Assignment 1

Programming and Written Assignment - Uninformed Search & Informed Search

Max possible score:

- 4308: 150 Points (+20 Points EC)
- 5360: 150 Points

Task 1
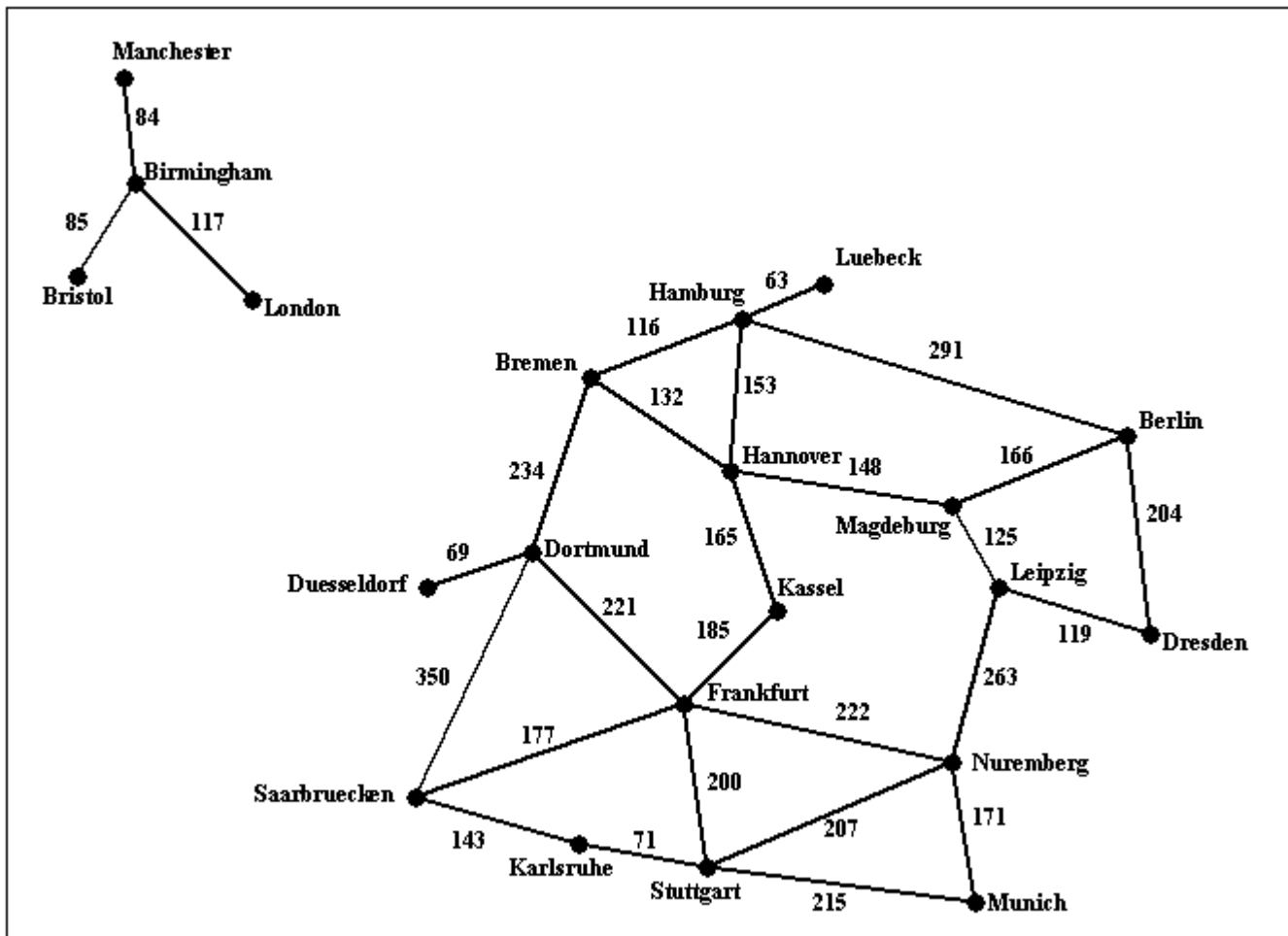
Max: [4308: 75 Points (+5 Points EC), 5360: 75 Points]

