Semantic Net and Frame

Mohammad Ashraful Islam

Assistant Professor

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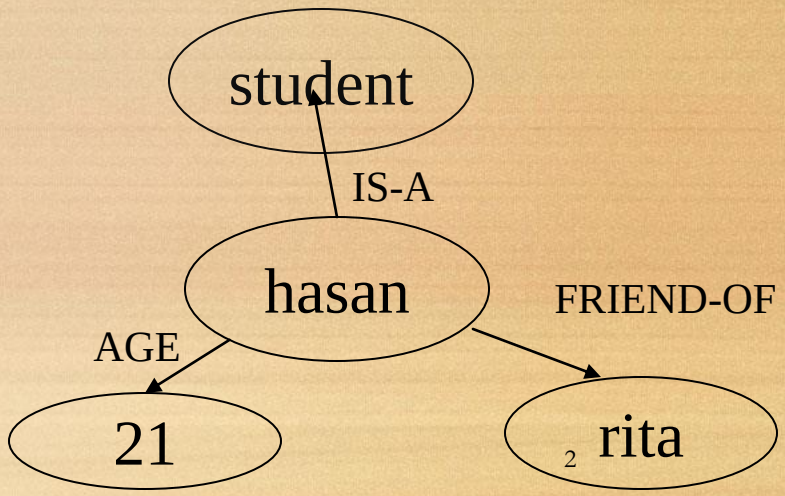
Semantic Net

- An long existing notion: there are different pieces of knowledge of world, and they are all linked together through certain semantics.
- Knowledge is expressed as a collection of concepts, represented by nodes (shown as boxes in the diagram), connected together by relationships, represented by arcs (shown as arrows in the diagram).
- certain arcs - particularly *isa* arcs - allow inheritance of properties.

Basic Components

- Nodes
  - Represent concepts
- Arcs
  - Represent relations
- Labels for nodes and arcs



Semantic Net

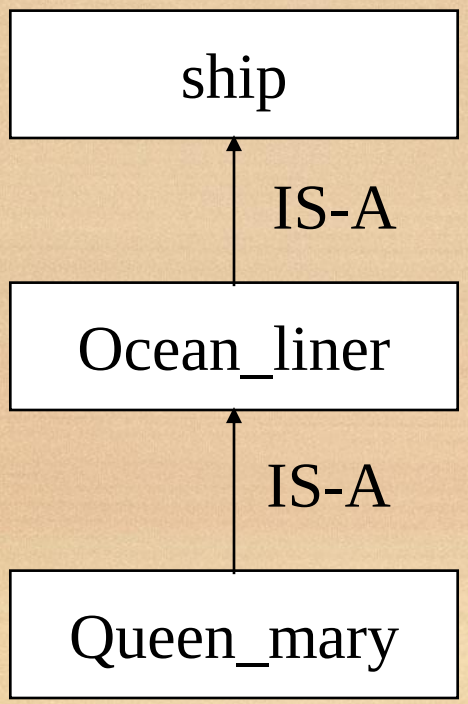
- Common arcs used for representing hierarchies include *isa* and *has-part.*

Example:

The Queen Mary is an ocean liner.

