Lecture 18: Heaps & Heapsort

CS 62
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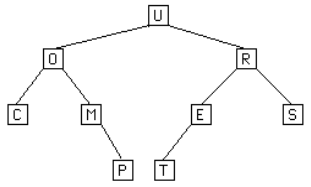
Assignments

- Lab: Compressed grid iterator
- Assignment: Darwin monster simulator
  Due: 3/11 Right before spring break.
  No mentor sessions on 3/12 or 3/13!

Array Representations of Trees

Array Representation

- data[0..n-1] can hold values in trees
  - left subtree of node k in 2k+1, right in 2k+2,
  - parent in (k-1)/2



Indices: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
data[]: U O R C M E S - - - P T - - -

Array Representation: Efficiency

- Tree of height h, takes 2^{h+1}-1 slots, even if only has O(h) elements
  - Bad for long, skinny trees
  - Good for full or complete trees.
- *Complete tree* is full except possibly bottom level and has all leaves at that level in leftmost positions.

PriorityQueue

```
public interface PriorityQueue<E extends Comparable<E>>
{
    /**
     * @pre !isEmpty()
     * @return The minimum value in the queue.
     */
    public E remove();
    public E getFirst();
    public void add(E value);
    public boolean isEmpty();
    public int size();
    public void clear();
}
```

Objects of type E can be compared

Implementations

Unsorted array: O(1) add, O(n) remove

Reverse sorted array: O(n) add, O(1) remove

Heap ordered array: O(log n) add, O(log n) remove

Min-Heap

A **min heap** is a complete full binary tree such that, the value in the root position is the smallest value and left and right subtrees of the root are both min heaps.

Typically a min heap is stored in an array using the array representation of trees.

See VectorHeap code

Heap Performance

- remove: O(log n)
- getFirst: O(1)
- add: (log n)
- isEmpty, size, clear: O(1)

Heapsort

1. Add all elements from vector into heap: O(n log n)
2. Remove elements in order from heap: O(n log n)
3. Total time: O(n log n)

Can get about a factor of 2 speed up by building the heap “in place” in O(n) time using heapify.