CS 35L- Software Construction Laboratory

Winter 19

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Course Information

- Presentation Schedule

Sena Ji	N/A	IBM Research Develops Fingernail Sensor to Monitor Disease Progression	Seiji Otsu	N/A	Button Offers Instant Gratification for Those Plagued by Airplane Noise	Yingge Zhou	Siyan Dong	Facial recognition

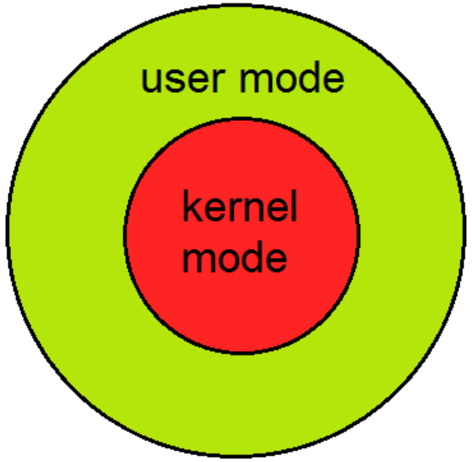
- No Class Next Monday Feb 18 (President day holiday)

System call programming and debugging

Week 6

Review: Processor Modes

- To understand system calls, first we need to distinguish between **supervisor (kernel) mode** and **user mode** of a CPU
  - **Mode** bit used to distinguish between execution on behalf of OS & behalf of user.
- Modern operating system supports these two modes
  - Supervisor (Kernel) mode: processor executes every instruction in it's hardware repertoire
  - User mode: can only use a subset of instructions



Review: Kernel vs User Mode

Kernel Mode

- When CPU is in **kernel mode**, the code being executed can access any memory address and any hardware resource.
- Hence kernel mode is a very privileged and powerful mode.
- If a program crashes in kernel mode, the entire system will be halted.

User Mode

- When CPU is in **user mode**, the programs don't have direct access to memory and hardware resources.
- In user mode, if any program crashes, only that particular program is halted.
- That means the system will be in a safe state even if a program in user mode crashes.
- Hence, most programs in an OS run in user mode.

Review: The Kernel

- Code of the OS **executes** in **supervisor** state
- Trusted software
  - manages hardware resources (CPU, memory, and I/O)
  - Implements protection mechanisms that could not be changed through actions of untrusted software in user space
- **System call interface** is a safe way to expose privileged functionality

