The C++ Standard Library

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C++ Standard Library History

- Belongs to C++ Standard proposed by ANSI/ISO
- Standard currently circulating for comments and review
- Incorporates Standard Template Library
- A major addition on the C++, starting from ARM
- Part of the gcc 2.7 distributed with VLT Software

Why interesting?

- General purpose components
- Extensible framework
- Reliable and efficient
- Standard
- Orthogonal

Library components

- language support
- diagnostics
- general utilities
- strings
- locales
- containers
- iterartors
- algorithms
- numeric
- input/output
- standard C Library facility with static type safety

Strings

- Automatic memory management
- Automatic resize when needed
- Clear syntax and semantics
- Support for iterators
- Allows redefinition of operations

Normal c program to find a file on CCS

```
ccsCOMPL_STAT ccsFindFile (const   char *fileName,
                           char         *filePath,
                           vltINT8      *mode,
                           vltUINT32    *size,
                           vltINT8      *dirFlag)
{
    char myFile[128];
    struct stat stbuf;
    char *pwd,*pchar;
    char *intRoot,*vltRoot,*vltData;

    /* Initialization */

    strcpy(filePath,"");
    *mode = 0; *size = 0; *dirFlag = 0;

    if ( fileName == (char *) NULL ) return(FAILURE);
    if ( filePath == (char *) NULL ) return(FAILURE);

    /*
     *  Check if file exist in the current directory
     */


if ( (pchar = strpbrk(fileName,"/")) != (char *) NULL)
       {
       pchar ++ ; strcpy(myFile,pchar);
       }
    else
       strcpy(myFile,fileName);


    if (stat(myFile,&stbuf) == 0) { goto exit_success; }
```

```
/*
 *  Check if file exist as current sub-directory
 */

if ((pwd = getenv("PWD"))!= (char *) NULL)
   sprintf(myFile,"%s/",pwd);
else
   strcpy(myFile,"./");

strcat(myFile,fileName);

if (stat(myFile,&stbuf) == 0) { goto exit_success; }

/*
 *  Check if file exist as sub-directory of current module
 */

strcpy(myFile,"../");
strcat(myFile,fileName);

if (stat(myFile,&stbuf) == 0) { goto exit_success ;}

/*
 *  Check if file exist in INTROOT or VLTROOT
 */

if (ccsGetInstallPath(&vltRoot,&intRoot,&vltData) != FAILURE)
   {
   if (intRoot != (char *) NULL)
      {
      sprintf(myFile,"%s/%s",intRoot,fileName);
      if (stat(myFile,&stbuf) == 0) { goto exit_success ;}
      }

   if (vltData != (char *) NULL)
      {
      sprintf(myFile,"%s/%s",vltData,fileName);
```

```
            if (stat(myFile,&stbuf) == 0) { goto exit_success ;}
            }

         if (vltRoot != (char *) NULL)
            {
            sprintf(myFile,"%s/%s",vltRoot,fileName);
            if (stat(myFile,&stbuf) == 0) { goto exit_success ;}
            }

         }
    /*
     *  File does not exist
     */

    return(FAILURE);

exit_success:

    strcpy(filePath,myFile);
    *mode    = stbuf.st_mode;
    *size    = stbuf.st_size;

    if ((stbuf.st_mode & S_IFDIR) == S_IFDIR ) *dirFlag = 1;

    return(SUCCESS);
}
```

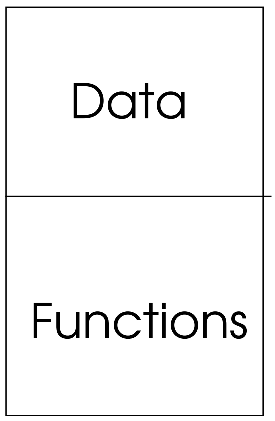
c++ using the standard library

```
#include <string>
#include <iostream.h>

main(int argc , char **argv)
{
    struct stat stbuf;
    string fileName=argv[1];

    // Check if file exist in the current directory
    string myFile = fileName.substr(fileName.rfind("/")+1);
    if (stat(myFile,&stbuf) == 0) { goto exit_success; }


    // Check if file exist as current sub-directory
    string pwd = getenv("PWD");
    if ( pwd.empty() ) pwd = ".";
    myFile = pwd + "/" + fileName;


    if (stat(myFile,&stbuf) == 0) { goto exit_success; }

    // Check if file exist as sub-directory of current module
    myFile = "../" + filename;
    if (stat(myFile,&stbuf) == 0) { goto exit_success; }


    //Check if file exist in INTROOT or VLTROOT
char *intRoot,*vltRoot,*vltData;
    if (ccsGetInstallPath(&vltRoot,&intRoot,&vltData) != FAILURE)
    {
    string svltRoot=vltRoot,sintRoot=intRoot,svltData=vltData;
            if ( !sintRoot.empty() )
        myFile = sintRoot + fileName;
```

```
    if ( !svltData.empty() )
        myFile = svltData + fileName;
    if ( !svltRoot.empty() )
        myFile = svltRoot + filename;

    if (stat(myFile,&stbuf) == 0) { goto exit_success ;}
}
    }

    // File does not exist
    return(FAILURE);


  exit_success:
    string filePath = myFile;
    *mode     = stbuf.st_mode;
    *size     = stbuf.st_size;

    if ((stbuf.st_mode & S_IFDIR) == S_IFDIR ) *dirFlag = 1;

    return(SUCCESS);
}
```