Figure 1: Visual representation of input1.txt

Implement a search algorithm that can find a route between any two cities. Your program will be called find_route, and will take exactly commandline arguments as follows:

find_route input_filename origin_city destination_city heuristic_filename

An example command line is:

find_route input1.txt Bremen Kassel (For doing Uninformed search)
or
find_route input1.txt Bremen Kassel h_kassel.txt (For doing Informed search)

If heuristic is not provided then program must do uninformed search. Argument input_filename is the name of a text file such as input1.txt, that describes road connections between cities in some part of the world. For example, the road system described by file input1.txt can be visualized in Figure 1 shown above. You can assume that the input file is formatted in the same way as input1.txt: each line contains three items. The last line contains the items "END OF INPUT", and that is how the program can detect that it has reached the end of the file. The other lines of the file contain, in this order, a source city, a destination city, and the length in kilometers of the road connecting directly those two cities. Each city name will be a single word (for example, we will use New_York instead of New York), consisting of upper and lowercase letters and possibly underscores.

IMPORTANT NOTE: MULTIPLE INPUT FILES WILL BE USED TO GRADE THE ASSIGNMENT, FILE input1.txt IS JUST AN EXAMPLE. YOUR CODE SHOULD WORK WITH ANY INPUT FILE FORMATTED AS SPECIFIED ABOVE.

The program will compute a route between the origin city and the destination city, and will print out both the length of the route and the list of all cities that lie on that route. It should also display the number of nodes expanded and nodes generated. For example,

find_route input1.txt Bremen Kassel

should have the following output:

nodes expanded: 12
nodes generated: 20
distance: 297.0 km
route:
Bremen to Hannover, 132.0 km
Hannover to Kassel, 165.0 km

and

find_route input1.txt London Kassel

should have the following output:

nodes expanded: 7
nodes generated: 7
distance: infinity
route:
none

For full credit, you should produce outputs identical in format to the above two examples.

The following part is required for students of CSE 5360 (It is extra credit CSE 4308): If a heuristic file is provided then program must perform Informed search. The heuristic file gives the estimate of what the cost could be to get to the given destination from any start state (note this is just an estimate). In this case the command line would look like

find_route input1.txt Bremen Kassel h_kassel.txt

Here the last argument contains a text file what has the heuristic values for every state wrt the given destination city (note different destinations will need different heuristic values). For example, you have been provided a sample file h_kassel.txt which gives the heuristic value for every state (assuming kassel is the goal). Your program should use this information to reduce the number of nodes it ends up expanding. Other than that, the solution returned by the program should be the same as the uninformed version. For example,

find_route input1.txt Bremen Kassel h_kassel.txt

should have the following output:

nodes expanded: 3
nodes generated: 8
distance: 297.0 km
route:
Bremen to Hannover, 132.0 km
Hannover to Kassel, 165.0 km

Suggestions

Pay close attention to all specifications on this page, including specifications about output format, submission format. Even in cases where the program works correctly, points will be taken off for non-compliance with the instructions given on this page (such as a different format for the program output, wrong compression format for the submitted code, and so on). The reason is that non-compliance with the instructions makes the grading process significantly (and unnecessarily) more time consuming.

Grading

The assignments will be graded out of 75 points.

- 38 points for CSE 4308, 35 points for CSE 5360: The program always finds a route between the origin and the destination, as long as such a route exists.
- 15 points for CSE 4308, 15 points for CSE 5360: The program terminates and reports that no route can be found when indeed no route exists that connects source and destination (e.g., if source is London and destination is Berlin, in the above example).
- 22 points for CSE 4308, 20 points for CSE 5360: In addition to the above requirements, the program always returns optimal routes. In other words, no shorter route exists than the one reported by the program.
- 5 points EC for CSE 4308, 5 points for CSE 5360: Correct implementation of any informed search method.
- Negative points: penalty points will be awarded by the instructor and TA generously and at will, for issues such as: submission not including precise and accurate instructions for how to run the code, wrong compression format for the submission, or other failures to comply with the instructions given for this assignment. Partial credit for incorrect solutions will be given ONLY for code that is well designed and well documented. Code that is badly designed and badly documented can still get full credit as long as it accomplishes the required tasks.

