

Hacettepe University
Department of Computer Engineering

BBM204 Programming Laboratory
Experiment III

Subject : Undirected Graphs
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Programming Language : ANSI C
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1. INTRODUCTION

In this experiment, you are going to practice on undirected graphs by using C programming language. Also you will perform some mathematical and File I/O operations in more detail.

2. EXPERIMENT

2.1. PROBLEM

You are expected to develop a **Travelling System**. In this system, there are cities connected to one another with some types of paths. The system is going to process several input files and generate results to an output file.

2.2. EXECUTION

The program will be executed with the specified command line arguments:

`<graph_information_file> <commands_file> <output_file>`

The first **2** files are input files and the last is output file.

Usage Example:

`> ./Travel GraphInfo.txt Commands.txt Output.txt`

Formats and details of each file are given in following sections.

2.3. GRAPH INFORMATION FILE

When your program starts, firstly it is going to read this file and construct the undirected graph. A sample **graph information file** is shown below (**Figure 1**).

```
Airway Speed:5
Highway Speed:2
Railway Speed:3
CITIES
Alaska: (3,4) Arizona: (12,12) California: (4,13) Florida: (30,6) Hawaii: (10,3) Indiana: (23,20) Kentucky: (26,18) Minnesota: (19,30) Oklahoma: (20,16) Texas: (17,7)
WAYS
Alaska - - A - A - - - - -
Arizona - - AHR - A - - - HR AHR
California A AHR - - A - - - -
Florida - - - - - HR - - AH
Hawaii A A A - - - - - A
Indiana - - - - - AHR R AR -
Kentucky - - - HR - AHR - - H -
Minnesota - - - - - R - - HR -
Oklahoma - HR - - - AR H HR - HR
Texas - AHR - AH A - - - HR -
```

Figure 1: A Sample Graph Information File

There are three types of transportation in the system; **Airway**, **Highway** and **Railway**.

- First three lines of the file contains speed values of transportation types. In the example file above, speed values are; **5** for **Airway**, **2** for **Highway** and **3** for **Railway**.
- After speed information, cities in the system are given with coordinate values. First one is **x** and second one is **y** coordinate of the city center.
- At last, ways between the cities are given with a matrix. **Note that, row and column order in the matrix are same.** **A**, **H** and **R** letters represent **Airway**, **Highway** and **Railway** respectively. For example; there are **Highway** and **Railway** between **Florida** and **Kentucky**, **Airway** between **Hawaii** and **Texas**, no way between **Alaska** and **Arizona**.

The graph in coordinate plane related to the sample graph information file is shown in **Figure 2**.

