Implementation of the Stockmeyer Algorithm

ECE 6133

Amanda Cummings

The Algorithm itself

- The goal of the algorithm is to find the optimal orientation of the blocks in the floorplan for the minimal area.
- Often used as a post-process to further optimize the area objective

How it was implemented

- Will use the example on pg 65 in the book.
  - Polish expression for the book example is "3-7-H-5-1-V-8-2-H-V-4-V-6-V-H".
  - The slicing tree and the original floorplan:

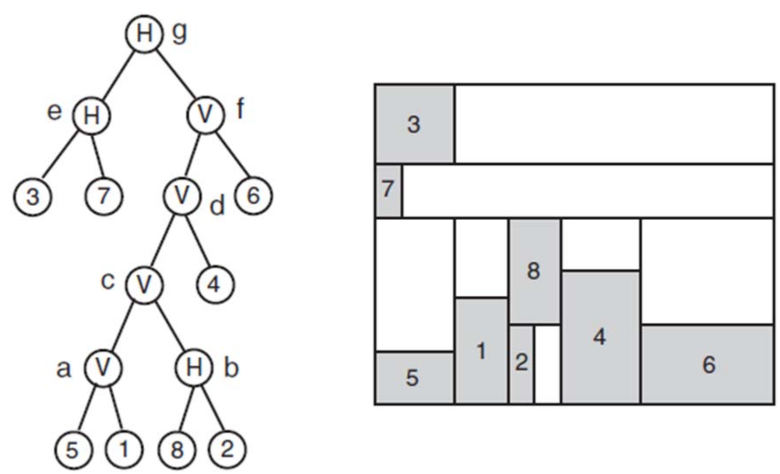


Figure 3.1. A slicing tree and its floorplan. Note that the lower left corner of each block is placed at the lower left corner of its room.

Polish Expression

- Postorder traversal
- Assume that *xyH* means x is top and y is bottom, and *xyV* means x is left and y is right
  - The area of the cut xyH has a width = $\max(W_x, W_y)$ and a height = $H_x + H_y$
  - The area of the cut xyV has a width = $W_x + W_y$ and a height = $\max(H_x, H_y)$

Inputs into Stockmeyer Code

- The input is a .ple file
  - The first line has the polish expression of the floorplan consisting of blocks starting a 0 and the '-' delimeter
  - The rest of the lines contain the width and height of a block separated by a space
    - 2nd line has the width and height of block 0, 3rd line has the width and height of block 1, etc.

Parse Input file

- My code takes the polish expression string out to parse
- Then, it places all of the widths and heights into a vector of pairs.
  - wh[0].first = width of block 0
  - wh[0].second = height of block 0

Start to build a Tree

- Created a structure called node that will be used to build a tree
- While loop with the condition of the polish expression string does not equal null, then parse the string using the '-' delimeter
  - If the parse is an H or a V, then it is a root, and special calculations need to happen
  - Else create a leaf with NULL left and right pointers

Connecting the root nodes to its children

- Postorder expression gives you left,right,root:

3-7-H-5-1-V-8-2-H-V-4-V-6-V-H

H

Right node = 7

Left node = 3

Temporary Vector = $\begin{bmatrix} H \\ 7 \\ \\ \\ \end{bmatrix}$

Calculations Needed

- First, sort width and height combinations (stored in a vector) of the children according to the root
  - H sorts into decreasing widths
  - V sorts into increasing widths
- Calculate width and height combinations of the root and store in a vector
  - Store information of what child combinations created the root combination in a separate vector

Calculations (cont'd)

Table 3.1. Summary of the bottom-up dimension computation in Stockmeyer algorithm. The minimum area floorplan is $13 \times 9 = 117$.

