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Advanced Programming

Lab 6, static library, parameters

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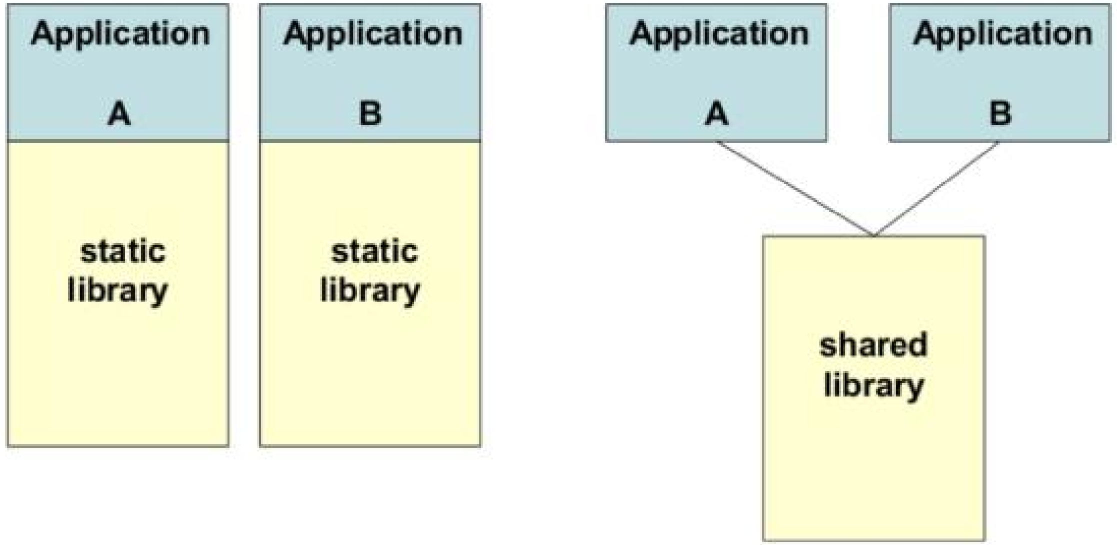
Topic

- Static library
  - ➢ build
  - ➢ use
  - ➢ makefile
  - ➢ CMake
- Parameters of function
  - ➢ pass by value
    - ✓ fundamental type
    - ✓ pointer
  - ➢ pass by reference
  - ➢ pass a huge structure vs pass its pointer
- Practice

1. Static library and Dynamic library

Static Linking and Static Libraries (also known as an **archive**) is the result of the linker making copy of all used library functions to the executable file. Static Linking creates larger binary files, and need more space on disk and main memory. Examples of static libraries are, ***.a*** files in Linux and ***.lib*** files in Windows.

Dynamic linking and Dynamic Libraries Dynamic Linking doesn't require the code to be copied, it is done by just placing name of the library in the binary file. The actual linking happens when the program is run, when both the binary file and the library are in memory. If multiple programs in the system link to the same dynamic link library, they all reference the library. Therefore, this library is shared by multiple programs and is called a "**shared library**" . Examples of Dynamic libraries are, ***.so*** in Linux and ***.dll*** in Windows.



	advantages	disadvantages
Static Library	1. Make the executable has fewer dependencies, has been packaged into the executable file. 2. The link is completed in the compilation stage, and the code is loaded quickly during execution.	1. Make the executable file larger. 2. Being a library dependent on another library will result in redundant copies because it must be packaged with the target file. 3. Upgrade is not convenient and easy. The entire executable needs to be replaced and recompiled.
Dynamic Library	1.Dynamic library can achieve resource sharing between processes, there can be only one library file. 2. The upgrade procedure is simple, do not need to recompile.	1. Loading during runtime will slow down the execution speed of code. 2. Add program dependencies that must be accompanied by an executable file.

1.1 Building a static library

- Suppose we have written the following code:

```
// mymath.h
#ifndef __MY_MATH_H__
#define __MY_MATH_H__
float arraySum(const float *array, size_t size);
#endif
```

```
// mymath.cpp
#include <iostream>
#include "mymath.h"

float arraySum(const float *array, size_t size)
{
    if(array == NULL)
    {
        std::cerr << "NULL pointer!" << std::endl;
        return 0.0f;
    }
    float sum = 0.0f;
    for(size_t i = 0; i < size; i++)
        sum += array[i];
    return sum;
}
```

```
// main.cpp
#include <iostream>
#include "mymath.h"
int main()
{
    float arr1[8]{1.f, 2.f, 3.f, 4.f, 5.f, 6.f, 7.f, 8.f};
    float * arr2 = NULL;

    float sum1 = arraySum(arr1, 8);
    float sum2 = arraySum(arr2, 8);

    std::cout << "The result1 is " << sum1 << 
std::endl;
    std::cout << "The result2 is " << sum2 << 
std::endl;

    return 0;
}
```

1.1 Building a static library

- In previous class we do the following:
- This will compile the “main.cpp” and “mymath.cpp” into “main”
- And then run “main”

```
➜  lab git:(main) ✗ g++ *.cpp -o main -std=c++11
➜  lab git:(main) ✗ ./main
NULL pointer!
The result1 is 36
The result2 is 0
```

1.1 Building a static library

- A static library is created by **.o** file.
- Remember to use **“ar”** command with arguments “**-cr**” when building it.
- Now we should see “libmymath.a” in the current directory

Compile the source file to the object file.

