National Taiwan University of Science and Technology
Department of Electrical Engineering
Algorithm Design and Application, Fall 2023
Programming Assignment #2
Global Routing (due December 24, 2023 (Sunday) on-line)

1. Problem Description

This programming assignment asks you to write a global router that can route 2-pin nets (connection between two points). The problem description below is a simplified routing problem. Given the problem size (the number of horizontal and vertical tiles), capacity, and a netlist, the global router routes all nets in the routing region. The main objective is to minimize the total overflows. Here the overflow on a tile boundary is calculated as the amount of demand that excesses the capacity, *i.e.*, overflow = max(0, demand-capacity).

2. Input

The file format for the global routing is illustrated, with comments in italics (these will not be in actual input files). The 1st line gives the problem size in terms of the number of horizontal and vertical tiles. Each global routing tile (tile in short) has a *capacity* on its four boundaries to measure the available space, which is the maximum number of routing paths passing through boundaries. The capacity value is given by the 2nd line. The 3rd line gives the number of nets and following indicate each net, including starting position and terminal position. The input file format is as follows:

> **grid # #**   *//number of horizontal tiles, number of vertical tiles*
> **capacity #**   *//capacity of tile*
> **num net #**   *//number of nets*
> **net_id x_s y_s x_t y_t**
> **...**
> *//repeat for the appropriate number of nets*

3. Output

All the routes in the output could only be horizontal lines and vertical lines. For example (18, 61)-(19, 62) is not acceptable, because it is diagonal. Remember that **each route could be different either in the x or y location only, and the difference must be 1.** The output file format is as follows:

> **[net_id] [# of routes, k]**
> **[x_{11}] [y_{11}] [x_{12}] [y_{12}]**
> **[x_{21}] [y_{21}] [x_{22}] [y_{22}]**
> **...**
> **[$x_{(k-1)1}$] [$y_{(k-1)1}$] [x_{k2}] [y_{k2}]**
> *//repeat for the appropriate number of nets*

Note that for a certain net, x_{11}, y_{11}, x_{k2} and y_{k2} must be the same as x_s, y_s, x_t and y_t in the input file respectively. Also, for any i, x_{i2} and y_{i2} must be the same as $x_{(i+1)1}$ and $y_{(i+1)1}$ respectively.

Sample case:
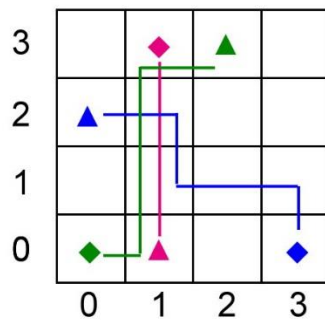
Sample input file:

```
grid 4 4
capacity 2
num net 3
0 2 3 0 0
1 0 2 3 0
2 1 0 1 3
```

Sample output file:

```
0 5
2 3 1 3
1 3 1 2
1 2 1 1
1 1 1 0
1 0 0 0
2 3
1 0 1 1
1 1 1 2
1 2 1 3
1 5
0 2 1 2
1 2 1 1
1 1 2 1
2 1 3 1
3 1 3 0
```

The total overflow is 1, which is caused by the boundary between tiles (1,1) and (1,2).
(The total wirelength is 13.)

4. Hints

You can first model the routing problem as a graph where each node represents a tile and each edge denotes the tile boundary between tiles. The cost of an edge could be set to reflect the capacity usage (*e.g*, edge cost = demand/capacity). Then this problem can be solved by Dijkstra's shortest path algorithm. Note that different edge costs would result in different routing results; for example, you also can apply the edge cost as $2^{(\text{demand/capacity})}-1$.

5. Language/Platform

    (a) Language: C or C++.

    (b) Platform: Unix/Linux.

6. Command-line Parameter

In order to test your program, you are asked to add the following command-line parameters to your program (e.g., ./routing 5x5.in 5x5.out):

<div align="center">[executable file name] [input file name] [output file name]</div>

7. Submission

You need to submit the following materials in a compressed [student id]-p2.tgz file (e.g., b11007000-p1.tgz) at the course website by the deadline: (1) source codes, (2) Makefile, and (3) a text readme file (readme.txt) stating how to build and conduct your program.

Hints:

- The compressed file [student id]-p2.tgz file contains only a single folder named [student id]-p2 (e.g., b11007000-p2). Use only lowercase letters for the compressed file and folder names.
- Only a compressed file in the *.tgz format will be accepted.
- Do not submit files or folders other than those specified above.
- Please ensure that your work can be successfully executed in the Linux environment.

**If the above requirements are not met, penalties will be imposed

8. Grading Policy

This programming assignment will be graded based on (1) the correctness (a solution is correct if all nets are well-connected, i.e. no disconnection), (2) solution quality (The quality is determined by the total overflows, and tie is broken by the total routing wirelength), (3) running time (the runtime is restricted in 15 minutes for each case), and (4) required submission files with correct file/folder names.

8. Online Resources

Sample input files (*.in) can be found at the course website.