

Air Cargo Planning Search Performance Analysis



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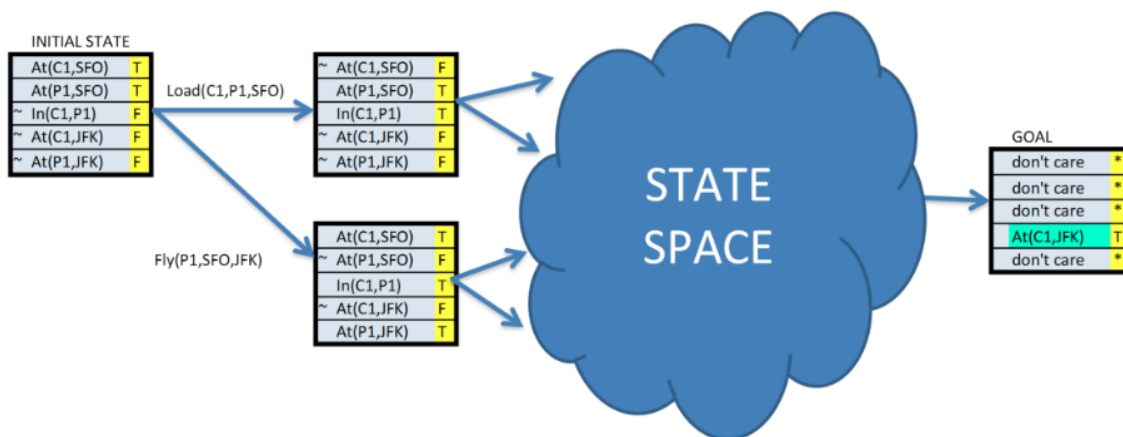
Performance Analysis Overview

1. Optimal plan for each scenario.
2. Compare and contrast non-heuristic search result metrics (optimality, time elapsed, number of node expansions) for all scenarios.
 - a. Breadth-first search
 - b. Depth-first search
 - c. one other uninformed non-heuristic search in your comparison; Your third choice of non-heuristic search may be skipped for Problem 3 if it takes longer than 10 minutes to run, but a note in this case should be included.
3. Compare and contrast heuristic search result metrics using A* with the "ignore preconditions" and "level-sum" heuristics for each scenario.
 - a. Best heuristic used in these scenarios?
 - b. Better than non-heuristic search planning methods for all problems? Why or why not?
 - c. Tables or other visual aids as needed for clarity in your discussion.

Optimal Planning: Scenario One

The initial state is that cargo one is at SFO and cargo two is at JFK. Plane one is at SFO and Plane two is at JFK. The goal is to get cargo one to JFK and cargo two to SFO.

Here is a graphical representation of the problem space after implemented in Planning Domain Definition Language.



The below table outlines the performance for each search method on scenario 1. Greedy Breadth First Graph Search performed the best and is presented as the optimal solution for scenario one.

Problem	Search	Expansions	Goal Tests	New Nodes	Plan Length	Time (sec)
1	BFS	43	56	180	6	0.0645
1	BFTS	1458	1459	5960	6	0.84789
1	DFGS	12	13	48	12	0.007
1	DLS	101	271	414	50	0.077
1	UCS	55	57	224	6	0.0398
1	RBFS_H1	4229	4230	17029	6	2.41
1	GBFGS_H1	7	8	28	6	0.004
1	A*_H1	55	57	224	6	0.033
1	A*_HIP	41	43	170	6	0.026
1	A*_HPGLS	11	13	50	6	0.7

Optimal Planning: Scenario Two

```
python run_search.py -p 2 -s 1 2 3 4 5 6 7 8 9 10
```

The below table outlines the performance for each search method on scenario 2. A*with H Ignore Preconditions performed best and is presented as the optimal solution for scenario two.

