Recitation 9: Tshlab + VM

Instructor: TAs

Outline

- Labs
- Signals
- IO
- Virtual Memory

TshLab and MallocLab

- **TshLab due Tuesday**

- **MallocLab is released immediately after**
  - Start early
  - Do the checkpoint first, don’t immediately go for the final
  - Expect a recitation next week
    - Working for several hours will improve the value significantly

Blocking Signals

- The shell is currently running its handler for SIGCHLD.

- What signals can it receive?
- What signals can it not receive (i.e., blocked)?

Signals

- Parent process sends SIGINT to a child process.

- What is the default behavior of the child?
- What else could the child do?

More Signals

- Parent process sends SIGKILL to a child process.

- What is the default behavior of the child?
- What else could the child do?

Errno

- **Included from <errno.h>**
- **Global int variable – usually 0**
- **When a system call fails, it also will set errno to a value describing what went wrong**

- **Example: let’s assume there is no “foo.txt” in our path**

```
int fd = open(”foo.txt”, O_RDONLY);
if(fd < 0) printf(“%d\n”, errno);
```

- **The code above will print 2 – in the man pages, we can see that 2 is ENOENT “No such file or directory”**

Errno

- Included from <errno.h>
- Global int variable – usually 0
- When a system call fails, it also will set errno to a value describing what went wrong

- IN SHELL LAB, YOUR SIGNAL HANDLERS MUST PRESERVE ERRNO.

Sending Signals

- Parent sends SIGKILL to a child process.

```
...
    pid_t pid = ...; // child pid
    kill(pid, SIGKILL);
    // At this point, what has happened
    //   to the child process?
```

Signals

- **How many times is Hi printed?**

```
int main(int argc, char** argv)
{
    pid_t ppid = getpid(), cpid, tpid;
    cpid = fork();
    if (cpid == 0) tpid = ppid;
    else tpid = cpid;
    kill(tpid, SIGINT);
    write(STDOUT_FILENO, “Hi”, strlen(“Hi”));
    return 0;
}
```

IO functions

Needed for tshlab

- `int open(const char *pathname, int flags);`
  - Some important flags:
  - O_CREAT – creates file if needed, opens for read/write
  - O_RDWR – opens for read/write
  - O_RDONLY – opens for read only
- `int close(int fd);`
- `int dup2(int oldfd, int newfd);`

Needed for life

- `ssize_t read(int fd, void *buf, size_t count);`
- `ssize_t write(int fd, const void *buf, size_t count);`
- `off_t lseek(int fd, off_t offset, int whence);`

dup2

- **dup2(int oldfd, int newfd);**
  - Turns newfd into a copy of oldfd

- **Example: What would end up in foo.txt and bar.txt as a result of the following code?**

```
int fd1 = open("foo.txt",O_WRONLY);
int fd2 = open("bar.txt",O_WRONLY);
char *bufs[3] = {"Recieved SIGSEGV","core ","dumped"};
write(fd2, bufs[0],strlen(bufs[0]));
dup2(fd1,fd2);
write(fd2, bufs[1],strlen(bufs[1]));
write(fd1, bufs[2],strlen(bufs[2]));
```

IO and Fork()

- File descriptor management can be tricky.
- How many file descriptors are open in the parent process at the indicated point?
- How many does each child have open at the call to execve?

```
int main(int argc, char** argv)
{
    int i;
    for (i = 0; i < 4; i++)
    {
        int fd = open(“foo”, O_RDONLY);
        pid_t pid = fork();
        if (pid == 0)
        {
            int ofd = open(“bar”, O_RDONLY);
            execve(...);
        }
    }
    // How many file descriptors are open in the parent?
```

Redirecting IO

- File descriptors can be directed to identify different open files.

```
int main(int argc, char** argv)
{
    int i;
    for (i = 0; i < 4; i++)
    {
        int fd = open(“foo”, O_RDONLY);
        pid_t pid = fork();
        if (pid == 0)
        {
            int ofd = open(“bar”, O_WRONLY);
            dup2(fd, STDIN_FILENO);
            dup2(ofd, STDOUT_FILENO);
            execve(...);
        }
    }
    // How many file descriptors are open in the parent?
```

Redirecting IO

- At the two points (A and B) in main, how many file descriptors are open?

```
int main(int argc, char** argv)
{
    int i, fd;
    fd = open(“foo”, O_WRONLY);
    dup2(fd, STDOUT_FILENO);
    // Point A
    close(fd);
    // Point B
    ...
```

Memory Access

- The processor tries to write to a memory address.
- List different steps that are required to complete this operation.

