**Algorithms**

Tutorial for C++, Compiler and Makefile Example

**0. Objectives**

This small example shows you what a C++ project looks like. We will sort array by insertion sort and STL. Although you do not have to submit this assignment, you are strongly recommended to run this example on EDA union lab machines before you start working on your PA.

**1. Insertion Sort**

Please try our first program, the insertion sort. Please go to the insertion sort directory by typing

cd TutorialC++/insertionsort

Use your text editor to open the file *insertionsort.cpp*

|  |
| --- |
| /\*  Program: Insertion Sort  Author Name:  Usage: insertionsort  Revision: V.2010.2.1  \*/  #include <iostream>  using namespace std;  #define ELEMENTS 6  void insertion\_sort(int x[],int length)//define function  {  int key,i;  for(int j=1;j<length;j++)  {  key=x[j];  i=j-1;  while(x[i]>key && i>=0)  {  x[i+1]=x[i];  i--;  }  x[i+1]=key;  }  }  int main()  {  int A[ELEMENTS]={5,2,4,6,1,3};//initial array  int x;  cout<<"NON SORTED LIST:"<<endl;  for(x=0;x<ELEMENTS;x++)  {  cout<<A[x]<<endl; //display the initial array  }  insertion\_sort(A,ELEMENTS);//call insertion\_sort function  cout<<endl<<"SORTED LIST"<<endl;  for(x=0;x<ELEMENTS;x++)  {  cout<<A[x]<<endl; //display the sorted array  }  return 0;  } |

to compile it, type

g++ insertionsort.cpp -o insertionsort

or

make insertionsort

to execute , type

./insertionsort

, where ‘./ ‘ means this directory. Please note that in Linux, you need to specify the correct path of files. If you simply type:

insertionsort

Linux will complain that it cannot find the file. This is a mistake often made by beginners.

|  |
| --- |
| NOTE:  If you are currently in the ~/my/TutorialC++/ directory, then  ~/ means my home directory  ./ means this current path ~/my/TutorialC++/  ../ means the upper directory ~/my/  ./test/ means the lower directory ~/my/TutorialC++/test |

**2. Using Sort Function in STL**

C++ STL is a *standard template library*, which contains useful containers, adaptors, iterators, function objects and algorithms. Now we show a simple example using the STL function ‘*sort’*.

cd ../STL

open the *stlsort.cpp* file and check the difference. Note that two lines are changed from the last example.

|  |
| --- |
| #include <iostream>  **#include <algorithm> // This line is different**  using namespace std;  #define ELEMENTS 6  int main()  {  int A[ELEMENTS]={5,2,4,6,1,3};//initial array  int x;  cout<<"NON SORTED LIST:"<<endl;  for(x=0;x<ELEMENTS;x++)  {  cout<<A[x]<<endl;//display the initial array  }  **sort (A, A+ELEMENTS); // This line is different**  cout<<endl<<"SORTED LIST"<<endl;  for(x=0;x<ELEMENTS;x++)  {  cout<<A[x]<<endl;//display the sorted array  }  return 0;  } |

then compile and execute.

g++ stlsort.cpp –o stlsort

or

make stlsort

to execute, type

./stlsort

**3. Makefile**

In a large project, source codes are separated into many files. For example, we may decide to have different sorters, each of which is an independent file. Please change the directory,

cd ../makefile\_demo

Now *main.cpp* is like this. Please note that the *replaceable\_sorter*() is no longer defined here in *main.cpp*. To make sure the compilation is successful, we must include a new header file *replaceable\_sorter.h*. To compile this *main.cpp*

g++ -c main.cpp -o main.o

|  |
| --- |
| #include <iostream>  using namespace std;  **#include "replaceable\_sorter.h" // add this line**  #define ELEMENTS 6  int main()  {  int A[ELEMENTS]={5,2,4,6,1,3};//initial array  int x;  ...  **replaceable\_sorter(A,ELEMENTS); // change this line**  ...  return 0;  } |

You will see a *main.o* object file generated. Please note that the –c option tells the compiler to generate an object file only ⎯ no linking is done for now.