Problem	Search	Expansions	Goal Tests	New Nodes	Plan Length	Time (sec)
2	BFS	3346	4612	30534	9	1.969
2*	BFTS					
2	DFGS	1124	1125	10017	1085	0.745
2*	DLS					
2	UCS	4853	4855	44041	9	2.4732
2*	RBFS_H1					
2	GBFGS_H1	998	1000	8982	21	0.5964
2	A*_H1	4853	4855	44041	9	2.433
2	A*_HIP	1450	1452	13303	9	0.98
2	A*_HPGLS	86	88	841	9	9.612

*Performance exceeded 10 minutes.

Optimal Planning: Scenario Three

```
python run_search.py -p 3 -s 1 2 3 4 5 6 7 8 9 10
```

The below table outlines the performance for each search method on scenario 3. A* with H Ignore Preconditions performed best and is presented as the optimal solution for scenario three.

Problem	Search	Expansions	Goal Tests	New Nodes	Plan Length	Time (sec)
3	BFS	14120	17673	124926	12	9.96
3*	BFTS					
3	DFGS	667	678	5608	660	0.48
3*	DLS					
3	UCS	18223	18225	159618	12	8.723
3*	RBFS_H1					
3	GBFGS_H1	5578	5580	49150	22	2.85
3	A*_H1	18223	18225	159618	12	8.87
3	A*_HIP	5040	5042	44944	12	2.868
3	A*_HPGLS	325	327	3002	12	47.669

*Performance exceeded 10 minutes.

Analysis

Breadth First Tree Search, Recursive Best First Search with H1, and Depth Limited Search exceeded the max search time of 10 minutes for scenarios two and three.

In general terms we can observe that DFS does not provide an optimal plan since the plan is generated based on downward graph progression. This creates solutions that are correct, but not optimal (minimum length).

The fastest and slowest uninformed algorithms are Depth First Graph Search and Breadth First Tree Search respectively. This is due to many more nodes and expansions relative to the other uninformed searches.

The fastest and slowest heuristic searches are Greedy Best First Graph Search with H1 and Recursive Best First Search with H1 respectively. GBFGS w/H1 has minimal node growth and expansion with RBFS w/H1 has the largest node count and number of expansions.

A* Search w/H PG Levelsum had the lowest node expansions and goal tests. This placed the performance about 14 times slower than A* Search with H Ignore Preconditions, demonstrating the tradeoff between minimizing system resources and search speed..


Conclusion

Overall I found that A*with H Ignore Preconditions performed best across the three different scenarios. This performed better than level search and H1 search attempts. These findings are consistent with those outlined in Chapters 10 and 11 [1] and the Udacity Planning lecture.

A just in time compiler, pypy3, was used to accelerate runtime performance

[Planning Domain Definition Language](#) (PDDL) was used to define each of the three situations described here as search problems. The PDDL stores states as a knowledge base consisting of first order logic statements. The conjunction of these logical statements completely defines a state.

Stepping back from why we use PDDL and what it is, the value is in understanding how this can be applied to other domains. Any planning graph can become an exponential tree that represents all possible paths. We create and use a planning graph to provide a polynomial-size



approximation of the exponential tree and used to provide automated admissible heuristics for any domain.

Hat Tip to Yan Holts for this: <https://python-graph-gallery.com/>

References

[1] Artificial Intelligence: A Modern Approach, Chaps 10 and 11, (<http://aima.cs.berkeley.edu>)

■ ■ ■

Appendix: Runtime Output for 30 Cases

```
python run_search.py -p 1 -s 1 2 3 4 5 6 7 8 9 10
```

Solving Air Cargo Problem 1 using breadth_first_search...

Expansions Goal Tests New Nodes

43 56 180

Plan length: 6 Time elapsed in seconds: 0.06485217295366726

Load(C2, P2, JFK)

Load(C1, P1, SFO)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)


Unload(C1, P1, JFK)

Solving Air Cargo Problem 1 using breadth_first_tree_search...

Expansions Goal Tests New Nodes

1458 1459 5960

Plan length: 6 Time elapsed in seconds: 0.8478977333955962



Load(C2, P2, JFK)

Load(C1, P1, SFO)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 1 using depth_first_graph_search...