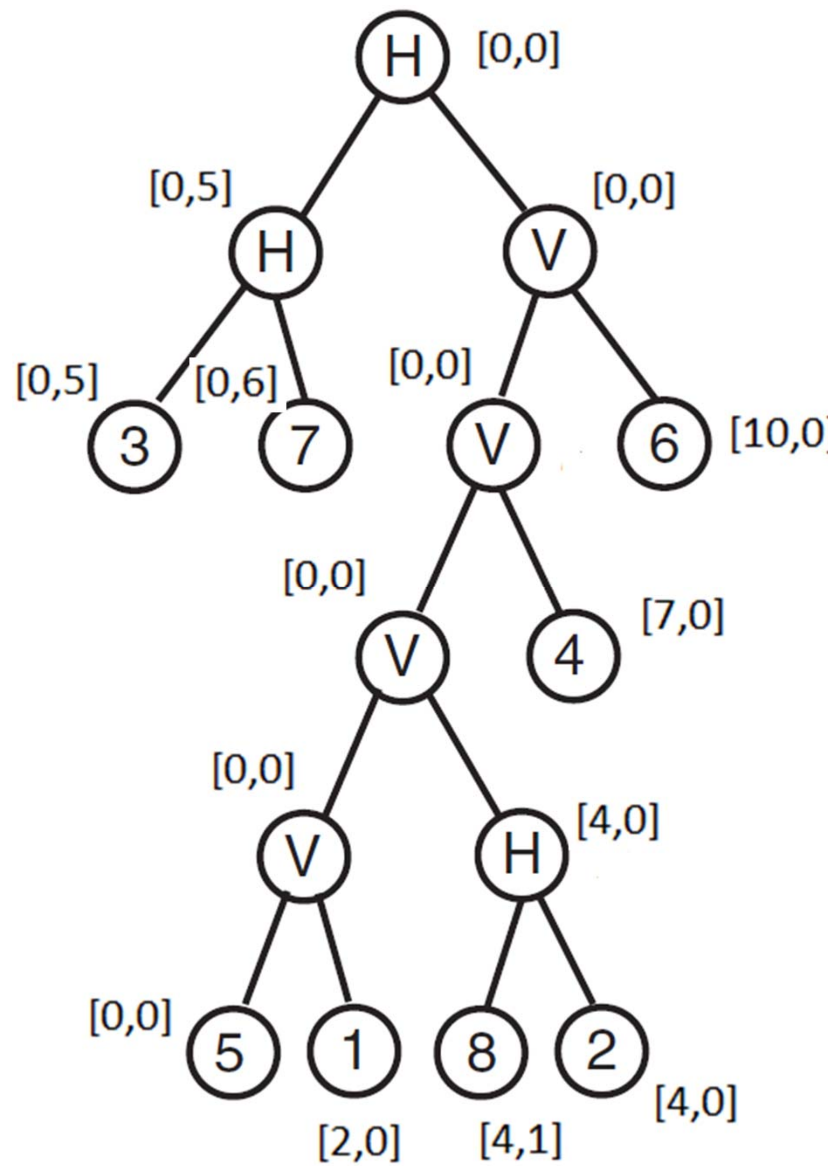
Node	Dir	Dimensions
a	ver	$L = \{(2,3),(3,2)\}$ $R = \{(2,4),(4,2)\}$ $D = \{(4,4),(6,3),(7,2)\}$
b	hor	$L = \{(4,2),(2,4)\}$ $R = \{(3,1),(1,3)\}$ $D = \{(4,3),(3,5),(2,7)\}$
c	ver	$L = \{(4,4),(6,3),(7,2)\}$ $R = \{(2,7),(3,5),(4,3)\}$ $D = \{(6,7),(7,5),(8,4),(10,3)\}$
d	ver	$L = \{(6,7),(7,5),(8,4),(10,3)\}$ $R = \{(3,5)(5,3)\}$ $D = \{(9,7),(10,5),(13,4),(15,3)\}$
f	ver	$L = \{(9,7),(10,5),(13,4),(15,3)\}$ $R = \{(3,5)(5,3)\}$ $D = \{(12,7),(13,5),(18,4),(20,3)\}$
e	hor	$L = \{(3,3)\}$ $R = \{(2,1)(1,2)\}$ $D = \{(3,4)\}$
g	hor	$L = \{(3,4)\}$ $R = \{(20,3),(18,4),(13,5),(12,7)\}$ $D = \{(20,7),(18,8),(13,9),(12,11)\}$

New Area and traversal

- Once all of the width and height calculations are done, sort through the Main Root's width and height combinations to get the minimum area
- Traverse back down the tree to change the orientations of the leaves that is needed to obtain the
- Calculate the coorinates of the leaves while traversing back down the tree

New Area and traversal (cont'd)