Task 2

Max: [4308: 32 Points, 5360: 28 Points]

Consider the navigation problem shown in Figure 2. The number next to each edge is the cost of the performing the action corresponding to that edge. You start from A and your goal is to get to G. List the order in which **nodes are expanded**, which **nodes are added to the fringe** and which **states are added to the closed set** when performing **Graph Search** using:

- breadth-first search.
- depth-first search.
- iterative deepening search.
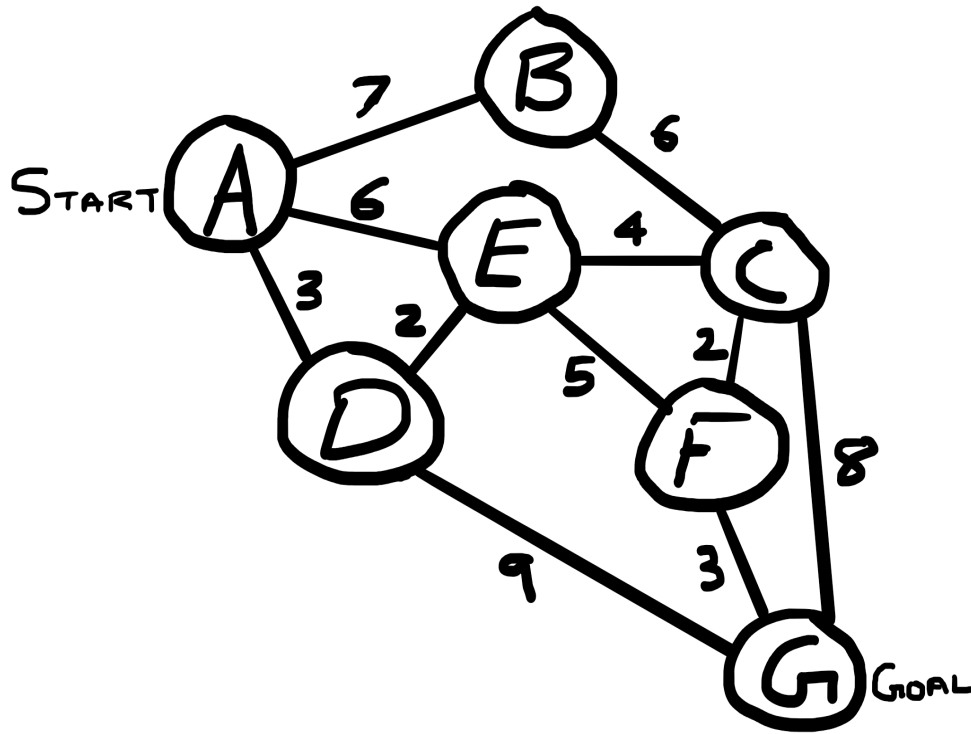- uniform cost search.

Figure 2: Search Tree for Task 2

Task 3

Max: [4308: 18 Points, 5360: 12 Points]

A social network graph (SNG) is a graph where each vertex is a person and each edge represents an acquaintance. In other words, an SNG is a graph showing who knows who. For example, in the graph shown on Figure 3, George knows Mary and John, Mary knows Christine, Peter and George, John knows Christine, Helen and George, Christine knows Mary and John, Helen knows John, Peter knows Mary.
The degrees of separation measure how closely connected two people are in the graph. For example, John has 0 degrees of separation from himself, 1 degree of separation from Christine, 2 degrees of separation from Mary, and 3 degrees of separation from Peter.

  i. From among **general tree search** using breadth-first search, depth-first search, iterative deepening search, and uniform cost search, which one(s) guarantee finding the correct number of degrees of separation between any two people in the graph?

  ii. For the SNG shown in Figure 3, draw the first three levels of the search tree, with John as the starting point (the first level of the tree is the root).

iii. Is there a one-to-one correspondence between nodes in the search tree and vertices in the SNG (i.e. does every node in the search tree correspond to a vertex in the SNG)? Why, or why not? In your answer here, you should assume that the search algorithm does not try to avoid revisiting the same state.