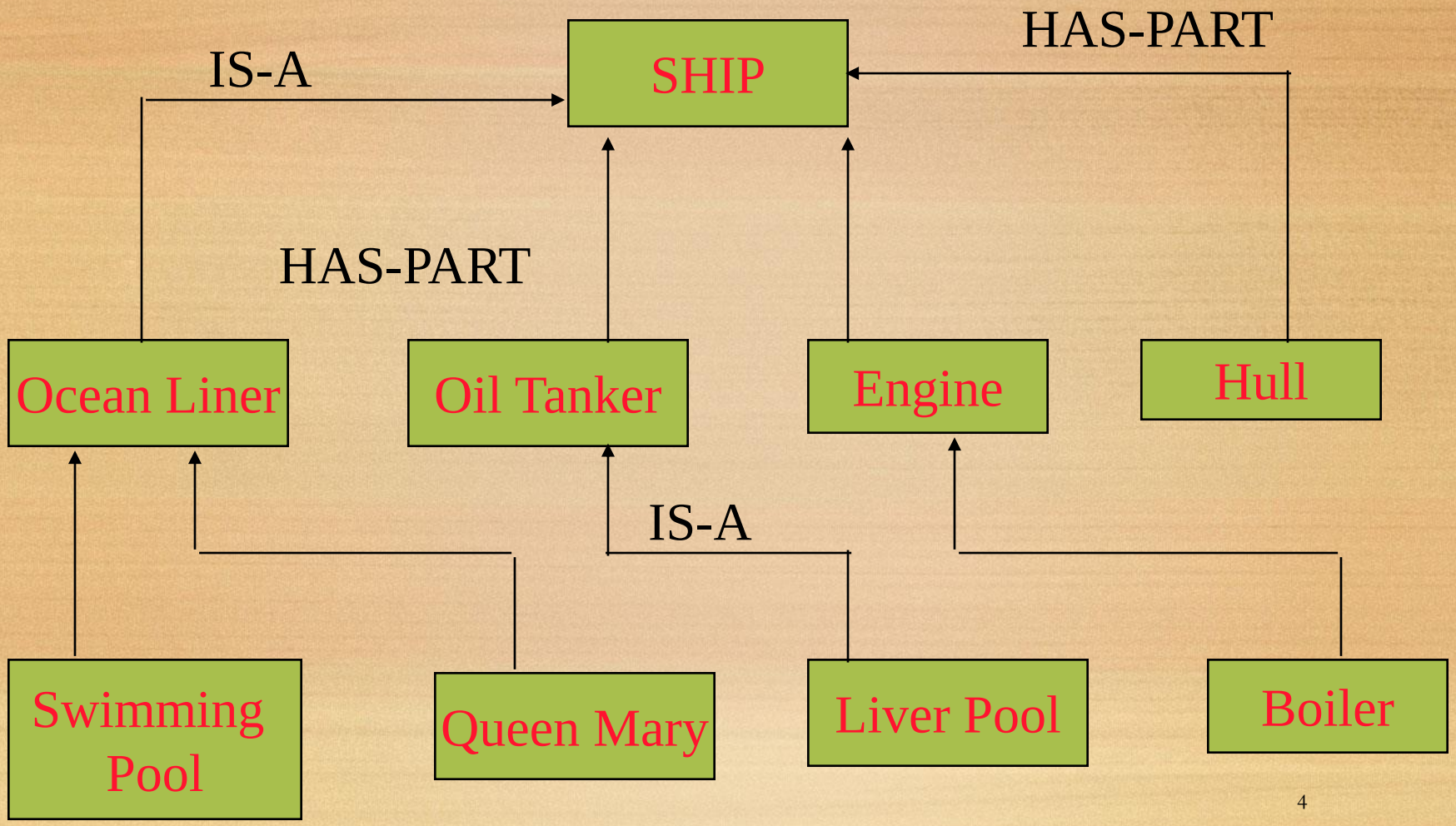
Every ocean liner is a ship

Circle – Physical, Rectangle - Situation & Ellipse - concept



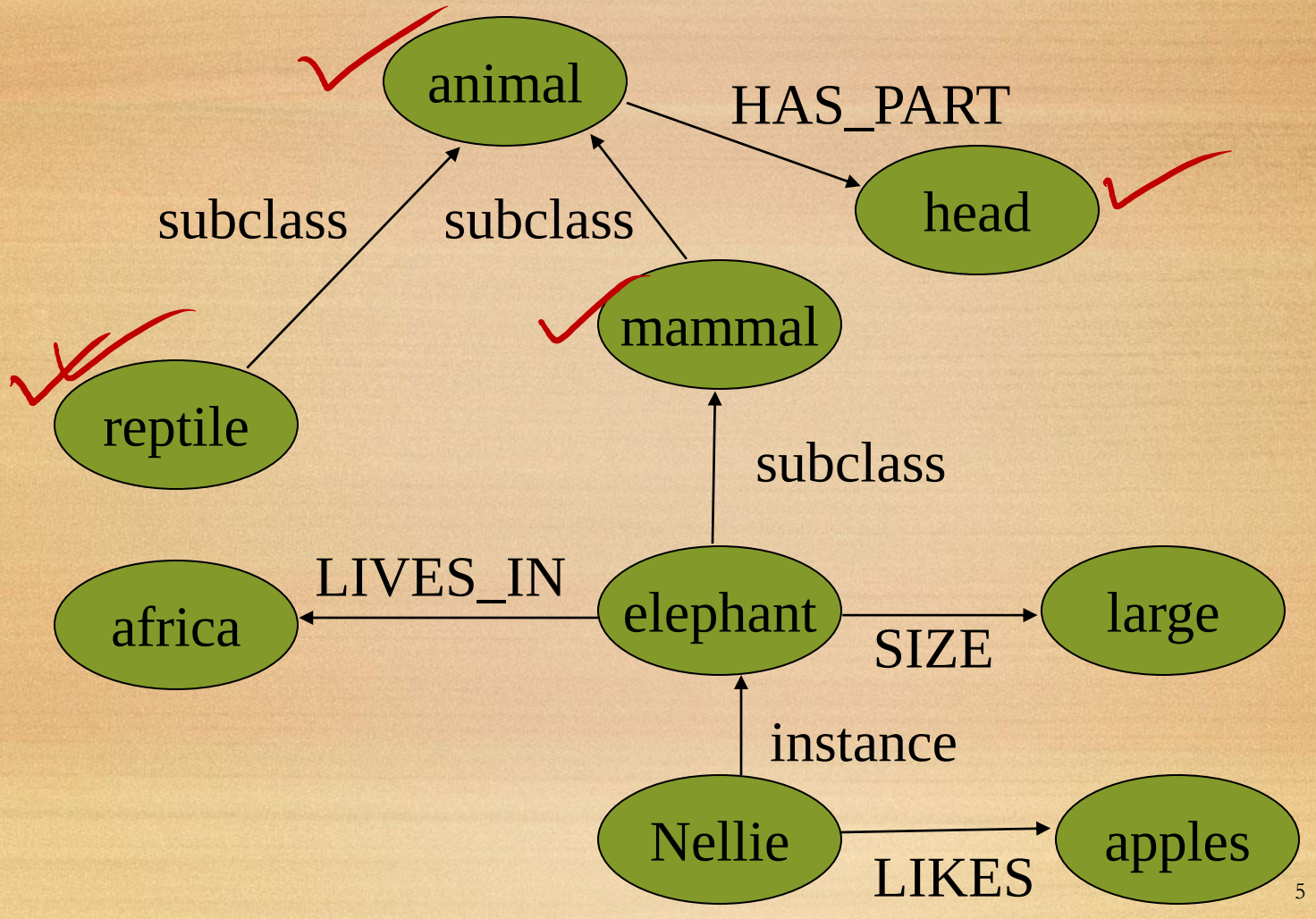
Semantic Net .....

