서강대학교 SOGANG UNIVERSITY

Makefile

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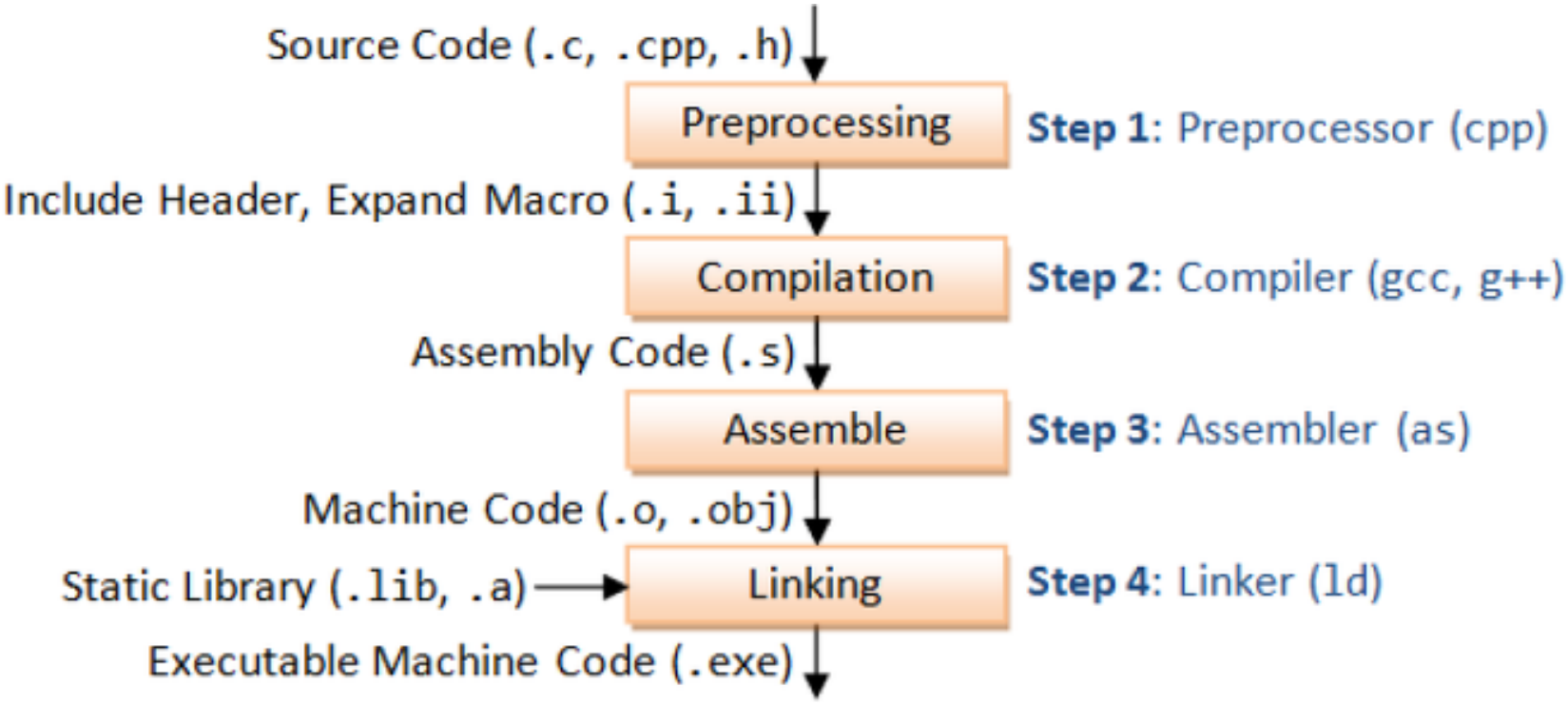
1 컴파일과 컴파일러


