Lab 1 - System Call Implementation

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Video Demo Link - https://youtu.be/DVp-2Bas94s

All Modified Files

- ~/kernel/ files:
  - Defs.h
  - Kalloc.c
  - Proc.c
  - Proc.h
  - Syscall.c
  - Syscall.h
  - Sysproc.c
- ~/user/ files:
  - User.h
  - Usys.pl
  - Test.c and lab1_test.c were created as test files for the syscalls
- Makefile

Change Explanations and Screenshots

Defs.h

```
110   void            print_hello(int);          // hello
111   int             sysinfo(int);              // sysinfo
112   int             procinfo(struct pinfo*);   // procinfo
```

Sysinfo and procinfo function headers were declared in defs.h

Kalloc.c

```
84  // Function to count the number of free pages
85  int
86  numFreePages(void)
87  {
88    // Declare variables
89    struct run *r;
90    int pageCount = 0;
91
92    // Loop through the freelist and count the number of pages
93    acquire(&kmem.lock);
94    for (r = kmem.freelist; r != 0; r = r->next) {
95      pageCount++;
96    }
97
98    // Return the count and release the lock
99    release(&kmem.lock);
100   return pageCount;
101 }
```

Function written to count the iterate over the list of free pages (kmem.freelist) and count each one

Proc.c

```
9   // Global variables
10  extern uint64 totalSyscalls;
11
12  // Outward functions
13  extern int numFreePages(void);
```

Global int to count totalSyscalls since boot declared
Global function header to count free pages (used in kalloc.c) declared

```
*/
int
sysinfo(int param)
{
  // Declare variables
  struct proc *p = myproc();
  struct proc *iter;
  int numProcs = 0;

  if (param == 0) {
    // Count the number of processes
    acquire(&p->lock);
    for (iter = proc; iter < &proc[NPROC]; ++iter) {
      if (iter->state != UNUSED) {
        numProcs++;
      }
    }
    release(&p->lock);
    return numProcs;
  }
  else if (param == 1) {
    // Count the number of system calls
    return totalSyscalls - 1;
  }
  else if (param == 2) {
    // Count the number of free pages
    return numFreePages();
  }
  else {
    // Return that an error occurred
    return -1;
  }
}
```

Functionality of sysinfo implemented. If param == 0, sysinfo will iterate over all processes and return the number of processes that are either READY, RUNNING, WAITING, or ZOMBIE (or simply put, not UNUSED). If param == 1 then it will return the global variable, totalSyscalls - 1. The -1 offset is to account for the fact that sysinfo itself is a syscall that should not be self counted. If param == 2 then sysinfo calls the global function, numFreePages() and returns the number of free pages in memory. If param is anything else then sysinfo will return -1 as an error code.

```c
int
procinfo(struct pinfo *in)
{
  // Declare variables
  struct proc *p = myproc();
  struct pinfo temp;

  // Check if the input is null
  if (!in) {
    return -1;
  }

  // Input the temp process info
  temp.ppid = p->parent->pid;
  temp.syscall_count = p->syscall_count - 1;
  temp.page_usage = p->sz / PGSIZE;

  // Copy the temp process info to the input process info
  if (copyout(p->pagetable, (uint64)in, (char *)&temp, sizeof(temp)) < 0) {
    return -1;
  }

  return 0;
}
```

Functionality of procinfo implemented. A proc pointer is declared to get the current process's PCB. A temp info struct is created since the kernel cannot write directly to the userspace info struct, in. If in is null then procinfo returns an error, otherwise procinfo will fill out the fields of temp based on data from the PCB from p. Once the data of temp is properly filled out, it is copied into the passed struct, in, using the copyout() function. This allows us to work around the fact that the kernel cannot write directly into the userspace memory.

Proc.h

```c
};

struct pinfo {
    int ppid;
    int syscall_count;
    int page_usage;
};
```

Pinfo struct declared to be filled out by the procinfo() syscall.

