



## Problem:- Lifeguards

### Key points from Problem Statement

- To keep pool safe, he hires  $N$  lifeguards.
- Each lifeguard works during time interval
  - start time
  - end time
- But farmer hired 1 extra lifeguard.

Goal:- Remove one lifeguard

But who?

↓

remove that lifeguard, the pool  
should still be watched for.

maximum time.

Approach - 1:- Remove one lifeguard and check time coverage by other guards.

→ Do similar thing to every lifeguard.

Let's see theoretically:-

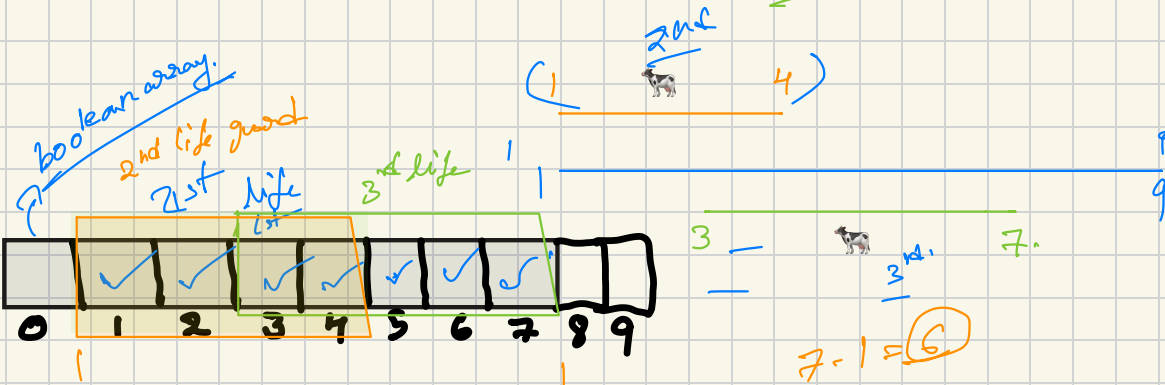
Sample input:- 3 → number of lifeguards

5	9
1	4
3	7

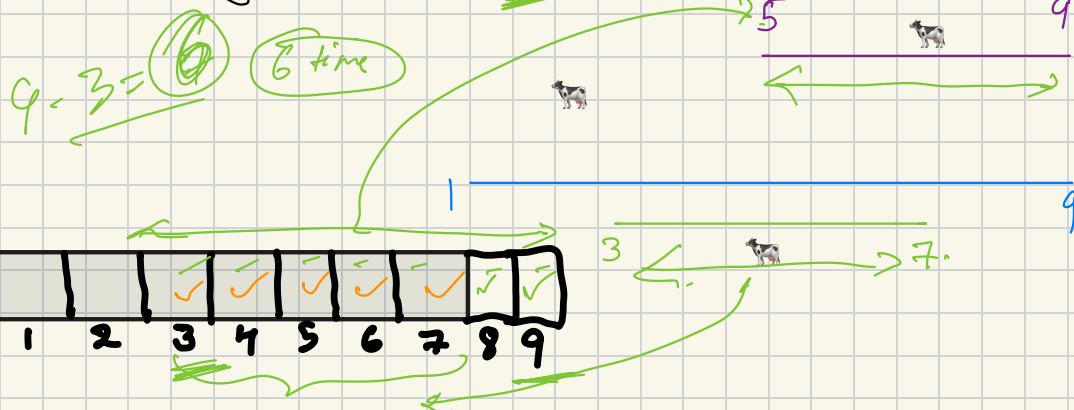
Each lifeguard start & end time.

final output:- maxCoverageTime = ?

