6.S081: Introduction

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6.S081 Objectives

- Understand how OSes are designed and implemented
- Hands-on experience building systems software
- Will extend a simple OS (xv6)
- Will learn about how hardware works (Risc-V)

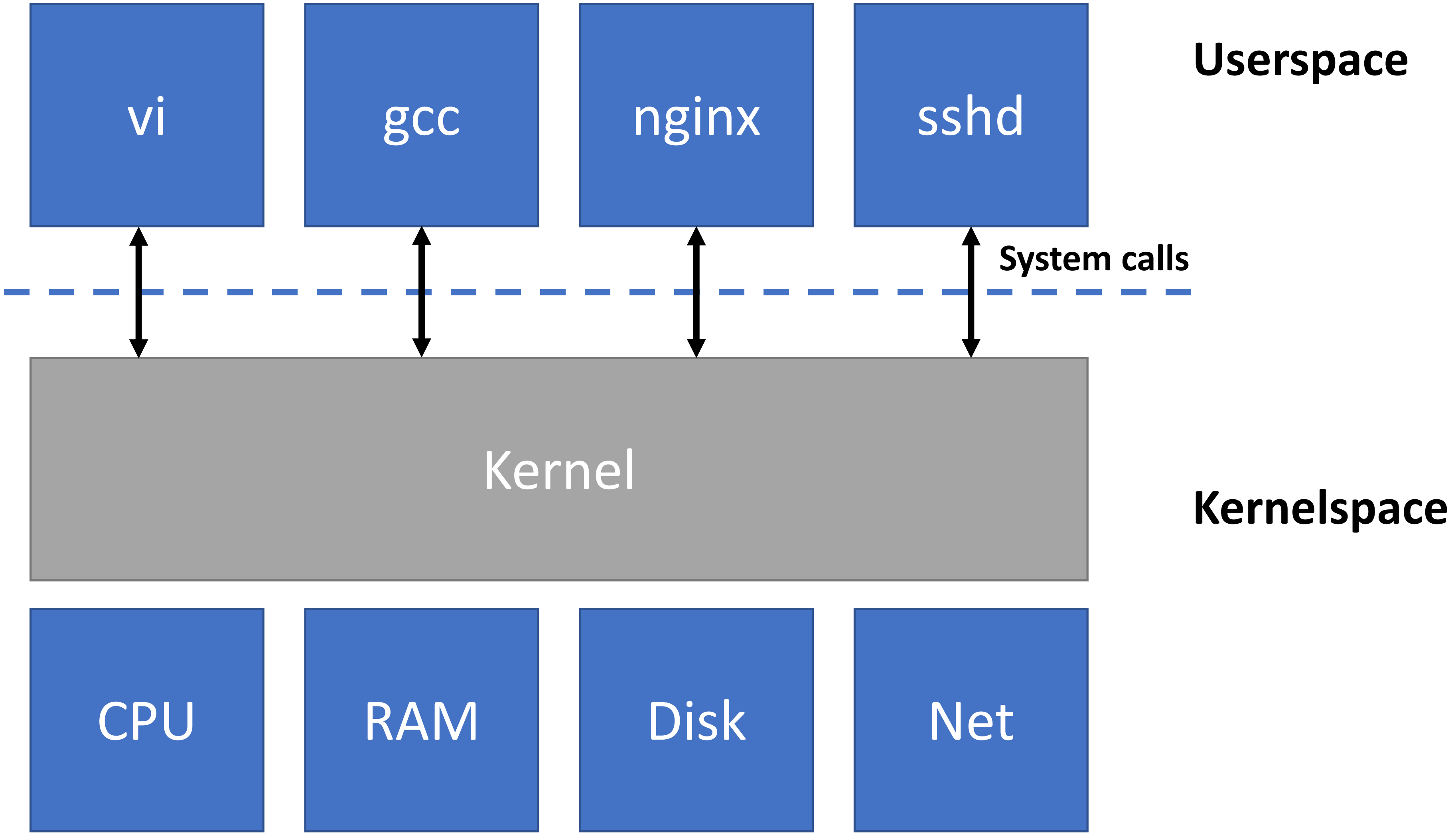
Some things you'll do in 6.S081

1. You will build a driver for a network stack that sends packets over the real Internet
2. You will redesign a memory allocator so that it can scale across multiple cores
3. You will implement fork and make it efficient through an optimization called copy-on-write

What is the purpose of an OS?

