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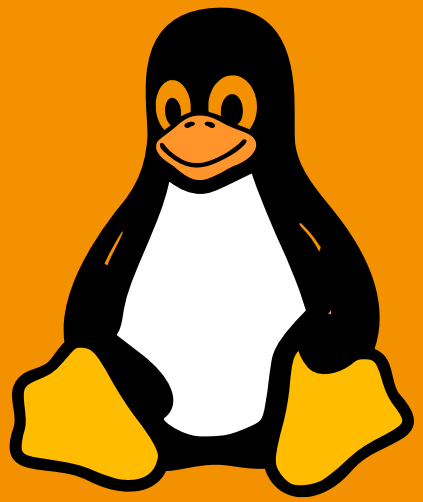
Prof. Florian Künzner
Technical University of Applied Sciences Rosenheim, Computer Science

OS 15 – File systems



source: iconspng.com

The lecture is based on the work and the documents of Prof. Dr. Ludwig Frank

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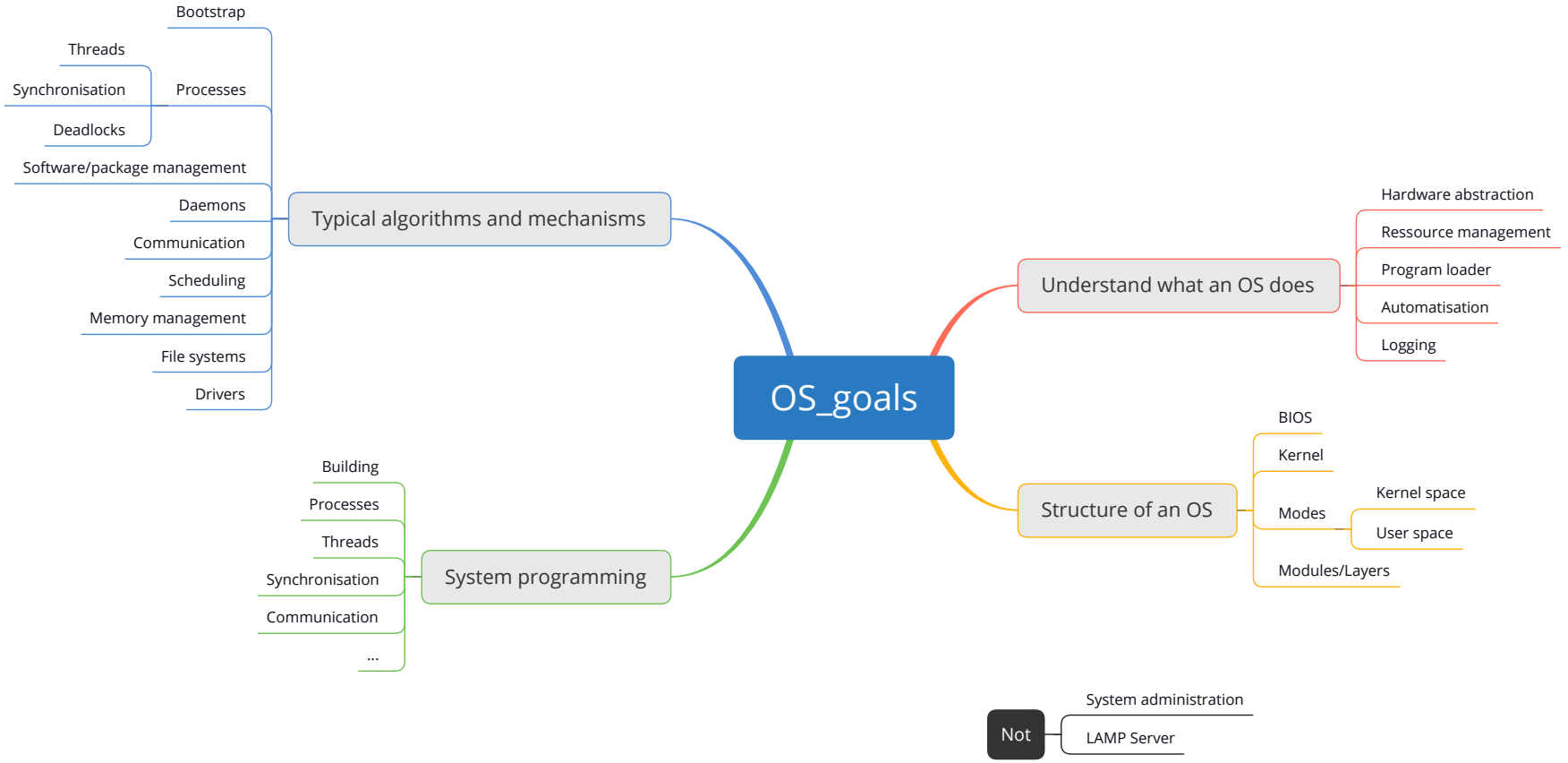
Goal



