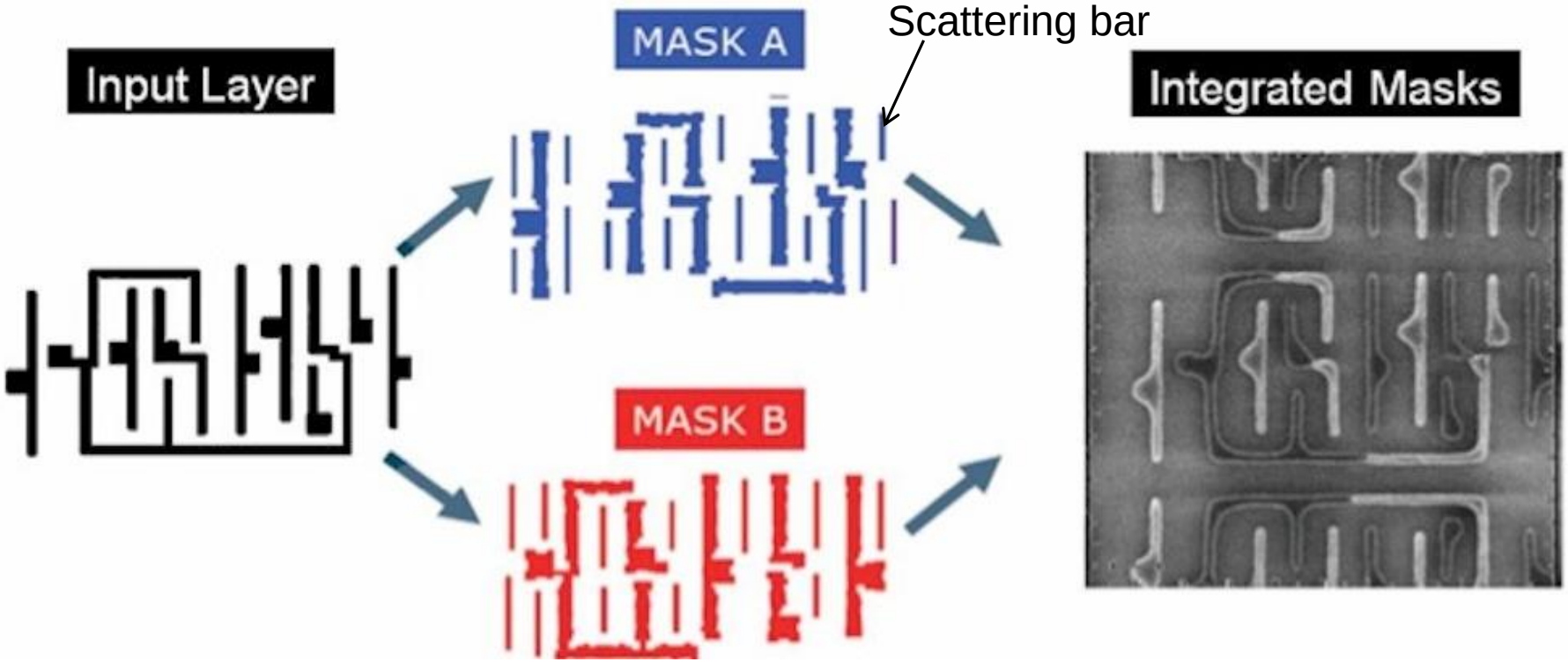
COLOR BALANCING FOR DOUBLE PATTERNING

Double Patterning

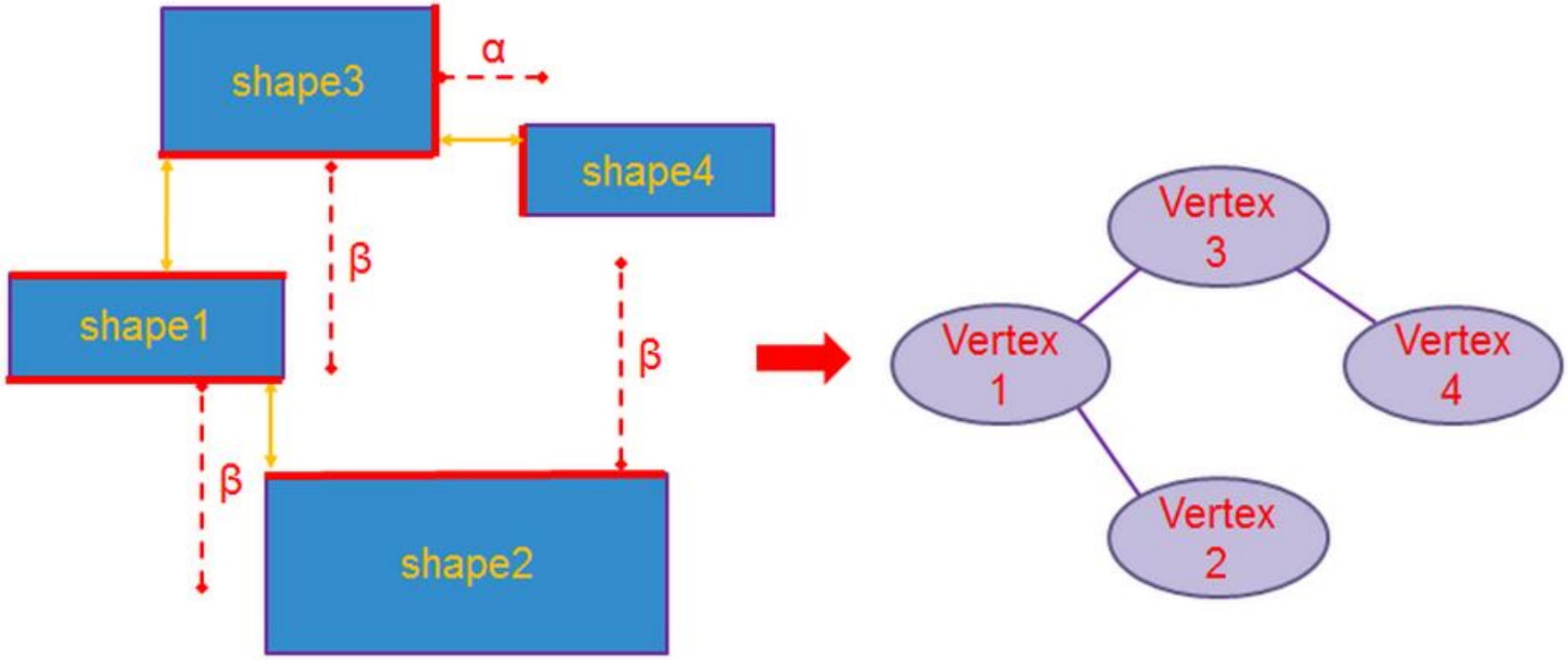
- **A balanced coloring