The Results

PROBLEM 1					
	Actions	**Expansions**	**Goal Tests**	**New Nodes**	**Time elapsed**
1. breadth_first_search	20	43	56	178	0.004302164000000275
2. depth_first_graph_search	20	21	22	84	0.0028322389999999587
3. uniform_cost_search	20	60	62	240	0.00946672300000001
4. greedy_best_first_graph_search h_unmet_goals	20	7	9	29	0.0014529329999999896
5. greedy_best_first_graph_search h_pg_levelsum	20	6	8	28	0.307627335
6. greedy_best_first_graph_search h_pg_maxlevel	20	6	8	24	0.328304074
7. greedy_best_first_graph_search h_pg_setlevel	20	13	15	53	1.09167212
8. astar_search h_unmet_goals	20	50	52	206	0.008700610000000025
9. astar_search h_pg_levelsum	20	28	30	122	0.755350613
10. astar_search h_pg_maxlevel	20	43	45	180	0.800117805
11. astar_search h_pg_setlevel	20	46	48	192	2.1371129663

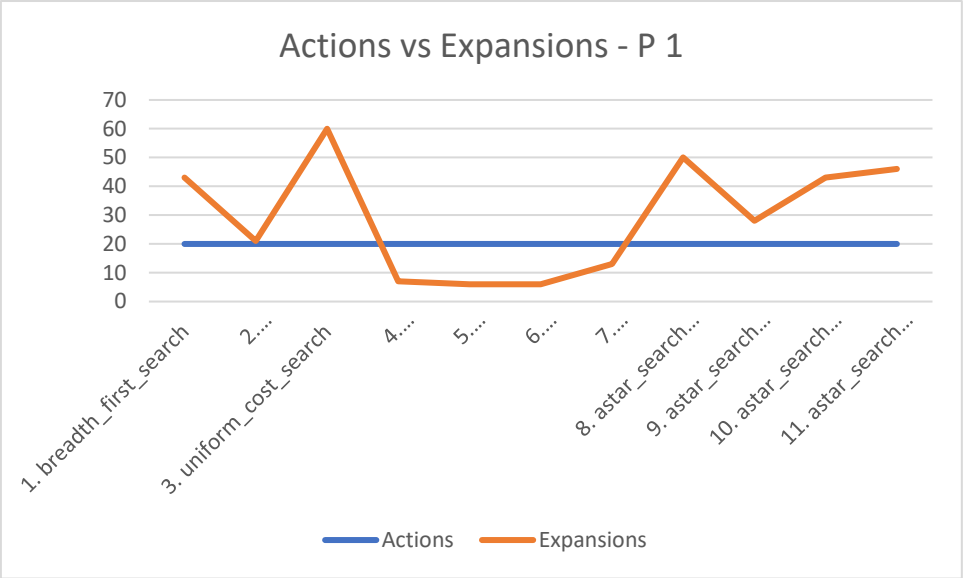
PROBLEM 2					
	Actions	**Expansions**	**Goal Tests**	**New Nodes**	**Time elapsed**
1. breadth_first_search	72	3343	4609	30503	1.559270286
2. depth_first_graph_search	72	624	625	5602	2.207107594
3. uniform_cost_search	72	5154	5156	46618	2.443899133
4. greedy_best_first_graph_search h_unmet_goals	72	17	19	170	0.012860047
5. greedy_best_first_graph_search h_pg_levelsum	72	9	11	86	8.067904630000001
6. greedy_best_first_graph_search h_pg_maxlevel	72	27	29	249	13.285995692
7. greedy_best_first_graph_search h_pg_setlevel	72	35	37	321	44.1936
8. astar_search h_unmet_goals	72	2467	2469	22522	2.243313504
9. astar_search h_pg_levelsum	72	357	359	3426	124.014
10. astar_search h_pg_maxlevel	72	2887	2889	26594	752.282171
11. astar_search h_pg_setlevel	72	2671	2673	24523	3034.21919

