

Operating System Concepts

- OS Concepts
- Linux commands
- Shell scripts
- Linux System call Programming

Learning OS

- step 1: End user
 - Linux commands
- step 2: Administrator
 - Install OS (Linux)
 - Configuration - Users, Networking, Storage, ...
 - Shell scripts
- step 3: Programmer
 - Linux System call programming
- step 4: Designer/Internals
 - UNIX & Linux internals

What is OS?

- Interface between end user and computer hardware.
- Interface between Programs and computer hardware.
- Control program that controls execution of all other programs.
- Resource manager/allocator that manage all hardware resources.
- Bootable CD/DVD = Core OS + Applications + Utilities
- Core OS = Kernel -- Performs all basic functions of OS.

OS Functions

- CPU scheduling
- Process Management
- Memory Management
- File & IO Management
- Hardware abstraction
- User interfacing
- Security & Protection
- Networking

Process Management

Program

- Set of instructions given to the computer --> Executable file.
- Program --> Sectioned binary --> "objdump" & "readelf".

- Exe header --> Magic number, Address of entry-point function, Information about all sections. (objdump -h program.out)
- Text --> Machine level code (objdump -S program.out)
- Data --> Global and Static variables (Initialized)
- BSS --> Global and Static variables (Uninitialized)
- RoData --> String constants
- Symbol Table --> Information about the symbols (Name, Size, section, Flags, Address) (objdump -t program.out)
- Program (Executable File) Format
 - Windows -- PE
 - Linux -- ELF
- Program are stored on disk (storage).

Process

- Program under execution
- Process execute in RAM.
- Process control block contains information about the process (required for the execution of process).
 - Process id
 - Exit status
 - 0 - Indicate successful execution
 - Non-zero - Indicate failure
 - Scheduling information (State, Priority, Sched algorithm, Time, ...)
 - Memory information (Base & Limit, Segment table, or Page table)
 - File information (Open files, Current directory, ...)
 - IPC information (Signals, ...)
 - Execution context (Values of CPU registers)
 - Kernel stack
- PCB is also called as process descriptor (PD), uarea (UNIX), or task_struct (Linux).
- In Linux size of task_struct is approx 4KB

Process

- Process is program in execution.
- Process has multiple sections i.e. text, data, rodata, heap, stack. ... into user space and its metadata is stored into kernel space in form of PCB struct.
- PCB contains
 - id, exit status,
 - scheduling info (state, priority, time left, scheduling policy, ...),
 - files info (current directory, root directory, open file descriptor table, ...),
 - memory information (base & limit, segment table, or page table),
 - ipc information (signals, ...),
 - execution context, kernel stack, ...

File Management

File

- File is collection of data/information on storage device.
 - File = Contents (Data) + Information (Metadata)
 - The data is stored in zero or more Data blocks (in FS), while metadata is stored in the FCB (in filesystem).
- FCB is called as "inode" on UNIX/Linux. It contains
 - type: UNIX/Linux has 7 types of files
 - -: regular, d: directory, l: symbolic link, p: pipe, s: socket, c: char device, b: block device
 - size: number of bytes
 - links: number of hard links
 - mode (permissions): (u) rwx, (g) rwx, (o) rwx
 - user & group
 - time-stamps: modification, creation, access.
 - info about data blocks
- terminal> ls -l
 - type, mode, links, user, group, size, timestamp, name.
- terminal> stat filepath

File System

- Files are stored on storage device. Arrangement of files in storage device is called as "File System".
- e.g. FAT, NTFS, EXT2/3/4, ReiserFS, XFS, HFS, etc.
- File System logically divide partition into 4 sections.
 - Boot block/Boot sector
 - Contains programs/info required for booting of OS
 - Typically contains bootstrap program and bootloader program
 - Super block/Volume control block
 - Contains information of whole partition.
 - Capacity, Label.
 - terminal> df -h
 - Total number of data blocks/inodes.
 - Number of used/free data blocks/inodes.
 - Information of free data blocks/inodes.
 - Inode List/Master file table
 - Inodes (FCB) for each file
 - Data blocks
 - Stores data of the file.
 - Each file have zero or more data blocks.
 - Size of data blocks can be configured while creating file system
- File system is created by the format utility while formatting the partition.
 - Windows: format.exe
 - Linux: mkfs
 - terminal> sudo mkfs -t ext3 /dev/sdb1
 - terminal> sudo mkfs -t vfat /dev/sdb1
 - -t fs_type e.g. ext3, ext4, vfat, ntfs, ...

- partition e.g. /dev/sdb1
- Disk/partition naming conventions
 - Windows:
 - Disks are named as disk0, disk1, ...
 - partitions are named as drives i.e. C:, D:, E:, ...
 - Linux:
 - Disks are named as /dev/sda, /dev/sdb, /dev/sdc, etc.
 - Partitions per disk are named as
 - sda partitions: sda1, sda2, sda3, ...
 - sdb partitions: sdb1, ...

Linux File Structure

- Linux follows "/" (root) file system.
- "/" is a starting point of Linux file system.
- All your data is stored in this partition.
- / contains boot, bin, sbin, etc, root, home, dev, proc, mnt, media, opt
- In Linux everything is a file.
- Mainly there are two types of files in Linux
 - File
 - Directory (Folder)
- Linux Directories
 - boot - files related to booting
 - vmlinuz - kernel Image
 - grub - boot loader
 - config - kernel configuration
 - initrd/initramfs - initail root file system
 - bin - user commands in binary format
 - sbin - all admin/system commands in binary format
 - etc - configuration files
 - root - home directory of root user
 - home - it contains sub directories for each user with its name
 - devendra -> /home/devendra
 - sunbeam -> /home/sunbeam
 - osboxes -> /home/osboxes
 - dev - it contains all device related files
 - lib - shared program libraries required by kernel
 - mnt - it is temporary mount point
 - media - it is mount point for media eg cdrom
 - opt - stores optional files of large softwares
 - proc - virtual file system - it contains information about system or processes
 - sys - entries of each block devices, subdirectories for each physical bus type supported, every device class registered with the kernel, global device hierarchy of all devices
 - tmp - temporary files that may be lost on system shutdown
 - usr - read only directory that stores small programs and files accessible to all users

User interfacing

- UI of OS is a program (Shell) that interface between End user and Kernel.
- Shell -- Command interpreter
 - End user --> Command --> Shell --> Kernel
- User interfacing (Shell)
 - Graphical User Interface (GUI)
 - Command Line Interface (CLI)

Example shells

- Windows
 - GUI shell: explorer.exe
 - CLI shell: cmd.exe, powershell.exe
- DOS
 - CLI shell: command.com
- Unix/Linux
 - CLI shell: bsh, "bash", ksh, csh, zsh, ...
 - ls /bin/*sh
 - echo \$SHELL
 - shell of current user can be changed using "chsh" command.
- GUI shell/standards
 - GNOME: GNU Network Object Model Environment (e.g. Ubuntu, Redhat, CentOS, ...)
 - KDE: Kommon Desktop Environment (e.g. Kubuntu, SuSE, ...)

Path

- It is a unique location of any file in the file system.
- It is represented by character strings with few delimiters ("/", "\", ":")
- Types of path
 - There are two types of paths in linux
 - Absolute path
 - Path which starts with "/" is called as absolute path.
 - E.g. /home/devendra/MyData/Demos/demo01.sh
 - Relative path
 - Path with respect to current directory is called as relative path
 - E.g. MyData/Assignments/assign02.pdf