hw期间，在公司事情比较少，就把之前没有系统研究过的二进制格式、linux c程序的从源码到二进制文件的转换以及二进制文件的装载和执行，再从头到尾捋一遍，把底层的原理弄清楚，让以前隐藏在迷雾中的摸棱两可的知识，一点一点呈现出来，也能让自己的基础更扎实些。

1. c源码设计

经过对各种设计类、架构类书籍的洗礼，应该可以“设计”出比较牛逼的软件架构了，然后就拿着各种编辑器啊、ide啊开始一顿写代码。
设计这块儿的内容，主要集中c的基础、c的高级技术、linux系统编程、linux网络编程、并行编程、IPC技术、内核编程等等，基础的编程技术的学习。还有操作系统、编译原理、网络原理、计算机体系结构、算法、架构设计、重构、系统分析、设计模式等等技术的学习。然后就是夜以继日无休止的撸代码，打副本升级。

2. c源码编写

然后在经历无数昼夜的百度、狗狗之后，终于把贼牛逼的架构实现了，虽然对写的什么东西一脸懵逼，但不耽误完成领导布置的任务，妹汁儿汁儿。

吭哧吭哧，终于把代码写完了，然后就是编译、执行。好像很自然的操作，但是这两部操作到底干了啥？我完全不知道，完全是傻子一样，等着计算机帮我处理好。所以，后面进入到linux c程序的编译阶段。

3. gcc预处理：cpp

4. gcc编译：cc1

5. gcc汇编：as

elf文件格式

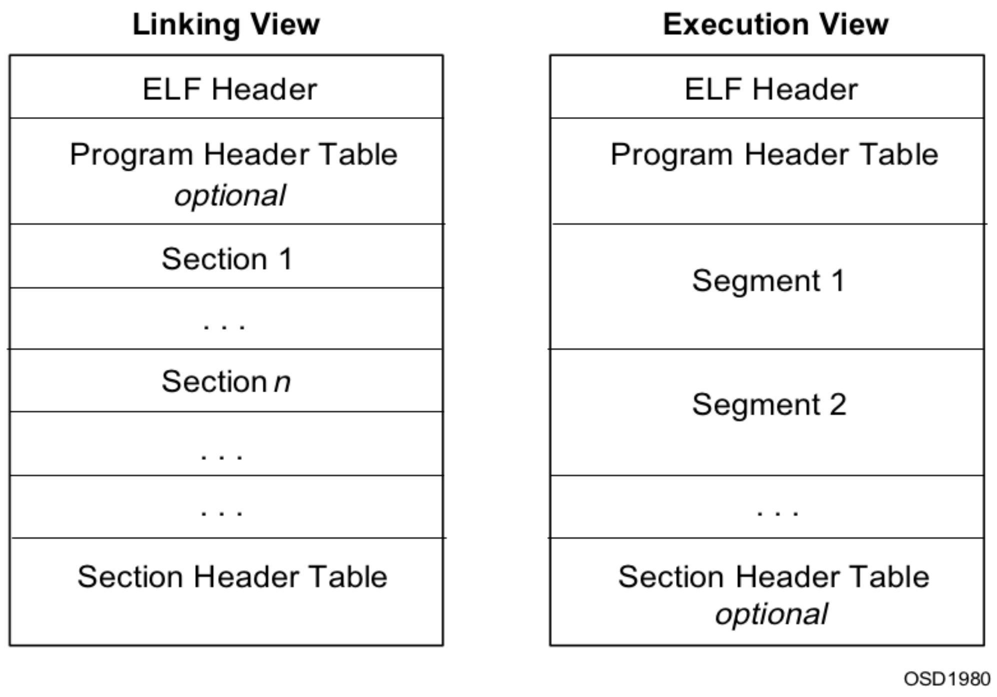
汇编之后会产生relocatable file，relocatable file是c程序生命周期中第一个以elf格式存在的文件，后面还有executable file和shared object file都是以elf格式存在，并且在elf定义中，都属于object file，因此在这里记录elf文件格式。
elf截至当前为止，分为两部分。一个是32位标准定义，一个是64位补充定义。

