Brief Tutorial: Programming in C/C++ for Digital Image Processing

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Basis structure of a C++ program

```
/**********************************************
 *   This program converts gallons to liters.
 *   This is our first C++ program.
 *    Author:
 *    Date: 10/07/99
 **********************************************/

#include <iostream>
using namespace std;

int main()
{
   float gallons, liters;

   cout << “Enter number of gallons: “;
   cin >> gallons;       // this inputs from the user

   liters = gallons * 3.7854;   // converts to liters

   cout <<  “Liters: “ << liters << “\n”;

   return 0;
}
```

Header comment - multi-line comment

header file is included in the system by **#include**. Here, <iostream> is used to support the C++ I/O system.

The **using** statement informs the compiler that you want to use the **std** namespace. This is the namespace in which the entire Standard C++ library is declared. By using the **std** namespace, you simplify access to the standard library.

The only function that any C++ program **must** include is the **main()** function.

Components of C++ program

- Comments
  - // for single line or /* */ for multiple lines
- Complier directive
  - #include
- Header file
  - <iostream>: input/output stream header
- Function block
  - int main()
- Braces
  - { begins the body of a function and } ends the body
- Statement
  - liters = gallons * 3.7854;
- Statement terminator
  - ;
- Return

```
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```
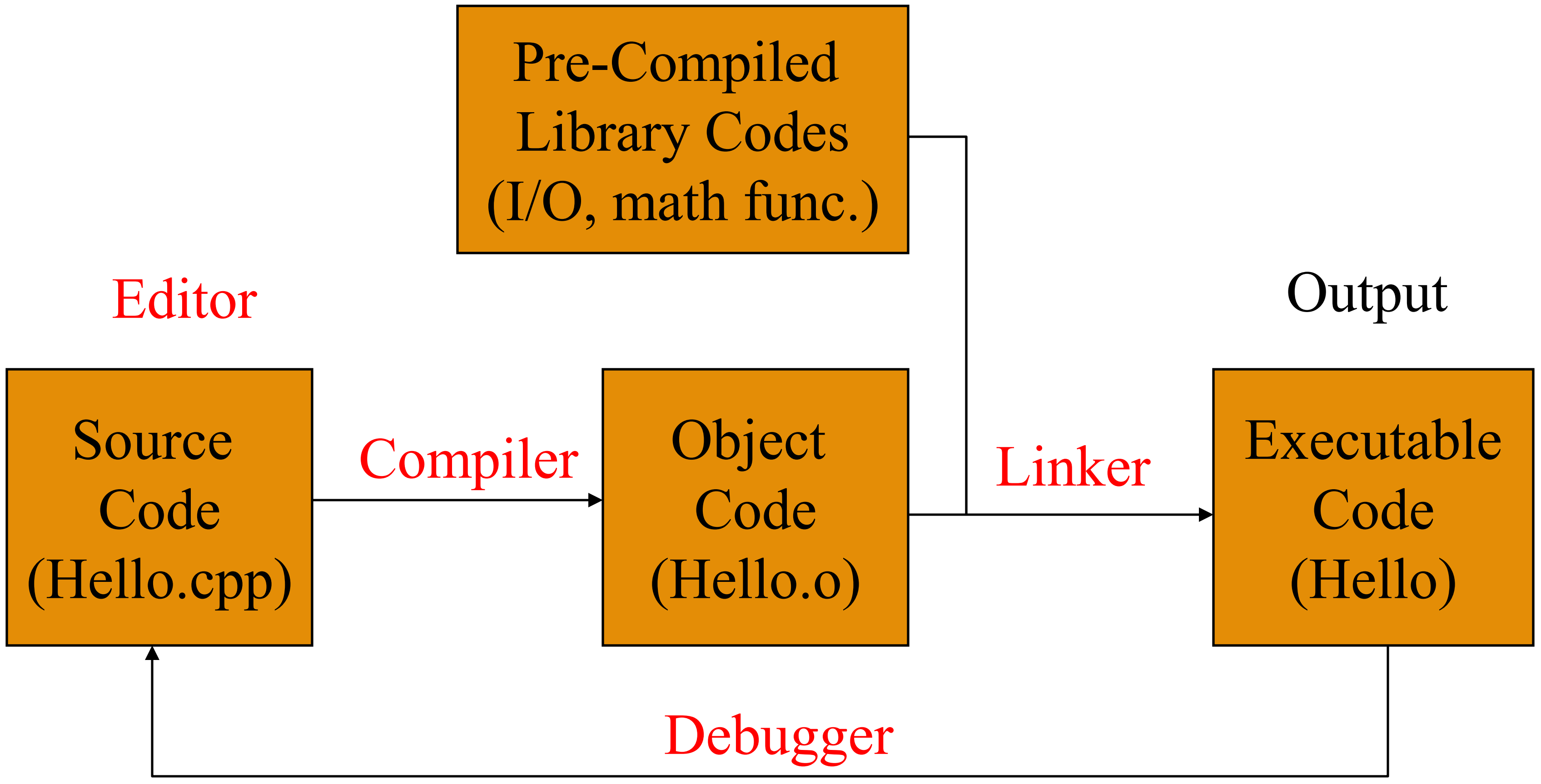
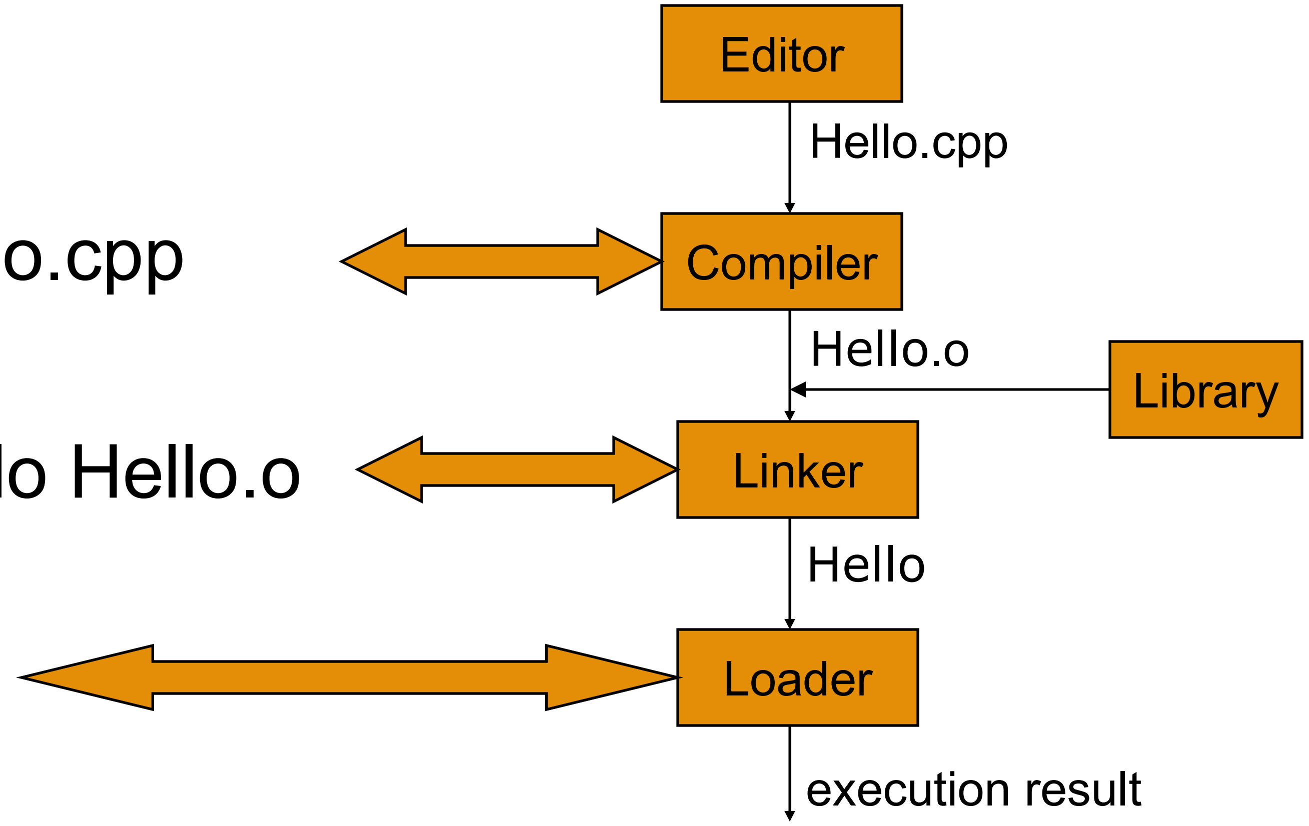

Programming environment



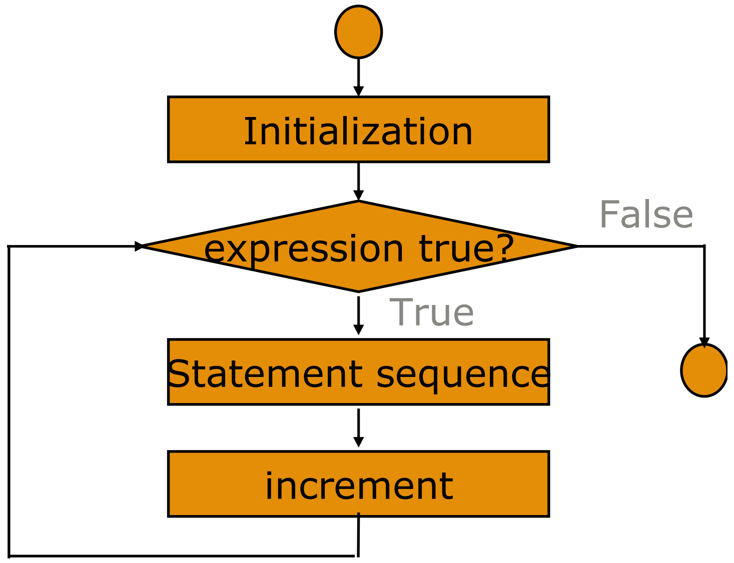
Linux commands

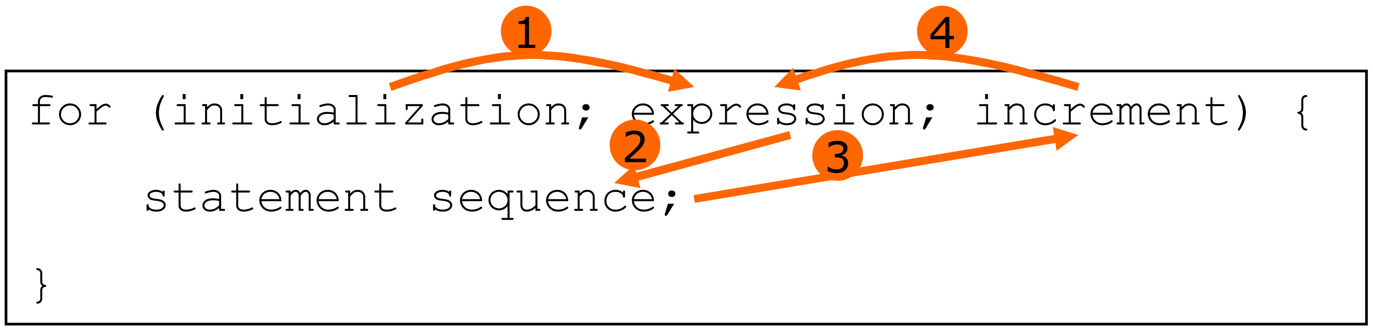
```
g++ -c Hello.cpp

