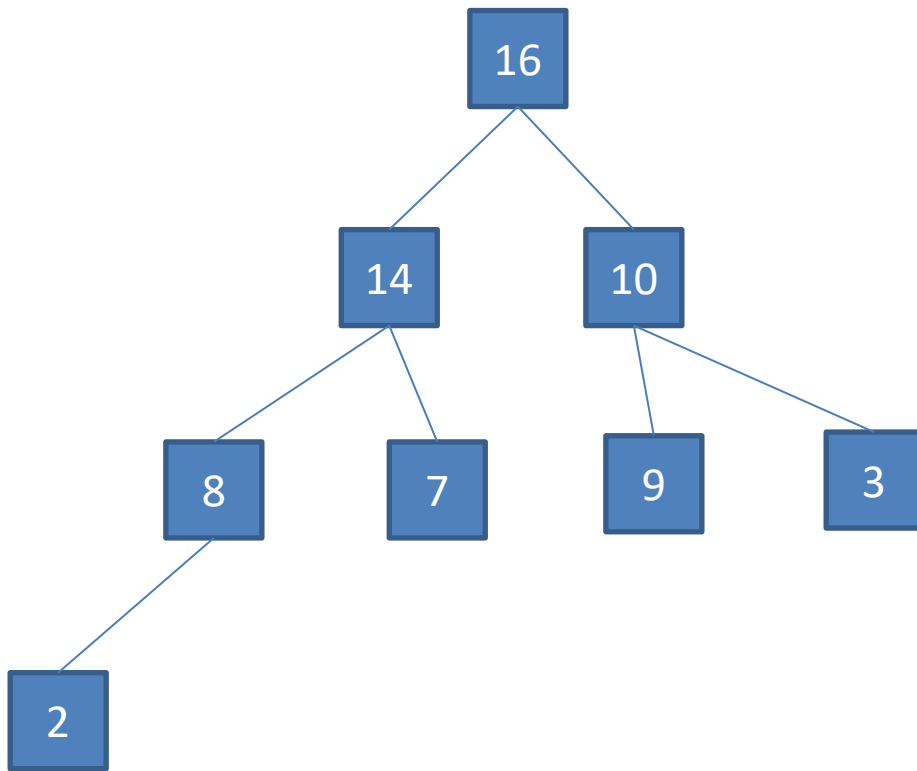


# Heapsort Example



**HEAP-SORT** (A):

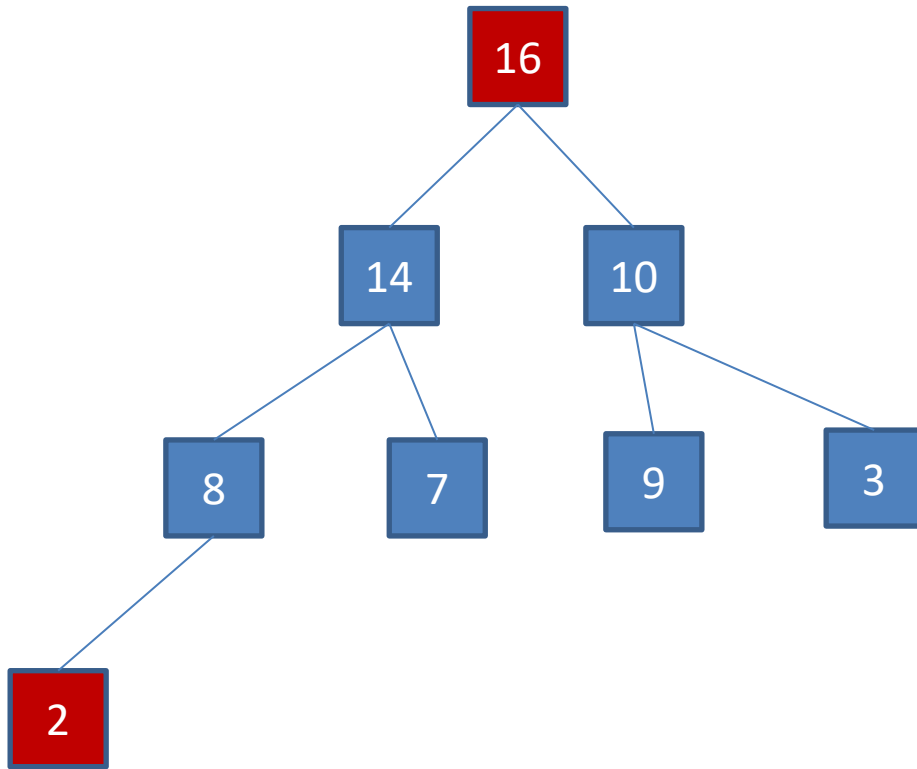
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

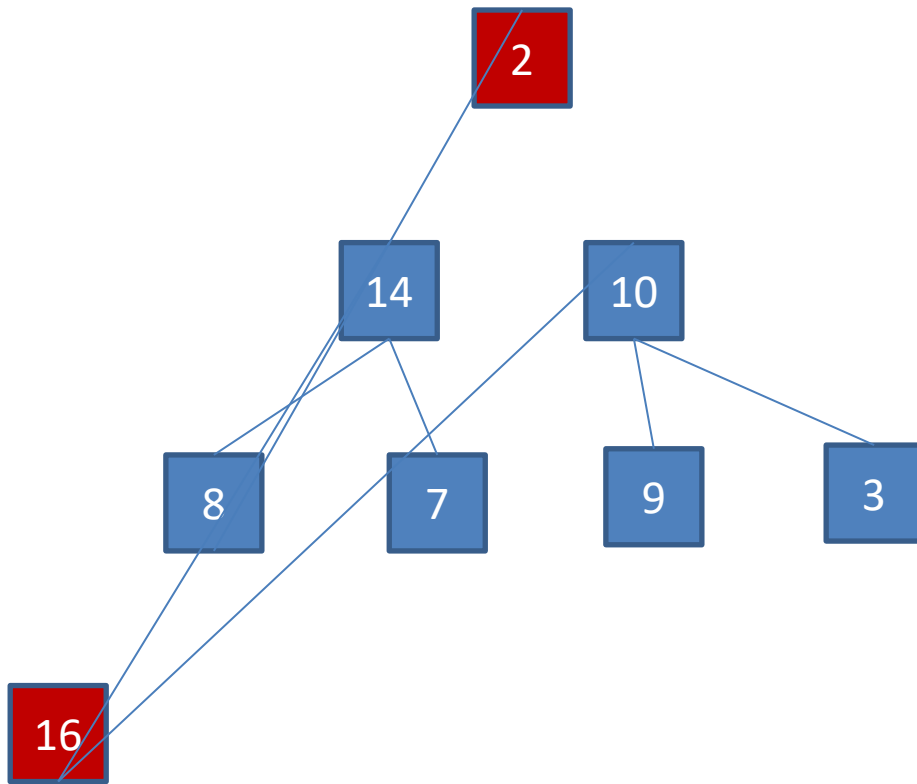
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

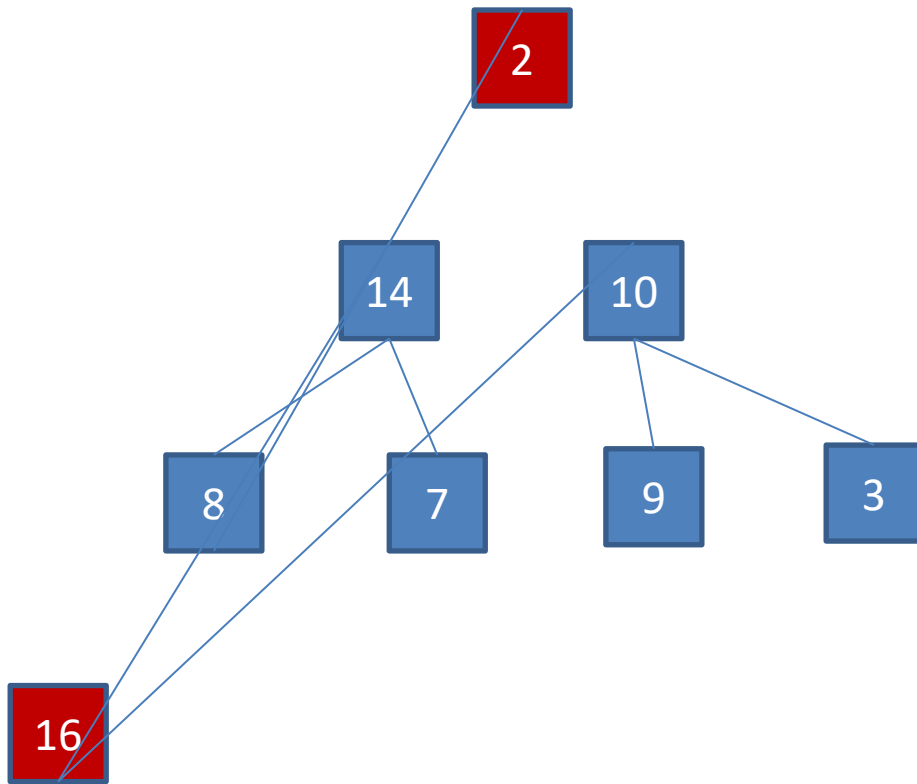
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i = A$ 's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

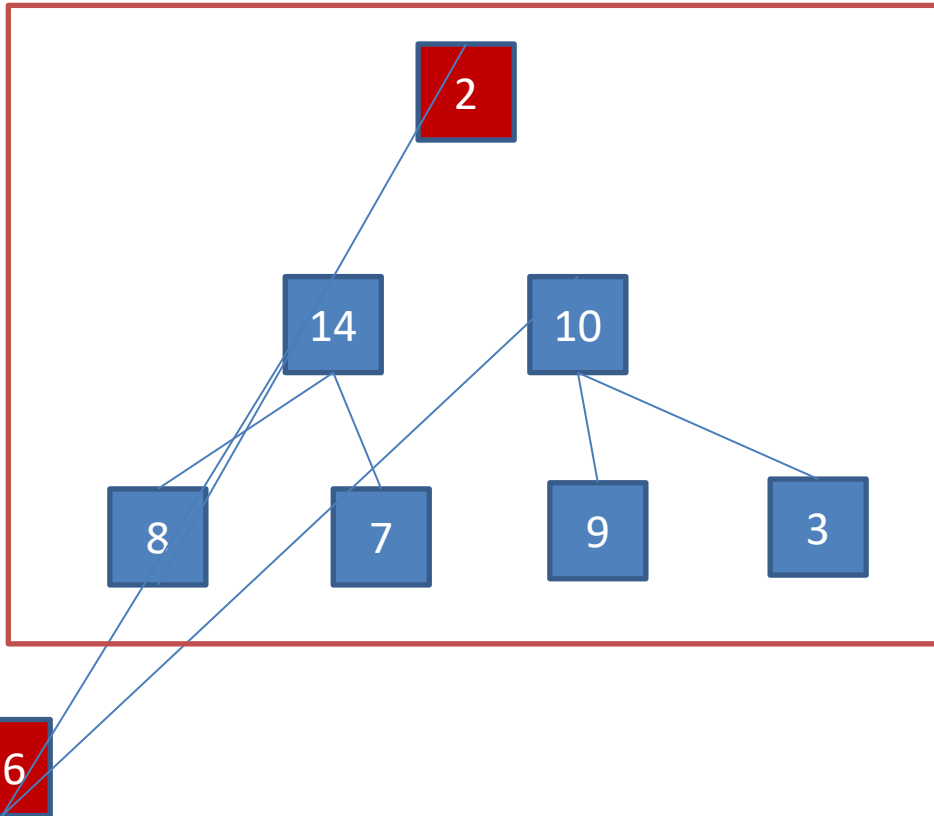
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
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     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

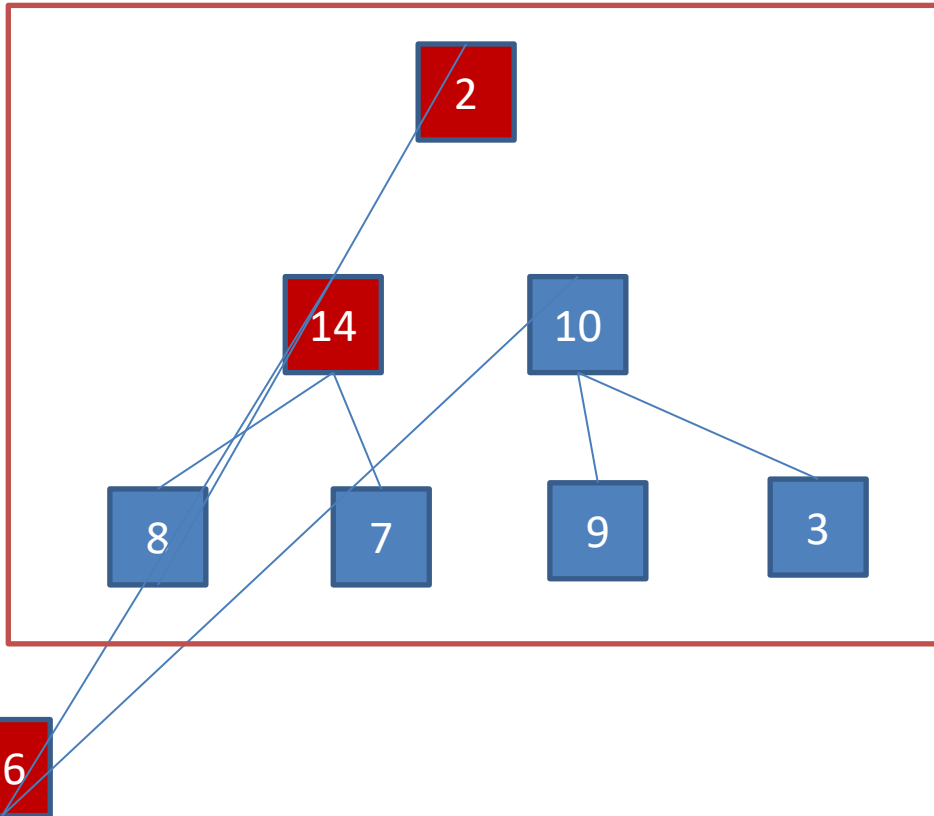
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

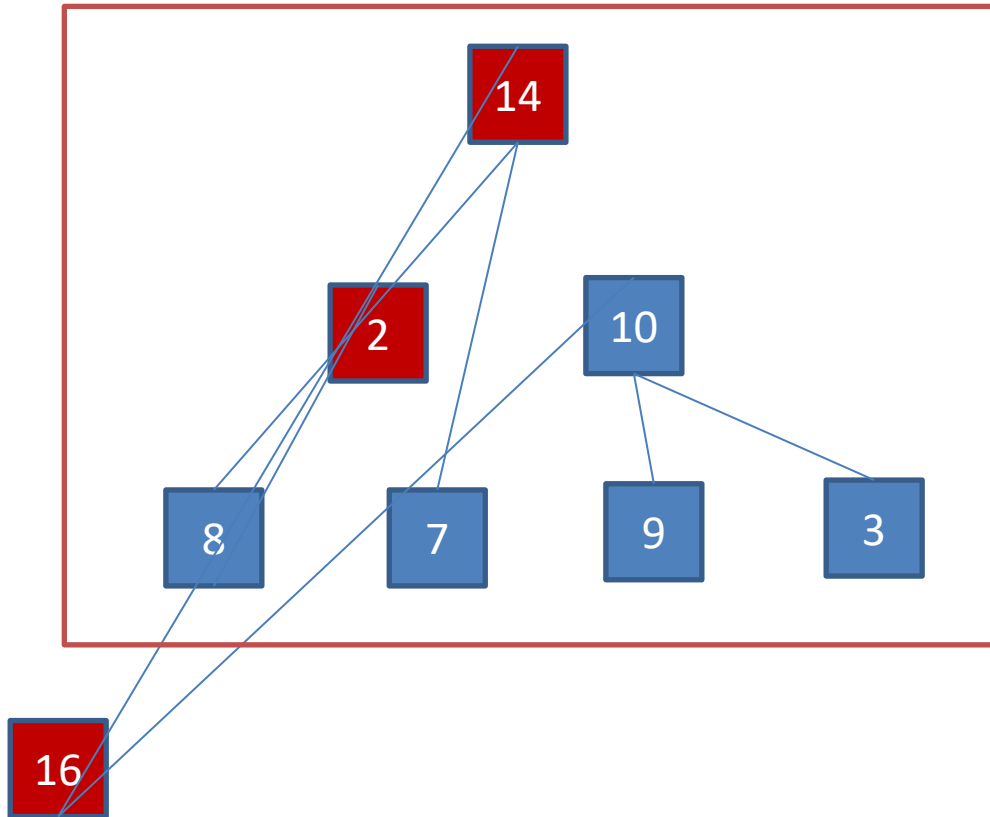
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

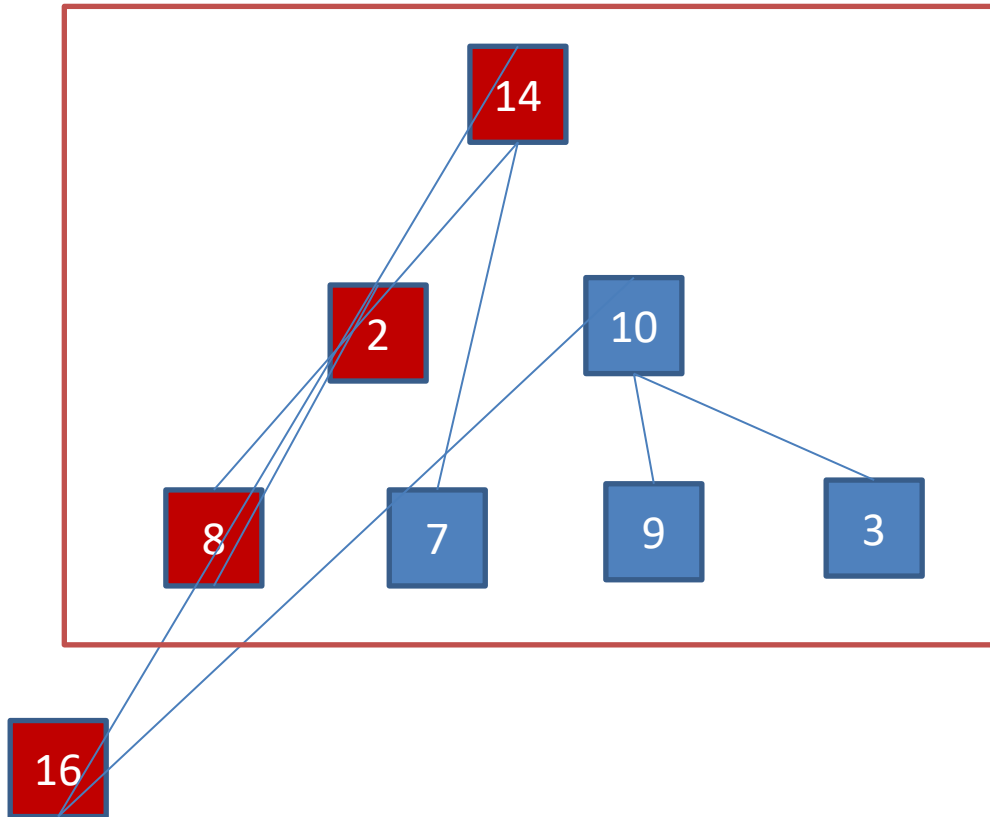
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

