Recitation 10

What’s Next???

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Milestone 1: You should be able to...

Scheduler:

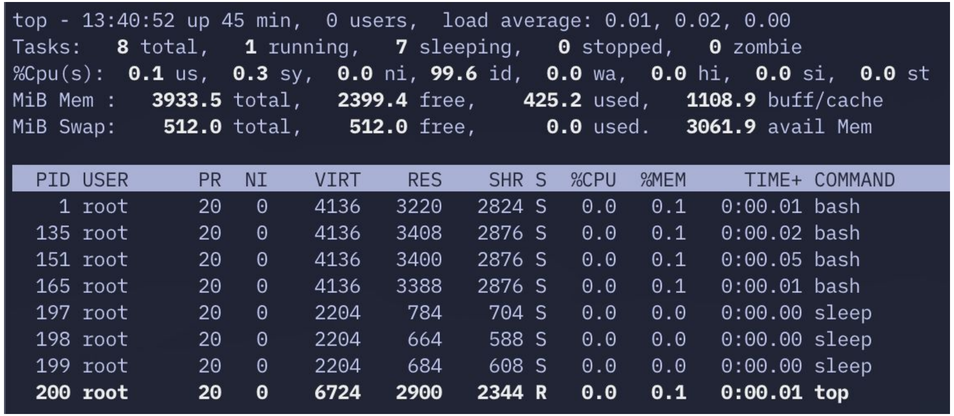
- Schedule processes with different priorities
- Send your own signals using k_process_kill
- Use the logger to debug

File System:

- mkfs and mount a file system
- Interact with the file system
    - What happens when you create a file? When you write to a file? ls? chmod?

Scheduler: Things to double check

- If all queues (-1, 0, 1) are empty, it should schedule “idle” process
  - Any empty queues should *not* be scheduled
  - Blocked/stopped processes should also *not* be scheduled
- p_waitpid should check for a state *change*
  - I.e. it’s not enough to just check if child’s state != Running
- p_waitpid, p_kill, etc. should error if provided pid is *not* a child process
- Check logs + `top` for scheduling



```
top - 13:40:52 up 45 min,  0 users,  load average: 0.01, 0.02, 0.00
Tasks:   8 total,   1 running,   7 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.1 us,  0.3 sy,  0.0 ni, 99.6 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :   3933.5 total,   2399.4 free,    425.2 used,   1108.9 buff/cache
MiB Swap:    512.0 total,    512.0 free,      0.0 used.   3061.9 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
    1 root      20   0    4136   3220   2824 S   0.0   0.1   0:00.01 bash
  135 root      20   0    4136   3408   2876 S   0.0   0.1   0:00.02 bash
  151 root      20   0    4136   3400   2876 S   0.0   0.1   0:00.05 bash
  165 root      20   0    4136   3388   2876 S   0.0   0.1   0:00.01 bash
  197 root      20   0    2204    784    704 S   0.0   0.0   0:00.00 sleep
  198 root      20   0    2204    664    588 S   0.0   0.0   0:00.00 sleep
  199 root      20   0    2204    684    608 S   0.0   0.0   0:00.00 sleep
  200 root      20   0    6724   2900   2344 R   0.0   0.1   0:00.01 top
```

Scheduler: Next Steps

- Sleep process (if not already implemented)
  - Should not consume CPU
  - Should work with multiple sleeping processes
- Add mounting of file system
  - E.g. `./pennos fatfs [schedlog]`
  - Keep track of file descriptor tables for each process you spawn
- Implement W_WIF...(status) macros for p_waitpid if you haven’t already
  - Will be needed for shell
- Replace read(), fprint(), etc. with f_write(), f_read(), etc.
- `nice` command to change process priority

File System: Next Steps

- Each process will have an “open file descriptor table”
    - Reserved fds for STDIN, STDOUT (at least)
- Somehow globally keep track of currently open files and their permissions
    - FILE structs?
    - Linked List?
- A user level program should be able to write to stdout using the same interface as it would write to a PennFAT file.
- **If a user level program is calling read(2), then you are doing something wrong.**

File System: System Calls

- Your own system calls!
- Mimic the behavior of C system calls in <cstdio.h> library
  - https://cplusplus.com/reference/cstdio/
- Calls to STDIN, STDOUT or your PennFAT filesystem

File System: System Calls Example

```
$ cat
```

What should be done?

1. Create a process for cat
2. Read from STDIN
3. Write to STDOUT

What system calls should be used?

f_read(int fd, int n, char *buf), f_write(int fd, const char *str, int n)

File System: File Corruption

- Write-write lock
  - If a process opens a file with write permissions, any other processes will be blocked (call error) from opening the same file with write permissions
  - Processes can read, though
- Cannot remove a file that is currently being used by another process
  - Make use of the flag name[0] = 2
  - What happens to the open FILEs struct?
  - How about the file descriptor table?

