

# Link 3A. Static Linking Overview

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## 1 Static Linking Overview

- Based on
- Creating Static Libraries
- Static Linking Examples
- `gcc -l, -L, and -Wl,option`

"Self-service Linux: Mastering the Art of Problem Determination",

Mark Wilding

"Computer Architecture: A Programmer's Perspective",

Bryant & O'Hallaron

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# Compiling 32-bit program on 64-bit gcc

- `gcc -v`
- `gcc -m32 t.c`
- `sudo apt-get install gcc-multilib`
- `sudo apt-get install g++-multilib`
- `-m32`
- `gcc-multilib`
- `g++-multilib`

# Example 1 codes

## main.c

```
#include <stdio.h>
#include "calc_mean.h"

int main(int argc, char* argv[]) {

    double m, v1 =5.2, v2 =7.9;

    m = mean(v1, v2);

    printf("The mean ");
    printf("of %3.2f ", v1);
    printf("and %3.2f ", v2);
    printf("is %3.2f\n", m);

    return 0;
}
```

## calc\_mean.h

```
double mean(double, double);
```

## calc\_mean.c

```
//#include <stdio.h>

double mean(double a, double b) {
    return (a+b) / 2;
}
```

<http://lsi.vc.ehu.eus/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>

## Example 1 creating a static library libmean.a

- a **static library** is basically a set of object files that were copied into a single file
  - first, `calc_mean.c` is turned into an object file:  
`gcc -c calc_mean.c -o calc_mean.o`
  - then, the archiver (**ar**) is invoked to produce a **static library** (named `libmean.a`) out of the object file `calc_mean.o`  
`ar rcs libmean.a calc_mean.o`
  - a library name must start with **lib** and have the suffix **.a**.

<http://lsi.vc.ehu.eus/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>

# Example | the archiver ar

- **ar** : a Linux tool to create, modify, and extract from archives  
some options
  - **r** replace files existing inside the archive
  - **c** create an archive if not already present
  - **s** create an object-file index into the archive

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

## Example 1 creating a shared library libmean.so (1)

- when an object file is created for shared libraries, it must be position independent
- the `-fPIC` option tells gcc to create position independent code

```
gcc -c -fPIC calc_mean.c -o calc_mean.o
```
- Now, create a shared library with the `-shared` option

```
gcc -shared -Wl,-soname,libmean.so.1 \  
-o libmean.so.1.0.1 calc_mean.o
```

<http://lsi.vc.ehu.eus/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>



## Example 1 (3-2)

- For some reason, gcc says:  
`cc1: warning: -fPIC ignored for target (all code is position independent)`
- It looks like `-fPIC` is not necessary on x86, but all manuals say, it's needed, so I use it too.
- Note: the library must start with the three letter `lib`

<http://lsi.vc.ehu.eus/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>

## Example 1 (5-1)

- Linking against static library (`libmean.a`)

```
gcc -static main.c -o s_linked -L. -lmean
```

- the first three letters (the `lib`) must not be specified,
- as well as the suffix (`.a`)

- Executing the statically linked program

```
./s_linked
```

<http://lsi.vc.ehu.es/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>

## Example 1 (5-2)

- Linking against shared library (`libmean.so`)

```
gcc main.c -o d_linked -L. -lmean
```

- e first three letters (the lib) must not be specified,
- as well as the suffix (`.so`)

- Executing the dynamically linked program

```
LD_LIBRARY_PATH=.  
./d_linked
```

<http://lsi.vc.ehu.eus/pablogn/docencia/ISO/Act5%20Libs/crealibdin.html>

## Example II (1)

- `gcc -c -o out.o out.c`
- `-c` means to create an intermediary object file, rather than an executable.
- `ar rcs libout.a out.o`
- This creates the static library. `r` means to insert with replacement, `c` means to create a new archive, and `s` means to write an index. As always, see the man page for more info.

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

## Example II (2)

```
TARGET = prog
$(TARGET): main.o lib.a gcc $^ -o $@
main.o: main.c gcc -c $< -o $@
lib.a: lib1.o lib2.o ar rcs $@ $^
lib1.o: lib1.c lib1.h gcc -c -o $@ $<
lib2.o: lib2.c lib2.h gcc -c -o $@ $<
clean: rm -f *.o *.a $(TARGET)
```

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

## Example II (3)

explaining the makefile:

target: prerequisites - the rule head  $\$@$  - means the target  $\$^*$  - means all prerequisites  $\$<$  - means just the first prerequisite

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

## Example II (5)

### main.c

```
#include <stdio.h>

#include "lib.h"

int main ( void )
{
    fun1(10);
    fun2(10);
    return 0;
}
```

