CS203 Programming with Data Structures
Heap

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Example: Print Job Scheduling

- Three jobs queued at a printer
  - Job 1: 5 minutes
  - Job 2: 1 minute
  - Job 3: 6 seconds
- How do we schedule them to minimize the average wait time??

Priority Queue

- `insert` – add an new item to the queue
- `removeMin` (or `removeMax`) – remove and return the smallest (or largest) item in the queue

Simple Implementations

- Complexities of `insert` and `removeMin`
  - Using array??
  - Using linked list??
  - Using ordered linked list??

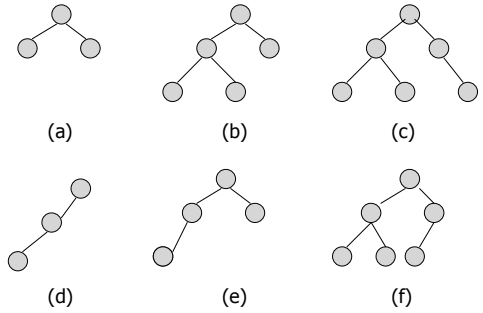
Heap

- A.K.A *Binary Heap*
- The most common implementation of priority queue

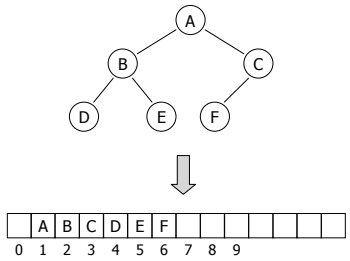
Complete Binary Tree (CBT)

- A binary tree that is completely filled, with the possible exception of the bottom level, which is filled with from left to right.
- The *height* of a CBT with N nodes is $\lfloor \log N \rfloor$

CBT and Non-CBT Examples



Array Representation of CBT…



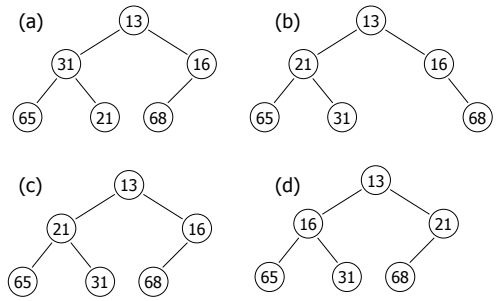
…Array Representation of CBT

- For an element in position **i**
  - Left child is in position **2i**
  - Right child is in position **2i+1**
  - Parent is in position $\lfloor \mathbf{i/2} \rfloor$

Heap Definition

- Min Heap - A CBT where the value of a node is always smaller than or equals to the value(s) of its child node(s)
  - … which implies that the root has the smallest value
- Max Heap

Heap and Non-heap Examples

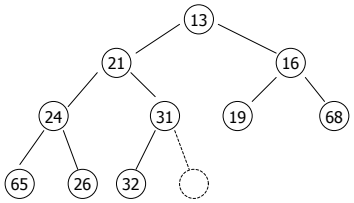


Insert

- Create a "hole" in the last position
- If the new value can be put in the hole without violating heap property, we are done; otherwise move the parent value into the hole (or in other words, move the hole up toward the root), and try inserting the value at the new hole. Repeat until the value can be inserted

Insert Example

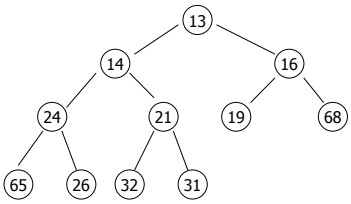
Insert 14 into the following heap:



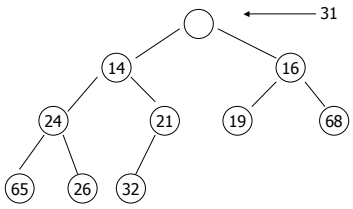
RemoveMin

- Create a "hole" in the root position
- If the last value can be put in the hole without violating heap property, we are done; otherwise move the smaller one of the two child values into the hole (or in other words, move the hole down toward leaf), and try inserting the value at the new hole. Repeat until the value can be inserted

RemoveMin Example …



… RemoveMin Example



Complexities

- insert() ??
- findMin() ??
- removeMin() ??

`MinHeap` Class

- insert(Comparable o)
- Comparable findMin()
- Comparable removeMin()
- int size()
- void clear()