ILP-based Footprint Arrangement

1

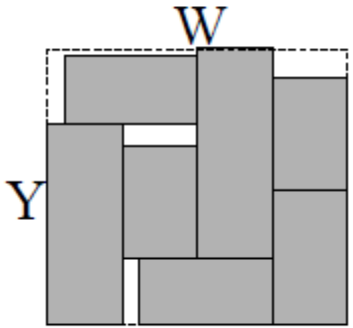
Results

- Block Graph 1
- Block Graph 2
- Block Graph 3
- Block Graph 4
- Block Graph 5

Formulation

- Minimize the packing area:
  - Assume that one dimension W is fixed.
  - Minimize the other dimension Y.
- Need to have constraints

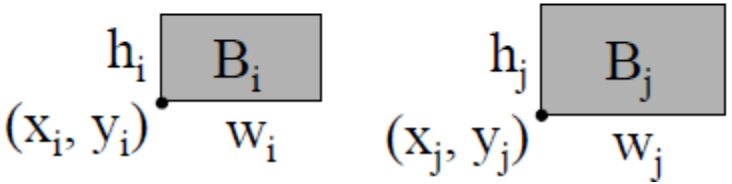
  so that blocks do not overlap.
- Associate each block B_i with 4 variables:
  - x_i and y_i: coordinates of its lower left corner.
  - w_i and h_i: width and height.



Non-overlapping Constraints

For two non-overlapping blocks B_i and B_j, at least one of the following four linear constraints must be satisfied:

(1)	$x_i + w_i \le x_j$	if B_i is to the left of B_j
or (2)	$x_i - w_j \ge x_j$	if B_i is to the right of B_j
or (3)	$y_i + h_i \le y_j$	if B_i is below B_j
or (4)	$y_i - h_j \ge y_j$	if B_i is above B_j



Non-overlapping Constraints (hard blocks)

- Use integer (0 or 1) variables x_{ij} and y_{ij}:
  $x_{ij}=0$ and $y_{ij}=0$ if (1) is true.
  $x_{ij}=0$ and $y_{ij}=1$ if (2) is true.
  $x_{ij}=1$ and $y_{ij}=0$ if (3) is true.
  $x_{ij}=1$ and $y_{ij}=1$ if (4) is true.
- Let W and H be upper bounds on the total width and height. Non-overlapping constraints:

$$
\begin{array}{ll}
(1') & x_i + w_i \le x_j + W(x_{ij} + y_{ij}) \\
(2') & x_i - w_j \ge x_j - W(1 + x_{ij} - y_{ij}) \\
(3') & y_i + h_i \le y_j + H(1 - x_{ij} + y_{ij}) \\
(4') & y_i - h_j \ge y_j - H(2 - x_{ij} - y_{ij})
\end{array}
$$

$$
\begin{array}{lll}
\text{Min.} & Y & \\
\text{s.t.} & 0 \le x_i,\ x_i + w_i \le W & 1 \le i \le n \\
 & 0 \le y_i,\ y_i + h_i \le Y & 1 \le i \le n \\
 & x_i + w_i \le x_j + W(x_{ij} + y_{ij}) & 1 \le i < j \le n \\
 & x_i - w_j \ge x_j - W(1 + x_{ij} - y_{ij}) & 1 \le i < j \le n \\
 & y_i + h_i \le y_j + H(1 - x_{ij} + y_{ij}) & 1 \le i < j \le n \\
 & y_i - h_j \ge y_j - H(2 - x_{ij} - y_{ij}) & 1 \le i < j \le n \\
 & x_{ij} = 0 \text{ or } 1 & 1 \le i < j \le n \\
 & y_{ij} = 0 \text{ or } 1 & 1 \le i < j \le n
\end{array}
$$

