C++ ITERATORS
HEAP DATA STRUCTURE

Problem Solving with Computers-II

C++STL

- The C++ Standard Template Library is a very handy set of three built-in components:
  - Containers: Data structures
  - Iterators: Standard way to move through elements of containers
  - Algorithms: These are what we ultimately use to solve problems

C++ Iterators behave like pointers

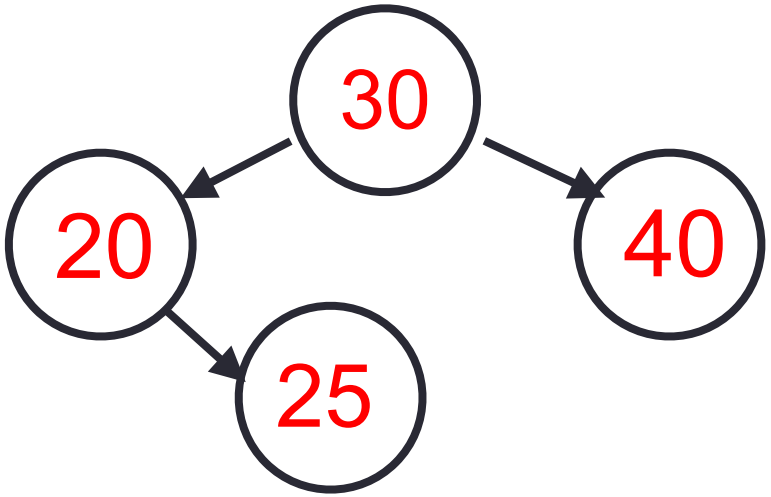
- Let's consider how we generally use pointers to parse an array

10	20	25	30	46	50	55	60

```
void printElements(int arr[], int size) {
    int* p= arr;
   for(int i=0; i<size; i++) {
         std::cout << *p << std::endl;
         ++p;
    }
}
```

- We would like our print "algorithm" to also work with other data structures
- E,g Linked list or BST

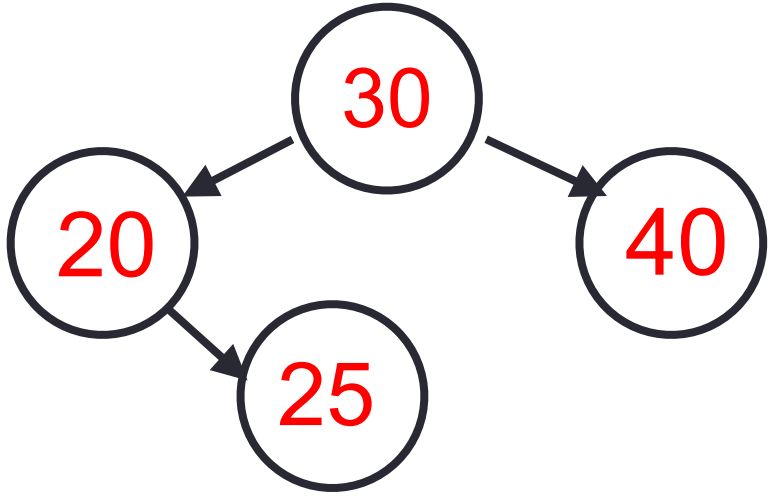
Can a similar pattern work with a BST? Why or Why not?




```
void printElements(set<int>& s) {
    _____________________________//How should we define p?
    for(int i=0; i<s.size(); i++) {
        std::cout << *p << std::endl;
        ++p;
    }
}
```