The name of **.a** must be started with “**lib**” followed by the .cpp name in which a function is defined.

```
➜  lab git:(main) ✗ g++ -c mymath.cpp
➜  lab git:(main) ✗ ls
main.cpp    mymath.cpp mymath.h    mymath.o
➜  lab git:(main) ✗ ar -cr libmymath.a mymath.o
➜  lab git:(main) ✗ ls
libmymath.a main.cpp     mymath.cpp  mymath.h     mymath.o
```

ar is a linux command.

c: create a static library.
r: add the object file to the static library.

1.2 Using a static library

- Now we can use ".a" static library.
- Let's compile "main" again:

"-lmymath" indicates to use "libmymath.a" or "libmymath.so"

"-L." indicates to find a library file in the current directory.

```
➜  lab git:(main) ✗ g++ main.cpp libmymath.a --std=c++11
➜  lab git:(main) ✗ g++ main.cpp -L. -lmymath --std=c++11
➜  lab git:(main) ✗ g++ -c main.cpp -std=c++11
➜  lab git:(main) ✗ g++ main.o -L. -lmymath
➜  lab git:(main) ✗ ./a.out
NULL pointer!
The result1 is 36
The result2 is 0
```

The 3 methods are equivalent.

- **-L**: indicates the directory of libraries
- **-l**: indicates the library name, the compiler can give the "**lib**" prefix to the library name and follows with **.a** as extension name.

1.2 Using a static library

If the static library is removed, the program can run normally.

```
→  lab git:(main) ✗ g++ main.cpp libmymath.a --std=c++11
→  lab git:(main) ✗ g++ main.cpp -L. -lmymath --std=c++11
→  lab git:(main) ✗ g++ -c main.cpp -std=c++11
→  lab git:(main) ✗ g++ main.o -L. -lmymath
→  lab git:(main) ✗ ./a.out
NULL pointer!
The result1 is 36
The result2 is 0
→  lab git:(main) ✗ rm libmymath.a
→  lab git:(main) ✗ ./a.out
NULL pointer!
The result1 is 36
The result2 is 0
```

remove the static library file.

To create a static library from multiple object files:

ar –cr libtest.a test1.o test2.o

1.3 Static library in makefile

staticlibmakefile
- fun.h
- main.c
- Makefile
- max.c
- min.c

All the files are in the same folder.

```
#makefile with static library

.PHONY:liba testliba clean

liba: libfun.a
libfun.a: max.o min.o
	ar cr $@ max.o min.o
max.o : max.c
	gcc -c max.c
min.o : min.c
	gcc -c min.c


testliba: main.out
main.out : main.c
	gcc main.c -L. -lfun -o main.out

clean:
	rm -f *.o *.a
```

three targets

the first target with its prerequisite

the second target with its prerequisite

the third target with no prerequisite

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefile$ make
gcc -c max.c
gcc -c min.c
ar cr libfun.a max.o min.o
```

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefile$ make testliba
gcc main.c -L. -lfun -o main.out
```

By default, the first target can run with only make command.

The target name followed make command can run the target.

The first step, creates a static library file with these two .o files in the current makefile.

This time we put the functions in the “lib_a” folder, and create a makefile in this folder.

```
staticlibmakefiles
  lib_a
    makefile
    max.c
    min.c
  fun.h
  main.c
  Makefile
```

```
# makefile with all the .c files created static library

OBJ = $(patsubst %.c, %.o, $(wildcard ./*.c))
TARGET = libmyfun.a
CC = gcc

$(TARGET): $(OBJ)
	ar -r $(TARGET) $^

%.o : %.c
	$(CC) -c $^ -o $@

clean:
	rm -f *.o $(TARGET)
```

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ cd lib_a
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles/lib_a$ make
gcc -c min.c -o min.o
gcc -c max.c -o max.o
ar -r libmyfun.a min.o max.o
ar: creating libmyfun.a
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles/lib_a$ ls
libmyfun.a  makefile  max.c  max.o  min.c  min.o
```

```
staticlibmakefiles
  lib_a
    makefile
    max.c
    min.c
  fun.h
  main.c
  Makefile
```

The second step, creates another makefile in the upper-level folder to link the static library into the executable file.

```makefile
#link with static library in makefile

OBJS = $(patsubst %.c, %.o, $(wildcard ./*.c))
TARGET = main
CC = gcc

LDFLAGE = -L./lib_a
LIB = -lmyfun

$(TARGET): $(OBJS)
	$(CC)  $^ -o $@  $(LIB) $(LDFLAGE)

%.o : %.c
	$(CC) -c $^ -o $@

clean:
	rm -f *.o $(TARGET)
```

Links the executable file with the static library.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles/lib_a$ cd ..
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ make
gcc -c main.c -o main.o
gcc   main.o -L./lib_a  -lmyfun  -o main
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ ./main
Please input two integers:4 9
maxNum = 9, minNum = 4
```

```makefile
#link with static library in makefile

OBJS = $(patsubst %.c, %.o, $(wildcard ./*.c))
TARGET = main
CC = gcc

LDFLAGE = -L./lib_a
LIB = -lmyfun

$(TARGET): $(OBJS)
	$(CC)   $(LIB) $(LDFLAGE)  $^ -o $@

%.o : %.c
	$(CC) -c $^ -o $@

clean:
	rm -f *.o $(TARGET)
```

