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Transform-and-Conquer
Representation Change

Quiz
What is the advantage of changing the representation in each case?

Rearrange to take advantage of efficient ops on new representation

Examples

- ✎ List to BST (or AVL)
- ✎ BST to 2-3 tree
- ✎ Heap

A heap is a simpler partially ordered *O*(log *n*) dictionary data structure.

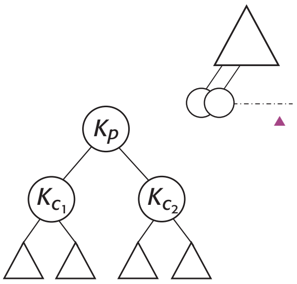
The Heap

- ➪ [Essentially] complete
- ➪ Parental dominance

A heap is recursive, every subtree is also a heap.

Definition

- ✎ Is a binary tree
- ✎ Tree shape requirement
- ✎ Heap (key) condition



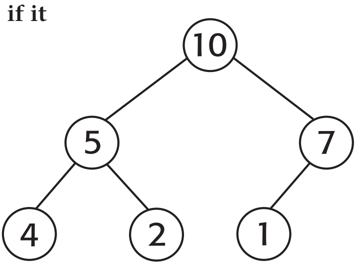
Quiz
Write the heap condition for the keys above.

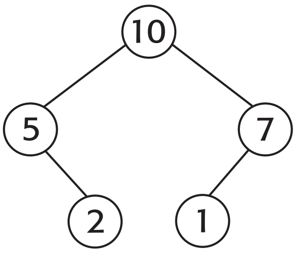
Heap Definition

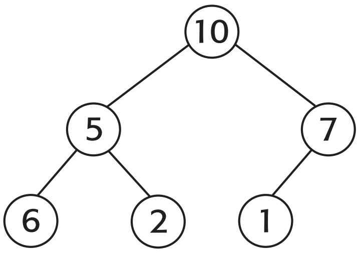
Which One is a Heap?

➪ Parental node

Recall, definition-based questions are really about set membership, check criteria in definition to decide if it applies.







Quiz
Which one is also a **full** binary tree? Does a heap need to be full? Does it have to be perfectly balanced? give an example. Can a search tree be both BST and a heap?

Heap Definition

More About Heaps

➪ **Properties**

✎ Root has largest (maximum) key

✎ Height of n-node heap: $h = \lfloor \log_2 n \rfloor$

🕮 ✎ More ...

➪ **Applications**

Characteristic operations efficient if keys stored as a heap instead of a list.

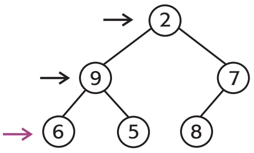
✎ Priority queues

✎ Heapsort: efficient in-place sort

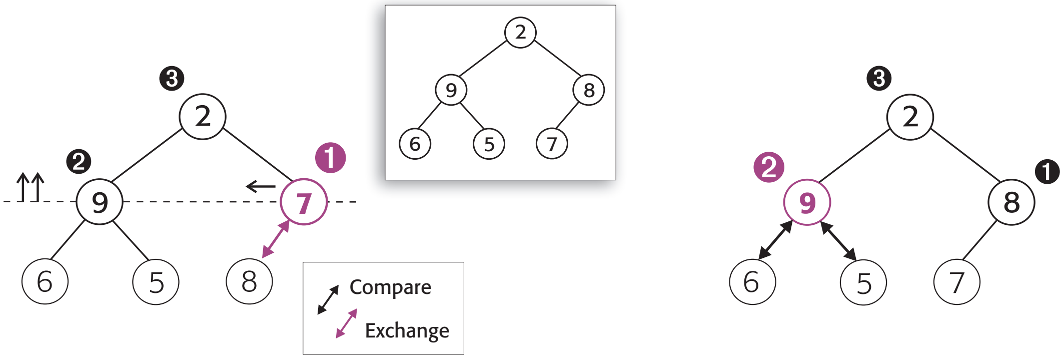
Heap Construction

➪ Bottom-up heapify

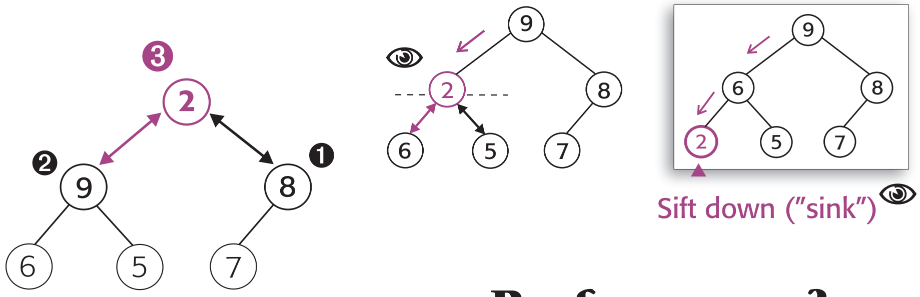
2,9,7,6,5,8



Big tree shows major iteration (labeled 1-3), small (boxed) shows result after heapify.