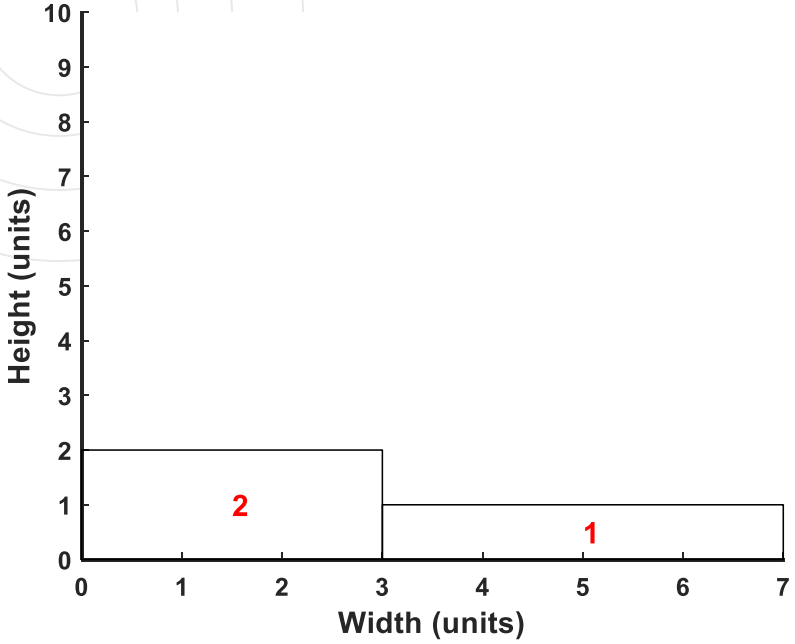
Block Graph 1

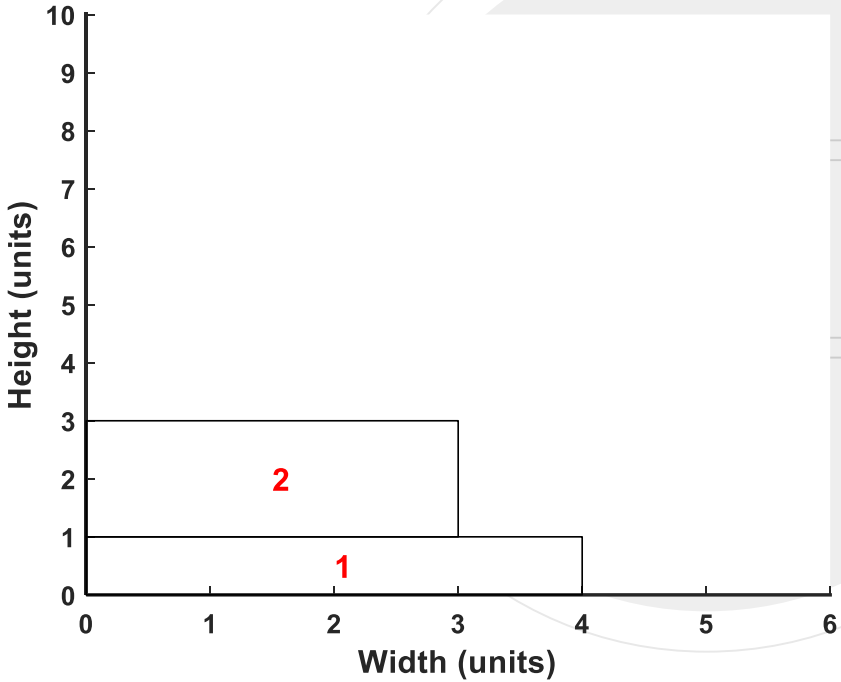
- Block Area Info 1

```
num_blocks 2
block_1 1
block_1 width 4 height 1 area 4
block_2 1
block_2 width 3 height 2 area 6
```

- Two hard blocks.
- We decreases width from 7 to 2 and see how minimized height changes.