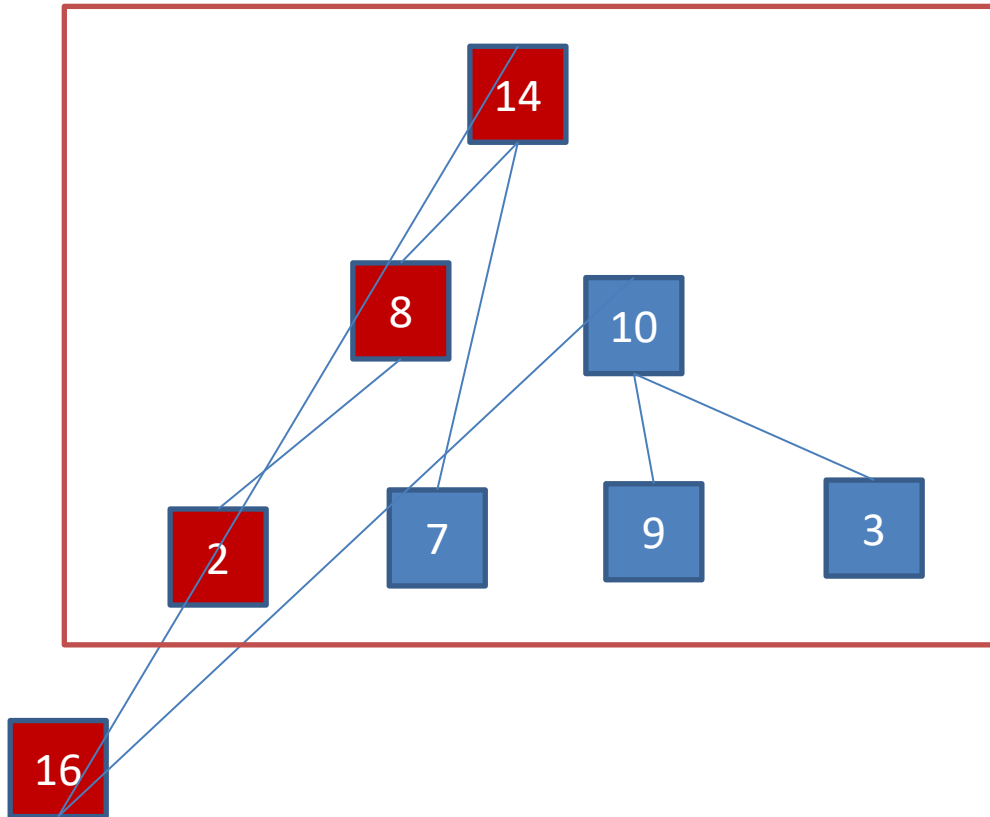
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

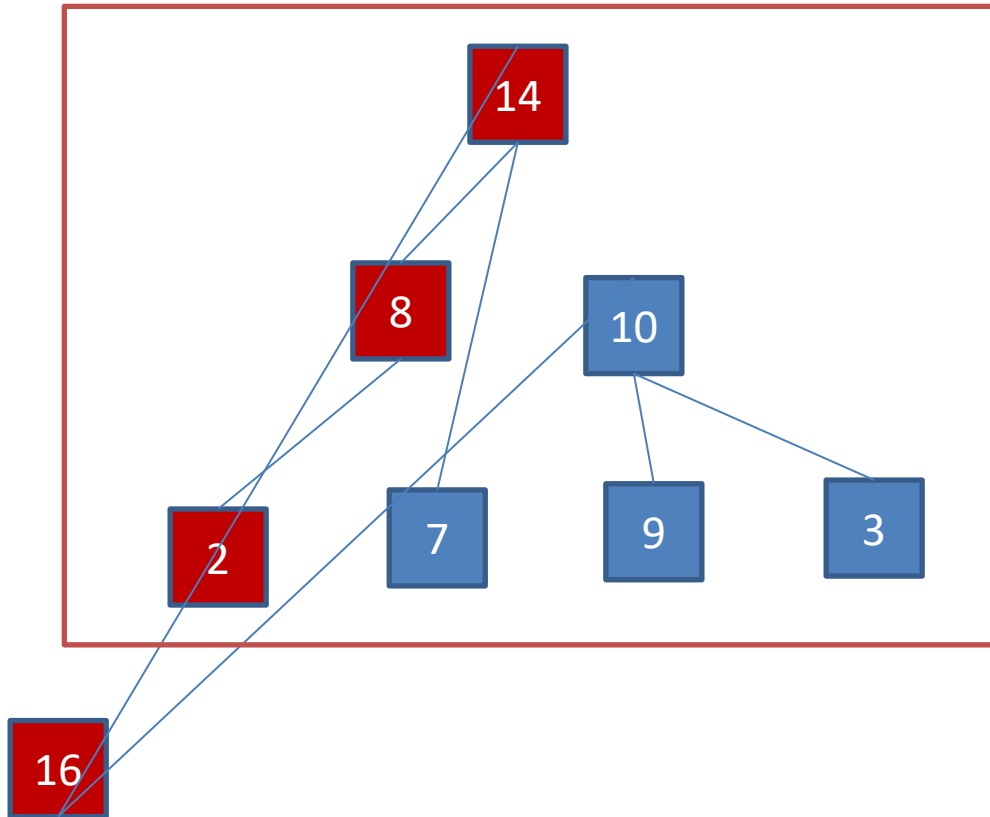
1. **BUILD-MAX-HEAP**(A)
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

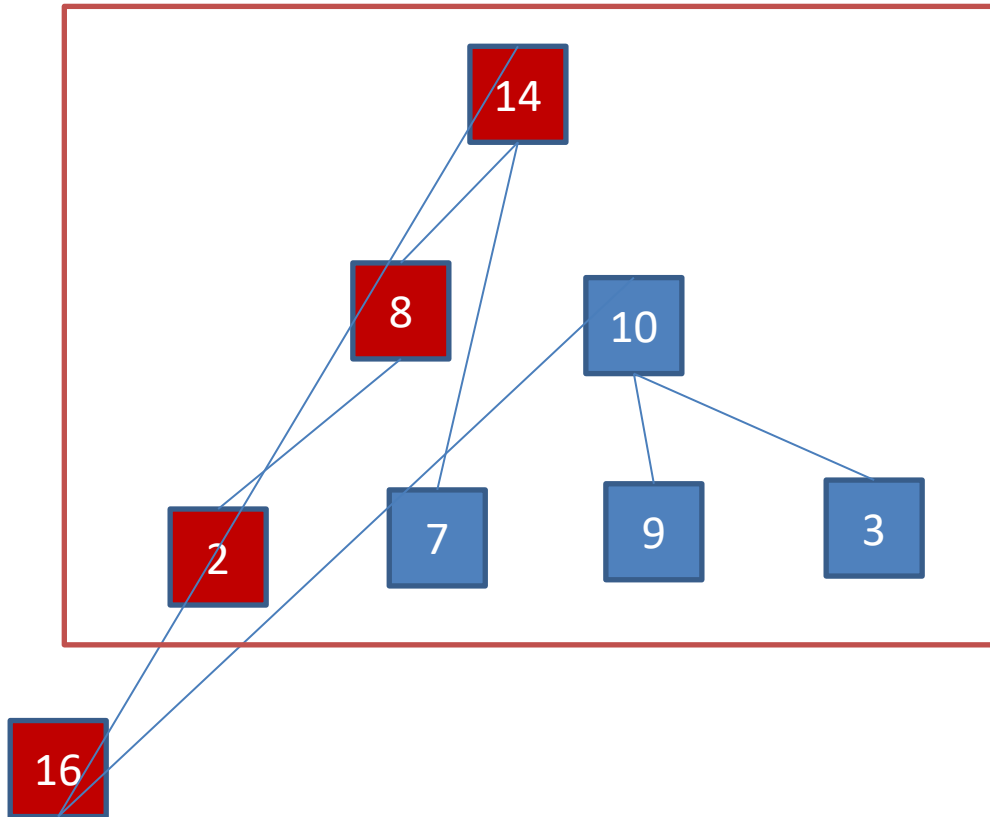
1. **BUILD-MAX-HEAP**(A)
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

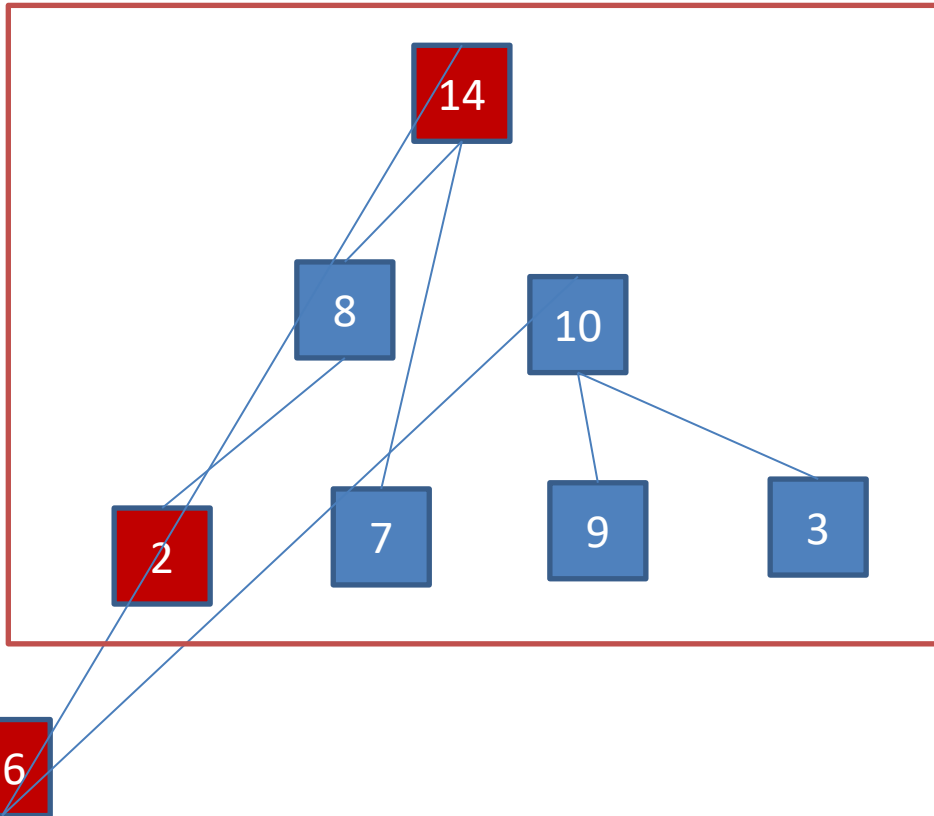
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

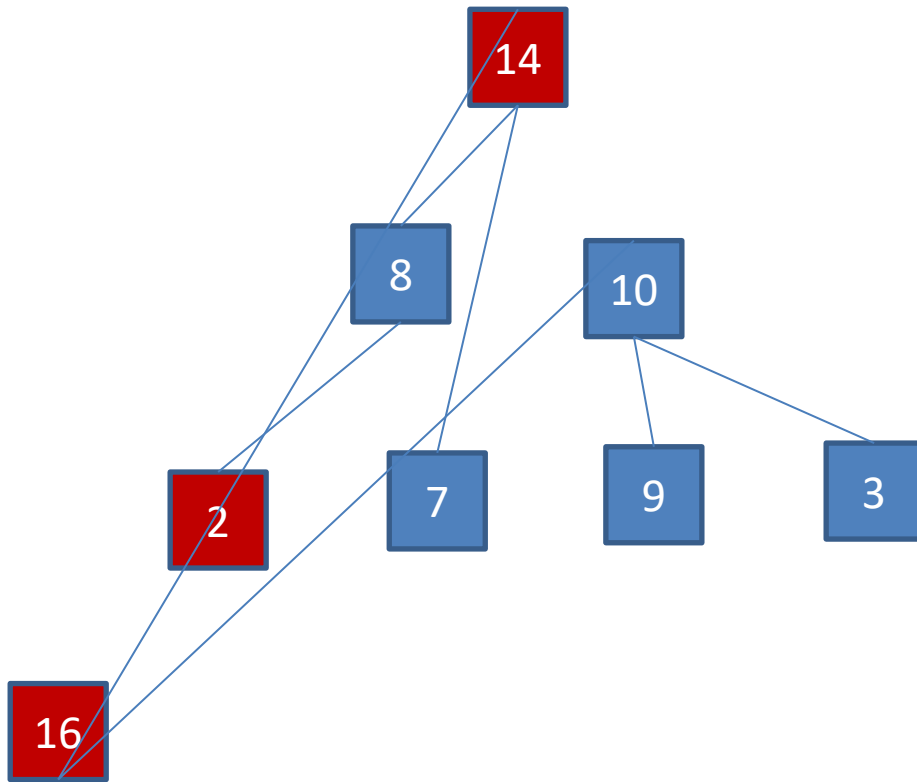
1. **BUILD-MAX-HEAP**(A)
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}



# Heapsort Example



**HEAP-SORT** (A):

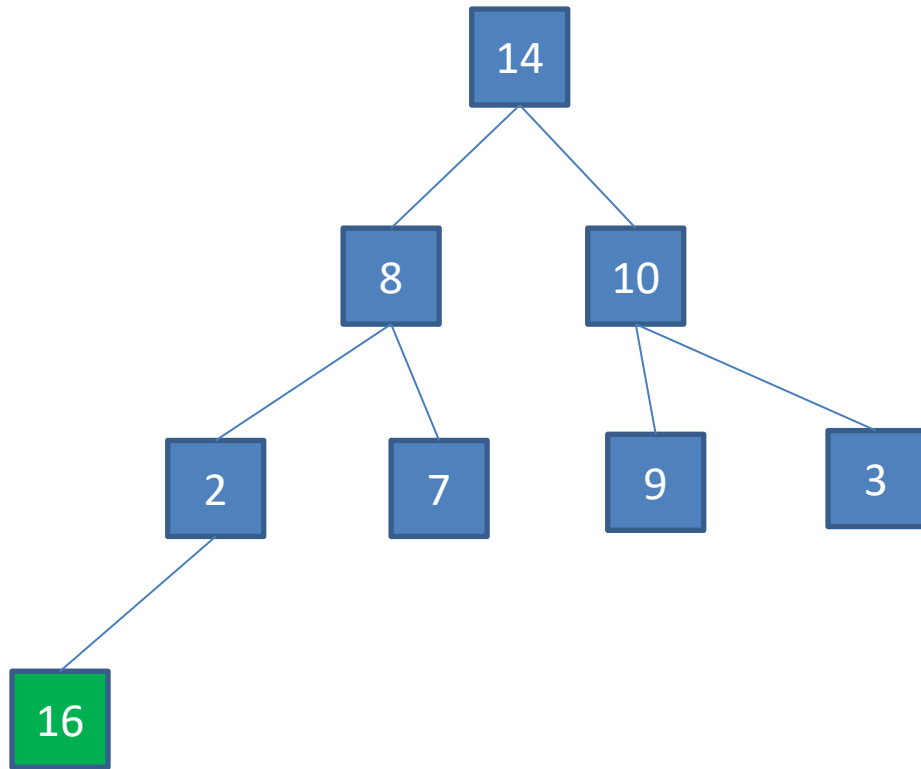
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
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# Heapsort Example



**HEAP-SORT** (A):

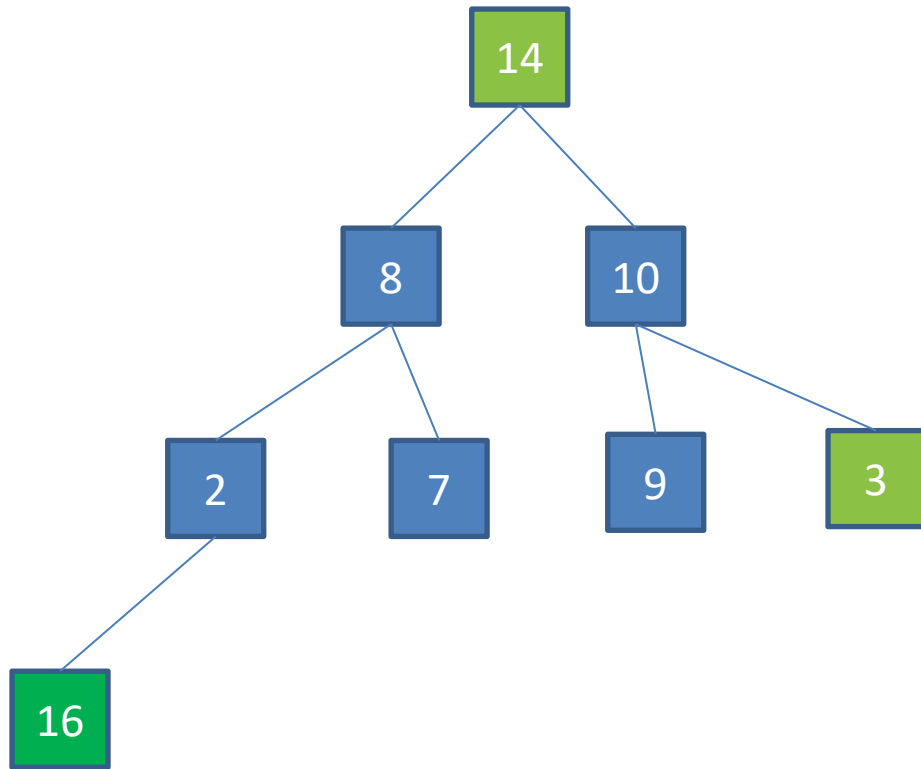
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

