جامـــــعـة المـــــسـتـقـبـل
AL MUSTAQBAL UNIVERSITY

كلية العــــــلوم
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LECTURE(8)

Subject: AI definition, history, concept, and applications
Level: 1
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AI Problems

1- Tower of Hanoi Problem

The Tower of Hanoi is a mathematical puzzle. It consists of three rods, and a number of disks of different sizes which can slide onto any rod. The puzzle starts with the disks in a neat stack in ascending order of size on one rod, the smallest at the top, thus making a conical shape.

Tower of Hanoi Problem

The objective of the puzzle is to move the entire stack to another rod, observing the following rules:

1. Only one disk can be moved at a time.
2. Each move consists of taking the upper disk from one of the rods and placing it on top of another rod (i.e. a disk can only be moved if it is the uppermost disk on a stack).
3. No disk may be placed on top of a smaller disk.

With **three disks**, the puzzle can be solved in **seven moves**.

The minimum number of moves required to solve a Tower of Hanoi puzzle is **2N+1**, where **N** is the number of disks.

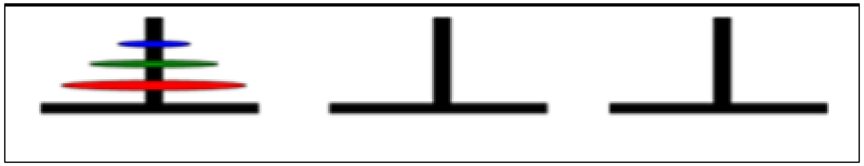
The below figure shows the steps to solve the Tower of Hanoi problem:

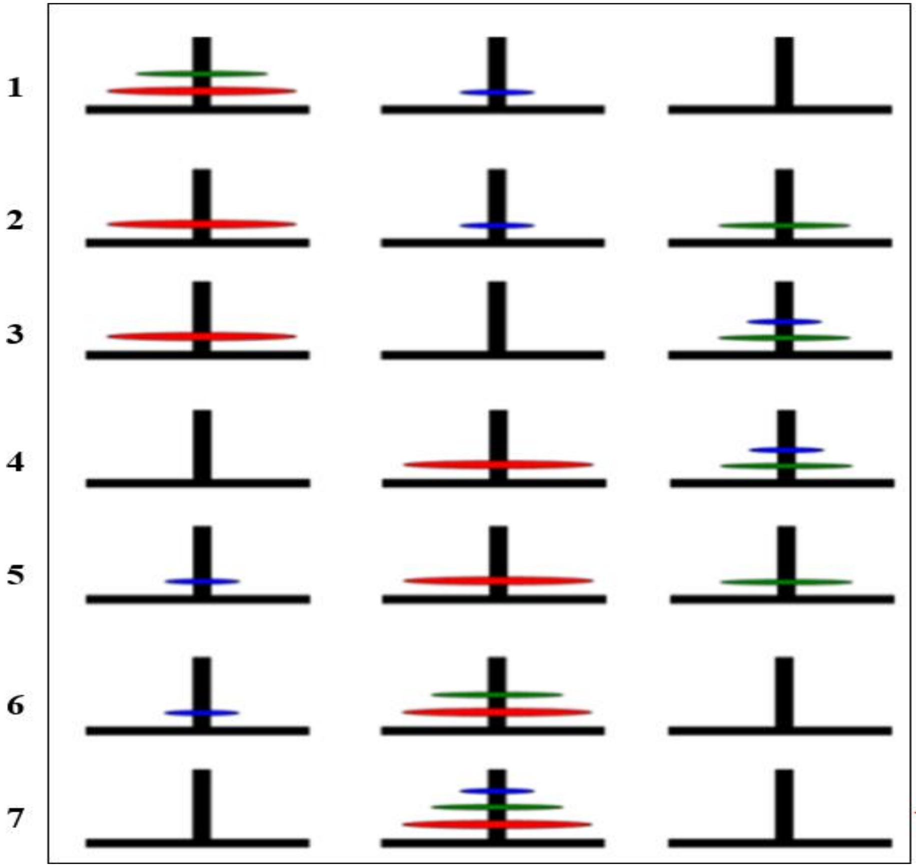
The number of moves required to solve this problem is:

2N+1

(2*3)+1= 7

Initial State





Goal State

AI Problems

2- Water Jugs Problem

There are two jugs, the first one is **4-liters** and another is **3-liters**. Neither have any measuring marker on them. There is a pump that can be used to fill the jugs with water. How can get exactly **2 liters** of water in the **4-liters** jug?

