

Insertion Sort

(insert each element into a sorted partition)

0	1	2	3	4	5	6	7	8	9
18	10	2	14	3	12	1	19		

Slides by **Sean Szumlanski**
for **CS106B**, Programming Abstractions

Summer 2025

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(insert each element into a sorted partition)

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18	10	2	14	3	12	1	19		

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Initially, consider the first element to constitute a separate, **sorted** vector.

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(insert each element into a sorted partition)

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Initially, consider the first element to constitute a separate, **sorted** vector.

Insertion Sort

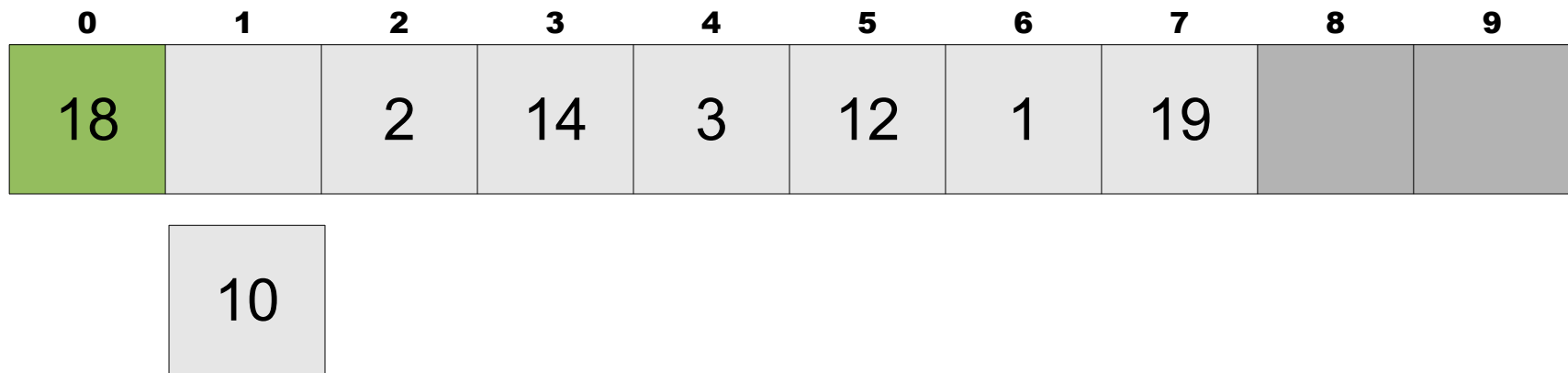
(insert each element into a sorted partition)

0	1	2	3	4	5	6	7	8	9
18	10	2	14	3	12	1	19		

Now pull the first element out of the **unsorted** partition of the vector.

Insertion Sort

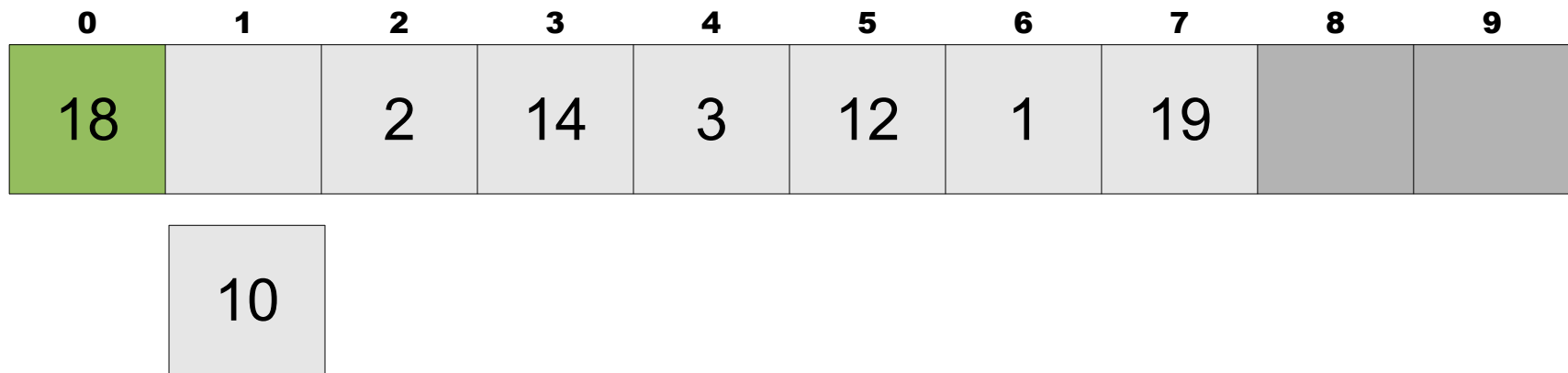
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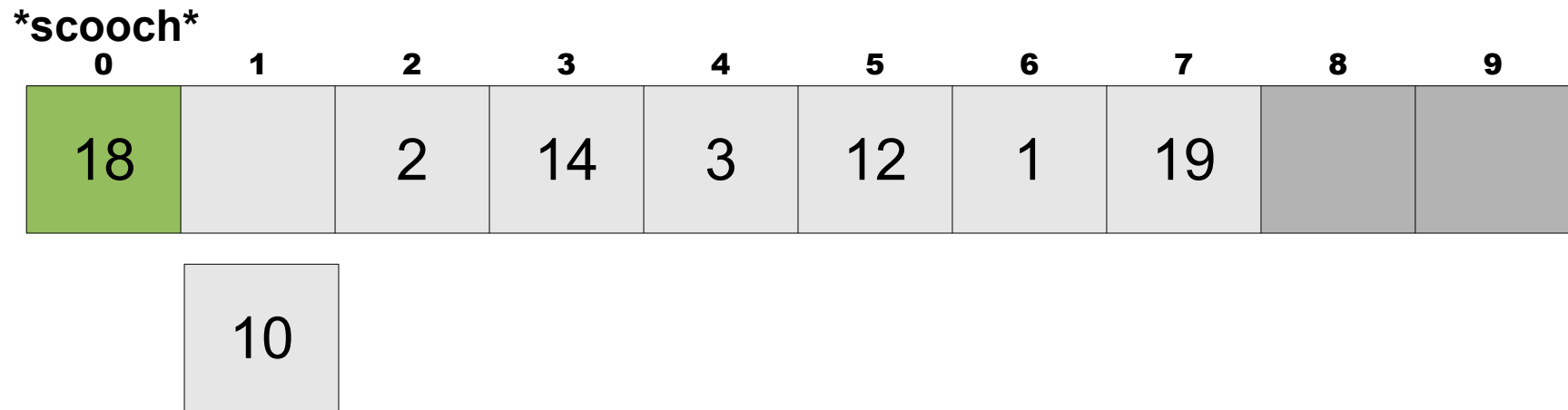


Now pull the first element out of the **unsorted** partition of the vector.

In the **sorted** partition, scooch everything over that is **greater** than that element.

Insertion Sort

(insert each element into a sorted partition)

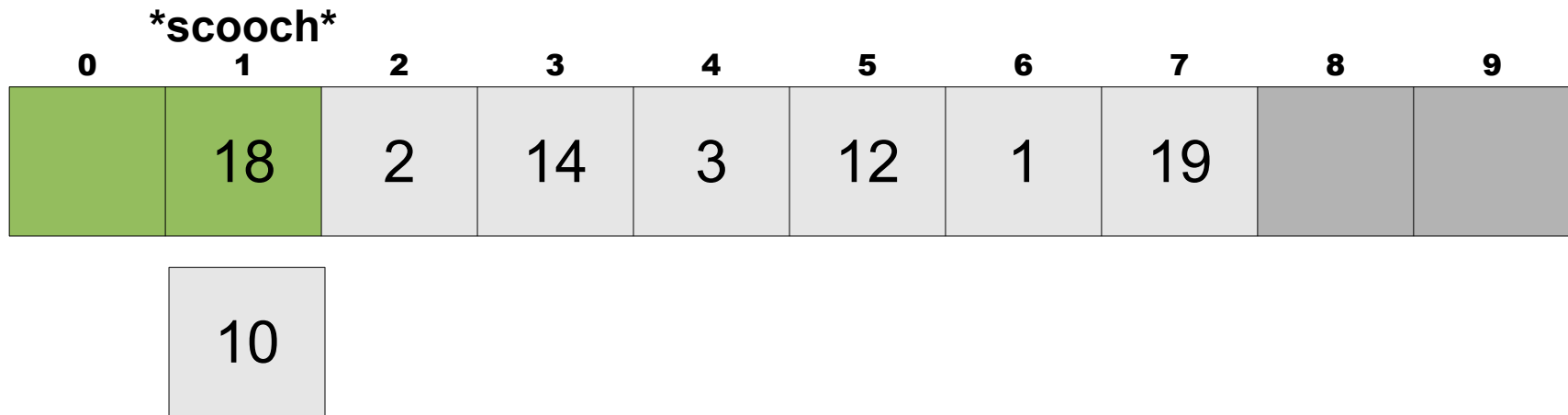


Now pull the first element out of the **unsorted** partition of the vector.

