

Author: Ilton Garcia dos Santos Silveira

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Heuristic Analysis for Planning Cargo

That analysis should expose it project results, showing:

1. The sequence of actions for each problem;
2. Comparing 3 uniformed planning algorithms for all 3 problems;
3. 2 heuristics used with A* search for planning on all 3 problems, from the planning graph;
4. Table of performances for each algorithm on each problem;
5. 1 reason for each result using the appropriate justification.

The Sequence of Actions for each Problem & table of performance

Sequence of actions for each problem, comparing 3 uniformed planning algorithms for all 3 problems
with table of performances.

- Problem 1 initial state and goal:

```
Init(At(C1, SF0) ∧ At(C2, JFK)
  ∧ At(P1, SF0) ∧ At(P2, JFK)
  ∧ Cargo(C1) ∧ Cargo(C2)
  ∧ Plane(P1) ∧ Plane(P2)
  ∧ Airport(JFK) ∧ Airport(SF0))
Goal(At(C1, JFK) ∧ At(C2, SF0))
```

- RESULT: Problem 1 - astar_search with h_1

Solving Air Cargo Problem 1 using astar_search with h_1...

Expansions	Goal Tests	New Nodes
55	57	224

Plan length: 6 Time elapsed in seconds: 0.035601461997430306

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Unload(C1, P1, JFK)
Unload(C2, P2, SFO)

- RESULT: Problem 1 - depth first graph search

Solving Air Cargo Problem 1 using depth_first_graph_search...

Expansions	Goal Tests	New Nodes
21	22	84

Plan length: 20 Time elapsed in seconds: 0.013117626000166638

Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Load(C2, P1, JFK)
Fly(P1, JFK, SFO)
Fly(P2, SFO, JFK)
Unload(C2, P1, SFO)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Load(C2, P2, SFO)
Fly(P1, JFK, SFO)
Load(C1, P2, SFO)
Fly(P2, SFO, JFK)
Fly(P1, SFO, JFK)
Unload(C2, P2, JFK)
Unload(C1, P2, JFK)
Fly(P2, JFK, SFO)
Load(C2, P1, JFK)
Fly(P1, JFK, SFO)
Fly(P2, SFO, JFK)
Unload(C2, P1, SFO)

- RESULT: Problem 1 - uniform cost search

Solving Air Cargo Problem 1 using uniform_cost_search...

Expansions	Goal Tests	New Nodes
55	57	224

Plan length: 6 Time elapsed in seconds: 0.037763554999401094

```
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Unload(C1, P1, JFK)
Unload(C2, P2, SFO)
```

- RESULT: Problem 1 - breadth first search

Solving Air Cargo Problem 1 using breadth_first_search...

Expansions	Goal Tests	New Nodes
43	56	180

Plan length: 6 Time elapsed in seconds: 0.028200085002026754

```
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)
```

- Problem 2 initial state and goal:

```
Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL)
    ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ At(P3, ATL)
    ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3)
    ∧ Plane(P1) ∧ Plane(P2) ∧ Plane(P3)
    ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL))
Goal(At(C1, JFK) ∧ At(C2, SFO) ∧ At(C3, SFO))
```

- RESULT: Problem 2 - astar_search with h_1

Solving Air Cargo Problem 2 using astar_search with h_1...

Expansions	Goal Tests	New Nodes
4853	4855	44041

Plan length: 9 Time elapsed in seconds: 10.50476367000374

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Load(C3, P3, ATL)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

- RESULT: Problem 2 - uniform cost search

Solving Air Cargo Problem 2 using uniform_cost_search...

Expansions	Goal Tests	New Nodes
4853	4855	44041

Plan length: 9 Time elapsed in seconds: 10.320910713002377

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Load(C3, P3, ATL)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

- RESULT: Problem 2 - breadth first search

Solving Air Cargo Problem 2 using breadth_first_search...

Expansions	Goal Tests	New Nodes
3343	4609	30509

Plan length: 9 Time elapsed in seconds: 7.134153706996585

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Load(C3, P3, ATL)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)

- RESULT: Problem 2 - depth first graph search

Solving Air Cargo Problem 2 using depth_first_graph_search...

