Artificial Intelligence

Knowledge Representation

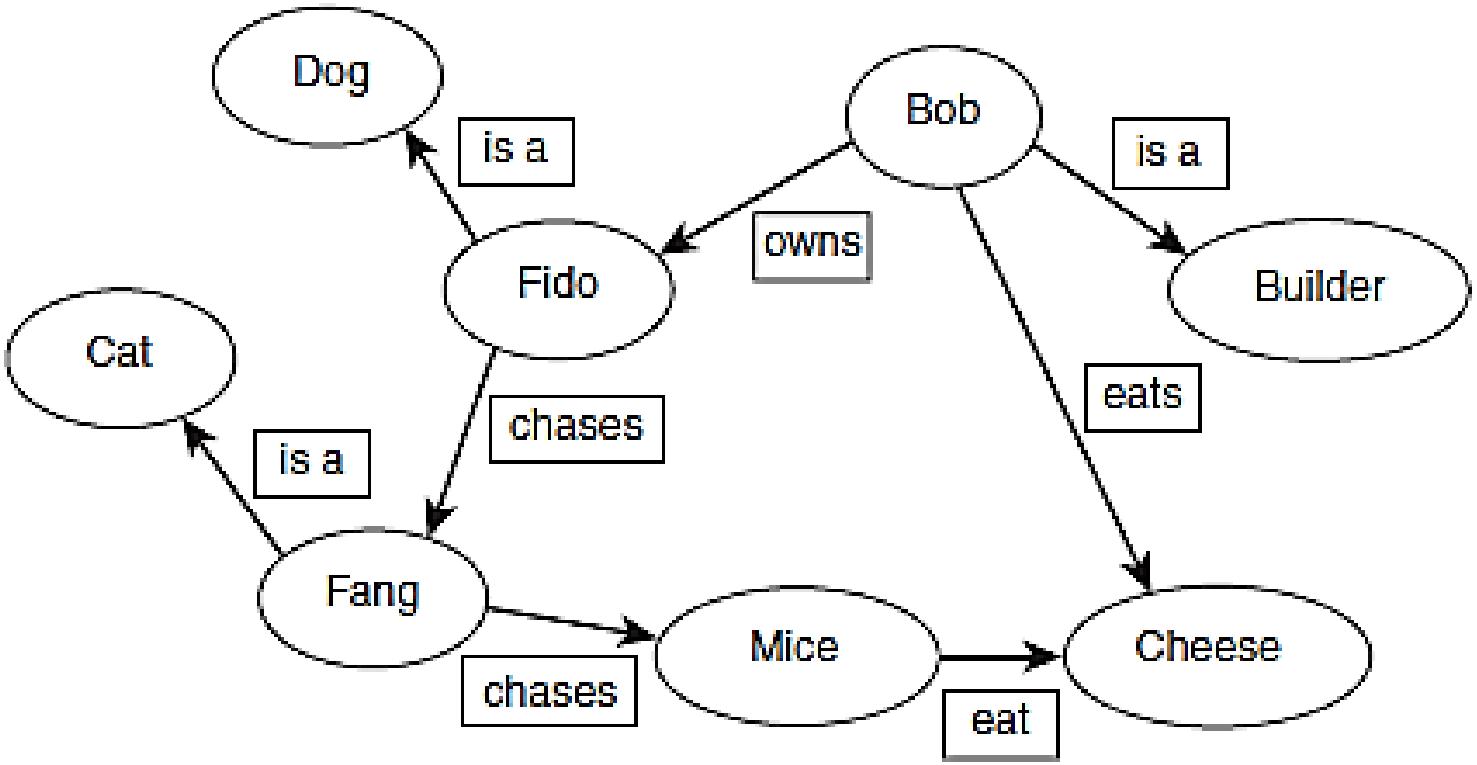
The Need for a Good Representation

- A computer needs a representation of a problem in order to solve it.
- A representation must be:
  - **Efficient** – not wasteful in time or resources.
  - **Useful** – allows the computer to solve the problem.
  - **Meaningful** – really relates to the problem.