Node	Dir	Dimensions
a	ver	$L = \{(2,3),(3,2)\}$ Rotate!!! $R = \{(2,4),(4,2)\}$ $D = \{(4,4),(6,3),(7,2)\}$
b	hor	$L = \{(4,2),(2,4)\}$ $R = \{(3,1),(1,3)\}$ Rotate!!! $D = \{(4,3),(3,5),(2,7)\}$
c	ver	$L = \{(4,4),(6,3),(7,2)\}$ $R = \{(2,7),(3,5),(4,3)\}$ $D = \{(6,7),(7,5),(8,4),(10,3)\}$
d	ver	$L = \{(6,7),(7,5),(8,4),(10,3)\}$ $R = \{(3,5)(5,3)\}$ $D = \{(9,7),(10,5),(13,4),(15,3)\}$
f	ver	$L = \{(9,7),(10,5),(13,4),(15,3)\}$ $R = \{(3,5)(5,3)\}$ Rotate!!! $D = \{(12,7),(13,5),(18,4),(20,3)\}$
e	hor	$L = \{(3,3)\}$ $R = \{(2,1)(1,2)\}$ Rotate!!! $D = \{(3,4)\}$
g	hor	$L = \{(3,4)\}$ $R = \{(20,3),(18,4),(13,5),(12,7)\}$ $D = \{(20,7),(18,8),(13,9),(12,11)\}$

