Homework Assignment 9

Question 16.3:- Define the following terms: disk, disk pack, track, block, cylinder, sector, interblock gap, and read/write head.

Solution:-

1. **Disk**:

   A disk is a storage device that stores data magnetically on rotating platters. Data is read from and written to the disk by a read/write head, making it one of the primary forms of non-volatile storage in computers.

2. **Disk Pack**:

   A disk pack is a set of stacked disks or platters mounted on a single spindle, usually enclosed in a casing. Each disk surface can be read or written to, allowing the storage capacity to increase with each additional disk in the pack.

3. **Track**:

   A track is a circular path on the surface of a disk where data is magnetically recorded and stored. Each platter surface is divided into multiple tracks, which are arranged in concentric circles.

4. **Block**:

   A block is a fixed-size unit of data that the operating system can read from or write to the disk. It is the smallest unit of data transfer in disk storage, typically containing a portion of data stored in a track.

5. **Cylinder**:

   A cylinder is a set of tracks that are vertically aligned across multiple platters in a disk pack. Each track within a cylinder is at the same distance from the spindle, allowing simultaneous reading or writing on each platter at the same position.

6. **Sector**:

   A sector is a segment of a track on a disk that represents the smallest physical storage unit that can be addressed by the disk controller. It is typically 512 bytes or more in size, depending on the disk format.

7. **Interblock Gap**:

The interblock gap is the space or gap between blocks on a disk track. It serves as a separator between data blocks, allowing the read/write head to distinguish between them and to provide space for disk movement adjustments.

8. **Read/Write Head**:

The read/write head is the component in a disk drive that reads data from or writes data to the disk surface. It moves across the surface of the platters to access different tracks and is positioned by an actuator to access data at specific locations.

Question 16.12. What is the difference between static and dynamic files?

Solution:-

Aspect	Static Files	Dynamic Files
Structure	Fixed and predetermined	Flexible and can change over time
Data Access	Usually sequential	Both sequential and random access
Modifications	Difficult and may require rewriting	Easy insertion, deletion, and updates
Efficiency	Efficient for read-only or infrequent writes	Efficient for frequent read-write operations
Use Cases	Configuration files, read-only data	Database tables, frequently updated files

Question 16.14. Discuss the techniques for record deletion

Solution:-

When deleting records in a database or file system, there are several techniques to handle the removal of data. The choice of technique depends on the system requirements, storage format, and whether the records may need to be recovered or reused later. Here are the primary techniques:

1. Physical Deletion

- **Description**: The record is removed from storage immediately and permanently. The storage space previously occupied by the record is released, making it available for new data.
- **Advantages**:
    - Frees up storage space immediately.
    - Simplifies storage management by removing unnecessary data.
- **Disadvantages**:
    - Deleted records cannot be recovered (unless a backup exists).
    - In files with sequential storage, removing records can cause fragmentation or require shifting of data to fill gaps, which can be time-consuming.
- **Use Case**: Physical deletion is suitable for data that does not need to be recovered, such as temporary logs or cache data.

2. Logical Deletion (Soft Deletion)

- **Description**: The record is marked as deleted, but it is not physically removed from storage. A special flag or marker (e.g., a "deleted" column) is set in the record, indicating that it is considered "deleted" and should be ignored by applications.
- **Advantages**:
    - Allows easy recovery of deleted records by unmarking them.
    - Avoids the need for immediate reorganization of data, making deletion faster.
- **Disadvantages**:

    - Requires extra storage space since deleted records are not physically removed.
    - Application queries need to filter out logically deleted records, which can add complexity.
- **Use Case**: Logical deletion is often used in systems where records may need to be recovered or restored, such as user accounts that can be reactivated.

3. Deferred Deletion

- **Description**: Records marked for deletion are not immediately removed but are deleted at a later time during a maintenance operation or batch process. This technique combines elements of logical and physical deletion.
- **Advantages**:
    - Reduces the performance impact of immediate deletions, as deletions are processed in bulk.
    - Allows time for records to be restored if deletion was accidental.
- **Disadvantages**:
    - Requires additional storage for marked records until they are physically deleted.
    - Requires periodic maintenance to perform the actual deletion.
- **Use Case**: Suitable for large databases where immediate physical deletion could impact performance, or when there is a requirement to maintain data for a certain period before permanent deletion (e.g., data retention policies).

