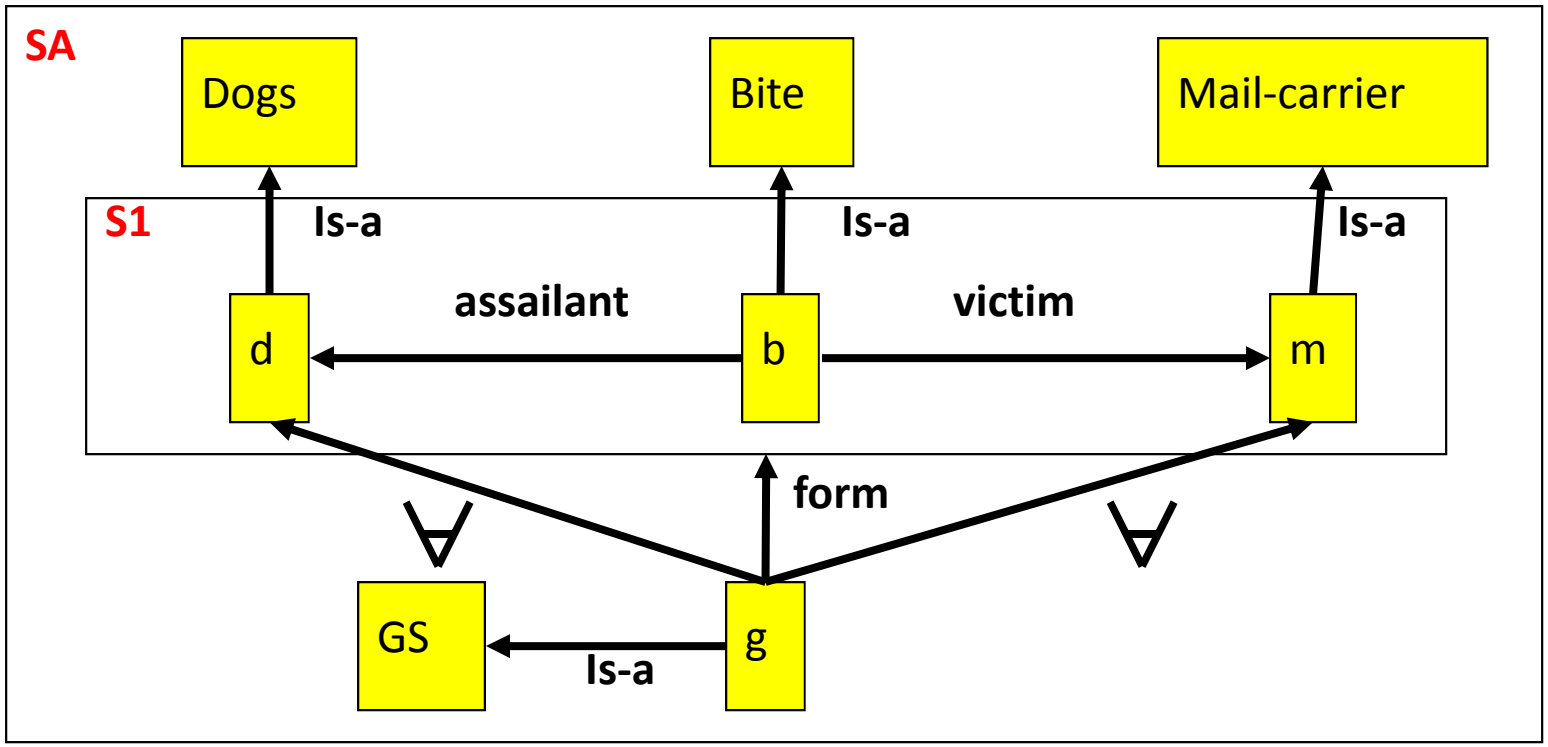
Partitioned Semantic Nets cont.

c) Every dog in town has bitten the constable.



Partitioned Semantic Nets cont.

d) Every dog has bitten every mail carrier.