### lib.h

```
#ifndef LIB_H_INCLUDED
#define LIB_H_INCLUDED

#include "lib1.h"
#include "lib2.h"

#endif
```

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

## Example II (6)

### lib1.c

```
#include "lib1.h"

#include <stdio.h>

void fun1 ( int x )
{
    printf("%i\n",x);
}
```

### lib1.h

```
#ifndef LIB1_H_INCLUDED
#define LIB1_H_INCLUDED

#ifdef __cplusplus
    extern "C" {
#endif

void fun1 ( int x );

#ifdef __cplusplus
    }
#endif

#endif /* LIB1_H_INCLUDED */
```

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>



## Example II (7)

### lib2.c

```
#include "lib2.h"

#include <stdio.h>

void fun2 ( int x )
{
    printf("%i\n",2*x);
}
```

### lib2.h

```
#ifndef LIB2_H_INCLUDED
#define LIB2_H_INCLUDED

#ifdef __cplusplus
    extern "C" {
#endif

void fun2 ( int x );

#ifdef __cplusplus
    }
#endif

#endif /* LIB2_H_INCLUDED */
```

<https://stackoverflow.com/questions/2734719/how-to-compile-a-static-library-in-linux>

# Static Linking Examples

- 1 Example Program
- 2 Static Linking Procedures
- 3 Static Linking Commands

# Example Program

## main.c

```
void swap();

int buf[2] = {1, 2};

int main()
{
    int tmp;

    swap();

    return 0;
}
```

## swap.c

```
extern int buf[];

int *p0 = &buf[0];
int *p1;

void swap()
{
    int tmp;

    p1 = &buf[1];

    tmp = *p0;
    *p0 = *p1;
    *p1 = tmp;
}
```

# Static Linking Procedures

cpp	preprocessor	main.c	main.i
cc1	compiler	main.i	main.s
as	assemble	main.s	main.o
cpp	preprocessor	swap.c	swap.i
cc1	compiler	swap.i	swap.s
as	assemble	swap.s	swap.o
ld	linker	main.o	p
		swap.o	

# Static Linking Commands

```
cpp main.c main.i
cc1 main.i -O2 -m32 -o main.s
as --32 -o main.o main.s
```

```
cpp swap.c swap.i
cc1 swap.i -O2 -m32 -o swap.s
as --32 -o swap.o swap.s
```

```
gcc -o p main.o swap.o
```

```
alias cc1=/usr/lib/gcc/x86_64-linux-gnu/5/cc1
```

```
ld -m elf_i386 -o p main.o swap.o -lc --entry_main --> not working
```

```
readelf -a main.o
readelf -a swap.o
```

# Intermediate and Assembly Files (main.i, main.s)

- 1 main.i
- 2 main.s

```
# 1 "main.c"
# 1 "<built-in>"
# 1 "<command-line>"
# 1 "/usr/include/stdc-predef.h" 1 3 4
# 1 "<command-line>" 2
# 1 "main.c"
void swap();

int buf[2] = {1, 2};

int main()
{
    int tmp;

    swap();

    return 0;
}
```

# main.s (1)

```
.file      "main.i"
.section   .text.unlikely,"ax",@progbits
.LCOLDB0:
.section   .text.startup,"ax",@progbits
.LHOTB0:
.p2align  4,,15
.globl    main
.type     main, @function

main:
.LFB0:
.cfi_startproc
leal     4(%esp), %ecx
.cfi_def_cfa 1, 0
andl     $-16, %esp
pushl    -4(%ecx)
pushl    %ebp
.cfi_escape 0x10,0x5,0x2,0x75,0
movl     %esp, %ebp
pushl    %ecx
.cfi_escape 0xf,0x3,0x75,0x7c,0x6
```



## main.s (2)

```
    subl     $4, %esp
    call    swap
    addl     $4, %esp
    xorl     %eax, %eax
    popl     %ecx
    .cfi_restore 1
    .cfi_def_cfa 1, 0
    popl     %ebp
    .cfi_restore 5
    leal     -4(%ecx), %esp
    .cfi_def_cfa 4, 4
    ret
    .cfi_endproc

.LFE0:
    .size    main, .-main
    .section .text.unlikely

.LCOLDE0:
    .section .text.startup
```

```
.LHOTE0:  
    .globl      buf  
    .data  
    .align 4  
    .type      buf, @object  
    .size      buf, 8  
  
buf:  
    .long      1  
    .long      2  
    .ident     "GCC: (Ubuntu 5.4.0-6ubuntu1~16.04.4) 5.4.0 20160609"  
    .section   .note.GNU-stack,"",@progbits
```