Semantic Nets

- The semantic net is a commonly used representation in Artificial Intelligence.
- A semantic net is a **graph** consisting of **nodes** that are connected by **edges**.
- The nodes represent objects, and the links (**edges**) between nodes represent relationships between those objects.
- The links are usually labeled to indicate the nature of the relationship.

A simple example of a semantic net

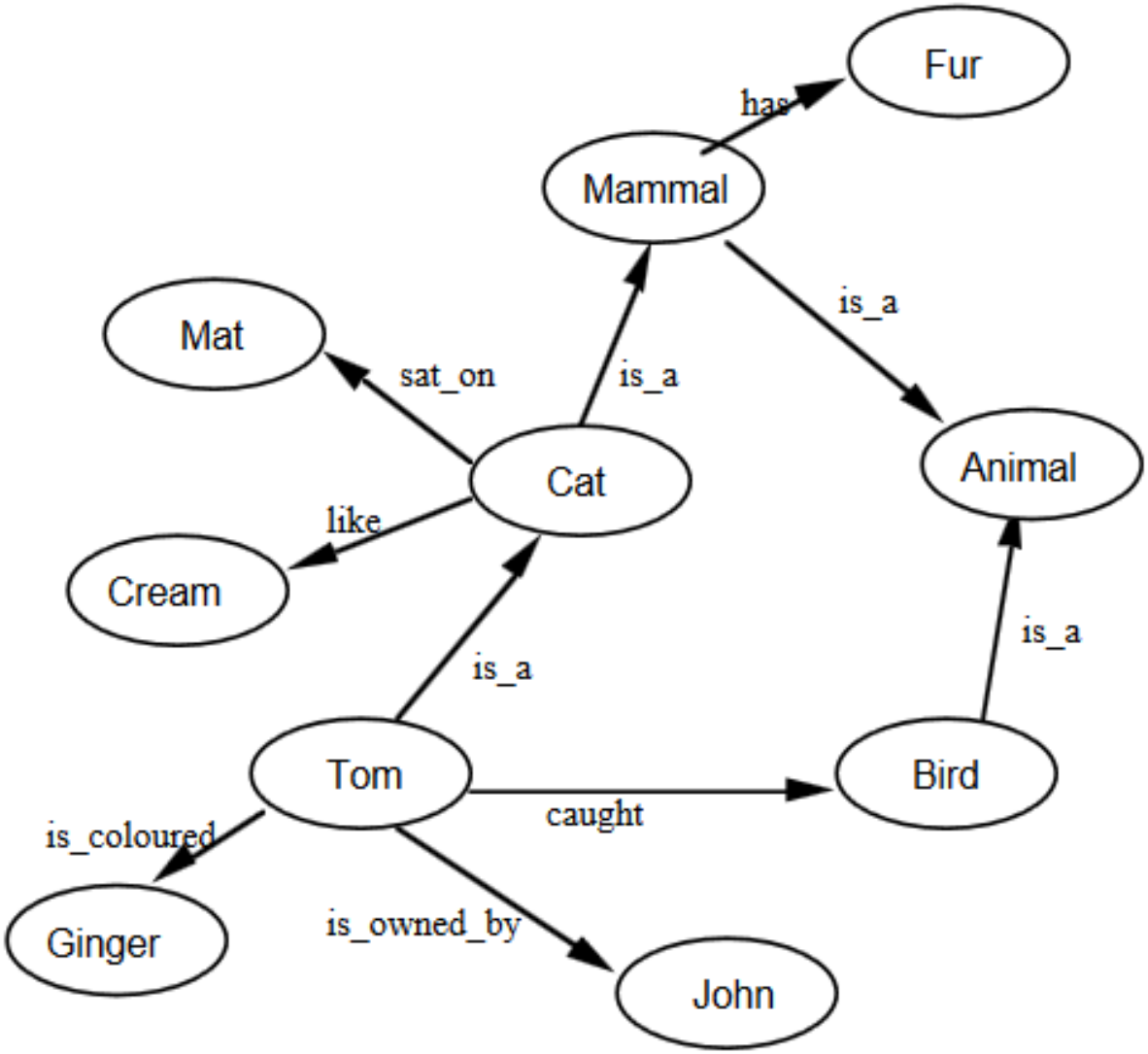


**Semantic networks are an alternative to predicate logic as a form of knowledge representation. The idea is that we can store our knowledge in the form of a graph

