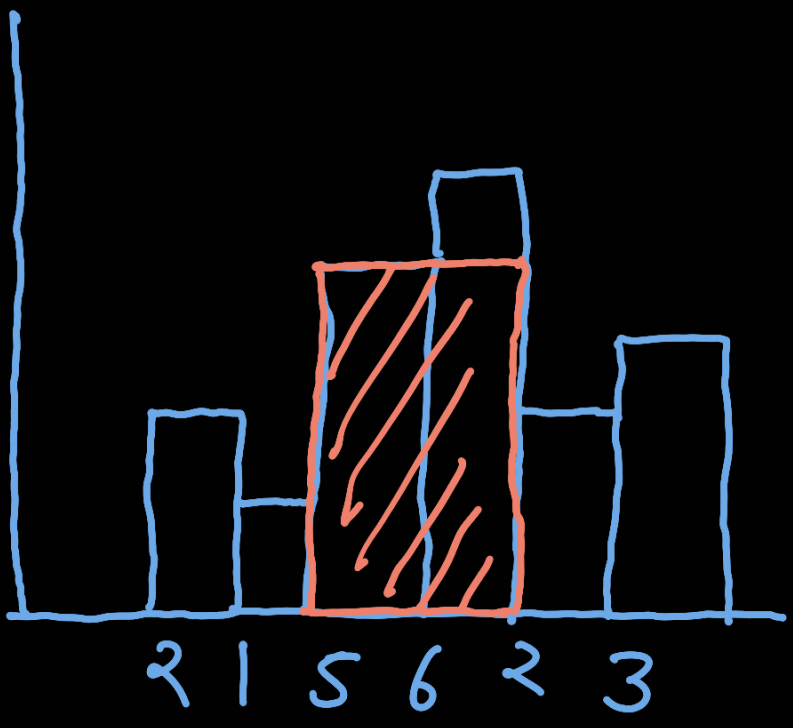
Leetcode 84

Largest Rectangle In Histogram



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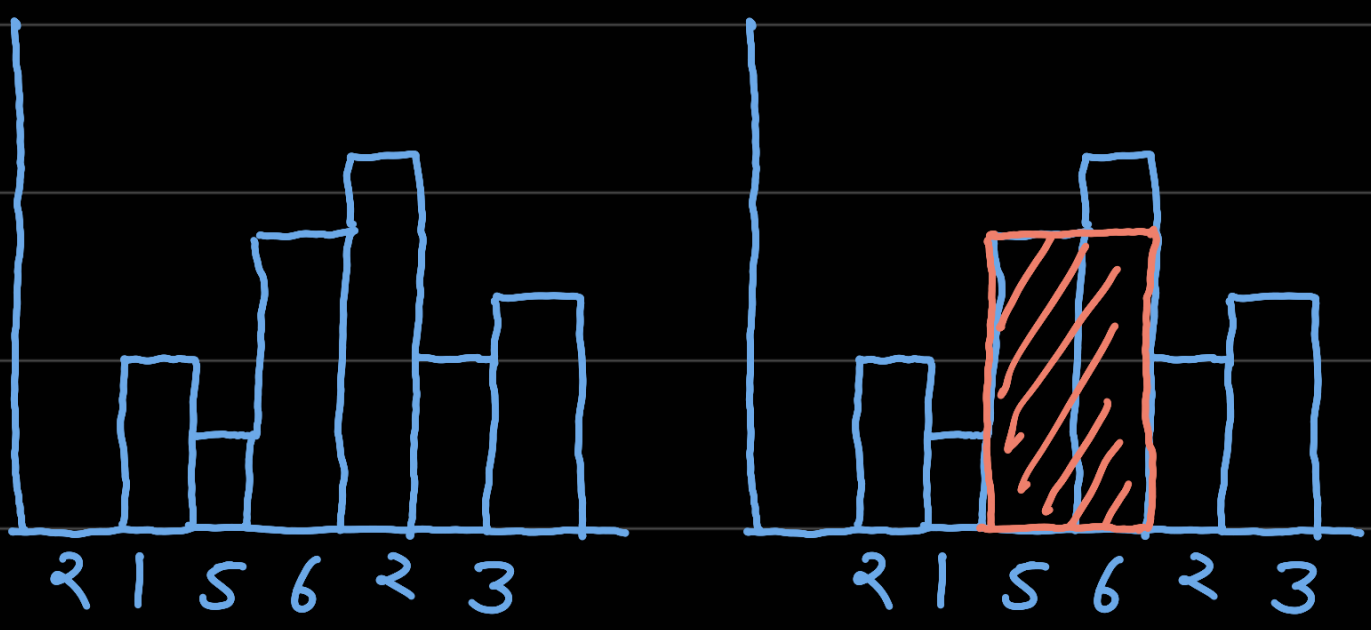
Amazon SDE-2

Largest Rectangle In Histogram

Given array of integers heights[] which represent height of bars of the histogram, find the area of largest rectangle in histogram. Width of bar is 1.