g++ -o Hello Hello.o

./ Hello
```



Control Structures

- if… / if… else… / if… else if…
- switch…
- while
- for...





```
for (initialization; expression; increment) {

     statement sequence;

}
```

Calculate the sum of all even numbers less than 1000.

<u>C++:</u>

```
int total = 0;
for ( int even=2; even<1000; even=even+2 )
   total += even;
```

Functions

- Functions
  - C++ standard library (Pre-packaged)
  - User defined
- More manageable program - simplify the problem by decomposing it into small pieces
- Software reusability - using existing functions as building blocks to create new programs
- Avoid repeating code
- Information hiding - all variables declared in function definitions are local variables

Function format

- Function prototype

```
return-type function-name ( parameter types );
```

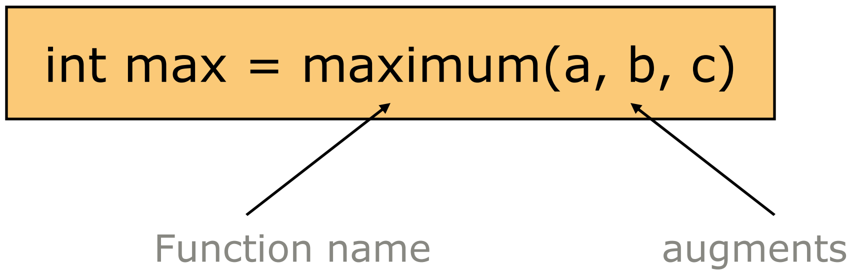
- Function definition

```
return-type function-name ( parameter-list )
{
    declarations and statements; // function body
}
```

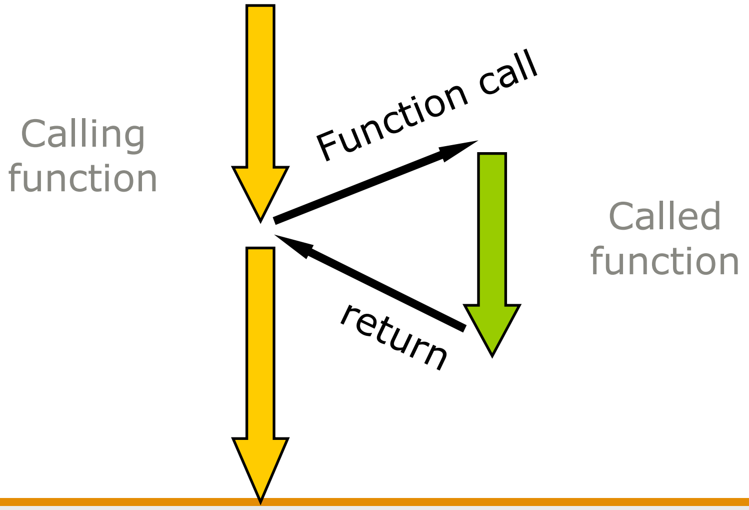
- Prototype and definition must be consistent

Function Call

- Functions can return values
- Returned value MUST match the type specified in the prototype
- Function augments
  - Variables, constants, expressions



```
int max = maximum(a, b, c)
```



Example

```
// the main source file
// saved as tests.cpp

#include <iostream>
#include "tests.h"
using namespace std;

int main()
{
    int a, b, c;

    cout << "Enter three integers: ";
    cin >> a >> b >> c;
    cout << "Maximum is: " ;
    cout << maximum(a, b, c) << endl;
    cout << minimum(a, b, c) << endl;

    return 0;
}
```

```
// the function file
// saved as maximum.cpp
#include "tests.h"

int maximum(int x, int y, int z)
{
    int max = x;

    if (y > max) max = y;
    if (z > max) max = z;

    return max;
}

int minimum(int x, int y, int z)
{
    int min = x;

    if (y < min) min = y;
    if (z < min) min = z;