Footprint Graph 1

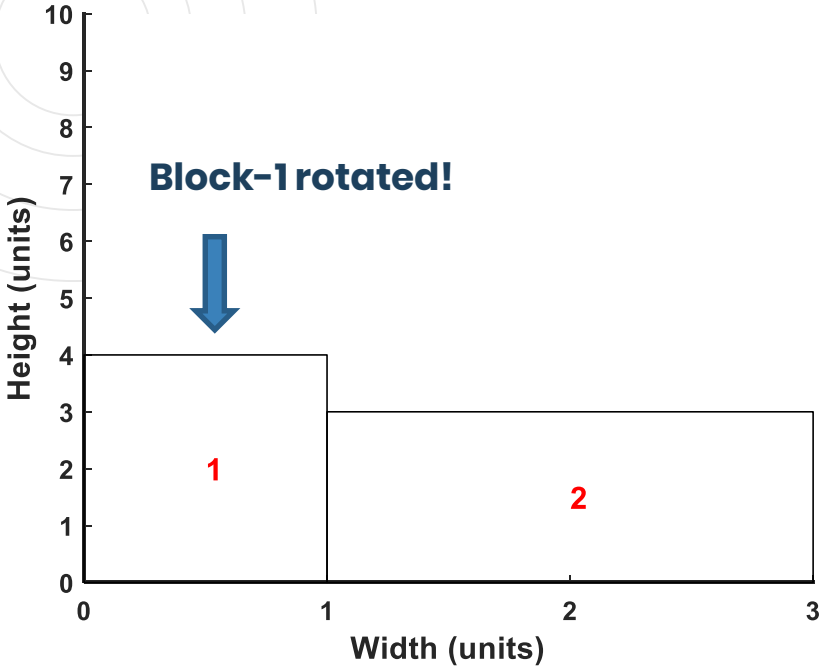




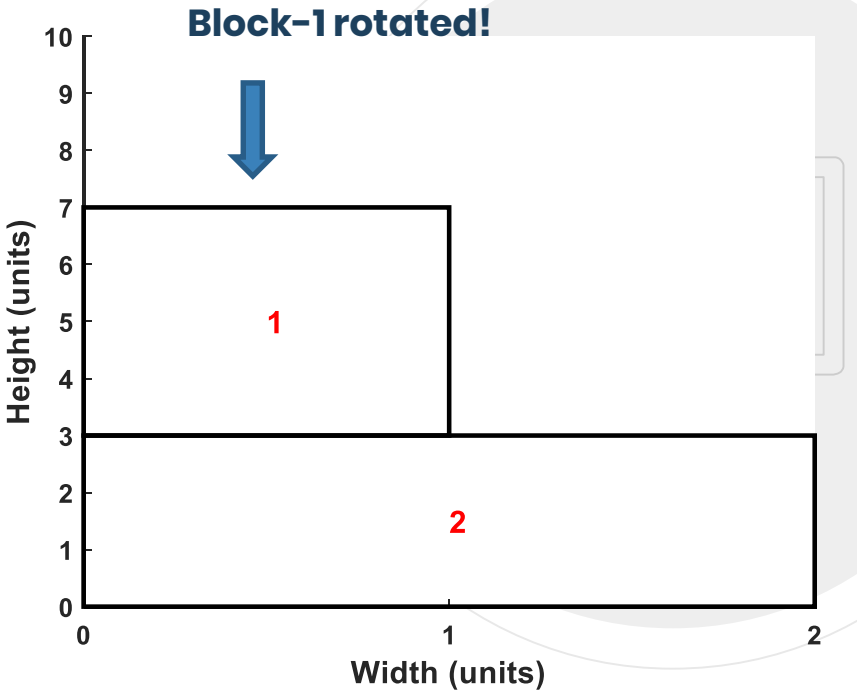
Width = 7 → Y = 2

Width = 6, 5, 4 → Y = 3

Footprint Graph 1

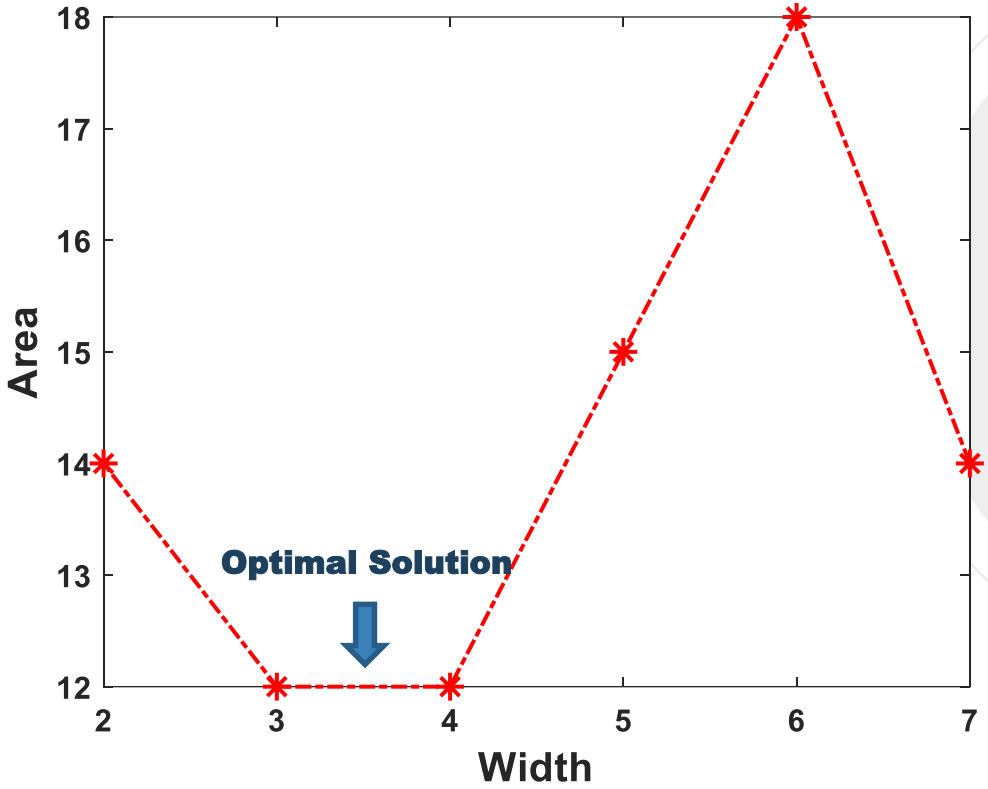


Width = 3 → Y = 4



Width = 2 → Y = 7

Footprint Graph 1