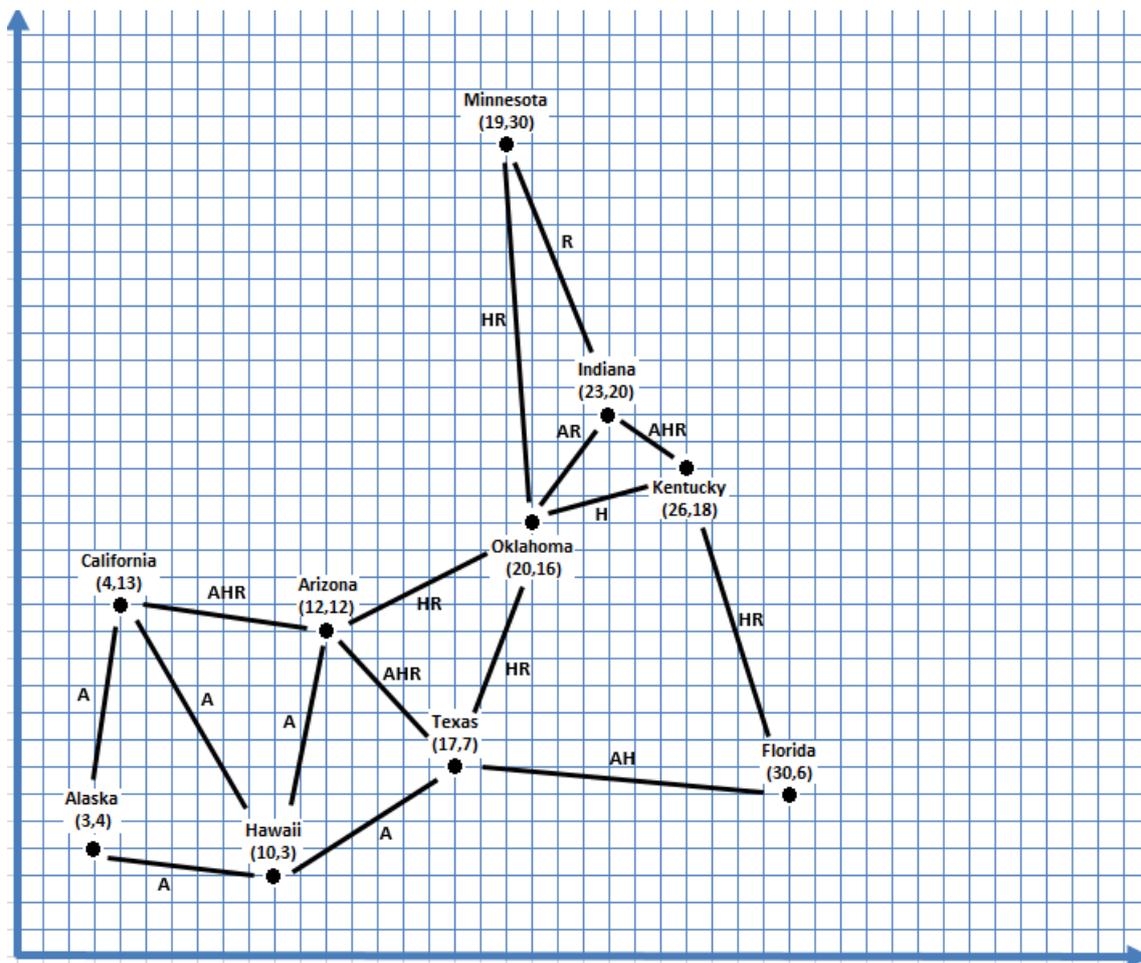


Figure 2: The Graph in Coordinate Plane for Sample Graph Information File

Speed and coordinate values in the **graph information file** are going to be **integer** numbers.

2.4. COMMANDS FILE

After construction of the undirected graph, commands in this file are going to be executed. There are **5** types of commands whose definitions and formats are given below.

1) ADDCITY<space><city_name>:(x_coordinate,y_coordinate)

- **city_name** : Name of the city which will be added
- **x_coordinate** : X coordinate of the city
- **y_coordinate** : Y coordinate of the city

This command adds a new city to the graph.

2) ADDWAY<space><*city_name_1*>-<*city_name_2*>:<*way_type*>

- *city_name_1* : Name of the first city which will be connected by new way
- *city_name_2* : Name of the second city which will be connected by new way
- *way_type* : Type of the way(s)

This command adds new way(s) which connects two cities (*city1* and *city2*) to the graph.

3) DELETACITY<space><*city_name*>

- *city_name* : Name of the city which will be deleted

This command deletes the specified city from the graph. **All ways connecting this city to others also will be deleted.**

4) LISTCITIESFROM<space><*city_name*><space>**WITHIN**<space><*time_value*><space>**HOURS**<space>**BY**<space><*way_type*>

- *city_name* : Name of the city which is the start point of transportation
- *time_value* : Maximum time for transportation
- *way_type* : Type of transportation

By processing this command, the cities which can be travelled from starting city in specified time by using specified transportation type will be listed. **The transportation type part is optional.**

For processing this command, distance between cities must be calculated. For calculating length of a way, the ***Euclidean Distance*** between the cities are going to be used.

Consider that we are going to calculate the length of way between **California (4,13)** and **Hawaii (10,3)**. The *Euclidean Distance* is $\sqrt{(4 - 10)^2 + (13 - 3)^2} = 11.7$.

