#28: Heaps and Priority Queues
October 30, 2019 · *G Carl Evans*
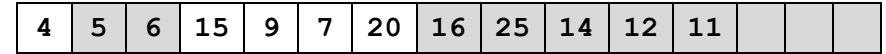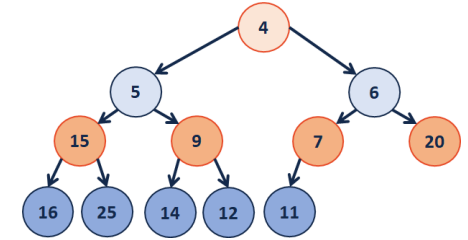
A New Data Structure Arrives:

ADT:

  insert

  remove

  isEmpty

Implementation of _____

insert	removeMin	Implementation
O(n)	O(n)	Unsorted Array
O(1)	O(n)	Unsorted List
O(lg(n))	O(1)	Sorted Array
O(lg(n))	O(1)	Sorted List

Q1: What errors exist in this table? (Fix them!)

Q2: Which algorithm would we use?
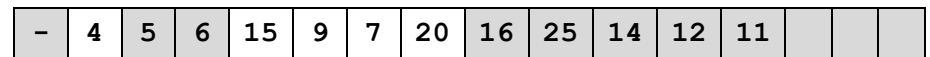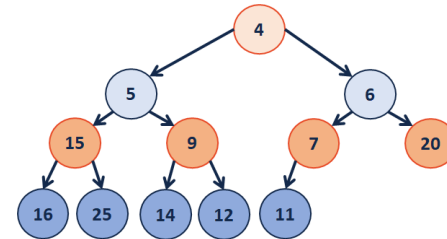
Implementing a (min)Heap as an Array

| 4 | 5 | 6 | 15 | 9 | 7 | 20 | 16 | 25 | 14 | 12 | 11 | | | |

Operations:

  leftChild(index) :=

  rightChild(index) :=

  parent(index) :=

Inserting into a Heap

| – | 4 | 5 | 6 | 15 | 9 | 7 | 20 | 16 | 25 | 14 | 12 | 11 | | | |

...running time?

Heap.hpp (partial)

```cpp
1   template <class T>
2   void Heap<T>::_insert(const T & key) {
3     // Check to ensure there's space to insert an element
4     // ...if not, grow the array
5     if ( size_ == capacity_ ) { _growArray(); }
6
7     // Insert the new element at the end of the array
8     item_[++size] = key;
9
10    // Restore the heap property
11    _heapifyUp(size);
12  }
```

```cpp
31  template <class T>
32  void Heap<T>::_heapifyUp( _____ ) {
33    if ( index > _____ ) {
34      if ( item_[index] < item_[ parent(index) ] ) {
35        std::swap( item_[index], item_[ parent(index) ]
36  );
37        _heapifyUp( _____ );
38      }
39    }
40  }
```

What's wrong with this code?

Heap.hpp (partial)

```cpp
1   template <class T>
2   void Heap<T>::_removeMin() {
3     // Swap with the last value
4     T minValue = item_[1];
5     item_[1] = item_[size_];
6     size--;
7
8     // Restore the heap property
9     heapifyDown();
10
11    // Return the minimum value
12    return minValue;
13  }
```

```cpp
1   template <class T>
2   void Heap<T>::_heapifyDown(int index) {
3     if ( !_isLeaf(index) ) {
4       T minChildIndex = _minChild(index);
5       if ( item_[index] ____ item_[minChildIndex] ) {
6         std::swap( item_[index], item_[minChildIndex] );
7         _heapifyDown( _____ );
8       }
9     }
10  }
```
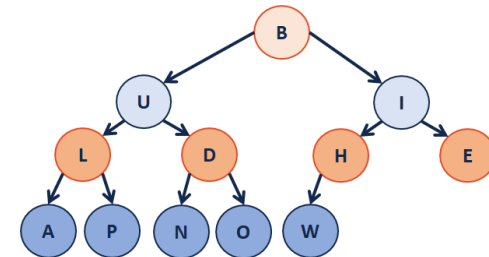
Heap Operation: removeMin / heapifyDown:

–	4	5	6	15	9	7	20	16	25	14	12	11			

Q: How do we construct a heap given data?
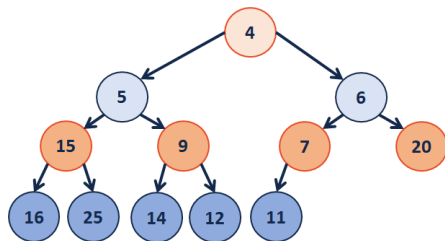
–	B	U	I	L	D	H	E	A	P	N	O	W			

CS 225 – Things To Be Doing:

1. Theory Exam 3 starts next Thursday (Nov. 7th)
2. MP5 +5 deadline is tonight; due next Monday (Nov. 4th)
3. lab_hash is out today, due on Sunday (Nov. 3th)
4. Daily POTDs are ongoing :)