Integer Linear Programming, hMetis, and Simulated Annealing for Graph Bi-Partitioning

Electronic Design Automation

Computer Science and Engineering Department

Yuan Ze University First Semester,2023

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I. Problem Description

使用一份含電路描述檔案，並計算出如何分配 Edge 中兩個 node 應置放於 set0 or set1,求出最小的透過模擬退火隨機探索解空間，逐漸移向更優的解。透過隨機性和溫度控制，能夠跳出局部最優解，朝向全局最優解靠攏。
並使用 LP_solve 與 hmetis 配合模擬,結果。

II.The 0/1 Integer Linear Programming Formulation of Graph Bi-partitioning

Vertex G = {E, V}

$\text{Minimize } \sum_{(i,j)\epsilon E}(|x_i - x_j|)$

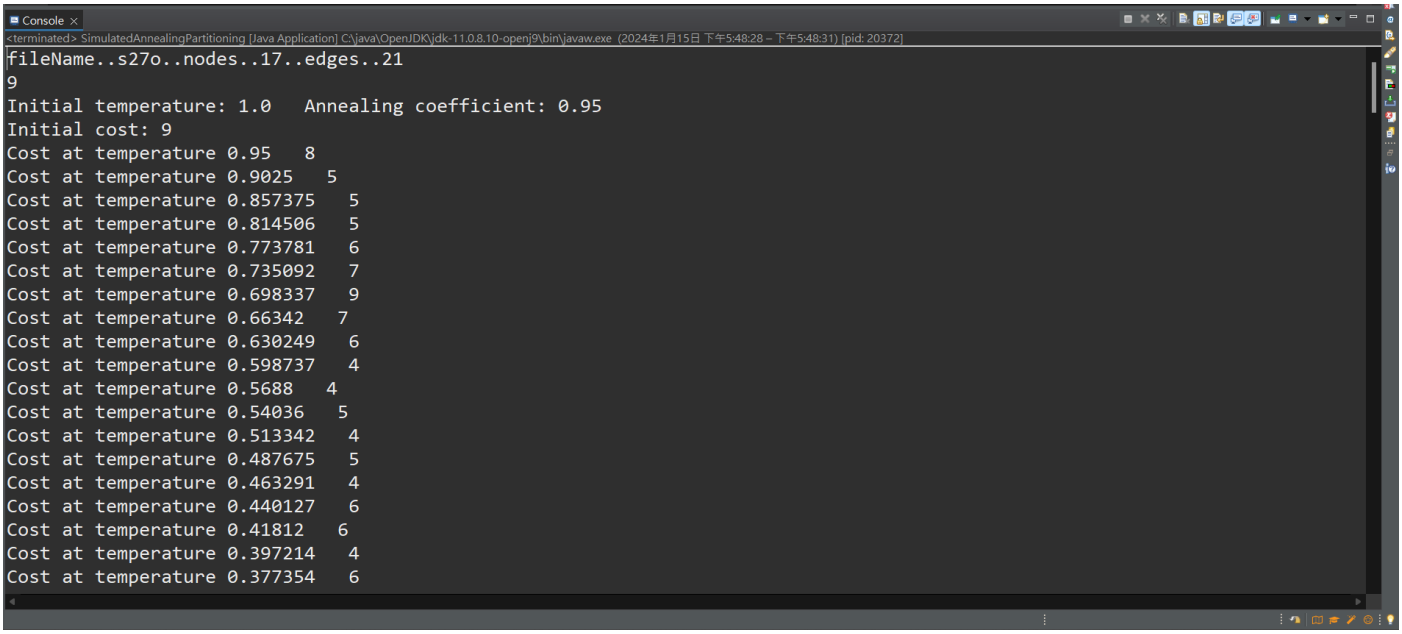
$\forall i \in V : x_i \in \{0,1\}$

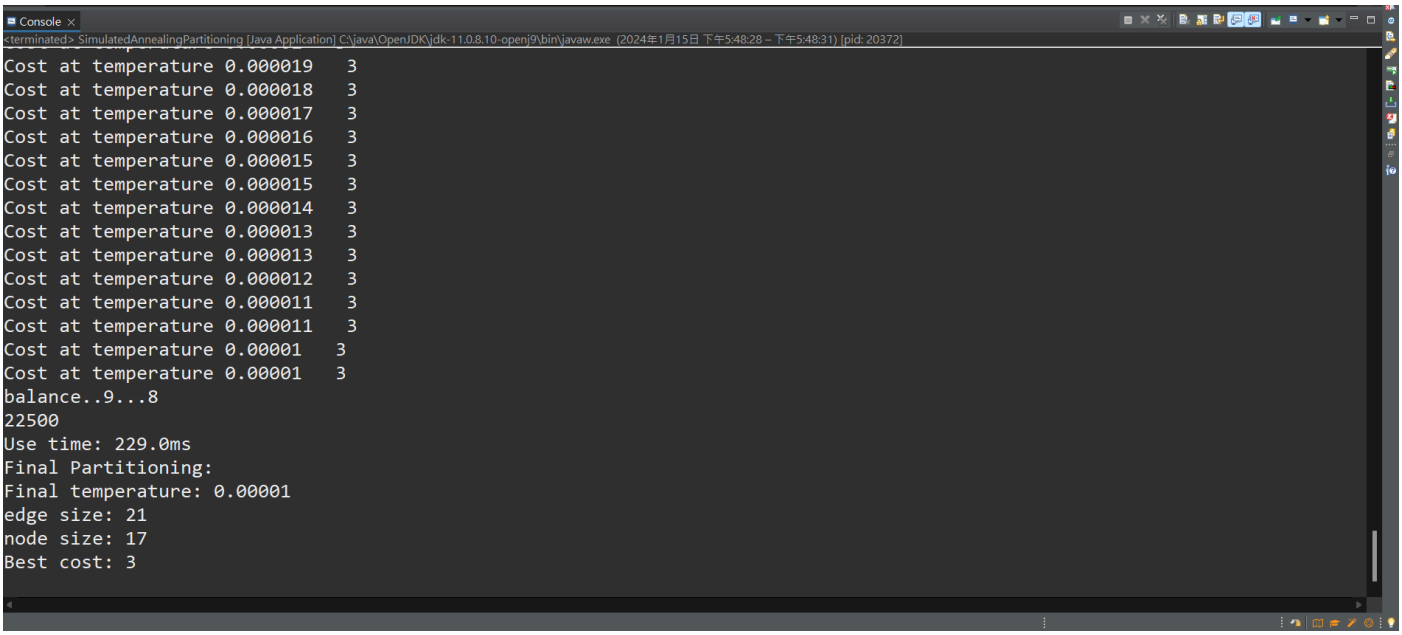
$$\sum_{i\epsilon V} x_i = ROUND(\frac{|v|}{2})$$

III. Simulated Annealing Implementation

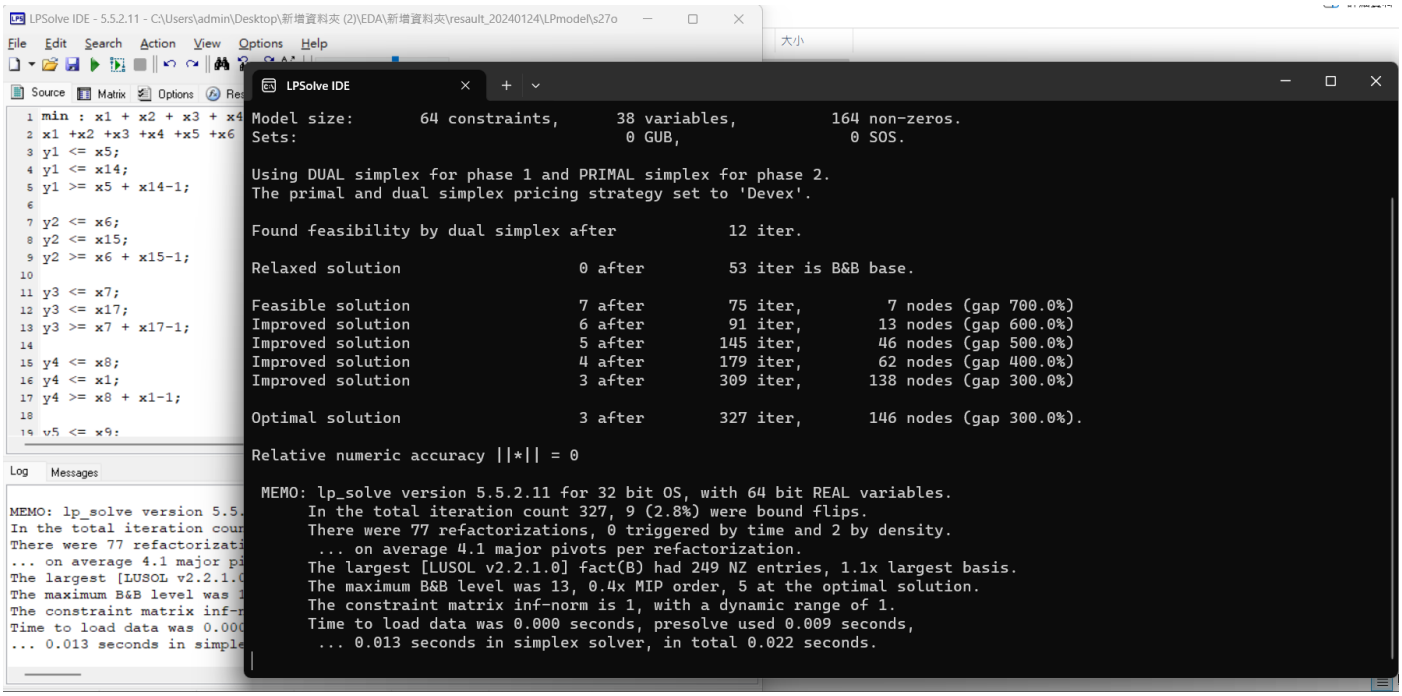
pesudo code.txt

SA:


