

Section 10

CSCI E-22

Will Begin Shortly

Heaps

Recall:

- *Heap*: a complete binary tree in which each interior node is greater than or equal to its children
- The maximum value is in the root node
- The minimum value can be in any one of the leaf nodes
- Often used to implement a priority queue
 - Can efficiently retrieve the highest priority value (root of max-at-top heap)
- Since a heap is a complete tree, we can use an array as a compact representation
 - For a parent node at index i , the left child is stored in index $2i + 1$ and right child is stored in index $2i + 2$

Heaps

We will now convert the following 6-element array into a valid max-heap. We start by taking our array and representing it as a heap in the usual manner, with the first element as the root.

0	1	2	3	4	5
7	11	5	39	16	20

Heaps

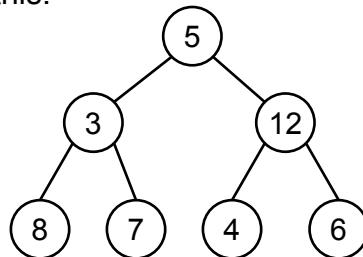
0	1	2	3	4	5
7	11	5	39	16	20

Heapsort

We will now run through an example of heapsort. Suppose we have the following numbers in an array:

0	1	2	3	4	5	6
5	3	12	8	7	4	6

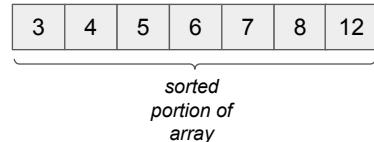
We want to sort the array in ascending order. If we interpret the array as a complete tree, it looks like this:



Heapsort

0	1	2	3	4	5	6
5	3	12	8	7	4	6

Heapsort



Algorithm:

[What is the runtime of Heapsort?](#)

Repeat:

- Remove largest element
- Re-heapify
- Place removed element into place in array

Hashing

Suppose we have a 7-element hash table, and we wish to insert following words:

apple, cat, anvil, boy, bag, dog, cup, down

We'll use the following hash function:

$h(\text{key})$: index related to first letter of the key ($a = 0, b = 1, \dots$)

Let's insert these keys into an initially empty hash table using *linear* probing and count the total length of the probes. Then, do the same exercise, but use *quadratic* probing.

Linear probe sequence: $h(x), h(x) + 1, h(x) + 2, h(x) + 3, \dots, h(x) + n-1$

Quadratic probe sequence: $h(x), h(x) + 1^2, h(x) + 2^2, h(x) + 3^2, \dots, h(x) + (n-1)^2$

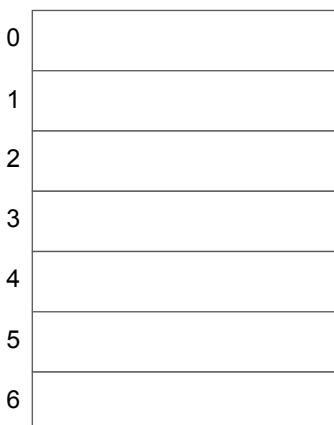
apple, cat, anvil, boy, bag, dog, cup, down

Linear probing



apple, cat, anvil, boy, bag, dog, cup, down

Quadratic probing



The `probe()` method in our `HashTable` class

The return value of the `probe()` method is an integer.

- If the key is in the table, the `probe()` method returns the index it is stored in
- If the key is *not* in the table, the `probe()` method returns the index of the first empty or removed cell encountered during the search for the key

The hash table to the right has been partially filled using linear probing and the hash function from the previous problem. A gray cell indicates that an item has been removed.

One of the items in the table has been inserted incorrectly. Which one?

0	aardvark
1	
2	cat
3	bear
4	
5	dog
6	

The `probe()` method in our `HashTable` class

0	aardvark
1	
2	cat
3	bear
4	
5	dog
6	

Determine the return value of the `probe()` method for:

bear

cow

buffalo

giraffe