Partitioned Semantic Net

- Spaces of partition Semantic Net are related to each other by inclusion hierarchy
- Space S1 is included in SA
- Whenever search operated on PSN
  - It can explore node and arcs in the space from which it starts
  - And in other space which contain starting point
  - Cannot move downward
    - Exceptional case : form arc

Advantage of semantic net

- Semantic net is useful to capture meanings of words and concepts in a graphical form, hence easy to understand
- Hierarchical concept are captured in a way that are similar to human way of capturing information
- Allows inheritance and instance representation
- Reasoning or inferencing is done by traversing the net
- Can be converted into logic
- Allows variables, quantifiers

Disadvantage

- No standardization and formalization as far as notation and reasoning are concerned , but overall concept of arcs and nodes in semantic network has been standardized
- Inheritance from multiple objects not possible
- Gets large with complex representation for all and there exist
- Simple SN cannot represent clausal form of logic
  - Example: *John gives apples to everyone he likes*
  - Like(John,X) → give (John,apple,X)
  - Such information where one clause is due to other cannot be presented in simple SN
  - Extended semantic network (ESNet) solves this problem

Frames

- Idea of semantic net started out simply as a way to represent labeled connection among entities
- As range of problems_solving task are expanded , representation becomes more complex in semantic network
- It becomes more useful to assign more structures to nodes and links
- Structured slot and filler representation - Frame

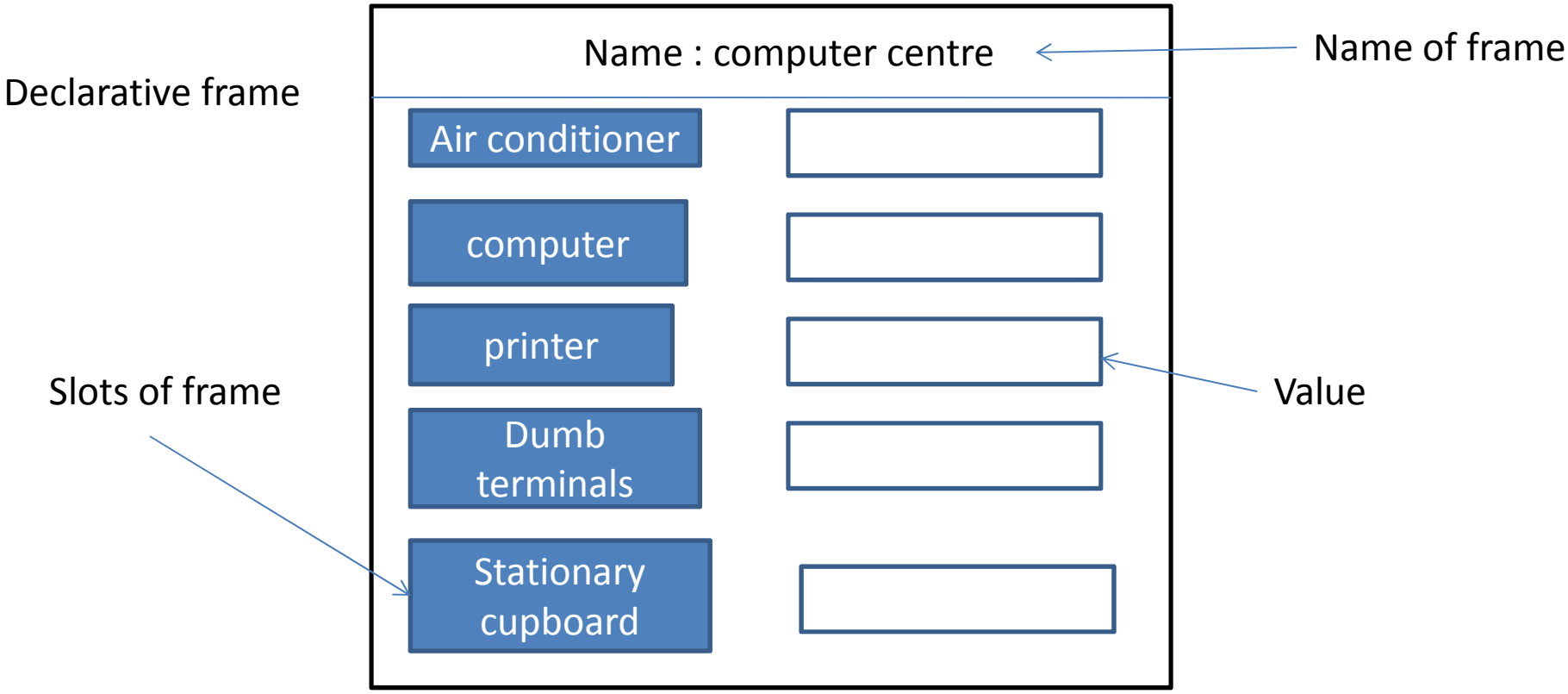
Frames

- Means of representing common sense knowledge
- Knowledge is organized into small “packets” called frame (Minsky)
- Contents of frame are certain **slots** which have **values**
- Example: A computer center in campus which may include
  - Computers, printers,AC,UPS,Cuboard
- When we visit another computer centre , we remove some item and add other

