Operating System

BIM IV Semester

Credits: 3

Lecture Hours:48

Er. Santosh Bhandari,
(Master Computer Science)

Unit–5

File Management:

File System

What is File System?

-It is software solution where user creates file.

-A file is a collection of correlated information which is recorded on secondary or non-volatile storage like magnetic disks, optical disks, and tapes.

In general, a file is a sequence of bits, bytes, or records whose meaning is defined by the file creator and user. Every File has a logical location where they are located for storage and retrieval.

File System

Objective of File management System

- It provides I/O support for a variety of storage device types.
- Minimizes the chances of lost or destroyed data
- Helps OS to standardized I/O interface routines for user processes.
- It provides I/O support for multiple users in a multiuser systems environment.

Naming file

File naming guidelines are:

- A file name can be up to 255 characters long and can contain letters, numbers, and underscores.
- The operating system is case-sensitive, which means it distinguishes between uppercase and lowercase letters in file names. Therefore, FILEA, FiLea, and filea are three distinct file names, even if they reside in the same directory.
- File names should be as descriptive and meaningful as possible.
- Directories follow the same naming conventions as files.

Naming file

-Almost every OS supports two-part file names. These two parts of the file names are separated by a period or dot (.).

-The part that comes after the period (.) is known as the file extension, and it typically provides some kind of information regarding the file.

The most common file extensions.

File Extension	File Meaning
myfile.bak	This indicates the existence of a backup file.
myfile.c	This denotes a source file for the C programming language.
myfile.gif	This denotes an image file in GIF format.
myfile.hlp	This indicates the presence of a help file.
myfile.html	This is an HTML (HyperText Markup Language) file.
myfile.jpg	This denotes an image file in JPG format.
myfile.mp3	This denotes an MP3 music or audio file.
myfile.mpg	This is an MPEG video file containing a movie encoded with the MPEG standard.
myfile.o	This indicates the presence of an object file.
myfile.pdf	This indicates a file in Portable Document Format (PDF).
myfile.txt	This denotes a standard text file.
myfile.zip	This indicates that the archive has been compressed.

File Structure

A File Structure needs to be predefined format in such a way that an operating system understands. It has an exclusively defined structure, which is based on its type.

Three types of files structure in OS:

1. **A text file:** It is a series of characters that is organized in lines.
2. **An object file:** It is a series of bytes that is organized into blocks.
3. **A source file:** It is a series of functions and processes.

Types of file systems

FAT (File Allocation Table): An older file system used by older versions of Windows and other operating systems.
NTFS (New Technology File System): A modern file system used by Windows. It supports features such as file and folder permissions, compression, and encryption.
ext (Extended File System): A file system commonly used on Linux and Unix-based operating systems.
HFS (Hierarchical File System): A file system used by macOS.
APFS (Apple File System): A new file system introduced by Apple for their Macs and iOS devices.

File Attribute

A file has a name and data. Moreover, it also stores meta information like file creation date and time, current size, last modified date, etc. All this information is called the attributes of a file system.

Some important File attributes used in OS:

Name: It is the only information stored in a human-readable form.

Extension: file type (.doc, .mp3)

Identifier: Every file is identified by a 16 byte unique tag number within a file system known as an identifier.

Location: Points to file location on device.

File Attribute

Type: This attribute is required for systems that support various types of files.

Size: Attribute used to display the current file size.

Protection: This attribute assigns and controls the access rights of reading, writing, and executing the file.

Time, date and security: It is used for protection, security, and also used for monitoring

Protection Permission:

Encryption Compression:

File Directories

File Directories

The collection of files is a file directory. The directory contains information about the files, including attributes, location, and ownership. Much of this information, especially that is concerned with storage, is managed by the operating system.

File Directories

Information contained in a directory.

- Name
- Type
- Address
- Current length
- Maximum length
- Date last accessed
- Date last updated
- Owner id
- Protection information

File Directories

The operations performed on the directory are:

- Search for a file
- Create a file
- Delete a file
- List a directory
- Truncate the file (concatenate)
- Rename a file
- Traverse the file system
- Repositioning

File Directories

Advantages of Maintaining Directories

Efficiency: A file can be located more quickly.

Naming: It becomes convenient for users as two users can have same name for different files or may have different name for same file.

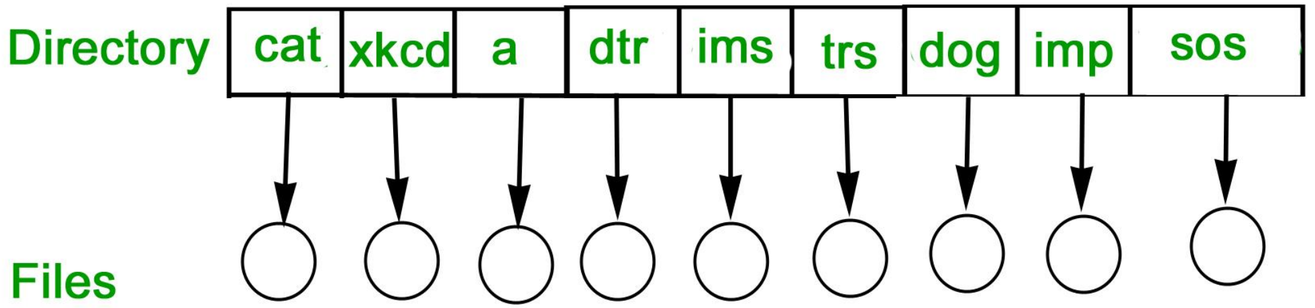
Grouping: Logical grouping of files can be done by properties e.g. all java programs, all games etc.

File Directories

Single-Level Directory: all files are stored in a single directory or folder. This directory is located at the root level of the file system

Advantages:

- It is simple and easy to implement.
- It is ideal for small-scale file management systems.



Disadvantages

- It is not suitable for large-scale file management systems.
- It does not provide a logical grouping of files.

File Directories

Two-level directory structure:

It is an improvement over the single-level directory system. In this system, files are organized into two levels of directories. The first level contains the user directories, while the second level contains the files.

Advantages

- It provides a logical grouping of files.
- It is suitable for moderate-scale file management systems.