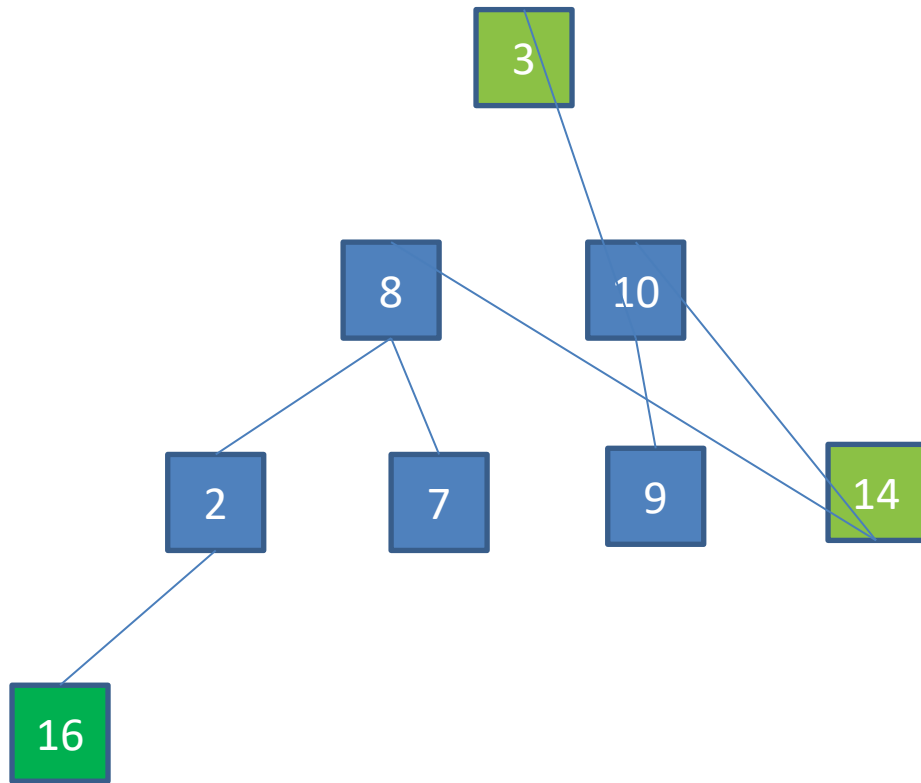
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

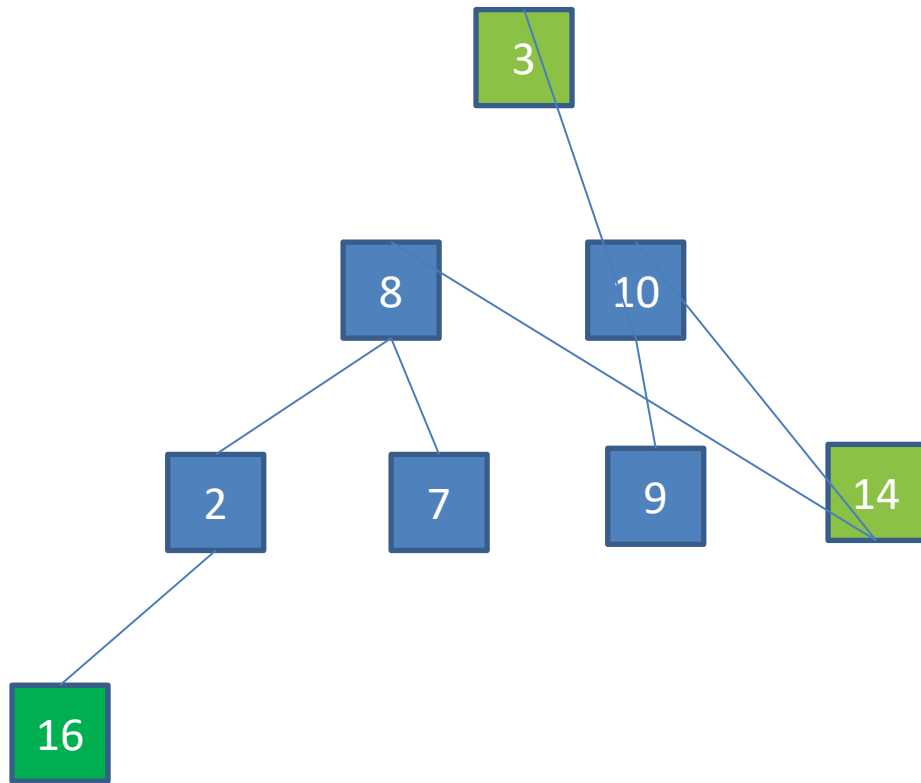
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

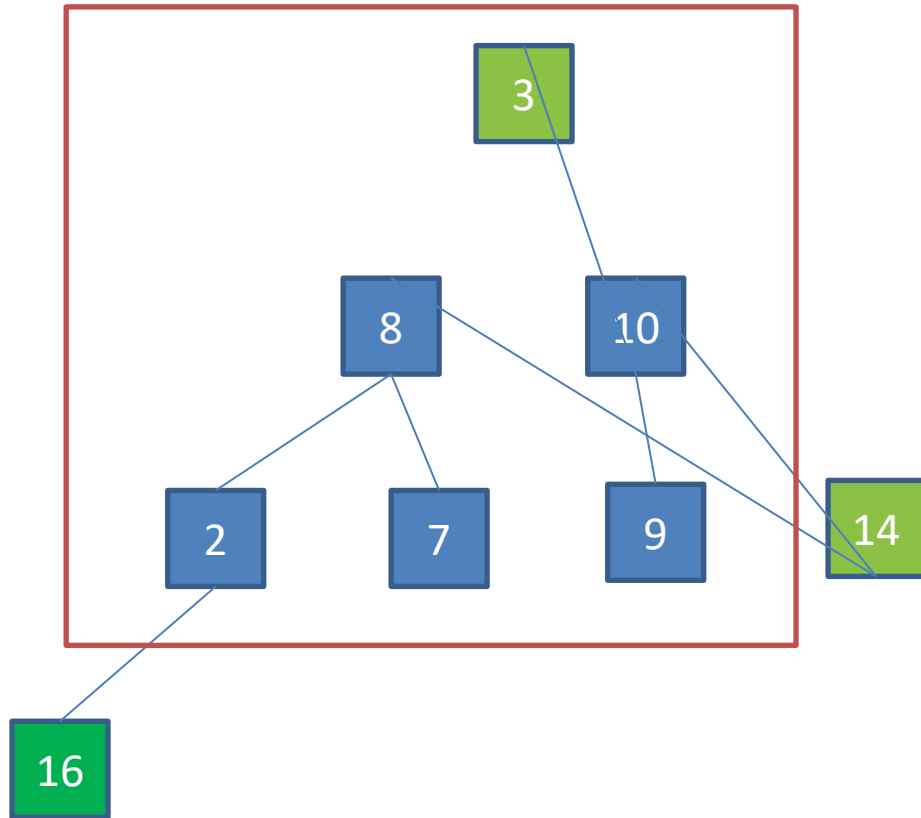
1. **BUILD-MAX-HEAP**(A)
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
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}



# Heapsort Example



**HEAP-SORT** (A):

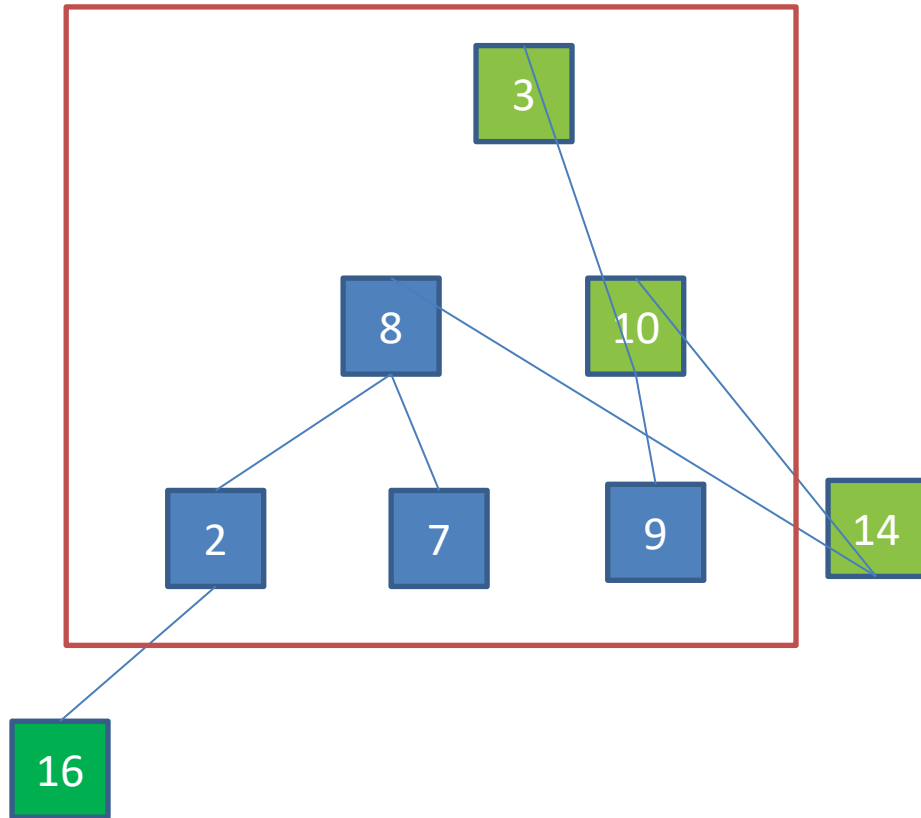
1. **BUILD-MAX-HEAP**(A)
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}



# Heapsort Example



**HEAP-SORT** (A):

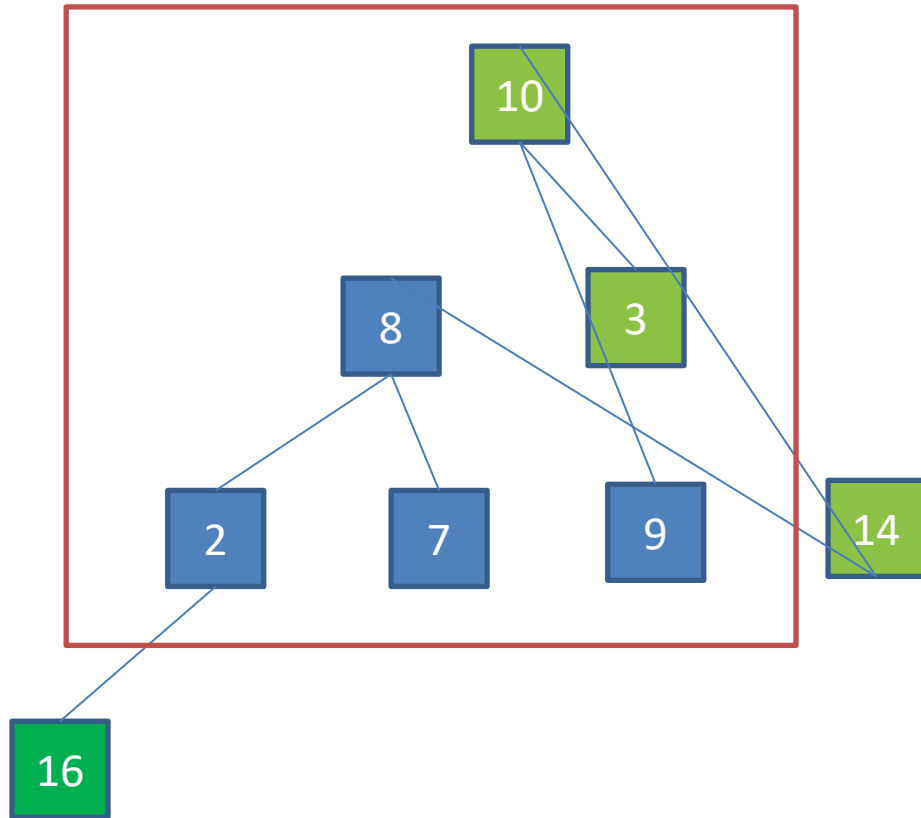
1. **BUILD-MAX-HEAP**(A)
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    Exchange  $i$  with the largest node  
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}



# Heapsort Example



**HEAP-SORT** (A):

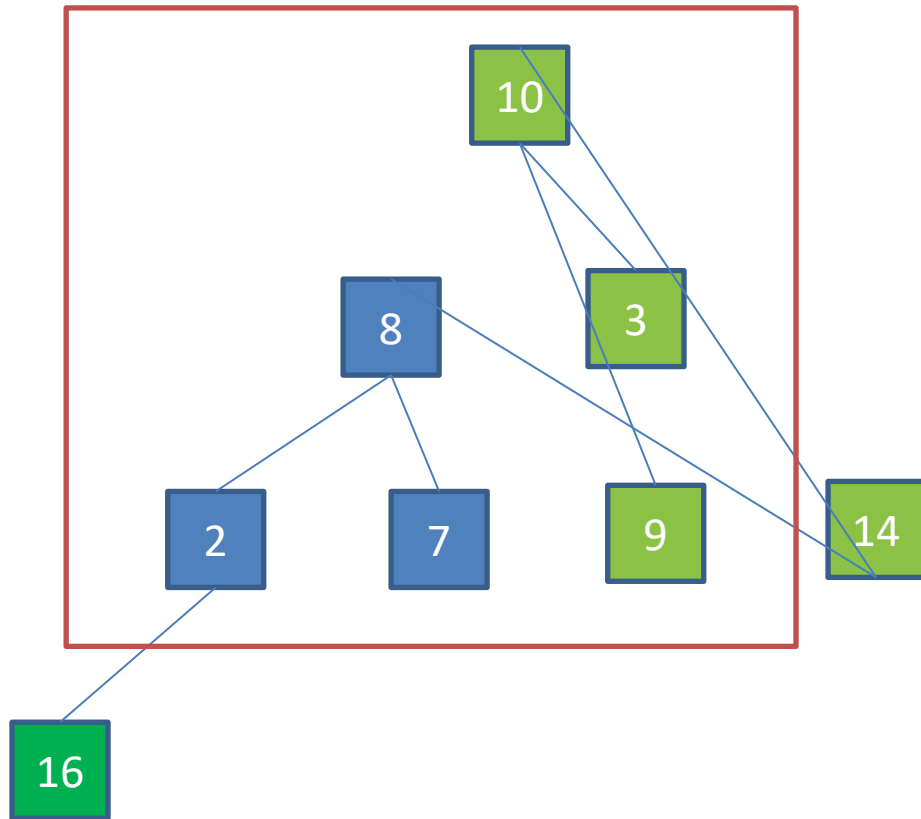
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2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

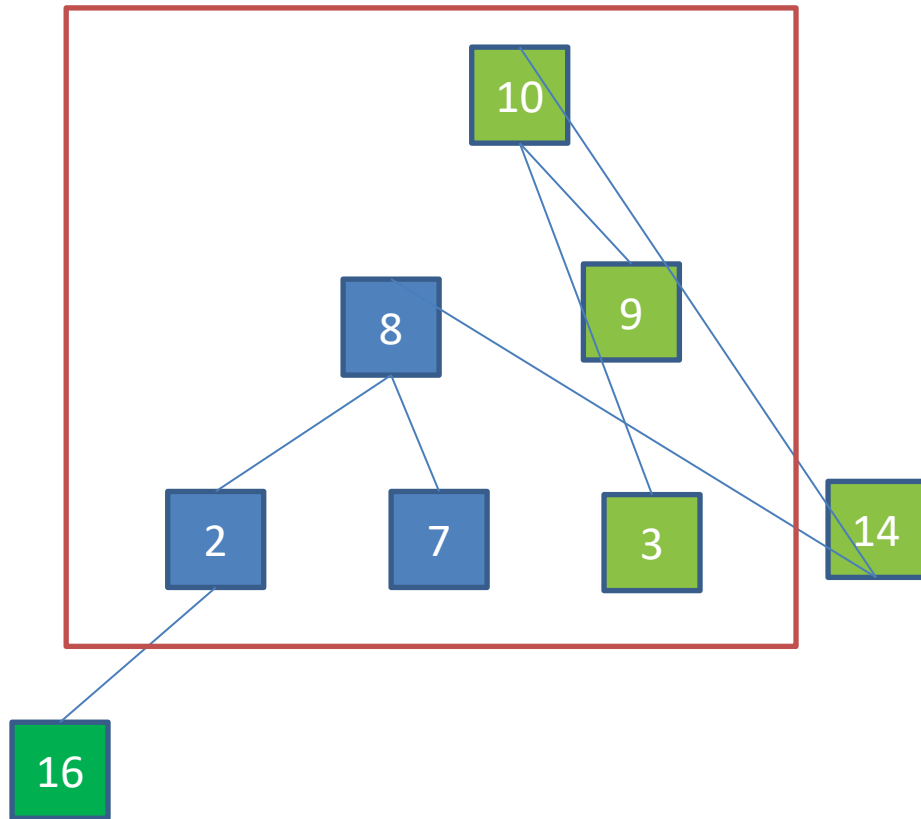
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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}



# Heapsort Example



**HEAP-SORT** (A):

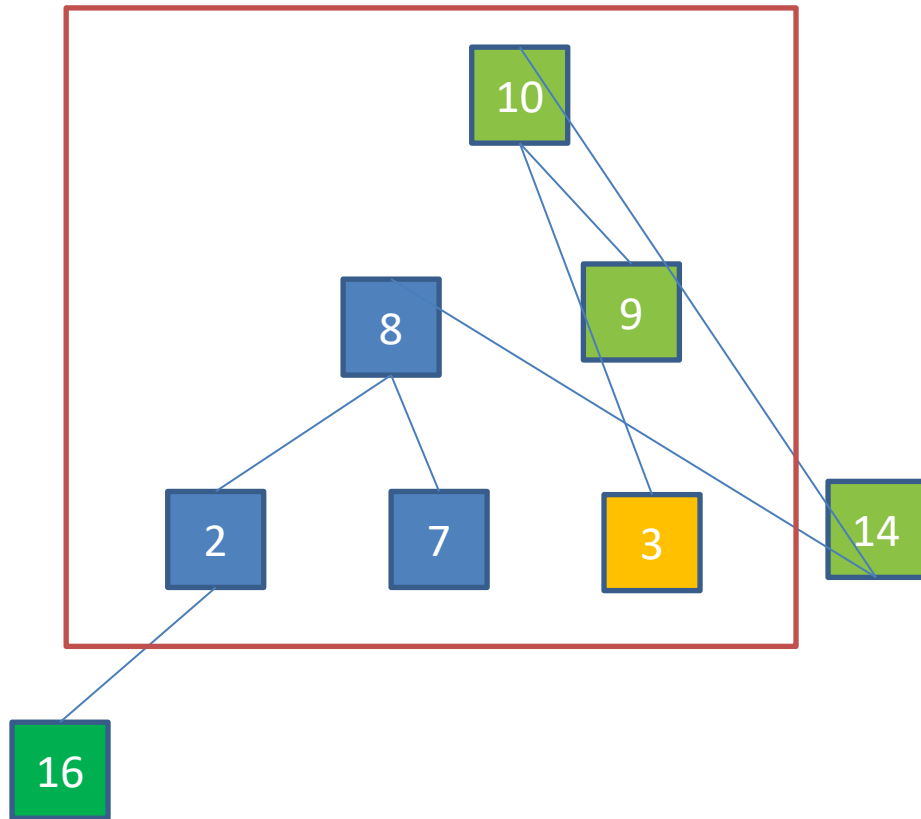
1. **BUILD-MAX-HEAP**(A)
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