would allow more space for scattering bar insertion during optical proximity (OPC)**



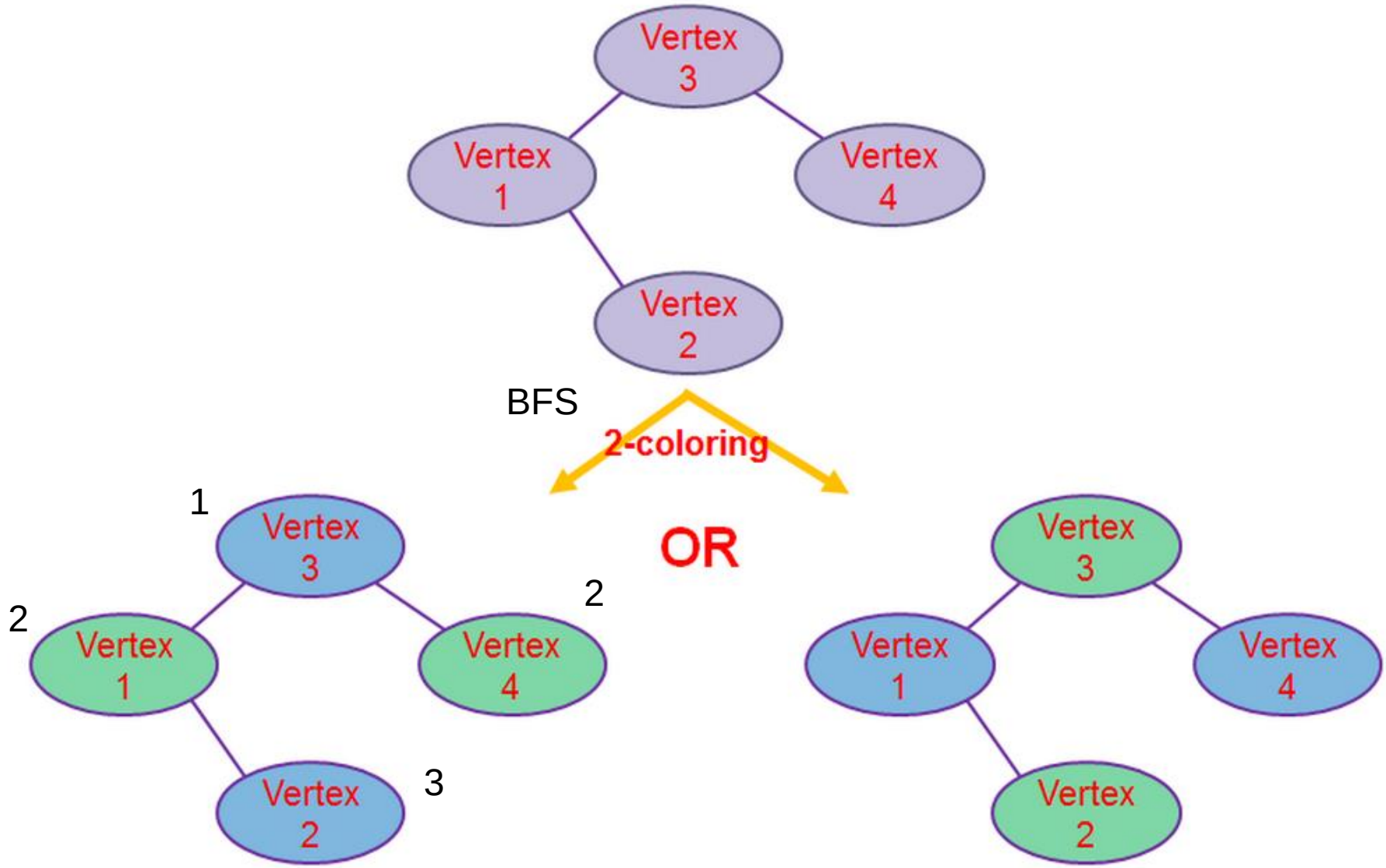
Source: C. Chiang, *et al*., Synopsys.

