CSE 373

APRIL 10TH – DICTIONARY ADT

ASSORTED MINUTIAE

- HW2 due Wednesday at Midnight

TODAY'S SCHEDULE

- Floyd's Algorithm examples
- Correctness proof
- Dictionary ADT

FLOYD'S METHOD

```
void buildHeap() {
  for(i = size/2; i>0; i--) {
    val  = arr[i];
    percolateDown(i,val);
    arr[hole] = val;
  }
}
```

FLOYD'S METHOD

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```

- **Review: what does this do?**
  - Size/2 – only nodes with children
  - Percolate down each of those nodes
  - How does this percolate down work?

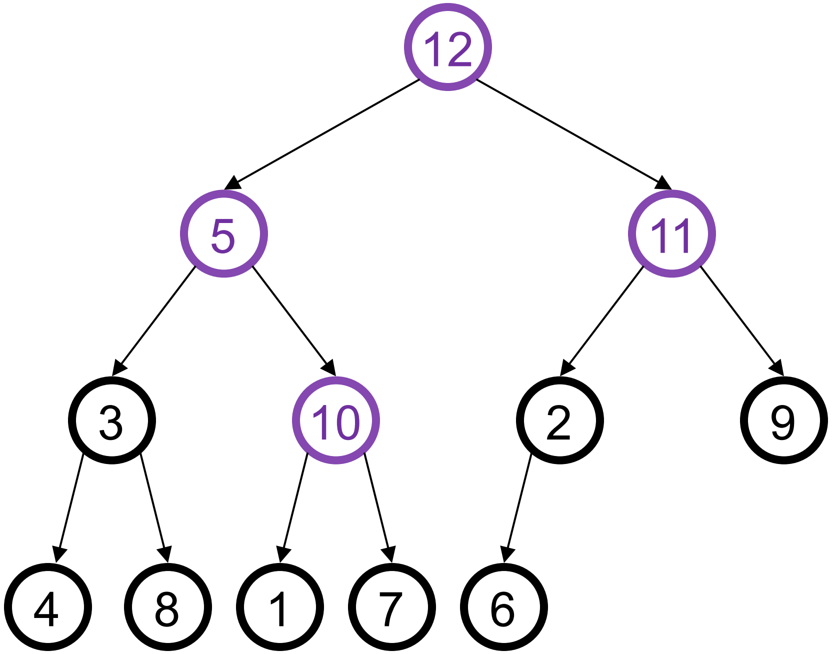
EXAMPLE

Build a heap with the values: 12, 5, 11, 3, 10, 2, 9, 4, 8, 1, 7, 6

Stick them all in the tree to make a valid structure

In tree form for readability. Notice:

- Purple for node values to fix (heap-order problem)
- Notice no leaves are purple
- Check/fix each non-leaf bottom-up (6 steps here)