# Intermediate and Assembly Files (swap.i, swap.s)

- 1 swap.i
- 2 swap.s

```
# 1 "swap.c"
# 1 "<built-in>"
# 1 "<command-line>"
# 1 "/usr/include/stdc-predef.h" 1 3 4
# 1 "<command-line>" 2
# 1 "swap.c"
extern int buf[];

int *p0 = &buf[0];
int *p1;

void swap()
{
    int tmp;

    p1 = &buf[1];

    tmp = *p0;
    *p0 = *p1;
    *p1 = tmp;
}
```

# swap.s (1)

```
.file "swap.i"
.section .text.unlikely,"ax",@progbits
.LCOLDB0:
.text
.LHOTB0:
.p2align 4,,15
.globl swap
.type swap, @function

swap:
.LFB0:
.cfi_startproc
movl    p0, %eax
movl    buf+4, %ecx
movl    $buf+4, p1
movl    (%eax), %edx
movl    %ecx, (%eax)
movl    %edx, buf+4
ret
.cfi_endproc
.LFE0:
.size   swap, .-swap
.section .text.unlikely
```

```
.LCOLDE0:  
    .text  
.LHOTE0:  
    .comm    p1,4,4  
    .globl  p0  
    .data  
    .align  4  
    .type   p0, @object  
    .size   p0, 4  
  
p0:  
    .long   buf  
    .ident  "GCC: (Ubuntu 5.4.0-6ubuntu1~16.04.4) 5.4.0 20160609"  
    .section      .note.GNU-stack,"",@progbits
```

# Relocatable Object Files (main.o)

- 1 main.o ELF Header
- 2 main.o Section Header
- 3 main.o Section
- 4 main.o Symbol Table

# main.o (1) ELF Header

## ELF Header:

```
Magic: 7f 45 4c 46 01 01 01 00 00 00 00 00 00 00 00 00
Class: ELF32
Data: 2's complement, little endian
Version: 1 (current)
OS/ABI: UNIX - System V
ABI Version: 0
Type: REL (Relocatable file)
Machine: Intel 80386
Version: 0x1
Entry point address: 0x0
Start of program headers: 0 (bytes into file)
Start of section headers: 584 (bytes into file)
Flags: 0x0
Size of this header: 52 (bytes)
Size of program headers: 0 (bytes)
Number of program headers: 0
Size of section headers: 40 (bytes)
Number of section headers: 14
Section header string table index: 11
```



# main.o (2) Section Header

## Section Headers:

[Nr]	Name	Type	Addr	Off	Size	ES	Flg	Lk	Inf	Al
[ 0]		NULL	00000000	000000	000000	00		0	0	0
[ 1]	.text	PROGBITS	00000000	000034	000000	00	AX	0	0	1
[ 2]	.data	PROGBITS	00000000	000034	000008	00	WA	0	0	4
[ 3]	.bss	NOBITS	00000000	00003c	000000	00	WA	0	0	1
[ 4]	.text.unlikely	PROGBITS	00000000	00003c	000000	00	AX	0	0	1
[ 5]	.text.startup	PROGBITS	00000000	000040	000021	00	AX	0	0	16
[ 6]	.rel.text.startup	REL	00000000	0001c4	000008	08	I	12	5	4
[ 7]	.comment	PROGBITS	00000000	000061	000035	01	MS	0	0	1
[ 8]	.note.GNU-stack	PROGBITS	00000000	000096	000000	00		0	0	1
[ 9]	.eh_frame	PROGBITS	00000000	000098	000044	00	A	0	0	4
[10]	.rel.eh_frame	REL	00000000	0001cc	000008	08	I	12	9	4
[11]	.shstrtab	STRTAB	00000000	0001d4	000074	00		0	0	1
[12]	.symtab	SYMTAB	00000000	0000dc	0000d0	10		13	10	4
[13]	.strtab	STRTAB	00000000	0001ac	000016	00		0	0	1

## Key to Flags:

W (write), A (alloc), X (execute), M (merge), S (strings)

I (info), L (link order), G (group), T (TLS), E (exclude), x (unknown)

0 (extra OS processing required) o (OS specific), p (processor specific)

## main.o (3) Sections

There are no section groups in this file.

There are no program headers in this file.

Relocation section '.rel.text.startup' at offset 0x1c4 contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
00000012	00000b02	R_386_PC32	00000000	swap

Relocation section '.rel.eh\_frame' at offset 0x1cc contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
00000020	00000602	R_386_PC32	00000000	.text.startup

The decoding of unwind sections for machine type Intel 80386 is not currently supported.