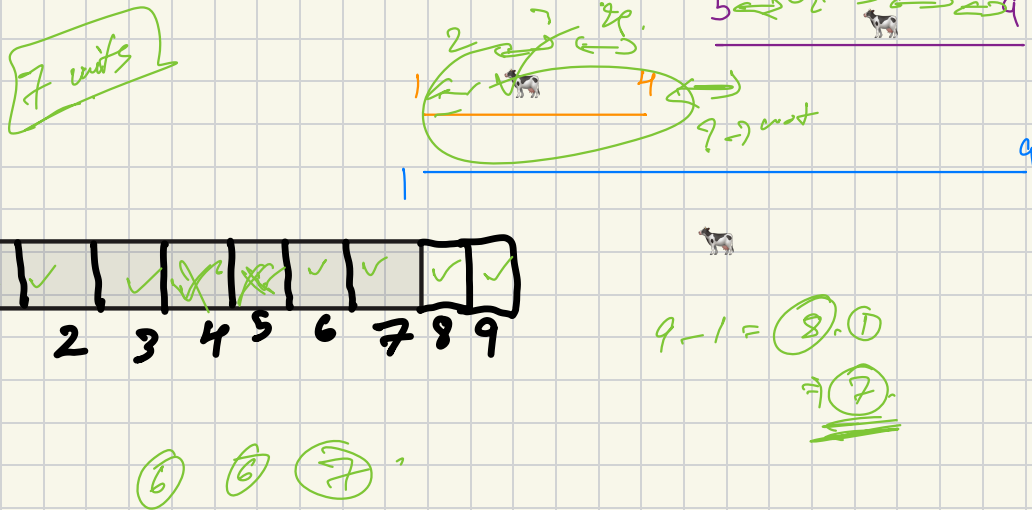
Case-i :- Removing 1<sup>st</sup> lifeguard 5-9. = 6 time.



Case-ii :- Removing 2<sup>nd</sup> lifeguard 1-4



Case-iii :- Removing 3<sup>rd</sup> lifeguard 3-7



Time Complexity:-  $(n \times (n-1))$   
 $(n^2)$  time.  
 Complexity  $\rightarrow$

Space Complexity:-  
 $\rightarrow O(n) \rightarrow \text{Array}$

$\rightarrow$  How to optimise?  $\rightarrow$  Total Covered time - Least alone time.  
 $\rightarrow$  We are checking again and again every time

Solution:- Can we check in one go?

$O(n \log n) < O(n^2)$   
 $O(n) + O(n \log n)$   
 once

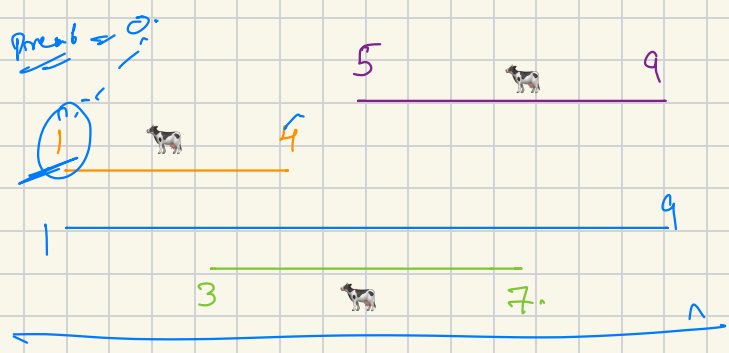
$\rightarrow \times \rightarrow$  why?

They are not in order.

Let's put them in order

$\rightarrow$  Sorting using Start time.

time complexity  
 $O(n^2) > O(n \log n)$



→ Go from Left to Right one pass.

What we need?  $\text{total time Covered} = ?$   
 $\text{min alone time} = ?$

1<sup>st</sup> Cow lifeguard:-  $\text{PreCov end} = 0$   
 $\text{time Covered by 1<sup>st</sup> Cow} = ?$   
 $\text{alone time Covered by Cow} = ?$

$$\begin{aligned}\text{time Covered} &= \max(0, \text{cow.endtime} - \max(\text{cow.starttime}, \text{PreCov end time})) \\ &= \max(0, 4 - \max(1, 0)) \\ &= \max(0, 4 - 1)\end{aligned}$$

$$\boxed{\text{time covered} = 3} \rightarrow \boxed{3 \text{ units.}}$$

Alone time = ? → Check left and Right overlap @ not

left overlap =  $\boxed{i < 0}$ ?  $\text{cow.start} : \max(\text{cow.start}, \text{PreCov end})$

$$\text{left overlap} = 1$$

Right overlap =  $\boxed{i > n-1}$ ?  $\text{cow.end} : \min(\text{cow.end}, \text{nextCov start})$   
 $= \min(4, 3)$   
→ 3