    return min;
}
```

```
// the header file
// saved as tests.h

int maximum(int, int, int);
int minimum(int, int, int);
```

Compile and link

- Compile each .cpp file individually
  - g++ -c maximum.cpp
  - g++ -c tests.cpp
- Link all object files
  - g++ -o tests tests.o maximum.o
- Modifications in one .cpp file DO NOT affect the compilation of other files

Using command-line arguments:

- It is possible to pass arguments to the **main** function from a command line by including the following two parameters in the parameter list
  - **int argc** (argc receives the number of command-line arguments)
  - **char *argv[]** (an array of strings where the actual command-line arguments are stored)

Header files:

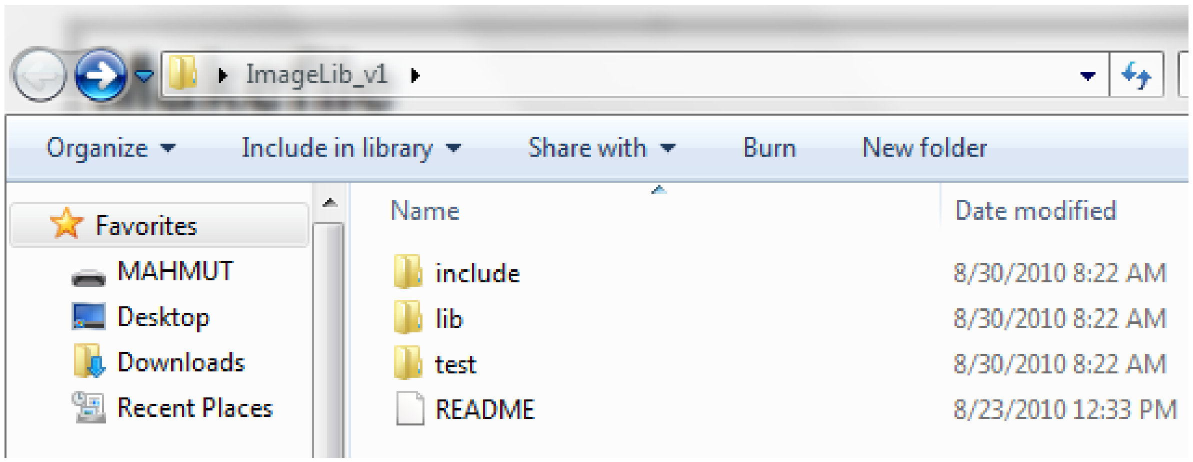
- Standard header files are used to provide function prototypes for functions defined in the standard C++ library.
- Access standard header files
  - #include <header-name>
- Access user-defined header files
  - #include “myfunctions.h”

```
// test code for contrast stretching
#include "Image.h"
#include "Dip.h"
#include <iostream>
#include <cstdlib>
using namespace std;

#define Usage "testcs inimg outimg slope\n"

int main(int argc, char **argv)
{
  Image inimg, outimg; // the original image
  float m, b;

  // check if the number of arguments is correct
  if (argc < 5) {
    cout << Usage;
    exit(3);
  }

  // read in command-line arguments
  m = atoi(argv[3]);
  b = atoi(argv[4]);

  // read in image
  inimg = readImage(argv[1]);

  // test the contrast stretching function
  outimg = cs(inimg, m, b);

  // output the image
  writeImage(outimg, argv[2]);
  return 0;
}
```

```
// Contrast stretching. s = m*r + b
#include "Image.h"
#include "Dip.h"
#include <iostream>
#include <cmath>

using namespace std;

Image cs(Image &inimg, float m, float b)
{
  Image outimg;
  int i, j, k;
  int nr, nc, ntype, nchan;

  // allocate memory
  nr = inimg.getRow();
  nc = inimg.getCol();
  ntype = inimg.getType();
  nchan = inimg.getChannel();

  outimg.createImage(nr, nc, ntype);

  // perform contrast stretching
  for (i=0; i<nr; i++)
    for (j=0; j<nc; j++)
      for (k=0; k<nchan; k++)
        outimg(i,j,k) = m * inimg(i,j,k) + b;

  return outimg;
}
```

```
// Dip.h - header file
#include "Image.h"

Image cs(Image &, float, float);

#endif
```

Makefile



ImageLib_v1

Name	Date modified
include	8/30/2010 8:22 AM
lib	8/30/2010 8:22 AM
test	8/30/2010 8:22 AM
README	8/23/2010 12:33 PM

```
OBJ = Image.o imageIO.o cs.o

AR = ar
INCLUDE = -I../include
all:
          ${MAKE} libimage.a

libimage.a: $(OBJ)
          $(AR) rvu $@ $(OBJ)
          ranlib $@

cs.o: cs.cpp
          g++ -c cs.cpp $(INCLUDE)

Image.o: Image.cpp
          g++ -c Image.cpp $(INCLUDE)

clean:
          -rm *.o *~
```

```
To generate the image library
    cd lib
    make

To run the test codes
    cd test
    make
```

```
EXES = testcs

all:
          ${MAKE} ${EXES}

INCLUDE = -I../include
LIB = -L../lib

testcs: testcs.o
          g++ -o testcs testcs.o $(LIB) -limage
testcs.o: testcs.cpp
          g++ -c testcs.cpp $(INCLUDE)

clean:
          -rm -rf *.o
```