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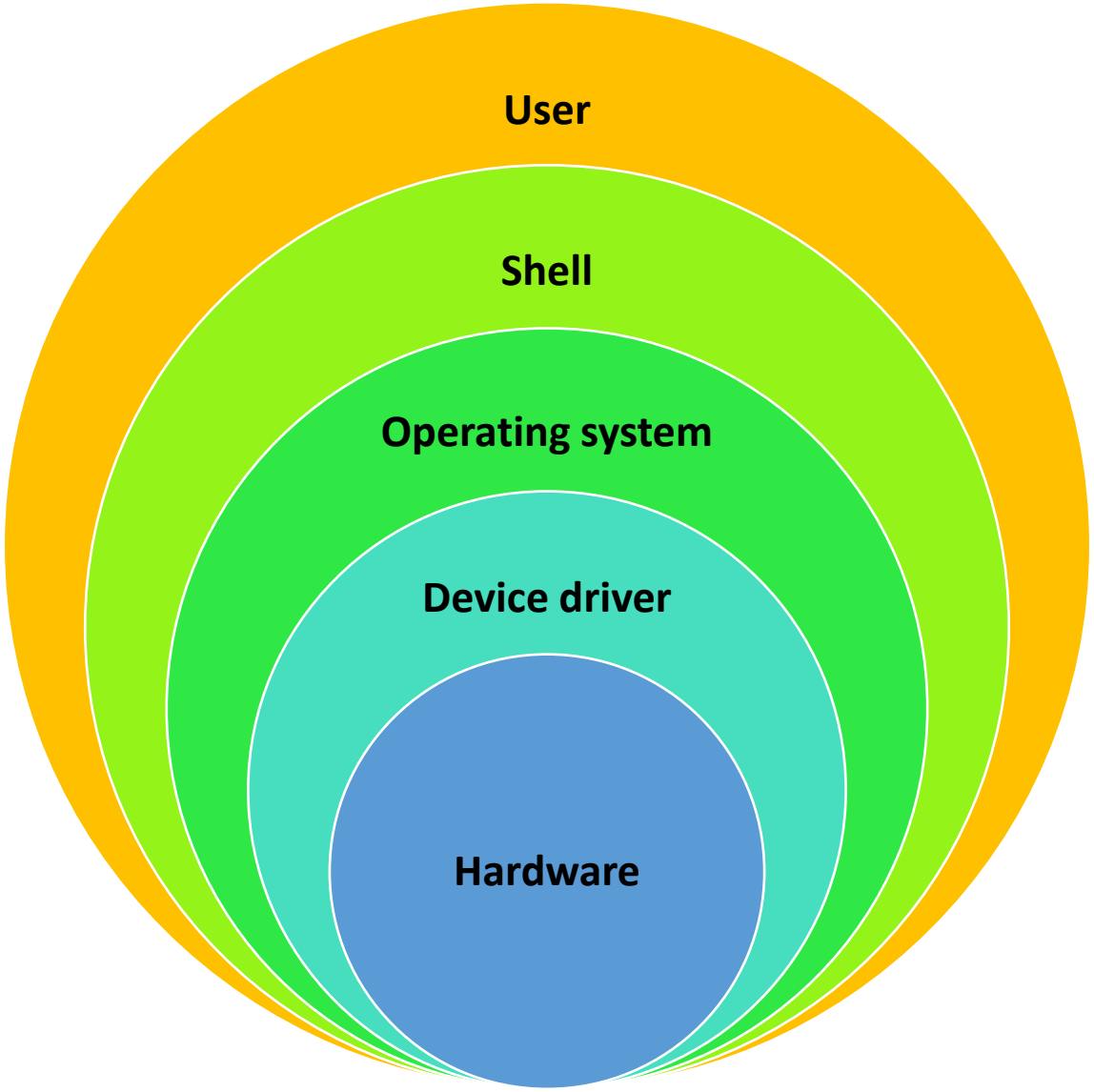
Disk partitioning and Filesystem management