In the **sorted** partition, scooch everything over that is **greater** than that element.

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(insert each element into a sorted partition)

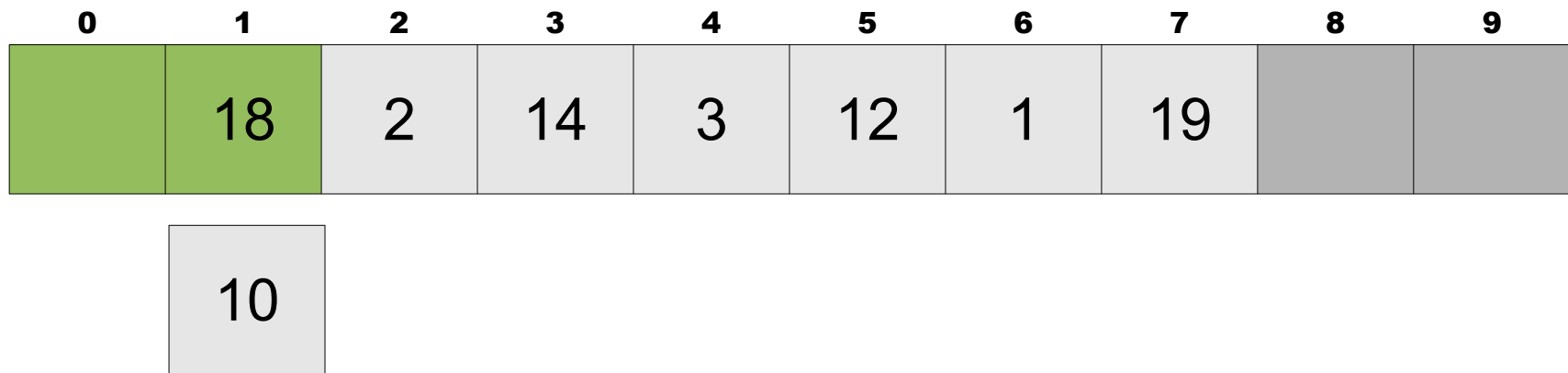


Now pull the first element out of the **unsorted** partition of the vector.

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Now pull the first element out of the **unsorted** partition of the vector.

In the **sorted** partition, scooch everything over that is **greater** than that element.

Stick the element into the hole left for it in the **sorted** portion of the vector.

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0	1	2	3	4	5	6	7	8	9
10	18	2	14	3	12	1	19		

That was easy!

Let's see if we can do it again.

Insertion Sort

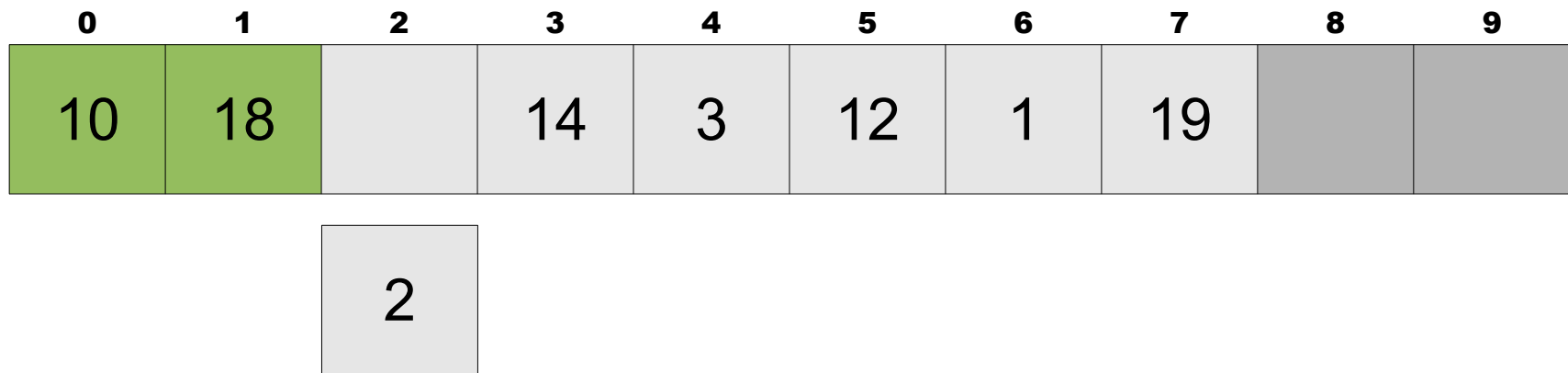
(insert each element into a sorted partition)

0	1	2	3	4	5	6	7	8	9
10	18	2	14	3	12	1	19		

Pull the first element out of the **unsorted** partition of the vector.

Insertion Sort

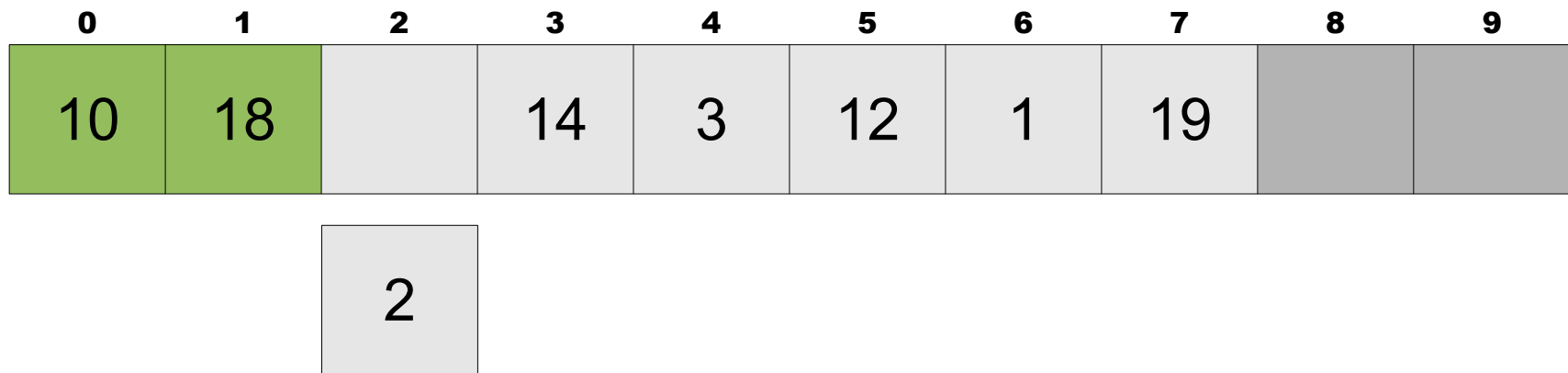
(insert each element into a sorted partition)



Pull the first element out of the **unsorted** partition of the vector.

