C Build Process

Content

- Model
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- Compiler
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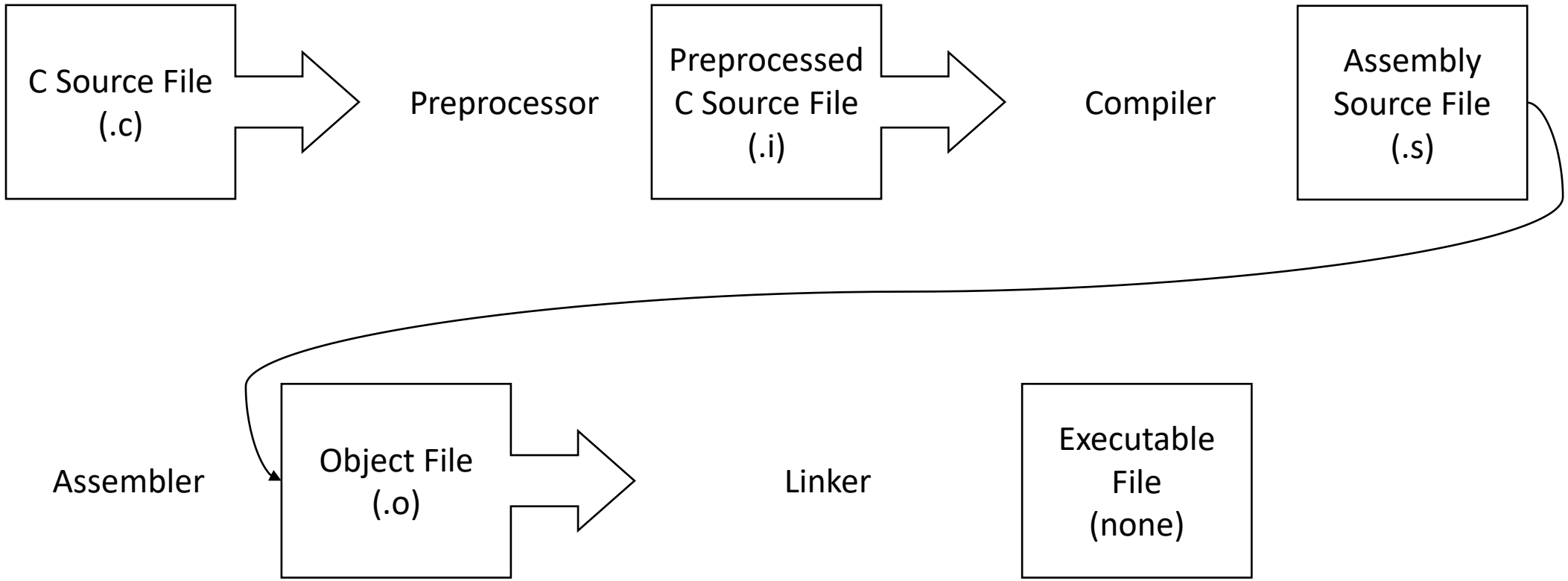
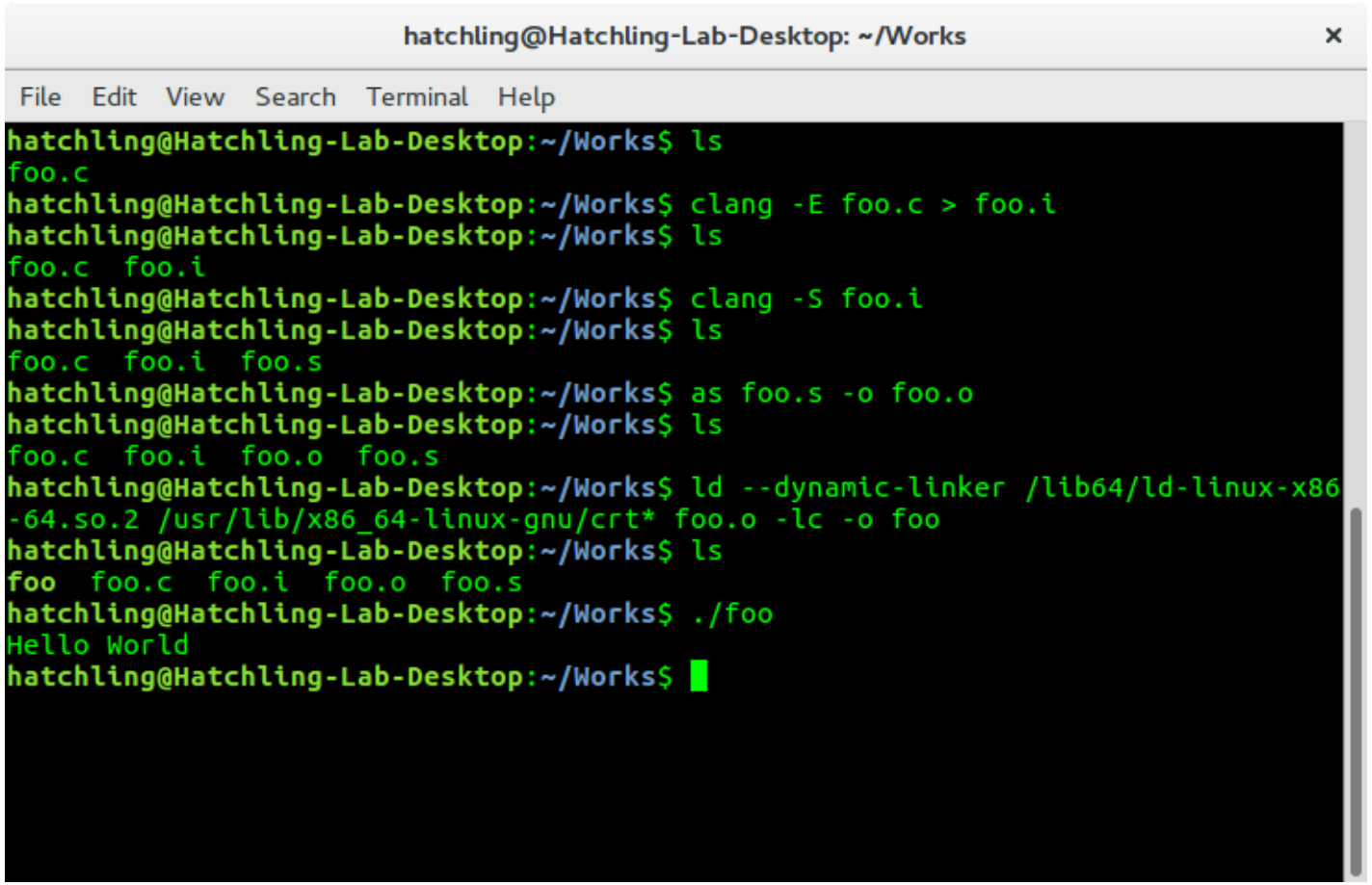
- Linker

