Project
A Simple Simulated-Annealing Cell Placement Tool

Introduction
Develop a simple simulated annealing-based placer that minimizes the total wire length. You will also study the effects of the cooling rate (see cooling parameters below) on the placement quality.

Assumptions
- HPWL (half-perimeter of the smallest bounding box containing all pins for a net) is used to estimate the wire length of any net
- The core area is a 2D array of empty squares (sites)
- Each cell is a square and matches the site size; the site size is 1x1.
- No site is assigned to more than one cell. In other words, the cell size is the same as the site size.
- The distance between two cells is measured from the center of one cell to the center of the other.

The Input Netlist
The input to the placer is a netlist file with the following format
- The first line contains 4 values:
  - the number of cells to be placed.
  - the number of connections (nets) between the cells.
  - the number of rows (ny)
  - the number of columns/sites per row (nx)
- Each of the following lines represents a net and it contains the following:
  - The number of components attached to the net
  - The list of components attached to the net

An example of a netlist file content is shown below:

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

- Line 1: The number of components is 3 and the number of nets is 3. The placement grid is 2x2 (2 rows; each of 2 sites).
- Line 2: The first net connects 3 components: 0, 1 and 2
- Line 3: The second net connects 2 components: 2 and 0
- Line 4: The third net connects 2 components: 1 and 2

The cooling schedule:
- Initial Temperature = 500 x Initial Cost
- Final Temperature = $5x10^{-6}$ x (Initial Cost) / (Number of Nets)
- Next Temperature = 0.95 x Current Temperature ← 0.95 is the cooling rate
- Moves/Temperature = 20 x (Number of cells)

The placer output
The placer displays (on the console) the final placement and the final wire length when it finishes. For example:

```
-- -- -- -- 01 08
09 -- 10 -- 02 03
-- 04 07 -- 05 --
06 -- -- 11 -- 12

Total wire length = 25
```

Where:
- `--` : Empty site
- `DD` : The site has the component number DD

Notes:

1) Your implementation must support swapping with empty cells.
2) You need to select the data structures carefully to reduce the implementation time complexity. Running T3 design in less than 60 seconds is a good indicator.
3) Plot the temperature against the total wire length (TWL) for the 6 designs.
4) Plot the TWL vs. the cooling rate for the 6 designs; make sure you use the same random seed for any given design. Use the cooling rates: 0.75, 0.8, 0.85, 0.9, and 0.95 (one graph/design)
5) Print the TWL after the initial random placement and after finishing the SA.
6) To make sense of how well your implementation is, print the grid in binary format after the initial random placement and after the SA. An Example for 3 rows by 5 columns grid is shown below, 0 means an occupied cell, and 1 means an empty cell:

```
01010
11010
00001
```

Grading:

a) 15%: Parsing the netlist
b) 15%: Initial Random Placement
c) 30%: Correctness of the results (through test cases)
d) 10%: Representing the placement on the console.
e) 10%: Cooling rate vs. TWL graphs.
f) 10%: Temperature vs. TWL graphs.
g) 10%: The report (at least 5 pages discussing the algorithm, the implementation, the graphs, and some conclusions)
h) 5% (Bonus): Animate the placement progress graphically (Animated GIF is sufficient).
i) 10% (Bonus): The fasted implementation (one group only).

Guidelines:

- Work in a group of three students.
- Use any programming language to implement your placer.
- Use GH for development.

Timeline:

- May 13: items ‘a’ to ‘d’, from the list above, are implemented and can be demonstrated; a few bugs are allowed. Failure to provide an acceptable demonstration will result in losing 25% of the grade.
- May 20: Final Demo. All deliverables must be ready before the interview.