

# **C++ Programming HOW-TO**

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# C++ Programming HOW-TO

AI Dev (Alavor Vasudevan) [alavor@yahoo.com](mailto:alavor@yahoo.com)

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*This document provides a comprehensive list of C++ URL pointers, links to C++ online textbooks, and programming tips on C++. This document also provides a C++ library which imitates Java-language, and which has various methods to avoid memory problems in C++. Using this library you can compile Java's source code under C++. This document serves as a "Home of C++ language". The information given here will help you to program properly in C++ language and applies to all the operating systems that is – Linux, MS DOS, BeOS, Apple Macintosh OS, Microsoft Windows 95/98/NT/2000, OS/2, IBM OSes (MVS, AS/400 etc..), VAX VMS, Novell Netware, all flavors of Unix like Solaris, HPUX, AIX, SCO, Sinix, BSD, etc.. and to all other operating systems which support "C++" compiler (it means almost all the operating systems on this planet).*

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### **[1. Introduction](#)**

The purpose of this document is to provide you with a comprehensive list of URL pointers and programming tips on C++. Also, this document provides a C++ library having Java-like String class, string tokenizer, memory functions and many other functions, which can be used in general C++ applications. Also various examples are given here which demonstrate the usage of this library.

This document is not a textbook on C++, and there are already several excellent "on-line Text books" on internet. If you are new to C++ and you never programmed in C++, then it is strongly suggested that you first read the online C++ Textbooks given in the chapter [C++ Online Textbooks](#) and then follow the subsequent chapters. It is suggested that you purchase a textbook on C++ for reference from online bookstores like [amazon](#) or [barnes](#).

## 1.1 C++ v/s Java

C++ is one of the most powerful language and will be used for a long time in the future inspite of emergence of Java. C++ runs **extremely fast** and is in fact **10 to 20 times FASTER than** Java. Java runs very slow because it is a byte-code-interpreted language running on top of "virtual machine". Java runs faster with JIT (Just-In-Time) compiler, but it is still slower than C++. And optimized C++ program is about **3 to 4 times faster** than Java (with JIT compiler). Then, why do people use Java? Because it is pure object oriented and is easier to program in Java, as Java automates memory management, and programmers do not directly deal with memory allocations. This document attempts to automate the memory management in C++ to make it much more easy to use. The library given here will make C++ look like Java and will enable "C++" to compete with Java language.

Because of manual memory allocations, debugging the C++ programs consumes a major portion of time. This document will give you some better ideas and tips to reduce the debugging time.

## 1.2 Which one Ada95, "C", "C++" or Java ??

Language choice is very difficult. There are too many parameters – people, people skills, cost, tools, politics (even national politics) and influence of businessmen/commercial companies. The best language based on technical merits does not get selected simply due to political decisions!

Java is much closer to Ada95 than C++. Java is derived from Ada95. Ada95 gets the maximum points as per David Wheeler's [Ada comparison chart](#). Ada got 93%, Java 72%, C++ 68% and C got 53%. C++ and Java are closer in points(only 4% difference), hence Java **is not** a very big revolution as compared to C++. On other hand, Ada is a very big revolution and improvement over C++. The scores are like 4 students taking exams and student with highest score is Ada (93%). Who knows? Perhaps in future Ada95 will replace Java!! Development costs of Ada is half of C++ as per [Stephen F. Zeigler](#). Ada95 is available at –

- Ada home <http://www.gnuada.org>.
- Google [Ada index](#)

Since C++ programmers are abundant, it is recommended you do programming in object-oriented "C++" for all your application programming or general purpose programming. You can take full advantage of object oriented facilities of C++. The C++ compiler is lot more complex than "C" compiler and C++ programs may run bit slower than "C" programs. But speed difference between "C" and "C++" is very minute – it could be few milli-seconds which may have little impact for real-time programming. Since computer hardware is becoming cheaper and faster and memory 'RAM' is getting faster and cheaper, it is worth doing code in C++ rather than "C" as time saved in clarity and re-usability of C++ code offsets the slow speed. Compiler optimizer options like -O or -O3 can speed up C++/C which is not available in Java.

Nowadays, "C" language is primarily used for "systems programming" to develop operating systems, device drivers etc..

**Note:** *Using the String, StringBuffer, StringTokenizer and StringReader classes given in this howto, you can code in C++ which "exactly" looks like Java. This document tries to close the gap between C++ and Java, by imitating Java classes in C++*

Java is platform independent language more suitable for developing GUI running inside web-browsers (Java applets) but runs very slow. Prefer to use web-server-side programming "Fast-CGI" with C++ and HTML, DHTML, XML to get better performance. Hence, the golden rule is "Web-server side programming use



C++ and web-client side (browser) programming use Java applets". The reason is – the server-side OS (Linux) is under your control and never changes, but you will never know what the client side web-browser OS is. It can be Internet appliance device (embedded linux+netscape) or computers running Windows 95/98/NT/2000 or Linux, Apple Mac, OS/2, Netware, Solaris etc..

The advantage of Java language is that you can create "Applets (GUI)" which can run on any client OS platform. Java was created to replace the Microsoft Windows 95/NT GUI APIs like MS Visual Basic or MS Visual C++. In other words – "Java is the cross-platform Windows-GUI API language of next century". Many web-browsers like Netscape supports Java applets and web-browser like Hot Java is written in java itself. But the price you pay for cross-platform portability is the performance, applications written in Java run very slow.

Hence, Java runs on "client" and C++ runs on servers.

### 1.3 Problems facing the current C++ compilers

Since C++ is super-set of C, it got all the bad features of "C" language. Manual allocation and deallocation of memory is tedious and error prone (see [Garbage Collector for C++](#)).

In "C" programming – memory leaks, memory overflows are very common due to usage of features like –

---

```
Datatype char * and char[]  
String functions like strcpy, strcat, strncpy, strncat, etc..  
Memory functions like malloc, realloc, strdup, etc..
```

---

The usage of **char \*** and **strcpy** causes *horrible* memory problems due to "overflow", "fence past errors", "memory corruption", "step-on-others-toe" (hurting other variable's memory locations) or "memory leaks". The memory problems are extremely hard to debug and are very time consuming to fix and trouble-shoot. Memory problems bring down the productivity of programmers. This document helps in increasing the productivity of programmers via different methods addressed to solve the memory defects in "C++". Memory related bugs are very tough to crack, and even experienced programmers take several days or weeks to debug memory related problems. Memory bugs may be hide inside the code for several months and can cause unexpected program crashes. The memory bugs due to usage of **char \*** and **pointers** in C/C++ is costing \$2 billion every year in time lost due to debugging and downtime of programs. If you use **char \*** and **pointers** in C++ then it is a very costly affair, especially if your program size is greater than 10,000 lines of code.

Hence, the following techniques are proposed to overcome the faults of "C" language. Give preference in the following order –

1. Use references instead of pointers.
2. Java style String class (given in this howto) or STDLIB string class.
3. Character pointers (char \*) in C++ **limit the usage** of char \* to cases where you cannot use the String class.
4. Character pointers (char \*) in C using extern linkage specification, if you do not want to use (char \*) in C++.

To use "C char \*", you would put all your "C" programs in a separate file and link to "C++" programs using the *linkage-specification* statement **extern "C"** –

```
extern "C" {
#include <stdlib.h>
}

extern "C" {
    comp();
    some_c_function();
}
```

---

The **extern "C"** is a linkage specification and is a flag that everything within the enclosing block (brace-surrounded) uses C linkage, not C++ linkage.

The **'String class'** utilises the constructor and destructor features to automate memory management and provides access to functions like *ltrim*, *substring*, etc..

See also related **'string class'** in the C++ compiler. The **string class** is part of the standard GNU C++ library and provides many string manipulation functions. Because the C++ **'string class'** and **'String class'** library provides many string manipulation functions, there is less need to use the character pointer approach to write your own string functions. Also, C++ programmers must be encouraged to use 'new', 'delete' operators instead of using 'malloc' or 'free'.

The **'String class'** does everything that **char \*** or **char []** does. It can completely replace **char** datatype. Plus added benefit is that programmers do not have to worry about the memory problems and memory allocation at all.

## 1.4 COOP – C++ Object Oriented Programming–language

A problem with C++ is that it is a superset of C, and, although programmers can use the good (object oriented) features of C++ and avoid the bad features of C, there is nothing to force them to do so. So, many C++ programs are written with no object oriented features and continue to use the bad features of C that the use of C++ should have overcome.

Therefore, I propose that we create a new version of C++ that does not allow the use of the bad features of C.

I propose that this new version of C++ be called **COOP** (say koop), which is an acronym for **C++ Object Oriented Programming–language**. COOP should be pronounced like chicken coop. (The logo of COOP language is a big fat Hen inside coop!) I propose that the file extension for COOP files be .coo, which will not conflict with .c for C programs or .cpp for C++ programs.

To begin with, write the COOP as a front end to C++. That is COOP pre-processes the code syntax and then uses the standard C++ compiler to compile the program. COOP acts as a front end to C++ compiler. (To start with, COOP will be a very good project/thesis topic for university students)

The following are some other proposed features of COOP:

- COOP will borrow some best ideas from Microsoft C#, Microsoft put lot of efforts, and you can simply utilize them. Specs are at [csharp-specs](#) and see [C# overview](#).
- Is a subset of C++ language but will force programmer to use object oriented programming.

- Pure Object-oriented language but retains syntax of C++.
- Remove all bad or confusing features of C++ in COOP, for e.g. multiple-inheritance, operator overloading, limit usage of pointers, etc...
- Prevent writing "C" like programming in COOP, something which C++ currently allows. Delete all C features which are considered bad or redundant/duplicates, like printf, fprintf, malloc, struct, free etc..
- No downward compatibility to "C" language.
- Code written in COOP will be easy to maintain and is easily understandable/readable.
- Code written in "COOP" will be re-usable (thru components, modules, objects). Supports re-usable software components, thereby facilitating Rapid Application Development.
- COOP is simple, robust, OOP, has bare minimum syntax (avoiding confusing, redundant, extra constructs of C++ for e.g remove struct and use class)

Also borrow ideas from –

- Java – Sun Microsystem put lot of effort, and you can simply utilize that.
  - Connective C++ at <http://www.quintessent.com/products/cc++>.
- 

## 2. String Class Varieties

The string class is the most vital object in programming, and string manipulations are most extensively used and they comprise of 20 to 60% of total code. There are 3 variety of string classes. Ofcourse, you can build your own string class by simply inheriting from these string classes –

- String class given in this document [Appendix A String.h](#)
- GNU string class
  - ◆ GNU C++ Library – Univ of Tech, Sydney  
[http://www.socs.uts.edu.au/doc/gnuinfo/libg++/libg++\\_18.html](http://www.socs.uts.edu.au/doc/gnuinfo/libg++/libg++_18.html) and [user's guide](#)
  - ◆ mirror site Gesellschaft [http://www-aix.gsi.de/doc/gnu/libg++\\_18.html#SEC23](http://www-aix.gsi.de/doc/gnu/libg++_18.html#SEC23) and [user's guide](#)
  - ◆ mirror site Techno, Russia  
[http://www.techno.spb.ru/~xbatob/FAQ/GNU/libg++\\_19.html#SEC27](http://www.techno.spb.ru/~xbatob/FAQ/GNU/libg++_19.html#SEC27) and [user's guide](#)
  - ◆ mirror site Univ of Utah [http://www.math.utah.edu/docs/info/libg++\\_19.html#SEC27](http://www.math.utah.edu/docs/info/libg++_19.html#SEC27) and [user's guide](#)
- Qt String class at <http://doc.trolltech.com/qstring.html> mirror at <http://www.cs.berkeley.edu/~dmartin/qt/qstring.html>
- If none of these alternatives are suitable, you can build your own string class. You can start with one or more of the pre-built classes listed above (by using single or multiple inheritance.)

### 2.1 Multiple Inheritance – Sample Custom String class

As mentioned above, you can build your own custom string class from the pre-built classes by single or multiple inheritance. In this section we will build a sample custom string class by using multiple inheritance, inheriting from the GNU string class and the string class presented in Appendix H.

Start by downloading the sample file 'string\_multi.h' from [Appendix A](#) . That file is reproduced below:

```
// *****
// Sample program to demonstrate constructing your own string class
// by deriving from the String class and stdlib's "string" class
// *****

#ifndef __STRING_MULTI_H_
#define __STRING_MULTI_H_

#include <string>
#include "String.h"

// Important Notes: In C++ the constructors, destructors and copy
// operator are NOT inherited by the derived classes!!
// Hence, if the operators like =, + etc.. are defined in
// base class and those operators use the base class's constructors
// then you MUST define equivalent constructors in the derived
// class. See the sample given below where constructors mystring(),
// mystring(char[]) are defined.
//
// Also when you use operator as in atmpstr + mstr, what you are really
// calling is atmpstr.operator+(mstr). The atmpstr is declared a mystring

class mystring:public String, string
{
public:
    mystring():String() {} // These are needed for operator=, +
    mystring(char bb[]):String(bb) {} // These are needed for operator=, +
    mystring(char bb[], int start, int slength):String(bb, start, slength) {}
    mystring(int bb):String(bb) {} // needed by operator+
    mystring(unsigned long bb):String(bb) {} // needed by operator+
    mystring(long bb):String(bb) {} // needed by operator+
    mystring(float bb):String(bb) {} // needed by operator+
    mystring(double bb):String(bb) {} // needed by operator+
    mystring(const String & rhs):String(rhs) {} // Copy Constructor needed by operat
    mystring(StringBuffer sb):String(sb) {} // Java compatibility
    mystring(int bb, bool dummy):String(bb, dummy) {} // for StringBuffer class

    int mystraa; // customizations of mystring
private:
    int mystrbb; // customizations of mystring
};

#endif // __STRING_MULTI_H_
```

---

---

### **[3. Best C++ compilers for MS Windows 2000/NT/95/98/ME/XP](#)**

Since MS Windows is quite popular for C++ development, the string class library given in this document works well and runs very well on all the versions of MS Windows i.e. MS Win XP/2000/NT/95/98/ME. The C++ compilers for MS Windows are :

- GNU BloodShed at <http://www.bloodshed.net/devcpp.html> rated 1st (the best among all)

- Borland C++ compiler <http://www.borland.com/bcppbuilder/freecompiler> rated 2nd
- Microsoft Visual C++ compiler <http://msdn.microsoft.com/visualc> rated 3rd
- MSDOS C++ compiler <http://www.delorie.com/djgpp>

The String class in this document is tested with all the above compilers. It works fine with MS Visual C++ compiler v6.0, Borland C++ v5.2, Borland C++ compiler v5.5.1 and Bloodshed compiler.

