CS 302 – Assignment #11, Final Project

Purpose: Learn concepts regarding graph algorithms and develop application specific data
          structures. Learn how graphs apply to real-world problems.
Due: Part A → Tuesday (4/18), Part B → Thursday (4/25)
Points: Part A → 75 pts, Part B → 225 pts

Assignment:
Given a large set of flight options, a business traveler typically desires a flight or set of flights from a origin location to a specific destination optimized based on some criteria, typically earliest arrival time.

This problem can be viewed as a graph problem where the airports are vertices's and the flights are directed graph edges.

Design a set of C++ classes to read and store a large, directed graph[1] of airports (vertices's) and flights (edges)[2]. Your design, at a minimum, must provide functionality to:

- Read and store the airport data.
- Read and store the flight data.
- Check/verify airport code validity.
- Find and show the travel itinerary.
    ◦ Given the origin airport, destination airport, and earliest allowable start time.
    ◦ A minimum layover of 30 minutes per stop (if any stops).
- Graph statistics (for reference).

To find the travel itinerary, the program should implement Dijkstra's single source shortest path algorithm[3] updated to optimize for arrival times in order to determine the flight path (itinerary) based on the earliest possible arrival time from the provided origin at the selected destination.

Part A:
Perform the basic design. Your design should address the class hierarchy and applicable data structures. The data structures should be customized and optimized for this problem.

For part A, create and submit a brief write-up including the following:
- Name, Assignment, Section.
- UML diagram of the classes.
    ◦ Please ensure the functions have appropriate names. Provide simple explanations as necessary. Include the applicable constructor's and destructor's.
    ◦ Additional features/functions, as needed.
- Detailed description of data structure for the graph (node type).
- Summary of other data structures proposed with an explanation.

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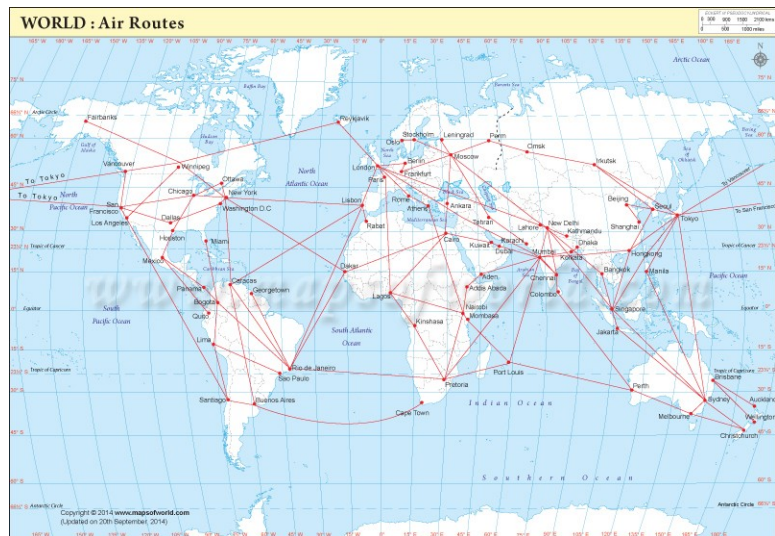
1 For more information, refer to: https://en.wikipedia.org/wiki/Graph_(abstract_data_type)
2 Data Source: http://openflights.org/data.html
3 For more information, refer to: http://en.wikipedia.org/wiki/Dijkstra's_algorithm

The class information format should be similar to past assignments, showing a UML diagram table with the class variables/functions and the function descriptions (1-2 sentences). In addition, the write-up should include a graph showing the class hierarchy.

The provided data files provide the origin airport code, destination airport code, flight number, departure time (24-hour format), and arrival time (24-hour format). There is additional information regarding aircraft type and flight amenities that is not used for this assignment.

The basic approach should use Dijkstra's single source shortest path algorithm (as per the previous assignment). However, instead of distances, the key will be the earliest possible arrival time at the final destination. If there are layovers, each layover must be > 30 minutes. The origin airport or source node key will be the earliest allowed trip start time (provided by traveler). In addition, the previous nodes array must be modified to accommodate the specific flight (not just the previous airport).

