Flight Management System
Projeto 2 AED 23/24

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Classes Diagram

Graph -> Graph.cpp, Graph.h

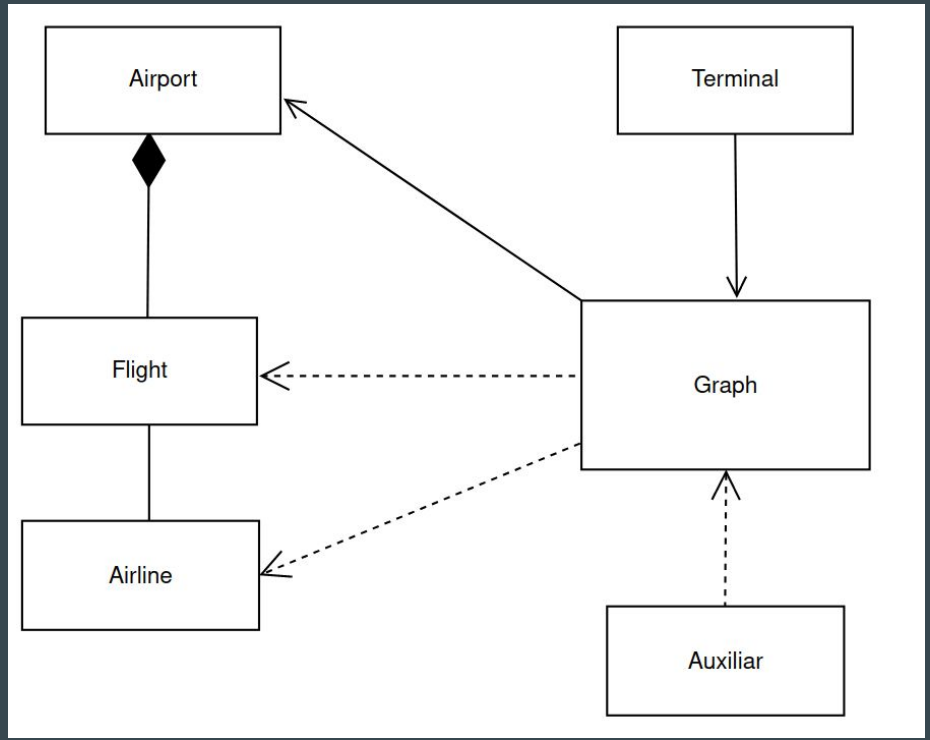
Airport -> Airport.cpp, Airport.h

Flight -> Flight.cpp, Flight.h

Airline -> Airline.cpp, Airline.h

Auxiliar -> Auxiliar.cpp, Auxiliar.h, airlines.csv, airports.csv, flights.csv

Terminal -> Terminal.cpp, Terminal.h



Reading the dataset

To read the given data, 3 functions were added in the “Auxiliar” class:

- readAirports
- readAirlines
- readFlights

These functions read the respective file line by line and create the appropriate object

(in the heap in the case of airport and airline), providing the read data as parameters of the constructor.

```
void Auxiliar::readAirports(Graph &g) {
    std::ifstream file( s: "../airports.csv");
    std::string line;
    std::string code, name, city, country, latitude, longitude;

    getline( &: file,  &: line);
    while (std::getline( &: file,  &: line)){...}
}
void Auxiliar::readAirlines(Graph &g) {
    std::ifstream file( s: "../airlines.csv");
    std::string line;
    std::string code, name, callsign, country;

    getline( &: file,  &: line);
    while (std::getline( &: file,  &: line)){...}
}
void Auxiliar::readFlights(Graph &g) {
    std::ifstream file( s: "../flights.csv");
    std::string line;
    std::string source, dest, airline;

    getline( &: file,  &: line);
    while (std::getline( &: file,  &: line)){...}
}
```

Reading the dataset

By finally calling the addAirport, addAirline or addFlight the new objects are then added to the appropriate data structure and to the graph.