Insertion Sort

(insert each element into a sorted partition)

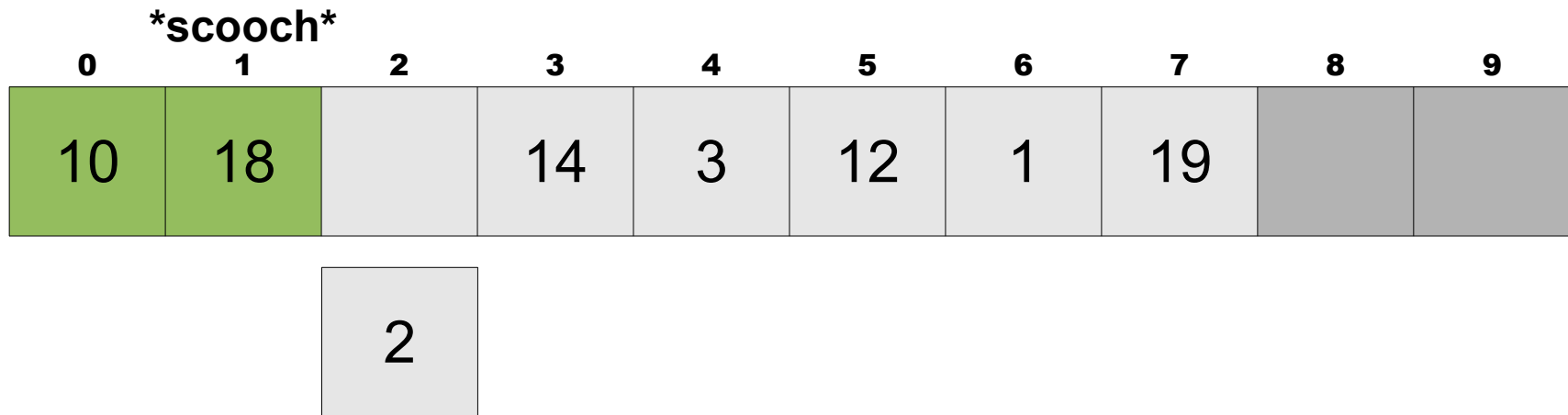


Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Insertion Sort

(insert each element into a sorted partition)

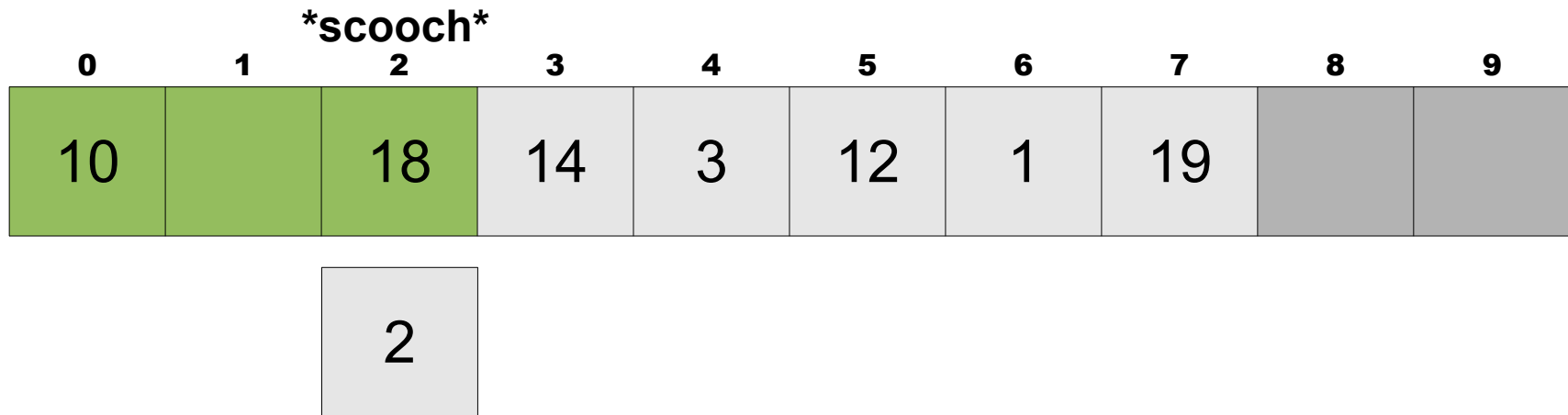


Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Insertion Sort

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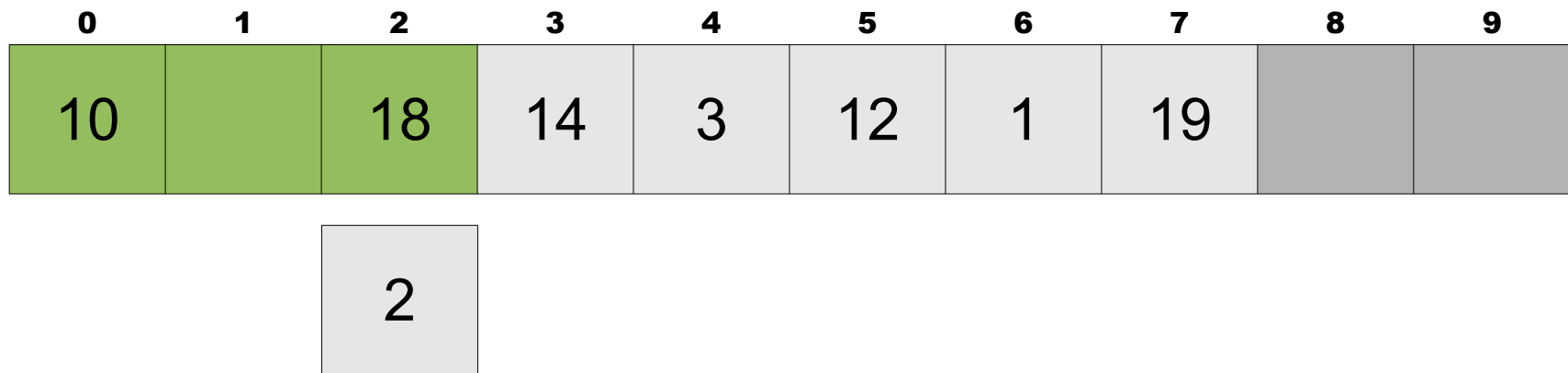


Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Insertion Sort

(insert each element into a sorted partition)

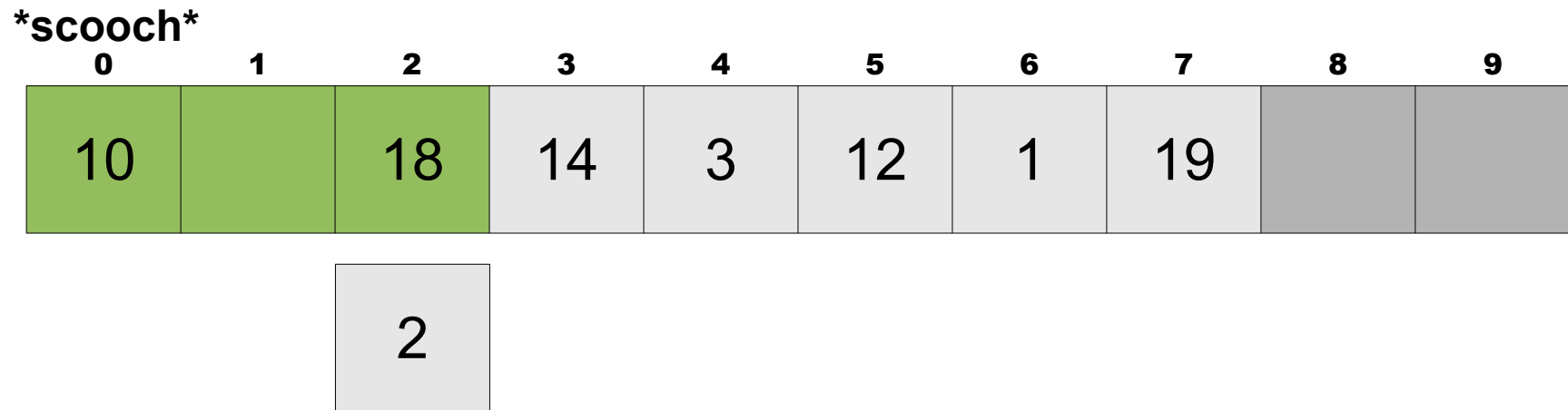


Pull the first element out of the **unsorted** partition of the vector.

