HEURISTIC ANALYSIS

FOR DETERMINISTIC LOGISTIC PLANNING PROBLEMS FOR AN AIR CARGO TRANSPORT SYSTEM USING A PLANNING SEARCH AGENT

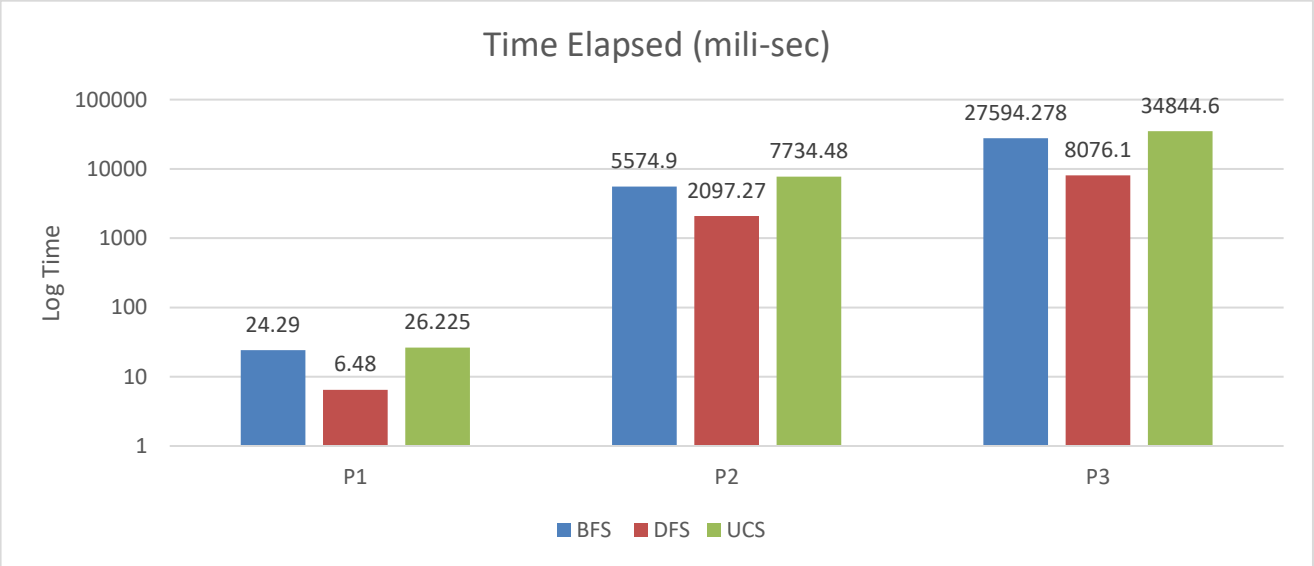
Uninformed Non-Heuristic Search:

The following table shows the result of the uninformed planning searches namely Breadth First Search(BFS), Depth First Search(DFS), and Uniform Cost Search (UCS).

Problems	Search	Plan Length	Time Elapse (secs)	Node Expended	Goal Test	Optimal
1	BFS	6	0.02429	43	56	Yes
2	BFS	9	5.57490	3343	4609	Yes
3	BFS	12	27.594	14663	18098	Yes
1	DFS	12	0.00648	12	12	No
2	DFS	575	2.09727	582	583	No
3	DFS	1451	8.0761	1501	1502	No
1	UCS	6	0.026224	55	57	Yes
2	UCS	9	7.73486	4853	4855	Yes
3	UCS	12	34.8446	18223	18225	Yes

Time Elapsed:

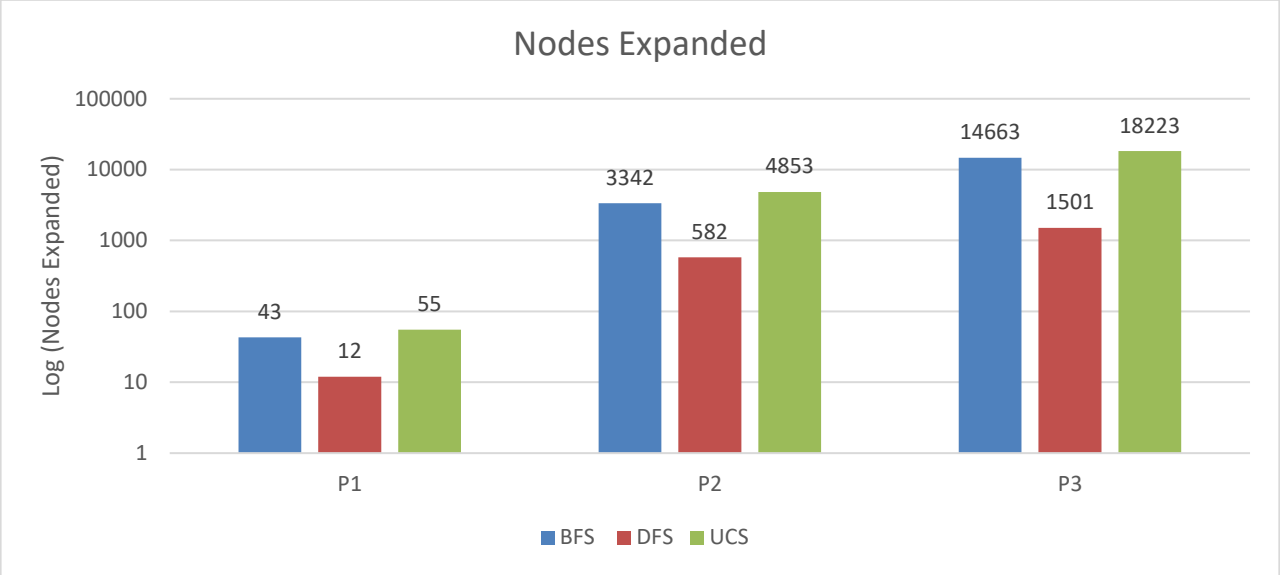
The following graph shows the time taken by different problems for various searches.



Each of the problem takes the least time for DFS followed by BFS & UCS. So DFS is the fastest search among the three.

Node Expanded:

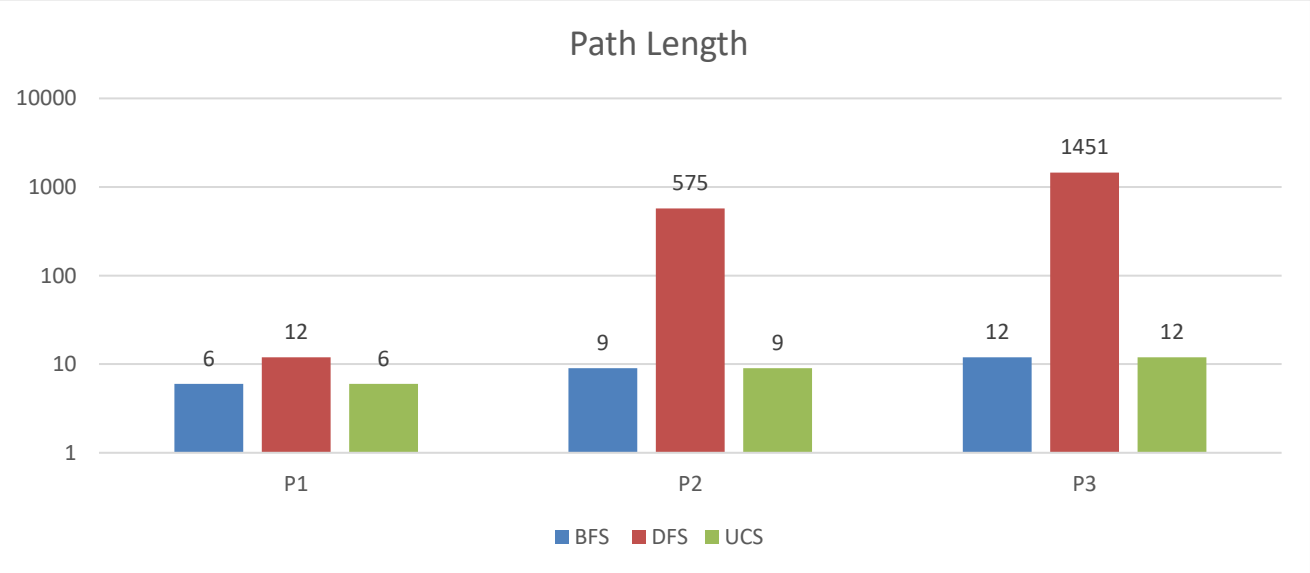
The graph shows the number of node expanded under various searches.



The UCS has the most number of nodes expanded for all the problems followed by BFS. DFS has the least nodes expanded which is the reason for its fastest execution time.

Path Length:

The optimality of the solution will depend on the path length. Least the length of the path greater its Optimality.



Since both the searches BFS &UCS have same length of path they are optimal for our solution, whereas the DFS has lengthy path, that means it is less likely for the optimality.