iv. Draw an SNG containing exactly 5 people, where at least two people have 4 degrees of separation between them.

v. Draw an SNG containing exactly 5 people, where all people have 1 degree of separation between them.

vi. In an implementation of breadth-first tree search for finding degrees of separation, suppose that every node in the search tree takes 1KB of memory. Suppose that the SNG contains one million people. Outline (briefly but precisely) how to make sure that the memory required to store search tree nodes will not exceed 1GB (the correct answer can be described in one-two lines of text). In your answer here you are free to enhance/modify the breadth-first search implementation as you wish, as long as it remains breadth-first (a modification that, for example, converts breadth-first search into depth-first search or iterative deepening search is not allowed).
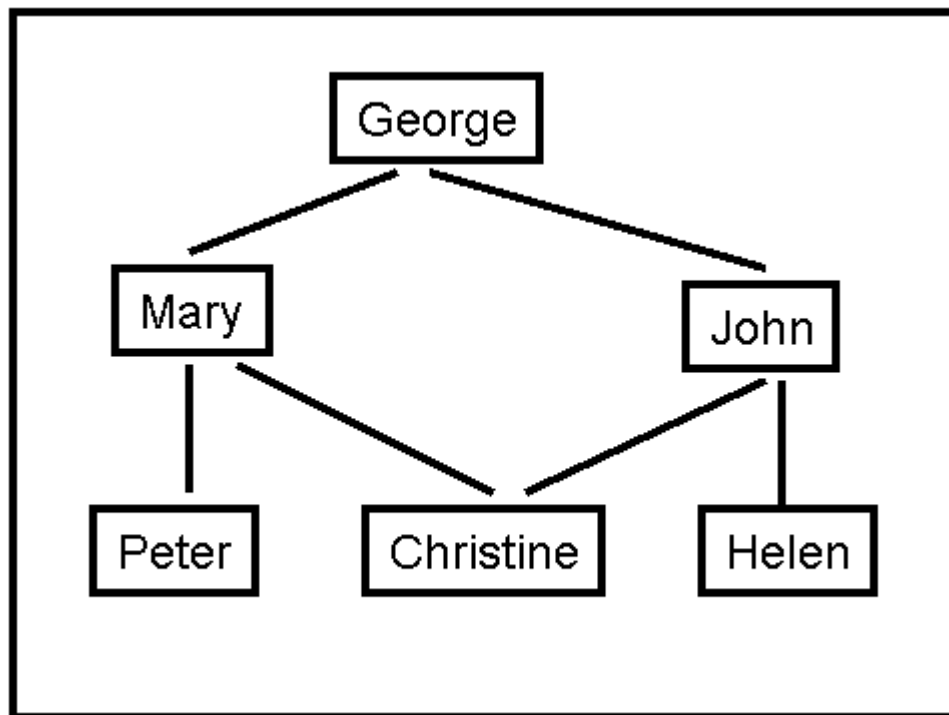

Figure 3: A Social Network Graph

Task 4

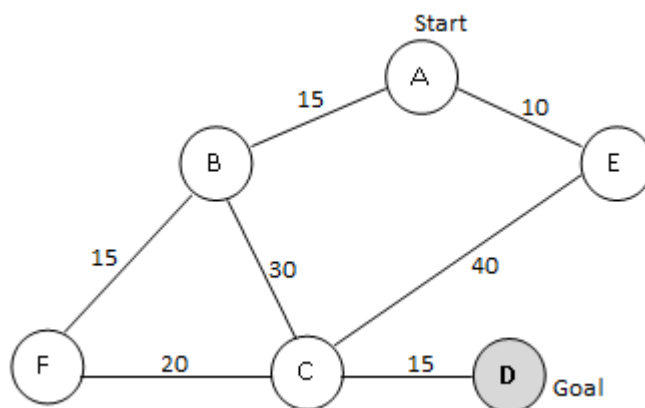**Max: [4308: 10 Points, 5360: 8 Points]**

Figure 4: A search graph showing states and costs of moving from one state to another. Costs are undirected.

Consider the search space shown in Figure 4. D is the only goal state. Costs are undirected. For each of the following heuristics, determine if it is admissible or not. For non-admissible heuristics, modify their values as needed to make them admissible.