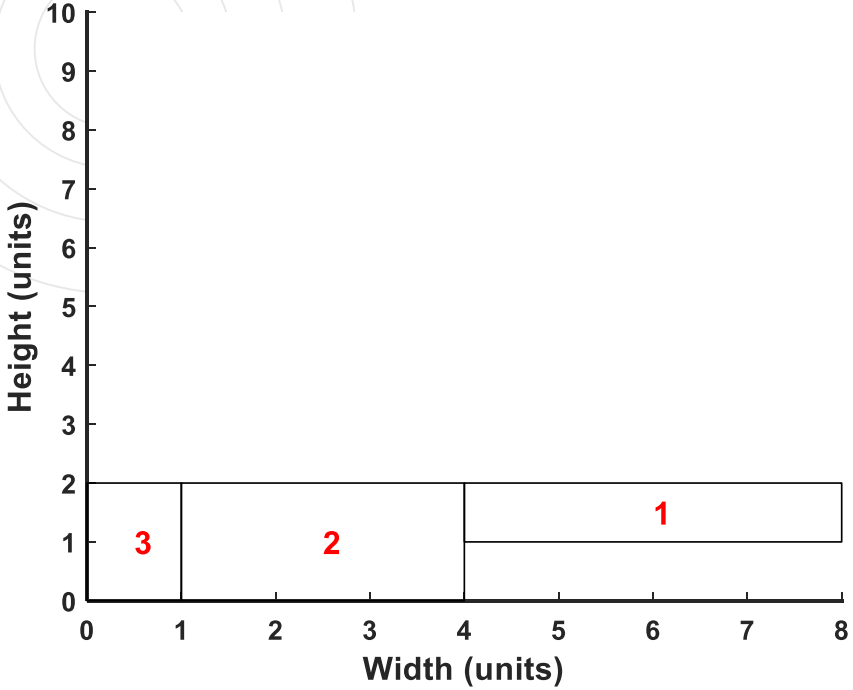
Block Graph 2

- Block Area Info 2

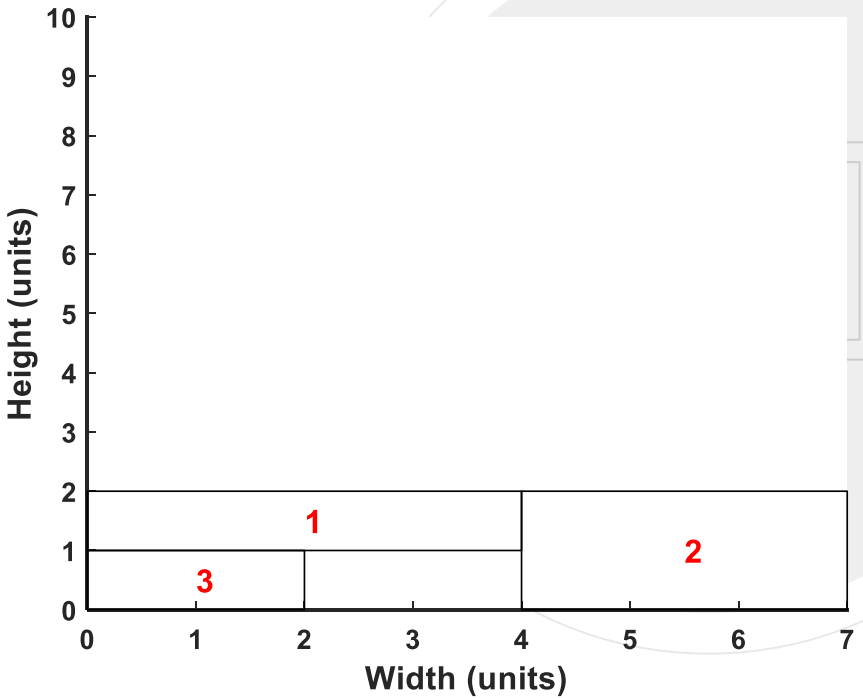
```
num_blocks 3
block_1 1
block_1 width 4 height 1 area 4
block_2 1
block_2 width 3 height 2 area 6
block_3 1
block_3 width 1 height 2 area 2
```