Source Code (.c, .cpp, .h)
Preprocessing
Step 1: Preprocessor (cpp)
Include Header, Expand Macro (.i, .ii)
Compilation
Step 2: Compiler (gcc, g++)
Assembly Code (.s)
Assemble
Step 3: Assembler (as)
Machine Code (.o, .obj)
Static Library (.lib, .a)
Linking
Step 4: Linker (ld)
Executable Machine Code (.exe)

1 컴파일과 컴파일러

Source Code

```
#include <stdio.h>

int main(void)
{
    printf("Hello, world!\n");
    return 0;
}
```

```
gcc main.c
```

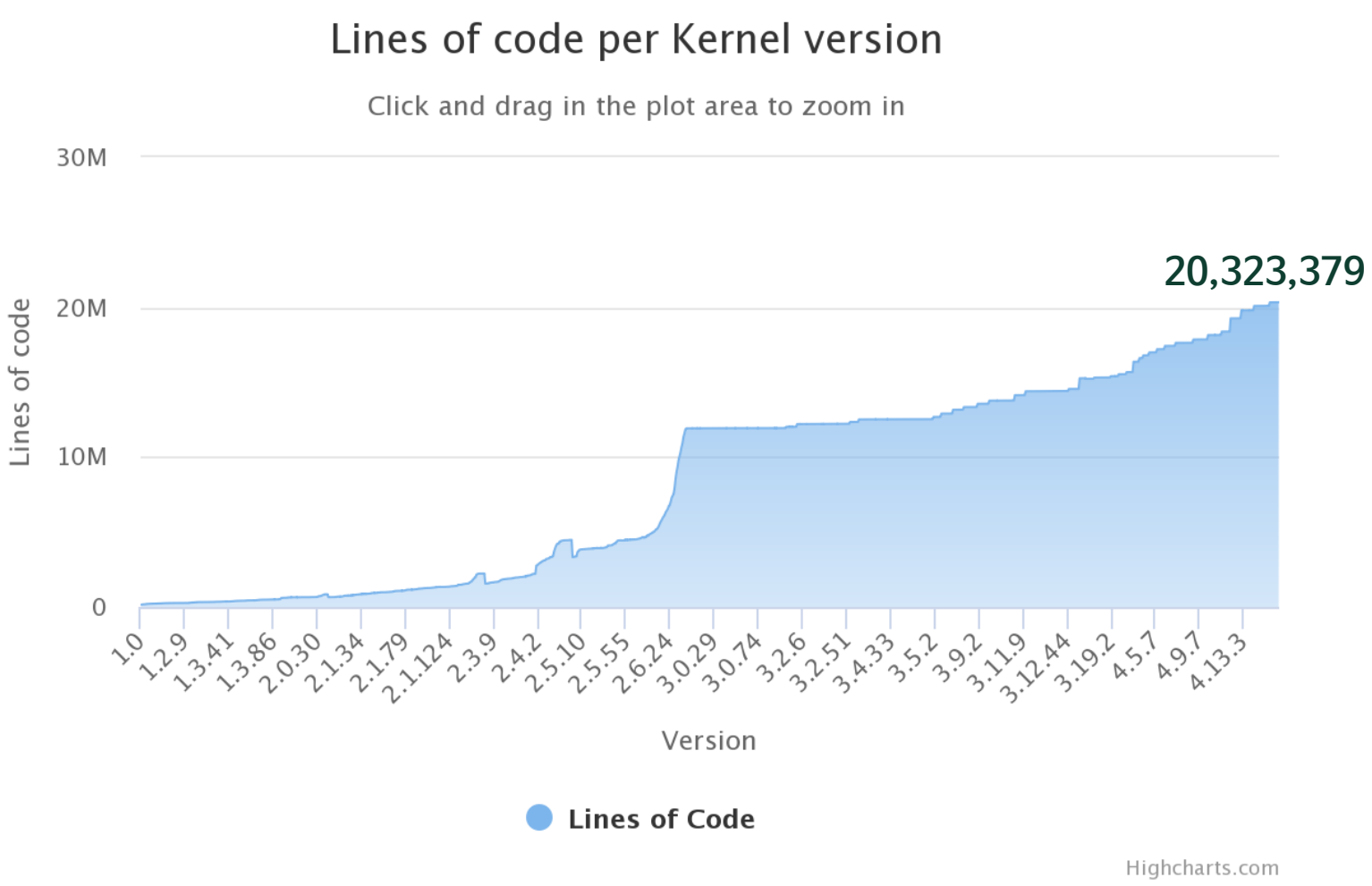