The *replaceable\_sorter.h* file just provides the forward declaration of the function.

|  |
| --- |
| **void replaceable\_sorter(int x[],int length);** |

Suppose we have two implementations of the replaceable\_sorter: one is insertionsort and the other is the stlsort. You can check the *stlsorter.cpp* file to see the details. To compile the stlsort, type

g++ -c stlsort.cpp -o stlsort.o

|  |
| --- |
| #include <algorithm>  using namespace std;  void replaceable\_sorter(int x[], int length)  {  sort (x, x+length);  } |

Now, we can link the object files to produce an executable file *demo\_stl.*

g++ main.o stlsort.o -o demo\_stl

The other implementation can also be compiled in the same way.

g++ -c insertionsort.cpp -o insertionsort.o

g++ main.o insertionsort.o -o demo\_is

As you can see, this process is very long and tedious. So we can write all this compilation instructions into a *makefile* like the following.

|  |
| --- |
| # CC and CFLAGS are variables  CC=g++  CFLAGS = -c  # -c option ask g++ to compile the source files, but do not link.  all : demo\_stl demo\_is  demo\_stl : main.o stlsort.o  $(CC) main.o stlsort.o -o demo\_stl  demo\_is : main.o insertionsort.o  $(CC) main.o insertionsort.o -o demo\_is  main.o : main.cpp replaceable\_sorter.h  $(CC) $(CFLAGS) main.cpp  stlsort.o : stlsort.cpp  $(CC) $(CFLAGS) stlsort.cpp  insertionsort.o : insertionsort.cpp  $(CC) $(CFLAGS) insertionsort.cpp  # clean all the .o and executable files  clean:  rm -rf \*.o demo\_is demo\_stl |

CC and CFLAGS are variables that will be used in the following text. The structure of makefile is simply ‘**target: source /n command**’. For example, the two lines in bold means to compile the *stlsort.o*, we need *stlsort.cpp*. And the command is g++ -c *stlsort.cpp*. The makefile can also be written in a more concise way by neglecting some common commands and variables that will be automatically generated with system default behaviors. An example is makefile\_2.

To compile *stlsort.o*, please type

make stlsort.o

To compile and link *demo\_stl*, please type

make demo\_stl

If you want to remove all the .o and executable file, simply type

make clean

Actually, you can compile both *demo\_stl* and *demo\_is* in just one step.

make

**4. File IO**

Now we learn how to read/write files in c++.

cd ../fileIO/

Use your text editor to open *fileIO.cpp.* This file contains two functions.



|  |
| --- |
| #include <iostream>  #include <fstream>  using namespace std;  int Max (int a, int b)  {  if (a> b) return a;  else return b;  }  int main ()  {  ifstream inFile("test.in");  ofstream outFile("test.out");  int a,b;  inFile >> a;  inFile >> b;  outFile << Max(a, b) << endl;  outFile.close();  inFile.close();  return 0;  } |

Also open the file *test.in* and you will see two numbers.

To compile it, type this command,

g++ fileIO.cpp -o fileIO

or

make fileIO

To execute, type this command

./fileIO

Check the results in *test.out.*

cat test.out

**5. To learn more….**

1. Makefile

<https://mropengate.blogspot.com/2018/01/makefile.html>

1. STL:Vector

<http://www.cplusplus.com/reference/vector/vector/>

<http://www.runoob.com/w3cnote/cpp-vector-container-analysis.html>

1. Class

<https://openhome.cc/Gossip/CppGossip/ClassABC.html>

<https://mropengate.blogspot.com/2018/01/makefile.html>

1. Call by value, address, reference

<https://ppt.cc/fkwgdx>

<https://ppt.cc/fFg9bx>