> elf 32位标准定义
> elf 64位补充定义

鉴于目前64位已比较普遍，所以在记录时，直接合并32位和64位定义中的相关数据结构定义。

---

object file会参与到程序的链接和执行过程中，因此elf文件划分出链接视图和执行视图，两种视图来体现链接和执行过程中的不同要素。



> **ELF header**：描述了整个elf的结构和组织。
> **Sections**：包含所有“链接视图”所需的信息。
> **Segments**：包含所有“执行视图”所需的信息。
> **program header table**：定义如何创建process image。
> **section header table**：包含所有section的全部信息。

Table 1. ELF-64 Data Types

Name	*Size*	*Alignment*	*Purpose*
Elf64_Addr	8	8	Unsigned program address
Elf64_Off	8	8	Unsigned file offset
Elf64_Half	2	2	Unsigned medium integer
Elf64_Word	4	4	Unsigned integer
Elf64_Sword	4	4	Signed integer
Elf64_Xword	8	8	Unsigned long integer
Elf64_Sxword	8	8	Signed long integer
unsigned char	1	1	Unsigned small integer

```
typedef struct
{
        unsigned char   e_ident[16];    /* ELF identification */
        Elf64_Half      e_type;         /* Object file type */
        Elf64_Half      e_machine;      /* Machine type */
        Elf64_Word      e_version;      /* Object file version */
        Elf64_Addr      e_entry;        /* Entry point address */
        Elf64_Off       e_phoff;        /* Program header offset */
        Elf64_Off       e_shoff;        /* Section header offset */
        Elf64_Word      e_flags;        /* Processor-specific flags */
        Elf64_Half      e_ehsize;       /* ELF header size */
        Elf64_Half      e_phentsize;    /* Size of program header entry */
        Elf64_Half      e_phnum;        /* Number of program header entries */
        Elf64_Half      e_shentsize;    /* Size of section header entry */
        Elf64_Half      e_shnum;        /* Number of section header entries */
        Elf64_Half      e_shstrndx;     /* Section name string table index */
} Elf64_Ehdr;
```

Figure 2. ELF-64 Header

Table 2. ELF Identification, e_ident

Name	*Value*	*Purpose*
EI_MAG0	0	File identification
EI_MAG1	1	
EI_MAG2	2	
EI_MAG3	3	
EI_CLASS	4	File class
EI_DATA	5	Data encoding
EI_VERSION	6	File version
EI_OSABI	7	OS/ABI identification
EI_ABIVERSION	8	ABI version
EI_PAD	9	Start of padding bytes
EI_NIDENT	16	Size of e_ident[]

Table 3. Object File Classes, e_ident[EI_CLASS]

Name	*Value*	*Meaning*
ELFCLASS32	1	32-bit objects
ELFCLASS64	2	64-bit objects

Table 4. Data Encodings, e_ident[EI_DATA]

Name	*Value*	*Meaning*
ELFDATA2LSB	1	Object file data structures are little-endian
ELFDATA2MSB	2	Object file data structures are big-endian

Table 5. Operating System and ABI Identifiers, e_ident[EI_OSABI]

Name	*Value*	*Meaning*
ELFOSABI_SYSV	0	System V ABI
ELFOSABI_HPUX	1	HP-UX operating system
ELFOSABI_STANDALONE	255	Standalone (embedded) application

Table 6. Object File Types, e_type

Name	*Value*	*Meaning*
ET_NONE	0	No file type
ET_REL	1	Relocatable object file
ET_EXEC	2	Executable file
ET_DYN	3	Shared object file
ET_CORE	4	Core file
ET_LOOS	0xFE00	Environment-specific use
ET_HIOS	0xFEFF	
ET_LOPROC	0xFF00	Processor-specific use
ET_HIPROC	0xFFFF	

Name	Value	Meaning
ET_NONE	0	No machine
EM_M32	1	AT&T WE 32100
EM_SPARC	2	SPARC
EM_386	3	Intel Architecture
EM_68K	4	Motorola 68000
EM_88K	5	Motorola 88000
EM_860	7	Intel 80860
EM_MIPS	8	MIPS RS3000 Big-Endian
EM_MIPS_RS4_BE	10	MIPS RS4000 Big-Endian
RESERVED	11-16	Reserved for future use