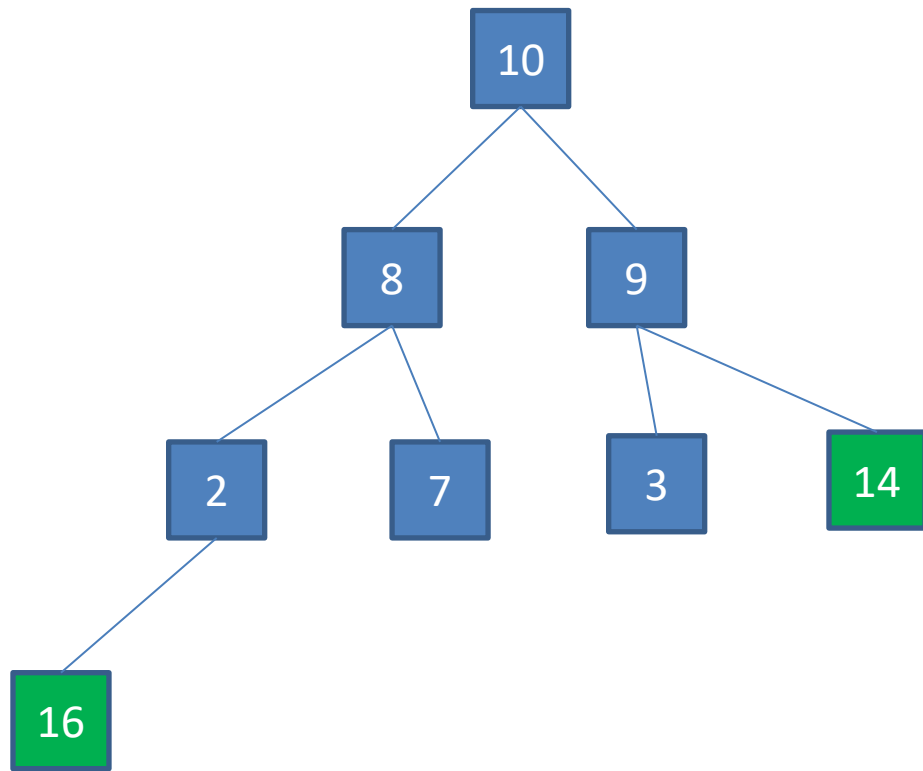
1. **BUILD-MAX-HEAP**(A)
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

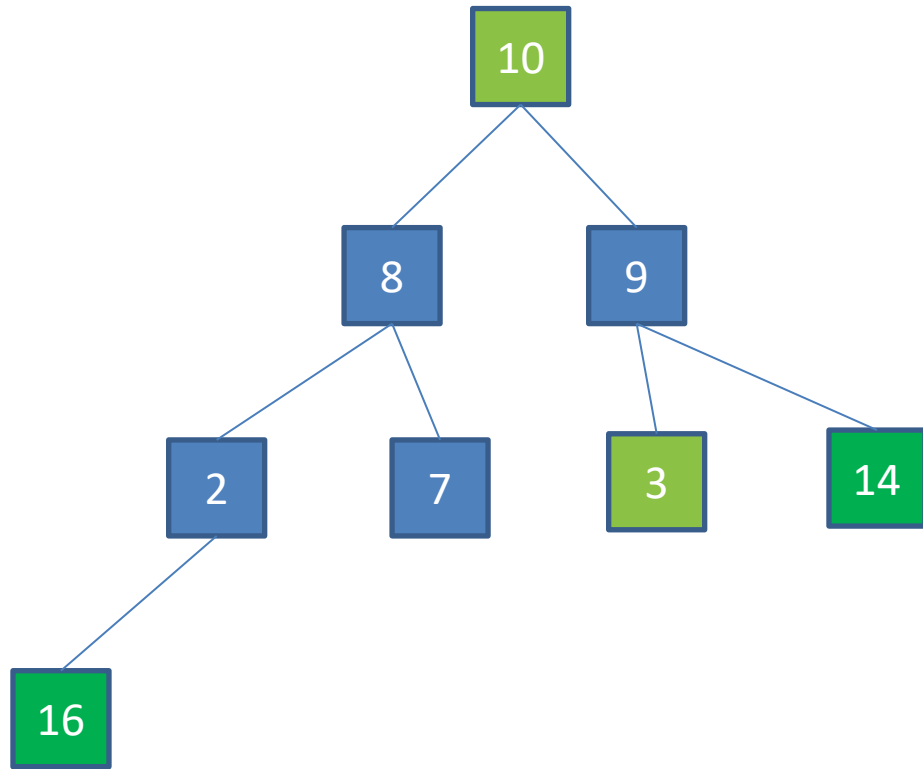
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

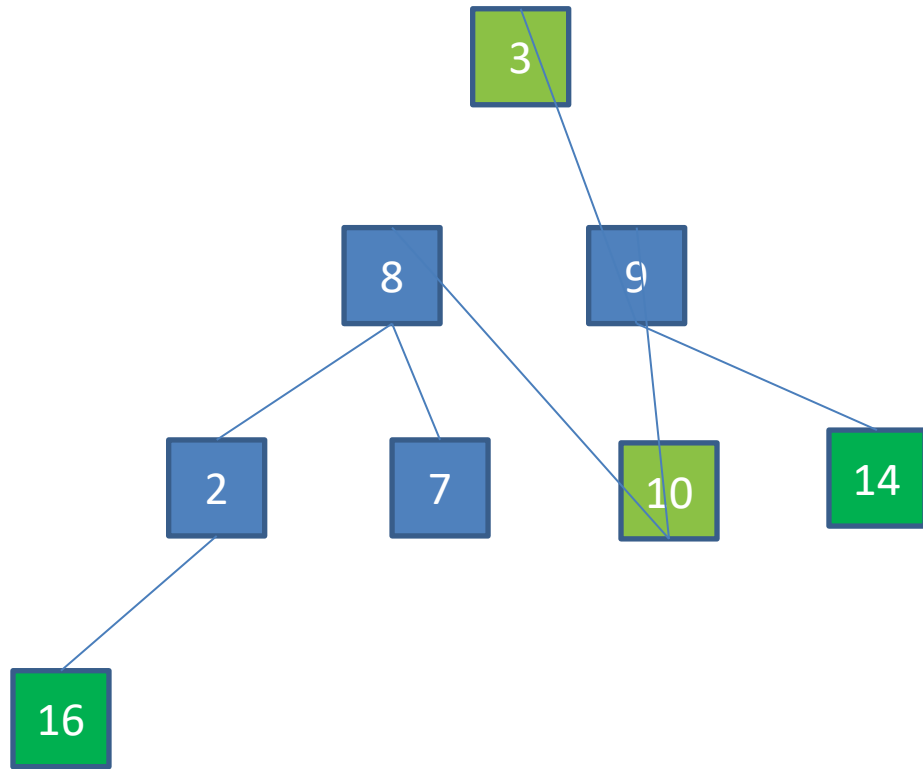
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

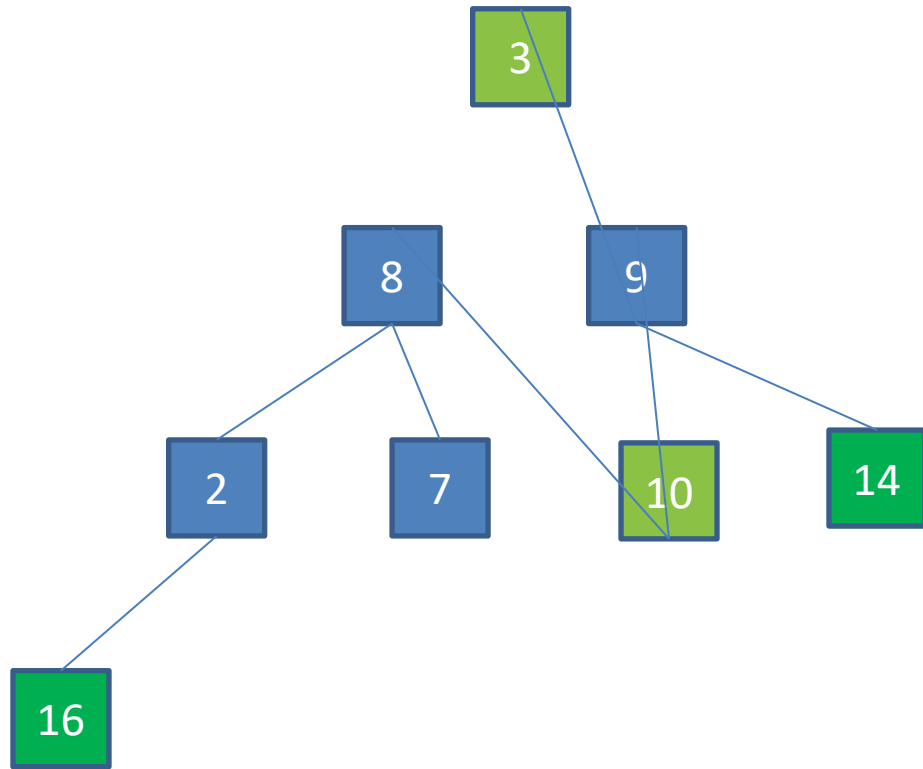
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

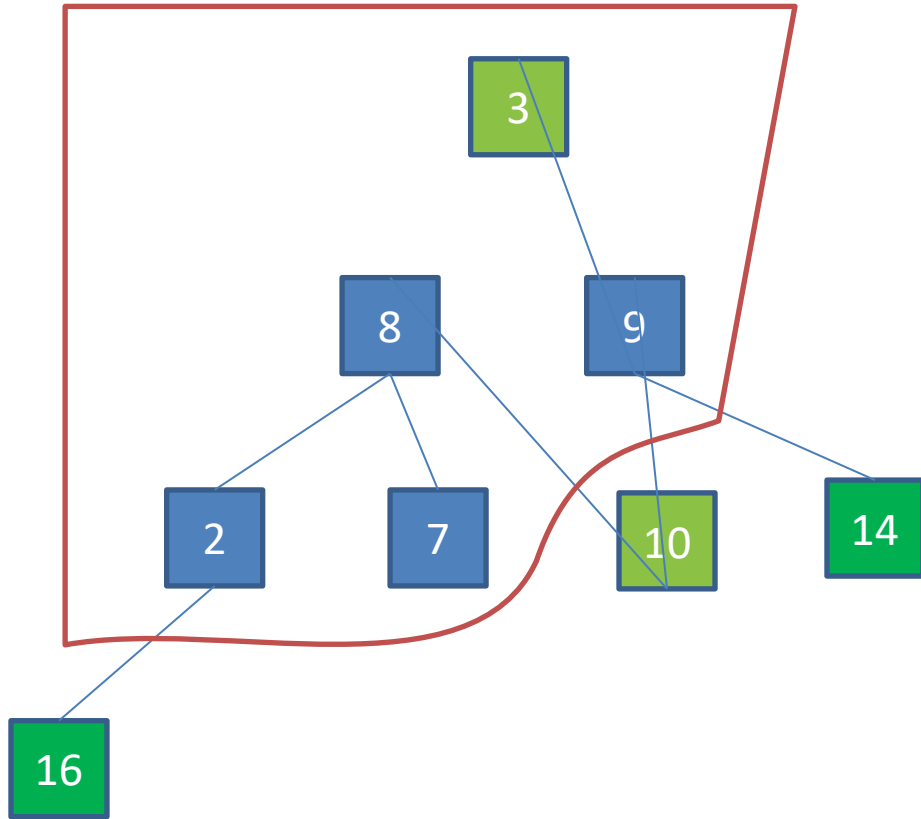
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

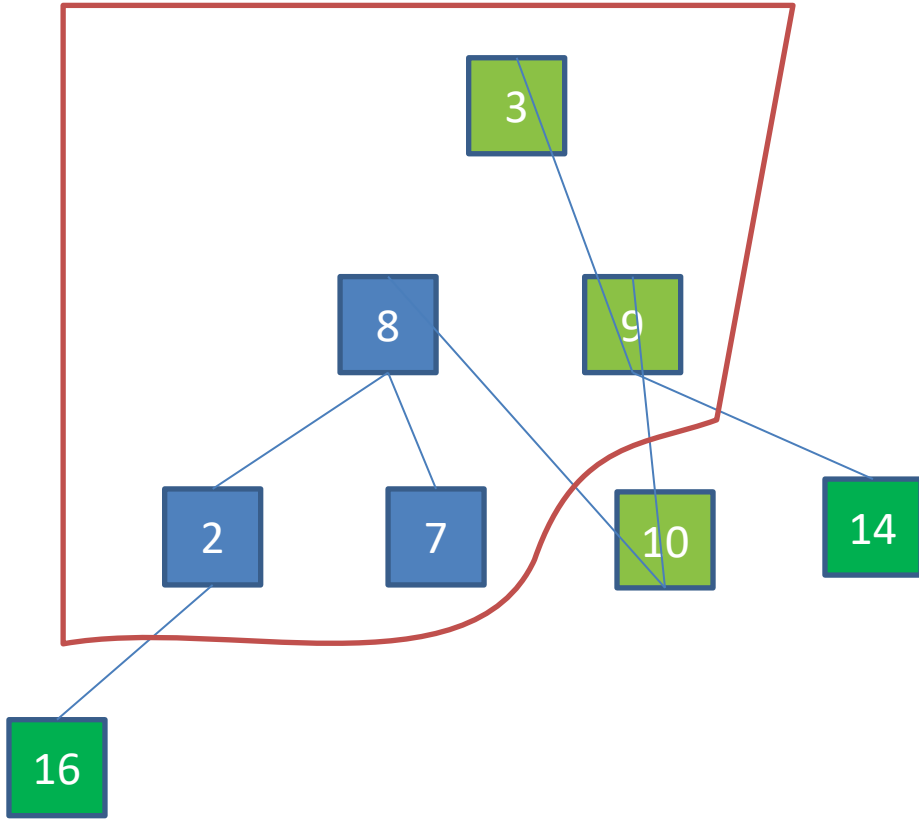
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



## HEAP-SORT (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i = A$ 's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

## MAX-HEAPIFY (A, i, t)

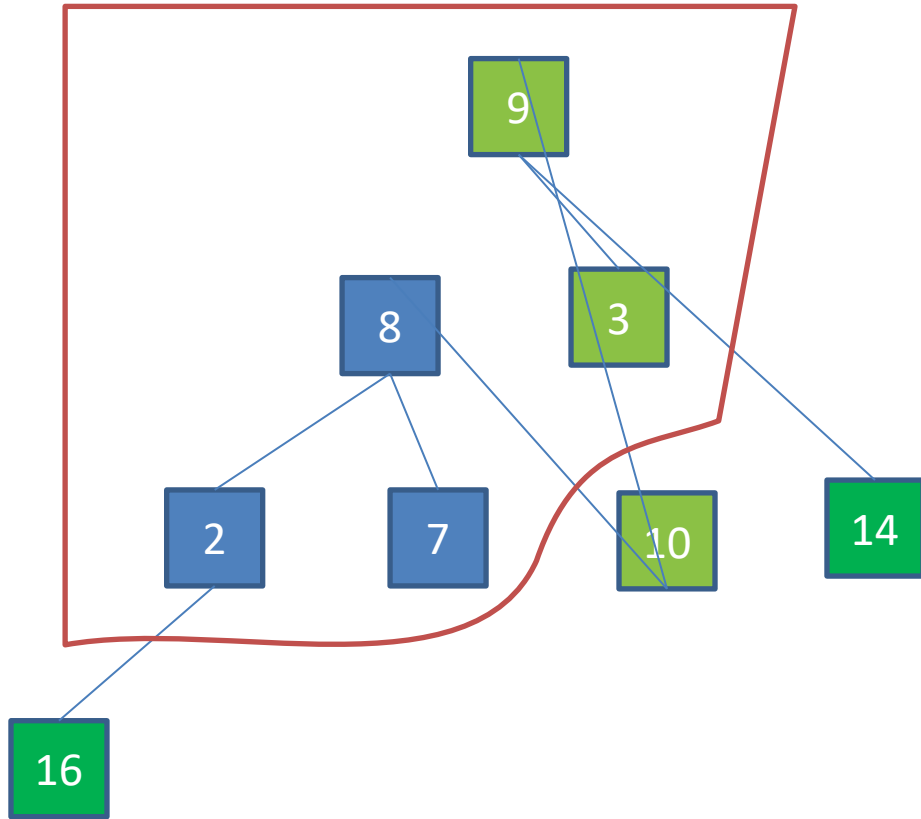
- ```

1. if(right(i)>t and left(i)>t) return;
2. Choose largest (node i, left(i), right(i) )
3. if(the largest node is not i) {
    m = the index of the larger node
    Exchange i with the largest node
    MAX-HEAPIFY (A, m, t)
}

```



# Heapsort Example



**HEAP-SORT** (A):

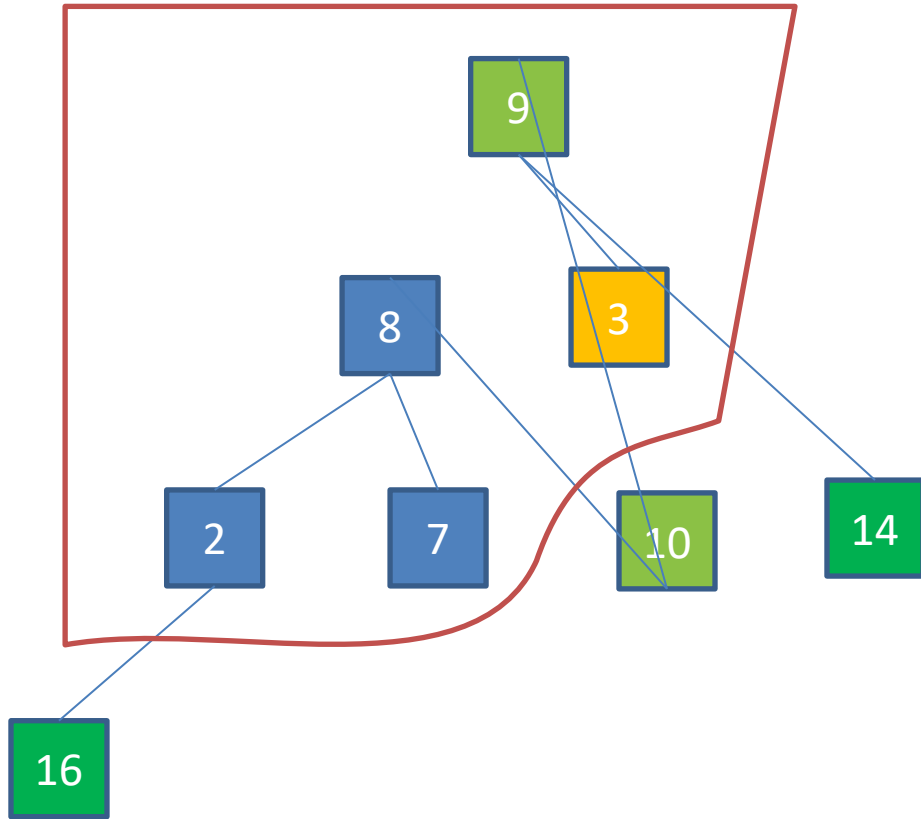
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