---

## 4. [Download String](#)

All the programs, examples are given in Appendix of this document. You can download as a single tar zip, the String class, libraries and example programs from

- Go here and click on C++Programming howto.tar.gz file <http://www.aldev.8m.com>
  - Mirror sites are at – <http://aldev0.webjump.com>, [angelfire](#), [geocities](#), [virtualave](#), [50megs](#), [theglobe](#), [NBCi](#), [Terrashare](#), [Fortunecity](#), [Freewebsites](#), [Tripod](#), [Spree](#), [Escalix](#), [Httpcity](#), [Freeservers](#).
- 

## 5. [How Can I trust Al Dev's String Class ??](#)

You may have a question of mis-trust on the String class software. To build confidence, there is a scientific method to verify the functionality of Al Dev's String class. In modern days, computer scientists use the CPU power instead of human brain power to verify and validate the software. Human brain is too slow and hence it is better to use the computer's power to test and validate software.

The program [example String.cpp](#) (and also given in [Appendix A](#)) has regression test module which you can use to run the regression tests several millions of times automatically. After running the regression tests on the String class you can certify that the String class program is a **ROCK SOLID** and a **BULLET-PROOF** program.

I tested the String class with **repeat cycle = 50000** and it ran and completed the program without crash. While it is running I did not notice any memory leak. On linux, I used /usr/bin/gtop, unix top command, KDEStart->System->KDE System Guard and KDEStart->System->Process management to monitor the cpu and memory usage.

I recommend that you start the regression test with **repeat cycle** equal to 10 million or greater. The greater the repeat cycle number the greater will be your confidence!! Start the test and go to lunch and come back to see the results!!

---

## 6. [Usage of String class](#)

To use String class, you should first refer to a sample program "example\_String.cpp" given in [Appendix A](#) and the String class which is given in [Appendix A](#).

The '**String class**' is a complete replacement for char and char \* datatype. You can use '**String class**' just like char and get much more functionalities. You should link with the library 'libString.a' which you can build

from the makefile given in [Appendix A](#) and copy the library to /usr/lib or /lib directory where all the "C++" libraries are located. To use the 'libString.a' compile your programs like –

---

```
g++ example.cpp -lString
```

---

See illustration sample code as given below –

---

```
String aa;

aa = "Creating an Universe is very easy, similar to creating a baby human.";

// You can use aa.val() like a 'char *' variable in programs
for (unsigned long tmpii = 0; tmpii < aa.length(); tmpii++)
{
    //fprintf(stdout, "aa.val()[%ld]=%c ", tmpii, aa.val()[tmpii]);
    fprintf(stdout, "aa[%ld]=%c ", tmpii, aa[tmpii]);
}

// Using pointers on 'char *' val ...
for (char *tmpcc = aa.val(); *tmpcc != 0; tmpcc++)
{
    fprintf(stdout, "aa.val()=%c ", *tmpcc);
}
```

---

## 6.1 Operators

The '**String class**' provides these operators :-

- Equal to ==
- Not equal to !=
- Assignment =
- Add to itself and Assignment +=
- String concatenation or addition +

For example to use operators –

---

```
String aa;
String bb("Bill Clinton");

aa = "put some value string"; // assignment operator
aa += "add some more"; // Add to itself and assign operator
aa = "My name is" + " Alavoor Vasudevan "; // string cat operator

if (bb == "Bill Clinton") // boolean equal to operator
    cout << "bb is equal to 'Bill Clinton' " << endl;

if (bb != "Al Gore") // boolean 'not equal' to operator
    cout << "bb is not equal to 'Al Gore' " << endl;
```

---

## 6.2 Functions

The functions provided by String class has the **same name** as that of Java language's String class. The function names and the behaviour is **exactly** same as that of Java's String class. StringBuffer class is also provided. This will facilitate portability of code between Java and C++ (you can cut and paste and do minimum changes to code). The code from Java's function body can be copied into C++ member function body and with very minimum changes the code will compile under C++. Another advantage is that developers coding in both Java and C++ do not need to remember two different syntax or function names.

For example to convert integer to string do –

---

```
String aa;

aa = 34; // The '=' operator will convert int to string
cout << "The value of aa is : " << aa.val() << endl;

aa = 234.878; // The '=' operator will convert float to string
cout << "The value of aa is : " << aa.val() << endl;

aa = 34 + 234.878;
cout << "The value of aa is : " << aa.val() << endl;
// The output aa will be '268.878'

// You must cast String to convert
aa = (String) 34 + " Can create infinite number of universes!! " + 234.878;
cout << "The value of aa is : " << aa.val() << endl;
// The output aa will be '34 Can create infinite number of universes!! 234.878'
```

---

Refer to [Appendix A String.h](#) for details about the String class function names. The same file String.h is reproduced here in next section.

## 7. [String.h](#) file

In C++ (or any object oriented language), you just read the "class data-structure" (i.e. interface) to begin using that object. You just need to understand the interface and not the implementation of the interface. In case of String class, you just need to read and understand the String class in String.h file. You **do not need** to read the entire implementation (String.cpp) in order to use String class. The object oriented classes are real time saver and they **very neatly hide** the implementation.

(In object oriented Java language there is the equivalent called '**interface**', which hides the implementation details.)

Given below is **String.h** file and see also [Appendix A String.h](#)

---

```
//
// Author : Al Dev Email: alavoor@yahoo.com
// Use string class or String class
//
// To prevent memory leaks - a char class to manage character variables
```

## C++ Programming HOW-TO

```
// Always prefer to use String or string class
// instead of char[] or char *
//

#ifndef __STRING_H_ALDEV_
#define __STRING_H_ALDEV_

// do not use iostream as program becomes bulky..
#ifdef NOT_MSWINDOWS
#include <iostream>
#else
#include <iostream.h> // some compilers like .h here. Why???
#endif // NOT_MSWINDOWS

#include <stdio.h> // for FILE and sprintf()
// #include <list.h> // for list

// For MS Windows 95 VC++ or Borland C++ compiler do -
// see file d:\program files\CBuilder\include\examples\stdlib\list.cpp and include\list.h
// #include <list> // for list
// using namespace std;

const short INITIAL_SIZE = 50;
const short NUMBER_LENGTH = 300;
const int MAX_ISTREAM_SIZE = 2048;

// class StringBuffer;

// I compiled and tested this string class on Linux (Redhat 7.1) and
// MS Windows Borland C++ version 5.2 (win32). This should also work
// using MS Visual C++ compiler
class String
{
public:
    String();
    String(const char bb[]); // needed by operator+
    String(const char bb[], int start, int length); // subset of chars
    String(int bb); // needed by operator+
    String(unsigned long bb); // needed by operator+
    String(long bb); // needed by operator+
    String(float bb); // needed by operator+
    String(double bb); // needed by operator+
    String(const String & rhs); // Copy Constructor needed by operator+
    //String(StringBuffer sb); // Java compatibility - but causes compile problem on
    String(int bb, bool dummy); // for StringBuffer class
    virtual ~String(); // Made virtual so that when base class is deleted
                        // then the derived class destructor is called

    char *val() {return sval;} // It is not safe to make sval public

    // Functions below imitate Java language's String object
    unsigned long length();
    char charAt(int where);
    void getChars(int sourceStart, int sourceEnd,
                 char target[], int targetStart);
    char* toCharArray();
    char* getBytes();

    bool equals(String str2); // See also == operator
    bool equals(char *str2); // See also == operator
    bool equalsIgnoreCase(String str2);
};
```



## C++ Programming HOW-TO

```
bool regionMatches(int startIndex, String str2,
                  int str2StartIndex, int numChars);
bool regionMatches(boolean ignoreCase, int startIndex,
                  String str2, int str2StartIndex, int numChars);

String toUpperCase();
String toLowerCase();

bool startsWith(String str2);
bool startsWith(char *str2);

bool endsWith(String str2);
bool endsWith(char *str2);

int compareTo(String str2);
int compareTo(char *str2);
int compareToIgnoreCase(String str2);
int compareToIgnoreCase(char *str2);

int indexOf(char ch, int startIndex = 0);
int indexOf(char *str2, int startIndex = 0);
int indexOf(String str2, int startIndex = 0);

int lastIndexOf(char ch, int startIndex = 0);
int lastIndexOf(char *str2, int startIndex = 0);
int lastIndexOf(String str2, int startIndex = 0);

String substring(int startIndex, int endIndex = 0);
String replace(char original, char replacement);
String replace(char *original, char *replacement);

String trim(); // See also overloaded trim()

String concat(String str2); // See also operator +
String concat(char *str2); // See also operator +
String concat(int bb);
String concat(unsigned long bb);
String concat(float bb);
String concat(double bb);

String reverse(); // See also overloaded reverse()
String deleteCharAt(int loc);
String deleteStr(int startIndex, int endIndex); // Java's "delete()"

String valueOf(char ch)
    {char aa[2]; aa[0]=ch; aa[1]=0; return String(aa);}
String valueOf(char chars[]){ return String(chars);}
String valueOf(char chars[], int startIndex, int numChars);
String valueOf(boolean tf)
    {if (tf) return String("true"); else return String("false");}
String valueOf(int num){ return String(num);}
String valueOf(long num){ return String(num);}
String valueOf(float num) {return String(num);}
String valueOf(double num) {return String(num);}

// See also StringBuffer class in this file given below

// ---- End of Java like String object functions ----

////////////////////////////////////
//                               List of additional functions not in java
////////////////////////////////////
```

## C++ Programming HOW-TO

```
String ltrim();
void ltrim(bool dummy); // Directly changes object. dummy to get different signature
String rtrim();
void rtrim(bool dummy); // Directly changes object. See also chopall().
// dummy to get different signature

void chopall(char ch='\n'); // removes trailing character 'ch'. See also rtrim()
void chop(); // removes one trailing character

void roundf(float input_val, short precision);
void decompose_float(long *integral, long *fraction);

void roundd(double input_val, short precision);
void decompose_double(long *integral, long *fraction);

void explode(char *separator); // see also token() and overloaded explode()
String *explode(int & strcount, char separator = ' '); // see also token()
void implode(char *glue);
void join(char *glue);
String repeat(char *input, unsigned int multiplier);
String tr(char *from, char *to); // translate characters
String center(int padlength, char padchar = ' ');
String space(int number = 0, char padchar = ' ');
String xrange(char start, char end);
String compress(char *list = " ");
String left(int slength = 0, char padchar = ' ');
String right(int slength = 0, char padchar = ' ');
String overlay(char *newstr, int start = 0, int slength = 0, char padchar = ' ');

String at(char *regx); // matches first match of regx
String before(char *regx); // returns string before regx
String after(char *regx); // returns string after regx
String mid(int startIndex = 0, int length = 0);

bool isNull();
bool isInteger();
bool isInteger(int pos);
bool isNumeric();
bool isNumeric(int pos);
bool isEmpty(); // same as length() == 0
bool isUpperCase();
bool isUpperCase(int pos);
bool isLowerCase();
bool isLowerCase(int pos);
bool isWhiteSpace();
bool isWhiteSpace(int pos);
bool isBlackSpace();
bool isBlackSpace(int pos);
bool isAlpha();
bool isAlpha(int pos);
bool isAlphaNumeric();
bool isAlphaNumeric(int pos);
bool isPunct();
bool isPunct(int pos);
bool isPrintable();
bool isPrintable(int pos);
bool isHexDigit();
bool isHexDigit(int pos);
bool isCntrl();
bool isCntrl(int pos);
bool isGraph();
bool isGraph(int pos);
```

## C++ Programming HOW-TO

```
void clear();
int toInteger();
long parseLong();

double toDouble();
String token(char separator = ' '); // see also StringTokenizer, explode()
String crypt(char *original, char *salt);
String getline(FILE *infp = stdin); // see also putline()
//String getline(fstream *infp = stdin); // see also putline()

void putline(FILE *outfp = stdout); // see also getline()
//void putline(fstream *outfp = stdout); // see also getline()

void swap(String aa, String bb); // swap aa to bb
String *sort(String aa[]); // sorts array of strings
String sort(int startIndex = 0, int length = 0); // sorts characters inside a st
int freq(char ch); // returns the number of distinct, nonoverlapping matches
void Format(const char *fmt, ...);
String replace (int startIndex, int endIndex, String str);

void substring(int startIndex, int endIndex, bool dummy); // Directly changes obj
void reverse(bool dummy); // Directly changes object. dummy to get different sign
String deleteCharAt(int loc, bool dummy); // Directly changes object
String deleteStr(int startIndex, int endIndex, bool dummy);
void trim(bool dummy); // Directly changes object. dummy to get different signatu
String insert(int index, String str2);
String insert(int index, String str2, bool dummy); // Directly changes object
String insert(int index, char ch);
String insert(int index, char ch, bool dummy); // Directly changes object
String insert(char *newstr, int start = 0, int length = 0, char padchar = ' ');

String dump(); // Dump the string like 'od -c' (octal dump) does

// required by java's StringBuffer
void ensureCapacity(int capacity);
void setLength(int len);
void setCharAt(int where, char ch); // see also charAt(), getCharAt()

// required by java's Integer class, Long, Double classes
int parseInt(String ss) {return ss.toInteger();}
int parseInt(char *ss)
    {String tmpstr(ss); return tmpstr.toInteger();}
long parseLong(String ss) {return ss.parseLong();}
long parseLong(char *ss)
    {String tmpstr(ss); return tmpstr.parseLong();}
float floatValue() {return (float) toDouble(); }
double doubleValue() {return toDouble(); }
char * number2string(int bb); // see also String(int)
char * number2string(long bb); // see also String(long)
char * number2string(unsigned long bb); // see also String(long)
char * number2string(double bb); // see also String(double)

////////////////////////////////////
// List of duplicate function names
////////////////////////////////////
// char * c_str() // use val()
// bool find(); // Use regionMatches()
// bool search(); // Use regionMatches()
// bool matches(); // Use regionMatches()
// int rindex(String str2, int startIndex = 0); Use lastIndexOf()
// String blanks(int slength); // Use repeat()
```