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Goal

OS::File systems

- File system tasks
- File system properties
- File attributes
- Linux file systems

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Intro

Which file systems do you know?

https://en.wikipedia.org/wiki/List_of_file_systems

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Intro

What is a file system?

A **file systems** is a **structure for data** on a data storage medium, to **efficiently access** (read/write) **persistent data**.

Inside the OS, a **file system** is a **component inside the kernel**, to **generalise** data access.

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File system artefacts

File

A file is a container of persistent stored information (of a similar structure).

Directory/Folder

A directory is a cataloguing structure to group files and other directories.

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Hierarchical file system

A file system is **hierarchical**, if **directories can contain sub directories**.

```
1 /
2 /etc/passwd
3     /group
4 /bin
5 /home/dev/Desktop
6           /.bashrc
7 /...
```

Tasks of a file system

- Persistence
- Access rights (read, write, execute)
- Virtualisation of hardware
- Basic mechanisms for databases
- Organisation of parallel file access
- Fast read/write (caching)
- Support of huge amounts of data (up to GB/TB)
- Quota system
- Data loss protection and consistency check

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Limitations

- Maximum filename length
- Allowable characters in directory entries
- Maximum pathname length
- Maximum file size
- Maximum volume size
- Max number of files

https://en.wikipedia.org/wiki/Comparison_of_file_systems#Limits

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Metadata

- File owner/group
- POSIX file permissions
- Creation timestamps
- Last access/read timestamps
- Last metadata change timestamps
- Last archive timestamps
- ...

https://en.wikipedia.org/wiki/Comparison_of_file_systems#Metadata

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File capabilities

- Hard links
- Symbolic links
- Journaling file system (block or metadata-only)
- Case-sensitive
- Case-preserving
- ...

https://en.wikipedia.org/wiki/Comparison_of_file_systems#Features

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Resize capabilities

- Host OS
- Online grow
- Offline grow
- Online shrink
- Offline shrink

https://en.wikipedia.org/wiki/Comparison_of_file_systems#Resize_capabilities

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File attributes

```
ls -l file
 -rw-r----- 1 flo repos 34 Sep  7 10:29 file
 ---------- - --- ----- -- ------------ ----
  ||         | |   |     |  |            |- filename
  ||         | |   |     |  |- last change
  ||         | |   |     |
  ||         | |   |     |- size (bytes)
  ||         | |   |- group
  ||         | |- user
  ||         |
  ||         |- number of names (hardlinks)
  ||
  ||- access rights
  |
  |- file type
```

File types

Type	Description
-	Regular file (e.g. text file)
d	Directory
l	Symbolic link
b	Block device file
c	Character device file
s	Local socket file
p	Named pipe