Linux OS

Recap: Fundamentals: Unix architecture



- Device driver:
  - It is a software that can perform I/O (input/output) with one type of hardware
- Major number:
  - Points to the Name of device driver loaded in the kernel
- Minor number:
  - Points to the instance of a device associated with a particular device driver

Disk Partitioning

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- Hard disk is usually connected to the machine over a SCSI interface of Fiber channel interface. Disk with SCSI interface are named as /dev/sd[a-h]
- The process to break-up the disk into two or more logical pieces is called as partitioning.
- You can create a maximum of 8 partitions on a single disk
  - The first four partitions are called as primary partitions
  - To create more than four partitions, one of these four partitions can be divided into many smaller partitions, called logical partitions. When a primary partition is subdivided in this way, it is known as an extended partition.
- The **information about the partitions on a disk is stored in the LABEL** area of the disk

Identify the disks connected to system

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- To identify the disk connected to the machine

$ dmesg | grep scsi | grep sd

```
[    1.986947] sd 2:0:3:0: [sdd] Attached SCSI disk
[    1.992789] sd 2:0:2:0: [sdc] Attached SCSI disk
[    1.999204] sd 2:0:1:0: [sdb] Attached SCSI disk
[    2.011098] sd 2:0:0:0: [sda] Attached SCSI disk
```

This machine has sda sdb sdc and sdd #4 disks connected

dmesg command show the system messages since the boot. The device detection happens during boot process.

Identify the OS disk

- To identify the OS disk, run

$ df –k (to show filesystem details) and swapon –s (swap details)

```
[root@localhost ~]# df -k
Filesystem     1K-blocks     Used Available Use% Mounted on
/dev/sda2      184860708 47704128 127743156  28% /
tmpfs            1891940   108448   1783492   6% /dev/shm
/dev/sda1         487652    86085    371871  19% /boot
[root@localhost ~]# swapon -s
Filename                                Type            Size    Used    Priority
/dev/sda3                               partition       8388604 0       -1
[root@localhost ~]#
```

- It shows that
  - / is mounted on /dev/sda2
  - /boot is mounted on /dev/sda1
  - Swap is located on /dev/sda3
- i.e. all partitions are located on the disk /dev/sd[a]

Partition details

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- To view the partition details of disk, run command

$ fdisk –l /dev/sda

```
[root@localhost ~]# fdisk -l /dev/sda

Disk /dev/sda: 214.7 GB, 214748364800 bytes
255 heads, 63 sectors/track, 26108 cylinders
Units = cylinders of 16065 * 512 = 8225280 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x000684a2

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1   *           1          64      512000   83  Linux
Partition 1 does not end on cylinder boundary.
/dev/sda2              64       23462   187940864   83  Linux
/dev/sda3           23462       24506     8388608   82  Linux swap / Solaris
/dev/sda4           24506       26108    12870014   83  Linux
[root@localhost ~]# fdisk -l /dev/sdd

Disk /dev/sdd: 10.7 GB, 10737418240 bytes
255 heads, 63 sectors/track, 1305 cylinders
Units = cylinders of 16065 * 512 = 8225280 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x00000000

[root@localhost ~]#
```