Task #1

- Tom is a cat.
- Tom caught a bird.
- Tom is owned by John.
- Tom is ginger in color.
- Cats like cream.
- The cat sat on the mat.
- A cat is a mammal.
- A bird is an animal.
- All mammals are animals.
- Mammals have fur.

Solution

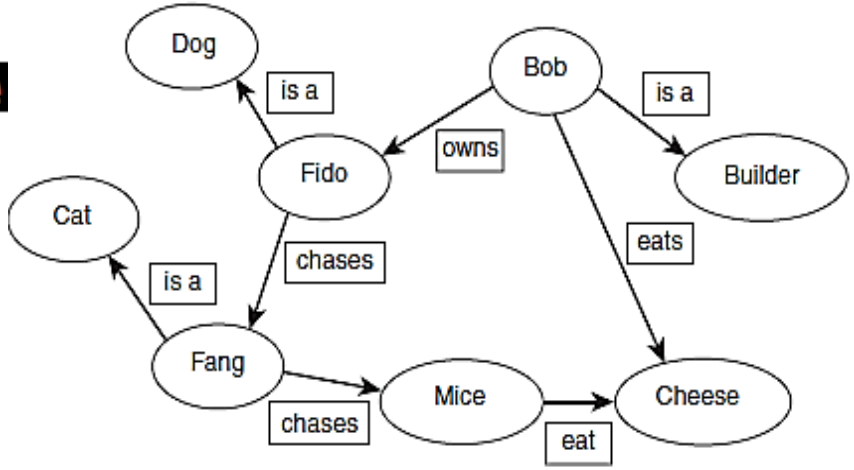

Fur
has
Mammal
is_a
Mat
sat_on
is_a
Cat
Animal
like
Cream
is_a
is_a
Tom
Bird
caught
is_coloured
Ginger
is_owned_by
John

Frames

- A frame system consists of a number of frames, connected by edges, like a semantic net.
- Class frames describe classes.
- Instance frames describe instances.
- Each frame has a number of slots.
- Each slot can be assigned a slot value.

the semantic net might be represented by the following frames:

Frame Name	Slot	Slot Value
Bob	is a	Builder
	owns	Fido
	eats	Cheese
Fido	is a	Dog
	chases	Fang
Fang	is a	Cat
	chases	Mice
Mice	eat	Cheese
Cheese		
Builder		
Dog		
Cat		



Frames: A Simple Example

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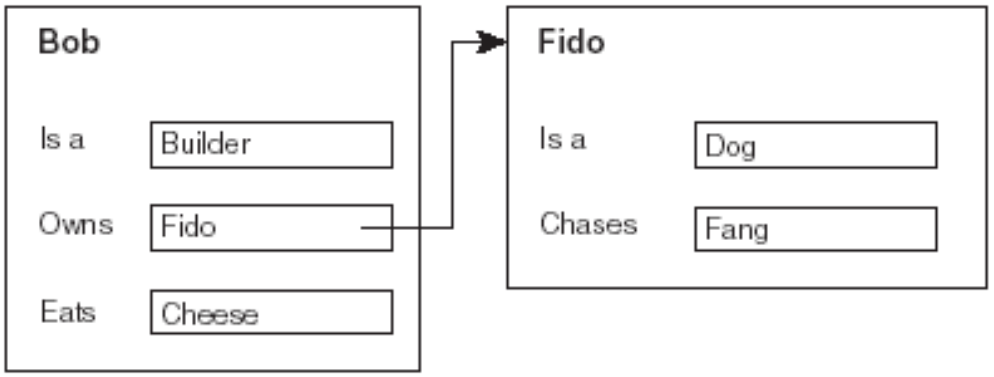


FOR EXPERT SYSTEMS

- Advantage of frame based system over rule based system is that all the info is stored in one place.