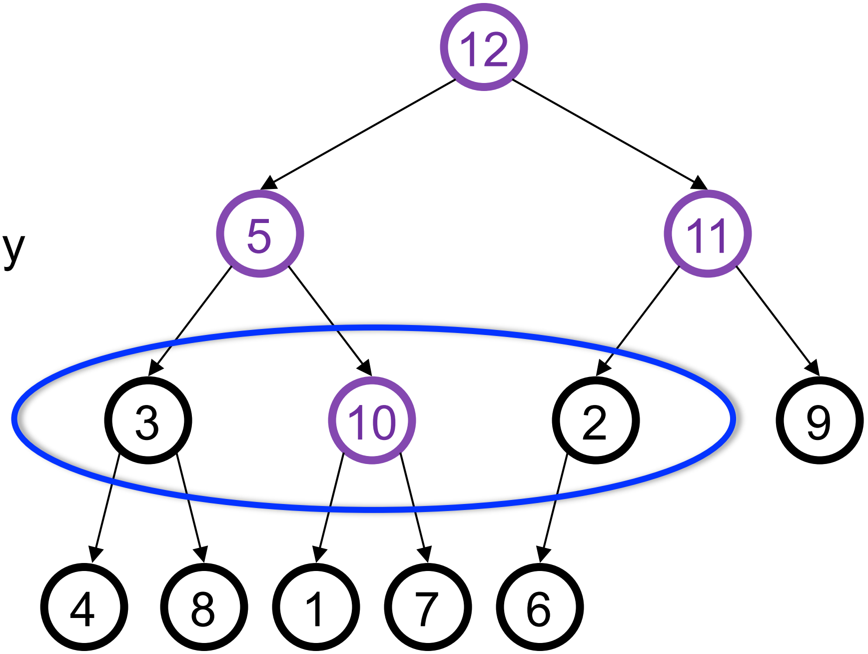


EXAMPLE

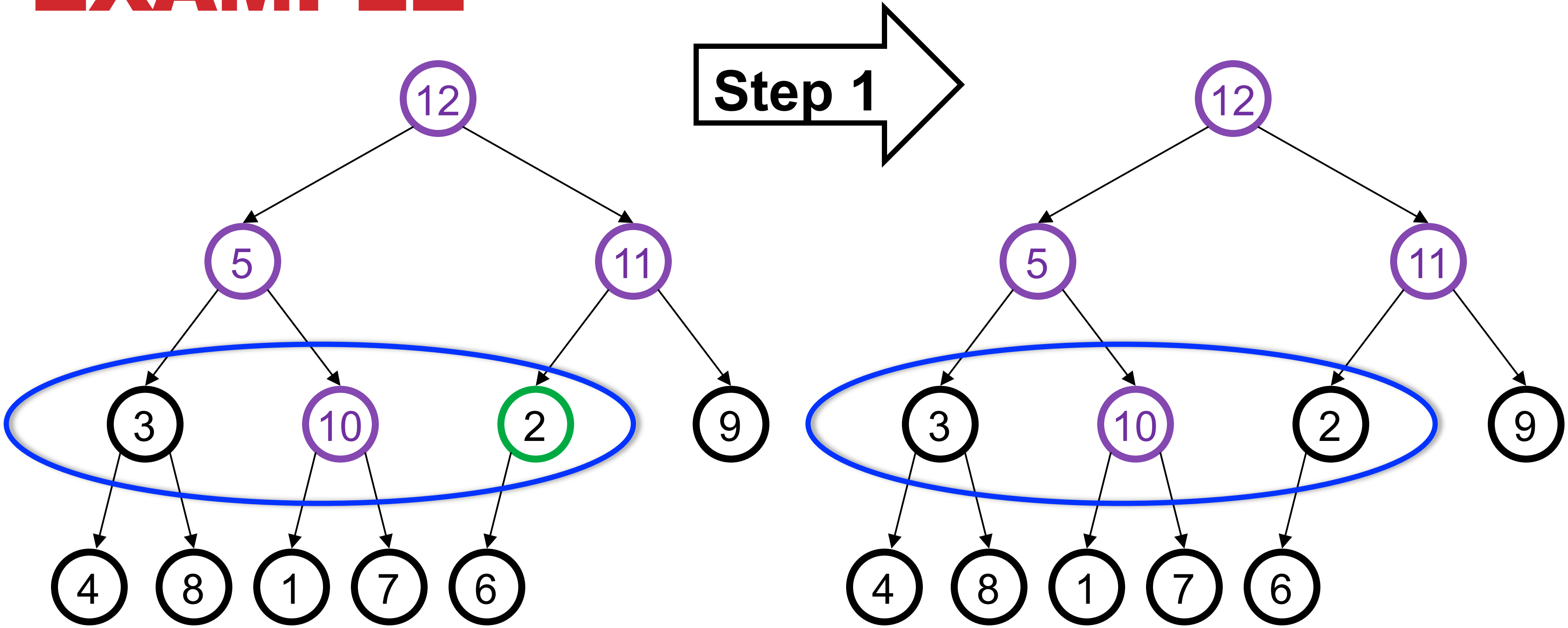
Purple shows the nodes that will need to be fixed.

We don't know which ones they are yet, so we'll traverse bottom up one level at a time and fix all the values.