1. Abstraction
   - Hides hardware details for portability and convenience
   - Must not get in the way of high performance
   - Must support a wide range of applications
2. Multiplexing
   - Allows multiple applications to share hardware
   - Isolation to contain bugs and provide security
   - Sharing to allow cooperation

OS Organization



OS abstractions

- Process (a running program)
- Memory allocation
- File descriptors
- File names and directories
- Access control and quotas
- Many others: users, IPC, network sockets, time, etc.

User <-> kernel interface

- Primarily system calls
- Examples:

```
fd = open(“out”, 1);
len = write(fd, “hello\n”, 6);
pid = fork();
```

- Look and behave like function calls, but they aren’t

Why OSes are interesting

- Unforgiving to build: Debugging is hard, a single bug can take down the entire machine
- Design tensions:
    - Efficiency vs. Portability/Generality
    - Powerful vs. Simple
    - Flexible vs. Secure
- Challenge: good orthogonality, feature interactions
- Varied uses from smartbulbs to supercomputers
- Evolving HW: NVRAM, Multicore, 200Gbit networks

Take this course if you:

- Want to understand how computers really work from an engineering perspective
- Want to build future system infrastructure
- Want to solve bugs and security problems
- Care about performance

Logistics

Online resources

- Course website
  - https://pdos.csail.mit.edu/6.S081/
  - Schedule, course policies, lab assignments, etc.
  - Videos and notes of 2020 lectures
- Piazza
  - https://piazza.com/mit/fall2021/6s081
  - Announcements and discussion
  - Ask questions about labs and lecture

Lectures

1. OS concepts
2. Case studies of xv6 --- a simple, small OS
3. Lab background and solutions
4. OS papers

- Submit a question before each lecture
- Resource: xv6 book

Labs

- Goal: Hands-on experience
- Three types of labs:
    1. Systems programming: due next week
    2. OS primitives: e.g., thread scheduling
    3. OS extensions: e.g., networking driver

Collaboration

- Feel free to ask and discussion questions about lab assignments in class or on Piazza
- Discussion is great
  - But all solutions (code and written work) must be your own
  - Acknowledge ideas from others (e.g., classmates, open source software, stackoverflow, etc.)
- Do not post your solutions (including on github)

Covid-19 and in-person learning

- Masks are **required**; must be worn correctly
- If you have symptoms or test positive…
  - Don’t attend class, contact us right away
  - We will work with you to provide course materials

Grading

- 70% labs, based on the same tests you will run
- 20% lab check off meetings
  - We will ask questions about randomly selected labs during office hours
- 10% homework and class/piazza participation

Back to system calls

- I'll show examples of using system calls
- Will use xv6, the same OS you'll build labs on
- xv6 is similar to UNIX or Linux, but way simpler
  - Why? So you can understand the entire thing.
- Why UNIX?
  - Clean design, widely used: Linux, OSx, Windows (mostly)
- xv6 runs on Risc-V, like 6.004
- You will use Qemu to run xv6 (emulation)

System call	Description
int fork()	Create a process, return child's PID.
int exit(int status)	Terminate the current process; status reported to wait(). No return.
int wait(int *status)	Wait for a child to exit; exit status in *status; returns child PID.
int kill(int pid)	Terminate process PID. Returns 0, or -1 for error.
int getpid()	Return the current process's PID.
int sleep(int n)	Pause for n clock ticks.
int exec(char *file, char *argv[])	Load a file and execute it with arguments; only returns if error.
char *sbrk(int n)	Grow process's memory by n bytes. Returns start of new memory.
int open(char *file, int flags)	Open a file; flags indicate read/write; returns an fd (file descriptor).
int write(int fd, char *buf, int n)	Write n bytes from buf to file descriptor fd; returns n.
int read(int fd, char *buf, int n)	Read n bytes into buf; returns number read; or 0 if end of file.
int close(int fd)	Release open file fd.
int dup(int fd)	Return a new file descriptor referring to the same file as fd.
int pipe(int p[])	Create a pipe, put read/write file descriptors in p[0] and p[1].
int chdir(char *dir)	Change the current directory.
int mkdir(char *dir)	Create a new directory.
int mknod(char *file, int, int)	Create a device file.
int fstat(int fd, struct stat *st)	Place info about an open file into *st.
int stat(char *file, struct stat *st)	Place info about a named file into *st.
int link(char *file1, char *file2)	Create another name (file2) for the file file1.
int unlink(char *file)	Remove a file.