Heuristic 1:
 h(A) = 5
 h(B) = 50
 h(C) = 15
 h(D) = 0
 h(E) = 10
 h(F) = 0

Heuristic 2:
 h(A) = 70
 h(B) = 70
 h(C) = 70
 h(D) = 70
 h(E) = 70
 h(F) = 70

Heuristic 3:
 h(A) = 35
 h(B) = 30
 h(C) = 20
 h(D) = 5
 h(E) = 0
 h(F) = 30

Heuristic 4:
 h(A) = 0
 h(B) = 0
 h(C) = 0
 h(D) = 0
 h(E) = 0
 h(F) = 0

Task 5

Max: [4308: 15 Points, 5360: 12 Points]

Consider a search space, where each state can be a city, suburb, village, farm, or mountain. The goal is to reach any state that is a mountain. Here are some rules on the successors of different states:

- Successors of a city are always suburbs.
  - Each city has at least one suburb as a successor.
- Successors of a suburb can only be cities, or suburbs, or villages.
  - Each suburb has at least one suburb as a successor.
- Successors of a village can only be villages, or farms, or mountains.
  - Each village has atleast one farm as a successor
- Successors of a farm can only be villages, or farms, or mountains.
  - Each farm has at least one other farm as a successor.
- Successors of a mountain can only be mountains.

Define the best admissible heuristic h you can define using only the above information (you should not assume knowledge of any additional information about the state space). By "best admissible" we mean that h(n) is always the highest possible value we can give, while ensuring that heuristic h is still admissible.

Assume that any move from one state to another has cost 1.

Task 6 (Extra Credit for 4308, Required for 5360)

Max: [4308: 15 Points EC, 5360: 15 Points]

Figures 5 and 6 show maps where all the towns are on a grid. Each town T has coordinates (Ti, Tj), where Ti Tj are non-negative integers. We use the term Euclidean distance for the straight-line distance between two towns, and the term driving distance for the length of the shortest driving route connecting two towns. The only roads that exist connect towns that have Euclidean (straight-line) distance 1 from each other (however, there may be towns with Euclidean distance 1 from each other that are NOT directly connected by a road, for example in Figure 6).

Consider greedy search, where the node to be expanded is always the one with the shortest Euclidean distance to the destination. Also consider A* search, where h(n) is the Euclidean distance from n to the destination (remember that the next node is picked not based on h(n) but based on f(n) = g(n) + h(n)). For each of the maps showing on Figures 5 and 6, which of the following statements is true?

- Greedy search always performs better than or the same as A*.
- Greedy search always performs worse than or the same as A*.
- Greedy search performs sometimes better, sometimes worse, and sometimes the same as A*, depending on the start and end states.