As an example, in the case of the Airport, it is added to the graph's vertex set and to all the hash maps.

```
Airport* airport =
        new Airport(code, name, city, country, latitude, longitude);
g.addAirport(airport);
```

```
vAirports.push_back(airport);
airports.insert( x: make_pair( x: airport->getCode(),  &: airport));
airportsName.insert( x: make_pair( x: airport->getName(),  &: airport));
auto cityIt : iterator<...> =airportsPerCity.find(
        x: make_pair( x: airport->getCity(),  y: airport->getCountry()));
if(cityIt!=airportsPerCity.end()){
    cityIt->second.push_back(airport);
}
else{
    airportsPerCity[make_pair( x: airport->getCity(),  y: airport->getCountry())]={airport};
}
```

Graph Description

- The graph is built with Airport's as vertices and Flight's as edges.
- It has hashmaps to allow constant-time lookup for airports, airlines and cities.

```
std::vector<Airport*> vAirports;
std::unordered_map<std::string, Airport *> airports;
std::unordered_map<std::string, Airport *> airportsName;
std::unordered_map<std::pair<std::string, std::string>, std::vector<Airport *>, CityCountryHash, CityCountryEqual> airportsPerCity;
std::unordered_map<std::string, Airline *> airlines;
```

- Each airport (vertex) has a group of outgoing flights (edges).
- Some attributes are auxiliary to the execution of some methods.

```
class Airport {
    std::string code;
    std::string name;
    std::string city;
    std::string country;
    std::string latitude;
    std::string longitude;
    std::vector<Flight> flights;  // list of outgoing flights
    int nFlightsOut;
    int num;
    int low;
    bool visited;          // auxiliary field
    bool processing;
```

Graph Description - continuation

- Each Flight has an origin Airport from which the Flight takes place to a destination Airport, which is done through an Airline.

```
class Flight {
    Airport * source;
    Airport * dest;      // destination vertex
    Airline * airline;
```

- Airline's have the following attributes that were read from the dataset.

```
class Airline {
    std::string code;
    std::string name;
    std::string callsign;
    std::string country;
```

Global numbers

Time Complexity: O(1)

```
Global numbers

There are 3019 airports
There are 63832 flights
There are 444 airlines
```

Countries that a city flies to directly

Time Complexity: O(A*F*log(n))

Flights from airport and per city/airline

Time Complexity:

- Airport: O(n*log(m))
- City: O(n)
- Airline: O(V+E)

```
There are 2484 flights from RYR


Press 'm' to go back to the main menu.
Press 'q' to quit.
```

Reachable destinations from an airport in n stops

Options:
From Airport:

- to Airports
- to Countries
- to Cities

In a maximum number of stops

Algorithms used: BFS

Time Complexity: O(V+E)

Other important aspects: With this functionality if 0 stops are provided, direct destinations are displayed as well as all possible destinations if stops are a high value (higher than airport number)

```
Reachable destinations from the airport YHO in a maximum of 3 lay-overs
There are 4 cities

|-----------------------------------------|-----------------------------------------|
|                  City                   |                 Country                 |
|-----------------------------------------|-----------------------------------------|
|                Goose Bay                |                 Canada                  |
|                Makkovik                 |                 Canada                  |
|                Postville                |                 Canada                  |
|                 Rigolet                 |                 Canada                  |
|-----------------------------------------|-----------------------------------------|
```

```
|-----|-----------------------------------|---------------------------------|---------------------------------|-------------------|-------------------|------------|
|Code |               Name                |              City               |             Country             |     Latitude      |     Longitude     | OutFlights |
|-----|-----------------------------------|---------------------------------|---------------------------------|-------------------|-------------------|------------|
| YMN |          Makkovik Airport         |             Makkovik            |             Canada              |     55.076900     |     -59.186400    |      2     |
| YRG |           Rigolet Airport         |              Rigolet            |             Canada              |     54.179700     |     -58.457500    |      2     |
| YSO |          Postville Airport        |             Postville           |             Canada              |     54.910278     |     -59.785278    |      2     |
| YYR |              Goose Bay            |             Goose Bay           |             Canada              |     53.319168     |     -60.425833    |      7     |
|-----|-----------------------------------|---------------------------------|---------------------------------|-------------------|-------------------|------------|
```

Maximum trip

Important aspects: For every airport was made a bfs in order to understand the maximum trip distance and destinations.

Algorithms used: BFS
Time Complexity: O(V(V+E))

Maximum trips available:
There are 18 trips with the greatest number of lay-overs (11)