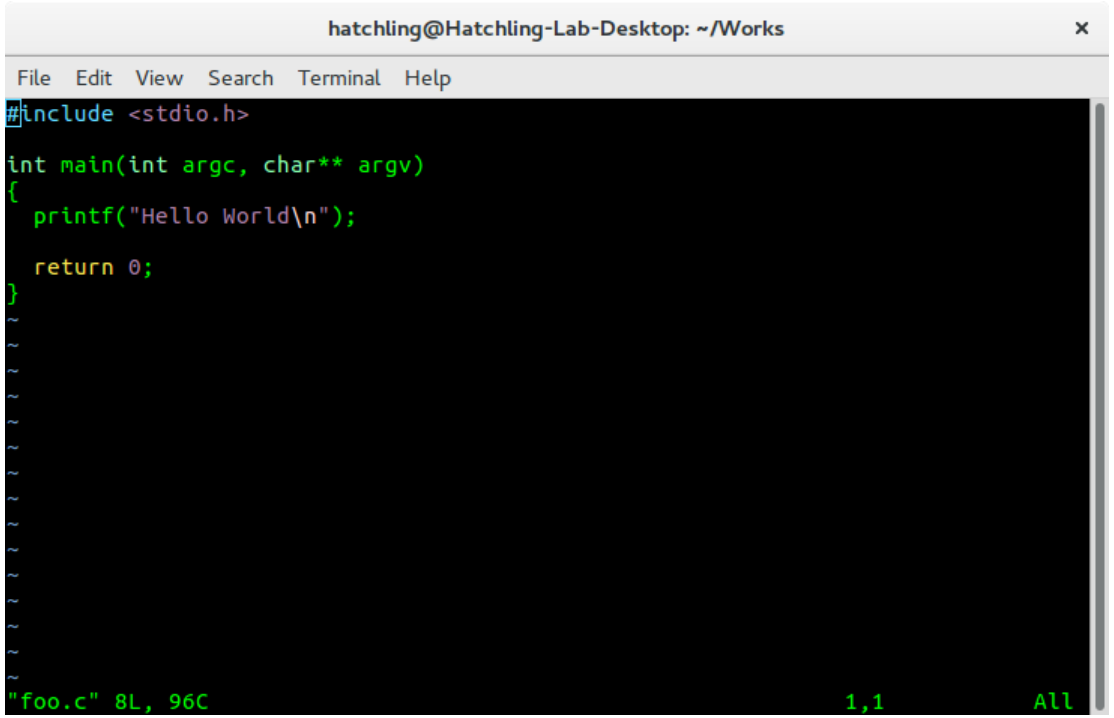
Model (Executable and Linkable Format)