# main.o (4) Symbol Table

Symbol table '.symtab' contains 13 entries:

Num:	Value	Size	Type	Bind	Vis	Ndx	Name
0:	00000000	0	NOTYPE	LOCAL	DEFAULT	UND	
1:	00000000	0	FILE	LOCAL	DEFAULT	ABS	main.i
2:	00000000	0	SECTION	LOCAL	DEFAULT	1	
3:	00000000	0	SECTION	LOCAL	DEFAULT	2	
4:	00000000	0	SECTION	LOCAL	DEFAULT	3	
5:	00000000	0	SECTION	LOCAL	DEFAULT	4	
6:	00000000	0	SECTION	LOCAL	DEFAULT	5	
7:	00000000	0	SECTION	LOCAL	DEFAULT	8	
8:	00000000	0	SECTION	LOCAL	DEFAULT	9	
9:	00000000	0	SECTION	LOCAL	DEFAULT	7	
10:	00000000	33	FUNC	GLOBAL	DEFAULT	5	main
11:	00000000	0	NOTYPE	GLOBAL	DEFAULT	UND	swap
12:	00000000	8	OBJECT	GLOBAL	DEFAULT	2	buf

No version information found in this file.

# Relocatable Object Files (swap.o)

- 1 swap.o ELF Header
- 2 swap.o Section Header
- 3 swap.o Section
- 4 swap.o Symbol Table

# swap.o (1) ELF Header

## ELF Header:

```
Magic: 7f 45 4c 46 01 01 01 00 00 00 00 00 00 00 00 00
Class: ELF32
Data: 2's complement, little endian
Version: 1 (current)
OS/ABI: UNIX - System V
ABI Version: 0
Type: REL (Relocatable file)
Machine: Intel 80386
Version: 0x1
Entry point address: 0x0
Start of program headers: 0 (bytes into file)
Start of section headers: 596 (bytes into file)
Flags: 0x0
Size of this header: 52 (bytes)
Size of program headers: 0 (bytes)
Number of program headers: 0
Size of section headers: 40 (bytes)
Number of section headers: 14
Section header string table index: 11
```

# swap.o (2) Section Header

## Section Headers:

[Nr]	Name	Type	Addr	Off	Size	ES	Flg	Lk	Inf	Al
[ 0]		NULL	00000000	000000	000000	00		0	0	0
[ 1]	.text	PROGBITS	00000000	000040	000020	00	AX	0	0	16
[ 2]	.rel.text	REL	00000000	0001b0	000028	08	I 12		1	4
[ 3]	.data	PROGBITS	00000000	000060	000004	00	WA	0	0	4
[ 4]	.rel.data	REL	00000000	0001d8	000008	08	I 12		3	4
[ 5]	.bss	NOBITS	00000000	000064	000000	00	WA	0	0	1
[ 6]	.text.unlikely	PROGBITS	00000000	000064	000000	00	AX	0	0	1
[ 7]	.comment	PROGBITS	00000000	000064	000035	01	MS	0	0	1
[ 8]	.note.GNU-stack	PROGBITS	00000000	000099	000000	00		0	0	1
[ 9]	.eh_frame	PROGBITS	00000000	00009c	00002c	00	A	0	0	4
[10]	.rel.eh_frame	REL	00000000	0001e0	000008	08	I 12		9	4
[11]	.shstrtab	STRTAB	00000000	0001e8	00006a	00		0	0	1
[12]	.symtab	SYMTAB	00000000	0000c8	0000d0	10		13	9	4
[13]	.strtab	STRTAB	00000000	000198	000017	00		0	0	1

## Key to Flags:

W (write), A (alloc), X (execute), M (merge), S (strings)

I (info), L (link order), G (group), T (TLS), E (exclude), x (unknown)

0 (extra OS processing required) o (OS specific), p (processor specific)

## swap.o (3) Sections

There are no section groups in this file.

There are no program headers in this file.

Relocation section '.rel.text' at offset 0x1b0 contains 5 entries:

Offset	Info	Type	Sym.Value	Sym. Name
00000001	00000a01	R_386_32	00000000	p0
00000007	00000b01	R_386_32	00000000	buf
0000000d	00000c01	R_386_32	00000004	p1
00000011	00000b01	R_386_32	00000000	buf
0000001b	00000b01	R_386_32	00000000	buf

Relocation section '.rel.data' at offset 0x1d8 contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
00000000	00000b01	R_386_32	00000000	buf

Relocation section '.rel.eh\_frame' at offset 0x1e0 contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
00000020	00000202	R_386_PC32	00000000	.text

The decoding of unwind sections for machine type Intel 80386 is not currently supported.

