Introduction: Use of Information

- Every software system makes use of information. Appropriate use of the information is crucial.
- To build the vital software systems of the future, we need to be able to structure and manipulate information effectively and efficiently.

Data Structures vs. Information Structures:
- quantities of data is larger (and organized as files)
- number of structures is greater
- their uses are specialized.

Features of Successful Sw. Systems

- Fast response time
- Obeisance to constraints
  - Real-time constraints
  - Development time constraints
  - Memory constraints
- Usability

Selecting right data or file structure
- will enable to develop applications that would otherwise be impossible, too slow, or too large.

Metrics to Evaluate File Structures

- **Simplicity**
- **Reliability** (correctness) --
  - it should work properly under all circumstances
- **Programmability**
  - in a reasonable time period
- **Maintainability**
  - easy to modify and update
- ⇨ ***Storage requirements (limitations)**
  - space complexity
- ⇨ ***Computational or time complexity** --
  - processing time or run-time performance

Database Management Systems

A database management system (DBMS)
- is a special-purpose sw system that is specifically designed for the purpose of storing and manipulating info.

File Org. &Processing Techniques vs. DBMS

1- Info mgmt: on a physical level vs. logical level

Physical Structuring:
- the manner in which the info is actually stored internally within a computer system

Logical Structuring
- is an abstraction of how information is actually stored.

File Org. &Proc. Techniques vs. DBMS

2- Usage:

to build system software (such as an O/S or a DBMS)

vs.

to develop application software such as an automated registration system.

Understanding about file org. techniques will help you to use them more efficiently and effectively.

Storage Media

- The reason for reviewing storage media is that they affect the decision of how best to structure and process info.
- **Access time** is the length of time required to locate a piece of info.
  - Storage on high-speed access device vs. slower access device
  - Why not store all info in a high-speed storage medium? It would be simple(no need for file strucs)
  - Need for info increases as rapidly as the decrease in the cost and the increase in the capacity of high-speed memory. (Physical and economic constraints.)

Storage Hierarchy

- Storage media forms a hierarchy since they have different
  - access times
  - storage capacities
  - costs.
- Storage media types:
  - Primary memory
    - uses semiconductor technology (i.e., VLSI chips)
    - regular access times ~0.5 usec
    - fast access, high cost, smaller capacity
  - Auxiliary memory: Secondary & Tertiary storage
    - decreasing unit storage costs, but increasing storage capacities and access times.

Auxiliary Storage Media

- Drums (10^{-2} sec)
- Fixed-head disks (10^{-2} sec)
- ***Moveable-head disks**
- Mass storage units
- ***Serial-Access Tapes**

+ Lower unit costs
+ Greater storage capacities
– Higher access times

A **track** is a unit for storing and referencing info.
Info is recorded as magnetic spots on this concentric circles.

Impact of Storage Hierarchy

- Differences in relative access times
- Example:
  - 5 seconds worth of accessing RAM would be equivalent to 1 million seconds (11.5 days) for a moveable-head disk.
    - It is important to choose the proper data structure.
- Cost of a given amount in main memory is about 100 times the cost of the same amount of disk space, and tapes are even less expensive than disks.

Other reasons for storing data on auxiliary storage?

Track Formats: Block Addressability

A **cylinder**, which is a vertical subsetting of the info, is all the info that can be accessed with one positioning of the access arm on a moveable-head disk.

- All read/write heads move in parallel, and at a given time, the same track value identifies each head's position on a recording surface.
  - For improved retrieval performance, it is actually better to store info from a file in a cylinder, that is on the same track numbers but on different recording surfaces, than on adjacent tracks on the same recording surface. (physical vs. electronic moves)

Track Formats: Sector Addressability

- A track is divided into equal size storage units called **sectors**.
  - A sector is addressed by its track and sector numbers.
  - Gaps, cyclic check bytes, preamble & postamble storage areas exist on each track.
  - Mostly used in formatting floppies and PCs' disk drives.

Read [Ramakrishnan, 1998] pp.39-42.