Assembly Code

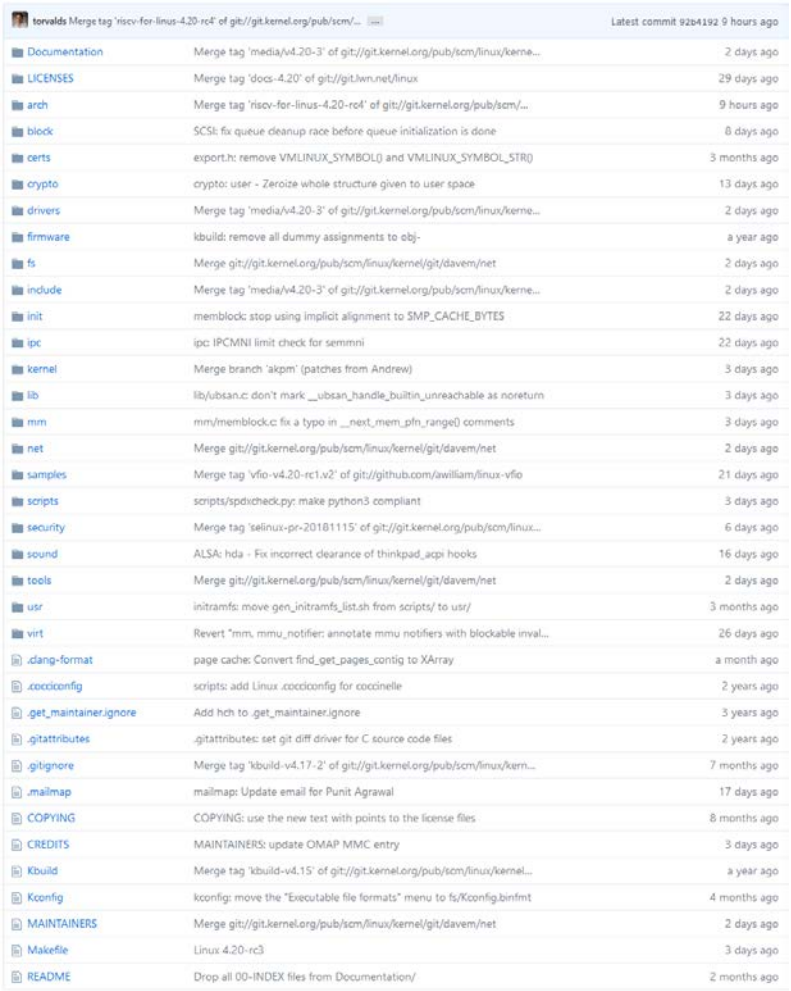
```
section .text
   global _start
_start:
   mov  edx,len
   mov  ecx,msg
   mov  ebx,1
   mov  eax,4
   int  0x80
   mov  eax,1
   int  0x80
section .data
msg db 'Hello, world!', 0xa
len equ $ - msg
```

Machine Code

```
7F454C46010101000000
00000000000002000300
010000003540B3042C00
00000000000000000000
340020000100000000000
0000040B304B20CEB1C
62000000620000000500
000001000048656C6C
6F20776F726C640AB94C
40B30493CD80EBFB
```

