

Embedded Software Essentials

Other Useful GNU Tools

C1 M2 V9



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GNU Binary Utilities

- Extra programs to help with the process of building
- These include
 - The Assembler (ar)
 - The Linker (ld)
 - Conversion of executables
 - Sizing compiled images
 - Library/Archive creation
 - Symbol Listing
 - Debugging
 - Many more!

```
alex@ubuntu14: ~/repos/ease-coursera/demos/c1/m2/v9
alex@ubuntu14:v9$ (test) ls -la /usr/bin/arm-none-eabi*
-rwxr-xr-x 1 root root 902876 Jun 28 08:48 /usr/bin/arm-none-eabi-addr2line
-rwxr-xr-x 1 root root 935648 Jun 28 08:48 /usr/bin/arm-none-eabi-ar
-rwxr-xr-x 1 root root 1508736 Jun 28 08:48 /usr/bin/arm-none-eabi-as
-rwxr-xr-x 1 root root 781840 Jun 28 08:48 /usr/bin/arm-none-eabi-c++
-rwxr-xr-x 1 root root 902652 Jun 28 08:48 /usr/bin/arm-none-eabi-c++filt
-rwxr-xr-x 1 root root 781840 Jun 28 08:48 /usr/bin/arm-none-eabi-cpp
-rwxr-xr-x 1 root root 30520 Jun 28 08:48 /usr/bin/arm-none-eabi-elfedit
-rwxr-xr-x 1 root root 781840 Jun 28 08:48 /usr/bin/arm-none-eabi-g++
-rwxr-xr-x 1 root root 777744 Jun 28 08:48 /usr/bin/arm-none-eabi-gcc
-rwxr-xr-x 1 root root 777744 Jun 28 08:48 /usr/bin/arm-none-eabi-gcc-5.4.1
-rwxr-xr-x 1 root root 26208 Jun 28 08:48 /usr/bin/arm-none-eabi-gcc-ar
-rwxr-xr-x 1 root root 26208 Jun 28 08:48 /usr/bin/arm-none-eabi-gcc-nm
-rwxr-xr-x 1 root root 26208 Jun 28 08:48 /usr/bin/arm-none-eabi-gcc-ranlib
-rwxr-xr-x 1 root root 452760 Jun 28 08:48 /usr/bin/arm-none-eabi-gcov
-rwxr-xr-x 1 root root 424080 Jun 28 08:48 /usr/bin/arm-none-eabi-gcov-tool
-rwxr-xr-x 1 root root 5530912 Jun 28 08:48 /usr/bin/arm-none-eabi-gdb
-rwxr-xr-x 1 root root 977340 Jun 28 08:48 /usr/bin/arm-none-eabi-gprof
-rwxr-xr-x 1 root root 1255520 Jun 28 08:48 /usr/bin/arm-none-eabi-ld
-rwxr-xr-x 1 root root 1255520 Jun 28 08:48 /usr/bin/arm-none-eabi-ld.bfd
-rwxr-xr-x 1 root root 915548 Jun 28 08:48 /usr/bin/arm-none-eabi-nm
-rwxr-xr-x 1 root root 1117788 Jun 28 08:48 /usr/bin/arm-none-eabi-objcopy
-rwxr-xr-x 1 root root 1372668 Jun 28 08:48 /usr/bin/arm-none-eabi-objdump
-rwxr-xr-x 1 root root 935648 Jun 28 08:48 /usr/bin/arm-none-eabi-ranlib
-rwxr-xr-x 1 root root 550876 Jun 28 08:48 /usr/bin/arm-none-eabi-readelf
-rwxr-xr-x 1 root root 902844 Jun 28 08:48 /usr/bin/arm-none-eabi-size
-rwxr-xr-x 1 root root 902908 Jun 28 08:48 /usr/bin/arm-none-eabi-strings
-rwxr-xr-x 1 root root 1117788 Jun 28 08:48 /usr/bin/arm-none-eabi-strip
alex@ubuntu14:v9$ (test)
```

Useful GNU Tools

Name	Purpose	ARM Executable
size	Lists the section sizes for object and executable files	arm-none-eabi-size
nm	Lists the symbols from object files	arm-none-eabi-nm
objcopy	Copies and translates object files	arm-none-eabi-objcopy
objdump	Displays information from object files	arm-none-eabi-objdump
readelf	Displays information from elf files	arm-none-eabi-readelf
gdb	GNU Project Debugger	gdb

GNU Size Utility

- Use GCC's size to display the sizes of the compiled sections inside your object files and executable file outputs
- Gives you an idea of your memory footprint is for you executable
 - Code Memory
 - Data Memory

```
alex@ubuntu14:v9$ (test) arm-none-eabi-size -Atd demo.out
demo.out :
section      size      addr
.init         12      32768
.text        34600      32780
.fini         12      67380
.rodata       1312      67392
.ARM.exidx      8      68704
.eh_frame      4      68712
.init_array    8     134252
.fini_array     4     134260
.jcr           4     134264
.data         2244     134272
.bss          112     136516
.stab         156         0
.stabstr       333         0
.comment       110         0
.debug_frame   4700         0
.ARM.attributes 40         0
Total        43659
```