Expansions	Goal Tests	New Nodes
624	625	5602

Plan length: 619 Time elapsed in seconds: 3.1242746479983907

Fly(P3, ATL, SFO)
 Fly(P1, SFO, ATL)
 Fly(P3, SFO, JFK)
 Fly(P1, ATL, JFK)
 Fly(P2, JFK, ATL)
 Fly(P3, JFK, ATL)
 Fly(P2, ATL, SFO)
 Fly(P3, ATL, SFO)
 Load(C2, P1, JFK)
 Fly(P2, SFO, ATL)
 Fly(P1, JFK, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Fly(P3, SFO, ATL)
 Fly(P1, SFO, JFK)
 Load(C3, P3, ATL)
 Fly(P3, ATL, SFO)
 Fly(P2, JFK, ATL)
 Fly(P3, SFO, JFK)
 Fly(P2, ATL, SFO)
 Fly(P1, JFK, ATL)
 Fly(P2, SFO, JFK)
 Fly(P1, ATL, SFO)
 Unload(C3, P3, JFK)
 Fly(P1, SFO, JFK)
 Fly(P3, JFK, ATL)
 Fly(P2, JFK, ATL)
 Fly(P3, ATL, SFO)
 Fly(P2, ATL, SFO)
 Fly(P1, JFK, ATL)
 Fly(P3, SFO, ATL)
 Fly(P1, ATL, SFO)
 Unload(C2, P1, SFO)
 Fly(P3, ATL, SFO)
 Fly(P2, SFO, ATL)
 Fly(P1, SFO, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, JFK)
 Fly(P3, SFO, ATL)
 Fly(P2, JFK, ATL)
 Fly(P3, ATL, JFK)
 Fly(P2, ATL, SFO)
 Fly(P1, JFK, ATL)
 Load(C3, P3, JFK)
 Fly(P1, ATL, SFO)
 Fly(P2, SFO, ATL)
 Fly(P3, JFK, ATL)
 Fly(P2, ATL, JFK)
 Fly(P3, ATL, SFO)
 Fly(P1, SFO, ATL)


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Fly(P2, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Fly(P3, SFO, ATL)
Unload(C3, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P3, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Load(C3, P2, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Unload(C3, P2, SFO)
Fly(P2, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P2, ATL, JFK)
Fly(P3, ATL, SFO)
Load(C2, P3, SFO)
Fly(P3, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, SFO)
Unload(C2, P3, JFK)
Fly(P1, SFO, JFK)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P3, SFO, ATL)
Fly(P1, ATL, SFO)
Load(C3, P2, SFO)
Fly(P3, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)

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Unload(C3, P2, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P1, SFO, JFK)
Fly(P2, JFK, ATL)
Fly(P3, SFO, ATL)
Fly(P2, ATL, SFO)
Load(C1, P2, SFO)
Fly(P3, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P3, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Unload(C2, P2, JFK)
Fly(P1, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P3, SFO, ATL)
Fly(P2, ATL, SFO)
Fly(P3, ATL, JFK)
Fly(P1, JFK, ATL)
Load(C3, P2, SFO)
Fly(P1, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C3, P2, JFK)
Fly(P3, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, SFO)
Fly(P1, SFO, ATL)
Fly(P2, SFO, JFK)
Unload(C1, P2, JFK)
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Fly(P1, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, SFO)
Fly(P3, JFK, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, SFO)
Load(C3, P2, JFK)
Fly(P2, JFK, ATL)
Fly(P3, SFO, ATL)
Fly(P2, ATL, SFO)
Fly(P3, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P2, SFO, ATL)
Fly(P1, ATL, SFO)
Unload(C3, P2, ATL)
Fly(P2, ATL, SFO)
Fly(P1, SFO, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P2, JFK, SFO)
Fly(P3, ATL, SFO)
Load(C2, P1, JFK)
Fly(P2, SFO, ATL)
Fly(P3, SFO, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, ATL, JFK)
Fly(P2, SFO, ATL)
Unload(C2, P1, SFO)
Fly(P2, ATL, JFK)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C2, P3, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P3, ATL, JFK)


