Lab-2 report

刘卓瀚-21307130254

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task 1

1

`a2`

2

对`f`的调用在第`26`行（因为返回结果是固定的，编译器直接计算了此结果）

```
    26:   45b1                    li  a1,12
```

对`g`的调用在第`14`行（编译器内联了对函数的调用）

```
    14:   250d                    addiw   a0,a0,3
```

3

`0x64a`

4

`0x38`

5

```
He110 World
unsigned int i = 0x726c6400;
```

不需要修改

6

会打印出来在调用`printf`之前的第三个参数寄存器原有的值。因为给的format表明`printf`还需要接收两个`int`参数，所以按照约定他会从第三个参数寄存器中取出值作为第二个`%d`的值，但是由于我们没有给`printf`传递第三个参数，所以这个值是在调用`printf`函数之前第三个参数寄存器原有的值。

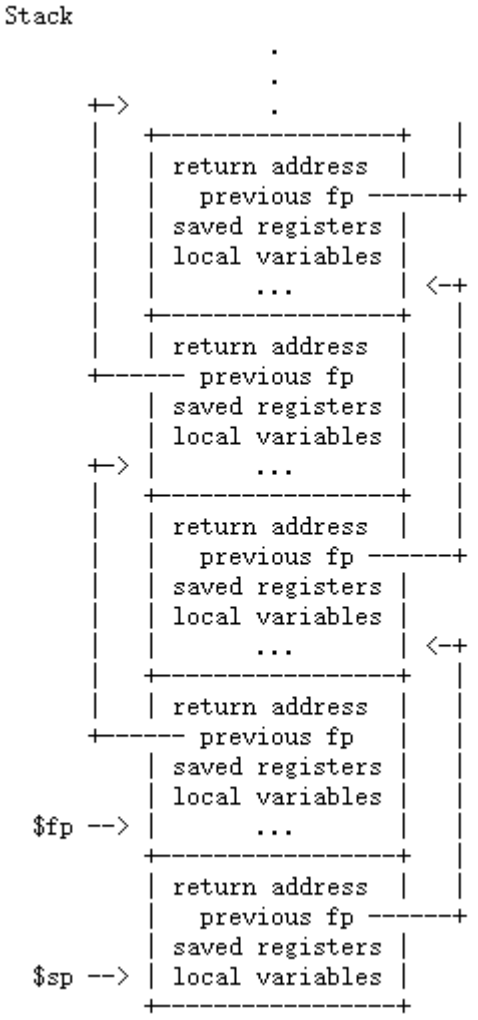
task 2

实现思路

- 获取当前fp指针

```
static inline uint64 r_fp() {
  uint64 x;
  asm volatile("mv %0, s0" : "=r" (x) );
  return x;
}
```

- 在kernel/defs.h添加backtrace()的声明，在kernel/printf.c中实现backtrace()：
  - 根据提示，内核栈都在同一个页中，栈帧依次向下扩展，所以最开始的调用函数的栈帧会从此页的起点处开始，即它的fp为此页的起点，且由于地址是与页大小对齐的，所以可以向上找到页大小的整数倍就是此页的起点了（根据PGROUNDUP()宏函数），以此为是否遍历到最开始的调用者的依据；
  - 根据如下所示的栈帧的排列，fp下8byte是函数的返回地址，下16byte是上一个函数的fp，所以可以打印返回地址并找到上一个函数的fp，以此类推，直到fp的值大于等于此页的起点，即遍历到最开始的调用者。




```
void backtrace()
{
  printf("backtrace:\n");
  uint64 fp = r_fp();
```

```
  uint64 kstart = PGROUNDUP(fp);
  while (fp < kstart)
  {
    printf("%p\n", *((uint64 *)fp - 1));
    fp = *((uint64 *)fp - 2);
  }
}
```

测试结果

```
xv6 kernel is booting

hart 2 starting
hart 1 starting
init: starting sh
$ bttest
backtrace:
0x00000000800021ca
0x00000000800020bc
0x0000000080001d72
```

```
● ➜ xv6-labs-2022 git:(traps) X addr2line -e kernel/kernel 0x00000000800021ca
  /home/kakilila/projects/xv6/xv6-labs-2022/kernel/sysproc.c:58
● ➜ xv6-labs-2022 git:(traps) X addr2line -e kernel/kernel 0x00000000800020bc
  /home/kakilila/projects/xv6/xv6-labs-2022/kernel/syscall.c:141
● ➜ xv6-labs-2022 git:(traps) X addr2line -e kernel/kernel 0x0000000080001d72
  /home/kakilila/projects/xv6/xv6-labs-2022/kernel/trap.c:78
```