Values to consider on each level circled in blue

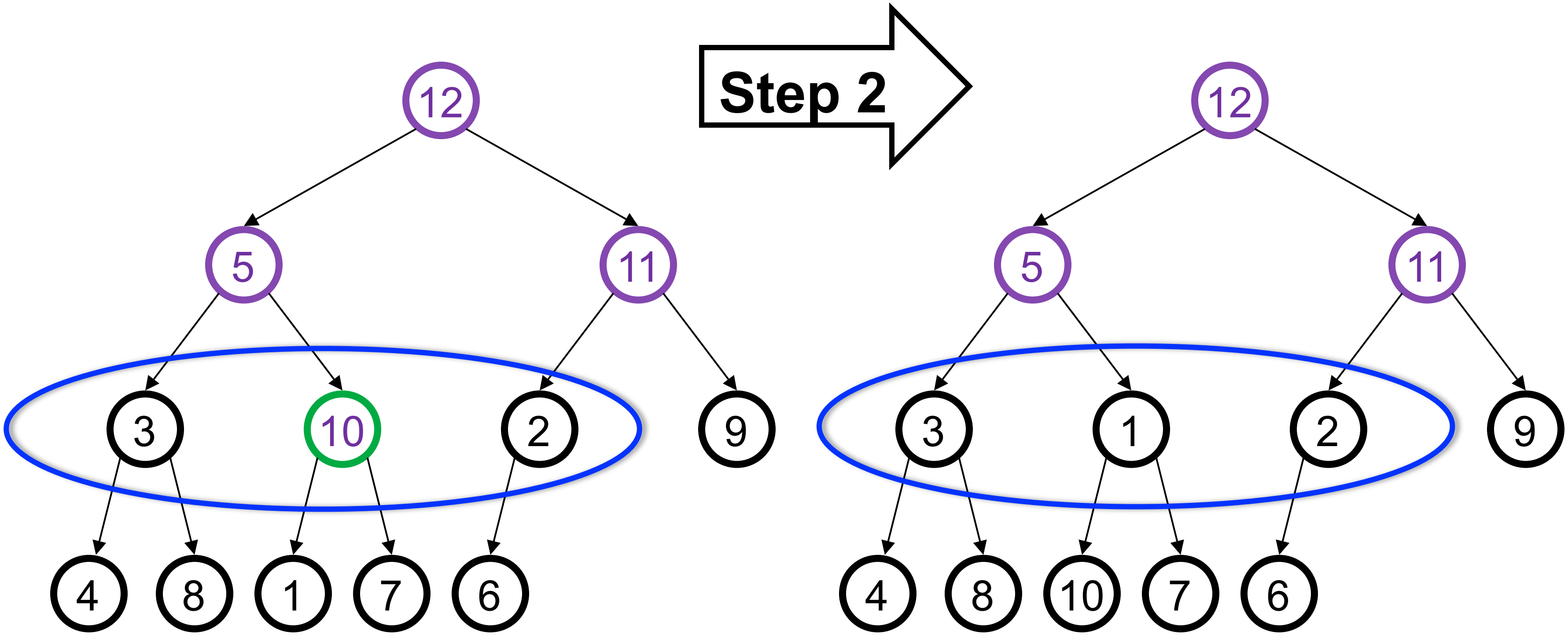


EXAMPLE



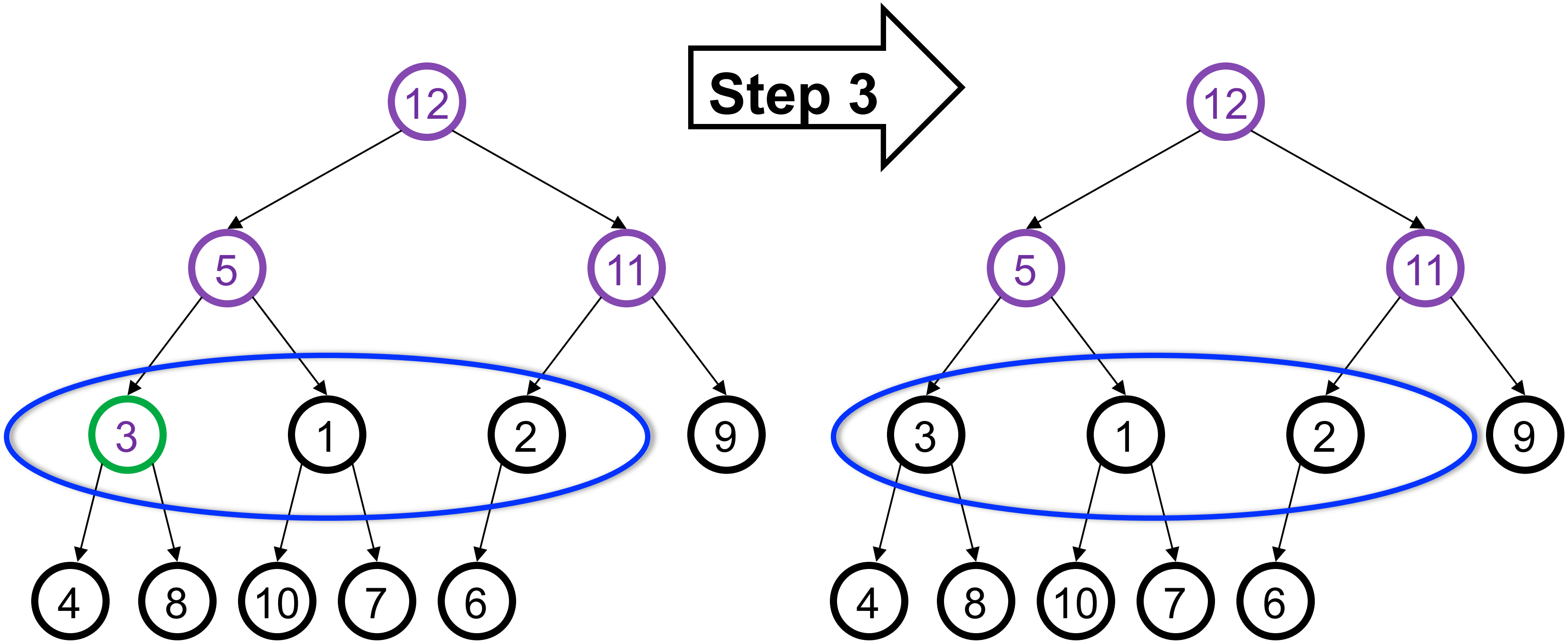
Happens to already be less than it's child