Frames

- A frame is collection of attributes called **slots** and associated **values** that describe some entity in the world
- Entity may represent physical or abstract object.
- It is a data structure that has slots for various objects and a collection of frames consists of expectations for a given situation
- It provides facility for describing objects , facts and procedure
- It represent two types of knowledge
  - Declarative knowledge
  - Procedural knowledge

Example



A sample frame of computer system

Types of frames

- **Declarative frame** : A frame that contains description about objects is called declarative or factual frame. Example : computer centre

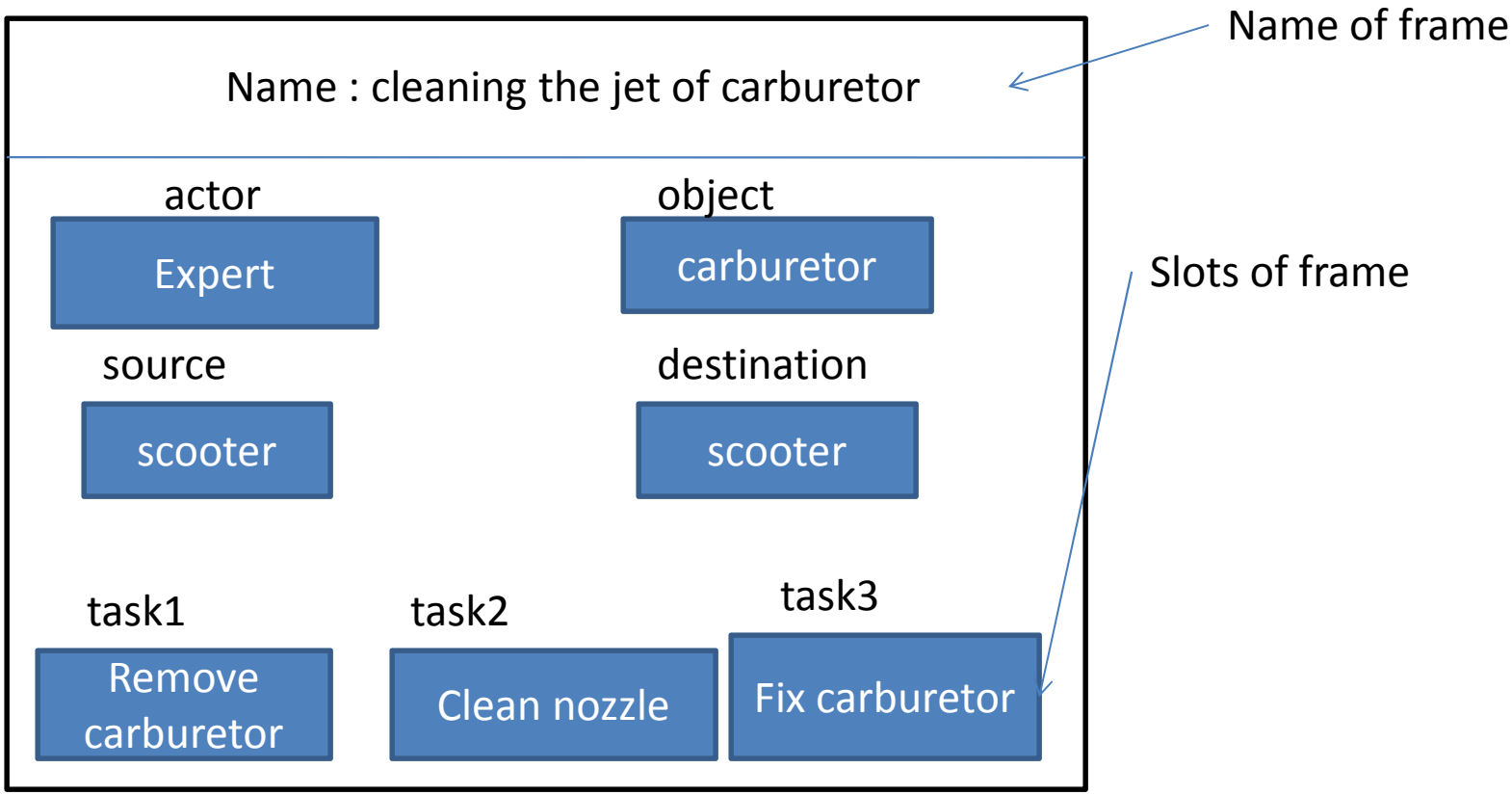
- **Procedural frame** When slots in frame describe how to perform task them such slots are procedural and are called procedural frame

