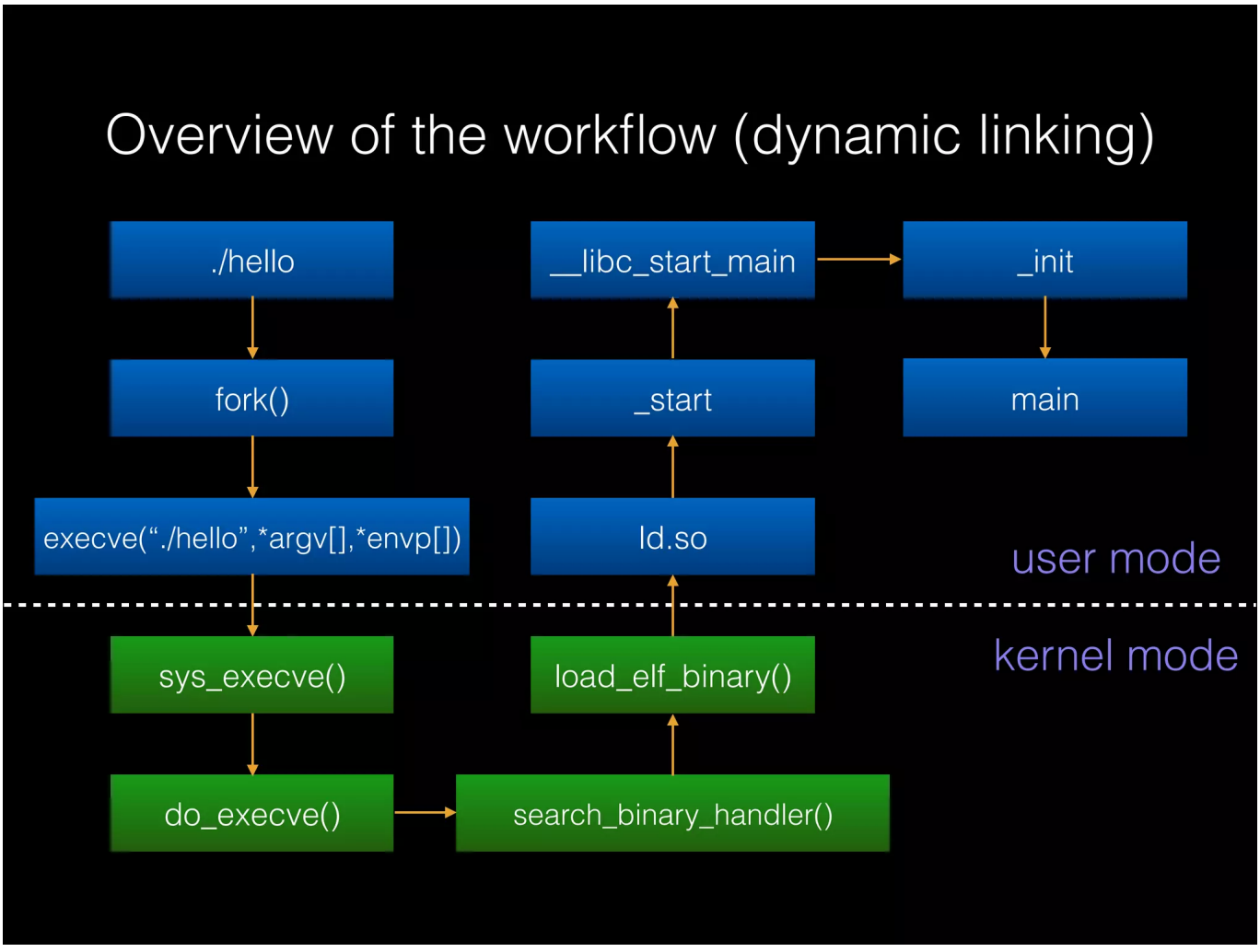
Execuation Explained

Overview

```
https://www.youtube.com/watch?v=Ss2e6JauS0Y
https://www.slideshare.net/AngelBoy1/execution-50215114 (recommended)
```