Expansions Goal Tests New Nodes

12 13 48

Plan length: 12 Time elapsed in seconds: 0.00705042514868659

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Load(C1, P2, SFO)

Fly(P2, SFO, JFK)

Fly(P1, JFK, SFO)

Unload(C1, P2, JFK)

Fly(P2, JFK, SFO)

Fly(P1, SFO, JFK)

Load(C2, P1, JFK)

Fly(P2, SFO, JFK)



Fly(P1, JFK, SFO)

Unload(C2, P1, SFO)

Solving Air Cargo Problem 1 using depth_limited_search...

Expansions Goal Tests New Nodes

101 271 414

Plan length: 50 Time elapsed in seconds: 0.07701201551779868

Load(C2, P2, JFK)

Load(C1, P1, SFO)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)


Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)



Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)


Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)



Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Unload(C2, P2, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 1 using uniform_cost_search...

Expansions Goal Tests New Nodes

55 57 224


Plan length: 6 Time elapsed in seconds: 0.03981824059772254

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)



Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

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

Expansions Goal Tests New Nodes

4229 4230 17029

Plan length: 6 Time elapsed in seconds: 2.4107893345922724

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)


Unload(C1, P1, JFK)

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

Expansions Goal Tests New Nodes

7 9 28

Plan length: 6 Time elapsed in seconds: 0.004469256900648144



Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

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

Expansions	Goal Tests	New Nodes
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55	57	224
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Plan length: 6 Time elapsed in seconds: 0.03297949177156401

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

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

Expansions Goal Tests New Nodes

41 43 170

Plan length: 6 Time elapsed in seconds: 0.026115726652742755

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

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

Expansions Goal Tests New Nodes

11 13 50

Plan length: 6 Time elapsed in seconds: 0.6698904542958748

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

Optimal Planning: Scenario Two

```
python run_search.py -p 2 -s 1 2 3 4 5 6 7 8 9 10
```

The initial state is that cargo one is at SFO and

```
pypy3 run_search.py -p 2 -s 1
```

Solving Air Cargo Problem 2 using breadth_first_search...

Expansions Goal Tests New Nodes

3346 4612 30534

Plan length: 9 Time elapsed in seconds: 1.96905577999999624

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Load(C3, P3, ATL)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

```
pypy3 run_search.py -p 2 -s 2
```


*Performance exceeded 10 minutes.

`pypy3 run_search.py -p 2 -s 3`

Solving Air Cargo Problem 2 using `depth_first_graph_search...`

Expansions Goal Tests New Nodes

1124 1125 10017

Plan length: 1085 Time elapsed in seconds: 0.7453566859999228

Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, SFO)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Load(C2, P3, JFK)


Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)



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



Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Load(C1, P3, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, ATL, JFK)

Load(C3, P1, ATL)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, JFK, SFO)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P1, ATL, JFK)


Unload(C1, P3, JFK)

Fly(P3, JFK, ATL)


Fly(P1, JFK, ATL)

Fly(P2, SFO, ATL)


Fly(P3, ATL, JFK)




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



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



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



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



Unload(C3, P2, JFK)

Fly(P2, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, SFO)

Fly(P1, ATL, JFK)

Load(C3, P1, JFK)

Fly(P1, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P3, JFK, SFO)

Fly(P2, ATL, JFK)

Unload(C3, P1, SFO)

Fly(P2, JFK, SFO)

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




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



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



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



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

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Load(C2, P3, ATL)

Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)

Unload(C2, P3, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)


Fly(P1, ATL, SFO)

Load(C1, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)



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



Fly(P3, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, JFK)

Load(C2, P3, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, JFK, ATL)

Unload(C3, P2, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, 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)



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



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

Fly(P1, JFK, ATL)

Load(C2, P2, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P2, JFK, SFO)

Fly(P1, JFK, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Unload(C2, P2, SFO)

Fly(P1, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P2, SFO, ATL)