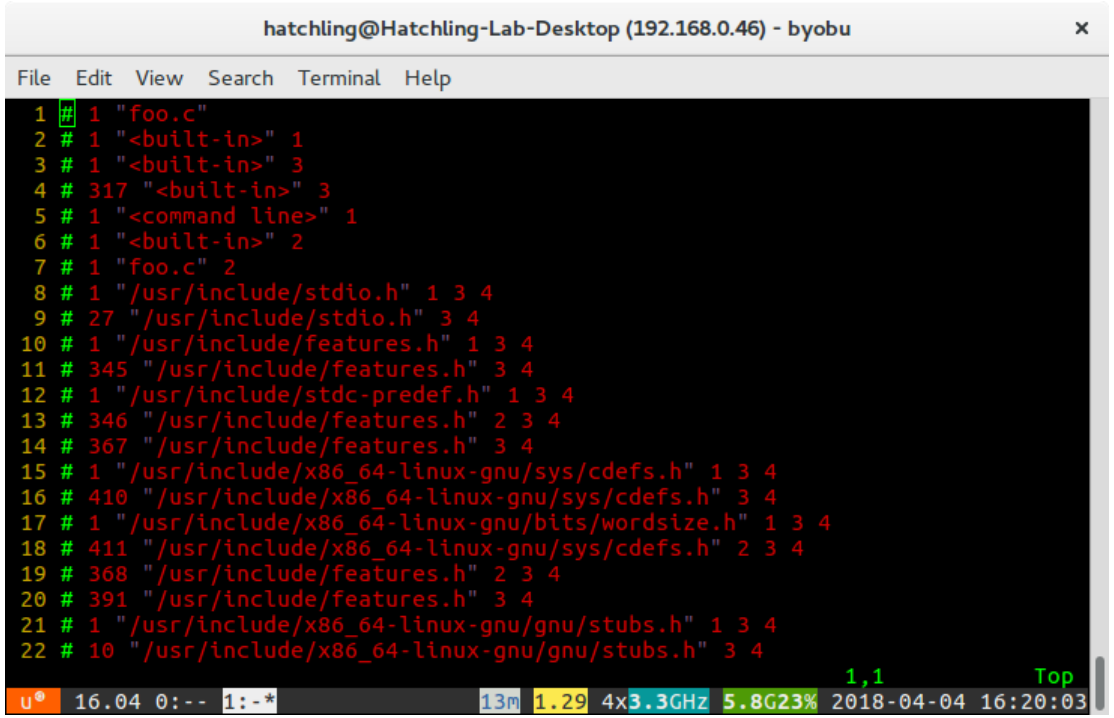
Model (Executable and Linkable Format)