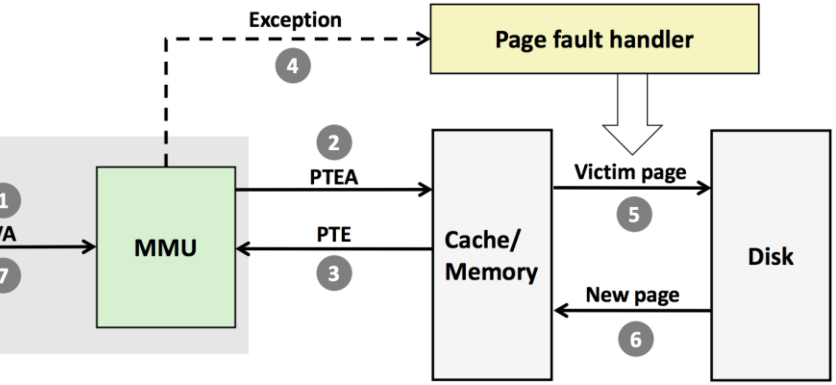
Memory Access

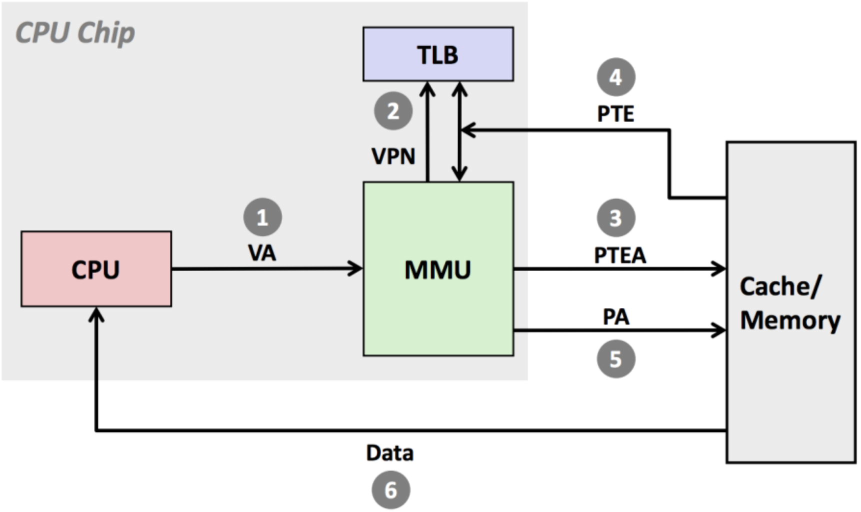
- The processor tries to write to a memory address.
- List some different steps that are required to complete this operation. (non exhaustive list)

- Virtual to physical address conversion (TLB lookup)
- TLB miss
- Page fault, page loaded from disk
- TLB updated, check permissions
- L1 Cache miss (and L2 … and)
- Request sent to memory
- Memory sends data to processor
- Cache updated

Memory Access

- The processor tries to write to a memory address.
- List different steps that are required to complete this operation. (non exhaustive list)





Address Translation with TLB

- **Translate 0x15213, given the contents of the TLB and the first 32 entries of the page table below.**
- **1MB Virtual Memory**
  256KB Physical Memory
  4KB page size

2-way set associative

Index	Tag	PPN	Valid
0	05	13	1
	3F	15	1
1	10	0F	1
	0F	1E	0
2	1F	01	1
	11	1F	0
3	03	2B	1
	1D	23	0

VPN	PPN	Valid	VPN	PPN	Valid
00	17	1	10	26	0
01	28	1	11	17	0
02	14	1	12	0E	1
03	0B	0	13	10	1
04	26	0	14	13	1
05	13	0	15	18	1
06	0F	1	16	31	1
07	10	1	17	12	0
08	1C	0	18	23	1
09	25	1	19	04	0
0A	31	0	1A	0C	1
0B	16	1	1B	2B	0
0C	01	0	1C	1E	0
0D	15	0	1D	3E	1
0E	0C	0	1E	27	1
0F	2B	1	1F	15	1

If you get stuck on TshLab

- **Read the writeup!**
- **Do manual unit testing before `runtrace` and `sdriver`!**
- **Post private questions on piazza!**

- **Read the man pages on the syscalls.**
  - Especially the error conditions
  - What errors should terminate the shell?
  - What errors should be reported?