National Taiwan University of Science and Technology
Department of Electrical Engineering

Software Development for Electronic Design Automation, Spring 2025

Programming Assignment #2

Single-Row-Height Cell Legalization (due April 20, 2025 (Sunday) on-line)

1. Problem Description

This programming assignment asks you to write a standard cell legalizer for designs containing only single-row-height cells. Given a set of standard cells and a global placement result, the legalizer places all cells to align the pre-defined rows and sites without any overlaps, follows the orientations of placed rows, and makes the overall cell displacement as small as possible. For simplicity, every cell is assumed to have the same cell width (in terms of placement sites), which will be specified through command-line parameters.

2. Input

Each test case (case*.def) gives die area, row configuration, and the global placement position of each cell. The file format is as follows:

Input Format

VERSION 5.8 ;
DIVIDERCHAR "/" ;
BUSBITCHARS "[]" ;
DESIGN <design name> ;
UNITS DISTANCE MICRONS <units> ;
 	
DIEAREA (<x0> <y0>) (<x1> <y1>) ;
 	
ROW <row_name> <site_name> <x> <y> <orientation> DO <num_x> BY <num_y> STEP <step_x> <step_y> ;
… // repeat for all rows
 	
COMPONENTS <num_components> ;
  - <inst_name> <macro_name>
  + PLACED (<x> <y>) <orientation> ;
… // repeat for all cells
END COMPONENTS
 	
END DESIGN

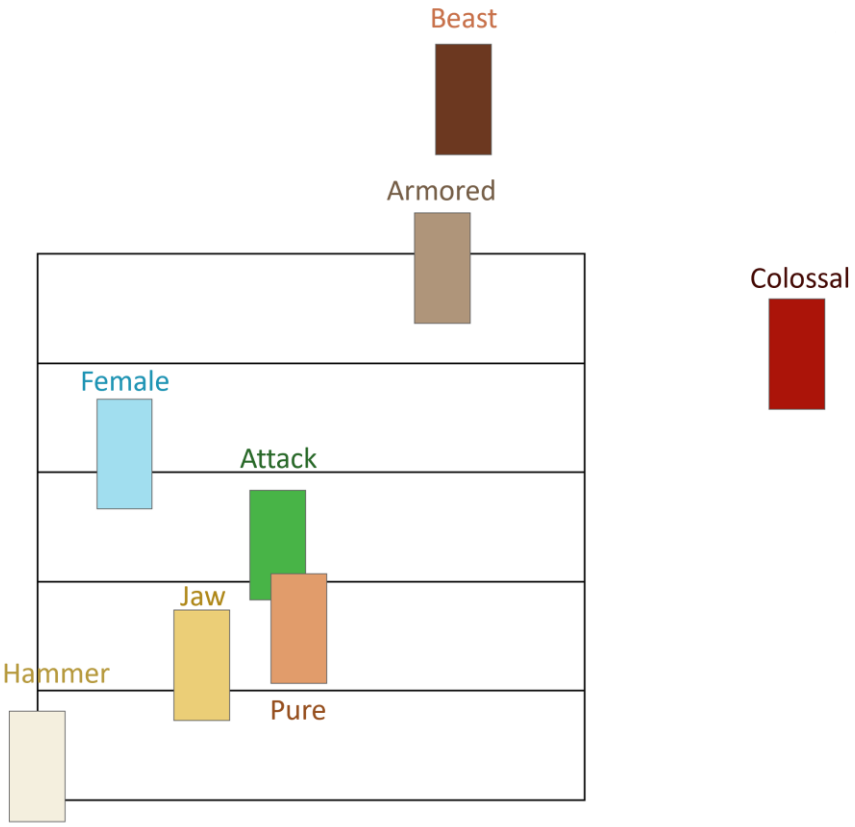
Sample Input
VERSION 5.8 ; DIVIDERCHAR "/" ; BUSBITCHARS "[]" ; DESIGN Attack_on_Titan ; UNITS DISTANCE MICRONS 1000 ;

```
DIEAREA ( 0 0 ) ( 10000 10000 ) ;

ROW core_SITE_ROW_0 core 0 0 N DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_1 core 0 2000 FS DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_2 core 0 4000 N DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_3 core 0 6000 FS DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_4 core 0 8000 N DO 50 BY 1 STEP 200 0 ;

COMPONENTS 8 ;
- Attack Titan + PLACED ( 3876 3684 ) N ;
- Armored Titan + PLACED ( 6879 8754 ) N ;
- Colossal Titan + PLACED ( 13358 7182 ) N ;
- Female Titan + PLACED ( 1069 5354 ) N ;
- Beast Titan + PLACED ( 7265 11842 ) N ;
- Hammer Titan + PLACED ( -523 -367 ) N ;
- Jaw Titan + PLACED ( 2483 1483 ) N ;
- Pure Titan + PLACED ( 4257 2154 ) N ;
END COMPONENTS

END DESIGN
```



3. Output

The output file (LG_case*.def) records the legalized placement of the input case, and the output format is exactly the same as that of the input file. An output result of the sample input above is shown below.