Common arcs used for representing hierarchies include *isa* and *has-part.*



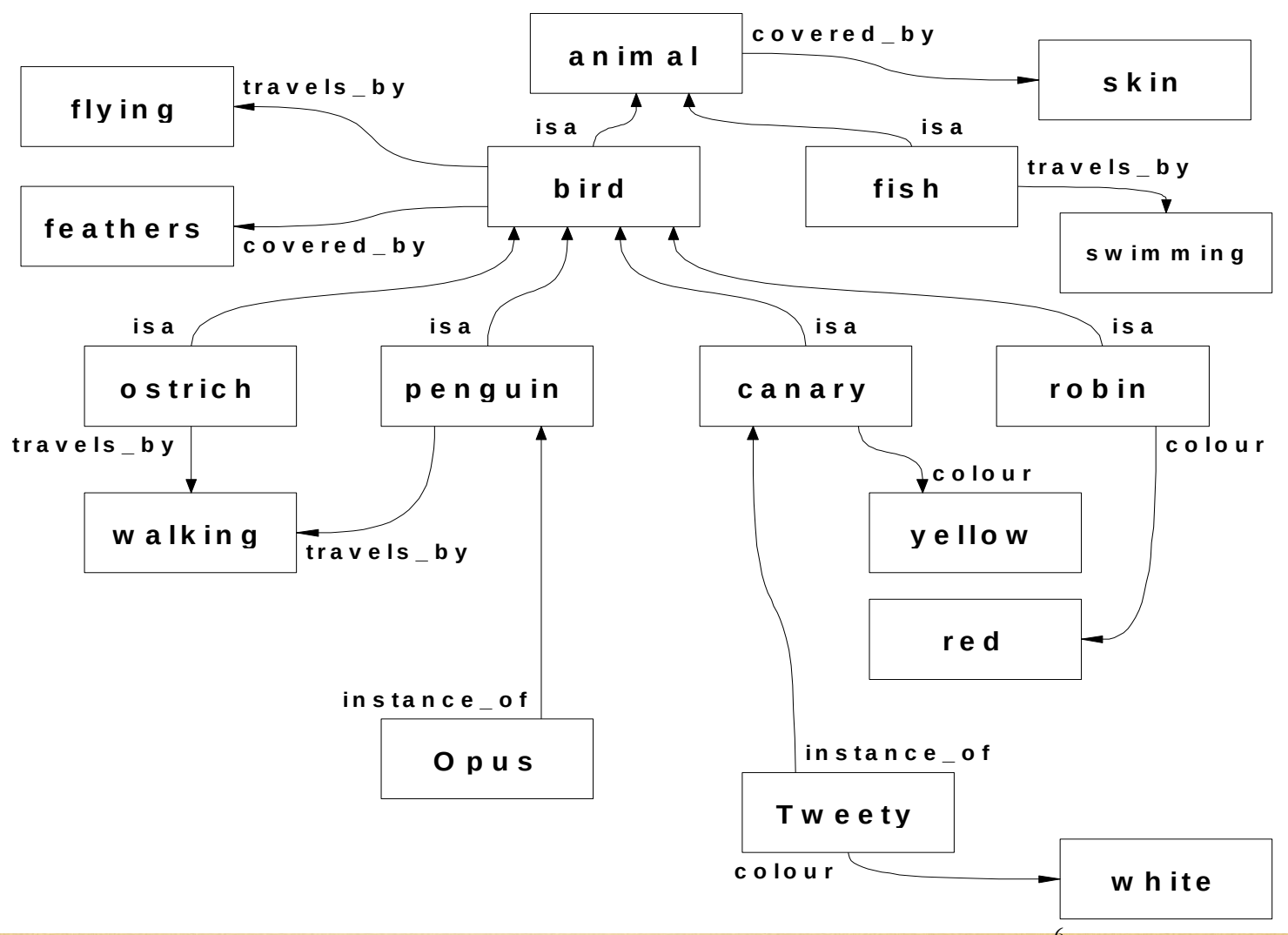
Semantic Networks

Knowledge is represented as a network or *graph*



Knowledge Representation: Semantic Net

An long existing notion: there are different pieces of knowledge of world, and they are all linked together through certain semantics.



Knowledge Representation: Semantic Net

- Developments of the semantic nets idea:
  - psychological research into whether human memory really was organised in this way.
  - used in the knowledge bases in certain expert systems: e.g. PROSPECTOR.
    - **Prospector:** U.S. Geological Survey to aid geologists in mineral exploration. The system, one of the world's first computer-based expert systems, attempted to represent the knowledge and reasoning process of geological experts.
  - special-purpose languages have been written to express knowledge in semantic nets.

Organization of Knowledge

- By traversing network we can find:
  - That Nellie has a head (by inheritance)
  - That certain concepts related in certain ways (e.g., apples and elephants).
- BUT: Meaning of semantic networks was not always well defined.
  - Are all Elephants big, or just typical elephants?
  - Do all Elephants live in the “same” Africa?
  - Do all animals have the same head?
- For machine processing these things must be defined.

Major Limitations

- **Lack of Semantics**
  - No formal semantic of the relations
    - E.g. Does “ISA” mean subclass, member, etc?
  - Possible multiple interpretations
  - Restricted expressiveness
    - E.g. can not distinguish between instance and class
- **Advantages:**
    - Easy to follow hierarchy, easy to trace association, flexible
- **Disadvantages:**
    - Meaning attached to nodes might be ambiguous
    - exception handling is difficult
    - difficult to program

Semantic Nets …

- Problems with semantic nets
  - **logical inadequacy -** vagueness about what types and tokens really mean.
  - **heuristic inadequacy** – finding a specific piece of information could be chronically inefficient.
  - trying to establish negation is likely to lead to a combinatorial explosion.
  - "spreading activation" search is very inefficient, because it is not knowledge-guided.

Frames

- Devised by Marvin Minsky, 1975.
- Incorporates certain valuable human thinking characteristics:
  - Expectations, assumptions, stereotypes. Exceptions. Fuzzy boundaries between classes.
- The essence of this form of knowledge representation is typicality, with exceptions, rather than definition.
- a data structure for representing a stereotyped situation
- a network of nodes and relations organized in a hierarchy
- the topmost nodes - general concepts
- the lower nodes - more specific instances

- The idea of frame hierarchies is very similar to the idea of class hierarchies found in object-orientated programming.