Representational Adequacy

- We can represent the kinds of relationships that we can describe with frames in first-order predicate logic (FOPL). For example
- $\forall x\ Dog(x) \rightarrow Mammal(x)$
- For all x's, if x is a dog, then x is a mammal."
- Note that:
- **Almost anything that can be expressed using frames can be expressed using first-order predicate logic (FOPL).**

Procedures and Demons

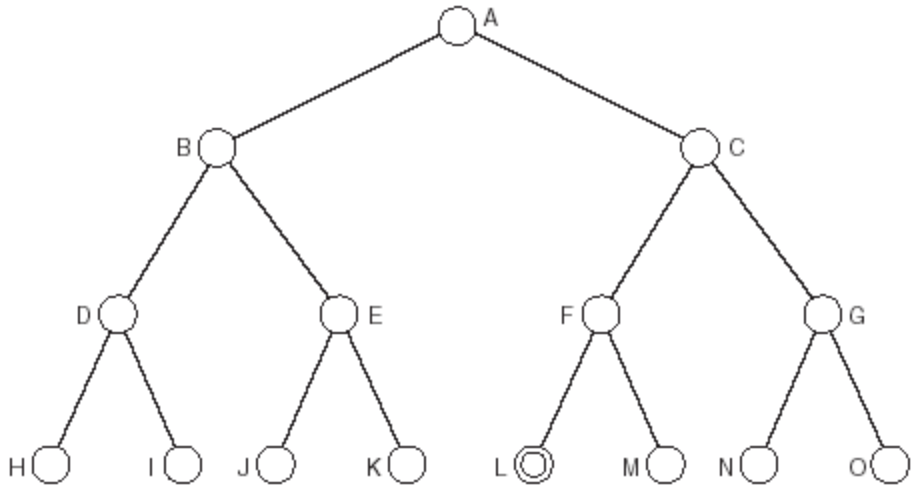
- A procedure is a set of instructions associated with a frame (or a slot).
- The procedure can be run upon request.
- A demon is a procedure that is run automatically, usually triggered by an event such as when a value is:
  - Read
  - Written
  - Created
  - Changed

Search Spaces

- Search Trees
- Semantic trees – a type of semantic net.
- Used to represent search spaces.
- Root node has no predecessor. (starting point)
- Leaf nodes have no successors.
- Goal nodes (of which there may be more than one) represent solutions to a problem.
- Note that :

A path that leads from the root node to a goal node is called a complete path. A path that leads from the root node to a leaf node that is not a goal node is called a partial path.