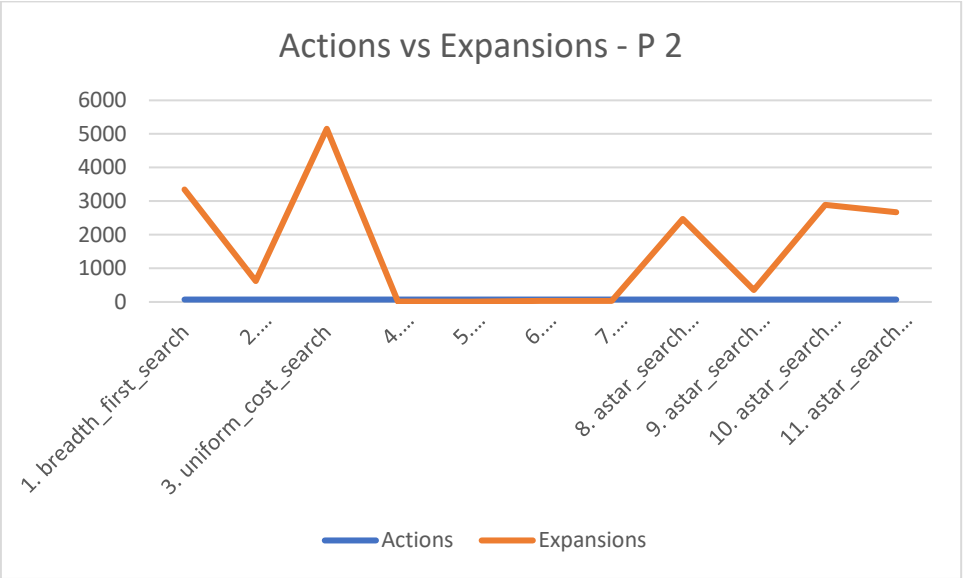
PROBLEM 3					
	Actions	**Expansions**	**Goal Tests**	**New Nodes**	**Time elapsed**
1. breadth_first_search	88	14663	18098	12965	8.566245348999999
2. depth_first_graph_search	88	408	409	3364	0.931719676
3. uniform_cost_search	88	18510	18512	161936	11.045990934

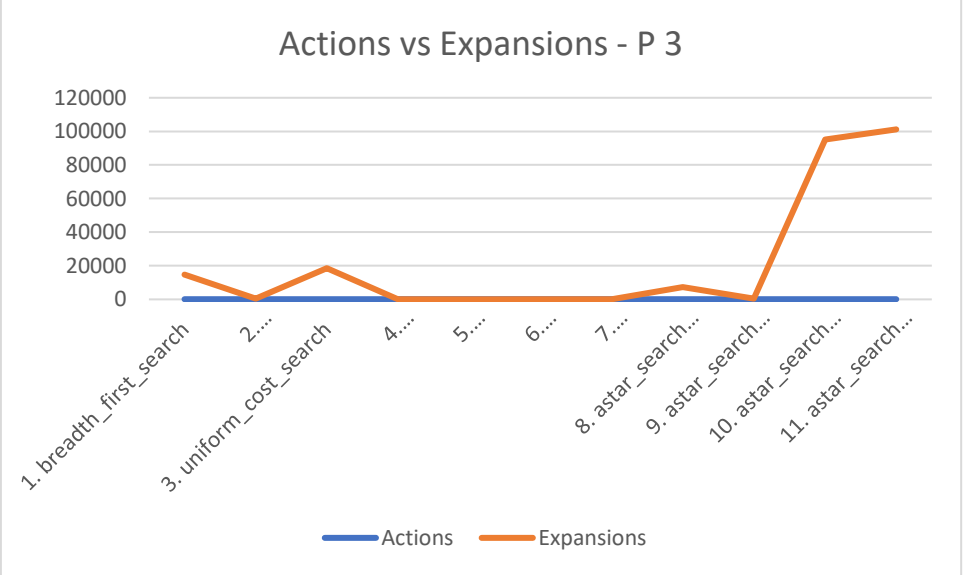
4. greedy_best_first_graph_search h_unmet_goals	88	25	27	230	0.032268869000000006
5. greedy_best_first_graph_search h_pg_levelsum	88	14	16	126	14.901587919
6. greedy_best_first_graph_search h_pg_maxlevel	88	21	23	195	18.387537923
7. greedy_best_first_graph_search h_pg_setlevel	88	68	70	722	180.282
8. astar_search h_unmet_goals	88	7388	7390	65711	9.018228374
9. astar_search h_pg_levelsum	88	369	371	3403	231.956421
10. astar_search h_pg_maxlevel	88	95080	9582	86312	4329.947494
11. astar_search h_pg_setlevel	88	101176	10178	90844	14123.0485937

