PROGRAMMING PROJECT I

AN ANALYSIS TOOL FOR WATER SUPPLY MANAGEMENT

G06_4
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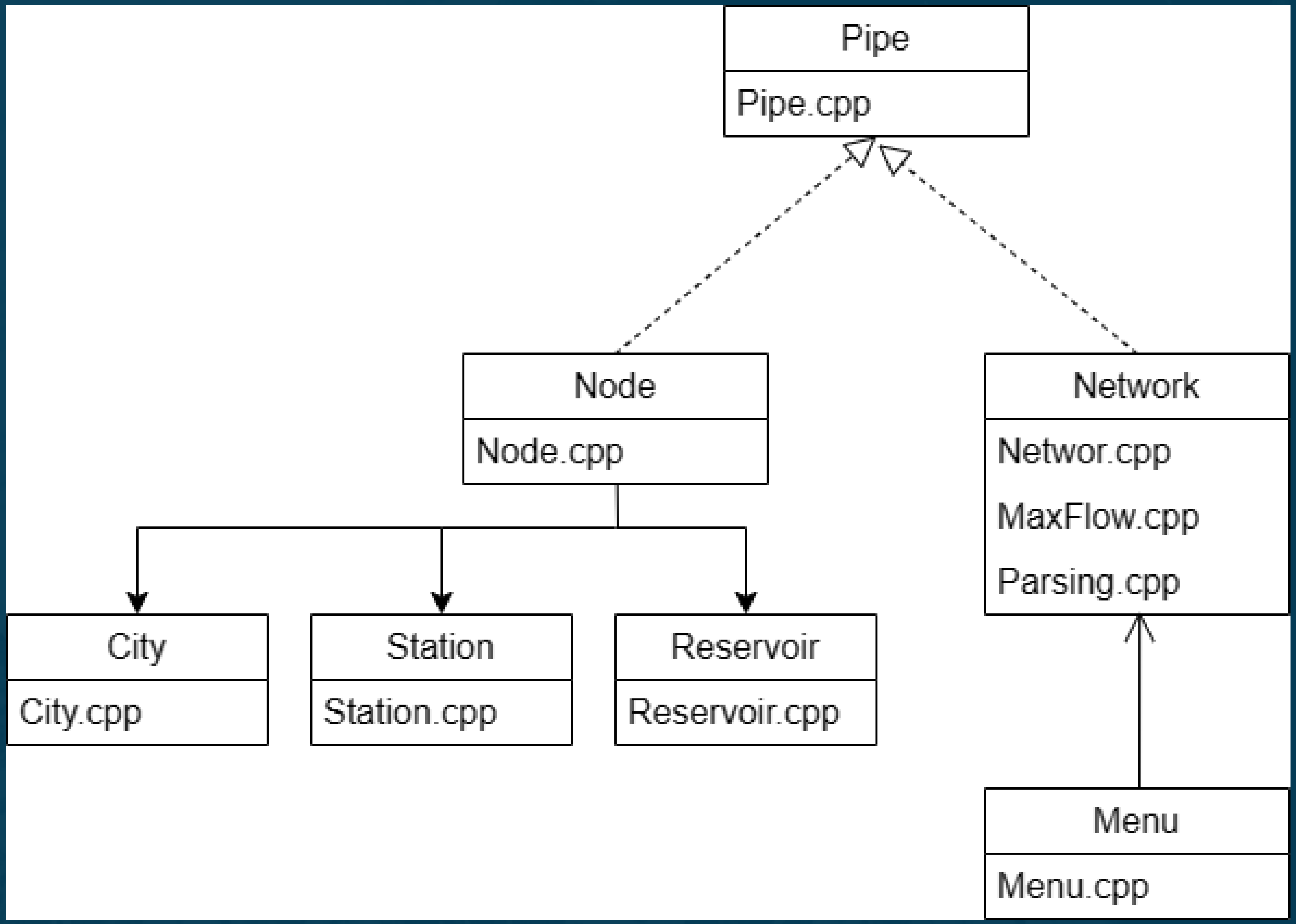
Class Diagram



Description of reading dataset

In the Parsing.cpp file we implement functions to analyze and process input data related to a water supply network in Portugal. Here's a summary of what each piece of code does:

filterString(string& input):

This function takes a string and filters the characters in it, keeping only alphanumeric and underscore characters. This is useful for cleaning input data.