Containers Iterators and algorithms

CLASS



ABSTRACT DATA TYPE

C++ Standard Library

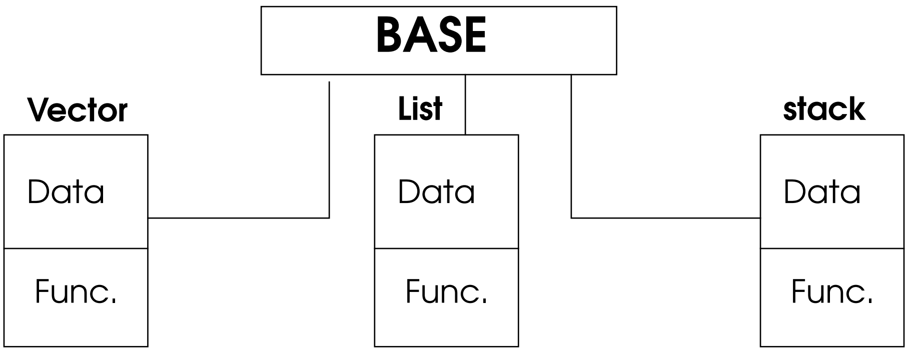
- Every application uses basic data structures like :

  - vector
  - list
  - stacks queues
  - sets

- Every application builds algorithms to access and manipulate those structures
- Every programmer reimplement code to do this

This library gives a general way to reuse code, define and manipulate these basic data structures

An OO Design Example



Functions in all classes can be grouped in two logical categories:

- Black-Box Algorithms
- Data access functions

Algorithms are common to the different data structutes and can be grouped logically in :

- Sorting
- Searching
- Mutating
- Numerics

The data access functions are also common to the different data structures:

- Traverse backward/forward
- read/write/insert elements

STL approach

- Data structures=Containers
- Algorithms = Algorithms
- Access Functions = Iterators

An example :

