KARNAVATI
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Operating Systems
Course Code: **71203002004**
Case Studies on File Systems

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What is a File System?

- A file system organizes data on storage devices (hard drive, USB, cloud, etc.).

- It lets users store, find, copy, edit, delete, or rename files easily.
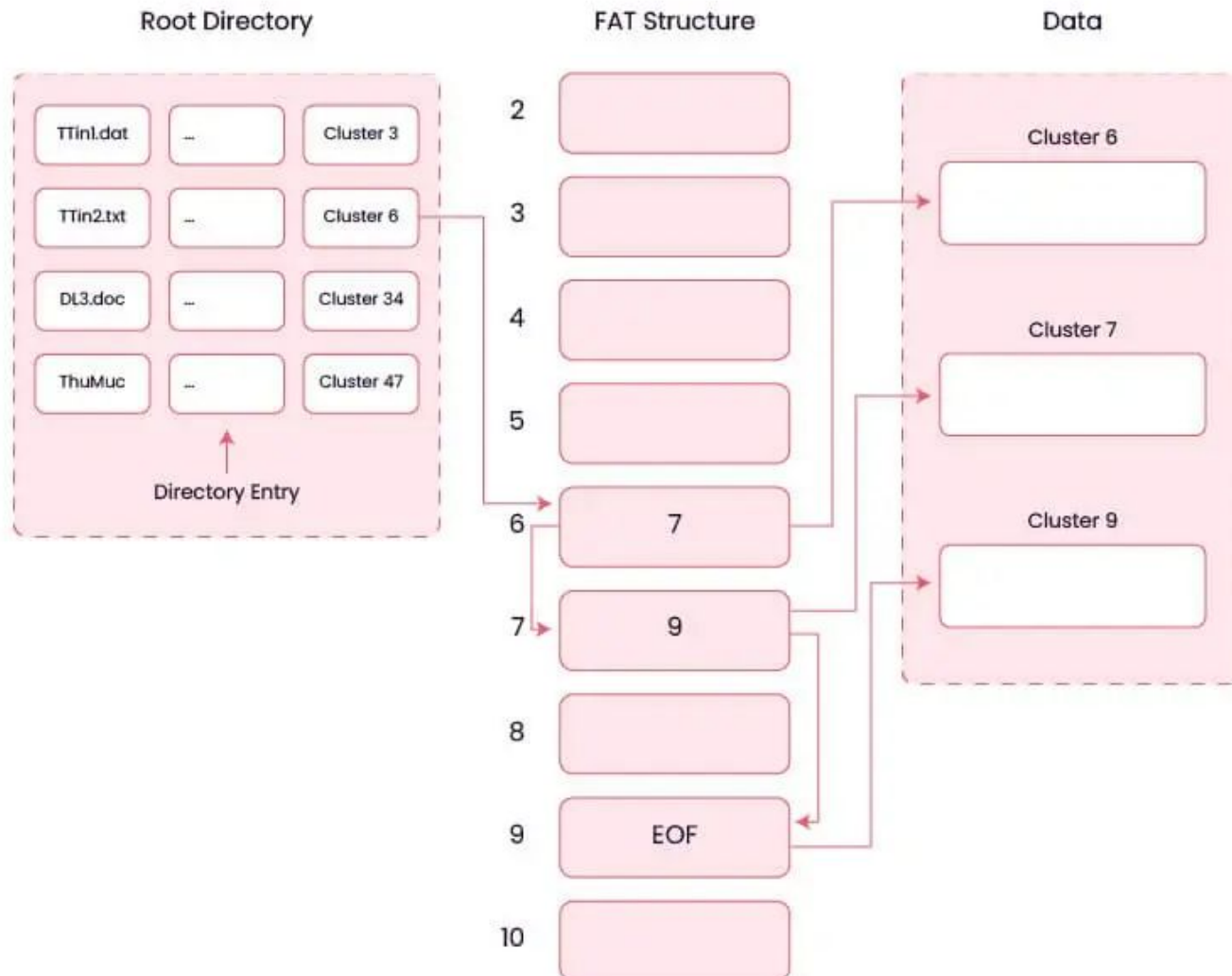
FAT32 (File Allocation Table 32)

