ECE353 Cheatsheet

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1 Operating System Structure

1.1 Useful Terminal Commands

Summary:
- `./hello-world-linux-aarch64` to run hello world.
- `readelf -a <FILE>` to see the ELF header.
- `strace <PROGRAM>` to trace all the system calls a process makes on Linux.

1.2 Program:

Definition: A file containing all the instructions and data required to run.

1.3 Process:

Definition: An instance of running a program.

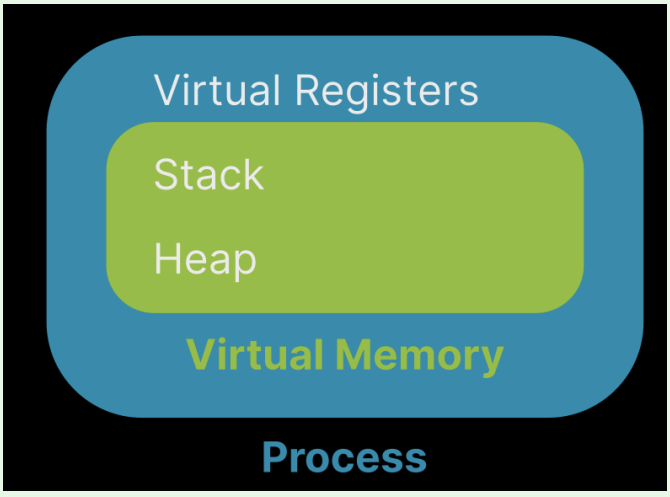

Figure 1: Process

1.3.1 What happens to global variables when you compile?

Definition: The compiler needs to pick a random address for each global variable when you compile.

1.3.2 What happens if two processes run the same program?

Definition:
- Was the address of local the same b/w the two processes? No, different physical memory.
- Was the address of global the same b/w the two processes? Yes, but uses virtual memory.

1.4 File Descriptor:

Definition:
1. **IPC:** Inter-process communication is transferring data b/w two processes.
2. **File Descriptor:** A resource that users may either read bytes from or write bytes to (identified by an index stored in a process).
   - e.g. File or terminal.
   - e.g. 0 is standard input, 1 is standard output, and 2 is standard error.

1.5 System Calls

Definition: System calls are the interface b/w user and kernel mode.

1.5.1 System Calls Make Requests to the Operating System

Definition:

```
ssize_t write(int fd, const void *buf, size_t count);
```

- Description: writes bytes from a byte array to a file descriptor
  - fd: the file descriptor
  - buf: the address of the start of the byte array (called a buffer)
  - count: how many bytes to write from the buffer

```
void exit_group(int status);
```

- Description: exits the current process and sets an exit status code
  - status: the exit status code (0–255)

1.6 API and ABI

Definition:
- Application Programming Interface (API) abstracts the details and describes the arguments and return value of a function.
- Application Binary Interface (ABI) specifies the details, specifically how to pass arguments and where the return value is.

1.7 Magic

Definition: The "magic bytes" refer to the first 4 bytes of a file that uniquely identify the file format.

1.7.1 Programs on Linux Use the ELF File Format

Definition: Executable and Linkable Format (ELF) specifies both executables and libraries.
- Always starts with the 4 bytes: 0x7F 0x45 0x4C 0x46 or with ASCII encoding: DEL 'E' 'L' 'F'

Example: Hello World ELF File

1. **168 Byte Program:**
   - Tells the OS to load the entire executable file into memory at address `0x10000`.
   - The file header is 64 bytes, and the "program header" is 56 bytes (120 bytes total).
   - The next 36 bytes are instructions, followed by 12 bytes for the string:
     - `"Hello world\n"`
     - Instructions start at `0x10078` (`0x78` is 120).
     - The string (data) starts at `0x1009C` (`0x9C` is 156).