Search Trees: An Example

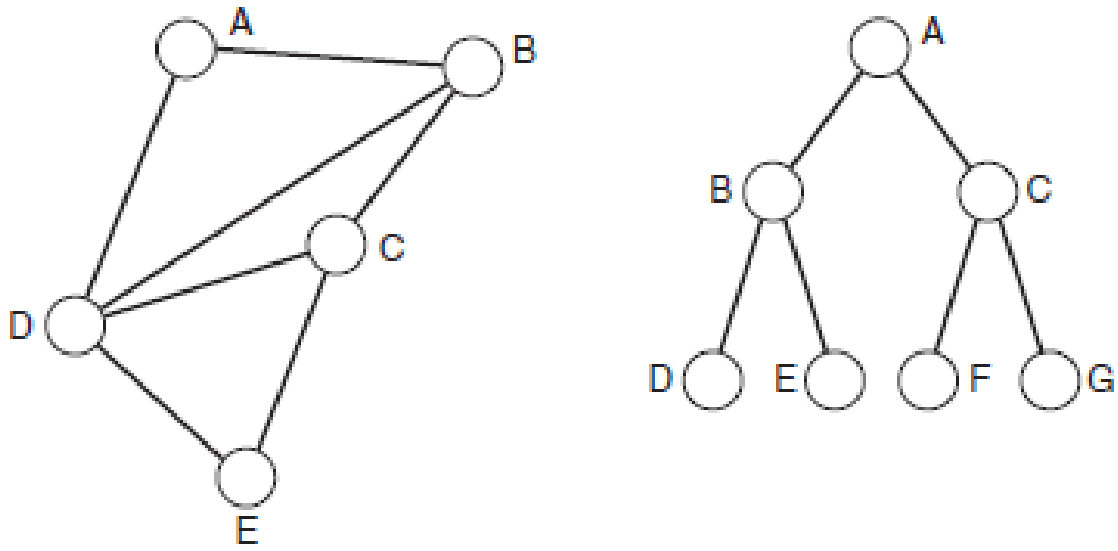


- A is the root node.
- L is the goal node.

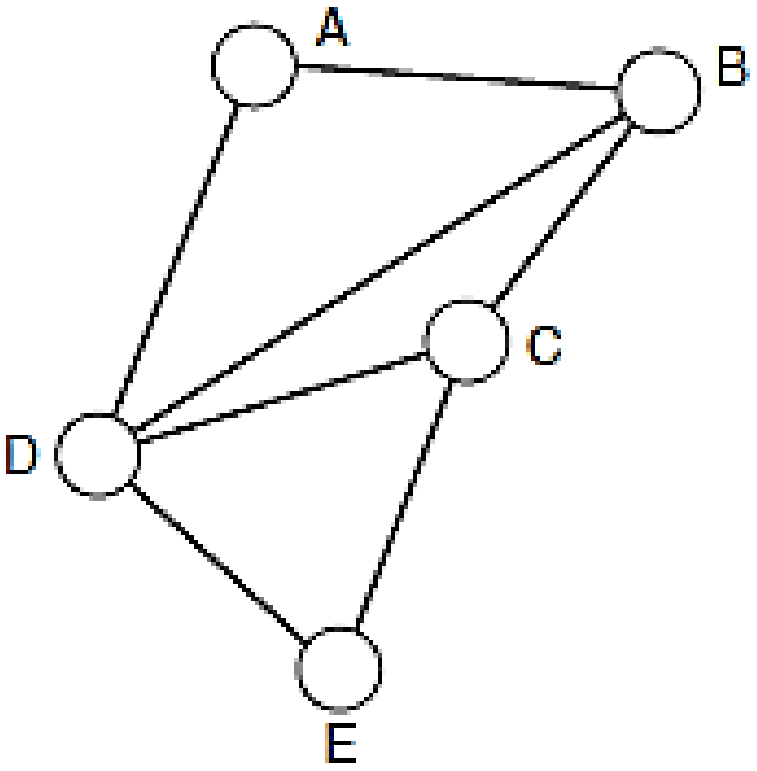
- H, I, J, K, M, N and O are **leaf nodes**.
- There is only one **complete path**:
- A, C, F, L