The state space for this problem can be described as the set of ordered pairs of integers (X,Y), such that X=0,1,2,3, or 4 and Y=0,1,2, or 3; where X represents the number of litters of water in the 4-liters jug, and Y represents the number of liters of water in 3-liters jug.

The start state is (0,0) and the goal state is (2,N) for any value of N (since the problem does not specify how many liters should be in the 3-liters jug).

The state space search for the water Jugs problem is:

- **(X,Y)**: order pair.
  - **X**: the quantity of water in 4-liters jug ➔ X = 0,1,2,3 or 4.
  - **Y**: the quantity of water in 3-liters jug ➔ Y = 0,1,2 or 3.

- **start state**: (0,0).

- **goal state**: (2,N) where N = any value.

The required rules to solve the water Jugs problem:

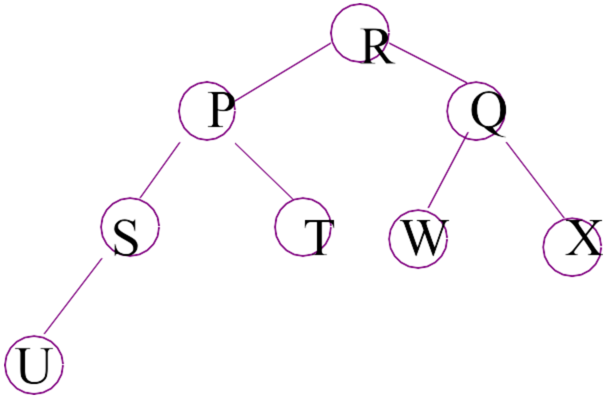
	Rule		Result	Description
1)	(X,Y: X<4)	→	(4,Y)	Fill the 4–liters jug
2)	(X,Y: Y<3)	→	(X,3)	Fill the 3-liters jug
3)	(X,Y: X>0)	→	(X-D,Y)	Pour some water out of the 4-liters jug
4)	(X,Y: Y>0)	→	(X,Y-D)	Pour some water out of the 3-liters jug
5)	(X,Y: X>0)	→	(0,Y)	Empty the 4-liters jug on the ground
6)	(X,Y: Y>0)	→	(X,0)	Empty the 3-liters jug on the ground
7)	(X,Y: X+Y>=4 ∧ Y>0)	→	(4,Y-(4-X))	Pour water from the 3-liters jug into the 4-liters jug until the 4-liters jug is full.
8)	(X,Y: X+Y>=3 ∧ X>0)	→	(X-(3-Y),3)	Pour water from the 4-liters jug into the 3-liters jug until the 3-liters jug is full.

9) $(X,Y: X+Y<=4 \wedge Y>0)$	$(X+Y,0)$	Pour all the water from 3-liters jug into the 4-liters jug.
10) $(X,Y: X+Y<=3 \wedge X>0)$	$(0,X+Y)$	Pour all the water from 4-liters jug into the 3-liters jug.

The below steps show how the goal was achieved, when the first jug is 4-liters and the second is 3-liters and the start state is (0,0), goal state is (2,N):

4-liters Jug	***3-liters Jug***	***Rule Applied No.***	
0	**0**		
0	**3**	**2**	Fill the 3-liters jug
3	**0**	**9**	pour all the water from 3- liters jug into the 4-liters jug
3	**3**	**2**	Fill the 3-liters jug
4	**2**	**7**	Pour water from the 3-liters jug into the 4-liters jug until the 4-liters jug is full.
0	**2**	**5**	Empty the 4-liters jug on the ground
2	**0**	**9**	Pour all the water from 3-liters jug into the 4-liters jug.

TREEs



Search problems and strategies can be described using trees.