## C++ Programming HOW-TO

```
// String append(String str2); // Use concat() or + operator
// String prepend(String str2); // Use + operator. See also append()
// String split(char separator = ' '); // Use token(), explode() or StringTokenizer
bool contains(char *str2, int startIndex = 0); // use indexOf()
// void empty(); Use is_empty()
// void vacuum(); Use clear()
// void erase(); Use clear()
// void zero(); Use clear()
// bool is_float(); Use is_numeric();
// bool is_decimal(); Use is_numeric();
// bool is_Digit(); Use is_numeric();
// float float_value(); Use toDouble();
// float tofloat(); Use toDouble();
// double double_value(); Use toDouble();
// double numeric_value(); Use toDouble();
// int int_value(); Use toInteger()
// int tonumber(); Use toInteger()
// String get(); Use substring() or val() but prefer java's substring
// String getFrom(); Use substring() or val() but prefer java's substring
// String head(int len); Use substring(0, len)
// String tail(int len); Use substring(length()-len, length())
// String cut(); Use deleteCharAt() or deleteStr()
// String cutFrom(); Use deleteCharAt() or deleteStr()
// String paste(); Use insert()
// String fill(); Use replace()
// char firstChar(); // Use substring(0, 1);
// char lastChar(); // Use substring(length()-1, length());
// String findNext(); Use token(), explode() or StringTokenizer class

// begin(); iterator. Use operator [ii]
// end(); iterator. Use operator [ii]
// copy(); Use assignment = operator, String aa = bb;
// clone(); Use assignment = operator, String aa = bb;
// void putCharAt(int where, char ch); Use setCharAt()
// void replaceCharAt(int where, char ch); Use setCharAt()
// char getCharAt(int where); Use CharAt()
// void parseArgs(int where, char ch); Use StringTokenizer class, token() or exp
// void truncate(); Use trim(), rtrim(), chop() or chopall()
// convert number to string notosttring(), int2str, long2str Use number2string()

// All Operators ...
String operator+ (const String & rhs);
friend String operator+ (const String & lhs, const String & rhs);

String& operator+= (const String & rhs); // using reference will be faster
String& operator= (const String & rhs); // using reference will be faster
bool operator== (const String & rhs); // using reference will be faster
bool operator== (const char *rhs);
bool operator!= (const String & rhs);
bool operator!= (const char *rhs);
char operator [] (unsigned long Index) const;
char& operator [] (unsigned long Index);
friend ostream & operator<< (ostream & Out, const String & str2);
friend istream & operator>> (istream & In, String & str2);

//do later: static list<String> explodeH; // list head
protected:
char *sval; // Not safe to make sval public
void verifyIndex(unsigned long index) const; // not "inline" because MS Win32 com
void verifyIndex(unsigned long index, char *aa) const; // not "inline" - MS Win32
```

## C++ Programming HOW-TO

```
void _str_cat(char bb[]);
void _str_cat(int bb);
void _str_cat(unsigned long bb);
void _str_cat(float bb);

void _str_cpy(char bb[]);
void _str_cpy(int bb); // itoa
void _str_cpy(unsigned long bb);
void _str_cpy(float bb); // itof

private:
    // Note: All the private variables and functions begin
    // with _ (underscore)

    //static String *_global_String; // for use in add operator
    //inline void _free_glob(String **aa);

    bool _equalto(const String & rhs, bool type = false);
    bool _equalto(const char *rhs, bool type = false);
    String *_pString; // temporary pointer for internal use..
    char *_pNumber2String; // temporary pointer for internal use..
    inline void _allocpString();
    inline void _allocpNumber2String();
    inline void Common2AllCstrs();
    inline void _reverse();
    inline void _deleteCharAt(int loc);
    inline void _deleteStr(int startIndex, int endIndex);
    inline void _trim();
    inline void _ltrim();
    inline void _rtrim();
    inline void _substring(int startIndex, int endIndex);
    void _roundno(double input_dbl, float input_flt, short precision, bool type);
};

// Global variables are defined in String.cpp

#endif // __STRING_H_ALDEV_
```

---

## 7.1 StringBuffer.h

---

```
//
// Author : Al Dev Email: alavoor@yahoo.com
//

#ifndef __STRINGBUFFER_H_ALDEV_
#define __STRINGBUFFER_H_ALDEV_

// Imitate Java's StringBuffer object
// This class is provided so that the Java code is
// portable to C++, requiring minimum code changes
// Note: While coding in C++ DO NOT use this class StringBuffer,
// this is provided only for compiling code written in Java
// which is cut/pasted inside C++ code.
class StringBuffer: public String
{
public:
    StringBuffer();
    ~StringBuffer();
```

## C++ Programming HOW-TO

```
StringBuffer(char *aa);
StringBuffer(int size);
StringBuffer(String str);

int capacity();
StringBuffer append(String str2);
    // See also operator +
    // { *this += str2; return *this; } // This is causing core dumps...

StringBuffer append(char *str2);
StringBuffer append(int bb);
StringBuffer append(unsigned long bb) ;
StringBuffer append(float bb) ;
StringBuffer append(double bb) ;

StringBuffer insert(int index, String str2);
StringBuffer insert(int index, char ch);

StringBuffer reverse();

// Java's "delete()". Cannot use name delete in C++
StringBuffer deleteStr(int startIndex, int endIndex);
StringBuffer deleteCharAt(int loc);

StringBuffer substring(int startIndex, int endIndex = 0);
void assign(char *str);

private:
    StringBuffer *_pStringBuffer;
    inline void allocpStringBuffer();
    inline void Common2AllCstrs();
};

#endif // __STRINGBUFFER_H_ALDEV_
```

---

## 7.2 StringTokenizer.h

---

```
//
// Author : Al Dev Email: alavoor@yahoo.com
//

#ifndef __STRINGTOKENIZER_H_ALDEV_
#define __STRINGTOKENIZER_H_ALDEV_

// Imitate java's StringTokenizer class
// provided to compile java code in C++ and vice-versa
class StringTokenizer: public String
{
public:
    StringTokenizer(String str);
    StringTokenizer(String str, String delimiters);
    StringTokenizer(String str, String delimiters, bool delimAsToken);
    ~StringTokenizer();

    int    countTokens();
    bool   hasMoreElements();
    bool   hasMoreTokens();
    String nextElement(); // in java returns type 'Object'
```

```

        String  nextToken();
        String  nextToken(String delimiters);
private:
        int      CurrentPosition; // current index on string
        int      TotalTokens;
        int      RemainingTokens;
        char *   ListOfDl; // list of delimiters
        char *   WorkStr; // temp work string
        char *   OrigStr; // original string passed
        bool     DlFlag; // delimiter flag
        inline   void vPrepWorkStr(char *delimiters = NULL);
};

#endif // __STRINGTOKENIZER_H_ALDEV_

```

---

## 8. [Renaming the String class](#)

### 8.1 Case 1: Simple rename

If you do not like the String class name then you can use "**typedef**" to rename the String class.

In all the files where you do include String.h, insert these lines:

---

```

// If you do not like the class name String, then you can rename using typedef
typedef String StringSomethingElseIwant;

// Your remaining code may be like this ....
int main()
{
    StringSomethingElseIwant aa_renstr;
    aa_renstr = "I renamed the String Class using typedef";

    .....etc...
}

```

---

See the [example String.cpp](#).

### 8.2 Case 2: Resolve conflict

If there is a conflict with another class-name having the same name, and you want to use both this class and conflicting class then you use this technique – in all the files where you do include String.h, insert these lines:

---

```

#define String String_somethingelse_which_I_want
#include "String.h"
#undef String

#include "ConflictingString.h" // This also has String class...

// All your code goes here...

```

```

main()
{
    String_somethingelse_which_I_want aa;
    String bb; // This string class from conflicting string class

    aa = " some sample string";
    bb = " another string abraka-dabraka";
    .....
}

```

---

The pre-processor will replace all literals of String to "String\_somethingelse\_which\_I\_want" and immediately undefines String. After undef the conflicting string class header file is included which defines the "String" class.

---

## 9. File Class

You would use the File class to manipulate the operating system files. This class is an imitation of Java's File class and will be very useful in C++ programming. Using this File class in C++ you can do if file **exists()** ?, if directory **exists()** ?, file **length()** and other functions.

- C++ File class is at File.h <http://www.angelfire.com/country/aldev0/cpphowto/File.h> and File.cpp <http://www.angelfire.com/country/aldev0/cpphowto/File.cpp>
  - Java java.io.File class definition <http://java.sun.com/j2se/1.3/docs/api/java/io/File.html>
  - Quick Reference on File Class <http://unicornsrest.org/reference/java/qref11/java.io.File.html>
  - File Class summary <http://www.idi.ntnu.no/~database/SIF8020/java-api/java.io.File.html>
- 

## 10. C++ Zap (Delete) function

The **delete** and **new** operators in C++ are much better than the malloc and free functions of C. Consider using new and zap (delete function) instead of malloc and free as much as possible.

To make **delete** operators even more cleaner, make a Zap() inline function. Define a zap() function like this:

---

```

// Put an assert to check if x is NULL, this is to catch
// program "logic" errors early. Even though delete works
// fine with NULL by using assert you are actually catching
// "bad code" very early

// Defining Zap using templates
// Use zap instead of delete as this will be very clean
template <class T>
inline void zap(T & x)
{
    {assert(x != NULL);}
    delete x;
    x = NULL;
}

// In C++ the reason there are 2 forms of the delete operator is - because

```



## C++ Programming HOW-TO

```
// there is no way for C++ to tell the difference between a pointer to
// an object and a pointer to an array of objects. The delete operator
// relies on the programmer using "[" to tell the two apart.
// Hence, we need to define zaparr function below.
// To delete array of pointers
template <class T>
inline void zaparr(T & x)
{
    {assert(x != NULL);}
    delete [] x;
    x = NULL;
}
```

---

The zap() function will delete the pointer and set it NULL. This will ensure that even if multiple zap()'s are called on the same deleted pointer then the program will not crash. Please see the function zap\_example() in [example\\_String.cpp](#).

---

```
// See zap_example() in example_String.cpp
zap(pFirstname);
//zap(pFirstname); // no core dumps. Because pFirstname is NULL now
//zap(pFirstname); // no core dumps. Because pFirstname is NULL now

zap(pLastname);
zap(pJobDescription);

int *iiarray = new int[10];
zaparr(iiarray);
```

---

There is nothing magical about this, it just saves repetitive code, saves typing time and makes programs more readable. The C++ programmers often forget to reset the deleted pointer to NULL, and this causes annoying problems causing core dumps and crashes. The zap() takes care of this automatically. Do not stick a typecast in the zap() function — if something errors out on the above zap() function it likely has another error somewhere.

Also [my\\_malloc\(\)](#), [my\\_realloc\(\)](#) and [my\\_free\(\)](#) should be used instead of [malloc\(\)](#), [realloc\(\)](#) and [free\(\)](#), as they are much cleaner and have additional checks. For an example, see the file "String.h" which is using the [my\\_malloc\(\)](#) and [my\\_free\(\)](#) functions.

**WARNING :** Do not use [free\(\)](#) to free memory allocated with 'new' or 'delete' to free memory allocated with [malloc](#). If you do, then results will be unpredictable.

See the zap examples in [example\\_String.cpp](#).

---

## 11. [Pointers are problems](#)

Pointers are not required for general purpose programming. In modern languages like Java there is no support for pointers (Java internally uses pointers). Pointers make the programs messy and programs using pointers are very hard to read.

Avoid using pointers as much as possible and use references. Pointers are really a great pain. It is possible to write an application without using pointers. *You should pointers only in those cases where references will not work.*

A **reference** is an alias; when you create a reference, you initialize it with the name of another object, the target. From the moment on, the reference acts as an alternative name of the target, and anything you do to the reference is really done to the target.

**Syntax of References:** Declare a reference by writing the type, followed by the reference operator (&), followed by the reference name. References **MUST** be initialized at the time of creation. For example –

---

```
int          weight;
int    & rweight = weight;

DOG          aa;
DOG & rDogRef = aa;
```

---

*Do's of references –*

- Do use references to create an alias to an object
- Do initialize all references
- Do use references for high efficiency and performance of program.
- Do use **const** to protect references and pointers whenever possible.

*Do not's of references –*

- **IMPORTANT:** Don't use references to NULL objects
  - Don't confuse the address of operator & with reference operator. The references are used in the declarations section (see Syntax of References above).
  - Don't try to reassign a reference
  - Don't use pointers if references will work
  - Don't return a reference to a local object
  - Don't pass by reference if the item referred to may go out of scope
- 

## [12. Usage of my\\_malloc and my\\_free](#)

Try to avoid using malloc and realloc as much as possible and use **new** and [zap\(delete\)](#). But sometimes you may need to use the "C" style memory allocations in "C++". Use the functions **my\_malloc()**, **my\_realloc()** and **my\_free()**. These functions do proper allocations and initialisations and try to prevent memory problems. Also these functions (in DEBUG mode) can keep track of memory allocated and print total memory usage before and after the program is run. This tells you if there are any memory leaks.

The my\_malloc and my\_realloc is defined as below. It allocates little more memory (SAFE\_MEM = 5) and initializes the space and if it cannot allocate it exits the program. The 'call\_check(), remove\_ptr()' functions are active only when DEBUG\_MEM is defined in makefile and are assigned to ((void)0) i.e. NULL for non-debug production release. They enable the total-memory used tracing.

