

## Lab3 Based on xv6

### Part 1. Prepare xv6.

在虚拟机中打开终端

安装 QEMU，在终端中输入

```
sudo apt-get install qemu-system  
qemu-system-i386 -version
```

```
y4n@y4n-virtual-machine:~/桌面$ qemu-system-i386 --version  
QEMU emulator version 6.2.0 (Debian 1:6.2+dfsg-2ubuntu6.22)  
Copyright (c) 2003-2021 Fabrice Bellard and the QEMU Project developers
```

设置 xv6，使用 `git clone` 命令从 GitHub 克隆 xv6 的公共仓库到本地目录，在终端中输入

```
cd ~  
git clone https://github.com/mit-pdos/xv6-public.git xv6  
进入 xv6 文件夹，使用 make 命令来编译 xv6，在终端中输入
```

```
cd xv6  
make
```

```
y4n@y4n-virtual-machine:~/xv6$ make  
make: "xv6.img"已是最新。
```

允许加载本地 `gdbinit`（只做一次），使用 `echo` 命令将 `add-auto-load-safe-path $HOME/xv6/.gdbinit` 添加到 `~/.gdbinit` 文件中，这样 GDB 就会自动加载 xv6 的调试配置，使用 `make qemu-gdb` 命令启动 QEMU，并附加 GDB 调试器，在终端中输入

```
echo "add-auto-load-safe-path $HOME/xv6/.gdbinit" > ~/.gdbinit  
make qemu-gdb
```

启动 QEMU 如图

```
QEMU [Paused]
Machine View
Guest has not initialized the display (yet).

register
register.py
shijian

"add-auto-load-safe-path $HOME

y4n@y4n-virtual-machine:~/xv6$ make qemu-gdb
*** Now run 'gdb'.
qemu-system-i386 -serial mon:stdio -drive file=fs.img,index=1,media=disk,format=raw -drive file=xv6.img,index=0,media=disk,format=raw -smp 2 -m 512 -S -gdb tcp::26000
```

开第二个终端，在运行 make 的同一目录下运行 gdb，在终端中输入

```
gdb -q -iex "set auto-load safe-path /home/y4n/xv6"
```

启动 GDB，并设置自动加载安全路径

```
y4n@y4n-virtual-machine:~/xv6$ gdb -q -iex "set auto-load safe-path /home/y4n/xv6"
+ target remote localhost:26000
warning: No executable has been specified and target does not support
determining executable automatically. Try using the "file" command.
The target architecture is set to "i8086".
[f000:fff0] 0xffff0: jmp 0x3630,0xf000e05b
0x0000fff0 in ?? ()
+ symbol-file kernel
warning: A handler for the OS ABI "GNU/Linux" is not built into this configuration
of GDB. Attempting to continue with the default i8086 settings.

(gdb)
```

在 gdb 中设置断点并继续执行

```
br * 0x0010000c
```

```
continue
```

```
(gdb) br * 0x0010000c
Breakpoint 1 at 0x10000c
(gdb) continue
Continuing.
The target architecture is set to "i386".
=> 0x10000c: mov %cr4,%eax

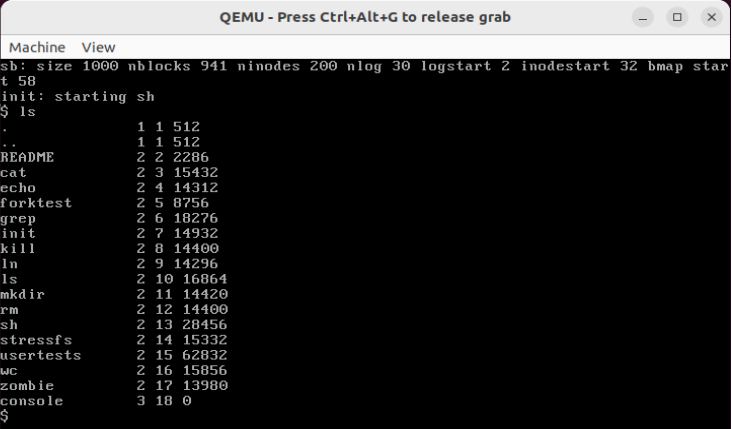
Thread 1 hit Breakpoint 1, 0x0010000c in ?? ()
```

查看文件系统

```
make qemu
```

```
ls
```

```
(gdb) make qemu
qemu-system-i386 -serial mon:stdio -drive file=fs.img,index=1,media=disk,format=raw -drive file=xv6.img,index=0,media=disk,format=raw -smp 2 -m 512
xv6...
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start 58
init: starting sh
$ ls
.          1 1 512
..         1 1 512
README    2 2 2286
cat        2 3 15432
echo       2 4 14312
```