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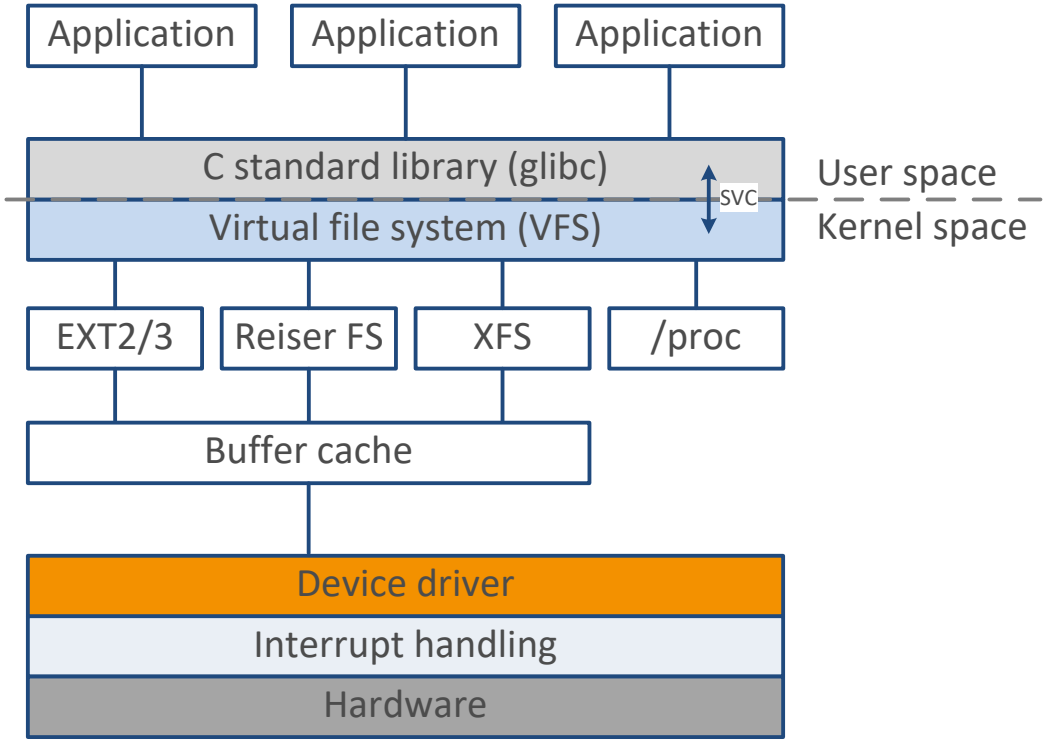
Virtual file system

A virtual file system is an abstraction of a concrete file systems that allows client applications to access files in a uniform way.



Inode

An **inode** (index node) is a data structure on a filesystem on Linux that contains all the information about a file or directory (except its name) and its actual data block pointers.

Inode properties

- Each inode has its own number.
- The inode number is unique inside the file system.
- File names are stored in the inode of the directory (inode, filename).
- Contains meta information about the file/directory.

`https://elixir.bootlin.com/linux/latest/source/include/linux/fs.h#L603`

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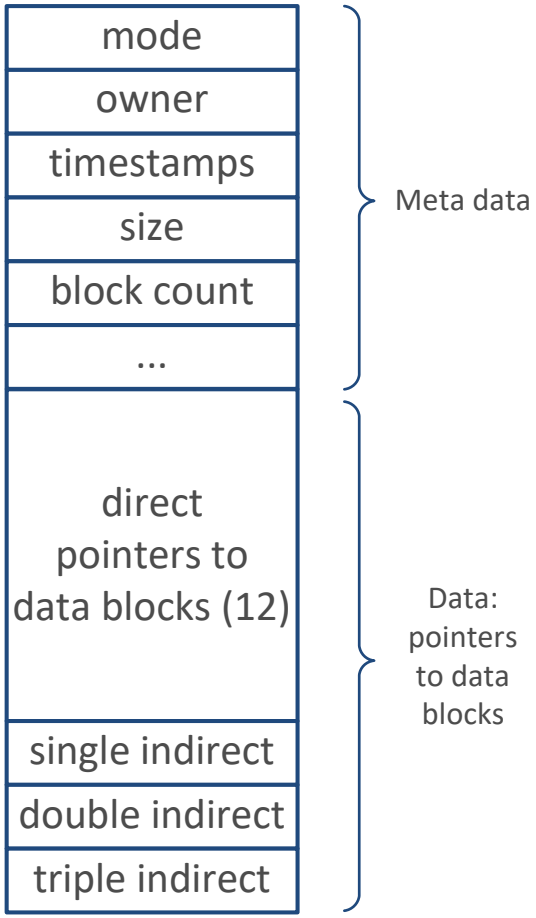
Inode structure

Inode meta data

- mode
- owner (uid), group (gid)
- access rights
- timestamps (mtime, ...)
- size
- block count
- ...