---

## C++ Programming HOW-TO

```
void *local_my_malloc(size_t size, char fname[], int lineno)
{
    size_t tmpii = size + SAFE_MEM;
    void *aa = NULL;
    aa = (void *) malloc(tmpii);
    if (aa == NULL)
        raise_error_exit(MALLOC, VOID_TYPE, fname, lineno);
    memset(aa, 0, tmpii);
    call_check(aa, tmpii, fname, lineno);
    return aa;
}

char *local_my_realloc(char *aa, size_t size, char fname[], int lineno)
{
    remove_ptr(aa, fname, lineno);
    unsigned long tmpjj = 0;
    if (aa) // aa != NULL
        tmpjj = strlen(aa);
    unsigned long tmpqq = size + SAFE_MEM;
    size_t tmpii = sizeof(char) * (tmpqq);
    aa = (char *) realloc(aa, tmpii);
    if (aa == NULL)
        raise_error_exit(REALLOC, CHAR_TYPE, fname, lineno);

    // do not memset
    aa[tmpqq-1] = 0;
    unsigned long kk = tmpjj;
    if (tmpjj > tmpqq)
        kk = tmpqq;
    for (; kk < tmpqq; kk++)
        aa[kk] = 0;
    call_check(aa, tmpii, fname, lineno);
    return aa;
}
```

---

See [my\\_malloc.cpp](#). and the header file [my\\_malloc.h](#). for full implementation of the my\_malloc program.

An example on usage of my\_malloc and my\_free as below:

---

```
char    *aa;
int     *bb;
float   *cc;
aa = (char *) my_malloc(sizeof(char)* 214);
bb = (int *) my_malloc(sizeof(int) * 10);
cc = (float *) my_malloc(sizeof(int) * 20);

aa = my_realloc(aa, sizeof(char) * 34);
bb = my_realloc(bb, sizeof(int) * 14);
cc = my_realloc(cc, sizeof(float) * 10);
```

---

Note that in my\_realloc you do not need to cast the datatype as the variable itself is passed and correct my\_realloc is called which returns the proper datatype pointer. The my\_realloc has overloaded functions for char\*, int\* and float\*.

## 12.1 Garbage Collector for C++

In C/C++ Garbage Collection is not a standard feature and hence allocating and freeing storage explicitly is difficult, complicated and is error-prone. The **Garbage Collection (GC)** is not part of the C++ standard because there are just so many ways how one could implement it; there are many GC techniques, and deciding to use a particular one would not be good for certain programs. Computer scientists had designed many GC algorithms, each one of them catering to a particular problem domain. There is no one single generic GC which will tackle all the problem domains. As a consequence, GC is not part of C++ standard, they just left it out. Still, you always have the choice of many freely available C++ libraries that do the job for you.

Visit the C++ [Garbage Collection](#) and [Memory management](#) site.

---

## 13. [Debug files](#)

To debug any C++ or C programs include the file [debug.h](#) and in your 'Makefile' define DEBUG\_STR, DEBUG\_PRT, DEBUG\_MEM to turn on the traces from the debug.h functions. When you remove the '-DDEBUG\_STR' etc.. then the debug function calls are set to ((void)0) i.e. NULL, hence it has no impact on final production release version of project. You can generously use the debug functions in your programs and it will not increase the size of production executable.

See the file [debug.cpp](#) for implementation of debug routines. And see the file [my\\_malloc.cpp](#) for sample which uses debug.h and debug functions.

See the sample [Makefile](#) .

---

## 14. [Java like API](#)

Visit the following sites for Java like API for C++

- Java utils in C++ <http://www.pulsar.org/users/ej/archive/oop>
  - PhD Thesis book Java API in C++ <http://www.pulsar.org/archive/phd/ejphd>
- 

## 15. [IDE tools for C++](#)

The following IDE tools (Integrated Development Environment) are available for C++:

- The "top rated" Dev-C++ is an full-featured Integrated Development Environment (IDE) for both Win32 and Linux. It uses GCC, Mingw or Cygwin as compiler and libraries set. It is at <http://www.bloodshed.net/devcpp.html> and at [mirror-site](#)
- KDE [Kdevelop](#)
- Blatura site [C++ Tools](#)
- Amulet [Amulet](#)
- App Dev suite [Angoss](#)
- Make replacement [Brass](#)

- S/W product metrics [CCC](#)
  - Project mgmt, edit, compile, debug [C-Forge](#)
  - Dev environment [Code Crusader](#)
  - Graphic gdb [Code Medic](#)
  - Code analysis [CodeWizard](#)
  - Gen HTML, LaTeX for C++ cod [Doc C++](#)
  - GUI toolkit OpenGL [Ftk](#)
  - C++ and Java IDE [GLG IDE](#)
  - HP IDE [HP Eloquence](#)
  - IDE C++, Java, Pascal [RHIDE](#)
  - IDE for C++, Java [SNiff](#)
  - IDE for C++, Java [Wipeout](#)
  - X-based dev env [XWPE](#)
- 

## 16. [C++ Online Textbooks and Docs](#)

- "C++ Annotations" online book main site: [Annotations](#) better site : [mirror-site](#)
- "Teach Yourself C++ in 21 days" online textbook [Teach C++](#)
- "C++ Online" Textbook [C++ Bruce Eckel](#)
- C++ Open books: [Panorama](#) and click on Open Books.
- "Who's Afraid of C++?" online textbook [Steveheller](#)
- "Introduction to Object Oriented Programming" an ebook [C++ OOP](#)
- C++ in Hypertext [C++ Hypertext](#)
- Object Oriented Systems [OOP article](#)
  
- Porting C++ to Java [PortingC](#)
- C/C++ Journals [UtahJournals](#)
- Yahoo C++ category site [CCyahoo](#)
- C Library Reference Guide [c\\_guide](#)
- Online textbooks C++/Java [FreeLib](#)

Java books which will be useful for C++ programmers:

- Great Web reference site [WebRef](#)
  - Many java books [JBooks](#)
  - Intro to Java V3.0 [JavaNotes](#) mirror [JavaNotes](#)
  - Web Library: <http://www.itlibrary.com>
  - Intermediate Level Java book: <http://www.bruceeckel.com>
  - Thinking in Java : [Thinking C++](#)
  - John Hopkins Univ – Java resources [Hall](#)
  - online java tutorial [Chortle](#)
  - Practical guide for Java [SunBooks](#)
  - Java [Soton](#)
- 

## 17. [C++ Coding Standards](#)

Coding standard is very essential for readability and maitainence of programs. And it also greatly improves

the productivity of the programmer. The GNU C++ compiler **must enforce** coding discipline. The following is suggested – inside class definition:

- All public variables must begin with **m** like **mFooVar**. The **m** stands for *member*.
- All protected variables must begin with **mt**, like **mtFooVar** and methods with **t**, like **tFooNum()**. The **t** stands for *protected*.
- All private variables must begin with **mv**, like **mvFooVar** and methods with **v**, like **vFooLone()**. The **v** stands for *private*.
- All public, protected and private variables must begin with uppercase after **m** like **F** in **mFooVar**.
- All pointer variables must be prefixed with **p**, like
  - ◆ Public variables **mpFooVar** and methods like **FooNum()**
  - ◆ Protected variables **mtpFooVar** and methods with **t** like **tFooNum()**
  - ◆ Private variables **mvpFooVar** and methods with **v** like **vFooNum()**

The compiler should generate error if the code does not follow above standard. The C++ compiler can provide a flag option to bypass strict coding standard to compile old source code, and for all new code being developed will follow the uniform world-wide coding standard.

In the sample code given below **t** stands for **protected**, **v** stands for **private**, **m** stands for **member-variable** and **p** stands for **pointer**.

---

```
class SomeFunMuncho
{
    public:
        int      mTempZimboniMacho; // Only temporary variables should be public as per OOP
        float    *mpTempArrayNumbers;
        int      HandleError();
        float    getBonyBox(); // Public accessor as per OOP design
        float    setBonyBox(); // Public accessor as per OOP design
    protected:
        float    mtBonyBox;
        int      *mtpBonyHands;
        char     *tHandsFull();
        int      tGetNumbers();
    private:
        float    mvJustDoIt;
        char     mvFirstName[30];
        int      *mvpTotalValue;
        char     *vSubmitBars();
        int      vGetNumbers();
};
```

---

When your program grows by millions of lines of code, then you will greatly appreciate the naming convention as above. The readability of code improves, because just by looking at the variable name like **mvFirstName** you can tell that it is member of a class and is a private variable.

Visit the C++ Coding Standards URLs

- C++ FAQ Lite – Coding standards  
<http://new-brunswick.net/workshop/c++/faq/coding-standards.html>
- Rice university coding standard <http://www.cs.rice.edu/~dwallach/CPlusPlusStyle.html>
- Identifiers to avoid in C++ Programs <http://oakroadsystems.com/tech/cppredef.htm>

- Coding standards from Possibility <http://www.possibility.com/Cpp/CppCodingStandard.html> and [mirror site](#)
- Coding standards for Java and C++ from Ambysoft <http://www.ambysoft.com/javaCodingStandards.html>
- Rules and recommendations <http://www.cs.umd.edu/users/cml/cstyle/>
- Indent and annotate <http://www.cs.umd.edu/users/cml/cstyle/indhill-annot.html>
- Elemental rules <http://www.cs.umd.edu/users/cml/cstyle/Ellemtel-rules.html>
- C++ style doc <http://www.cs.umd.edu/users/cml/cstyle/Wildfire-C++Style.html>
- C++ Coding Standards by Brett Scolcum <http://www.skypoint.com/~slocum/prog/cppstds.html>
- Logikos C++ Coding Standards [http://www.logikos.com/standards/cpp\\_std.html](http://www.logikos.com/standards/cpp_std.html)
- NRad C++ coding standards <http://cadswes.colorado.edu/~billo/standards/nrad>
- BEJUG C++ coding standards <http://www.meurrens.org/ip-Links/java/joodcs/ToddHoff.html>
- Arctic Labs coding standards <http://www.arcticlabs.com/codingstandards>

See also

- For rapid navigation with ctags [Vim color text editor](#)
  - To improve productivity see [C++ Beautifier HOWTO](#)
- 

## 18. [C++ Online Docs](#)

There are **MORE THAN ONE MILLION** online articles/textbooks/reference guides on C++ language. That is because C++ is used extensively for a very long period of time. You can find them using the Internet search engines like Yahoo, Lycos, Excite etc..

Visit the following C++ sites :-

- C++ STL basic string class [http://www.sgi.com/Technology/STL/basic\\_string.html](http://www.sgi.com/Technology/STL/basic_string.html)
- See the section [STL References](#)
  
- C++ Crash-proof site <http://www.troubleshooters.com/codecorn/crashprf.htm>
- C++ Memory site <http://www.troubleshooters.com/codecorn/memleak.htm>
  
- GNU Main site <http://www.gnu.org> and gnu C++ site at <http://www.gnu.org/software/gcc/gcc.html>
- GNU C++ Library – socs [http://www.socs.uts.edu.au/doc/gnuinfo/libg++/libg++\\_18.html](http://www.socs.uts.edu.au/doc/gnuinfo/libg++/libg++_18.html)
- GNU C++ Library – gsi [http://www.gsi.de/doc/gnu/libg++\\_toc.html](http://www.gsi.de/doc/gnu/libg++_toc.html)
- GNU C++ Library – techno [http://www.techno.spb.ru/~xbatob/FAQ/GNU/libg++\\_toc.html](http://www.techno.spb.ru/~xbatob/FAQ/GNU/libg++_toc.html)
- GNU C++ Library – utah [http://www.math.utah.edu/docs/info/libg++\\_toc.html](http://www.math.utah.edu/docs/info/libg++_toc.html)
- AS University C++ Standard String class <http://www.eas.asu.edu/~cse200/outline>
  
- Java JString for C++ [http://www.mike95.com/c\\_plusplus/classes/JString/JString\\_cpp.asp](http://www.mike95.com/c_plusplus/classes/JString/JString_cpp.asp)
- C++ Language Reference <http://www.msoe.edu/~tritt/cpplang.html>
- C++ Program examples and samples <http://www.msoe.edu/~tritt/cpp/examples.html>
- Neil's C++ stuff <http://www.cyclone7.com/cpp>

Internet has vast amounts of documentation on C++. Visit the search engines like Yahoo, Lycos, Infoseek, Excite. Type in the keywords 'C++ tutorials' 'C++ references' 'C++ books' . You can narrow down the search criteria by clicking on *Advanced* search and select *search by exact phrase*

- <http://www.yahoo.com>
- <http://www.lycos.com>
- <http://www.infoseek.com>
- <http://www.excite.com>
- <http://www.mamma.com>

## 18.1 C++ Tutorials

There are many on-line tutorials available on internet. Type 'C++ tutorials' in the search engine.

- C++ Tutorial <http://www.xploiter.com/programming/c/index.shtml>
- C++ Tutorial IISc, India  
<http://www.csa.iisc.ernet.in/Documentation/Tutorials/StyleGuides/c++-style.html>
- C++ Tutorial Brown Univ <http://wilma.cs.brown.edu/courses/cs032/resources/C++tutorial.html>
- C++ Tutorial <http://home.msuiit.edu.ph/~ddd/tutorials/cpp/cplist.htm>
- C++ Tutorial IOstreams <http://osiris.sunderland.ac.uk/~cs0pdu/pub/com365/Sched3/iocpp.html>

## 18.2 Useful links

Bird's eye view of C++ URLs (about 153 url links)

<http://www.enteract.com/~bradapp/links/cplusplus-links.html>

This [URL: http://www.snippets.org](http://www.snippets.org) portable C code contains over 360 files.

## 18.3 C++ Quick-Reference

Type 'C++ Reference' in the search engine.

- C++ quick ref <http://www.cs.jcu.edu.au/~david/C++SYNTAX.html>
- C++ Standard Library Quick Reference  
<http://www.halpernwrightsoftware.com/stdlib-scratch/quickref.html>
- C++ STL from halpern <http://www.halpernwrightsoftware.com/stdlib-scratch/quickref.html>

## 18.4 C++ Usenet Newsgroups

- C++ newsgroups : [comp.lang.c++.announce](mailto:comp.lang.c++.announce)
- C++ newsgroups : [comp.lang.c++.](mailto:comp.lang.c++.)\*
- C++ newsgroups : <http://marshall-cline.home.att.net/cpp-faq-lite>

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## 19. [Memory Tools](#)

Use the following memory debugging tools

- The "MPatrol" is a very powerful memory debugging tool. It is at <http://www.cbmamiga.demon.co.uk/mpatrol> and at <http://www.rpmfind.net> go here and search mpatrol. If you are using linux then you must download the mpatrol\*.src.rpm file from the rpmfind.net. To update the mpatrol\*.src.rpm to latest version, you can use the old mpatrol.spec file



and latest mpatrol\*.tar.gz file to rebuild new \*.src.rpm.