Coloring Graph – Example 1

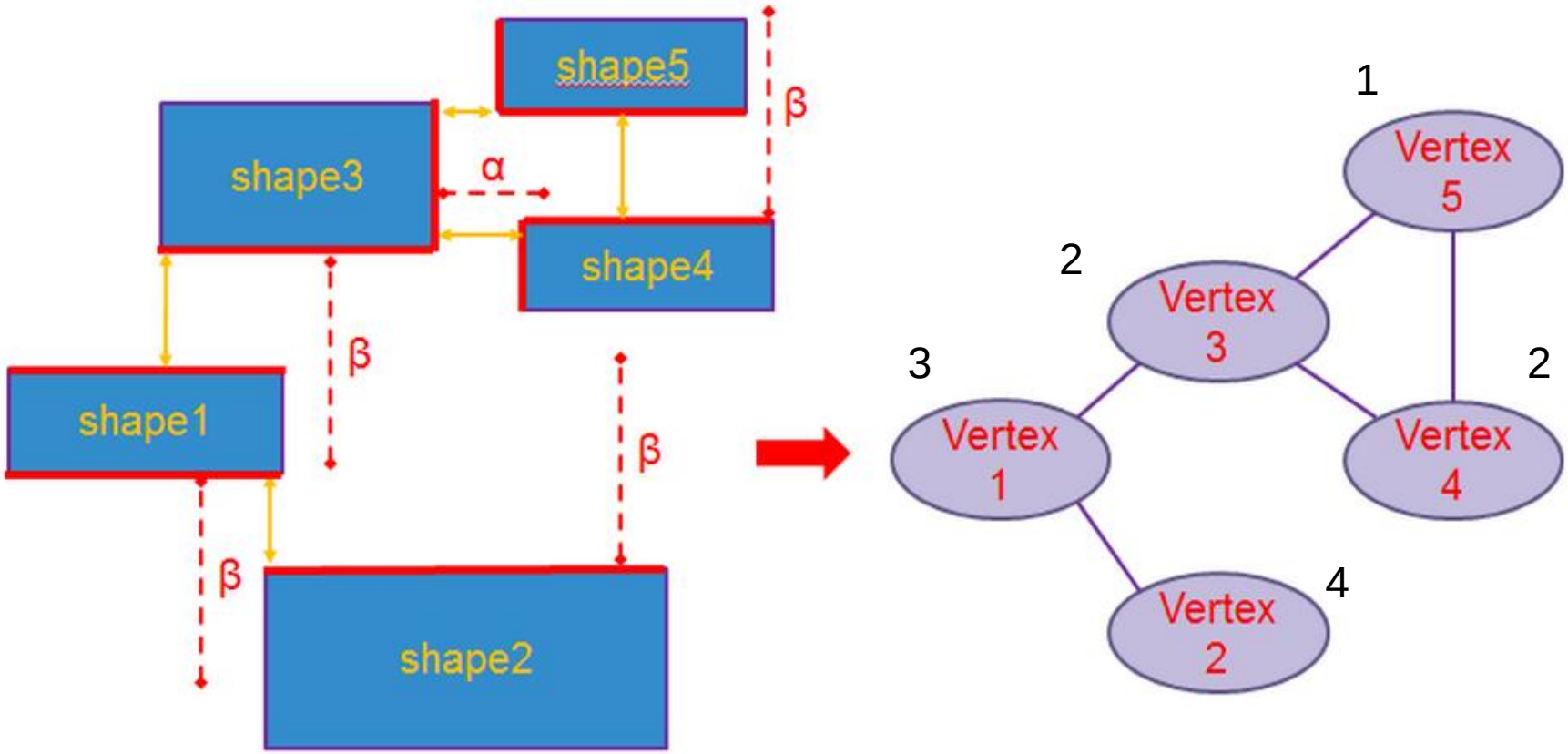
- **α:** minimum x-spacing
- **β:** minimum y-spacing



