UNDER THE HOOD OF PRIORITY QUEUES (HEAPS)

Problem Solving with Computers-II

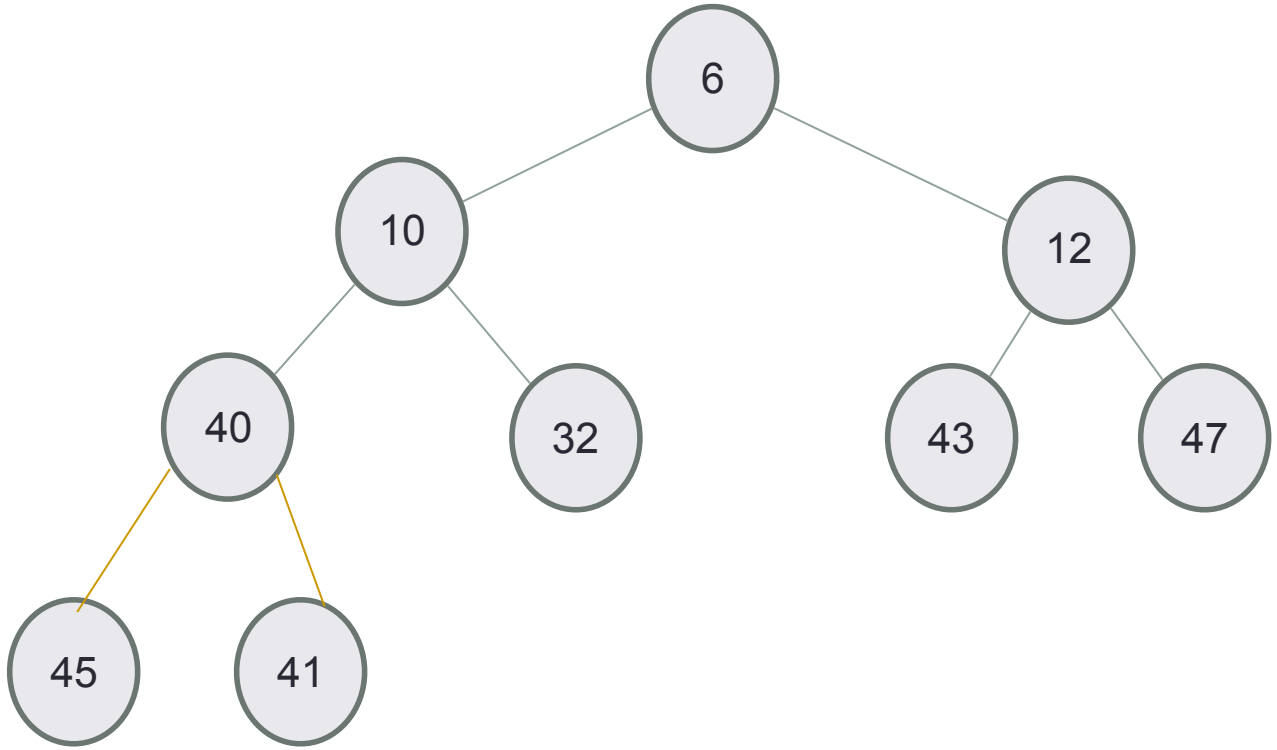
Priority Queues or Heaps (Review)

- Clarification
  - *heap*, the data structure is not related to *heap,* the region of memory
- What are the operations supported?
- What are the running times?

