SORTING ALGORITHMS

PRESENTER: MUHAMMAD UMER

Sorting algorithm is an algorithm that puts elements of a list/array in a certain order.

INPUT:

A sequence of n numbers $a_1, a_2, \ldots, a_n$

OUTPUT:

A permutation (reordering) $a_1', a_2', \ldots, a_n'$ of the input sequence such that $a_1' \leq a_2' \leq \cdots \leq a_n'$

BUBBLE SORT

PRESENTER: MUHAMMAD UMER

Bubble Sort : Idea

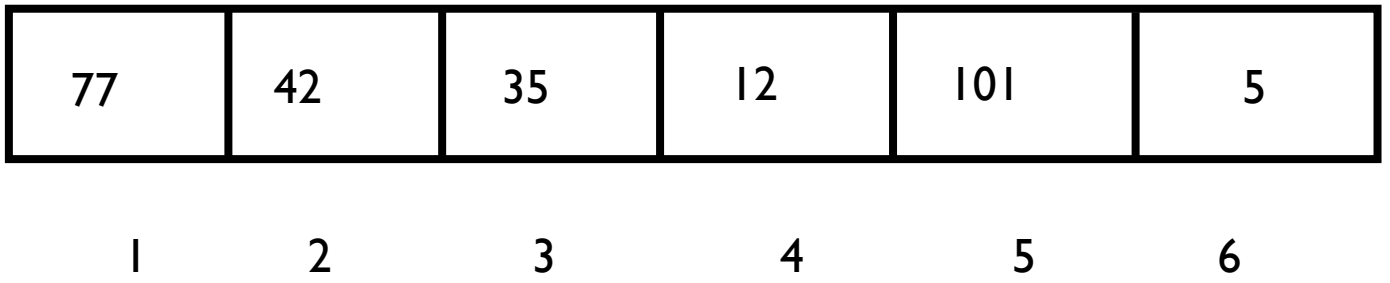
Idea : Bubbles in water

- Bubbles in water move upwards and when bubble moves upward the water from above will move downward to fill in the space left by the bubble

"BUBBLING UP" THE LARGEST ELEMENT

Traverse a collection of elements

- **Move from the front to the end**
- **"Bubble" the largest value to the end using pair-wise comparisons and swapping**



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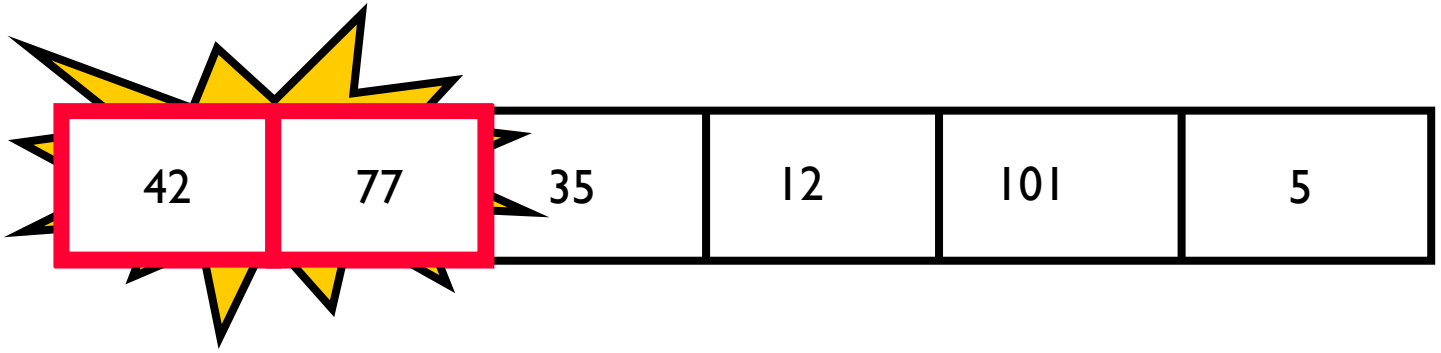

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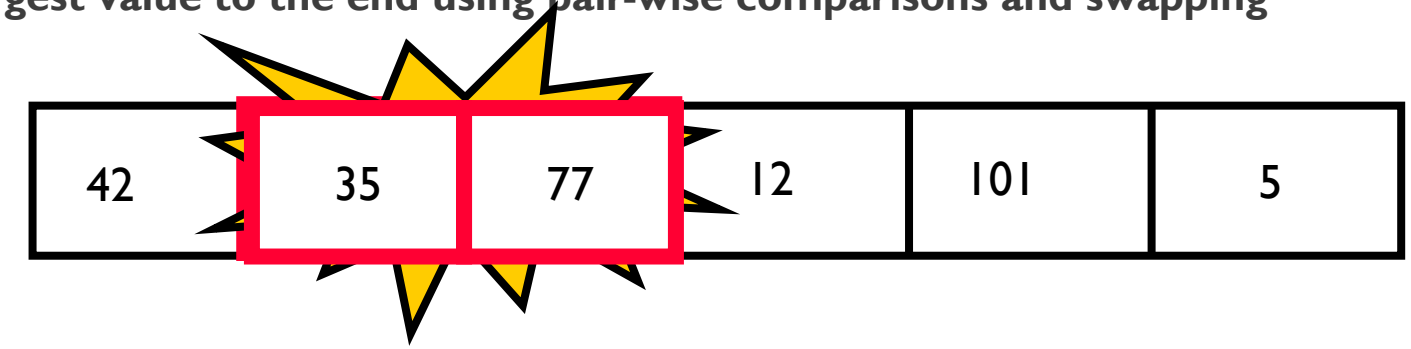

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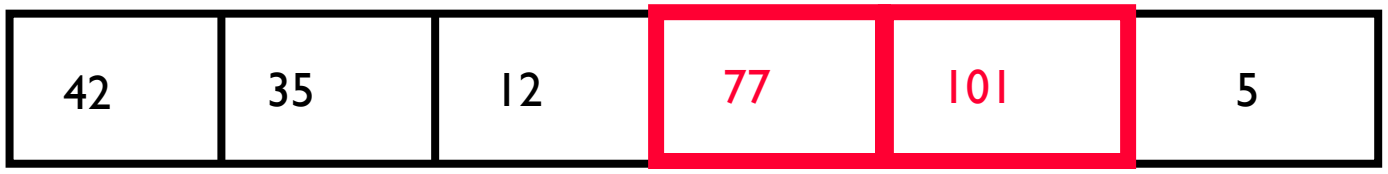

No need to swap

"BUBBLING UP" THE LARGEST ELEMENT

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  - **Move from the front to the end**
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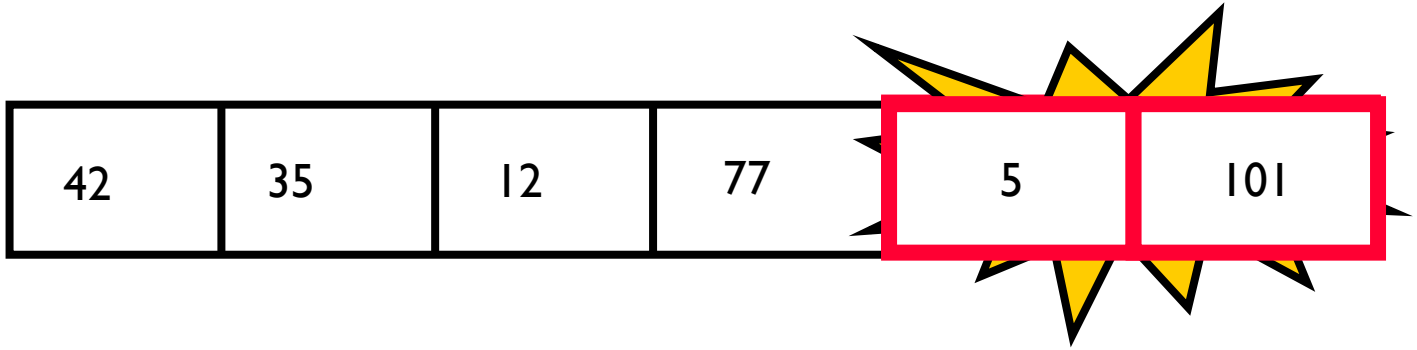

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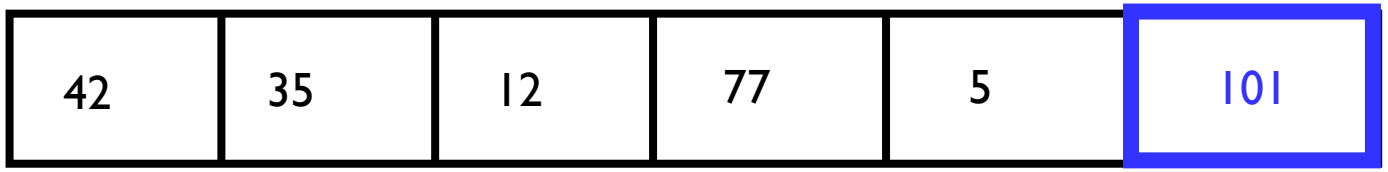
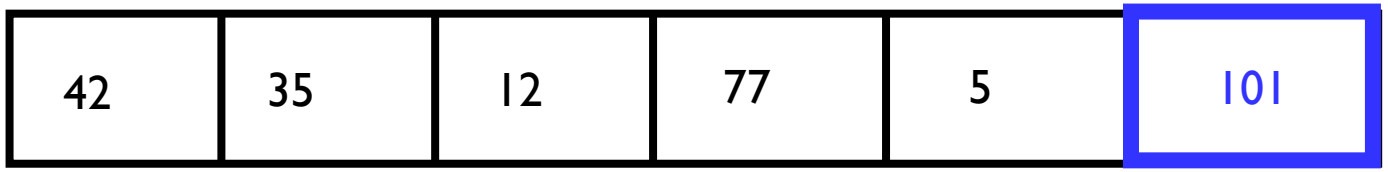


Largest value correctly placed

ITEMS OF INTEREST

- **Notice that only the largest value is correctly placed**
- **All other values are still out of order**
- **So we need to repeat this process**



Largest value correctly placed

REPEAT "BUBBLE UP" HOW MANY TIMES?

N - 1

42	35	12	77	5	101
35	12	42	5	77	101
12	35	5	42	77	101
12	5	35	42	77	101
5	12	35	42	77	101

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REPEAT "BUBBLE UP" HOW MANY TIMES?

- If we have N elements…
- And if each time we bubble an element, we place it in its correct location…
- Then we repeat the "bubble up" process N – 1 times.
- This guarantees we'll correctly place all N elements.

BUBBLE SORT – PSEUDO CODE


```
A = [x1 , x2 , x3 , …. ]

for i = 1 to A.length – 1
    for j = 1 to A.length-i
        if A[j]>A[j+1]
            swap A[j] with A[j+1]
```

YOUR TASK !!!

- Implement Bubble Sort Algorithm for sorting the list in descending order.
- Is there any way that we can make our Bubble Sort Algorithm more time efficient ? Think about it …

IMPROVED BUBBLE SORT

PRESENTER: MUHAMMAD UMER

First of all lets see what improvements we can do in our previously build bubble sort Algorithm

ALREADY SORTED COLLECTIONS?

- **What if the collection was already sorted?**
- **What if only a few elements were out of place and after a couple of "bubble ups," the collection was sorted?**

- **We want to be able to detect this and "stop early"!**

5	12	35	42	77	101

USING A BOOLEAN "FLAG"

- We can use a boolean variable to determine if any swapping occurred during the "bubble up."
- If no swapping occurred, then we know that the collection is already sorted!
- This boolean "flag" needs to be reset after each "bubble up."

AN ANIMATED EXAMPLE

N	8
to_do	7
index	

did_swap	

98	23	45	14	6	67	33	42
1	2	3	4	5	6	7	8

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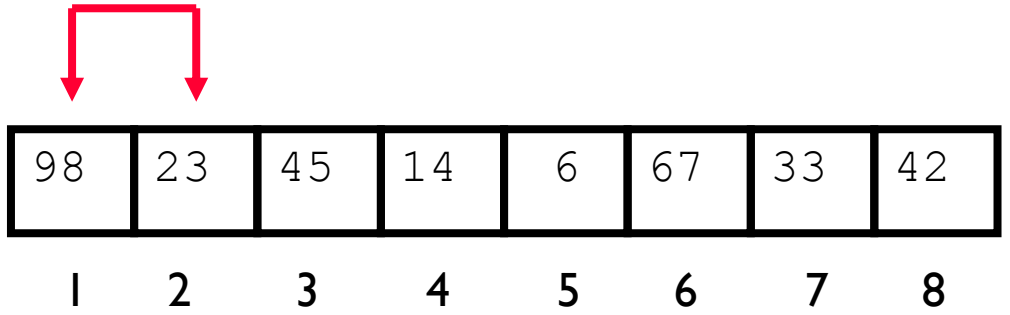
AN ANIMATED EXAMPLE

N	8
to_do	7
index	1

did_swap	false



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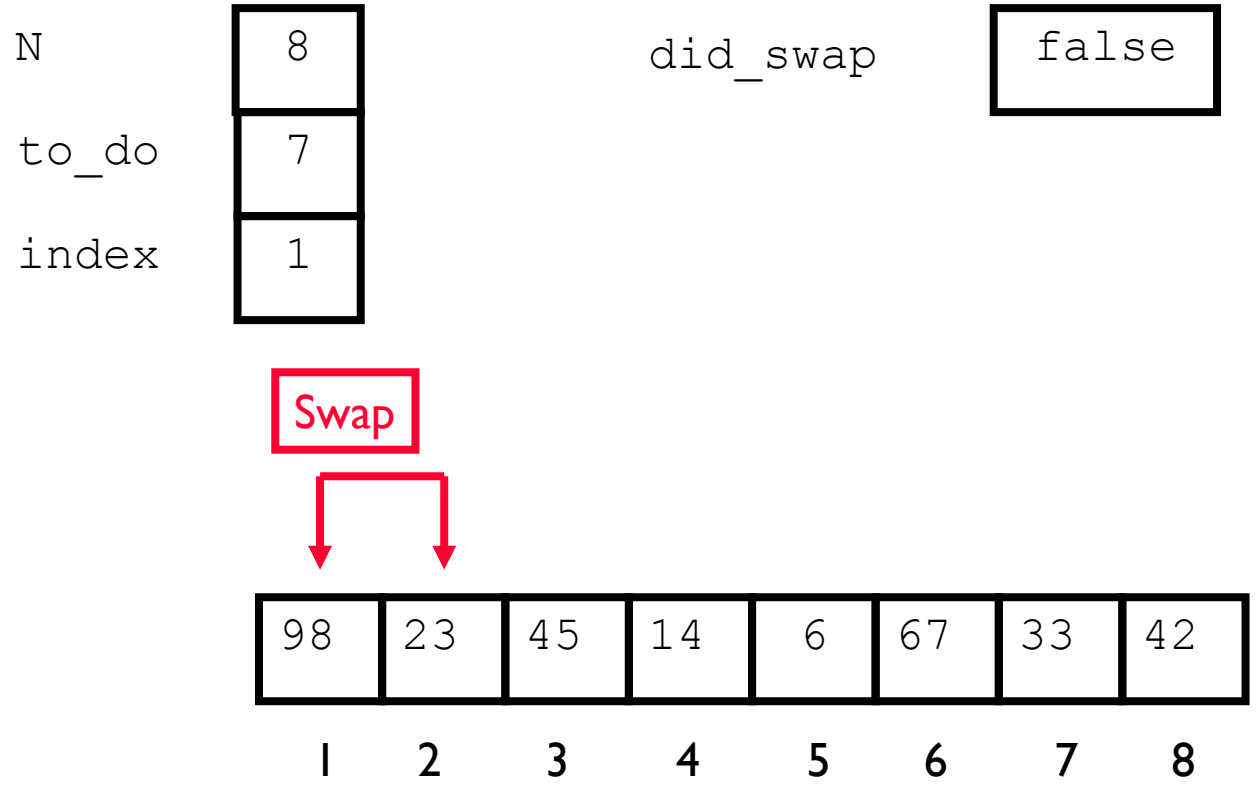
AN ANIMATED EXAMPLE



