# DESIGN OF ALGORITHMS PROGRAMMING PROJECT - AN ANALYSIS TOOL FOR RAILWAY NETWORK MANAGEMENT


MADE BY GROUP G03_2 :

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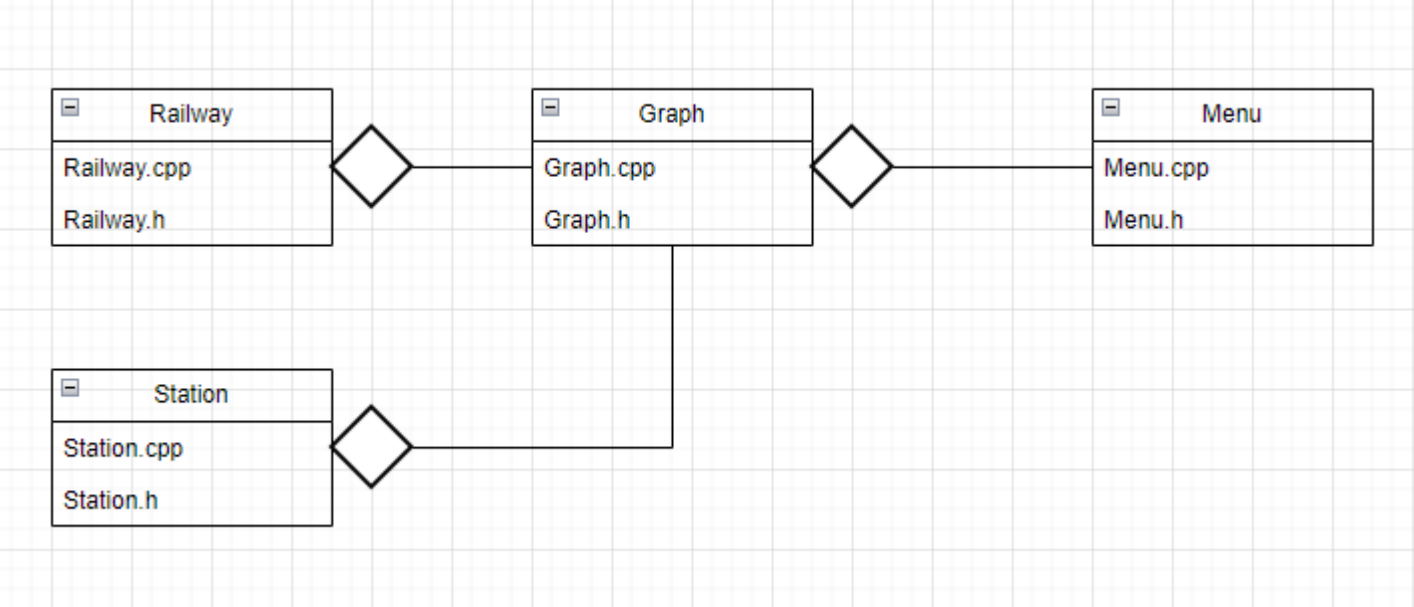
# CLASS DIAGRAM



# DATASET READING

When an object of the class Graph is created, the files network.csv and stations.csv are loaded into the Graph.

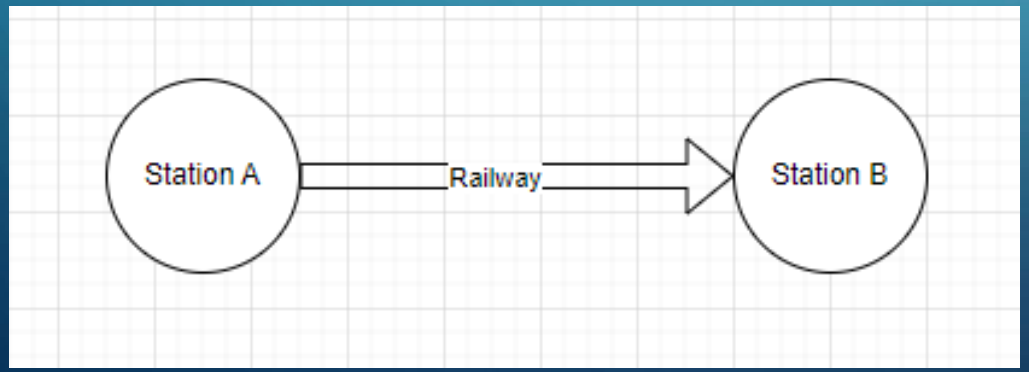
The stations.csv file is read and the function “input_vertex” creates the objects of the class Station and stores them in a vector, defined in the Graph Class. The network.csv file is read and the function “input_edge” implements the same process but stores objects of the class Railway in another vector, also defined in the Graph Class.

In the class Graph, it is also defined an unordered map with an association between the name of a Station and its previously defined index.

# GRAPH DESCRIPTION

This is how the Graph has been organized:

- Objects of the class Station are the vertices of the Graph
- Objects of the class Railways are the edges of the Graph
- Each Station is represented by a specific integer stored in an unordered map, connecting the Station's name to this integer, named index (or Ind).