Preprocessor

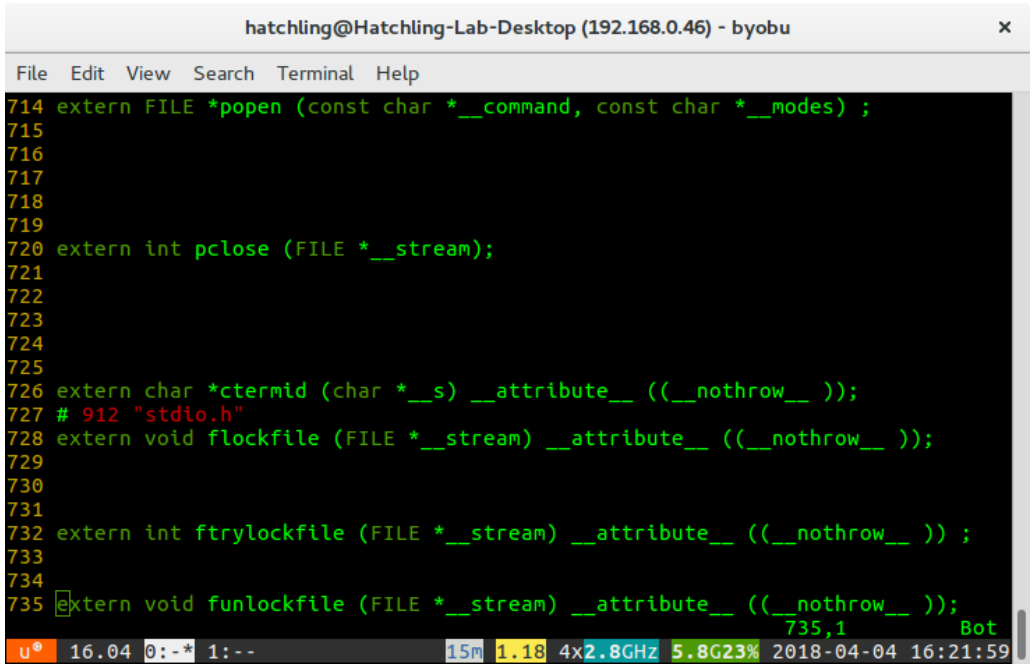


C Source code(foo.c)

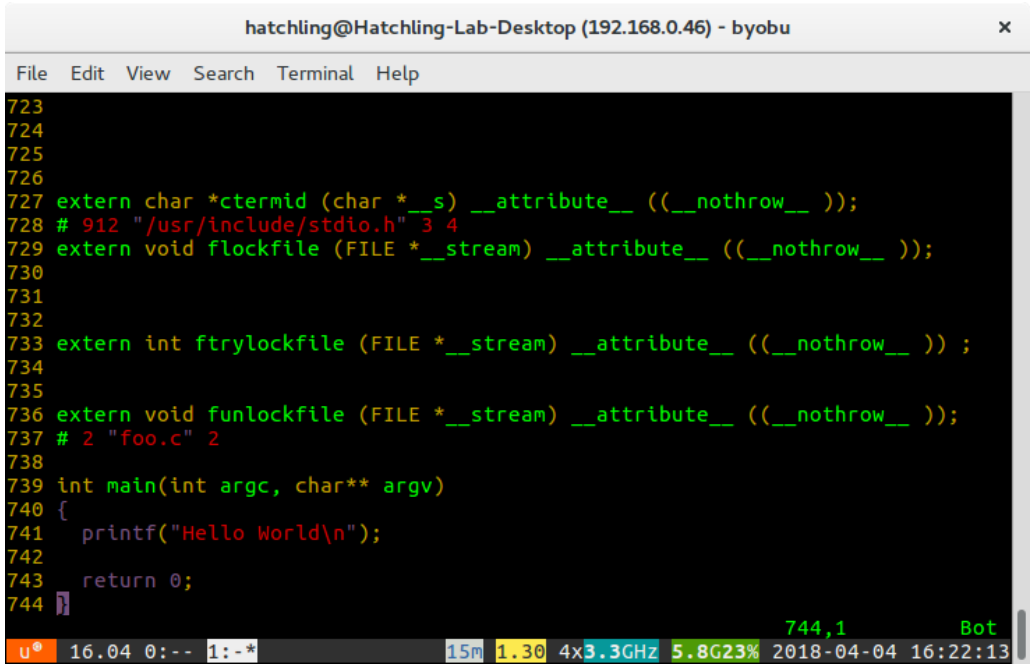


Preprocessed C Source code(foo.i)