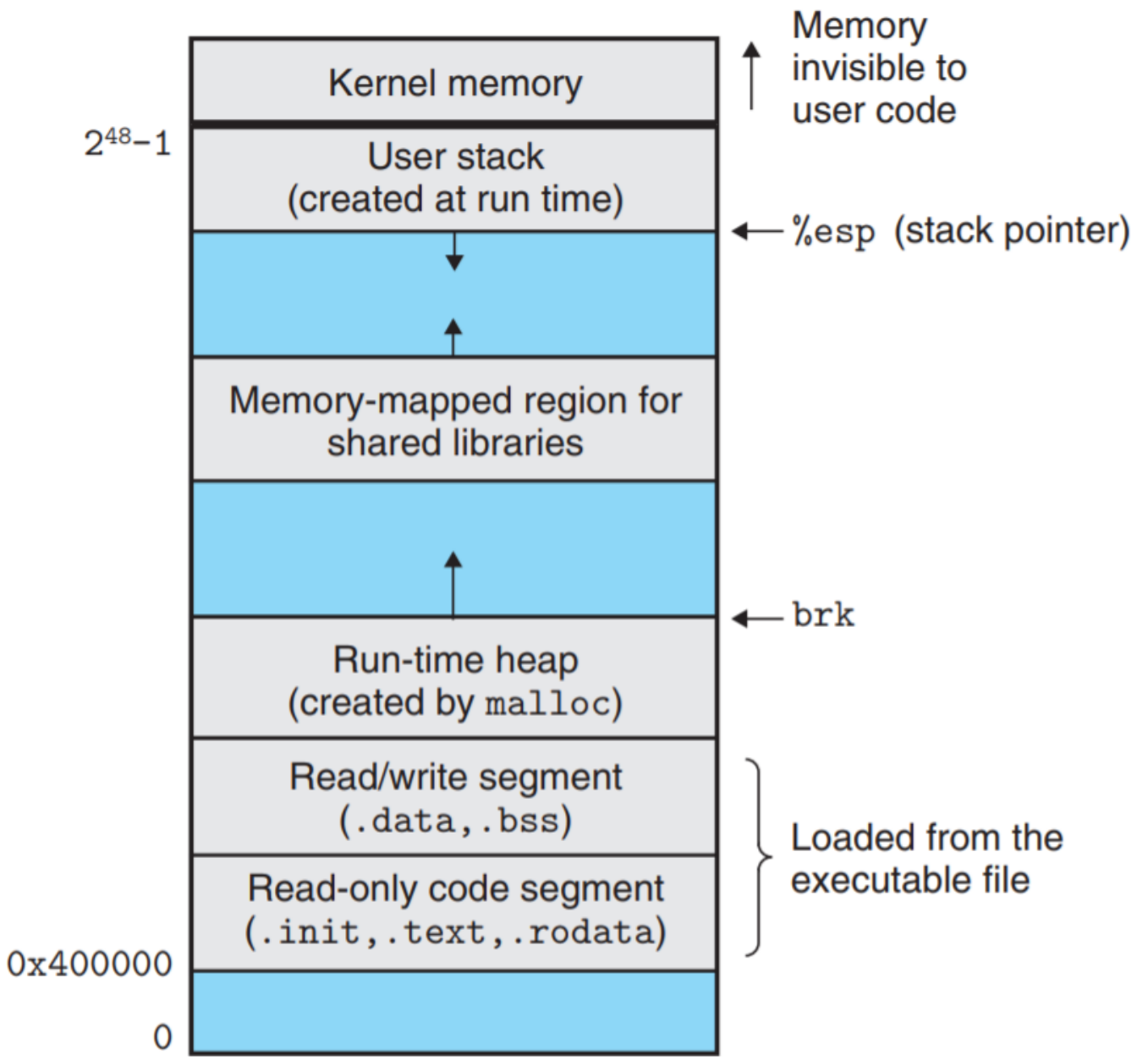


keyword: dynamic linker, rellocation, PIC, GOT, PLT

Preliminary

Unix Process Memory Layout