Before performing Dijkstra's algorithm, the find flights function should ensure that a graph exists, the passed origin airport, destination airport, and start time are valid. Additionally, the function should determine if there are any flights from the origin airport, and if not display an error message ("No flights from XXX") and exit (see example output).

There are over 5,000 airports and over 1,000,000 flights. As such, the choices for the data structures are very important for efficiency. There are many options for the data structures and your choices should be as efficient as possible. A set of data files will be provided. All code must be your own. You should **not** use the standard template library. The goal is to provide an overall solution as efficient as possible and demonstrate effect coding techniques.

Part B:

Implement the objects designed in Part A. You do **_not_** need to wait until Part A is scored to start on part B. A simple main is provided. As needed, you may update/correct/alter the original design. Any major changes should be coordinated with the instructor. The graph statistics should be displayed. Based on the provided input, the flight itinerary should be displayed.

Even with over 1,000,000 flights, not every airport will be reachable. If the destination airport is not reachable from the origin airport (either because there are not flights or no flights after the provided start time), a "not reachable" message should be displayed (see example).

Refer to the output formatting section for additional information.

Submission:

Part A (4/18)
- Submit a copy of the write-up (open document, word, or PDF format).
  - You are welcome to come to my office to discuss your approach before submission.

Part B (4/25)
- Submit a compressed zip file of the program source files, header files, and makefile via the on-line submission by 23:50.
- All necessary files must be included in the ZIP file. The grader will download, uncompress, and type **make**. You must have a valid, working _makefile_.
- Do **not** submit the data files (we have them).

Output Formatting

To accommodate the testing, the program output must follow a specific format. The output should include the graph statistics in the format shown. The final output should include the graph statistics, a **From / To** header showing the origin and destination airport codes along with the full airport name, and then the itinerary.