Disadvantages:

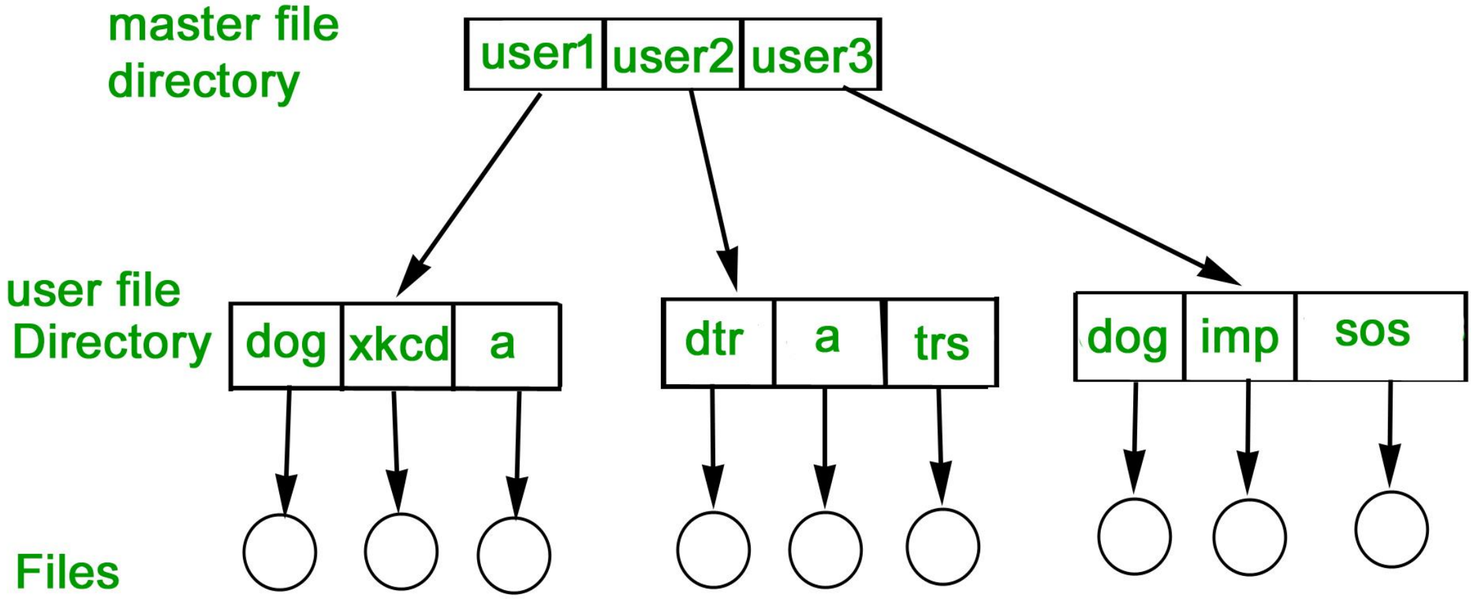
- It is not suitable for large-scale file management systems.
- It is difficult to maintain when the number of users or files increases.

File Directories

In this separate directories for each user is maintained.

Path name: Due to two levels there is a path name for every file to locate that file.

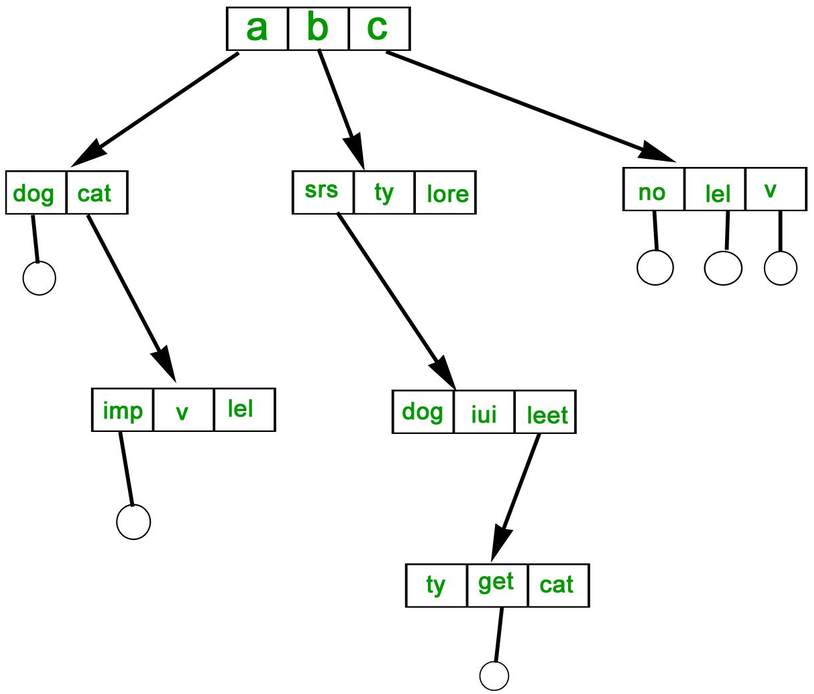
-We can have the same file name for different users.
-Searching is efficient in this method.



File Directories

Tree-Structured Directory

The directory is maintained in the form of a tree. Searching is efficient and also there is a grouping capability.



Advantages

- It provides a highly logical grouping
- Suitable for large-scale file management systems.

Disadvantages

- It is complex
- Requires significant maintenance.

File Directories: Path Name

When the file system is organized as a directory tree, some way is needed for specifying file names.

Two different methods are commonly used:

1. Absolute Path name – In this method, each file is given an absolute path name consisting of the path from the root directory to the file.

Example, the path /usr/ast/mailbox means that the root directory contains a subdirectory usr, which in turn contains a subdirectory ast, which contains the file mailbox.

-Absolute path names always start at the root directory and are unique.

File Directories: Path Name

-In UNIX the components of the path are separated by ‘/’. In Windows, the separator is ‘\’. Windows \usr\ast\mailbox UNIX /usr/ast/mailbox

2. Relative Path name – This is used in conjunction with the concept of the working directory (also called the current directory). All path names not beginning at the root directory are taken relative to the working directory. For example, if the current working directory is /usr/ast, then the file whose absolute path is /usr/ast/mailbox can be referenced simply as mailbox.

File Access

When a file is used, information is read and accessed into computer memory and there are several ways to access this information of the file.