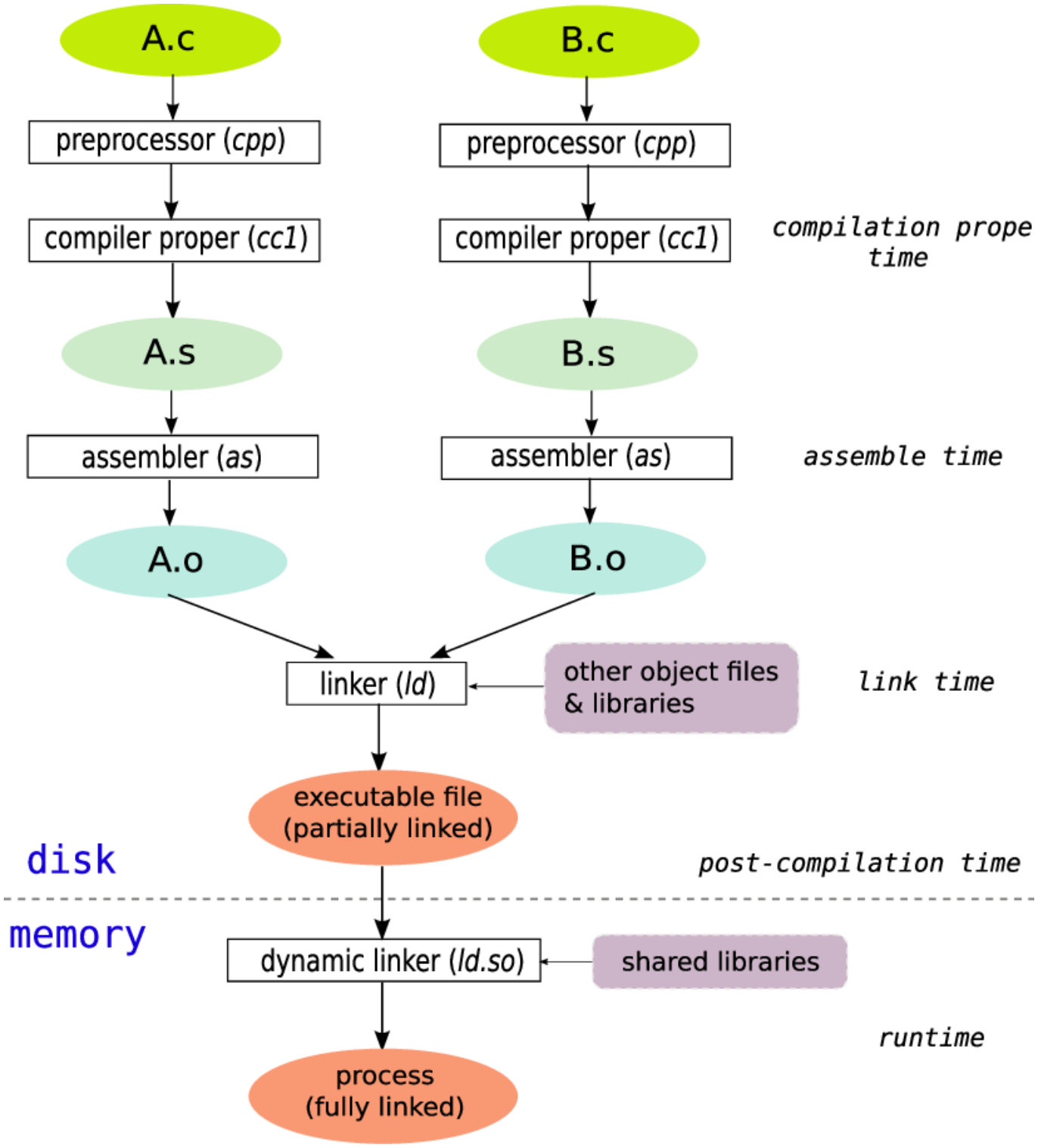
```
https://www.geeksforgeeks.org/memory-layout-of-c-program/
```