Syscall.c

```
10   // Global variables
11   uint64 totalSyscalls = 0;
```

Global variable to count syscalls initialized to 0 on bootup.

```
135  [SYS_hello]   =sys_hello,       // hello: syscall entry
136  [SYS_sysinfo] =sys_sysinfo,     // sysinfo: syscall entry
137  [SYS_procinfo] =sys_procinfo,    // procinfo: syscall entry
138  };
139
```

SYS_sysinfo and SYS_procinfo syscalls added to the entry table

```
146    num = p->trapframe->a7;
147    if (num > 0 && num < NELEM(syscalls) && syscalls[num]) {
148      // System call number is valid, increment totalSyscalls
149      totalSyscalls++;
150      p->syscall_count++;
151
152      // Use num to lookup the system call function for num, call it,
153      // and store its return value in p->trapframe->a0
154      p->trapframe->a0 = syscalls[num]();
155    }
```

Increment the global totalSyscalls and the calling process's syscall_count each time a successful is made.

Syscall.h

```
23   #define SYS_hello  22 // hello
24   #define SYS_sysinfo 23 // sysinfo
25   #define SYS_procinfo 24 // procinfo
26
```

Syscall numbers declared for sysinfo and procinfo

Sysproc.c

```
103  // sysinfo syscall definition
104  uint64
105  sys_sysinfo(void)
106  {
107    int n;
108    argint(0, &n);
109    return sysinfo(n);
110  }
111
112  // procinfo syscall definition
113  uint64
114  sys_procinfo(void)
115  {
116    struct pinfo *p;
117    argaddr(0, (uint64 *)&p);
118    return procinfo(p);
119  }
```

Sys_sysinfo and sys_procinfo functions implemented. In sys_sysinfo(), a integer is read from the command line and passed as a parameter to sysinfo() in proc.c. In sys_procinfo(), a pinfo struct pointer is declared and is pushed through argaddr() so that we can properly pass it to procinfo(). You cannot pass pointers as input to functions without this conversion via argaddr().

User.h

```
27   int sysinfo(int); // sysinfo
28   int procinfo(struct pinfo*); // procinfo
```

Function headers for sysinfo and procinfo declared in the userspace. The previous headers in defs.h were declared in the kernel space.

usys.pl

```
39  entry("hello"); # hello syscall for user
40  entry("sysinfo"); # sysinfo syscall for user
41  entry("procinfo"); # procinfo syscall for user
```

Lines 40 and 41 create wrapper functions in usys.S which will then call the appropriate system call. usys.S essentially acts as a medium between user and kernel space and usys.pl makes the user aware of the availability of the syscalls.

Makefile

```
135             $U/_test\
136             $U/_lab1_test\
```

Added these lines to the list of UPROGS for running the test files in qemu.

Lab1_test.c output

```
➜Antheagao 〈~/xv6-riscv 〉 Git:(⁉ riscv) make qemu
qemu-system-riscv64 -machine virt -bios none -kernel kernel/kernel
tio-mmio-bus.0

xv6 kernel is booting

init: starting sh
$ lab1_test 65535 2
[sysinfo] active proc: 3, syscalls: 51, free pages: 32564
[procinfo 4] ppid: 3, syscalls: 10, page usage: 20
[procinfo 5] ppid: 3, syscalls: 10, page usage: 20
[sysinfo] active proc: 5, syscalls: 243, free pages: 32510
$ lab1_test 65000 1
[sysinfo] active proc: 3, syscalls: 333, free pages: 32564
[procinfo 7] ppid: 6, syscalls: 10, page usage: 20
[sysinfo] active proc: 4, syscalls: 461, free pages: 32538
```

Description of XV6 Source Code

To start an info syscall, the user must perform a trap into the kernel space. When executing a trap, control is transferred to trap.c where it can determine that the user is performing a valid syscall. Once the validity is confirmed via syscall number (23 or 24), control is transferred to syscall.c which calls the correct function in sysproc.c. For 23 (sysinfo), it would call sys_sysinfo. Likewise, for 24 (procinfo), it would call sys_procinfo. The function in sysproc.c then calls the corresponding function in proc.c where the actual functionality of the syscall is implemented and returned. Once the syscall is done processing in proc.c, the return value is returned to the user via the trap frame initiated at the start of the syscall and control is given back to syscall.c which forwards control back to trap.c. Trap.c then restores the user's saved state before the syscall and returns control to the user at the point where he/she made the syscall.

Summary of Contributions

Jordan Kuschner mainly contributed on part 1 and the report/video demonstration. Jordan handled the initial setup and implemented the functionality of sysinfo(), as well as assisted on debugging part 2. A large majority of part 1 was implemented by Jordan.

Anthony Mendez mainly contributed on part 2, implementing most of the functionality of the procinfo() syscall, as well as debugging part 1 and making some minor edits to the final report. A large majority of part 2 was implemented by Anthony.