STL – Standard Template Library

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STL – Standard Template Library

- Collections of useful classes for common data structures
- Ability to store objects of any type (template)
- Containers form the basis for treatment of data structures
- Container – class that stores a collection of data
- STL consists of 10 container classes:

STL Containers

- Sequence Container
  - Stores data by position in linear order:
  - First element, second element , etc.
  - All containers
    - Use same names for common operations
    - Have specific operations
- Associate Container
  - Stores elements by key, such as name, ID number or part number
  - Access an element by its key which may bear no relationship to the location of the element in the container
- Adapter Container
  - Contains another container as its underlying storage structure

STL Containers

- Sequence Container
  - Vector
  - Deque
  - List
- Adapter Containers
  - Stack
  - Queue
  - Priority queue
- Associative Container
  - Set, multiset
  - Map, multimap

How to access Components - Iterator

- Iterator is an object that can access a collection of like objects one object at a time.
- An iterator can traverse the collection of objects.
- Each container class in STL has a corresponding iterator that functions appropriately for the container
- For example: an iterator in a vector class allows random access
- An iterator in a list class would not allow random access (list requires sequential access)

Common Iterator Operations

- $\star$ Return the item that the iterator currently references
- $++$ Move the iterator to the next item in the list
- $-$ Move the iterator to the previous item in the list
- $==$ Compare two iterators for equality
- $!=$ Compare two iterators for inequality

Vector Container

- Generalized array that stores a collection of elements of the same data type
- Vector – similar to an array
    - Vectors allow access to its elements by using an index in the range from *0* to *n-1* where *n* is the size of the vector
- Vector vs array
    - Vector has operations that allow the collection to grow and contract dynamically at the rear of the sequence

Vector Container

Example:

```
#include <vector>
.
.
.
vector<int> scores (100);                //100 integer scores
vector<Passenger>passengerList(20);      //list of 20 passengers
```

Vector Container

- Allows direct access to the elements via an index operator
- Indices for the vector elements are in the range from 0 to size() -1
- Example:

```
#include <vector>
vector <int> v(20);
v[5]=15;
```

Vector Example

```cpp
// constructing vectors
#include <iostream>
#include <vector>
using namespace std;
int main ()
{
  // constructors used in the same order as described above:
  vector<int> first;                                // empty vector of ints
  vector<int> second (4,100);                       // four ints with value 100
  vector<int> third (second.begin(),second.end());  // iterating through second
  vector<int> fourth (third);                       // a copy of third

  // the iterator constructor can also be used to construct from arrays:
  int myints[] = {16,2,77,29};
  vector<int> fifth (myints, myints + sizeof(myints) / sizeof(int) );

  cout << "The contents of fifth are:";
  for (vector<int>::iterator it = fifth.begin(); it != fifth.end(); ++it)
    cout << ' ' << *it;
  cout << '\n';

  return 0;
}
```

List Container

- Stores elements by position
- Each item in the list has both a value and a memory address (pointer) that identifies the next item in the sequence
- To access a specific data value in the list, one must start at the first position (front) and follow the pointers from element to element until data item is located.
- List is not a direct access structure
- Advantage: ability to add and remove items efficiently at any position in the sequence

STL List Class

- Constructors and assignment
  - `list <T> v;`
  - `list <T> v(aList);`
  - `ll=aList;`
- Access
  - `l.front()` returns the first element in the list
  - `l.back()` returns the last element in the list

STL List Class (Cont.)

- Insert and Remove
  - `l.push_front(value)`
  - `l.push_back(value)`
- Iterator Delaration
  - `list<T>::iterator itr;`
- Iterator Options
  - `itr = l.begin()` set iterator to beginning of the list
  - `itr = l.end()` set iterator to after the end of the list

List Example

```
#include <iostream>
#include <list>
using namespace std;

// Simple example uses type int

int main()
{
   list<int> L;
   L.push_back(0);          // Insert a new element at the end
   L.push_front(0);         // Insert a new element at the beginning
   L.insert(++L.begin(),2); // Insert "2" before position of first argument
                            // (Place before second argument)
   L.push_back(5);
   L.push_back(6);

   list<int>::iterator i;

   for(i=L.begin(); i != L.end(); ++i) cout << *i << " ";
   cout << endl;
   return 0;
}
```