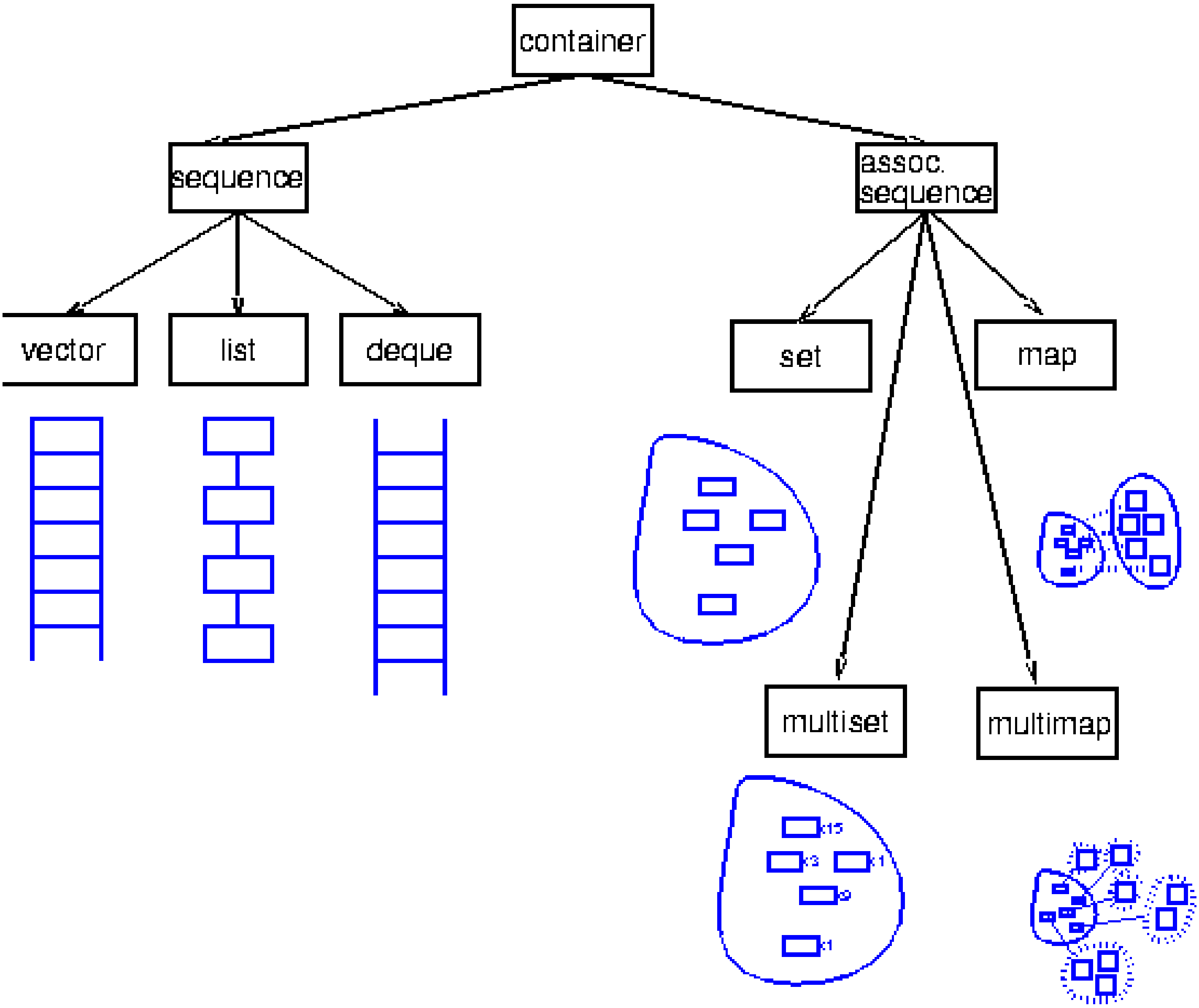
Following a C++ program to sort a list of integers being read-ed from stdin :

```
#include <stdlib.h>
#include <iostream.h>

// a and b point to integers.  cmp returns -1 if a is less than b,
// 0 if they are equal, and 1 if a is greater than b.
inline int cmp (const void *a, const void *b)
{
  int aa = *(int *)a;
  int bb = *(int *)b;
  return (aa < bb) ? -1 : (aa > bb) ? 1 : 0;
}

main (int argc, char *argv[])
{
  const int size = 1e5;  // array of 100,000 integers
  int array [size];
  int n = 0;
  // read an integer into the n+1 th element of array
```

```
  while (cin >> array[n++]);
  n--; // it got incremented once too many times

  qsort (array, n, sizeof(int), cmp);

  for (int i = 0; i < n; i++)
    cout << array[i] << "\n";
}
```

Simple version using containers iterators and algorithms:

```
#include <string.h>
#include <algo.h>
#include <vector.h>
#include <stdlib.h>
#include <iostream.h>

main ()
{
  vector<int> v;  // create an empty vector of integers
  int input;
  while (cin >> input)     // while not end of file
    v.push_back (input);   // append to vector

     sort(v.begin(), v.end());

  int n = v.size();
  for (int i = 0; i < n; i++)
    cout << v[i] << "\n";
}
```