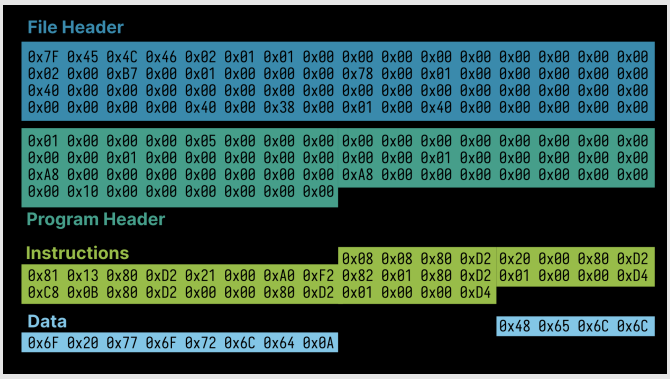

Figure 2: ELF File Division

2. **C Program:** Takes 500 bytes.
3. **Python Program:** Takes 2000 bytes.
4. **Java Program:** Takes 2000000 bytes.

1.8 Kernel

Definition: Kernel is a core part of the operating system that interacts with hardware that runs in kernel mode.

1.8.1 Kernel Mode

Definition: Kernel mode is a privilege level on your CPU that gives access to more instructions.

1.8.2 Levels of Privelege

Definition:

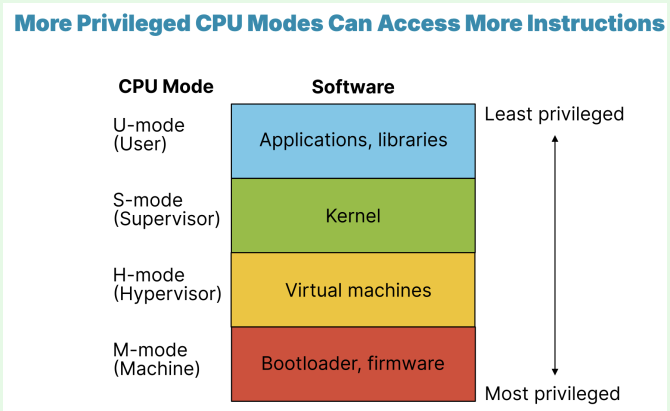

Figure 3: Levels of Privelege

1.8.3 System Calls Transition Between User and Kernel Mode

Definition:

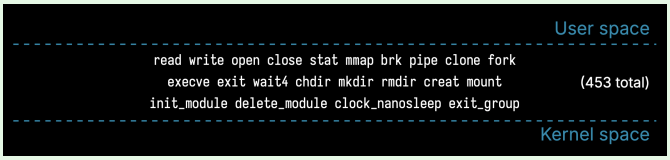

Figure 4: System Calls Transition

1.8.4 Different Tpyes of Kernel Architectures

Definition:

- **Monolithic Kernel:** All the services are in the kernel.

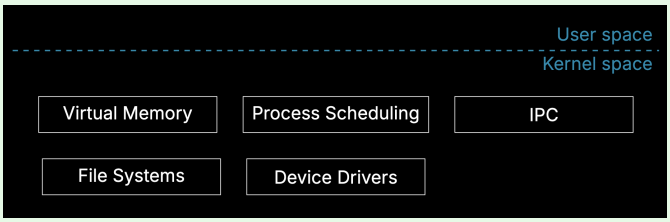

Figure 5: Monolithic Kernel

- **Microkernel:** Only the essential services are in the kernel.

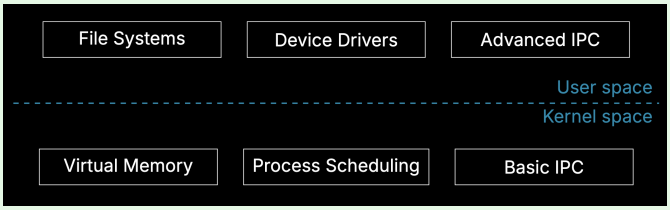

Figure 6: Microkernel

- **Hybrid Kernel:** A mix of monolithic and microkernel.
- **Nanokernel and picokernel:** Even smaller services than microkernel.

Warning: Short answer question.

2 Virtualization

Definition: Share one resource by mimicking multiple independent copies.

3 Concurrency

Definition: Handle multiple things happening at the same time.

4 Persistence

Definition: Retain data consistency even without power.