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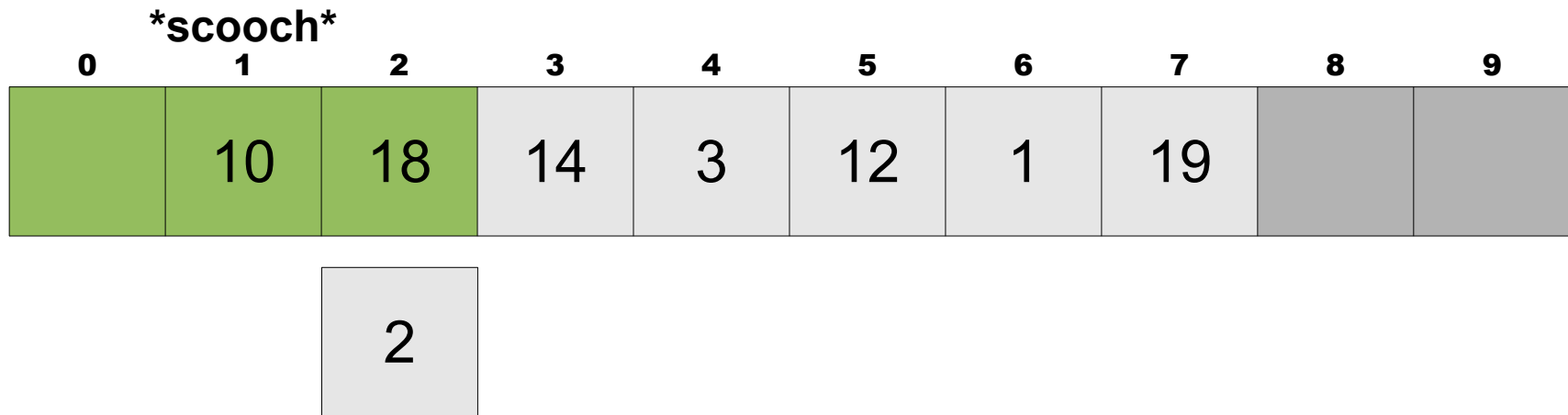


Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Insertion Sort

(insert each element into a sorted partition)

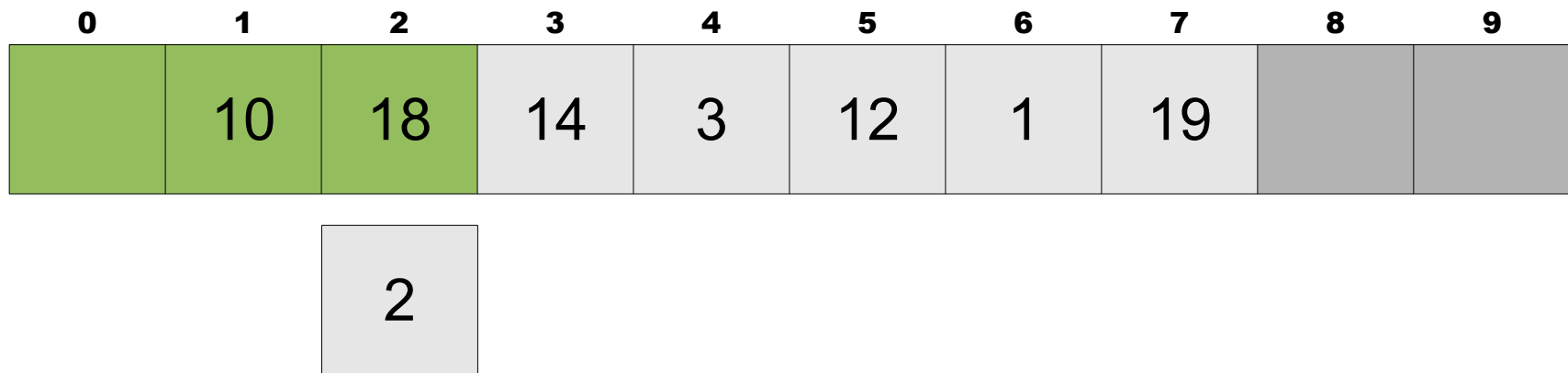


Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Insertion Sort

(insert each element into a sorted partition)

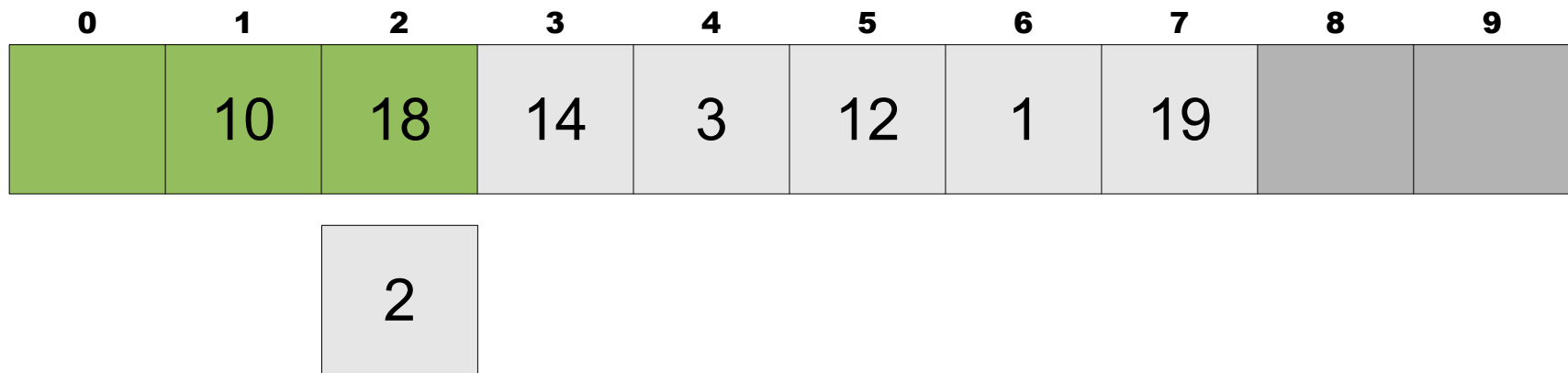


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Insertion Sort

(insert each element into a sorted partition)



Pull the first element out of the **unsorted** partition of the vector.

Start **scooching** things over if they're greater than 2.

Stick the element into the hole left for it in the **sorted** portion of the vector.

Insertion Sort

(insert each element into a sorted partition)

0	1	2	3	4	5	6	7	8	9
2	10	18	14	3	12	1	19		

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2	10	18	14	3	12	1	19		

TADA!

Pull the first element out of the **unsorted** partition of the vector.

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Stick the element into the hole left for it in the **sorted** portion of the vector.

Insertion Sort

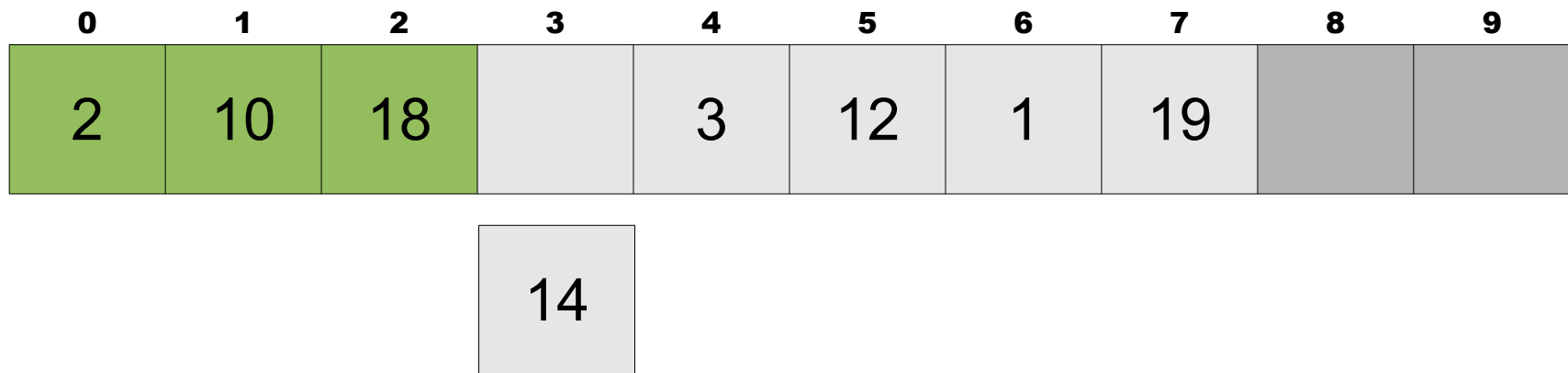
(insert each element into a sorted partition)

0	1	2	3	4	5	6	7	8	9
2	10	18	14	3	12	1	19		

See if you can follow along...