Moveable Head Disks

- Density of info in inner tracks are greater than that of outer tracks
- Has a single read/write head per recording surface (In [Salzberg, 1988] assumes two heads, pp.13&17, which equally shares available cylinders.)
- All R/W heads move together and this access tracks in the same vertical plane

Optical disks - CD-ROMs
  – stores info by using a laser to burn holes into one of the layers of the recording medium. On reading, each hole allows light to pass through it so that a 0 or 1 bits can be distinguished.

Hardware Parameters

- Disks
- Seek time
- Rotational latency and block transfer time
- Records and buckets
- Double buffering

1 - DISKS

- Amount of data to be processed does not fit into the primary memory of the computer.
- A **disk** is a metal platter, covered on both sides with a magnetic recording medium.
  - Rotates on a spindle
  - A circle of data at a fixed distance from the center is called a track
  - A head moves on the tracks and can read/write the data contained in the track it is over
  - The piece of metal that moves the head in and out and keeps at a constant height above the surface of the disk is called an arm. (usually 2 arms per surface, on the same arm.)

Disk Drives

- A **disk drive** consists of disks spaced apart on a common spindle.
- Most modern disk drives are **Winchester disk drives**, i.e., the disks and the arms and the spindle are fixed in place in an airtight box. Why?)
- All the arms on a disk drive move together, and form a **cylinder**. Only one head on the same cylinder transfers data at a time. (Switching heads is electronically instantaneous)

Three Main Disk Parameters

- **Seek time**: the time it takes to move the arm to the correct cylinder.
- **Rotational Latency time**: the time it takes for the disk to revolve so that the correct place on the track is just reaching the head.
- **Block transfer time**: the time for the read/write head to pass over a block.
  - The tracks are broken up into units of data called **blocks**. This is the amount of data which is read from the disk to the memory or written from the memory to the disk at one time.

Performance Implications of Disk Structure

- Data must be in memory for the application programs to operate on it.
- The unit for data transfer bw disk and main memory is a block. Even a single item on a block is needed, the entire block is transferred. Reading or writing a disk block is called an I/O (input/output) operation.
- The time to read or write a block varies, depending on the location of the data:

access time= seek time + rotational delay + transfer time

These observations imply that the time taken for the application programs is affected significantly by how data is stored on disks.

Manufacturer Specs

- Average seek time (in msecs),
- Average rotational latency time (in msecs),
- Data transfer times (in bytes per msec) are given.

Seek time > Rotational latency time

Assumptions:

- Calculations are assumed to have zero cost when disk access is required during calculations. Why?
- Only single-user systems are considered. Why?

2 - SEEK TIME

- The average seek time is the same as the time it takes to traverse **1/3** of the cylinders.
  - The average seek time, s, is calculated under the assumption that all cylinders are equally likely to be sources or destinations. Think how 1/3 is computed?

Questions:

- Does a disk drive with more cylinders have a higher average seek time than a disk drive with a smaller number of cylinders?
- How can we control or minimize seek time?
  - Think about comparing data from two different files.

3 - ROTATIONAL LATENCY AND BLOCK TRANSFER TIME

The **average rotational latency**, r, is the average time it takes to locate the correct block on a track once the head is on the correct track.

The **block transfer time**, btt, is the time it takes to transfer the info in one block on the disk to memory once the head has been correctly positioned at the beginning of the block.

The **effective block transfer time**, ebt, is the time it takes to read a block and its associated gap when reading many blocks at once.

Parameters for the IBM 3380

B	Block size	2400 bytes
btt	Block transfer time	0.8 ms = B/t
C	Blocks Per cylinder	600
ebt	Effective btt	0,84 ms = B/t'
m	Mimimum seek time	3 ms
N	Number of cylinders	885 (Per spindle)
r	Average rotational latency	8,3 ms
s	Average seek time	16 ms
t	Speed	3000 bytes/ms
t'	Formatted speed	2857 bytes/ms

- Examples:
  - Sequential Reading of 10 Blocks
  - Random Reading of 10 Blocks

Fast Sequential Reading - Assumptions?

- Is there any chance that we have to wait for the disk to revolve to the right place when we move to a new cylinder?
- What about when we move from one track to another?