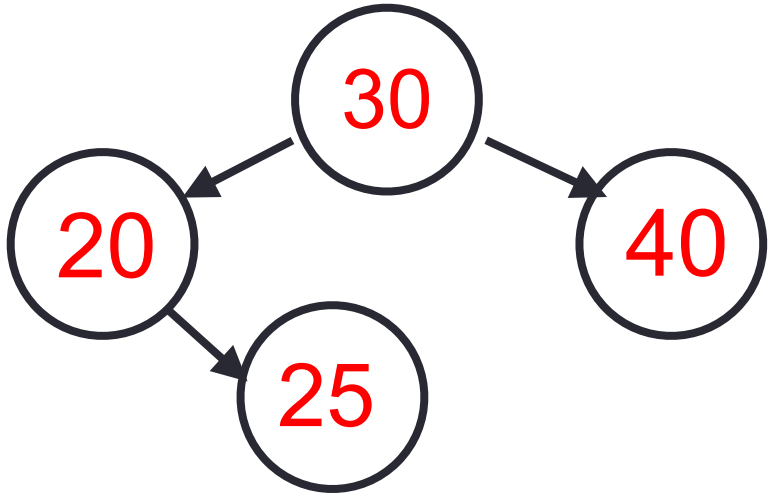
Iterators are objects that behave like pointers

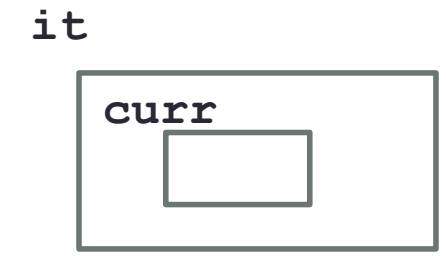
```
set<int> s;
//insert keys 20, 30, 35, 40

________ =  s.find(25);
```



- “it” is an iterator object which can be used to access data in the container sequentially, without exposing the underlying details of the class

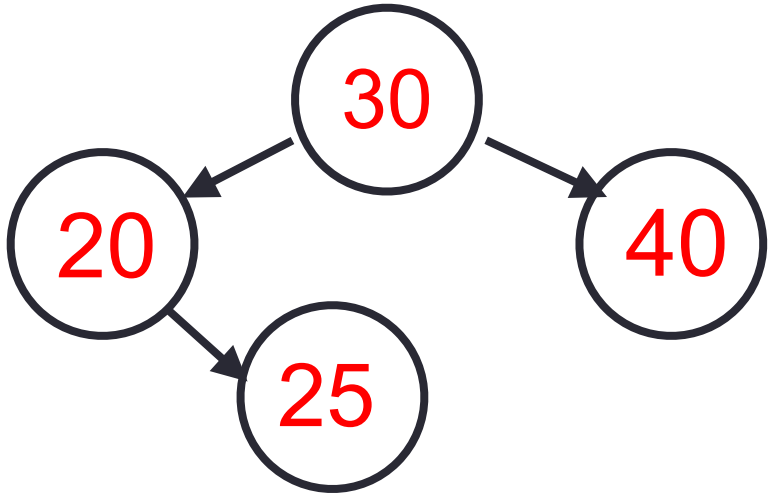
```
set<int> s;
//insert keys 20, 30, 35, 40
set<int>::iterator it;
it =  s.find(25);
cout<<*it;
```

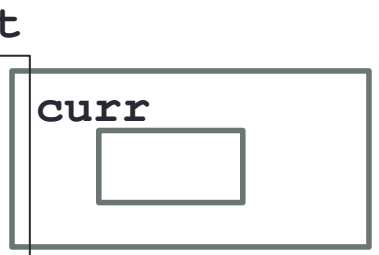




- “it” is an iterator object which can be used to access data in the container sequentially, without exposing the underlying details of the class

```
set<int> s;
//insert keys 20, 30, 35, 40
set<int>::iterator it;
it =  s.find(25);
cout<<*it;
it++;
```