Insertion Sort

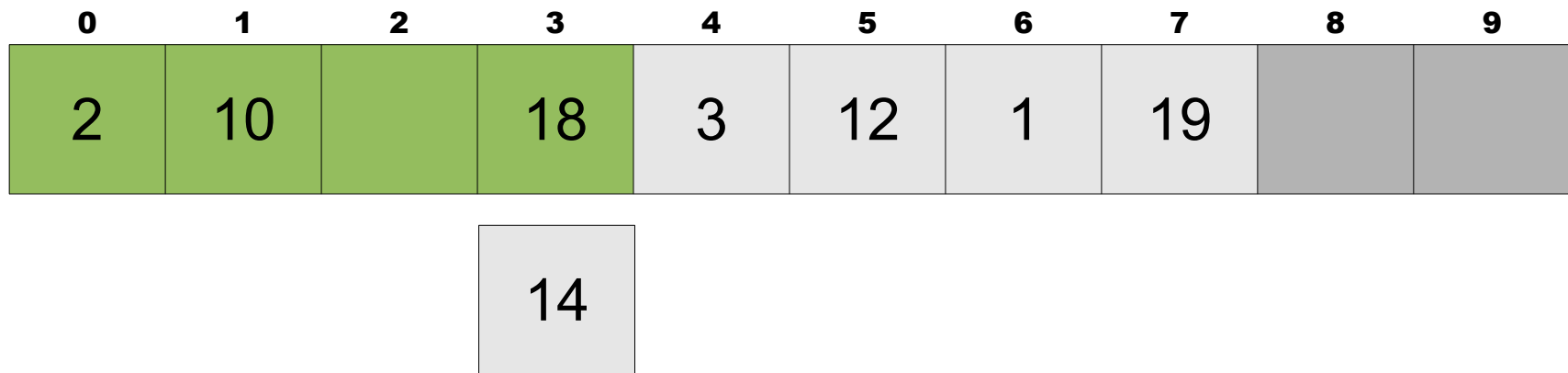
(insert each element into a sorted partition)



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Insertion Sort

(insert each element into a sorted partition)



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Insertion Sort

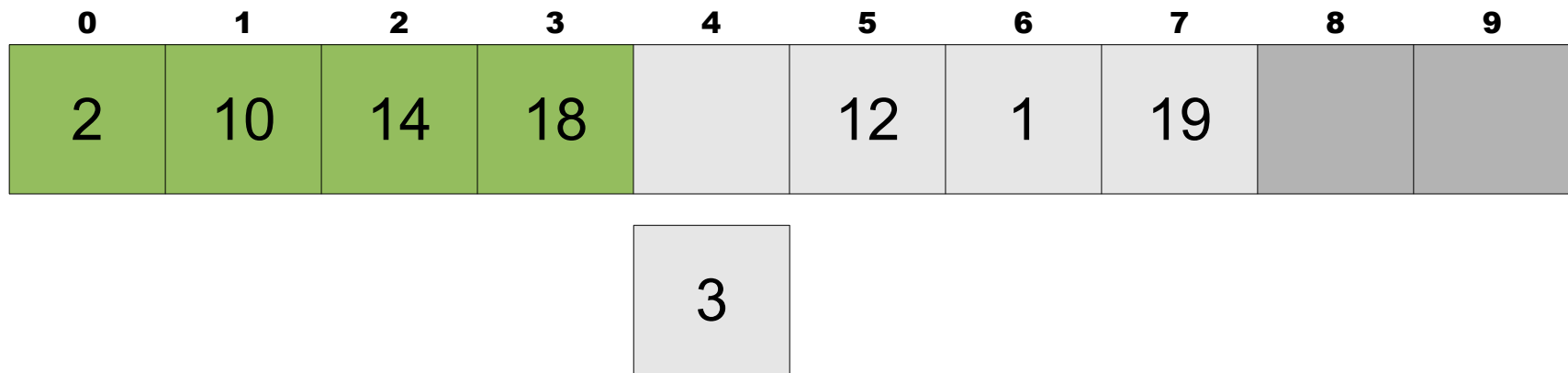
(insert each element into a sorted partition)

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2	10	14	18	3	12	1	19		

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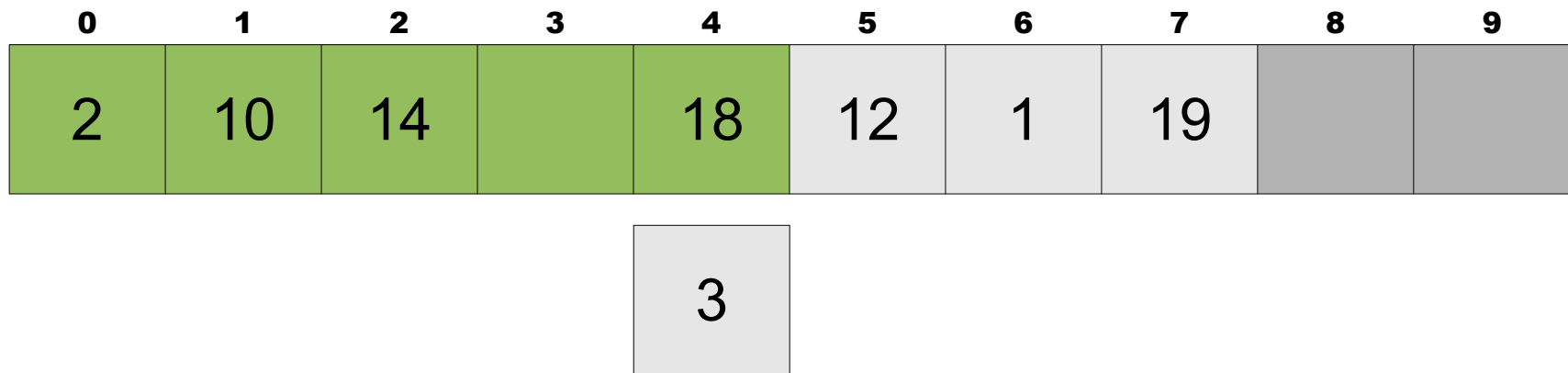
(insert each element into a sorted partition)



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Insertion Sort

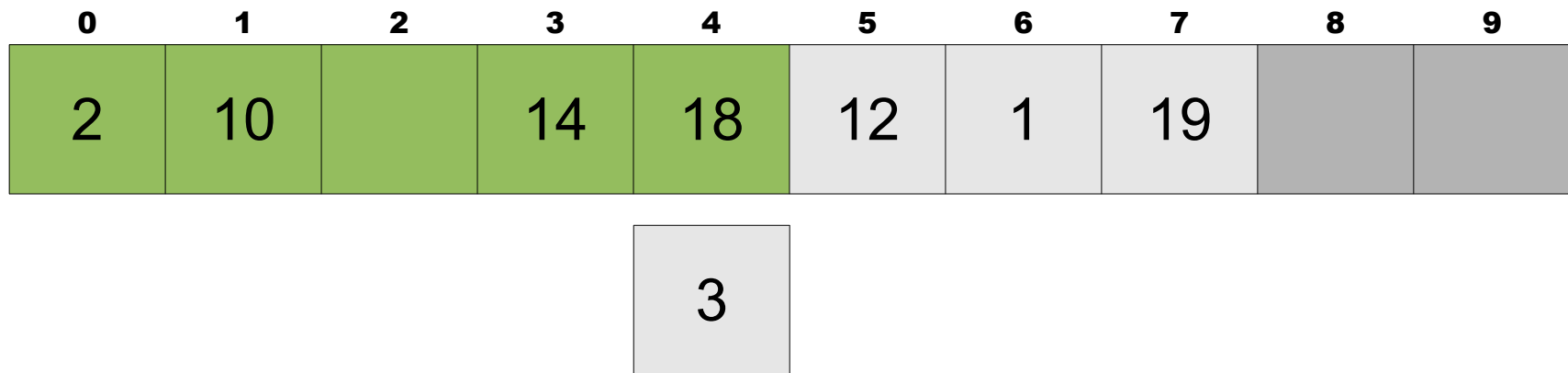
(insert each element into a sorted partition)



See if you can follow along...