- On linux contrib cdrom see mem\_test\*.rpm package and at <http://www.rpmfind.net> go here and search mem\_test.
  - On linux cdrom see ElectricFence\*.rpm package and at <http://www.rpmfind.net> go here and search electricfence.
  - Purify Tool from Rational Software Corp <http://www.rational.com>
  - Insure++ Tool from Parasoft Corp <http://www.parasoft.com>
  - Linux Tools at <http://www.xnet.com/~blatura/linapp6.html#tools>
  - Search the Internet engines like Yahoo, Lycos, Excite, Mamma.com for keyword "Linux memory debugging tools".
- 

## 20. Related URLs

You MUST use a color editor like 'Vim' (Vi improved) while coding in C++. Color editors greatly increase your productivity. Visit the URL for Vim howto below.

Visit following locators which are related to C, C++ –

- Vim color text editor for C++, C <http://metalab.unc.edu/LDP/HOWTO/Vim-HOWTO.html>
  - C++ Beautifier HOWTO <http://metalab.unc.edu/LDP/HOWTO/C-C++Beautifier-HOWTO.html>
  - Source code control system for C++ programs (CVS HOWTO) <http://metalab.unc.edu/LDP/HOWTO/CVS-HOWTO.html>
  - Linux goodies main site is at <http://www.aldev.8m.com> Mirror sites are at – <http://aldev0.webjump.com>, [angelfire](http://angelfire.com), [geocities](http://geocities.com), [virtualave](http://virtualave.com), [50megs](http://50megs.com), [theglobe](http://theglobe.com), [NBCi](http://NBCi.com), [Terrashare](http://Terrashare.com), [Fortunecity](http://Fortunecity.com), [Freewebsites](http://Freewebsites.com), [Tripod](http://Tripod.com), [Spree](http://Spree.com), [Escalix](http://Escalix.com), [Httpcity](http://Httpcity.com), [Freeservers](http://Freeservers.com).
- 

## 21. C++ Scripting Languages

The major disadvantage of C++ is that you must recompile and link the object files to create a executable anytime you make a small change. The compile/link/debug cycles take away a lot of time and is quite unproductive. Since modern CPU's and RAM are becoming extremely fast and cheap, it is better to spend more money on hardware and use scripting languages for development.

### 21.1 PIKE (C/C++ Scripting Language)

The scripting language like PIKE eliminates the linking and re-compiling and will really speed up the development process.

As memory (RAM) prices are dropping and CPU speeds are increasing, scripting language like PIKE will **EXPLODE in popularity**. PIKE will become most widely used scripting language as it is object oriented and it's syntax is very identical to that of C++ language.

Programming productivity will increase by **five times** by using the Pike C++ scripting language. And Pike is very useful for 'proof of concept' and developing prototypes rapidly.

The Pike is at <http://pike.roxen.com> and at <http://www.roxen.com>.

The Roxen Web server is completely written in Pike, which demonstrates how powerful Pike is. Pike runs much faster than Java for some operations and is quite efficient in using memory resources.

## 21.2 SoftIntegration Ch (C/C++ Scripting Language)

If you want commercial scripting language, get the 'Ch scripting' product from SoftIntegration corporation at <http://www.softintegration.com>.

The scripting language environment called Ch is a superset of C with high-level extensions, and salient features from C++ and other languages so that users can learn the language once and use it anywhere for almost any programming purposes. This C-compatible scripting language environment is also a middleware serving as crucial software infrastructure for running portable applications in heterogeneous platforms. The portable Ch code can be deployed safely over the internet or intranets to run anywhere ranging from supercomputers, workstations, PCs, Palm Pilots, PDA, to non-traditional computing devices such as CNC machines, robots, TVs, refrigerators, among others.

## 21.3 PHP (C++ Scripting Language)

PHP is hypertext-preprocessor scripting language and is very rapidly evolving and getting object oriented features. It has the "class" keyword through which it tries to implement object oriented scripting. May be in near future PHP will mature rapidly to become a robust scripting language for object oriented projects. In future it will tackle both the web applications and general purpose applications. Why have different scripting languages for web and general applications, instead just use PHP for both. PHP is at <http://www.linuxdoc.org/HOWTO/PHP-HOWTO.html>.

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## 22. Templates

- [http://babbage.cs.qc.edu/STL\\_Docs/templates.htm](http://babbage.cs.qc.edu/STL_Docs/templates.htm) Mirror at: [http://www.mike95.com/c\\_plusplus/tutorial/templates](http://www.mike95.com/c_plusplus/tutorial/templates)
- This tells about #pragma template : – <http://www.dgp.toronto.edu/people/JamesStewart/270/9697f/notes/Nov25-tut.html>
- Very GOOD site: <http://www.cplusplus.com/doc/tutorial/tut5-1.html> <http://www.cplusplus.com/doc/tutorial>
- For certification of C++: goto <http://examware.com> and click on "Tutorials" and then C/C++ button
- C++ Open books: <http://www.softpanorama.org/Lang/cpp.shtml> and click on tutorials

- Templates tutorial : <http://www.infosys.tuwien.ac.at/Research/Component/tutorial/prwmain.htm>
- 

## 23. STL References

Please visit the following sites for STL –

- Very good intro to iterators <http://www.cs.trinity.edu/~joldham/1321/lectures/iterators/>
- CMU univ <http://www.cs.cmu.edu/afs/andrew/course/15/129/Cpp/10-STL/>
- Intro to STL SGI [http://www.sgi.com/Technology/STL/stl\\_introduction.html](http://www.sgi.com/Technology/STL/stl_introduction.html)
- Mumits STL Newbie guide  
<http://www.xraylith.wisc.edu/~khan/software/stl/STL.newbie.html> Mumit Khan's informative STL introduction is full of examples <http://abel.hive.no/C++/STL/stlnew.html>
- ObjectSpace examples: ObjectSpace has contributed over 300 examples to the public domain and these are a very good start for beginners. <ftp://butler.hpl.hp.com/stl/examples.zip>
- Joseph Y. Laurino's STL page. [http://weber.u.washington.edu/~bytewave/bytewave\\_stl.html](http://weber.u.washington.edu/~bytewave/bytewave_stl.html)
- Musser's STL docs and examples. Very nice. <http://www.cs.rpi.edu/~musser/stl.html>
- STL Newbie home site. <http://www.xraylith.wisc.edu/~khan/software/stl/STL.newbie.html>
- Marian Corcoran's STL FAQ. <ftp://butler.hpl.hp.com/stl/stl.faq>

STL Tutorial:

- The best doc on tutorial – <http://www.decompile.com/html/tut.html> Mirror: <http://mip.ups-tlse.fr/~grundman/stl-tutorial/tutorial.html>
- very good – <http://www.yrl.co.uk/~phil/stl/stl.htmlx>
- C++ Standard Template Library Another great tutorial, by Mark Sebern <http://www.msoe.edu/eecs/cese/resources/stl/index.htm>
- By Jak Kirman: [http://129.187.112.56/Misc/Computer/stl-tutorial/tutorial\\_9.html](http://129.187.112.56/Misc/Computer/stl-tutorial/tutorial_9.html) Mirrors : <http://www.cs.brown.edu/people/jak/proglang/cpp/stltut/tut.html> <http://saturn.math.uaa.alaska.edu/~afjhj/cs403>
- Technical University Vienna by Johannes Weidl <http://dnaugler.cs.semo.edu/tutorials/stl> mirror <http://www.infosys.tuwien.ac.at/Research/Component/tutorial/prwmain.htm>
- Colorful Tutorial <http://www.codeproject.com/cpp/stl/introduction.asp>

Ready-made Components for use with the STL

- STL components Collected by Boris Fomitche <http://www.metabyte.com/~fbp/stl/components.html>

Main STL sites –

- C++ STL from SGI <http://www.sgi.com/Technology/STL>
- C++ STL from RPI univ <http://www.cs.rpi.edu/projects/STL/htdocs/stl.html>
- C++ STL site [ODP for STL](http://www.odp.com/STL) and the [mirrorsite](http://www.mirrorsite.com)
- STL for C++ Programmers <http://userwww.econ.hvu.nl/~ammeraal/stlcpp.html>
- C++ STL from halper <http://www.halpernwrightsoftware.com/stdlib-scratch/quickref.html>

### 23.1 Overview of the STL

The STL offers the programmer a number of useful data structures and algorithms. It is made up of the following components.

- Containers. There are two types:
  - ◆ Sequential. This group comprises the vector, list and dequeue types.
  - ◆ Sorted Associative. This group comprises the set, map, multiset and multimap types.
- Iterators. These are pointer like objects that allow the user to step through the contents of a container.
- Generic Algorithms. The STL provides a wide range of efficiently implemented standard algorithms (for example find, sort and merge) that work with the container types. (Some of the containers have special purpose implementations of these algorithms as member functions.)
- Function Objects. A function object is an instance of a class that provides a definition of operator(). This means that you can use such an object like a function.
- Adaptors. The STL provides
  - ◆ Container adaptors that allow the user to use, say, a vector as the basis of a stack.
  - ◆ Function adaptors that allow the user to construct new function objects from existing function objects.
- Allocators. Every STL container class uses an Allocator class to hold information about the memory model the program is using. I shall totally ignore this aspect of the STL.

I will be considering the use of the vector, list, set and map containers. To make use of these containers you have to be able to use iterators so I shall have something to say about STL iterators. Using the set and map containers can mean having to supply a simple function object to the instantiation so I shall also have something to say about function objects. I will only briefly mention the algorithms supplied by the STL. I will not mention adaptors at all.

I have taken liberties with some of the types of function arguments — for example most of the integer arguments referred to in what follows actually have type `size_type` which is typedef'ed to an appropriate basic type depending on the allocation model being used. If you want to see the true signatures of the various functions discussed have a look at the Working Paper or the header files.

There are a number of utility classes supplied with the STL. The only one of importance to us is the pair class. This has the following definition:

---

```
template<class T1, class T2>
class pair {
public:
    T1 first;
    T2 second;
    pair(const T1& a, const T2& b) : first(a), second(b) {}
};
```

---

and there is a convenient function `make_pair` with signature:

---

```
pair<T1,T2> make_pair(const T1& f, const T2& s)
```

---

as well as implementations of `operator==` and `operator <`. There is nothing complicated about this template class and you should be able to use it without further guidance. To use it `#include` the header file `pair.h`. It crops up in a number of places but particularly when using the `set` and `map` classes.

## 23.2 Header Files

To use the various bits of the STL you have to `#include` the appropriate header files. These may differ slightly from compiler to compiler but for `g++` the ones of interest are:

- *vector.h* for the vector type.
- *list.h* for the list type.
- *set.h* for the set type.
- *map.h* for the map type.
- *algo.h* for access to the generic algorithms.

If you don't want to remember which is which you could just use `stl.h` which includes all the above (and all the other header files of the STL as well).

## 23.3 The Container Classes Interface

The container classes have many member functions that have the same names. These functions provide the same (or very similar) services for each of the classes (though, of course, the implementations will be different). The following table lists the functions that we shall consider in more detail. A star opposite a function name indicates that the container type heading the column provides a member function of that name.

Operation	Purpose	Vector	List	Set	Map
<code>==</code>	comparison	*	*	*	*
<code>&lt;</code>	comparison	*	*	*	*
<code>begin</code>	iterator	*	*	*	*
<code>end</code>	iterator	*	*	*	*
<code>size</code>	no. of elements	*	*	*	*
<code>empty</code>	is container empty	*	*	*	*
<code>front</code>	first element	*	*		
<code>back</code>	last element	*	*		
<code>[ ]</code>	element access/modification	*			*
<code>insert</code>	insert element(s)	*	*	*	*
<code>push_back</code>	insert new last element	*	*		
<code>push_front</code>	insert new first element		*		
<code>erase</code>	remove element(s)	*	*	*	*
<code>pop_back</code>	remove last element	*	*		

pop_front	remove last element	*
<b>Container Class Interface</b>		

If the following discussion leaves something unclear (and it will) you can always write a small test program to investigate how some function or feature behaves.

## 23.4 Vectors

A vector is an array like container that improves on the C++ array types. In particular it is not necessary to know how big you want the vector to be when you declare it, you can add new elements to the end of a vector using the *push\_back* function. (In fact the *insert* function allows you insert new elements at any position of the vector, but this is a very inefficient operation — if you need to do this often consider using a list instead).

### Constructing Vectors

*vector* is a class template so that when declaring a vector object you have to state the type of the objects the vector is to contain. For example the following code fragment

---

```
vector<int> v1;
vector<string> v2;
vector<FiniteAutomaton> v3;
```

---

declares that *v1* is a vector that holds integers, *v2* a vector that holds strings and *v3* holds objects of type *FiniteAutomaton* (presumably an user defined class type). These declarations do not say anything about how large the vectors are to be (implementations will use a default starting size) and you can grow them to as large as you require.

You can give an initial size to a vector by using a declaration like

---

```
vector<char> v4(26);
```

---

which says that *v4* is to be vector of characters that initially has room for 26 characters. There is also a way to initialise a vector's elements. The declaration

---

```
vector<float> v5(100,1.0);
```

---

says that *v5* is a vector of 100 floating point numbers each of which has been initialised to 1.0.

## Checking Up on Your Vector

Once you have created a vector you can find out the current number of elements it contains by using the `size` function. This function takes no arguments and returns an integer (strictly a value of type `size_type`, but this gets converted to an integer) which says how many elements there are in the vector. What will be printed out by the following small program?

---

```
<vector-size.cc>=
#include <iostream.h>
#include <vector.h>

void main()
{
    vector<int> v1;
    vector<int> v2(10);
    vector<int> v3(10,7);

    cout << "v1.size() returns " << v1.size() << endl;
    cout << "v2.size() returns " << v2.size() << endl;
    cout << "v3.size() returns " << v3.size() << endl;
}
```

---

To check on whether your vector is empty or not you can use the `empty` function. This takes no arguments and returns a boolean value, true if the vector is empty, false if it is not empty. What will be printed out by the following small program (true prints as 1 and false prints as 0)?