Semantic nets *vs.* Semantic trees

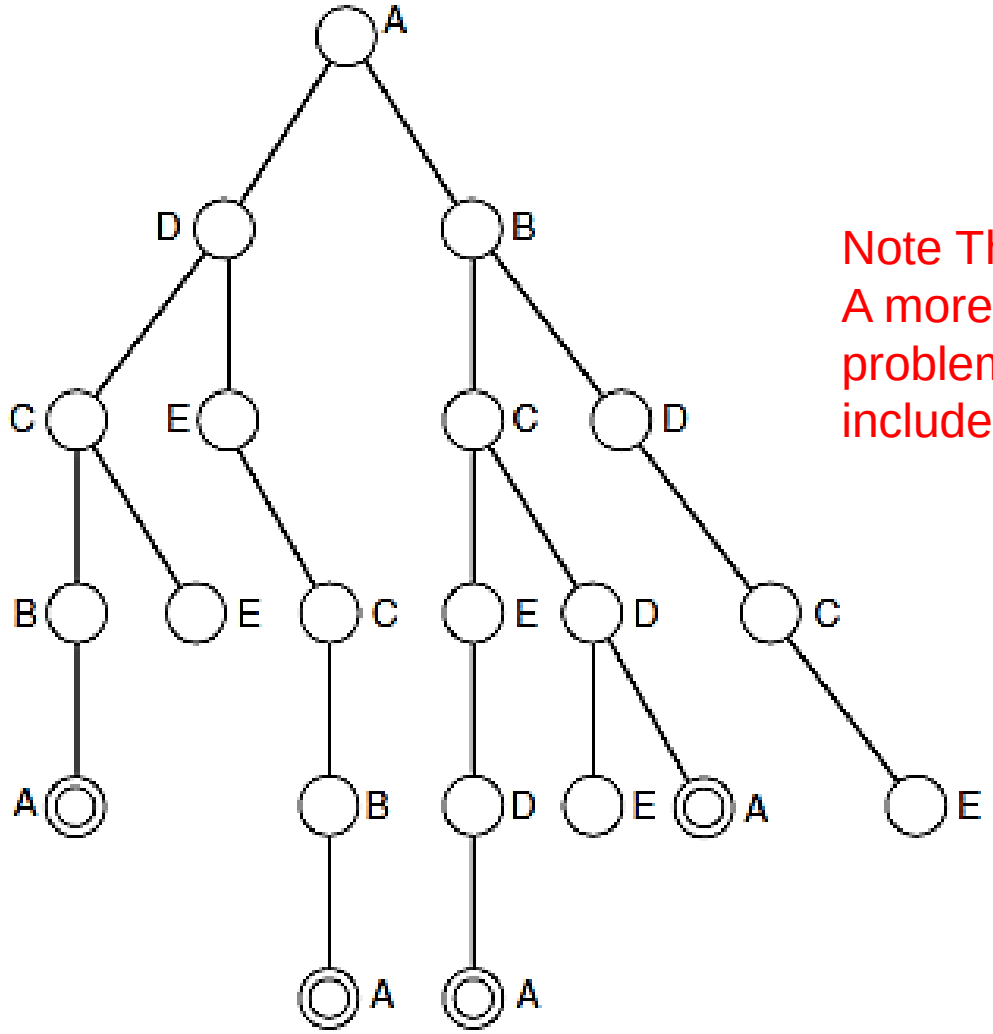
- One of the most obvious differences is that semantic nets can contain cycles, but semantic trees cannot