Design / Structure

- Uses a linked list of clusters to store files.
- Key components:
  - **Boot Sector** → Disk info (sectors, cluster size).
  - **File Allocation Table (FAT)** → Tracks used/free clusters and file chain order.
  - **Root Directory** → Top-level file list.
  - **Data Area** → Actual storage space.

How It Works

- A file is split into clusters, which may be scattered.
- FAT keeps track of cluster order, so the system can read files sequentially.

FAT32 (File Allocation Table 32)

| Strengths (Advantages)	Limitations
Cross-platform support (Windows, Linux, macOS, consoles, cameras)	File size limit → Max 4 GB per file
Simple structure → Low overhead, fast on small/medium drives	Volume size limit → Usually up to 2 TB (some versions up to 8 TB)
Widely used on USB, SD cards, external drives	No security → Lacks permissions and encryption
Stable for small storage (less chance of corruption)	Performance issues → Slower with large files, fragmentation over time
Lightweight → Saves processing power and battery	—

NTFS (New Technology File System)

What is NTFS?

- Default Windows file system (modern PCs, servers, enterprise storage).
- Supports large files, long filenames, and efficient storage.

Limitations

1. **Compatibility** → Works best on Windows; macOS/Linux need extra drivers/software.
2. **External storage issues** → USB/SD cards may require reformatting for NTFS.
3. **Less efficient for small devices** → Higher overhead than FAT32.
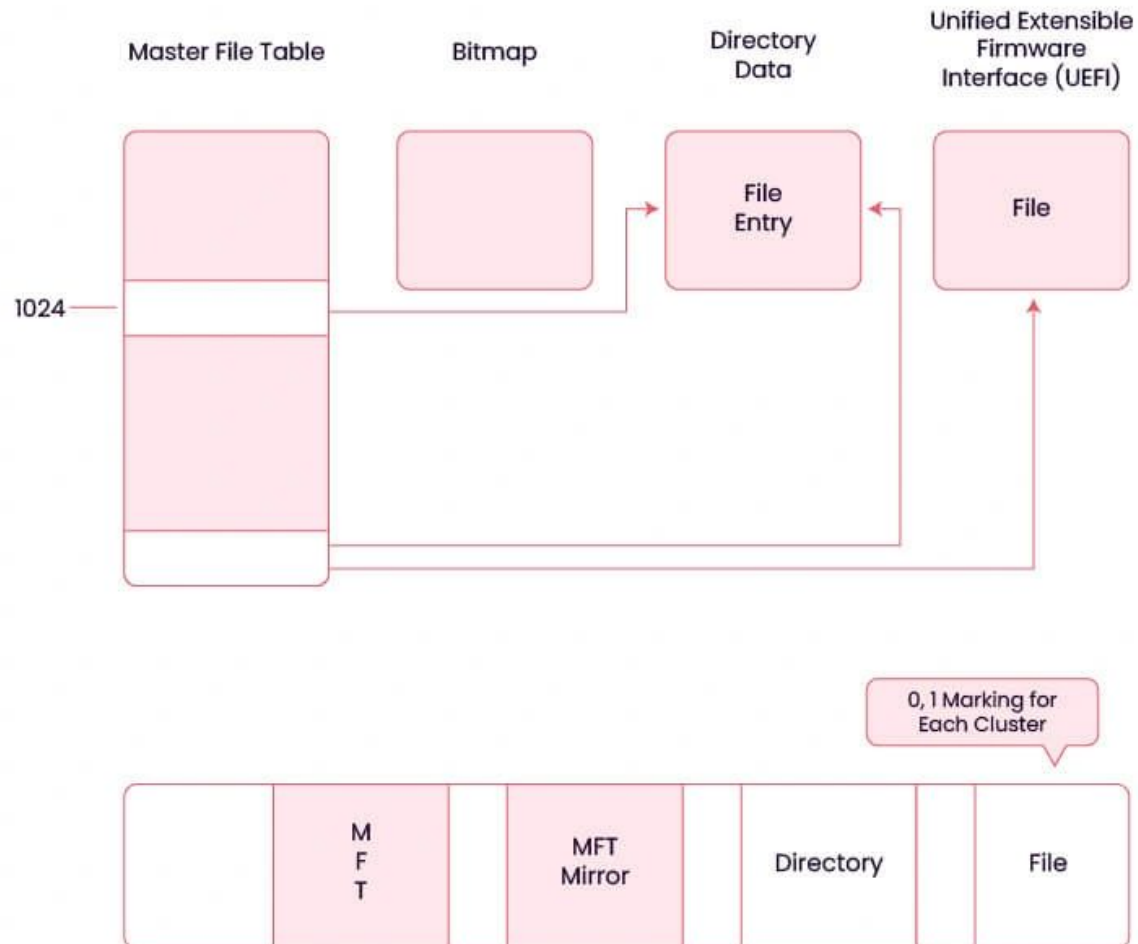
NTFS (New Technology File System)