## swap.o (4) Symbol Table

Symbol table '.symtab' contains 13 entries:

Num:	Value	Size	Type	Bind	Vis	Ndx	Name
0:	00000000	0	NOTYPE	LOCAL	DEFAULT	UND	
1:	00000000	0	FILE	LOCAL	DEFAULT	ABS	swap.i
2:	00000000	0	SECTION	LOCAL	DEFAULT	1	
3:	00000000	0	SECTION	LOCAL	DEFAULT	3	
4:	00000000	0	SECTION	LOCAL	DEFAULT	5	
5:	00000000	0	SECTION	LOCAL	DEFAULT	6	
6:	00000000	0	SECTION	LOCAL	DEFAULT	8	
7:	00000000	0	SECTION	LOCAL	DEFAULT	9	
8:	00000000	0	SECTION	LOCAL	DEFAULT	7	
9:	00000000	32	FUNC	GLOBAL	DEFAULT	1	swap
10:	00000000	4	OBJECT	GLOBAL	DEFAULT	3	p0
11:	00000000	0	NOTYPE	GLOBAL	DEFAULT	UND	buf
12:	00000004	4	OBJECT	GLOBAL	DEFAULT	COM	p1

No version information found in this file.



# Executable Object Files (p)

- 1 p ELF Header
- 2 p Section Header
- 3 p Program Header
- 4 p Section to Segment Mapping
- 5 p Dynamic Sections
- 6 p Misc Sections
- 7 p Symbol Table
- 8 p Others

# p (1) ELF Header

## ELF Header:

```
Magic: 7f 45 4c 46 01 01 01 00 00 00 00 00 00 00 00 00
Class: ELF32
Data: 2's complement, little endian
Version: 1 (current)
OS/ABI: UNIX - System V
ABI Version: 0
Type: EXEC (Executable file)
Machine: Intel 80386
Version: 0x1
Entry point address: 0x8048301
Start of program headers: 52 (bytes into file)
Start of section headers: 6180 (bytes into file)
Flags: 0x0
Size of this header: 52 (bytes)
Size of program headers: 32 (bytes)
Number of program headers: 9
Size of section headers: 40 (bytes)
Number of section headers: 31
Section header string table index: 28
```

# p (2) Section Header (a)

## Section Headers:

[Nr]	Name	Type	Addr	Off	Size	ES	Flg	Lk	Inf	Al
[ 0]		NULL	00000000	000000	000000	00		0	0	0
[ 1]	.interp	PROGBITS	08048154	000154	000013	00	A	0	0	1
[ 2]	.note.ABI-tag	NOTE	08048168	000168	000020	00	A	0	0	4
[ 3]	.note.gnu.build-id	NOTE	08048188	000188	000024	00	A	0	0	4
[ 4]	.gnu.hash	GNU_HASH	080481ac	0001ac	000020	04	A	5	0	4
[ 5]	.dynsym	DYNSYM	080481cc	0001cc	000040	10	A	6	1	4
[ 6]	.dynstr	STRTAB	0804820c	00020c	000045	00	A	0	0	1
[ 7]	.gnu.version	VERSYM	08048252	000252	000008	02	A	5	0	2
[ 8]	.gnu.version_r	VERNEED	0804825c	00025c	000020	00	A	6	1	4
[ 9]	.rel.dyn	REL	0804827c	00027c	000008	08	A	5	0	4
[10]	.rel.plt	REL	08048284	000284	000008	08	AI	5	24	4
[11]	.init	PROGBITS	0804828c	00028c	000023	00	AX	0	0	4
[12]	.plt	PROGBITS	080482b0	0002b0	000020	04	AX	0	0	16
[13]	.plt.got	PROGBITS	080482d0	0002d0	000008	00	AX	0	0	8
[14]	.text	PROGBITS	080482e0	0002e0	0001a2	00	AX	0	0	16
[15]	.fini	PROGBITS	08048484	000484	000014	00	AX	0	0	4
[16]	.rodata	PROGBITS	08048498	000498	000008	00	A	0	0	4
[17]	.eh_frame_hdr	PROGBITS	080484a0	0004a0	000034	00	A	0	0	4
[18]	.eh_frame	PROGBITS	080484d4	0004d4	0000e0	00	A	0	0	4
[19]	.init_array	INIT_ARRAY	08049f08	000f08	000004	00	WA	0	0	4
[20]	.fini_array	FINI_ARRAY	08049f0c	000f0c	000004	00	WA	0	0	4

# p (3) Section Header (b)

[21]	.jcr	PROGBITS	08049f10	000f10	000004	00	WA	0	0	4
[22]	.dynamic	DYNAMIC	08049f14	000f14	0000e8	08	WA	6	0	4
[23]	.got	PROGBITS	08049ffc	000ffc	000004	04	WA	0	0	4
[24]	.got.plt	PROGBITS	0804a000	001000	000010	04	WA	0	0	4
[25]	.data	PROGBITS	0804a010	001010	000014	00	WA	0	0	4
[26]	.bss	NOBITS	0804a024	001024	000008	00	WA	0	0	4
[27]	.comment	PROGBITS	00000000	001024	000034	01	MS	0	0	1
[28]	.shstrtab	STRTAB	00000000	00171a	00010a	00		0	0	1
[29]	.symtab	SYMTAB	00000000	001058	000490	10		30	48	4
[30]	.strtab	STRTAB	00000000	0014e8	000232	00		0	0	1