实验中遇到的问题，如何思考并解决

- 看官方文档的描述以为`r_fp()`函数返回的是对`fp`的指针，所以一直少打印一个输出，实际上是返回`fp`的值

task 3

实现思路

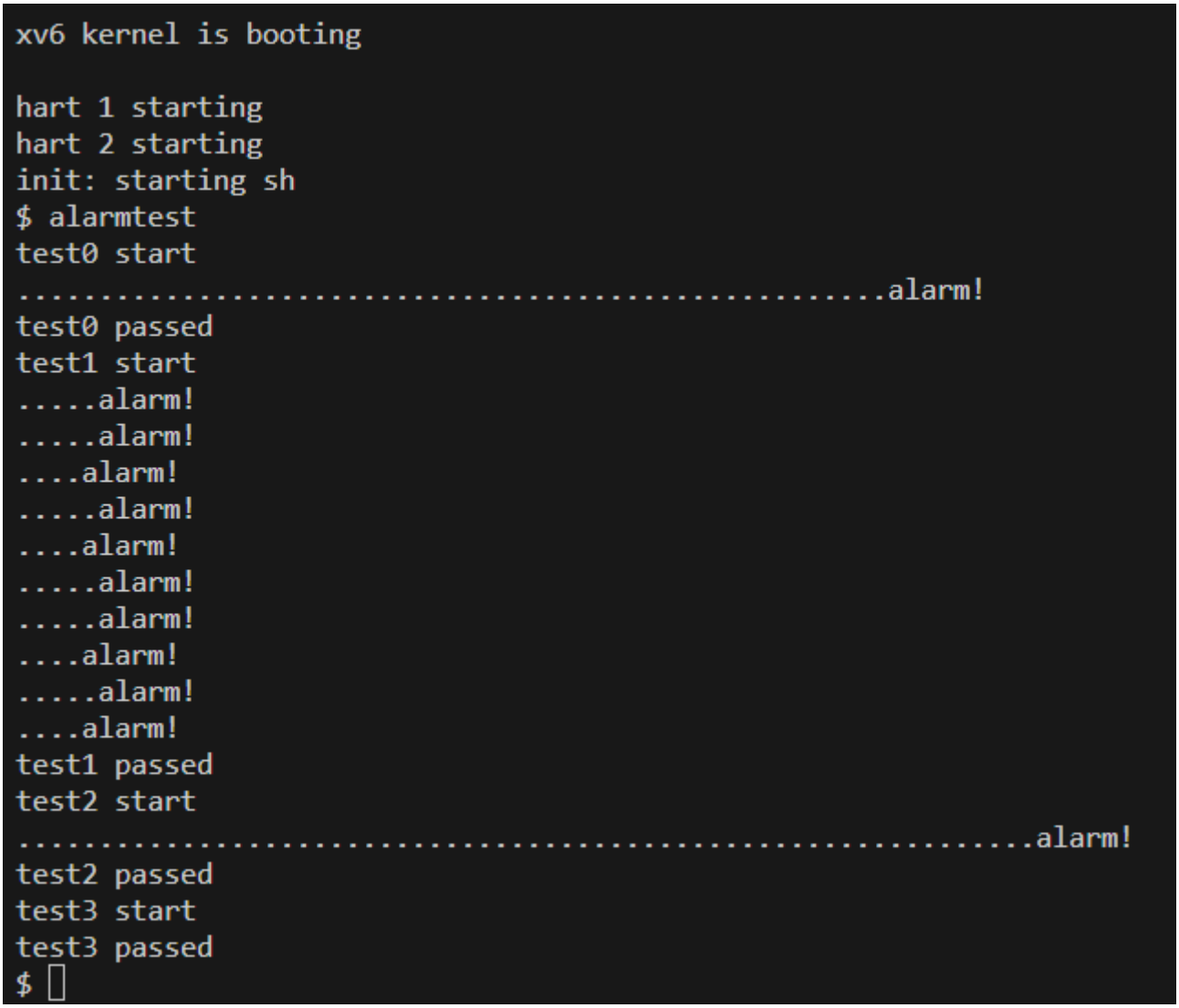
- 修改`kernel/sysproc.c kernel/syscall.c kernel/syscall.h user/usys.pl user/user.h`添加系统调用`sys_sigalarm()`和`sys_sigreturn()`
- task0：在`kernel/proc.h`中添加三个变量`uint64 handler; int ticks; int counter;`，分别表示alarm的处理函数、间隔数和当前的经过了多少个间隔
  - 在`sys_sigalarm()`中用`argint()`和`argaddr()`获取参数，然后将参数赋值给`ticks`和`handler`，并将`counter`置为0
  - 当cpu遇到时钟中断时（对应`kernel/trap.c`中`if (which_dev == 2)`的情况），先判断alarm是否开启（根据`ticks`是否大于`0`）如果是就递增`counter`，表示经过了一个时钟周期
  - 当`counter`大于等于`ticks`时，就调用`handler`，并将`counter`置为0；因为`handler`是用户态的函数，也会修改用户态中的变量，所以在内核态中不能直接调用，方法是将陷阱的返回地址由原本的`trapframe`中的`epc`改为`handler`的地址，这样从陷阱返回用户态的时候就会跳转到`handler`