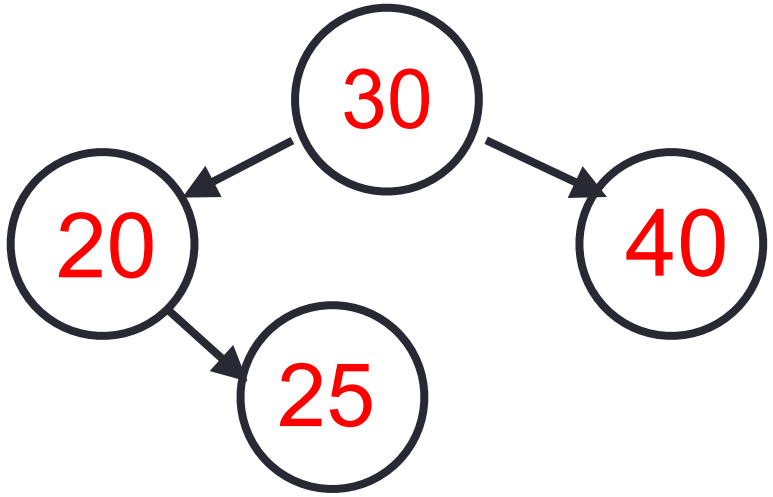


Which operators that must be overloaded for the iterator type?

A. *
B. ++
C. <<
D. All of the above
E. Only A and B

C++ Iterators

```
void printElements(set<int>& s)  {
  set<int>::iterator it = s.begin();
  set<int>::iterator en = s.end();
  while(it!=en){
        std::cout << *it <<" ";
        it++;
  }
  cout<<endl;
}
```



C++ shorthand: auto

```
void printElements(set<int>& s)   {
  auto it = s.begin();
  auto en = s.end();
  while(it!=en){
        std::cout << *it <<" ";
        it++;
  }
  cout<<endl;
}
```

Finally: unveiling the range based for-loop

```
void printElements(set<int>& s)   {
  for(auto item:s){
        std::cout << item <<" ";
  }
  cout<<endl;
}
```

PA02 Learning Goal

- Get familiarized with the STL documentation
- Select among available data structures

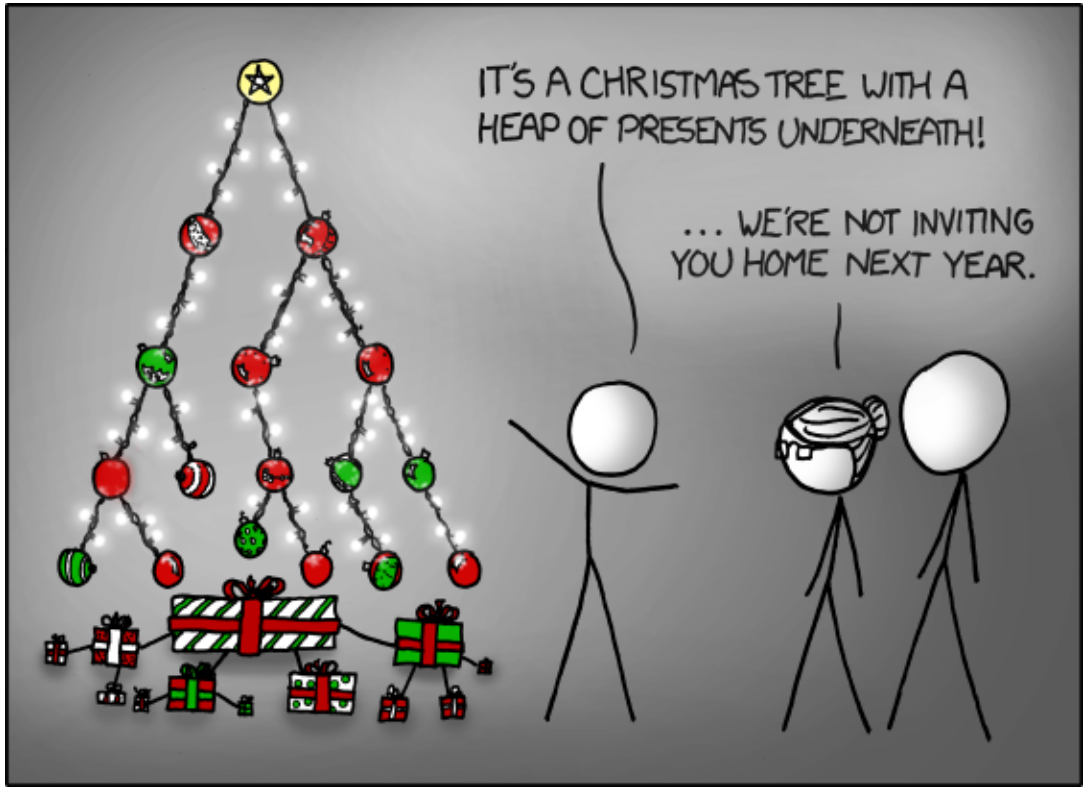
Check out the member functions of set and vector
https://www.cplusplus.com/reference/set/set/set/