File access methods: Three primary

1. Sequential-Access,
2. Direct Access,
3. Index sequential Method.

Additional methods

1. Relative Record Access
2. Content Addressable Access-

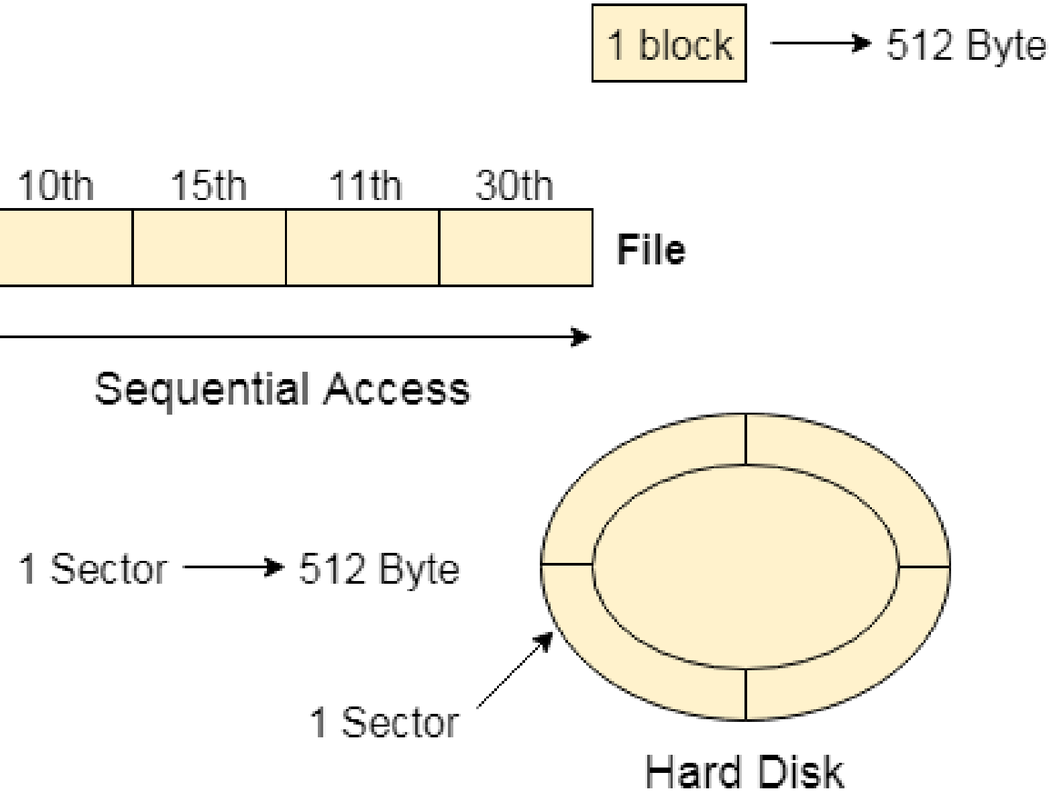
Sequential-Access

Sequential-Access:

-In sequential access, the OS reads the file word by word.

-A pointer is maintained which initially points to the base address of the file.

-If the user wants to read first word of the file then the pointer provides that word to the user and increases its value by 1 word.



Sequential-Access

Key points:

- Data is accessed one record right after another record in an order.
- When we use read command, it move ahead pointer by one
- When we use write command, it will allocate memory and move the pointer to the end of the file

Sequential-Access

Advantages

- It is simple to implement this file access mechanism.
- It is suitable for applications that require access to all records in a file, in a specific order.
- It is less prone to data corruption as the data is written sequentially and not randomly.
- It is a reliable method for backup and restore operations, as the data is stored sequentially and can be easily restored if required.

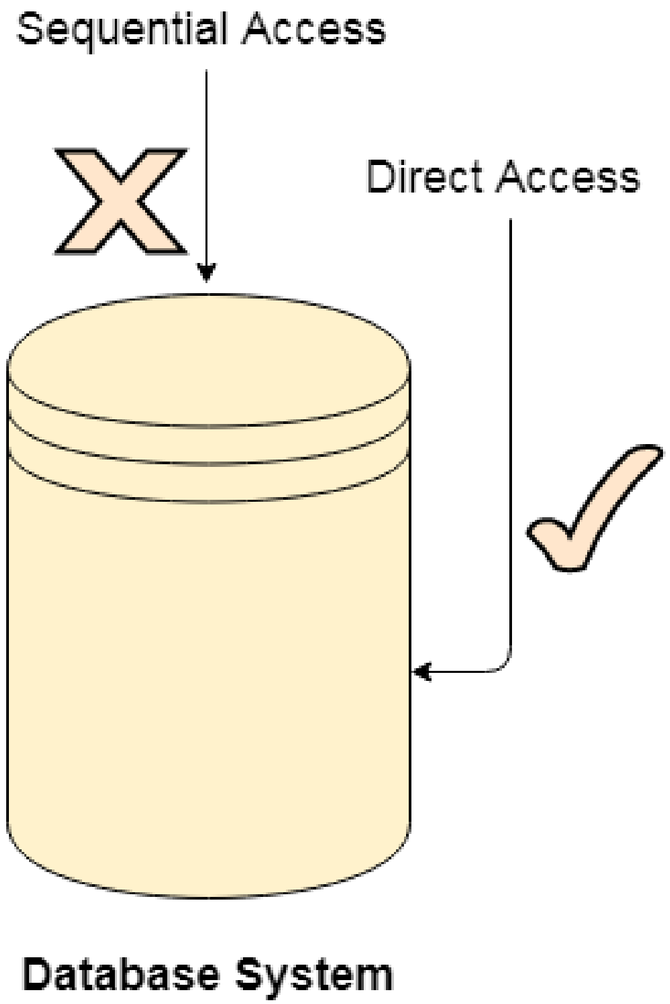
Sequential-Access

Disadvantages:

- This type of file access method is slow.
- It does not allow for quick access to specific records in the file.
- It is not well-suited for applications that require frequent updates or modifications to the file.
- The space between records cannot be used by other records, which can result in inefficient use of storage.

Direct Access

-Also known as relative access method.
-A fixed-length logical record that allows the program to read and write record rapidly.
-It is based on the disk model of a file since disk allows random access to any file block.
-Example. we may read block 14 then block 59, and then we can write block 17.
-There is no restriction on the order of reading and writing for a direct access file.



Direct Access

Advantages:

- The files can be immediately accessed decreasing the average access time.
- In the direct access method, in order to access a block, there is no need of traversing all the blocks present before it.

Index sequential method

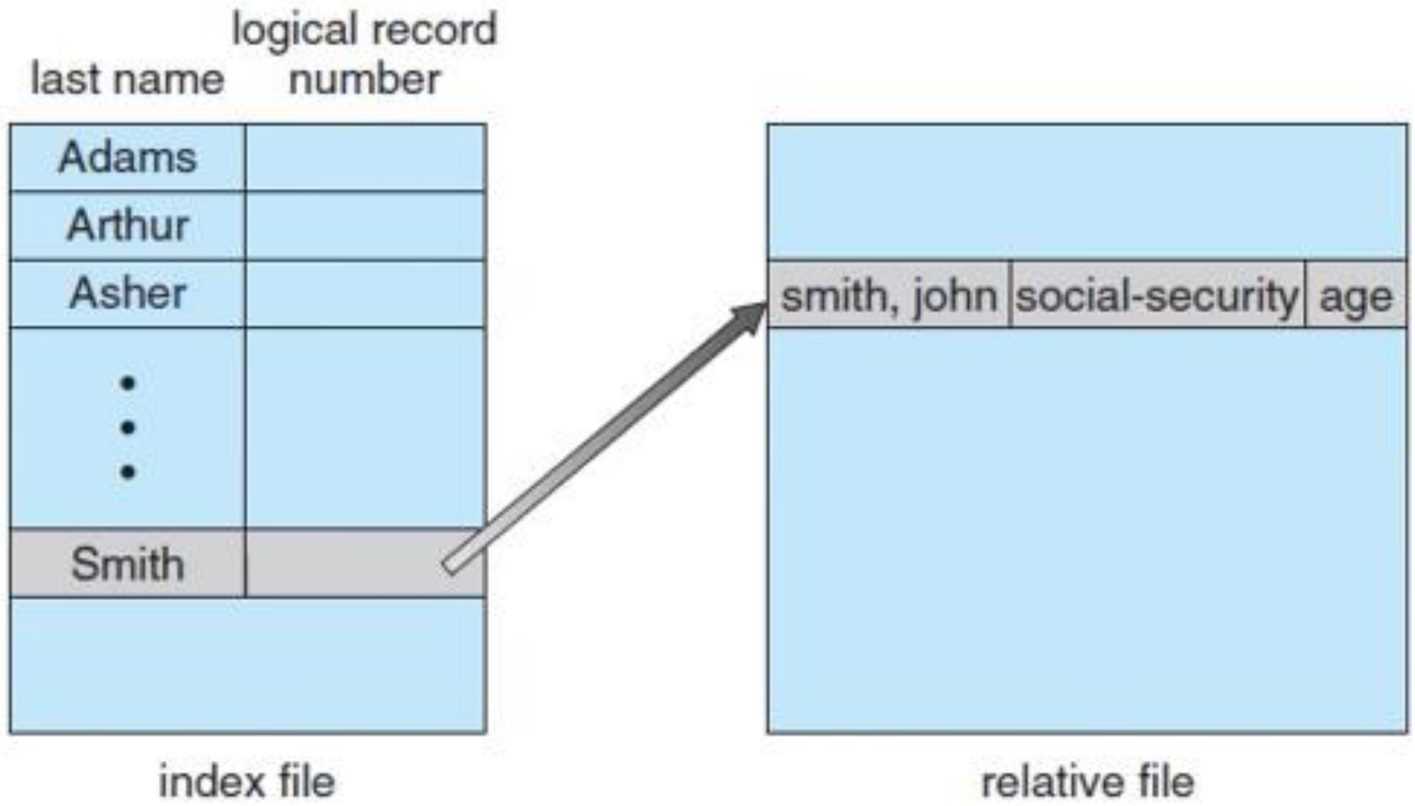
-These methods construct an index for the file.
-The index, like an index in the back of a book, contains the pointer to the various blocks.
-To find a record in the file, we first search the index, and then by the help of pointer we access the file directly.