If you put the flag before $^, it will cause error.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ make
gcc  -lmyfun  -L./lib_a  main.o -o main
/usr/bin/ld: main.o: in function `main':
main.c:(.text+0x53): undefined reference to `max'
/usr/bin/ld: main.c:(.text+0x65): undefined reference to `min'
collect2: error: ld returned 1 exit status
make: *** [Makefile:11: main] Error 1
```

```
STATICLIBMAKEFILES [...
  include
    fun.h
  src
    main.c
    max.c
    min.c
  Makefile
```

This time we put all the source files in the “src” folder, the function header file in the “include” folder, and create a makefile in the current folder.(Only one makefile)

```
lib_srcs := $(filter-out src/main.c, $(wildcard src/*.c))

lib_objs := $(patsubst %.c, %.o, $(lib_srcs))

include_path := ./include

I_options := $(include_path:%=-I%)

lib/%.o : src/%.c
	mkdir -p $(dir $@)
	gcc -c $^ -o $@ $(I_options)

lib/libmath.a : $(lib_objs)
	mkdir -p $(dir $@)
	ar -r $@ $^

static_lib : lib/libmath.a

clean :
	rm -rf ./lib

.PHONY : clean static_lib
```

The first part of the makefile just creates a static library named **libmath.a**

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ make
ar: creating lib/libmath.a
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ ls ./lib
libmath.a
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$
```

```
#=========== Linking static library=========
library_path := ./lib
linking_libs := math

l_options := $(linking_libs:%=-l%)
L_options := $(library_path:%=-L%)

linking_flags := $(l_options) $(L_options)

objs/main.o : src/main.c
	mkdir -p $(dir $@)
	gcc -c $^ -o $@ $(I_options)

objs/test : objs/main.o
	mkdir -p $(dir $@)
	gcc $^ -o $@ $(linking_flags)

run : objs/test
	./$<

clean :
	rm -rf ./lib ./objs

.PHONY : clean static_lib run
```

The second part of the makefile links the static library **libmath.a** to the executable file **test** in the “objs” folder.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ make run
mkdir -p objs/
gcc objs/main.o -o objs/test -lmath -L./lib
./objs/test
Please input two integers:5 9
maxNum = 9, minNum = 5
```

or

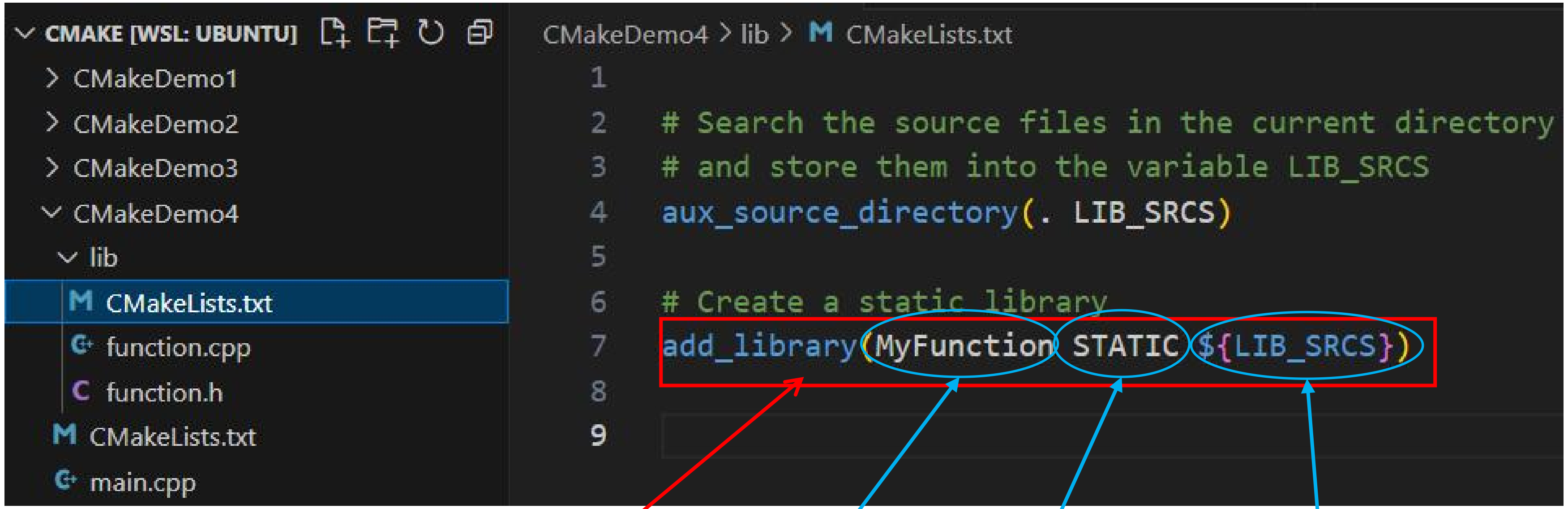
```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ make objs/test
mkdir -p objs/
gcc -c src/main.c -o objs/main.o -I./include
mkdir -p objs/
gcc objs/main.o -o objs/test -lmath -L./lib
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/staticlib/staticlibmakefiles$ ./objs/test
Please input two integers:4 8
maxNum = 8, minNum = 4
```

1.4 Creating and linking a static library by CMake

We want to create a static(or dynamic) library by function.cpp and call the static library in main.cpp. This time we write two CMakeLists.txt files, one in **CmakeDemo4** folder and another in **lib** folder.

The CMakeLists.txt in **lib folder** creates a static library.

