操作系统实验Lab1

1. Exercise 1.1

- 修改交叉编译路径为 /OSLAB/compiler/usr/bin/mips_4KC-

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ vim include.mk
jovyan@05d57a817610:~/kernel/1034180228-1ab$ cat include.mk
# Common includes in Makefile
#
# Copyright (C) 2007 Beihang University
# Written By Zhu Like ( zlike@cse.buaa.edu.cn )


CROSS_COMPILE :=  /OSLAB/compiler/usr/bin/mips_4KC-
CC                      := $(CROSS_COMPILE)gcc
CFLAGS          := -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC
LD                      := $(CROSS_COMPILE)ld
jovyan@05d57a817610:~/kernel/1034180228-1ab$ make
make --directory=boot
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/boot'
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I../include/ -c start.S
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/boot'
make --directory=drivers
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=gxconsole
make[2]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC   -c -o console.o console.c
make[2]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=init
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/init'
/OSLAB/compiler/usr/bin/mips_4KC-gcc  -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I../include -c init.c
/OSLAB/compiler/usr/bin/mips_4KC-gcc  -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I../include -c main.c
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/init'
make --directory=lib
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I./ -I../ -I../include/ -c print.c
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I./ -I../ -I../include/ -c printf.c
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-ld -o gxemul/vmlinux -N -T tools/scse0_3.lds boot/start.o init/main.o init/init.o drivers/gxconsole/console.o lib/*.o
jovyan@05d57a817610:~/kernel/1034180228-1ab$
```

- gxemul/ 目录下生成vmlinux 内核文件

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ cd gxemul/
jovyan@05d57a817610:~/kernel/1034180228-1ab/gxemul$ ls
elfinfo  r3000  r3000_test  test  vmlinux
jovyan@05d57a817610:~/kernel/1034180228-1ab/gxemul$
```

2. Exercise 1.2

2.1. 补全 readelf.c 文件

- 方法1

```c
// get section table addr, section header number and section header size.
shdr = (Elf32_Shdr *)(binary + ehdr -> e_shoff); //section table addr
sh_entry_count = ehdr -> e_shnum; //section header number
sh_entry_size = ehdr -> e_shentsize; //section header size
// for each section header, output section number and section addr.
for(Nr = 0; Nr < sh_entry_count; ++ Nr)
{
    printf("%d:0x%x\n" , Nr , shdr->sh_addr);
    shdr ++ ;
}
```

- 方法2

```c
// get section table addr, section header number and section header size.
ptr_sh_table = binary + ehdr -> e_shoff;
sh_entry_count = ehdr -> e_shnum; //section header number
sh_entry_size = ehdr -> e_shentsize; //section header size
// for each section header, output section number and section addr.
for(Nr = 0; Nr < sh_entry_count; ++ Nr)
{
    shdr = (Elf32_Shdr *)(ptr_sh_table);
    printf("%d:0x%x\n" , Nr , shdr->sh_addr);
    ptr_sh_table += sh_entry_size;
}
```