4. Archiving or Moving to a Separate Storage

- **Description**: Records are moved from the main database or active storage to an archive, often on a less expensive or slower storage medium. The records are no longer available in the primary system but can be accessed in the archive if needed.
- **Advantages**:
    - Reduces the size of active data, improving system performance.
    - Allows retention of historical data without occupying prime storage.
- **Disadvantages**:

    - Archived records are not readily available and may take time to retrieve.
    - Requires a separate storage system and potentially additional management.
- **Use Case**: Used for data that is no longer actively used but may be needed for historical reference, such as old transactions, inactive user accounts, or regulatory compliance data.

5. Garbage Collection (for Systems with Automatic Memory Management)

- **Description**: In some systems (like certain file systems or databases with automated memory management), "garbage collection" is used to periodically find and delete records or data that are no longer accessible or referenced.
- **Advantages**:
    - Frees up space without requiring manual deletion.
    - Can optimize system performance by reclaiming fragmented space.
- **Disadvantages**:
    - Timing of garbage collection is usually out of the user's control.
    - Can impact system performance during the collection process.
- **Use Case**: Common in systems like document-oriented databases (e.g., MongoDB) or in-memory databases that handle data management through automated memory reclamation.

6. Tombstone Marking (for Distributed Systems)

- **Description**: In distributed databases, a "tombstone" marker is added to indicate that a record has been deleted. This allows for consistent deletion across multiple nodes or replicas in a distributed system.
- **Advantages**:
    - Ensures eventual consistency in deletion across distributed nodes.
    - Allows deleted records to be cleaned up during system maintenance or compaction.
- **Disadvantages**:
    - Tombstones take up space until they are purged.

    - If not purged regularly, tombstones can accumulate and degrade system performance.
- **Use Case**: Common in distributed databases and systems like Cassandra or Apache CouchDB, where replication and consistency are key concerns.

Each of these techniques has its advantages and disadvantages, and the best choice depends on the specific requirements for data retention, system performance, and storage management.

Question 16.34:

16.34

Consider a disk with the following characteristics (these are not parameters of any particular disk

unit): block size B=512 bytes, interblock gap size G=128 bytes, number of blocks per track=20,

number of tracks per surface=400. A disk pack consists of 15 double-sided disks.

(a) What is the total capacity of a track and what is its useful capacity (excluding interblock gaps)?

(b) How many cylinders are there?

(c) What is the total capacity and the useful capacity of a cylinder?

(d) What is the total capacity and the useful capacity of a disk pack?

(e) Suppose the disk drive rotates the disk pack at a speed of 2400 rpm

(revolutions per minute); what is the transfer rate in bytes/msec and the block

transfer time btt in msec? What is the average rotational delay rd in msec? What

is the bulk transfer rate (see Appendix B)?

(f) Suppose the average seek time is 30 msec. How much time does it take (on the

average) in msec to locate and transfer a single block given its block address?

(g) Calculate the average time it would take to transfer 20 random blocks and

compare it with the time it would take to transfer 20 consecutive blocks using double buffering to save seek time and rotational delay.

Solution:-

Given Data

- **Block size B=512B = 512B=512 bytes**
- **Interblock gap size G=128G = 128G=128 bytes**
- **Number of blocks per track =20= 20=20**
- **Number of tracks per surface =400= 400=400**
- **Disk pack consists of 15 double-sided disks** (i.e., 30 surfaces total)
- **Disk rotation speed =2400= 2400=2400 rpm** (revolutions per minute)
- **Average seek time =30= 30=30 ms**

Part (a) Total Capacity of a Track and Useful Capacity

1. **Total capacity of a track**:
    - Each block is 512 bytes, and each interblock gap is 128 bytes.
    - Number of blocks per track = 20
    - Total bytes per block (including interblock gap) = B+G=512+128=640B + G = 512 + 128 = 640B+G=512+128=640 bytes
    - Therefore, the total capacity of a track =20×640=12800= 20 \times 640 = 12800=20×640=12800 bytes
2. **Useful capacity of a track (excluding interblock gaps)**:
    - Useful capacity is just the space used by the blocks, excluding gaps.
    - Useful capacity =20×512=10240= 20 \times 512 = 10240=20×512=10240 bytes

