Algorithmics I - Assessed Exercise

Status and Implementation Reports

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Status report

Both programs are in a fully functional state. They work correctly and, moreover, I have tried to design 2 implementations as efficient as possible, speeding up the running time.
I have compiled the 2 source folders and I ran the Main classes with all the data .txt files, as well as with a 1 million data file I created using a bash script. They all compiled and built successfully.

Implementation report

(a) I have implemented the Dijkstra's algorithm building up on the skeleton pseudo-code we were given during lectures.

- Firstly, I have been careful in all classes that, when looping, I would in advance store the size so we won't compute it unnecessarily all the time. Moreover, I have chosen to use a visited boolean array for having quick index access while being inside the algorithm.
- Finishing with the design decisions, let's start on the actual algorithm implementation. We are initializing, at the beginning, the distances array elements with infinity, the pathList array (that will contain the vertex indices in the shortest path) elements with -1 and the visited array elements with false. After this, we initialize the distance to the sourceVertex to 0 (as we will start our search from there).
- Then, we go on and start the first loop that will visit all the nodes (however, we will stop once we get to the destination vertex so that we avoid unnecessary iterations). In there, we find out the minimum distanced vertex from the last visited vertex (obviously, this minimum distanced vertex will be adjacent to the last visited one).

- Once we've got that, we check, as mentioned above, if the minimum vertex found is the destination one. If so, we break. Otherwise, we mark it as visited and perform relaxation on the edges between this vertex and the adjacent nodes.
- Relaxation is done by updating the distances to all adjacent vertices if those distances could be shortened by adding the node to the path. If we perform relaxation, then we update pathList as well and add in there the minimum vertex found in the previous step.
- Last step is printing out the path. This is done recursively, as our nodes are in reverse order.

The time complexity of the algorithm is, at worst, $O(n^2)$, where n is the number of vertices in the graph. I have obtained very good results during testing with the data files, the ones with 2,20,40,60,80 entries giving me a running time between 0 milliseconds and 1-2 milliseconds. The 1000 ones gave me a running time of maximum 17 milliseconds.

I have tested numerous approaches, including a HashSet (that does not allow, by default, inserting duplicates), but the method I've chosen in the end gave the best results. The biggest factors in having such a small running time are breaking out of the loop when the destination vertex is found, keeping track of the visited vertices using an array of booleans, pre-computing sizes and storing them when it was possible, as well as storing all the path vertices in an array and not using an additional field for the Vertex class (I have tried using a predecessor field, that would store the previously visited vertex, but it was less efficient than the final implementation).

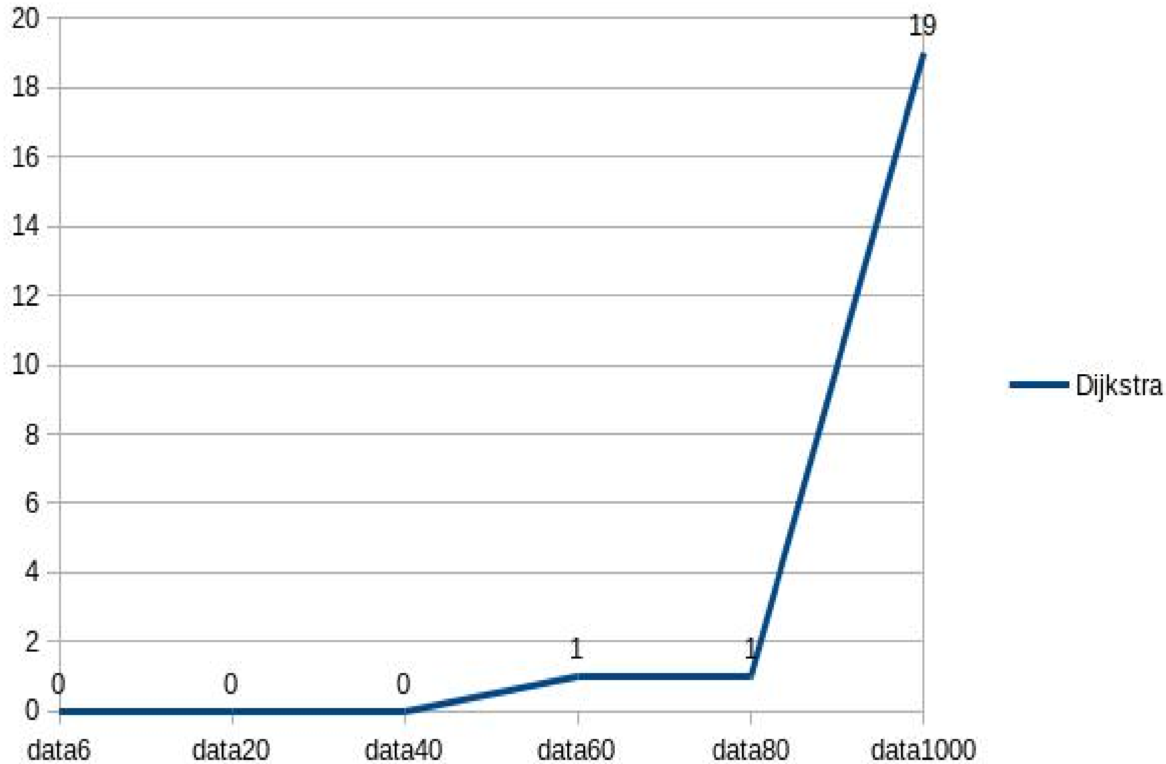
(b) I have implemented the backtracking algorithm, again, building upon the skeleton that was provided in the appendix of the assignment pdf.