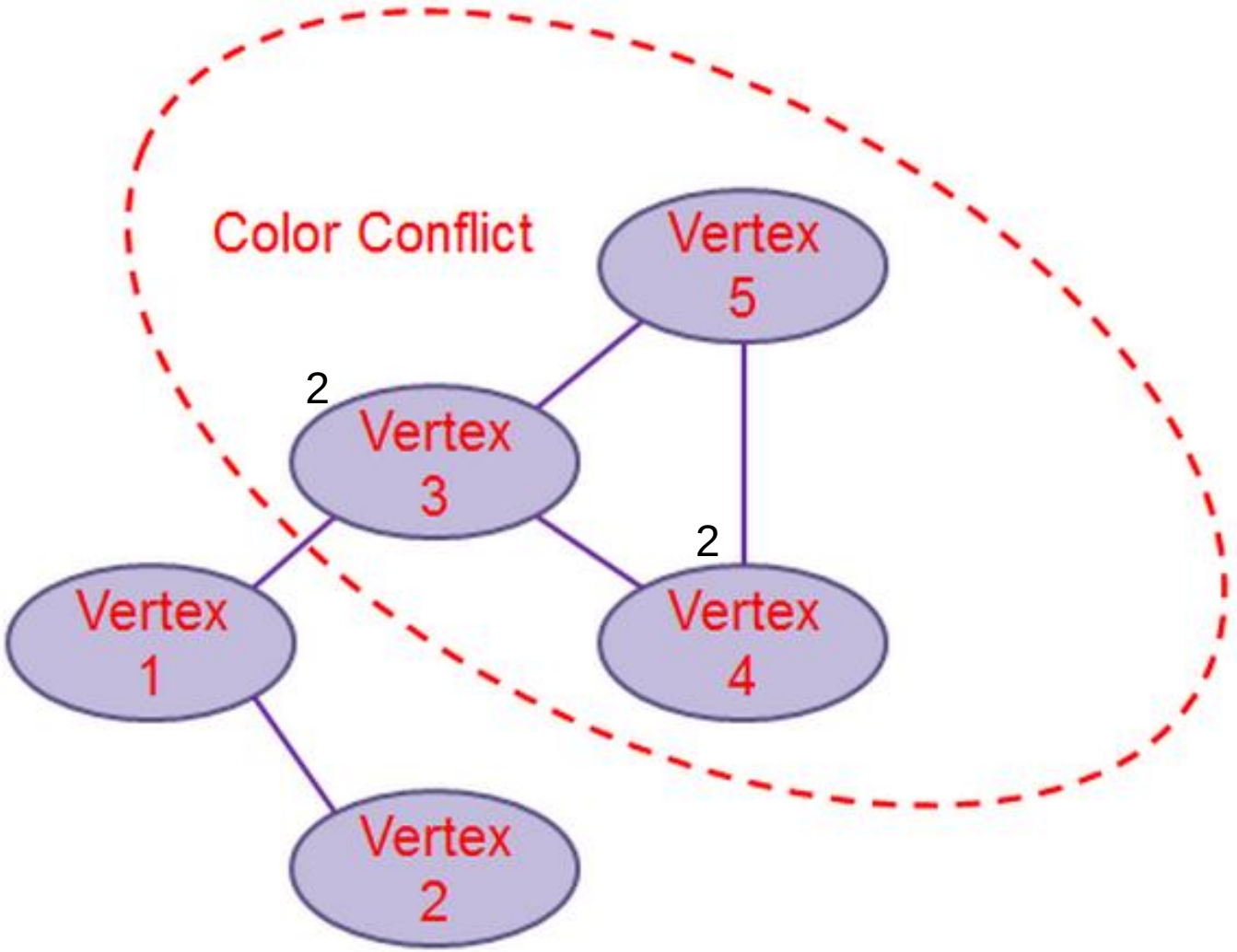
Coloring


Vertex 3
Vertex 1
Vertex 4
Vertex 2
BFS
2-coloring
OR
1
2
2
3
Vertex 3
Vertex 1
Vertex 4
Vertex 2
Vertex 3
Vertex 1
Vertex 4
Vertex 2