中，所以只需把trapframe中的epc改为handler的地址即可，这样就能保证能跳到handler中，就能通过task0

- task1~3：虽然能调用handler，但是还需要保证handler结束之后能返回到最初被时钟中断的地方，并且相应的环境（寄存器的值）不能改变（handler是有可能改变寄存器的值的），也就是说，需要保证好像handler从没被调用一样，时钟中断好像仅仅完成了一次陷入陷阱和从陷阱中返回
    - 因为保证了handler的末尾一定会调用sigreturn，所以可以在将要调用handler的时候先保存此时的trapframe，然后在sys_sigreturn中将trapframe恢复，这样就能保证handler结束之后能返回到最初被时钟中断的地方，并且相应的环境（寄存器的值）不会改变；在proc结构体中新添加一项former_trapframe用于存储调用handler之前的trapframe
    - 要防止在执行handler的时候再次发生时钟中断，然后再次进入handler，所以在proc结构体中再添加一项int handler_end，表示handler是否结束，当其为1时才能进入handler，并且将其置为0；当handler结束，调用sigreturn时，在sys_sigreturn中将其置为1；还需要修改counter，因为在handler的处理过程中如果发生中断counter还是会递增，而counter应该表示的是在handler执行完之后经过的时钟周期，所以应该在sys_sigreturn中将counter置为0
    - 因为sys_return是有一个uint64的返回值的，会存储在a0中，在trampoline.S/userret中除了a0寄存器都会恢复，所以我们还需要额外恢复a0寄存器为former_trapframe中的a0，我的方法是直接将返回值设为former_trapframe中的a0
    - 在kernel/proc.c中，allocproc()中初始化proc中新添加的变量，在freeproc中释放新添加的变量