Fly(P3, ATL, SFO)

Fly(P2, ATL, JFK)


Fly(P1, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, SFO)



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



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



Fly(P1, SFO, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P1, JFK, ATL)

Load(C3, P3, JFK)

Fly(P1, ATL, SFO)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Load(C1, P3, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)



Fly(P1, ATL, SFO)

Fly(P2, JFK, ATL)

Load(C2, P3, SFO)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P1, JFK, SFO)

Fly(P2, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Unload(C2, P3, ATL)



Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)

Fly(P3, JFK, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Load(C2, P2, 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)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)


Load(C3, P3, SFO)

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

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Load(C1, P1, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Unload(C2, P2, SFO)

Fly(P1, ATL, SFO)

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



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



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



Unload(C1, P1, ATL)

Fly(P1, ATL, JFK)

Fly(P3, SFO, ATL)

Fly(P1, JFK, SFO)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P3, JFK, SFO)

Load(C2, P2, ATL)

Fly(P2, ATL, JFK)

Fly(P3, SFO, ATL)

Unload(C2, P2, JFK)

Fly(P3, ATL, JFK)

Fly(P2, JFK, SFO)

Fly(P3, JFK, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P2, SFO, ATL)

Load(C1, P3, ATL)


Fly(P3, ATL, SFO)

Fly(P2, ATL, JFK)


Load(C2, P1, JFK)

Fly(P1, JFK, ATL)


Fly(P2, JFK, ATL)




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



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



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



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



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



Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, JFK)

Load(C2, P1, JFK)

Fly(P1, JFK, ATL)

Unload(C1, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, SFO)

Fly(P3, JFK, ATL)

Load(C1, P1, SFO)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)


Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)


Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P1, JFK, SFO)



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



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



Fly(P1, ATL, JFK)

Fly(P3, SFO, JFK)

Fly(P2, SFO, ATL)

Load(C1, P2, ATL)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, JFK, SFO)

Fly(P1, ATL, JFK)

Unload(C3, P2, SFO)

Fly(P1, JFK, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)


Load(C2, P3, ATL)

Fly(P3, ATL, JFK)


Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)


Fly(P3, JFK, ATL)




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




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




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



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



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



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



Unload(C3, P1, JFK)

Fly(P1, JFK, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, JFK)

Load(C3, P2, JFK)

Unload(C2, P1, SFO)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)

Unload(C3, P2, SFO)

`pypy3 run_search.py -p 2 -s 4`

Solving Air Cargo Problem 2 using `depth_limited_search...`

Timeout

`pypy3 run_search.py -p 2 -s 5`

Solving Air Cargo Problem 2 using `uniform_cost_search...`

Expansions Goal Tests New Nodes

4853 4855 44041

Plan length: 9 Time elapsed in seconds: 2.4732374099999106

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)

`python3 run_search.py -p 2 -s 6`

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

*timeout

`python3 run_search.py -p 2 -s 7`

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



Expansions Goal Tests New Nodes

998 1000 8982

Plan length: 21 Time elapsed in seconds: 0.5963665700001002

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Load(C3, P3, ATL)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Unload(C2, P2, SFO)

Fly(P2, SFO, ATL)

Fly(P3, JFK, SFO)

Load(C2, P3, SFO)

Fly(P3, SFO, JFK)

Fly(P1, ATL, JFK)

Unload(C1, P1, JFK)

Load(C1, P3, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, SFO)

Unload(C3, P3, SFO)

Unload(C2, P3, SFO)

Fly(P3, SFO, JFK)



Unload(C1, P3, JFK)

`python3 run_search.py -p 2 -s 8`

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: 2.4339690850001716

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)

`python3 run_search.py -p 2 -s 9`

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

Expansions Goal Tests New Nodes

1450 1452 13303

Plan length: 9 Time elapsed in seconds: 0.9818611729999702

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

pypy3 run_search.py -p 2 -s 10

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

Expansions Goal Tests New Nodes

86 88 841

Plan length: 9 Time elapsed in seconds: 9.612501326000029

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)



Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

`python3 run_search.py -p 3 -s 1`

Solving Air Cargo Problem 3 using breadth_first_search...