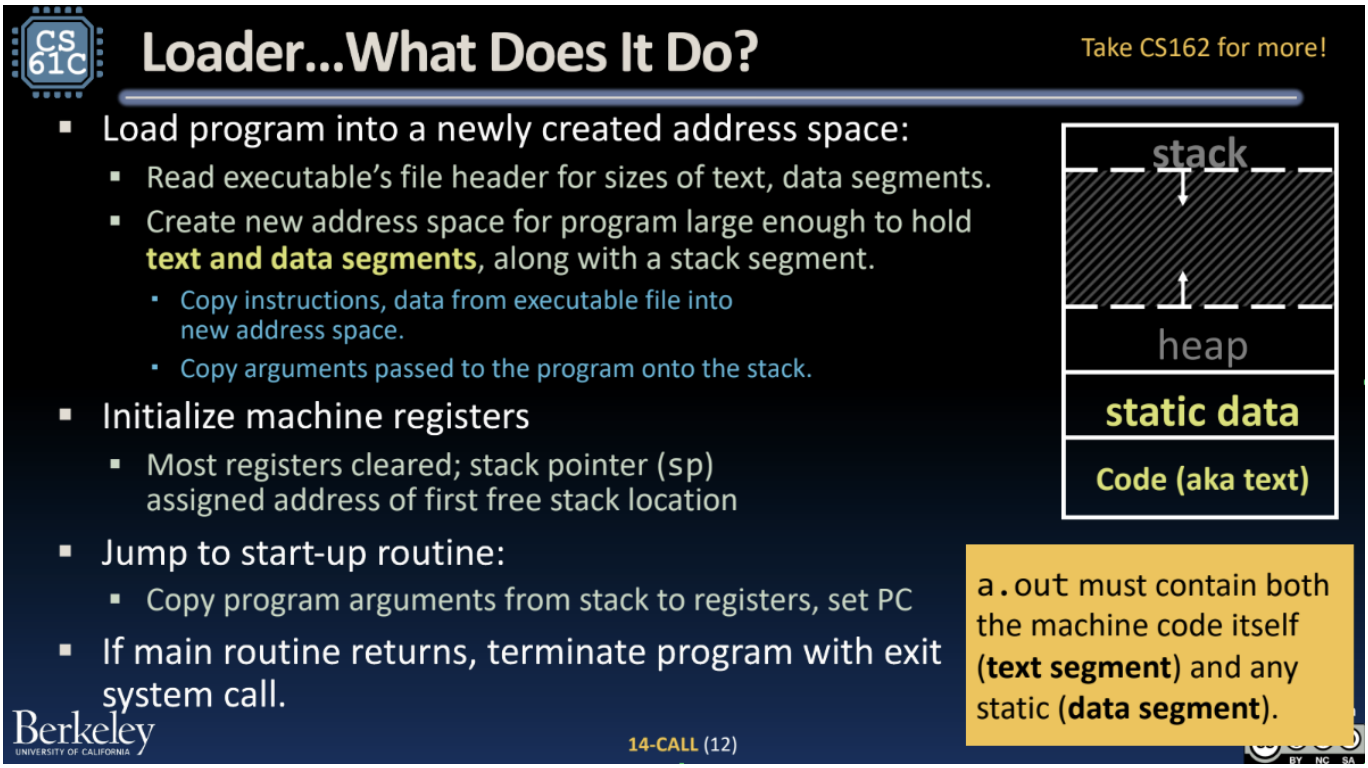
keyword: section, segment, variable, allocation.