2.2. 解析 testELF 文件

```
jovyan@05d57a817610:~/kernel/1034180228-lab/readelf$ vim readelf.c
jovyan@05d57a817610:~/kernel/1034180228-lab/readelf$ make
gcc -I./ -c readelf.c
gcc main.o readelf.o -o readelf
jovyan@05d57a817610:~/kernel/1034180228-lab/readelf$ ./readelf testELF
0:0x0
1:0x8048154
2:0x8048168
3:0x8048188
4:0x80481ac
5:0x80481cc
6:0x804828c
7:0x804830e
8:0x8048328
9:0x8048358
10:0x8048360
11:0x80483b0
12:0x80483e0
13:0x8048490
14:0x804888c
15:0x80488a8
16:0x80488fc
17:0x8048940
18:0x8049f14
19:0x8049f1c
20:0x8049f24
21:0x8049f28
22:0x8049ff0
23:0x8049ff4
24:0x804a028
25:0x804a030
26:0x0
27:0x0
28:0x0
29:0x0
jovyan@05d57a817610:~/kernel/1034180228-lab/readelf$
```

```
jovyan@05d57a817610:~/kernel/1034180228-lab/readelf$ readelf -S testELF
There are 30 section headers, starting at offset 0x1158:

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-i 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 0000c0 10   A  6   1  4
  [ 6] .dynstr           STRTAB          0804828c 00028c 000081 00   A  0   0  1
  [ 7] .gnu.version      VERSYM          0804830e 00030e 000018 02   A  5   0  2
  [ 8] .gnu.version_r    VERNEED         08048328 000328 000030 00   A  6   1  4
  [ 9] .rel.dyn          REL             08048358 000358 000008 08   A  5   0  4
  [10] .rel.plt          REL             08048360 000360 000050 08   A  5  12  4
  [11] .init             PROGBITS        080483b0 0003b0 00002e 00  AX  0   0  4
  [12] .plt              PROGBITS        080483e0 0003e0 0000b0 04  AX  0   0 16
  [13] .text             PROGBITS        08048490 000490 0003fc 00  AX  0   0 16
  [14] .fini             PROGBITS        0804888c 00088c 00001a 00  AX  0   0  4
  [15] .rodata           PROGBITS        080488a8 0008a8 000053 00   A  0   0  4
  [16] .eh_frame_hdr     PROGBITS        080488fc 0008fc 000044 00   A  0   0  4
  [17] .eh_frame         PROGBITS        08048940 000940 000104 00   A  0   0  4
  [18] .ctors            PROGBITS        08049f14 000f14 000008 00  WA  0   0  4
  [19] .dtors            PROGBITS        08049f1c 000f1c 000008 00  WA  0   0  4
  [20] .jcr              PROGBITS        08049f24 000f24 000004 00  WA  0   0  4
  [21] .dynamic          DYNAMIC         08049f28 000f28 0000c8 08  WA  6   0  4
  [22] .got              PROGBITS        08049ff0 000ff0 000004 04  WA  0   0  4
  [23] .got.plt          PROGBITS        08049ff4 000ff4 000034 04  WA  0   0  4
  [24] .data             PROGBITS        0804a028 001028 000008 00  WA  0   0  4
  [25] .bss              NOBITS          0804a030 001030 000008 00  WA  0   0  4
  [26] .comment          PROGBITS        00000000 001030 00002a 01  MS  0   0  1
  [27] .shstrtab         STRTAB          00000000 00105a 0000fc 00      0   0  1
  [28] .symtab           SYMTAB          00000000 001608 0004b0 10     29  46  4
  [29] .strtab           STRTAB          00000000 001ab8 000294 00      0   0  1
Key to Flags:
  W (write), A (alloc), X (execute), M (merge), S (strings), I (info),
```

3. Exercise 1.3

3.1. 补全 tools/scse_03.lds

- 将起始地址设为 0x80010000

```asm
SECTIONS
{
  . = 0x80010000;
  .text : { *(.text) }
  .data : { *(.data) }
  .bss : { *(.bss) }
end = . ;
}
```

3.2. 查看地址

- 重新make，生成vmlinux内核文件

```
jovyan@05d57a817610:~/kernel/1034180228-lab$ cd tools/
jovyan@05d57a817610:~/kernel/1034180228-lab/tools$ vim scse0_3.lds
jovyan@05d57a817610:~/kernel/1034180228-lab/tools$ cd ..
jovyan@05d57a817610:~/kernel/1034180228-lab$ make
make --directory=boot
make[1]: Entering directory '/home/jovyan/kernel/1034180228-lab/boot'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-lab/boot'
make --directory=drivers
make[1]: Entering directory '/home/jovyan/kernel/1034180228-lab/drivers'
make --directory=gxconsole
make[2]: Entering directory '/home/jovyan/kernel/1034180228-lab/drivers/gxconsole'
make[2]: Nothing to be done for 'all'.
make[2]: Leaving directory '/home/jovyan/kernel/1034180228-lab/drivers/gxconsole'
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-lab/drivers'
make --directory=init
make[1]: Entering directory '/home/jovyan/kernel/1034180228-lab/init'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-lab/init'
make --directory=lib
make[1]: Entering directory '/home/jovyan/kernel/1034180228-lab/lib'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-lab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-ld -o gxemul/vmlinux -N -T tools/scse0_3.lds boot/start.o init/main.o init/init.o drivers/gxconsole/console.o lib/*.o
jovyan@05d57a817610:~/kernel/1034180228-lab$ cd gxemul/
```

- 查看各个section的地址

```
jovyan@05d57a817610:~/kernel/1034180228-lab$ cd gxemul/
jovyan@05d57a817610:~/kernel/1034180228-lab/gxemul$ readelf -S vmlinux
There are 14 section headers, starting at offset 0x90cc:

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        80010000 000080 000aa0 00  WAX  0   0 16
  [ 2] .reginfo          MIPS_REGINFO    80010aa0 000b20 000018 18   A  0   0  4
  [ 3] .rodata.str1.4    PROGBITS        80010ab8 000b38 0000a2 01 AMS  0   0  4
  [ 4] .rodata           PROGBITS        80010b60 000be0 000210 00   A  0   0 16
  [ 5] .data             PROGBITS        80010d70 000df0 000000 00  WA  0   0 16
  [ 6] .data.stk         PROGBITS        80010d70 000df0 008000 00  WA  0   0  1
  [ 7] .bss              NOBITS          80018d70 008df0 000000 00  WA  0   0 16
  [ 8] .pdr              PROGBITS        00000000 008df0 0001a0 00      0   0  4
  [ 9] .mdebug.abi32     PROGBITS        00000000 008f90 000000 00      0   0  1
  [10] .comment          PROGBITS        00000000 008f90 0000c8 00      0   0  1
  [11] .shstrtab         STRTAB          00000000 009058 000072 00      0   0  1
  [12] .symtab           SYMTAB          00000000 0092fc 000250 10     13  24  4
  [13] .strtab           STRTAB          00000000 00954c 0000c2 00      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),
  p (processor specific)
jovyan@05d57a817610:~/kernel/1034180228-lab/gxemul$
```