Example : heights = [2, 1, 5, 6, 2, 3]



Largest Rectangle Area = 5 x 2 = 10

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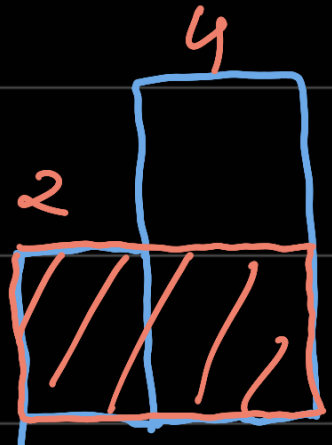
Deep Dive on Problem

(1) We know each bar is of fixed width i.e. 1

(2) We notice the given input, the height of the rectangle depends on the smallest bar of the choosen set of bars.



We Cannot use height = 4

Area = W x H
= 2 x 2

(3) This also implies that if we choose more bars, it will maximize the area. The height will get restricted to the height of minimum bar in that group. Let us call that smallest bar of group as Special Bar.

(4) So we can take each bar one by one and consider this as our Special Bar. Means we will choose its neighbours which are greater or equal

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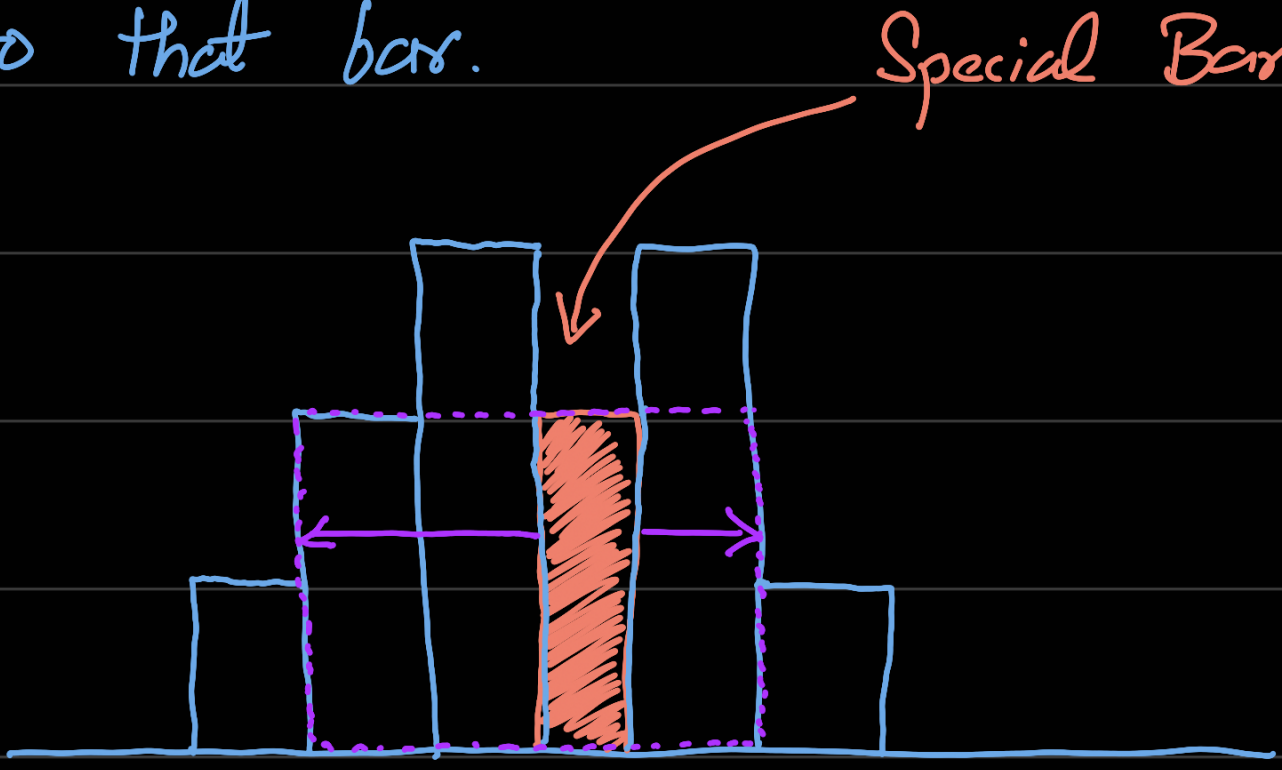
to that bar.