---

```
<vector-empty.cc>=
#include <iostream.h>
#include <vector.h>

void main()
{
    vector<int> v1;
    vector<int> v2(10);
    vector<int> v3(10,7);

    cout << "v1.empty() has value " << v1.empty() << endl;
    cout << "v2.empty() has value " << v2.empty() << endl;
    cout << "v3.empty() has value " << v3.empty() << endl;
}
```

---

## Accessing Elements of a Vector

You can access a vector's elements using operator`[]`. Thus, if you wanted to print out all the elements in a vector you could use code like

---

```
vector<int> v;
// ...
for (int i=0; i<v.size(); i++)
    cout << v[i];
```

(which is very similar to what you might write for a builtin array).

You can also use operator[] to set the values of the elements of a vector.

---

```
vector<int> v;  
// ...  
for (int i=0; i<v.size(); i++)  
    v[i] = 2*i;
```

---

The function front gives access to the first element of the vector.

---

```
vector<char> v(10,'a');  
// ...  
char ch = v.front();
```

---

You can also change the first element using front.

---

```
vector<char> v(10,'a');  
// ...  
v.front() = 'b';
```

---

The function back works the same as front but for the last element of the vector.

---

```
vector<char> v(10,'z');  
// ...  
char last = v.back();  
v.back() = 'a';
```

---

Here is a simple example of the use of [].

---

```
<vector-access.cc>=  
#include <vector.h>  
#include <iostream.h>  
  
void main()  
{  
    vector<int> v1(5);  
    int x;  
    cout << "Enter 5 integers (seperated by spaces):" << endl;  
    for (int i=0; i<5; i++)  
        cin >> v1[i];  
    cout << "You entered:" << endl;  
    for (int i=0; i<5; i++)
```



```

    cout << v1[i] << ' ';
    cout << endl;
}

```

---

## Inserting and Erasing Vector Elements

Along with operator[] as described above there are a number of other ways to change or access the elements in a vector.

- `push_back` will add a new element to the end of a vector.
- `pop_back` will remove the last element of a vector.
- `insert` will insert one or more new elements, at a designated position, in the vector.
- `erase` will remove one or more elements from a vector between designated positions.

Note that `insert` and `erase` are expensive operations on vectors. If you use them a lot then you should consider using the list data structure for which they are more efficient.

---

```

<vector-mod.cc>=
#include <iostream.h>
#include <vector.h>

void main()
{
    vector<int> v;

    for (int i=0; i<10; i++) v.push_back(i);
    cout << "Vector initialised to:" << endl;
    for (int i=0; i<10; i++) cout << v[i] << ' ';
    cout << endl;

    for (int i=0; i<3; i++) v.pop_back();
    cout << "Vector length now: " << v.size() << endl;
    cout << "It contains:" << endl;
    for (int i=0; i<v.size(); i++) cout << v[i] << ' ';
    cout << endl;

    int a1[5];
    for (int i=0; i<5; i++) a1[i] = 100;

    v.insert(& v[3], & a1[0], & a1[3]);
    cout << "Vector now contains:" << endl;
    for (int i=0; i<v.size(); i++) cout << v[i] << ' ';
    cout << endl;

    v.erase(& v[4], & v[7]);
    cout << "Vector now contains:" << endl;
    for (int i=0; i<v.size(); i++) cout << v[i] << ' ';
    cout << endl;
}

```

---

In the above a vector `v` has been declared then initialised using `push_back`. Then some elements have been trimmed off it's end using `pop_back`. Next an ordinary integer array has been created and then some of its elements inserted into `v` using `insert`. Finally `erase` has been used to remove elements from `v`. The functions

used above take arguments as follows.

- `push_back` takes a single argument of the type of the elements held in the vector.
- `pop_back` takes no arguments. It is a mistake to use `pop_back` on an empty vector.
- `insert` has three forms:
  - ◆ `insert(pos, T& x)` which will insert the single element `x` at position `pos` in the vector.
  - ◆ `insert(pos, start, end)` which inserts a sequence of elements from some other container at position `pos` in the vector. The sequence of elements is identified as starting at the `start` element and continuing to, but not including, the `end` element.
  - ◆ `insert(pos, int rep, T& x)` inserts `rep` copies of `x` at position `pos` in the vector.

As indicated in the code above the position `pos` should be the address of the element to insert at, whilst the `start` and `end` arguments are likewise also addresses. (The true story is that they are iterators — see next subsection and following section).

- `erase` has two forms (`pos`, `start` and `end` have the same types as for the `insert` function):
  - ◆ `erase(pos)` which will remove the element at position `pos` in the vector.
  - ◆ `erase(start,end)` which will remove elements starting at position `start` upto, but not including, the element at position `end`.

## Vector Iterators

The simple way to step through the elements of a vector `v` is as we have done above:

---

```
for (int i=0; i<v.size(); i++) { ... v[i] ... }
```

---

Another way is to use iterators. An iterator can be thought of as a pointer into the container, incrementing the iterator allows you to step through the container. For container types other than vectors iterators are the only way to step through the container.

For a vector containing elements of type `T`:

---

```
vector<T> v;
```

---

an iterator is declared as follows:

---

```
vector<T>::iterator i;
```

---

Such iterators are constructed and returned by the functions `begin()` and `end()`. You can compare two iterators (of the same type) using `==` and `!=`, increment using `++` and dereference using `*`. [In fact vector iterators allow more operations on them – see next section for more information].

Here is an illustration of how to use iterators with vectors.

---

```

<vector-iterator.cc>=
#include <iostream.h>
#include <vector.h>

void main()
{
    vector<int> v(10);
    first is ``less'' than the second

    int j = 1;

    vector<int>::iterator i;

    // Fill the vector v with integers 1 to 10.
    i = v.begin();
    while (i != v.end())
    {
        *i = j;
        j++;
        i++;
    }

    // Square each element of v.
    for (i=v.begin(); i!=v.end(); i++) *i = (*i) * (*i);

    // Print out the vector v.
    cout << "The vector v contains: ";
    for (i=v.begin(); i!=v.end(); i++) cout << *i << ' ';
    cout << endl;
}

```

---

Note how `*i` can be used on the left-hand side of an assignment statement so as to update the element pointed at by `i`, and on the right-hand side to access the current value.

## Comparing Vectors

You can compare two vectors using `==` and `<`. `==` will return true only if both vectors have the same number of elements and all elements are equal. The `<` functions performs a lexicographic comparison of the two vectors. This works by comparing the vectors element by element. Suppose we are comparing `v1` and `v2` (that is `v1 < v2`?). Set `i=0`. If `v1[i] < v2[i]` then return true, if `v1[i] > v2[i]` then return false, otherwise increment `i` (that is move on to the next element). If the end of `v1` is reached before `v2` return true, otherwise return false. Lexicographic order is also known as dictionary order. Some examples:

---

```

(1,2,3,4) < (5,6,7,8,9,10) is false.
(1,2,3) < (1,2,3,4) is true
(1,2,3,4) < (1,2,3) is false
(0,1,2,3) < (1,2,3) is true

```

---

The following code illustrates the third example above.

---

```

<vector-comp.cc>=
#include <vector.h>

```

```

#include <iostream.h>

void main()
{
    vector<int> v1;
    vector<int> v2;
    for (int i=0; i<4; i++) v1.push_back(i+1);
    for (int i=0; i<3; i++) v2.push_back(i+1);

    cout << "v1: ";
    for (int i=0; i<v1.size(); i++) cout << v1[i] << ' ';
    cout << endl;

    cout << "v2: ";
    for (int i=0; i<v2.size(); i++) cout << v2[i] << ' ';
    cout << endl;

    cout << "v1 < v2 is: " << (v1<v2 ? "true" : "false") << endl;
}

```

---

The comparison operators `<=` and `>=` also work.

## 23.5 Iterators and the STL

See the section [STL References](#)

## 23.6 Lists

See the section [STL References](#)

## 23.7 Sets

The set container type allows an user to store and retrieve elements directly rather than through an index into the container. The set container acts as a mathematical set in that it holds only distinct elements. However unlike a mathematical set, elements in a set container are held in (an user-supplied) order. In practise this is only a minor restriction on treating a set container as an implementation of the mathematical set abstract data type, and it allows for a much more efficient implementation than an unordered approach.

### Constructing Sets

Two template arguments are required to construct a set container -- the type of the objects the set is to contain and a function object that can compare two elements of the given type, that is:

---

```
set<T, Compare> s;
```

---

(The declaration `set<T> s` should also be possible -- it would use a default template argument `less<T>` as the second argument, but many C++ compilers (including g++) cannot as yet cope with default template arguments.)

For simple types **T** we can use the function object `less < T >` (without having to worry about what a "function object" is), for example all the following are legal set declarations.

---

```
set<int, less<int> > s1;
set<double, less<double> > s2;
set<char, less<char> > s3;
set<string, less<string> > s4;
```

---

(Note that the space between the two final `>`'s in the template is required – otherwise the compiler will interpret `>>` as the right shift operator.) In each of these cases the function object makes use of the operator `<` as defined for the underlying type (that is `int`, `double`, `char` and `string`).

The following code declares a set of integers, then adds some integers to the set using the `insert` method and then prints out the set members by iterating through the set. You will note that the set's contents are printed out in ascending order even though they were added in no particular order.

---

```
<set-construct1.cc>=
#include <iostream.h>
#include <set.h>

void main()
{
    set<int, less<int> > s;
    set<int, less<int> >::iterator i;

    s.insert(4);
    s.insert(0);
    s.insert(-9);
    s.insert(7);
    s.insert(-2);
    s.insert(4);
    s.insert(2);

    cout << "The set contains the elements: ";
    for (i=s.begin(); i!=s.end(); i++) cout << *i << " ";
    cout << endl;
}
```

---

Note that 4 is added twice but only turns up once on the list of elements — which is what one expects of a set.

## What are Function Objects?

One of the nifty features of C++ is the ability to overload operators, so that one can have `+` mean whatever one likes for your newly designed class. One of the operators C++ allows you to overload is the function call operator `()` and this allows you to create classes whose instances can behave like functions in many ways. These are function objects.

Here is a simple example.

---

```

<function-object.cc>=
#include <iostream.h>

template<class T>
class square {
public:
    T operator()(T x) { return x*x; }
};
// This can be used with any T for which * is defined.

void main()
{
    // Create some function objects.
    square<double> f1;
    square<int> f2;

    // Use them.
    cout << 5.1^2 = << f1(5.1) << endl;
    cout << 100^2 = << f2(100) << endl;

    // The following would result in a compile time error.
    // cout << 100.1^2 = << f2(100.1) << endl;
}

```

---

Function objects are used in a number of places in the STL. In particular they are used when declaring sets and maps.

The function object required for these purposes, let's suppose it is called *comp*, must satisfy the following requirements.

1. If  $\text{comp}(x,y)$  and  $\text{comp}(y,z)$  are true for objects  $x$ ,  $y$  and  $z$  then  $\text{comp}(x,z)$  is also true.
2.  $\text{comp}(x,x)$  is false for every object  $x$ .

If for any particular objects  $x$  and  $y$ , both  $\text{comp}(x,y)$  and  $\text{comp}(y,x)$  are false then  $x$  and  $y$  are deemed to be equal.

This, in fact, is just the behaviour of the *strictly-less-than* relation (ie  $<$ ) on numbers. The function object `less < T >` used above is defined in terms of a  $<$  operator for the type  $T$ . It's definition can be thought of as follows.

---

```

template<class T>
struct less {
    bool operator()(T x, T y) { return x<y; }
}

```

---

(The actual definition uses references, has appropriate const annotations and inherits from a template class `binary_function`.)

This means that if the type  $T$  has operator  $<$  defined for it then you can use `less < T >` as the comparator when declaring sets of  $T$ . You might still want to use a special purpose comparator if the supplied  $<$  operator is not appropriate for your purposes. Here is another example. This defines a simple class with a definition of

operator < and a function object that performs a different comparison. Note that the overloaded < and () operators should be given const annotations so that the functions work correctly with the STL.

---

```
<set-construct2.cc>=
#include <iostream.h>
#include <set.h>

// This class has two data members. The overloaded operator< compares
// such classes on the basis of the member f1.
class myClass {
private:
    int f1;
    char f2;
public:
    myClass(int a, char b) : f1(a), f2(b) {}
    int field1() const { return f1; }
    char field2() const { return f2; }
    bool operator<(myClass y) const
        { return (f1<y.field1()); }
};

// This function object compares objects of type myClass on the basis
// of the data member f2.
class comp_myClass {
public:
    bool operator()(myClass c1, myClass c2) const
        { return (c1.field2() < c2.field2()); }
};

void main()
{
    set<myClass, less<myClass> > s1;
    set<myClass, less<myClass> >::iterator i;
    set<myClass, comp_myClass> s2;
    set<myClass, comp_myClass>::iterator j;

    s1.insert(myClass(1,'a'));
    s2.insert(myClass(1,'a'));
    s1.insert(myClass(1,'b'));
    s2.insert(myClass(1,'b'));
    s1.insert(myClass(2,'a'));
    s2.insert(myClass(2,'a'));

    cout << Set s1 contains: ;
    for (i=s1.begin(); i!=s1.end(); i++)
        { cout << ( << (*i).field1() << ,
                    << (*i).field2() << ) << ' ';
        }
    cout << endl;

    cout << Set s2 contains: ;
    for (j=s2.begin(); j!=s2.end(); j++)
        { cout << ( << (*j).field1() << ,
                    << (*j).field2() << ) << ' ';
        }
    cout << endl;
}

```

---

The set `s1` contains (1,a) and (2,a) as comparison is on the data member `f1`, so that (1,a) and (1,b) are deemed the same element. The set `s2` contains (1,a) and (1,b) as comparison is on the data member `f2`, so that (1,a) and (2,a) are deemed the same element.

## A Printing Utility

The way we have printed out the sets in the previous examples is a little awkward so the following header file containing a simple overloaded version of `operator<<` has been written. It works fine for small sets with simple element types.