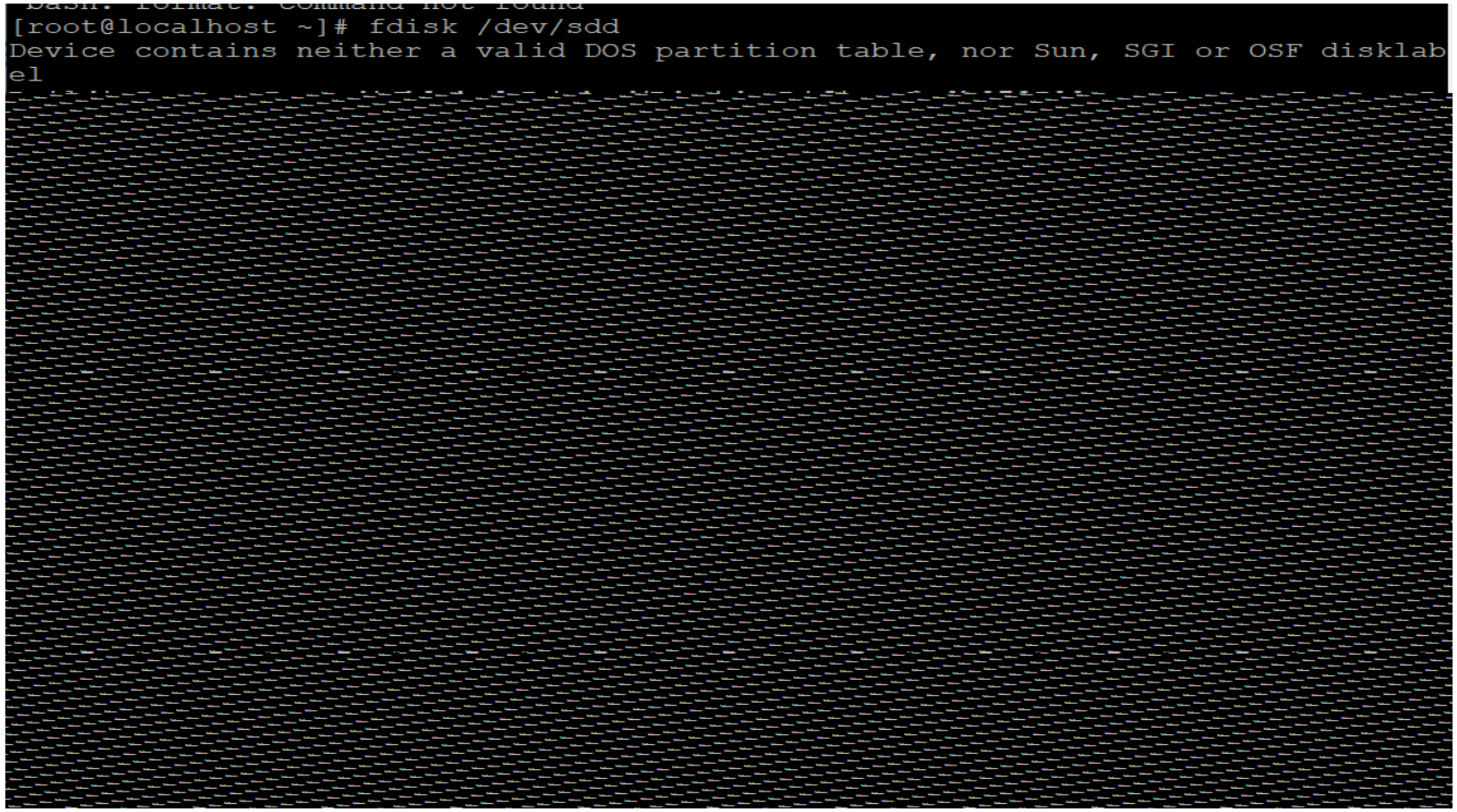
/dev/sda disk is already partitioned, so you can see the details of each partition

/dev/sdd disk is new disk and has not been partitioned, so you do not see any partition details, just the basic configuration of the disk

Performing partition activities

- To partition a disk, run command

$ fdisk /dev/sdd



Type ‘m’ to get the help menu on the screen as shown in the picture

Warning: *

- **The purpose of identifying OS disk and Swap disk is to ensure that you do not mess-up a working machine.**
- **Even a small mistake in the partition details, can mess-up the system and make it un-bootable.**
- **Never try to partition the OS disk till the time you have full confidence in performing this action.**
- **In case you mess-up, remember NOT to save the changed date or Label the disk**

Performing partition activities

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root@sipl-152:~

```
Command (m for help): n
Partition type
   p   primary (0 primary, 0 extended, 4 free)
   e   extended (container for logical partitions)
Select (default p): p
Partition number (1-4, default 1): 1
First sector (2048-1953525167, default 2048):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (2048-1953525167, default 1953525167): +100G

Created a new partition 1 of type 'Linux' and of size 100 GiB.

Command (m for help): p
Disk /dev/sdb: 931.51 GiB, 1000204886016 bytes, 1953525168 sectors
Disk model: ST1000DM003-1SB1
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0xa8f5ecc3

Device     Boot Start       End   Sectors  Size Id Type
/dev/sdb1        2048 209717247 209715200  100G 83 Linux

Command (m for help):
```

When you type ‘n’ to create new partition, you will be prompted for creating an extended partition or primary partition.