Insert into heap

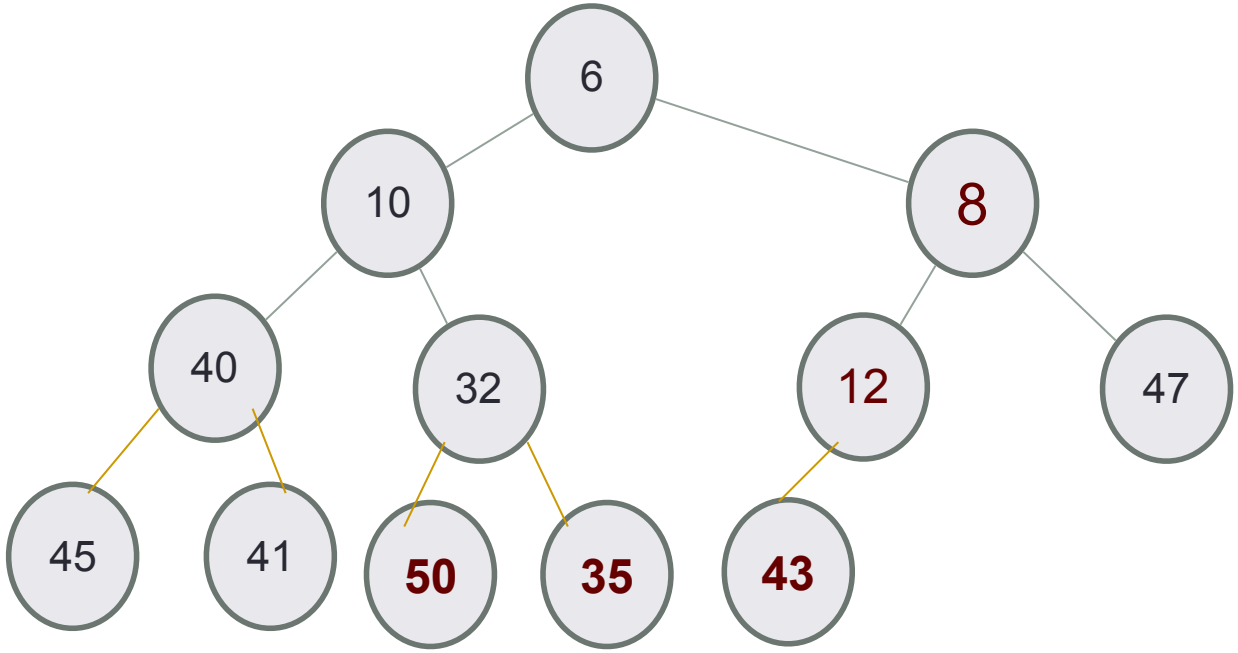
- **Insert key(x) in the first open slot at the last level of tree (going from left to right)**
- **If the heap property is not violated - Done**
- **Else: while(key(parent(x))>key(x)) swap the key(x) with key(parent(x))**
- **Example: Insert the elements 12, 42, 47, 45, 32 into a min-Heap**