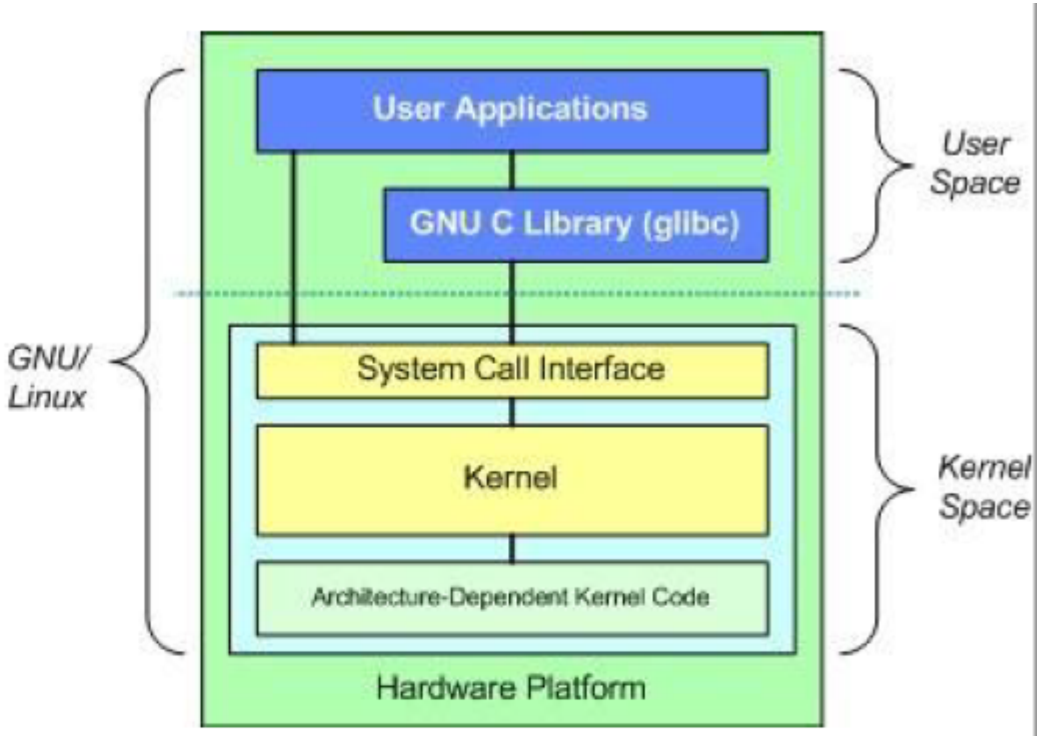
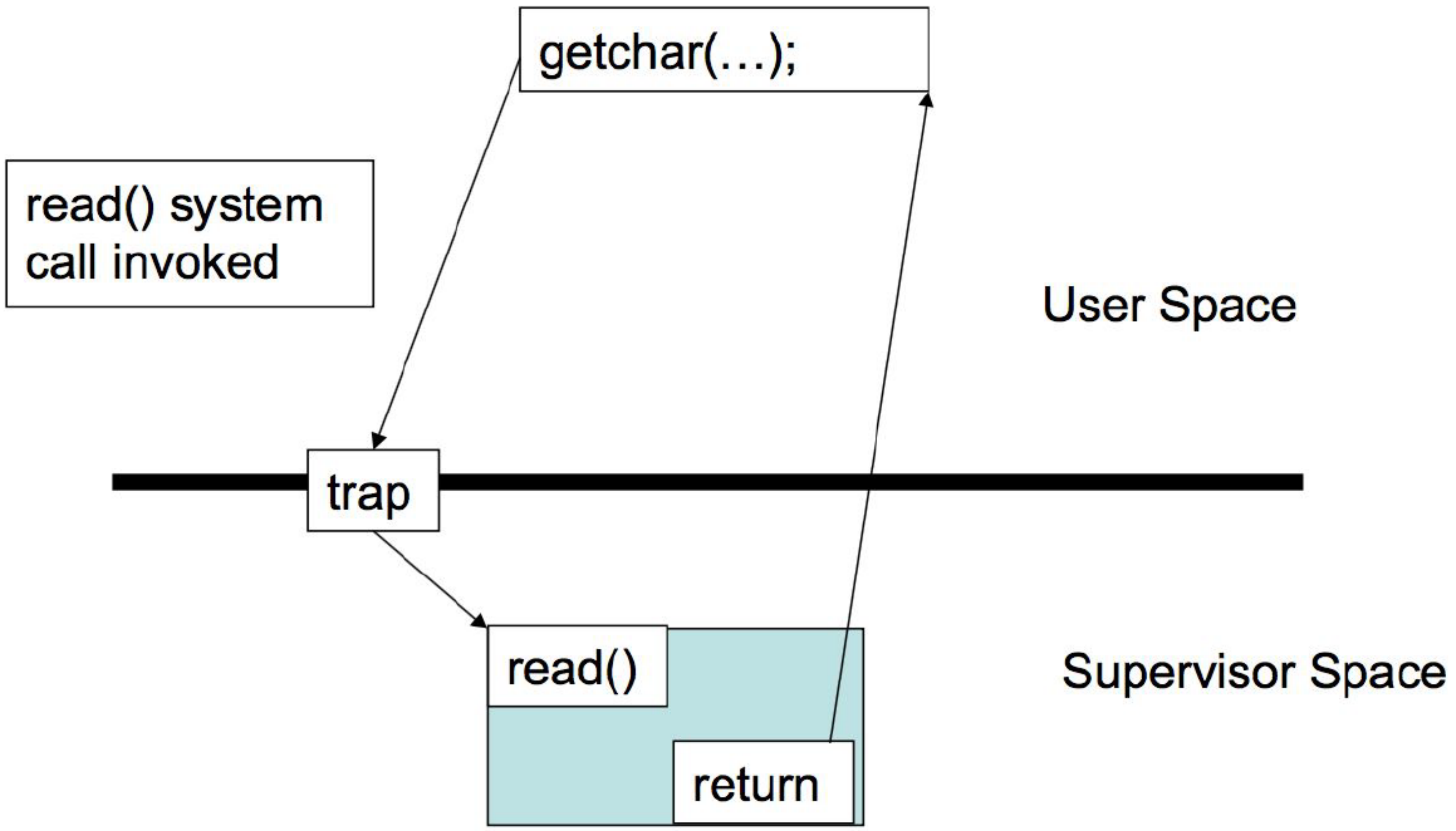


Image by: Tim Jones (IBM)

Reminder of how System calls work



Trap: System call causes a switch from user mode to kernel mode

Reminder of how System calls work

- 1. program get to the system call in the user's code

  int res = sys_call(a_few_params)
- 2. puts the parameters on the stack
- 3. performs a system 'trap' -- hardware switch

  now in system mode
- 4. operating system code may copy large data structures into system memory
- 5. starts operation…

Reminder of how System calls work (cont.)