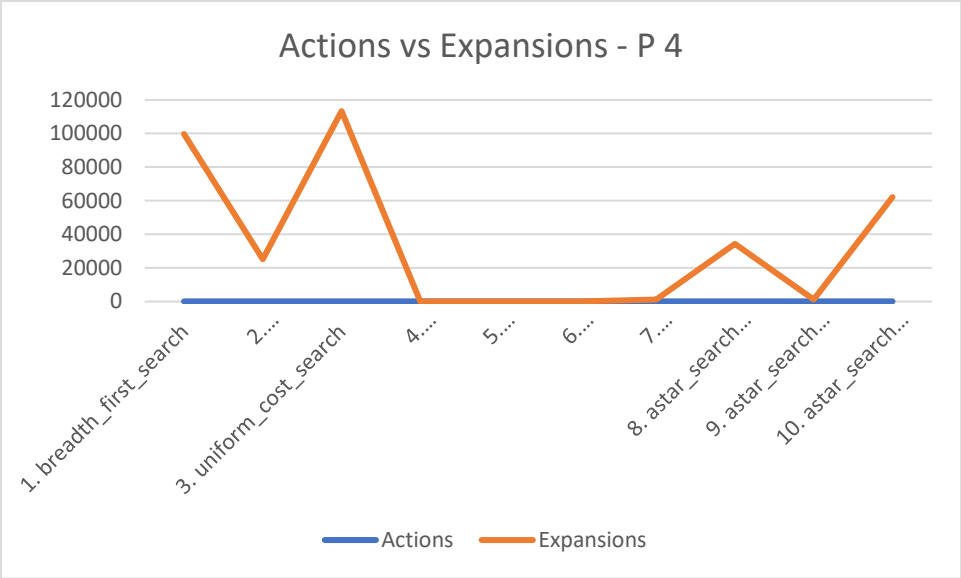
PROBLEM 4					
	Actions	**Expansions**	**Goal Tests**	**New Nodes**	**Time elapsed**
1. breadth_first_search	104	99736	114953	944130	104.238634514
2. depth_first_graph_search	104	25174	25175	228849	3254.3905
3. uniform_cost_search	104	113339	113341	1066413	106.6252
4. greedy_best_first_graph_search h_unmet_goals	104	29	31	280	0.0571
5. greedy_best_first_graph_search h_pg_levelsum	104	17	19	165	24.6594
6. greedy_best_first_graph_search h_pg_maxlevel	104	56	58	580	59.2432
7. greedy_best_first_graph_search h_pg_setlevel	104	1283	1285	13475	4076.94742
8. astar_search h_unmet_goals	104	34330	34332	328509	58.048492
9. astar_search h_pg_levelsum	104	1208	1210	12210	1321.0475252
10. astar_search h_pg_maxlevel	104	62077	62079	599376	46.2323
11. astar_search h_pg_setlevel	104				

1 - Number of nodes expanded versus number of actions


Actions vs Expansions - P 1
70
60
50
40
30
20
10
0
1. breadth_first_search
2....
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...
11. astar_search...
Actions
Expansions