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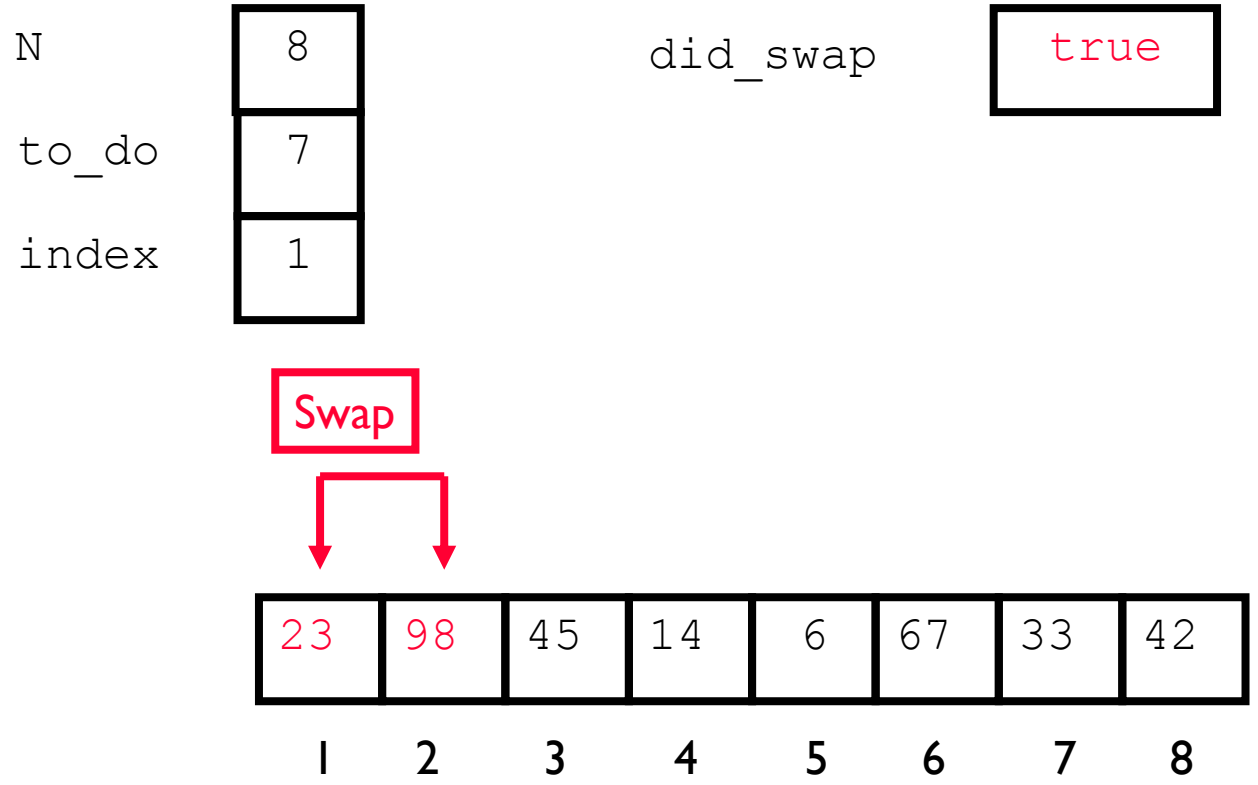

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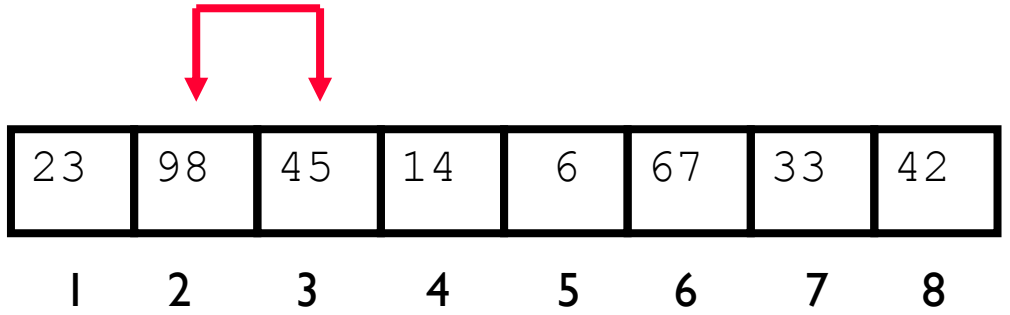
AN ANIMATED EXAMPLE

N	8
to_do	7
index	2

did_swap	true



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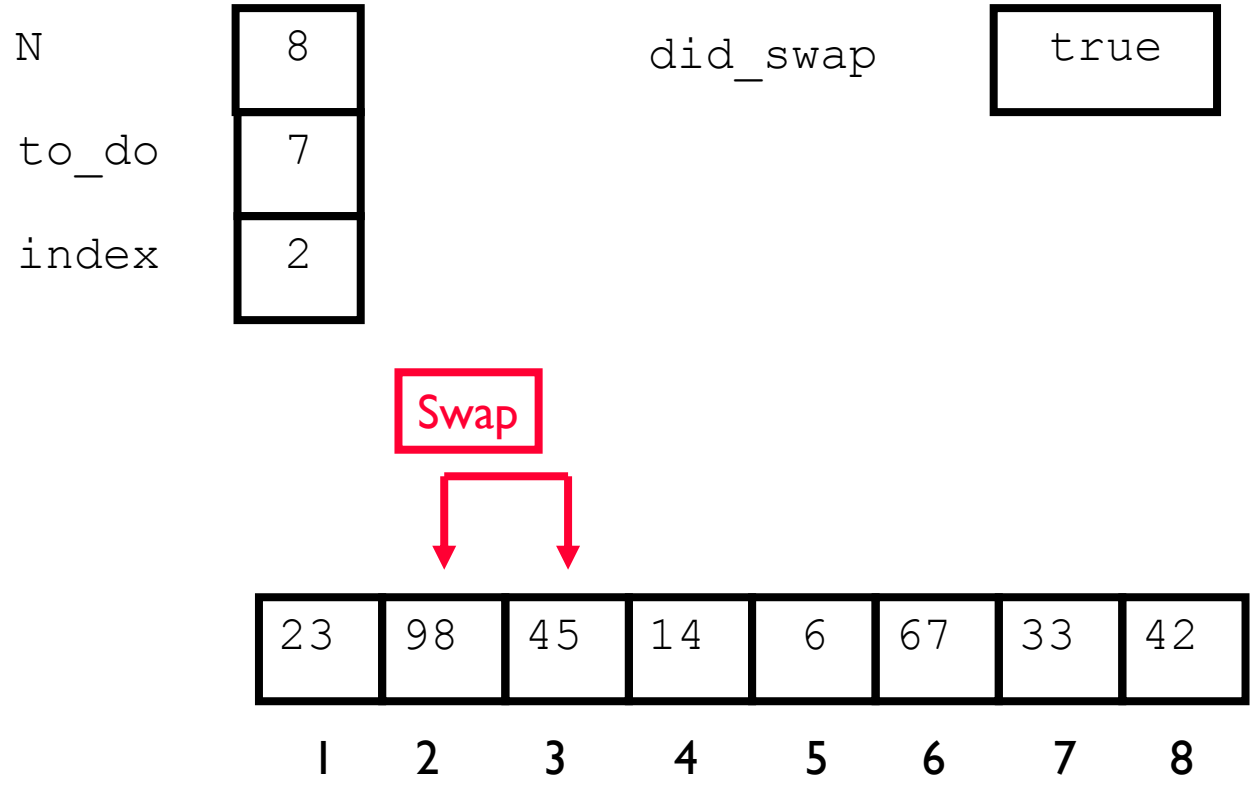

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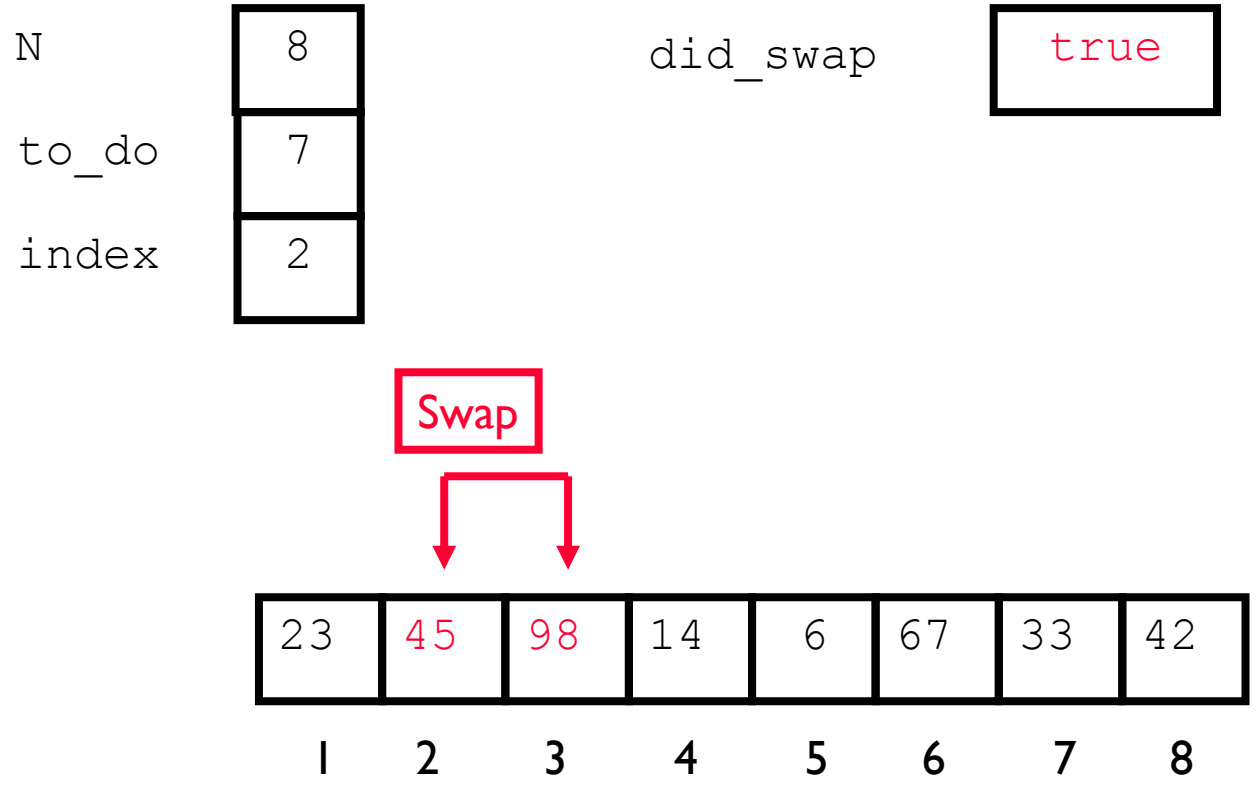

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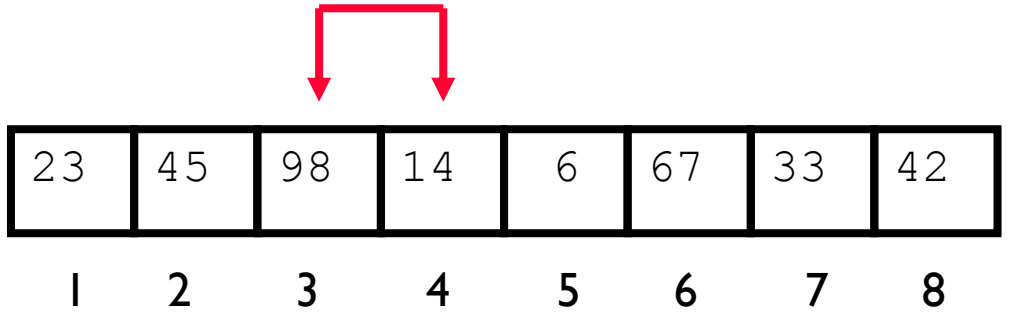
AN ANIMATED EXAMPLE

N	8
to_do	7
index	3

did_swap	true



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AN ANIMATED EXAMPLE

N	8
to_do	7
index	3

did_swap	true

Swap

23	45	98	14	6	67	33	42
1	2	3	4	5	6	7	8

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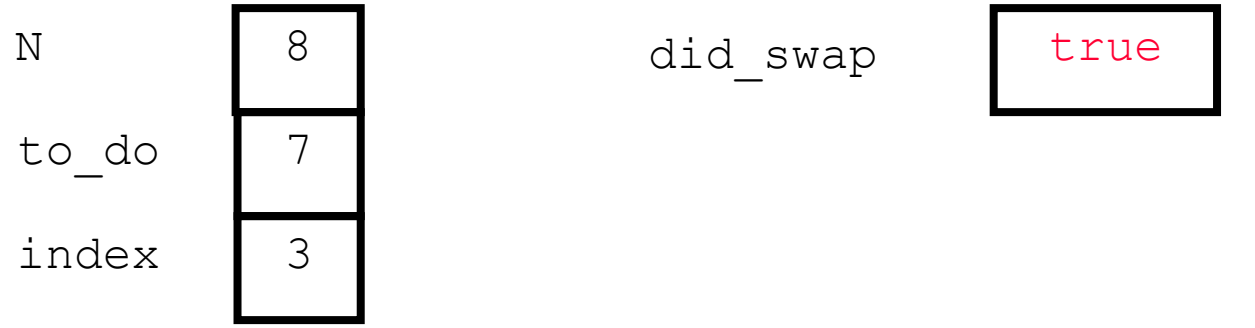
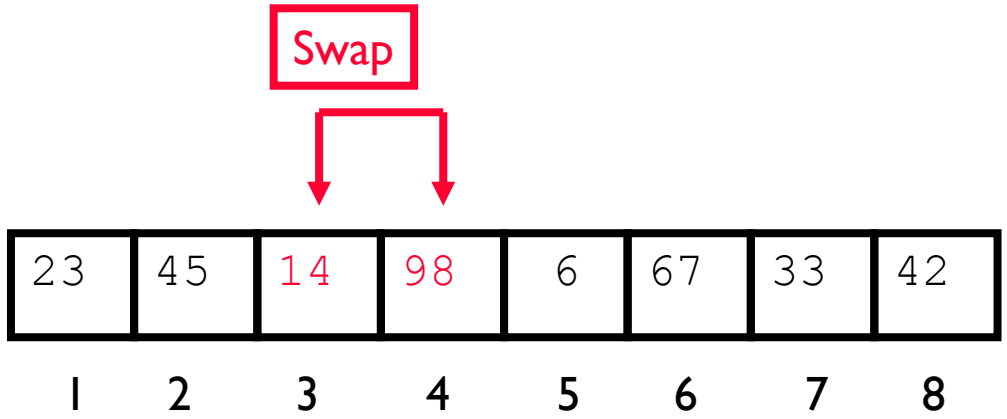
AN ANIMATED EXAMPLE





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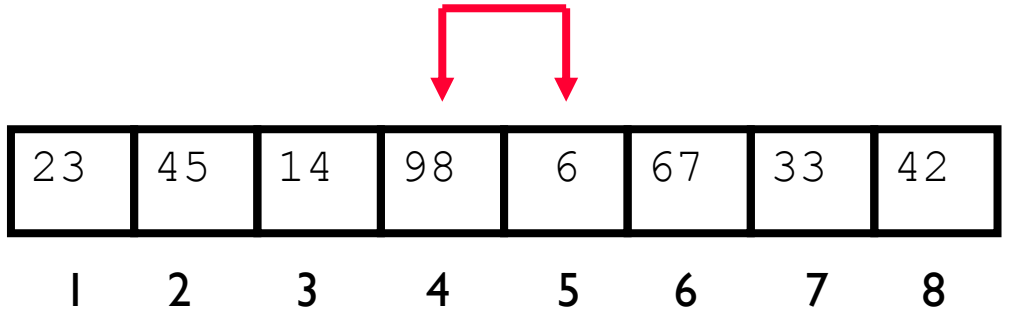
AN ANIMATED EXAMPLE

N	8
to_do	7
index	4

did_swap	true



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AN ANIMATED EXAMPLE

N	8
to_do	7
index	4

did_swap	true

Swap

23	45	14	98	6	67	33	42
1	2	3	4	5	6	7	8

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AN ANIMATED EXAMPLE

N	8
to_do	7
index	4

did_swap	true

Swap

23	45	14	6	98	67	33	42
1	2	3	4	5	6	7	8

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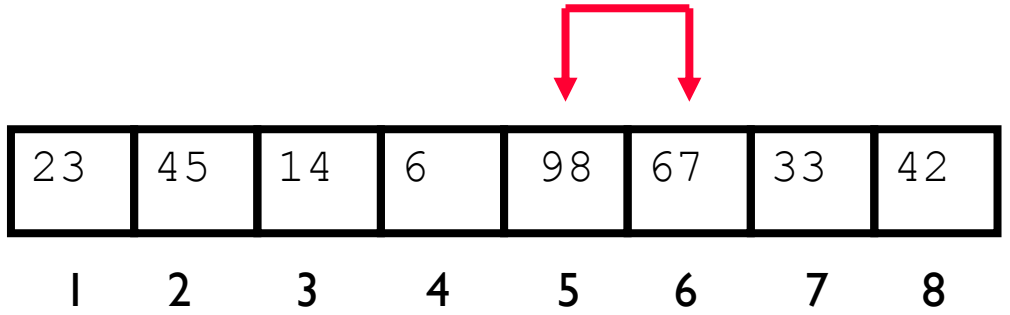
AN ANIMATED EXAMPLE