4. Exercise 1.4

4.1. 补全 boot/start.S

- 栈指针地址应设为 0x80400000

```asm
/*To do:
  set up stack
  you can reference the memory layout in the include/mmu.h
*/
li sp, 0x80400000 // 设置栈指针
jal main // 跳转到main函数
nop
```

4.2. 运行 vmlinux 文件

- 重新make

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ vim boot/start.S
jovyan@05d57a817610:~/kernel/1034180228-1ab$ make
make --directory=boot
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/boot'
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I../include/ -c start.S
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/boot'
make --directory=drivers
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=gxconsole
make[2]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
make[2]: Nothing to be done for 'all'.
make[2]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=init
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/init'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/init'
make --directory=lib
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/lib'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-ld -o gxemul/vmlinux -N -T tools/scse0_3.lds boot/start.o init/main.o init/init.o drivers/gxconsole/console.o lib/*.o
jovyan@05d57a817610:~/kernel/1034180228-1ab$
```

- 执行命令 gxemul -E testmips -C R3000 -M 64 elf-file

elf-file为编译生成的vmlinux文件的路径

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ gxemul -E testmips -C R3000 -M 64 gxemul/vmlinux
GXemul 0.4.6    Copyright (C) 2003-2007  Anders Gavare
Read the source code and/or documentation for other Copyright messages.

Simple setup...
    net: simulating 10.0.0.0/8 (max outgoing: TCP=100, UDP=100)
        simulated gateway: 10.0.0.254 (60:50:40:30:20:10)
            using nameserver 192.168.100.254
    machine "default":
        memory: 64 MB
        cpu0: R3000 (I+D = 4+4 KB)
        machine: MIPS test machine
        loading gxemul/vmlinux
        starting cpu0 at 0x80010000
--------------------------------------------------------------------------------

main.:  main imain.:    main is start ...

 s start ...

tart ...

GXemul> quit
jovyan@05d57a817610:~/kernel/1034180228-1ab$
```

5. Exercise 1.5

5.1. 补全 lp_Print() 函数

- 找到 %

```c
/* scan for the next '%' */
while((*fmt) != '\0' && (*fmt) != '%') {
    OUTPUT(arg, fmt, 1);//其他字符，直接输出
    fmt ++ ;
}
/* flush the string found so far */

/* are we hitting the end? */
if((*fmt) == '\0' ) break; //结束了
```

- 取出参数

```c
/*init the variable */
longFlag = 0;
negFlag = 0;
width = 0;
ladjust = 0;//默认右对齐
prec = 0;
padc = ' ';

/* we found a '%' */
fmt ++ ;

/* check for other prefixes */

/*check for flag */
if(*fmt == '-') ladjust = 1, fmt ++;
else if(*fmt == '0') padc = '0' , fmt ++;

/*check for width */
for(; IsDigit(*fmt); fmt ++ ) width = width * 10 + Ctod(*fmt) ;

/*check for precision */
if(*fmt == '.')
{
    fmt ++ ;
    for(; IsDigit(*fmt); fmt ++ )
        prec = prec * 10 + Ctod(*fmt) ;
}

/* check for long */
if( *fmt == 'l' ) {
    longFlag = 1;
    fmt ++ ;
}
```

5.2. 输出结果

- 重新make

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ vim lib/print.c
jovyan@05d57a817610:~/kernel/1034180228-1ab$ make
make --directory=boot
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/boot'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/boot'
make --directory=drivers
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=gxconsole
make[2]: Entering directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
make[2]: Nothing to be done for 'all'.
make[2]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers/gxconsole'
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/drivers'
make --directory=init
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/init'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/init'
make --directory=lib
make[1]: Entering directory '/home/jovyan/kernel/1034180228-1ab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-gcc -O -G 0 -mno-abicalls -fno-builtin -Wa,-xgot -Wall -fPIC -I./ -I../ -I../include/ -c print.c
make[1]: Leaving directory '/home/jovyan/kernel/1034180228-1ab/lib'
/OSLAB/compiler/usr/bin/mips_4KC-ld -o gxemul/vmlinux -N -T tools/scse0_3.lds boot/start.o init/main.o init/init.o drivers/gxconsole/console.o lib/*.o
```

- 执行命令 `gxemul -E testmips -C R3000 -M 64 elf-file` ，查看输出结果

```
jovyan@05d57a817610:~/kernel/1034180228-1ab$ gxemul -E testmips -C R3000 -M 64 gxemul/vmlinux
GXemul 0.4.6    Copyright (C) 2003-2007  Anders Gavare
Read the source code and/or documentation for other Copyright messages.