The following are a series of example program executions;

```
ed-vm% ./travel airports.dat flights.dat
*************************************************************
CS 302 - Assignment #11
Final Project - Air Travel Routing Program

Graph Statistics:
   Nodes: 5432
   Edges: 1018792


===========================================================
Travel Agent
  Origin Airport Code (3 letters): ABQ
  Destination Airport Code (3 letters): PHL
  Earliest Departure Time: 600


-------------------------------------------
From / To
  ABQ - Albuquerque International Sunport Airport
  PHL - Philadelphia International Airport

Flight:
  ABQ-ELP :: DeptTime: 615   ArrvTime: 710
  Flight Number: WN 348

Flight:
  ELP-SAT :: DeptTime: 745   ArrvTime: 1005
  Flight Number: WN2262

Flight:
  SAT-PHL :: DeptTime: 1050   ArrvTime: 1520
  Flight Number: WN2270

Another (Y/y/N/n): y
===========================================================
Travel Agent
  Origin Airport Code (3 letters): AAA
  Destination Airport Code (3 letters): LAS
  Earliest Departure Time: 500

No flights from AAA

Another (Y/y/N/n): n
*************************************************************
Game over, thanks for playing.
ed-vm%
```

```
ed-vm% ./travel airports.dat flights.dat
****************************************************************
CS 302 - Assignment #11
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Graph Statistics:
   Nodes: 5432
   Edges: 1018792


================================================================
Travel Agent
  Origin Airport Code (3 letters): LAX
  Destination Airport Code (3 letters): dca
  Earliest Departure Time: 500


---------------------------------------------
From / To
  LAX - Los Angeles International Airport
  DCA - Ronald Reagan Washington National Airport

Flight:
  LAX-CMH :: DeptTime: 700   ArrvTime: 1420
  Flight Number: CO 395

Flight:
  CMH-DCA :: DeptTime: 1505   ArrvTime: 1618
  Flight Number: OH5538

Another (Y/y/N/n): n
****************************************************************
Game over, thanks for playing.
ed-vm%
ed-vm%
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****************************************************************
CS 302 - Assignment #11
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Graph Statistics:
   Nodes: 5432
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================================================================
Travel Agent
  Origin Airport Code (3 letters): LAS
  Destination Airport Code (3 letters): BKH
  Earliest Departure Time: 700


---------------------------------------------
From / To
  LAS - McCarran International Airport
  BKH - Barking Sands Airport

  BKH is not reachable from LAS.

Another (Y/y/N/n): n
****************************************************************
Game over, thanks for playing.
ed-vm%
```

```
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****************************************************************
CS 302 - Assignment #11
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Graph Statistics:
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================================================================
Travel Agent
   Origin Airport Code (3 letters): DCA
   Destination Airport Code (3 letters): ABQ
   Earliest Departure Time: 500


------------------------------------------------
From / To
   DCA - Ronald Reagan Washington National Airport
   ABQ - Albuquerque International Sunport Airport

Flight:
   DCA-DFW :: DeptTime: 600    ArrvTime: 755
   Flight Number: AA1107

Flight:
   DFW-ABQ :: DeptTime: 845    ArrvTime: 935
   Flight Number: AA1873

Another (Y/y/N/n): y
================================================================
Travel Agent
   Origin Airport Code (3 letters): ABQ
   Destination Airport Code (3 letters): ADK
   Earliest Departure Time: 600


------------------------------------------------
From / To
   ABQ - Albuquerque International Sunport Airport
   ADK - Adak Airport

Flight:
   ABQ-DEN :: DeptTime: 635    ArrvTime: 750
   Flight Number: WN1218

Flight:
   DEN-ANC :: DeptTime: 830    ArrvTime: 1200
   Flight Number: F9 886

Flight:
   ANC-ADK :: DeptTime: 1420    ArrvTime: 1620
   Flight Number: AS 138

Another (Y/y/N/n): n
****************************************************************
Game over, thanks for playing.
ed-vm%
```

```
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****************************************************************
CS 302 - Assignment #11
Final Project - Air Travel Routing Program

Graph Statistics:
    Nodes: 5432
    Edges: 1018792


================================================================
Travel Agent
  Origin Airport Code (3 letters): pqi
  Destination Airport Code (3 letters): sdm
  Earliest Departure Time: 530


---------------------------------------------
From / To
  PQI - Northern Maine Regional Airport at Presque Isle
  SDM - Brown Field Municipal Airport

Flight:
  PQI-PVC :: DeptTime: 600    ArrvTime: 625
  Flight Number: RA0012

Flight:
  PVC-HLG :: DeptTime: 700    ArrvTime: 723
  Flight Number: AA1002

Flight:
  HLG-ELD :: DeptTime: 755    ArrvTime: 840
  Flight Number: AK0137

Flight:
  ELD-GGG :: DeptTime: 915    ArrvTime: 958
  Flight Number: WW1010

Flight:
  GGG-DFW :: DeptTime: 1030    ArrvTime: 1130
  Flight Number: MQ3224

Flight:
  DFW-TUS :: DeptTime: 1215    ArrvTime: 1225
  Flight Number: AA1437

Flight:
  TUS-LAS :: DeptTime: 1345    ArrvTime: 1400
  Flight Number: WN2377

Flight:
  LAS-SDM :: DeptTime: 1435    ArrvTime: 1555
  Flight Number: RA0667

Another (Y/y/N/n): n
****************************************************************
Game over, thanks for playing.
ed-vm%
```

```
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****************************************************************
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Graph Statistics:
   Nodes: 5432
   Edges: 1018792


================================================================
Travel Agent
  Origin Airport Code (3 letters): lxx

Error, invalid airport code, please try again.

================================================================
Travel Agent
  Origin Airport Code (3 letters): lax
  Destination Airport Code (3 letters): lax

Error, origin and destination  airports are the same, please try again.

================================================================
Travel Agent
  Origin Airport Code (3 letters): lax
  Destination Airport Code (3 letters): lss
  Earliest Departure Time: 900


---------------------------------------------
From / To
  LAX - Los Angeles International Airport
  LSS - Terre-de-Haut Airport

  LSS is not reachable from LAX.

Another (Y/y/N/n): y
================================================================
Travel Agent
  Origin Airport Code (3 letters): lax
  Destination Airport Code (3 letters): lxx

Error, invalid airport code, please try again.

================================================================
Travel Agent
  Origin Airport Code (3 letters): aaa
  Destination Airport Code (3 letters): las
  Earliest Departure Time: 900

No flights from AAA

Another (Y/y/N/n): n
****************************************************************
Game over, thanks for playing.
ed-vm%
```