Sample Output

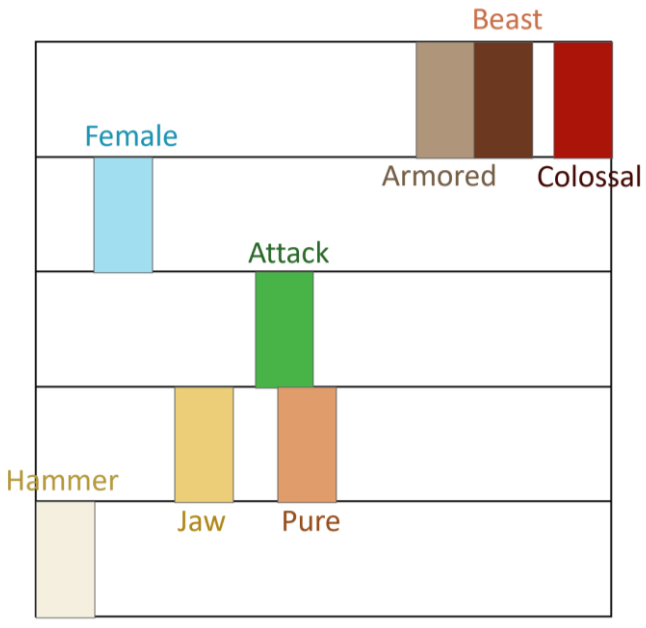
```
VERSION 5.8 ;
DIVIDERCHAR "/" ;
BUSBITCHARS "[]" ;
DESIGN Attack_on_Titan ;
UNITS DISTANCE MICRONS 1000 ;

DIEAREA ( 0 0 ) ( 10000 10000 ) ;

ROW core_SITE_ROW_0 core 0 0 N DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_1 core 0 2000 FS DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_2 core 0 4000 N DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_3 core 0 6000 FS DO 50 BY 1 STEP 200 0 ;
ROW core_SITE_ROW_4 core 0 8000 N DO 50 BY 1 STEP 200 0 ;

COMPONENTS 8 ;
- Attack Titan + PLACED ( 3800 4000 ) N ;
- Armored Titan + PLACED ( 6600 8000 ) N ;
- Colossal Titan + PLACED ( 9000 8000 ) N ;
- Female Titan + PLACED ( 1000 6000 ) FS ;
- Beast Titan + PLACED ( 7600 8000 ) N ;
- Hammer Titan + PLACED ( 0 0 ) N ;
- Jaw Titan + PLACED ( 2400 2000 ) FS ;
- Pure Titan + PLACED ( 4200 2000 ) FS ;
END COMPONENTS

END DESIGN
```



4. Language/Platform

(a) Language: C or C++.

(b) Platform: Unix/Linux.

5. Command-line Parameter

In order to test your program, you are asked to add the following command-line parameters to your program:

./legalizer [cell width (in terms of sites)] [alpha] [input file name] [output file name]

6. Submission

You need to submit the following materials in a compressed [student id]-p2.tgz file (e.g., b11107000-p2.tgz) at the course website by the deadline: (1) source codes, (2) Makefile, (3) a text readme file (readme.txt) stating how to build and conduct your program, and (4) **a report (report.docx) no more than 2 pages introducing your data structures and algorithms**. Please carefully read the following instructions:

- The compressed file [student id]-p2.tgz file contains only a single folder named [student id]-p2 (e.g., b11107000-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

7. Grading Policy

This programming assignment will be graded based on (1) the correctness (cells must be aligned to rows and sites with the same orientations of rows), (2) readme.txt and report, (3) running time of no more than 5 minutes, and (4) solution quality evaluated by:

$$Avg.cell\ \ displacement + \alpha \cdot Max.cell\ \ displacement$$

8. Online Resources

Sample input files can be found at the course website.