Key points:

- It is built on top of Sequential access.
- It control the pointer by using index.

Index sequential method

The primary index file contains the pointer to the secondary index file.



Relative Record Access

-Relative record access is a file access method used in operating systems where records are accessed relative to the current position of the file pointer.
-In this method, records are located based on their position relative to the current record, rather than by a specific address or key value.

Content-addressable access (CAA)

Content-addressable access (CAA) is a file access method used in operating systems that allows records or blocks to be accessed based on their content rather than their address.

Keys in Content-Addressable Access:

Unique: Each record or block has a unique key that is generated using a hash function.

Calculated based on content: The key is calculated based on the content of the record or block, rather than its location or address.

File allocation methods

The allocation methods define how the files are stored in the disk blocks.

Types of file allocation methods

1. Continuous Allocation
2. Non-contiguous allocation

a. Linked Allocation

b. Indexed Allocation

File allocation methods

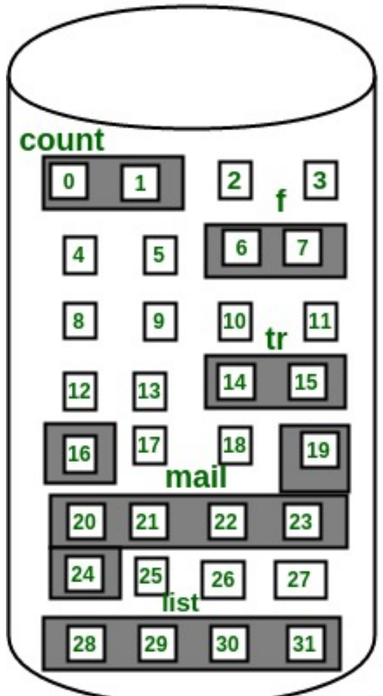
The main idea behind these methods is to provide:

- Efficient disk space utilization.
- Fast access to the file blocks.

Continuous Allocation

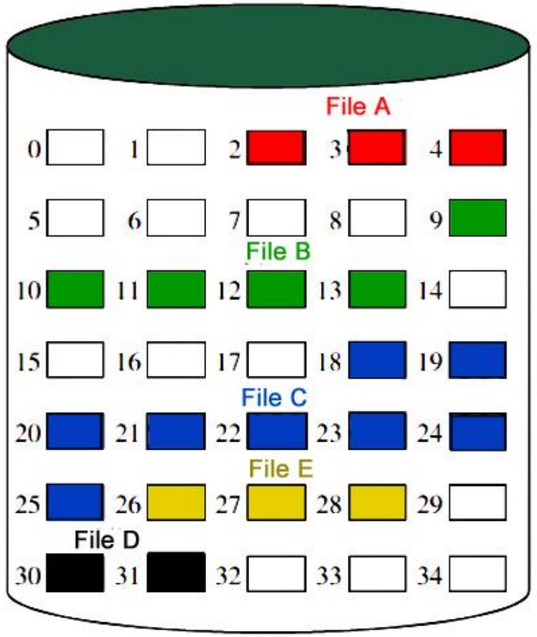
In this scheme, each file occupies a contiguous set of blocks on the disk

-Can start from any block but allocation should be contiguous.



Directory

file	start	length
count	0	2
tr	14	3
mail	19	6
list	28	4
f	6	2



File allocation table

File name	Start block	Length
File A	2	3
File B	9	5
File C	18	8
File D	30	2
File E	26	3

Continuous Allocation

Advantages:

- Both the Sequential and Direct Accesses are supported by this.
- This is extremely fast since the number of seeks are minimal because of contiguous allocation of file blocks.

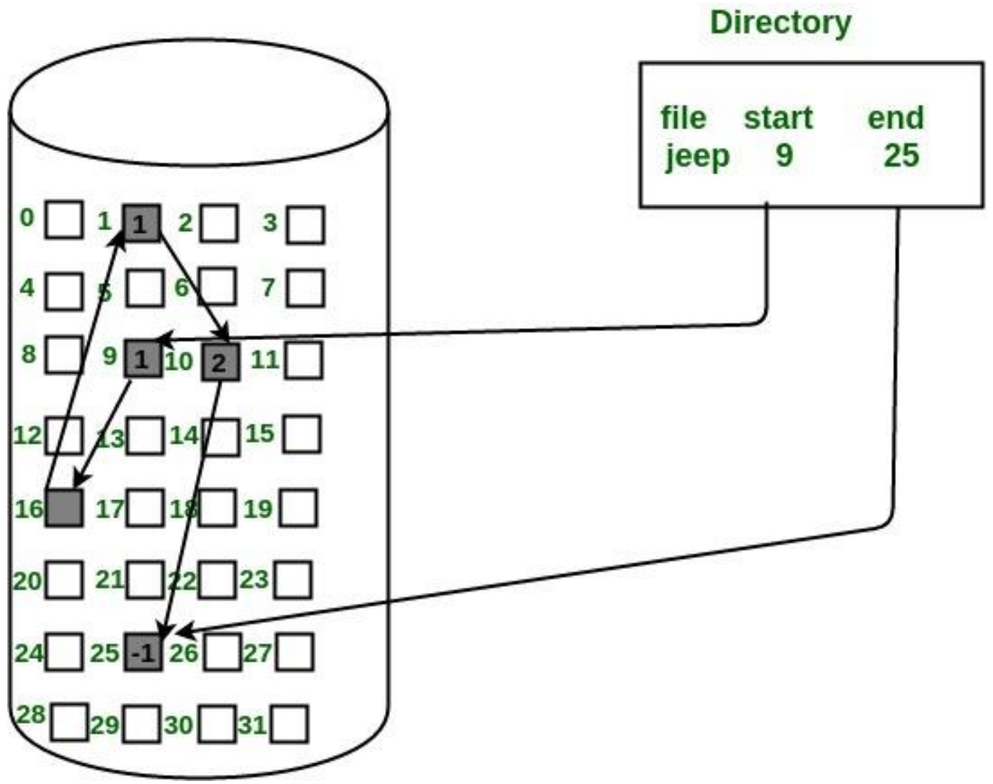
Disadvantages:

- This method suffers from both internal and external fragmentation.
- This makes it inefficient in terms of memory utilization.
- Increasing file size is difficult because it depends on the availability of contiguous memory at a particular instance.

