CS6135 VLSI Physical Design Automation

Homework 2: Two-way Min-cut Partitioning

Due: 23:59, November 14, 2021

1. Introduction

Let $\boldsymbol{C}$ be a set of cells and $\boldsymbol{N}$ be a set of nets. Each net connects a subset of cells. The two-way min-cut partitioning problem is to partition the cell set into two groups $\boldsymbol{A}$ and $\boldsymbol{B}$. The cost of a two-way partitioning is measured by the cut size, which is the number of nets having cells in both groups. In this homework assignment, you are asked to implement **FM ALGORITHM** to solve the problem of two-way min-cut partitioning. Note that any form of plagiarism is strictly prohibited. If you have any problem, please contact TA.

2. Problem Description

The two-way min-cut partitioning problem is defined as follows:

(1) Input:

- ✓ A netlist for a circuit (.nets)
- ✓ The size of each cell (.cells)

(2) Output:

- ✓ The final cut size and a partition result (.out)

(3) Objective:

Partition the circuit in two sub-circuits $\boldsymbol{A}$ and $\boldsymbol{B}$, such that the cut size is minimized under the constraint of $|area(\boldsymbol{A}) - area(\boldsymbol{B})| < \frac{\boldsymbol{n}}{10}$, where $area(\boldsymbol{A})$ is the sum of all cell sizes in $\boldsymbol{A}$, $area(\boldsymbol{B})$ is the sum of all cell sizes in $\boldsymbol{B}$, and $\boldsymbol{n}$ is the sum of all cell sizes in the circuit.

3. Input File

(1) The *.cells* file:

The .cell file specifies the cell name (unordered) and its size (a positive integer). Here is an example:

```
c2 1
// cellName cell size
      ⋮
```

(2) The ***.nets*** file:

The .nets file specifies the netlist. Here is an example:

```
NET n1 { c2 c3 c4 }
// NET netName { cellName1 cellName2 … }
      ⋮
```

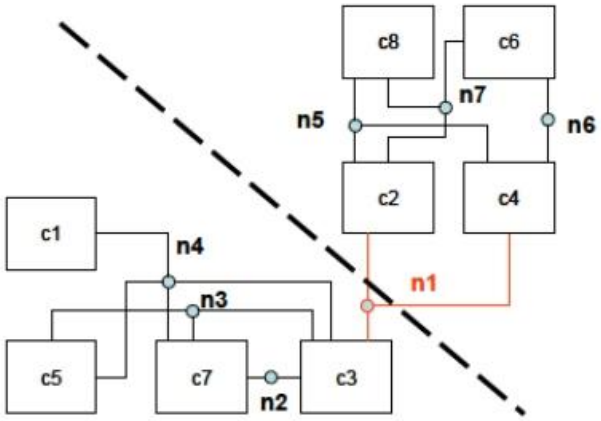
Example:

.cells

```
c2 1
c3 2
c4 1
c7 2
c5 1
c1 1
c8 2
c6 2
```

.nets

```
NET n1 { c2 c3 c4 }
NET n2 { c3 c7 }
NET n3 { c3 c5 c7 }
NET n4 { c1 c3 c5 c7 }
NET n5 { c2 c4 c8 }
NET n6 { c4 c6 }
NET n7 { c2 c6 c8 }
```



4. Output File

(1) The ***.out*** file:

Report the cells in each group and the cut size. You can run the "verifier" to check whether your result is legal or not. Here is an example:

```
cut_size 1
// cut_size cut size
A 4
// A number of cells in group A
c1
// cellName
c3
c5
c7
B 4
// B number of cells in group B
c2
c4
c6
c8
```

5. Language/Platform

(1) Language: C/C++

(2) Platform: Unix/Linux

6. Report

Your report should contain the following content, and you can add more as you wish.

(1) Your name and student ID

(2) How to compile and execute your program, and give an execution example.

(3) The final cut size and the runtime of each testcase

P.S. You could use the command `time` to measure runtime.

e.g., `$ /usr/bin/time -p ./hw2 …`

```
$ echo "alias time '/usr/bin/time -p'" >> ~/.tcshrc
```

Re-log in then `$ time ./hw2 …` is equal to `$ /usr/bin/time -p ./hw2 …`

(4) Runtime = $T_{IO} + T_{computation}$. For each case, please analyze your runtime and find out how much time you spent on I/O and how much time you spent on the computation (FM Algorithm).

