Complexity Study

Table 1 Complexity Study

N. º DELIVERY WAREHOUSES	N.º SOLUTIONS	SEQUENCE LIST DELIVERY WAREHOUSES	DELIVERY TIME (min)	TSOL (themselves)
5	120	[8, 1, 3, 11, 9]	412.57	0.017
6	720	[8, 3, 1, 17, 11, 9]	453.60	0.051
7	5040	[17, 8, 3, 1, 14, 11, 9]	500.45	0.188
8	40320	[17, 8, 3, 12, 1, 14, 11, 9]	532.44	1.051
9	362880	[8, 3, 12, 6, 14, 1, 17, 11, 9]	562.66	10.054
10	3628800	[17, 8, 3, 12, 6, 14, 1, 11, 13|...]	618.03	111.037
11	39916800	[9, 13, 11, 17, 2, 12, 6, 14, 1|...]	676.88	1313.312
12	479001600	...	...	...
13	6227020800	...	...	...
14	8.7178 * 10^10	...	...	...
15	1.31 * 10^12	...	...	...
16	2.1 * 10^13	...	...	...

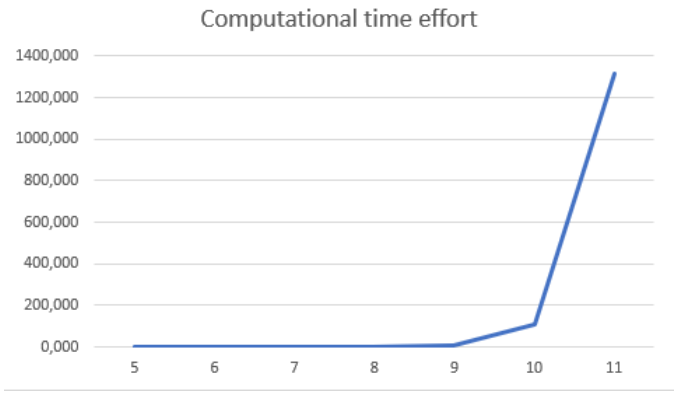

Figure 1 Computational Time Effort

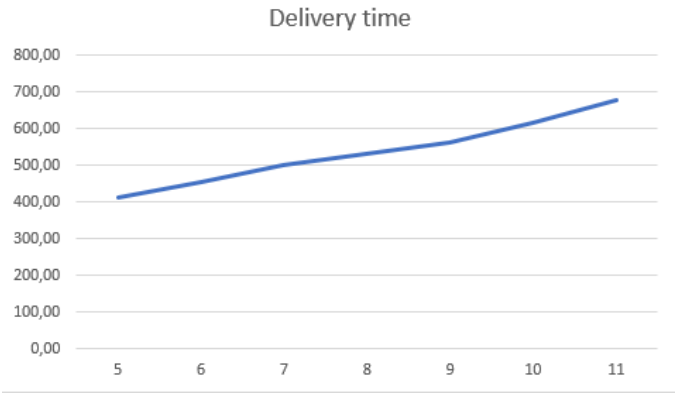

Figure 2 Delivery Time

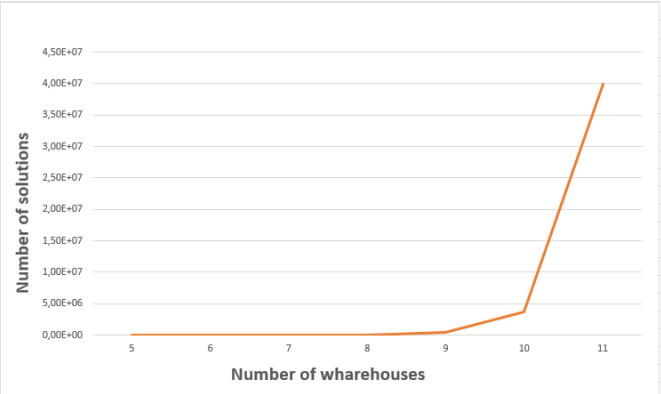

Figure 3 Number of Solutions

Conclusions

With the third chart, we can conclude that in the Big-O notation the complexity of the problem would be O(N!).

In the first table, we didn't present more results because it would take much time and exceed the stack limit. We can only study eleven warehouses until the stack reaches the limit.

Through the tables and graphs observed above, we can see that despite the greater the number of nodes and layers present in the graph, the number of path solutions it will have will be factorially greater than this number.

The same doesn't happen in relation to the time to generate these solutions, which is directly proportional to the number of solutions in the graph.

Through these two assumptions, we conclude that the time required to generate the solutions of the graph is factorially proportional to the number of warehouses.

Summing up, the greater the number of warehouses, the longer it takes to deliver all deliveries.

Note:

Note that if we are in a problem of reduced dimension, where the solution obtained by the generator of all solutions is feasible, then it does not make sense to use the heuristics (the previous table was only constructed to try to gain sensitivity to the quality of the 3 heuristics).

From a given dimension of the problem, the generation of all solutions to choose the best one is no longer feasible, at that time it is interesting to apply the 3 heuristics and choose the one that causes the shortest time for deliveries.

As it happened in the first table, in the next one presented we can only study eleven warehouses. As we can see in the table the optimal solution will always be the best solution, in contrary to the three heuristics which are unable to improve the time record.

However, as for the three heuristics, we can see that the first heuristic is the one that achieves the best time up to a quantity of 6 stores. From 7 stores onwards, the third heuristic will obtain the most economical solutions.

Table 2 Heuristics Study

NUMBER OF DELIVERIES	OPTIMAL SOLUTION	OPTIMAL SOLUTION TIME	TIME 1ª HEURISTICS	TIME 2ª HEURISTICS	TIME 3ª HEURISTICS	BEST SOLUTION
5	[8, 1, 3, 11, 9]	412.57	453.18	580.89	433.95	433.95
6	[8, 3, 1, 17, 11, 9]	453.60	502.96	637.45	490.20	490.20
7	[17, 8, 3, 1, 14, 11, 9]	500.45	552.51	671.96	620.13	552.51
8	[17, 8, 3, 12, 1, 14, 11, 9]	532.44	590.94	661.27	694.34	590.94
9	[8, 3, 12, 6, 14, 1, 17, 11, 9]	562.66	620.05	717.94	725.71	620.05
10	[17, 8, 3, 12, 6, 14, 1, 11, 13|...]	618.03	678.31	881.70	799.51	678.31
11	[9, 13, 11, 17, 2, 12, 6, 14, 1|...]	676.88	702.56	996.61	896.45	702.56
12	...	...	...	...	...	...
13	...	...	...	...	...	...
14	...	...	...	...	...	...
15	...	...	...	...	...	...
16	...	...	...	...	...	...