EXAMPLE



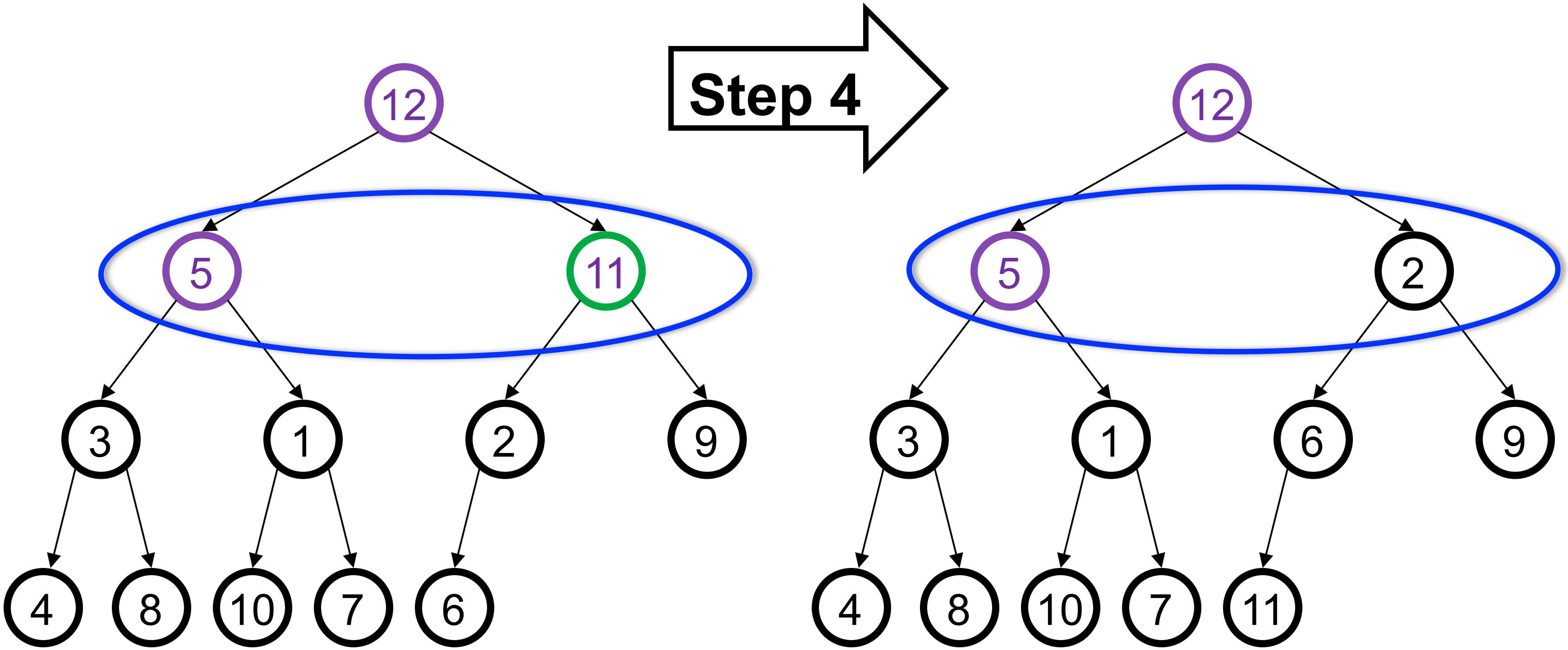
Percolate down (notice that moves 1 up)