```
./CMakeDemo4
   |
   +--- main.cpp
   |
   +--- lib/
         |
         +--- function.h
         |
         +--- function.cpp
```



library file name

static library

The directory from which the library file originates.

Create a static library named **libMyFunction.a** by the files in the current directory.

The CMakeLists.txt in **CMakeDemo4** folder creates the project.

- CMAKE [WSL: UBUNTU]
  - CMakeDemo1
  - CMakeDemo2
  - CMakeDemo3
  - CMakeDemo4
    - lib
      - CMakeLists.txt
      - function.cpp
      - function.h
    - CMakeLists.txt
    - main.cpp
  - CMakeLists.txt
  - hello.cpp

CMakeDemo4 > CMakeLists.txt

```cmake
# CMake minimum version
cmake_minimum_required(VERSION 3.10)

# project information
project(CMakeDemo4)

# Search the source files in the current directory
# and store them into the variable DIR_SRCS
aux_source_directory(. DIR_SRCS)

# add the directory of include
include_directories(lib)

# add the subdirectory of lib
add_subdirectory(lib)

# Specify the build target
add_executable(CMakeDemo4 ${DIR_SRCS})

# Add the static library
target_link_libraries(CMakeDemo4 MyFunction)
```

add_subdirectory command indicates there is a subdirectory in the project. When running the command, it will execute the CMakeLists.txt in the subdirectory automatically.

Indicates that the project needs link a library named **MyFunction**, MyFunction can be a static library file or a dynamic library file.

project name

library file name

If there are more than one file, list them using space as the separator.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4$ mkdir build
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4$ cd build
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4/build$ cmake ..
-- The C compiler identification is GNU 9.4.0
-- The CXX compiler identification is GNU 9.4.0
-- Check for working C compiler: /usr/bin/cc
-- Check for working C compiler: /usr/bin/cc -- works
-- Detecting C compiler ABI info
-- Detecting C compiler ABI info - done
-- Detecting C compile features
-- Detecting C compile features - done
-- Check for working CXX compiler: /usr/bin/c++
-- Check for working CXX compiler: /usr/bin/c++ -- works
-- Detecting CXX compiler ABI info
-- Detecting CXX compiler ABI info - done
-- Detecting CXX compile features
-- Detecting CXX compile features - done
-- Configuring done
-- Generating done
-- Build files have been written to: /mnt/d/CMake/CMakeDemo4/build
```

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4/build$ ls
CMakeCache.txt  CMakeDemo4  CMakeFiles  Makefile  cmake_install.cmake  lib
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4/build$ cd lib
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4/build/lib$ ls
CMakeFiles  Makefile  cmake_install.cmake  libMyFunction.a
```

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/CMake/CMakeDemo4/build$ make
Scanning dependencies of target MyFunction
[ 25%] Building CXX object lib/CMakeFiles/MyFunction.dir/function.cpp.o
[ 50%] Linking CXX static library libMyFunction.a
[ 50%] Built target MyFunction
Scanning dependencies of target CMakeDemo4
[ 75%] Building CXX object CMakeFiles/CMakeDemo4.dir/main.cpp.o
[100%] Linking CXX executable CMakeDemo4
[100%] Built target CMakeDemo4
```

2. Parameters

```c
#include<stdio.h>
int add1(int a,int b){
    int sum = (a++)+(b++);
    return sum;
}
int add2(int *x,int *y){
    int sum = ((*x)++)+((*y)++);
    return sum;
}
int add3(int &c,int &d){
    int sum = (c++)+(d++);
    return sum;
}
int main(){
    int i=0,j=0;
    scanf("%d",&i);
    scanf("%d",&j);
    printf("i_address:%p,j_address:%p\n",&i,&j);
    int sum=add1(i,j);
    printf("%d+%d=%d\n",i,j,sum);
    sum=add3(i,j);
    printf("%d+%d=%d\n",i,j,sum);
    return 0;
}
```

Q1. How to compile the source code on the left hand, by using gcc or g++ ?

Q2. Is there any compiling error on the source code, if no, compile it, if yes, correct and compile.

Q3. What's the output of this piece of code while input data is 1 and 2?