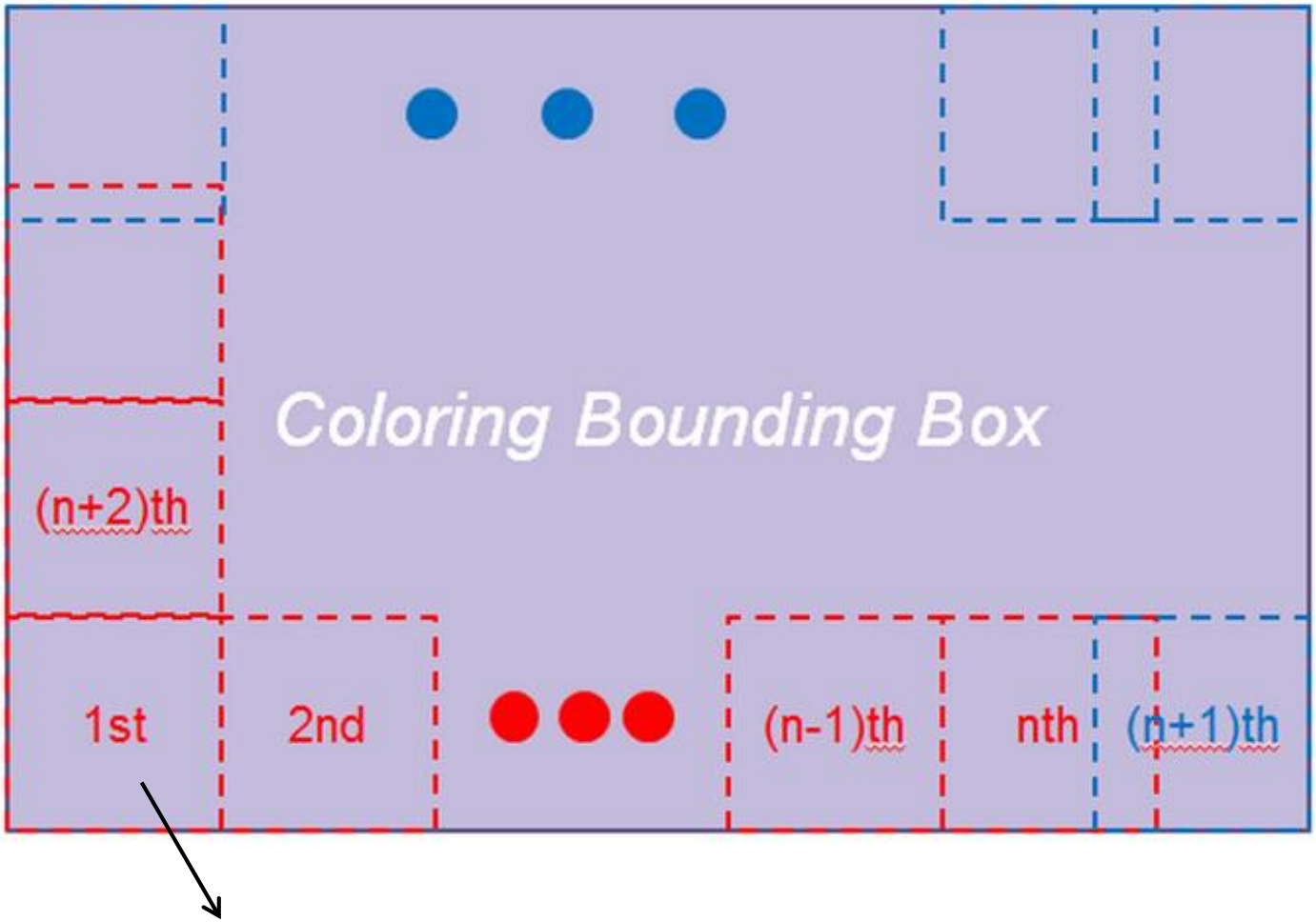
Coloring Graph – Example 2



Coloring


Color Conflict
Vertex 5
2
Vertex 3
2
Vertex 1
Vertex 4
Vertex 2

Color Density Calculation



Color Density Calculation

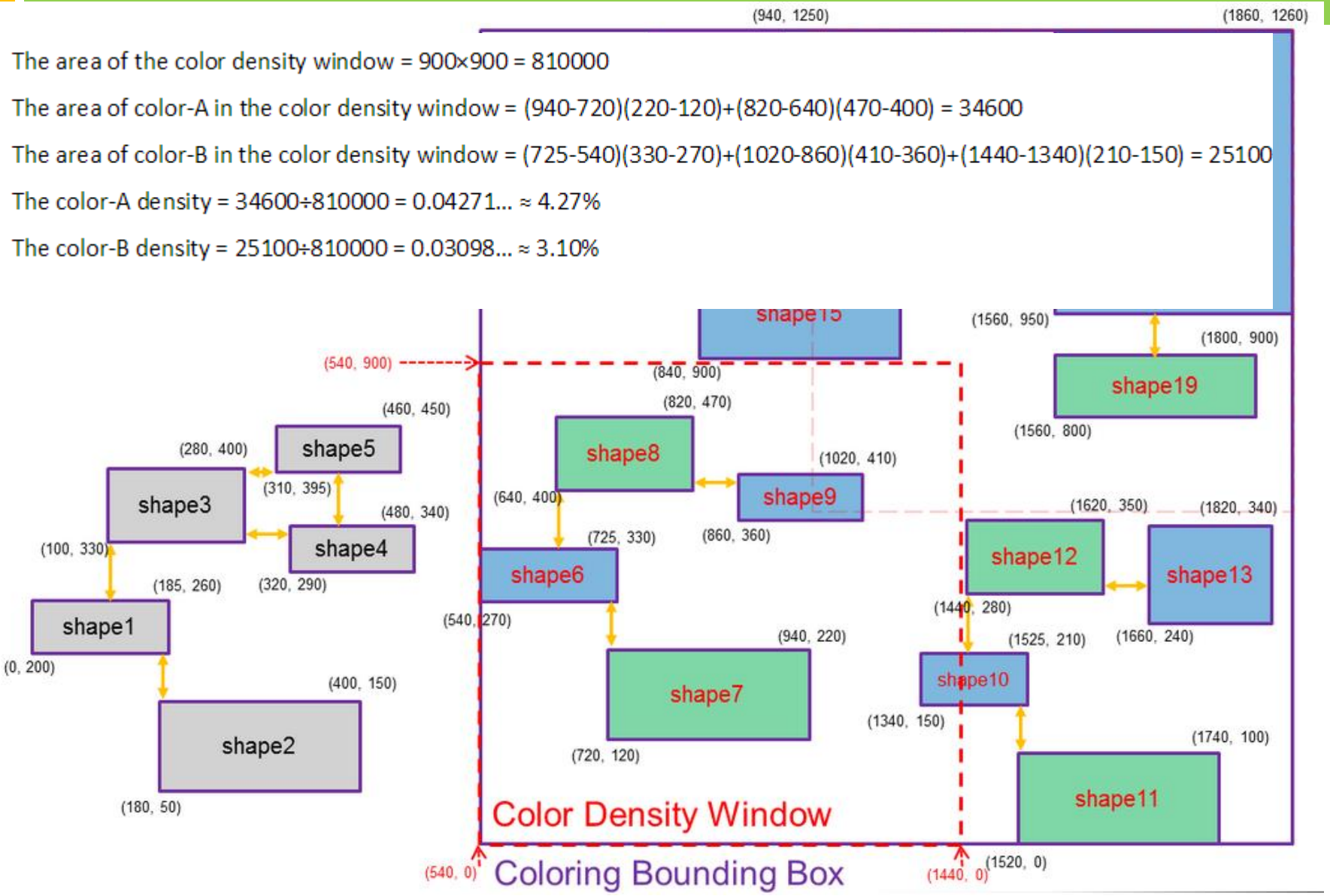
The area of the color density window = 900×900 = 810000

