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Programming Assignment #1: Clustering – [best-choice]

1. Problem Statement

A mixed-size circuit can be represented as a hypergraph $H = (V, E)$, Let $V = \{v_1, v_2, \ldots, v_n\}$ be the set of n blocks and $E = \{e_1, e_2, \ldots, e_m\}$ be the set of m nets. The circuit may contain some preplaced blocks that have fixed coordinates and cannot be moved. This programming assignment is asking you to write a coarsening algorithm to cluster blocks to reduce the number of movable blocks. Fig. 1 shows the framework of the algorithm. The hierarchy of clusters can be built by the first-choice clustering algorithm [1]. The following requirements must be satisfied during the clustering process. First, for each clustered blocks c_i, $A_{c_i} \leq 3 \cdot (A_{total}/N_c)$ where A_{c_i} denote the area of c_i, A_{total} denote the total area of movable blocks, and N_c denote the number of clustered blocks. Fig. 2 shows the calculation of N_c. Second, if two or more nets connecting same blocks (or clustered blocks), you have to merge those nets into one net, which the net weight is the sum of net weight of those nets. Third, the preplaced block is not allowed to cluster. The clustering algorithm will be applied several times until the number of blocks in the resulting clustered circuit is less than a user-specified number n_{max}, which equals to 6000 by default.

Input:
hypergraph H_0: a mixed-size circuit
n_{max}: the maximum block number in the coarsest level
Output:
The clustering result of each level

```
1. level = 0;
2. while(BlockNumber(H_level) > n_max)
3.         level++;
4.         H_level = Clustering(H_level-1);
```

Fig. 1. The framework of the coarsening algorithm

```
1. If level equals to 0
2.         then N_c = the number of all blocks;
3. else
4.         then N_c = the number of clustered blocks in level-1;
5.
6. If any two clustered blocks (or blocks) are clustered
7.         then N_c = N_c -1;
```

Fig. 2. The calculation of N_c

Input

- **.nodes file**

Sample Input

```
UCLA nodes 1.0
# Created   :    Jan  6 2005
# User      :    Gi-Joon Nam & Mehmet Yildiz at IBM Austin Research({gnam, mcan}@us.ibm.com)

NumNodes :          211447
NumTerminals :      543
    o0      8     12
    o1      13    12
    o2      13    12
    o3      13    12
    o4      13    12
    o5      13    12
    o6      13    12
    o7      13    12
    o8      13    12
    o9      13    12
    o211434 80    1020  terminal
    o211435 164   2136  terminal
    o211436 164   2136  terminal
    o211437 164   2136  terminal
    o211438 164   2136  terminal
```

→ **Total number of cells**

Cell Name, The width of cell, The height of cell (Sequentially)

[Do NOT need to consider FIXED nodes]

FIXED nodes

- **.nets file**

Sample Input

UCLA nets 1.0

Created : Jan 6 2005

User : Gi-Joon Nam & Mehmet Yildiz at IBM Austin Research({gnam, mcan}@us.ibm.com)

NumNets : 221142 → **Total number of nets**

NumPins : 944053 → **Total number of pins**

NetDegree : 4 n0 → **Net n0 linking 4 cells**

o197239 I : -0.500000 -6.000000

o197110 O : -1.500000 -3.000000

o85644 I : -6.000000 -2.000000

o0 I : -3.000000 -5.000000

Cells linked by n0

Cell Name, Input/Output Pin, OffsetX, OffsetY (Sequentially)

[Only need Cell Name]

2. Output Format

- **. clusters file**

The .cluster file consists of runtime and information of all clusters in each level. For each level, you need to list each cluster and the blocks (or clustered blocks) contained in the cluster. The following table gives the output format of .clusters file.

Sample Output

Time: 0.000 s

Level : 0 → **Level index**

Cluster0_1 o1 o2 o3 o4 → **Cluster0_1 contains four blocks, which are o1, o2, o3, and o4 in level 0**

Cluster0_2 o5 o6 o9

Cluster0_3 o7 o8

Level : 1

Cluster1_1 Cluster0_1 Cluster0_3 → **Cluster1_1 contains two clustered blocks, which are Cluster0_1 and Cluster0_3 in level 1**

Cluster1_2 Cluster0_2

- **.cnets file**

The .cnets file lists the connection between clusters in each level. The following table gives the output format of .cnets file.

Sample Output
Level : 0 → **Level index**
NumNets : 2 → **Total number of nets in level 0**
NumPins : 4 → **Total number of pins in level 0**
NetDegree : 2 cn0 → **Net cn0 linking 2 clustered blocks in level 0**
Cluster0_1
Cluster0_3
NetDegree : 2 cn1
Cluster0_2
Cluster0_3
Level : 1
NumNets : 1 → **Total number of nets in level 1**
NumPins : 2 → **Total number of pins in level 1**
NetDegree : 2 ccn0 → **Net ccn0 linking 2 clustered blocks in level 1**
Cluster1_1
Cluster1_2

3. Language/Platform

The program should be performed on the Linux machine.

4. Command Line Format

BC_StudentID <circuit.nodes> <circuit.nets> [circuit.clusters] [circuit.cnets]

Example: ./BC_XXXXXXXXX adaptec1.nodes adaptec1.nets adaptec1.clusters adaptec1.cnets

Note that you should write your own make file.

5. Grading Strategy

This programming assignment will be graded based on the following terms

- Correctness of the program
- Solution quality

6. Reference

[1] G. Karpis and V. Kumar, “Multilevel k-way hypergraph partitioning”, DAC, 1999.

作業 #1：BC 說明

- 截止時間：2019/10/14 (Mon.)
  - BC program 作業內容說明請看 Physical_Design_Hw1.pdf
  - 若對 Benchmark 格式有興趣，可參考 Benchmark_Description.pdf

- 關於 Physical_Design_Hw1.pdf：
  - 請注意 $A_{c_i} \leq 3 \cdot (A_{total}/N_c)$，$n_{max}$=6000
  - 請用 best-choice 來考慮
  - Output 格式請照規定輸出
  - 程式要可以在 Linux 上編譯和執行，所以請一併繳交 makefile 檔
  - Command Line 請依照規定，不可自行變更
  - Benchmark 共有 5 個，會提供其中 4 個，另 1 個是隱藏測資

- 需繳交檔案：
  - **程式碼**（檔名請一律：BC_學號，例如 BC_N2608XXXX.cpp）
  - **Makefile，.clusters file，.cnets file，**