N	8
to_do	7
index	5

did_swap	true



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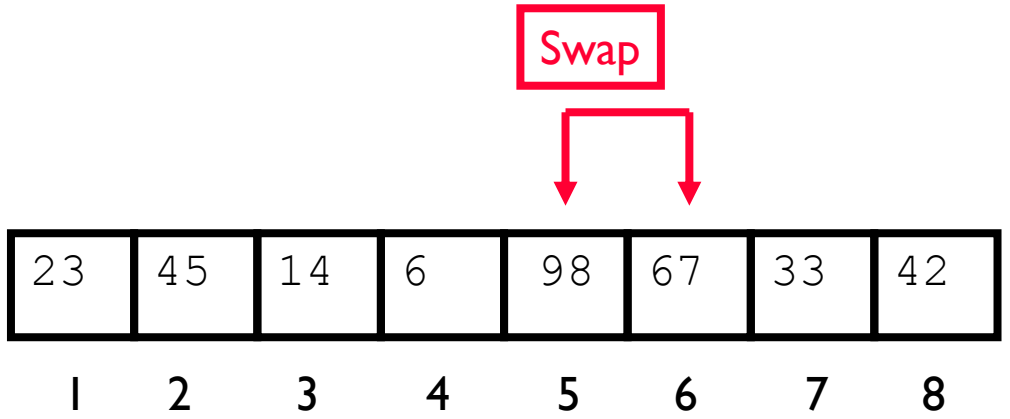
AN ANIMATED EXAMPLE

N	8
to_do	7
index	5

did_swap	true



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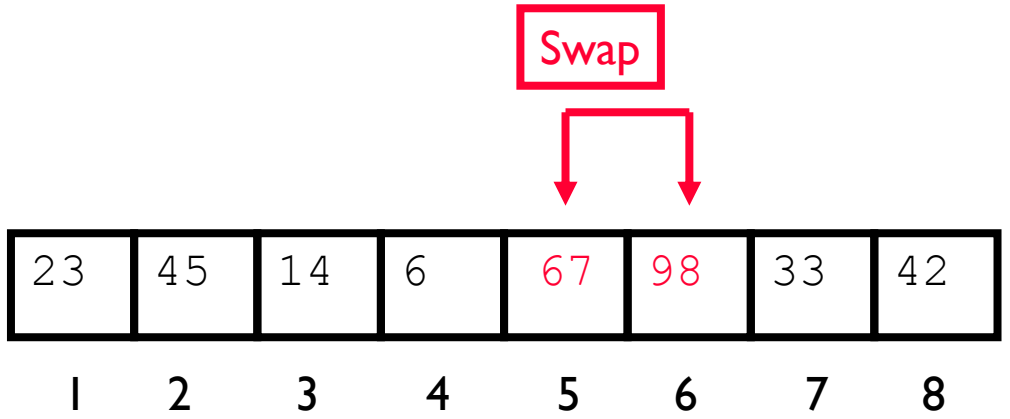
AN ANIMATED EXAMPLE

N	8
to_do	7
index	5

did_swap	true



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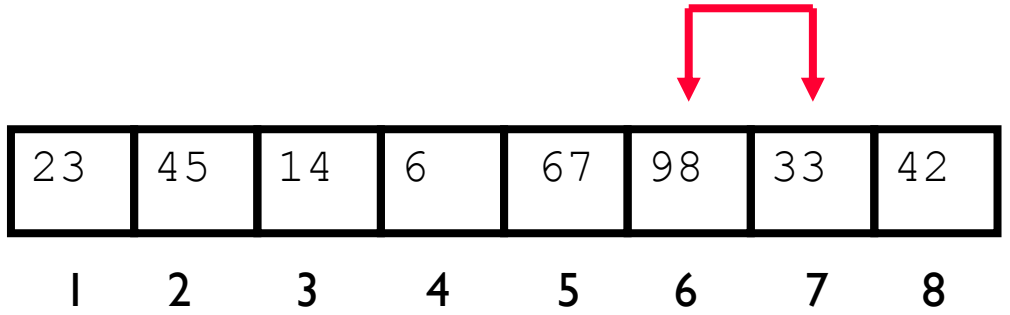
AN ANIMATED EXAMPLE

N	8
to_do	7
index	6

did_swap	true



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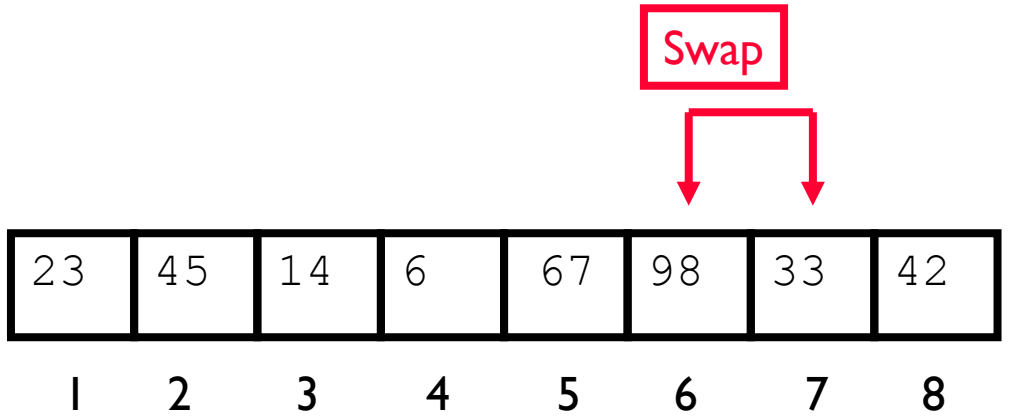
AN ANIMATED EXAMPLE

N	8
to_do	7
index	6

did_swap	true



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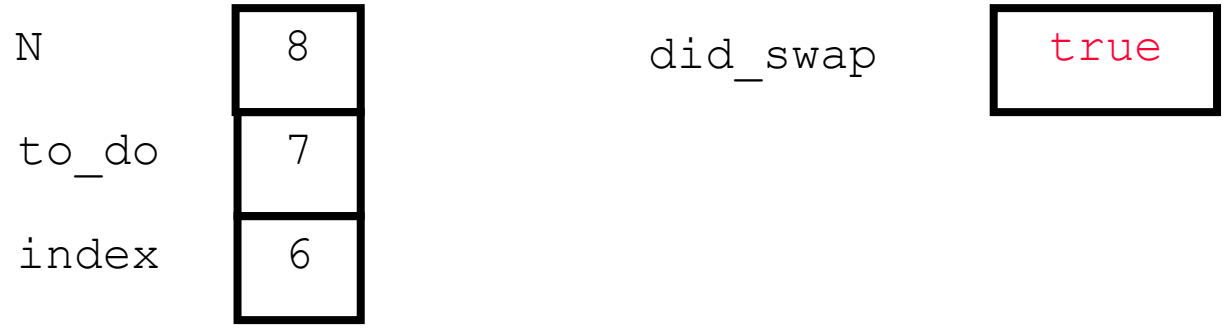

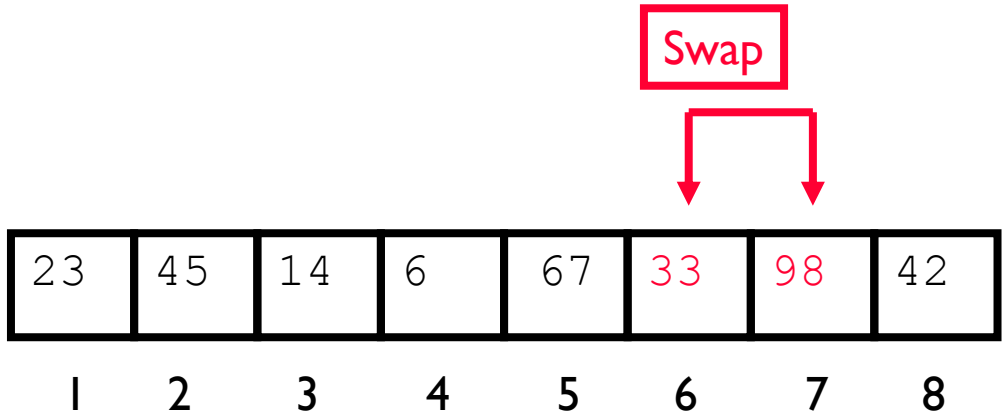

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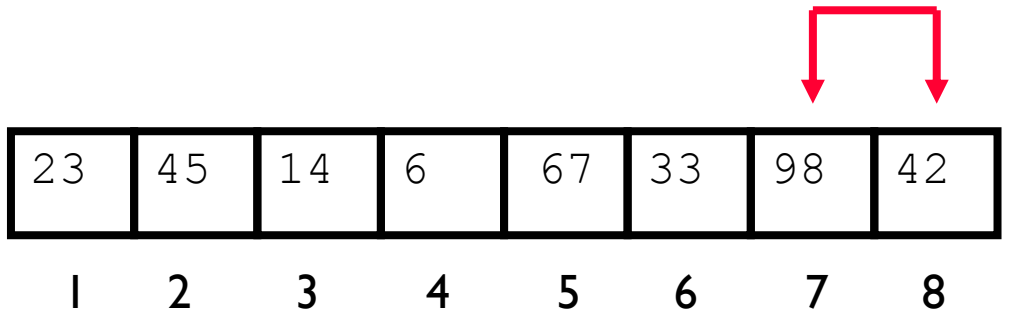
AN ANIMATED EXAMPLE

N	8
to_do	7
index	7

did_swap	true



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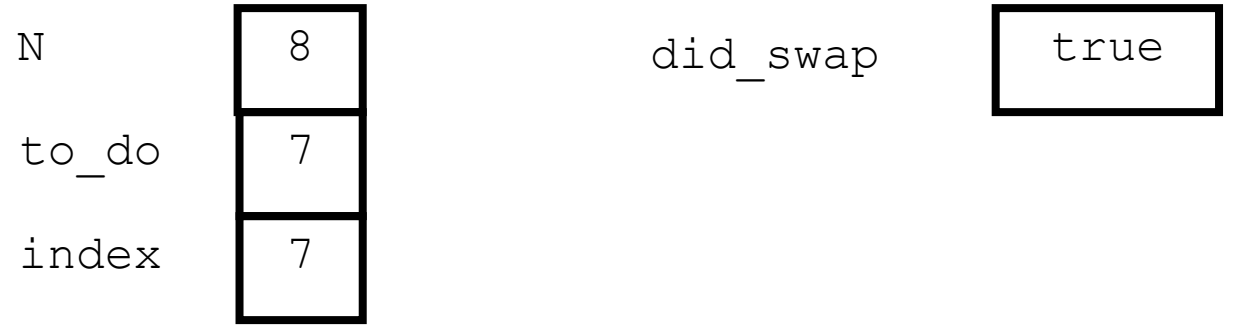

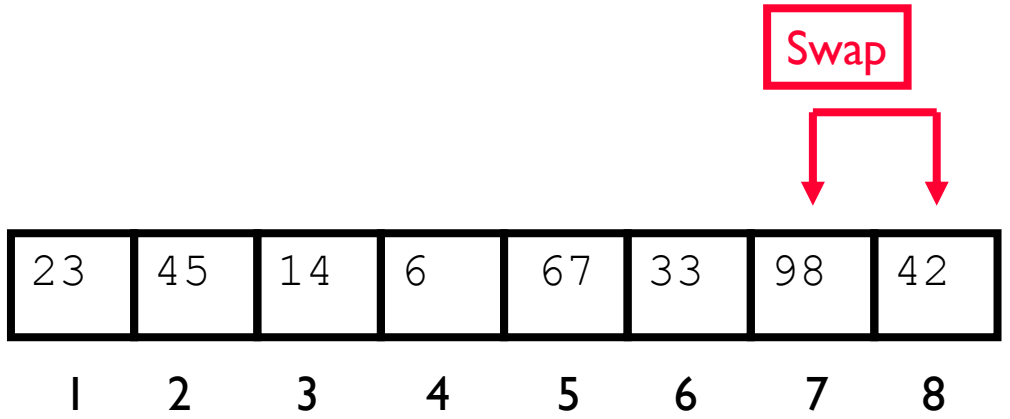

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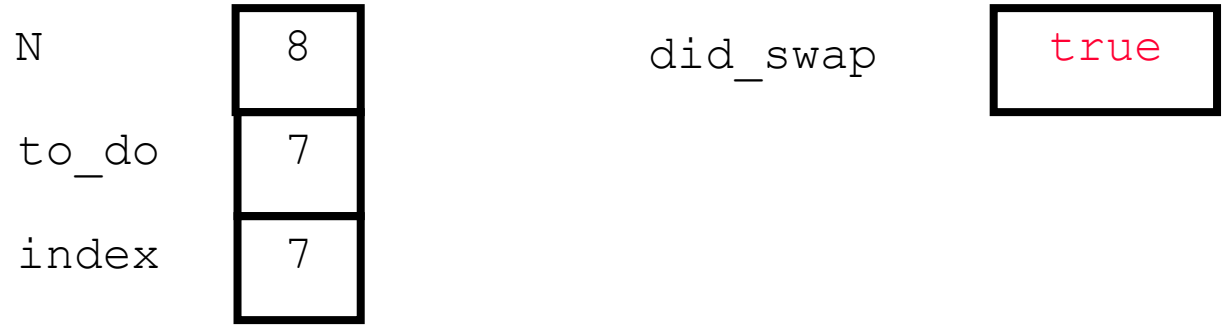

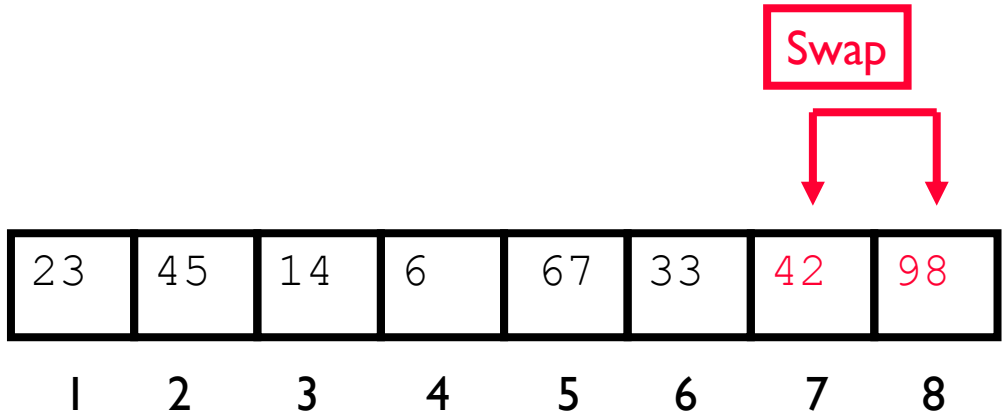

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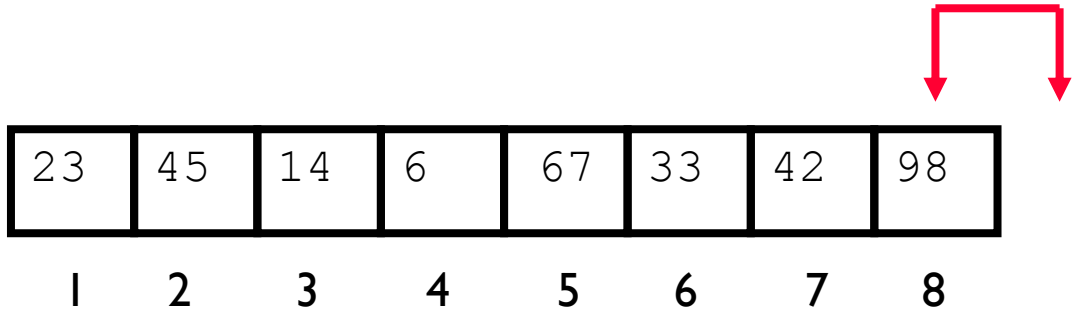
AFTER FIRST PASS OF OUTER LOOP

N	8
to_do	7
index	8

did_swap	true

Finished first "Bubble Up"