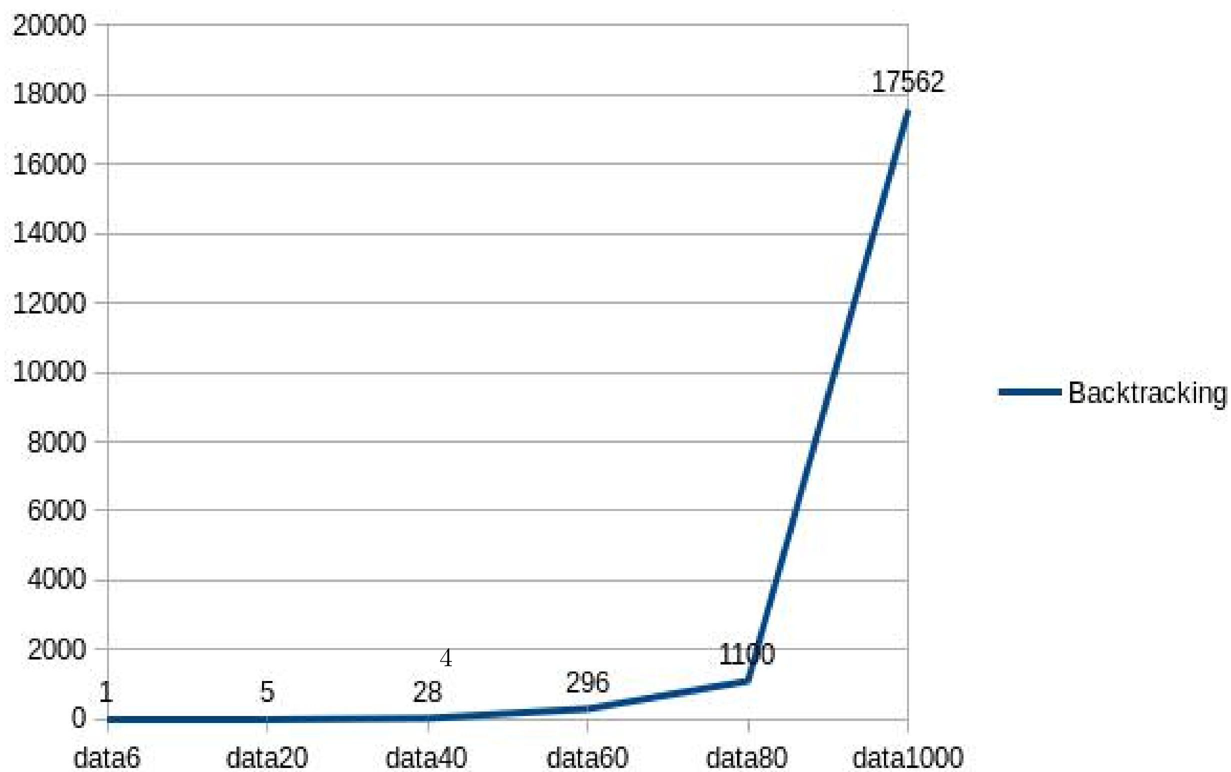
- Firstly, we will start again with design choices. I have created a Path class that stores a path and has the following fields: distance, vertices array (an arraylist of vertex indices in the path) and the graph associated with the Path object. The distance in my algorithm is automatically calculated at each insertion or removal from the path, as it drastically improves efficiency. Again, we use a visited array of booleans instead of the getVisited method for each vertex. I have saved the sizes/lists before each loop iteration such that we don't repeadetly compute the same things.
- The first step of the algorithm is initializing 2 Path objects, currentPath and bestPath. The first one will store the vertices as we go along and the second one will be updated once we find a shorter path from the source vertex to the end vertex. Moreover, we set the distance of the best path, when we create it, to the maximum possible value.

- Then, we get the adjacency list of the last vertex in the current path. We loop through its nodes and, when we find an unvisited one, we add it to the path and mark it as visited.
- Afterwards, we check if the current distance of the path is less than the best path's distance. If so, we go inside and check if the current vertex is the destination one or not. In the former case, we update the best path, while in the latter we backtrack to the next step.
- In the end, we remove the last vertex in the current path and mark it as not visited. We print the path in the Main class looping through the nodes in the arraylist, as well as the distance stored in BestPath's field.

The running time was far greater for this algorithm. Even though for small input the differences between Dijkstra's algorithm and this one were not significant, for the 1000 input files the running time was in terms of seconds, not milliseconds. For data 2,20,40,60,80 files the running time was at maximum 800-900 milliseconds, while for the 1000 one the running time was between 17-20 seconds (on the lab machines; on mine, it was between 12 and 14, depending on the load of the laptop).

Empirical results





These results are very conclusive right from the data ranges. The average running time for Dijkstra's algorithm was 4, while for Backtracking was around 3578 (I have included the worst running times that I have got on the lab machines).

Summing up, we have shown here that Dijkstra's algorithm is far more efficient than Backtracking for finding the shortest path in a adjacency list represented graph. Even though Backtracking can solve most of the problems thrown at it, that does not mean it will also be time/space efficient.