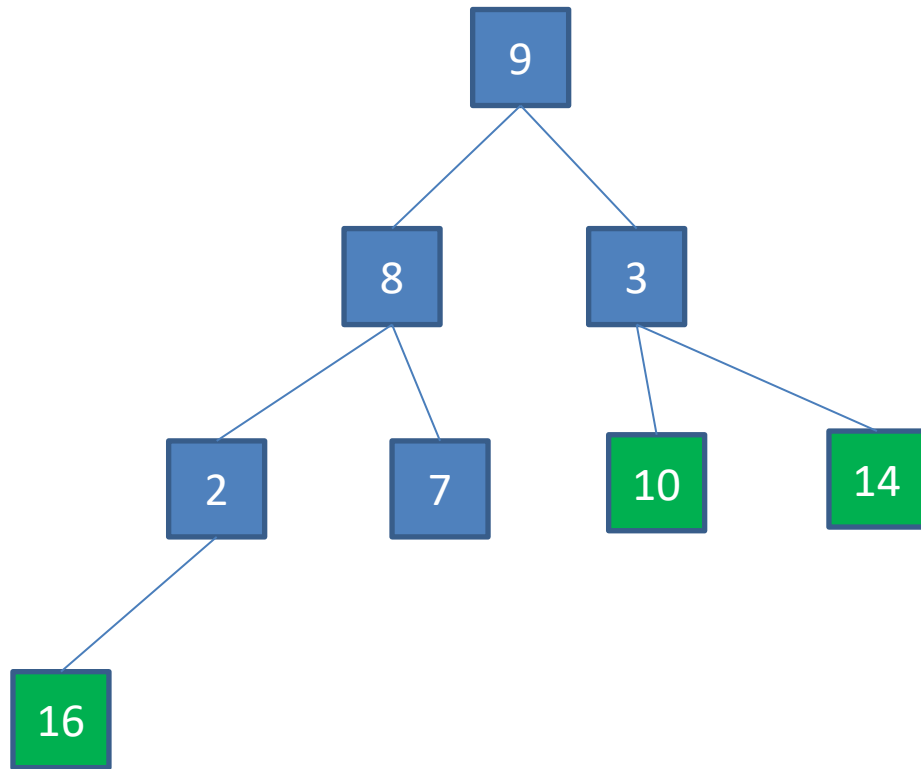
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

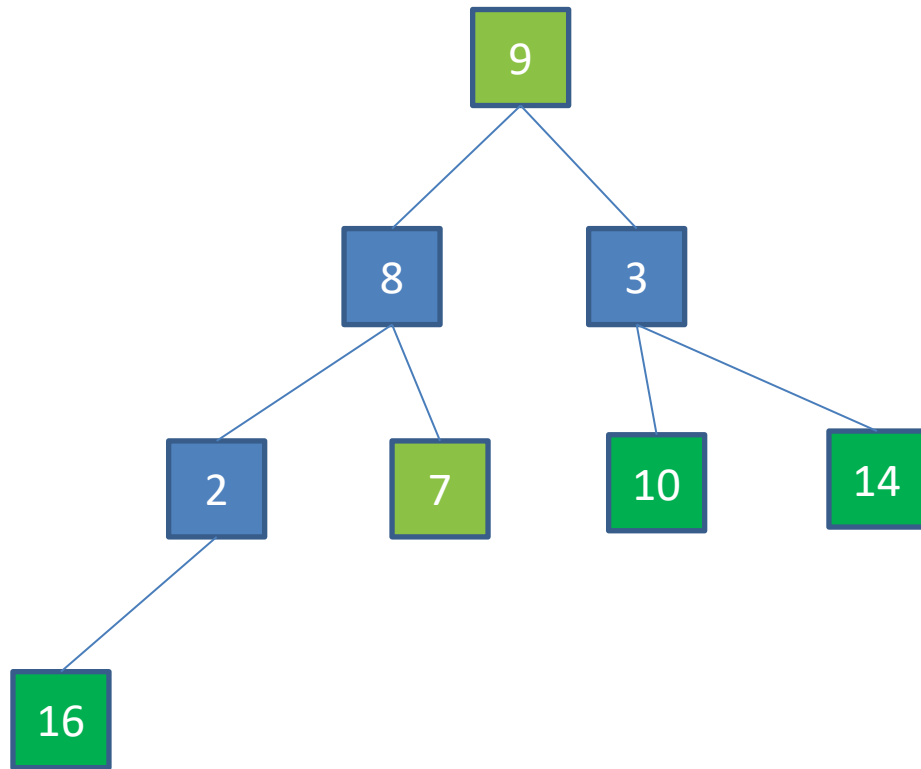
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

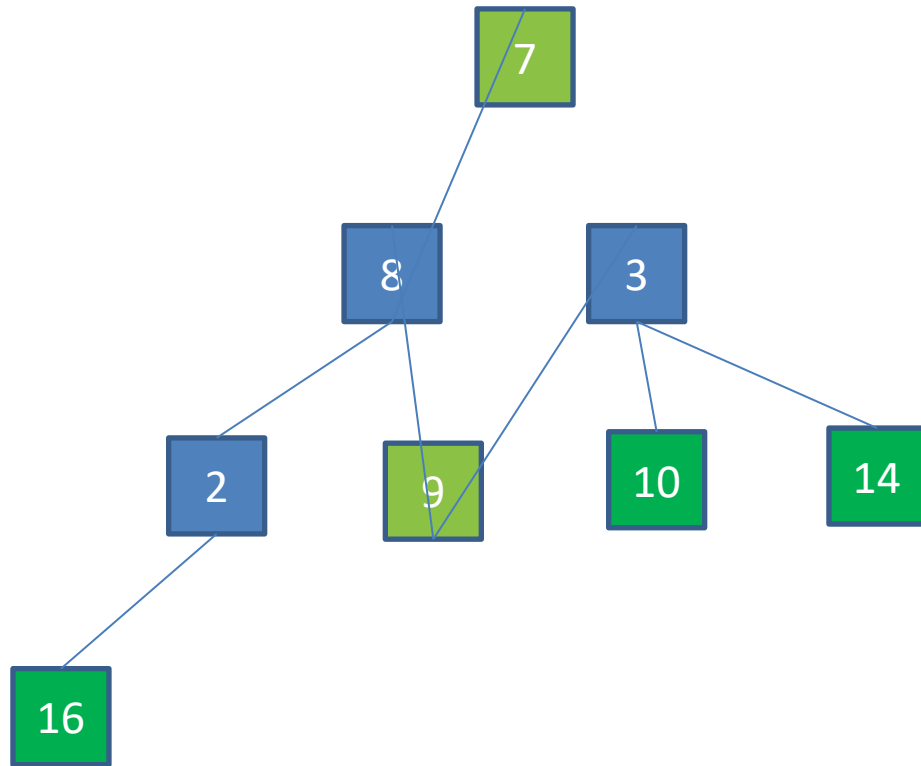
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

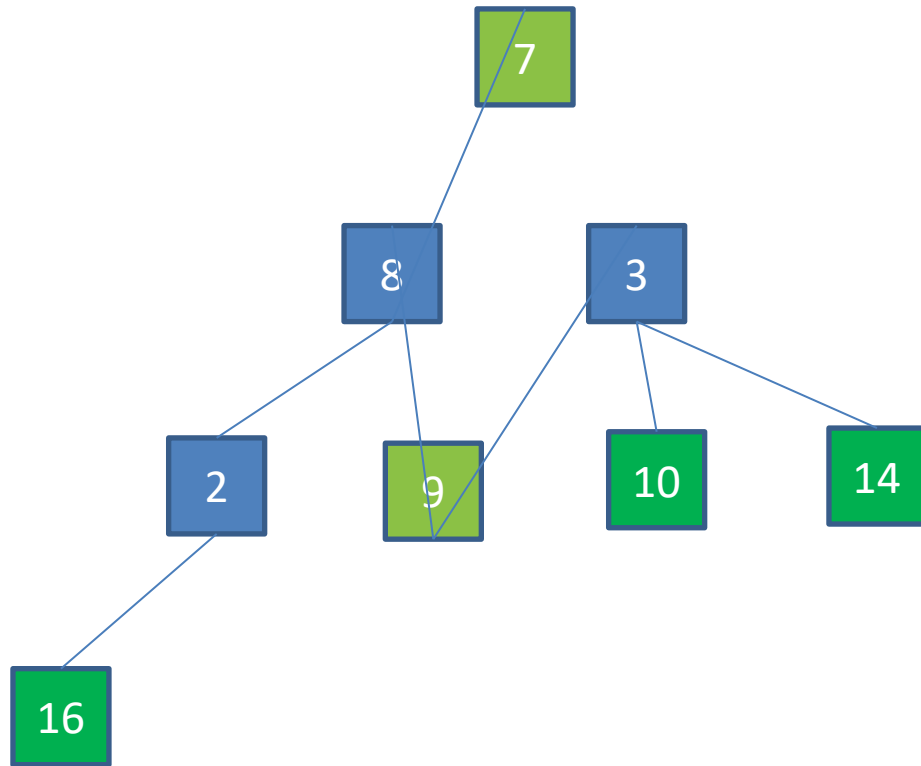
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

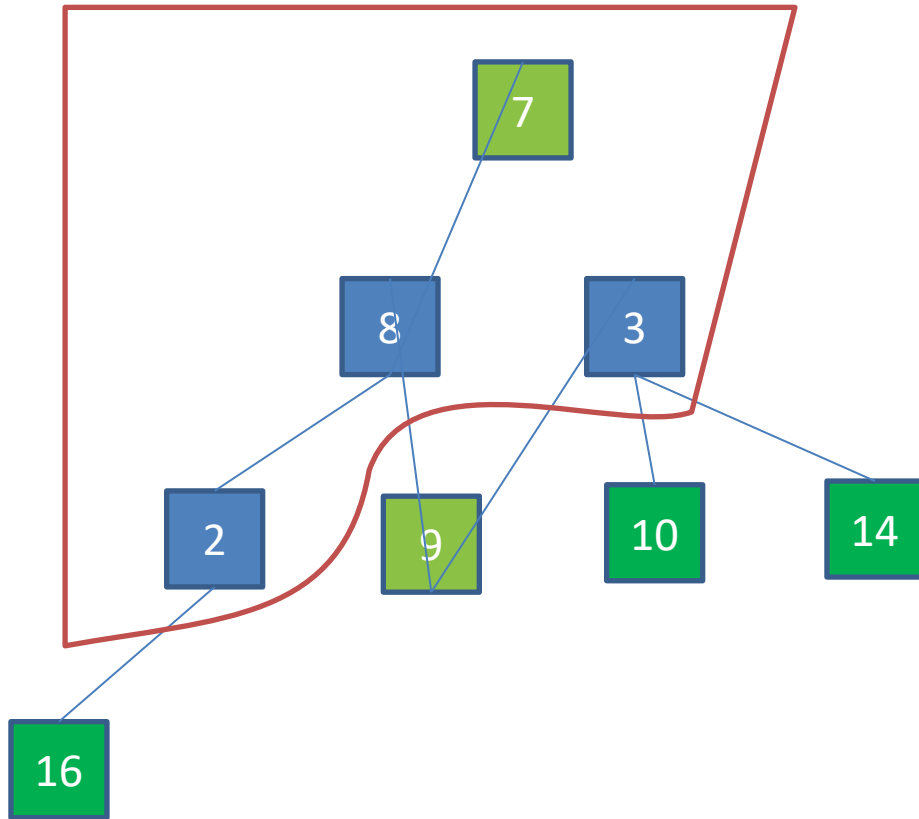
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

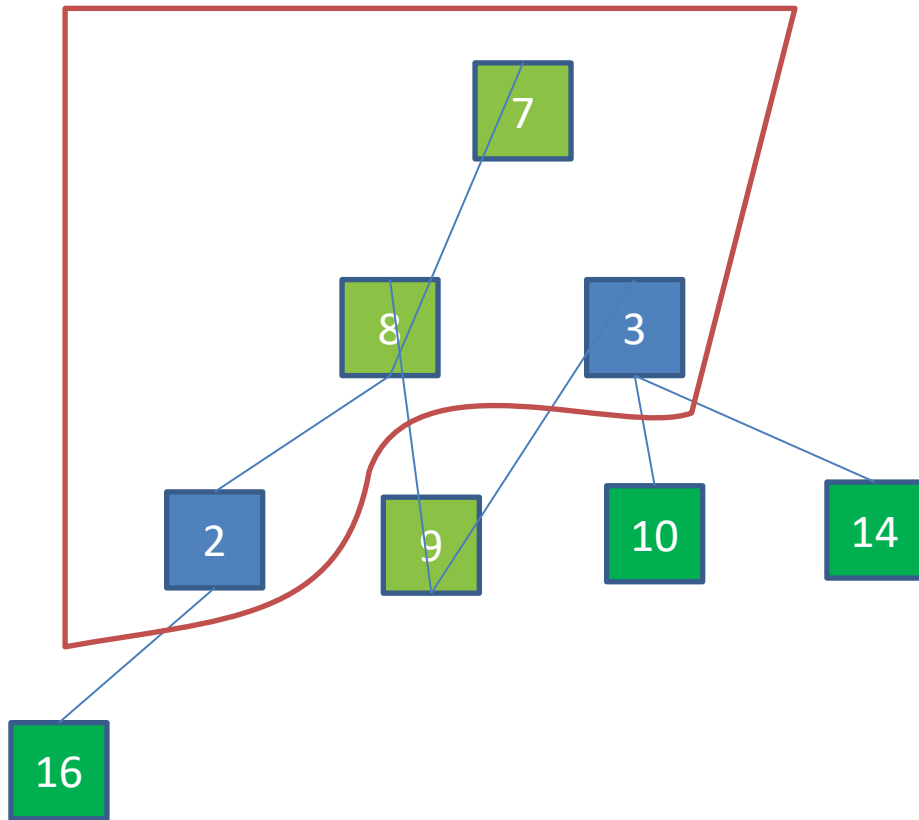
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

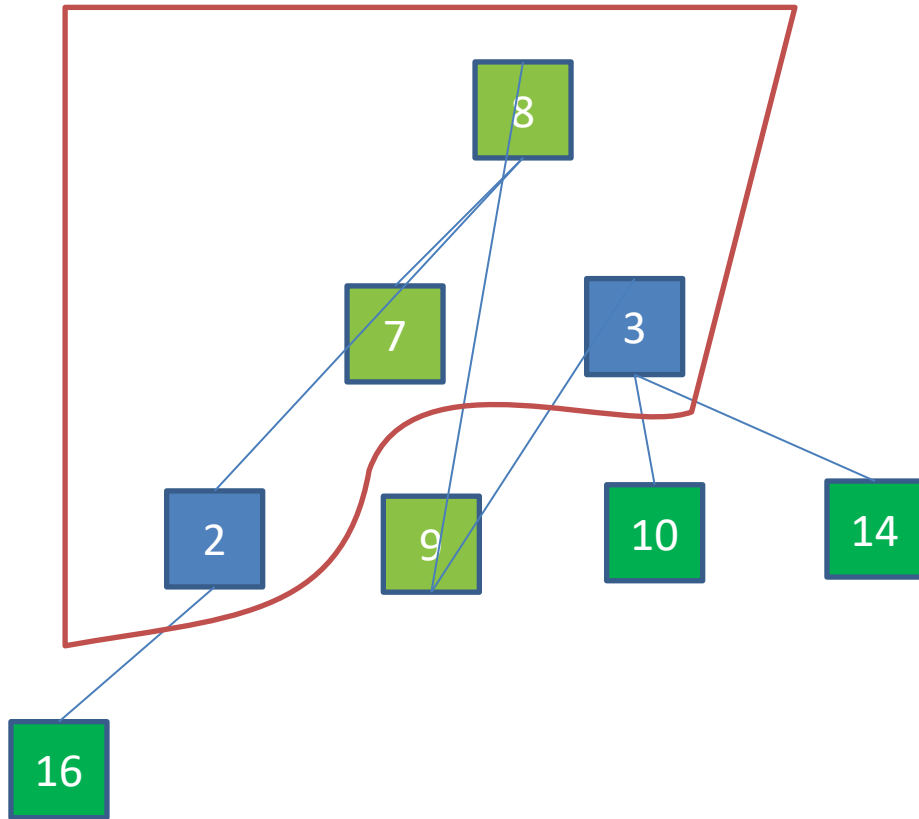
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