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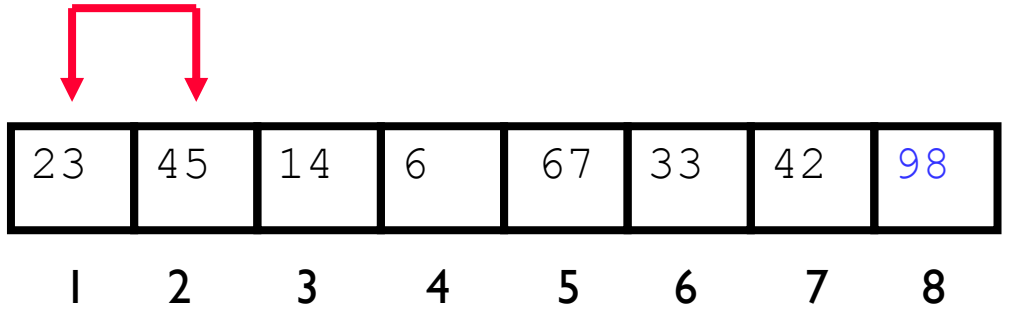
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	1

did_swap	false



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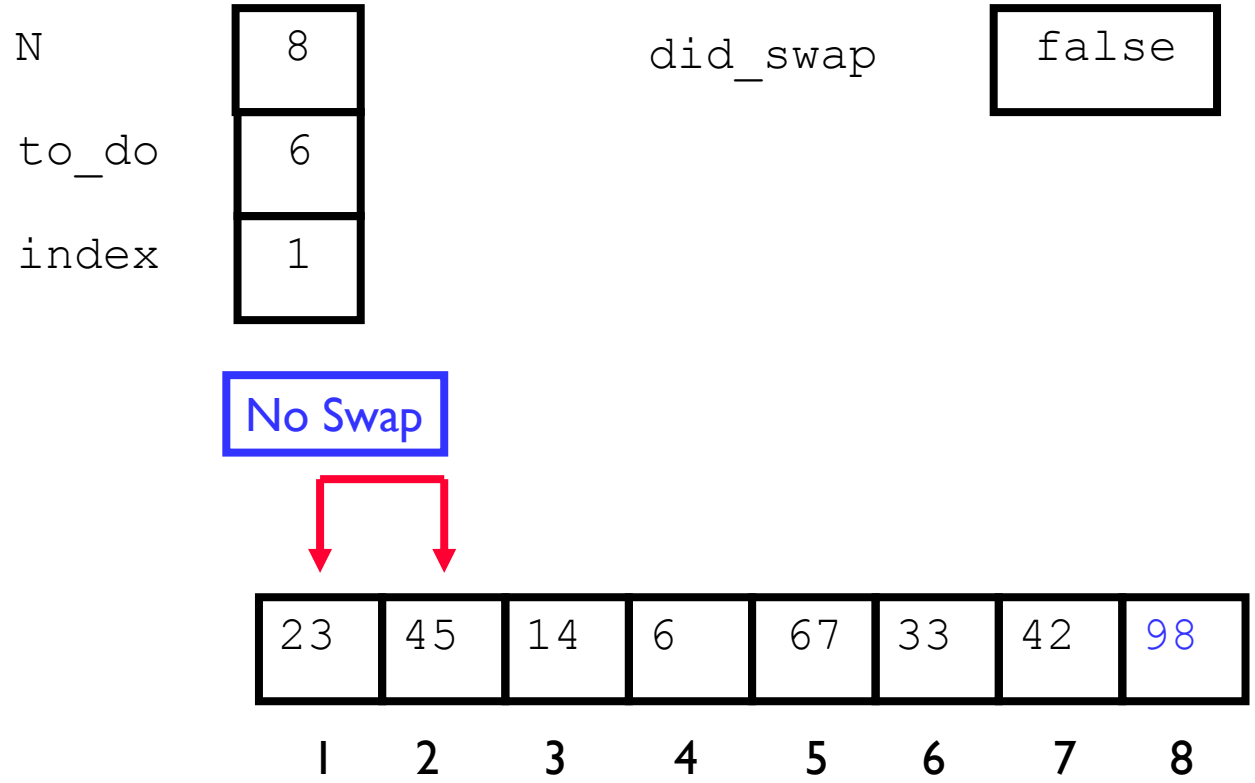
THE SECOND "BUBBLE UP"



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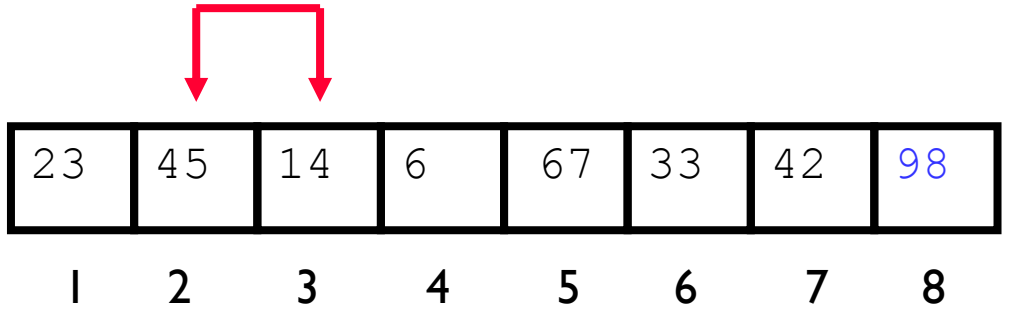
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	2

did_swap	false



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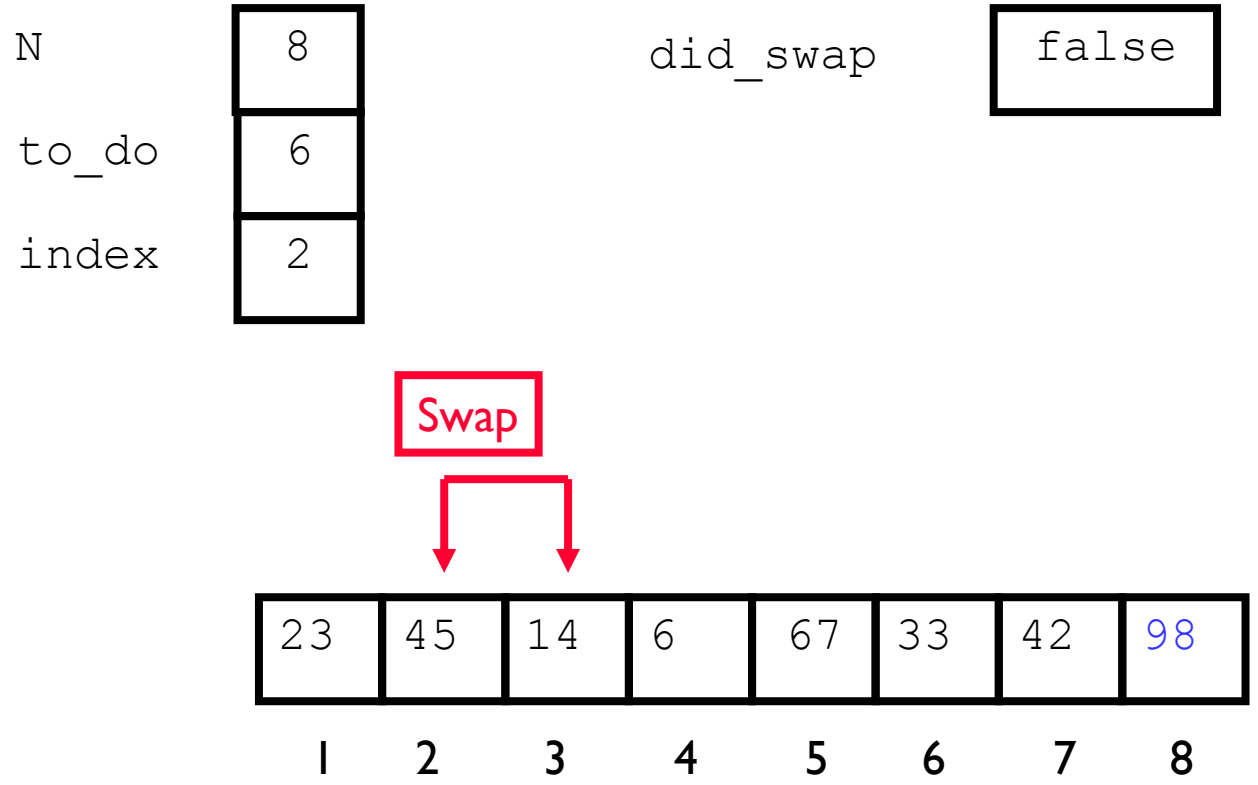

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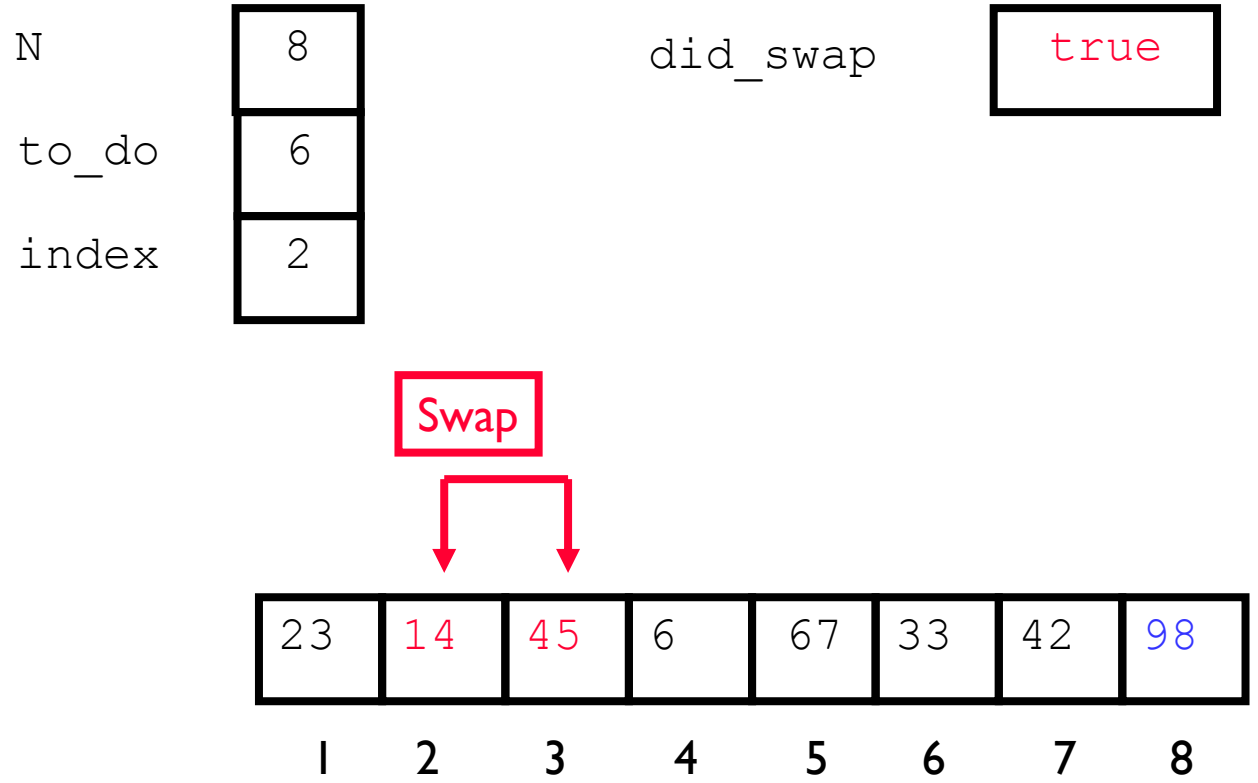

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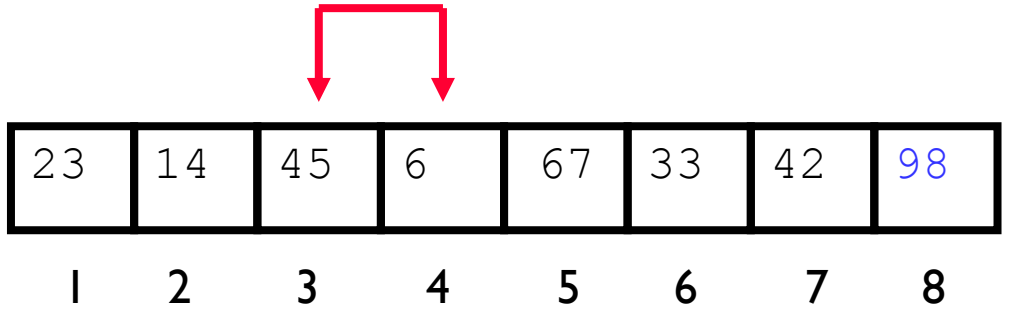
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	3

did_swap	true



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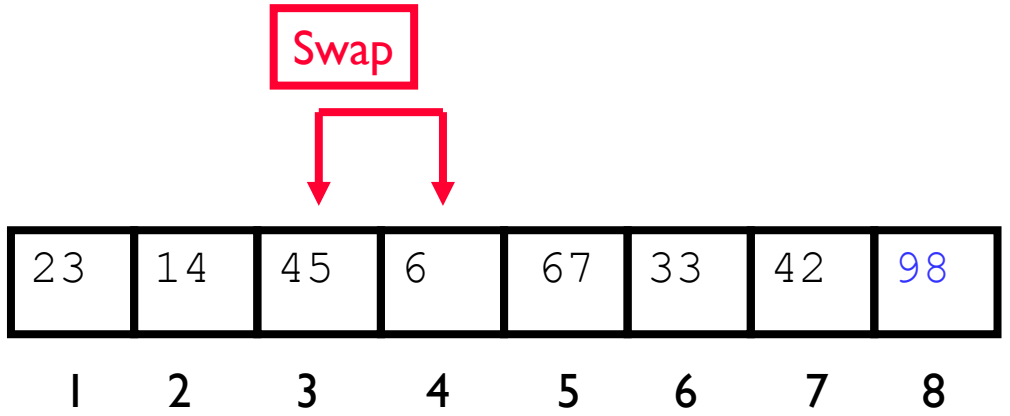
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	3

did_swap	true



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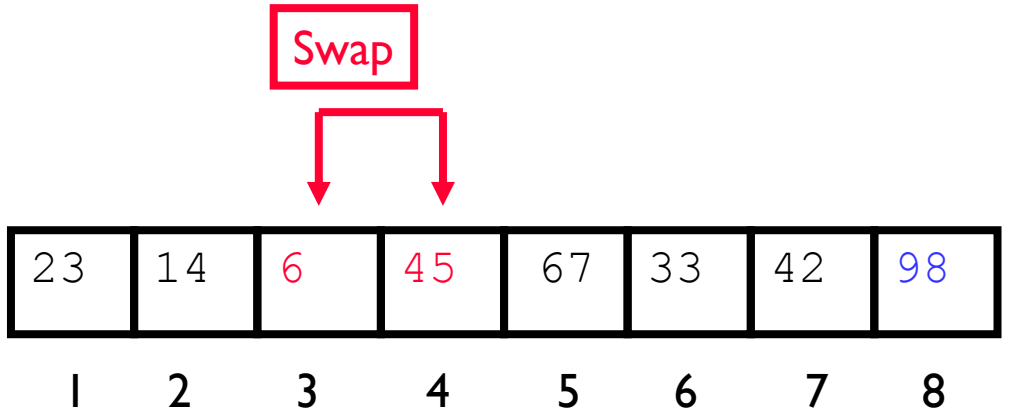
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	3

did_swap	true



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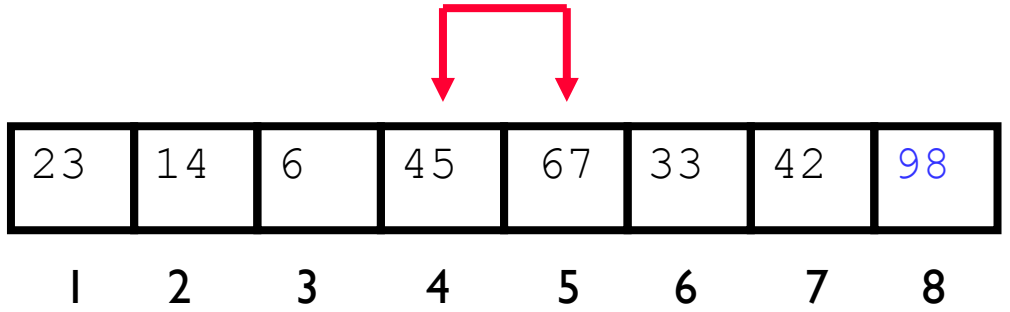
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	4

did_swap	true



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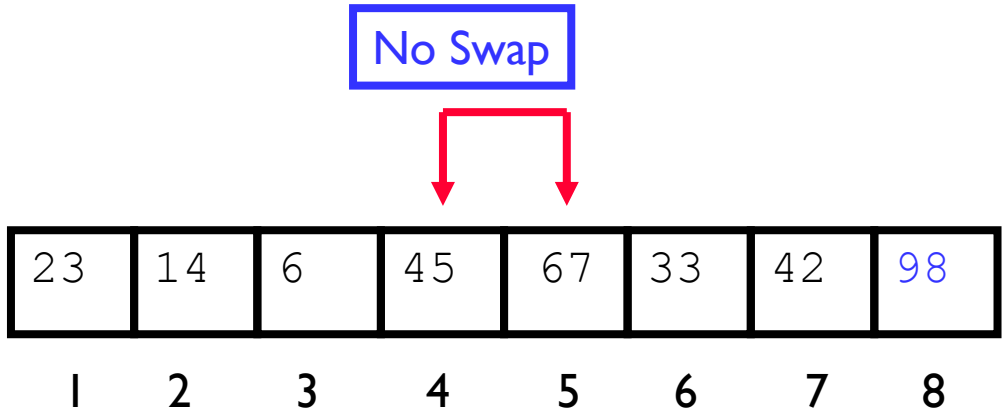
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	4