Expansions Goal Tests New Nodes

14120 17673 124926

Plan length: 12 Time elapsed in seconds: 9.968324875000008

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(P1, ATL, JFK)

Unload(C1, P1, JFK)



Unload(C3, P1, JFK)

Fly(P2, ORD, SFO)

Unload(C2, P2, SFO)

Unload(C4, P2, SFO)

pypy3 run_search.py -p 3 -s 2

Solving Air Cargo Problem 3 using breadth_first_tree_search...

*timeout

pypy3 run_search.py -p 3 -s 3

Solving Air Cargo Problem 3 using depth_first_graph_search...

Expansions Goal Tests New Nodes

677 678 5608


Plan length: 660 Time elapsed in seconds: 0.48077487900013693

Fly(P2, JFK, ORD)


Fly(P1, SFO, ORD)

Fly(P2, ORD, ATL)

Fly(P1, ORD, ATL)



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



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



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



Fly(P2, ORD, JFK)

Fly(P1, ORD, ATL)

Unload(C3, P2, JFK)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ORD)

Fly(P1, JFK, ORD)

Fly(P2, ORD, ATL)

Fly(P1, ORD, SFO)

Load(C2, P2, ATL)

Fly(P2, ATL, ORD)

Fly(P1, SFO, ORD)

Fly(P2, ORD, JFK)

Fly(P1, ORD, ATL)

Fly(P2, JFK, SFO)

Fly(P1, ATL, JFK)

Unload(C2, P2, SFO)

Fly(P1, JFK, ORD)

Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, SFO)

Fly(P2, ATL, JFK)

Load(C3, P2, JFK)

Fly(P2, JFK, ORD)



Fly(P1, SFO, ORD)

Fly(P2, ORD, ATL)

Fly(P1, ORD, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)

Unload(C3, P2, SFO)

Fly(P1, JFK, ORD)

Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, SFO)

Fly(P2, ATL, JFK)

Load(C1, P2, JFK)

Fly(P2, JFK, ORD)

Fly(P1, SFO, ORD)

Fly(P2, ORD, ATL)

Fly(P1, ORD, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)


Unload(C1, P2, SFO)

Fly(P1, JFK, ORD)


Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)


Fly(P2, ORD, ATL)




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



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



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

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)


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



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



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



Fly(P1, ATL, JFK)

Unload(C2, P2, SFO)

Fly(P1, JFK, ORD)

Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, SFO)

Fly(P2, ATL, JFK)

Load(C2, P1, SFO)

Fly(P2, JFK, ORD)

Fly(P1, SFO, ORD)

Fly(P2, ORD, ATL)

Fly(P1, ORD, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, JFK)

Unload(C2, P1, JFK)

Fly(P1, JFK, ORD)

Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)

Load(C4, P1, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ORD)



Fly(P2, JFK, SFO)

Fly(P1, ORD, SFO)

Unload(C4, P1, 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)

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, JFK)

Fly(P1, ORD, ATL)


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




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



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



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



Fly(P1, ORD, ATL)

Fly(P2, ATL, SFO)

Load(C4, P1, ATL)

Fly(P1, ATL, ORD)

Fly(P2, SFO, JFK)

Fly(P1, ORD, JFK)

Fly(P2, JFK, ORD)

Fly(P1, JFK, SFO)

Fly(P2, ORD, ATL)

Unload(C4, P1, SFO)

Fly(P2, ATL, JFK)

Fly(P1, SFO, ORD)

Fly(P2, JFK, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ORD, SFO)

Fly(P1, ATL, JFK)

Load(C1, P1, JFK)

Fly(P1, JFK, ORD)

Fly(P2, SFO, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, SFO)

Fly(P2, ATL, JFK)

Load(C4, P1, SFO)



Fly(P2, JFK, ORD)

