Digital Asset Management

3. Multimedia Database System

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Outline

1. MM content organization
2. MM database system architecture
3. MM system service model
4. Multimedia Data Storage
5. Multimedia application
3.3 Multimedia System

Service Model
What is a Media Service/Server?

• A scalable storage manager
  – Allocates multimedia data optimally among disk resources
  – Performs memory and disk-based I/O optimization
• Supports
  – real-time and non-real-time clients
  – presentation of continuous-media data
  – mixed workloads: schedules the retrieval of blocks
• Performs admission control
Service Models

• Random Access
  – **Maximize the number of clients** that can be served concurrently at any time with a low response time
  – **Minimize latency** (等待时间)

• Enhanced Pay-per-view (EPPV)
  – **Increase the number of clients** that can be serviced concurrently beyond the available disk and memory bandwidth, while guaranteeing a constraint on the response time
Service Models

• Example

  – Server

  • Random Access Model
    – Case 1: after 20 movies, no more memory left. 21st movie waits for 80 minutes, 22nd movie waits for 81 minutes …
    – Case 2: after 20 movies, more memory can be allocated. 21st movie has to wait (initial latency) till one round of the previous 20 movies each has been served.

• EPPV Model:
  – At any time 20 movies are served, movies are initiated every 5 minutes
  – Streams are distributed uniformly during these 20 minutes

• 50 movies, 100 min. each
• Request rate: 1 movie/min
• Max. capacity: 20 streams
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3.4 Multimedia Data Storage
Multimedia Data Storage

- Storage Requirements
- RAID Technology
- Optical Storage Technology
Requirements of MM Information

- **Storage and Bandwidth Requirement**
  - measured in bytes or Mbytes for storage
  - measured in bits/s or Mbits/s for bandwidth

- An image 480 x 600 (24 bits per pixel),
  - 864k bytes (without compression).
  - To transmit it within 2 sec => 3.456Mb/s.

- 1GB Hard-disk
  - 1.5 hr. of CD-audio or
  - 36 seconds of TV quality video
  - require 800s to be transferred (10Mbits/s network).
Storage & Bandwidth Requirements

- 500 page text: 1
- clr img: 7
- 1-hr CD-audio: 29
- 1-hr TV: 635
- 1-hr TV: 24,300
- 389,000
Delay and Delay Jitter Requirements

- Digital audio and video are **time-dependent** continuous media
- **dynamic media** => achieve a **reasonable quality playback** of audio and video, media samples must be received and played back at regular intervals.
- E.g. audio playback, 8K samples/sec have to be achieved

- **End-to-end delay is the sum of all delays** in all the components of a MM system, disk access, ADC, encoding, host processing, network access & transmission, buffering, decoding, and DAC

  In most conversation type applications, end-to-end delay should be kept below **300ms**

- Delay variation is commonly called **delay jitter**. It should be small enough to achieve smooth playback of continuous media, e.g.,
  - < **10ms** for telephone-quality voice and TV-quality video,
  - < **1ms** for stereo effect in high quality audio.
Other Requirements

Quest for Semantic Structure
- For alphanumerical information, computer can search & retrieve alphanumerical items from a DB or document collection.
- It is hard to automatically retrieve digital audio, image, & video as no semantic structure is revealed from the series of sampled values.

Spatial-Temporal Relationship Among Related Media
- Retrieval and transmission of MM data must be coordinated and presented so that their specified temporal relationship are maintained for presentation.
- A synchronization scheme therefore defines the mechanisms used to achieve the required degree of synchronization.
- Two areas of works: user-oriented and system-oriented synchronization.
Other Requirements

Error and Loss Tolerance
• Unlike alphanumeric information, we can tolerate some error or loss in MM.
• For voice, we can tolerate a bit error rate of $10^{-2}$.
• For images and video, we can tolerate a bit rate from $10^{-4}$ to $10^{-6}$.
• Another parameter: packet loss rate - a much more stringent requirement.

Text v.s. MM Data Requirements

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Text-based Data</th>
<th>Multimedia Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Req.</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Data Rate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Traffic Pattern</td>
<td>Bursty</td>
<td>Stream-oriented, highly bursty</td>
</tr>
<tr>
<td>Error/Reliability Req.</td>
<td>No loss</td>
<td>Some loss</td>
</tr>
<tr>
<td>Delay/Latency Req.</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>Temporal Relationship</td>
<td>None</td>
<td>Synchronized Trans.</td>
</tr>
</tbody>
</table>
Quality of Service (QoS)

- To provide a uniform framework to specify and guarantee these diverse requirement, a concept called QoS has been introduced.

- QoS is a set of requirement, but there is no universally agreed one.

- QoS is a contract negotiated and agreed among MM applications and MM system (service provider)

- The QoS requirement is normally specified in two grades: the preferable quality and the acceptable one.