To the extent possible, always choose primary partition.

Size of the partition depends on the number of cylinder’s choosen.

Type ‘p’ to print the partition details you have created

Performing partition activities

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root@sipl-152:~

```
Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p): p
Partition number (2-4, default 2): 2
First sector (209717248-1953525167, default 209717248):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (209717248-1953525167, default 1953525167): +100G

Created a new partition 2 of type 'Linux' and of size 100 GiB.

Command (m for help): p
Disk /dev/sdb: 931.51 GiB, 1000204886016 bytes, 1953525168 sectors
Disk model: ST1000DM003-1SB1
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0xa8f5ecc3

Device     Boot     Start       End   Sectors  Size Id Type
/dev/sdb1            2048 209717247 209715200  100G 83 Linux
/dev/sdb2       209717248 419432447 209715200  100G 83 Linux
```

When you type ‘n’ to create second partition,

Choose P as primary partition
Partition number is 2
Starting cylinder is 501, as our ending cyclinder for previous partition was 500

Warning * * * One cylinder can be part of only one partition. NO overlapping of cylinders is allowed

We can either choose ending cylinder number of size of the partition in M (MB), K(KB), G(GB)

Performing partition activities

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root@sipl-152:~

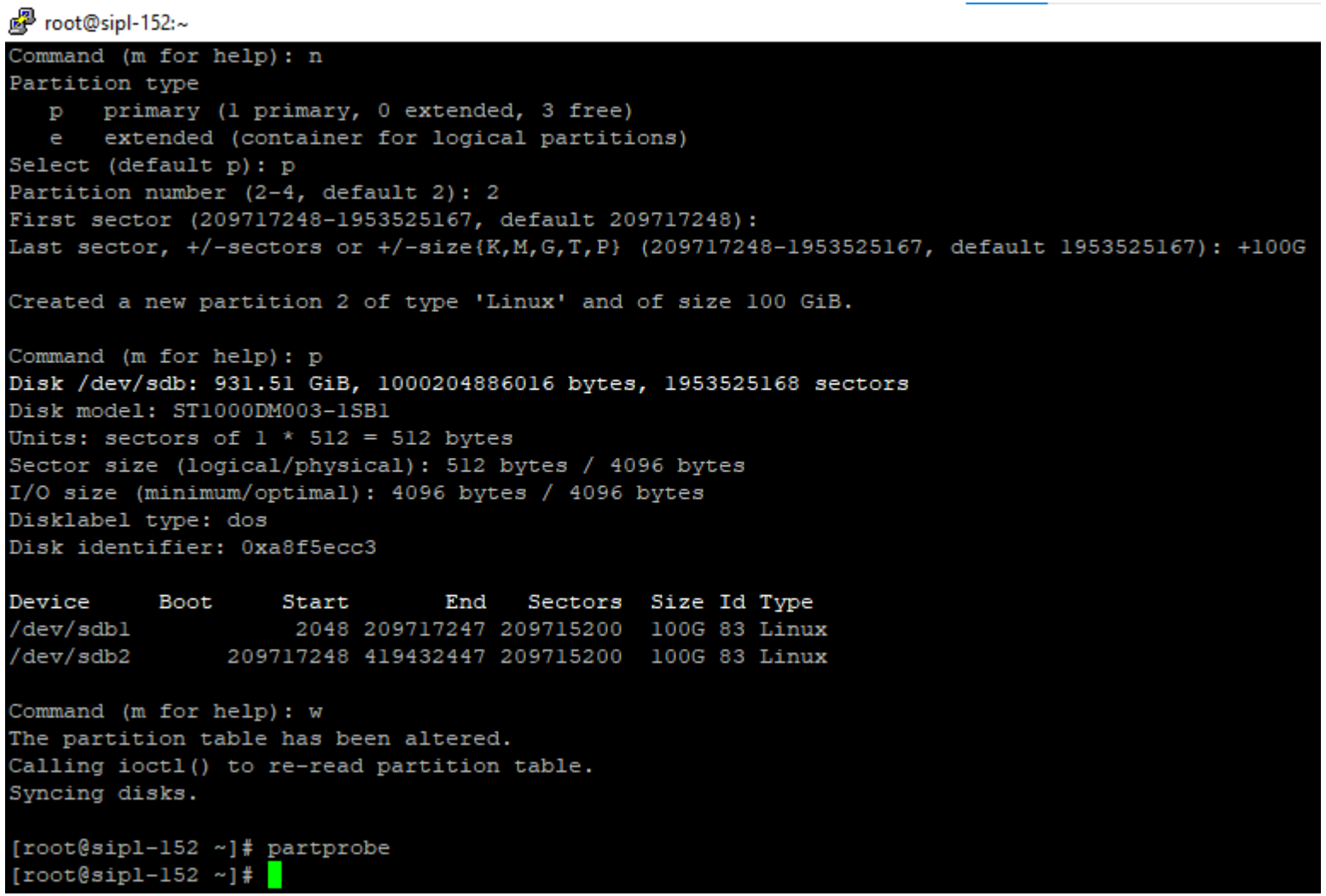
```
Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p): p
Partition number (2-4, default 2): 2
First sector (209717248-1953525167, default 209717248):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (209717248-1953525167, default 1953525167): +100G

Created a new partition 2 of type 'Linux' and of size 100 GiB.

Command (m for help): p
Disk /dev/sdb: 931.51 GiB, 1000204886016 bytes, 1953525168 sectors
Disk model: ST1000DM003-1SB1
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0xa8f5ecc3

Device     Boot     Start       End   Sectors  Size Id Type
/dev/sdb1             2048 209717247 209715200  100G 83 Linux
/dev/sdb2        209717248 419432447 209715200  100G 83 Linux
```