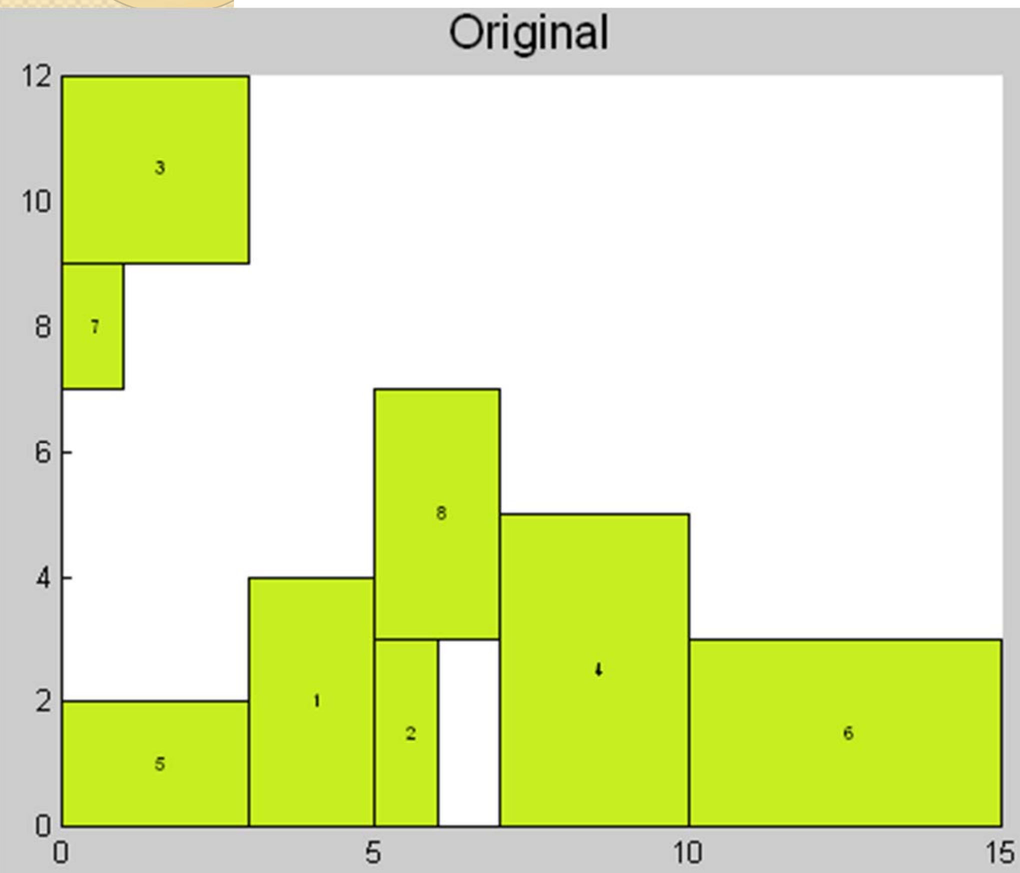


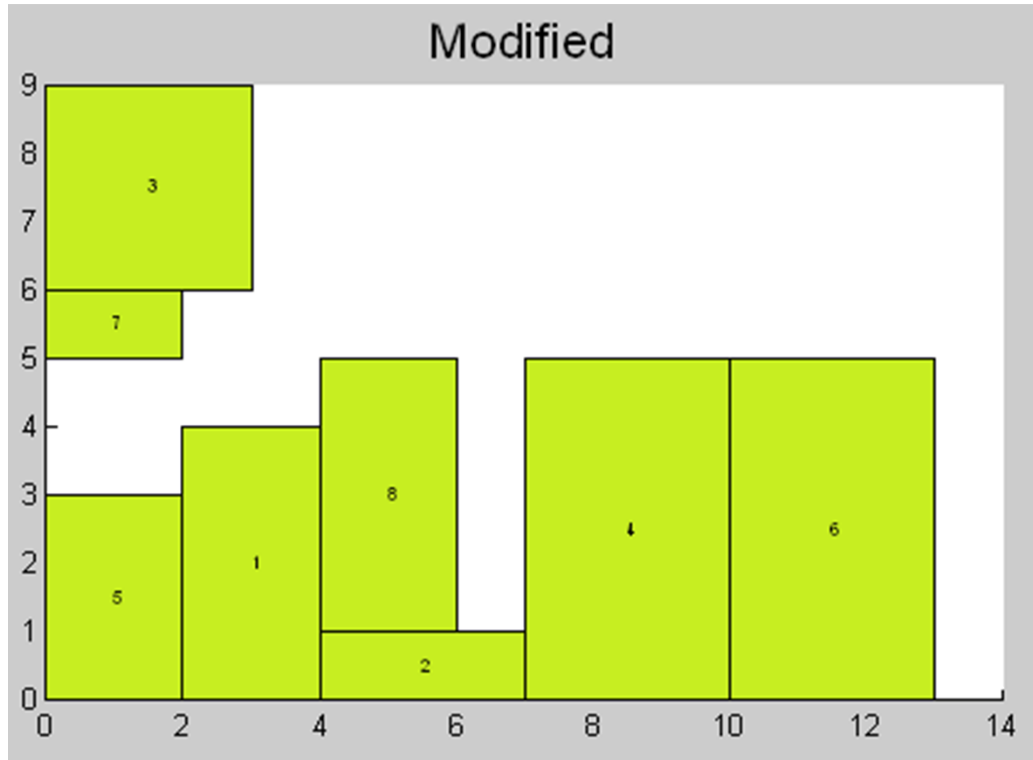
Plotting Floorplan

- Not part of the Stockmeyer Algorithm!
- Output the old coordinates, old width and heights, and block number into a .txt file
- Output the new coordinates, new width and heights, and block number into a .txt file
- Use Matlab to plot