2 모듈화


Lines of code per Kernel version
Click and drag in the plot area to zoom in
30M
20M
10M
0
Lines of code
20,323,379
1.0
1.2.9
1.3.41
1.3.86
2.0.30
2.1.34
2.1.79
2.1.124
2.3.9
2.4.2
2.5.10
2.5.55
2.6.24
3.0.29
3.0.74
3.2.6
3.2.51
3.4.33
3.5.2
3.9.2
3.11.9
3.12.44
3.19.2
4.5.7
4.9.7
4.13.3
Version
Lines of Code
Highcharts.com


torvalds Merge tag 'riscv-for-linus-4.20-rc4' of git://git.kernel.org/pub/scm/...
Latest commit 92b4192 9 hours ago
Documentation Merge tag 'media/v4.20-3' of git://git.kernel.org/pub/scm/linux/kerne... 2 days ago
LICENSES Merge tag 'docs-4.20' of git://git.lwn.net/linux 29 days ago
arch Merge tag 'riscv-for-linus-4.20-rc4' of git://git.kernel.org/pub/scm/... 9 hours ago
block SCSI: fix queue cleanup race before queue initialization is done 8 days ago
certs export.h: remove VMLINUX_SYMBOL() and VMLINUX_SYMBOL_STR() 3 months ago
crypto crypto: user - Zeroize whole structure given to user space 13 days ago
drivers Merge tag 'media/v4.20-3' of git://git.kernel.org/pub/scm/linux/kerne... 2 days ago
firmware kbuild: remove all dummy assignments to obj- a year ago
fs Merge git://git.kernel.org/pub/scm/linux/kernel/git/davem/net 2 days ago
include Merge tag 'media/v4.20-3' of git://git.kernel.org/pub/scm/linux/kerne... 2 days ago
init memblock: stop using implicit alignment to SMP_CACHE_BYTES 22 days ago
ipc ipc: IPCMNI limit check for semmni 22 days ago
kernel Merge branch 'akpm' (patches from Andrew) 3 days ago
lib lib/ubsan.c: don't mark __ubsan_handle_builtin_unreachable as noreturn 3 days ago
mm mm/memblock.c: fix a typo in __next_mem_pfn_range() comments 3 days ago
net Merge git://git.kernel.org/pub/scm/linux/kernel/git/davem/net 2 days ago
samples Merge tag 'vfio-v4.20-rc1.v2' of git://github.com/awilliam/linux-vfio 21 days ago
scripts scripts/spdxcheck.py: make python3 compliant 3 days ago
security Merge tag 'selinux-pr-20181115' of git://git.kernel.org/pub/scm/linux... 6 days ago
sound ALSA: hda - Fix incorrect clearance of thinkpad_acpi hooks 16 days ago
tools Merge git://git.kernel.org/pub/scm/linux/kernel/git/davem/net 2 days ago
usr initramfs: move gen_initramfs_list.sh from scripts/ to usr/ 3 months ago
virt Revert "mm, mmu_notifier: annotate mmu notifiers with blockable inval... 26 days ago
.clang-format page cache: Convert find_get_pages_contig to XArray a month ago
.cocciconfig scripts: add Linux .cocciconfig for coccinelle 2 years ago
.get_maintainer.ignore Add hch to .get_maintainer.ignore 3 years ago
.gitattributes .gitattributes: set git diff driver for C source code files 2 years ago
.gitignore Merge tag 'kbuild-v4.17-2' of git://git.kernel.org/pub/scm/linux/kern... 7 months ago
.mailmap mailmap: Update email for Punit Agrawal 17 days ago
COPYING COPYING: use the new text with points to the license files 8 months ago
CREDITS MAINTAINERS: update OMAP MMC entry 3 days ago
Kbuild Merge tag 'kbuild-v4.15' of git://git.kernel.org/pub/scm/linux/kernel... a year ago
Kconfig kconfig: move the "Executable file formats" menu to fs/Kconfig.binfmt 4 months ago
MAINTAINERS Merge git://git.kernel.org/pub/scm/linux/kernel/git/davem/net 2 days ago
Makefile Linux 4.20-rc3 3 days ago
README Drop all 00-INDEX files from Documentation/ 2 months ago