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Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C1, P3, JFK)
Fly(P2, SFO, JFK)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Unload(C2, P3, ATL)
Fly(P3, ATL, SFO)

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Fly(P2, ATL, SFO)
Fly(P3, JFK, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P3, SFO, JFK)
Fly(P1, ATL, SFO)
Load(C1, P2, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P2, SFO, ATL)
Fly(P1, ATL, SFO)
Unload(C1, P2, ATL)
Fly(P2, ATL, SFO)
Fly(P1, SFO, ATL)
Fly(P3, SFO, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, JFK)
Fly(P2, SFO, JFK)
Fly(P1, JFK, ATL)
Fly(P2, JFK, ATL)
Load(C3, P2, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P2, SFO, JFK)
Fly(P1, SFO, JFK)

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Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Unload(C3, P2, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, SFO, ATL)
Load(C3, P3, SFO)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)
Load(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P3, SFO, JFK)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, SFO)
Unload(C3, P3, JFK)
Fly(P1, SFO, JFK)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P3, SFO, ATL)
Fly(P1, ATL, SFO)
Unload(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Load(C3, P1, JFK)
Fly(P3, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Load(C2, P1, ATL)
Fly(P1, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C3, P1, SFO)
Fly(P3, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P3, ATL, JFK)
Fly(P2, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P3, JFK, ATL)
Load(C3, P2, SFO)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P3, SFO, ATL)
Fly(P2, ATL, JFK)
Fly(P3, ATL, JFK)

Fly(P1, SFO, ATL)
Unload(C3, P2, JFK)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P1, SFO, ATL)
Load(C1, P1, ATL)
Fly(P1, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P3, SFO, ATL)

fly(P3, SFO, ATL)
fly(P2, ATL, JFK)
fly(P1, SFO, JFK)
fly(P3, ATL, SFO)
Load(C3, P2, JFK)
fly(P3, SFO, JFK)
fly(P2, JFK, ATL)
fly(P3, JFK, ATL)
fly(P2, ATL, SFO)
fly(P1, JFK, SFO)
fly(P3, ATL, SFO)
fly(P2, SFO, ATL)
fly(P1, SFO, ATL)
Unload(C3, P2, ATL)
fly(P2, ATL, SFO)
fly(P1, ATL, SFO)
fly(P3, SFO, ATL)
fly(P2, SFO, ATL)
fly(P3, ATL, JFK)
fly(P2, ATL, JFK)
fly(P1, SFO, ATL)
fly(P3, JFK, ATL)
fly(P1, ATL, JFK)
fly(P3, ATL, SFO)
Unload(C2, P1, JFK)
fly(P2, JFK, ATL)
fly(P3, SFO, ATL)
fly(P1, JFK, ATL)
fly(P2, ATL, SFO)
fly(P3, ATL, SFO)
fly(P1, ATL, SFO)
fly(P3, SFO, JFK)
fly(P2, SFO, ATL)
Load(C3, P2, ATL)
fly(P2, ATL, SFO)
fly(P1, SFO, ATL)
fly(P2, SFO, JFK)
fly(P3, JFK, ATL)
fly(P1, ATL, SFO)
fly(P3, ATL, SFO)
Unload(C3, P2, JFK)
fly(P1, SFO, ATL)
fly(P2, JFK, ATL)
fly(P1, ATL, JFK)
fly(P2, ATL, SFO)
Load(C3, P1, JFK)

Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, SFO, ATL)
Unload(C1, P1, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Unload(C3, P1, SFO)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P2, JFK, ATL)
Load(C1, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, JFK)
Fly(P1, SFO, ATL)
Fly(P2, JFK, SFO)
Fly(P1, ATL, JFK)
Fly(P2, SFO, ATL)
Unload(C1, P3, JFK)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Load(C3, P1, SFO)
Fly(P3, ATL, JFK)
Fly(P2, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P3, SFO, ATL)