Justify your answer. For the purposes of this question, the performance of a search algorithm is simply measured by the number of nodes visited by that algorithm. **Note that you have to provide separate answers for Figure 5 and for Figure 6**.
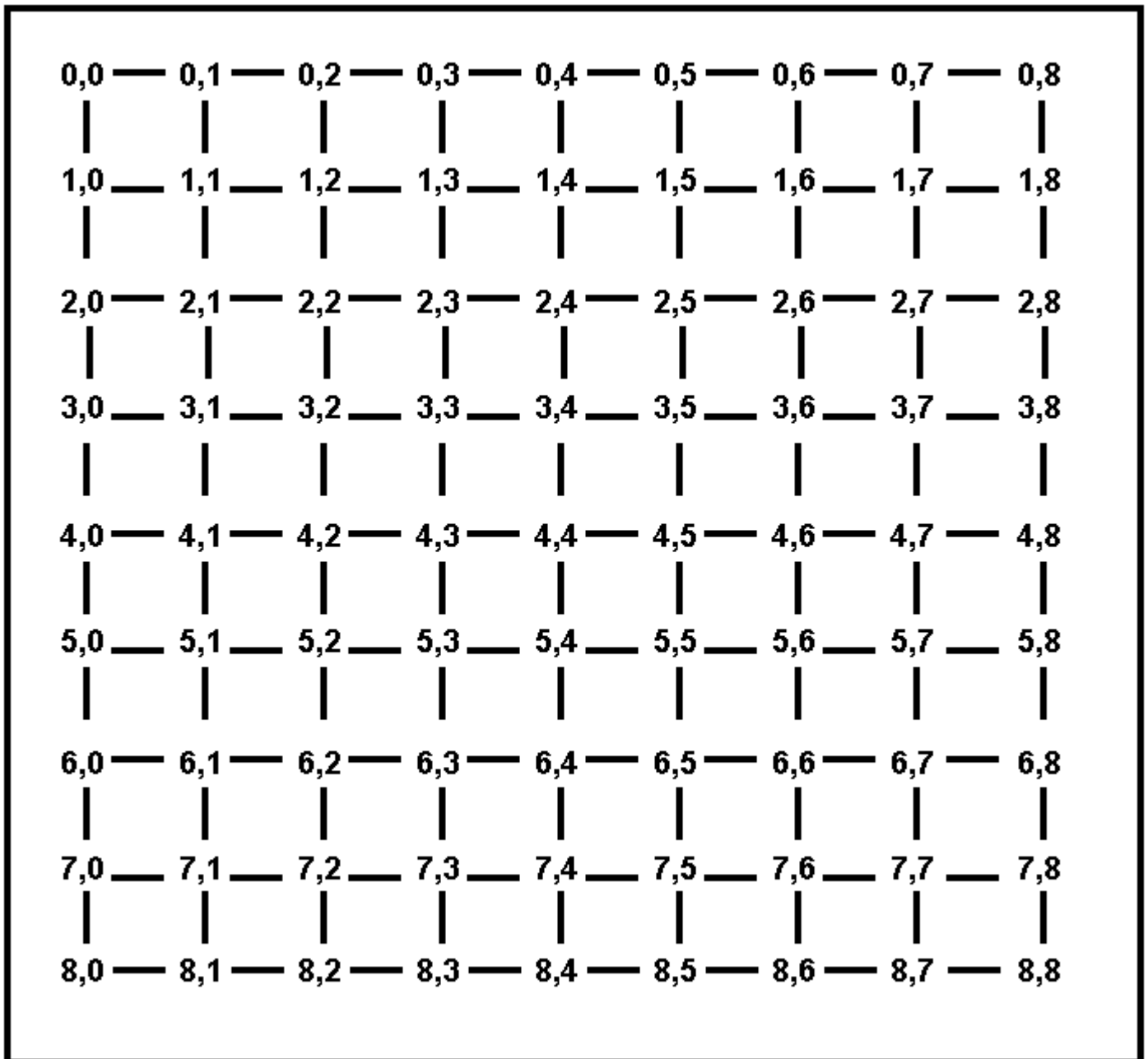
Figure 5: A map of cities on a fully connected grid. Every city is simply named by its coordinates.
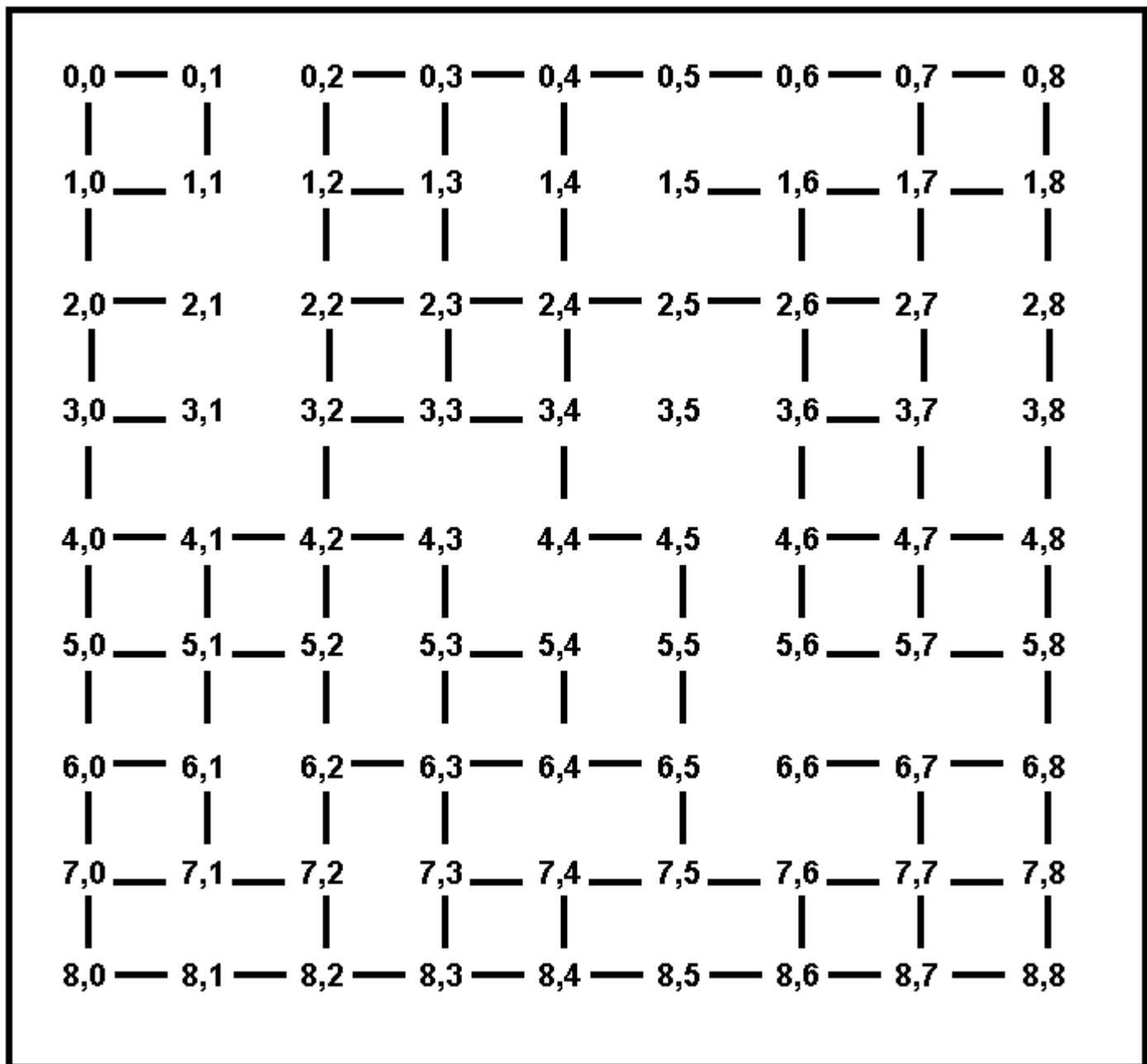
Figure 6: A map of cities on a partially connected grid. Every city is simply named by its coordinates.

