2. File systems in Operating Systems

A file system is a crucial component of an operating system that manages how data is stored, retrieved, and organized on a storage device, such as a hard disk or SSD. It provides a logical structure for managing files and directories, allowing users to easily access and manipulate their data.

File System Functions

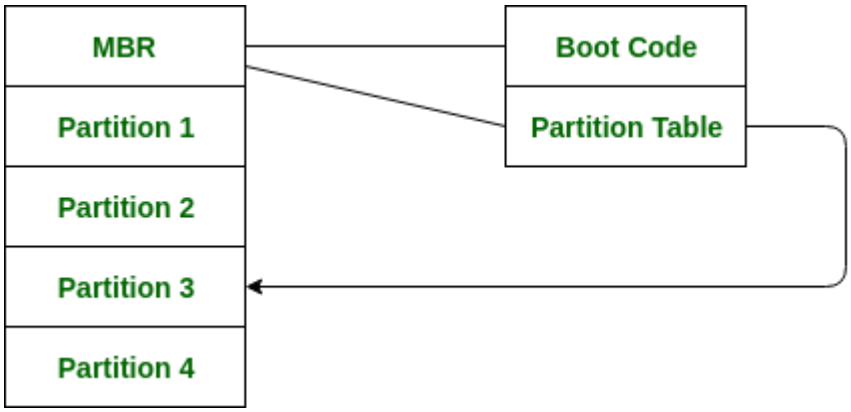
The primary functions of a file system include:

1. **Naming**: Assigning unique names to files and directories for easy identification and access.
2. **Organization**: Arranging files and directories in a hierarchical structure, using directories and subdirectories.
3. **Storage Management**: Efficiently allocating and deallocating storage space on the storage device.
4. **Access Control**: Enforcing permissions and access rights to files and directories, ensuring data security and privacy.
5. **Metadata Management**: Maintaining information about files and directories, such as creation date, size, and ownership.

File System Structure

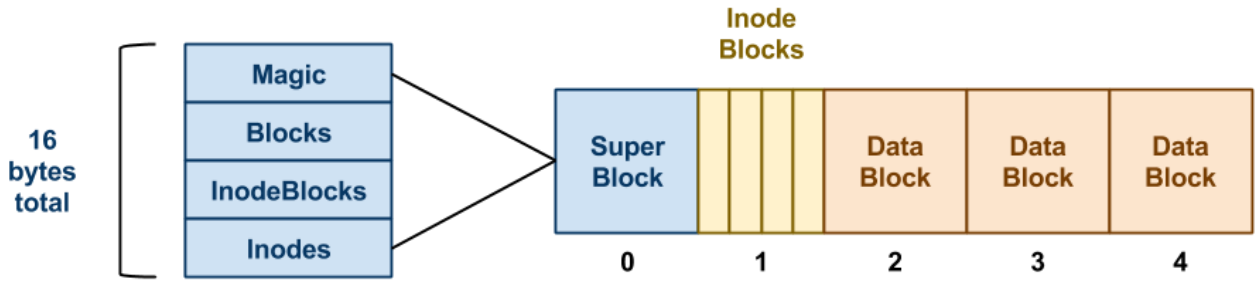
A file system typically consists of the following components:

1. **Boot Block**: Contains information required to boot the operating system and is located at the beginning of the file system.



2. **Super Block**: Stores vital information about the file system, such as the size of the file system, the number of blocks, and the location of important structures.

3. **Inode Table**: Contains a list of inodes, which store metadata about files and directories, such as permissions, size, and location of data blocks.
4. **Data Blocks**: The actual storage units where file data is stored.