- Three hard blocks
- We decreases width from 8 to 2 and see how minimized height changes.

Footprint Graph 2

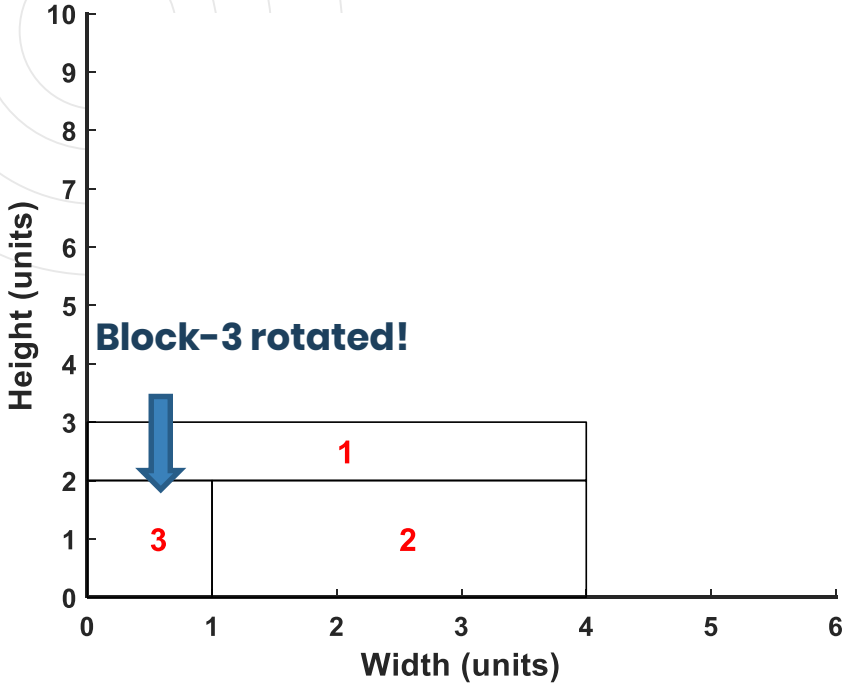


Width = 8 → Y = 2

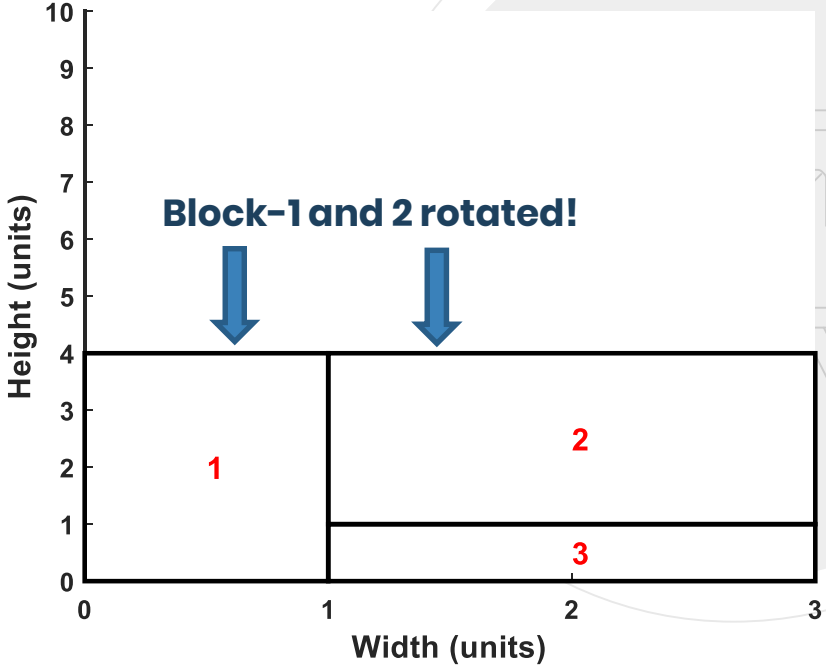