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# LIST OF FEATURES AND ITS ALGORITHMS

- Maximum flow between stations
  - Complexity: O(V1 + V2 + (E * f)). V1 – number of stations from, V2 – number of stations to, E – number of edges (or railways), f – maximum flow in the network
  - Associated algorithms – Ford-Fulkerson and DFS or Edmonds-Karp and BFS
- Railways and Pairs of Stations with the most trains
  - Complexity: O(E * ((f * V^2) + log E)). V – number of vertices (or stations), E – number of edges (or railways), f – maximum flow in the network
  - Associated algorithms – Ford-Fulkerson and DFS
- Top k Municipalities and/or Districts that require the most amount of trains
  - Complexity: O(E * (f + E)). E – number of edges (or railways), f – maximum flow in the network
  - Associated algorithms – Ford-Fulkerson and DFS

# LIST OF FEATURES AND ITS ALGORITHMS

- Number of trains that arrive on a specific station
  - Complexity: O(V + (E * f)). V – number of vertices (or stations), E – number of edges (or railways), f – maximum flow in the network
  - Associated algorithms - Ford-Fulkerson and DFS
- Minimum cost to maintain maximum flow in a network
  - Complexity: O(E * (V + E) * log V). V – number of vertices (or stations), E – number of edges (or railways)
  - Associated algorithms - Dijkstra
- Maximum flow in the segments/stations of a reduced network
  - Complexity: O(S + (f * R)) . S – number of vertices (or stations) that will be added to the network (0 if we are only testing the segments of the reduced network). R – number of edges (or railways) of the reduced network
  - Associated algorithms - Ford-Fulkerson and DFS
- Most affected Stations in a reduced network
  - Complexity: O(R + f * E). R - number of elements of the reduced network (should be equal or less than E). E – number of edges (or railways) of the full network. f – maximum flow of the full network
  - Associated algorithms – Ford-Fulkerson and DFS

# OTHER FEATURES

- Add Stations to a Graph (as vertices)
- Add Railways to a Graph (as edges)
- Change the file(s) from which the Graph's Stations and Railways are loaded
- Read the file containing the Stations and their attributes
- Read the file containing the Railways and their attributes

# USER INTERFACE

```
|=============================================================================================================|
|                                          Basic Service                                                      |
|=============================================================================================================|
| Maximum flow between 2 stations                                                                      [21] |
| Maximum flow between sets of stations                                                                [22] |
| The railway with highest amount of trains                                                            [23] |
| Pairs of stations that require the most amount of trains                                             [24] |
| Top-k municipalities or districts, regarding their transportation needs in full advantage            [25] |
| Top-k municipalities or districts, regarding their transportation needs in limit mode                [26] |
| Number of trains that arrived in station in max flow                                                 [27] |
| Number of trains that arrived in station in full advantage                                           [28] |
| Maximize number of trains in max flow                                                                [29] |
|=============================================================================================================|
|                     Line Failures                         |                 Operation Cost                |
|=============================================================|===============================================|
| Maximum flow in a reduced network segments           [41]|  Minimum cost of maintaining maximum flow  [31] |
| Maximum flow in a reduced network stations           [42]|                                                |
| Top-k most affected stations for each segment failure [43]|                                                |
|=============================================================================================================|
|                                          Other operations                                                   |
|=============================================================================================================|
|  Add stations to the network                        [11] |   Read network file                        [14] |
|  Add railways to the network                        [12] |   Read station file                        [15] |
|  Change files                                       [13] |                                                 |
|  Exit                                               [0]  |                                                 |
|=============================================================================================================|

Please choose an option:
```

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# USER INTERFACE

```
Please choose an option:25

Please enter the source station name:
Pombal Resguardo

Please enter the destination station name:
Pereira

Please enter a number:
2

Search municipalities [0] or districts [1]
1

COIMBRA 6
LEIRIA 4

|=============================================================================================================|
|                                          Basic Service                                                      |
|=============================================================================================================|
| Maximum flow between 2 stations                                                                      [21] |
| Maximum flow between sets of stations                                                                [22] |
| The railway with highest amount of trains                                                            [23] |
| Pairs of stations that require the most amount of trains                                             [24] |
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|                    Line Failures                        |                Operation Cost                      |
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|=============================================================================================================|
|                                          Other operations                                                   |
|=============================================================================================================|
|  Add stations to the network                        [11] |   Read network file                            [14] |
```

```
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|                                          Basic Service                                                      |
|=============================================================================================================|
| Maximum flow between 2 stations                                                                      [21] |
| Maximum flow between sets of stations                                                                [22] |
| The railway with highest amount of trains                                                            [23] |
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|                                          Other operations                                                   |
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|  Add stations to the network                        [11] |   Read network file                            [14] |
|  Add railways to the network                        [12] |   Read station file                            [15] |
|  Change files                                       [13] |                                                |
|  Exit                                               [0]  |                                                |
|=============================================================================================================|

Please choose an option:24

Entroncamento -> Santar├®m (22)
Lisboa Oriente -> Santar├®m (22)
Lisboa Oriente -> Entroncamento (22)
```

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# MAIN DIFFICULTIES

The main difficulties of this project were the interpretation of certain tasks, developing an organized management of the railway network and optimizing some of the algorithms.

# EFFORT OF EACH MEMBER

- Mansur Mustafin – Main Functions, Data Structure Organization
- Francisco Gonçalves de Sousa – User Interface, Menu Functions
- José Nuno Barbosa Quintas – Documentation, Presentation

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