Example of choosing partition size in GB

Start point is chosen as cylinder number 501 (as prompted by the system).

End point is given as +2G

Saving partition details



Type ‘w’ to save the partition table

Once you come out, Run the ‘partprobe’ command to scan the newly modified partition table:

To view disk partitions, Run fdisk –l /dev/sdb

Recap: Filesystem

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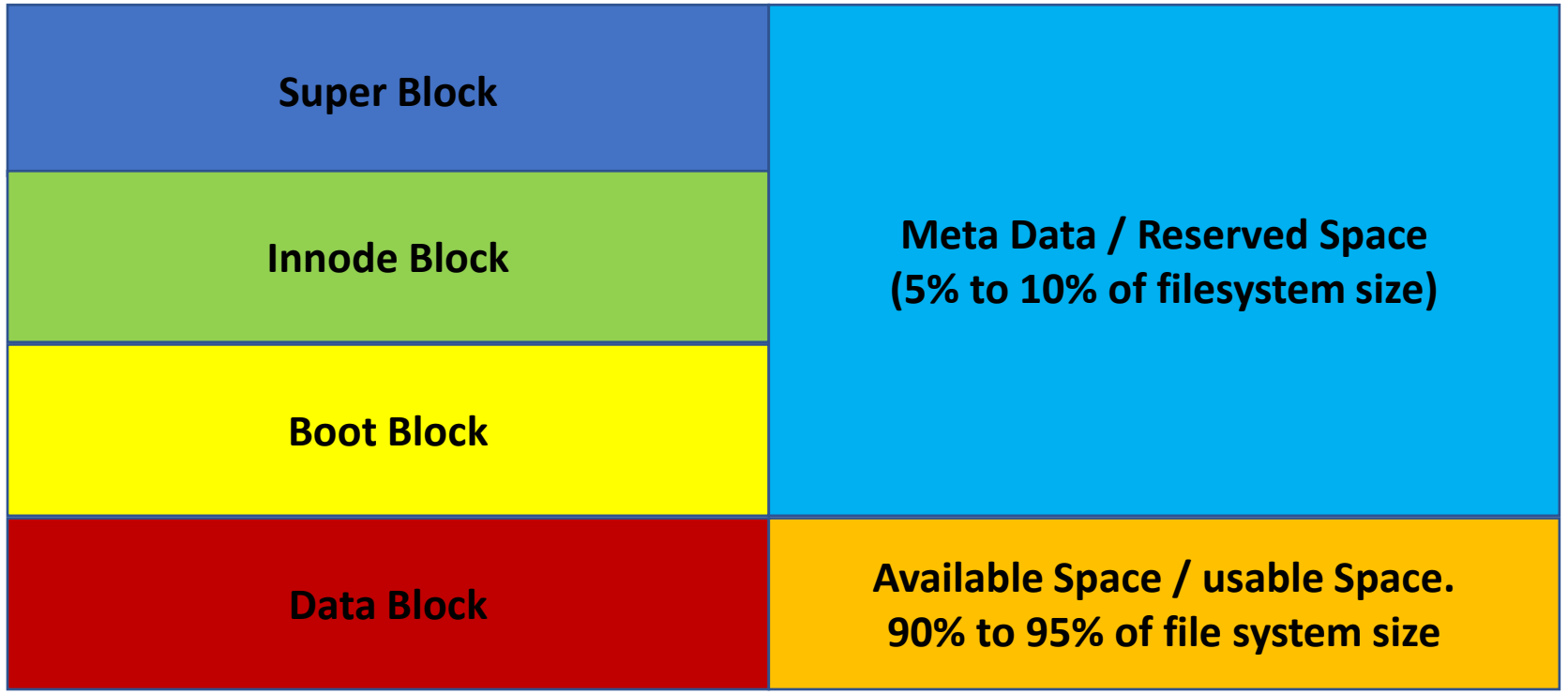
- When you create a filesystem, the available space is broken into an allocation unit. The allocation units are categorized in Four sets that form the meta data and usable space in a filesystem.
- Anything between 5% to 10% of space is reserved for meta-data



Recap : Filesystem

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Super Block

- Holds the information related to used-list, free-list, recycle-list (optional) of data blocks
- Used list and recycle list has pair of values (Innode-num and name of file)
- Free list has (Innode number)
- Multiple copies of super block are stored while creating a file system. These location are shown when you create a file system

Boot Block

- Boot block (master boot record related information)

Inode Block

- This holds information related to properties of the files stored in data block. Example
  - File permissions (rwx/s, Mode of file)
  - Owner, group, link count, time stamp
  - size of file, type of file (d, -, s, p, l)

Data Block

- User save data.
- Modifiable Content

Introduction to Filesystem Management

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- **Data Storage**

Efficiently organize and store data within various type of filesystem for optimal access and performance.

- **Disk Utilization**

Monitor and manage disk usage to prevent space overload and maintain system performance effectively.

- **Filesystem creation**

Learn how to create and format filesystem to ensure compatibility with different operating systems.

- **System Recovery**

Utilize repair tools to recover damage filesystem, minimizing data loss in critical situations.

Filesystem Concepts and Terminology

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- **Mount Points**

Configure mount points for effective filesystem access.

- **Disk Usage**

Monitor disk usage with tools like df and du .

- **Permission management**

Set appropriate permissions to secure filesystem data

- **Filesystems Types**

Choose the right filesystem type for your application needs.

- **Swap Setup**

Configure swap space for optimized memory management.

