North South University

Department of Electrical and Computer Engineering

CSE 225L.13 (Data Structures and Algorithms Lab)

Lab 20: Priority Queue

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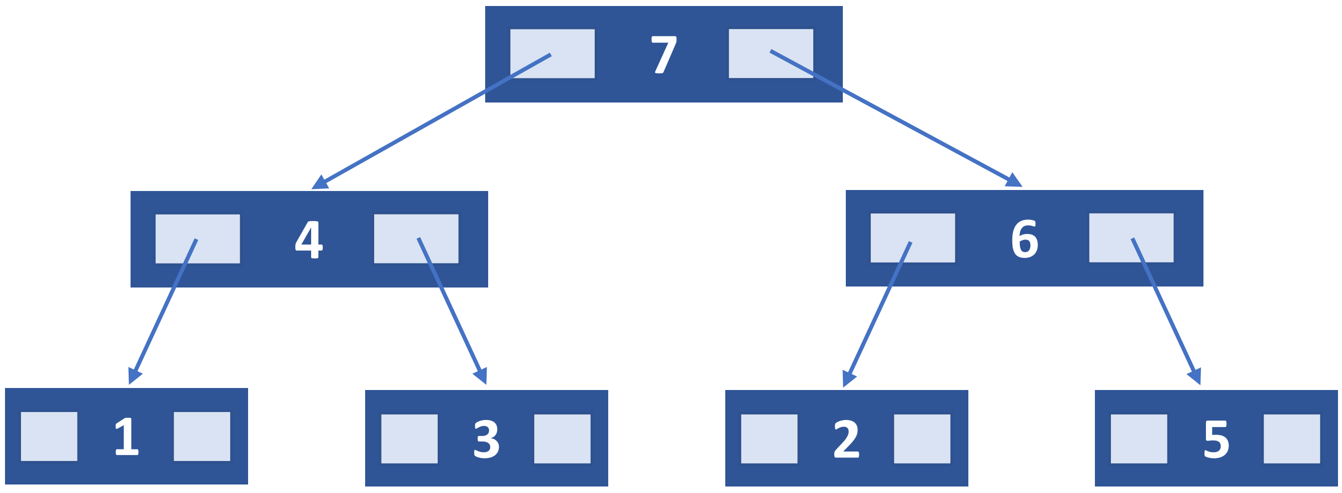
Objective:

- Learn about how Priority Queues work

What is a Priority Queue:

A priority queue is a type of Queue that arranges elements based on their priority values. Elements with higher priority values are typically retrieved before elements with lower priority values. The element with the highest value is usually considered the highest-priority element (where max-heaps are used). However, in other cases, we can assume the element with the lowest value as the highest priority element (where min-heaps) is used.

We use heaps for making priority queues, so it looks something like this:



We have made a max-heap; thus, the highest value is at the root by this time. However, every time a new element is placed, it is placed in the latest possible empty position; thus, based on the value, the Heap performs the reheapUp functions as much as required.

Prototype of Heaps:

The header and source file of the Heap are given as follows.

heaptype.h

```
#ifndef HEAPTYPE_H_INCLUDED
#define HEAPTYPE_H_INCLUDED
template<class ItemType>
struct HeapType
{
    void ReheapDown(int root, int bottom); void ReheapUp(int root, int bottom);
    ItemType* elements; int numElements;
};
#endif // HEAPTYPE_H_INCLUDED
```

heaptype.cpp

```
#include "heaptype.h"
template<class ItemType>
void Swap(ItemType& one, ItemType& two)
{
    ItemType temp; temp = one; one = two; two = temp;
}
template<class ItemType>
void HeapType<ItemType>::ReheapDown(int root, int bottom)
{
    int maxChild; int rightChild; int leftChild;
    leftChild = root*2+1; rightChild = root*2+2;
    if (leftChild <= bottom)
    {
        if (leftChild == bottom)
        {
            maxChild = leftChild;
        }
        else
        {
          if(elements[leftChild]<=elements[rightChild])
                maxChild = rightChild;
            else
                maxChild = leftChild;
        }
        if (elements[root] < elements[maxChild])
        {
            Swap(elements[root], elements[maxChild]);
            ReheapDown(maxChild, bottom);
        }
    }
}

template<class ItemType>
void HeapType<ItemType>::ReheapUp(int root, int bottom)
{
    int parent;
    if (bottom > root)
    {
        parent = (bottom-1) / 2;
        if (elements[parent] < elements[bottom])
        {
            Swap(elements[parent], elements[bottom]);
            ReheapUp(root, parent);
        }
    }
}
```

Prototype of Priority Queue:

The header and source file of the Priority Queue are given as follows.

pqtype.h

```
#ifndef PQTYPE_H_INCLUDED
#define PQTYPE_H_INCLUDED
#include "heaptype.h"
#include "heaptype.cpp"
class FullPQ{};
class EmptyPQ{};
template<class ItemType>
class PQType
{
public:
    PQType(int); ~PQType();
    void MakeEmpty(); bool IsEmpty();
    bool IsFull(); void Enqueue(ItemType);
    void Dequeue(ItemType&);
private:
    int length; HeapType<ItemType> items; int maxItems;
};
#endif // PQTYPE_H_INCLUDED
```

pqtype.cpp

```
#include "pqtype.h"
template<class ItemType>
PQType<ItemType>::PQType(int max)
{
    maxItems = max;
    items.elements=new ItemType[max];
    length = 0;
}
template<class ItemType>
PQType<ItemType>::~PQType()
{
    delete [] items.elements;
}
template<class ItemType>
void PQType<ItemType>::MakeEmpty()
{
    length = 0;
}
template<class ItemType>
bool PQType<ItemType>::IsEmpty()
{
    return length == 0;
}
```

```
template<class ItemType>
bool PQType<ItemType>::IsFull()
{
    return length == maxItems;
}
template<class ItemType>
void PQType<ItemType>::Enqueue(ItemType newItem)
{
    if (length == maxItems)
        throw FullPQ();
    else
    {
        length++;
        items.elements[length-1] = newItem;
        items.ReheapUp(0, length-1);
    }
}
template<class ItemType>
void PQType<ItemType>::Dequeue(ItemType& item)
{
    if (length == 0)
        throw EmptyPQ();
    else
    {
        item = items.elements[0];
        items.elements[0] = items.elements[length-1];
        length--;
        items.ReheapDown(0, length-1);
    }
}
```

Tasks:

Operation to Be Tested and Description of Action	Input Values	Expected Output
• Create a PQType object with a size 15		
• Print if the Queue is empty or not		Queue is empty
• Insert ten items in order they appear	4 9 2 7 3 11 17 0 5 1	
• Print if the Queue is empty or not		Queue is not empty.
• Dequeue one element and print the dequeued value		17
• Dequeue one element and print the dequeued value		11
• You have ***N*** magical bags of candies in front of you. The ith bag has ***A_i*** candies in it. It takes you one minute to finish a bag of candies, no matter how many candies in it. Every time you finish a bag with ***X*** candies in it, the bag is magically replenished with ***X/2*** (rounded down to the nearest integer) more candies. Write a program that determines the maximum number of candies you can eat in K minutes. The input is a sequence of integers. The first integer ***N*** is the number of bags. The next integer ***K*** is the number of minutes you have. The next ***N*** integers is the number of candies in the bags. The output of your program is a single integer which represents the maximum number of candies you can eat.	5 3 2 1 7 4 2	14