- Such frames in which procedural knowledge is embedded is also called action-procedure frame

Action-procedure frame

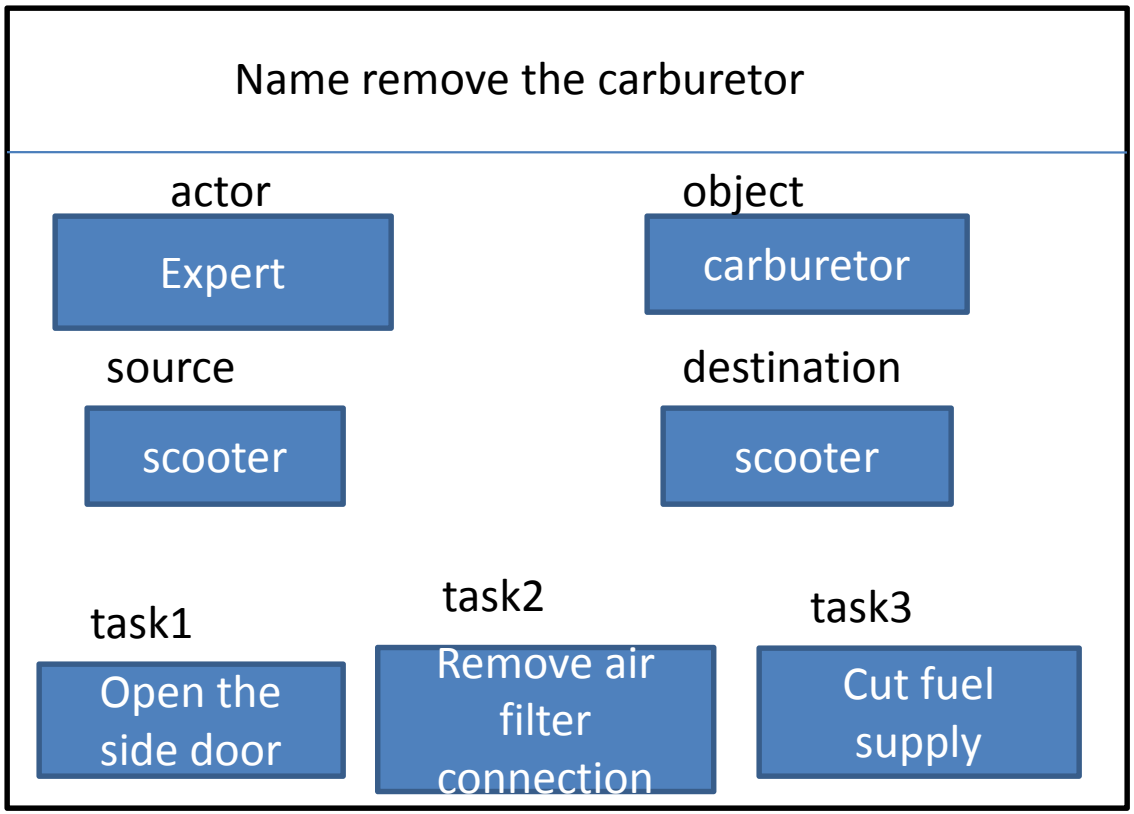
- Action procedure frame have following slots:
  - **Actor slots** : hold information about who is performing the job
  - **Object slots**: it has information about the item to be operated upon
  - **Source slots**: holds information from where the action has to begin
  - **Destination slots**: hold information about place where action has to end
  - **Task slots**: generates the necessary sub frames required to perform operation