Floorplan of Example

- The blocks that rotated were 6, 2, 5 and 7

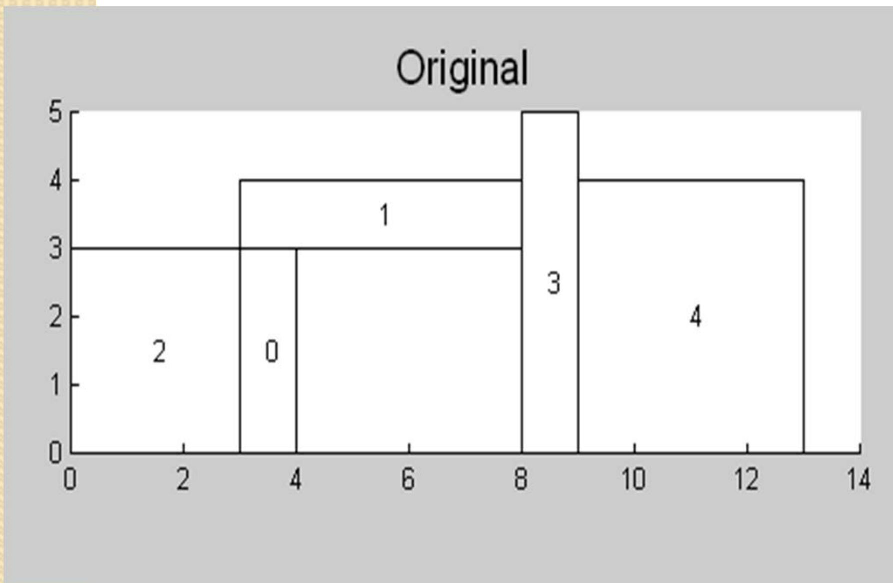


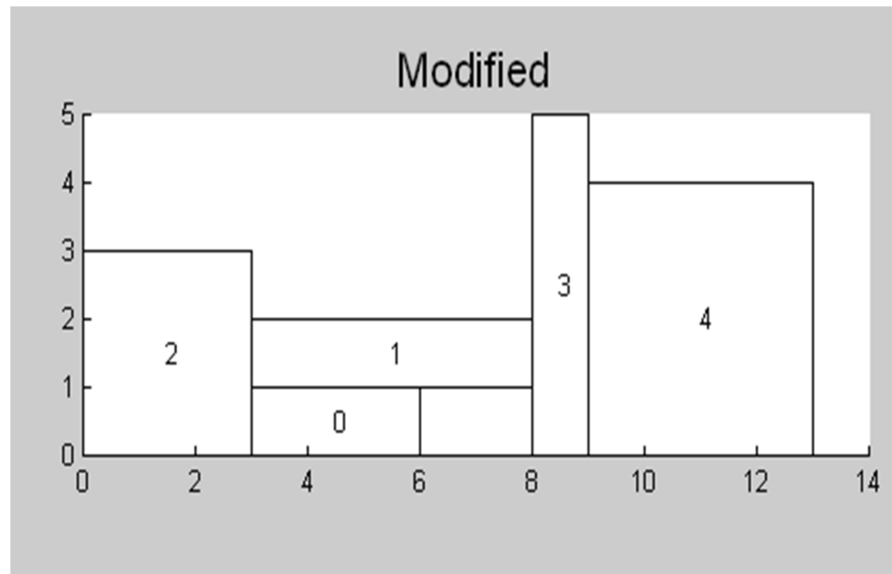


Results

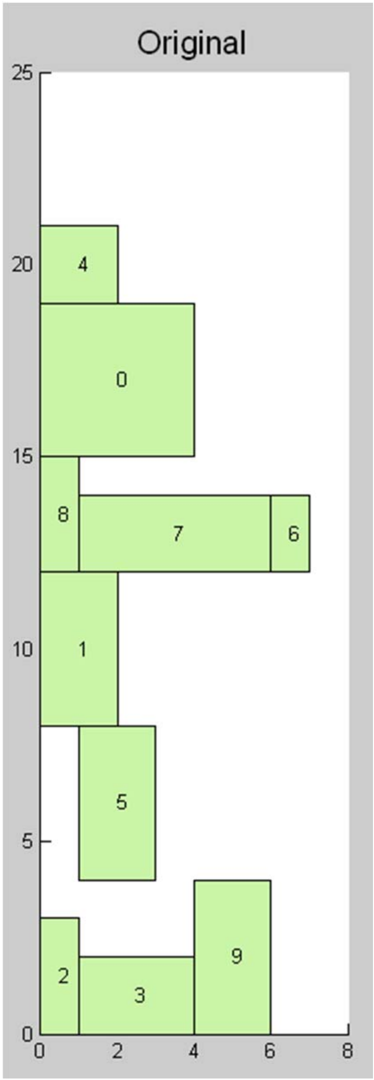
# Blocks	Original Area	New Area	% improvement	Performance Time	# Blocks Rotated	Blocks rotated
5	65	65	0	0.009017778	1	0
10	147	95	35.37414966	0.009522222	4	1, 3, 5, 7
30	1075	748	30.41860465	0.010381111	8	2, 15, 16, 18, 22, 23, 24, 27, 28
100	7119	4264	40.10394718	0.015953333	38	1, 2, 3, 5, 7, 8, 10, 11, 16, 18, 21, 23, 26, 32, 33, 41, 42, 49, 50, 54, 55, 62, 63, 64, 66, 68, 74, 75, 76, 77, 78, 80, 81, 82, 87, 90, 91, 96
150	14104	8316	41.0380034	0.018414444	56	3, 7, 8, 10, 18, 20, 23, 25, 31, 32, 34, 35, 39, 44, 45, 46, 47, 58, 63, 64, 65, 66, 70, 71, 72, 73, 74, 78, 79, 82, 83, 85, 86, 88, 91, 97, 98, 99, 102, 105, 113, 114, 118, 119, 121, 124, 134, 135, 137, 139, 141, 142, 143, 144, 146, 147

