50.021 Artificial Intelligence

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Homework 8

1 Logistic Problem I

(a) Propositional variables:

- **At(x)**: indicates whether the truck is at location x, where x can be a, b or c.
- **PackageAt(x)**: indicates whether the package is at location x, where x can be a, b or c.
- **Loaded**: indicates whether the truck is loaded with the package (It can be true or false).

(b) Operators:

- **move(x,y):**
  - **Pre-conditions:** At(x)
  - **Post-conditions:** At(y)
- **load(x):**
  - **Pre-conditions:** At(x), PackageAt(x), not Loaded
  - **Post-conditions:** not At(x), not PackageA(x), Loaded
- **unload(x):**
  - **Pre-conditions:** At(x), not PackageAt(x), Loaded
  - **Post-conditions:** At(x), PackageAt(x), not Loaded

(c) Initial State: At(a), PackageAt(c), not Loaded

(d) Goal State: At(b), PackageAt(b), not Loaded

2 Logistic Problem II

(a) The optimal solution is:

1. move(a,b): The truck moves from a to b.
2. move(b,c): The truck moves from b to c.
3. load(c): The truck loads the package at c.
4. move(c,b): The truck moves from c to b.
5. unload(b): The truck unloads the package at b.

(b) The truck can now move directly from a to c without passing through b (remove the requirement for movement only between adjacent locations).

(c)

- F_0 : At(a), PackageAt(c), not Loaded
- A_0 : move(a,c)
- F_1 : At(c), PackageAt(c), not Loaded

- A_1 : load(c)
- F_2 : At(c), PackageAt(c), Loaded
- A_2 : move(c,b)
- F_3 : At(b), PackageAt(b), Loaded
- A_3 : unload(b)
- F_4 : At(b), PackageAt(b), not Loaded (Goal State)

3 Logistic Problem III

(a) The new optimal solution is now:

1. move(a,c): The truck moves from a to c.
2. load(c): The truck loads the package at c.
3. move(c,b): The truck moves from c to b.
4. unload(b): The truck unloads the package at b.

The heuristic used in this problem is called the Delete-Relaxed Heuristic. It relaxes the preconditions of actions, allowing the planner to explore more potential paths that might not be feasible in reality but help in finding a solution faster.

(b) $h_{add} = 4$

In the context of the logistic problem, the goal fact is: At(b), PackageAt(b), not Loaded. h_{max} is the summed cost of all goal facts. As there is only one goal fact, and it requires 4 actions to get there, $h_{add} = 4$.

(c) $h_{max} = 4$

h_{max} is the maximum number of actions needed to satisfy any one goal condition. In this case, the maximum number of actions needed is 4 (from F_0 to F_4), considering the optimal solution provided. Therefore, $h_{max} = 4$.

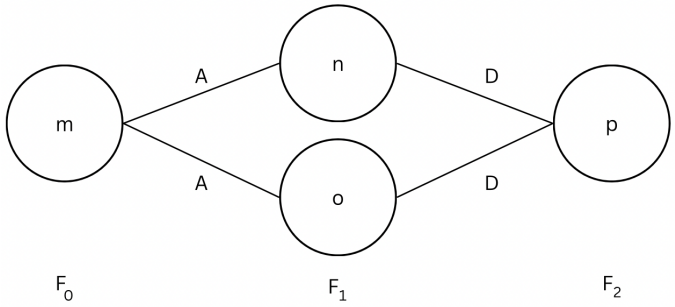
4 Generic Planning I

(a) $h_+ = 4$

As h_+ heuristic is the optimal plan for a delete-relaxed problem, the delete column is removed. The table is now:

Action	Pre	Add
A	m	n,o
B	m,o	p
C	p	m
D	n,o	p

The optimal solution is:



Based on the above definition and the optimal plan having 4 actions, the h_+ is 4.

(b) $h_{add} = 6$

The goal states are $\{m, n, o, p\}$.

- Goal state m: 0
- Goal state n: 1
- Goal state o: 1
- Goal state p: 2 + 2 = 4

Therefore, $h_{add} = 0 + 1 + 1 + 4 = 6$

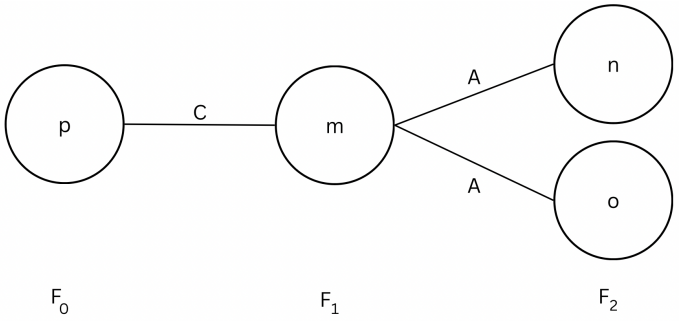
(c) $h_{max} = 2$

As h_{max} is the cost of the single most costly goal fact, given the goals $\{m, n, o, p\}$, $h_{max} = 2$ (from F_0 to F_2).

5 Generic Planning II

(a) $h_+ = 3$

The optimal solution is:



Based on the above definition and the optimal plan having 3 actions, the h_+ is 3.

(b) $h_{add} = 5$

The goal states are $\{m, n, o, p\}$.

- Goal state p: 0
- Goal state m: 1
- Goal state n: 2
- Goal state o: 2

Therefore, $h_{add} = 0 + 1 + 2 + 2 = 5$

(c) $h_{max} = 2$

As h_{max} is the cost of the single most costly goal fact, given the goals $\{m, n, o, p\}$, $h_{max} = 2$ (from F_0 to F_2).