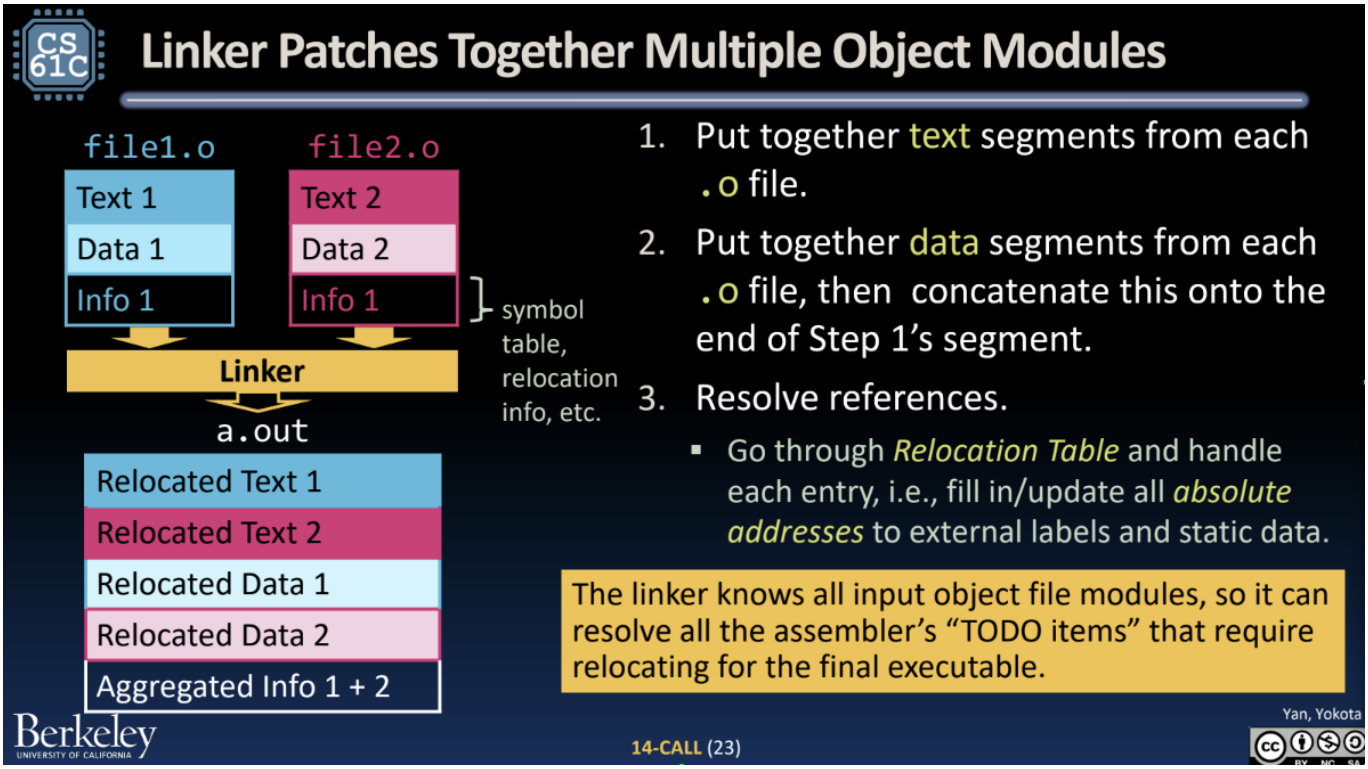
Build Process

```
CS61C:https://drive.google.com/file/d/1Gg1pKejSDy_dUPWdwQ1zuquI0RW8UKUu/view?pli=1
```