For each major iteration potentially, while not heap repeatedly keep sifting down to fix.



Performance?

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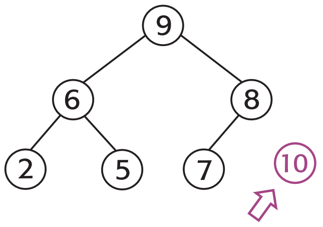
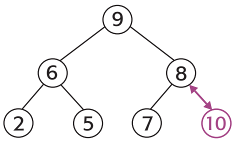
Heap Operations

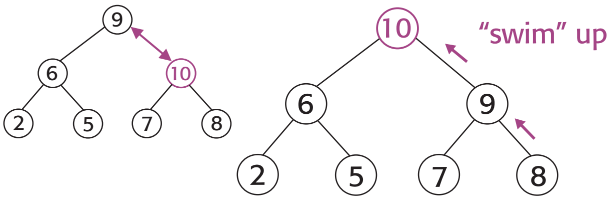
Key insert

Quiz
What are the efficiencies of these operations?



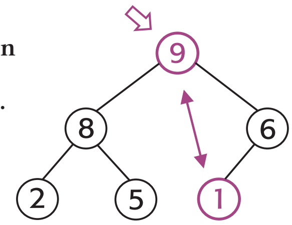


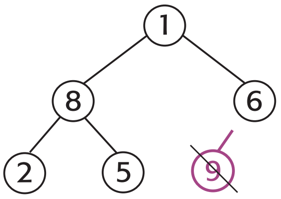
Exercise
Write pseudocode for pen-paper application to describe operations (note where iteration may, potentially, be needed).



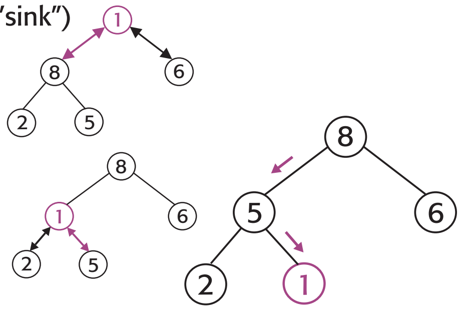
Max key delete

To check or dequeue highest priority item in a heap-based priority queue is very efficient.



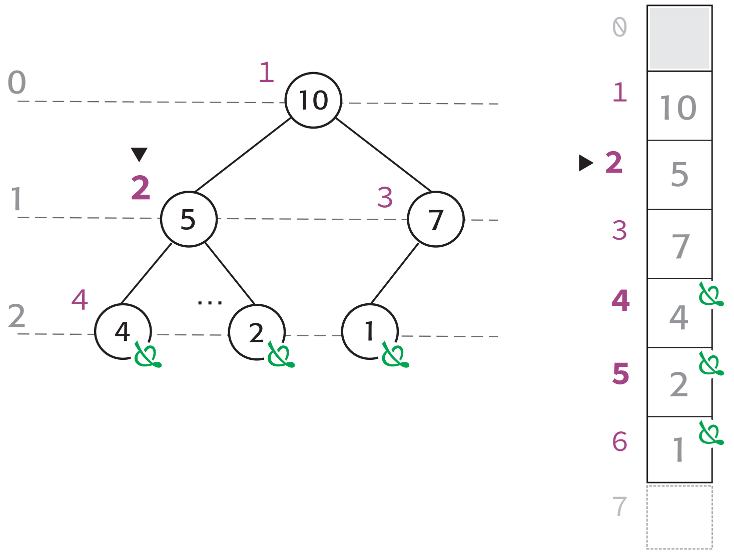


Sift down ("sink")



Array Representation

Quiz
What are the indices of children of node *i*? What's the index of the last **parental** node?



An array representation is attractive because of the simple relations between node indices.

Exercise
Write the array after each change in the heap construction example?