For ***Airway*** transportation, travel time between **California** and **Hawaii** is $\frac{11.7}{5} = 2.3$ hours.

The most important point is that; while computing way length and travel time, the calculation results must be rounded to one decimal place. Also the time value in the command can be integer or have one decimal place.

If transportation type part exists, only specified type is going to be used in travel. **If not, the fastest type is going to be chosen.** For example, suppose that the command is;

LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS BY HIGHWAY

The result is; **Arizona** and **Kentucky** because only highways can be used.

If the command is in the form of;

LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS

The result will contain; **Arizona, California, Indiana, Kentucky, Minnesota** and **Texas** because the fastest way type(s) is used.

5) PRINTGRAPH

This command will print graph structure.

A sample *commands file* is shown below (*Figure 3*).

```
PRINTGRAPH
ADDCITY Maryland: (35,19)
ADDWAY Indiana-Maryland:HR
ADDWAY Kentucky-Maryland:AH
ADDWAY Maryland-Florida:R
ADDWAY Hawaii-Florida:AH
ADDWAY Indiana-Arizona:AH
DELETECITY Maryland
LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS BY HIGHWAY
LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS
LISTCITIESFROM Oklahoma WITHIN 0.5 HOURS
PRINTGRAPH
```

Figure 3: A Sample Commands File

2.5. OUTPUT FILE

After processing each command, the results are going to be written to the **output file**. Each command's output is going to contain the command and related result. General format of the output file is;

COMMAND<space>#:<command>
<results>

Detailed format of each command's result is given below.

1) ADDCITY

COMMAND<space>#:ADDCITY<space><city_name>:(x_coordinate,y_coordinate)
SUCCESSFULL

2) ADDWAY

COMMAND<space>#:ADDWAY<space><city_name_1>-<city_name_2>:<way_type>
SUCCESSFULL

3) DELETECITY

COMMAND<space>#:DELETECITY<space><city_name>
SUCCESSFULL

4) LISTCITIESFROM

COMMAND<space>#:LISTCITIESFROM<space><city_name><space>WITHIN<space><time_value><space>
HOURS<space>BY<space><way_type>
<city_name>
<city_name>

.
.

- Note that city names must be listed in alphabetical order.

5) PRINTGRAPH

COMMAND<space>#:PRINTGRAPH

City:<city_name>:(x_coordinate,y_coordinate)

Destination:<city_name><space>Type:<way_type><space>Distance:<distance_value><space>Airway Time:<airway_time><space>Highway Time:<highway_time><space>Railway Time:<railway_time>

Destination:<city_name><space>Type:<way_type><space>Distance:<distance_value><space>Airway Time:<airway_time><space>Highway Time:<highway_time><space>Railway Time:<railway_time>

.

.

- Note that source and destination cities must be listed in alphabetical order.