How to submit

For Programming part: Implementations in C, C++, Java, and Python will be accepted. Points will be taken off for failure to comply with this requirement.

Create a ZIPPED directory called assignment1_code_<net-id>.zip (no other forms of compression accepted, contact the instructor or TA if you do not know how to produce .zip files). The directory should contain source code.The folder should also contain a file called readme.txt, which should specify precisely:

- Name and UTA ID of the student.
- What programming language is used. (also mention if the code is omega compatible)
- How the code is structured.
- How to run the code, including very specific compilation instructions, if compilation is needed. Instructions such as "compile using g++" are NOT considered specific.
- Insufficient or unclear instructions will be penalized by up to 10 points.

- **Code that the TA cannot run gets AT MOST 75% credit**.

For Written part:

- The answers can be typed as a document or handwritten and scanned.
- Name files as assignment1_written_<net-id>.<format>
- Accepted document formats .pdf. If you are using Word, OpenOffice or LibreOffice, make sure to save as .pdf
- Please do not submit .txt files.
- If you are scanning handwritten documents make sure to scan it at a minimum of 600dpi and save as a .pdf or .png file. Do not insert images in word document and submit.
- If there are multiple files in your submission, zip them together as assignment1_written_<net-id>.zip.

The assignment should be submitted via CANVAS. Zip all the files for both the programming and written files together into assignment1_<net-id>.zip and submit it.

Submission checklist

- Does the programming section submission include a readme.txt file, as specified?
- Have scanned all the documents for the written section as specified?
- Did you zip and name the files as described?
- Did you upload the file correctly?
- Did you submit the uploaded file?