(5) The details of your implementation containing explanations of the following questions:

I. Where is the difference between your algorithm and FM Algorithm described in class? Are they exactly the same?

II. Did you implement the bucket list data structure?

- ✓ If so, is it exactly the same as that described in the slide? How many are they?
- ✓ If not, why? You had a better data structure? Or, is bucket list useless?

III. How did you find the maximum partial sum and restore the result?

IV. What else did you do to enhance your solution quality or to speed up your program?

V. If you implement parallelization, please describe the implementation details and provide some experimental results.

(6) Please compare your results with the top 5 students' results from last year and show your advantage either in runtime or in solution quality. Are your results better than them?

- ✓ If so, please express your advantages to beat them.
- ✓ If not, it's fine. If your program is too slow, then what could be the bottleneck of your program? If your solution quality is inferior, what do you think that you could do to improve the result in the future?

	Cut size					Runtime (s)				
Ranks	p2-1	p2-2	p2-3	p2-4	p2-5	p2-1	p2-2	p2-3	p2-4	p2-5
1	6	191	4441	**43326**	**122101**	0.01	0.07	3.05	5.01	42.06
2	6	**161**	1065	43748	125059	0.01	0.1	3.11	9.84	18.77
3	6	358	2186	45430	122873	0.04	0.78	21.21	115.38	59.78
4	**5**	302	1988	46064	124862	0.03	0.17	7.04	6.93	8.22
5	6	411	**779**	46356	125151	0.01	0.16	5.49	12.31	13.57

(7) What have you learned from this homework? What problem(s) have you encountered in this homework?

7. Required Items

Please compress `HW2/` (using tar) into one with the name `CS6135_HW2_${StudentID}.tar.gz` before uploading it to eeclass.

(1) `src/` contains all your source code, your `Makefile` and `README`.

- `README` must contain how to compile and execute your program. An example of `README` is like the following figure:

```
--How to Compile
  In this directory, enter the following command:
  $ make
  It will generate the executable file "hw2" in "HW2/bin/".

  If you want to remove it, please enter the following command:
  $ make clean

--How to Run
  In this directory, enter the following command:
  Usage: ../bin/<exe> <net file> <cell file> <output file>
  e.g.:
  $ ../bin/hw2 ../testcases/p2-1.nets ../testcases/p2-1.cells ../output/p2-1.out

  In "HW2/bin/", enter the following command:
  Usage: ./<exe> <net file> <cell file> <output file>
  e.g.:
  $ ./hw2 ../testcases/p2-1.nets ../testcases/p2-1.cells ../output/p2-1.out
```

(2) `output/` contains all your outputs of testcases for the TA to verify.

(3) `bin/` contains your executable file.

(4) `CS6135_HW2_${StudentID}_report.pdf` contains your report.

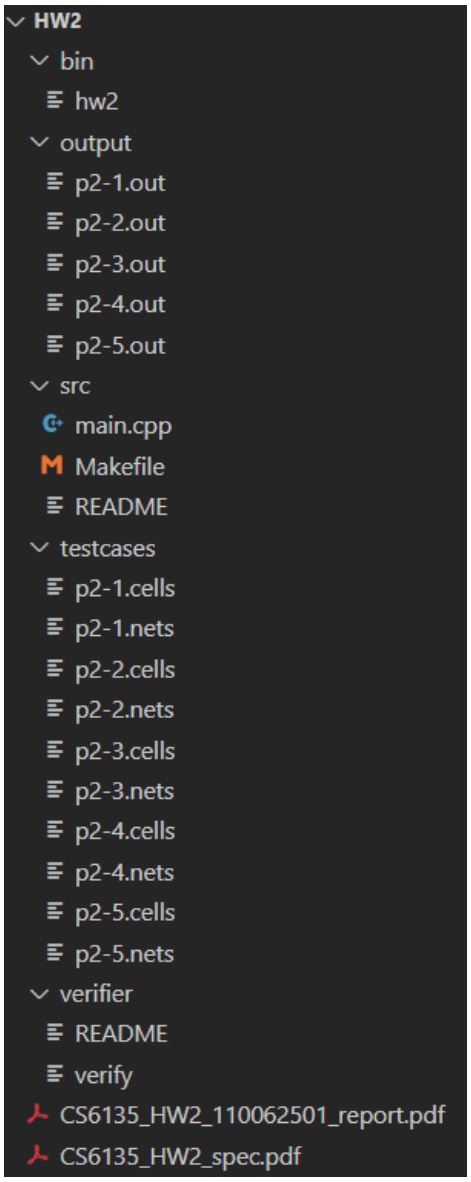
You can use the following command to compress your directory on a workstation:

```
$ tar -zcvf CS6135_HW2_${StudentID}.tar.gz <directory>
```