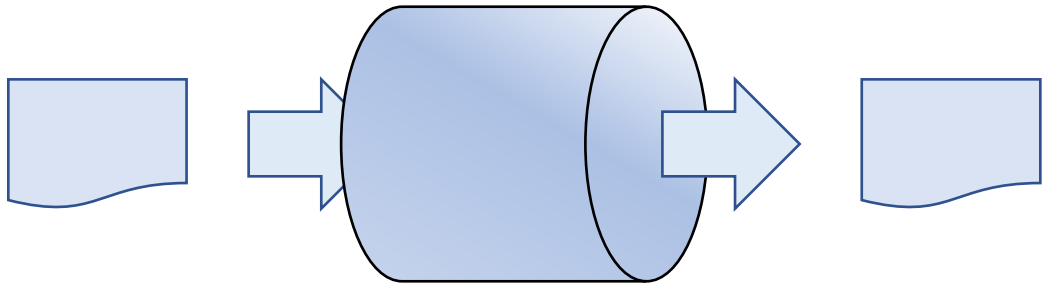
Preprocessor



VS.



Compiler



.c / .i

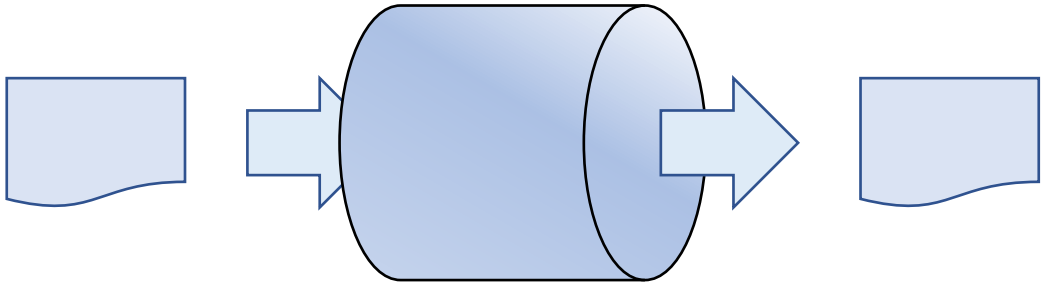
.s

```
        .text
        .file   "foo.i"
        .globl  main
        .align  16, 0x90
        .type   main,@function
main:                                   # @main
        .cfi_startproc
# BB#0:
        pushq   %rbp
.Ltmp0:
        .cfi_def_cfa_offset 16
.Ltmp1:
        .cfi_offset %rbp, -16
        movq    %rsp, %rbp
.Ltmp2:
        .cfi_def_cfa_register %rbp
        subq    $32, %rsp
        movabsq $.L.str, %rax
        movl    $0, -4(%rbp)
        movl    %edi, -8(%rbp)
        movq    %rsi, -16(%rbp)
        movq    %rax, %rdi
        movb    $0, %al
        callq   printf
        xorl    %ecx, %ecx
        movl    %eax, -20(%rbp)         # 4-byte Spill
        movl    %ecx, %eax
        addq    $32, %rsp
        popq    %rbp
        retq
.Lfunc_end0:
        .size   main, .Lfunc_end0-main
        .cfi_endproc

        .type   .L.str,@object          # @.str
        .section        .rodata.str1.1,"aMS",@progbits,1
.L.str:
        .asciz  "Hello World\n"
        .size   .L.str, 13


        .ident  "clang version 3.8.0-2ubuntu4 (tags/RELEASE_380/final)"
        .section        ".note.GNU-stack","",@progbits
                                                        1,1-8         All
```