Key to Flags:

W (write), A (alloc), X (execute), M (merge), S (strings)

I (info), L (link order), G (group), T (TLS), E (exclude), x (unknown)

0 (extra OS processing required) o (OS specific), p (processor specific)

# p (4) Program Header

## Program Headers:

Type	Offset	VirtAddr	PhysAddr	FileSiz	MemSiz	Flg	Align
PHDR	0x000034	0x08048034	0x08048034	0x00120	0x00120	R E	0x4
INTERP	0x000154	0x08048154	0x08048154	0x00013	0x00013	R	0x1
[Requesting program interpreter: /lib/ld-linux.so.2]							
LOAD	0x000000	0x08048000	0x08048000	0x005b4	0x005b4	R E	0x1000
LOAD	0x000f08	0x08049f08	0x08049f08	0x0011c	0x00124	RW	0x1000
DYNAMIC	0x000f14	0x08049f14	0x08049f14	0x000e8	0x000e8	RW	0x4
NOTE	0x000168	0x08048168	0x08048168	0x00044	0x00044	R	0x4
GNU_EH_FRAME	0x0004a0	0x080484a0	0x080484a0	0x00034	0x00034	R	0x4
GNU_STACK	0x000000	0x00000000	0x00000000	0x00000	0x00000	RW	0x10
GNU_RELRO	0x000f08	0x08049f08	0x08049f08	0x000f8	0x000f8	R	0x1

## p (5) Section to Segment Mapping

Section to Segment mapping:

Segment Sections...

00

01 .interp

02 .interp .note.ABI-tag .note.gnu.build-id .gnu.hash .dynsym .dynstr .gnu.v

03 .init\_array .fini\_array .jcr .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 .jcr .dynamic .got

## p (6) Dynamic Sections (a)

Dynamic section at offset 0xf14 contains 24 entries:

Tag	Type	Name/Value
0x00000001	(NEEDED)	Shared library: [libc.so.6]
0x0000000c	(INIT)	0x804828c
0x0000000d	(FINI)	0x8048484
0x00000019	(INIT_ARRAY)	0x8049f08
0x0000001b	(INIT_ARRAYSZ)	4 (bytes)
0x0000001a	(FINI_ARRAY)	0x8049f0c
0x0000001c	(FINI_ARRAYSZ)	4 (bytes)
0x6ffffef5	(GNU_HASH)	0x80481ac
0x00000005	(STRTAB)	0x804820c
0x00000006	(SYMTAB)	0x80481cc
0x0000000a	(STRSZ)	69 (bytes)
0x0000000b	(SYMENT)	16 (bytes)

## p (7) Dynamic Sections (b)

Dynamic section at offset 0xf14 contains 24 entries:

Tag	Type	Name/Value
0x00000003	(PLTGOT)	0x804a000
0x00000002	(PLTRELSZ)	8 (bytes)
0x00000014	(PLTREL)	REL
0x00000017	(JMPREL)	0x8048284
0x00000011	(REL)	0x804827c
0x00000012	(RELSZ)	8 (bytes)
0x00000013	(RELENT)	8 (bytes)
0x6fffffff	(VERNEED)	0x804825c
0x6fffffff	(VERNEEDNUM)	1
0x6fffffff0	(VERSYM)	0x8048252
0x00000000	(NULL)	0x0



## p (8) Misc Sections

Relocation section '.rel.dyn' at offset 0x27c contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
08049ffc	00000106	R_386_GLOB_DAT	00000000	__gmon_start__

Relocation section '.rel.plt' at offset 0x284 contains 1 entries:

Offset	Info	Type	Sym.Value	Sym. Name
0804a00c	00000207	R_386_JUMP_SLOT	00000000	__libc_start_main@GLIBC_2.0

The decoding of unwind sections for machine type Intel 80386 is not currently supported.

Symbol table '.dynsym' contains 4 entries:

Num:	Value	Size	Type	Bind	Vis	Ndx	Name
0:	00000000	0	NOTYPE	LOCAL	DEFAULT	UND	
1:	00000000	0	NOTYPE	WEAK	DEFAULT	UND	__gmon_start__
2:	00000000	0	FUNC	GLOBAL	DEFAULT	UND	__libc_start_main@GLIBC_2.0 (2)
3:	0804849c	4	OBJECT	GLOBAL	DEFAULT	16	_IO_stdin_used

# p (9) Symbol Table (a)

Symbol table '.symtab' contains 73 entries:

Num:	Value	Size	Type	Bind	Vis	Ndx	Name
0:	00000000	0	NOTYPE	LOCAL	DEFAULT	UND	
1:	08048154	0	SECTION	LOCAL	DEFAULT	1	
2:	08048168	0	SECTION	LOCAL	DEFAULT	2	
3:	08048188	0	SECTION	LOCAL	DEFAULT	3	
4:	080481ac	0	SECTION	LOCAL	DEFAULT	4	
5:	080481cc	0	SECTION	LOCAL	DEFAULT	5	
6:	0804820c	0	SECTION	LOCAL	DEFAULT	6	
7:	08048252	0	SECTION	LOCAL	DEFAULT	7	
8:	0804825c	0	SECTION	LOCAL	DEFAULT	8	
9:	0804827c	0	SECTION	LOCAL	DEFAULT	9	
10:	08048284	0	SECTION	LOCAL	DEFAULT	10	
11:	0804828c	0	SECTION	LOCAL	DEFAULT	11	
12:	080482b0	0	SECTION	LOCAL	DEFAULT	12	
13:	080482d0	0	SECTION	LOCAL	DEFAULT	13	
14:	080482e0	0	SECTION	LOCAL	DEFAULT	14	
15:	08048484	0	SECTION	LOCAL	DEFAULT	15	
16:	08048498	0	SECTION	LOCAL	DEFAULT	16	
17:	080484a0	0	SECTION	LOCAL	DEFAULT	17	
18:	080484d4	0	SECTION	LOCAL	DEFAULT	18	
19:	08049f08	0	SECTION	LOCAL	DEFAULT	19	
20:	08049f0c	0	SECTION	LOCAL	DEFAULT	20	

# p (10) Symbol Table (b)

21:	08049f10	0	SECTION	LOCAL	DEFAULT	21	
22:	08049f14	0	SECTION	LOCAL	DEFAULT	22	
23:	08049ffc	0	SECTION	LOCAL	DEFAULT	23	
24:	0804a000	0	SECTION	LOCAL	DEFAULT	24	
25:	0804a010	0	SECTION	LOCAL	DEFAULT	25	
26:	0804a024	0	SECTION	LOCAL	DEFAULT	26	
27:	00000000	0	SECTION	LOCAL	DEFAULT	27	
28:	00000000	0	FILE		DEFAULT	ABS	crtstuff.c
29:	08049f10	0	OBJECT	LOCAL	DEFAULT	21	__JCR_LIST__
30:	08048340	0	FUNC	LOCAL	DEFAULT	14	deregister_tm_clones
31:	08048370	0	FUNC	LOCAL	DEFAULT	14	register_tm_clones
32:	080483b0	0	FUNC	LOCAL	DEFAULT	14	__do_global_dtors_aux
33:	0804a024	1	OBJECT	LOCAL	DEFAULT	26	completed.7200
34:	08049f0c	0	OBJECT	LOCAL	DEFAULT	20	__do_global_dtors_aux_fin
35:	080483d0	0	FUNC	LOCAL	DEFAULT	14	frame_dummy
36:	08049f08	0	OBJECT	LOCAL	DEFAULT	19	__frame_dummy_init_array_
37:	00000000	0	FILE		DEFAULT	ABS	main.i
38:	00000000	0	FILE		DEFAULT	ABS	swap.i
39:	00000000	0	FILE		DEFAULT	ABS	crtstuff.c
40:	080485b0	0	OBJECT	LOCAL	DEFAULT	18	__FRAME_END__

# p (11) Symbol Table (c)

50:	08048330	4	FUNC	GLOBAL	HIDDEN	14	__x86.get_pc_thunk.bx
51:	0804a010	0	NOTYPE	WEAK	DEFAULT	25	data_start
52:	0804a024	0	NOTYPE	GLOBAL	DEFAULT	25	_edata
53:	0804a020	4	OBJECT	GLOBAL	DEFAULT	25	p0
54:	08048484	0	FUNC	GLOBAL	DEFAULT	15	_fini
55:	0804a010	0	NOTYPE	GLOBAL	DEFAULT	25	__data_start
56:	00000000	0	NOTYPE	WEAK	DEFAULT	UND	__gmon_start__
57:	0804a014	0	OBJECT	GLOBAL	HIDDEN	25	__dso_handle
58:	0804849c	4	OBJECT	GLOBAL	DEFAULT	16	_IO_stdin_used
59:	00000000	0	FUNC	GLOBAL	DEFAULT	UND	__libc_start_main@@GLIBC_
60:	08048420	93	FUNC	GLOBAL	DEFAULT	14	__libc_csu_init
61:	0804a02c	0	NOTYPE	GLOBAL	DEFAULT	26	_end
62:	08048301	0	FUNC	GLOBAL	DEFAULT	14	_start
63:	08048498	4	OBJECT	GLOBAL	DEFAULT	16	_fp_hw
64:	0804a018	8	OBJECT	GLOBAL	DEFAULT	25	buf
65:	0804a024	0	NOTYPE	GLOBAL	DEFAULT	26	__bss_start
66:	080482e0	33	FUNC	GLOBAL	DEFAULT	14	main
67:	0804a028	4	OBJECT	GLOBAL	DEFAULT	26	p1
68:	00000000	0	NOTYPE	WEAK	DEFAULT	UND	_Jv_RegisterClasses
69:	0804a024	0	OBJECT	GLOBAL	HIDDEN	25	__TMC_END__
70:	00000000	0	NOTYPE	WEAK	DEFAULT	UND	_ITM_registerTMCloneTable
71:	08048400	32	FUNC	GLOBAL	DEFAULT	14	swap
72:	0804828c	0	FUNC	GLOBAL	DEFAULT	11	_init