did_swap	true



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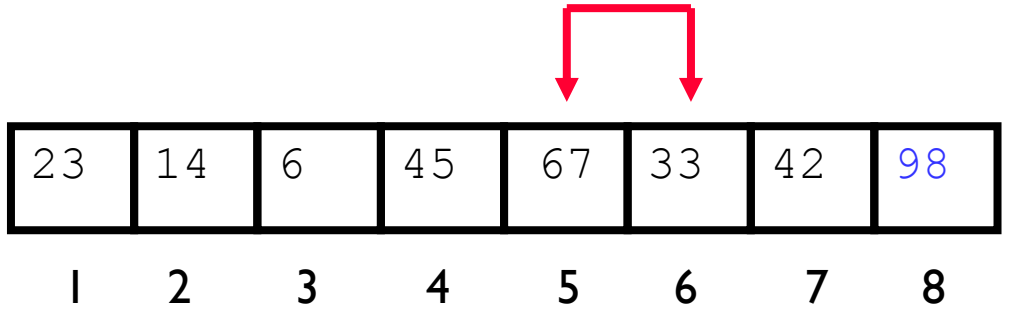
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	5

did_swap	true



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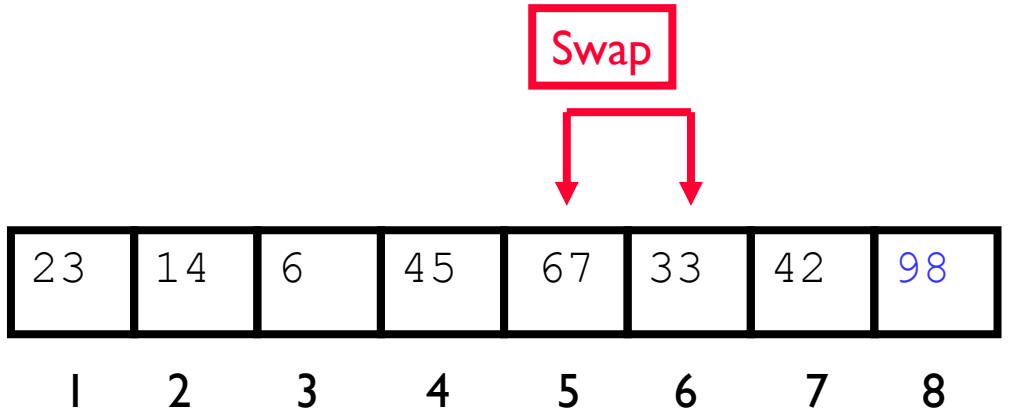
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	5

did_swap	true



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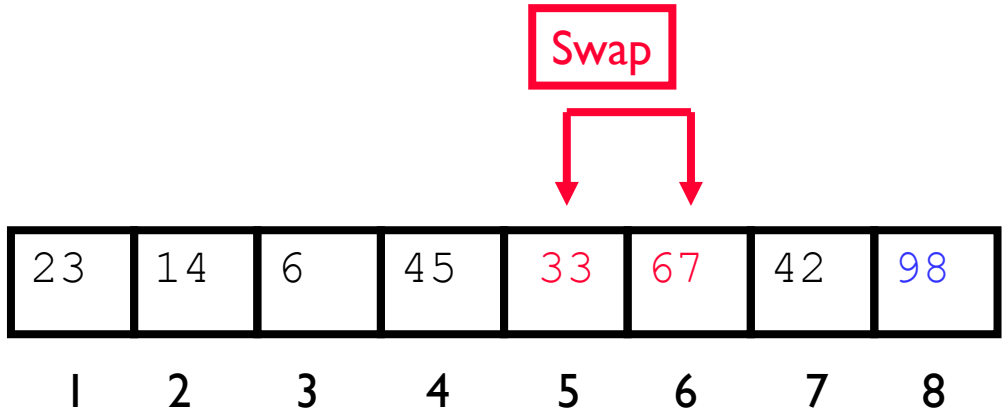
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	5

did_swap	true



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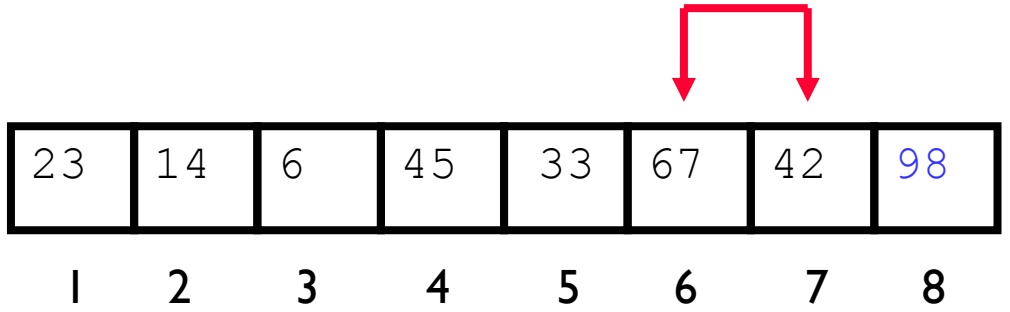
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	6

did_swap	true



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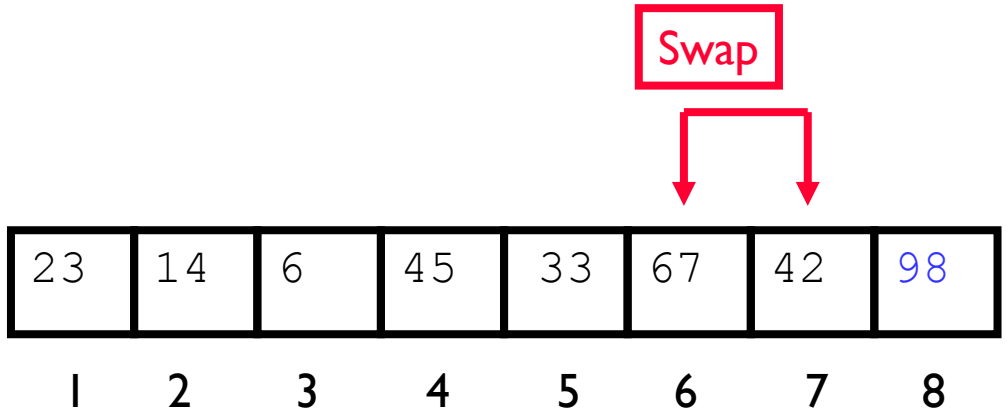
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	6

did_swap	true



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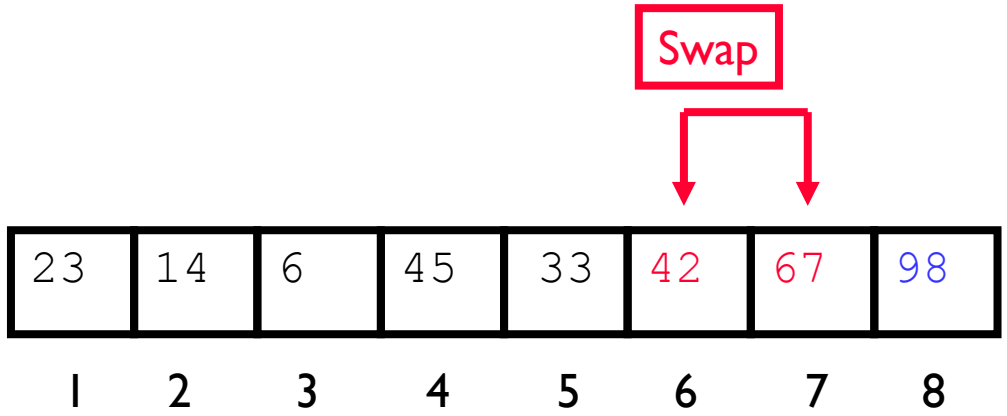
THE SECOND "BUBBLE UP"

N	8
to_do	6
index	6

did_swap	true



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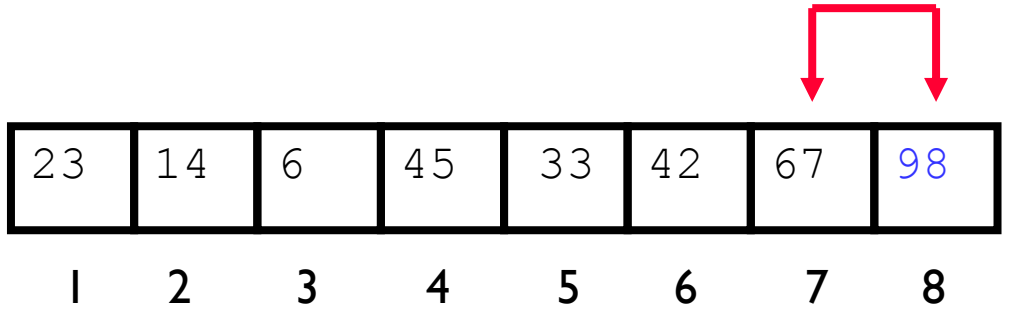
AFTER SECOND PASS OF OUTER LOOP

N	8
to_do	6
index	7

did_swap	true

Finished second "Bubble Up"



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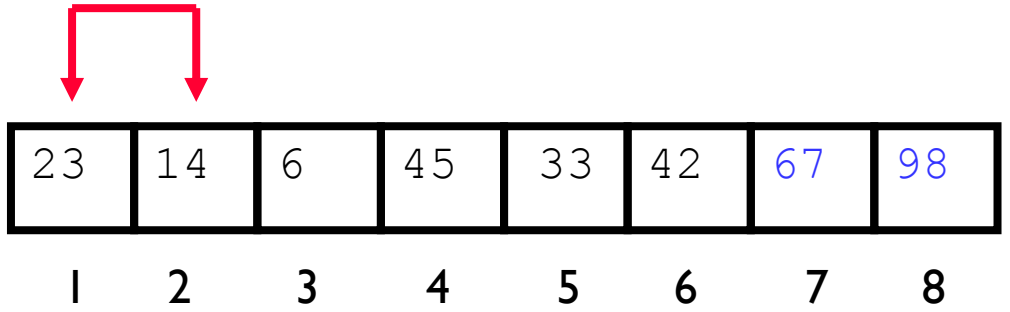
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	1

did_swap	false



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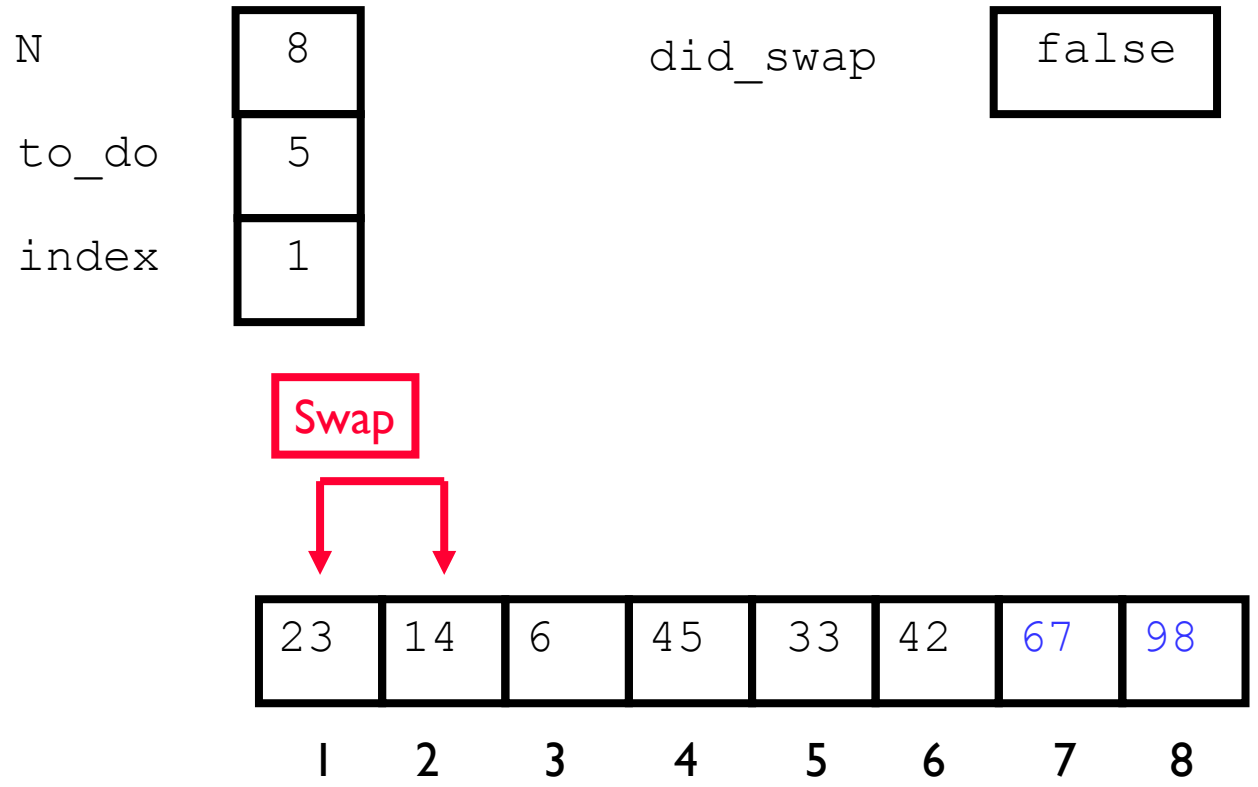

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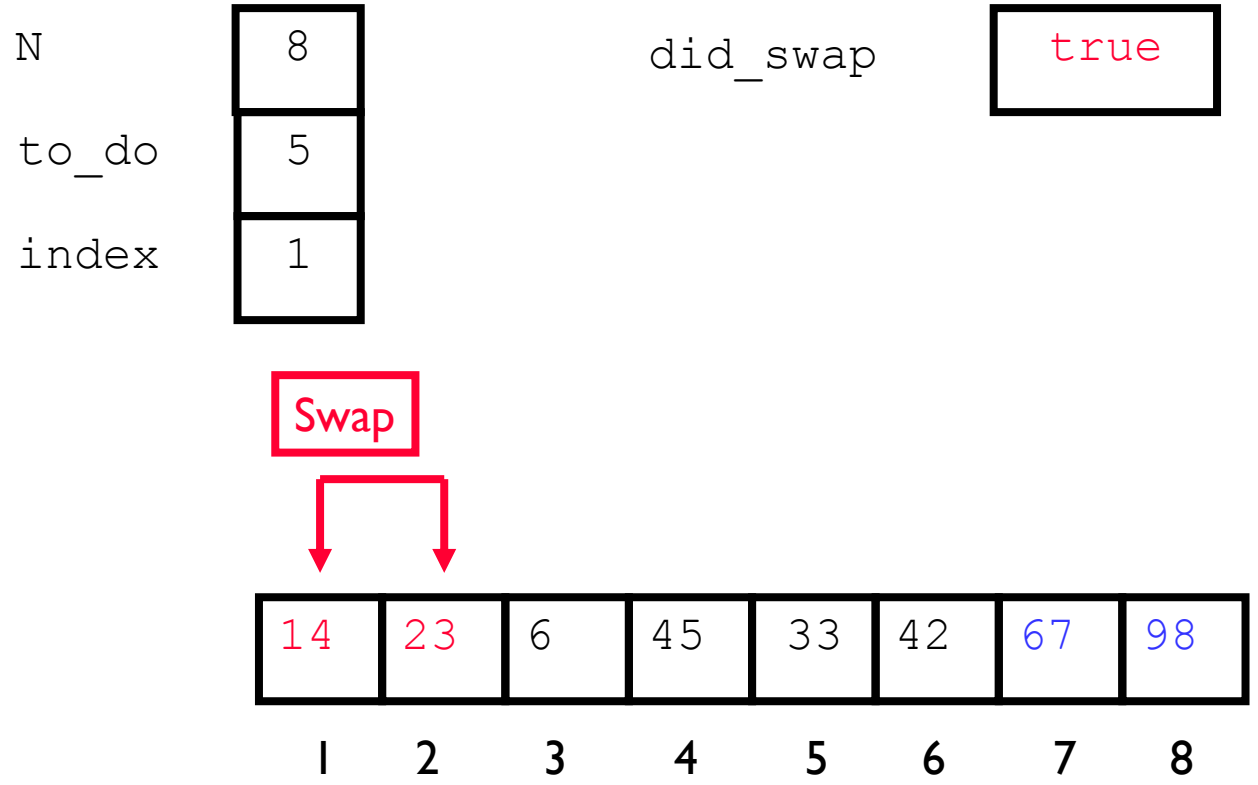