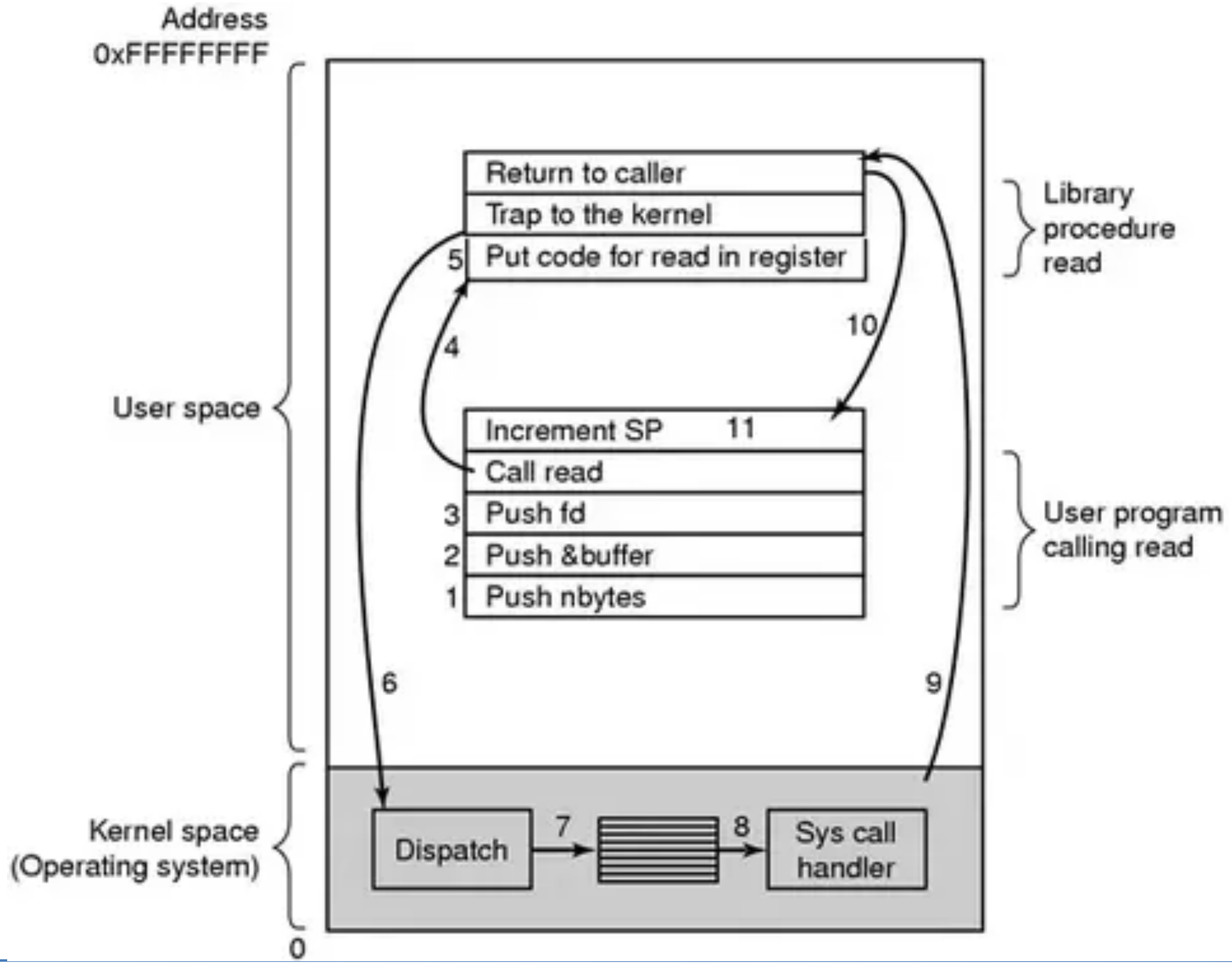
- 6. operation complete!
- 7. if necessary copies result data structures back to user program's memory

return to user mode

- 8. user program puts return code into res(the return value from the system call)
- 9. program recommences

More detailed steps for making a system call:

- 1-3: push parameters on stack
- 4: invoke the system call
- 5: put code for system call on register
- 6: trap to the kernel
- 7-10: since a number is associated with each system call, system call interface invokes/dispatch intended system call in OS kernel and return status of the system call and any return value
- 11: increment stack pointer



System calls and Library calls usage

- Library calls
  - executed in the **user program**
  - may perform **several task**
  - may call system calls
- System calls
  - executed by **the operating system**
  - perform simple **single** operations

Types of system calls

System calls can be roughly grouped into five major categories:

1. Process Control
   - load
   - execute
   - end, abort
   - create process (for example, fork on Unix-like systems)
   - terminate process
   - get/set process attributes
   - wait for time, wait event, signal event
   - allocate, free memory
2. File Management
   - create file, delete file
   - open, close
   - read, write, reposition
   - get/set file attributes