Assembler



.s .o

hatchling@Hatchling-Lab-Desktop (192.168.0.46) - byobu

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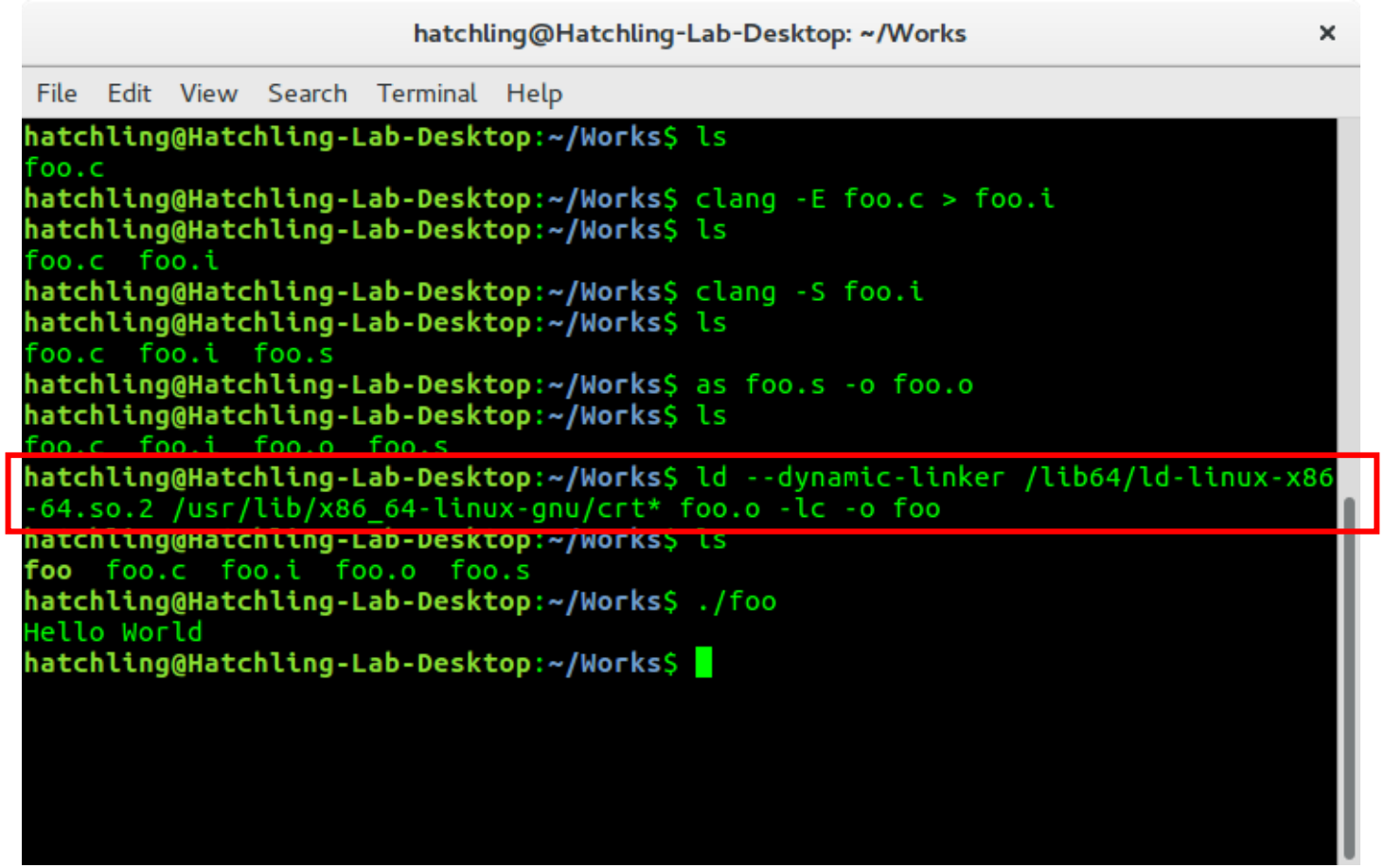
```
00000000: 7f45 4c46 0201 0100 0000 0000 0000 0000  .ELF............
00000010: 0100 3e00 0100 0000 0000 0000 0000 0000  ..>.............
00000020: 0000 0000 0000 0000 c802 0000 0000 0000  ................
00000030: 0000 0000 4000 0000 0000 4000 0d00 0a00  ....@.....@.....
00000040: 5548 89e5 4883 ec20 48b8 0000 0000 0000  UH..H.. H.......
00000050: 0000 c745 fc00 0000 0089 7df8 4889 75f0  ...E......}.H.u.
00000060: 4889 c7b0 00e8 0000 0000 31c9 8945 ec89  H.........1..E..
00000070: c848 83c4 205d c348 656c 6c6f 2057 6f72  .H.. ].Hello Wor
00000080: 6c64 0a00 0063 6c61 6e67 2076 6572 7369  ld...clang versi
00000090: 6f6e 2033 2e38 2e30 2d32 7562 756e 7475  on 3.8.0-2ubuntu
000000a0: 3420 2874 6167 732f 5245 4c45 4153 455f  4 (tags/RELEASE_
000000b0: 3338 302f 6669 6e61 6c29 0000 0000 0000  380/final)......
000000c0: 1400 0000 0000 0000 017a 5200 0178 1001  .........zR..x..
000000d0: 1b0c 0708 9001 0000 1c00 0000 1c00 0000  ................
000000e0: 0000 0000 3700 0000 0041 0e10 8602 430d  ....7....A....C.
000000f0: 0600 0000 0000 0000 0000 0000 0000 0000  ................
00000100: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000110: 0100 0000 0400 f1ff 0000 0000 0000 0000  ................
00000120: 0000 0000 0000 0000 0000 0000 0300 0100  ................
00000130: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000140: 0000 0000 0300 0300 0000 0000 0000 0000  ................
00000150: 0000 0000 0000 0000 0000 0000 0300 0400  ................
"foo.x" 97L, 6588C                                          1,1           T
```