Key Features

1. **Large file & partition support** → No 4 GB / 2 TB limits like FAT32.
2. **File compression** → Saves space, can improve transfer speed.
3. **Encryption & security** → File-level encryption + access permissions.
4. **Disk quotas** → Limits storage space per user.
5. **Journaling** → Logs file system changes for crash recovery.
6. **Fault tolerance** → Built-in recovery protects against corruption.
7. **Metadata support** → Tracks extra info (timestamps, permissions, attributes).
8. **Efficient storage** → Uses small clusters (default 4 KB) to save space.
9. **Master File Table (MFT)** → Stores file data + metadata, improves organization.

EXT Filesystem Family

Ext2 (Second Extended Filesystem)

- **Introduced**: 1993 (by Rémy Card).
- **Structure**: Uses **inodes** to store metadata, supports up to 4 TB partitions and 2 TB files (with 4 KB blocks).
- **Performance**: Fast for writes (no journaling overhead).
- **Journaling**: No journaling → longer recovery after crashes.
- **Use Case**: Embedded systems, where speed is more important than crash recovery.

EXT Filesystem Family

Ext3 (Third Extended Filesystem)

- **Introduced**: 2001 (upgrade of Ext2).
- **Structure**: Based on Ext2 → easy upgrade (backward compatible).
- **Performance**: Slight overhead due to journaling.
- **Journaling**: Added → improves reliability.
  - **Modes**: Writeback (fastest), Ordered (balanced), Journal (safest).
- **Advantages over Ext2**: Faster recovery, no need for lengthy fsck checks.
- **Limitations**: Still limited scalability (same file/partition limits as Ext2).

EXT Filesystem Family

Ext4 (Fourth Extended Filesystem)

- **Introduced**: 2006 (stable in 2008).
- **Structure**:
  - **Extents** → store large chunks of data contiguously (less fragmentation).
  - **Delayed Allocation** → allocates blocks only when data is actually written.
  - **64-bit support** → very large volumes.
- **Performance**: Much faster due to extents, delayed allocation, and optimized metadata handling.
- **Journaling**: Improved (with checksums for extra reliability).
- **Scalability**: Supports files up to 16 TB and partitions up to 1 EB.
- **Use Case**: Default in modern Linux (Ubuntu, Fedora).

DISCUSSION & REVISION

1. Which file system has a 4 GB file size limit?
2. Which file system uses the Master File Table (MFT)?
3. Which Linux file system introduced journaling?
4. Which file system supports extents and delayed allocation?
5. Which FAT32 component tracks used and free clusters?

REFERENCES

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