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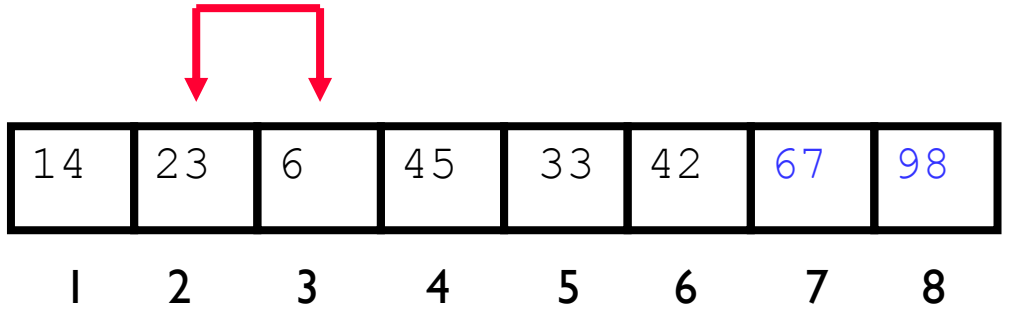
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	2

did_swap	true



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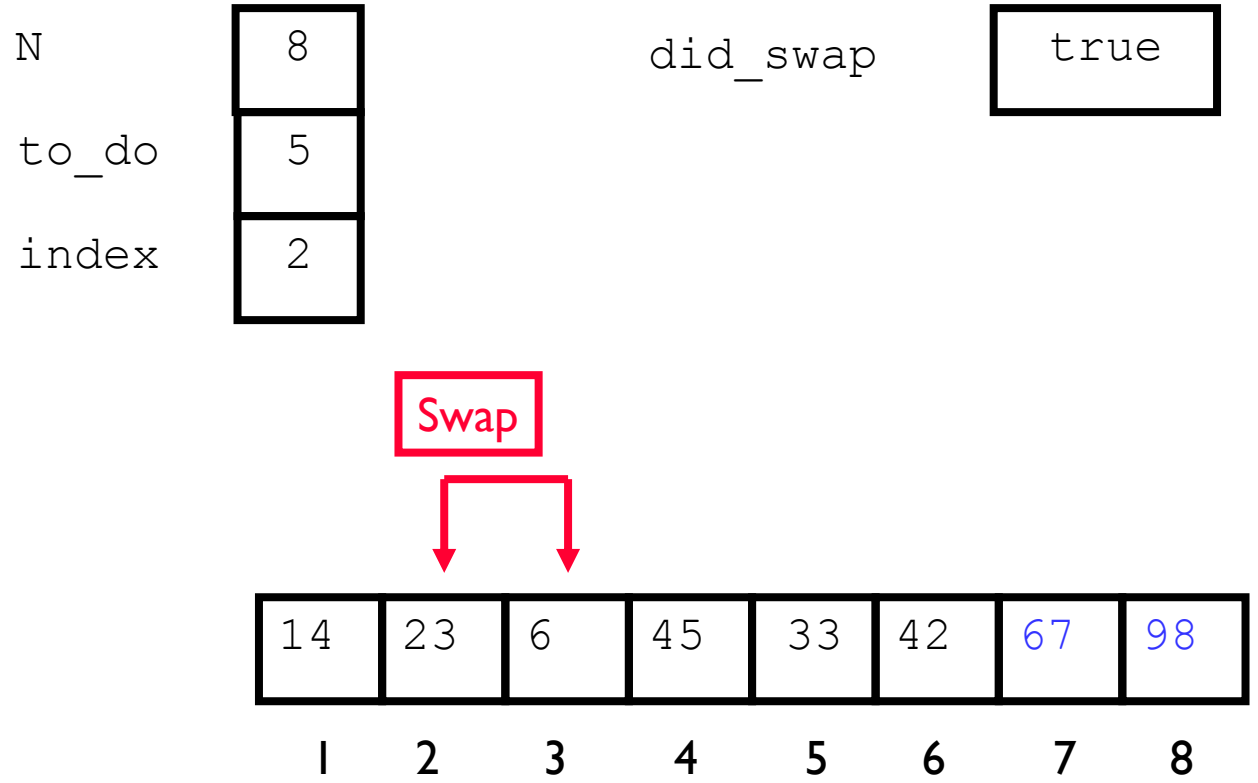

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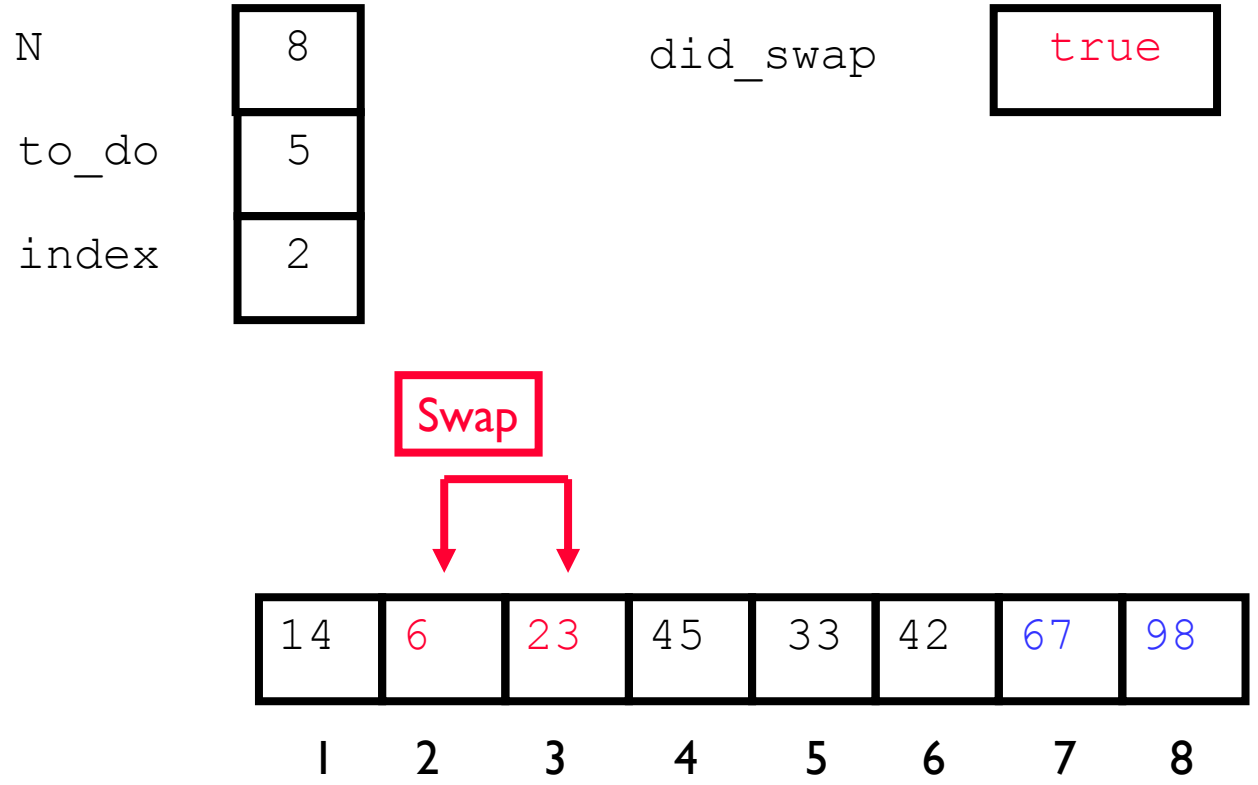

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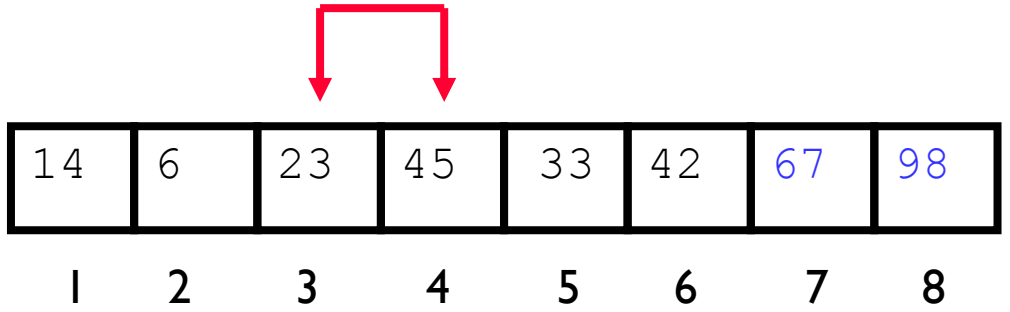
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	3

did_swap	true



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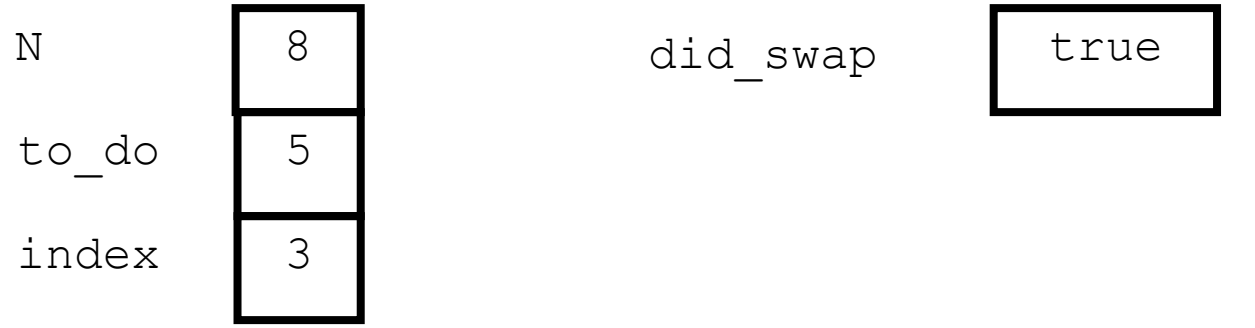

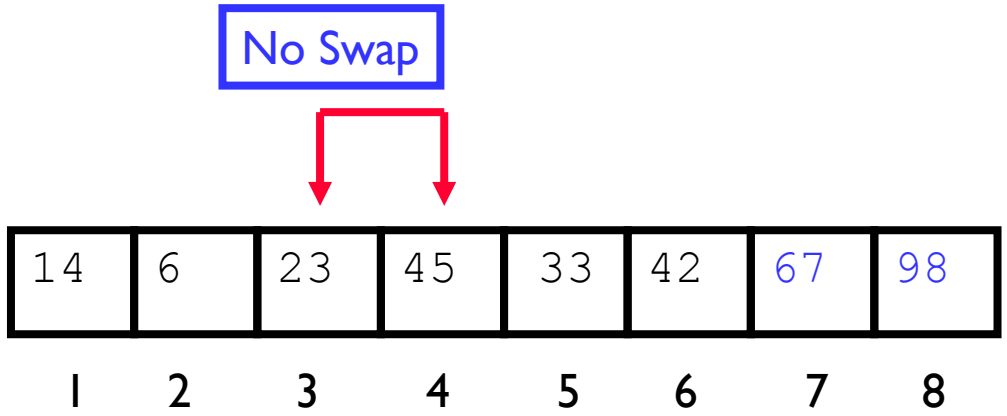

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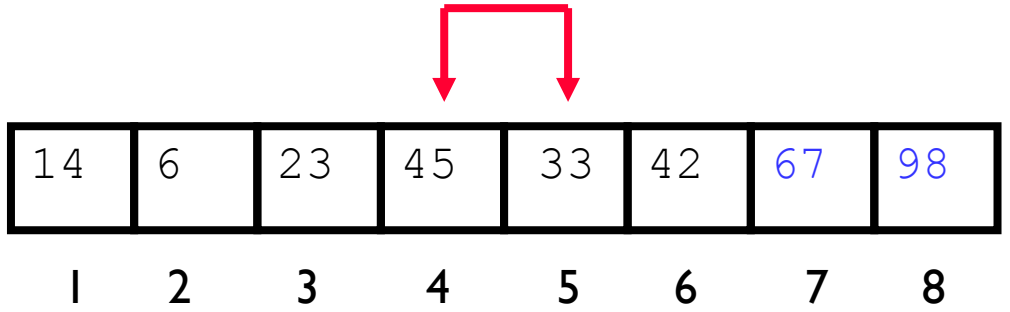
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	4

did_swap	true



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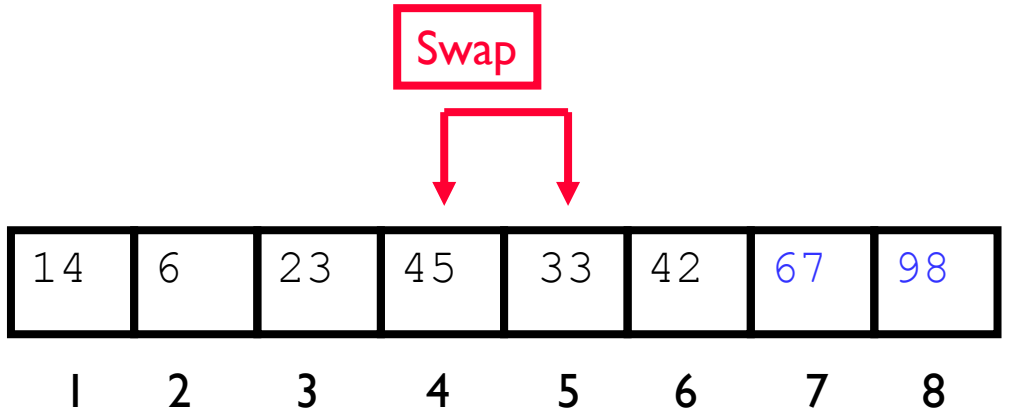
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	4

did_swap	true



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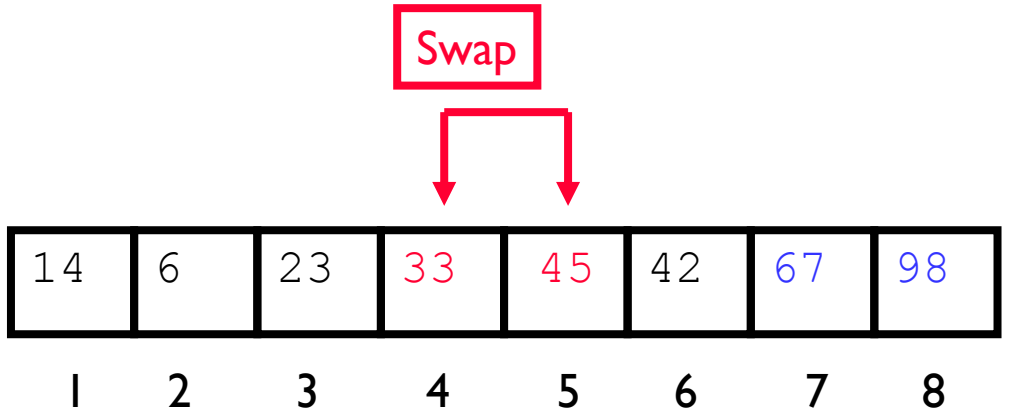
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	4

did_swap	true



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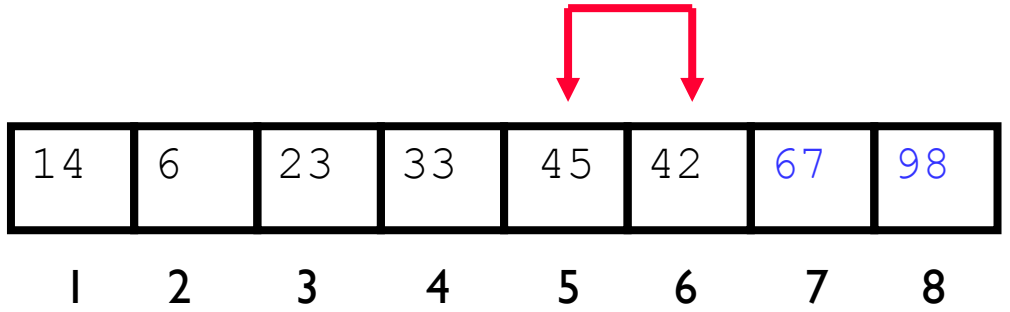
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	5

did_swap	true



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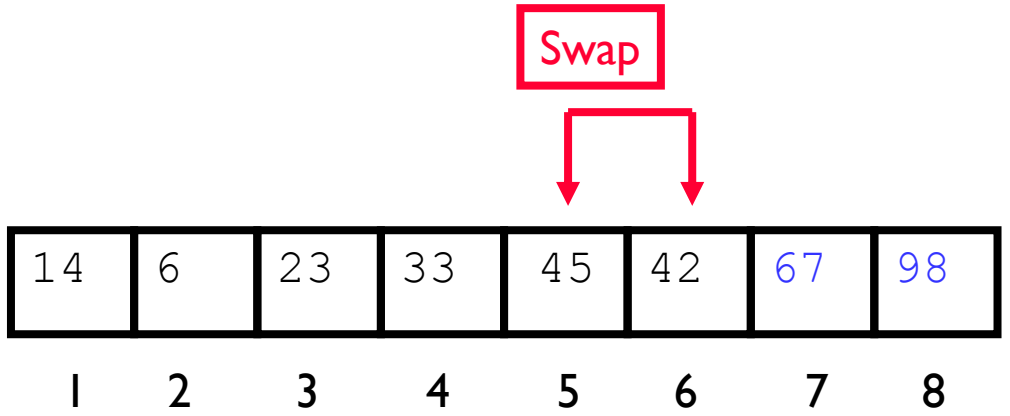
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	5

did_swap	true



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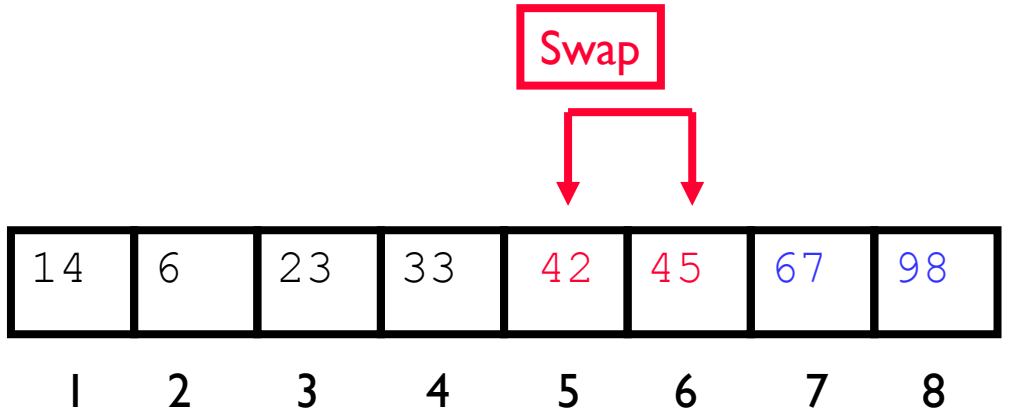
THE THIRD "BUBBLE UP"