The area of color-A in the color density window = (940-720)(220-120)+(820-640)(470-400) = 34600

The area of color-B in the color density window = (725-540)(330-270)+(1020-860)(410-360)+(1440-1340)(210-150) = 25100

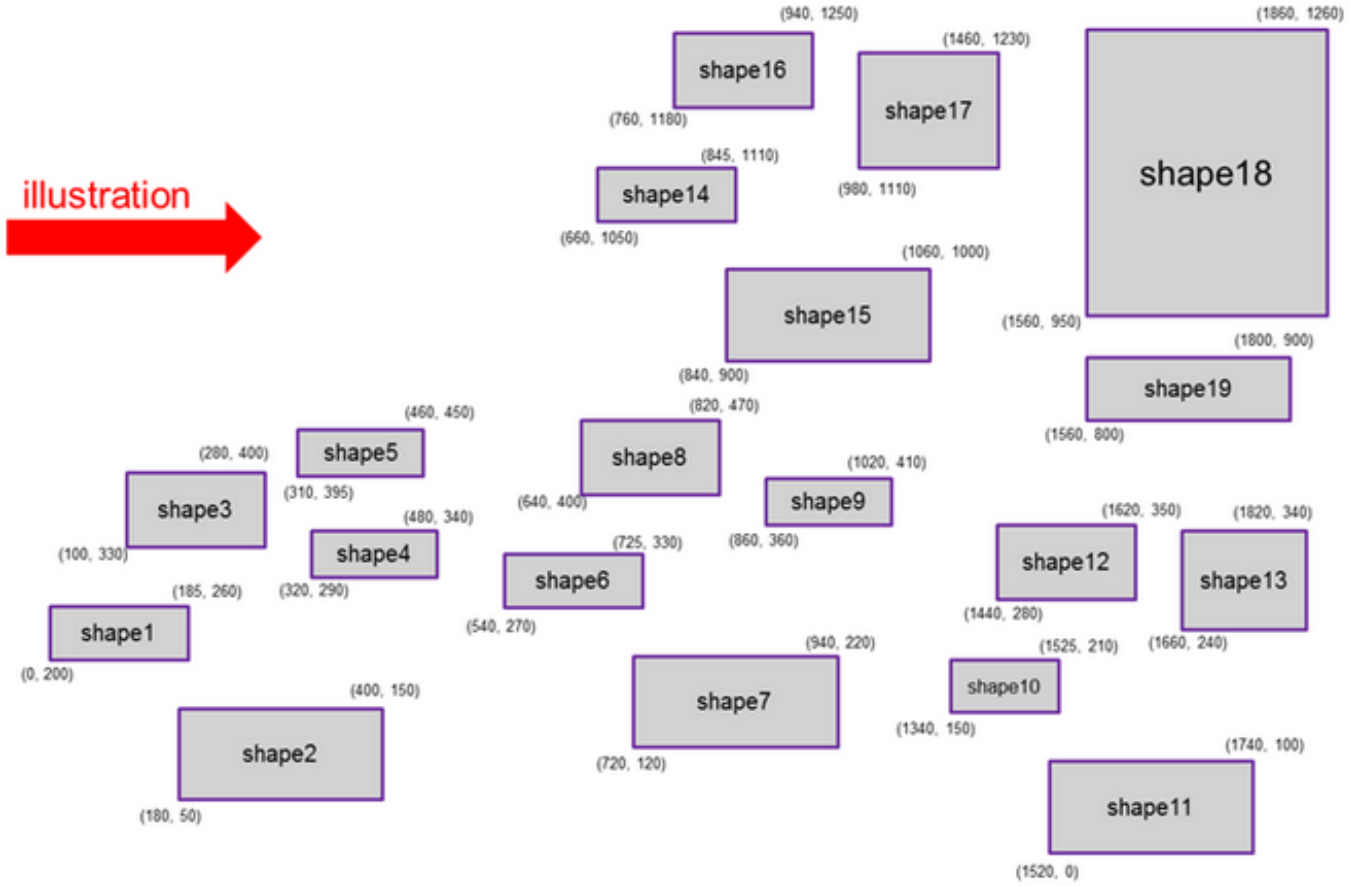
The color-A density = 34600÷810000 = 0.04271... ≈ 4.27%