container
sequence
assoc. sequence
vector
list
deque
set
map
multiset
multimap

Containers attributes

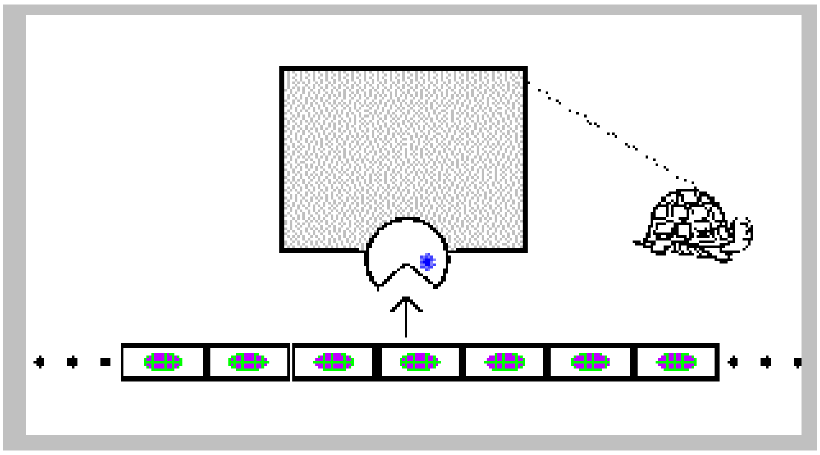
- Contain other objects
- Do not depend on the object they contain
- Templated
- Provided by the library
- More can be coherently added

Iterators

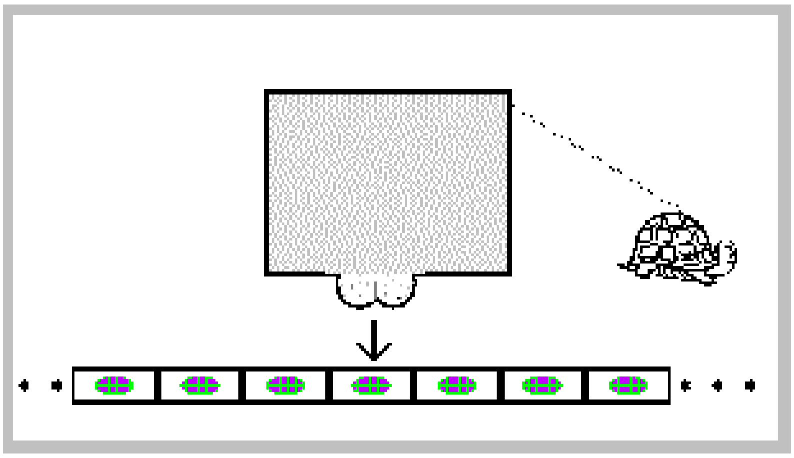
- Common way for algorithms to access containers
- Pointer generalization
- Interface independent of type of container
- Traverse and read/write a container
- Every template function working with iterators work as well with pointers