Insertion Sort

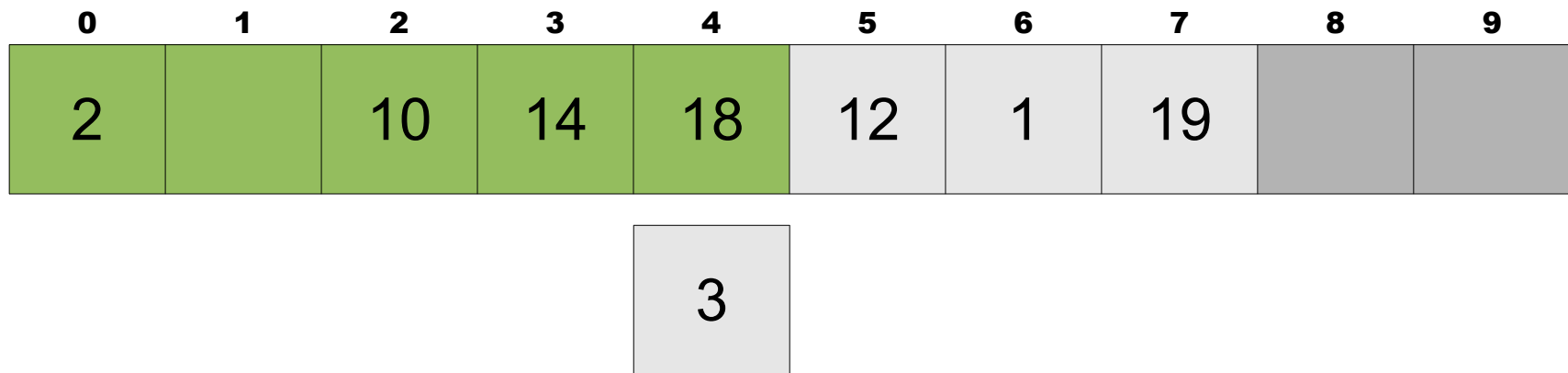
(insert each element into a sorted partition)



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Insertion Sort

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Insertion Sort

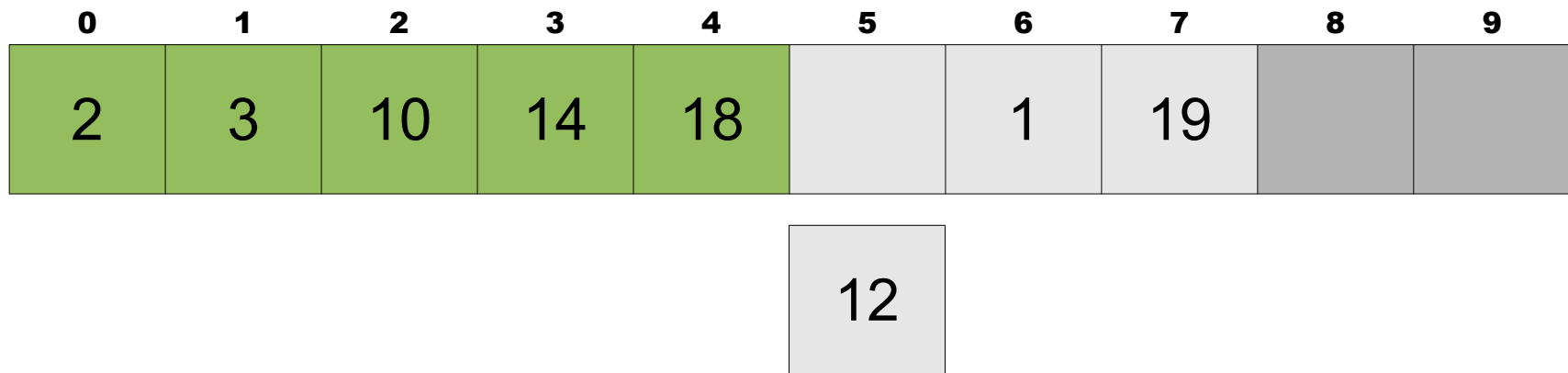
(insert each element into a sorted partition)

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2	3	10	14	18	12	1	19		

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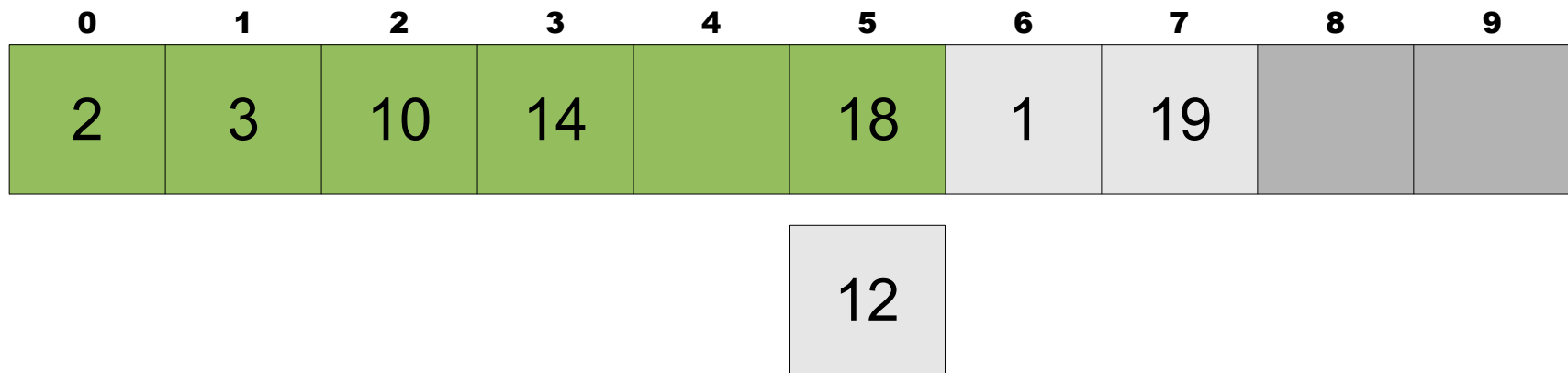
(insert each element into a sorted partition)



See if you can follow along...

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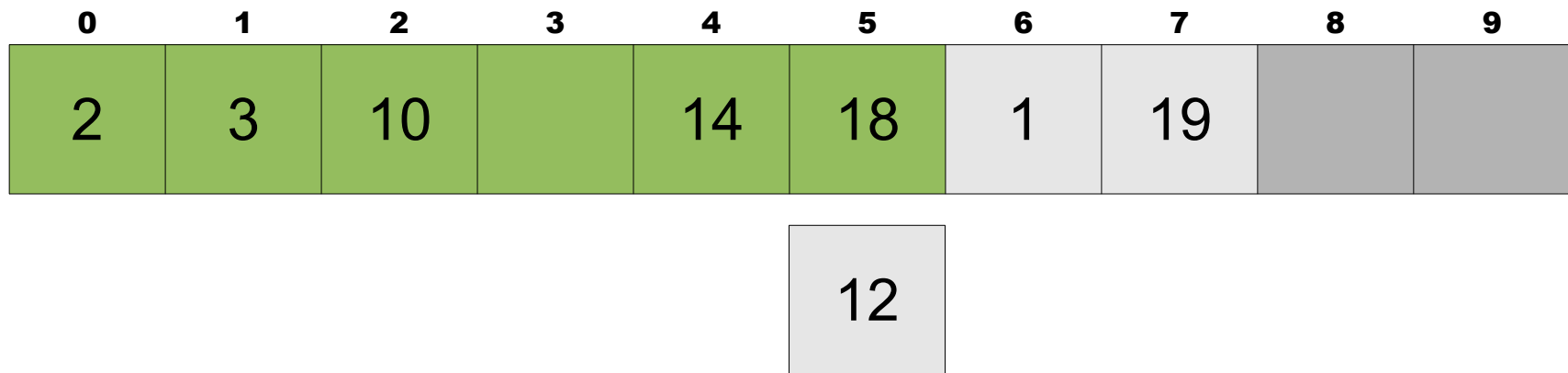
(insert each element into a sorted partition)



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Insertion Sort

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See if you can follow along...