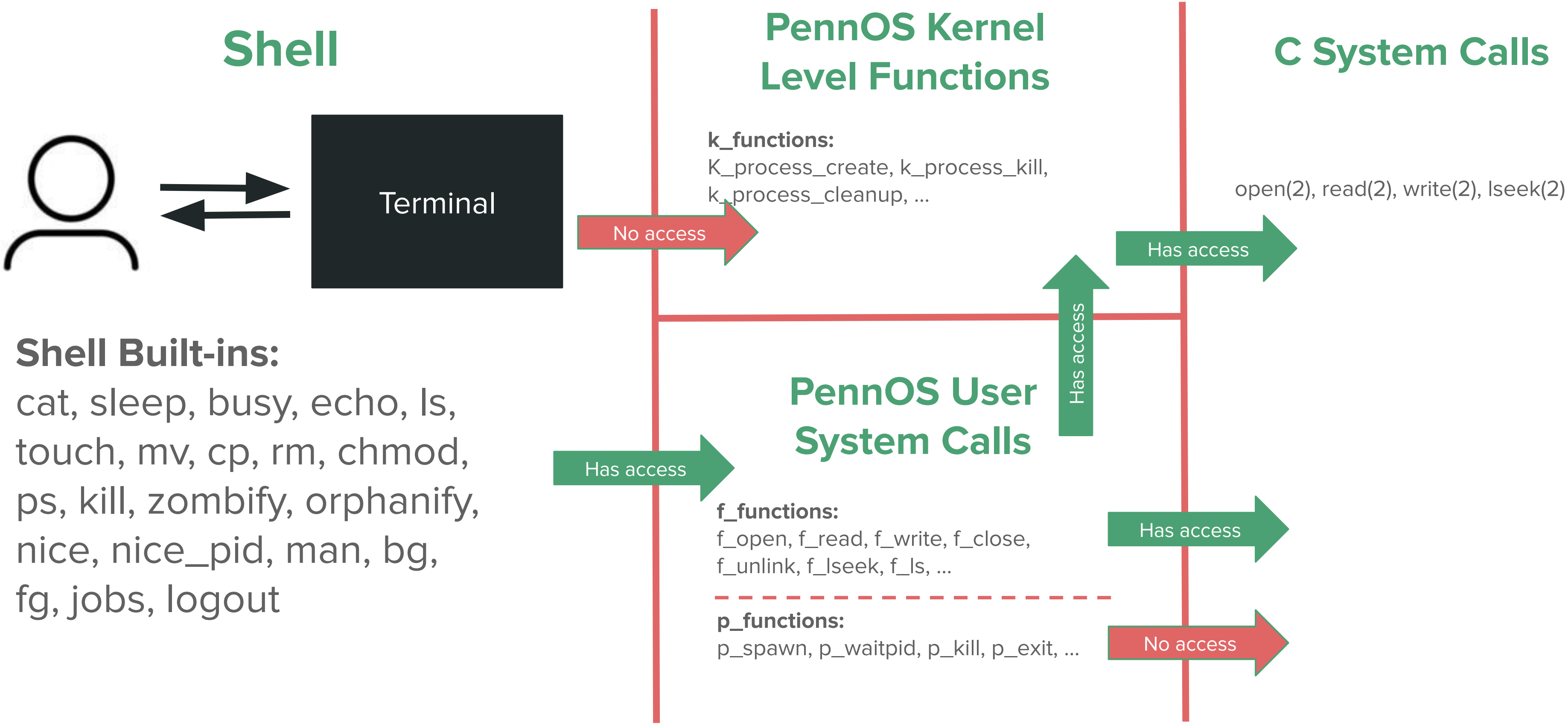
Final Touches: Shell

- Synchronous Child Waiting
  - Shell attempts to wait on ALL children using p_waitpid before reprompt
- Redirections
- Parsing
  - May use parser.o
- Terminal Signal Handling
  - Ctrl-Z, Ctrl-C should not stop or terminate PennOS
  - Relay the signal to the proper thread via user-system calls
  - Ctrl-D or `logout` will exit PennOS
- Terminal Control of stdin
  - If a process tries to take control of stdin when it should not, send a S_SIGSTOP to it
  - Should not be using tcsetpgrp(2)

Final Touches: Error Handling

- errno.h, p_perror
- Have global ERRNO macros
- Call p_perror for PennOS System call errors like f_open, p_spawn
- Call perror(3) for any host OS System call error like malloc(3) or open(2)

Final Touches - Abstraction!



Shell

Shell Built-ins:
cat, sleep, busy, echo, ls, touch, mv, cp, rm, chmod, ps, kill, zombify, orphanify, nice, nice_pid, man, bg, fg, jobs, logout

PennOS Kernel Level Functions

k_functions:
K_process_create, k_process_kill, k_process_cleanup, ...

PennOS User System Calls

f_functions:
f_open, f_read, f_write, f_close, f_unlink, f_lseek, f_ls, ...

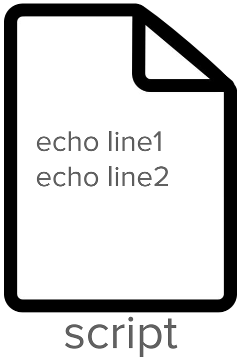
p_functions:
p_spawn, p_waitpid, p_kill, p_exit, ...

C System Calls

open(2), read(2), write(2), lseek(2)

Final Touches: Shell Scripts

```
$ echo echo line1 >script
$ echo echo line2 >>script
$ cat script
echo line1
echo line2
$ chmod +x script
$ script > out
$ cat out
line1
line2
```



```
echo line1
echo line2
```

script

Final Touches: Companion Document

Doxygen:

https://www.doxygen.nl/

https://www.gnu.org/software/gsasl/doxygen/gsasl.pdf

Or just write your own

- Include functions for shell builtins, PennOS system calls, but not every single helper function needs to be there
- Include Global Variables, structs, enums, and macros you create and use

Any Questions?