Inode data

- pointers to data blocks
- ...



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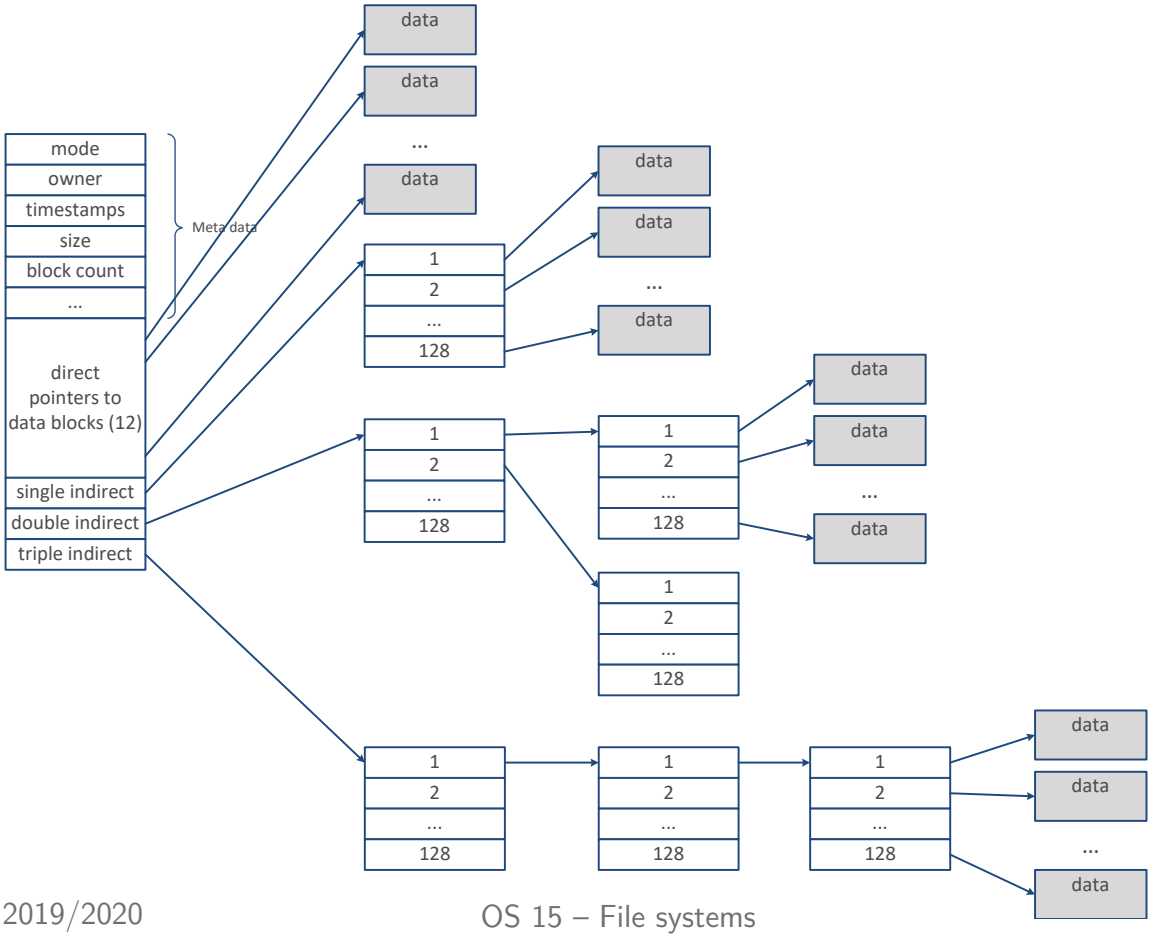
Inode structure

Inode data: pointers to data structures



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Linux file systems

Linux works with **hierarchical** file systems.