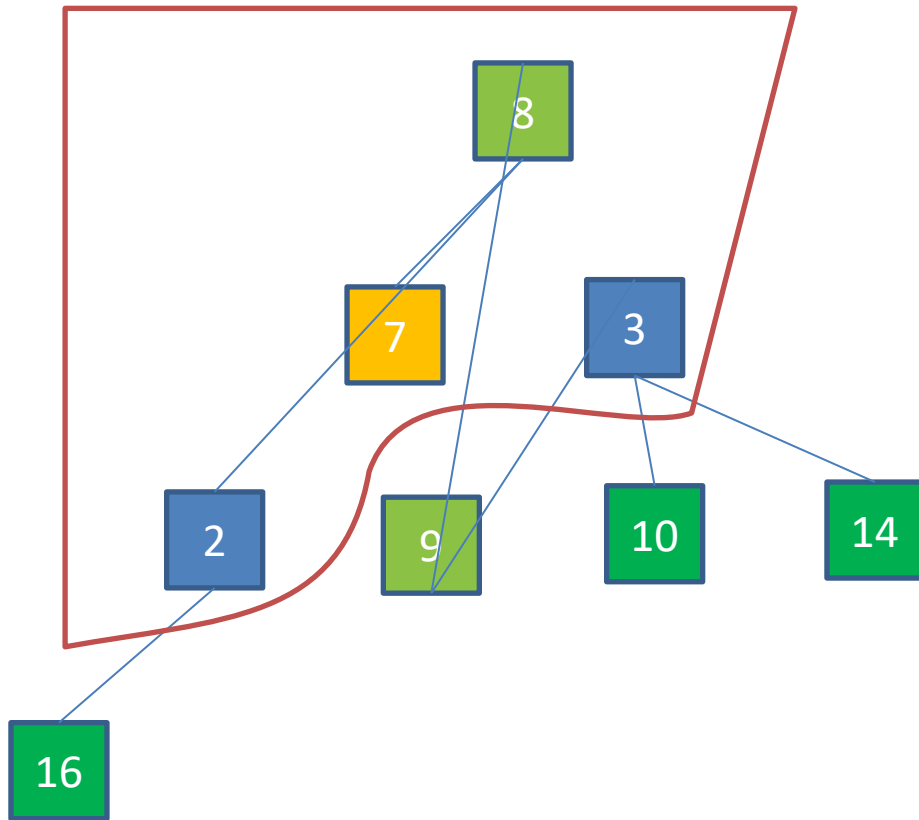
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

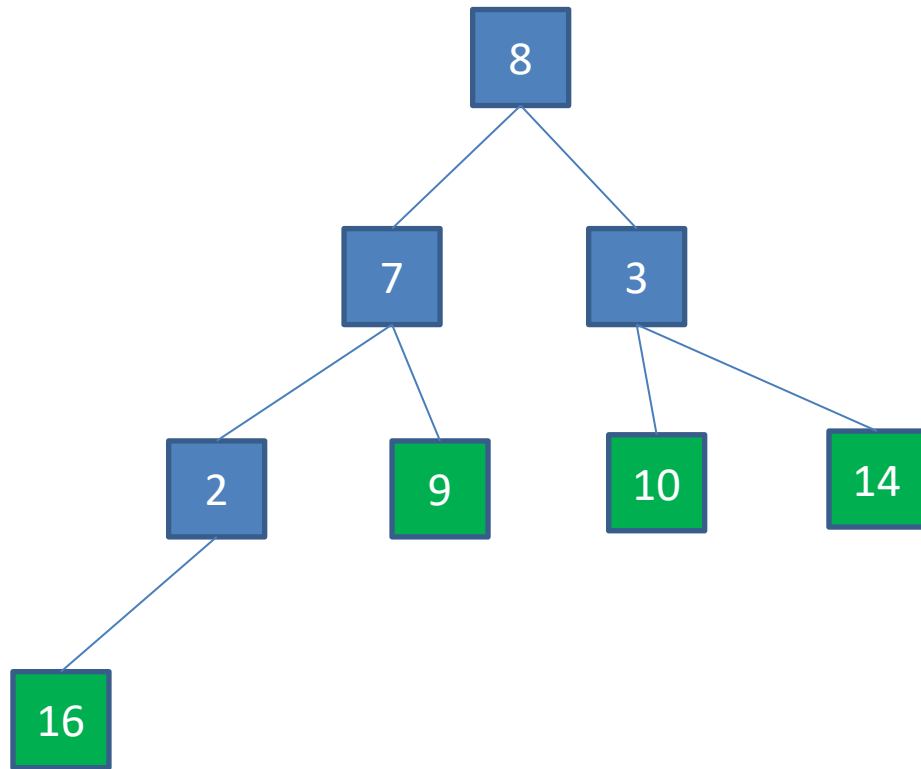
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

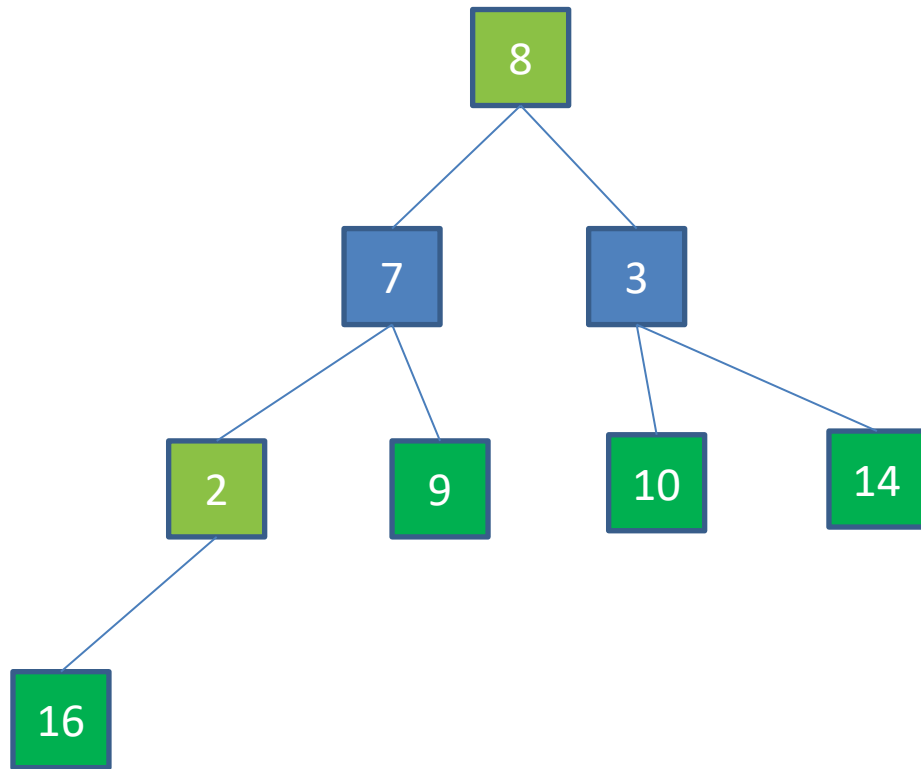
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

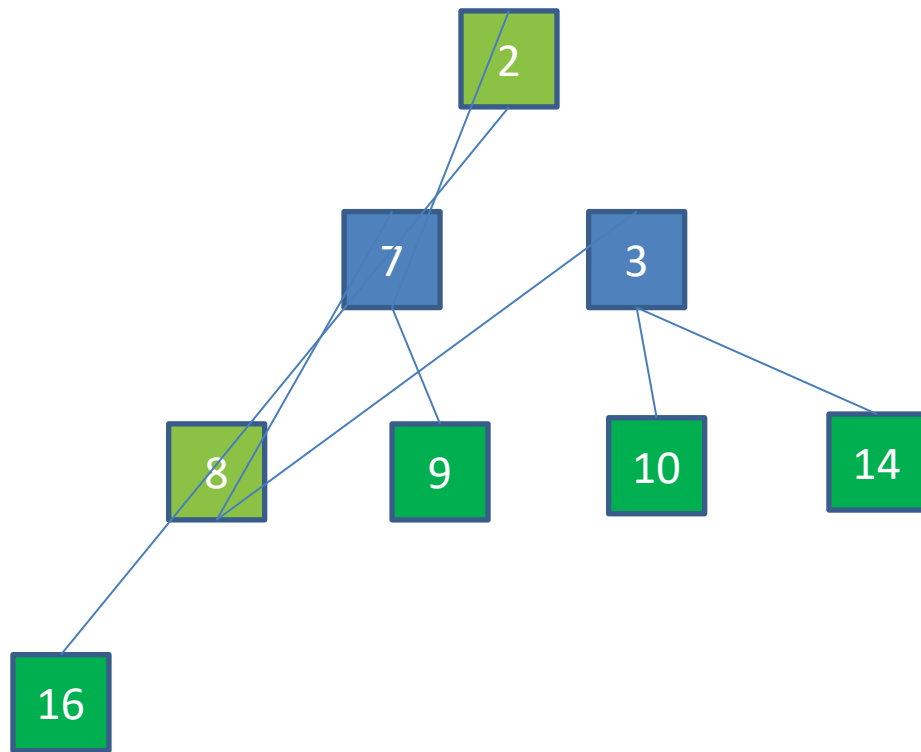
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

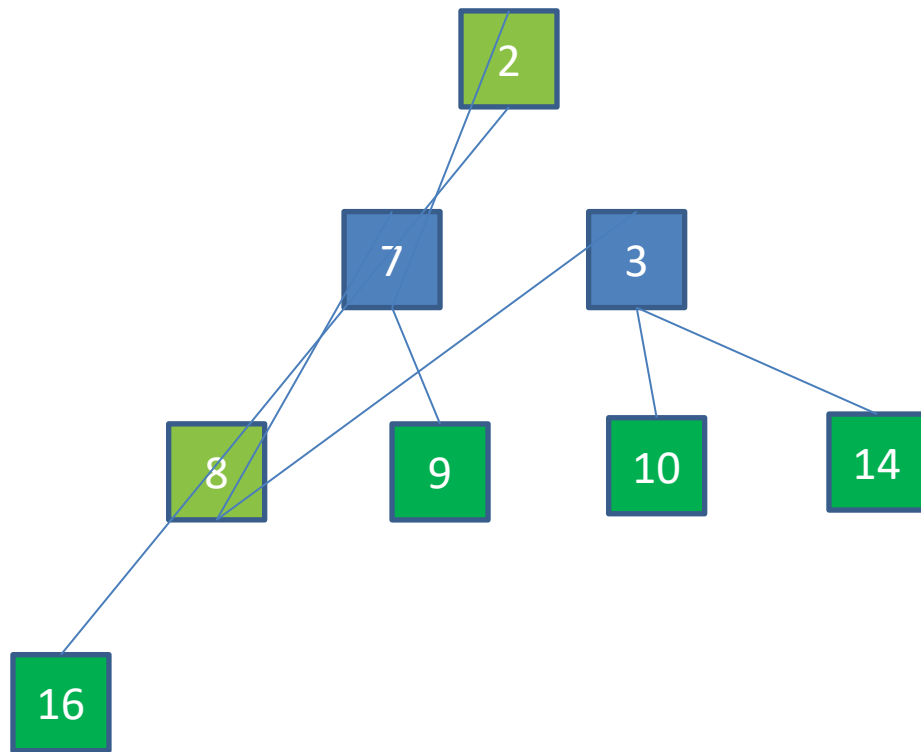
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

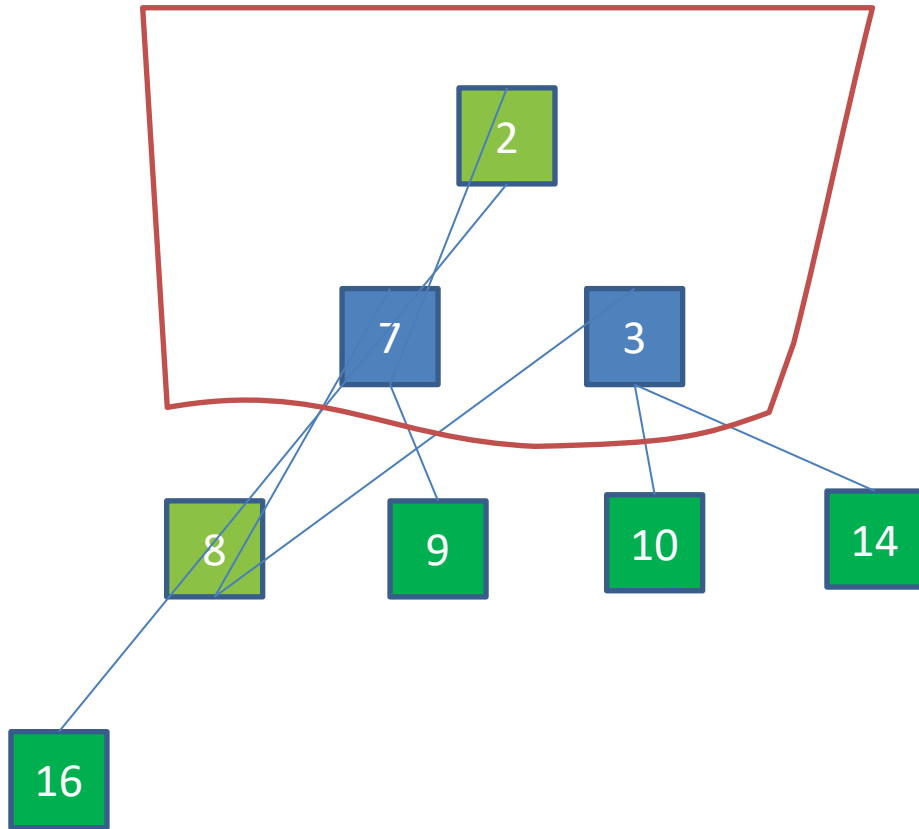
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i = A$ 's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

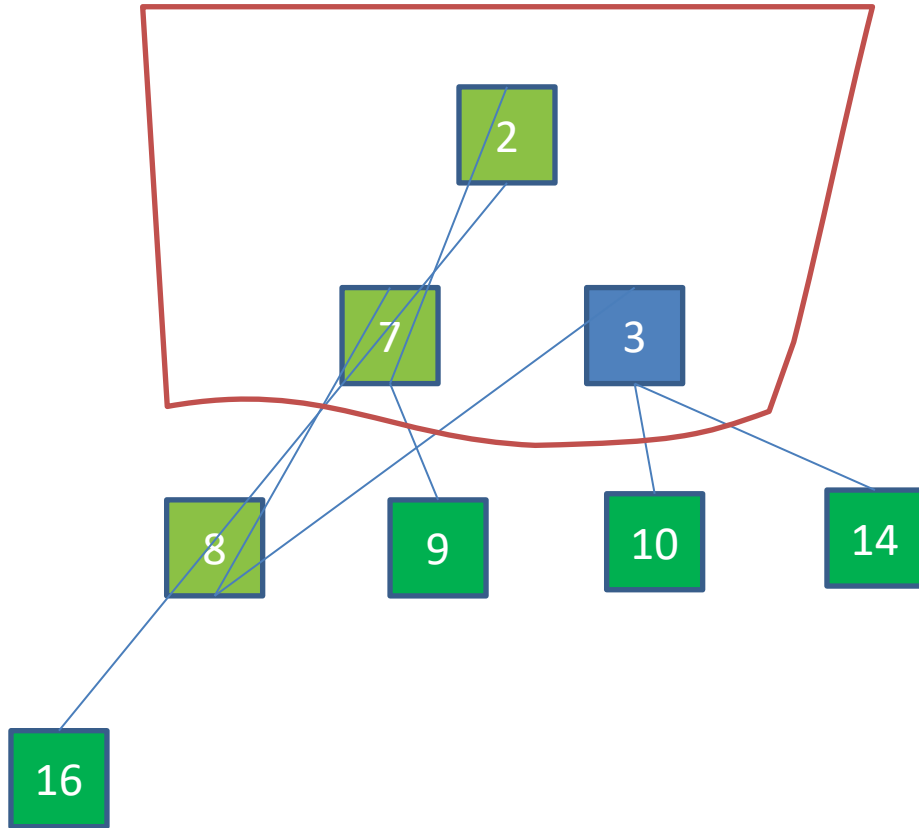
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

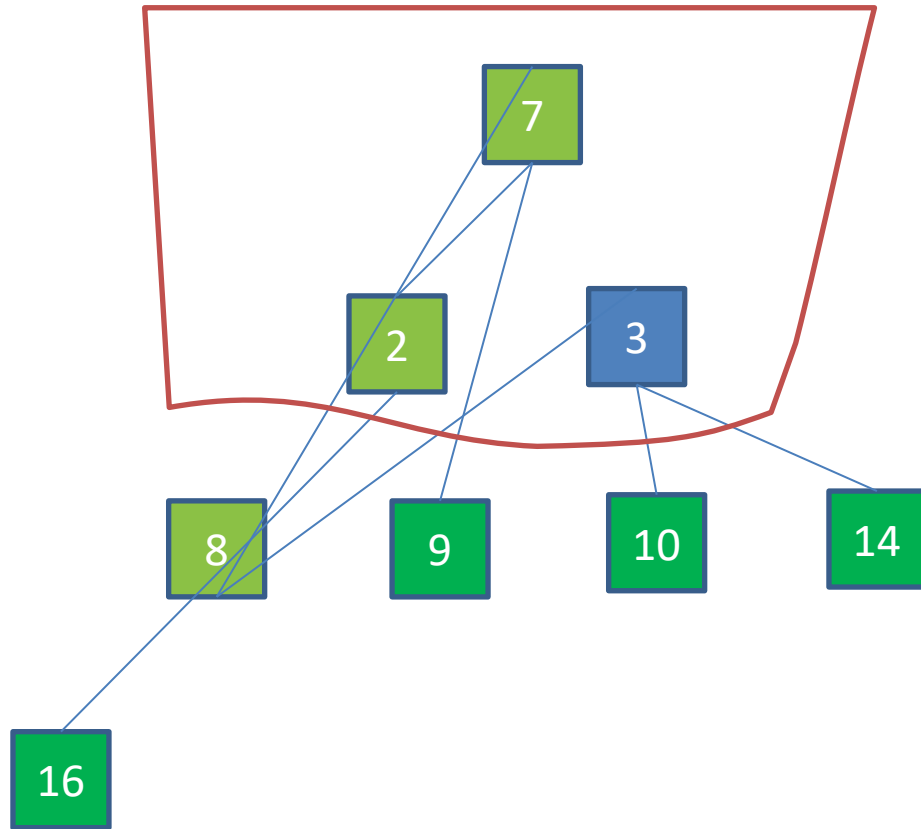
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