Fly(P1, SFO, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, ORD)

Unload(C1, P1, ORD)

Fly(P1, ORD, ATL)

Fly(P2, ATL, ORD)

Fly(P1, ATL, JFK)

Fly(P2, ORD, JFK)

Fly(P1, JFK, SFO)

Fly(P2, JFK, SFO)

Unload(C4, P1, SFO)

Fly(P2, SFO, ORD)

Fly(P1, SFO, ATL)

Fly(P2, ORD, ATL)

Fly(P1, ATL, ORD)

Load(C3, P2, ATL)

Fly(P1, ORD, JFK)

Fly(P2, ATL, ORD)


Fly(P1, JFK, ATL)

Fly(P2, ORD, JFK)


Fly(P1, ATL, SFO)

Fly(P2, JFK, SFO)


Unload(C3, P2, SFO)



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



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



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



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



Fly(P2, ORD, ATL)

Fly(P1, ATL, SFO)

Load(C1, P2, ATL)

Fly(P2, ATL, ORD)

Fly(P1, SFO, ORD)

Fly(P2, ORD, JFK)

Fly(P1, ORD, ATL)

Unload(C1, P2, JFK)

python3 run_search.py -p 3 -s 4

Solving Air Cargo Problem 3 using depth_limited_search...

*timeout

python3 run_search.py -p 3 -s 5

Solving Air Cargo Problem 3 using uniform_cost_search...

Expansions Goal Tests New Nodes

18223 18225 159618

Plan length: 12 Time elapsed in seconds: 8.723444427999993

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)

Optimal Planning: Scenario Three

```
pypy3 run_search.py -p 3 -s 6
```

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

*timeout

```
pypy3 run_search.py -p 3 -s 7
```

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

Expansions Goal Tests New Nodes

5578 5580 49150

Plan length: 22 Time elapsed in seconds: 2.84968935400002

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P1, SFO, ORD)

Load(C4, P1, ORD)

Fly(P2, JFK, ATL)

Load(C3, P2, ATL)

Fly(P2, ATL, ORD)

Fly(P1, ORD, ATL)

Unload(C4, P1, ATL)

Fly(P1, ATL, ORD)

Fly(P2, ORD, ATL)

Load(C4, P2, ATL)

Fly(P2, ATL, ORD)

Unload(C3, P2, ORD)

Load(C3, P1, ORD)

Fly(P1, ORD, JFK)

Unload(C3, P1, JFK)

Unload(C1, P1, JFK)



Fly(P1, JFK, ORD)

Fly(P2, ORD, SFO)

Unload(C4, P2, SFO)

Unload(C2, P2, SFO)

`pypy3 run_search.py -p 3 -s 8`

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: 8.868754142999933

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)

`python3 run_search.py -p 3 -s 9`

Solving Air Cargo Problem 3 using `astar_search` with `h_ignore_preconditions...`

Expansions Goal Tests New Nodes

5040 5042 44944

Plan length: 12 Time elapsed in seconds: 2.8680524030000925

Load(C2, P2, JFK)

Fly(P2, JFK, ORD)

Load(C4, P2, ORD)

Fly(P2, ORD, SFO)

Unload(C4, P2, SFO)

Load(C1, P1, SFO)

Fly(P1, SFO, ATL)


Load(C3, P1, ATL)

Fly(P1, ATL, JFK)

Unload(C3, P1, JFK)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)



```
pypy3 run_search.py -p 3 -s 10
```

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

Expansions	Goal Tests	New Nodes
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325	327	3002
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Plan length: 12 Time elapsed in seconds: 47.669487694000054

Load(C2, P2, JFK)

Fly(P2, JFK, ORD)

Load(C4, P2, ORD)

Fly(P2, ORD, SFO)

Load(C1, P1, SFO)

Fly(P1, SFO, ATL)

Load(C3, P1, ATL)

Fly(P1, ATL, JFK)

Unload(C4, P2, SFO)

Unload(C3, P1, JFK)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

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