Insert 50, then 35, then 8



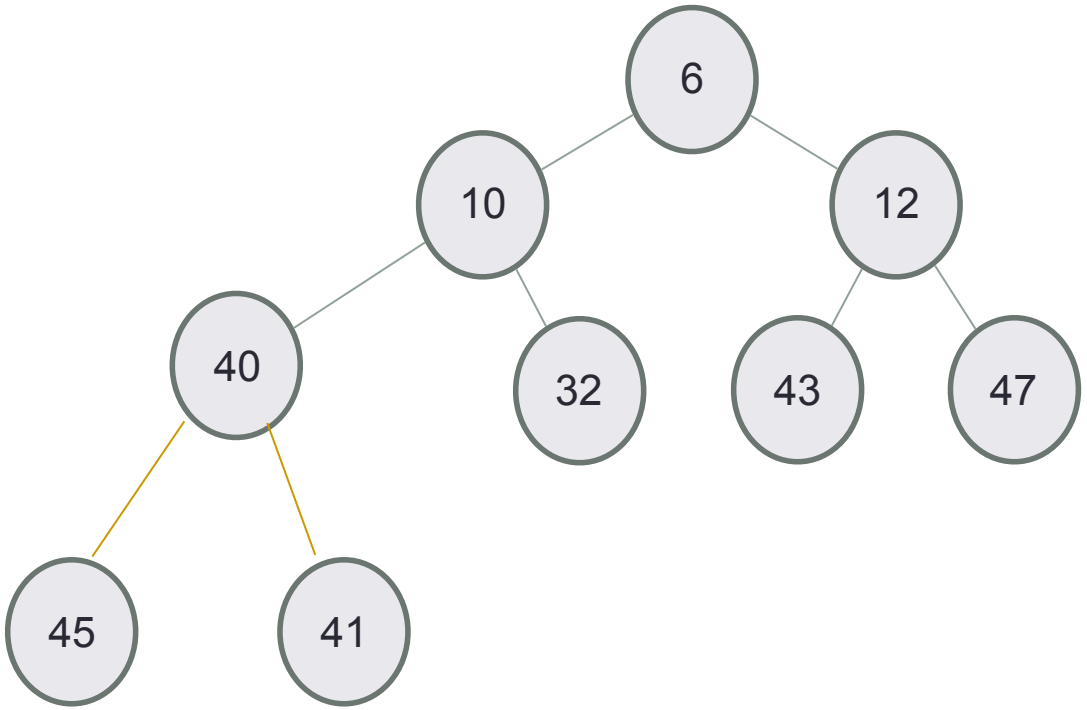
Delete min

- **Replace the root with the rightmost node at the last level**
- **“Bubble down”- swap node with one of the children until the heap property is restored**



Implementing heaps using an array or vector

Value									
Index	0	1	2	3	4	5	6	7	8



Using vector as the internal data structure of the heap has some advantages:

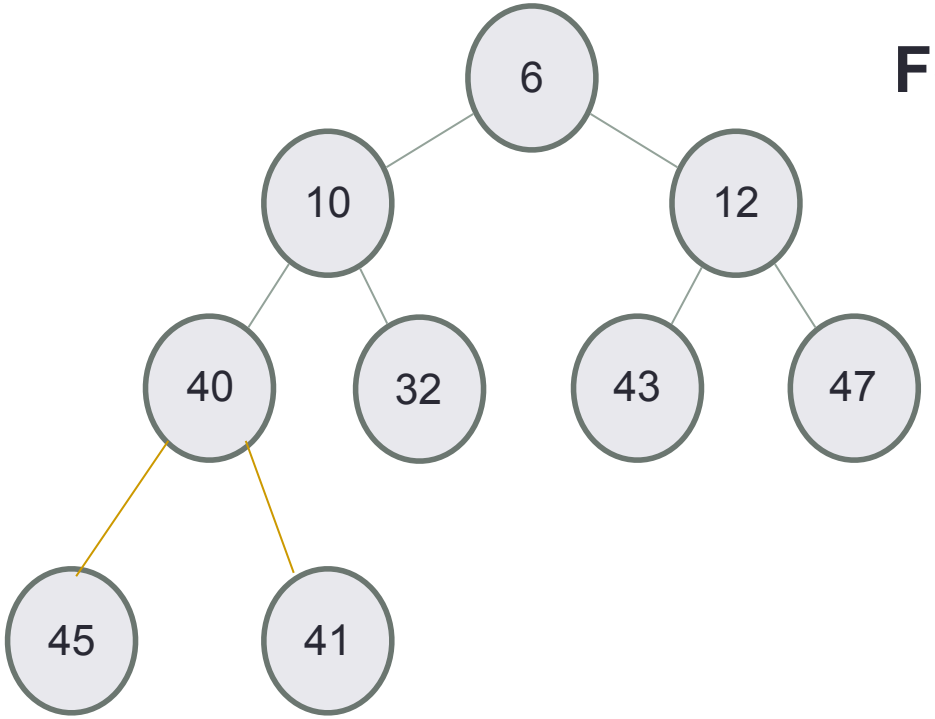
- **More space efficient than trees**
- **Easier to insert nodes into the heap**

Insert into a heap

- **Insert key(x) in the first open slot at the last level of tree (going from left to right)**
- **If the heap property is not violated - Done**
- **Else….**

Insert the elements {12, 41, 47, 45, 32} in a min-Heap using the vector representation of the heap