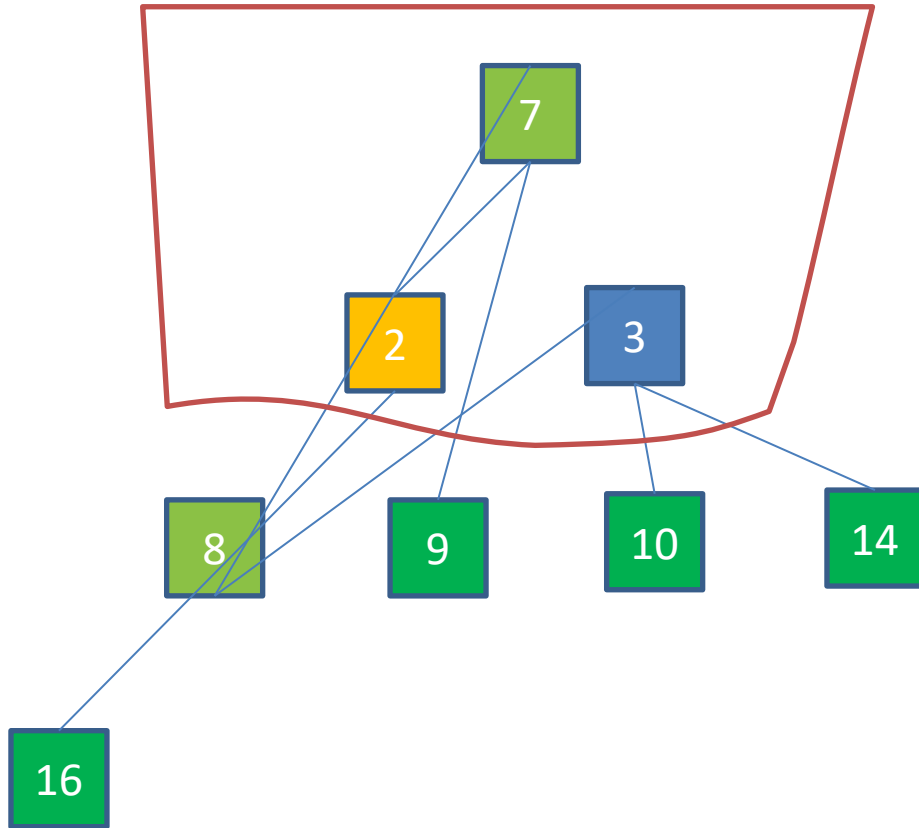
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

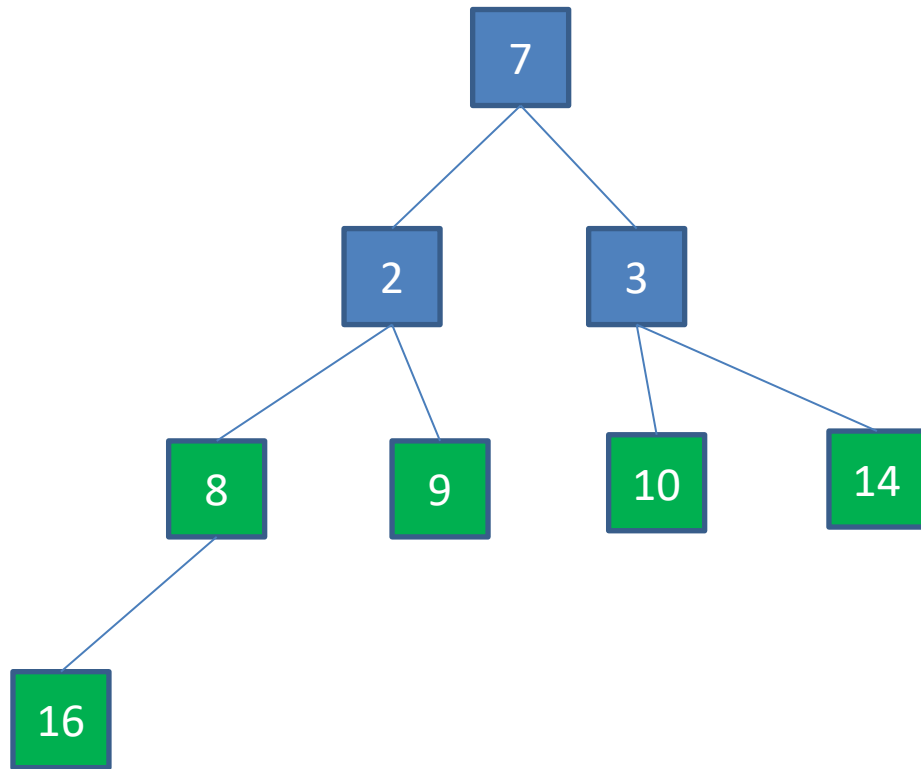
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

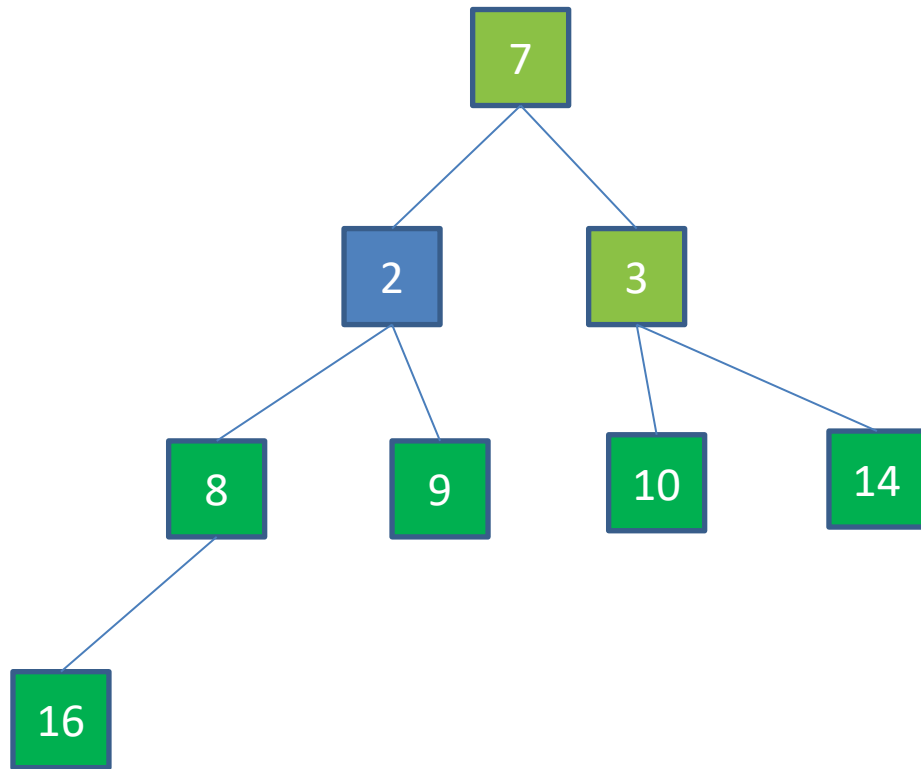
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
2. Choose largest (node  $i$ , left( $i$ ), right( $i$ ))
3. if(the largest node is not  $i$ ) {  
     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

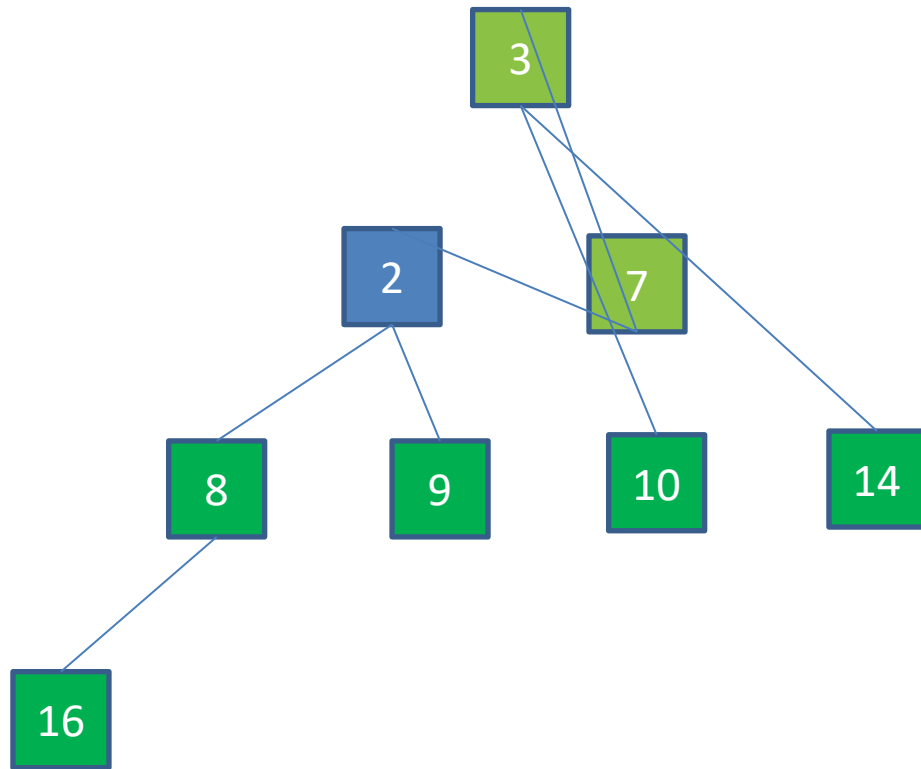
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

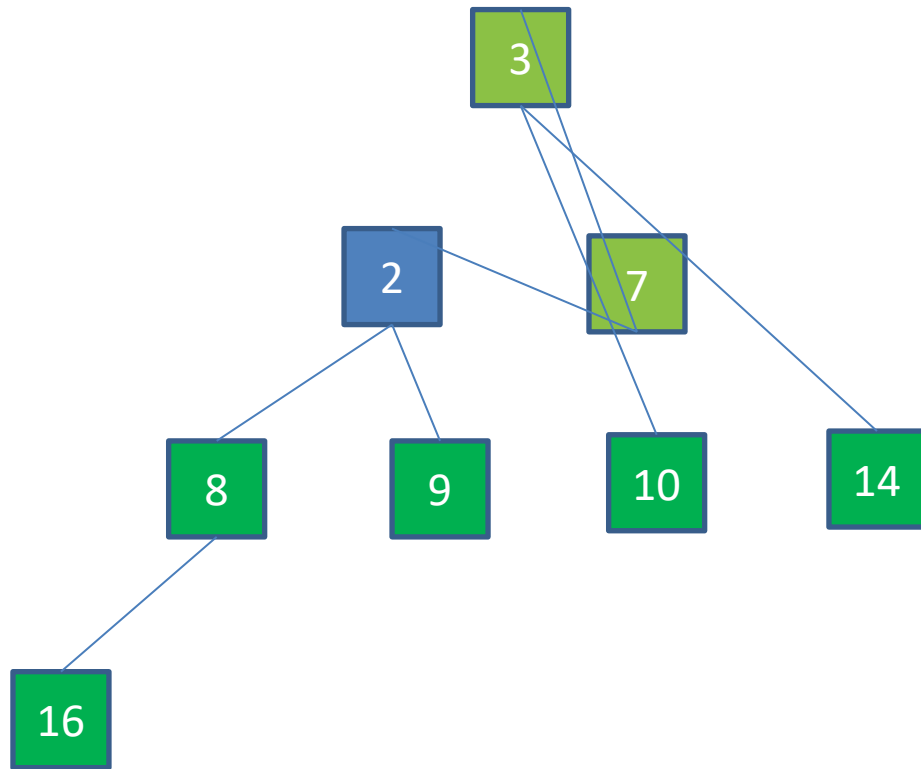
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

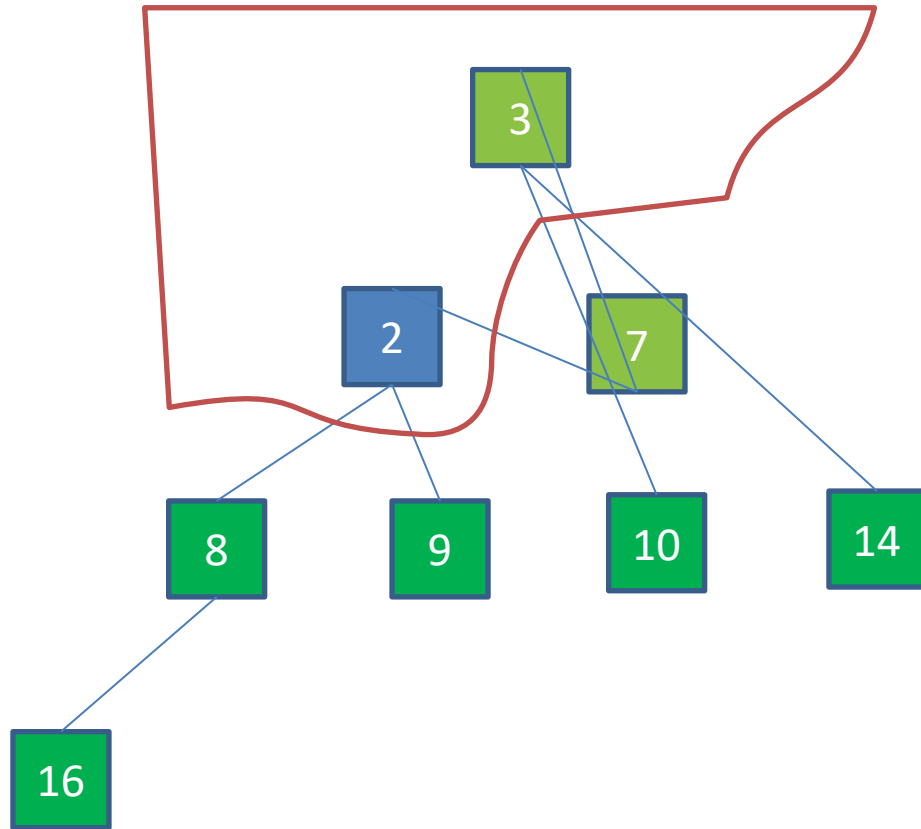
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

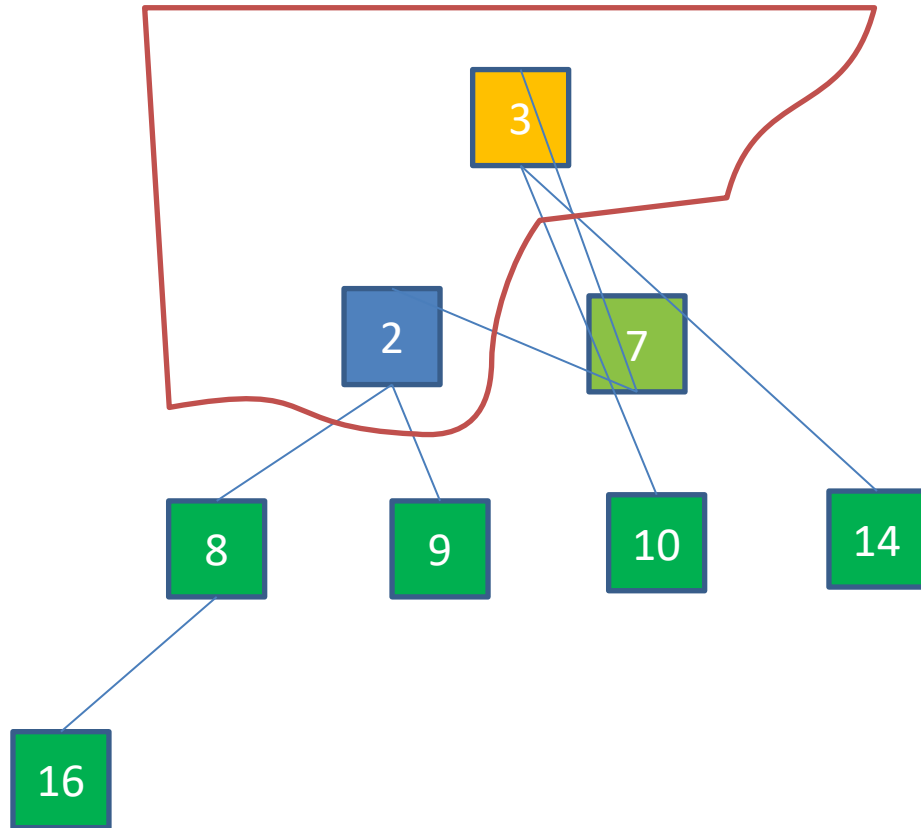
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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}

**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

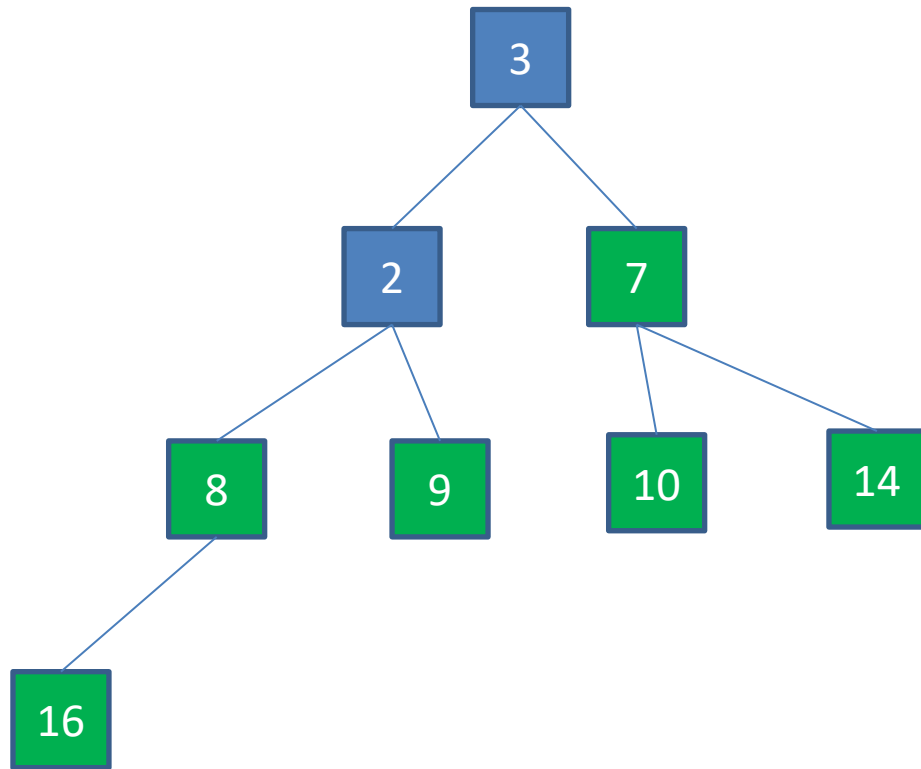
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