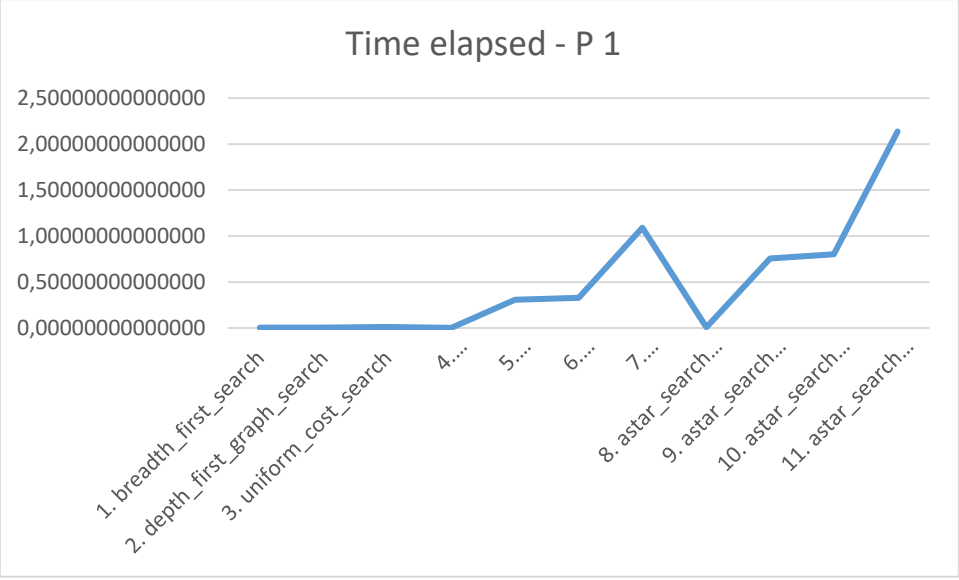

Actions vs Expansions - P 2
6000
5000
4000
3000
2000
1000
0
1. breadth_first_search
2....
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...
11. astar_search...
Actions
Expansions

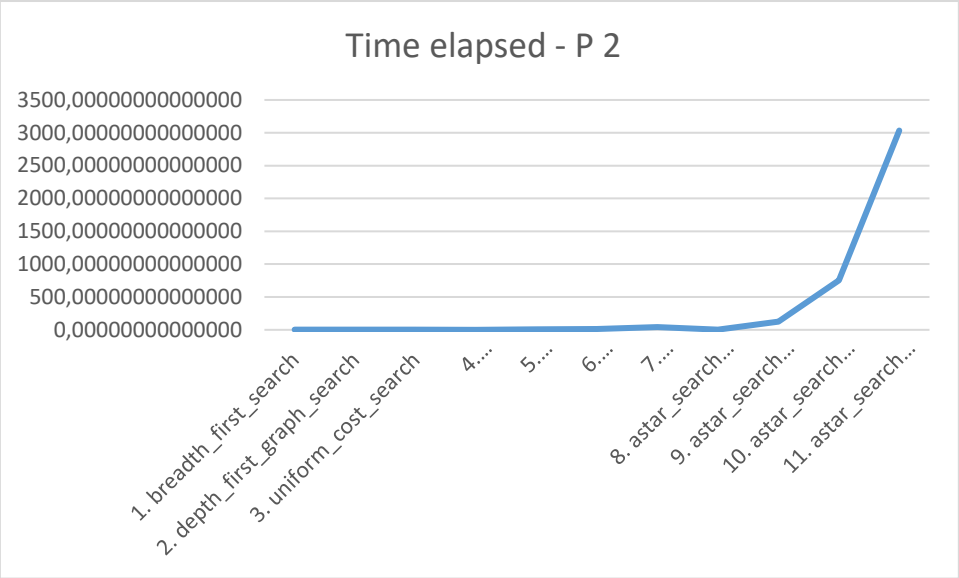

Actions vs Expansions - P 3
120000
100000
80000
60000
40000
20000
0
1. breadth_first_search
2....
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...
11. astar_search...
Actions
Expansions

