Problem Formulation in Artificial Intelligence

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Water-Jug Problem

- **Problem:**
- You are given two jugs, a 4-gallon one and a 3-gallon one. Neither has any measuring mark on it. There is a pump that can be used to fill the jugs with water. How can you get exactly 2 gallons of water into the 4-gallon jug.

Solutions Steps

- **Solution:**
- The state space for this problem can be described as the set of ordered pairs of integers (x,y)
- Where,
- X represents the quantity of water in the 4-gallon jug
  X= 0,1,2,3,4
- Y represents the quantity of water in 3-gallon jug
  Y=0,1,2,3
- **Start State:** (0,0)
- **Goal State:** (2,0)

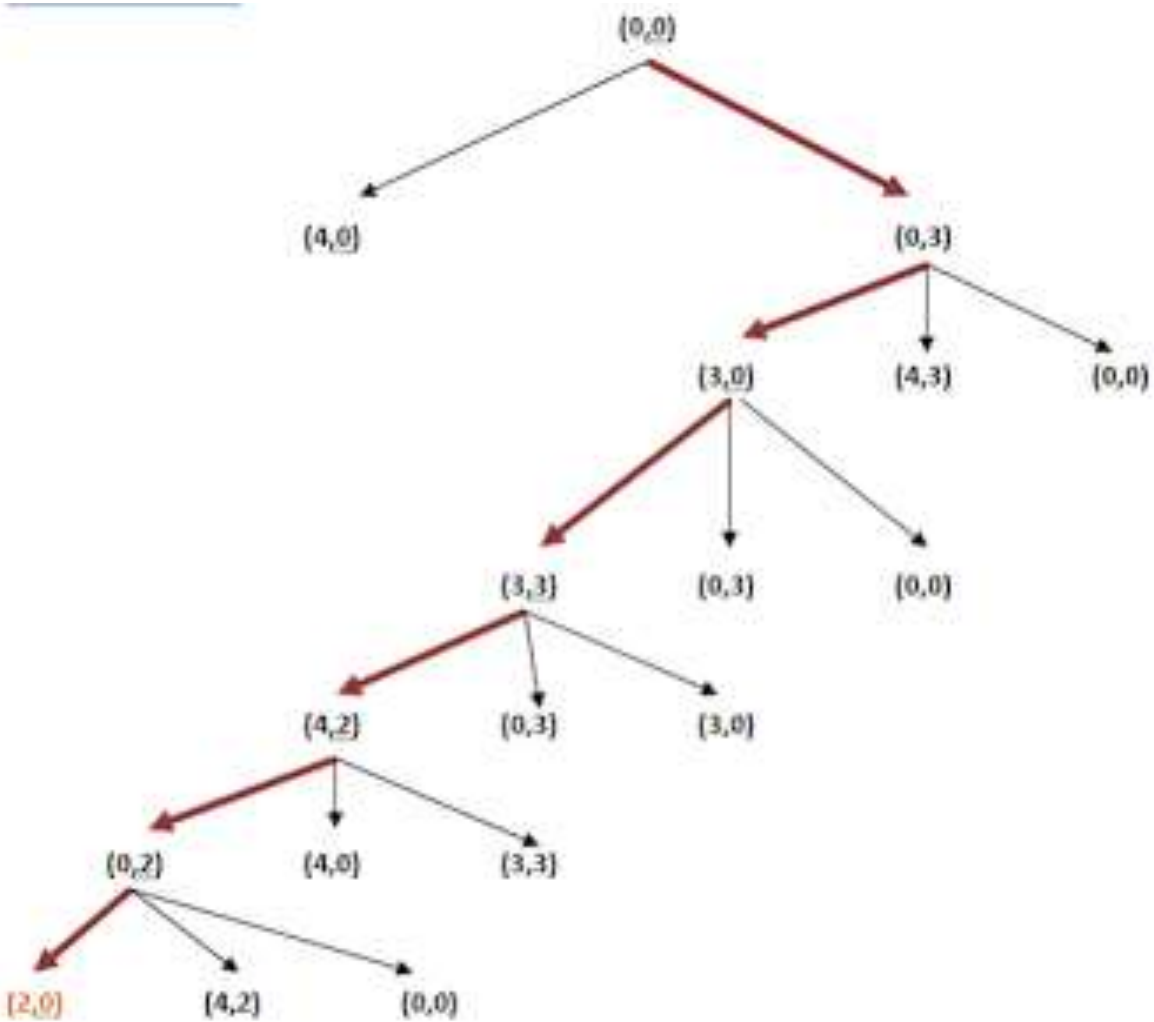
Production Rules

Rule	State	Process
1	(X,Y | X<4)	(4,Y) {Fill 4-gallon jug}
2	(X,Y |Y<3)	(X,3) {Fill 3-gallon jug}
3	(X,Y |X>0)	(0,Y) {Empty 4-gallon jug}
4	(X,Y | Y>0)	(X,0) {Empty 3-gallon jug}
5	(X,Y | X+Y>=4 ^ Y>0)	(4,Y-(4-X)) {Pour water from 3-gallon jug into 4-gallon jug until 4-gallon jug is full}
6	(X,Y | X+Y>=3 ^X>0)	(X-(3-Y),3) {Pour water from 4-gallon jug into 3-gallon jug until 3-gallon jug is full}
7	(X,Y | X+Y<=4 ^Y>0)	(X+Y,0) {Pour all water from 3-gallon jug into 4-gallon jug}
8	(X,Y | X+Y <=3^ X>0)	(0,X+Y) {Pour all water from 4-gallon jug into 3-gallon jug}
9	(0,2)	(2,0) {Pour 2 gallon water from 3 gallon jug into 4 gallon jug}

One Solution to the water jug problem

4-Gallon Jug	3 Gallon Jug	Rule Applied
0	0	2
0	3	9
3	0	8
3	3	7
4	2	5
0	2	9
2	0	

State Space Tree