Alone time = Right overlap - left overlap.

$$= 3 - 1$$

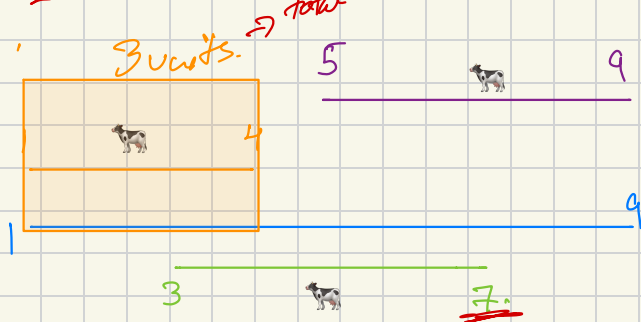
Alone time = 2 units  $\rightarrow$  1st life guard  $\rightarrow$  2 units  
3 units

total time covered  $\neq$  time covered. ;

min Alone time = min (min alone time, alone time) ;

Pre end = max (Pre end, Guard end) ;

1st life guard ! -  
 2 units  $\rightarrow$  unique time



(7 - max (Pre end, Guard start))

7 - max (4, 3)

7 - 4  $\Rightarrow$  3

2<sup>nd</sup> Cow lifeguard :-  $\text{PreCend} = 4$   
 time Covered by 2<sup>nd</sup> Cow = ? ✓  
 alone time Covered by Cow = ? ✓.

$$\begin{aligned} \text{time Covered} &= \max(0, \text{cow.endtime} - \max(\text{cow.starttime}, \\ &= \max(0, 7 - \max(3, 4)) \quad \text{PreCow end time}) \\ &= \max(0, 7 - 4) \end{aligned}$$

$$\boxed{\text{total covered by 2<sup>nd</sup>} = \underline{3}}$$

Alone time = ?  $\rightarrow$  Check left and Right overlap @ not

$$\begin{aligned} \text{left overlap} &= i < 0 ? \text{ cow.start} : \max(\text{cow.start}, \text{PreCow.end}) \\ &= \max(4, 3) \\ &= 4 \end{aligned}$$

$$\begin{aligned} \text{Right overlap} &= \underline{i \geq n-1} ? \text{ cow.end} : \min(\text{cow.end}, \text{nextCow.start}) \\ &= \min(7, 5) \\ &= 5 \end{aligned}$$

Alone time = Right overlap - left overlap.

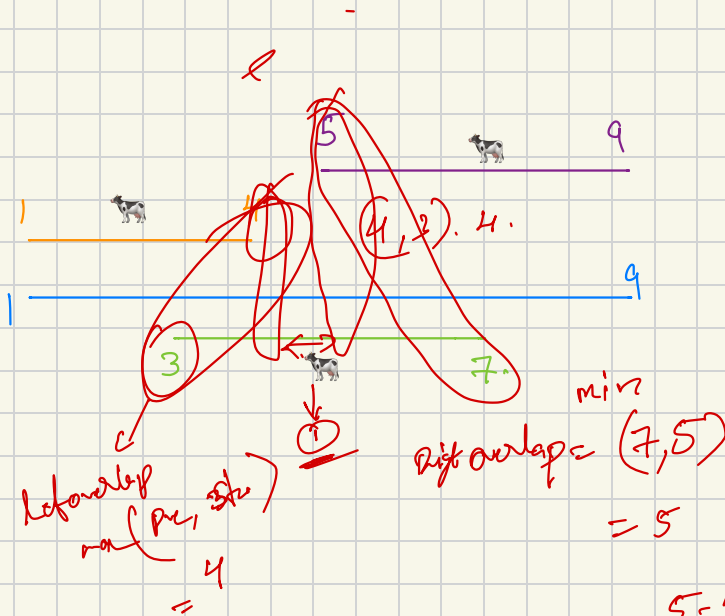
$$= 5 - 4$$

Alone time  $\Rightarrow$  1 unit

total time covered  $\neq$  time covered.  $\Rightarrow 3 + 3 \Rightarrow$  6 total time

min Alone time  $= \min(\min(\text{alone time}, \text{alone time})) \Rightarrow$  1