Part (b) Number of Cylinders

- A cylinder is formed by all the tracks with the same position on each surface of the disk pack.
- Number of cylinders === Number of tracks per surface =400= 400=400

Part (c) Total Capacity and Useful Capacity of a Cylinder

1. **Total capacity of a cylinder**:
    - Each track has a total capacity of 12800 bytes.
    - Since there are 30 surfaces (15 double-sided disks), each cylinder consists of 30 tracks.
    - Total capacity of a cylinder =30×12800=384000= 30 \times 12800 = 384000=30×12800=384000 bytes
2. **Useful capacity of a cylinder**:
    - Each track has a useful capacity of 10240 bytes.
    - Useful capacity of a cylinder =30×10240=307200= 30 \times 10240 = 307200=30×10240=307200 bytes

Part (d) Total Capacity and Useful Capacity of a Disk Pack

1. **Total capacity of the disk pack**:
    - Each cylinder has a total capacity of 384000 bytes.
    - There are 400 cylinders in the disk pack.
    - Total capacity of the disk pack =400×384000=153600000= 400 \times 384000 = 153600000=400×384000=153600000 bytes
2. **Useful capacity of the disk pack**:
    - Each cylinder has a useful capacity of 307200 bytes.
    - Useful capacity of the disk pack =400×307200=122880000= 400 \times 307200 = 122880000=400×307200=122880000 bytes

Part (e) Transfer Rate, Block Transfer Time, and Average Rotational Delay

1. **Transfer rate**:
    - Disk speed is 2400 rpm, or 40 revolutions per second.
    - Each revolution (one track) transfers 10240 useful bytes (useful capacity of a track).
    - Transfer rate =10240×40=409600= 10240 \times 40 = 409600=10240×40=409600 bytes per second, or 409.6 bytes per millisecond.
2. **Block transfer time bttbttbtt**:
    - Each block is 512 bytes.
    - Block transfer time btt=512409.6≈1.25btt = \frac{512}{409.6} \approx 1.25btt=409.6512≈1.25 ms
3. **Average rotational delay rdrdrd**:
    - Rotational delay is half the time for one rotation.
    - One rotation time =60000 ms2400 rpm=25= \frac{60000 \, \text{ms}}{2400 \, \text{rpm}} = 25=2400rpm60000ms=25 ms
    - Average rotational delay rd=252=12.5rd = \frac{25}{2} = 12.5rd=225=12.5 ms
4. **Bulk transfer rate**:
    - Bulk transfer rate is the data rate for reading an entire track.
    - Since each track has a useful capacity of 10240 bytes and the rotation time is 25 ms:
    - Bulk transfer rate =1024025=409.6= \frac{10240}{25} = 409.6=2510240 =409.6 bytes/ms (same as the transfer rate calculated above).

Part (f) Average Time to Locate and Transfer a Single Block

- Average time to locate a block = Average seek time + Average rotational delay + Block transfer time
- Given:

    - Average seek time = 30 ms
    - Average rotational delay = 12.5 ms
    - Block transfer time btt≈1.25btt \approx 1.25btt≈1.25 ms
- Total time =30+12.5+1.25=43.75= 30 + 12.5 + 1.25 = 43.75=30+12.5+1.25=43.75 ms

Part (g) Average Time to Transfer 20 Random Blocks vs. 20 Consecutive Blocks

1. **Time to transfer 20 random blocks**:
    - For each block, we need the full seek, rotational delay, and transfer time.
    - Average time per random block =43.75= 43.75=43.75 ms (from part (f))
    - Total time for 20 random blocks =20×43.75=875= 20 \times 43.75 = 875=20×43.75=875 ms
2. **Time to transfer 20 consecutive blocks using double buffering**:
    - Consecutive blocks can be transferred in a single read operation without additional seeks or rotational delays, as long as double buffering allows overlapping I/O with processing.
    - Total transfer time === Transfer time for 20 blocks
    - Total data size =20×512=10240= 20 \times 512 = 10240=20×512=10240 bytes
    - Transfer time for 10240 bytes =10240409.6=25= \frac{10240}{409.6} = 25=409.610240=25 ms
3. **Comparison**:
    - **Random blocks**: 875 ms
    - **Consecutive blocks with double buffering**: 25 ms

Using double buffering to transfer consecutive blocks is significantly faster than transferring 20 random blocks due to the elimination of multiple seek and rotational delays.