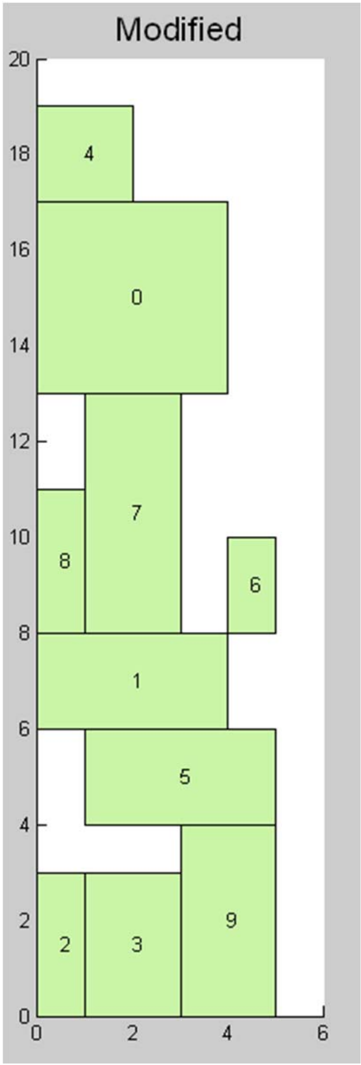
5 Block Problem



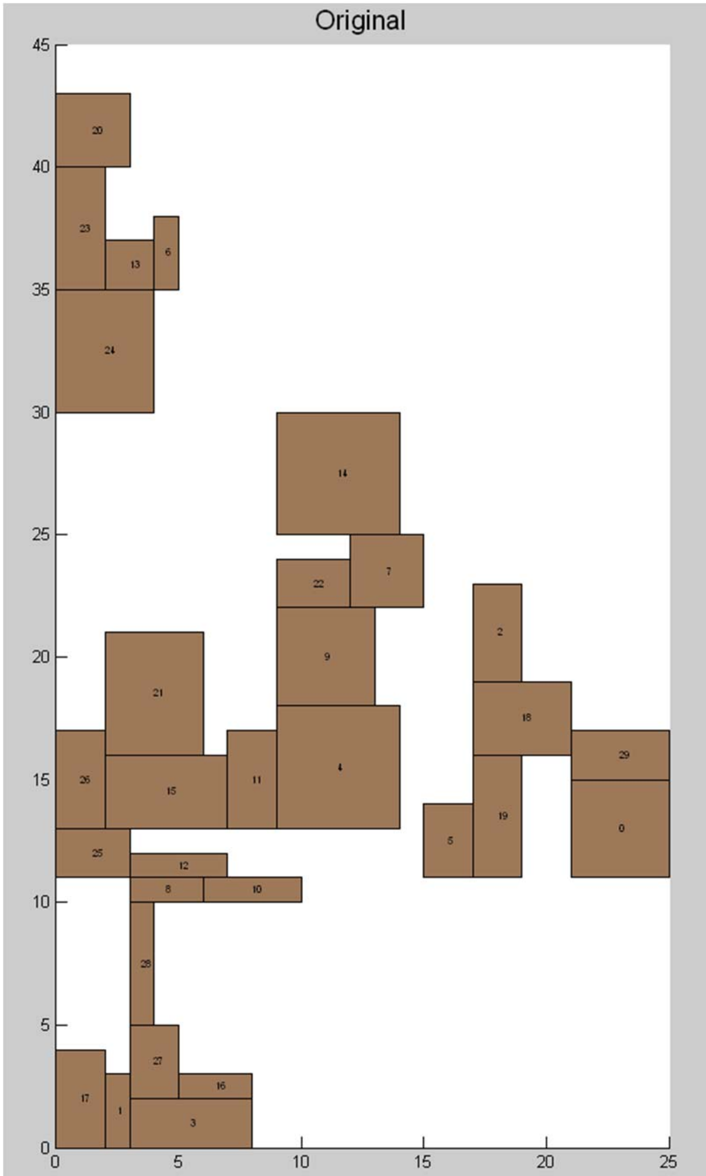


10 Block Problem

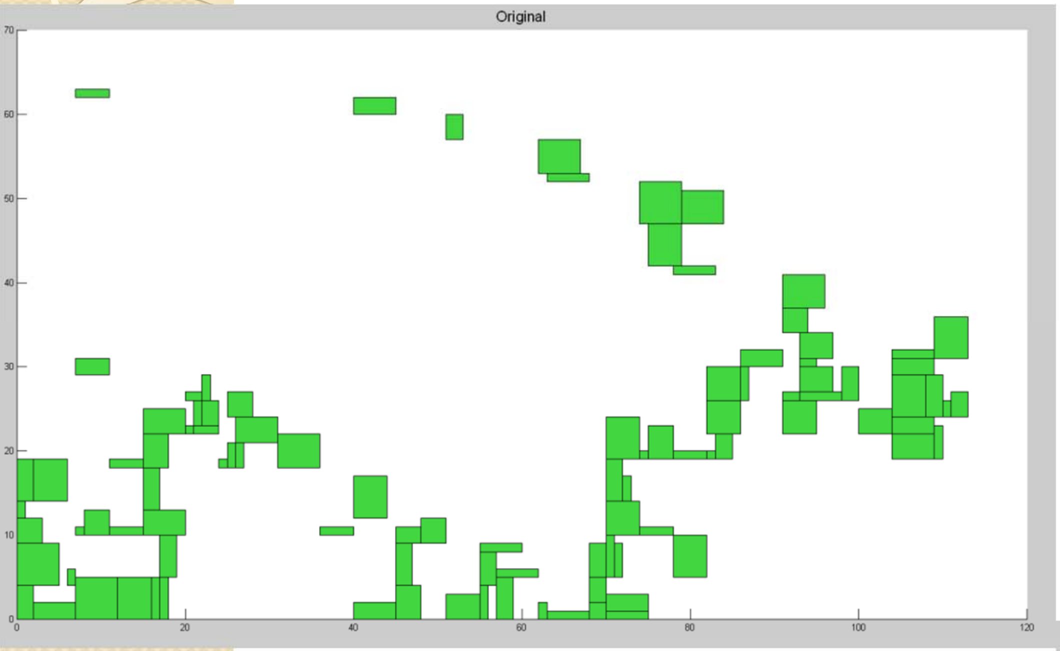


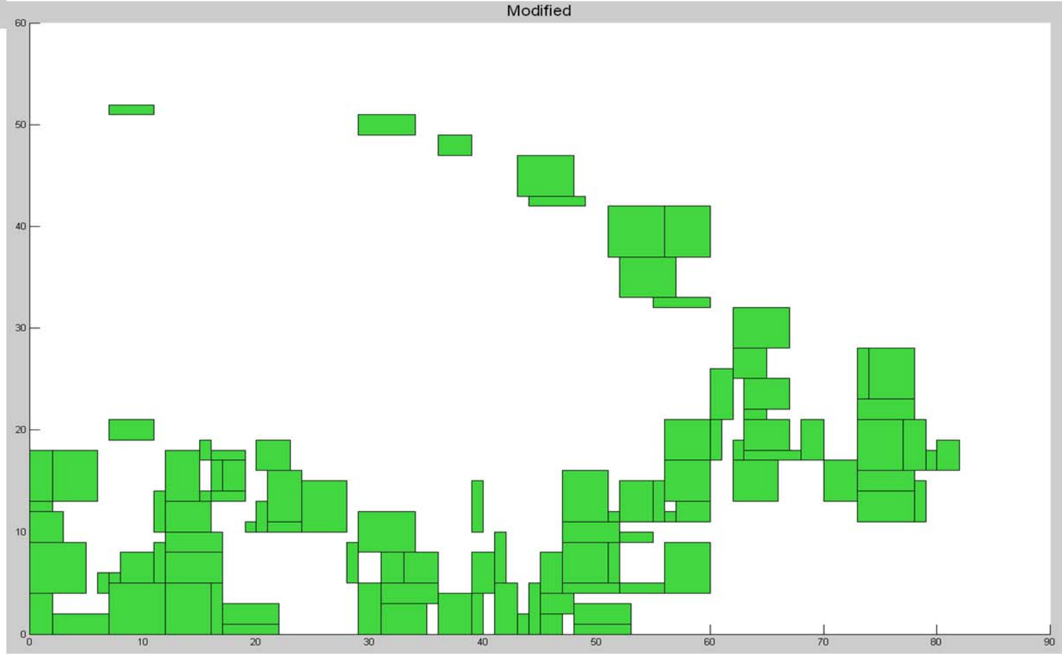


30 Block Problem

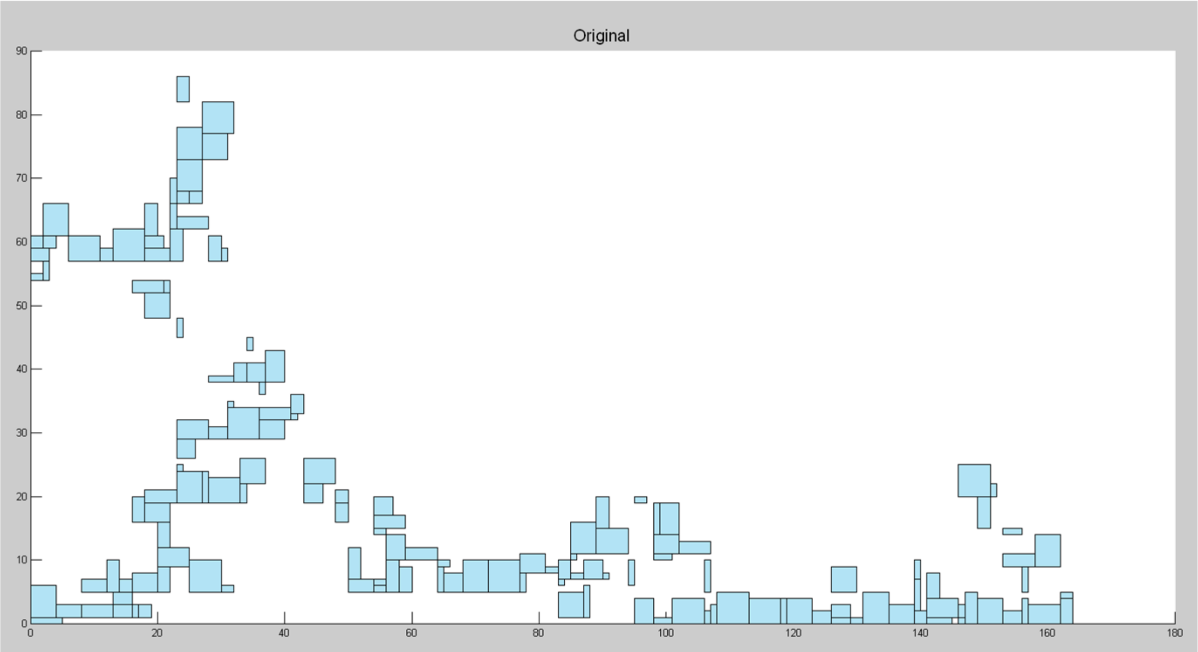


