

Operating System (CS-182)

Operating systems Lab

Dated: 23-03-2022

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Experiment 3

**Installation: File system: Introduction to File system,
File system Architecture and File Types.**

- A Linux file system is a structured collection of files on a disk drive or a partition. A partition is a segment of memory and contains some specific data. In our machine, there can be various partitions of the memory. Generally, every partition contains a file system.
- The general-purpose computer system needs to store data systematically so that we can easily access the files in less time. It stores the data on hard disks (HDD) or some equivalent storage type.

There may be below reasons for maintaining the file system:

- Primarily the computer saves data to the RAM storage; it may lose the data if it gets turned off. However, there is non-volatile RAM (Flash RAM and SSD) that is available to maintain the data after the power interruption.
- Data storage is preferred on hard drives as compared to standard RAM as RAM costs more than disk space. The hard disks costs are dropping gradually comparatively the RAM.

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- The **Linux** file system contains the following sections:
 - The root directory (/)
 - A specific data storage format (EXT3, EXT4, BTRFS, XFS and so on)
 - A partition or logical volume having a particular file system.

Linux File System Structure



- Linux file system has a hierarchal file structure as it contains a root directory and its subdirectories. All other directories can be accessed from the root directory. A partition usually has only one file system, but it may have more than one file system.

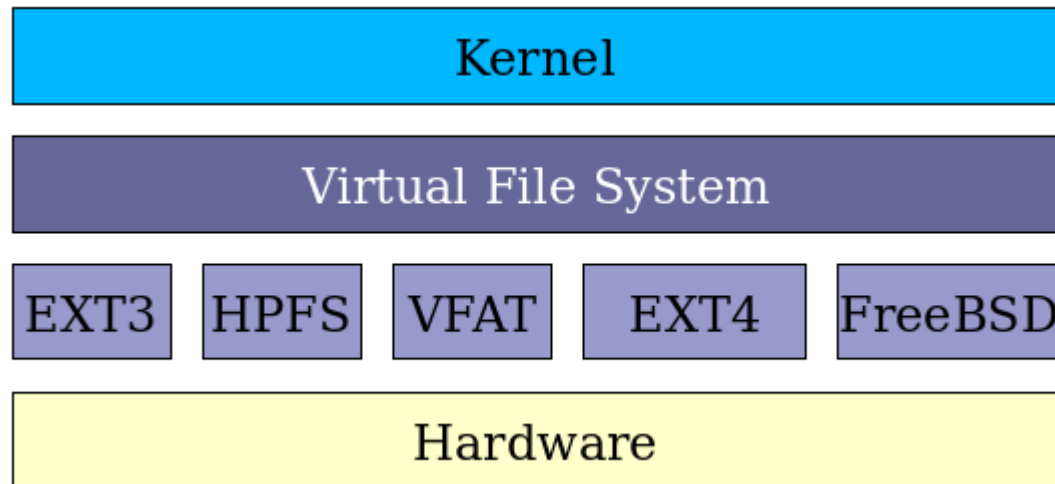


Figure: The Linux two-part filesystem software implementation.

Linux two-part filesystem software implementation

- The first part of this two-part implementation is the Linux virtual filesystem.
- This virtual filesystem provides a single set of commands for the kernel, and developers, to access all types of filesystems.
- The virtual filesystem software calls the specific device driver required to interface to the various types of filesystems.
- The filesystem-specific device drivers are the second part of the implementation. The device driver interprets the standard set of filesystem commands to ones specific to the type of filesystem on the partition or logical volume.

Linux File System Features

In Linux, the file system **creates a tree structure**. All the files are arranged as a tree and its branches. The **topmost directory called the root (/) directory**. All other directories in Linux can be accessed from the root directory.

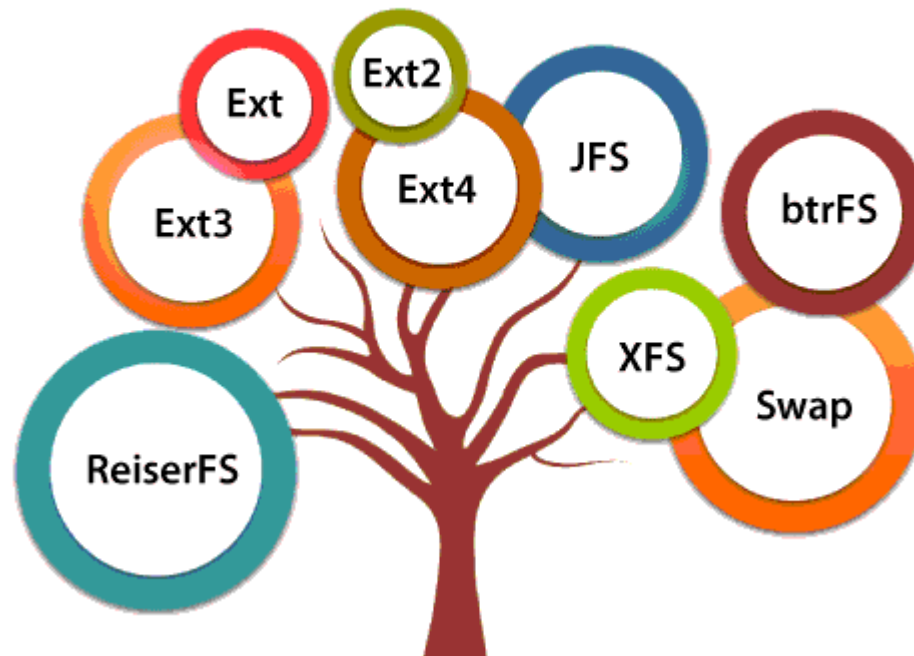
Some key features of Linux file system are as following:

- **Specifying paths:** Linux does not use the backslash (\) to separate the components; it uses forward slash (/) as an alternative. For example, as in Windows, the data may be stored in C:\ My Documents\ Work, whereas, in Linux, it would be stored in /home/ My Document/ Work.
- **Partition, Directories, and Drives:** Linux does not use drive letters to organize the drive as Windows does. In Linux, we cannot tell whether we are addressing a partition, a network device, or an "ordinary" directory and a Drive.
- **Case Sensitivity:** Linux file system is case sensitive. It distinguishes between lowercase and uppercase file names. Such as, there is a difference between test.txt and Test.txt in Linux. This rule is also applied for directories and Linux commands.
- **File Extensions:** In Linux, a file may have the extension '.txt,' but it is not necessary that a file should have a file extension. While working with Shell, it creates some problems for the beginners to differentiate between files and directories. If we use the graphical file manager, it symbolizes the files and folders.
- **Hidden files:** Linux distinguishes between standard files and hidden files, mostly the configuration files are hidden in Linux OS. Usually, we don't need to access or read the hidden files. The hidden files in Linux are represented by a dot (.) before the file name (e.g., .ignore). To access the files, we need to change the view in the file manager or need to use a specific command in the shell.

Types of Linux File System

- When we install the Linux operating system, Linux offers many file systems such as Ext, Ext2, Ext3, Ext4, JFS, ReiserFS, XFS, btrfs, and swap.

Types of Linux File System



- The file system Ext stands for **Extended File System**. It was primarily developed for **MINIX OS**. The Ext file system is an older version, and is no longer used due to some limitations.
- **Ext2** is the **first Linux file system** that allows **managing two terabytes of data**. Ext3 is developed through Ext2; it is an upgraded version of Ext2 and contains backward compatibility. **The major drawback of Ext3 is that it does not support servers because this file system does not support file recovery and disk snapshot.**
- **Ext4 file system is the faster file system** among all the Ext file systems. It is a very compatible option for the SSD (solid-state drive) disks, and it is the default file system in Linux distribution.

1. JFS stands for **Journaled File System**, and it is developed by **IBM for AIX Unix**. It is an alternative to the Ext file system. It can also be used in place of Ext4, where stability is needed with few resources. It is a handy file system when CPU power is limited.

2. ReiserFS is an alternative to the Ext3 file system. It has improved performance and advanced features. In the earlier time, the ReiserFS was used as the default file system in SUSE Linux, but later it has changed some policies, so SUSE returned to Ext3. This file system dynamically supports the file extension, but it has some drawbacks in performance.

4. XFS File System

XFS file system was considered as high-speed JFS, which is developed for parallel I/O processing. NASA still using this file system with its high storage server (300+ Terabyte server).

5. Btrfs File System

Btrfs stands for the B tree file system. It is used for fault tolerance, repair system, fun administration, extensive storage configuration, and more. It is not a good suit for the production system.

6. Swap File System

The swap file system is used for memory paging in Linux operating system during the system hibernation. A system that never goes in hibernate state is required to have swap space equal to its RAM size.

Directory structure

Directory	Description
/ (root filesystem)	The root filesystem is the top-level directory of the filesystem. It must contain all of the files required to boot the Linux system before other filesystems are mounted. It must include all of the required executables and libraries required to boot the remaining filesystems. After the system is booted, all other filesystems are mounted on standard, well-defined mount points as subdirectories of the root filesystem.
/bin	The /bin directory contains user executable files.
/boot	Contains the static bootloader and kernel executable and configuration files required to boot a Linux computer.
/dev	This directory contains the device files for every hardware device attached to the system. These are not device drivers, rather they are files that represent each device on the computer and facilitate access to those devices.
/etc	Contains the local system configuration files for the host computer.
/home	Home directory storage for user files. Each user has a subdirectory in /home.
/lib	Contains shared library files that are required to boot the system.
/media	A place to mount external removable media devices such as USB thumb drives that may be connected to the host.
/mnt	A temporary mountpoint for regular filesystems (as in not removable media) that can be used while the administrator is repairing or working on a filesystem.
/opt	Optional files such as vendor supplied application programs should be located here.
/root	This is not the root (/) filesystem. It is the home directory for the root user.
/sbin	System binary files. These are executables used for system administration.
/tmp	Temporary directory. Used by the operating system and many programs to store temporary files. Users may also store files here temporarily. Note that files stored here may be deleted at any time without prior notice.
/usr	These are shareable, read-only files, including executable binaries and libraries, man files, and other types of documentation.
/var	Variable data files are stored here. This can include things like log files, MySQL, and other database files, web server data files, email inboxes, and much more.