实例:

```
[root@localhost tmp]# readelf -h /bin/ls
ELF Header:
  Magic:   7f 45 4c 46 02 01 01 00 00 00 00 00 00 00 00 00
  Class:                             ELF64
  Data:                              2's complement, little endian
  Version:                           1 (current)
  OS/ABI:                            UNIX - System V
  ABI Version:                       0
  Type:                              EXEC (Executable file)
  Machine:                           Advanced Micro Devices X86-64
  Version:                           0x1
  Entry point address:               0x404324
  Start of program headers:          64 (bytes into file)
  Start of section headers:          115688 (bytes into file)
  Flags:                             0x0
  Size of this header:               64 (bytes)
  Size of program headers:           56 (bytes)
  Number of program headers:         9
  Size of section headers:           64 (bytes)
  Number of section headers:         30
  Section header string table index: 29
```

```
[root@localhost tmp]# xxd -s 0x0 -l 0x40 /bin/ls
0000000: 7f45 4c46 0201 0100 0000 0000 0000 0000  .ELF............
0000010: 0200 3e00 0100 0000 2443 4000 0000 0000  ..>.....$C@.....
0000020: 4000 0000 0000 0000 e8c3 0100 0000 0000  @...............
0000030: 0000 0000 4000 3800 0900 4000 1e00 1d00  ....@.8...@.....
```

Section Header

```
typedef struct
{
        Elf64_Word      sh_name;        /* Section name */
        Elf64_Word      sh_type;        /* Section type */
        Elf64_Xword     sh_flags;       /* Section attributes */
        Elf64_Addr      sh_addr;        /* Virtual address in memory */
        Elf64_Off       sh_offset;      /* Offset in file */
        Elf64_Xword     sh_size;        /* Size of section */
        Elf64_Word      sh_link;        /* Link to other section */
        Elf64_Word      sh_info;        /* Miscellaneous information */
        Elf64_Xword     sh_addralign;   /* Address alignment boundary */
        Elf64_Xword     sh_entsize;     /* Size of entries, if section has table */
} Elf64_Shdr;
```
Figure 3. ELF-64 Section Header

Table 8. Section Types, sh_type

Name	*Value*	*Meaning*
SHT_NULL	0	Marks an unused section header
SHT_PROGBITS	1	Contains information defined by the program
SHT_SYMTAB	2	Contains a linker symbol table
SHT_STRTAB	3	Contains a string table
SHT_RELA	4	Contains “Rela” type relocation entries
SHT_HASH	5	Contains a symbol hash table
SHT_DYNAMIC	6	Contains dynamic linking tables
SHT_NOTE	7	Contains note information
SHT_NOBITS	8	Contains uninitialized space; does not occupy any space in the file
SHT_REL	9	Contains “Rel” type relocation entries
SHT_SHLIB	10	Reserved
SHT_DYNSYM	11	Contains a dynamic loader symbol table
SHT_LOOS	0x6000 0000	Environment-specific use
SHT_HIOS	0x6FFF FFFF	
SHT_LOPROC	0x7000 0000	Processor-specific use
SHT_HIPROC	0x7FFF FFFF	

Table 9. Section Attributes, sh_flags

Name	*Value*	*Meaning*
SHF_WRITE	0x1	Section contains writable data
SHF_ALLOC	0x2	Section is allocated in memory image of program
SHF_EXECINSTR	0x4	Section contains executable instructions
SHF_MASKOS	0x0F000000	Environment-specific use
SHF_MASKPROC	0xF0000000	Processor-specific use

Table 10. Use of the sh_link Field

Section Type	*Associated Section*
SHT_DYNAMIC	String table used by entries in this section
SHT_HASH	Symbol table to which the hash table applies
SHT_REL SHT_RELA	Symbol table referenced by relocations
SHT_SYMTAB SHT_DYNSYM	String table used by entries in this section
Other	SHN_UNDEF