A tree is a graph in which two nodes have at most one path between them

The node at top (eg R above) is called the root and represents the initial state

Each node can have zero or more child nodes Eg, P and Q are child nodes of node R
R is the parent of nodes P and Q
R is also the ancestor of all nodes in the tree

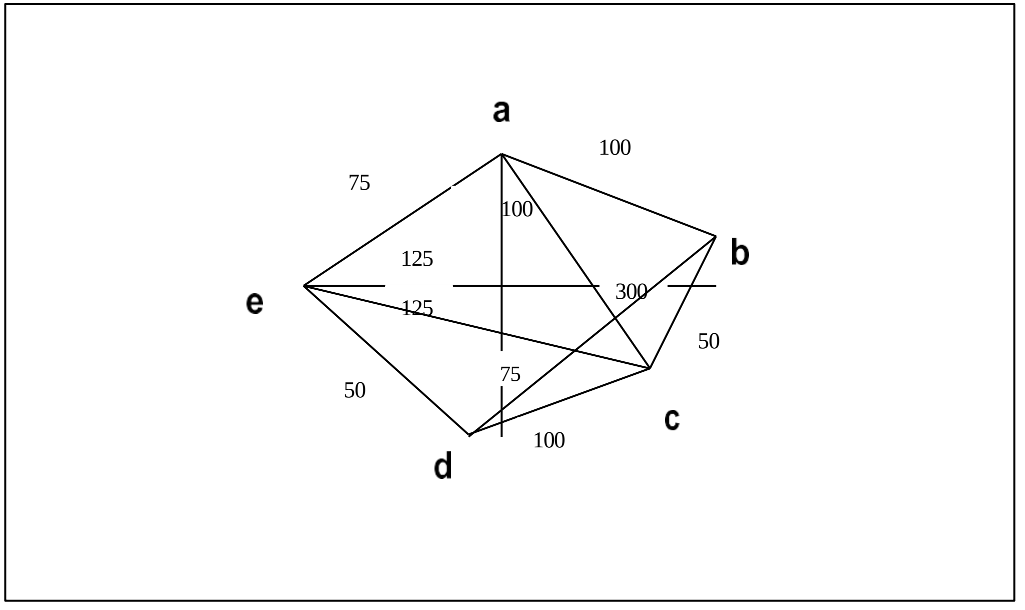
Nodes with the same parent are siblings eg, S and T Nodes with no child nodes are called leaf nodes

A node with b children is said to have a branching factor of b

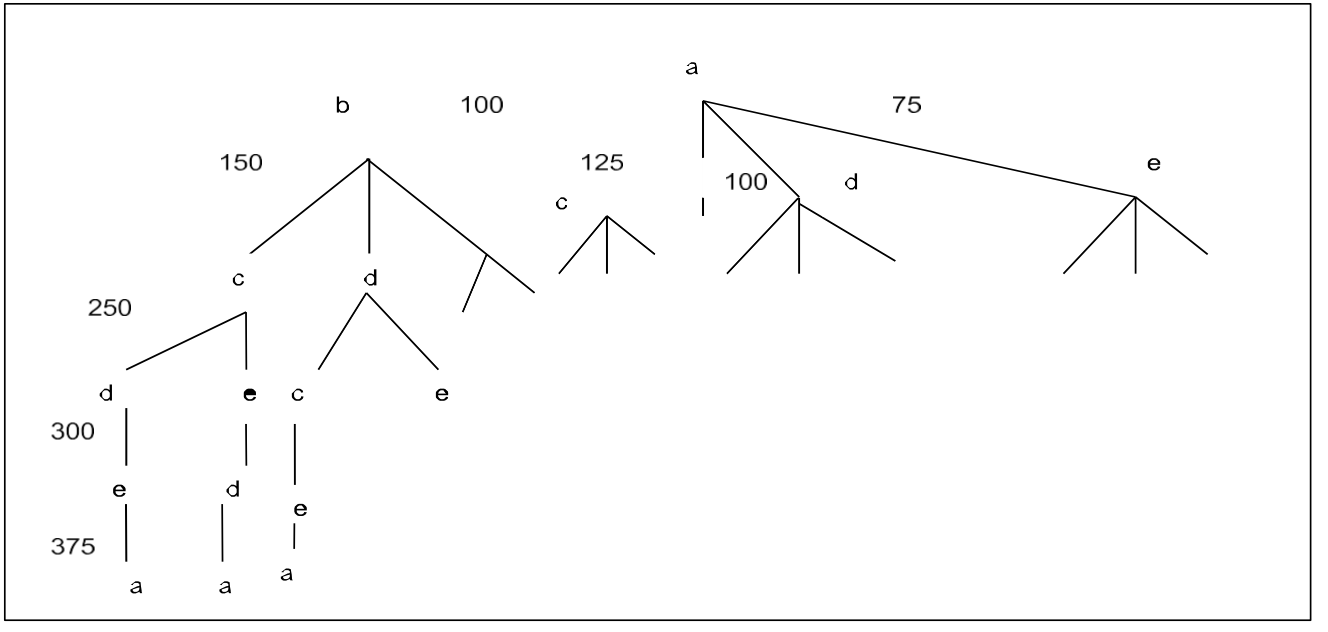
Example:- Traveling Saleman Problem

Starting at A , find the shortest path through all the cities , visiting each city exactly once returning to A.