Task#2



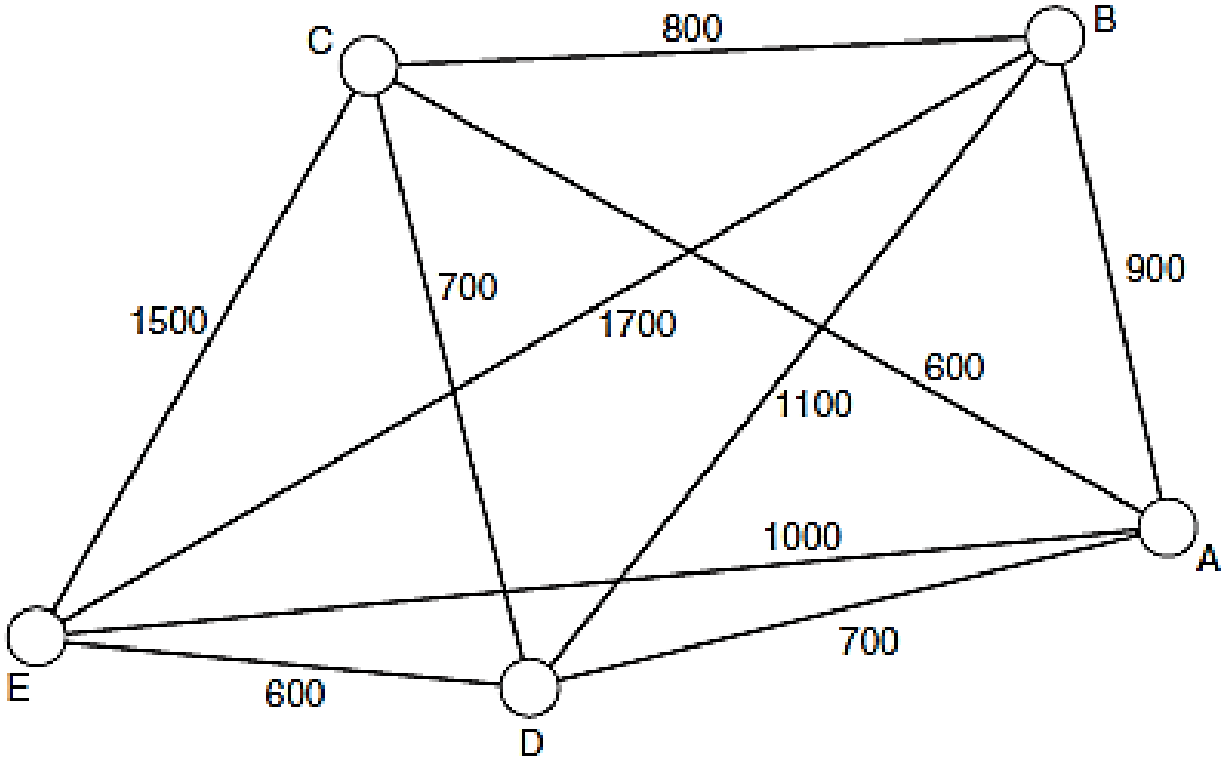
Solution



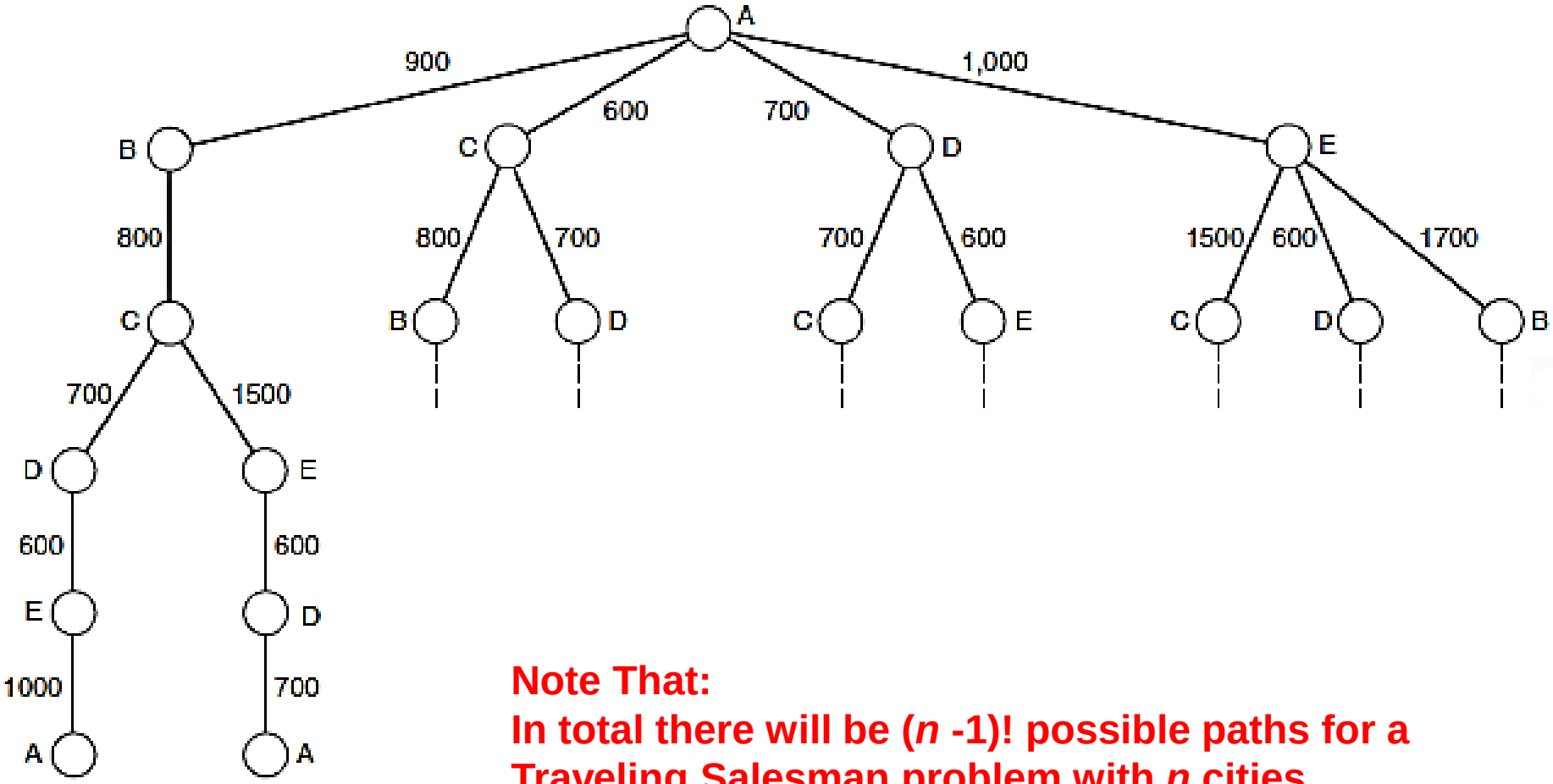
Note That:
A more effective representation for the problem would be one that did not include any cycles