https://www.cplusplus.com/reference/vector/vector/?kw=vector

The complexity of each of the member functions is provided:
https://www.cplusplus.com/reference/set/set/find/

New data structure: Heap

- Clarification
  - *heap*, the data structure is not related to *heap,* the region of memory
- What are the operations supported?
- What are the running times?



Heap

	Min-Heaps	Max-Heap	BST
• Insert :			
• Min:			
• Delete Min:			
• Max			
• Delete Max			

Applications:

- Efficient sort
- Finding the median of a sequence of numbers
- Compression codes

Choose heap if you are doing repeated insert/delete/(min OR max) operations

std::priority_queue (STL's version of heap)

A C++ `priority_queue` is a generic container, and can store any data type on which an ordering can be defined: for example `ints, structs (Card),` pointers etc.

```
#include <queue>
priority_queue<int> pq;
```

Methods:

```
* push()  //insert
* pop()   //delete max priority item
* top()   //get max priority item
* empty()  //returns true if the priority queue is empty
* size() //returns the number of elements in the PQ
```

- You can extract object of highest priority in O(log N)
- To determine priority: objects in a priority queue must be comparable to each other

STL Heap implementation: Priority Queues in C++

What is the output of this code?

```
priority_queue<int> pq;
pq.push(10);
pq.push(2);
pq.push(80);
cout<<pq.top();
pq.pop();
cout<<pq.top();
pq.pop();
cout<<pq.top();
pq.pop();
```

A. 10 2 80
B. 2 10 80
C. 80 10 2
D. 80 2 10
E. None of the above

std::priority_queue template arguments

```
template <
      class T,
      class Container= vector<T>,
      class Compare = less <T>
      > class priority_queue;
```

The template for priority_queue takes 3 arguments:

1. Type elements contained in the queue.
2. Container class used as the internal store for the priority_queue, the default is **vector<T>**
3. Class that provides priority comparisons, the default is **less**

std::priority_queue template arguments

```
//Template parameters for a max-heap
priority_queue<int, vector<int>, std::less<int>> pq;

//Template parameters for a min-heap
priority_queue<int, vector<int>, std::greater<int>> pq;
```

Comparison class

- Comparison class: A class that implements a function operator for comparing objects

```
class compareClass{
        bool operator()(int& a, int & b) const {
                return a>b;
        }
};
```

Comparison class

```
class compareClass{
        bool operator()(int& a, int & b) const {
                return a>b;
        }
};
```

```
int main(){
    compareClass c;
    cout<<c(10, 20)<<endl;
}
```

What is the output of this code?

A. 1

B. 0

C. Error

STL Heap implementation: Priority Queues in C++

```
class cmp{
        bool operator()(int& a, int & b) const {
                return a>b;
        }
};
 priority_queue<int, vector<int>, cmp> pq;
 pq.push(10);
 pq.push(2);
 pq.push(80);
 cout<<pq.top();
 pq.pop();
 cout<<pq.top();
 pq.pop();
 cout<<pq.top();
 pq.pop();
```

Output: _____

pq is a _____heap