Network::readStations(const std::string &fileLocation):

This function reads pump stations from a CSV file. It extracts the ID and code of each station, creates corresponding Station objects, and stores them in the network node set.

Network::readCities(const std::string &fileLocation):

This function reads cities from a CSV file. It extracts the name, ID, code, demand and population of each city, creates corresponding City objects and stores them in the network node set.

Description of reading dataset

The code processes the data from the provided CSV file, creates objects, and builds the water supply network, which can be used for further analysis.

Network::readReservoirs(const std::string &fileLocation):

This function reads shells from a CSV file. It extracts the name, municipality, ID, code and maximum delivery capacity of each reservoir, creates corresponding Reservoir objects and stores them in the network node set.

Network::readPipes(const std::string &fileLocation):

This function reads the pipes from a CSV file. It extracts the source station, destination station, capacity and direction of each pipe, adds the pipes to the corresponding nodes in the network.

Network::readSuperElements():

This function identifies the super source and super target nodes in the network and adds them to the node set. It adds pipes from the reservoirs to the super source and from the cities to the super destination.

DESCRIPTION OF THE GRAPH USED TO REPRESENT THE DATASETS

WITH ILLUSTRATIVE IMAGES

TO DESCRIBE THE GRAPH USED TO REPRESENT THE DATASET'S DATA SET, WE CAN DIVIDE THE DESCRIPTION INTO THREE MAIN PARTS: NODES (OR VERTICES), PIPES (OR EDGES), AND THE SPECIAL SUPER SOURCE AND SUPER TARGET ELEMENTS.

Nodes

- Os nós representam as diferentes entidades do sistema de abastecimento de água, como cidades, estações de bombeamento e reservatórios.
- Cada nó tem um código único que o identifica, e pode ter uma capacidade associada, dependendo do tipo de entidade que representa.