A	B	C	D
1+2=3 1+2=3 1+2=3	1+2=3 2+3=5 2+3=5	1+2=3 2+3=3 3+4=5	1+2=3 2+3=5 3+4=7

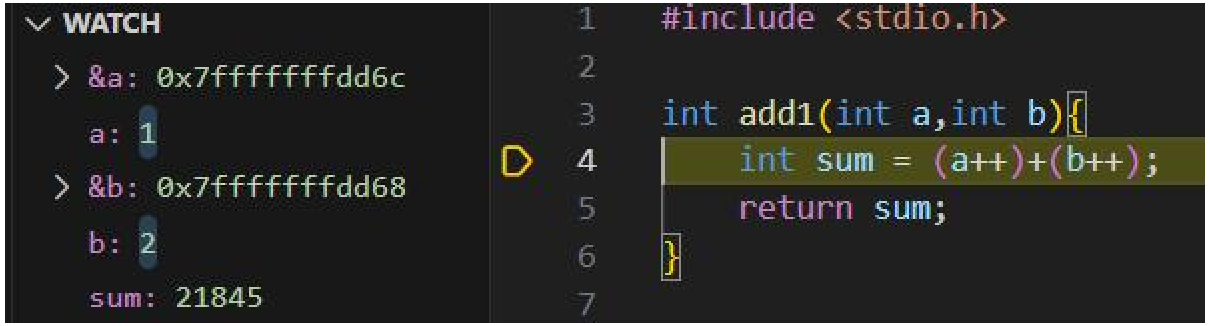
2.1 Pass by value: fundamental type

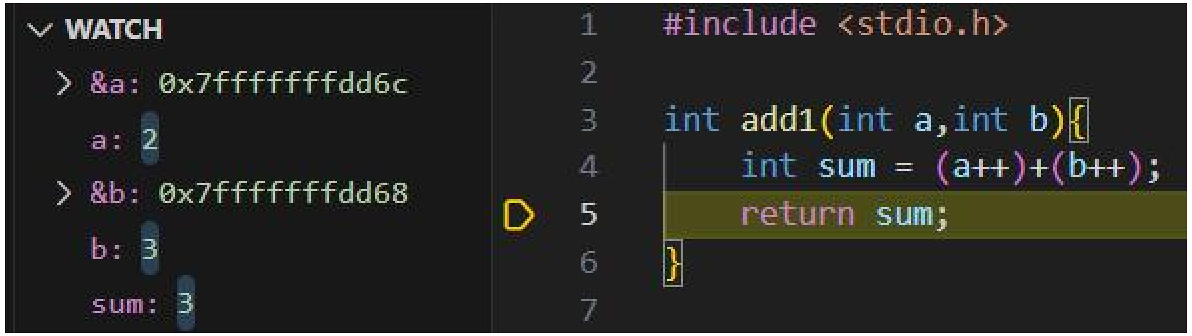
Using “-g” option while compiling to generate the executable file, then set break point and debug.

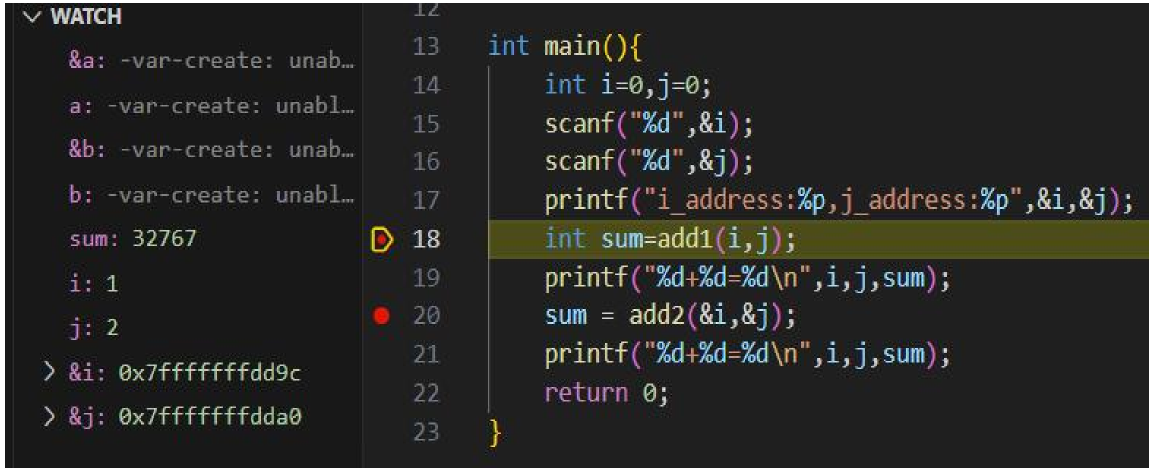
Q1. What’s the address of variable “i” and “j” ?