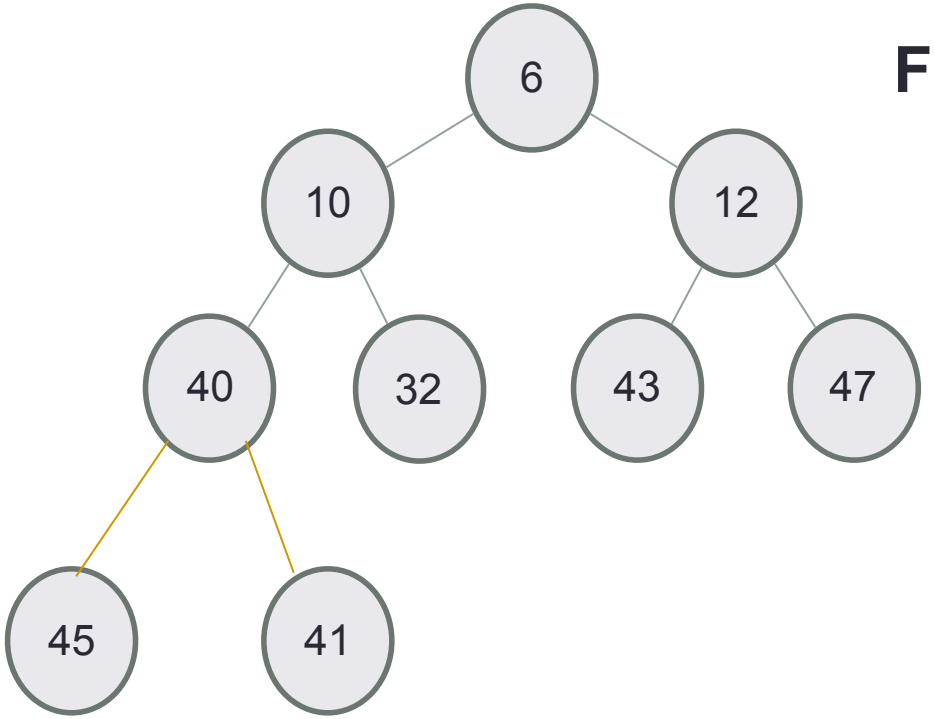
Traversing up the “tree”



For a node at index i, index of the parent is int(i/2)

Value	6	10	12	40	32	43	47	45	41	
Index	0	1	2	3	4	5	6	7	8	

Insert 50, then 35



For a node at index i, index of the parent is int(i/2)

Value	6	10	12	40	32	43	47	45	41	
Index	0	1	2	3	4	5	6	7	8	

Insert 8 into a heap

Value	6	10	12	40	32	43	47	45	41	50	35
Index	0	1	2	3	4	5	6	7	8	9	10

After inserting 8, which node is the parent of 8 ?