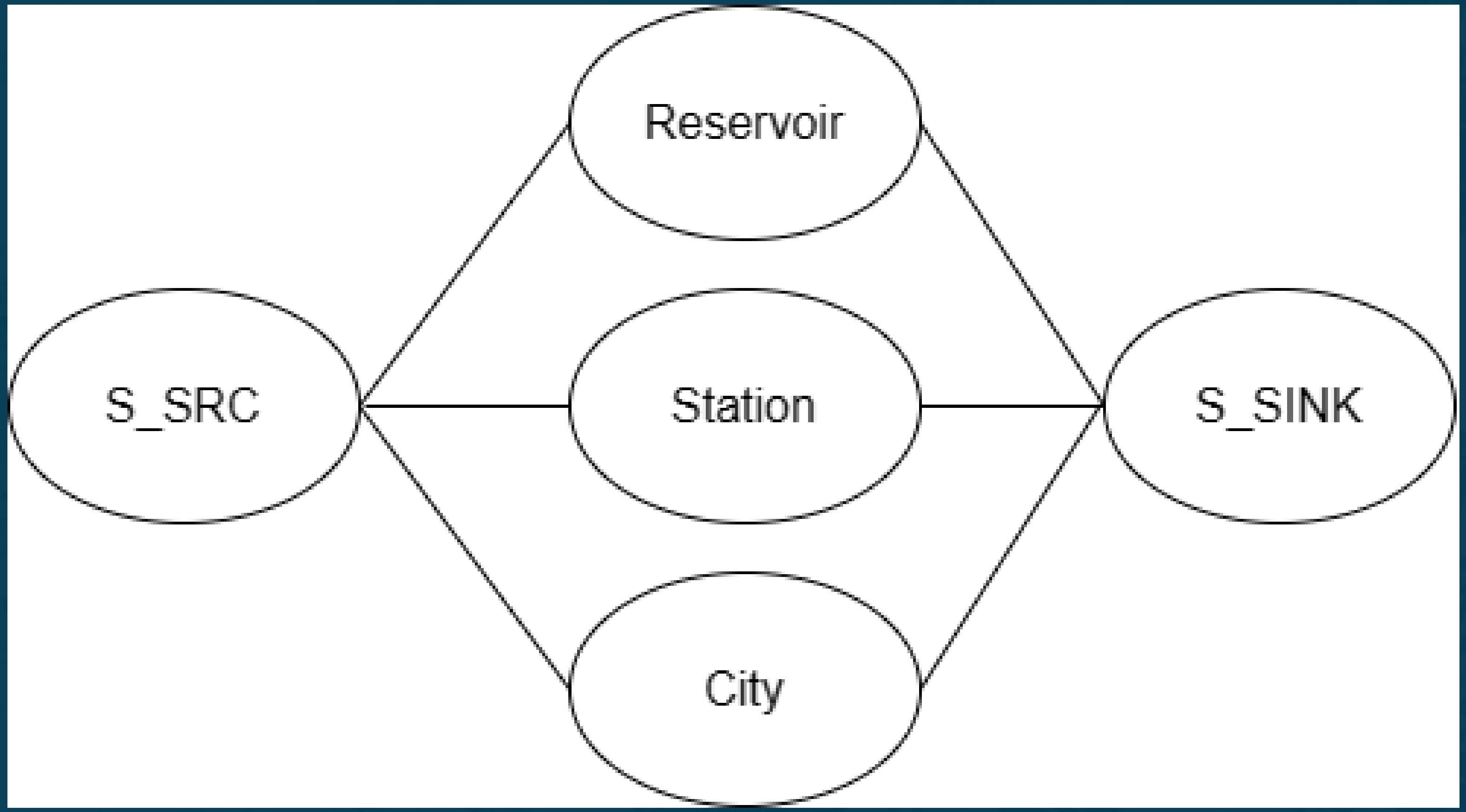
Pipes

- As tubulações conectam os nós do grafo e representam o fluxo de água entre eles.
- Cada tubulação tem uma capacidade máxima de transporte de água.
- A direção das tubulações indica o fluxo da água de um nó de origem para um nó de destino.

Special Elements

The **super source** node ("S_SRC") is connected to all reservoirs and has maximum transport capacity.
The **super sink** node ("S_SINK") is connected to all cities and has maximum transport capacity.

THE GRAPHICAL REPRESENTATION OF THE GRAPH WOULD INCLUDE NODES REPRESENTING CITIES, PUMPING STATIONS AND RESERVOIRS, CONNECTED BY PIPES THAT SHOW THE FLOW OF WATER BETWEEN THEM. THE SUPER SOURCE AND SUPER DESTINATION NODES WOULD ALSO BE REPRESENTED, CONNECTED TO THE RELEVANT NODES OF THE GRAPH.



IMPLEMENTED FUNCTIONALITIES AND ASSOCIATED ALGORITHMS

Finding Augmenting Paths

- **Algorithm:** Breadth-First Search (BFS) is used to find augmenting paths from the source node to the sink node.
- **Description:** Starting from the source node, BFS explores all reachable nodes in the residual network until it reaches the sink node or there are no more augmenting paths available.
- **Time Complexity:** $O(V+E)$, where V is the number of vertices (nodes) and �E is the number of edges (pipes) in the network.

IMPLEMENTED FUNCTIONALITIES AND ASSOCIATED ALGORITHMS

Finding Minimum Residual along Path

- **Algorithm:** Along the augmenting path found by BFS, the minimum residual capacity of the pipes is determined.
- **Description:** The minimum residual capacity along the path is calculated by traversing from the sink node back to the source node and considering the minimum residual capacity of the pipes encountered.
- **Time Complexity:** $O(V)$, where V is the number of vertices (nodes) in the network.