u® 16.04 0:-* 12m 0.54 4x2.4GHz 5.8G22% 2018-04-04 17:09

Linker


hatchling@Hatchling-Lab-Desktop: ~/Works
File Edit View Search Terminal Help
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c
hatchling@Hatchling-Lab-Desktop:~/Works$ clang -E foo.c > foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ clang -S foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ as foo.s -o foo.o
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i foo.o foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ ld --dynamic-linker /lib64/ld-linux-x86
-64.so.2 /usr/lib/x86_64-linux-gnu/crt* foo.o -lc -o foo
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo foo.c foo.i foo.o foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ ./foo
Hello World
hatchling@Hatchling-Lab-Desktop:~/Works$

Linker

- main() is not the entry point of program; _start() is

- crt1.o: contains _start()
- crti.o: contains prologue part of __init() and __fini()
- crtn.o: contains epilogue part of __init() and __fini()

Linker

```
hatchling@Hatchling-Lab-Desktop:~$ nm /usr/lib/x86_64-linux-gnu/crt1.o
0000000000000000 D __data_start
0000000000000000 W data_start
0000000000000000 R _IO_stdin_used
                 U __libc_csu_fini
                 U __libc_csu_init
                 U __libc_start_main
                 U main
0000000000000000 T _start
hatchling@Hatchling-Lab-Desktop:~$
```

```
/* crti.S puts a function prologue at the beginning of the .init and
   .fini sections and defines global symbols for those addresses, so
   they can be called as functions.  The symbols _init and _fini are
   magic and cause the linker to emit DT_INIT and DT_FINI.  */
```

```
/* crtn.S puts function epilogues in the .init and .fini sections
   corresponding to the prologues in crti.S. */
```