If we try to make rectangle using our Special bar, we can take all those adjacent bars who are greater or equal in height of our special bar. If we take smaller, then the height is no more determined by our so-called Special Bar. So we follow this rule

on each and every bar.

⑤ Now, we have a working algorithm for this problem with valid reasons for our logic.

⑥ We need to move to each bar, take this as special, expand the window on both left and right sides until we get bars with greater or equal heights. When we are done, we know the width as well as height

and finally area. Similarly we can check each bar and find the maximum area.

Complexity : $O(N^2)$

We can still optimize it more.

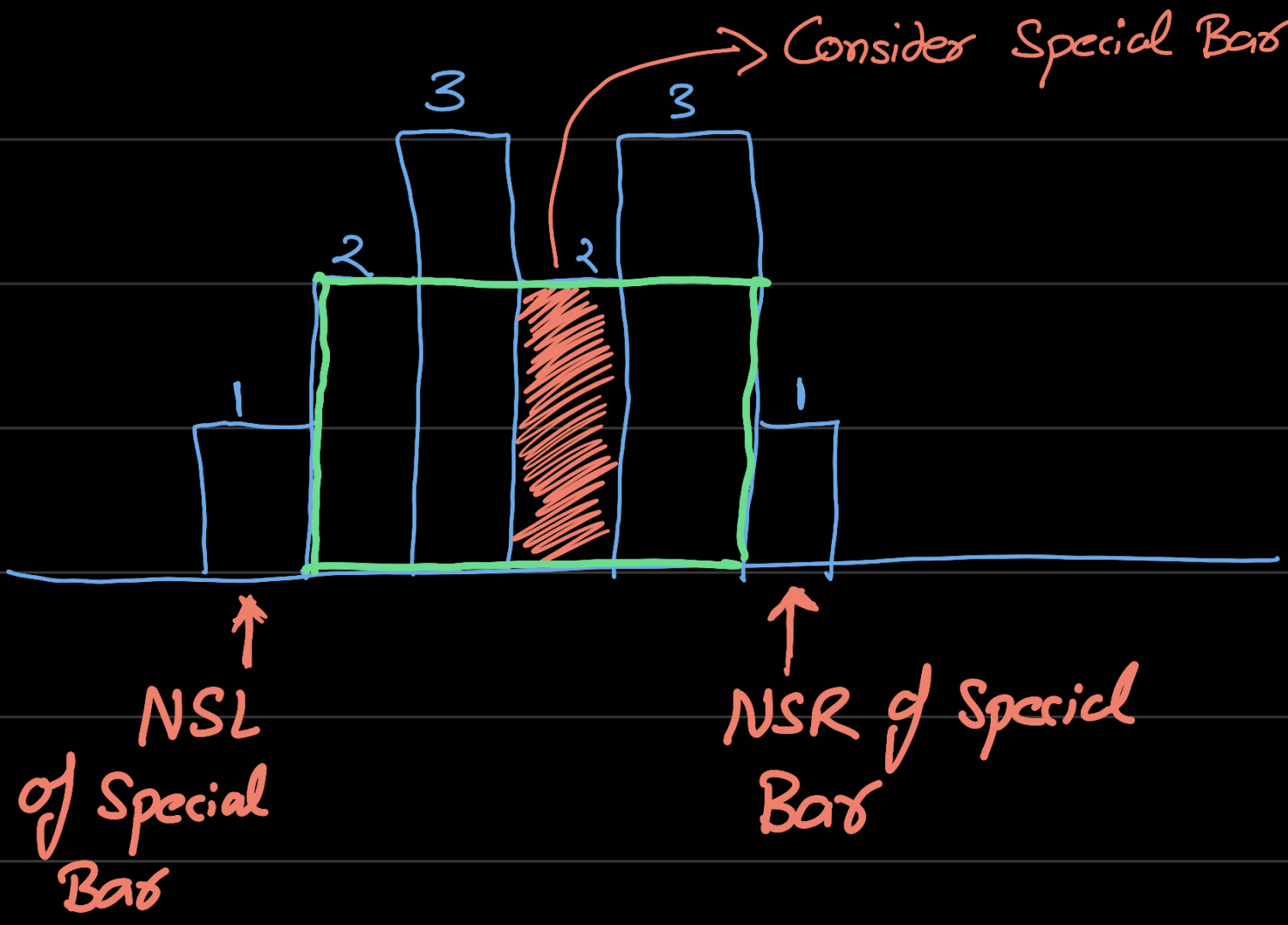
More Optimization

① If you think more, we just need to know the position of the next smaller bar on both left & right side of

each bar. We can precompute this very easily using Stacks in O(N) time and O(N) space.

(2) This is a classical Stack problem known as Next Smaller Left (NSL) and Next Smaller Right (NSR)

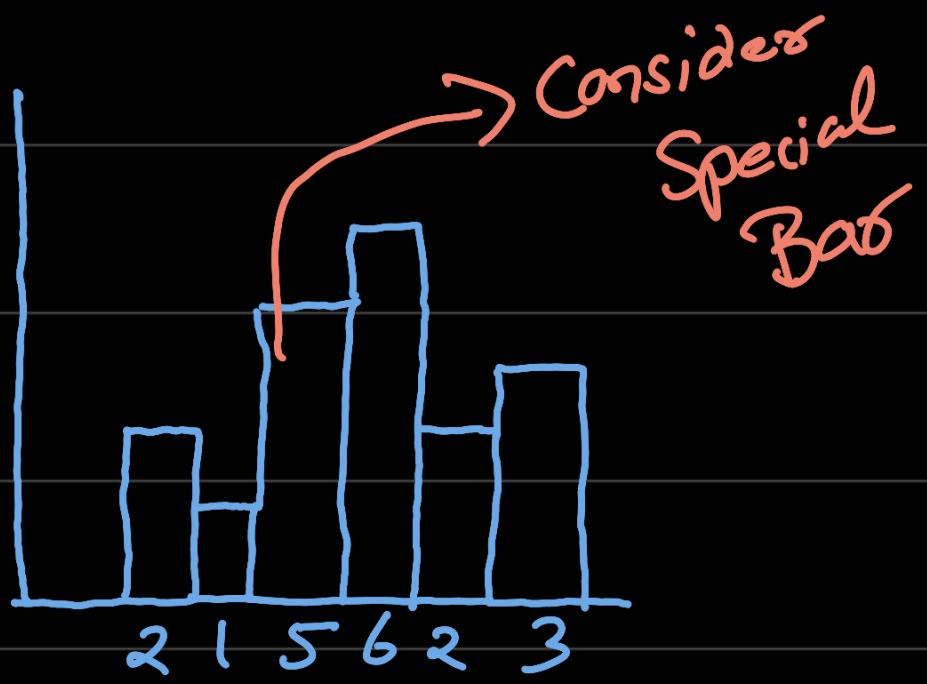
(3) Once we have height[], NSL[] and NSR[] we can find max area in single loop.