Example of procedural frame



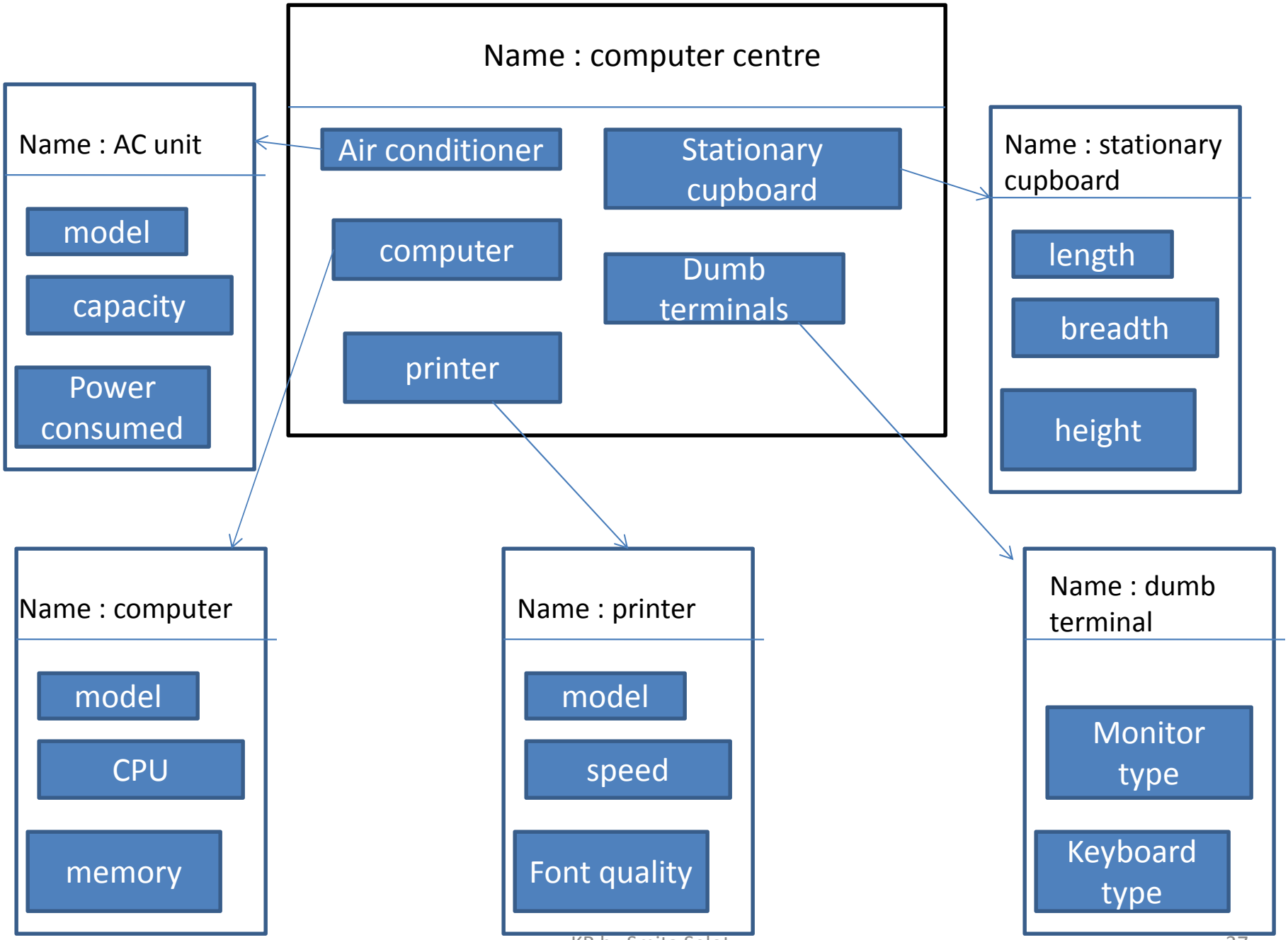
A procedural frame

Example of procedural frame

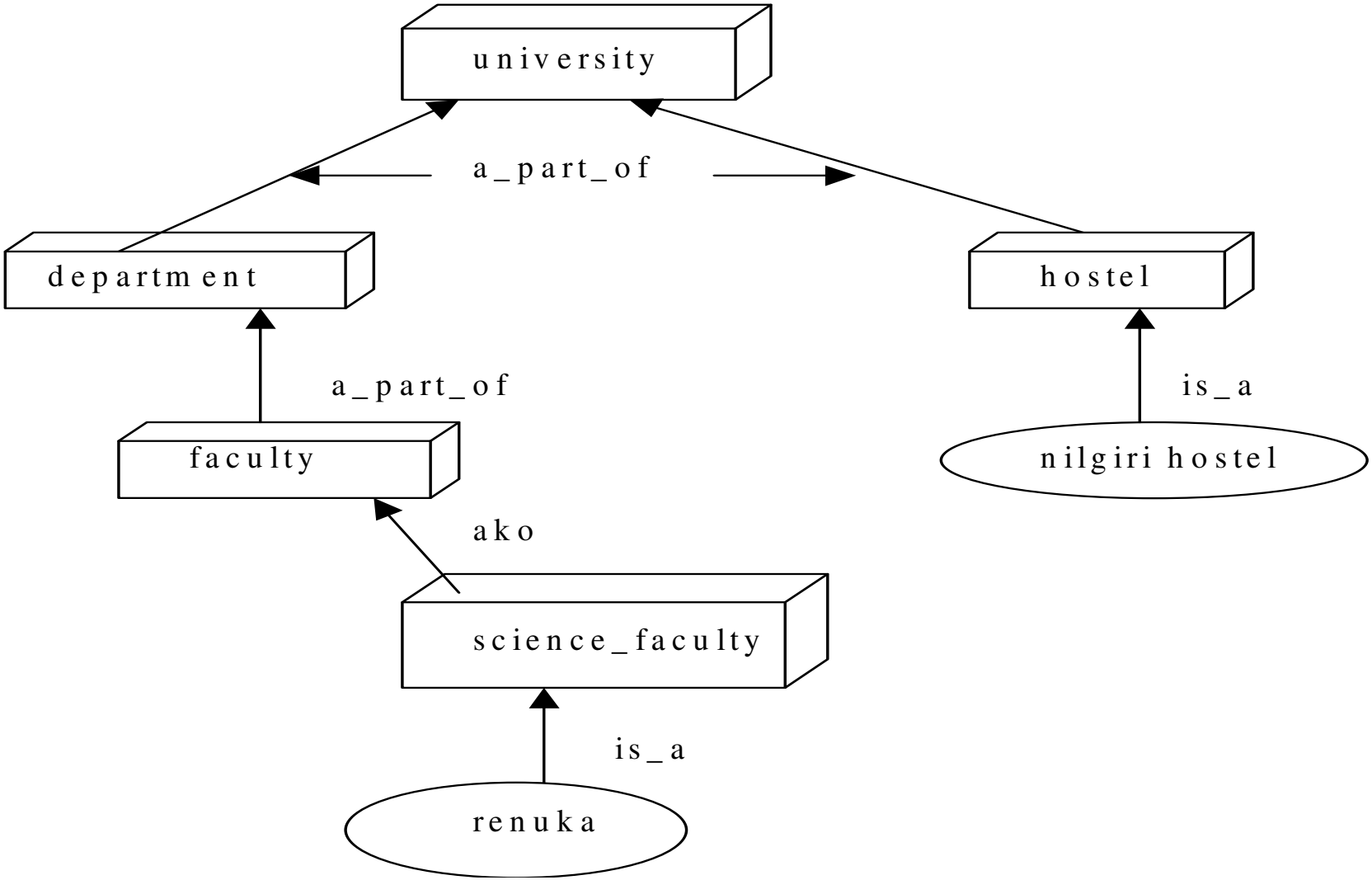


Frames

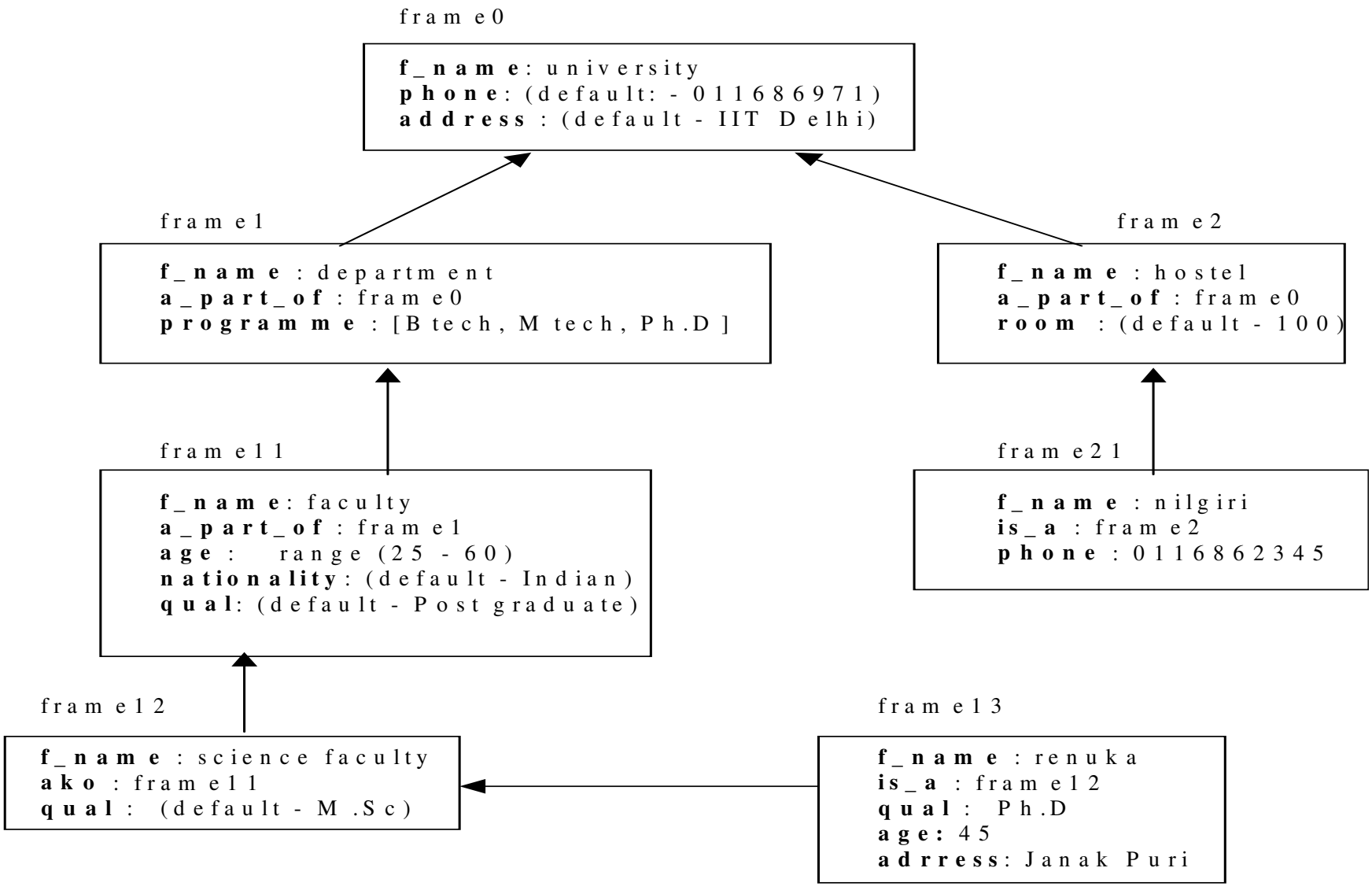
- A single frame taken alone is rarely useful
- Frames system may be built from collections of frames that are connected to each other by virtue of the fact that value of an attribute of one frame may be another frame.
- It helps in breaking problem in sub task which can be described as top-down design
- Frames are linked to one another by following associations
  - Is-a: relating super class and subclass(subset relation)
  - Ako– a kind of
  - A-part-of: shows belonging of one entity in to other


Name : computer centre
Air conditioner
Stationary cupboard
computer
Dumb terminals
printer
Name : AC unit
model
capacity
Power consumed
Name : stationary cupboard
length
breadth
height
Name : computer
model
CPU
memory
Name : printer
model
speed
Font quality
Name : dumb terminal
Monitor type
Keyboard type

Frame Network - Example



Detailed Representation of Frame Network



Frames as set and instances

- Set theory provides good idea for understanding frames
- Each frame represent a set(class) or a instance (element of class)
- Is-a relation is a subset relation
- Instance relation expresses the concept-element-of
- There are two kind of attribute associated with set
  - Attribute about the set itself
  - Attributes that are to be inherited by each element of set (marked by *)

Reasoning using frames

- It is done by instantiation
- Instantiation process begins when one given situation is matched with frames that already exist.
- Once it matches , it then fills ups the slots with values which depict a particular situation and reasoning process tries to move towards the goal
- Reasoning process can be defined as filling frames slots in frame
- If value is not available it uses default value
- If different characteristics is observed values of the corresponding slots are updated

Reasoning

- Reasoning using frames allow moving from one frame to another to match the current situation
- It builds a wide network of frames there by facilitating the building of knowledge base representing knowledge about common sense