- The QoS guarantee can be in one of three forms: hard or deterministic (fully satisfied), soft or statistic (guaranteed with a certain probability), and best effort (no guarantee at all)

- A lot of research issues are involved and still undergoing!!
File Systems

- **The most visible part** of an operating system.
- **organization of the file system**
  - an important factor for the usability and convenience of the operating system.
- Files are stored in secondary storage, so they can be used by different applications.
- In **traditional file systems**, the information types stored in files are sources, objects, libraries and executables of programs etc.
- In **multimedia systems**, the stored information also covers digitized video and audio with their related real-time "read" and "write" demands.
- >>> additional requirements in the design and implementation
**File Systems**

**Traditional File Systems**
- The main goals of traditional file systems are:
  - to **provide** a comfortable interface for file access to the user
  - to **make** efficient use of storage media
  - to **allow** arbitrary deletion and extension of files

**Multimedia File Systems**
- The main goal is to provide a **constant and timely retrieval** of data.
- It can be achieved through providing enough buffer for each data stream and the employment of disk scheduling algorithms, especially optimized for real-time storage and retrieval of data.
Multimedia File Systems

- The much greater size of continuous media files and the fact that they will usually be retrieved sequentially are reasons for an optimization of the disk layout.
- Continuous media streams predominantly belong to the write-once-read-many nature (ROM?), and streams that are recorded at the same time are likely to be played back at the same time.
- Hence, it seems to be reasonable to store continuous media data in large data blocks contiguously on disk.
- Files that are likely to be retrieved together are grouped together on the disk.
- With such a disk layout, the buffer requirements and seek times decrease.
- The disadvantage of the continuous approach is external fragmentation and copying overhead during insertion and deletion.
Data Management & Disk Spanning

Data Management:

• **Command queuing**: allows execution of multiple sequential commands with system CPU intervention. It helps in minimizing head switching and disk rotational latency.

• **Scatter-gather**: scatter is a process whereby data is set for best fit in available block of memory or disk. Gather reassembles data into contiguous blocks on disk or in memory.

Disk Spanning

• Attach multiple devices to a single host adapter.

• good way to increase storage capacity by adding incremental drives.
RAID  Redundant Arrays of Inexpensive Disks

- By definition RAID has three attributes:
  - a set of disk drives viewed by the user as one or more logical drives
  - data is distributed across the set of drives in a pre-defined manner
  - redundant capacity or data reconstruction capability is added, in order to recover data in the event of a disk failure

- Objectives of RAID
  - Hot backup of disk systems (as in mirroring)
  - Large volume storage at lower cost
  - Higher performance at lower cost
  - Ease of data recovery (fault tolerance)
  - High MTBF (mean time between failure)
Different Levels of RAID

- Eight discrete levels of RAID functionality
  - Level 0 - disk striping
  - Level 1 - disk mirroring
  - Level 2 - bit interleaving and Hamming Error Correction (HEC) parity
  - Level 3 - bit interleaving and XOR parity
  - Level 4 - block interleaving with XOR parity
  - Level 5 - block interleaving with parity distribution
  - Level 6 - Fault tolerant system
  - Level 7 - Heterogeneous system

- Data is spread across the drives in units of 512 bytes called **segments**. Multiple segments form a block.
RAID Level 0 - Disk Striping

- To improve performance by overlapping disk reads and writes
- Multiple drives connected to a single disk controller
- Data is striped to spread segments of data across multiple drives in block sizes ranging from 1 to 64 Kbytes
- Disk striping provides a higher transfer rate for write and retrieve block of data
- Typical application: database applications
- Drawbacks:
  - If one drive fails, the whole drive system fails
  - Does not offer any data redundancy, no fault tolerance
RAID Level 1 - Disk Mirroring

- Each main drive has a mirror drive
- Two copies of every file will write to two separate drives, ensuring complete redundancy

Performance:
- Disk write: take almost twice the time
- Disk read: can be speed up by overlapping seeks

Typical use:
- In file servers provides backup in the event of disk failure

Duplexing:
- Use two separate controllers
- The second controller enhances both fault tolerance and performance
- Separate controllers allow parallel writes and parallel reads
RAID Level 2
- Bit Interleaving and HEC Parity

• Contain arrays of multiple drives connected to a disk array controller.

• Data is written interleaved across multiple drives (often one bit at a time) and multiple check disks are used to detect and correct errors.

• **Hamming error correction (HEC)** code is used for error detection and correction.

• The drive spindles must be **synchronized** as a single I/O operation accesses all drives

• Benefits:
  * High level of data integrity and reliability (error correction feature)
  * Mainly use for **supercomputers** to access large volumes of data with a small number of I/O request.
RAID Level 2
- Bit Interleaving and HEC Parity

Drawbacks:

- **Expensive** - requires *multiple drives* for error detection and correction
- **Error-correcting scheme**: slow and cumbersome
- Multimedia applications can afford to *lose occasional bit* or there without any significant impact on the system or the display quality.
- Each sector on a drive is associated with sectors on other drives to form a single storage unit, it takes multiple sectors across all data drives to storage even just a few bytes, **resulting in waste of storage**.
- Should not be used for transaction processing where the data size of each transaction is small.
RAID Level 3
- Bit Interleaving with XOR Parity