Table 11. Use of the sh_info Field

Section Type	*sh_info*
SHT_REL SHT_RELA	Section index of section to which the relocations apply
SHT_SYMTAB SHT_DYNSYM	Index of first non-local symbol (i.e., number of local symbols)
Other	0

```
[root@localhost 3]# readelf -S /bin/ls
There are 30 section headers, starting at offset 0x1c3e8:

Section Headers:
  [Nr] Name              Type             Address           Offset
       Size              EntSize          Flags  Link  Info  Align
  [ 0]                   NULL             0000000000000000  00000000
       0000000000000000  0000000000000000           0     0     0
  [ 1] .interp           PROGBITS         0000000000400238  00000238
       000000000000001c  0000000000000000   A       0     0     1
  [ 2] .note.ABI-tag     NOTE             0000000000400254  00000254
       0000000000000020  0000000000000000   A       0     0     4
  [ 3] .note.gnu.build-i NOTE             0000000000400274  00000274
       0000000000000024  0000000000000000   A       0     0     4
  [ 4] .gnu.hash         GNU_HASH         0000000000400298  00000298
       0000000000000038  0000000000000000   A       5     0     8
  [ 5] .dynsym           DYNSYM           00000000004002d0  000002d0
       0000000000000c18  0000000000000018   A       6     1     8
  [ 6] .dynstr           STRTAB           0000000000400ee8  00000ee8
```

```
       0000000000000572  0000000000000000   A       0     0     1
  [ 7] .gnu.version      VERSYM           000000000040145a  0000145a
       0000000000000102  0000000000000002   A       5     0     2
  [ 8] .gnu.version_r    VERNEED          0000000000401560  00001560
       0000000000000090  0000000000000000   A       6     2     8
  [ 9] .rela.dyn         RELA             00000000004015f0  000015f0
       00000000000000d8  0000000000000018   A       5     0     8
  [10] .rela.plt         RELA             00000000004016c8  000016c8
       0000000000000ac8  0000000000000018  AI       5    24     8
  [11] .init             PROGBITS         0000000000402190  00002190
       000000000000001a  0000000000000000  AX       0     0     4
  [12] .plt              PROGBITS         00000000004021b0  000021b0
       0000000000000740  0000000000000010  AX       0     0     16
  [13] .text             PROGBITS         00000000004028f0  000028f0
       000000000001014a  0000000000000000  AX       0     0     16
  [14] .fini             PROGBITS         0000000000412a3c  00012a3c
       0000000000000009  0000000000000000  AX       0     0     4
  [15] .rodata           PROGBITS         0000000000412a60  00012a60
       0000000000003cce  0000000000000000   A       0     0     32
  [16] .eh_frame_hdr     PROGBITS         0000000000416730  00016730
       0000000000000754  0000000000000000   A       0     0     4
  [17] .eh_frame         PROGBITS         0000000000416e88  00016e88
       0000000000002704  0000000000000000   A       0     0     8
  [18] .init_array       INIT_ARRAY       000000000061a328  0001a328
       0000000000000008  0000000000000008  WA       0     0     8
  [19] .fini_array       FINI_ARRAY       000000000061a330  0001a330
       0000000000000008  0000000000000008  WA       0     0     8
  [20] .jcr              PROGBITS         000000000061a338  0001a338
       0000000000000008  0000000000000000  WA       0     0     8
  [21] .data.rel.ro      PROGBITS         000000000061a340  0001a340
       0000000000000a68  0000000000000000  WA       0     0     32
  [22] .dynamic          DYNAMIC          000000000061ada8  0001ada8
       0000000000000200  0000000000000010  WA       6     0     8
  [23] .got              PROGBITS         000000000061afa8  0001afa8
       0000000000000048  0000000000000008  WA       0     0     8
  [24] .got.plt          PROGBITS         000000000061b000  0001b000
       00000000000003b0  0000000000000008  WA       0     0     8
  [25] .data             PROGBITS         000000000061b3c0  0001b3c0
       0000000000000240  0000000000000000  WA       0     0     32
  [26] .bss              NOBITS           000000000061b600  0001b600
       0000000000000d20  0000000000000000  WA       0     0     32
  [27] .gnu_debuglink    PROGBITS         0000000000000000  0001b600
       0000000000000010  0000000000000000           0     0     4