All Memory sections compiled in output executable

```
alex@ubuntu14:v9$ (test) arm-none-eabi-size -Bx demo.out
text  data  bss  dec  hex filename
0x8c6c 0x8d4 0x70 38320 95b0 demo.out
alex@ubuntu14:v9$ (test) arm-none-eabi-size -Bd demo.out
text  data  bss  dec  hex filename
35948 2260 112 38320 95b0 demo.out
```

HEX

Decimal

```
alex@ubuntu14:v9$ (test) arm-none-eabi-size -Btd demo.out main.o my_file.o
text  data  bss  dec  hex filename
35948 2260 112 38320 95b0 demo.out
30    0    0    30    1e main.o
192   0    0    192   c0 my_file.o
36170 2260 112 38542 968e (TOTALS)
```

Each File Section size

NM Utility

- The symbol utility allows us to investigate the size of all the possible symbols that are defined in a given executable or object file
- Symbols are identifiers in your source code that can be referenced
 - Variables
 - Functions
 - Debug

Symbol Descriptions

- **T**: Code
- **R**: Read Only
- **D**: Initialized Data
- **B**: Uninitialized Data (BSS)

```
alex@ubuntu14:v9$ (test) arm-none-eabi-nm -S --defined --size-sort -s demo.out
000084f8 00000002 T _exit
0000850c 00000004 R _global_impure_ptr
00018960 00000004 D _impure_ptr
00018980 0000000a B memory
000083e0 00000010 T atexit
0000802c 00000018 t register_fini
00008194 0000001a T get_value
000081f0 0000001e T clear_all
00008174 0000001e T clear_value
0000800c 00000020 T exit
00008150 00000022 T set_value
000083f0 00000034 T __libc_fini_array
0000811c 00000034 T main
000081b0 0000003e T set_all
00008210 00000048 T __libc_init_array
00008258 0000008c T memset
00008424 000000d4 T __register_exitproc
000082e4 000000fc T __call_exitprocs
00018538 00000428 d impure_data
```

**All defined
symbols (variables
and code) in the
output executable**

NM example

- *my_file.c* contains 5 function definitions, no global variables
- Ending Code Address: 0xBE
 - ~190 Bytes of code Memory
- **Biggest Function:** *set_all*
- **Smallest Function:** *clear_value*, *set_value*

my_file.c Symbol Table

Name	Starting Address	Code Size [Bytes]
clear_all	0x00	0x22
clear_value	0x24	0x1E
get_value	0x44	0x1A
set_all	0x60	0x3E
set_value	0xA0	0x1E

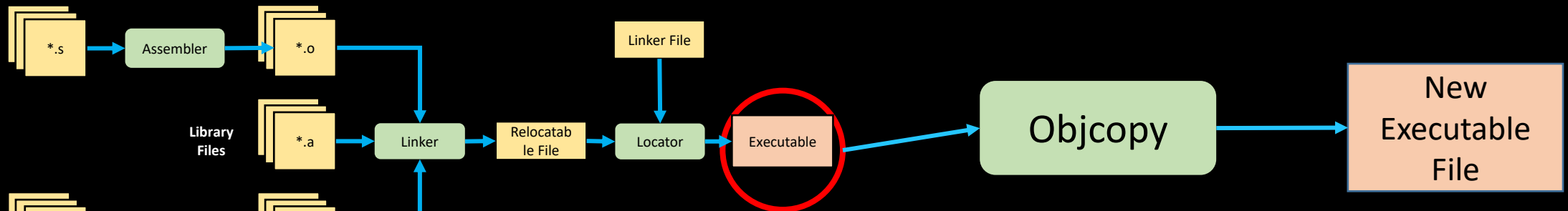
```
alex@ubuntu14:v9$ (test) arm-none-eabi-nm -S --defined -s my_file.o
000000a0 0000001e T clear_all
00000024 0000001e T clear_value
00000044 0000001a T get_value
00000060 0000003e T set_all
00000000 00000022 T set_value
```

Objcopy Utility

- The object copy utility is used to:
 - Convert objects files from one format to another
 - Make a copy of an object file
- Executables are a type of object file
 - Many different object file formats

Object Format Types:

- Binary
- srec (Motorola S-record)
- intel Hex Record (ihex)
- elf32-littlearm
- elf32-bigarm



```
$ arm-none-eabi-objcopy -O srec demo.out demo.s19
```


Objdump Utility

- Dumps information about an object file
 - Section Headers
 - Symbols
 - Debugging
- Can take object files and dump assembly from the machine code
 - Regular object files
 - Output Executables

demo: file format elf32-littlearm

Disassembly of section .init:

00008000 <_init>:

8000:	b5f8	push	{r3, r4, r5, r6, r7, lr}
8002:	46c0	nop	; (mov r8, r8)
8004:	bcf8	pop	{r3, r4, r5, r6, r7}
8006:	bc08	pop	{r3}
8008:	469e	mov	lr, r3
800a:	4770	bx	lr