Non-Contiguous: Linked List

Linked List Allocation: In this scheme, each file is a linked list of disk blocks that need not be contiguous. The disk blocks can be scattered anywhere on the disk.

-Starting block will be known.
-We can reach another block using pointer like a linked list.



Non-Contiguous: Linked List

Advantages:

- This is very flexible in terms of file size. File size can be increased easily since the system does not have to look for a contiguous chunk of memory.
- This method does not suffer from external fragmentation. This makes it relatively better in terms of memory utilization.

Disadvantages:

- Because the file blocks are distributed randomly on the disk, a large number of seeks are needed to access every block.
- It does not support random or direct access.
- Pointer consumes memory (Pointer Overhead)

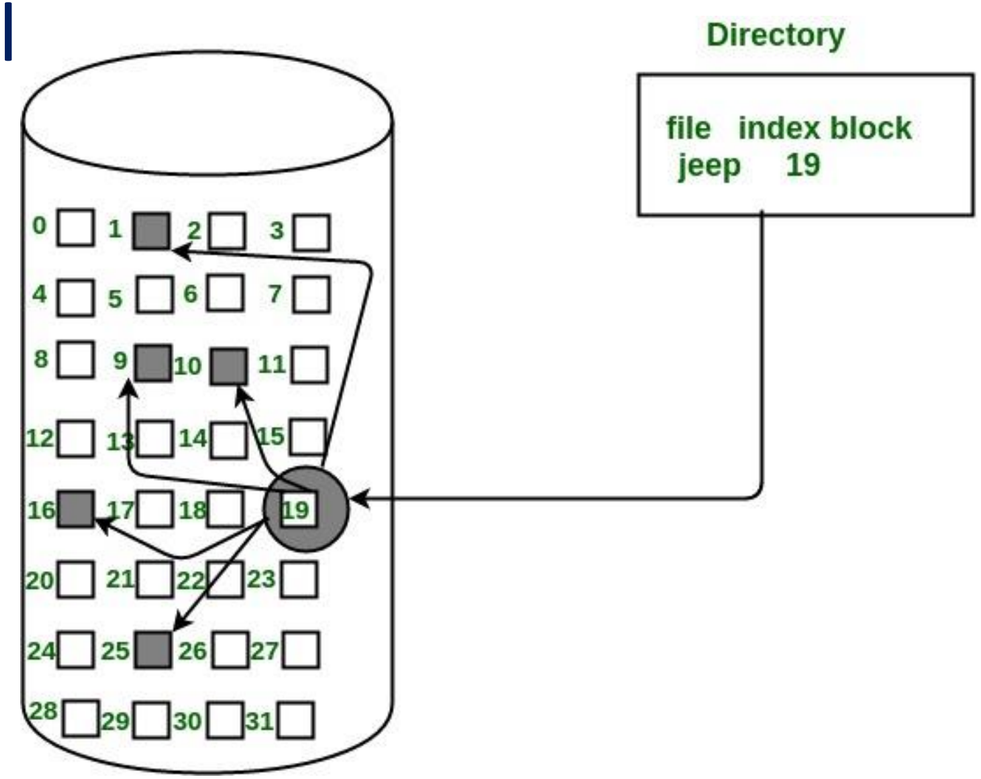
Non-Contiguous: Indexed Allocation

-In this method, a special block known as the Index block contains the pointers to all the blocks occupied by a file.

-Each file has its index block.

-The ith entry in the index block contains the disk address of the ith file block.

-The directory entry contains the address of the index block as shown in the image:



Non-Contiguous: Indexed Allocation

Advantages:

- This supports direct access to the blocks occupied by the file and therefore provides fast access to the file blocks.
- It overcomes the problem of external fragmentation.

Disadvantages:

- The pointer overhead for indexed allocation is greater than linked allocation.
- Need to create multilevel Index

Inode in Operating System

-In Unix based operating system each file is indexed by an Inode. Inode are special disk blocks they are created when the file system is created. The number of Inode limits the total number of files/directories that can be stored in the file system.

An Inode is a data structure in UNIX operating system that contains important information pertaining to files within a file system. When a file system is created in UNIX, a set amount of indoes is created as well.

Inode in Operating System

The Inode contains the following information:

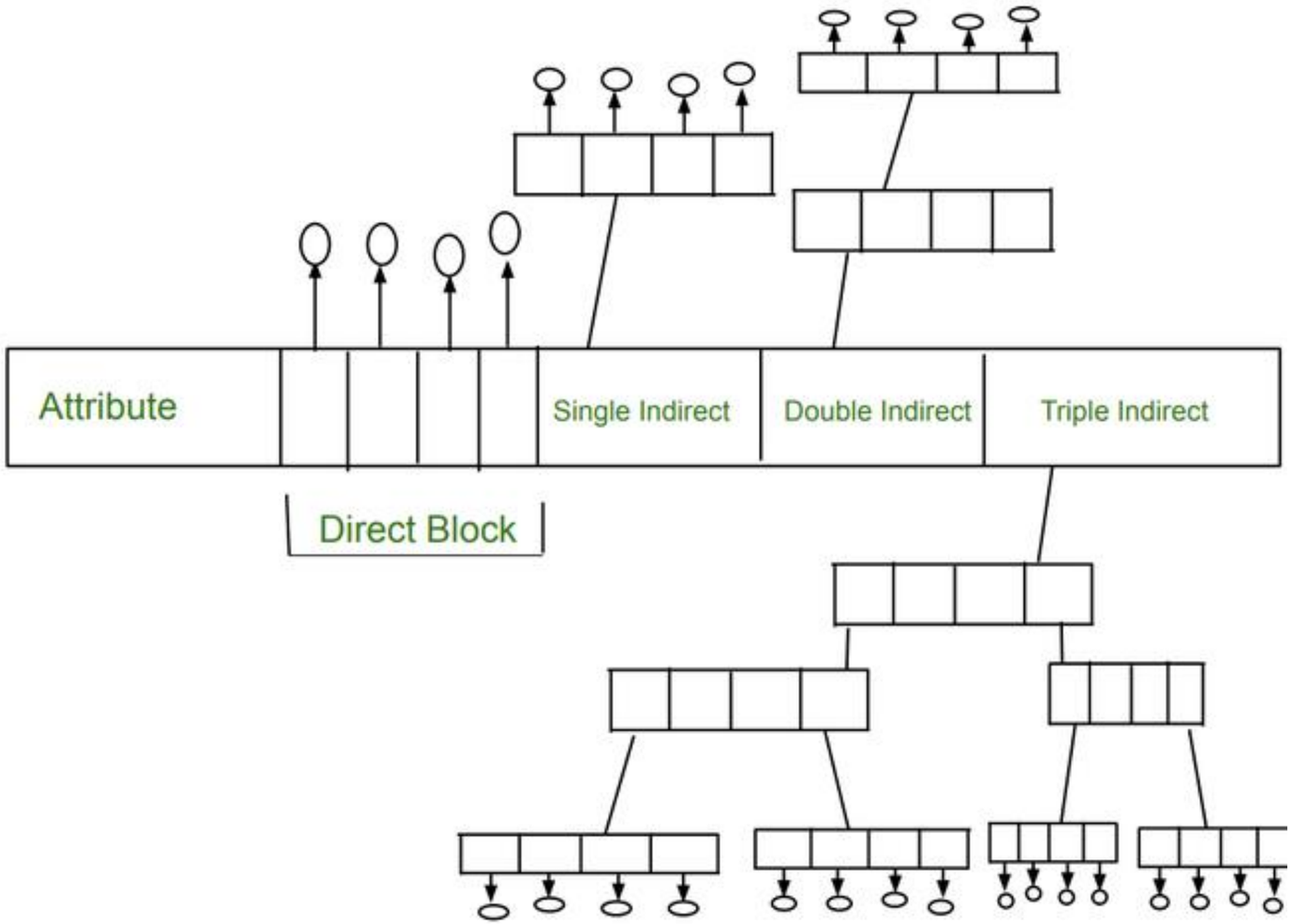
14 Bytes	2 Bytes
File name 1	i-node 1
File name 2	i-node 2
Directory name 1	i-node 3

Inode Structure

Information contained in an inode:

- File size
- Device on which the file is stored
- User and group IDs associated with the file
- Permissions needed to access the file
- Creation, read, and write timestamps
- Location of the data (though not the filepath)

Inode Structure



Inode Numerical

A file system usages unix inode data structure. Which contain 8 direct block pointer (addresses), one indirect block, one double and one triple indirect block. The size of each disk block is 128B and the size of each block address is 8B. Find the max. possible file size.

Solution:

Direct block pointer = 8

Total number of pointers in each block = 128B/8B = 16

One indirect block contains 16 pointers.

One double block contains (16*16) pointers

One triple block contains (16*16*16) pointers.

Total file size = ((8+(16)+(16*16) + (16*16*16))*128B

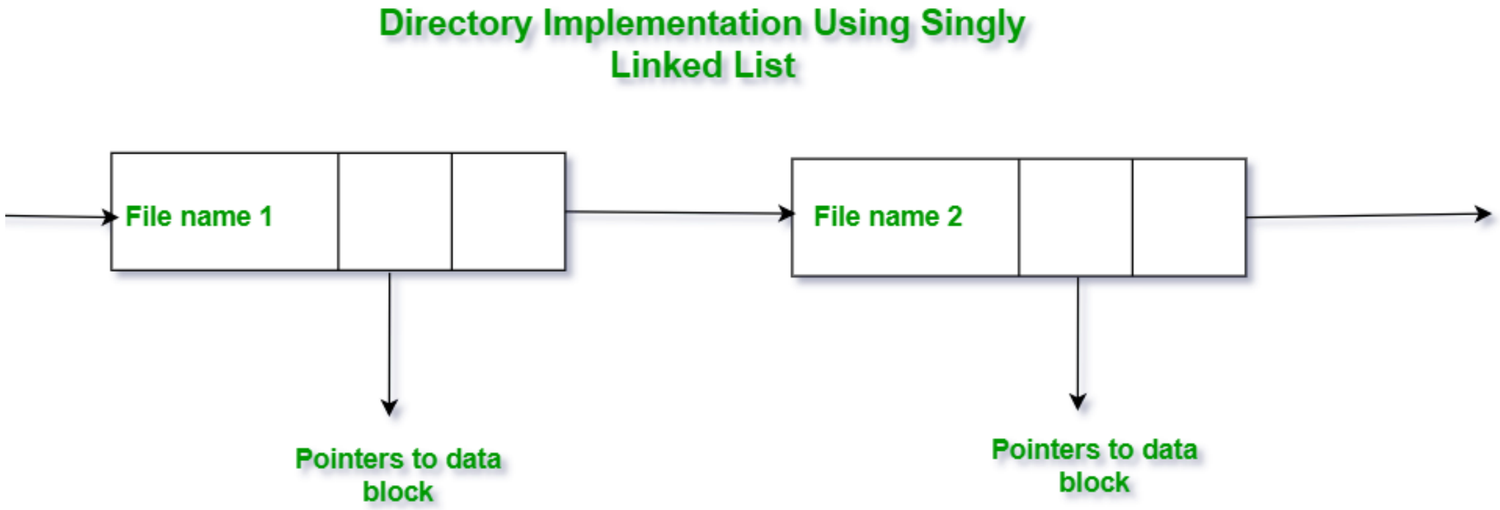
Directory Implementation

Directory implementation in the operating system can be done using Singly Linked List and Hash table.

Directory Implementation

Using Linked list:

Here we implement a directory by using a linear list of filenames with pointers to the data blocks.