Iterator types

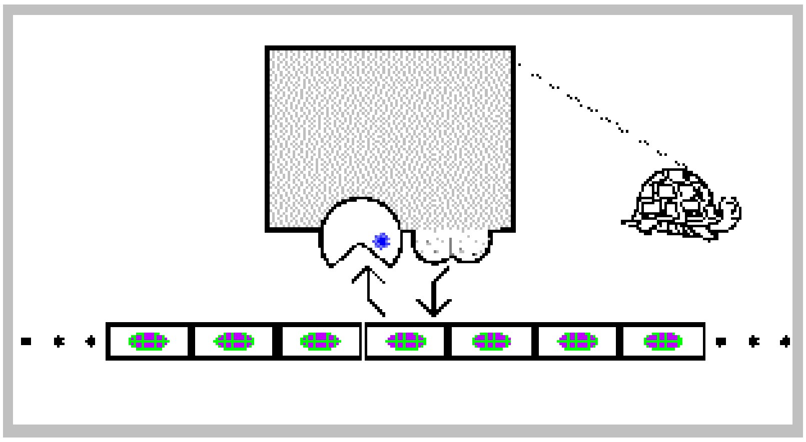
1.-Input Iterator



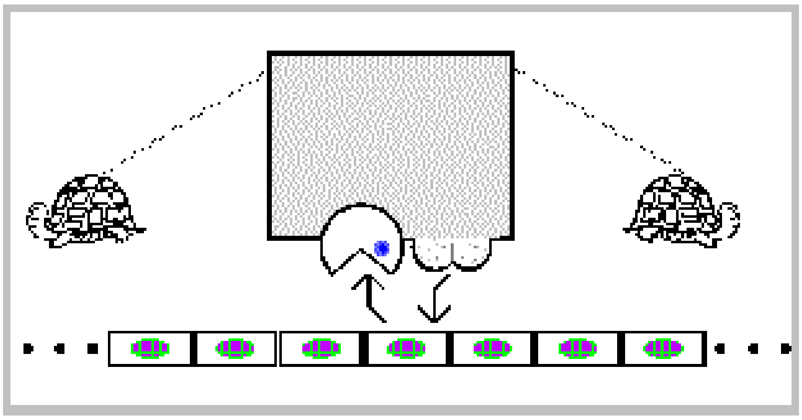
2.-Output Iterators



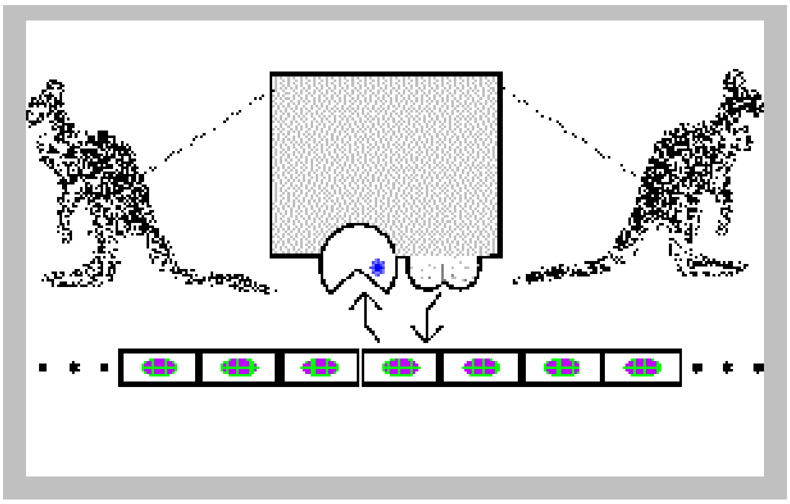
3.-Forward Iterators



4.- Bidirectional Iterators



5.-Random Access Iterators



Algorithms

- Operate on containers
- Do not take containers as arguments
- Use iterators as arguments
- Template C++ functions

Some special STL components

Function Objects

- User defined functions
- To be used by algorithms
- Are implemented in classes with the () operator
- Context can be maintained in the class

Examples

Vectors :

```
#define _POSIX_SOURCE 1

#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <iostream.h>
#include <string>
#include <vector.h>
#include <algo.h>

struct stdCOMMAND {
    string name;
    string help;
    int    number;

    void Output() const
        { cout << " - " << name << ":  " << help << endl ; }
};

typedef vector<stdCOMMAND> stdCMD_VECTOR;


void ReadCommands(stdCMD_VECTOR& cmds)
{
    stdCOMMAND cmd1;

    // This is necessary because of a problem in libstdc++
    char       tmpChar[256];

    cout << "Enter command's definitions (--- to finish)\n";
```

```
    while (true)
    {
    cout  << "Name: ";

    // This is necessary because of a problem in libstdc++
    // Should be correct just: cin  >> cmd1.name;
    cin  >> tmpChar; cmd1.name = tmpChar;
    if ( cmd1.name == string("---") )
        break;

    cout << "Help: ";
    cin  >> tmpChar; cmd1.help = tmpChar;

    cout << "Num.: ";
    cin  >> cmd1.number;

    cout << "Given command was: ";
    cmd1.Output();

    // Put cmd1 in the vector, using its name as key
    cmds.push_back(cmd1);
    }
}

void OutputCommands(stdCMD_VECTOR& cmds)
{
    // --------------------------------------------------
    // Use an iterator to print the whole dictionary
    cout << "Current commands are:\n\n";

    for (stdCMD_VECTOR::iterator i = cmds.begin();
     i != cmds.end(); ++i)
    {
    //
    (*i).Output();
    }
    cout << "\n\n";
}
```

```
// ------------------------------------------------------
// Following is a function object type,
// defines how to compare commands (for sorting/searching)
struct commandCompare {
  bool operator()(const stdCOMMAND& a, const stdCOMMAND& b) {
      return a.name < b.name;  // based on names only
  }
};
// ------------------------------------------------------
// Declares a comparison function object
commandCompare cmdComp;


int main(int, char *)
{
    stdCMD_VECTOR cmds;

    // -------------------------------------------------
    // Fill the dictionary (vector)
    ReadCommands(cmds);

    // -------------------------------------------------
    // Sorts the vector

    sort(cmds.begin(), cmds.end(), cmdComp);

    // -------------------------------------------------
    // Print the dictionary (map)
    OutputCommands(cmds);

    // -------------------------------------------------
    // Search in the dictionary for a given command
    char       tmpChar[256];
    string     key("");
    cout << "Enter command's name for search (--- to finish)\n";
    while (true)
    {
```

```
    cout  << "Name: ";

    // This is necessary because of a problem in libstdc++
    // Should be correct just: cin  >> cmd1.name;
    cin  >> tmpChar; key = tmpChar;
    if ( key == string("---") )
        break;




    // The correct way to check for existence
    // of an entry
    stdCMD_VECTOR::const_iterator i;
    for ( i = cmds.begin();i != cmds.end(); ++i)
        {
        if ((*i).name == key )
        {
        cout << "Found: ";
        (*i).Output();
        break;
        }
        }
    if(i == cmds.end())
        cout << "Key: " << key <<  "  not found!" << endl ;

    }




    return 0;
}
```

