An optimal plan for air cargo p1 is:

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

An optimal plan for air cargo p2 is:

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)

An optimal plan for air cargo p3 is:

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(C1, P1, JFK)
Unload(C2, P2, SFO)
Unload(C3, P1, JFK)
Unload(C4, P2, SFO)

The performance metrics for three breadth first, depth first and uniform cost search are shown in Table 1 below. Overall, depth first search performs better in terms of the time spent, number of goal tests and number of node expansions, however, since it searches by first executing actions to get to states deeper in the tree, it fails to provide an optimal solution. Uniform cost search and breadth first search both provide optimal solutions, and their performances are similar in terms of number of goal tests. Uniform cost search peforms worse than breadth first search in terms of node expansions. However, as the problems gets more challenging, uniform cost search performs better than breadth first search in terms of time spent.

The performance metrics for A* search using the three different heuristic functions are shown in Table 2 below. We focus on the heuristics h ignore preconditions and h pg level sum. Both heuristics give an optimal solution, but as the problem gets more challenging, h ignore preconditions spends less time that h pg level sum. However, h ignore preconditions performs more

Table 1: Performance metrics of three uninformed search techniques

| Problem | Technique | No of node expansions | No of goal tests | Time elapsed in seconds | Optimal Solution Obtained |
|---|---|---|---|---|---|
| air cargo p1 | Breadth first search | 43 | 56 | 0.0209 | Yes |
| air cargo p1 | Depth first graph search | 21 | 22 | 0.0096 | No |
| air cargo p1 | Uniform cost search | 55 | 57 | 0.0249 | Yes |
| air cargo p2 | Breadth first search | 3346 | 4612 | 9.0769 | Yes |
| air cargo p2 | Depth first graph search | 107 | 108 | 0.2132 | No |
| air cargo p2 | Uniform cost search | 4853 | 4855 | 7.5028 | Yes |
| air cargo p3 | Breadth first search | 14663 | 18098 | 67.5347 | Yes |
| air cargo p3 | Depth first graph search | 408 | 409 | 1.1598 | No |
| air cargo p3 | Uniform cost search | 17882 | 17884 | 32.0927 | Yes |

node expansions and more goal tests.

Table 2: Performance metrics of the three heuristics using informed search technique A*

| Problem | Heuristic | No of node expansions | No of goal tests | Time elapsed in seconds | Optimal Solution Obtained |
|---|---|---|---|---|---|
| air cargo p1 | h1 | 55 | 57 | 0.0251 | Yes |
| air cargo p1 | h ignore preconditions | 41 | 43 | 0.0268 | Yes |
| air cargo p1 | h pg levelsum | 39 | 41 | 0.9640 | Yes |
| air cargo p2 | h1 | 4853 | 4855 | 7.3531 | Yes |
| air cargo p2 | h ignore preconditions | 1450 | 1452 | 2.7441 | Yes |
| air cargo p2 | h pg levelsum | 1129 | 1131 | 301.4720 | Yes |
| air cargo p3 | h1 | 17882 | 17884 | 31.3946 | Yes |
| air cargo p3 | h ignore preconditions | 5034 | 5036 | 10.6019 | Yes |
| air cargo p3 | h pg levelsum | 2025 | 2027 | 1038.5874 | Yes |

To compare performance of uninformed search to heuristic search techniques, its perhaps better to focus on the more challenging air cargo p3. In this regard, depth first search is the best technique in terms of time spent, number of node expansions and number of goal tests, however it fails to provide an optimal solution. Among the techniques that give an optimal solution the h ignore precondition heuristic performed best in terms of time spent, however h pg level sum performs best in terms of number of node expansions and number of goal tests. Overall the best heuristic is h ignore preconditions.