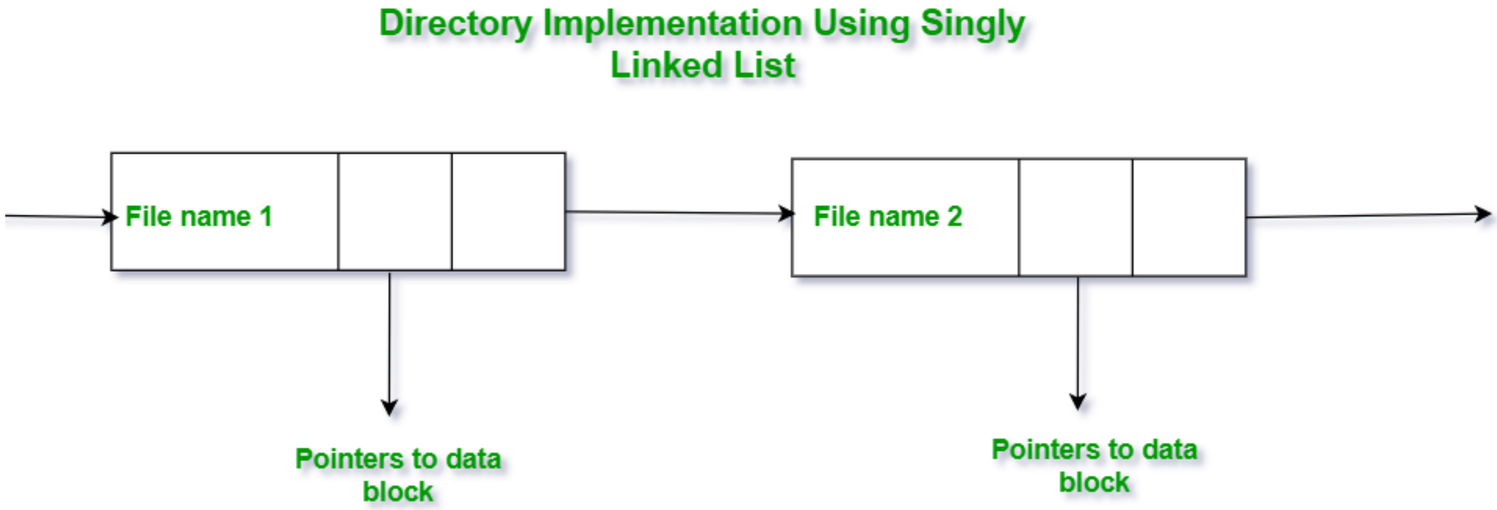
Directory Implementation

Using Linked list:

Here we implement a directory by using a linear list of filenames with pointers to the data blocks.

Disadvantage

The main disadvantage of using a linked list is that when the user needs to find a file the user has to do a linear search.



Directory Implementation

Directory Implementation using Hash Table

-It overcomes the major drawbacks of directory implementation using a linked list.

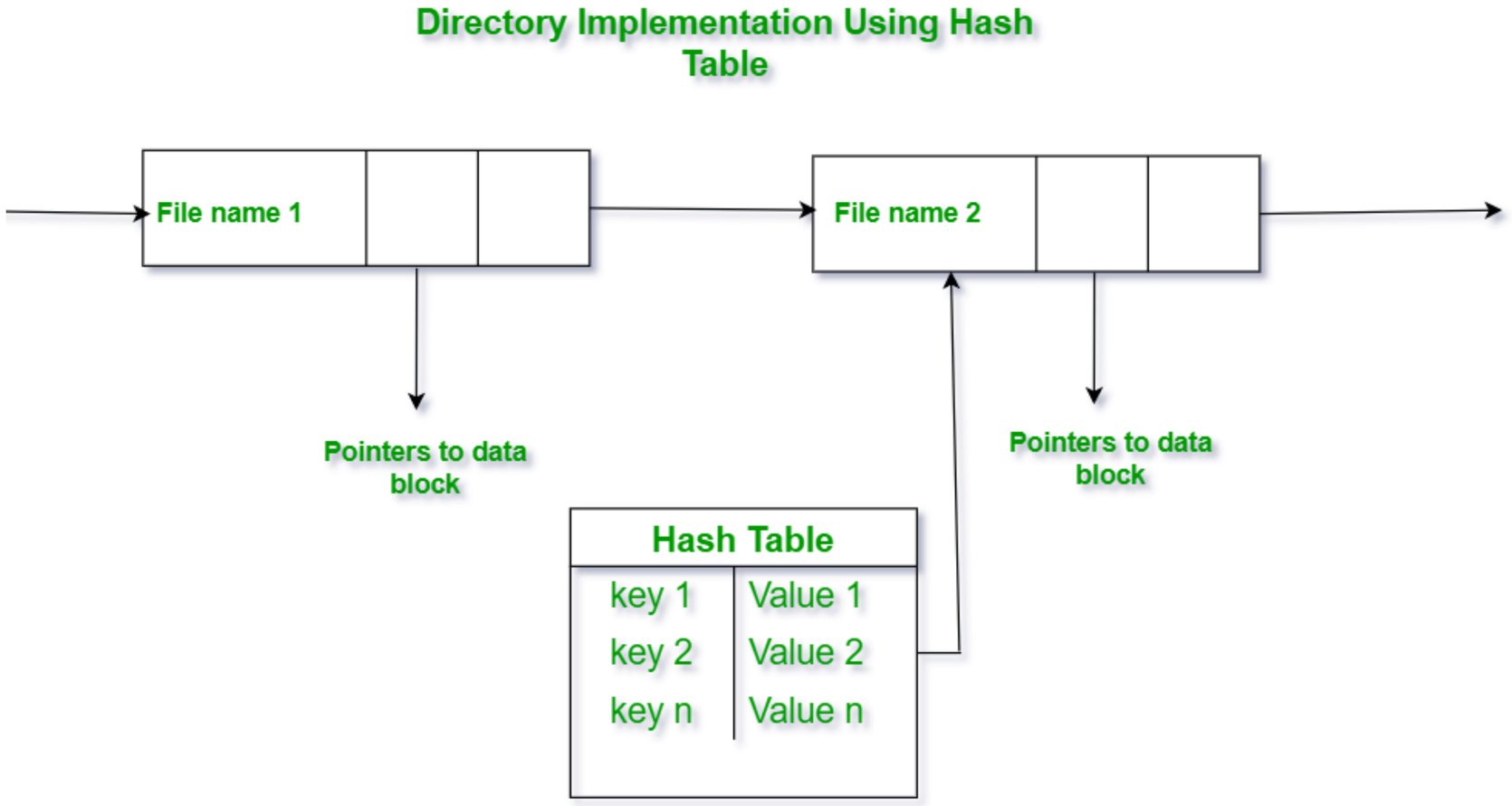
-In this method, we use a hash table along with the linked list.

-Here the linked list stores the directory entries, but a hash data structure is used in combination with the linked list.

-In the hash table for each pair in the directory key-value pair is generated.

Directory Implementation

Disadvantage:
The major drawback of using the hash table is that generally, it has a fixed size and its dependency on size.



File sharing

File Sharing in an Operating System(OS) denotes how information and files are shared between different users, computers, or devices on a network; and files are units of data that are stored in a computer in the form of documents/images/videos or any others types of information needed.

File sharing

Key Terminologies Related to File Sharing

Folder/Directory: It is basically like a container for all of our files on a computer.

Networking: It is involved in connecting computers or devices where we need to share the resources. Networks can be local (LAN) or global (Internet).

IP Address: It is numerical data given to every connected device on the network

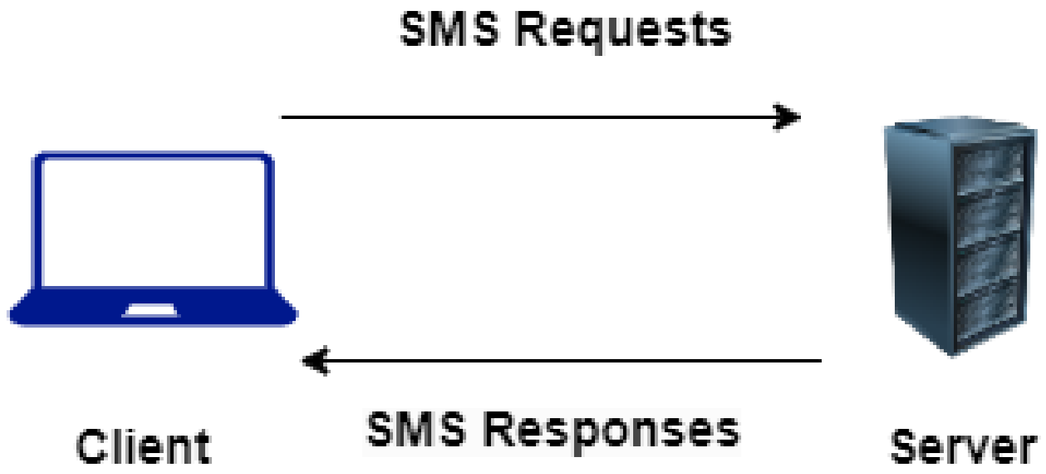
Protocol: It is given as the set of rules which drives the communication between devices on a network.