  [28] .gnu_debugdata    PROGBITS         0000000000000000  0001b610
       0000000000000cb8  0000000000000000           0     0     1
  [29] .shstrtab         STRTAB           0000000000000000  0001c2c8
       000000000000011a  0000000000000000           0     0     1
Key to Flags:
  W (write), A (alloc), X (execute), M (merge), S (strings), I (info),
  L (link order), O (extra OS processing required), G (group), T (TLS),
  C (compressed), x (unknown), o (OS specific), E (exclude),
  l (large), p (processor specific)
```

```
[root@localhost 3]# xxd -s 0x1c3e8 -l 0x780 /bin/ls
001c3e8: 0000 0000 0000 0000 0000 0000 0000 0000  ................
001c3f8: 0000 0000 0000 0000 0000 0000 0000 0000  ................
001c408: 0000 0000 0000 0000 0000 0000 0000 0000  ................
```

```
001c418: 0000 0000 0000 0000 0000 0000 0000 0000  ................
001c428: 0b00 0000 0100 0000 0200 0000 0000 0000  ................
001c438: 3802 4000 0000 0000 3802 0000 0000 0000  8.@.....8.......
001c448: 1c00 0000 0000 0000 0000 0000 0000 0000  ................
001c458: 0100 0000 0000 0000 0000 0000 0000 0000  ................
001c468: 1300 0000 0700 0000 0200 0000 0000 0000  ................
001c478: 5402 4000 0000 0000 5402 0000 0000 0000  T.@.....T.......
001c488: 2000 0000 0000 0000 0000 0000 0000 0000   ...............
001c498: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001c4a8: 2100 0000 0700 0000 0200 0000 0000 0000  !...............
001c4b8: 7402 4000 0000 0000 7402 0000 0000 0000  t.@.....t.......
001c4c8: 2400 0000 0000 0000 0000 0000 0000 0000  $...............
001c4d8: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001c4e8: 3400 0000 f6ff ff6f 0200 0000 0000 0000  4......o........
001c4f8: 9802 4000 0000 0000 9802 0000 0000 0000  ..@.............
001c508: 3800 0000 0000 0000 0500 0000 0000 0000  8...............
001c518: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c528: 3e00 0000 0b00 0000 0200 0000 0000 0000  >...............
001c538: d002 4000 0000 0000 d002 0000 0000 0000  ..@.............
001c548: 180c 0000 0000 0000 0600 0000 0100 0000  ................
001c558: 0800 0000 0000 0000 1800 0000 0000 0000  ................
001c568: 4600 0000 0300 0000 0200 0000 0000 0000  F...............
001c578: e80e 4000 0000 0000 e80e 0000 0000 0000  ..@.............
001c588: 7205 0000 0000 0000 0000 0000 0000 0000  r...............
001c598: 0100 0000 0000 0000 0000 0000 0000 0000  ................
001c5a8: 4e00 0000 ffff ff6f 0200 0000 0000 0000  N......o........
001c5b8: 5a14 4000 0000 0000 5a14 0000 0000 0000  Z.@.....Z.......
001c5c8: 0201 0000 0000 0000 0500 0000 0000 0000  ................
001c5d8: 0200 0000 0000 0000 0200 0000 0000 0000  ................
001c5e8: 5b00 0000 feff ff6f 0200 0000 0000 0000  [......o........
001c5f8: 6015 4000 0000 0000 6015 0000 0000 0000  `.@.....`.......
001c608: 9000 0000 0000 0000 0600 0000 0200 0000  ................
001c618: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c628: 6a00 0000 0400 0000 0200 0000 0000 0000  j...............
001c638: f015 4000 0000 0000 f015 0000 0000 0000  ..@.............
001c648: d800 0000 0000 0000 0500 0000 0000 0000  ................
001c658: 0800 0000 0000 0000 1800 0000 0000 0000  ................
001c668: 7400 0000 0400 0000 4200 0000 0000 0000  t.......B.......
001c678: c816 4000 0000 0000 c816 0000 0000 0000  ..@.............
001c688: c80a 0000 0000 0000 0500 0000 1800 0000  ................
001c698: 0800 0000 0000 0000 1800 0000 0000 0000  ................
001c6a8: 7e00 0000 0100 0000 0600 0000 0000 0000  ~...............
001c6b8: 9021 4000 0000 0000 9021 0000 0000 0000  .!@......!......
001c6c8: 1a00 0000 0000 0000 0000 0000 0000 0000  ................
001c6d8: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001c6e8: 7900 0000 0100 0000 0600 0000 0000 0000  y...............
001c6f8: b021 4000 0000 0000 b021 0000 0000 0000  .!@......!......
001c708: 4007 0000 0000 0000 0000 0000 0000 0000  @...............
001c718: 1000 0000 0000 0000 1000 0000 0000 0000  ................
001c728: 8400 0000 0100 0000 0600 0000 0000 0000  ................
001c738: f028 4000 0000 0000 f028 0000 0000 0000  .(@......(......
001c748: 4a01 0100 0000 0000 0000 0000 0000 0000  J...............
001c758: 1000 0000 0000 0000 0000 0000 0000 0000  ................