The color-B density = 25100÷810000 = 0.03098... ≈ 3.10%



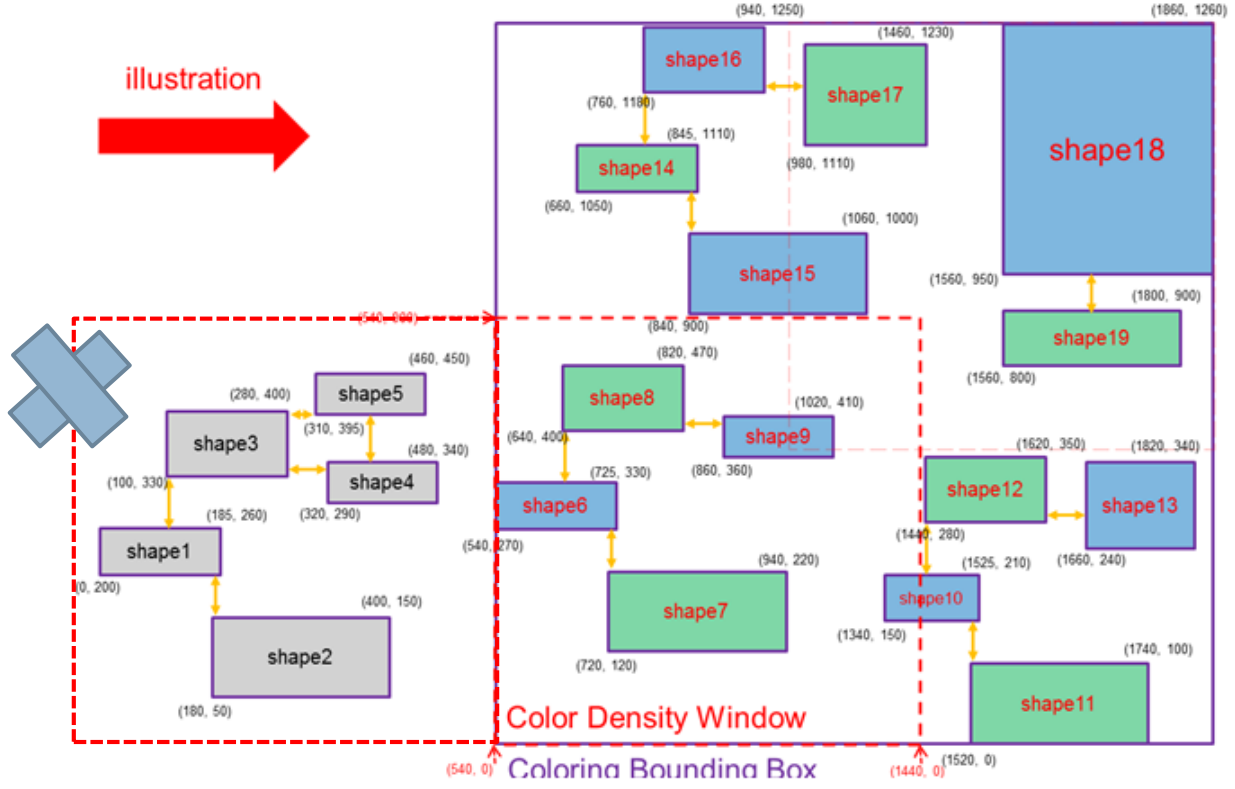
Input File

ALPHA=50
BETA=100
OMEGA=900
0,200,185,260
180,50,400,150
100,330,280,400
320,290,480,340
310,395,460,450
540,270,725,330
720,120,940,220
640,400,820,470
860,360,1020,410
1340,150,1525,210
1520,0,1740,100
1440,280,1620,350
1660,240,1820,340
660,1050,845,1110
840,900,1060,1000
760,1180,940,1250
980,1110,1460,1230
1560,950,1860,1260
1560,800,1800,900