Missionaries and Cannibals

- **Problem:**
- Three missionaries and three cannibals are on one side of a river that they wish to cross.
- A boat is available that can hold at most two people and at least one.
- You must never leave a group of missionaries outnumbered by cannibals on the same bank.

- Find an action sequence that brings everyone safely to the opposite bank.

Solution Steps

- State space: triple (x,y,z) with $0 \leq x,y,z \leq 3$, where x,y, and z represent the number of missionaries, cannibals and boats currently on the original bank.
- Initial State: (3,3,1)
- Goal State: (0,0,0)
- Path Costs: 1 unit per crossing

Production Rules

Rule 1 :	(0, M)	:	One missionary sailing the boat from bank-1 to bank-2
Rule 2 :	(M, 0)	:	One missionary sailing the boat from bank-2 to bank-1
Rule 3 :	(M, M)	:	Two missionaries sailing the boat from bank-1 to bank-2
Rule 4 :	(M, M)	:	Two missionaries sailing the boat from bank-2 to bank-1
Rule 5 :	(M, C)	:	One missionary and one Cannibal sailing the boat from bank-1 to bank-2
Rule 6 :	(C, M)	:	One missionary and one Cannibal sailing the boat from bank-2 to bank-1
Rule 7 :	(C, C)	:	Two Cannibals sailing the boat from bank-1 to bank-2
Rule 8 :	(C, C)	:	Two Cannibals sailing the boat from bank-2 to bank-1
Rule 9 :	(0, C)	:	One Cannibal sailing the boat from bank-1 to bank-2
Rule 10 :	(C, 0)	:	One Cannibal sailing the boat from bank-2 to bank-1

Solution

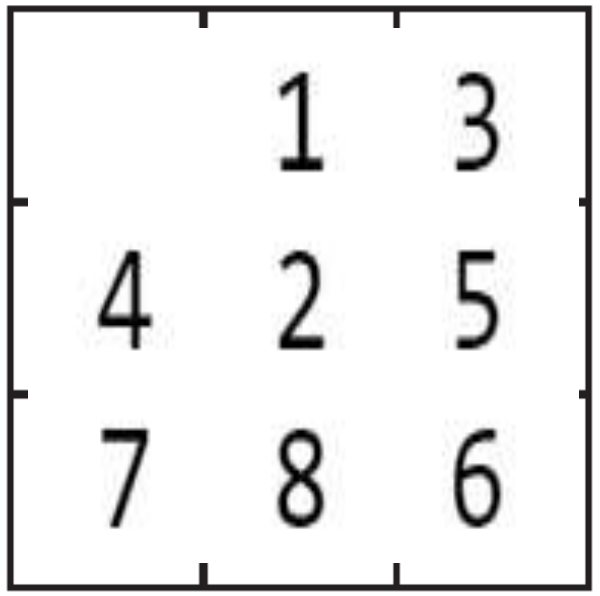
Table 2.2: Rules applied and their sequence in Missionaries and Cannibals problem