Current Area = W × H = 4 × 2 = 8

(4) See how easily NSR[] and NSL[] can help us determine the relevant width.

Dry Run With NSL & NSR



heights = | 2 | 1 | 5 | 6 | 2 | 3 |
0 1 2 3 4 5

NSL = | X | X | 1 | 2 | 1 | 4 |
0 1 2 3 4 5

So next smaller left of Bar of height 6 is Bar of height 5 at index 2.

NSR =

1	X	4	4	X	X
0	1	2	3	4	5

Now, let us see how we can find area considering Bar of height 5 as Special Bar.

height =	2	1	5	6	2	3
NSL =	X	X	1	2	1	4
NSR =	1	X	4	4	X	X
	0	1	2	3	4	5

Current Area = W X H

Height = 5 fixed

Width we need to use NSL & NSR

Width = Bars between NSR & NSL

= NSR - NSL - 1

= 4 - 1 - 1 = (2)

Current Area = W x H = 2 x 5 = 10

→ Similarly you can run a loop and consider each bar as Special Bar and find area and keep track of max. area.

→ NSL & NSR can be calculated using stack easily in O(N)

→ We finally solved this problem in O(N) time & O(N) space.

→ NSL & NSR is also easy. We will cover in next post or you can check it online as well.

→ This is the simplest & most intuitive explanation of HARD problem.

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