测试结果

alarmtest



usertests -q（暂时关闭了backtrace()，不然会打印很多）

```
$ usertests -q
usertests starting
test copyin: OK
test copyout: OK
test copyinstr1: OK
test copyinstr2: OK
test copyinstr3: OK
test rwsbrk: OK
test truncate1: OK
test truncate2: OK
test truncate3: OK
test openiput: OK
test exitiput: OK
test iput: OK
test opentest: OK
test writetest: OK
test writebig: OK
test createtest: OK
test dirtest: OK
test exectest: OK
```

```
test pipe1: OK
test killstatus: OK
test preempt: kill... wait... OK
test exitwait: OK
test reparent: OK
test twochildren: OK
test forkfork: OK
test forkforkfork: OK
test reparent2: OK
test mem: OK
test sharedfd: OK
test fourfiles: OK
test createdelete: OK
test unlinkread: OK
test linktest: OK
test concreate: OK
test linkunlink: OK
test subdir: OK
test bigwrite: OK
test bigfile: OK
test fourteen: OK
test rmdot: OK
test dirfile: OK
test iref: OK
test forktest: OK
test sbrkbasic: OK
test sbrkmuch: OK
test kernmem: usertrap(): unexpected scause 0x000000000000000d pid=6475
            sepc=0x00000000000021f2 stval=0x0000000080000000
usertrap(): unexpected scause 0x000000000000000d pid=6476
            sepc=0x00000000000021f2 stval=0x000000008000c350
usertrap(): unexpected scause 0x000000000000000d pid=6477
            sepc=0x00000000000021f2 stval=0x0000000800186a0
usertrap(): unexpected scause 0x000000000000000d pid=6478
            sepc=0x00000000000021f2 stval=0x0000000800249f0
usertrap(): unexpected scause 0x000000000000000d pid=6479
            sepc=0x00000000000021f2 stval=0x0000000080030d40
usertrap(): unexpected scause 0x000000000000000d pid=6480
            sepc=0x00000000000021f2 stval=0x000000008003d090
usertrap(): unexpected scause 0x000000000000000d pid=6481
            sepc=0x00000000000021f2 stval=0x0000000800493e0
usertrap(): unexpected scause 0x000000000000000d pid=6482
            sepc=0x00000000000021f2 stval=0x0000000080055730
usertrap(): unexpected scause 0x000000000000000d pid=6483
            sepc=0x00000000000021f2 stval=0x0000000080061a80
usertrap(): unexpected scause 0x000000000000000d pid=6484
            sepc=0x00000000000021f2 stval=0x000000008006ddd0
usertrap(): unexpected scause 0x000000000000000d pid=6485
            sepc=0x00000000000021f2 stval=0x000000008007a120
usertrap(): unexpected scause 0x000000000000000d pid=6486
            sepc=0x00000000000021f2 stval=0x0000000080086470
usertrap(): unexpected scause 0x000000000000000d pid=6487
            sepc=0x00000000000021f2 stval=0x0000000800927c0
usertrap(): unexpected scause 0x000000000000000d pid=6488
```

```
            sepc=0x00000000000021f2 stval=0x000000008009eb10
usertrap(): unexpected scause 0x000000000000000d pid=6489
            sepc=0x00000000000021f2 stval=0x00000000800aae60
usertrap(): unexpected scause 0x000000000000000d pid=6490
            sepc=0x00000000000021f2 stval=0x00000000800b71b0
usertrap(): unexpected scause 0x000000000000000d pid=6491
            sepc=0x00000000000021f2 stval=0x00000000800c3500
usertrap(): unexpected scause 0x000000000000000d pid=6492
            sepc=0x00000000000021f2 stval=0x00000000800cf850
usertrap(): unexpected scause 0x000000000000000d pid=6493
            sepc=0x00000000000021f2 stval=0x00000000800dbba0
usertrap(): unexpected scause 0x000000000000000d pid=6494
            sepc=0x00000000000021f2 stval=0x00000000800e7ef0
usertrap(): unexpected scause 0x000000000000000d pid=6495
            sepc=0x00000000000021f2 stval=0x00000000800f4240
usertrap(): unexpected scause 0x000000000000000d pid=6496
            sepc=0x00000000000021f2 stval=0x0000000080100590
usertrap(): unexpected scause 0x000000000000000d pid=6497
            sepc=0x00000000000021f2 stval=0x000000008010c8e0
usertrap(): unexpected scause 0x000000000000000d pid=6498
            sepc=0x00000000000021f2 stval=0x0000000080118c30
usertrap(): unexpected scause 0x000000000000000d pid=6499
            sepc=0x00000000000021f2 stval=0x0000000080124f80
usertrap(): unexpected scause 0x000000000000000d pid=6500
            sepc=0x00000000000021f2 stval=0x00000000801312d0
usertrap(): unexpected scause 0x000000000000000d pid=6501
            sepc=0x00000000000021f2 stval=0x000000008013d620
usertrap(): unexpected scause 0x000000000000000d pid=6502
            sepc=0x00000000000021f2 stval=0x0000000080149970
usertrap(): unexpected scause 0x000000000000000d pid=6503
            sepc=0x00000000000021f2 stval=0x0000000080155cc0
usertrap(): unexpected scause 0x000000000000000d pid=6504
            sepc=0x00000000000021f2 stval=0x0000000080162010
usertrap(): unexpected scause 0x000000000000000d pid=6505
            sepc=0x00000000000021f2 stval=0x000000008016e360
usertrap(): unexpected scause 0x000000000000000d pid=6506
            sepc=0x00000000000021f2 stval=0x000000008017a6b0
usertrap(): unexpected scause 0x000000000000000d pid=6507
            sepc=0x00000000000021f2 stval=0x0000000080186a00
usertrap(): unexpected scause 0x000000000000000d pid=6508