Table : The top level of the Linux filesystem hierarchy.

The Root Directory

- All the directories in the Linux system comes under the root directory which is represented by a forward slash (/).
- Everything in your system can be found under this root directory even if they are stored in different virtual or physical devices.

```
sssit@JavaTpoint: ~  
sssit@JavaTpoint:~$ ls /  
bin      dev      initrd.img  media  proc  sbin  sys  var  
boot     etc      lib         mnt    root  selinux tmp  vmlinuz  
cdrom    home    lost+found  opt    run   srv   usr  
sssit@JavaTpoint:~$
```

Ubuntu with the help of the command "ls /". Here, we have written (/) to represent root directory.

- We have categorized the directories according to the type of file as given below:

Directory type	Types of files stored
<u>Binary directories</u>	Contains binary or compiled source code files, eg, /bin, /sbin, etc.
<u>Configuration directories</u>	Contains configuration files of the system, eg, /etc, /boot.
<u>Data directories</u>	Stores data files, eg, /home, /root, etc.
<u>Memory directories</u>	Stores device files which doesn't take up actual hard disk space, eg, /dev, /proc, /sys.
<u>Uusr (Unix System Resources)</u>	Contains sharable, read only data, eg, /usr/bin, /usr/lib, etc.
<u>var (variable directory)</u>	Contains larger size data, eg, /var/log, /var/cache, etc.
<u>Non-standard directories</u>	Directories which do not come under standard FHS, eg, lost+found, /run, etc.

Linux Binary Directory

- Binary files are the files which contain compiled source code (or machine code). They are also called executable files because they can be executed on the computer. Binary directory contains following directories:
 - **/bin:** Directory contains user binaries, executable files, Linux commands that are used in single user mode, and common commands that are used by all the users, like cat, cp, cd, ls, etc. **command "ls /bin" displays the list of '/bin' directory. Note: The '/bin' directory doesn't contain directories.**
 - **/sbin:** The '/sbin' directory also contains executable files, but unlike '/bin' it only contains system binaries which require root privilege to perform certain tasks and are helpful for system maintenance purpose. e.g. fsck, root, init, ifconfig, etc.
 - **/lib:** The '/lib' directory contains shared libraries which are often used by the '/bin' and '/sbin' directories. It also contains kernel module. These filenames are identifiable as ld* or lib*.so.*. For example, ld-linux.so.2 and libfuse.so.2.8.6
 - **/opt:** The term 'opt' is short for optional. Its main purpose is to store optional application software packages. Add-on applications from individual vendors should be installed in '/opt'. And so in some systems '/opt' is empty as they may not have any add-on application.

Linux Configuration Directory

- The configuration directory contains configured files which configures the parameters and initial settings for some computer programs.
- Configuration directory have following sub-directories:
 - **/boot**
 - **/etc**

Linux Data directory

- Data directory is used to store data of the system.
- Data directory contains following directories.
 - /home
 - /root
 - /srv
 - /media
 - /mnt
 - /tmp

Linux Memory Directory

- Memory directory contains files of the whole system. All the device information, process running in data or system related information are stored in this directory.
- Memory directory contains the following directories.
 - /dev
 - /proc
 - /sys

Unix System Resources (/usr)

- Although it is pronounced as user but in actual it stands for Unix System Resources. It is also called secondary hierarchy as it contains binaries, libraries, documentation for all the user applications. It only contains shareable read-only data.

command "ls /usr" displays the '/usr' directories.

- /usr/bin
- /usr/include
- /usr/lib
- /usr/share
- /usr/local
- /usr/src

Variable Directory (/var)

- The term 'var' is short for variable. Files that have an unexpected size and whose content is expected to change continuously (that's why it is named as variable) during normal operation of the system are stored here. For example, log files, spool files and cache files.
- Example: Is /var
 - /var/log
 - /var/cache
 - /var/spool
 - /var/lib

Non-Standard Directories

- Directories which do not come under the standard FHS are called non-standard directories.
- Non-standard directories are as follows:
 - /cdrom
 - /run
 - /lost + found

1. **Regular files (-)**: It contain programs, executable files and text files.
2. **Directory files (d)**: It is shown in blue color. It contain list of files.
3. **Special files**
 - Block file (b)
 - Character device file (c)
 - Named pipe file (p)
 - Symbolic link file (l)
 - Socket file (s)



Thank You