Output File

WIN[1]=540,0,1440,900(4.27 3.10)
WIN[2]=960, 0,1860,900(7.23 3.72)
WIN[3]=540,360,1440,1260(9.51 5.26)
WIN[4]=960,360,1860,1260(10.07 13.09)
GROUP
NO[1]=0,200,185,260
NO[2]=180,50,400,150
NO[3]=100,330,280,400
NO[4]=320,290,480,340
NO[5]=310,395,460,450
GROUP
CA[1]=720,120,940,220
CA[2]=640,400,820,470
CB[1]=540,270,725,330
CB[2]=860,360,1020,410
GROUP
CA[1]=1520,0,1740,100
CA[2]=1440,280,1620,350
CB[1]=1340,150,1525,210
CB[2]=1660,240,1820,340
GROUP
CA[1]=660,1050,845,1110
CA[2]=980,1110,1460,1230
CB[1]=840,900,1060,1000
CB[2]=760,1180,940,1250
GROUP
CA[1]=1560,800,1800,900
CB[1]=1560,950,1860,1260



Evaluation

./DPT_balance_color case1 case1.out

$$final\_score = \frac{1}{n}\sum_{x=1}^{n} score(x)$$

where score(x) ≥ 0 for x=1, 2, ..., n, assuming there are *n* test cases.

$$score(x) = f(x) + g(x) + h(x)$$

where

$$f(x) = \begin{cases} 20, & \text{if coloring graphs for test case } x \text{ are built correctly} \\ 0, & \text{others} \end{cases}$$

$$g(x) = \begin{cases} 10, & \text{if color density windows for test case } x \text{ are shown correctly} \\ 0, & \text{others} \end{cases}$$

$$h(x) = \begin{cases} \sum_{d=1}^{k(x)} \left| \frac{70}{k(x)} - \frac{|color\_A\_density_d - color\_B\_density_d|}{5} \right|, & \text{if coloring for test case } x \text{ is correct} \\ 0, & \text{others} \end{cases}$$

$k(x)$ is the number of color density windows

Evaluation

WIN[1]=540,0,1440,900(4.27 3.10)
WIN[2]=960, 0,1860,900(7.23 3.72)
WIN[3]=540,360,1440,1260(9.51 5.26)
WIN[4]=960,360,1860,1260(10.07 13.09)
GROUP
NO[1]=0,200,185,260
NO[2]=180,50,400,150
NO[3]=100,330,280,400
NO[4]=320,290,480,340
NO[5]=310,395,460,450
GROUP
CA[1]=720,120,940,220
CA[2]=640,400,820,470
CB[1]=540,270,725,330
CB[2]=860,360,1020,410
GROUP
CA[1]=1520,0,1740,100
CA[2]=1440,280,1620,350
CB[1]=1340,150,1525,210
CB[2]=1660,240,1820,340
GROUP
CA[1]=660,1050,845,1110
CA[2]=980,1110,1460,1230
CB[1]=840,900,1060,1000
CB[2]=760,1180,940,1250
GROUP
CA[1]=1560,800,1800,900
CB[1]=1560,950,1860,1260

(20+
10+
(70/4-(4.27-3.10)/5)+
(70/4-(7.23-3.72)/5)+
(70/4-(9.51-5.26)/5)+
(70/4-(13.09-10.07)/5)
=97.61

Schedule

- **2015/04/13 midnight**

  Stage 0

  On-line registration

- **2015/5/18 midnight**

  Stage 1

  Coloring graph generation &
  Coloring (conflict graph)

  Color density window allocation

- **2015/6/15 midnight**

  Stage 2

  Color balancing method application

CAD Contest 2015

- **CAD contest 2015** http://cad-contest.el.cycu.edu.tw/problem_E/default.htm
  - 2015國際積體電路電腦輔助設計軟體製作競賽

2015

2015國際積體電路電腦輔助設計軟體製作競賽

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國內賽題目與報名 (Problems & Registration)

點我報名國內賽

國內賽題目

A. 3D-ICON: 3D Interlayer Cooling Optimized Network
Mohamed M. Sabry[1], Arvind Sridhar[2], and David Atienza[3]
[1]Stanford University, [2]IBM Zurich, [3]ESL-EPFL

B. Large-Scale Equivalence Checking and Function Correction
Chih-Jen (Jacky) Hsu, *Cadence Taiwan, Inc., Taiwan*

C. Incremental Timing-driven Placement
Myung-Chul Kim, *IBM Corporation, TX, USA*

D. Routabilitydriven macro placement推薦題
Bauli Yang & Mike Wu, *MediaTek Inc., Taiwan*

E. Color Balancing for Double Patterning推薦題
Ru-Lin Yang, Vincent Hsu, *Synopsys Taiwan Co., Ltd.*

注意事項

- 紙本資料收件截止日期：2015年5月六日(三)
- 寄出報名資料前請確認需簽名的欄位

Thank You!