Pre end =  $\max(\text{Pre end}, \text{Cur end}) \Rightarrow$  7



3<sup>rd</sup> Cow lifeguard :- PreCend =  
 time Covered by 3<sup>rd</sup> Cow = ?  
 alone time Covered by Cow = ?

$$\begin{aligned}
 \text{time Covered} &= \max(0, \text{cow.endtime} - \max(\text{cow.starttime}, \\
 &\quad \text{PreCow.endtime})) \\
 &= \max(0, 9 - \max(5, 7)) \\
 &= \max(0, 9 - 7) \\
 &\Rightarrow 2
 \end{aligned}$$

Alone time = ?  $\rightarrow$  Check left and Right overlap @ not

$$\begin{aligned}
 \text{left overlap} &= \text{if } i < 0 ? \text{ cow.start} : \max(\text{cow.start}, \text{PreCow.end}) \\
 &= \max(5, 7) \Rightarrow 7
 \end{aligned}$$

$$\begin{aligned}
 \text{Right overlap} &= \text{if } i > n-1 ? \text{ cow.end} : \min(\text{cow.end}, \text{nextCow.start}) \\
 &= 9.
 \end{aligned}$$

Alone time = Right overlap - left overlap.

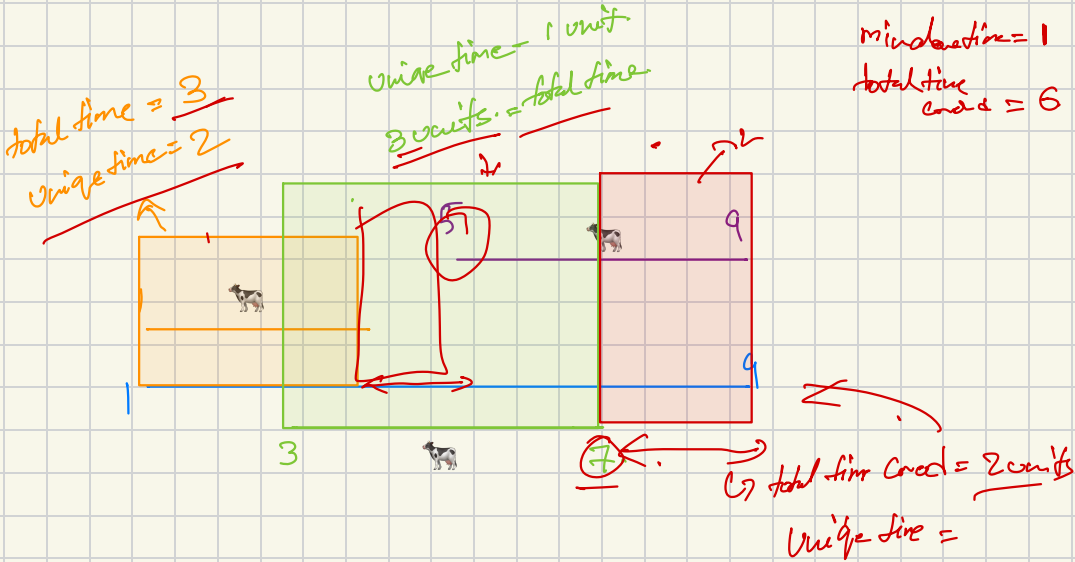
$$= 9 - 7$$

Alone time  $\Rightarrow$  2 units

total time covered  $\neq$  time covered.  $\therefore \rightarrow$

min Alone time  $= \min(\text{min alone time}, \text{alone time}) ;$

Pre end  $= \max(\text{Pre end}, \text{Goes end}) ;$



Final output :-

$3 + 2 + 2 \Rightarrow \underline{8 \text{ units}} \rightarrow \text{total time covered.}$

1st life = 2

2nd life = 1

3rd life = 2

min alone = 1.

$$= 8 - 1$$

$$\Rightarrow 7 \dots N$$

fine complexity  $\rightarrow O(n) + O(n \log n)$

$$O(n \log n) \checkmark$$

$r$

$$O(n^2) \Rightarrow O(n \log n)$$

Space  $O(n) \rightarrow \text{soln.}$