001c768: 8a00 0000 0100 0000 0600 0000 0000 0000  ................
001c778: 3c2a 4100 0000 0000 3c2a 0100 0000 0000  <*A.....<*......
001c788: 0900 0000 0000 0000 0000 0000 0000 0000  ................
001c798: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001c7a8: 9000 0000 0100 0000 0200 0000 0000 0000  ................
```

```
001c7b8: 602a 4100 0000 0000 602a 0100 0000 0000  `*A.....`*......
001c7c8: ce3c 0000 0000 0000 0000 0000 0000 0000  .<..............
001c7d8: 2000 0000 0000 0000 0000 0000 0000 0000   ...............
001c7e8: 9800 0000 0100 0000 0200 0000 0000 0000  ................
001c7f8: 3067 4100 0000 0000 3067 0100 0000 0000  0gA.....0g......
001c808: 5407 0000 0000 0000 0000 0000 0000 0000  T...............
001c818: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001c828: a600 0000 0100 0000 0200 0000 0000 0000  ................
001c838: 886e 4100 0000 0000 886e 0100 0000 0000  .nA......n......
001c848: 0427 0000 0000 0000 0000 0000 0000 0000  .'..............
001c858: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c868: b000 0000 0e00 0000 0300 0000 0000 0000  ................
001c878: 28a3 6100 0000 0000 28a3 0100 0000 0000  (.a.....(.......
001c888: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c898: 0800 0000 0000 0000 0800 0000 0000 0000  ................
001c8a8: bc00 0000 0f00 0000 0300 0000 0000 0000  ................
001c8b8: 30a3 6100 0000 0000 30a3 0100 0000 0000  0.a.....0.......
001c8c8: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c8d8: 0800 0000 0000 0000 0800 0000 0000 0000  ................
001c8e8: c800 0000 0100 0000 0300 0000 0000 0000  ................
001c8f8: 38a3 6100 0000 0000 38a3 0100 0000 0000  8.a.....8.......
001c908: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c918: 0800 0000 0000 0000 0000 0000 0000 0000  ................
001c928: cd00 0000 0100 0000 0300 0000 0000 0000  ................
001c938: 40a3 6100 0000 0000 40a3 0100 0000 0000  @.a.....@.......
001c948: 680a 0000 0000 0000 0000 0000 0000 0000  h...............
001c958: 2000 0000 0000 0000 0000 0000 0000 0000   ...............
001c968: da00 0000 0600 0000 0300 0000 0000 0000  ................
001c978: a8ad 6100 0000 0000 a8ad 0100 0000 0000  ..a.............
001c988: 0002 0000 0000 0000 0600 0000 0000 0000  ................
001c998: 0800 0000 0000 0000 1000 0000 0000 0000  ................
001c9a8: e300 0000 0100 0000 0300 0000 0000 0000  ................
001c9b8: a8af 6100 0000 0000 a8af 0100 0000 0000  ..a.............
001c9c8: 4800 0000 0000 0000 0000 0000 0000 0000  H...............
001c9d8: 0800 0000 0000 0000 0800 0000 0000 0000  ................
001c9e8: e800 0000 0100 0000 0300 0000 0000 0000  ................
001c9f8: 00b0 6100 0000 0000 00b0 0100 0000 0000  ..a.............
001ca08: b003 0000 0000 0000 0000 0000 0000 0000  ................
001ca18: 0800 0000 0000 0000 0800 0000 0000 0000  ................
001ca28: f100 0000 0100 0000 0300 0000 0000 0000  ................
001ca38: c0b3 6100 0000 0000 c0b3 0100 0000 0000  ..a.............
001ca48: 4002 0000 0000 0000 0000 0000 0000 0000  @...............
001ca58: 2000 0000 0000 0000 0000 0000 0000 0000   ...............
001ca68: f700 0000 0800 0000 0300 0000 0000 0000  ................
001ca78: 00b6 6100 0000 0000 00b6 0100 0000 0000  ..a.............
001ca88: 200d 0000 0000 0000 0000 0000 0000 0000   ...............
001ca98: 2000 0000 0000 0000 0000 0000 0000 0000   ...............
001caa8: fc00 0000 0100 0000 0000 0000 0000 0000  ................
001cab8: 0000 0000 0000 0000 00b6 0100 0000 0000  ................
001cac8: 1000 0000 0000 0000 0000 0000 0000 0000  ................
001cad8: 0400 0000 0000 0000 0000 0000 0000 0000  ................
001cae8: 0b01 0000 0100 0000 0000 0000 0000 0000  ................
001caf8: 0000 0000 0000 0000 10b6 0100 0000 0000  ................
001cb08: b80c 0000 0000 0000 0000 0000 0000 0000  ................
001cb18: 0100 0000 0000 0000 0000 0000 0000 0000  ................
001cb28: 0100 0000 0300 0000 0000 0000 0000 0000  ................
001cb38: 0000 0000 0000 0000 c8c2 0100 0000 0000  ................
001cb48: 1a01 0000 0000 0000 0000 0000 0000 0000  ................
```

```
001cb58: 0100 0000 0000 0000 0000 0000 0000 0000  ................
```