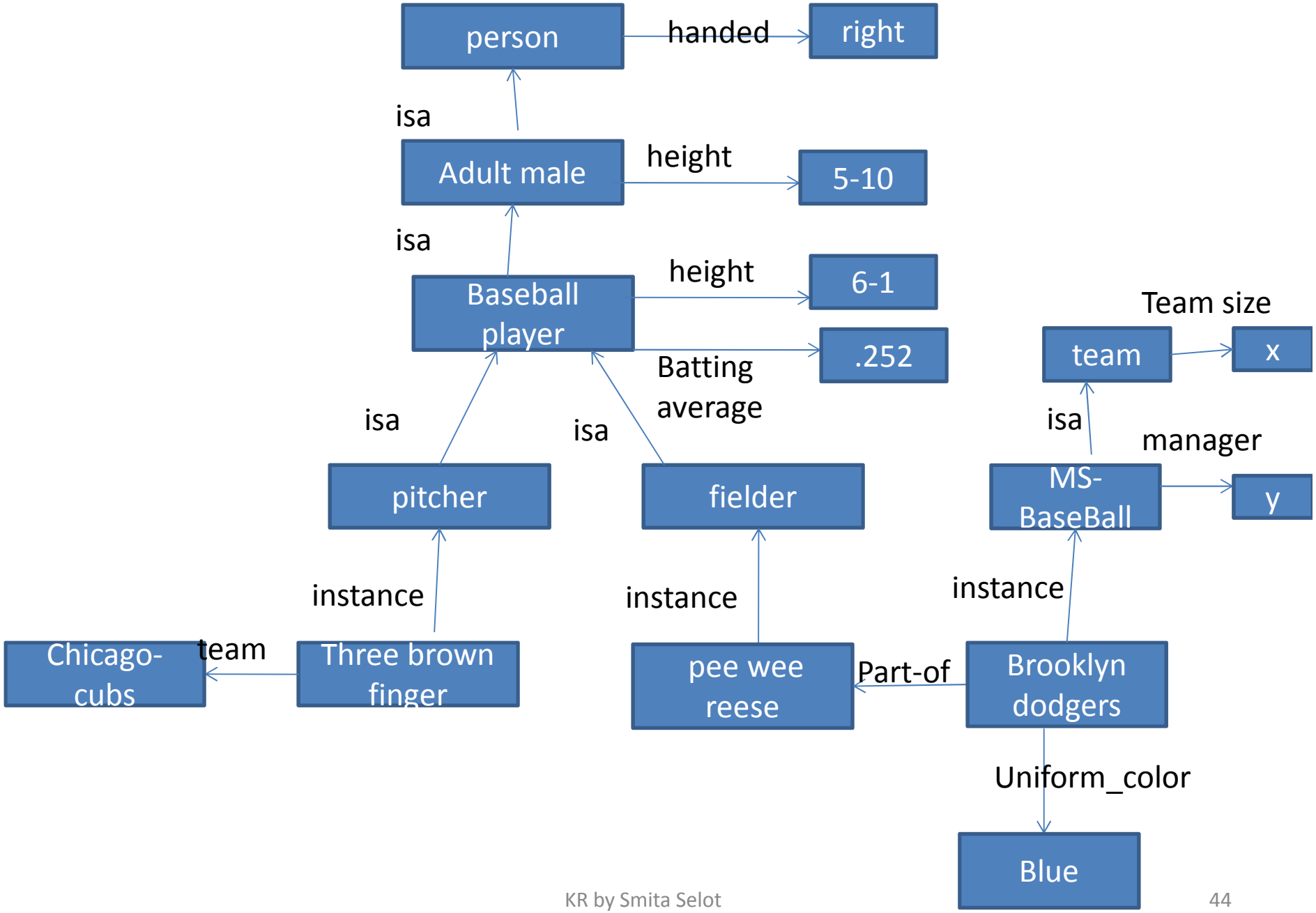
Frames as set and instances

- In this view each frame represent a class (set) or an instance(element of class)
- Isa relation is used as subset
- Instance is used as element-of
- Class represent the set and each set has 2 kinds of attribute
  - One about the set itself
  - Other attributes are to be inherited by each element of set

Frame name: **person**
Is_a: mammal
cardinality:6,000,000,000
*handed : right

Frame Name**: Adult male**
Is_a: person
cardinality:6,000,000,000
*height: 5-10

MS-baseball player
isa: adult male
cardinality: 624
*height : 6-1
*bats : equal to handed
*batting avg: 26.2
*team :
*uniform color:


person
handed
right
isa
Adult male
height
5-10
isa
Baseball player
height
6-1
.252
Batting average
Team size
team
x
isa
manager
MS-BaseBall
y
isa
isa
pitcher
fielder
instance
instance
instance
Chicago-cubs
team
Three brown finger
pee wee reese
Part-of
Brooklyn dodgers
Uniform_color
Blue

Frame based language

- CYC
  - Large knowledge based project aims at capturing common sense knowledge
  - Goal is to represent large body of knowledge which is so obvious
  - It represents the theory of how to describe a world
  - CYC contain representation of event, objects, attributes
  - CYC's knowledge is captured in a representational language called CYCL

Frames

- Advantages
  - Makes programming easier by grouping related knowledge
  - Easily understood by non-developers
  - Expressive power
  - Easy to set up slots for new properties and relations
  - Easy to include default information and detect missing values
- Disadvantages
  - No standards (slot-filler values)
  - More of a general methodology than a specific representation:
  - Frame for a class-room will be different for a professor and for a maintenance worker
  - No associated reasoning/inference mechanisms
  - Multiple inheritance causes entangled hierarchies giving contradictary answers