Fly(P3, JFK, ATL)
Fly(P2, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C2, P2, JFK)
Fly(P3, SFO, ATL)

Fly(P2, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, SFO)
Fly(P1, ATL, SFO)
Load(C3, P3, SFO)
Fly(P3, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P1, ATL, JFK)
Fly(P2, JFK, ATL)
Fly(P3, JFK, ATL)
Load(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P3, SFO, JFK)
Fly(P2, SFO, JFK)
Fly(P1, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P1, ATL, SFO)
Load(C1, P3, JFK)
Fly(P2, ATL, SFO)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Unload(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P1, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)
Fly(P3, SFO, JFK)
Fly(P1, JFK, ATL)
Unload(C3, P3, JFK)
Fly(P1, ATL, SFO)
Fly(P2, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C1, P3, SFO)
Fly(P3, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P1, ATL, JFK)
Fly(P2, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P3, ATL, SFO)
Load(C3, P1, JFK)
Fly(P2, SFO, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P1, SFO, JFK)
Load(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P3, SFO, JFK)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Unload(C3, P1, SFO)
Fly(P2, SFO, ATL)
Unload(C2, P3, SFO)
Load(C3, P1, SFO)
Fly(P2, ATL, JFK)
Fly(P3, SFO, ATL)
Fly(P2, JFK, SFO)
Fly(P3, ATL, JFK)
Fly(P1, SFO, ATL)

Fly(P3, JFK, SFO)
Fly(P1, ATL, JFK)
Load(C2, P2, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Unload(C3, P1, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Load(C1, P1, SFO)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)

Fly(P1, SFO, JFK)
Load(C2, P3, ATL)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P3, SFO, JFK)
Fly(P2, ATL, SFO)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, SFO)
Fly(P3, ATL, SFO)
Unload(C3, P1, SFO)
Fly(P2, SFO, ATL)
Unload(C2, P3, SFO)
Load(C3, P1, SFO)
Fly(P2, ATL, JFK)
Fly(P3, SFO, ATL)
Fly(P2, JFK, SFO)
Fly(P3, ATL, JFK)
Fly(P1, SFO, ATL)
Fly(P3, JFK, SFO)

```
Fly(P1, ATL, JFK)
Load(C2, P2, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, ATL)
Unload(C3, P1, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Load(C1, P1, SFO)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P2, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Fly(P3, SFO, JFK)
Unload(C2, P2, SFO)
Fly(P2, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P2, ATL, SFO)
Unload(C1, P1, ATL)
Fly(P1, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, JFK)
Fly(P1, SFO, ATL)
Fly(P3, JFK, ATL)
Fly(P1, ATL, JFK)
Fly(P3, ATL, SFO)
Fly(P2, JFK, ATL)
Load(C3, P2, ATL)
```



```
Fly(P2, ATL, SFO)
Fly(P3, SFO, ATL)
Fly(P2, SFO, JFK)
Fly(P3, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P2, JFK, ATL)
Fly(P3, JFK, ATL)
Load(C1, P3, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Fly(P3, ATL, JFK)
Fly(P2, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ATL)
Fly(P3, JFK, SFO)
Fly(P1, ATL, SFO)
Unload(C3, P2, JFK)
Fly(P3, SFO, ATL)
Fly(P1, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P3, ATL, JFK)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C1, P3, JFK)
Fly(P2, SFO, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Fly(P3, JFK, ATL)
Fly(P1, JFK, ATL)
Fly(P3, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C3, P2, JFK)
Fly(P3, SFO, ATL)
Fly(P2, JFK, ATL)
Fly(P1, SFO, ATL)
Fly(P2, ATL, SFO)
Fly(P3, ATL, SFO)
Fly(P1, ATL, JFK)
Fly(P3, SFO, JFK)
Unload(C3, P2, SFO)
```

- Problem 3 initial state and goal:


```

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(C4, ORD)
    ∧ At(P1, SFO) ∧ At(P2, JFK)
    ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4)
    ∧ Plane(P1) ∧ Plane(P2)
    ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL) ∧ Airport(ORD))
Goal(At(C1, JFK) ∧ At(C3, JFK) ∧ At(C2, SFO) ∧ At(C4, SFO))

```

- RESULT: Problem 3 - astar_search with h_1

Solving Air Cargo Problem 3 using astar_search with h_1...