Stack Container

- Adapter Container
- These containers restrict how elements enter and leave a sequence
- Stack
  - allows access at only one end of the sequence (top)
  - Adds objects to container by pushing the object onto the stack
  - Removes objects from container by popping the stack
  - LIFO ordering (last end, first out)

Stack Example

```
// stack::push/pop
#include <iostream>        // cout
#include <stack>           // stack
using namespace std;

int main ()
{
  stack<int> mystack;

  for (int i=0; i<5; ++i) mystack.push(i);

  cout << "Popping out elements...";
  while (!mystack.empty())
  {
     cout << ' ' << mystack.top();
     mystack.pop();
  }
  cout << '\n';

  return 0;
}
```

Queue Container

- Queue
  - Allows access only at the front and rear of the sequence
  - Items enter at the rear and exit from the front
  - Example: waiting line at a grocery store
  - FIFO ordering (first-in first-out)
  - push(add object to a queue)
  - pop (remove object from queue)

Queue Example

```cpp
#include <iostream>       // cin, cout
#include <queue>          // queue
using namespace std;
int main ()
{
        queue<int> myqueue;
        int myint;

        cout << "Please enter some integers (enter 0 to end):\n";

        do {
                cin >> myint;
                myqueue.push (myint);
        } while (myint);

        cout << "myqueue contains: ";
        while (!myqueue.empty())
        {
                cout << ' ' << myqueue.front();
                myqueue.pop();
        }
        cout << '\n';

        return 0;
}
```

Priority Queue Container

- Priority queue
  - Operations are similar to those of a stack or queue
  - Elements can enter the priority queue in any order
  - Once in the container, a delete operation removes the largest (or smallest) value

Set Container

- Set
  - Collection of unique values, called keys or set members
  - Contains operations that allow a programmer to:
    - determine whether an item is a member of the set
    - insert and delete items very efficiently

Set Example

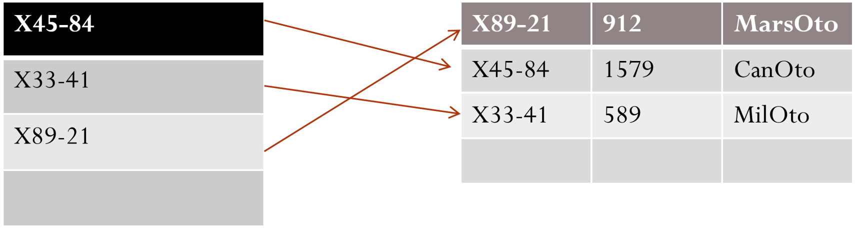
```
#include <iostream>
#include <set>
using namespace std;
int main ()
{
  set<string> s;
  cout << "Adding ’Hello’ and ’World’ to the set twice" << endl;

  s.insert("Hello");
  s.insert("World");
  s.insert("Hello");
  s.insert("World");

  cout << "Set contains:";
  while (!s.empty()) {
    cout << ’ ’ << *s.begin();
    s.erase(s.begin());
  }

  return 0;
}
```

Multi-Set Container

- A multi-set is similar to a set, but the same value can be in the set more than once
- Multi-set container allows duplicates

Map Container

- Implements a key-value relationship
- Implements Programmer can use a key to access corresponding values
- Example: key could be a part number such as X89-21 that corresponds to a part: 912 price and MarsOto manufacturer



X45-84

X33-41

X89-21

X89-21	912	MarsOto
X45-84	1579	CanOto
X33-41	589	MilOto

Multi-map Container

- Similar to a map container
- Multi-map container allows duplicates

Writing classes that work with the STL

- Classes that will be stored in STL containers should explicitly define the following:
  - Default constructor
  - Copy constructor
  - Destructor
  - operator=
  - operator==
  - operator<
- Not all of these are always necessary, but it might be easier to define them than to figure out which ones you actually need
- Many STL programming errors can be traced to omitting or improperly defining these methods