Heuristic Search:

The following heuristics will be discussed:

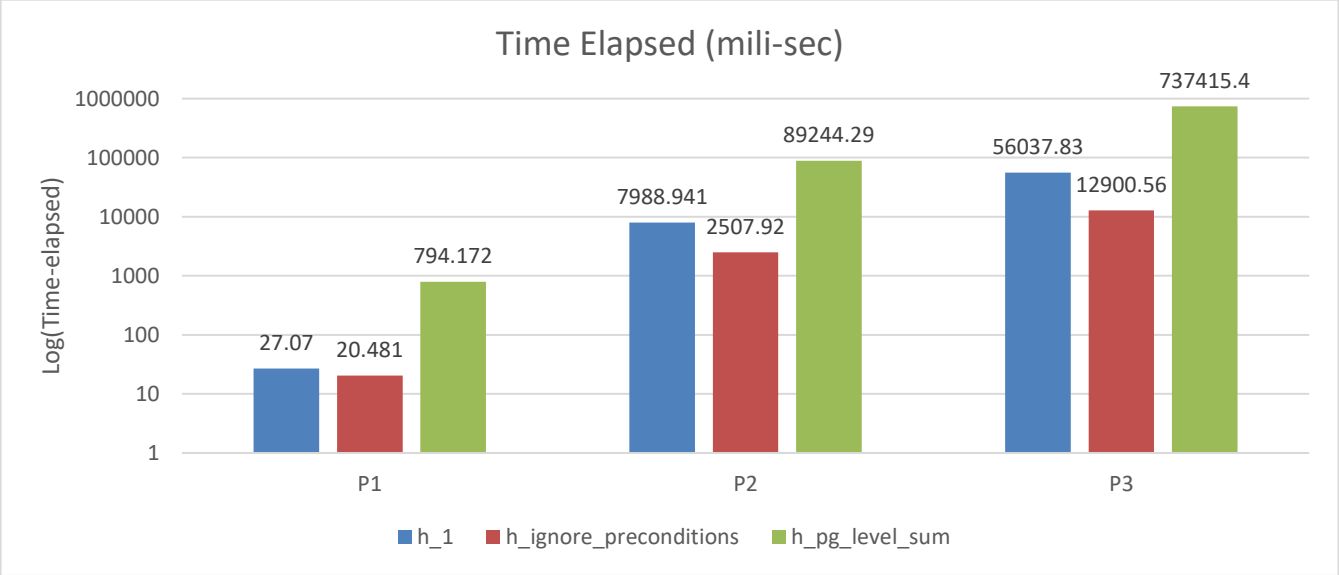
- h_1: returns 1
- h_ignore_preconditions: obtained from the suggestion given in the book "AIMA-3rd edition"
- h_pg_level_search: obtained through planning graph

We will be applying A* search over these heuristics for the 3 different problems that were discussed earlier.

Problems	Search	Plan Length	Time Elapse (sec)	Node Expended	Goal Test	Optimal
P1	h_1	6	0.02707	55	57	Yes
P1	h_ignore_preconditions	6	0.020481	41	43	Yes
P1	h_pg_level_sum	6	0.794172	11	13	Yes
P2	h_1	9	7.988941	4853	4855	Yes
P2	h_ignore_preconditions	9	2.50792	1450	1452	Yes
P2	h_pg_level_sum	9	89.24429	86	88	Yes
P3	h_1	12	56.03783	18233	18225	Yes
P3	h_ignore_preconditions	12	12.90056	5040	5042	Yes
P3	h_pg_level_sum	12	737.4154	315	317	Yes

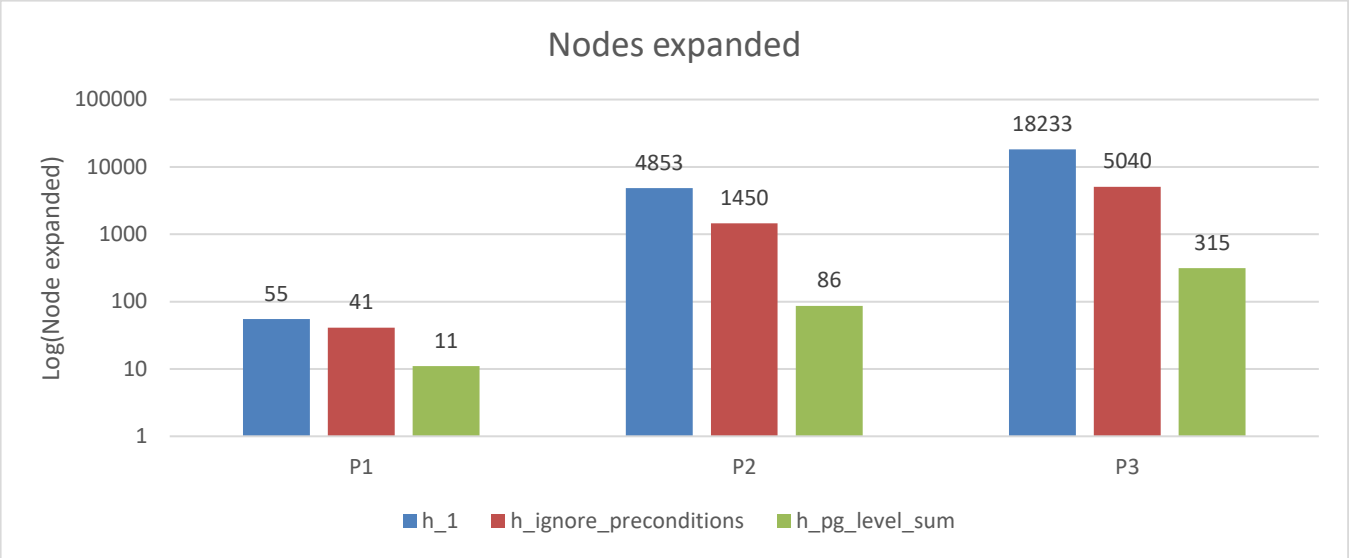
The above table shows the metrics for the heuristic search. The values for the columns Node expanded and goal tests are similar.