IMPLEMENTED FUNCTIONALITIES AND ASSOCIATED ALGORITHMS

Augmenting Flow along Path

- **Algorithm:** Once an augmenting path is found, the flow along that path is augmented to increase the total flow in the network.
- **Description:** The flow is augmented by updating the capacities and residuals of the pipes along the path, as well as updating the flow values.
- **Time Complexity:** $O(V)$, where V is the number of vertices (nodes) in the network.

IMPLEMENTED FUNCTIONALITIES AND ASSOCIATED ALGORITHMS

Edmonds-Karp Algorithm for Max Flow

- **Algorithm:** The Edmonds-Karp algorithm is implemented to find the maximum flow in the network.
- **Description:** It repeatedly finds augmenting paths using BFS and augments the flow along these paths until no more augmenting paths can be found. The total flow is then calculated.
- **Time Complexity:** $O(VE^2)$, where V is the number of vertices (nodes) and E is the number of edges (pipes) in the network. This complexity arises from the fact that each BFS step takes $O(E)$ time, and there can be at most $O(V)$ augmenting paths.

IMPLEMENTED FUNCTIONALITIES AND ASSOCIATED ALGORITHMS

Associated Graphs

- **Residual Network:** The residual network is a graph derived from the original network, where each pipe's capacity represents the residual capacity for flow. It is used to find augmenting paths efficiently.
- **Flow Network:** The flow network is a graph that represents the flow of water through the network. It is updated dynamically as flow is augmented along paths.

These functionalities and algorithms form the core of the network analysis tool, allowing for efficient determination of maximum flow and critical paths within the water supply network.

User Interface Description

The water supply management system provides a user-friendly interface for analyzing and managing a water distribution network. Here's how the interface works:

Main Menu

- Upon launching the application, the main menu is displayed, offering options to access basic service metrics, reliability and sensitivity to line failures, change the dataset, or exit the application.
- Users can select options by typing the corresponding number and pressing enter.

Basic Service Metrics

- This menu allows users to view basic service metrics such as network max flow and cities' water demand.
- Users can choose to view all data or select a specific city to view its information.

Reliability and Sensitivity to Line Failures

- In this menu, users can simulate failures in the network, such as removing a reservoir, station, or pipe, to analyze the impact on water flow and city water demand.
- Users can select the type of failure to simulate and input the relevant details, such as the code of the reservoir, station, or pipe to remove.

Change Data Set

- Users can change the dataset used for analysis by selecting options to load a small dataset, large dataset, or specify a custom dataset path.
- If choosing a custom dataset path, users will be prompted to input the path to the dataset.

Example of Use

1. Data Set

```
Please select the data set:

  1. Small Data Set

  2. Large Data Set

  3. Custom Data Set

Select your option:
```

2. Main Menu

```
---------------------------------------------------------------------
Please select your desired option by typing it on the selector intake

  1. Basic Service Metrics

  2. Reliability and Sensitivity to Failures


  9. Change Data Set

  0. Exit application

Select your option :
```

3. Basic Metrics

```
Please select your desired option by typing it on the selector intake

  1. Network Max Flow

  2. Cities Water Demand


  9. Go back

  0. Exit application

Select your option :
```

4. Network Max Flow

```
---------------------------------------------------------------------
Please select your desired option by typing it on the selector intake

  1. View all data

  2. Select a specific city


  9. Go back

  0. Exit application

Select your option :
```

5.Reliability and Sensitivity to Failures

```
Please select your desired option by typing it on the selector intake

  1. Remove a Reservoir

  2. Remove a Station

  3. Remove a Pipe


  9. Return to Main Menu

  0. Exit application

Select your option :
```

MAIN DIFFICULTIES AND PARTICIPATION OF EACH GROUP MEMBER

WE ALL PARTICIPATE EQUALLY IN CARRYING OUT THE PROJECT