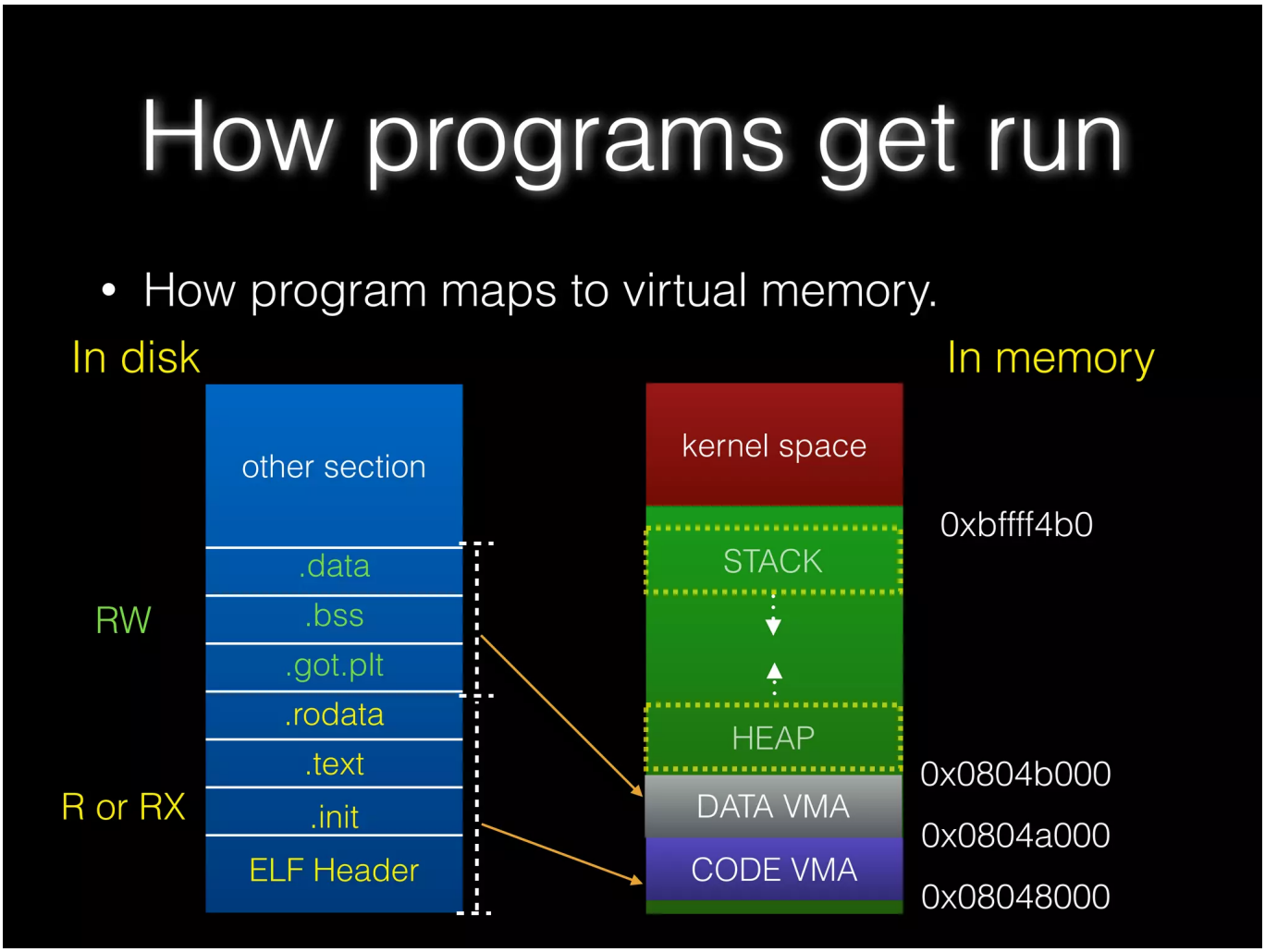

A.c
B.c
preprocessor (cpp)
preprocessor (cpp)
compiler proper (cc1)
compiler proper (cc1)
compilation prope
time
A.s
B.s
assembler (as)
assembler (as)
assemble time
A.o
B.o
linker (ld)
other object files
& libraries
link time
executable file
(partially linked)
disk
post-compilation time
memory
dynamic linker (ld.so)
shared libraries
runtime
process
(fully linked)

Linker





Memory Mapping



Dynamic linking - Code sharing

```
https://bottomupcs.com/ch09s03.html
https://github.com/jserv/min-dl
https://hackmd.io/@RinHizakura/S1tNA0RZv
```