FROM			TO		
Code	City	Country	Code	City	Country
THU	Thule	Greenland	ZLT	La Tabatiere	Canada
THU	Thule	Greenland	YBX	Lourdes-De-Blanc-Sablon	Canada
THU	Thule	Greenland	YHO	Hopedale	Canada
THU	Thule	Greenland	SRV	Stony River	United States
ZLT	La Tabatiere	Canada	THU	Thule	Greenland
ZLT	La Tabatiere	Canada	SRV	Stony River	United States
YBX	Lourdes-De-Blanc-Sablon	Canada	THU	Thule	Greenland
YBX	Lourdes-De-Blanc-Sablon	Canada	SRV	Stony River	United States
YHO	Hopedale	Canada	THU	Thule	Greenland
YHO	Hopedale	Canada	BVI	Birdsville	Australia
YHO	Hopedale	Canada	XTG	Thargomindah	Australia
YHO	Hopedale	Canada	SRV	Stony River	United States
YHO	Hopedale	Canada	CMP	Santana do Araguaia	Brazil
BVI	Birdsville	Australia	YHO	Hopedale	Canada
PTJ	Portland	Australia	YHO	Hopedale	Canada
XTG	Thargomindah	Australia	YHO	Hopedale	Canada
STZ	Santa Terezinha	Brazil	YHO	Hopedale	Canada
STZ	Santa Terezinha	Brazil	SRV	Stony River	United States

Top airports with the greatest air capacity

Options:

- Number n of airports to show

Time Complexity: O(V)

Other important aspects: It was possible to do it in a single iteration of the vertex set using a min heap where the size can't exceed n. It was needed to create a custom comparator.

```
struct compareNFlightsOut {
    bool operator()(Airport* a, Airport* b) {
        return a->getNFlightsOut() > b->getNFlightsOut();
    }
};
std::priority_queue<Airport *, std::vector<Airport *>, compareNFlightsOut> topMin;
```

```
Display Top-3
Top-3 airports with the greatest air traffic capacity

|-----|----------------------------------------|--------------------------------|--------------------------------|------------------|------------------|------------|
|Code |                  Name                  |              City              |            Country             |     Latitude     |    Longitude     | OutFlights |
|-----|----------------------------------------|--------------------------------|--------------------------------|------------------|------------------|------------|
| ATL |      Hartsfield Jackson Atlanta Intl   |            Atlanta             |         United States          |    33.636719     |    -84.428067    |    909     |
| ORD |           Chicago Ohare Intl           |            Chicago             |         United States          |    41.978603     |    -87.904842    |    556     |
| PEK |              Capital Intl              |            Beijing             |             China              |    40.080111     |    116.584556    |    526     |
|-----|----------------------------------------|--------------------------------|--------------------------------|------------------|------------------|------------|
```

Essential airports to the circulation capability

Algorithms used: similar to Tarjan's

Time Complexity: O(V+E)

Other important aspects:

- The function uses a stack to keep track of visited airports during the DFS traversal.
- Temporarily addition and deletion of flights is done to achieve the desired functionality without directly modifying the original graph structure.

Essential airports to the network's circulation capability
There are 314 airports

Code	Name	City	Country
ABQ	Albuquerque International Sunport	Albuquerque	United States
ACC	Kotoka Intl	Accra	Ghana
ACK	Nantucket Mem	Nantucket	United States
ADD	Bole Intl	Addis Ababa	Ethiopia
ADL	Adelaide Intl	Adelaide	Australia

...

YYC	Calgary Intl	Calgary	Canada
YYR	Goose Bay	Goose Bay	Canada
YYZ	Lester B Pearson Intl	Toronto	Canada
YZF	Yellowknife	Yellowknife	Canada
YZV	Sept Iles	Sept-iles	Canada
ZAG	Zagreb	Zagreb	Croatia
ZAM	Zamboanga Intl	Zamboanga	Philippines

Best Flight Option(s)

Options:
From and To:

- airport code or name
- city
- geographical coordinates

Using maximum number of airlines
Using only specified airlines

Algorithms used: BFS

Time Complexity: O(S*D*(V+E+F))

Other important aspects: These are all possible options with the least amount of stops, including trips that stop at the same airports but fly in different airlines

```
Best flight option(s) from OPO to Munster,Germany
There are 4 options

There are 2 flights
From OPO To FMO
|-------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                        FROM                                        ||                                        TO                                        || AIRLINE |
|-----|----------------------------------------|----------------------------------------||-----|----------------------------------------|----------------------------------------||---------|
|Code |                City                    |                Country                 ||Code |                City                    |                Country                 ||  Code   |
|-----|----------------------------------------|----------------------------------------||-----|----------------------------------------|----------------------------------------||---------|
| OPO |                Porto                   |               Portugal                 || FRA |               Frankfurt                |                Germany                 ||   DLH   |
| FRA |              Frankfurt                 |                Germany                 || FMO |                Munster                 |                Germany                 ||   DLH   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|
```

...