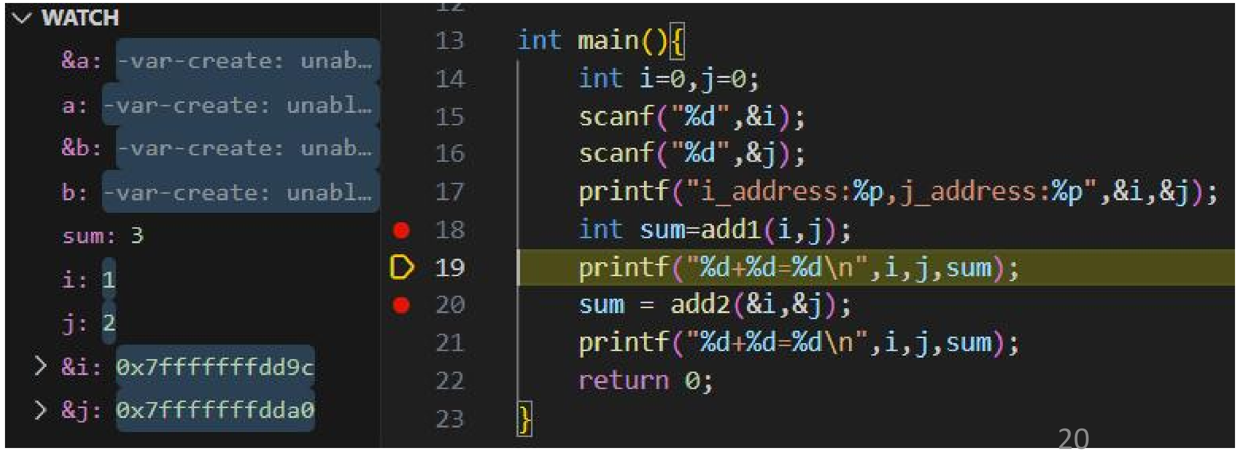
Q2. Is the address of variable “a” same with the address of “i”? how about “b” and “j” ?

Q3. Do variables a and b still exist after returning from the “add1” to the “main” ?









2.2 Pass by value: pointer

Using “-g” option while compiling to generate the executable file, then set break point and debug.

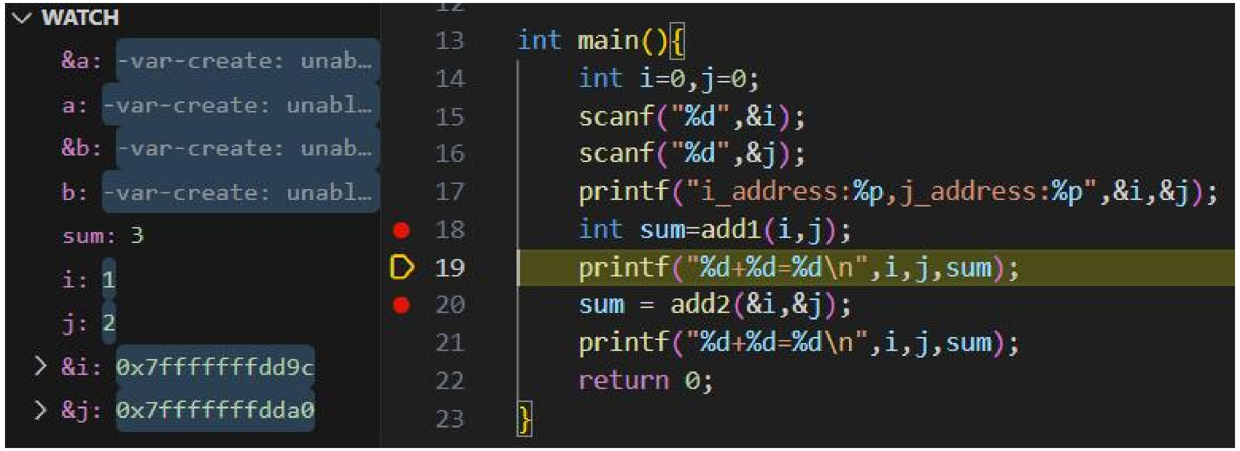
Q1. Is the value of variable “x” same with the address of “i”? how about the value of “b” and the address of “j” ?

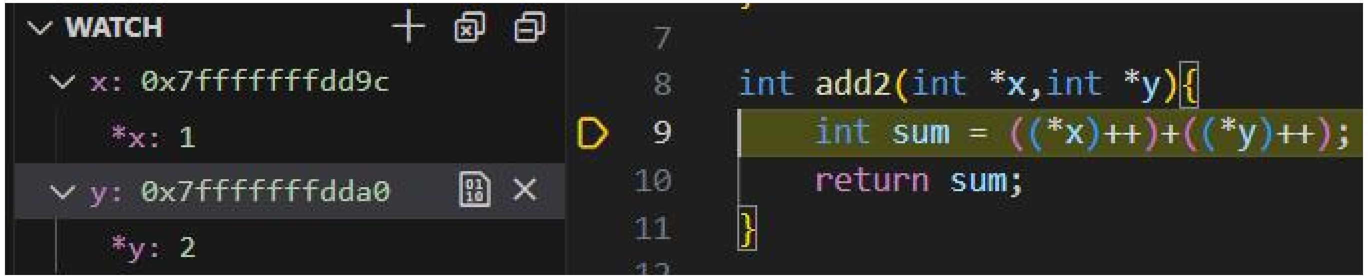
Q2. Do variables x and y still exist after returning from the “add2” to the “main” ?