The sample output file is shown in *Figure 4* and *Figure 5*.

```
COMMAND 1:PRINTGRAPH
City:Alaska:(3,4)
Destination:California Type:A Distance:9.1 Airway Time:1.8
Destination:Hawaii Type:A Distance:7.1 Airway Time:1.4
City:Arizona:(12,12)
Destination:California Type:AHR Distance:8.1 Airway Time:1.6 Highway Time:4.1 Railway Time:2.7
Destination:Hawaii Type:A Distance:9.2 Airway Time:1.8
Destination:Oklahoma Type:HR Distance:8.9 Highway Time:4.5 Railway Time:3.0
Destination:Texas Type:AHR Distance:7.1 Airway Time:1.4 Highway Time:3.6 Railway Time:2.4
City:California:(4,13)
Destination:Alaska Type:A Distance:9.1 Airway Time:1.8
Destination:Arizona Type:AHR Distance:8.1 Airway Time:1.6 Highway Time:4.1 Railway Time:2.7
Destination:Hawaii Type:A Distance:11.7 Airway Time:2.3
City:Florida:(30,6)
Destination:Kentucky Type:HR Distance:12.6 Highway Time:6.3 Railway Time:4.2
Destination:Texas Type:AH Distance:13.0 Airway Time:2.6 Highway Time:6.5
City:Hawaii:(10,3)
Destination:Alaska Type:A Distance:7.1 Airway Time:1.4
Destination:Arizona Type:A Distance:9.2 Airway Time:1.8
Destination:California Type:A Distance:11.7 Airway Time:2.3
Destination:Texas Type:A Distance:8.1 Airway Time:1.6
City:Indiana:(23,20)
Destination:Kentucky Type:AHR Distance:3.6 Airway Time:0.7 Highway Time:1.8 Railway Time:1.2
Destination:Minnesota Type:R Distance:10.8 Railway Time:3.6
Destination:Oklahoma Type:AR Distance:5.0 Airway Time:1.0 Railway Time:1.7
City:Kentucky:(26,18)
Destination:Florida Type:HR Distance:12.6 Highway Time:6.3 Railway Time:4.2
Destination:Indiana Type:AHR Distance:3.6 Airway Time:0.7 Highway Time:1.8 Railway Time:1.2
Destination:Oklahoma Type:H Distance:6.3 Highway Time:3.2
City:Minnesota:(19,30)
Destination:Indiana Type:R Distance:10.8 Railway Time:3.6
Destination:Oklahoma Type:HR Distance:14.0 Highway Time:7.0 Railway Time:4.7
City:Oklahoma:(20,16)
Destination:Arizona Type:HR Distance:8.9 Highway Time:4.5 Railway Time:3.0
Destination:Indiana Type:AR Distance:5.0 Airway Time:1.0 Railway Time:1.7
Destination:Kentucky Type:H Distance:6.3 Highway Time:3.2
Destination:Minnesota Type:HR Distance:14.0 Highway Time:7.0 Railway Time:4.7
Destination:Texas Type:HR Distance:9.5 Highway Time:4.8 Railway Time:3.2
City:Texas:(17,7)
Destination:Arizona Type:AHR Distance:7.1 Airway Time:1.4 Highway Time:3.6 Railway Time:2.4
Destination:Florida Type:AH Distance:13.0 Airway Time:2.6 Highway Time:6.5
Destination:Hawaii Type:A Distance:8.1 Airway Time:1.6
Destination:Oklahoma Type:HR Distance:9.5 Highway Time:4.8 Railway Time:3.2

COMMAND 2:ADDCITY Maryland:(35,19)
SUCCESSFULL

COMMAND 3:ADDWAY Indiana-Maryland:HR
SUCCESSFULL
```

Figure 4: A Sample Output File

```

COMMAND 4:ADDWAY Kentucky-Maryland:AH
SUCCESSFULL

COMMAND 5:ADDWAY Maryland-Florida:R
SUCCESSFULL

COMMAND 6:ADDWAY Hawaii-Florida:AH
SUCCESSFULL

COMMAND 7:ADDWAY Indiana-Arizona:AH
SUCCESSFULL

COMMAND 8:DELETECITY Maryland
SUCCESSFULL

COMMAND 9:LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS BY HIGHWAY
Arizona
Kentucky

COMMAND 10:LISTCITIESFROM Oklahoma WITHIN 4.6 HOURS
Arizona
California
Indiana
Kentucky
Minnesota
Texas

COMMAND 11:LISTCITIESFROM Oklahoma WITHIN 0.5 HOURS
NO CITY FOUND