配置完成

## Part 2. Adding a system call

需要修改以下文件，本实验统一使用 vim 修改

1. 编辑 syscall.c 文件，添加新的系统调用函数 sys\_wolfie 的声明

```
extern int sys_wolfie(void);
```

```
[SYS_wolfie] sys_wolfie,
```

```
extern int sys_wait(void);
extern int sys_write(void);
extern int sys_uptime(void);
extern int sys_wolfie(void);

static int (*syscalls[])(void) = {
```

```
[SYS_link] sys_link,
[SYS_mkdir] sys_mkdir,
[SYS_close] sys_close,
[SYS_wolfie] sys_wolfie,
};
```

2.编辑 syscall.h 文件, 定义新的系统调用编号 SYS\_wolfie

```
#define SYS_wolfie 22
```

```
#define SYS_unlink 18
#define SYS_link 19
#define SYS_mkdir 20
#define SYS_close 21
#define SYS_wolfie 22
```

3.编辑 user.h 文件, 添加用户级程序调用 wolfie 函数的声明

```
int wolfie(void* buf, unsigned int size);
```

```
int chdir(const char*);
int dup(int);
int getpid(void);
char* sbrk(int);
int sleep(int);
int uptime(void);
int wolfie(void* buf, unsigned int size);

// ulib.c
```

4.编辑 usys.S 文件, 添加新的系统调用的汇编代码

```
SYSCALL(wolfie)
```

```
SYSCALL(getpid)
SYSCALL(sbrk)
SYSCALL(sleep)
SYSCALL(uptime)
SYSCALL(wolfie)
```

5.在 sysproc.c 文件中实现 sys\_wolfie 函数, 它将用户空间的参数传递给内核空间的 wolfie 函数

```

int
sys_wolfie(void)
{
    char* buf;
    int size;
    if( argint(1, &size) < 0){
        return -1;
    }
    if( argptr(0, &buf, size) < 0){
        return -1;
    }
    return wolfie(buf, size);
}

```

```

//new syscall
int
sys_wolfie(void)
{
    char* buf;
    int size;
    if( argint(1, &size) < 0){
        return -1;
    }
    if( argptr(0, &buf, size) < 0){
        return -1;
    }
    return wolfie(buf, size);
}

```

6. 在 proc.c 文件中实现 wolfie 函数，该函数检查传入的缓冲区大小，并在满足条件时打印 ASCII 艺术图形并复制到用户空间的缓冲区

```

int
wolfie(char *buf, unsigned int size)
{
    if(size < 200)
    {
        return -1;
    }
}

```

```

char temp[300] = "*****\n*          name:y4n12345
                *\n*      ASCII Art      *\n*      (y4n@y4n12345.cn)      *\n**
*****\n";
cprintf(temp);
strncpy( (char*)buf, temp, size);
return 200;
}

```

```

int
wolfie(char *buf, unsigned int size)
{
    if(size < 200)
    {
        return -1;
    }
    char temp[300] = "*****\n*          name:y4n12345
                    *\n*      ASCII Art      *\n*      (y4n@y4n12345.cn)      *\n*****
*****\n";
    cprintf(temp);
    strncpy( (char*)buf, temp, size);
    return 200;
}

```

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7.编辑 Makefile 文件, 在 `UPROGS=\`中添加代码 `_wolfie\`以添加新的用户程序 `_wolfie`, 这样在编译时会包含这个程序

```
UPROGS=\
    _cat\
    _echo\
    _forktest\
    _grep\
    _init\
    _kill\
    _ln\
    _ls\
    _mkdir\
    _rm\
    _sh\
    _stressfs\
    _usertests\
    _wc\
    _zombie\
    _wolfie\
```

8.编辑 defs.h 文件，在 defs.h 文件中添加 wolfie 函数的声明，在 proc.c 中添加代码

```
int wolfie(char* buf, unsigned int size);
```

```

//PAGEBREAK: 16
// proc.c
int      cpuid(void);
void     exit(void);
int      fork(void);
int      growproc(int);
int      kill(int);
struct cpu* mycpu(void);
struct proc* myproc();
void     pinit(void);
void     procdump(void);
void     scheduler(void) __attribute__((noreturn));
void     sched(void);
void     setproc(struct proc*);
void     sleep(void*, struct spinlock*);
void     userinit(void);
int      wait(void);
void     wakeup(void*);
void     yield(void);
int      wolfie(char* buf, unsigned int size);

```

9.编写一个用户级应用程序 wolfie.c，它调用新的系统调用 wolfie，并将结果打印到控制台，具体代码如下

```

#include "types.h"
#include "stat.h"
#include "user.h"

void show_ans(int ans)
{
    if(ans == -1)
    {
        printf(0, "the buffer is not enough\n");
    }
    else
    {
        printf(0, "the string length is %d\n", ans);
    }
    printf(0, "\n");
}