## p (12) Others

Histogram for '.gnu.hash' bucket list length (total of 2 buckets):

Length	Number	% of total	Coverage
0	1	( 50.0%)	
1	1	( 50.0%)	100.0%

Version symbols section '.gnu.version' contains 4 entries:

```
Addr: 0000000008048252  Offset: 0x000252  Link: 5 (.dynsym)
000:  0 (*local*)          0 (*local*)          2 (GLIBC_2.0)        1 (*global*)
```

Version needs section '.gnu.version\_r' contains 1 entries:

```
Addr: 0x000000000804825c  Offset: 0x00025c  Link: 6 (.dynstr)
000000:  Version: 1  File: libc.so.6  Cnt: 1
0x0010:  Name: GLIBC_2.0  Flags: none  Version: 2
```

Displaying notes found at file offset 0x00000168 with length 0x00000020:

Owner	Data size	Description
GNU	0x00000010	NT_GNU_ABI_TAG (ABI version tag)
OS: Linux, ABI: 2.6.32		

Displaying notes found at file offset 0x00000188 with length 0x00000024:

Owner	Data size	Description
GNU	0x00000014	NT_GNU_BUILD_ID (unique build ID bitstring)
Build ID: 1574c15c3270ef63673147a7608a8d225665af50		









# gcc -llibrary (1)

- `-llibrary`  
`-l library`
  - Search the library named `library` when linking
    - the second alternative with the library `-l library` as a separate argument is only for POSIX compliance and is not recommended
  - The `-l` option is passed directly to the linker by GCC.
  - the linker searches a standard list of directories for the library `library`
    - the directories searched include several standard system directories plus any that you specify with `-L`

man gcc

# gcc -llibrary (2)

- `-llibrary`
  - `-l library`
    - static libraries are archives of object files, and have file names like `liblibrary.a`
    - some targets also support shared libraries, which typically have names like `liblibrary.so`
    - if both static and shared libraries are found, the linker gives preference to linking with the shared library unless the `-static` option is used.

`man gcc`

# gcc -llibrary (3)

- `-llibrary`
  - l library
    - it makes a difference where in the command you write this option;
    - the linker searches and processes libraries and object files in the order they are specified.
      - Thus, `foo.o -lz bar.o` searches library `z` after file `foo.o` but before `bar.o`
      - if `bar.o` refers to functions in library `z`, those functions may not be loaded.

`man gcc`

- `-Ldir`
  - Add directory `dir` to the list of directories to be searched for `-l`.
- `-Lsearchdir`
  - `--library-path=searchdir`
    - add path `searchdir` to the list of paths that `ld` will search for archive libraries and `ld` control scripts.
    - you may use this option any number of times.
    - The directories are searched in the order in which they are specified on the command line.
    - Directories specified on the command line are searched before the default directories.

[http://ftp.gnu.org/old-gnu/Manuals/ld-2.9.1/html\\_node/ld\\_3.html](http://ftp.gnu.org/old-gnu/Manuals/ld-2.9.1/html_node/ld_3.html)

- -Ldir
- -Lsearchdir
  - library-path=searchdir
    - All -L options apply to all -l options, regardless of the order in which the options appear.
    - the default set of paths searched (without using -L) depends on which emulation mode ld is using, and in some cases also on how it was configured.
    - The paths can also be specified in a link script with the SEARCH\_DIR command.
    - Directories specified this way are searched at the point in which the linker script appears in the command line.

[http://ftp.gnu.org/old-gnu/Manuals/ld-2.9.1/html\\_node/ld\\_3.html](http://ftp.gnu.org/old-gnu/Manuals/ld-2.9.1/html_node/ld_3.html)

- -Wl,/option/
  - pass option as an *option* to the linker.
  - if option contains *commas*, it is split into multiple options at the *commas*
  - use the *comma* (,) syntax to *pass* an argument to the option.  
-Wl,-Map,output.map  
passes -Map output.map to the linker.
  - When using the GNU linker, you can also get the same effect with =  
-Wl,-Map=output.map

man gcc