**Bubble Sort**

# Bubble Sort

• The simplest sorting algorithm is bubble sort. The bubble sort works by iterating down an array to be sorted from the first element to the last, comparing each pair of elements and switching their positions if necessary. This process is repeated as many times as necessary, until the array is sorted. Since the worst-case scenario is that the array is in reverse order, and that the first element in sorted array is the last element in the starting array.

# Sorting

• **Sorting takes an unordered collection and makes it an ordered one.**

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **77** | **42** | **35** | **12** | **101** | **5** |

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **5** | **12** | **35** | **42** | **77** | **101** |

# "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**

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **77** | **42** | **35** | **12** | **101** | **5** |

# "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**

**5**

**12**

**35**

**42**

**77**

**101**

**1**

**2 3 4 5**

**6**

**Swap**

**42**

**77**

# "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**

**1 2 3 4 5 6**

**42 7735Swap3577 12 101 5**

# "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**

**1 2 3 4 5 6**

**42 35 7712Swap1277 101 5**

# "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**

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **42** | **35** | **12** | **77** | **101** | **5** |

**No need to swap**

# "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**

**1 2 3 4 5 6**

**42 35 12 77 1015Swap1015**

# "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**

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **42** | **35** | **12** | **77** | **5** | **101** |

## Largest value correctly placed

**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.**

# “Bubbling” All the Elements

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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** |

**1 2 3 4 5 6**

**N**

**-**

**1**

**1 2 3 4 5 6**

**1 2 3 4 5 6**

**1 2 3 4 5 6**

# Number of Comparisons

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **77** | **42** | **35** | **12** | **101** | **5** |

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **42** | **35** | **12** | **77** | **5** | **101** |

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **35** | **12** | **42** | **5** | **77** | **101** |

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **12** | **35** | **5** | **42** | **77** | **101** |

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **12** | **5** | **35** | **42** | **77** | **101** |

# ALGORITHM

* **Bubble Sort**
* **BubbleSort(DATA, N)**

•

* Repeat step 2 -3 for K:=1 to N-1
* Set PTR :=1
* Repeat While PTR≤N-K
  + If DATA[PTR] > DATA[PTR+1], then
* Interchange DATA[PTR] and DATA[PTR+1]
* [End of if structure]
  + Set PTR:= PTR+1
* [End of Step 3 loop]
* [End of Step 1 loop]
* Exit

# Putting It All Together

**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”!**

**1 2 3 4 5 6**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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

|  |
| --- |
| **8** |
| **7** |
|  |

**N did\_swap true to\_do index**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**98 23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **1** |

**N did\_swap false to\_do index**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**98 23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **1** |

**N did\_swap false to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**98 23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **1** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 98 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **2** |

**N did\_swap true to\_do index**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 98 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **2** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 98 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **2** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 98 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **3** |

**N did\_swap true to\_do index**

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| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 98 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **3** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 98 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **3** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 14 9842**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **4** |

**N did\_swap true to\_do index**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 14 9842**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **4** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |
| --- | --- | --- |
| **6** | **67** | **33** |

**23 45 14 9842**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **4** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **98** | **67** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **5** |

**N did\_swap true to\_do index**

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| --- | --- | --- | --- |
| **6** | **98** | **67** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

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| --- | --- | --- | --- |
| **6** | **98** | **67** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

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| --- | --- | --- | --- |
| **6** | **67** | **98** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **6** |

**N did\_swap true to\_do index**

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| --- | --- | --- | --- |
| **6** | **67** | **98** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **6** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **98** | **33** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **6** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **98** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **7** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **98** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **7** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **98** |

**23 45 1442**

**1 2 3 4 5 6 7 8**

# An Animated Example

|  |
| --- |
| **8** |
| **7** |
| **7** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# After First Pass of Outer Loop

|  |
| --- |
| **8** |
| **7** |
| **8** |

**N did\_swap true to\_do indexFinished first “Bubble Up”**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **1** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **1** |

**N did\_swap false to\_do index**

**No Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **2** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **2** |

**N did\_swap false to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 45 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **2** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 14 4598**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **3** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 14 4598**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **3** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **67** | **33** | **42** |

**23 14 4598**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **3** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 67** | **33** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **4** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 67** | **33** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **4** |

**N did\_swap true to\_do index**

## No Swap

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 67** | **33** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **5** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 67** | **33** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 67** | **33** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **67** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **6** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **67** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **6** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **67** | **42** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Second “Bubble Up”

|  |
| --- |
| **8** |
| **6** |
| **6** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**23 1498**

**1 2 3 4 5 6 7 8**

# After Second Pass of Outer Loop

|  |
| --- |
| **8** |
| **6** |
| **7** |

**N did\_swap true to\_do indexFinished second “Bubble Up”**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **1** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **1** |

**N did\_swap false to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**23 1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **1** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**14 2398**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **2** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**14 2398**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **2** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **45 33** | **42** | **67** |

**14 2398**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **2** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 45 33** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **3** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 45 33** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **3** |

**N did\_swap true to\_do index**

## No Swap

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 45 33** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **4** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 45 33** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **4** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 45 33** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **4** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 45** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **5** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 45** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 45** | **42** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Third “Bubble Up”

|  |
| --- |
| **8** |
| **5** |
| **5** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 42** | **45** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# After Third Pass of Outer Loop

|  |
| --- |
| **8** |
| **5** |
| **6** |

**N did\_swap true to\_do indexFinished third “Bubble Up”**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 42** | **45** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **1** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 42** | **45** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **1** |

**N did\_swap false to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **23 33 42** | **45** | **67** |

**1498**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **1** |

**N did\_swap true to\_do index**

**Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **2** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **2** |

**N did\_swap true to\_do index**

**No Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **3** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **3** |

**N did\_swap true to\_do index**

## No Swap

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **4** |

**N did\_swap true to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fourth “Bubble Up”

|  |
| --- |
| **8** |
| **4** |
| **4** |

**N did\_swap true to\_do index**

## No Swap

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# After Fourth Pass of Outer Loop

|  |
| --- |
| **8** |
| **4** |
| **5** |

**N did\_swap true to\_do indexFinished fourth “Bubble Up”**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **1** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **1** |

**N did\_swap false to\_do index**

**No Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **2** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **2** |

**N did\_swap false to\_do index**

**No Swap**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **3** |

**N did\_swap false to\_do index**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# The Fifth “Bubble Up”

|  |
| --- |
| **8** |
| **3** |
| **3** |

**N did\_swap false to\_do index**

## No Swap

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# After Fifth Pass of Outer Loop

|  |
| --- |
| **8** |
| **3** |
| **4** |

**N did\_swap false to\_do indexFinished fifth “Bubble Up”**

|  |  |  |  |
| --- | --- | --- | --- |
| **6** | **14 23 33 42** | **45** | **67** |

**98**

**1 2 3 4 5 6 7 8**

# Finished “Early”

|  |
| --- |
| **8** |
| **3** |
| **4** |

**N did\_swap false to\_do**

**We didn’t do any swapping,**

**indexso 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**

# 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**