---

```
<printset.h>=
#ifndef _PRINTSET_H
#define _PRINTSET_H

#include <iostream.h>
#include <set.h>

template<class T, class Comp>
ostream& operator<<(ostream& os, const set<T,Comp>& s)
{
    set<T,Comp>::iterator iter = s.begin();
    int sz = s.size();
    int cnt = 0;

    os << {;
    while (cnt < sz-1)
        {
            os << *iter << ,;
            iter++;
            cnt++;
        }
    if (sz != 0) os << *iter;
    os << };

    return os;
}
#endif
```

---

The use here of `<<` as an output routine for a set assumes that `<<` has been defined for the set elements, and uses this to print a comma delimited list of the set elements wrapped in curly braces. It will be used without comment in the following examples.

## How Many Elements?

You can determine if a set is empty or not by using the `empty()` method. You can find out how many elements there are in a set by using the `size()` method. These methods take no arguments, `empty()` returns true or false and `size()` returns an integer.

---

```
<set-size.cc>=
#include <iostream.h>
#include <set.h>
#include printset.h
```



```

void main()
{
    set<int, less<int> > s;

    cout << The set s is
         << (s.empty() ? empty. : non-empty.) << endl;
    cout << It has << s.size() << elements. << endl;

    cout << Now adding some elements... << endl;

    s.insert(1);
    s.insert(6);
    s.insert(7);
    s.insert(-7);
    s.insert(5);
    s.insert(2);
    s.insert(1);
    s.insert(6);

    cout << The set s is now
         << (s.empty() ? empty. : non-empty.) << endl;
    cout << It has << s.size() << elements. << endl;
    cout << s = << s << endl;
}

```

---

## Checking the Equality of Sets.

Two sets may be checked for equality by using `==`. This equality test works by testing in order the corresponding elements of each set for equality using `T::operator==`.

---

```

<set-equality.cc>=
#include <iostream.h>
#include <set.h>
#include printset.h

void main()
{
    set<int, less<int> > s1, s2 ,s3;

    for (int i=0; i<10; i++)
    {
        s1.insert(i);
        s2.insert(2*i);
        s3.insert(i);
    }

    cout << s1 = << s1 << endl;
    cout << s2 = << s2 << endl;
    cout << s3 = << s3 << endl;
    cout << s1==s2 is: << (s1==s2 ? true. : false.) << endl;
    cout << s1==s3 is: << (s1==s3 ? true. : false.) << endl;
}

```

---

It is also possible to compare two sets using `<`. The comparison `s1 < s2` is true if the set `s1` is lexicographically less than the set `s2`, otherwise it is false.

## Adding and Deleting Elements

The way to add elements to a set is to use the insert method (as we have done above). The way to delete elements from a set is to use the erase method.

For a set holding elements of type T these methods come in following forms:

- **pair < iterator, bool> insert(T& x).** This is the standard insert function. The return value may be ignored or used to test if the insertion succeeded (that is the element was not already in the set). If the insertion succeeded the boolean component will be true and the iterator will point at the just inserted element. If the element is already present the boolean component will be false and the iterator will point at the element x already present.
- **iterator insert(iterator position, T& x).** This version of the insert function takes, in addition to the element to insert, an iterator stating where the insert function should begin to search. The returned iterator points at the newly inserted element, (or the already present element).
- **int erase(T& x).** This version of the erase method takes an element to delete and returns 1 if the element was present (and removes it) or 0 if the element was not present.
- **void erase(iterator position).** This version takes an iterator pointing at some element in the set and removes that element.
- **void erase(iterator first, iterator last).** This version takes two iterators pointing into the set and removes all the elements in the range [ first,last ] .

The following example illustrates these various forms.

---

```
<set-add-delete.cc>=
#include <iostream.h>
#include <set.h>
#include printset.h

void main()
{
    set<int, less<int> > s1;

    // Insert elements in the standard fashion.
    s1.insert(1);
    s1.insert(2);
    s1.insert(-2);

    // Insert elements at particular positions.
    s1.insert(s1.end(), 3);
    s1.insert(s1.begin(), -3);
    s1.insert((s1.begin()++)++, 0);

    cout << s1 = << s1 << endl;

    // Check to see if an insertion has been successful.
    pair<set<int, less<int> >::iterator,bool> x = s1.insert(4);
    cout << Insertion of 4 << (x.second ? worked. : failed.)
        << endl;
    x = s1.insert(0);
```

```

cout << Insertion of 0 << (x.second ? worked. : failed.)
    << endl;

// The iterator returned by insert can be used as the position
// component of the second form of insert.
cout << Inserting 10, 8 and 7. << endl;
s1.insert(10);
x=s1.insert(7);
s1.insert(x.first, 8);

cout << s1 = << s1 << endl;

// Attempt to remove some elements.
cout << Removal of 0 << (s1.erase(0) ? worked. : failed.)
    << endl;
cout << Removal of 5 << (s1.erase(5) ? worked. : failed.)
    << endl;

// Locate an element, then remove it. (See below for find.)
cout << Searching for 7. << endl;
set<int,less<int> >::iterator e = s1.find(7);
cout << Removing 7. << endl;
s1.erase(e);

cout << s1 = << s1 << endl;

// Finally erase everything from the set.
cout << Removing all elements from s1. << endl;
s1.erase(s1.begin(), s1.end());
cout << s1 = << s1 << endl;
cout << s1 is now << (s1.empty() ? empty. : non-empty.)
    << endl;
}

```

---

## Finding Elements

We mention two member functions that can be used to test if an element is present in a set or not.

- **iterator find(T& x)**. This searches for the element x in the set. If x is found it returns an iterator pointing at x otherwise it returns end().
- **int count(T& x)**. This returns 1 if it finds x in the set and 0 otherwise. (The count function for multisets returns the number of copies of the element in the set which may be more than 1. Hence, I guess, the name of the function.)

The use of find has been illustrated above. We could use count to write a simple template based set membership function. (This should also provide a version that takes a reference to the argument x.)

---

```

<setmember.h>=
#ifndef _SETMEMBER_H
#define _SETMEMBER_H
#include <set.h>

template<class T, class Comp>
bool member(T x, set<T,Comp>& s)
{
    return (s.count(x)==1 ? true : false);
}

```

```

}
#endif

```

Which might be used as follows.

```

<set-membership.cc>=
#include <iostream.h>
#include <set.h>
#include printset.h
#include setmember.h

void main()
{
    set<int, less<int> > s;
    for (int i= 0; i<10; i++) s.insert(i);
    cout << s = << s << endl;
    cout << 1 is << (member(1,s) ? : not) << a member of s
        << endl;
    cout << 10 is << (member(10,s) ? : not) << a member of s
        << endl;
}

```

---

## Set Theoretic Operations

The STL supplies as generic algorithms the set operations includes, union, intersection, difference and symmetric difference. To gain access to these functions you need to include algo.h. (In what follows iter stands for an appropriate iterator).

- bool includes(iter f1,iter l1,iter f2,iter l2).

This checks to see if the set represented by the range [f2,l2] is included in the set [f1,l1]. It returns true if it is and false otherwise. So to check to see if one set is included in another you would use

```
includes(s1.begin(), s1.end(), s2.begin(), s2.end())
```

The includes function checks the truth of  $A \subseteq B$  (that is of  $A \subseteq B$ ). This function assumes that the sets are ordered using the comparison operator  $<$ . If some other comparison operator has been used this needs to be passed to includes as an extra (function object) argument after the other arguments.

- iter set\_union(iter f1,iter l1,iter f2,iter l2,iter result).

This forms the union of the sets represented by the ranges [f1,l1] and [f2,l2]. The argument result is an output iterator that points at the start of the set that is going to hold the union. The return value of the function is an output iterator that points at the end of the new set.

The fact that the result argument is an output iterator means that you cannot use set\_union in the following, natural, fashion:

---

```

set<int, less<int> > s1, s2, s3;
// Add some elements to s1 and s2 ...
// Then form their union. (This does not work!)
set_union(s1.begin(), s1.end(),
          s2.begin(), s2.end(),

```

```
s3.begin());
```

---

The reason is that `begin()` (also `end()`) when used with sets (or maps) returns a (constant) input iterator. This type of iterator allows you to access elements of the set for reading but not writing. (And this is a Good Thing since if you could assign to a dereferenced iterator (as in `(*i)= ...`) then you could destroy the underlying order of the set.)

The solution is to use an insert iterator based on the set type. This, basically, converts an assignment `(*i)=value` (which is illegal) into a (legal) insertion `s.insert(i,value)` (where `s` is the set object that the iterator `i` is pointing into). It is used as follows:

---

```
// Typedef for convenience.
typedef set<int, less<int> > intSet;
intSet s1, s2, s3;
// Add some elements to s1 and s2 ...
// Then form their union.
set_union(s1.begin(), s1.end(),
          s2.begin(), s2.end(),
          insert_iterator<intSet>(s3,s3.begin()) );
```

---

Here is an example illustrating all these operations.

---

```
<set-theory.cc>=
#include <iostream.h>
#include <set.h>
#include <algo.h>
#include <iterator.h>
#include printset.h

void main()
{
    typedef set<int, less<int> > intSet;

    intSet s1, s2, s3, s4;

    for (int i=0; i<10; i++)
    { s1.insert(i);
      s2.insert(i+4);
    }
    for (int i=0; i<5; i++) s3.insert(i);

    cout << s1 = << s1 << endl;
    cout << s2 = << s2 << endl;
    cout << s3 = << s3 << endl;

    // Is s1 a subset of s2?
    bool test = includes(s2.begin(),s2.end(),s1.begin(),s1.end());
    cout << s1 subset of s2 is << (test ? true. : false.) << endl;

    // Is s3 a subset of s1?
    test = includes(s1.begin(),s1.end(),s3.begin(),s3.end());
    cout << s3 subset of s1 is << (test ? true. : false.) << endl;

    // Form the union of s1 and s2.
```

```

set_union(s1.begin(), s1.end(), s2.begin(), s2.end(),
          insert_iterator<intSet>(s4,s4.begin()) );
cout << s1 union s2 = << s4 << endl;

// Erase s4 and form intersection of s1 and s2. (If we don't erase
// s4 then we will get the previous contents of s4 as well).
s4.erase(s4.begin(),s4.end());
set_intersection(s1.begin(), s1.end(), s2.begin(), s2.end(),
                insert_iterator<intSet>(s4,s4.begin()) );
cout << s1 intersection s2 = << s4 << endl;

// Now set difference.
s4.erase(s4.begin(),s4.end());
set_difference(s1.begin(), s1.end(), s2.begin(), s2.end(),
              insert_iterator<intSet>(s4,s4.begin()) );
cout << s1 minus s2 = << s4 << endl;

// Set difference is not symmetric.
s4.erase(s4.begin(),s4.end());
set_difference(s2.begin(), s2.end(), s1.begin(), s1.end(),
              insert_iterator<intSet>(s4,s4.begin()) );
cout << s2 minus s1 = << s4 << endl;

// Finally symmetric difference.
s4.erase(s4.begin(),s4.end());
set_symmetric_difference(s1.begin(), s1.end(), s2.begin(), s2.end(),
                        insert_iterator<intSet>(s4,s4.begin()) );
cout << s1 symmetric_difference s2 = << s4 << endl;

// Which is symmetric!
s4.erase(s4.begin(),s4.end());
set_symmetric_difference(s2.begin(), s2.end(), s1.begin(), s1.end(),
                        insert_iterator<intSet>(s4,s4.begin()) );
cout << s2 symmetric_difference s1 = << s4 << endl;
}

```

---

## 23.8 Maps

See the section [STL References](#)

## 23.9 STL Algorithms

See the section

---

## 24. [Threads in C++](#)

- IBM pthread User Guide, Thread concepts, API reference <http://www.as400.ibm.com/developer/threads/uguide/document.htm> and mirror site is at [IBM main site](#)
- QpThread Library for C++ provides object oriented framework in C++ for threads and Unix signals on top of system level threads (currently POSIX Threads) <http://lin.fsid.cvut.cz/~kra/index.html>

- ThreadJack supports Java-like multi-thread programming model with platform independent C++ class library <http://www.esm.co.jp/divisions/open-sys/ThreadJack/index-e.html> and here is the [download-site](#)
- APE is the "APE Portable Environment" and class libraries for writing portable threaded servers in C++, under UNIX (pthread) and Win32 API's. APE provides portable class abstraction for threads, sockets, file handling, and synchronization objects. The goal of APE is to make writing threaded servers in C++ both practical and convenient, even for small and simple projects, and hence simplicity and low runtime overhead are design goals <http://www.voxilla.org/projects/projape.html>
- Portable Thread Lib <http://www.media.osaka-cu.ac.jp/~k-abe/PTL>
- Thread-Recycling in C++ <http://www.sigs.de/html/kuhlmann.html>

## 24.1 Threads Tutorial

- You can download all the tutorials in one file from [aldev-site](#)
- Threads tutorial is at <http://www.math.arizona.edu/swig/pthreads/threads.html>
- HERT tutorial at <http://www.hert.org/docs/tutorials>, go here to search for "Threads".
- Intro to threads at [linuxjournal](#)
- North Arizona Univ [NAU](#)
- Posix threads [Acctcom multi-thread](#)

## 24.2 Designing a Thread Class in C++

This section is written by [Ryan Teixeira](#) and the document is located [here](#) .

### Introduction

Multi threaded programming is becoming ever more popular. This section presents a design for a C++ class that will encapsulate the threading mechanism. Certain aspects of thread programming, like mutexes and semaphores are not discussed here. Also, operating system calls to manipulate threads are shown in a generic form.

### Brief Introduction To Threads

To understand threads one must think of several programs running at once. Imagine further that all these programs have access to the same set of global variables and function calls. Each of these programs would represent a thread of execution and is thus called a thread. The important differentiation is that each thread does not have to wait for any other thread to proceed. All the threads proceed simultaneously. To use a metaphor, they are like runners in a race, no runner waits for another runner. They all proceed at their own rate.