```



```

    return;
}

int main(int argc, char* argv[])
{
    char buf_one[1000] = {0};
    printf(0, "create a buffer which size is 1000\n");
    int ans_one = wolfie(buf_one, 1000);
    show_ans(ans_one);
    printf(0, "%s", buf_one);

    char buf_two[10] = {0};
    printf(0, "create a buffer which size is 10\n");
    int ans_two = wolfie(buf_two, 10);
    show_ans(ans_two);

    return 0;
}

```

```

#include "types.h"
#include "stat.h"
#include "user.h"

void show_ans(int ans)
{
    if(ans == -1)
    {
        printf(0, "the buffer is not enough\n");
    }
    else
    {
        printf(0, "the string length is %d\n", ans);
    }
    printf(0, "\n");
    return;
}

```

```

int main(int argc, char* argv[])
{
    char buf_one[1000] = {0};
    printf(0, "create a buffer which size is 1000\n");
    int ans_one = wolfie(buf_one, 1000);
    show_ans(ans_one);
    printf(0, "%s", buf_one);

    char buf_two[10] = {0};
    printf(0, "create a buffer which size is 10\n");
    int ans_two = wolfie(buf_two, 10);
    show_ans(ans_two);

    return 0;
}

```

10.在终端中输入 `make qemu` 编译并运行 xv6，然后执行 `wolfie` 函数，可以看到第一次创建了一个 1000 个字符大小的数组，大于 200，调用系统函数后返回了长度，第二次创建了一个 10 个字符大小的数组，小于 200，调用系统函数后返回 `not enough` 的提示。

```

Machine View
Booting from Hard Disk...
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap
t 58
init: starting sh
$ wolfie
create a buffer which size is 1000
*****
*      name:y4n12345      *
*      ASCII Art        *
*      (y4n@y4n12345.cn) *
*****
the string length is 200

*****
*      name:y4n12345      *
*      ASCII Art        *
*      (y4n@y4n12345.cn) *
*****

create a buffer which size is 10
the buffer is not enough

pid 3 wolfie: trap 14 err 5 on cpu 0
$ -

pid 3 wolfie: trap 14 err 5 on cpu 0 eip 0xffffffff addr 0xffffffff--kill pr
oc
$

```

## Based on RISC-V

使用 git clone 命令从 GitHub 克隆 xv6-riscv 到本地目录，安装 gcc-riscv64-linux-gnu 编译程序，配置环境

```
git clone https://github.com/mit-pdos/xv6-riscv.git xv6-riscv
```

```
y4n@y4n-virtual-machine:~/xv6-riscv$ sudo apt-get install gcc-  
riscv64-linux-gnu  
[sudo] y4n 的密码:  
正在读取软件包列表... 完成  
正在分析软件包的依赖关系树... 完成  
正在读取状态信息... 完成
```

要添加一个新的系统调用需要修改以下文件

1. 编辑 kernel/syscall.c 文件，添加新的系统调用函数 sys\_wolfie 的声明

```
extern int sys_wolfie(void);  
[SYS_wolfie] sys_wolfie,
```

```
extern uint64 sys_open(void);  
extern uint64 sys_write(void);  
extern uint64 sys_mknod(void);  
extern uint64 sys_unlink(void);  
extern uint64 sys_link(void);  
extern uint64 sys_mkdir(void);  
extern uint64 sys_close(void);  
extern uint64 sys_wolfie(void);
```

```
[SYS_uptime] sys_uptime,  
[SYS_open] sys_open,  
[SYS_write] sys_write,  
[SYS_mknod] sys_mknod,  
[SYS_unlink] sys_unlink,  
[SYS_link] sys_link,  
[SYS_mkdir] sys_mkdir,  
[SYS_close] sys_close,  
[SYS_wolfie] sys_wolfie,  
};
```

2. 编辑 kernel/syscall.h 文件，定义新的系统调用编号 SYS\_wolfie

```
#define SYS_wolfie 22
```

```

#define SYS_write 16
#define SYS_mknod 17
#define SYS_unlink 18
#define SYS_link 19
#define SYS_mkdir 20
#define SYS_close 21
#define SYS_wolfie 22

```

3.编辑 user/user.h 文件，添加用户级程序调用 wolfie 函数的声明

```
int wolfie(void* buf, unsigned int size);
```

```

int getpid(void);
char* sbrk(int);
int sleep(int);
int uptime(void);
int wolfie(void* buf,unsigned int size);

```

4.编辑 user/usys.S 文件，定义一个名为 wolfie 的系统调用，当调用这个系统调用时，它会将系统调用号加载到 a7 寄存器，然后执行 ecall 指令来触发系统调用，最后通过 ret 指令返回到调用点。

```

.global wolfie
wolfie:
    li a7, SYS_wolfie
    ecall
    ret