Insertion Sort

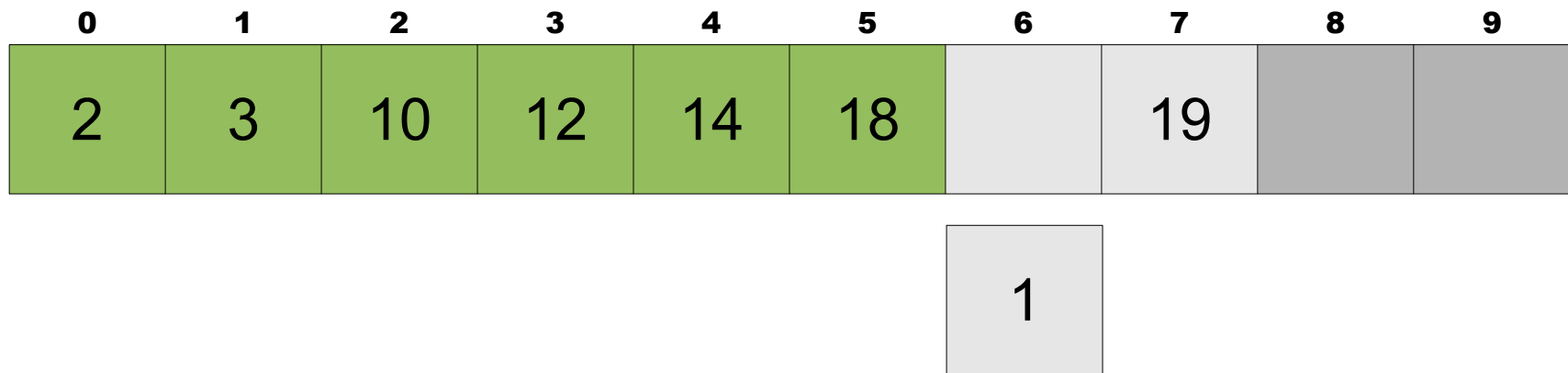
(insert each element into a sorted partition)

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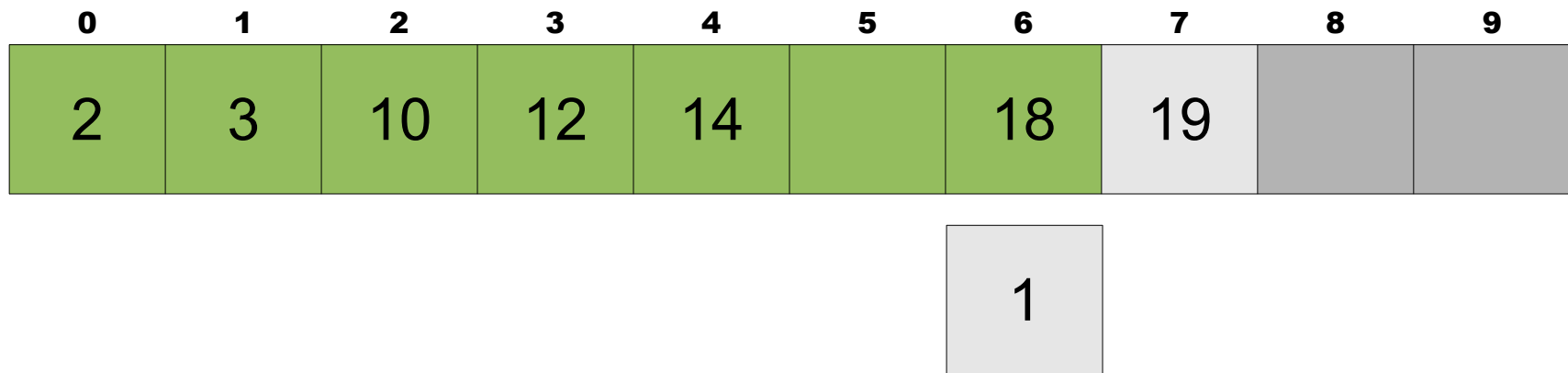
(insert each element into a sorted partition)



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Insertion Sort

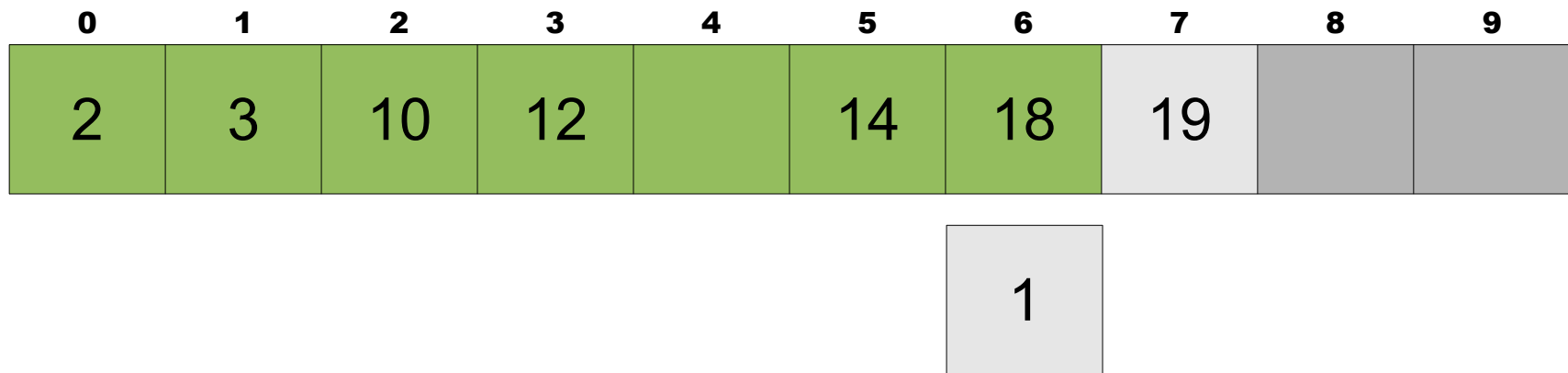
(insert each element into a sorted partition)



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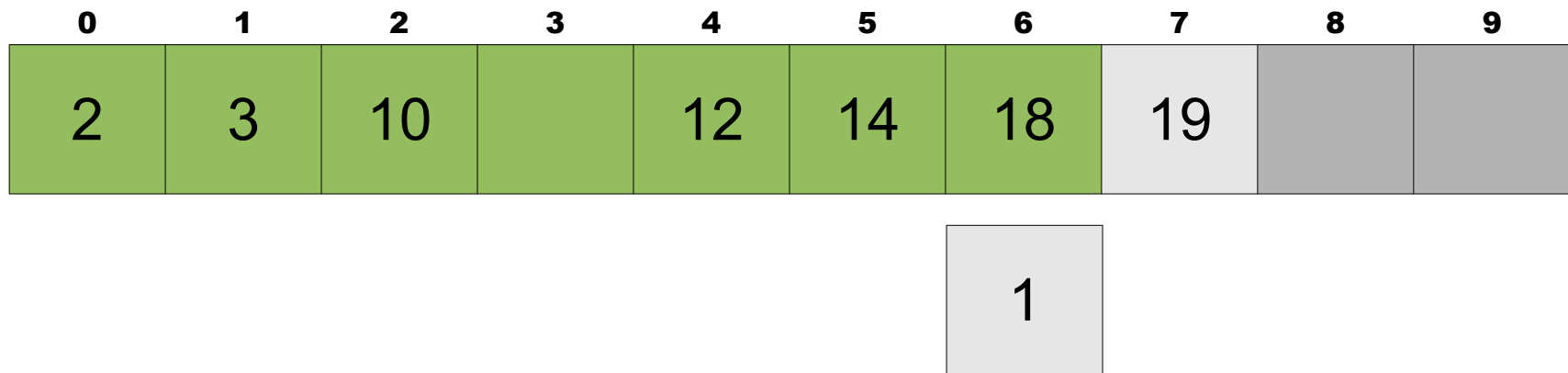
(insert each element into a sorted partition)



See if you can follow along...