Console
<terminated> SimulatedAnnealingPartitioning [Java Application] C:\java\OpenJDK\jdk-11.0.8.10-openj9\bin\javaw.exe (2024年1月15日 下午5:48:28 – 下午5:48:31) [pid: 20372]
fileName..s27o..nodes..17..edges..21
9
Initial temperature: 1.0 Annealing coefficient: 0.95
Initial cost: 9
Cost at temperature 0.95 8
Cost at temperature 0.9025 5
Cost at temperature 0.857375 5
Cost at temperature 0.814506 5
Cost at temperature 0.773781 6
Cost at temperature 0.735092 7
Cost at temperature 0.698337 9
Cost at temperature 0.66342 7
Cost at temperature 0.630249 6
Cost at temperature 0.598737 4
Cost at temperature 0.5688 4
Cost at temperature 0.54036 5
Cost at temperature 0.513342 4
Cost at temperature 0.487675 5
Cost at temperature 0.463291 4
Cost at temperature 0.440127 6
Cost at temperature 0.41812 6
Cost at temperature 0.397214 4
Cost at temperature 0.377354 6


Console
<terminated> SimulatedAnnealingPartitioning [Java Application] C:\java\OpenJDK\jdk-11.0.8.10-openj9\bin\javaw.exe (2024年1月15日 下午5:48:28 – 下午5:48:31) [pid: 20372]
Cost at temperature 0.000019 3
Cost at temperature 0.000018 3
Cost at temperature 0.000017 3
Cost at temperature 0.000016 3
Cost at temperature 0.000015 3
Cost at temperature 0.000015 3
Cost at temperature 0.000014 3
Cost at temperature 0.000013 3
Cost at temperature 0.000013 3
Cost at temperature 0.000012 3
Cost at temperature 0.000011 3
Cost at temperature 0.000011 3
Cost at temperature 0.00001 3
Cost at temperature 0.00001 3
balance..9...8
22500
Use time: 229.0ms
Final Partitioning:
Final temperature: 0.00001
edge size: 21
node size: 17
Best cost: 3

ILP model:



Shmetis:

```
D:\aa>hmetis s38584o 2 5 10 1 1 0 0 0
********************************************************************************
 HMETIS 1.5.3  Copyright 1998, Regents of the University of Minnesota

HyperGraph Information ----------------------------------------------------
 Name: s38584o, #Vtxs: 20717, #Hedges: 34208, #Parts: 2, UBfactor: 0.05
 Options: HFC, FM, Reconst-False, No V-cycles, No Fixed Vertices

Recursive Partitioning... -------------------------------------------------

 ---------------------------------------------------------------------------
  Summary for the 2-way partition:
              Hyperedge Cut:       121              (minimize)
     Sum of External Degrees:       242              (minimize)
                Scaled Cost: 1.14e-006              (minimize)
                 Absorption:  34087.00              (maximize)

      Partition Sizes & External Degrees:
          9369[ 121]  11348[ 121]

Timing Information --------------------------------------------------------
  Partitioning Time:              0.327sec
           I/O Time:              0.009sec
********************************************************************************

D:\aa>
```

IV. Experimental Results

Graph			0/1 ILP model					SA		shmetis	
Graph name	edge	node	# of cnstr	# of vars	# of non-zero vars	Best cost	rTime (sec.)	cost	rTime	Best Cost	RTIME
s38584o	34209	20718	102625	54925	260173	205	4000	894	>2days	121	0.481
s38417o	33665	23844	100993	57057	259491	159	4546	2886	613.35	107	0.411
s35932o	29998	17829	89992	47825	227807	917	4100	2819	600.864	734	0.407
s15850o	14243	10384	42727	24625	110077	124	2230	707	606.356	74	0.195
s13207o	11835	8652	35503	20485	91489	251	4200	445	602.231	96	0.207
s5378o	4392	2994	13174	7384	33730	105	6553	204	361.963	77	0.101
s1448o	1394	668	4180	2060	10418	193	1105	231	102.64	218	0.074
s953o	773	441	2317	1212	5844	142	920	66	59.12	65	0.046
s510o	431	237	1291	666	3246	68	800	60	31.533	55	0.035
s386o	354	173	1060	525	2643	56	1452	50	22.159	51	0.023
s298o	259	137	775	394	1942	23	1.93	22	16.528	22	0.021
s27o	22	18	64	38	164	3	0.02	3	4.17	3	0.008