How Frames are Organized

- A frame system is a hierarchy of frames
- Each frame has:
  - a name.
  - slots: these are the properties of the entity that has the name, and they have values. A particular value may be:
    - a default value
    - an inherited value from a higher frame
    - a procedure, called a demon, to find a value
- In the higher levels of the frame hierarchy, typical knowledge about the class is stored.
  - The value in a slot may be a range or a condition.
- In the lower levels, the value in a slot may be a specific value, to overwrite the value which would otherwise be inherited from a higher frame.

Frames … …

- An instance of an object is joined to its class by an 'instance_of' relationship.
- A class is joined to its superclass by a 'subclass_of' relationship.
- Frames may contain both procedural and declarative knowledge.
  - Slot values normally amount to declarative knowledge, but a daemon is in effect a small program. So a slot with a daemon in it amounts to procedural knowledge.

- Note that a frames system may allow multiple inheritance but, if it does so, it must make provision for cases when inherited values conflict.

Frames …

- **Advantages:**
  - Expressive power, easy to set up slots for new properties and relations
  - easy to create specialized procedures
  - easy to include default information and detect missing values
- **Disadvantages:**
  - Difficult to program
  - difficult for inference

A car has 4 wheels, is moved by an engine, and runs on petrol or diesel.

We can now add three slots to the frame.
The last of these has a restriction rather than a specific value.

Name: car	Subclass of: thing	
	Slots:	
Name:	Value:	Restrictions:
wheels	4	
moved by	engine	
fuel	?	petrol or diesel

```
car subclass_of
                    thing
with
   wheels: 4,
   moved_by:
engine,
   fuel:
      [value:
            unknown,
       type:
      [petrol,diesel]].
```

"There is a particular type of car called Toyota, manufactured in Japan."

- We can add a second frame to our system, with one slot. We don't need to repeat the slots and values in the previous frame: they will be inherited.

Name: Toyota	Subclass of: car	
Slots:		
Name:	Value:	Restrictions:
made in	Japan	

'Toyota'
subclass_of
car
with
made_in:
'Japan'.

"There is a particular type of Golf called a TDi, which runs on diesel , has 4 cylinders, and has a 1.8 litre engine."

Name: TDi Subclass of: Golf

Slots:

Name:	Value:	Restrictions:
Fuel	diesel	
Cylinder	4	
Engine	1.8	

"There is a particular type of Golf called a TDi, which runs on diesel, has 4 cylinders, and has a 1.8 litre engine."

Name: TDi	Subclass of: Golf	
Slots:		
Name:	Value:	Restrictions:
fuel	diesel	
engine capacity	1.8 litres	
cylinders	4	

'TDi' subclass_of 'Golf'
with
fuel: diesel,
engine_capacity: 1.8,
cylinders: 4.

Semantic Networks and Logic

- How do we precisely define the semantics of a frame system or semantic network?
- Modern trend is to have special knowledge representation languages which look a bit like frames to users, but which:
  - use logic to define what relations mean
  - don't provide the full power of predicate logic, but a subset that allows efficient inference. (May not want more than inheritance).

Summary

- Predicate logic provides well defined language for knowledge representation supporting inference.
- Semantic nets, frames and objects all allow you to define relations between objects, including class relations (X isa Y).
- Only restricted inference supported by the methods - that based on *inheritance.*
- *So.. Jimy is a dog, dogs have 4 legs, so Jimy has 4 legs.*
- Frames/Networks/Objects more natural, but only explicitly support inheritance, and may not have well defined semantics.
- Current trend is either to just use OO, or to use logic, but specialises non-logic-based languages still exist.

Exercise

- Represent the following knowledge in Semantic net and Frame:

The aorta is a particular kind of artery which has a diameter of 2.5cm. An artery is a kind of blood vessel. An artery always has a muscular wall, and generally has a diameter of 0.4cm. A vein is a kind of blood vessel, but has a fibrous wall. Blood vessels all have tubular form and contain blood.

Name: car	Subclass of: thing	
Slots:		
Name:	Value:	Restrictions:
wheels	4	
moved by	engine	
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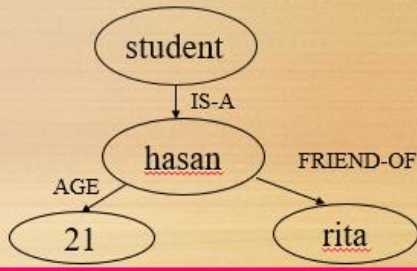

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Thank you