Simple setup...
    net: simulating 10.0.0.0/8 (max outgoing: TCP=100, UDP=100)
        simulated gateway: 10.0.0.254 (60:50:40:30:20:10)
            using nameserver 192.168.100.254
    machine "default":
        memory: 64 MB
        cpu0: R3000 (I+D = 4+4 KB)
        machine: MIPS test machine
        loading gxemul/vmlinux
        starting cpu0 at 0x80010000
--------------------------------------------------------------------------------

main.c: main is start ...

init.c: mips_init() is called

panic at init.c:24: ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

GXemul> quit
jovyan@05d57a817610:~/kernel/1034180228-1ab$
```

5.3. push到远程进行测试

- `git push`

```
jovyan@05d57a817610:~/kernel/1034180228-lab$ git add -u
jovyan@05d57a817610:~/kernel/1034180228-lab$ git commit -m "Get result"
[lab1 8b50fb5] Get result
 2 files changed, 1 insertion(+), 1 deletion(-)
jovyan@05d57a817610:~/kernel/1034180228-lab$ git push origin lab1
Counting objects: 4, done.
Delta compression using up to 8 threads.
Compressing objects: 100% (4/4), done.
Writing objects: 100% (4/4), 426 bytes | 426.00 KiB/s, done.
Total 4 (delta 2), reused 0 (delta 0)
remote: **********************************************************************
remote:
remote:                     BUAA OSLAB AUTOTEST SYSTEM
remote:                    Copyright (c) BUAA 2015-2019
remote:
remote: **********************************************************************
remote:
remote: [ You are changing the branch: refs/heads/lab1. ]
remote:
remote: Autotest: Begin at Fri Apr 10 20:57:15 CST 2020
remote:
remote: warning: remote HEAD refers to nonexistent ref, unable to checkout.
remote:
remote: Switched to a new branch 'lab1'
remote: Branch lab1 set up to track remote branch lab1 from origin.
remote: lab variable value is lab1
remote: [ readelf.c found ]
```

- 结果

```
remote: End build at Fri Apr 10 20:57:30 CST 2020
remote: [ PASSED:5 ]
remote: [ TOTAL:5 ]
remote: [ You have passed all testcases of extra printf. ]
remote: [ You got 100 (of 100) this time. Fri Apr 10 20:57:40 CST 2020 ]
remote:
remote:
remote: >>>>>> Collecting autotest results >>>>>>
remote: Switched to a new branch 'lab1-result'
remote: Branch lab1-result set up to track remote branch lab1-result from origin.
remote: Already up-to-date.
remote: [lab1-result 54f0731] Judgement for lab1 at 2020-04-10T20:57:41+0800
remote:  1 file changed, 133 insertions(+)
remote:  create mode 100644 log/2020-04-10T20:57:15+0800.log
remote: To git@localhost:1034180228-lab
remote:    06583d2..54f0731  lab1-result -> lab1-result
remote: Please find the autotest log in lab1-result branch.
remote:
remote: [ Congratulations! You have passed the current lab. ]
remote: Switched to a new branch 'lab2'
remote: Branch lab2 set up to track remote branch lab2 from origin.
remote: [ lab2 already exists. ]
To 192.168.100.204:1034180228-lab
   a09b306..8b50fb5  lab1 -> lab1
jovyan@05d57a817610:~/kernel/1034180228-lab$
```

-

6. 奇怪的地方

刚开始我使用的实验指导书版本比较就。老师后来又发了一个最新版本的实验指导书。我开始做实验用的都是旧版本指导书里的交叉编译路径 `/opt/eldk/usr/bin/mips_4KC-` ， 在本地能正常的生成`vmlinux` 文件,没有报任何错误。但是当我`git push`到远程仓库时，测试结果显示报错了，显示交叉编译路径不对。

后来我把交叉编译路径改为新版本指导书里的交叉编译路径`/OSLAB/compiler/usr/bin/mips_4KC-`就能通过了，为什么老版本书籍里的路径在本地不会报错，远程就会报错呢？