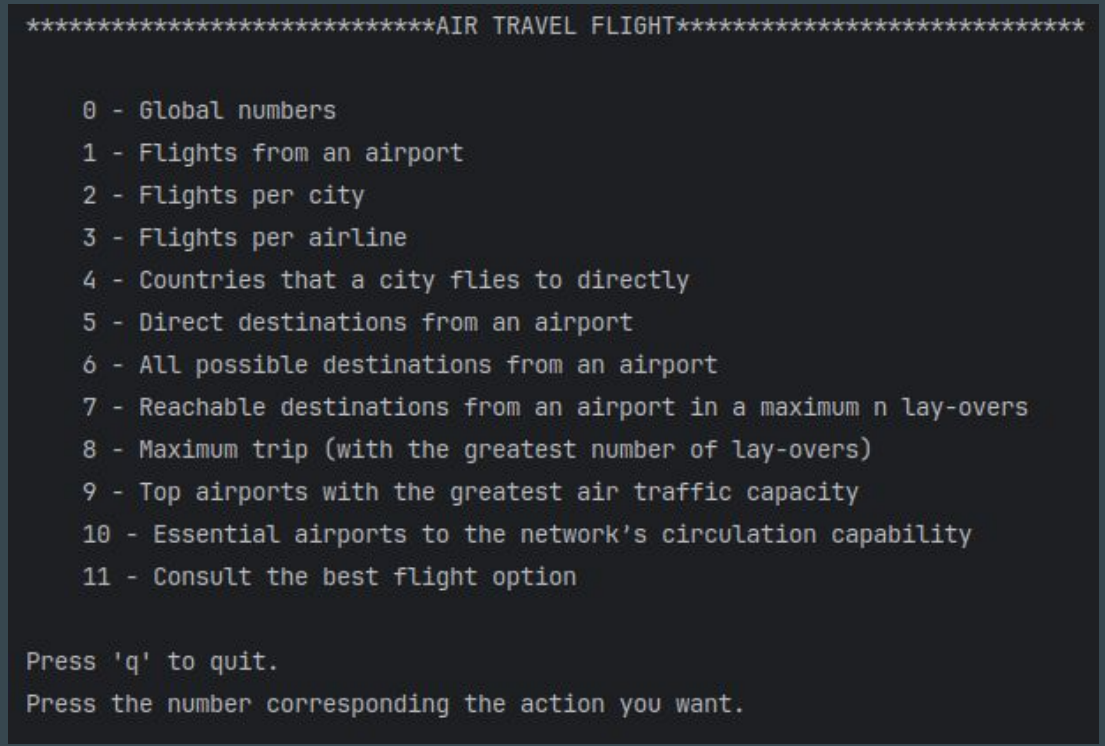
```
There are 2 flights
From OPO To FMO
|-------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                        FROM                                        ||                                        TO                                        || AIRLINE |
|-----|----------------------------------------|----------------------------------------||-----|----------------------------------------|----------------------------------------||---------|
|Code |                City                    |                Country                 ||Code |                City                    |                Country                 ||  Code   |
|-----|----------------------------------------|----------------------------------------||-----|----------------------------------------|----------------------------------------||---------|
| OPO |                Porto                   |               Portugal                 || PMI |           Palma de Mallorca            |                 Spain                  ||   RYR   |
| PMI |           Palma de Mallorca            |                 Spain                  || FMO |                Munster                 |                Germany                 ||   BER   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|
```

Interface

The interface is implemented with the Terminal class, that is responsible for managing the execution of the program as wished by the user.

All functionalities are displayed in the console by menus.

For each menu the user can choose one option with the corresponding string and then follow the steps that are shown



Interface

Some lists can be sorted by each column, by ascending or descending order:

```
Press 's' for sorting options.
Press 'm' to go back to the main menu.
Press 'q' to quit.
s

SORTING OPTIONS

Type the number of the column (starting at 0) to order by: 0
Type 0 for descending order or 1 for ascending order: 0
```

The interface is very flexible and the user can choose when and how things are displayed:

```
There are 7 options
Do you wish to display them? (y/n)
```

```
FROM
Search by:
    0 - Airport code
    1 - Airport name
    2 - City ("city,country")
    3 - Geographical coordinates ("lat,lon")
```

Highlights

- For the complexity involved, the speed and responsiveness of the program is very good.
- The interface has a good look, is intuitive and has some interesting and useful features, for example, sorting options.
- For each trip, all flights used are displayed
- Multiple querying options and combinations, such as, best options from a city to the nearest location from geographical coordinates using a maximum of three airlines

Conclusion

During the project the biggest struggle was to compute the best flight option, because we wanted to show for all options what flights to catch and it was hard to keep track of them.

After the difficulties that we faced on the last project, we improved some aspects that facilitated the development of this project.

In general, we accomplished everything that was asked and also added our personal touch.

All elements equally contributed to the project.