After application of rule	persons in the river bank-1	persons in the river bank-2	boat position
Start state	M, M, M, C, C, C	0	bank-1
5	M, M, C, C	M, C	bank-2
2	M, M, C, C, M	C	bank-1
7	M, M, M	C, C, C	bank-2
10	M, M, M, C	C, C	bank-1
3	M, C	C, C, M, M	bank-2
6	M, C, C, M	C, M	bank-1
3	C, C	C, M, M, M	bank-2
10	C, C, C	M, M, M	bank-1
7	C	M, M, M, C, C	bank-2
10	C, C	M, M, M, C	bank-1
7	0	M, M, M, C, C, C	bank-2

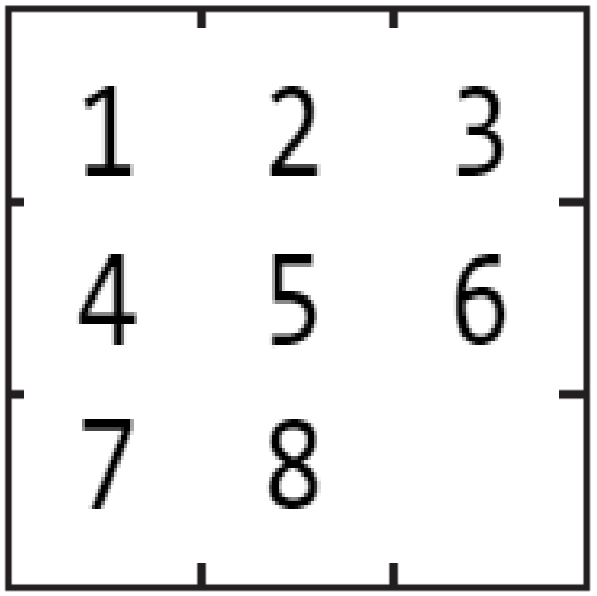
8-Puzzle Problem

- The 8-puzzle problem belongs to the category of "sliding-block puzzle" types of problems.
- It has set of a 3x3 board having 9 block spaces out of which, 8 blocks are having tiles bearing number from 1 to 8. One space is left blank. The tile adjacent to blank space can move into it. We have to arrange the tiles in a sequence.

Solution Steps



(a) Start state



(b) Goal state

Fig. 2.4: Start and Goal states of 8 puzzle problem

Solution Stages

	1	3		1	2	3
4	2	5		4		5
7	8	6		7	8	6
1		3		1	2	3
4	2	5		4	5	
7	8	6		7	8	6
1	2	3		1	2	3
4		5		4	5	6
7	8	6		7	8	

Nature of AI Problems

- **Path Finding Problems:** Traveling salesperson problem
- **Decomposable Problems:** Maths equations
- **Recoverable Problems:** 8 puzzle problem
- **Predictable Problems:** 8 puzzle problem
- **Problems Affecting the Quality of Solution:** Traveling salesperson problem
- **State Finding Problem:** Medical diagnosis problems using expert system
- **Problems Requiring Interaction:** Interacting with user
- **Knowledge Intensive Problems:** Chess or Tic Tac Toe Problem

Problem characteristics

- 1. If the problem is decomposable into independent smaller or easier sub problems.
- 2. Is backtracking possible or not.
- 3. Is the problem's universe predictable.
- 4. Is a good solution to the problem obvious without comparison to all other possible solutions.
- 5. Is the desired solution a state or a path.
- 6. Is a large amount of knowledge absolutely required to solve the problem or is knowledge important only to constrain the search.

Thank You

Any Queries ??