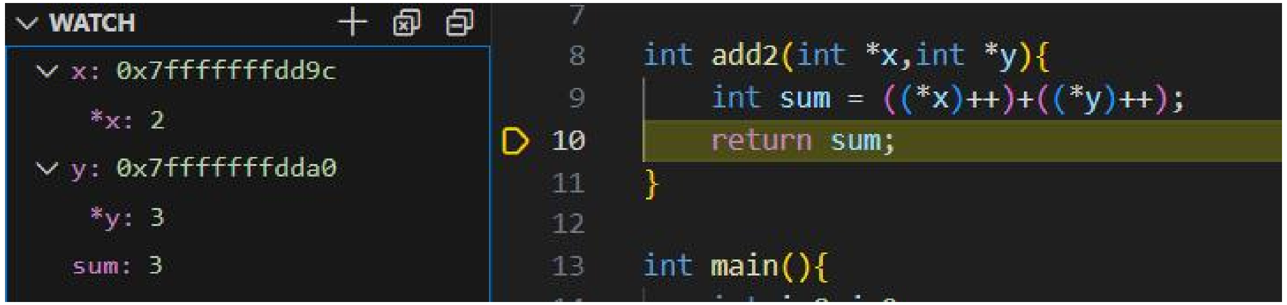
Q3. Which following piece(s) of add2 would cause segment falut, or both ? Why?

```
//option A
int add2(int*x,int*y){
    int sum= ((*x)++)+((*y)++);
    return sum;
    free(x);
    free(y);
    x=NULL;
    y=NULL;
}
```

```
//option B
int add2(int*x,int*y){
    int sum= ((*x)++)+((*y)++);
     free(x);
     free(y);
     x=NULL;
     y=NULL;
     return sum;
}
```







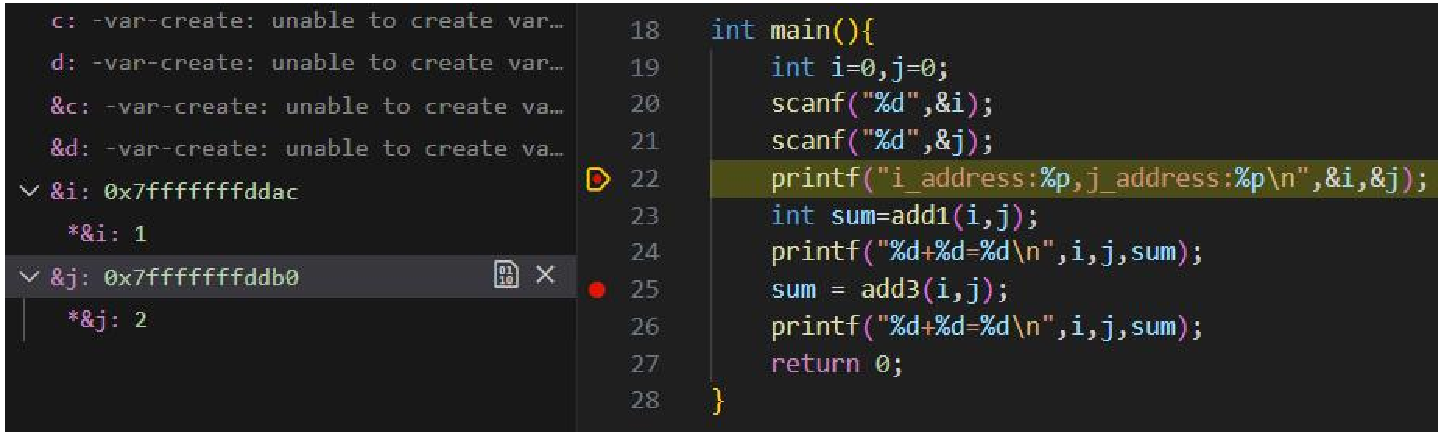
2.3 Pass by reference

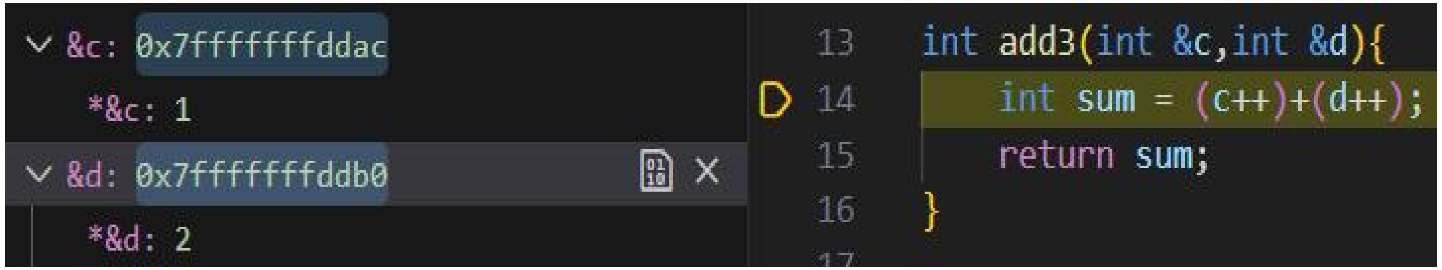
Using “-g” option while compiling to generate the executable file, then set break point and debug.

Q1. Is the address of variable “c” same with the address of “i”? how about the address of “b” and the address of “j” ?