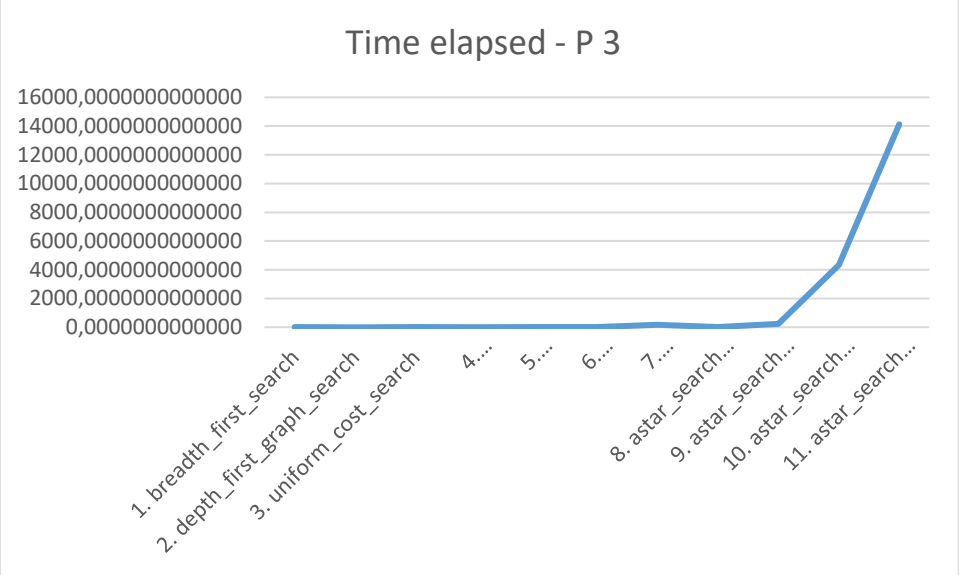


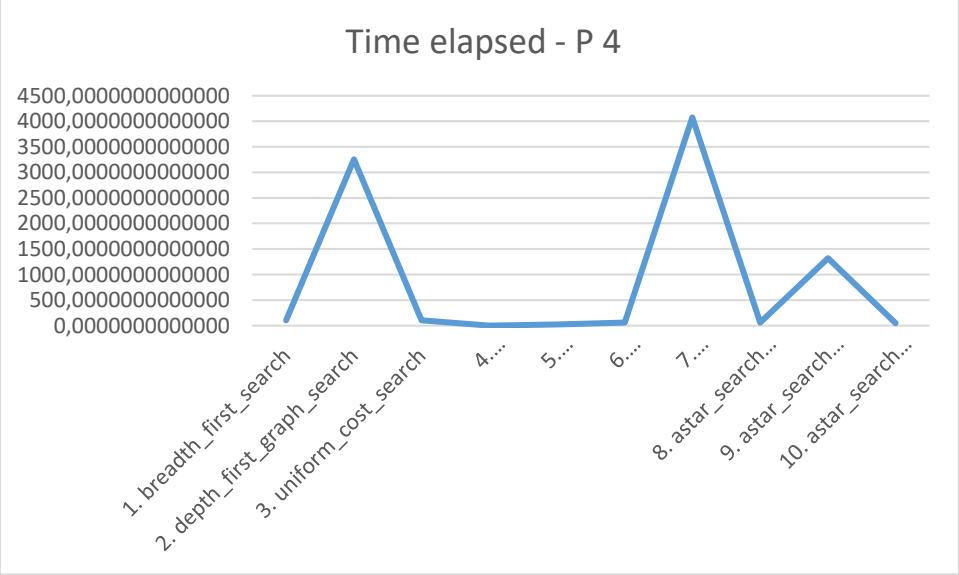
The graphs show that the higher the number of actions in depth_first graph the smaller the number of nodes expanded than in the search algorithms. The number of expanded nodes increases significantly as the number of shares increases. The numbers of expanded nodes for the greedy algorithms are virtually the same and are smaller than the uninformed search as well as the astar search.

2 - Number of actions versus search time




Time elapsed - P 2
3500,00000000000000
3000,00000000000000
2500,00000000000000
2000,00000000000000
1500,00000000000000
1000,00000000000000
500,00000000000000
0,00000000000000
1. breadth_first_search
2. depth_first_graph_search
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...
11. astar_search...


Time elapsed - P 3
16000,00000000000000
14000,00000000000000
12000,00000000000000
10000,00000000000000
8000,00000000000000
6000,00000000000000
4000,00000000000000
2000,00000000000000
0,00000000000000
1. breadth_first_search
2. depth_first_graph_search
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...
11. astar_search...


Time elapsed - P 4
4500,00000000000000
4000,00000000000000
3500,00000000000000
3000,00000000000000
2500,00000000000000
2000,00000000000000
1500,00000000000000
1000,00000000000000
500,00000000000000
0,00000000000000
1. breadth_first_search
2. depth_first_graph_search
3. uniform_cost_search
4....
5....
6....
7....
8. astar_search...
9. astar_search...
10. astar_search...

By analyzing the graphs, the search time increases exponentially in relation to the number of actions. The greedy_best_first_graph_search h_unmet_goals is the quickest to execute in all four air cargo problems.

3 - Questions

A - Which algorithm or algorithms would be most appropriate for planning in a very restricted domain (i.e., one that has only a few actions) and needs to operate in real time?

- The Breadth First Search
- Depth First Graph
- Uniform cost search
- Greedy best first graph search with unmet goals

It is the algorithms that take less time to achieve the goals.

B - Which algorithm or algorithms would be most appropriate for planning in very large domains (e.g., planning delivery routes for all UPS drivers in the U.S. on a given day)

- Astar
- Greedy_best_search with the heuristic suitable

They are the best algorithms to achieve the goals (the domain).

C - Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans

- Breadth First Search,
- Depth First Graph,
- Uniform cost search

They are most appropriate when space is finite, but for searching in a space of partial plans, astar is appropriate.