EXAMPLE



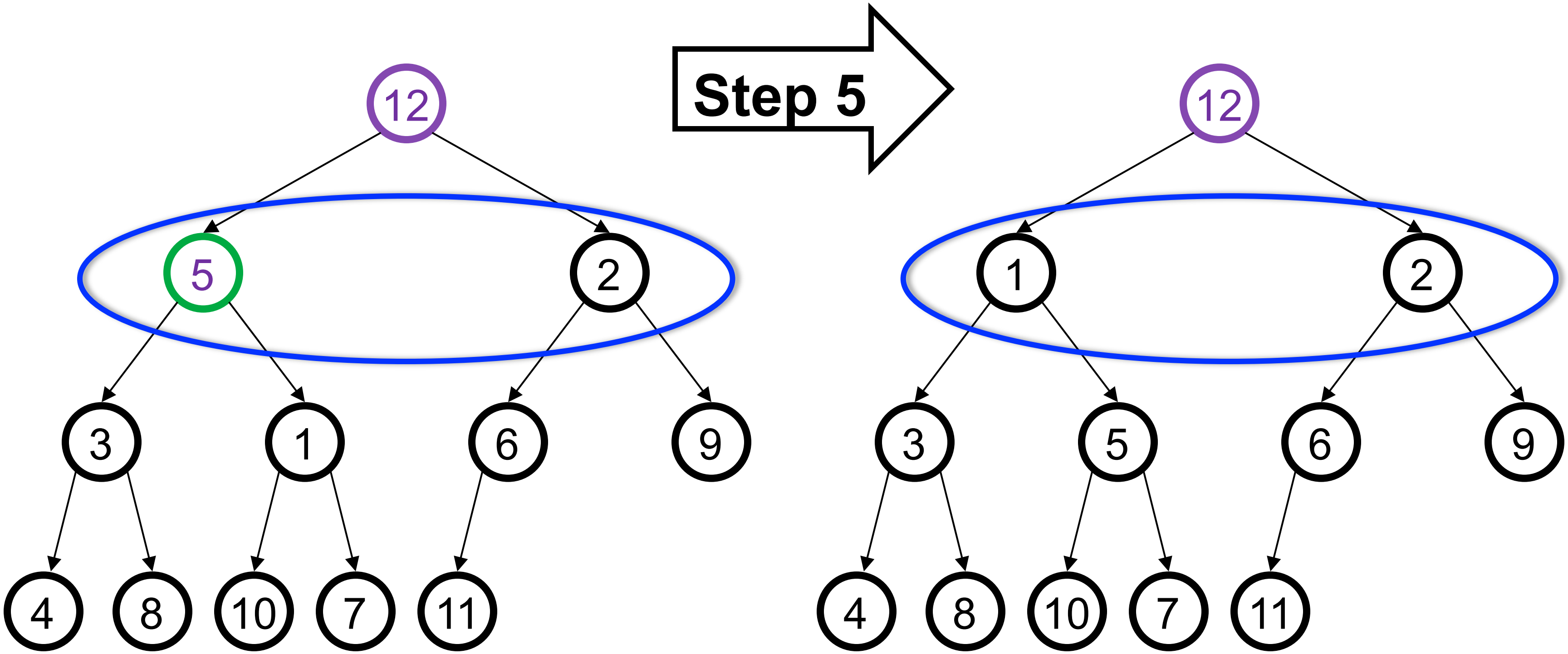
Another nothing-to-do step

EXAMPLE