Expansions	Goal Tests	New Nodes
18223	18225	159618

Plan length: 12 Time elapsed in seconds: 43.55415961300605

```

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ATL, JFK)
Unload(C4, P2, SFO)
Unload(C3, P1, JFK)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

```

- RESULT: Problem 3 - uniform cost search

Solving Air Cargo Problem 3 using uniform_cost_search...

Expansions	Goal Tests	New Nodes
18223	18225	159618

Plan length: 12 Time elapsed in seconds: 48.96890531799727

```

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ATL, JFK)
Unload(C4, P2, SFO)
Unload(C3, P1, JFK)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

```

- RESULT: Problem 2 - breadth first search

Solving Air Cargo Problem 2 using breadth_first_search...

Expansions	Goal Tests	New Nodes
3343	4609	30509

Plan length: 9 Time elapsed in seconds: 7.134153706996585

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Load(C3, P3, ATL)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)

- o RESULT: Problem 3 - depth first graph search

Solving Air Cargo Problem 3 using depth_first_graph_search...

Expansions	Goal Tests	New Nodes
408	409	3364

Plan length: 392 Time elapsed in seconds: 1.56169097199745

Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C2, P1, JFK)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Unload(C2, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C2, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Load(C3, P1, ATL)
Fly(P1, ATL, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, SFO)
Unload(C3, P1, JFK)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Unload(C2, P2, JFK)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)

Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C3, P1, JFK)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, SFO)
Fly(P2, ATL, JFK)
Unload(C3, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C3, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, SFO)
Load(C1, P1, SFO)
Fly(P2, ATL, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, JFK)
Unload(C3, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Unload(C1, P1, ATL)
Fly(P1, ATL, ORD)
Fly(P2, SFO, ORD)
Fly(P1, ORD, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, JFK)
Load(C3, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Unload(C3, P2, ATL)
Fly(P2, ATL, ORD)
Fly(P1, ATL, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ORD, SFO)
Fly(P2, SFO, JFK)
Fly(P1, SFO, JFK)
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C2, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Load(C3, P1, ATL)
Fly(P1, ATL, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, JFK)

Fly(P2, ATL, SFO)
 Unload(C3, P1, JFK)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Load(C3, P2, JFK)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, SFO)
 Fly(P1, ATL, JFK)
 Fly(P2, SFO, ATL)
 Load(C1, P2, ATL)
 Fly(P2, ATL, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, SFO)
 Fly(P1, ORD, ATL)
 Fly(P2, SFO, JFK)
 Fly(P1, ATL, SFO)
 Unload(C3, P2, JFK)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, SFO)
 Fly(P1, ATL, JFK)
 Load(C3, P1, JFK)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Unload(C3, P1, SFO)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Fly(P2, ATL, SFO)
 Unload(C1, P2, SFO)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)

Load(C3, P1, ATL)
 Fly(P1, ATL, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, SFO)
 Fly(P2, ORD, ATL)
 Fly(P1, SFO, JFK)
 Fly(P2, ATL, SFO)
 Unload(C3, P1, JFK)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Load(C3, P2, JFK)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, SFO)
 Fly(P1, ATL, JFK)
 Fly(P2, SFO, ATL)
 Load(C1, P2, ATL)

