STL

Object-Oriented Programming with C++

What is STL

- STL = Standard Template Library
- Part of the ISO Standard C++ Library
- Data Structures and algorithms for C++.

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Book:
From Mathematics to Generic Programming

Why should I use STL?

- Reduce development time.
  - Data-structures already written and debugged.
- Code readability
  - Fit more meaningful stuff on one page.
- Robustness
  - STL data structures grow automatically.
- Portable code.
- Maintainable code
- Easy

C++ Standard Library

- Library includes:
  - A pair class (pairs of anything, int/int, int/char, etc)
  - Containers
    - vector **(expandable array)**
    - deque **(expandable array, expands at both ends)**
    - list **(double-linked)**
    - set **and** map
  - Basic Algorithms (sort, search, etc)
- All identifiers in library are in std namespace

using namespace std;

The three parts of STL

- Containers
- Algorithms
- Iterators

The 'Top 3' data structures

- map
  - Any key type, any value type.
  - Sorted.
- vector
  - Like c array, but auto-extending.
- list
  - doubly-linked list

All sequential containers

- vector: variable array
- deque: dual-end queue
- list: double-linked-list
- forward_list: as it
- array: as "array"
- string: char array

Example using the vector class

- Use "namespace std" so that you can refer to vectors in C++ library

- Just declare a vector of ints (no need to worry about size)

- Add elements

- Have a pre-defined iterator for vector class, can use it to print out the items in vector

```cpp
#include <iostream>
#include <vector>
using namespace std;

int main( ) {
    vector<int> x;
    for (int a=0; a<1000; a++)
        x.push_back(a);
    vector<int>::iterator p;
    for (p=x.begin();
            p<x.end(); p++)
        cout << *p << " ";
    return 0;
}
```

Basic vector operations

- Constructors

  vector<Elem> c;

  vector<Elem> c1(c2);

- Simple methods

  V.size( )   **// num items**

  V.empty( )   **// empty?**

  ==, !=, <, >, <=, >=

  v1.swap(v2)   **// swap**

- Iterators

  I.begin( )   **// first position**

  I.end( )   **// last position**

- Element access

  V.at(index)

  V[index]

  V.front( )   **// first item**

  V.back( )   **// last item**

- Add/Remove/Find

  V.push_back(e)

  V.pop_back( )

  V.insert(pos, e)

  V.erase(pos)

  V.clear( )

  V.find(first, last, item)

Pay attention to efficiency

- Estimate and preserve the memory
- Avoid extra copies

code & demo

List class

- Same basic concepts as vector
  - Constructors
  - Ability to compare lists (==, !=, <, <=, >, >=)
  - Ability to access front and back of list
    x.front(), x.back()
  - Ability to assign items to a list, remove items
    x.push_back(item),
    x.push_front(item) x.pop_back(),
    x.pop_front() x.remove(item)

Sample list application

- Declare a list of strings
- Add elements
  - Some to the back
  - Some to the front
- Iterate through the list
  - Note the termination condition for our iterator

  p != s.end( )

  - Cannot use **p < s.end( )** as with vectors, as the list elements may not be stored in order

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

int main( ) {
    list<string> s;
    s.push_back("hello");
    s.push_back("world");
    s.push_front("tide");
    s.push_front("crimson");
    s.push_front("alabama");
    list<string>::iterator p;
    for (p=s.begin(); p!=s.end(); p++)
            cout << *p << " ";
    cout << endl;
}
```

maps

- Maps are collections that contain pairs of values.

- Pairs consist of a <u>key</u> and a <u>value</u>.

- Lookup works by supplying a key, and retrieving a value.
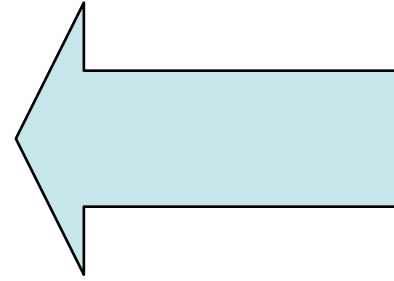
- An example: a telephone book.

Using maps

- A map with strings as keys and values

:map<string, string>

|	
"Charles Nguyen"	"(531) 9392 4587"
"Lisa Jones"	"(402) 4536 4674"
"William H. Smith"	"(998) 5488 0123"

Example program