```

```

COMMAND 12:PRINTGRAPH
City:Alaska: (3,4)
Destination:California Type:A Distance:9.1 Airway Time:1.8
Destination:Hawaii Type:A Distance:7.1 Airway Time:1.4
City:Arizona: (12,12)
Destination:California Type:AHR Distance:8.1 Airway Time:1.6 Highway Time:4.1 Railway Time:2.7
Destination:Hawaii Type:A Distance:9.2 Airway Time:1.8
Destination:Indiana Type:AH Distance:13.6 Airway Time:2.7 Highway Time:6.8
Destination:Oklahoma Type:HR Distance:8.9 Highway Time:4.5 Railway Time:3.0
Destination:Texas Type:AHR Distance:7.1 Airway Time:1.4 Highway Time:3.6 Railway Time:2.4
City:California: (4,13)
Destination:Alaska Type:A Distance:9.1 Airway Time:1.8
Destination:Arizona Type:AHR Distance:8.1 Airway Time:1.6 Highway Time:4.1 Railway Time:2.7
Destination:Hawaii Type:A Distance:11.7 Airway Time:2.3
City:Florida: (30,6)
Destination:Hawaii Type:AH Distance:20.2 Airway Time:4.0 Highway Time:10.1
Destination:Kentucky Type:HR Distance:12.6 Highway Time:6.3 Railway Time:4.2
Destination:Texas Type:AH Distance:13.0 Airway Time:2.6 Highway Time:6.5
City:Hawaii: (10,3)
Destination:Alaska Type:A Distance:7.1 Airway Time:1.4
Destination:Arizona Type:A Distance:9.2 Airway Time:1.8
Destination:California Type:A Distance:11.7 Airway Time:2.3
Destination:Florida Type:AH Distance:20.2 Airway Time:4.0 Highway Time:10.1
Destination:Texas Type:A Distance:8.1 Airway Time:1.6
City:Indiana: (23,20)
Destination:Arizona Type:AH Distance:13.6 Airway Time:2.7 Highway Time:6.8
Destination:Kentucky Type:AHR Distance:3.6 Airway Time:0.7 Highway Time:1.8 Railway Time:1.2
Destination:Minnesota Type:R Distance:10.8 Railway Time:3.6
Destination:Oklahoma Type:AR Distance:5.0 Airway Time:1.0 Railway Time:1.7
City:Kentucky: (26,18)
Destination:Florida Type:HR Distance:12.6 Highway Time:6.3 Railway Time:4.2
Destination:Indiana Type:AHR Distance:3.6 Airway Time:0.7 Highway Time:1.8 Railway Time:1.2
Destination:Oklahoma Type:H Distance:6.3 Highway Time:3.2
City:Minnesota: (19,30)
Destination:Indiana Type:R Distance:10.8 Railway Time:3.6
Destination:Oklahoma Type:HR Distance:14.0 Highway Time:7.0 Railway Time:4.7
City:Oklahoma: (20,16)
Destination:Arizona Type:HR Distance:8.9 Highway Time:4.5 Railway Time:3.0
Destination:Indiana Type:AR Distance:5.0 Airway Time:1.0 Railway Time:1.7
Destination:Kentucky Type:H Distance:6.3 Highway Time:3.2
Destination:Minnesota Type:HR Distance:14.0 Highway Time:7.0 Railway Time:4.7
Destination:Texas Type:HR Distance:9.5 Highway Time:4.8 Railway Time:3.2
City:Texas: (17,7)
Destination:Arizona Type:AHR Distance:7.1 Airway Time:1.4 Highway Time:3.6 Railway Time:2.4
Destination:Florida Type:AH Distance:13.0 Airway Time:2.6 Highway Time:6.5
Destination:Hawaii Type:A Distance:8.1 Airway Time:1.6
Destination:Oklahoma Type:HR Distance:9.5 Highway Time:4.8 Railway Time:3.2

```

Figure 5: A Sample Output File (Continued)

3.NOTES

- Take care about the output file format explained above. Your experiments will be evaluated automatically, so your output files should be exactly the same with the advisor's one.
- Your programs are going to be tested on the dev machine.
- You will use online submission system to submit your experiments.
<https://submit.cs.hacettepe.edu.tr/> (No other submission method such as e-mail will be accepted.)
- Your submission file structure must implement this template:
 <student_id>.zip
 |-- src
 |-- Travel.c
 |-- *.h
 |-- report
 |-- report.pdf
- **SAVE** all your work until the assignment is graded.
- The assignment must be original, **INDIVIDUAL** work. Duplicate or very similar assignments are both going to be punished.
- You can ask your questions through <https://piazza.com/hacettepe.edu.tr/spring2014/bbm202>

4. REFERENCES

- 1) C: The Complete Reference, Herbert Schildt
- 2) http://en.wikipedia.org/wiki/Euclidean_distance