Fly(P2, ATL, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, SFO)
Unload(C3, P2, JFK)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, SFO)
Fly(P1, ATL, JFK)
Load(C3, P1, JFK)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Unload(C3, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Unload(C1, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Load(C3, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, JFK)
Fly(P2, ORD, ATL)
Unload(C3, P1, JFK)
Fly(P2, ATL, JFK)
Fly(P1, JFK, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Load(C4, P2, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ATL, ORD)
Fly(P2, ATL, SFO)
Fly(P1, ORD, SFO)
Fly(P2, SFO, JFK)
Fly(P1, SFO, JFK)
Unload(C4, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C2, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Unload(C2, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C1, P2, SFO)
Fly(P2, SFO, ORD)


```

Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Unload(C1, P2, JFK)
Fly(P2, JFK, ORD)
Load(C4, P1, JFK)
Fly(P2, ORD, ATL)
Fly(P1, JFK, ORD)
Fly(P2, ATL, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, SFO)
Unload(C4, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C4, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Load(C3, P2, JFK)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Unload(C4, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Load(C2, P2, JFK)
Fly(P1, ATL, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, SFO)
Unload(C3, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, SFO)
Unload(C2, P2, JFK)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Load(C2, P1, JFK)
Fly(P2, ATL, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, SFO)
Unload(C2, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)

```

Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Load(C1, P1, JFK)
 Fly(P2, ATL, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, SFO)

Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Fly(P2, ATL, SFO)
 Load(C4, P2, SFO)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Load(C3, P2, JFK)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Fly(P2, ATL, SFO)
 Unload(C4, P2, SFO)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Load(C2, P2, JFK)
 Fly(P1, ATL, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, SFO)
 Fly(P2, ORD, ATL)
 Fly(P1, SFO, JFK)
 Fly(P2, ATL, SFO)
 Unload(C3, P2, SFO)
 Fly(P2, SFO, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, ATL)
 Fly(P1, ORD, ATL)
 Fly(P2, ATL, JFK)
 Fly(P1, ATL, SFO)
 Unload(C2, P2, JFK)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Load(C2, P1, JFK)
 Fly(P2, ATL, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, SFO)
 Fly(P1, ORD, ATL)
 Fly(P2, SFO, JFK)
 Fly(P1, ATL, SFO)
 Unload(C2, P1, SFO)
 Fly(P1, SFO, ORD)
 Fly(P2, JFK, ORD)
 Fly(P1, ORD, ATL)
 Fly(P2, ORD, ATL)
 Fly(P1, ATL, JFK)
 Load(C1, P1, JFK)
 Fly(P2, ATL, ORD)
 Fly(P1, JFK, ORD)
 Fly(P2, ORD, SFO)
 Fly(P1, ORD, ATL)
 Fly(P2, SFO, JFK)
 Fly(P1, ATL, SFO)

```

Load(C1, P1, SFO)
Unload(C1, P1, SFO)
Fly(P1, SFO, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, JFK)
Fly(P2, ATL, SFO)
Load(C4, P2, SFO)
Fly(P2, SFO, ATL)
Fly(P1, JFK, ORD)
Fly(P2, ATL, JFK)
Fly(P1, ORD, ATL)
Fly(P2, JFK, ORD)
Fly(P1, ATL, SFO)
Load(C3, P1, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, ORD)
Fly(P2, ATL, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Unload(C4, P2, JFK)
Fly(P1, ATL, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, SFO)
Fly(P2, ORD, ATL)
Fly(P1, SFO, JFK)
Fly(P2, ATL, SFO)
Load(C4, P1, JFK)
Fly(P2, SFO, ORD)
Fly(P1, JFK, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, ORD)
Fly(P2, ATL, SFO)
Fly(P1, ORD, SFO)
Load(C2, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Unload(C2, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Load(C1, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Unload(C1, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Load(C3, P1, ORD)

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```

Fly(P1, ORD, ATL)
Fly(P2, ATL, ORD)
Fly(P1, ATL, SFO)
Fly(P2, ORD, SFO)
Fly(P1, SFO, JFK)
Load(C4, P1, JFK)
Fly(P2, SFO, JFK)
Fly(P1, JFK, ORD)
Fly(P2, JFK, ORD)
Fly(P1, ORD, ATL)
Fly(P2, ORD, ATL)
Fly(P1, ATL, SFO)
Unload(C4, P1, SFO)
Fly(P2, ATL, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, SFO)
Fly(P1, ORD, ATL)
Fly(P2, SFO, JFK)
Fly(P1, ATL, JFK)
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Fly(P1, JFK, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, SFO)
Fly(P1, ATL, SFO)
Unload(C2, P2, SFO)
Fly(P2, SFO, ORD)
Fly(P1, SFO, ORD)
Fly(P2, ORD, ATL)
Fly(P1, ORD, ATL)
Fly(P2, ATL, JFK)
Fly(P1, ATL, JFK)
Unload(C3, P1, JFK)