Example 2: **The Traveling Salesman**

- The Traveling Salesman problem is defined as follows: A salesman must visit each of a set of cities and then return home. The aim of the problem is to find the shortest path that lets the salesman visit each city.
- The Traveling Salesman problem is another classic problem in Artificial Intelligence and is **NP-Complete**. for large instances of the problem, it can be very difficult for a computer program to solve in a reasonable period of time



A Atlanta
B Boston
C Chicago
D Dallas
E El Paso



Note That:
In total there will be (*n* -1)! possible paths for a Traveling Salesman problem with *n* cities.

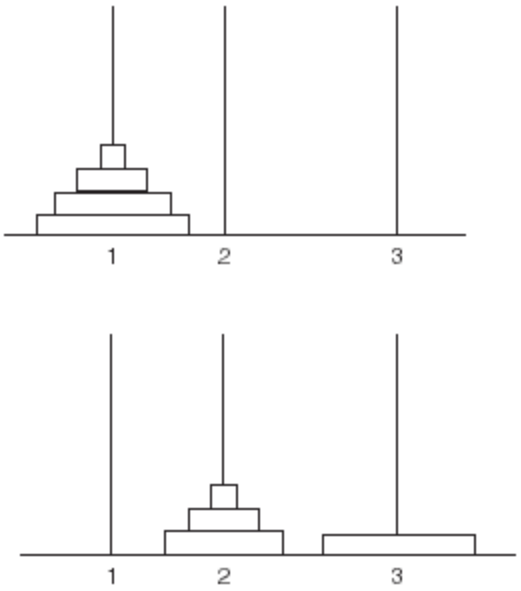
Combinatorial Explosion

- Problems that involve assigning values to a set of variables can grow exponentially with the number of variables. This is the problem of combinatorial explosion.
- Some such problems can be extremely hard to solve (NP-Complete, NP-Hard).
- Selecting the correct representation can help to reduce this, as can using heuristics

Problem Reduction

- Breaking a problem down into smaller sub-problems (or sub-goals).
- Can be represented using goal trees (or and-or trees).
- Nodes in the tree represent sub-problems.
- The root node represents the overall problem.
- Some nodes are and nodes, meaning all their children must be solved.

Problem Reduction: Example



- E.g. to solve the Towers of Hanoi problem with 4 disks, you can first solve the same problem with 3 disks.
- The solution is thus to get from the first diagram on the left, to the second, and then to apply the solution recursively.