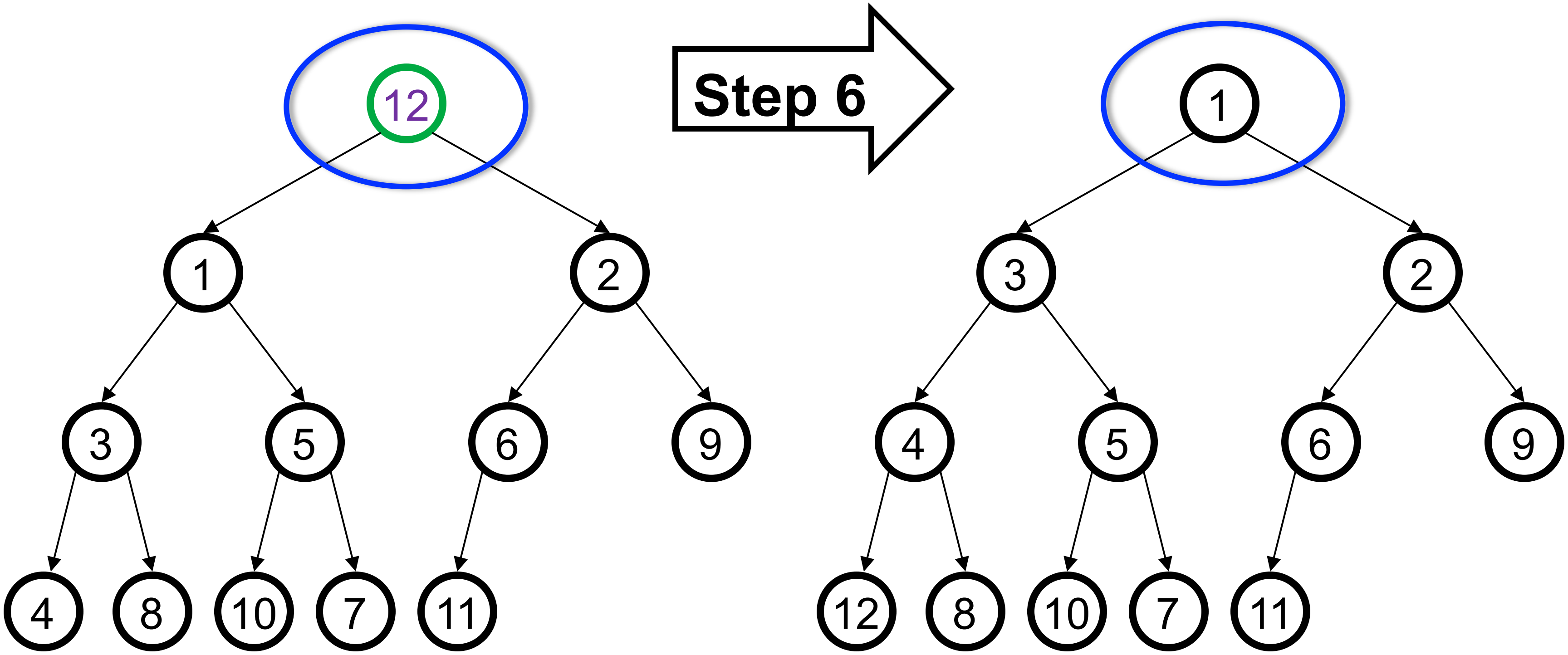


Percolate down as necessary (steps 4a and 4b)