N	8
to_do	5
index	5

did_swap	true



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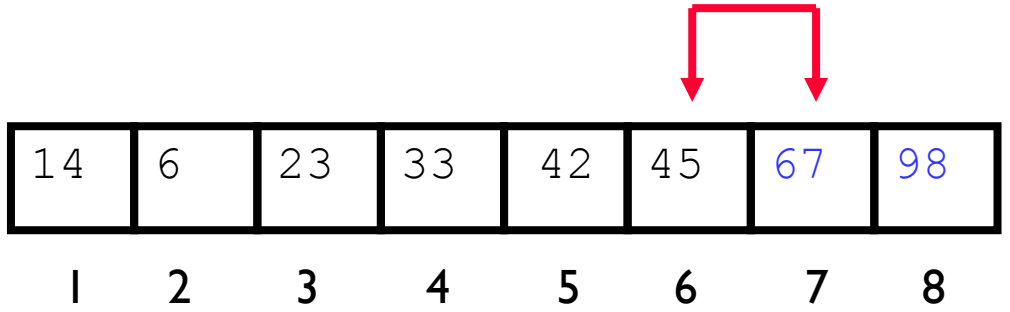
AFTER THIRD PASS OF OUTER LOOP

N	8
to_do	5
index	6

did_swap	true

Finished third "Bubble Up"



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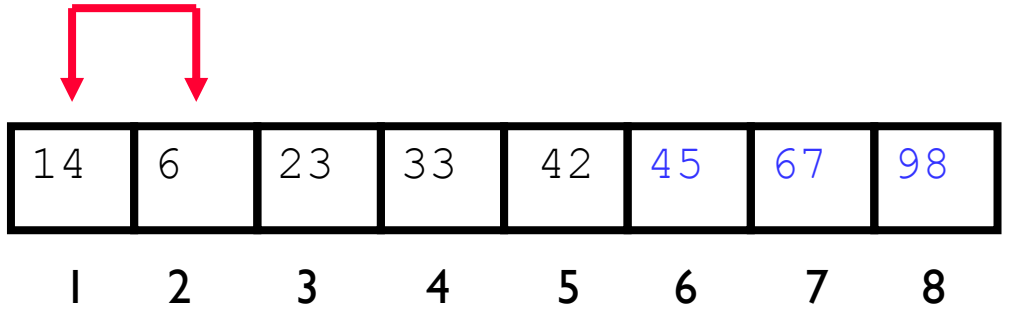
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	1

did_swap	false



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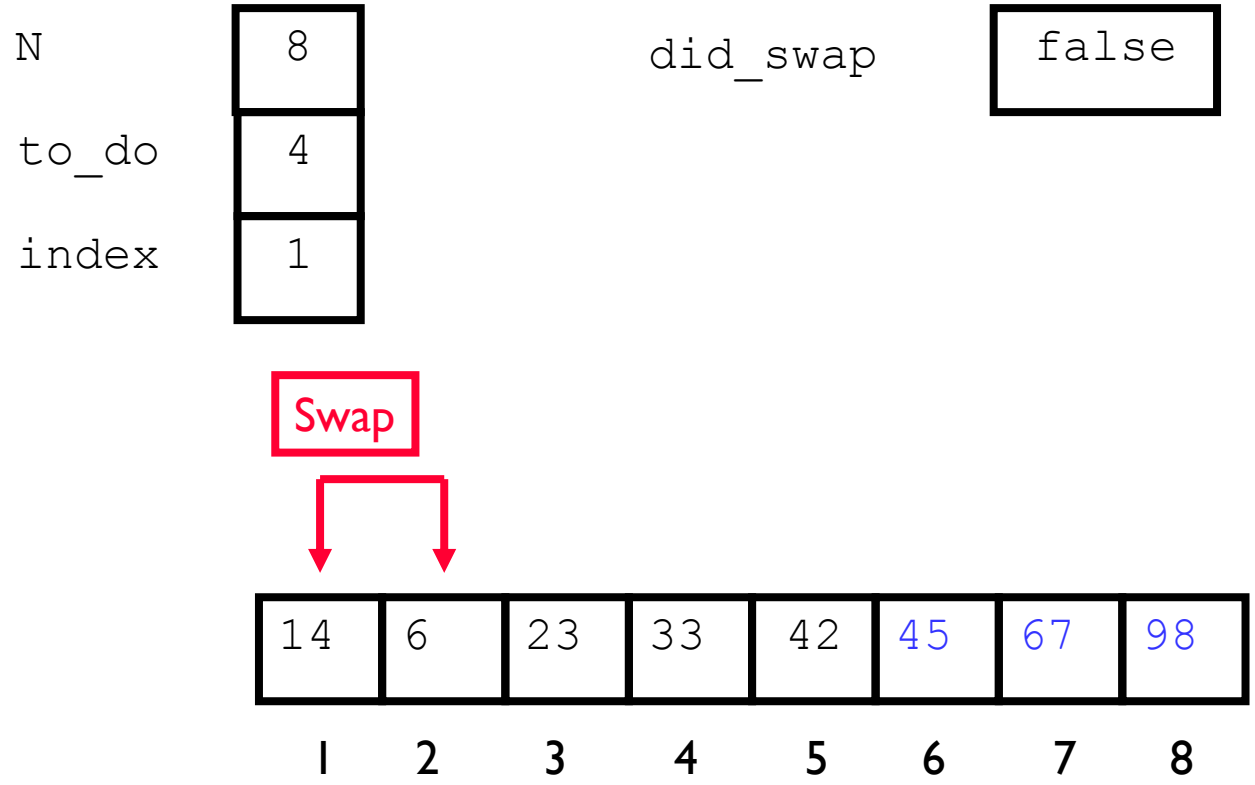

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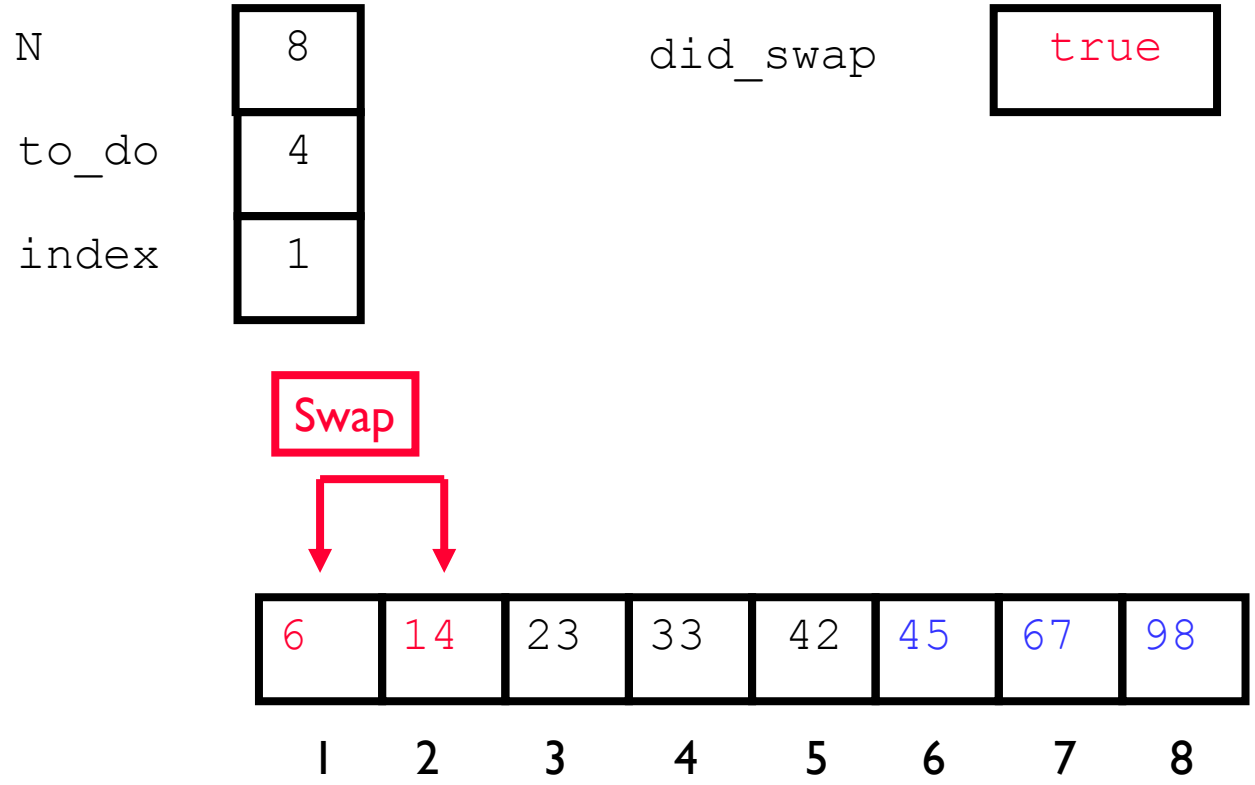

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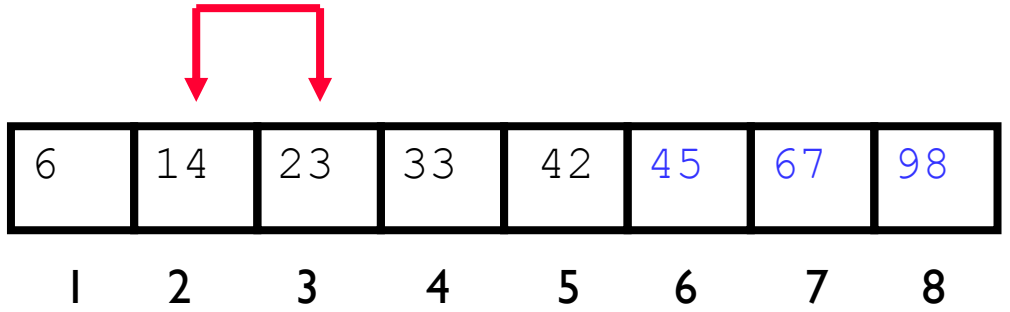
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	2

did_swap	true



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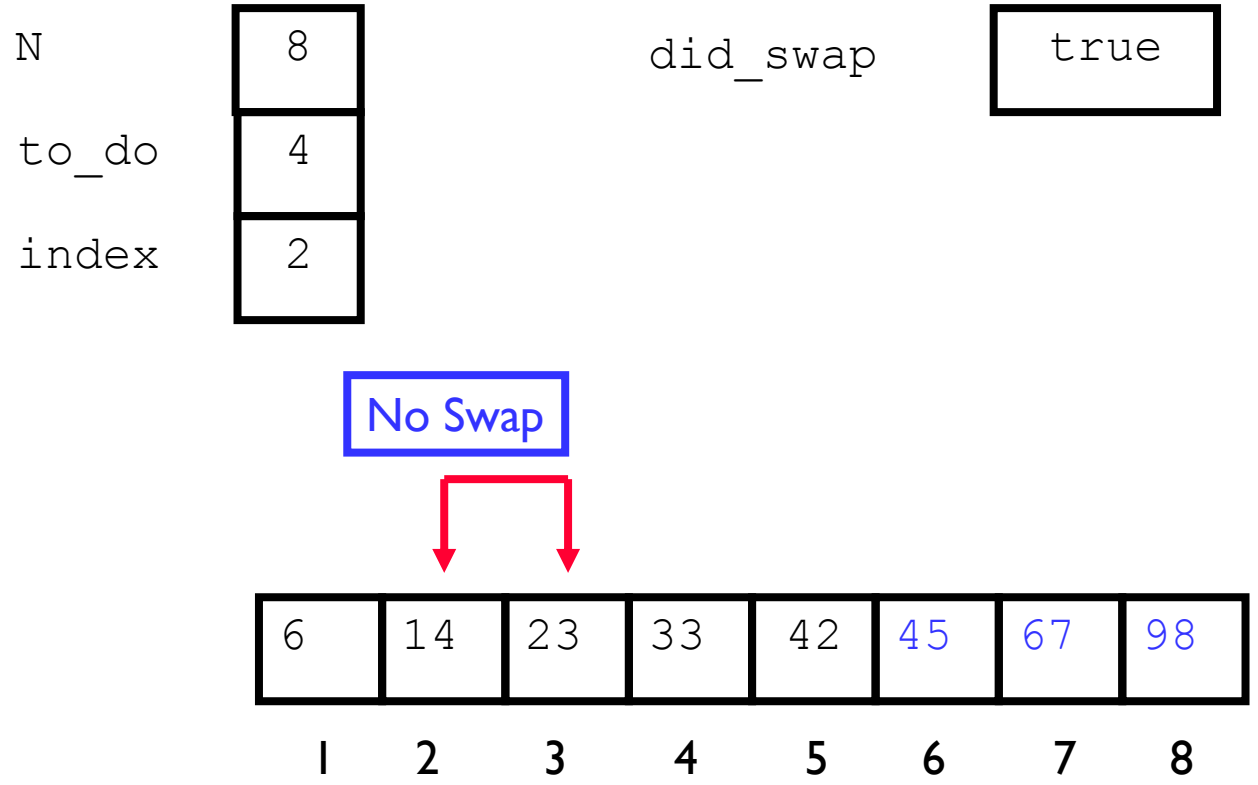