Why use threads you might ask. Well threads can often improve the performance of an application and they do not incur significant overhead to implement. They effectively give good bang for a buck. Imagine an image server program that must service requests for images. The program gets a request for an image from another program. It must then retrieve the image from a database and send it to the program that requested it. If the server were implemented in a single threaded approach, only one program could request at a time. When it was busy retrieving an image and sending it to a requestor, it could not service other requests. Of course one could still implement such a system without using threads. It would be a challenge though. Using threads, one can very naturally design a system to handle multiple requests. A simple approach would be to create a thread for each request received. The main thread would create this thread upon receipt of a request. The thread would then be responsible for the conversation with the client program from that point on. After retrieving the image, the thread would terminate itself. This would provide a smooth system that would continue to service requests even though it was busy servicing other requests at the same time.

## Basic Approach

To create a thread, you must specify a function that will become the entry point for the thread. At the operating system level, this is a normal function. We have to do a few tricks to wrap a C++ class around it because the entry function cannot be a normal member function of a class. However, it can be a static member function of a class. This is what we will use as the entry point. There is a gotcha here though. Static member functions do not have access to the this pointer of a C++ object. They can only access static data. Fortunately, there is a way to do it. Thread entry point functions take a void \* as a parameter so that the caller can typecast any data and pass it to the thread. We will use this to pass this to the static function. The static function will then typecast the void \* and use it to call a non static member function.

## The Implementation

It should be mentioned that we are going to discuss a thread class with limited functionality. It is possible to do more with threads than this class will allow.

---

```
class Thread
{
public:
    Thread();
    int Start(void * arg);
protected:
    int Run(void * arg);
    static void * EntryPoint(void*);
    virtual void Setup();
    virtual void Execute(void*);
    void * Arg() const {return Arg_;}
    void Arg(void* a){Arg_ = a;}
private:
    THREADID ThreadId_;
    void * Arg_;
};

Thread::Thread() {}

int Thread::Start(void * arg)
{
    Arg(arg); // store user data
    int code = thread_create(Thread::EntryPoint, this, & ThreadId_);
    return code;
}
```



```

}

int Thread::Run(void * arg)
{
    Setup();
    Execute( arg );
}

/*static */
void * Thread::EntryPoint(void * pthis)
{
    Thread * pt = (Thread*)pthis;
    pthis->Run( Arg() );
}

virtual void Thread::Setup()
{
    // Do any setup here
}

virtual void Thread::Execute(void* arg)
{
    // Your code goes here
}

```

---

It is important to understand that we are wrapping a C++ object around a thread. Each object will provide an interface to a single thread. The thread and the object are not the same. The object can exist without a thread. In this implementation, the thread does not actually exist until the Start function is called.

Notice that we store the user argument in the class. This is necessary because we need a place to store it temporarily until the thread is started. The operating system thread call allows us to pass an argument but we have used it to pass the this pointer. So we store the real user argument in the class itself and when the execute function is called it can get access to the argument.

**Thread();** This is the constructor.

**int Start(void \* arg);** This function provides the means to create the thread and start it going. The argument arg provides a way for user data to be passed into the thread. Start() creates the thread by calling the operating system thread creation function.

**int Run(void \* arg);** This is a protected function that should never be tampered with.

**static void \* EntryPoint(void \* pthis);** This function serves as the entry point to the thread. It simply casts pthis to Thread \* and

**virtual void Setup();** This function is called after the thread has been created but before Execute() is called. If you override this function, remember to call the parent class Execute().

**virtual void Execute(void \*);** You must override this function to provide your own functionality.

## Using The Thread Class

To use the thread class, you derive a new class. you override the Execute() function where you provide your own functionality. You may override the Setup() function to do any start up duties before Execute is called. If

you override Setup(), remember to call the parent class Setup().

### Conclusion

This section presented an implementation of a thread class written in C++. Of course it is a simple approach but it provides a sound foundation upon which to build a more robust design.

If you have comments or suggestions, email to

---

## 25. C++ Utilities

Visit the following sites for C++ Utilities

- C++ Binary File I/O [http://www.angelfire.com/country/aldev0/cpphowto/cpp\\_BinaryFileIO.html](http://www.angelfire.com/country/aldev0/cpphowto/cpp_BinaryFileIO.html) and at [mirror site](#)
  - Portability Guide [http://www.angelfire.com/country/aldev0/cpphowto/cpp\\_PortabilityGuide.html](http://www.angelfire.com/country/aldev0/cpphowto/cpp_PortabilityGuide.html) and at [mirror site](#)
  - Snippets collections of C++ routines [http://www.angelfire.com/country/aldev0/cpphowto/cpp\\_Snippets.html](http://www.angelfire.com/country/aldev0/cpphowto/cpp_Snippets.html) and at [mirror site](#) and at [snippets site](#)
  - escape ISB for C++ – Provides information on how to develop and program distributed, object-based applications in C++ for Windows and Unix using the Netscape Internet Service Broker <http://docs.iplanet.com/docs/manuals/enterprise/cpluspg/contents.htm>
  - Common c++ <http://www.voxilla.org/projects/projape.html>
  - Large List of free C++ libs <http://www.thefreecountry.com/developercity/freelib.html>
  - C++ Tools <http://development.freeservers.com>
  - C++ Tools CUJ <http://www.cuj.com/code>
  - C++libs Univ of vaasa <http://garbo.uwasa.fi/pc/c-lang.html>
- 

## 26. Other Formats of this Document

This document is published in 14 different formats namely – DVI, Postscript, Latex, Adobe Acrobat PDF, LyX, GNU-info, HTML, RTF(Rich Text Format), Plain-text, Unix man pages, single HTML file, SGML (Linuxdoc format), SGML (Docbook format), MS WinHelp format.

This howto document is located at –

- <http://www.linuxdoc.org> and click on HOWTOs and search for howto document name using CTRL+f or ALT+f within the web-browser.

You can also find this document at the following mirrors sites –

- <http://www.caldera.com/LDP/HOWTO>
- <http://www.linux.ucla.edu/LDP>
- <http://www.cc.gatech.edu/linux/LDP>
- <http://www.redhat.com/mirrors/LDP>
- Other mirror sites near you (network–address–wise) can be found at <http://www.linuxdoc.org/mirrors.html> select a site and go to directory /LDP/HOWTO/xxxxx–HOWTO.html
- You can get this HOWTO document as a single file tar ball in HTML, DVI, Postscript or SGML formats from – <ftp://www.linuxdoc.org/pub/Linux/docs/HOWTO/other-formats/> and <http://www.linuxdoc.org/docs.html#howto>
- Plain text format is in: <ftp://www.linuxdoc.org/pub/Linux/docs/HOWTO> and <http://www.linuxdoc.org/docs.html#howto>
- Single HTML file format is in: <http://www.linuxdoc.org/docs.html#howto>

Single HTML file can be created with command (see man sgml2html) – `sgml2html –split 0 xxxxhowto.sgml`

- Translations to other languages like French, German, Spanish, Chinese, Japanese are in <ftp://www.linuxdoc.org/pub/Linux/docs/HOWTO> and <http://www.linuxdoc.org/docs.html#howto> Any help from you to translate to other languages is welcome.

The document is written using a tool called "SGML–Tools" which can be got from – <http://www.sgmltools.org> Compiling the source you will get the following commands like

- `sgml2html xxxxhowto.sgml` (to generate html file)
- `sgml2html –split 0 xxxxhowto.sgml` (to generate a single page html file)
- `sgml2rtf xxxxhowto.sgml` (to generate RTF file)
- `sgml2latex xxxxhowto.sgml` (to generate latex file)

## 26.1 Acrobat PDF format

PDF file can be generated from postscript file using either acrobat **distill** or **Ghostscript**. And postscript file is generated from DVI which in turn is generated from LaTeX file. You can download distill software from <http://www.adobe.com>. Given below is a sample session:

---

```
bash$ man sgml2latex
bash$ sgml2latex filename.sgml
bash$ man dvips
bash$ dvips -o filename.ps filename.dvi
bash$ distill filename.ps
bash$ man ghostscript
bash$ man ps2pdf
bash$ ps2pdf input.ps output.pdf
bash$ acroread output.pdf &
```

---

Or you can use Ghostscript command **ps2pdf**. ps2pdf is a work-alike for nearly all the functionality of Adobe's Acrobat Distiller product: it converts PostScript files to Portable Document Format (PDF) files. **ps2pdf** is implemented as a very small command script (batch file) that invokes Ghostscript, selecting a special "output device" called **pdfwrite**. In order to use ps2pdf, the pdfwrite device must be included in the makefile when Ghostscript was compiled; see the documentation on building Ghostscript for details.

## 26.2 Convert Linuxdoc to Docbook format

This document is written in linuxdoc SGML format. The Docbook SGML format supercedes the linuxdoc format and has lot more features than linuxdoc. The linuxdoc is very simple and is easy to use. To convert linuxdoc SGML file to Docbook SGML use the program **ld2db.sh** and some perl scripts. The ld2db output is not 100% clean and you need to use the **clean\_ld2db.pl** perl script. You may need to manually correct few lines in the document.

- Download ld2db program from <http://www.dcs.gla.ac.uk/~rrt/docbook.html> or from [Al Dev site](#)
- Download the cleanup\_ld2db.pl perl script from from [Al Dev site](#)

The ld2db.sh is not 100% clean, you will get lots of errors when you run

---

```
bash$ ld2db.sh file-linuxdoc.sgml db.sgml
bash$ cleanup.pl db.sgml > db_clean.sgml
bash$ gvim db_clean.sgml
bash$ docbook2html db.sgml
```

---

And you may have to manually edit some of the minor errors after running the perl script. For e.g. you may need to put closing tag </Para> for each <Listitem>

## 26.3 Convert to MS WinHelp format

You can convert the SGML howto document to Microsoft Windows Help file, first convert the sgml to html using:

---

```
bash$ sgml2html xxxxhowto.sgml      (to generate html file)
bash$ sgml2html -split 0 xxxxhowto.sgml (to generate a single page html file)
```

---

Then use the tool [HtmlToHlp](#). You can also use sgml2rtf and then use the RTF files for generating winhelp files.

## 26.4 Reading various formats

In order to view the document in dvi format, use the xdvi program. The xdvi program is located in tetex-xdvi\*.rpm package in Redhat Linux which can be located through ControlPanel | Applications | Publishing | TeX menu buttons. To read dvi document give the command –

```
xdvi -geometry 80x90 howto.dvi
man xdvi
```

And resize the window with mouse. To navigate use Arrow keys, Page Up, Page Down keys, also you can use 'f', 'd', 'u', 'c', 'l', 'r', 'p', 'n' letter keys to move up, down, center, next page, previous page etc. To turn off expert menu press 'x'.

You can read postscript file using the program 'gv' (ghostview) or 'ghostscript'. The ghostscript program is in ghostscript\*.rpm package and gv program is in gv\*.rpm package in Redhat Linux which can be located through ControlPanel | Applications | Graphics menu buttons. The gv program is much more user friendly than ghostscript. Also ghostscript and gv are available on other platforms like OS/2, Windows 95 and NT, you view this document even on those platforms.

- Get ghostscript for Windows 95, OS/2, and for all OSes from <http://www.cs.wisc.edu/~ghost>

To read postscript document give the command –

```
gv howto.ps
ghostscript howto.ps
```

You can read HTML format document using Netscape Navigator, Microsoft Internet explorer, Redhat Baron Web browser or any of the 10 other web browsers.

You can read the latex, LyX output using LyX a X-Windows front end to latex.

---

## 27. [Copyright](#)

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## 28. [Appendix A String Program Files](#)

You can **download all programs as a single tar.gz** file from [Download String](#) and give the following command to unpack

---

```
bash$ man tar
bash$ tar ztvf C++Programming-HOWTO.tar.gz
This will list the table of contents

bash$ tar zxvf C++Programming-HOWTO.tar.gz
This will extract the files
```

---

- Read the header file first and then see the example cpp program
  - ◆ String.h <http://www.angelfire.com/country/aldev0/cpphowto/String.h>
  - ◆ StringBuffer.h <http://www.angelfire.com/country/aldev0/cpphowto/StringBuffer.h>
  - ◆ StringTokenizer.h <http://www.angelfire.com/country/aldev0/cpphowto/StringTokenizer.h>
  - ◆ StringRW.h <http://www.angelfire.com/country/aldev0/cpphowto/StringRW.h>

- ◆ string\_multi.h [http://www.angelfire.com/country/aldev0/cpphowto/string\\_multi.h](http://www.angelfire.com/country/aldev0/cpphowto/string_multi.h)
  - ◆ example\_String.cpp [http://www.angelfire.com/country/aldev0/cpphowto/example\\_String.cpp](http://www.angelfire.com/country/aldev0/cpphowto/example_String.cpp)
  
  - File manipulation class, only length() function is implemented..
    - ◆ File.h <http://www.angelfire.com/country/aldev0/cpphowto/File.h>
    - ◆ File.cpp <http://www.angelfire.com/country/aldev0/cpphowto/File.cpp>
  
  - The zap() implemented here ..
    - ◆ my\_malloc.h [http://www.angelfire.com/country/aldev0/cpphowto/my\\_malloc.h](http://www.angelfire.com/country/aldev0/cpphowto/my_malloc.h)
    - ◆ my\_malloc.cpp [http://www.angelfire.com/country/aldev0/cpphowto/my\\_malloc.cpp](http://www.angelfire.com/country/aldev0/cpphowto/my_malloc.cpp)
  
  - Implementation of string class..
    - ◆ String.cpp <http://www.angelfire.com/country/aldev0/cpphowto/String.cpp>
    - ◆ StringTokenizer.cpp <http://www.angelfire.com/country/aldev0/cpphowto/StringTokenizer.cpp>
    - ◆ StringBuffer.cpp <http://www.angelfire.com/country/aldev0/cpphowto/StringBuffer.cpp>
    - ◆ StringRW.cpp <http://www.angelfire.com/country/aldev0/cpphowto/StringRW.cpp>
  
  - Debug facilities ..
    - ◆ debug.h <http://www.angelfire.com/country/aldev0/cpphowto/debug.h>
    - ◆ debug.cpp <http://www.angelfire.com/country/aldev0/cpphowto/debug.cpp>
    - ◆ Makefile <http://www.angelfire.com/country/aldev0/cpphowto/Makefile>
  
  - Sample java file for testing the functionalities of String class ..
    - ◆ string.java <http://www.angelfire.com/country/aldev0/cpphowto/string.java>
-