Time Elapsed:



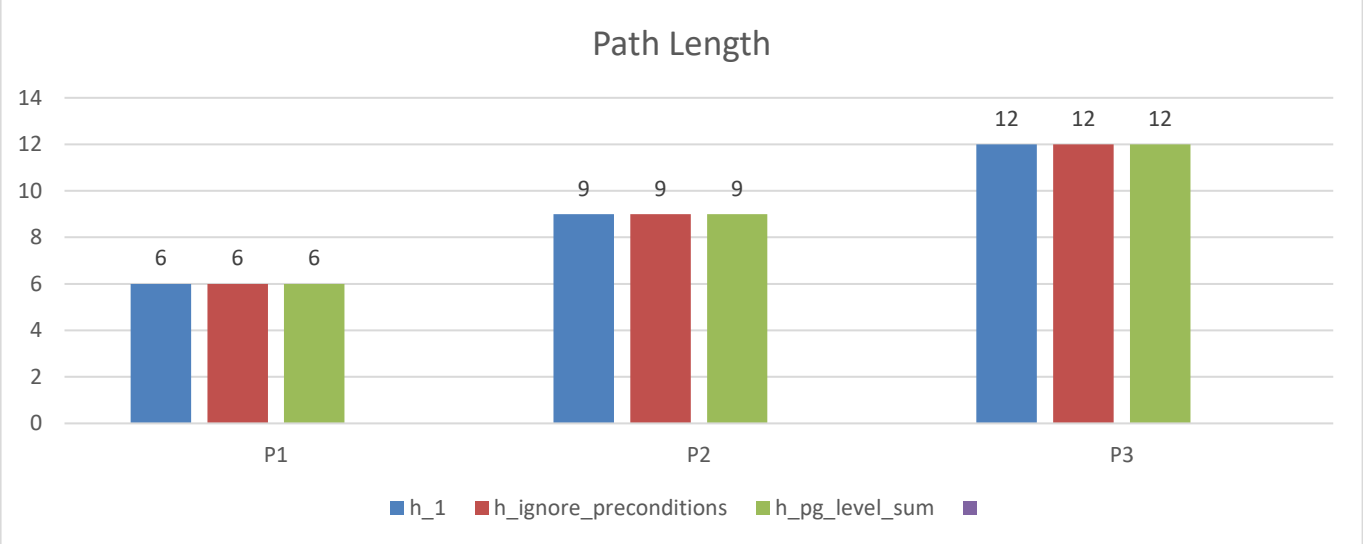
The time taken to execute the planning is the highest for the h_pg_level_sum heuristic. The reason for it is the high computation it undergoes. The heuristic h_ignore_preconditions turns out to be the fastest to execute.

Nodes Expanded:



H_1 heuristic has the most number of nodes expanded while h_pg_level_sum has the least.

Path Length:



Since all the heuristic have same path length they all are admissible for the optimality of the solution.

Optimality of A* Search:

A* is admissible and considers fewer nodes than any other admissible search algorithm with the same heuristic. This is because A* uses an "optimistic" estimate of the cost of a path through every node that it considers—optimistic in that the true cost of a path through that node to the goal will be at least as great as the estimate.

Conclusion:

Overall, the best heuristic is the h_ignore_preconditions, which compared to other heuristics took the least time for the execution at the same time has the significant number of nodes expanded. The worst among the six heuristics is the h_pg_level_sum because of its slowness and had least node expanded.

Optimal Plans:

The optimal plans for the 3 problems using best heuristic i.e. h_ignore_preconditions are carried out by A* search.

Problem1:

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

Problem2:

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

Problem 3:

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