            sepc=0x00000000000021f2 stval=0x0000000080192d50
usertrap(): unexpected scause 0x000000000000000d pid=6509
            sepc=0x00000000000021f2 stval=0x000000008019f0a0
usertrap(): unexpected scause 0x000000000000000d pid=6510
            sepc=0x00000000000021f2 stval=0x00000000801ab3f0
usertrap(): unexpected scause 0x000000000000000d pid=6511
            sepc=0x00000000000021f2 stval=0x00000000801b7740
usertrap(): unexpected scause 0x000000000000000d pid=6512
            sepc=0x00000000000021f2 stval=0x00000000801c3a90
usertrap(): unexpected scause 0x000000000000000d pid=6513
            sepc=0x00000000000021f2 stval=0x00000000801cfde0
usertrap(): unexpected scause 0x000000000000000d pid=6514
            sepc=0x00000000000021f2 stval=0x00000000801dc130
OK
```

```
test MAXVAplus: usertrap(): unexpected scause 0x000000000000000f pid=6516
            sepc=0x000000000000229e stval=0x0000004000000000
usertrap(): unexpected scause 0x000000000000000f pid=6517
            sepc=0x000000000000229e stval=0x0000008000000000
usertrap(): unexpected scause 0x000000000000000f pid=6518
            sepc=0x000000000000229e stval=0x0000010000000000
usertrap(): unexpected scause 0x000000000000000f pid=6519
            sepc=0x000000000000229e stval=0x0000020000000000
usertrap(): unexpected scause 0x000000000000000f pid=6520
            sepc=0x000000000000229e stval=0x0000040000000000
usertrap(): unexpected scause 0x000000000000000f pid=6521
            sepc=0x000000000000229e stval=0x0000080000000000
usertrap(): unexpected scause 0x000000000000000f pid=6522
            sepc=0x000000000000229e stval=0x0000100000000000
usertrap(): unexpected scause 0x000000000000000f pid=6523
            sepc=0x000000000000229e stval=0x0000200000000000
usertrap(): unexpected scause 0x000000000000000f pid=6524
            sepc=0x000000000000229e stval=0x0000400000000000
usertrap(): unexpected scause 0x000000000000000f pid=6525
            sepc=0x000000000000229e stval=0x0000800000000000
usertrap(): unexpected scause 0x000000000000000f pid=6526
            sepc=0x000000000000229e stval=0x0001000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6527
            sepc=0x000000000000229e stval=0x0002000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6528
            sepc=0x000000000000229e stval=0x0004000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6529
            sepc=0x000000000000229e stval=0x0008000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6530
            sepc=0x000000000000229e stval=0x0010000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6531
            sepc=0x000000000000229e stval=0x0020000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6532
            sepc=0x000000000000229e stval=0x0040000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6533
            sepc=0x000000000000229e stval=0x0080000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6534
            sepc=0x000000000000229e stval=0x0100000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6535
            sepc=0x000000000000229e stval=0x0200000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6536
            sepc=0x000000000000229e stval=0x0400000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6537
            sepc=0x000000000000229e stval=0x0800000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6538
            sepc=0x000000000000229e stval=0x1000000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6539
            sepc=0x000000000000229e stval=0x2000000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6540
            sepc=0x000000000000229e stval=0x4000000000000000
usertrap(): unexpected scause 0x000000000000000f pid=6541
            sepc=0x000000000000229e stval=0x8000000000000000
OK
test sbrkfail: usertrap(): unexpected scause 0x000000000000000d pid=6553
```

```
             sepc=0x0000000000004994 stval=0x0000000000013000
OK
test sbrkarg: OK
test validatetest: OK
test bsstest: OK
test bigargtest: OK
test argptest: OK
test stacktest: usertrap(): unexpected scause 0x000000000000000d pid=6561
             sepc=0x0000000000002410 stval=0x0000000000010eb0
OK
test textwrite: usertrap(): unexpected scause 0x000000000000000f pid=6563
             sepc=0x0000000000002490 stval=0x0000000000000000
OK
test pgbug: OK
test sbrkbugs: usertrap(): unexpected scause 0x000000000000000c pid=6566
             sepc=0x0000000000005c5e stval=0x0000000000005c5e
usertrap(): unexpected scause 0x000000000000000c pid=6567
             sepc=0x0000000000005c5e stval=0x0000000000005c5e
OK
test sbrklast: OK
test sbrk8000: OK
test badarg: OK
ALL TESTS PASSED
```

实验中遇到的问题，如何思考并解决

- 真难!
- 一开始发现在内核态运行不了`handler`这个函数，debug发现`handler`的地址是0，就一直在纠结为什么是0，结果看`alarmtest.asm`和用`gdb`调试后才发现`periodic()`函数的地址本来就是0，然后就纠结怎么跳转到用户态为0的地址……后来想到了`handler`还要修改用户态的变量，所以应该在用户态执行
- 开始想改`usertrapret()`让他`w_sepc()`设置别的值，后来发现只需改改`epc`就好了，反正之后也会全部恢复的
- 搞了好久才真正理解题目要干什么