A. Node 6

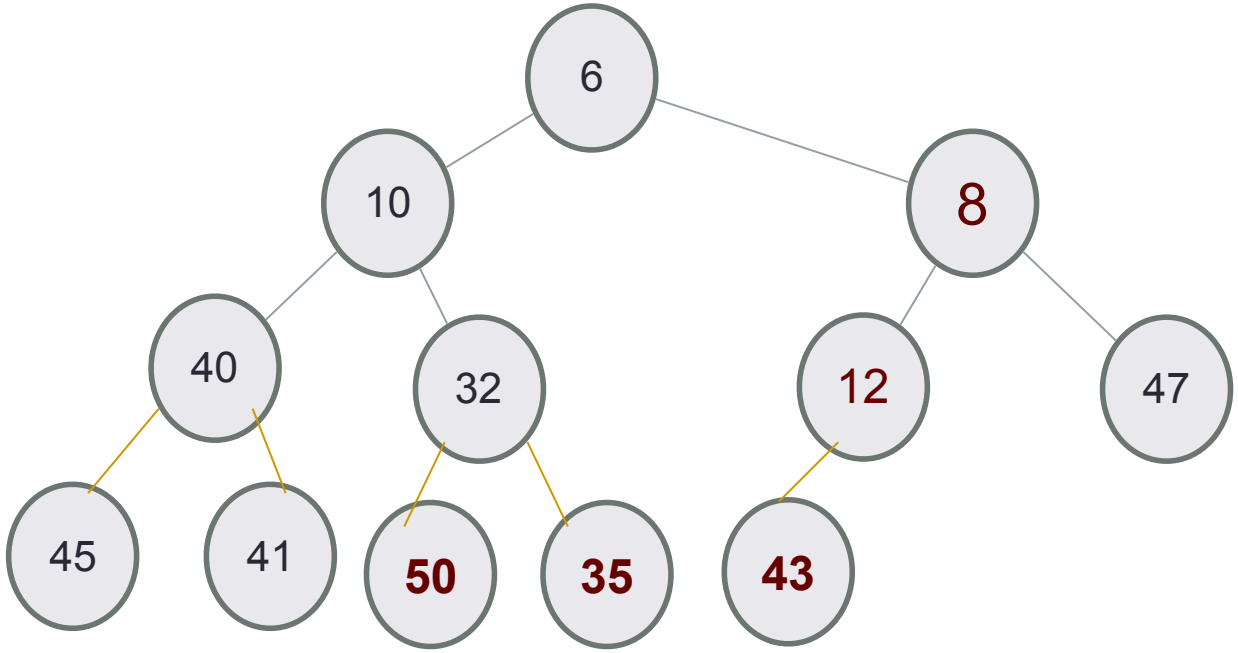
B. Node 12

C. None 43

D. None - Node 8 will be the root

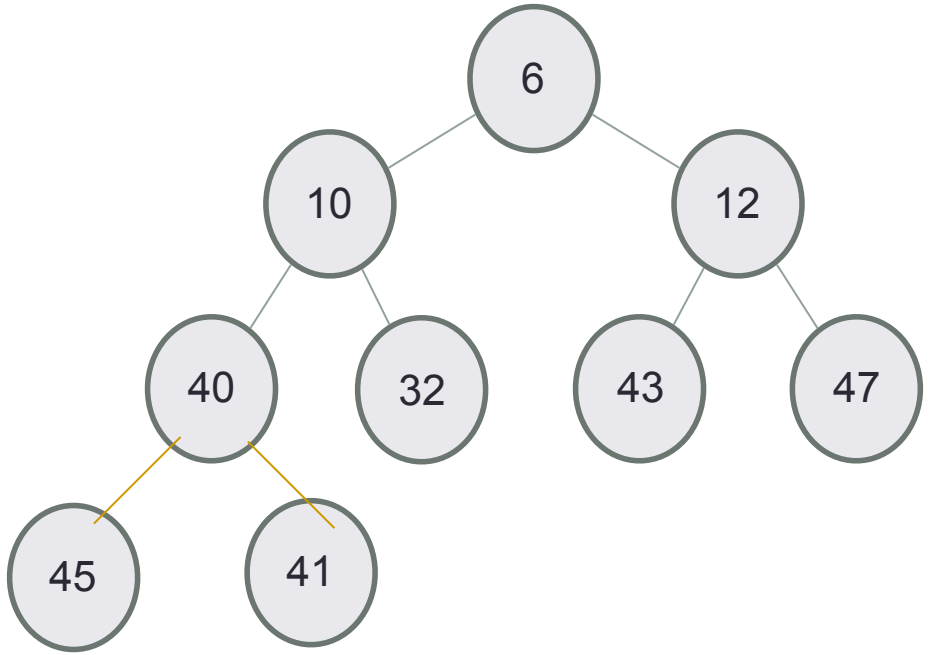
Delete min

- **Replace the root with the rightmost node at the last level**
- **“Bubble down”- swap node with one of the children until the heap property is restored**



Traversing down the tree

Value	6	10	12	40	32	43	47	45	41	
Index	0	1	2	3	4	5	6	7	8	



For a node at index i, what is the index of the left and right children?

A. (2*i, 2*i+1)

B. (2*i+1, 2*i+2)

C. (log(i), log(i)+1)

D. None of the above

std::priority_queue (STL's version of heap)

A C++ `priority_queue` is a generic container, and can store any data type on which an ordering can be defined: for example `ints, structs (Card),` pointers etc.

```
#include <queue>
priority_queue<int> pq;
```

Methods:

```
* push()  //insert
* pop()   //delete max priority item
* top()   //get max priority item
* empty()  //returns true if the priority queue is empty
```

- You can extract object of highest priority in O(log N)
- To determine priority: objects in a priority queue must be comparable to each other

Next lecture

* More on the STL priority_queue
* Applications of heaps and priority queues