Q2. For the following code “add3_x”, is the space of “e” belongs to heap or stack?
What’s the problem of the following code?
Fix it and make the return value is 4.

```
int add3_x(int &c,int &d){
    int sum= (c++)+(d++);
    int *e= (int*)malloc(sizeof(int));
    c=*e;
    d=*e;
    *e=1;
    sum= (c++)+(d++);
    return sum;
}
```





2.4 pass a huge structure vs pass its pointer(1)

- using "**g++ -S -o**" to generate assembly code based on **x64**.

(The CPU of the testing machine is based on x64)

- In x64, register "**rsp**" is stack pointer.

here passing the value of a huge struct needs more stack space (1040+8+1032) than passing the value of a pointer which points the buge struct(16+1040).

```c
#include<stdio.h>    //fdemo3.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu stud){
    printf("Student_id:%d\tinfo:%s\n",
           stud.id,stud.description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(stum);
    return 0;
}
```

```c
#include<stdio.h>   //fdemo3_ptr.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu* stud){
    printf("Student_id: %d\tinfo:%s\n",
           stud->id,stud->description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(&stum);
    return0;
}
```

```
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ g++ -S -o fdemo3-x64.s fdemo3.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3-x64.s | grep sub
        subq    $1040, %rsp
        subq    $8, %rsp
        subq    $1032, %rsp
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ g++ -S -o fdemo3_ptr-x64.s fdemo3_ptr.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3_ptr-x64.s | grep sub
        subq    $16, %rsp
        subq    $1040, %rsp
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$
```

2.4 pass a huge structure vs pass its pointer(2)

- using “aarch64-linux-gnu-g++ -S -o” to generate assembly code based on **ARM64**.
- In ARM64, register “**sp**” is stack pointer.

here passing the value of the huge struct needs more stack space (2096) than passing the value of a pointer which points the buge struct(1056).

```c
#include<stdio.h>    //fdemo3.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu stud){
    printf("Student_id:%d\tinfo:%s\n",
            stud.id,stud.description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(stum);
    return 0;
}
```

```c
#include<stdio.h>   //fdemo3_ptr.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu* stud){
    printf("Student_id: %d\tinfo:%s\n",
            stud->id,stud->description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(&stum);
    return0;
}
```

```
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ aarch64-linux-gnu-g++ -S -o fdemo3-arm64.s fdemo3.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3-arm64.s | grep sub | grep sp
        sub     sp, sp, #2096
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ aarch64-linux-gnu-g++ -S -o fdemo3_ptr-arm64.s fdemo3_ptr.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3_ptr-arm64.s | grep sub | grep sp
        sub     sp, sp, #1056
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$
```

2.4 pass a huge structure vs pass its pointer(3)

- using "riscv64-linux-gnu-gcc -S -o" to generate assembly code based on **RISC-V64.**
- In **RISC-V64**, register "**sp**" is stack pointer.

here passing the value of the huge struct needs more stack space (16+64+2032) than passing the value of a pointer which points the buge struct(32+1056).

```c
#include<stdio.h>    //fdemo3.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu stud){
    printf("Student_id:%d\tinfo:%s\n",
            stud.id,stud.description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(stum);
    return 0;
}
```

```c
#include<stdio.h>   //fdemo3_ptr.c
typedef struct {
    int id;
    char description[1024];
}Stu;
void disp_struct(Stu* stud){
    printf("Student_id: %d\tinfo:%s\n",
            stud->id,stud->description);
}
int main(){
     Stu stum={3,"NAZHA"};
    disp_struct(&stum);
    return0;
}
```

```
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ riscv64-linux-gnu-gcc -S -o fdemo3-risc-v64.s fdemo3.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3-risc-v64.s |  grep addi | grep sp,-
        addi    sp,sp,-16
        addi    sp,sp,-64
        addi    sp,sp,-2032
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ riscv64-linux-gnu-gcc -S -o fdemo3_ptr-risc-v64.s fdemo3_ptr.c
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$ cat fdemo3_ptr-risc-v64.s |  grep addi | grep sp,-
        addi    sp,sp,-32
        addi    sp,sp,-1056
ww2@DESKTOP-4NIH4UK:/mnt/c/Users/sustech/Desktop/C_CPP_CODE/lab6/part2$
```

Exercise 1

```
#include <iostream>
using namespace std;
int * create_array(int size)
{
   int arr[size];

   for(int i = 0; i < size; i++)
      arr[i] = i * 10;
   return arr;
}
int main()
{
   int len = 16;
   int *ptr = create_array(len);
   for(int i = 0; i < len; i++)
      cout << ptr[i] << " ";
   return 0;
}
```

What compilation warnings occur when you compile the program? Why?

What will happen if you ignore the warning and run the program?

Fix bugs of the program and run it correctly without memory leak.

Exercise 2

Define a function that swaps two values of integers. Write a test program to call the function and display the result.

You are required to compile the function into a static library “libswap.a”, and then compile and run your program with this static library.

Exercise 3

- 3-1. Run the demo code on page 21 and 22, answer the questions on these pages.
- 3-2. Change fdemo3_ptr.c on page 23 to pass the reference instead of pass the pointer, generate the assembly soure code on your PC and answer the question: Would passing the reference use more stack space than passing the pointer in this situation ?
- 3-3. Compare the differences between pointers and references in C++, as well as the differences between references in C++and Python, make a summay.