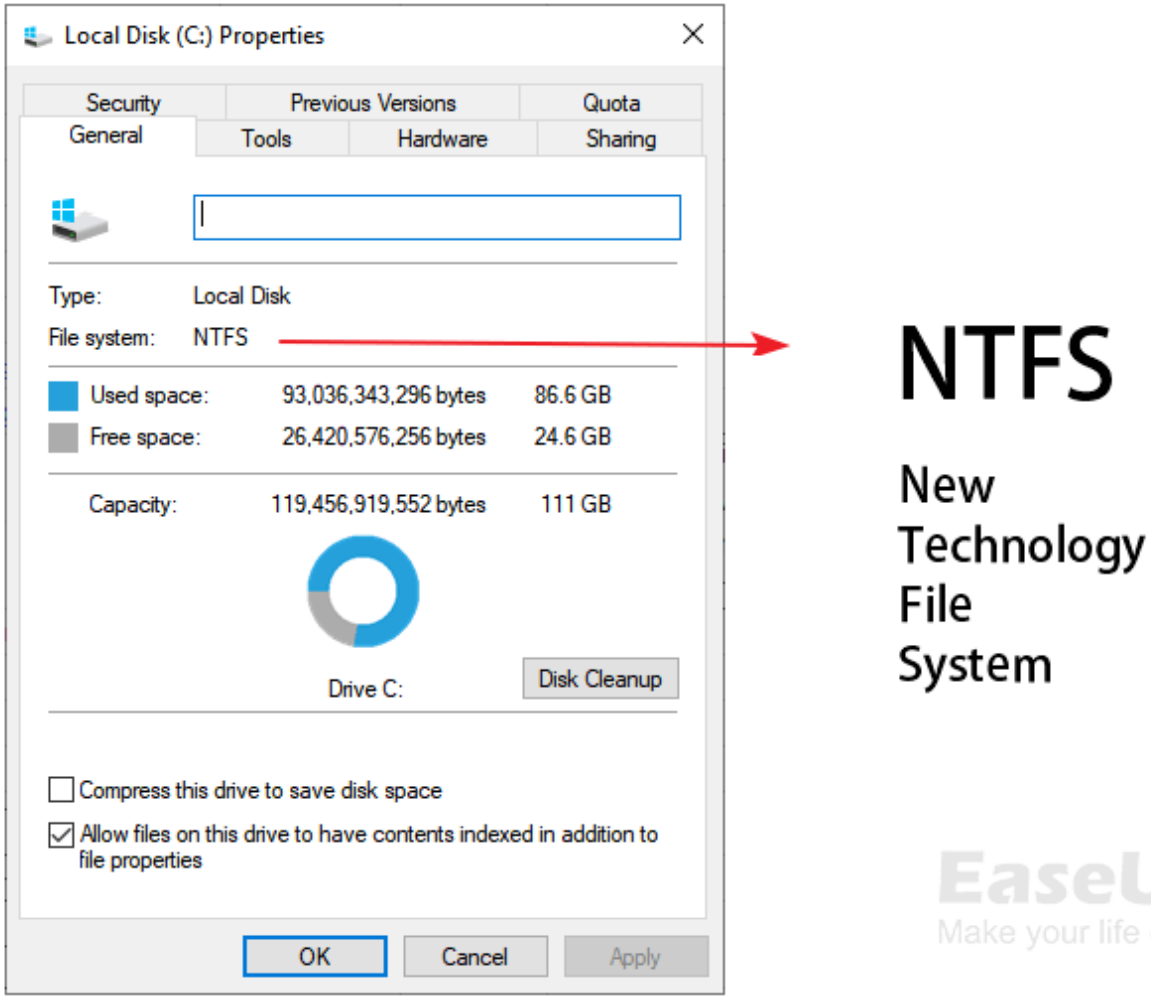


File System Implementation

Windows File System (NTFS)

The New Technology File System (NTFS) is the default file system for modern Windows operating systems. Some key features of NTFS include:

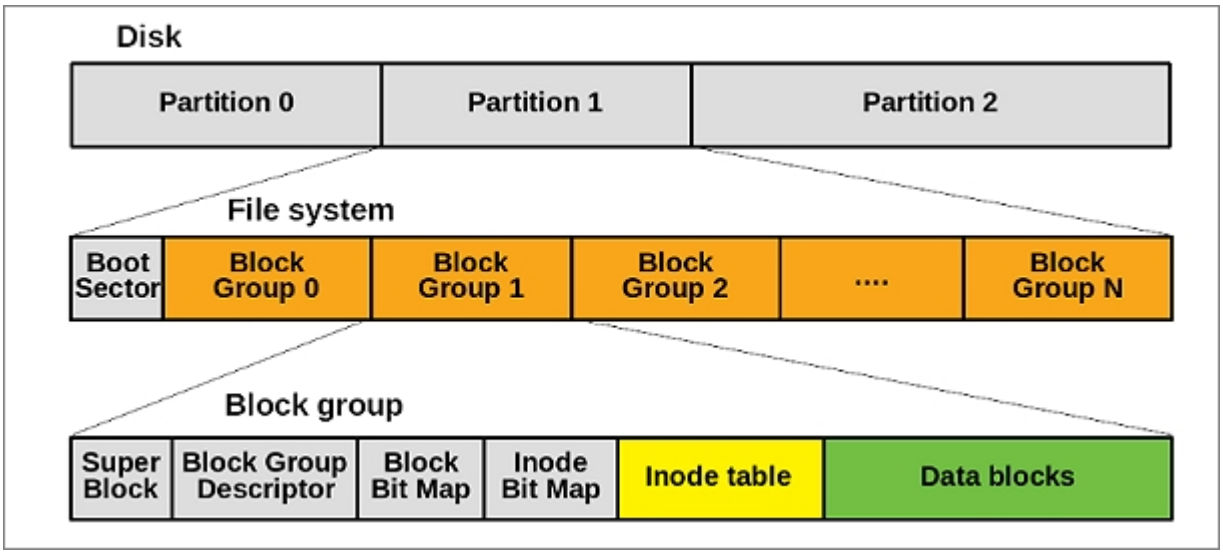
1. **Journaling**: NTFS maintains a log of file system transactions, ensuring data integrity in case of system crashes or power failures.
2. **Security**: NTFS supports advanced security features, such as access control lists (ACLs) and file encryption.
3. **Large File Support**: NTFS can handle files up to 16 exabytes in size.



Unix File System (ext4)

The Fourth Extended File System (ext4) is a widely used file system in Unix-based operating systems, such as Linux. Some key features of ext4 include:

1. **Extents**: ext4 uses extents, which are contiguous blocks of storage, to improve performance and reduce fragmentation.
2. **Delayed Allocation**: ext4 delays the allocation of data blocks until the data is actually written to disk, improving efficiency and reducing fragmentation.
3. **Timestamps**: ext4 supports nanosecond-precision timestamps, allowing for more accurate file and directory metadata.



File and Directory Management

File Creation and Deletion

When a file is created, the file system allocates an inode and the necessary data blocks to store the file's data. The inode contains metadata about the file, such as its size, permissions, and pointers to the data blocks. When a file is deleted, the file system marks the inode and data blocks as free, making them available for future use.

Directory Management

Directories are special types of files that contain a list of file and subdirectory names, along with their corresponding inodes. When a directory is created, the file system allocates an inode and data blocks to store the directory's contents. As files and subdirectories are added or removed, the directory's contents are updated accordingly.

File and Directory Growth and Shrinkage

When a file grows, the file system allocates additional data blocks to accommodate the new data. If the file system uses extents, it attempts to allocate contiguous blocks to minimize fragmentation. When a file shrinks, the file system marks the unused data blocks as free, allowing them to be used by other files.

Similarly, when a directory grows or shrinks, the file system allocates or deallocates data blocks as needed to store the directory's contents.

See Also 3. Processes in Operating Systems