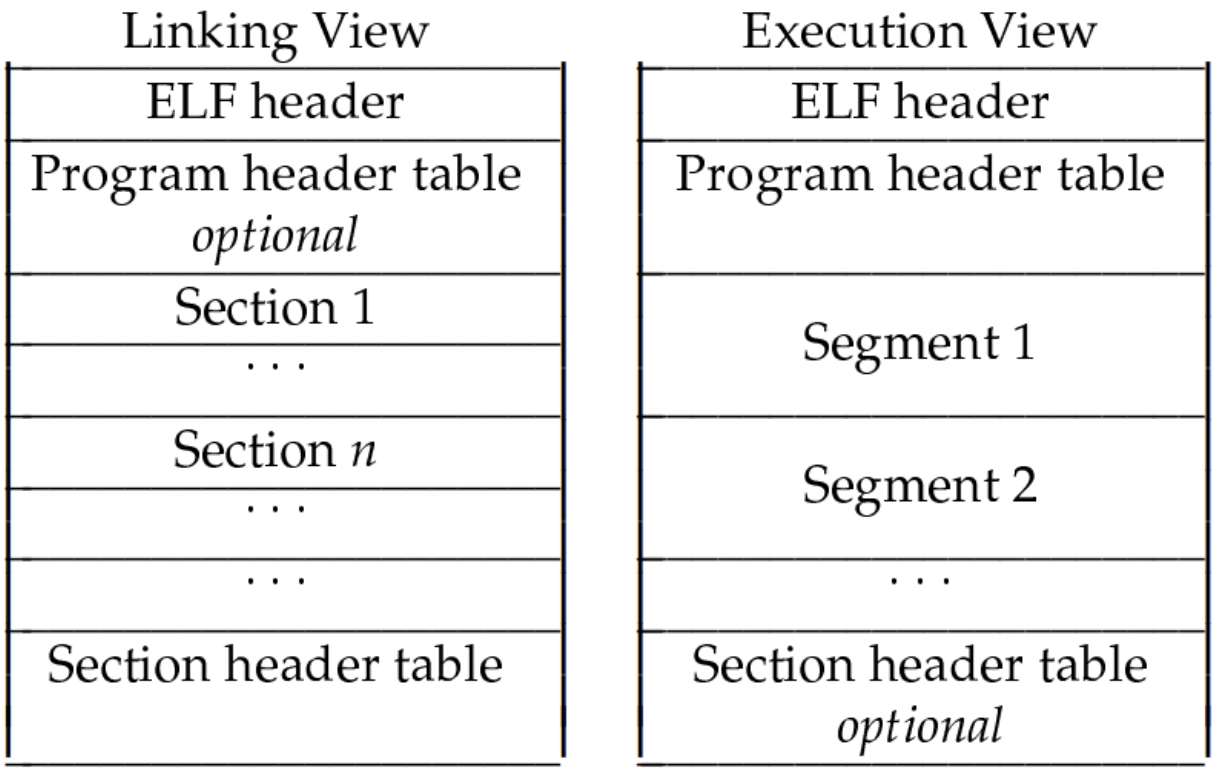
keyword: virtual memory, shared library

Elf specification

```
ELF Document:
https://www.cs.cmu.edu/afs/cs/academic/class/15213-f00/docs/elf.pdf

ELF explained:
https://www.youtube.com/watch?v=nC1U1LJQL8o

Linker & Loader:
https://www.cs.cornell.edu/courses/cs3410/2013sp/lecture/15-linkers2-w.pdf
```



Lazy binding - Startup time reduction

```
https://stackoverflow.com/questions/63745016/why-use-lazy-binding-for-
position-independent-code-function-calls
https://rafaelchen.wordpress.com/2017/09/25/pwn%e7%9a%84%e4%bf%ae%e7%85%89%
e4%b9%8b%e8%b7%af-lazy-binding/#more-1244
```

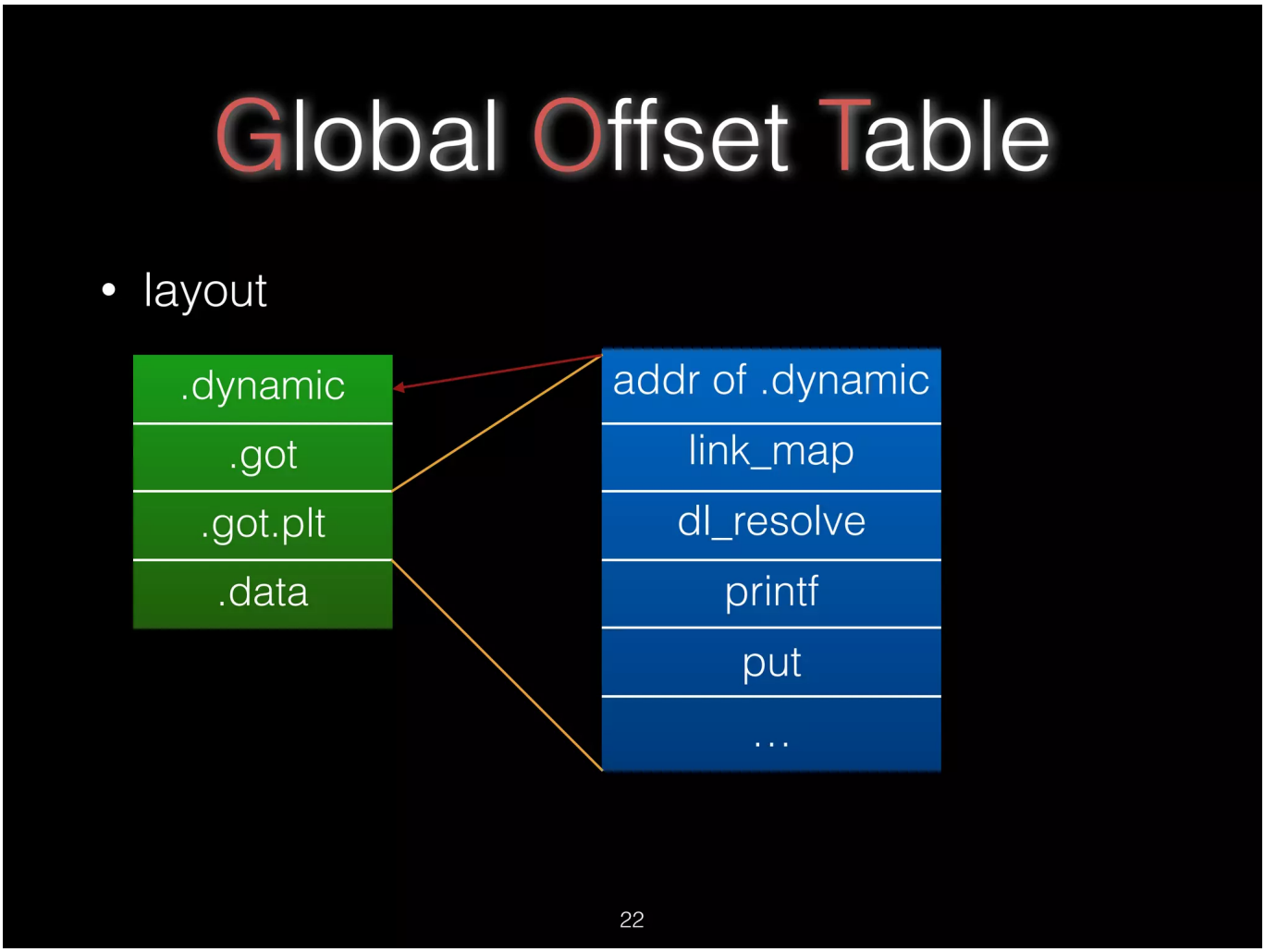
Position Independent Code

```
https://docs.oracle.com/cd/E26505_01/html/E26506/glmqp.html
https://bottomupcs.com/ch09s02.html#dynamic_linker_s2
```