A **directory entry** contains information about its **files** and **sub directories**.

inode nr.	file name

Create file:

Write the new data (inode + blocks) to data storage medium AND add (inode nr. + file name) to the directory inode data block.

Delete file:

Delete the data (inode + [blocks]) from data storage medium AND remove (inode nr. + file name) from the directory inode data block.

Move file:

Move the (inode nr. + file name) from source inode data block to the destination inode data block.

`https://elixir.bootlin.com/linux/latest/source/include/linux/dcache.h#L88`

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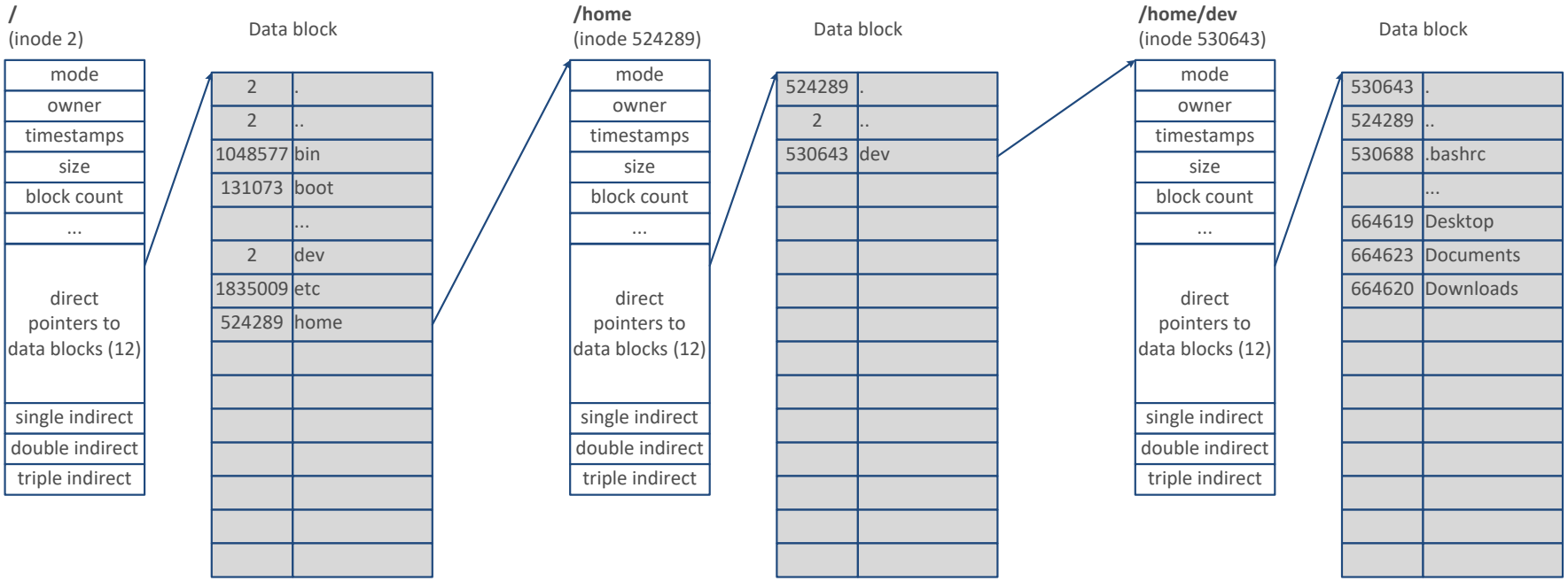
Inode directory example

With „`ls -i`“ the bash shows the inode numbers.