6. gcc链接：collect2:ld//lib64/ld-linux-x86-64.so.2

动态链接

实验：
`[root@localhost 3]# cat Program1.c`

```
#include "Lib.h"

int main(void) {
   foobar(1);
   return 0;
}
```

`[root@localhost 3]# cat Program2.c`

```
#include "Lib.h"

int main(void) {
   foobar(2);
   return 0;
}
```

`[root@localhost 3]# cat Lib.c`

```
#include <stdio.h>

void foobar(int i) {
    printf("Printing from Lib.so %d\n", i);
}
```

`[root@localhost 3]# cat Lib.h`

```
#ifndef LIB_H
#define LIB_H

void foobar(int i);

#endif
```

```
[root@localhost 3]# gcc -fPIC -shared -o Lib.so Lib.c
[root@localhost 3]# gcc -o Program1 Program1.c ./Lib.so
[root@localhost 3]# gcc -o Program2 Program2.c ./Lib.so
```

7. elf装载

program headers

```
int main(void) {
    int a = 0x12345678;

    return 0;
}
```

```
[root@localhost tmp]# readelf -l test

Elf file type is EXEC (Executable file)
Entry point 0x400400
There are 9 program headers, starting at offset 64

Program Headers:
  Type           Offset             VirtAddr           PhysAddr
                 FileSiz            MemSiz              Flags  Align
  PHDR           0x0000000000000040 0x0000000000400040 0x0000000000400040
                 0x00000000000001f8 0x00000000000001f8  R E    8
  INTERP         0x0000000000000238 0x0000000000400238 0x0000000000400238
                 0x000000000000001c 0x000000000000001c  R      1
      [Requesting program interpreter: /lib64/ld-linux-x86-64.so.2]
  LOAD           0x0000000000000000 0x0000000000400000 0x0000000000400000
                 0x000000000000069c 0x000000000000069c  R E    200000
  LOAD           0x0000000000000e18 0x0000000000600e18 0x0000000000600e18
                 0x0000000000000220 0x0000000000000228  RW     200000
  DYNAMIC        0x0000000000000e28 0x0000000000600e28 0x0000000000600e28
                 0x00000000000001d0 0x00000000000001d0  RW     8
  NOTE           0x0000000000000254 0x0000000000400254 0x0000000000400254
                 0x0000000000000044 0x0000000000000044  R      4
  GNU_EH_FRAME   0x0000000000000574 0x0000000000400574 0x0000000000400574
                 0x0000000000000034 0x0000000000000034  R      4
  GNU_STACK      0x0000000000000000 0x0000000000000000 0x0000000000000000
                 0x0000000000000000 0x0000000000000000  RW     10
  GNU_RELRO      0x0000000000000e18 0x0000000000600e18 0x0000000000600e18
                 0x00000000000001e8 0x00000000000001e8  R      1

 Section to Segment mapping:
  Segment Sections...
   00
   01     .interp
   02     .interp .note.ABI-tag .note.gnu.build-id .gnu.hash .dynsym .dynstr
.gnu.version .gnu.version_r .rela.dyn .rela.plt .init .plt .text .fini .rodata
.eh_frame_hdr .eh_frame
   03     .init_array .fini_array .dynamic .got .got.plt .data .bss
   04     .dynamic
   05     .note.ABI-tag .note.gnu.build-id
   06     .eh_frame_hdr
   07