EXAMPLE



EXAMPLE



CORRECTNESS

```
void buildHeap() {
  for(i = size/2; i>0; i--) {
    val  = arr[i];
    percolateDown(i,val);
    arr[hole] = val;
  }
}
```

- **How do we prove this works?**
  - Use inductive proof
    - Base case
      - The heap property is maintained for all elements after size/2 because they have no children
    - Step
      - When adding each element, the algorithm puts it into the right spot

CORRECTNESS

```
void buildHeap() {
  for(i = size/2; i>0; i--) {
    val  = arr[i];
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  }
}
```

- **For all elements after i, the heap property should be preserved**
  - This is why we can start at size/2
- **percolateDown() ensures that each new element goes to the right place**
- **Once a loop has gotten to a node, the smallest elements are at the top of their subtrees.**

LESSONS FROM BUILDHEAP

Without `buildHeap`, our ADT already let clients implement their own in *O*(*n* `log` *n*) worst case

- Worst case is inserting better priority values later

By providing a specialized operation internal to the data structure (with access to the internal data), we can do *O*(*n*) worst case

- Intuition: Most data is near a leaf, so better to percolate down

Can analyze this algorithm for:

- Correctness and Efficiency:
  - First analysis easily proved it was O(*n* `log` *n*)
  - Tighter analysis shows same algorithm is *O*(*n*)

LESSONS FROM BUILDHEAP

- **Should all priority queues support buildHeap()?**
  - No downside to implementation
  - Faster than `O(n log n)` naïve approach
  - Not required for HW 2, but is commonly implemented

HEAPS

- **What to know**
  - How to implement all functions
  - How to analyze all functions
  - Understand the benefits of array implementation
  - Types of client problems
    - Hospitals, server scheduling, etc…

DICTIONARY ADT

- **New abstract data type**
  - Dictionary (aka Map)
  - Data – Key and Value pairs
    - Keys: must be comparable, used for lookup
    - Values: the actual data itself
  - Example (Store inventory):
    - Keys: IDs (barcodes)
    - Values: Product information

DICTIONARY ADT

- **Operations**
  - `insert(key, value):` inserts the key, value pair into the dictionary
  - `find(key)`: returns the stored value for a particular key in the dictionary, returns null if not found.
  - `delete(key)`: removes the key value pair specified by the given key from the dictionary. In this course you may assume unique keys.

SET ADT

- **Slightly different from Dictionary**
- **No values, the set only cares if a key is present or not**
- **Find, insert and delete have few differences**
- **Possible to implement other functions from sets**
  - Union, intersection, difference

APPLICATIONS

- **Store information in key, value pairs**
  - Very common usage pattern
    - Phone directories
    - Indexing
    - OS page tables
    - Databases

IMPLEMENTATIONS

- **Important to allow fast operations over the keys**
  - Dependent on what the client uses most
  - Could be many lookups and few inserts
- **Keys and Values should be stored together in some way**
  - Both objects in one node
  - Paired arrays (one stores keys and the other values)

IMPLEMENTATIONS

- **Simple implementations**

	`insert`	`find`	`delete`
Unsorted linked-list	*O(1)**	*O(n)*	*O(n)*
Unsorted array	*O(1)**	*O(n)*	*O(n)*
Sorted linked list	*O(n)*	*O(n)*	*O(n)*
Sorted array	*O(n)*	*O(log n)*	*O(n)*

* Unless we need to check for duplicates

IMPLEMENTATIONS

- **Other implementations**
    - Binary Search Trees
    - Hashtables

NEXT CLASS

- Trees and traversals
- BST Dictionaries
- Analysis and tree balance