Types of Filesystem in Linux

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- Linux supports various filesystem types to manage storage, each with different features and performance characteristics. Some common types include:
- **JFS (Journaled File System)**
- **Ext3 (Third Extended Filesystem)**
- **Ext4 (Fourth Extended Filesystem)**
- **XFS (Extended File System)**
- **FAT (File Allocation Table)**
- **VFAT (Virtual File Allocation Table)**

Understanding of Ext4 filesystem Features

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- **Ext4** (Fourth Extended Filesystem) is the default and widely used filesystem for Linux operating systems. It is the successor to ext3 and provides numerous improvements in performance, scalability, and reliability. **Ext4** is particularly known for its stability, support for large files and filesystems, and modern features that make it suitable for both personal and enterprise-level use. It is the most used filesystem for Linux servers, desktops, and embedded systems.
- Ext4 supports journaling, which logs changes before they are committed to the filesystem. This helps protect data integrity in the event of a crash or power failure by ensuring that incomplete operations can be recovered upon system restart.
- Improves performance by reducing fragmentation through contiguous allocation.
- Ext4 is backward-compatible with ext3 and ext2. This allows ext3 and ext2 partitions to be mounted on ext4 systems.
- Dynamically reserve inodes based on filesystem usage patterns.

Understanding XFS filesystem Advantages

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- XFS is a high-performance, 64-bit journaling filesystem that was originally developed by Silicon Graphics (SGI) for their IRIX operating system and later ported to Linux. XFS is designed for scalability, high performance, and data integrity, especially in enterprise environments. It is particularly suited for systems that handle large files and require efficient, high-throughput data access.
- **Scalability**:

XFS is designed to handle extremely large files and filesystems, making it suitable for enterprise-level storage systems. It can support filesystems up to 8 exabytes (EB) and individual file sizes up to 8 exabytes.

- **Journaling**

XFS is a journaling filesystem, meaning it logs metadata changes before committing them to disk. This ensures that in the event of a system crash or power failure, the filesystem can recover quickly and avoid corruption, thus providing enhanced data integrity. XFS focuses on journaling metadata rather than full data journaling, which allows for faster performance while still ensuring data consistency.

- **Online Defragmentation**

XFS supports **online defragmentation**, allowing filesystems to be defragmented while they are mounted and in use. This reduces fragmentation over time and improves system performance without requiring downtime.

Command Line Tools for Filesystem

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- **Mkfs**

Use mkfs command to create a filesystem on a specified device partition

- **e2fsck**

Execute e2fsck to check and repair inconsistencies in the filesystem on a specified device.

- **Resize2fs**

Resizes an ext2/ext3/ext4 filesystem. It adjusts the filesystem size after resizing the underlying partition.

- **xfs_growfs**

Increases the size of an XFS filesystem after resizing the underlying partition.

- **xfs_repair**

Repairs a damaged XFS filesystem.

- **Mount**

Mounts a filesystem to a directory, making it accessible for use. You can mount a device or partition to a specific mount point.

Create a file system

- To create file system from /dev/sdb1 partition run
- mkfs /dev/sdb1

root@sipl-152:~

```
[root@sipl-152 ~]# mkfs /dev/sdb1
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 26214400 4k blocks and 6553600 inodes
Filesystem UUID: 6029126c-2a1d-4206-ad1d-8978342a0c0b
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000, 7962624, 11239424, 20480000, 23887872

Allocating group tables: done
Writing inode tables: done
Writing superblocks and filesystem accounting information: done

[root@sipl-152 ~]# lsblk -f /dev/sdb1
NAME FSTYPE FSVER LABEL UUID                                 FSAVAIL FSUSE% MOUNTPOINTS
sdb1 ext2   1.0         6029126c-2a1d-4206-ad1d-8978342a0c0b
[root@sipl-152 ~]#
```

In the first example, we are using mkfs without any option.

By default ext2 filesystem gets created.