   08     .init_array .fini_array .dynamic .got
```

```
[root@localhost tmp]# xxd -s 0x40 -l 0x1f8 /tmp/test
0000040: 0600 0000 0500 0000 4000 0000 0000 0000  ........@.......
0000050: 4000 4000 0000 0000 4000 4000 0000 0000  @.@.....@.@.....
```

```
0000060: f801 0000 0000 0000 f801 0000 0000 0000  ................
0000070: 0800 0000 0000 0000 0300 0000 0400 0000  ................
0000080: 3802 0000 0000 0000 3802 4000 0000 0000  8.......8.@.....
0000090: 3802 4000 0000 0000 1c00 0000 0000 0000  8.@.............
00000a0: 1c00 0000 0000 0000 0100 0000 0000 0000  ................
00000b0: 0100 0000 0500 0000 0000 0000 0000 0000  ................
00000c0: 0000 4000 0000 0000 0000 4000 0000 0000  ..@.......@.....
00000d0: 9c06 0000 0000 0000 9c06 0000 0000 0000  ................
00000e0: 0000 2000 0000 0000 0100 0000 0600 0000  .. .............
00000f0: 180e 0000 0000 0000 180e 6000 0000 0000  ..........`.....
0000100: 180e 6000 0000 0000 2002 0000 0000 0000  ..`..... .......
0000110: 2802 0000 0000 0000 0000 2000 0000 0000  (......... .....
0000120: 0200 0000 0600 0000 280e 0000 0000 0000  ........(.......
0000130: 280e 6000 0000 0000 280e 6000 0000 0000  (.`.....(.`.....
0000140: d001 0000 0000 0000 d001 0000 0000 0000  ................
0000150: 0800 0000 0000 0000 0400 0000 0400 0000  ................
0000160: 5402 0000 0000 0000 5402 4000 0000 0000  T.......T.@.....
0000170: 5402 4000 0000 0000 4400 0000 0000 0000  T.@.....D.......
0000180: 4400 0000 0000 0000 0400 0000 0000 0000  D...............
0000190: 50e5 7464 0400 0000 7405 0000 0000 0000  P.td....t.......
00001a0: 7405 4000 0000 0000 7405 4000 0000 0000  t.@.....t.@.....
00001b0: 3400 0000 0000 0000 3400 0000 0000 0000  4.......4.......
00001c0: 0400 0000 0000 0000 51e5 7464 0600 0000  ........Q.td....
00001d0: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00001e0: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00001f0: 0000 0000 0000 0000 1000 0000 0000 0000  ................
0000200: 52e5 7464 0400 0000 180e 0000 0000 0000  R.td............
0000210: 180e 6000 0000 0000 180e 6000 0000 0000  ..`.......`.....
0000220: e801 0000 0000 0000 e801 0000 0000 0000  ................
0000230: 0100 0000 0000 0000                      ........
```

```
[root@localhost tmp]# xxd -s 0x40 -l 56 /tmp/test
0000040: 0600 0000 0500 0000 4000 0000 0000 0000  ........@.......
0000050: 4000 4000 0000 0000 4000 4000 0000 0000  @.@.....@.@.....
0000060: f801 0000 0000 0000 f801 0000 0000 0000  ................
0000070: 0800 0000 0000 0000                      ........
```

```
> ELF二进制文件load到内存并执行，内核源码：
> https://github.com/GabrielJiang-J/study_information/blob/master/%E4%BA%8C%E8%BF%9B%E5%88%B6%E5%88%86%E6%9E%90/linux/elf-64-gen.pdf
> linux-2.6.34/fs/binfmt_elf.c:elf_format.load_binary
> linux-2.6.34/arch/ia64/kernel/process.c:sys_execve
```

8. elf执行