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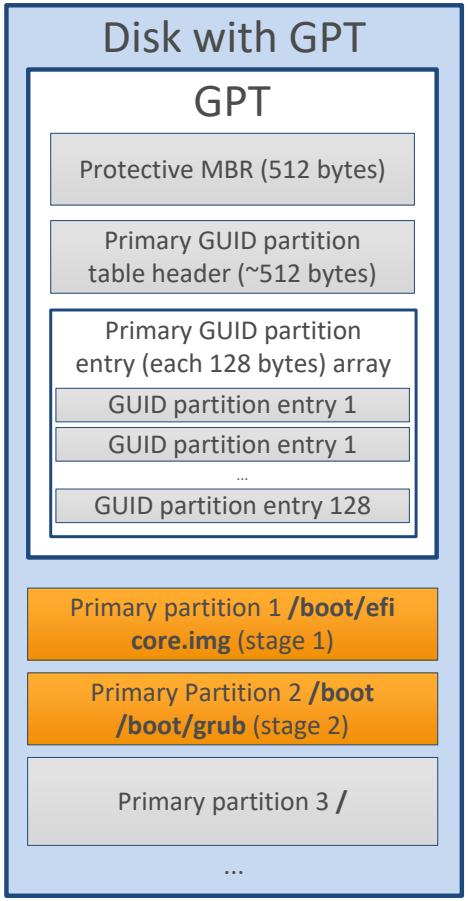
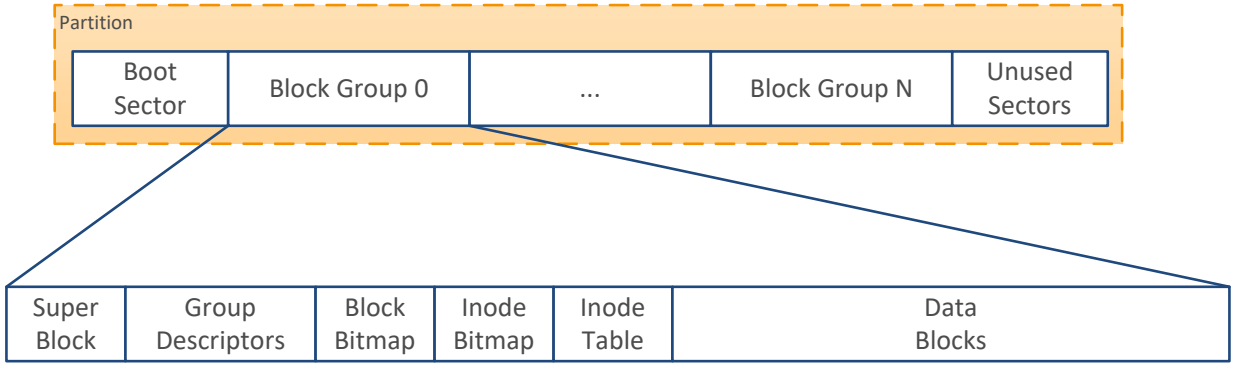
EXT4 file system structure





https://selvamvasu.wordpress.com/2014/08/01/inode-vs-ext4/

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Linux commands and files

Command/file	Description
`fdisk -l`	List disks and their partitions.
`fdisk /dev/sda1`	Enters `fdisk` in command mode to: delete/create partition table, delete/create partitions.
`gparted`	Graphical tool to show/delete/create partition tables, partitions, and file systems.
`mkfs -t ext4 /dev/sda1`	Creates a EXT4 file system on partition `/dev/sda1`.
`mkfs.ext4 /dev/sda1`	Creates a EXT4 file system on partition `/dev/sda1`.
`mount -l`	Show mounted file systems
`mount /dev/sda1 /mnt`	Mount `/dev/sda1` on `/mnt`
`umount /mnt`	Unmount the filesystem that is mounted in `/mnt`
`/etc/fstab`	Contains a list of file systems to be mounted at boot time.
`/etc/mtab`	Contains a list of currently mounted file systems.

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Summary and outlook

Summary

- File system tasks
- File system properties
- File attributes
- Linux file systems

Outlook

- Drivers