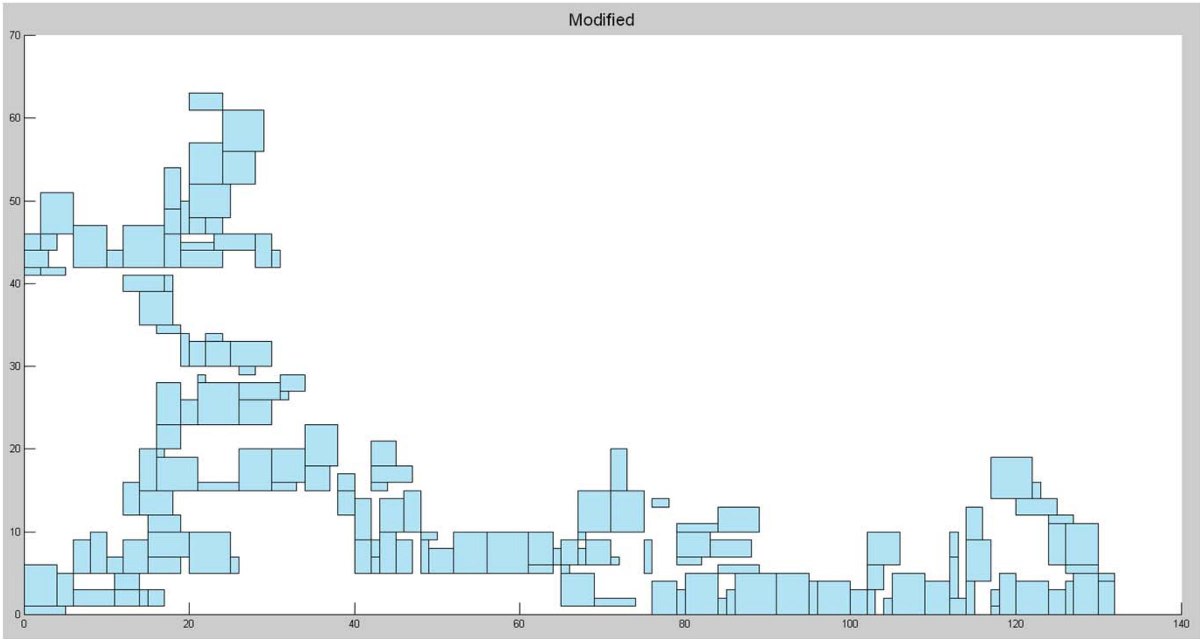
100 Block Problem





150 Block Problem





Conclusion

- The Stockmeyer Algorithm can improve the area significantly, or not at all, depending on the original placement and the critical path
  - If critical path is already minimized, then the area will stay the same.
- Wire routing would become a significant real world problem that the algorithm does not take into account

Any Questions?

Sources

- Lim, Sung Kyu, “Practical Problems in VLSI Physical Design Automation”
- L. Stockmeyer, "Optimal Orientation of Cells in Slicing Floorplan Designs"