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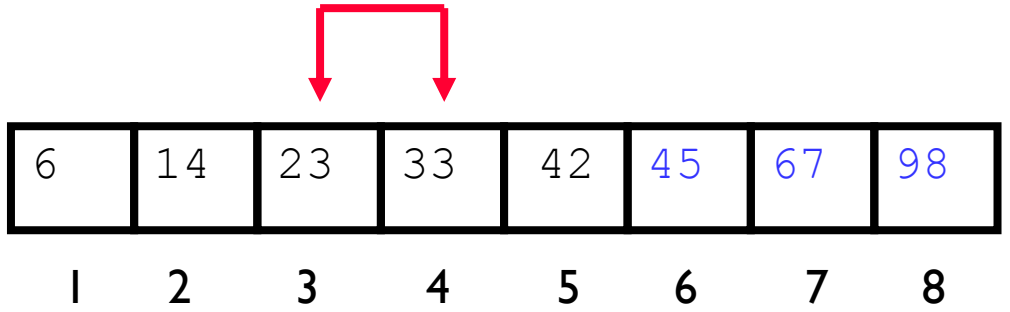
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	3

did_swap	true



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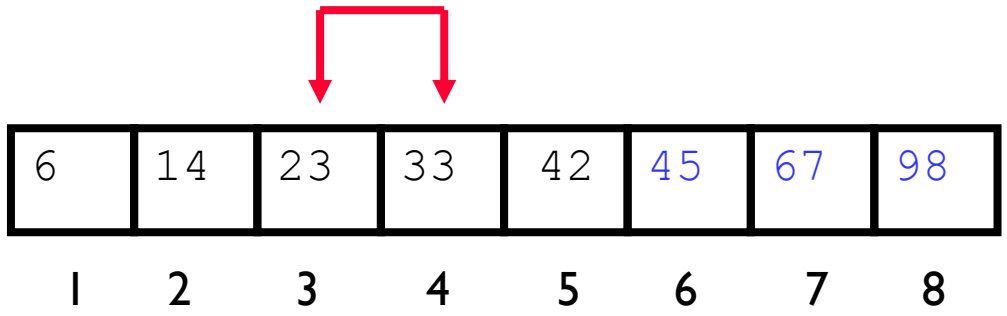
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	3

did_swap	true

No Swap



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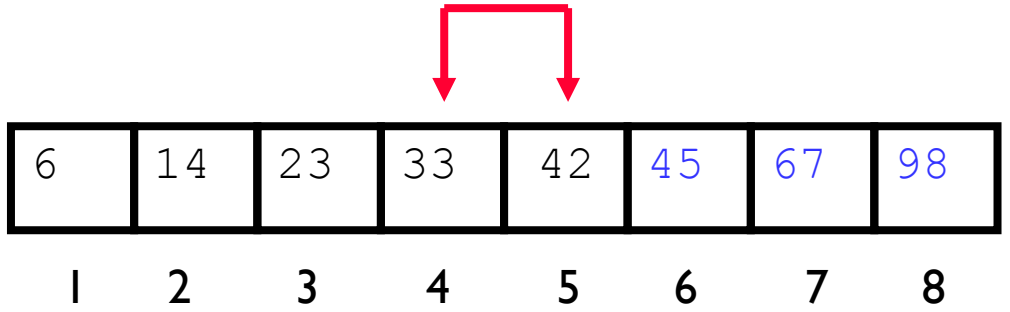
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	4

did_swap	true



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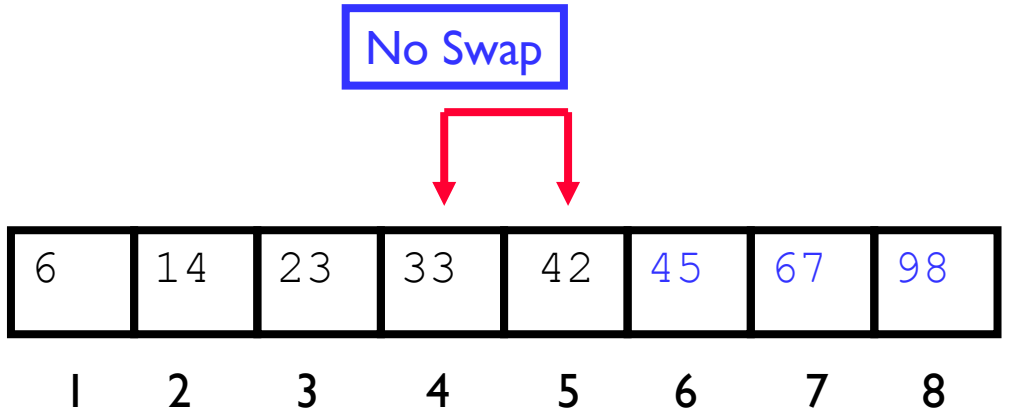
THE FOURTH "BUBBLE UP"

N	8
to_do	4
index	4

did_swap	true



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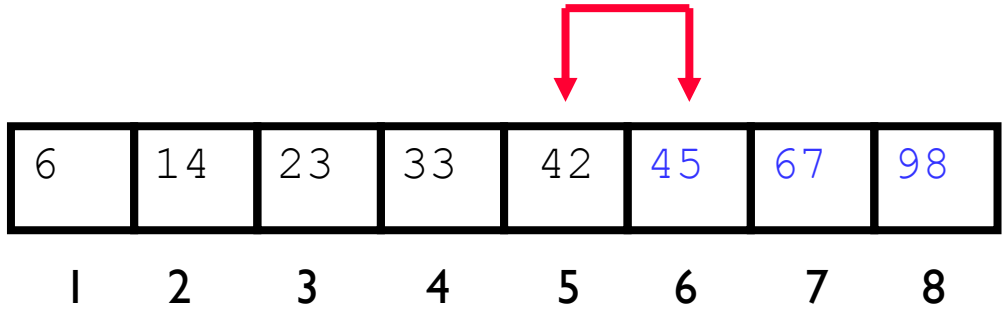
AFTER FOURTH PASS OF OUTER LOOP

N	8
to_do	4
index	5

did_swap	true

Finished fourth "Bubble Up"



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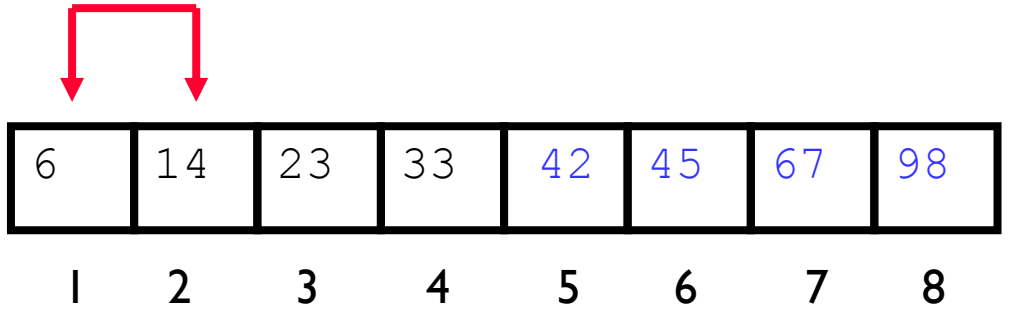
THE FIFTH "BUBBLE UP"

N	8
to_do	3
index	1

did_swap	false



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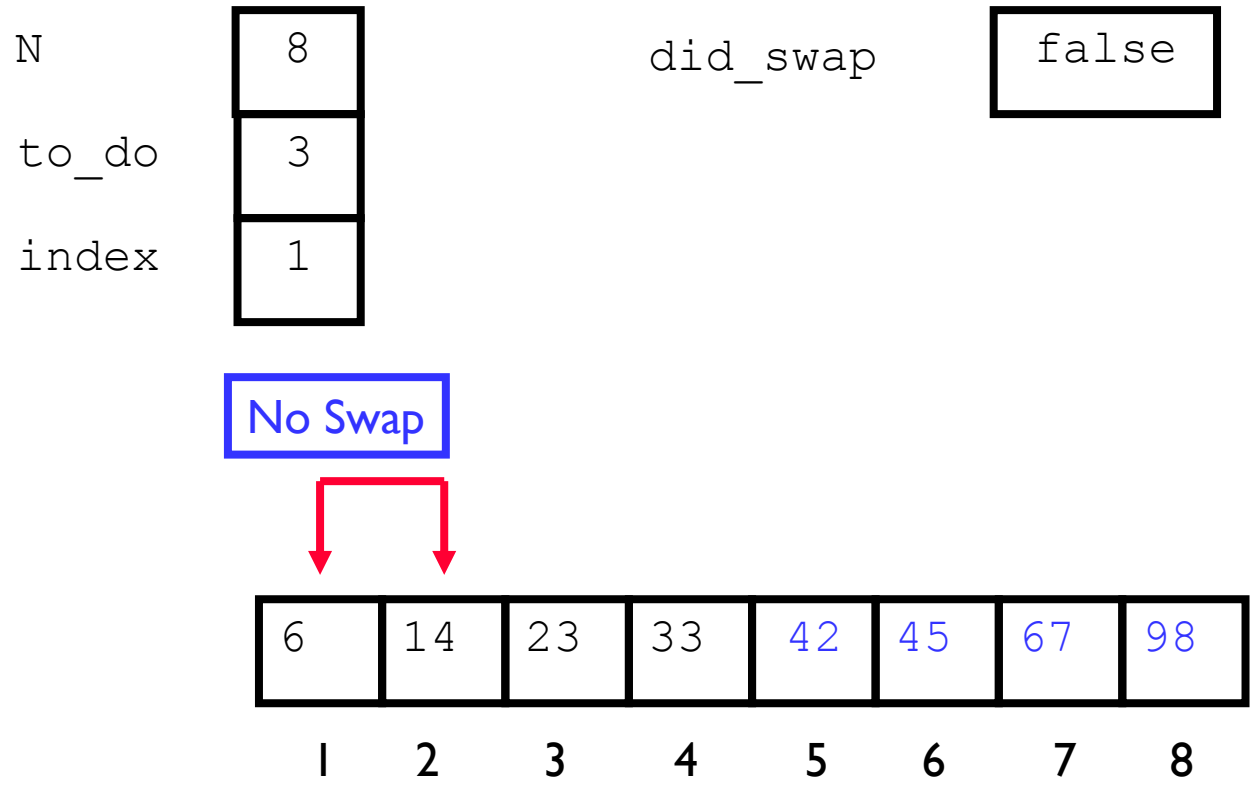
THE FIFTH "BUBBLE UP"



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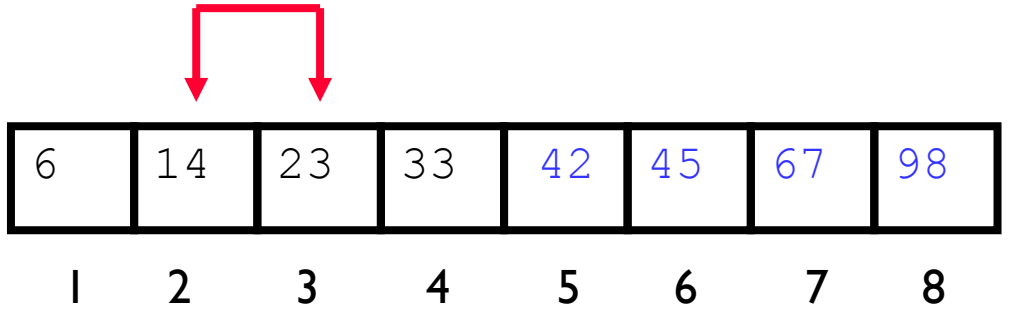
THE FIFTH "BUBBLE UP"

N	8
to_do	3
index	2

did_swap	false



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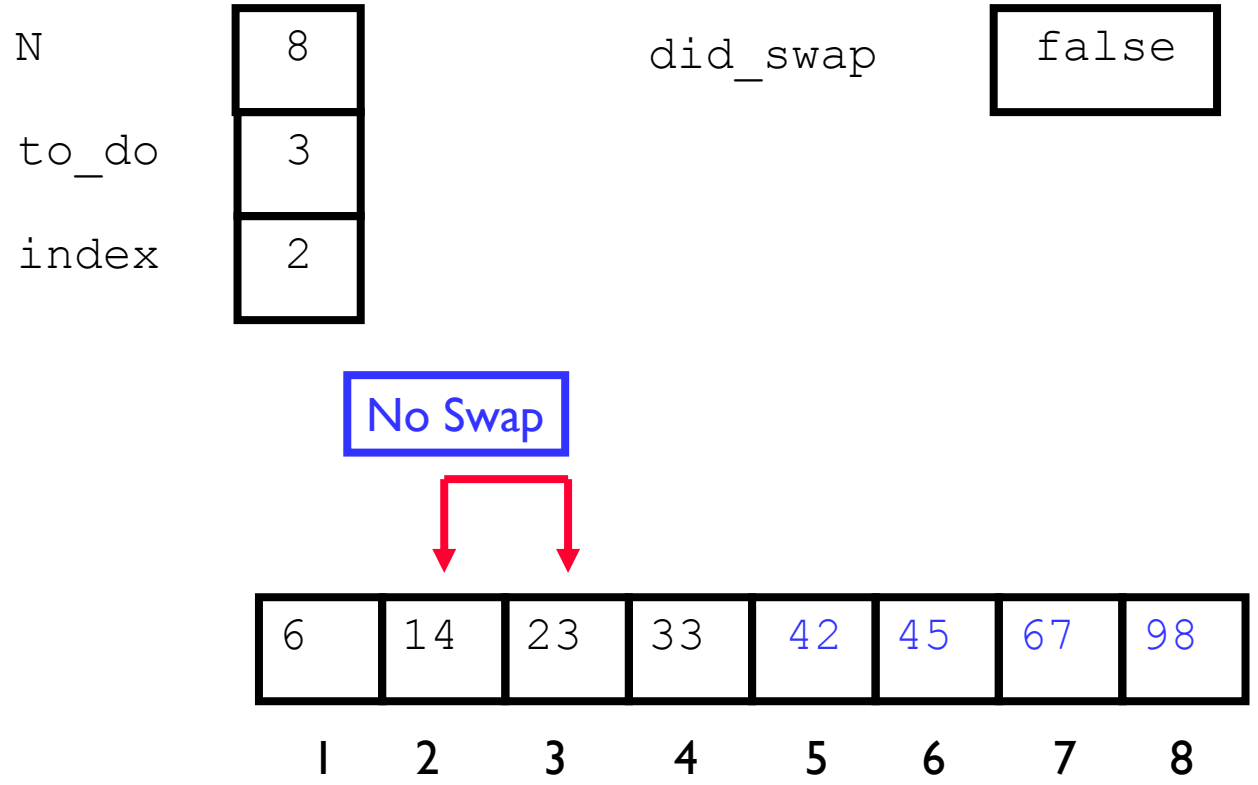
THE FIFTH "BUBBLE UP"



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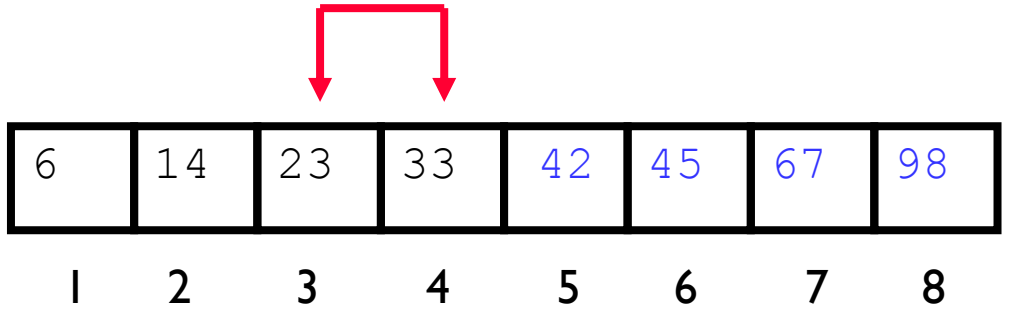
THE FIFTH "BUBBLE UP"

N	8
to_do	3
index	3

did_swap	false



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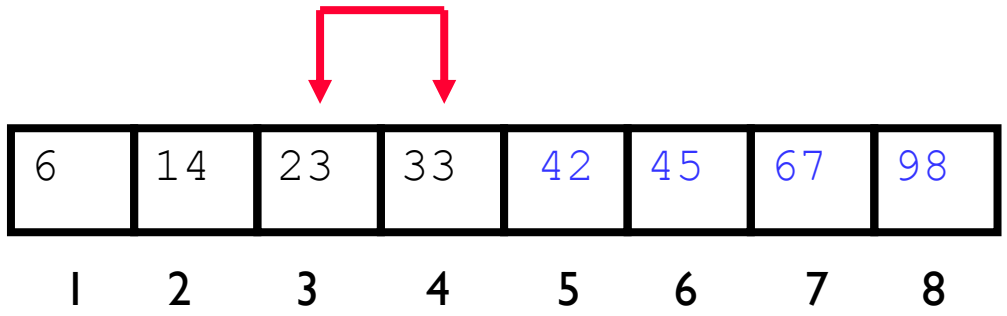
THE FIFTH "BUBBLE UP"

N	8
to_do	3
index	3

did_swap	false

No Swap



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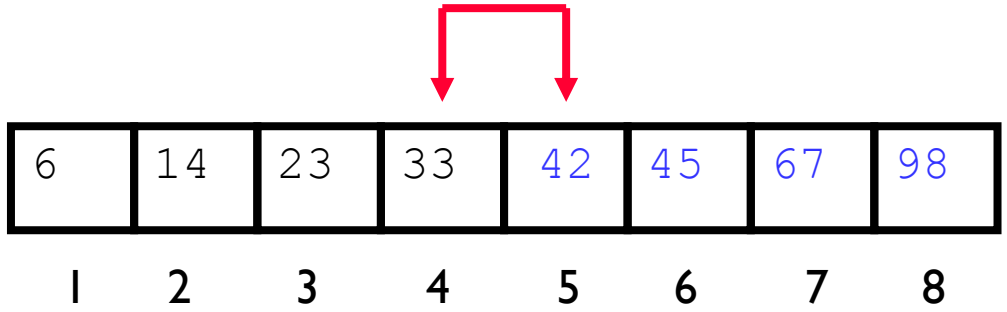
AFTER FIFTH PASS OF OUTER LOOP

N	8
to_do	3
index	4

did_swap	false

Finished fifth "Bubble Up"



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FINISHED "EARLY"

N	8
to_do	3
index	4

did_swap	false

We didn't do any swapping, so all of the other elements must be correctly placed.

We can "skip" the last two passes of the outer loop.

6	14	23	33	42	45	67	98
1	2	3	4	5	6	7	8

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SUMMARY

- "Bubble Up" algorithm will move largest value to its correct location (to the right)
- Repeat "Bubble Up" until all elements are correctly placed:
  - Maximum of N-1 times
  - Can finish early if no swapping occurs
- We reduce the number of elements we compare each time one is correctly placed

YOUR TASK

- Compare the Running time of the two versions of Bubble Sort that I taught you previously (i.e Conventional Bubble Sort and Improved Bubble Sort) [Hint : Use Python's time Module]