Disassembly of section .text:

0000800c <exit>:

800c:	b510	push	{r4, lr}
800e:	2100	movs	r1, #0
8010:	0004	movs	r4, r0
8012:	f000 f967	bl	82e4 <__call_exitprocs>
8016:	4b04	ldr	r3, [pc, #16] ; (8028 <exit+0x1c>)
8018:	6818	ldr	r0, [r3, #0]
801a:	6bc3	ldr	r3, [r0, #60] ; 0x3c
801c:	2b00	cmp	r3, #0
801e:	d000	beq.n	8022 <exit+0x16>
8020:	4798	blx	r3
8022:	0020	movs	r0, r4
8024:	f000 fa68	bl	84f8 <_exit>
8028:	0000850c	.word	0x0000850c

Address

Machine
code

Assembly Instructions

Objdump Utility

- Debug symbols allow your C-program and assembly to intermix
- Debugger uses this debug software

C-programming
Statements

```
main.o:      file format elf32-littlearm

Disassembly of section .text:

00000000 <main>:
#include "my_memory.h"

extern char memory[MAX_LENGTH];

/* A pretty boring main file */
int main(void){
0:   b580          push    {r7, lr}
2:   af00          add     r7, sp, #0

clear_all(memory, MAX_LENGTH);
4:   4b0a          ldr     r3, [pc, #40]    ; (30 <main+0x30>)
6:   210a          movs    r1, #10
8:   0018          movs    r0, r3
a:   f7ff fffe     bl      0 <clear_all>
set_value(memory, 0xAA, 0);
e:   4b08          ldr     r3, [pc, #32]    ; (30 <main+0x30>)
10:  2200          movs    r2, #0
12:  21aa          movs    r1, #170        ; 0xaa
14:  0018          movs    r0, r3
16:  f7ff fffe     bl      0 <set_value>
set_value(memory, 0xFF, 1);
1a:  4b05          ldr     r3, [pc, #20]    ; (30 <main+0x30>)
1c:  2201          movs    r2, #1
1e:  21ff          movs    r1, #255        ; 0xff
20:  0018          movs    r0, r3
22:  f7ff fffe     bl      0 <set_value>

return 0;
26:  2300          movs    r3, #0
}
```

Address

Machine
code

Assembly Instructions

Readelf Utility

- Displays information about a ELF formatted file
 - Compiled Sections
 - Memory Sections
 - Symbol Tables
 - Architecture Specifics

ELF Files are not human readable
they contain lots of hidden
information in binary data

```
alex@ubuntu14:v9$ (test) arm-none-eabi-readelf demo.out --all
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:                             ARM
  Version:                             0x1
  Entry point address:                 0x80a5
  Start of program headers:            52 (bytes into file)
  Start of section headers:           39140 (bytes into file)
  Flags:                               0x5000200, Version5 EABI, soft-float ABI
  Size of this header:                 52 (bytes)
  Size of program headers:             32 (bytes)
  Number of program headers:           3
  Size of section headers:             40 (bytes)
  Number of section headers:           18
  Section header string table index: 15

Section Headers:
[Nr] Name                Type              Addr             Off             Size            ES Flg Lk Inf Al
[ 0]                     NULL              00000000         000000         000000         00   0  0  0  0
[ 1] .init                 PROGBITS          00008000         008000         00000c         00  AX  0  0  4
[ 2] .text                 PROGBITS          0000800c         00800c         0004f0         00  AX  0  0  4
[ 3] .fini                 PROGBITS          000084fc         0084fc         00000c         00  AX  0  0  4
[ 4] .rodata               PROGBITS          00008508         008508         000008         00   A  0  0  4
[ 5] .ARM.exidx            ARM_EXIDX         00008510         008510         000008         00  AL  2  0  4
[ 6] .eh_frame             PROGBITS          00008518         008518         000004         00   A  0  0  4
[ 7] .init_array            INIT_ARRAY        0001851c         00851c         000008         00  WA  0  0  4
[ 8] .fini_array            FINI_ARRAY        00018524         008524         000004         00  WA  0  0  4
[ 9] .jcr                  PROGBITS          00018528         008528         000004         00  WA  0  0  4
[10] .data                 PROGBITS          00018530         008530         000434         00  WA  0  0  8
[11] .bss                  NOBITS            00018964         008964         000028         00  WA  0  0  4
[12] .comment              PROGBITS          00000000         008964         00006e         01  MS  0  0  1
[13] .debug_frame          PROGBITS          00000000         0089d4         000184         00   0  0  4
[14] .ARM.attributes        ARM_ATTRIBUTES    00000000         008b58         000028         00   0  0  1
[15] .shstrtab              STRTAB            00000000         009849         000098         00   0  0  1
[16] .symtab                SYMTAB            00000000         008b80         0008b0         10   17 99  4
[17] .strtab                STRTAB            00000000         009430         000419         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)
O (extra OS processing required) o (OS specific), p (processor specific)
```