Width = 7 → Y = 2

Footprint Graph 2

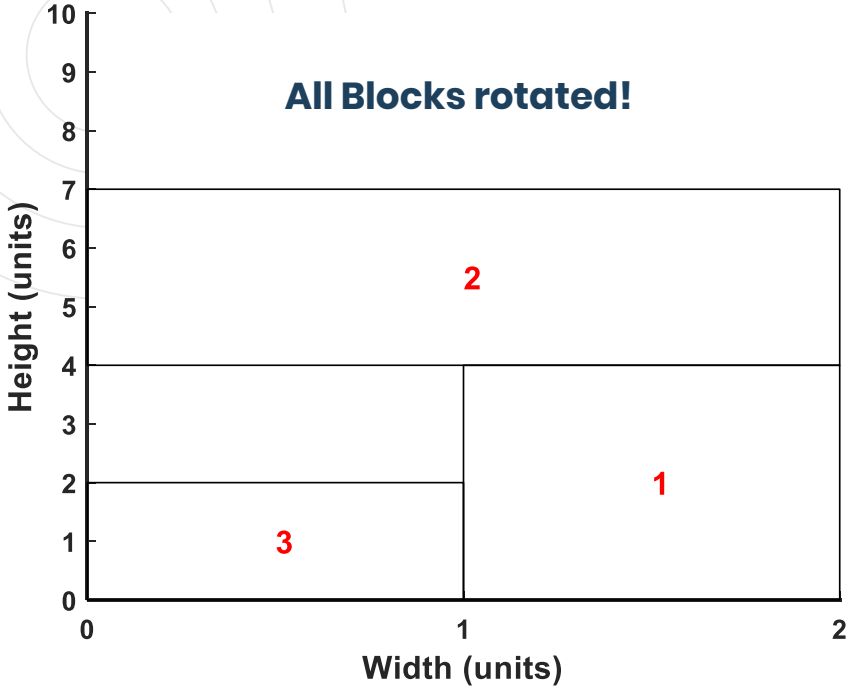


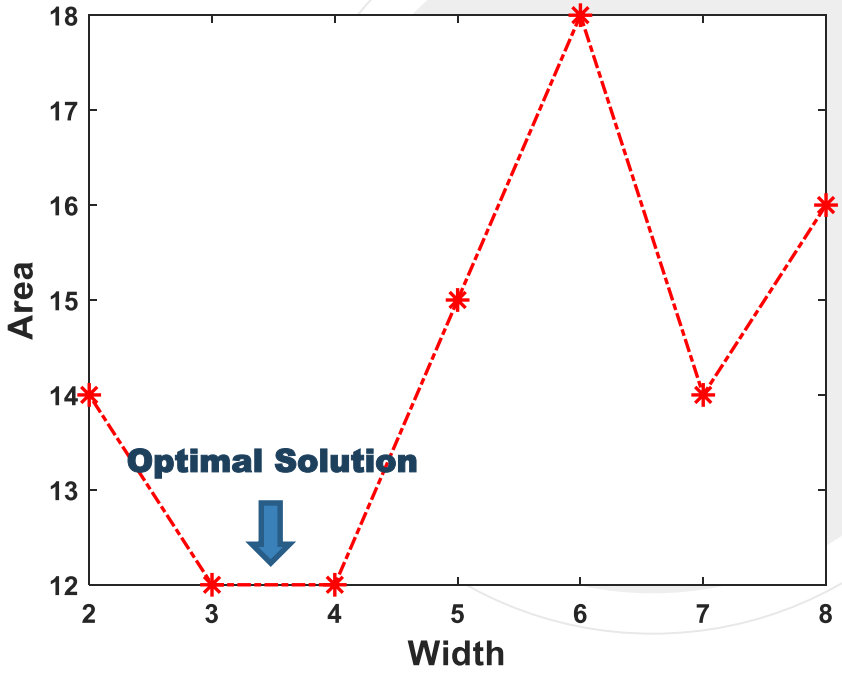
Width = 6, 5, 4 → Y = 3



Width = 3 → Y = 4

Footprint Graph 2





Width = 2 → Y = 7