File Transfer Protocol (FTP): FTP is a standard network protocol used to transfer file

File sharing Methods

1. Server Message Block (SMB)

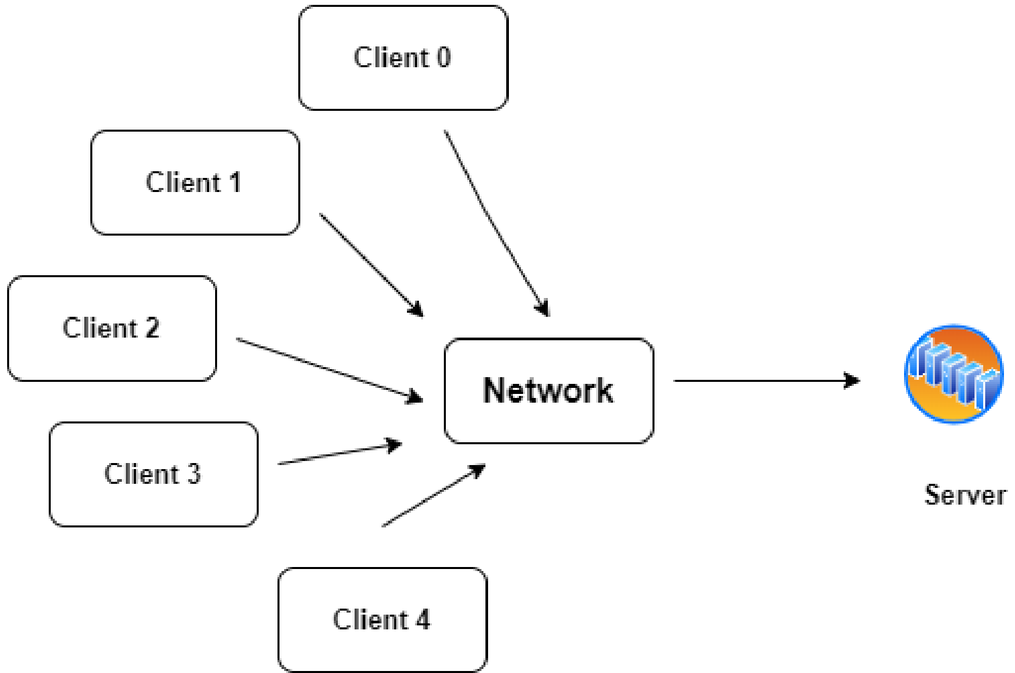
SMB is like a network based file sharing protocol mainly used in windows operating systems. It allows our computer to share files/printer on a network. SMB is now the standard way for seamless file transfer method and printer sharing.



File sharing Methods

2. Network File System (NFS)

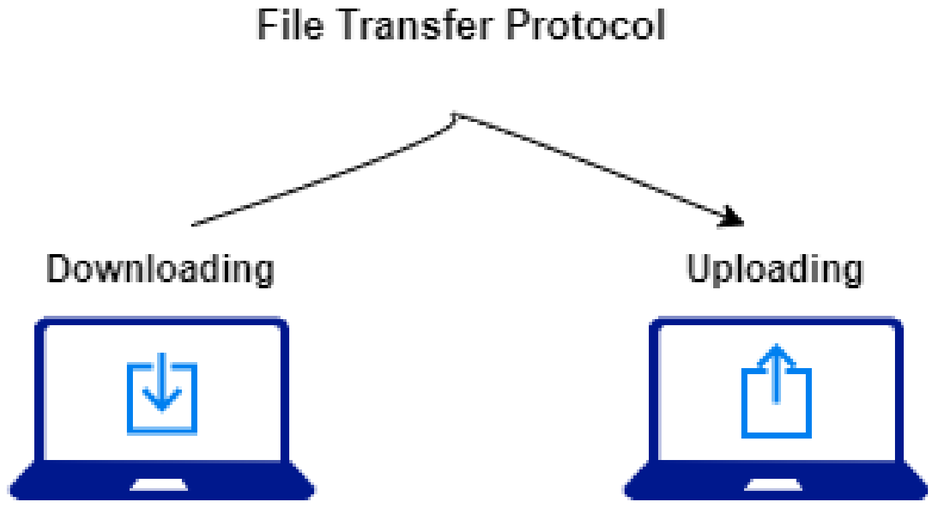
NFS is a distributed based file sharing protocol mainly used in Linux/Unix based operating System. It allows a computer to share files over a network as if they were based on local. It provides a efficient way of transfer of files between servers and clients.



File sharing Methods

3. File Transfer Protocol (FTP)

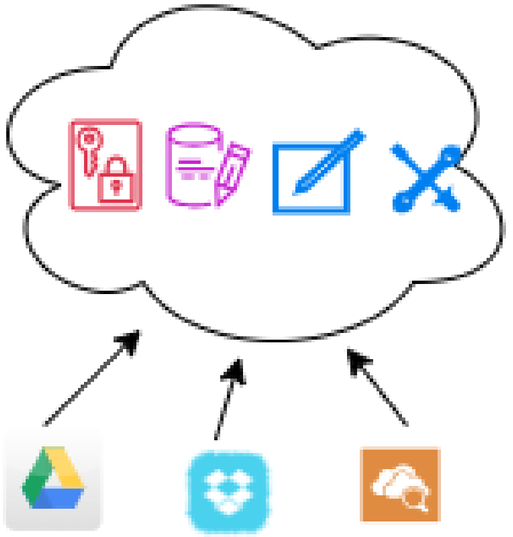
It is the most common standard protocol for transferring of the files between a client and a server on a computer network. FTPs supports both uploading and downloading of the files, here we can download,upload and transfer of files from Computer A to Computer B over the internet or between computer systems.



File sharing Methods

4. Cloud-Based File Sharing

It involves the famous ways of using online services like Google Drive, DropBox , One Drive ,etc. Any user can store files over these cloud services and they can share that with others, and providing access from many users. It includes collaboration in realtime file sharing and version control access.



Free space management

Free space management is a critical aspect of operating systems as it involves managing the available storage space on the hard disk or other secondary storage devices.

OS uses various free space management techniques:

1. Bit-MAP
2. Linked List

Refer to slides of Memory Management

Find me

9851083215

Santosh.it288@mail.com

www.phtechno.com

Kathmandu