Insertion Sort

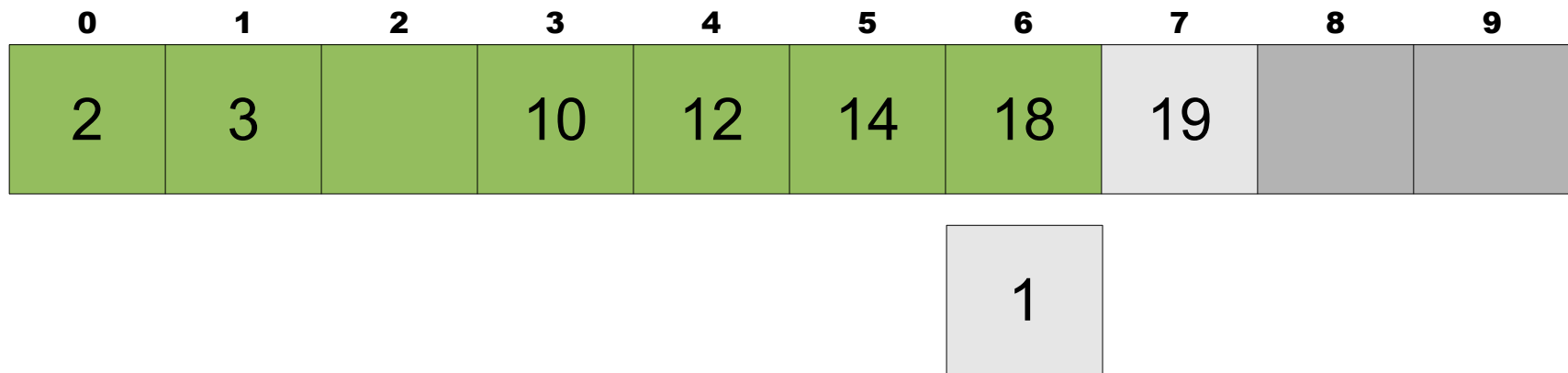
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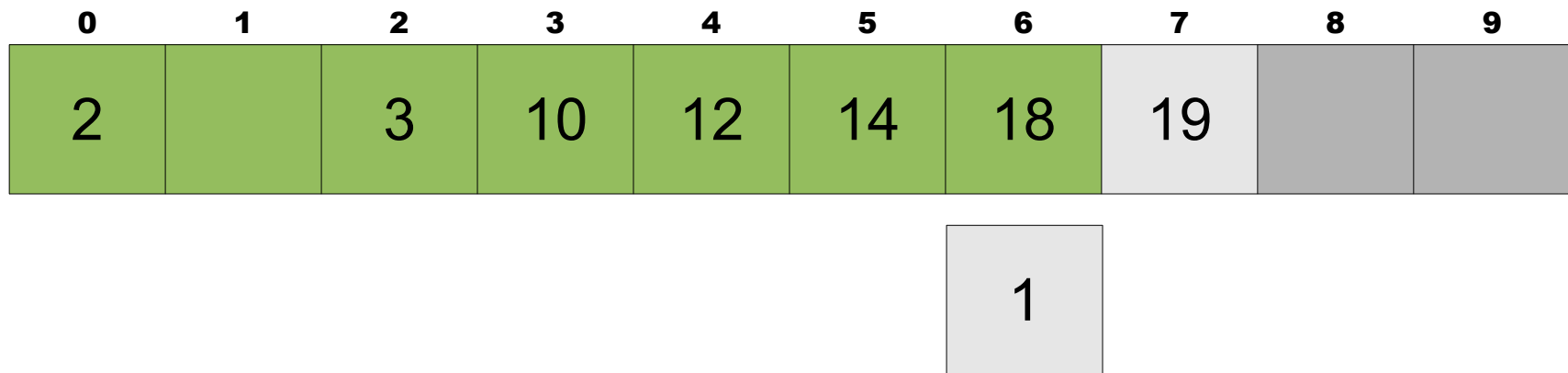
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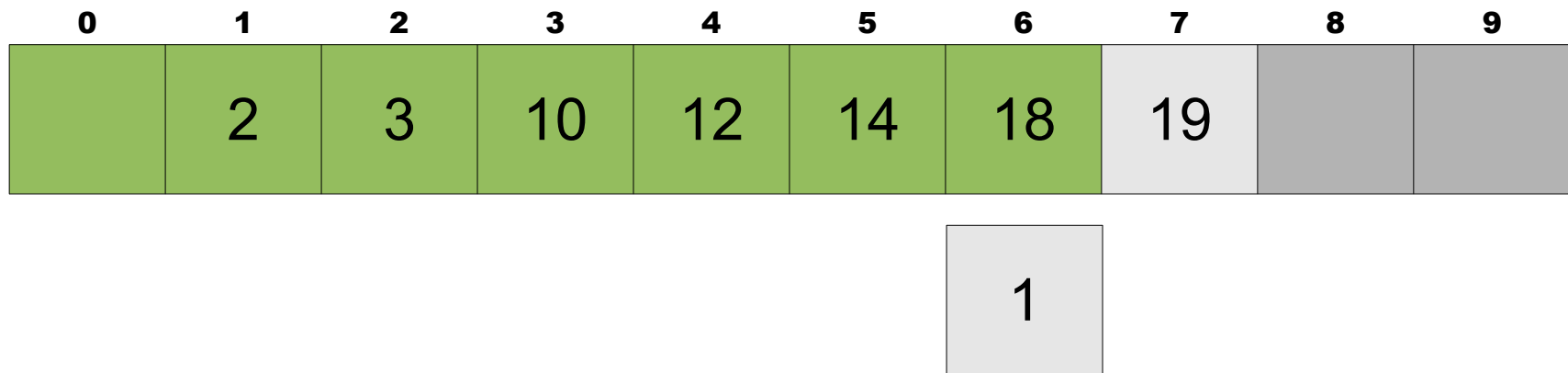
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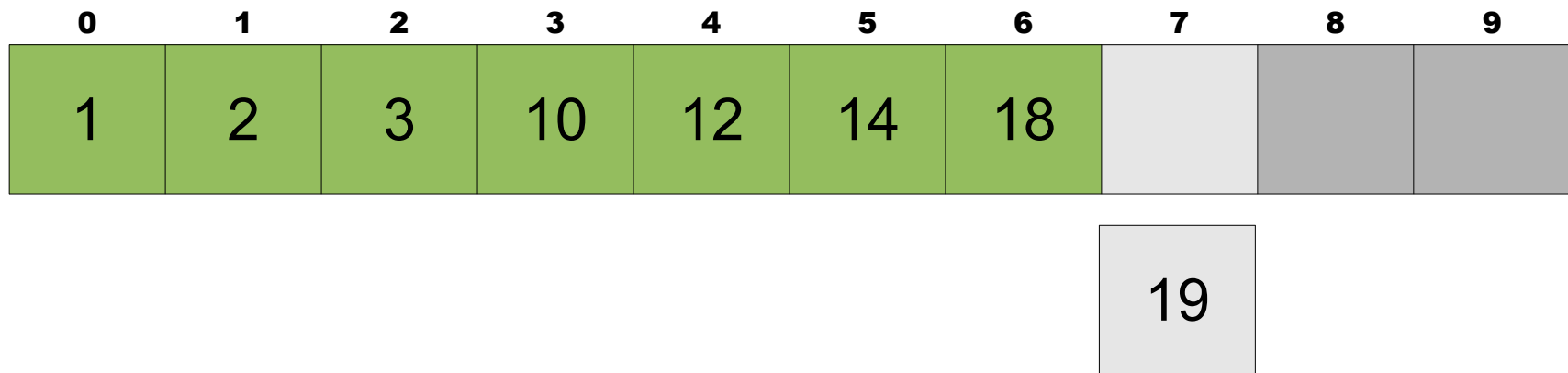
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We're finished!

(Hooray!)

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1. What's the **worst-case** Big-Oh runtime?
2. What's the **best-case** Big-Oh runtime?
3. Show the vector after **each pass** of Insertion Sort.

Insertion Sort

(let's code it up)

18	10	2	14	3	12	1	19		
----	----	---	----	---	----	---	----	--	--

```
void insertionSort(Vector<int>& v)
{
    for (int i = 1; i < v.size(); i++)
    {
        int val = v[i];
        int gap = i;

        for (int j = gap - 1; j >= 0 && v[j] > val; j--)
        {
            v[j + 1] = v[j];
            gap--;
        }

        v[gap] = val;
    }
}
```