```

Comparing 3 uniformed planning algorithms & A*

- Problem 1:
 - Best perform: **breadth_first**
 - Key metrics comparing to the others algorithms: All algorithms, except the depth first, found the best solution (less actions), but breadth was the cheapest algorithm (expanded less nodes). The best solution had ~3x less actions than the depth first algorithm solution. All the key metrics (number of node expansions, goal tests & new nodes) were the same for astar & uniform, but astar was a little bit faster than the uniform_cost;
- Problem 2:
 - Best perform: **breadth_first**
 - Key metrics comparing to the others algorithms: All algorithms, except the depth first, found the best solution (less actions), but breadth was the cheapest algorithm (expanded less nodes). The best solution had ~68,77x than the depth first algorithm solution. All the key metrics (number of node expansions, goal tests & new nodes) were the

same for astar & uniform, but uniform_cost_search was a little bit faster;

- Problem 3:
 - Best perform: **breadth_first**
 - Key metrics comparing to the others algorithms: All algorithms, except the depth first, found the best solution (less actions), but breadth was the cheapest algorithm (expanded less nodes). The best solution had ~32,66x than the depth first algorithm solution. All the key metrics (number of node expansions, goal tests & new nodes) were the same for astar & uniform, but uniform_cost_search was a little bit faster;

Comparing A* with level-sum & ignore-preconditions

Key Metrics: Expansions; Goal Test; New Nodes; Plan Length (solution); Spent Time.

Problem 1 Table

Tables	Expan.	Goal Tests	New Nodes	Plan Length	Spent Time
astar	4853	57	224	6	0.030
h_levelsum	11	13	50	6	0.551
h_ignore_preconditions	41	43	170	6	0.030

For the Problem1, about the time to take a decision, the A* was the best algorithm, but about the less expansion metric

the best algorithm was the levelsum. Selecting a "middle term", the best was the ignore_predictions, that found the solution using a bit more time than the A* and expanding a bit more, comparing to levelsum.

Problem 2 Table

Tables	Expan.	Goal Tests	New Nodes	Plan Length	Spent Time
astar	4853	4855	44041	9	11.131

h_levelsum	86	88	841	9	44.135
h_ignore_preconditions	1450	1452	13303	9	4.4341

For the Problem2, about the time to take the best decision, the ignore_predictions was the best algorithm, but about the one that less expanded, the winner was the levelsum, but it took so long time to find the solution.

Problem 3 Table

Tables	Expan.	Goal Tests	New Nodes	Plan Length	Spent Time
astar	18223	18225	159618	12	49.961
h_levelsum	325	327	3002	12	234.37
h_ignore_preconditions	5040	5042	44944	12	18.444

For the Problem3, about the time to take the best decision, the ignore_predictions was the winner algorithm, but about the one that less expanded, the winner was the levelsum, but it took so long time to find the solution.

As a result is clear that the levelsum use less visits/expansions, but it logics takes so much longer to execute, so it is not so efficiently, the ignore_predictions, instead, perform more expansions, but it logic is so "time-cheap".

Reason for each result

The depth first grown up it expansion of nodes exponentially, getting worse for each problem. According to the classes videos, it is caused by the search algorithm which search in the depth level for each branch, taking a long way to the solution. The breadth first was the best because it only consider the shortest path instead of the cheapest total cost, this way it expanded less nodes & got the answer faster than the A* and the Uniform Cost.