The complexity of exhaustive search in the traveling Salesman is (N-1)!, where N is the No. of cities in the graph. There are several technique that reduce the search complexity.

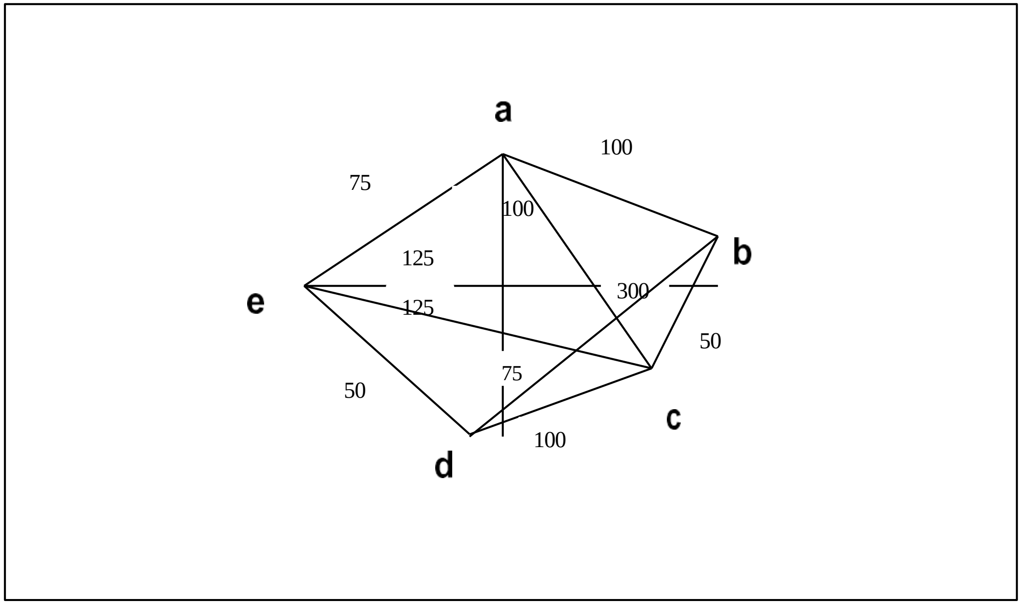


1- Branch and Bound Algorithm:-Generate one path at a time, keeping track of the best circuit so far. Use the best circuit so far as a bound of future branches of the search. Figure below illustrate branch and bound algorithm.



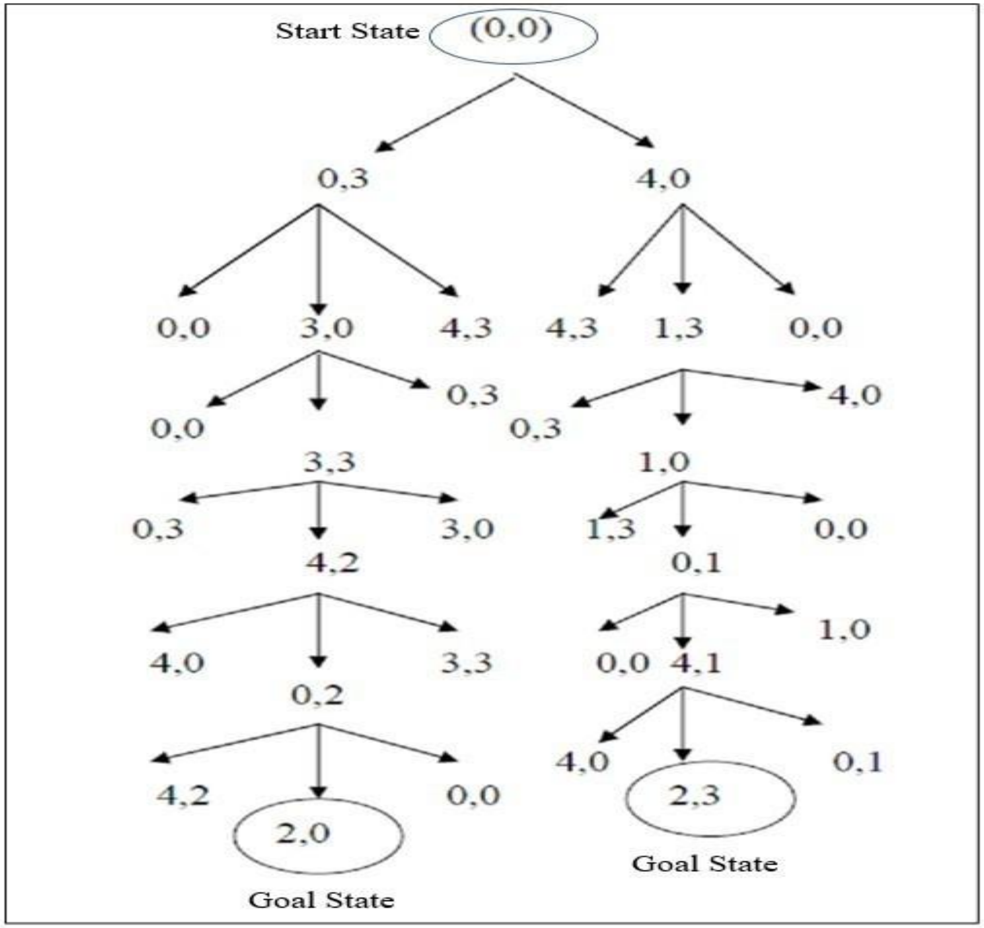
a b c d e a=375 a b c e d a =425 a b d c e a=474 ....

