

G205

Fundamentals of Computer Engineering

CLASS 4, Wed Sept. 17 2003

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M-W, 9:50am-11:30am, 410 EII

C++ Libraries

- ◆ Concept of programming language library
- ◆ C++ Standard library
- ◆ C++ Standard Template Library = powerful, template-based, reusable software components

C++ Standard Template Library (STL)

- ◆ Implements common data structures and related algorithms
- ◆ Three key components:
 - **Containers:** Popular templated data structures
 - **Iterators:** like pointers, used to manipulate STL-container elements
 - **Algorithms:** Functions that performs data popular data manipulation

STL Containers

- ◆ An STL container implements a (popular) data structure
- ◆ Three major categories:
 - **Sequence containers**, for linear data structures (lists, arrays, etc.)
 - **Associative containers**, non-linear data structures (sets, maps, etc.)
 - **Container adapters**: Sequential containers in a constrained manner (stacks, queues, etc.)

STL Container Classes

◆ Sequence containers:

- vector: rapid direct access anywhere, dynamic size
- deque: rapid ins and del at front and back, rapid direct access
- list: doubly-linked list, rapid ins and del anywhere

◆ Associative containers:

- set, multiset: rapid lookup without/with duplicates
- map, multimap: one-to-one/many mapping

◆ Container adapters:

- stack: LIFO
- queue: FIFO
- priority_queue: highest priority element is the first out

Member Functions for All STL Containers

- ◆ Default constructor, copy constructor, destructor
- ◆ empty
- ◆ max_size, size
- ◆ =, <, <=, >, >=, ==, !=
- ◆ swap

Member Functions for FIRST CLASS Containers Only

- ◆ First class containers = sequential and associative containers only
- ◆ Member functions:
 - begin
 - end
 - rbegin
 - rend
 - erase
 - clear

STL Header Files

- ◆ `<vector>`
- ◆ `<deque>`
- ◆ `<list>`
- ◆ `<set>` (for `set` and `multiset`)
- ◆ `<map>` (for `map` and `multimap`)
- ◆ `<queue>` (for `queue` and `priority_queue`)
- ◆ `<stack>`

(All in namespace `std`)

STL Iterators

- ◆ Used to point to elements of first class containers
- ◆ Common features with pointers:
 - Dereferencing operator `*` allows to use the element the iterator is pointing to
 - The `++` operation on an iterator moves the iterator to the next element in the container
 - Iterators can be constant (`const_iterator` for non modifiable elements) or not (`iterator`)

Categories of Iterators

- ◆ Input: Read an element from a container, only forward
- ◆ Output: Write an element to a container, only forward
- ◆ Forward = input + output
- ◆ bidirectional: All of the above, multi-pass algorithms
- ◆ Random access: Can directly access any element, jumping an arbitrary number of elements

Categories Supported by STL Containers

- ◆ Sequence containers:
 - vector: random access
 - deque: random access
 - list: bidirectional
- ◆ Associative containers:
 - set, multiset: bidirectional
 - map, multimap: bidirectional
- ◆ Container adapters: No iterators supported

STL Algorithms

- ◆ Over 70 standard algorithms for manipulating containers:
 - Inserting
 - Deleting
 - Searching
 - Sorting
- ◆ Almost all for any type of container
- ◆ Often they use iterators and return iterators

STL Algorithms, examples

- ◆ **find()** locates an element and return an iterator to that element or the **end()** iterator if the element is not present
- ◆ **remove()** removes all occurrences of a given element from the corresponding container

Vector Container

- ◆ Class **vector** is based on array
- ◆ It can change size dynamically
- ◆ Vectors can be assigned to one another (impossible with pointer-based C-like arrays)
- ◆ Insertion at the back of a vector is efficient and the vector resizes if needed
- ◆ Vector subscripting DOES not perform range checking, but class vector allows it via the member function **at**

Vector Operations

- ◆ Common to all sequence containers:
 - front
 - back
 - push_back
 - pop_back
- ◆ All STL algorithms can operate on a vector

Vector, the Use, 1

```
#include <iostream>
```

```
using std::cout;
```

```
using std::cin;
```

```
using std::endl;
```

```
#include <vector>
```

```
Template <class T>
```

```
void print_vector(const std::vector< T > &integers2);
```

```
int main() {
```

```
    std::vector<int> integers;
```


Vector, the Use, 2

```
cout << integers.size() << `` << integers.capacity() << endl;
integers.push_back(2);
integers.push_back(3);
integers.push_back(4);
cout << integers.size() << `` << integers.capacity() << endl;
print_vector( integers );
std::vector<int>::reverse_iterator ri;
for (ri = integers.rbegin(); ri != integers.rend(); ++ri)
    cout << ri << ``;
cout << endl;
return 0;
}
```

Vector, the Use, 3

```
template<class T>
void printVector(const std::vector<T> &integers2) {
    std::vector<T>::const_iterator ci;
    for (ci = integers2.begin(); ci != integers2.end(); ci++)
        cout << *ci << ` `;
}
```

List Container

- ◆ Class **list** is based on pointers (doubly linked list)
- ◆ Supports bidirectional iterators
- ◆ Insertion and deletion at any location is implemented efficiently
- ◆ All member functions of STL containers are provided

List Operations

◆ Eight new member functions:

- splice
- push
- push_front
- pop_front
- remove
- unique
- merge
- reverse
- sort

STL Used for Defining Other Data Structures

- ◆ The class `Matrix`, for bidimensional matrices
- ◆ `#include <matrix>`
- ◆ `matrix M(10,15,0)`: defines a 10x15 matrix whose entries are all 0
- ◆ Defined as a vector of vectors

Assignments

- ◆ Deitel & Deitel book, chapter 21
- ◆ Updated information on the class web page:

www.ece.neu.edu/courses/eceg205/2003fa