For example:

```
$ tar -zcvf CS6135_HW2_110062501.tar.gz HW2/
```

The file structure would be like the following figure:



8. Grading

- ✓ 80%: The solution quality (final cut size) of each testcase, hidden testcases included. This part will be evaluated with single thread version.
- ✓ 20%: The completeness of your report
- ✓ **5% (bonus)**: Parallelization

P.S. hMETIS

If you have time, you can learn how to run hMETIS and compare your results with those generated by hMETIS.
(http://glaros.dtc.umn.edu/gkhome/metis/hmetis/overview)

P.S. Using C++11, C++14, or C++17

The C++11 standard is implemented in GCC 4.8.1 and beyond. If you want to use C++14 or C++17, you need to use GCC 6.1 and beyond.

```
[      @ic51 ~]$ g++ --version
g++ (GCC) 4.8.5 20150623 (Red Hat 4.8.5-44)
Copyright (C) 2015 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

If you want to change the GCC version, you can follow the news of the login information and change your GCC version by yourself.

```
--------------------NTHU CS VLSI/CAD News--------------------
.For gcc 4.8.5 on centos 5 or gcc 4.9.3 on centos 6, use command
    "source /tools/linux/gnu/setup_toolkit.csh".
.For gcc 9.3.0 on ic21, ic22, ic51, and ic55, use command
    "source /tools/linux/gnu/setup_gcc_9.3.0.csh".
.For loading information, use command "lab_uptime".
.For platform information, use command "lab_plat".
.For apply new account, please fill this sheet:
    https://bit.ly/2FGbnMg
.If you have any problem, please contact us:
    nthucad.cs@gmail.com
.Please read this FAQ.
    http://nthucad.cs.nthu.edu.tw/~webster/CADWorkstationFAQ.html
```

In this way, you need to source it every time when you log in on a server. Instead, you can create a shell resource file called `.tcshrc` in the root folder and put the source command in it. Just enter the following command once, re-login, and then it will never bother you anymore.

```
$ echo "source /tools/linux/gnu/setup_gcc_9.3.0.csh" >> ~/.tcshrc
```

P.S. Using Boost C++ Library

The boost C++ library is installed on ic21, ic22, ic51, and ic55. If you want to use boost C++ library, you must add the following include path while compiling your source code.

```
-I /usr/local/include/boost/
```

For example:

```
$ g++ -O3 -std=c++11 -I /usr/local/include/boost/ main.cpp -o hw2
```

Notes:

- Make sure the following commands can be executed.
  - Go into directory "`src/`", enter "`make`" to compile your program and generate the executable file, called "`hw2`", which will be in directory "`bin/`".
  - Go into directory "`src/`", enter "`make clean`" to delete your executable file.

- Please use the following command format to run your program.
  ```
  $ ./hw2 *.nets *.cells *.out
  ```
  E.g.:
  ```
  $ ./hw2 p2-1.nets p2-1.cells p2-1.out
  ```
- If you implement parallelization, please name your parallel version executable file as "`hw2_parallel`" and name your sequential version executable file as "`hw2`".
- Use arguments to read the file path. Do not write the file path in your code.
- Program must be terminated within 5 minutes for each testcase.
- Please use ic21, ic22, ic51 or ic55 to test your program.
- We will test your program by shell script with GCC 9.3.0 on ic51. Please make sure your program can be executed by **HW2_grading.sh**.