2 모듈화

```c
#include "addition.h"
#include "subtraction.h"

int main(void) {
    int a = 5;
    int b = 3;

    printf("add: %d\n", add(a, b));
    printf("sub: %d\n", sub(a, b));

    return 0;
}
```

main.c

```c
#ifndef _ADD_H_
#define _ADD_H_

#include <stdio.h>

int add(int a, int b);

#endif
```

addition.h

```c
#include "addition.h"

int add(int a, int b) {
    int c = a + b;
    printf("%d + %d = %d\n", a, b, c);

    return c;
}
```

addition.c

subtraction.h

```c
#ifndef _SUB_H_
#define _SUB_H_

#include <stdio.h>

int sub(int a, int b);

#endif
```

subtraction.c

```c
#include "subtraction.h"

int sub(int a, int b) {
    int c = a - b;
    printf("%d - %d = %d\n", a, b, c);

    return c;
}
```

2 모듈화

Compile을 해 봅시다.

```
gcc main.c
```

오류가 발생합니다.

```
/tmp/ccuXC3rT.o: In function `main':
main.c:(.text+0x21): undefined reference to `add'
main.c:(.text+0x41): undefined reference to `sub'
collect2: error: ld returned 1 exit status
```

2 모듈화

모듈화 하면 컴파일 하는 과정이 살짝 복잡해집니다.

각 소스코드 별로 object 파일을 생성합니다.

```
gcc -c -o addition.o addition.c
gcc -c -o subtraction.o subtraction.c
gcc -c -o main.o main.c
```

그 이후, 생생한 object 코드를 합쳐 컴파일을 진행해야 합니다.

```
gcc -o main addition.o subtraction.o main.o
```

3 make

리눅스 계열 운영체제에서는 이러한 불편함을 줄이기 위해 make라는 명령어를 지원합니다.

```
make
```

다만 이러한 명령어를 사용하기 위해서는 해당 폴더에 Makefile이 필요하며, 이 Makefile에 컴파일에 필요한 다양한 명령어 및 내용을 담아 저장합니다.

```
vi Makefile
```

4 Makefile

기초적인 Makefile을 만들어봅시다.

```
main : addition.o subtraction.o main.o
    gcc -o main addition.o subtraction.o main.o

addition.o : addtition.c
    gcc -c -o addition.o addition.c

subtraction.o : subtraction.c
    gcc -c -o subtraction.o subtraction.c

main.o : main.c
    gcc -c -o main.o main.o
```

(타겟) : (의존)
(명령어)

4 Makefile

효율적인 Makefile을 만들어봅시다.

```
CC = gcc
CFLAGS = -W -Wall
TARGET = main
OBJECTS = addition.o subtraction.o main.o

all : $(TARGET)

$(TARGET) : $(OBJECTS)
    $(CC) $(CFLAGS) -o $@ $^
```

(타겟) : (의존)
(명령어)

5 clean

컴파일 한 이후에는 .o 파일이 쌓인다. 이를 정리할 수 있는 코드를 추가하자.

```
CC = gcc
CFLAGS = -W -Wall
TARGET = main
OBJECTS = addition.o subtraction.o main.o

all : $(TARGET)

$(TARGET) : $(OBJECTS)
    $(CC) $(CFLAGS) -o $@ $^

clean :
    rm -f $(OBJECTS) $(TARGET)
```

(타겟) : (의존)
(명령어)

6 Practice

앞의 예시에서 multiplication(*), division(/), modular(%) 연산을 진행할 소스코드를 추가하고, 이에 대한 Makefile을 구성해본다.

추가 할 헤더: multiplication.h, division.h, modular.h

추가 할 코드: multiplication.c, division.c, modular.c

실습에 사용된 Makefile 및 소스 코드를 “Makefile_학번.zip”로 압축하여 제출