```

li 指令是 "load immediate" 的缩写，用于将立即数加载到寄存器中。ecall 指令是环境调用 (environment call) 指令，用于触发系统调用。

5.编辑 user/usys.pl 文件，添加新的系统调用的汇编代码

```

entry("getpid");
entry("sbrk");
entry("sleep");
entry("uptime");
entry("wolfie");

```

6. 在 kernel/sysproc.c 文件中实现 sys\_wolfie 函数，它将用户空间的参数传递给内核空间的 wolfie 函数

```

uint64
sys_wolfie(void)
{
    char* buf;
    int size;
    if( argint(1, &size) < 0){
        return -1;
    }
    if( argptr(0, &buf, size) < 0){
        return -1;
    }
    return wolfie(buf, size);
}

```

7. 在 kernel/proc.c 文件中实现 wolfie 函数，该函数检查传入的缓冲区大小，并在满足条件时打印 ASCII 艺术图形并复制到用户空间的缓冲区

```

int
wolfie(char *buf, unsigned int size)
{
    if(size < 200)
    {
        return -1;
    }
    char temp[300] = "*****\n*          name:y4n12345          *\n*      ASCII Art      *\n*          (y4n@y4n12345.cn)          *\n*****\n";
    printk(temp);
    strncpy( (char*)buf, temp, size);
    return 200;
}

```

8.编辑 Makefile 文件, 在 `UPROGS=` 中添加代码 `$U/_wolfie\` 以添加新的用户程序\_wolfie, 这样在编译时会包含这个程序

```
$U/_usertests\  
$U/_grind\  
$U/_wc\  
$U/_zombie\  
$U/_wolfie\
```

9.编辑 kernel/defs.h 文件, 添加 wolfie 函数的声明,

```
int wolfie(char* buf, unsigned int size);
```

```
int          either_copyin(void *dst, int user_src, uint64 src, uint64  
);  
void          procdump(void);  
int          wolfie(char* buf, unsigned int size);
```

10.编写一个用户级应用程序 wolfie.c, 它调用新的系统调用 wolfie, 并将结果打印到控制台, 具体代码和结果如下, 这里使用相同的代码

```

#include "types.h"
#include "stat.h"
#include "user.h"

void show_ans(int ans)
{
    if(ans == -1)
    {
        printf(0, "the buffer is not enough\n");
    }
    else
    {
        printf(0, "the string length is %d\n", ans);
    }
    printf(0, "\n");
    return;
}

int main(int argc, char* argv[])
{
    char buf_one[1000] = {0};
    printf(0, "create a buffer which size is 1000\n");
    int ans_one = wolfie(buf_one, 1000);
    show_ans(ans_one);
    printf(0, "%s", buf_one);

    char buf_two[10] = {0};
    printf(0, "create a buffer which size is 10\n");
    int ans_two = wolfie(buf_two, 10);
    show_ans(ans_two);

    return 0;
}

```

\$wolfie

create a buffer which size is 1000

\*\*\*\*\*

```

*      name:y4n12345      *
*      ASCII Art         *
*      (y4n@y4n12345.cn) *

```

\*\*\*\*\*

the string length is 200

\*\*\*\*\*

```

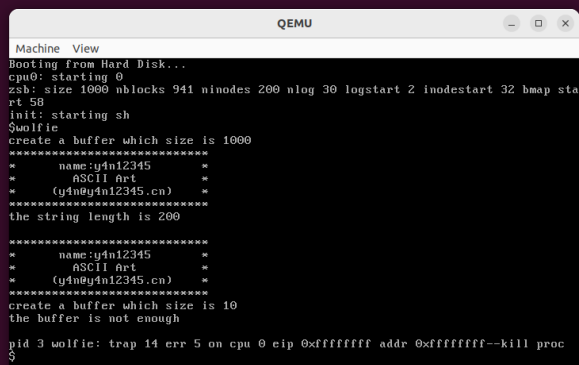
*      name:y4n12345      *
*      ASCII Art         *
*      (y4n@y4n12345.cn) *

```

\*\*\*\*\*

create a buffer which size is 10

the buffer is not enough



```

Machine View
Booting from Hard Disk...
cpu0: starting 0
zsb: size 1000 nblocks 941 minodes 200 nlog 30 logstart 2 inodestart 32 bmap sta
rt 50
init: starting sh
$wolfie
create a buffer which size is 1000
*****
*      name:y4n12345      *
*      ASCII Art         *
*      (y4n@y4n12345.cn) *
*****
the string length is 200
*****
*      name:y4n12345      *
*      ASCII Art         *
*      (y4n@y4n12345.cn) *
*****
create a buffer which size is 10
the buffer is not enough
pid 3 wolfie: trap 14 err 5 on cpu 0 cip 0xffffffff addr 0xffffffff--kill proc
$

```