In the second option we create the filesystem by defining the type as ext4, so ext4 filesystem gets created.

df –T can be used to identify type of mounted filesystem

Create a file system

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- Second example with filesystem type::: mkfs -t ext4 /dev/sdb2

root@sipl-152:~

```
[root@sipl-152 ~]# mkfs -t ext4 /dev/sdb2
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 26214400 4k blocks and 6553600 inodes
Filesystem UUID: 3613eb07-a692-4dfe-b2b1-7e76adf338c1
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000, 7962624, 11239424, 20480000, 23887872

Allocating group tables: done
Writing inode tables: done
Creating journal (131072 blocks): done
Writing superblocks and filesystem accounting information: done

[root@sipl-152 ~]# mkdir /u8
[root@sipl-152 ~]# mount /dev/sdb2 /u8
[root@sipl-152 ~]# df -T
Filesystem     Type      1K-blocks     Used Available Use% Mounted on
devtmpfs       devtmpfs       4096        0      4096   0% /dev
tmpfs          tmpfs       3866836        0   3866836   0% /dev/shm
tmpfs          tmpfs       1546736     9844   1536892   1% /run
/dev/sda3      xfs       104792064  5533624  99258440   6% /
/dev/sda9      xfs        26148864   215416  25933448   1% /u02
/dev/sda8      xfs        26148864   215416  25933448   1% /u01
/dev/sda7      xfs        52363264  1470904  50892360   3% /var
/dev/sda11     xfs        26148864   215416  25933448   1% /src
/dev/sda5      xfs       262016000  2157156 259858844   1% /home
/dev/sda6      xfs        52363264   398172  51965092   1% /opt
/dev/sda2      xfs          983040   314628    668412  33% /boot
tmpfs          tmpfs        773364      116    773248   1% /run/user/1000
/dev/sdb2      ext4      102626232       24  97366944   1% /u8
[root@sipl-152 ~]#
```

After creating the ext4 type of file system, we create a place holder on the ON the / filesystem where this partition can be loaded / mounted

$mkdir /u8

Mount the device /dev/sdb2 on the directory

df –T can be used to identify type of mounted filesystem

Imp options while creating a filesystem

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Option	Value
-t	Filesystem type, Example • for disks ext2, ext3, ext4. • For network file system, nfs • For loop back filesystem, loop • Default is ext2
-L	Label for the partition. • In case disks are swapped / replaced, then using the Label information we can understanding / identify the purpose of this partition

Mount command

- Mount command is used to attach the disk/partition with the OS, so that an access point can be created for users to get into that particular device.
- To create a unique access-point / entry-point into device, create a **NEW** directory on the OS level
- When mount command completes successful, ‘cd’ into this directory will take the user into the new device / disk / partition
- Syntax:
  - mount [mount options] device name
- Example:
  - mount –o rw /dev/sdc2 /u8

Unmount command

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- To remove the access to the device simply run unmount command.
- unmount command first check if the mount-point is in use, i.e. is any user accessing this directory or any underlying part of this directory.
- If yes, then mount will throw an error and stop
- If no, the mount, will flush all the data currently in RAM back to the disk and then remove detach this device from the directory.
- Once unmount is done, the directory remains on the machine as an ordinary directory
- Syntax:
  - umount /u8; --or unmount /dev/sdc2

FSTAB: Intro

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- FSTAB file is referred by the operating system, during the boot/startup of the machine.
- Boot process will automatically mount all filesystems that are actively defined in the /etc/fstab file.
- In case of mount failure, the system will continue mounting other file systems.
- In case of mount of ‘/’ itself fails, then the system will throw relevant error message on the CONSOLE and stop the boot sequence.

FSTAB: Structure

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Device to be mounted	Mount point	Type of file system	mount options	FS dump required (1/0)	FSCK pass number (0/1/2)
/dev/sda2	/	Ext4	Defaults	1	1
/dev/sda1	/boot	Ext4	Defaults	1	2
UUID=19245658-510a-43cb-a7ad-075853a1267a	swap	Swap	Defaults	0	0

- **Instead of giving a device name, we can also give Label and UUID number**
- **UUID number for a device can be found if you run the command, blkid device-name**
- **Example:**
  - **$ blkid /dev/sdc1**
  - **/dev/sdc1: UUID="623f3b98-be14-4578-8804-c9ddd43742a1" TYPE="ext2"**

Practical's

- Partition with the help of fdisk command
- Create filesystem
- Manually mount the file system
- Update /etc/fstab file so th at file system is automatically mounted whenever the machine reboots.