MAPS:

```
#define _POSIX_SOURCE 1

#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <iostream.h>
#include <string>
#include <map.h>
#include <algo.h>

struct stdCOMMAND {
    string name;
    string help;
    int    number;

    void Output() const
        { cout << number << " - " << name << ":  " << help << endl ; }
};

typedef map<string, stdCOMMAND, less<string> > stdCMD_MAP;


void ReadCommands(stdCMD_MAP& cmds)
{
    stdCOMMAND cmd1;

    // This is necessary because of a problem in libstdc++
    char        tmpChar[256];

    cout << "Enter command's definitions (--- to finish)\n";
    while (true)
    {
    cout  << "Name: ";

    // This is necessary because of a problem in libstdc++
```

```
    // Should be correct just: cin  >> cmd1.name;
    cin  >> tmpChar; cmd1.name = tmpChar;
    if ( cmd1.name == string("---"))
        break;

    cout << "Help: ";
    cin  >> tmpChar; cmd1.help = tmpChar;

    cout << "Num.: ";
    cin  >> cmd1.number;

    cout << "Given command was: ";
    cmd1.Output();

    // Put cmd1 in the map, using its name as key
    cmds[cmd1.name] = cmd1;
    }
}

void OutputCommands(stdCMD_MAP& cmds)
{
    // -------------------------------------------------
    // Use an iterator to print the whole dictionary
    cout << "Current commands are:\n\n";

    for (stdCMD_MAP::iterator i = cmds.begin();
     i != cmds.end(); ++i)
    {
    // (*i) get the pair (key,value), so (*i).second extracts the value
    (*i).second.Output();
    }
    cout << "\n\n";
}

int main(int, char *)
{
    stdCMD_MAP cmds;
```

```
    // ---------------------------------------------------
    // Fill the dictionary (map)
    ReadCommands(cmds);

    // ---------------------------------------------------
    // Print the dictionary (map)
    OutputCommands(cmds);

    // ---------------------------------------------------
    // Search in the dictionary for a given command
    char       tmpChar[256];
    string     key;

    cout << "Enter command's name for search (--- to finish)\n";
    while (true)
    {
    cout  << "Name: ";

    // This is necessary because of a problem in libstdc++
    // Should be correct just: cin  >> cmd1.name;
    cin  >> tmpChar; key = tmpChar;
    if ( key == string("---"))
        break;

    // The correct way to check for existence
    // of an entry
    stdCMD_MAP::const_iterator i = cmds.find(key);
    if(i == cmds.end())
        cout << "Key not found!\n";
    else
        {
        cout << "Key is: ";
        (*i).second.Output();
        }
    }
return 0;
}
```

Conclusions

GOOD POINTS

- Generalize, clarify many concepts in use
- Orthogonal and complete without being too big
- Not binded to a single company
- Allow fast prototyping

BAD POINTS

- Poor documentation
- Standard not approved yet
- Compilers not fully supporting it yet
  - Problems with the template implementation
  - Problems stream library on gcc
- Requires some knowlegde of C++

Library components

Language support

- Types
- Implementation properties (limits)
- Start and Termination
- Dynamic memory management
- Type identification
- exception handling
- Other runtime support

Diagnostics

- Exception classes
- Assertions
- Error numbers

General Utilities

- Allocators (encapsulate memory models)
- Utility components
- Function Objects (via class with operator ())
- Dynamic Memory Management
- Date and time

Strings

- String classes
- Null-terminated sequence utilities

Localization

- Locales
- Standard locale Categories
- C library locales

Containers

- Sequence
- Associattive containers

Iterators

- Predefined iterators
- Stream Iterators

Algorithms

- Non-modifying sequence operations
- Mutating sequence operations
- Sorting and related operations
- C library algorithms

Numerics

- Complex numbers
- Numeric arrays
- Generalized numeric operations
- C library

Input/output

- Forward declarations
- Standard iostream
- Stream buffers
- Formatting and manipulators
- String streams
- File streams