```
#include <map>

#include <string>

map<string, float> price;

price["snapple"] = 0.75;

price["coke"] = 0.50;

string item;

double total=0;

while ( cin >> item )

        total += price[item];
```
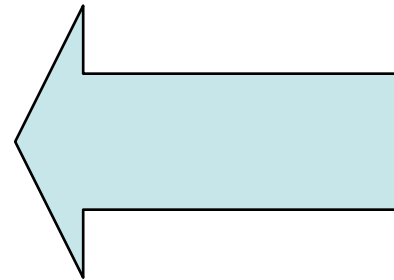
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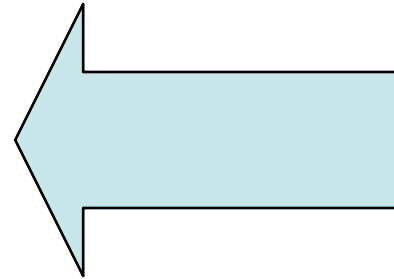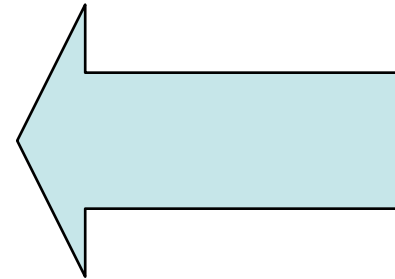
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Algorithms

- Take iterators as arguments

```
list<int> L;
vector<int> V;
// put list in vector
copy (L.begin(),
      L.end(),
      V.begin());
```

code & demo

The World Map of C++ STL Algorithms

https://www.fluentcpp.com/getthemap/

Typedefs

- Annoying to type long names
  - `map<Name,list<PhoneNum>> phonebook;`
  - `map<Name,list<PhoneNum>>::iterator finger;`
- Simplify with typedef
  - `typedef PB map<Name,list<PhoneNum>>;`
  - `PB phonebook;`
  - `PB::iterator finger;`
- Easy to change implementation.

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- C++ 11: *auto, using*

Using your own classes

- Might need:
  - Assignment Operator, `operator=()`
  - Default Constructor
- For sorted types, like `set,map,…`
  - Need less-than operator: `operator<()`
    - Some types have this by default:
      - int, char, string
    - Some do not:
      - char *

Example of user-defined type

- Sorted container needs sort function.

```
struct full_name {
    char * first;
    char * last;
    bool operator<(full_name & a) {
        return strcmp(first, a.first) < 0;
    }
}
map<full_name,int> phonebook;
```

Pitfalls

- Accessing an invalid `vector<>` element.

```
vector<int> v;
v[100]=1; // Whoops!
```

Solutions:

- use `push_back()`
- Preallocate with constructor.
- Reallocate with `resize()`
- Check `size()`

Pitfalls

- Inadvertently inserting into `map<>`

```
if (foo["bob"]==1)
// silently created entry "bob"
```

Use `count()` to check for a key without creating a new entry.

```
if (foo.count("bob"))
```

Or `contains()` introduced in C++20

```
if (foo.contains("bob"))
```

Pitfalls

- **Using** `empty()` **on** `list<>`
  - **–Slow**

    ```
    if (my_list.size()== 0)  {...}
    ```
  - **–Fast**

    ```
    if (my_list.empty())  {...}
    ```

Pitfalls

- Using invalid iterator

```
list<int> L;
list<int>::iterator li;
li = L.begin();
L.erase(li);
++li; // WRONG
```

- Use return value of erase to advance

```
li = L.erase(li); // RIGHT
```

Other data structures

- set, multiset, multimap

- queue, priority_queue

- stack, deque

- slist, bitset, valarray