2- Nearest Neighbor Heuristic: At each stage of the circuit, go to the nearest unvisited city. This strategy reduces the complexity to N, so it is highly efficient, but it is not guaranteed to find the shortest path, as the following example:



Cost of Nearest neighbor path is a e d b c a=550
Is not the shortest path , the comparatively high cost of arc (C,A) defeated the heuristic.

The solution can be shown as a search tree as follows for water Jugs problem



AI Problem Characteristics

The ***AI problem characteristics***: is a heuristic technique designed for solving a problem more quickly, or for finding a satisfactory solution to problems in AI. These characteristics are often used to classify problems in AI, The 7 characteristics are:

1. Decomposable to smaller or easier problems.
2. Solution steps can be ignored or undone.
3. Predictable problem universe.
4. Good solutions are obvious.
5. Uses internally consistent knowledge base.
6. Requires lots of knowledge or uses knowledge to constrain solutions.
7. Requires periodic interaction between human and computer.

Below is an example of the 7 AI problem characteristics being applied to solve a Tower of Hanoi problem.

Characteristics	Answer	Description
Is the problem decomposable?	No	Problem cannot broken down into sub-problems.
Can solution steps be ignored or undone?	Yes	Previous steps can be undone.
Is the problem universe predictable?	Yes	**Problem universe** is predictable to solve this problem it requires only one person who can predict what will happen in the next step. There is only a single possible outcome.

Is a good solution absolute or relative?	Absolute	**Absolute solution**: once you get one solution you do not need to bother about other possible solution. **Relative solution**: once you get one solution you have to find another possible solution to check which solution is best (i.e. low cost) By considering tower of Hanoi solution is absolute
Is the solution state or path?	Path	The solution is a path to the goal state.
What is the role of knowledge?	----	A lot of knowledge helps to constrain the search for the solution
Does the task require human interaction?	No	**Human Interaction means** there is intermediate communication between a human and the computer, either to provide additional assistance to the computer or to provide additional information to the human, or both. In the tower of Hanoi additional assistance is not required.

Below is an example of the 7 AI problem characteristics being applied to solve water jugs problem.

Characteristics	Answer	Description
Is the problem decomposable?	No	Problem cannot broken down into sub-problems.
Can solution steps be ignored or undone?	Yes	Previous steps can be undone.
Is the problem universe predictable?	Yes	**Problem universe** is predictable to solve this problem it requires only one person who can predict what will happen in the next step. There are more than one outcome.

Is a good solution absolute or relative?	Absolute	An **absolute** solution, water jugs problem may have a number of solutions, when found one solution, no need to bother about other solution. Because it does not effect on the cost.
Is the solution state or path?	Path	The solution is a path to the goal state.
What is the role of knowledge?		A lot of knowledge helps to constrain the search of the solution
Does the task require human interaction?	Yes	Additional assistance is required. Additional assistance, like to get jugs or pump.