**Performance Analysis**

1. **Optimal Solutions**

The optimal planning solution for each of the 3 problems are described below:

* **Problem 1**

**Plan length: 6**

1. Load(C1, P1, SFO)
2. Fly(P1, SFO, JFK)
3. Load(C2, P2, JFK)
4. Fly(P2, JFK, SFO)
5. Unload(C1, P1, JFK)
6. Unload(C2, P2, SFO)

* **Problem 2**

**Plan length: 9**

1. Load(C1, P1, SFO)
2. Fly(P1, SFO, JFK)
3. Load(C2, P2, JFK)
4. Fly(P2, JFK, SFO)
5. Load(C3, P3, ATL)
6. Fly(P3, ATL, SFO)
7. Unload(C1, P1, JFK)
8. Unload(C2, P2, SFO)
9. Unload(C3, P3, SFO)

* **Problem 3**

**Plan length: 12**

1. Load(C2, P2, JFK)
2. Fly(P2, JFK, ORD)
3. Load(C4, P2, ORD)
4. Fly(P2, ORD, SFO)
5. Load(C1, P1, SFO)
6. Fly(P1, SFO, ATL)
7. Load(C3, P1, ATL)
8. Fly(P1, ATL, JFK)
9. Unload(C1, P1, JFK)
10. Unload(C2, P2, SFO)
11. Unload(C3, P1, JFK)
12. Unload(C4, P2, SFO)
13. **Non – Heuristic search methods comparison:**

The Performance analysis of few search methods are displayed below in their repective tables.

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| --- |
| **Breadth First Search** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 6 | 43 | 56 | 180 | | 2 | 9 | 3343 | 4609 | 30509 | | 3 | 12 | 14663 | 18098 | 129631 | |
| **Depth First Graph Search** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 20 | 21 | 22 | 84 | | 2 | 619 | 624 | 625 | 5602 | | 3 | 392 | 408 | 409 | 3364 | |
| **Depth Limited Search** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 50 | 101 | 271 | 414 | | 2 | 50 | 222719 | 2053741 | 2054119 | | 3 |  |  |  |  | |
| **Uniform Cost Search** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 6 | 55 | 57 | 224 | | 2 | 9 | 4780 | 4782 | 43381 | | 3 |  |  |  |  | |

1. **Automatic Heuristics Comparison:**

The Planning problem is solved with A\* search using 2 automatic heuristics - Ignore Preconditions and Levelsum heuristics. The comparison table is laid out below. It is very clear that though both of them give plan length of equal size, Level Sum(planning graph) heuristic is better in terms of node expansions and goal tests.

|  |  |
| --- | --- |
| **Ignore Preconditions** | **Levelsum** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 6 | 41 | 43 | 170 | | 2 | 9 | 1506 | 1508 | 13820 | | 3 | 12 | 5114 | 5116 | 45610 | | |  |  |  |  |  | | --- | --- | --- | --- | --- | | Problem | Plan length | Expansions | Goal Tests | New Nodes | | 1 | 6 | 11 | 13 | 50 | | 2 | 9 | 86 | 88 | 841 | | 3 | 12 | 404 | 406 | 3718 | |

**Conclusion:**

The most optimal and cost effective solution was found using A-star search with planning graph and Level Sum heuristic.