> In an executable file, the code and data segment is given a specified base address in virtual memory. The executable code is not shared, and each executable gets its own fresh address space. This means that the compiler knows exactly where the data section will be, and can reference it directly. Consequently all libraries must be produced with code that can execute no matter where it is put into memory, known as position independent code (or PIC for short). Note that the data section is still a fixed offset from the code section; but to actually find the address of data the offset needs to be added to the load address.

.got - Runtime symbol resolve

```
https://bottomupcs.com/ch09s03.html
```



_start - The entry point of the program

```
0000000000001050 <_start>:
    1050:       f3 0f 1e fa             endbr64
    1054:       31 ed                   xor    %ebp,%ebp
    1056:       49 89 d1                mov    %rdx,%r9
    1059:       5e                      pop    %rsi
    105a:       48 89 e2                mov    %rsp,%rdx
    105d:       48 83 e4 f0             and    $0xfffffffffffffff0,%rsp
    1061:       50                      push   %rax
    1062:       54                      push   %rsp
    1063:       45 31 c0                xor    %r8d,%r8d
    1066:       31 c9                   xor    %ecx,%ecx
    1068:       48 8d 3d d1 00 00 00    lea    0xd1(%rip),%rdi        #
1140 <main>
    106f:       ff 15 63 2f 00 00       call   *0x2f63(%rip)        # 3fd8
<__libc_start_main@GLIBC_2.34>
    1075:       f4                      hlt
    1076:       66 2e 0f 1f 84 00 00    cs nopw 0x0(%rax,%rax,1)
    107d:       00 00 00
```

__libc_start_main - Initialization funtion

```
https://hammertux.github.io/libc-start
https://bottomupcs.com/ch08s08.html#startup
```

Signature of __libc_start_main.

```
int __libc_start_main(int (*main)(int, char *[], char *[]), int argc, char
*argv[], void (*init)(void), void (*fini)(void), void (*rtld_fini)(void),
void *stack_end) {
    // Perform initialization tasks here
    // ...

    // Call the main function
    int result = main(argc, argv, environ);

    // Perform cleanup tasks here
    // ...

    return result;
}
```

keyword: __libc_start_main, .init, .fini, __do_global_ctors_aux

Appendix

Stack allocation padding and alignment

```
https://stackoverflow.com/questions/1061818/stack-allocation-padding-and-
alignment
```

keyword: cache block size, data structure alignment, performance.

__Attribute__

In C, __attribute__ is a keyword-like syntax extension that allows you to provide additional information or directives to the compiler about various attributes of a function, variable, or type.

```
void __attribute__((constructor)) program_init(void)  {
  printf("init\n");
}

void  __attribute__((destructor)) program_fini(void) {
  printf("fini\n");
}

int main(void)
```

```
{
  return 0;
}

$ gcc -Wall  -o test test.c

$ ./test
init
fini
```