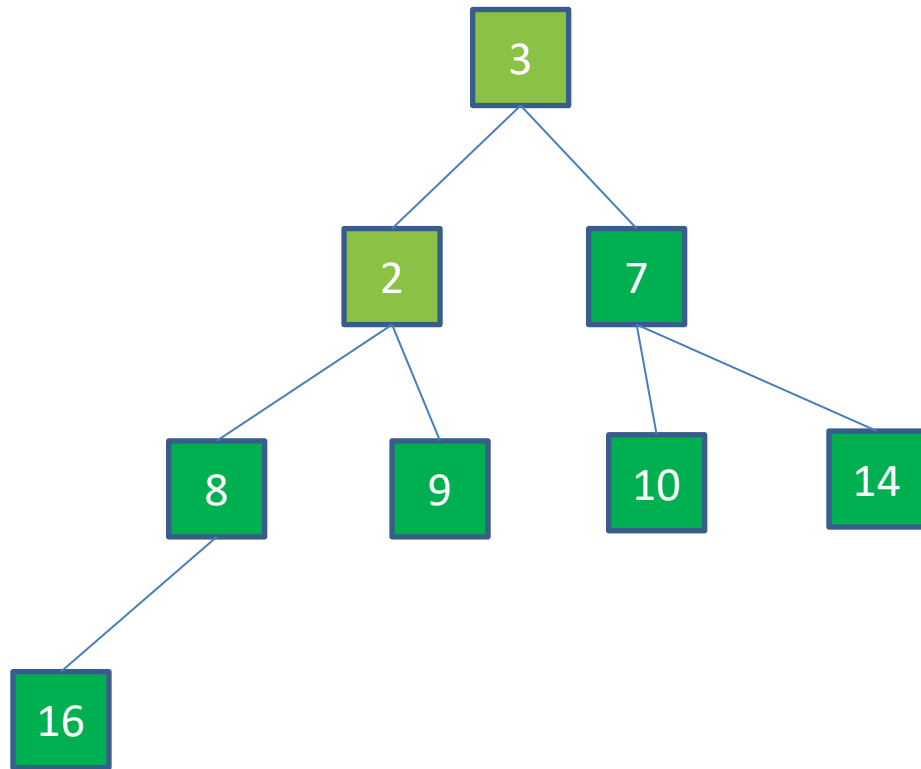
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
    exchange ( $i$ , root);  
     $i--$ ;  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

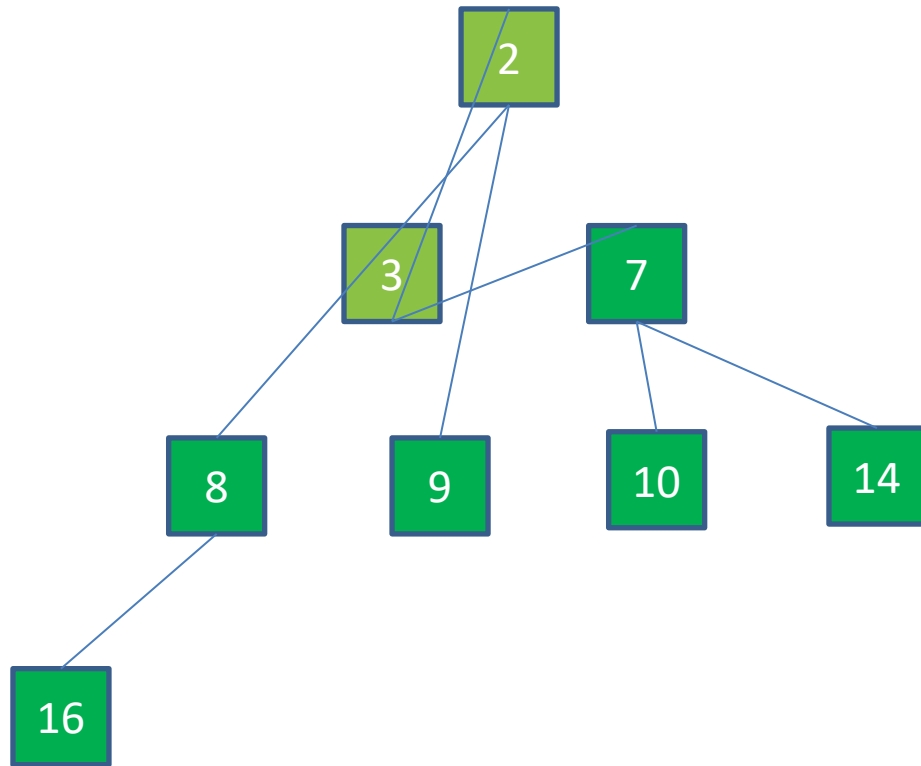
1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
3. From last element to the second in A {  
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**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

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# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
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     $i--$ ;  
    **MAX-HEAPIFY**(A, root,  $i$ );  
}

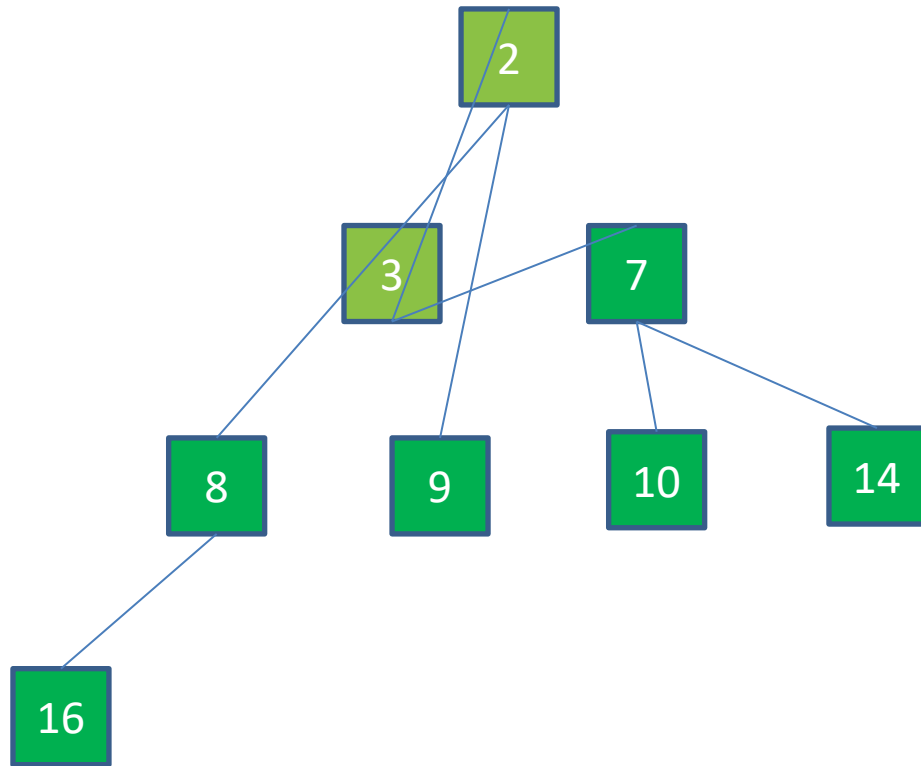
**MAX-HEAPIFY** (A,  $i$ ,  $t$ )

1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}





# Heapsort Example



**HEAP-SORT** (A):

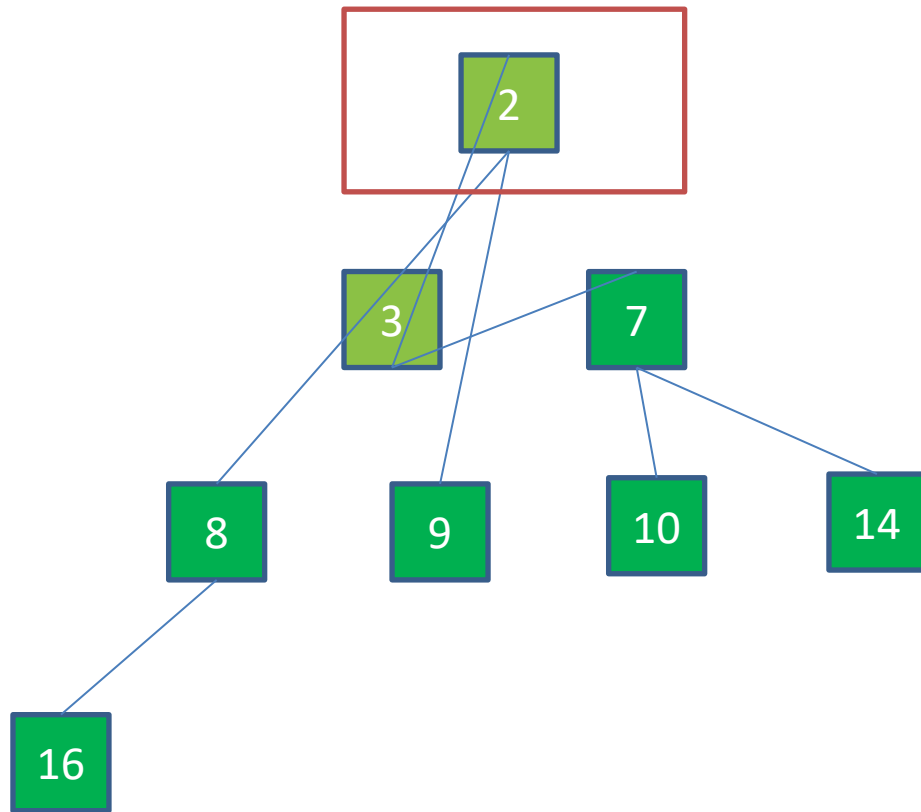
1. **BUILD-MAX-HEAP**(A)
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}



# Heapsort Example



**HEAP-SORT** (A):

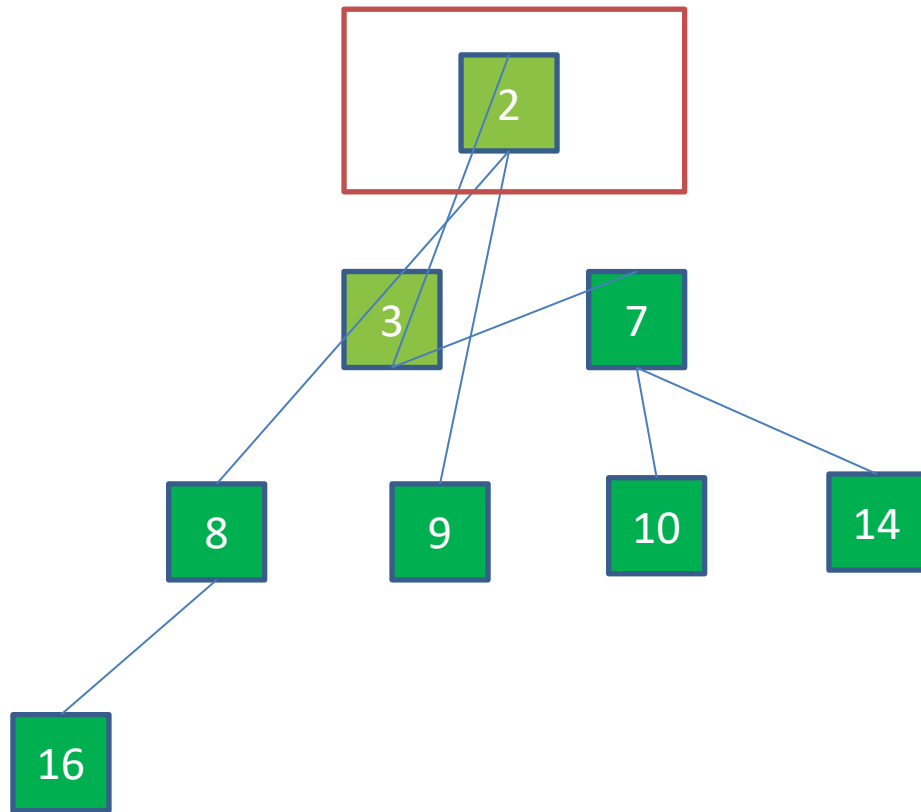
1. **BUILD-MAX-HEAP**(A)
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    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
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# Heapsort Example



**HEAP-SORT** (A):

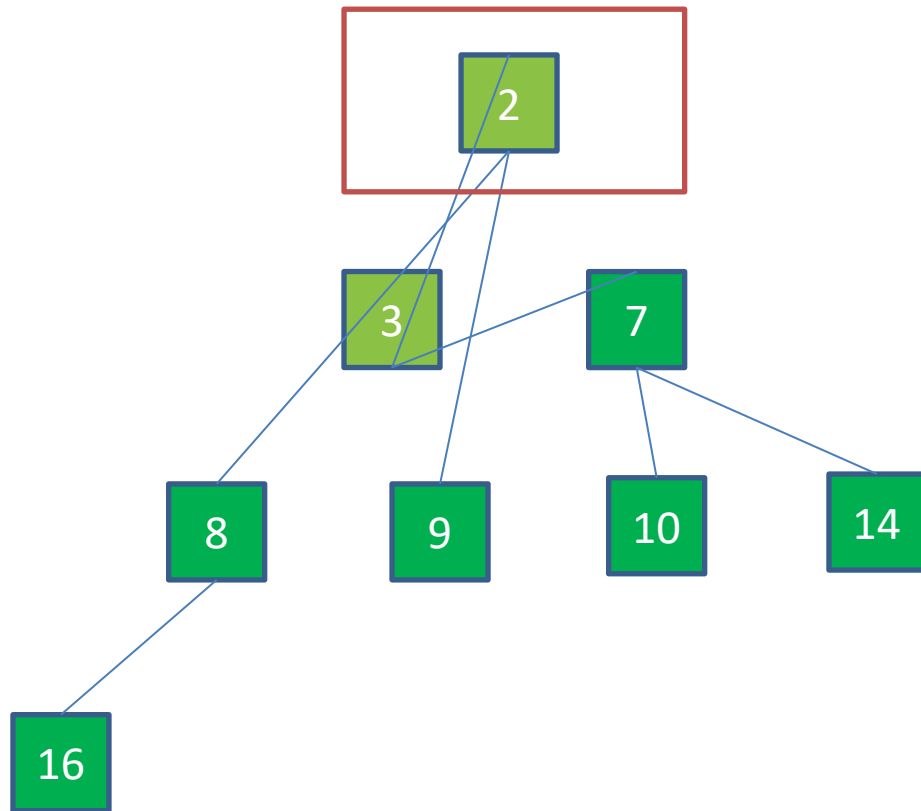
1. **BUILD-MAX-HEAP**(A)
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# Heapsort Example



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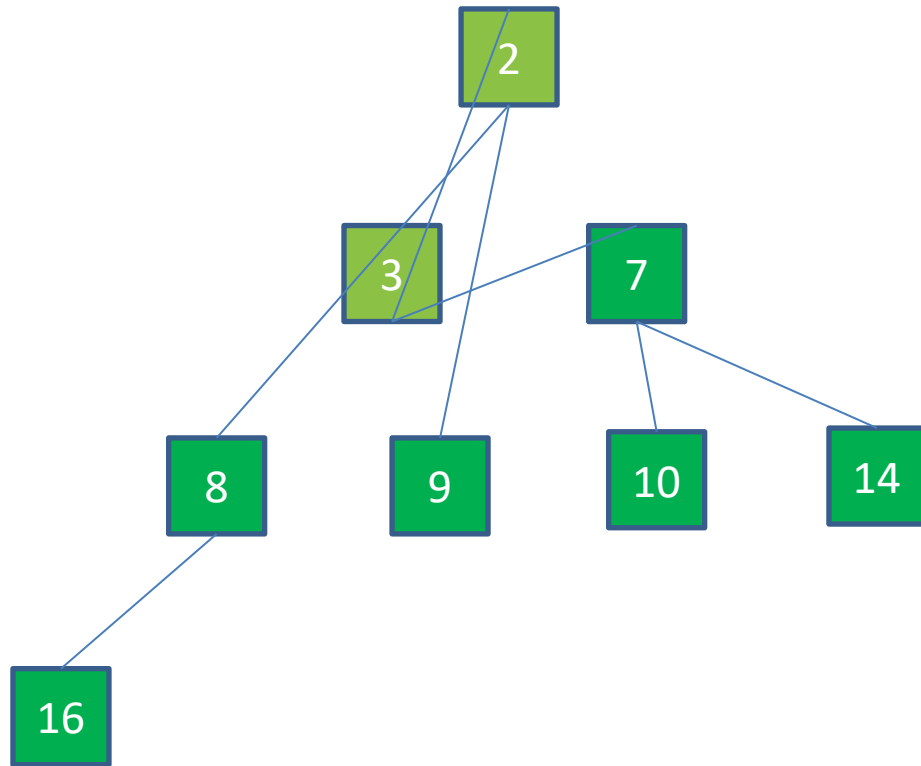
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    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}



# Heapsort Example



**HEAP-SORT** (A):

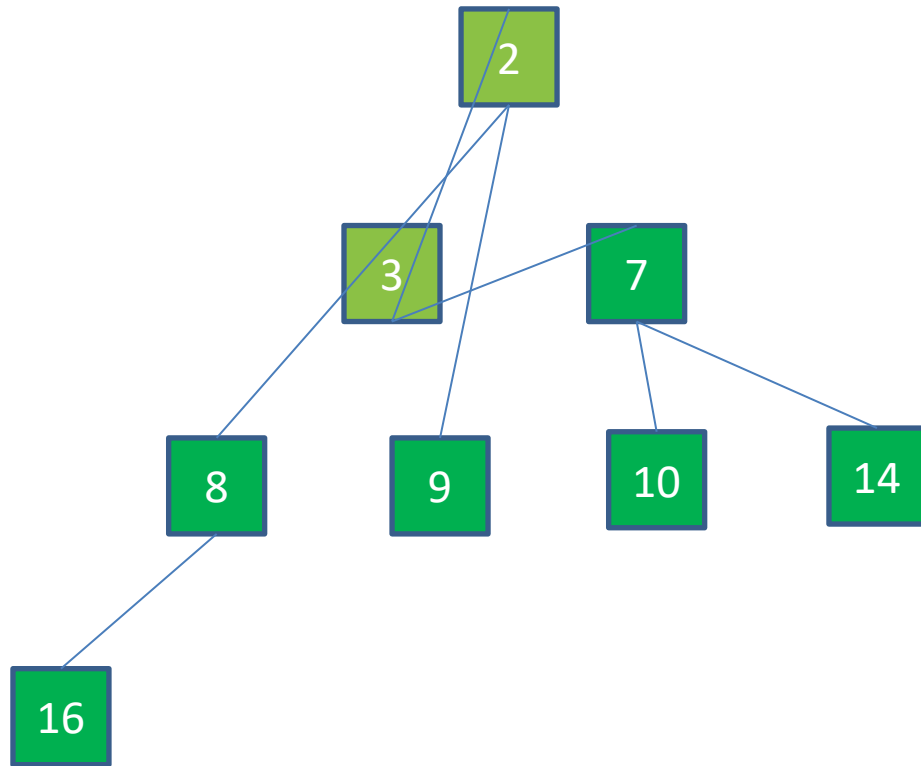
1. **BUILD-MAX-HEAP**(A)
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# Heapsort Example



**HEAP-SORT** (A):

1. **BUILD-MAX-HEAP**(A)
2. Last node index  $i$  = A's last node index
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1. if(right( $i$ )> $t$  and left( $i$ )> $t$ ) return;
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     $m$  = the index of the larger node  
    Exchange  $i$  with the largest node  
    **MAX-HEAPIFY** (A,  $m$ ,  $t$ )  
}

Final result: a sorted array A