Types of system calls

3. Device Management
   - request device, release device
   - read, write, reposition
   - get/set device attributes
   - logically attach or detach devices
4. Information Maintenance
   - get/set time or date
   - get/set system data
   - get/set process, file, or device attributes
5. Communication
   - create, delete communication connection
   - send, receive messages
   - transfer status information
   - attach or detach remote devices

System calls—Examples I

- ssize_t **read**(int fildes, void *buf, size_t nbyte)
  - fildes: file descriptor
  - buf: buffer to write to
  - nbyte: number of bytes to read
- ssize_t **write**(int fildes,const void *buf,size_t nbyte)
  - fildes: file descriptor
  - buf: buffer to write to
  - nbyte: number of bytes to write
- int **open**(const char *pathname,int flags,mode_t mode)
- int **close**(int fd)

System calls—Examples II

- pid_t **getpid** (void)
  - returns the process id of the calling process
- int **dup**(int fd)
  - Duplicates a file descriptor fd. Returns a second file descriptor that points to the same file table entry as fd does.
- int **fstat**(int filedes, struct stat *buf)
- Returns information about the file with the descriptor filedes to buf
- *Why are these system calls and not just regular library functions?*

System calls vs library call conventions

- Library functions often return pointers
  - FILE *fp = fopen(“cs35l”,”r”)
  - return NULL for failure
- System calls usually return an integer
  - int res=system_call_function(a_few_args)
  - Where the return value
    - res >= 0 → all is well
    - res < 0 → failure
    - See the global variable errorno for more info

More hints for Assignment 5

- **Lab 5: Programs tr2b and tr2u in 'C':**
  - Take two arguments 'from' and 'to'.
  - Transliterate every **byte** in 'from' to corresponding byte in 'to'
  - Report an error ***from*** and ***to*** are not the same length, or if ***from*** has duplicate bytes

```
./tr2b 'abc' < bigfile.txt => Error
./tr2b 'abc' 'wxyz' < bigfile.txt => Error
./tr2b 'abad' 'wxyz' < bigfile.txt => Error
```

- `tr2b`: **getchar** and **putchar**
- `tr2u`: **read** and **write**
  - ret = read(STDIN_FILENO, *buf*, *nbyte*=1);
  - ret = write(STDOUT_FILENO, *buf*, *nbyte*=1);

The following symbolic constants shall be defined for file streams:
STDIN_FILENO File number of stdin; 0.
STDOUT_FILENO File number of stdout; 1.
STDERR_FILENO File number of stderr; 2.

Homework 5

- Recall Homework 4!
- Rewrite *sfrob* using **system calls** (*sfrobu*)
- *sfrobu* should behave like *sfrob* except
  - If stdin is a regular file, it should initially allocate enough memory to **hold all data in the file all at once**
  - It outputs a line with the number of comparisons performed
- System call functions you'll need: **read, write, and fstat**

Homework 5

- Measure differences in **performance** between *sfrob* and *sfrobu* using the ***time*** command
- Estimate the number of **comparisons** as a function of the number of input lines provided to *sfrobu*
- Write a shell script "*sfrobs*" that uses tr and the sort utility to perform the same overall operation as *sfrob*
- Encrypted input -> tr (decrypt) -> sort (sort decrypted text) -> tr (encrypt) -> encrypted output

More hints for Assignment 5

- **Homework 5: Encrypted sort revisited**
- `int` **`fstat`**`(int filedes, struct stat *buf)`
  - Returns information about the file with the descriptor filedes into buf
- `sfrobu` should behave like `sfrob` except:
  - If stdin is a regular file, it should initially allocate enough memory to hold all data in the file all at once

/ File Information */*

ret = fstat(STDIN_FILENO, &buf);

fileSize = buf.st_size + 1;

/ Setup Initial Buffer */*

input = (char) malloc(sizeof(char) * fileSize);*

```
struct stat {
    dev_t     st_dev;     /* ID of device containing file */
    ino_t     st_ino;     /* inode number */
    mode_t    st_mode;    /* protection */
    nlink_t   st_nlink;   /* number of hard links */
    uid_t     st_uid;     /* user ID of owner */
    gid_t     st_gid;     /* group ID of owner */
    dev_t     st_rdev;    /* device ID (if special file) */
    off_t     st_size;    /* total size, in bytes */
    blksize_t st_blksize; /* blocksize for file system I/O */
    blkcnt_t  st_blocks;  /* number of 512B blocks allocated */
    time_t    st_atime;   /* time of last access */
    time_t    st_mtime;   /* time of last modification */
    time_t    st_ctime;   /* time of last status change */
};
```