- **Bit interleaved** across multiple drives
- **Only offer error detection** - not error correction
- **More efficient than RAID 2**: parity bits are written into the data stream and only one parity drive is needed to check data accuracy.
- Parity generation and parity checking performed by **hardware**
- **Not suitable for small transaction**
- **Good for supercomputer and data server**: large sequential I/O request
RAID Level 3
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RAID Level 4
- Block Interleaving with XOR Parity
RAID Level 4
- Block Interleaving with XOR Parity

- **Write successive blocks of data on different drives.**
- Data is interleaved at block level.
- RAID 4 access is to individual strips rather than to all disks at once (as in RAID 3); therefore disks operate individually
- Separate I/O requests can be satisfied
- Good for applications that require high I/O request rates but bad for applications that require high data transfer rate
- Bit-by-bit parity is calculated across corresponding strips on each disk
- Parity bits stored in the redundant disk
- **Write penalty**
  - For every write to a strip, the parity strip must also be recalculated and written, i.e., updated (by an array management software)
  - When an I/O write request of small size is performed, RAID 4 involves a write penalty.
RAID Level 5
- Block Interleaving with Parity Distribution
RAID Level 5
- Block Interleaving with Parity Distribution

• RAID 5 is organized in a similar fashion to RAID 4 but avoids the bottleneck encountered in RAID 4.
• It does not use a dedicated parity drive
• Parity data is interspersed in the data stream and spread across multiple drives.
• Block of data falling within the specified block size requires only a single I/O access.
• Block of data are stored on a different drive, multiple concurrent block-sized accesses can be initiated.
• Good for database applications in which most I/O occurs randomly and in small chunks.
• Drawbacks: high cost and low performance for large block sizes objects such as audio and video.
RAID Level 6-7
- Fault-Tolerant and Heterogeneous System

Disk 0
A1
B1
C1
Dp

Disk 1
A2
B2
Cp
Dq

Disk 2
A3
Bp
Cq
D1

Disk 3
Ap
Bq
C2
D2

Disk 4
Aq
B3
C3
D3
RAID Level 6-7
- Fault-Tolerant and Heterogeneous System

- RAID 6 has become a common feature in many systems. RAID 6 is an improvement over RAID 5 model through the addition error recovery information.

- Conceptually, the disks are considered to be in a matrix formation and the parity is generated for rows and for columns of disks in the matrix. The multi-dimensional level of parity is computed and distributed among the disks in the matrix.

- RAID 7 is the most recent development in the RAID taxonomy. Its architecture allows each individual drive to access data as fast as possible by incorporating a few crucial features.

- With the growth in the speed of computers and communications in response to the demands for speed & reliability, the RAID theme has begun to attract significant attention as a potential mass storage solution for the future.
The strategy adopted for data storage will depend on the storage technology, storage design, and the nature of data itself.

Any storage has the following parameters:
- Storage capacity
- Standard operations of Read and Write
- Unit of transfer for Read and Write
- Physical organization of storage units
- Read-Write heads, Cylinders per Disc, Tracks per Cylinder, and Sectors per Track
- Read time and seek time

Of the storage technologies that are available as computer peripherals, the optical medium is the most popular in the multimedia context.
<table>
<thead>
<tr>
<th>Magnetic</th>
<th>Hard Disk, Floppy Disk, PCMCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages:</td>
<td>Faster than tape</td>
</tr>
<tr>
<td></td>
<td>Allows direct access to data</td>
</tr>
<tr>
<td>Disadvantages:</td>
<td>Performance relies on speed of mechanical heads</td>
</tr>
<tr>
<td></td>
<td>Neither fault nor damage resistant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optical</th>
<th>CD-ROM, DVD, Magneto-Optical Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages:</td>
<td>More data capacity than magnetic disk</td>
</tr>
<tr>
<td></td>
<td>High quality storage of sound and images</td>
</tr>
<tr>
<td>Disadvantages:</td>
<td>Data capacity is small for videos in CD and DVD are better</td>
</tr>
<tr>
<td></td>
<td>Limited Data densities</td>
</tr>
</tbody>
</table>
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3.5 Multimedia System Application
Multimedia Systems Application Chain
Multimedia Systems Application Chain
Applications of Multimedia

Application classes:
- Local
- Distributed

Basic multimedia services:
- Interpersonal communication
- Information retrieval
- Information recording and editing
Application Areas, Industries and Usage

Application areas:
- Learning and education
- Simulation
- Visualisation
- Presentation
- Documentation
- Archivation
- Customer information
- Cooperative work
- Supervision and control
- Entertainment

Industries:
- Bank
- Trade
- Insurance
- Research
- Education
- Manufacturing
- ...

Information
- Books on CDs
- Electr. Newspaper
- Kiosks

Communication
- CSCW
- Video conferences
- Remote diagnosis

Entertainment
- Interactive TV
- Interactive Audio
- Games
Multimedia Applications

- Hypermedia courseware
- Video conferencing
- Video on demand
- Interactive TV
- Home shopping
- Game
- Digital video editing and production systems