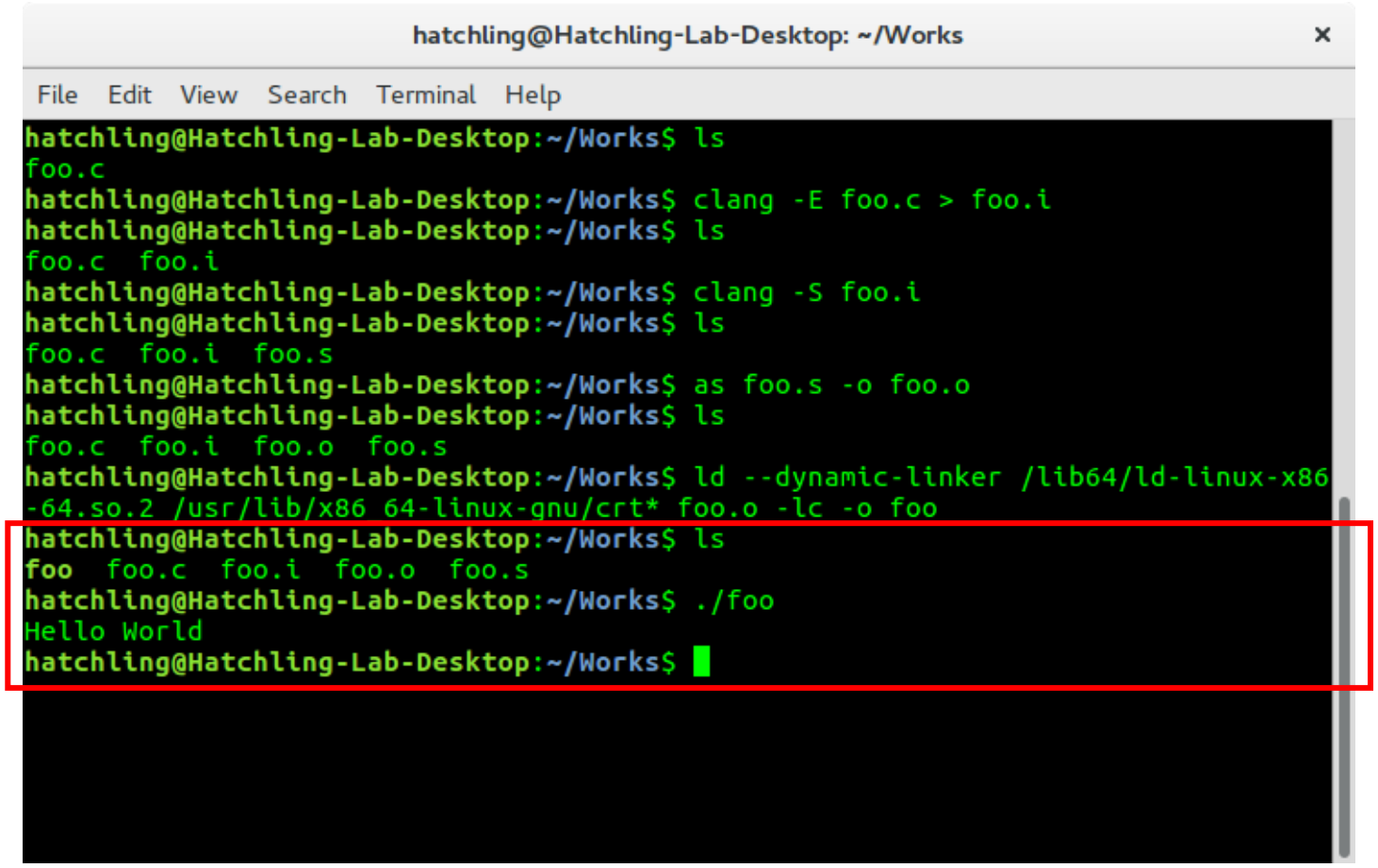
Function prologue/epilogue

- Prologue
  - Appears at the beginning of a function
  - Prepares the stack and registers for use within the function

- Epilogue
  - Appears at the end of a function
  - Restores the stack and registers to previous state(before the function call)

- - Terms in assembly language programming

Executable


hatchling@Hatchling-Lab-Desktop: ~/Works
File Edit View Search Terminal Help
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c
hatchling@Hatchling-Lab-Desktop:~/Works$ clang -E foo.c > foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ clang -S foo.i
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ as foo.s -o foo.o
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo.c foo.i foo.o foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ ld --dynamic-linker /lib64/ld-linux-x86
-64.so.2 /usr/lib/x86_64-linux-gnu/crt* foo.o -lc -o foo
hatchling@Hatchling-Lab-Desktop:~/Works$ ls
foo foo.c foo.i foo.o foo.s
hatchling@Hatchling-Lab-Desktop:~/Works$ ./foo
Hello World
hatchling@Hatchling-Lab-Desktop:~/Works$