Multimedia Database Architecture

- Multimedia Architecture Requirements
- ACID test
- Multimedia Server Requirements
- Distributed Multimedia System
  - Super server concept
- Client-Server Systems
- P2P
- Media Streams
Multimedia Architecture
Requirements

- Database architecture as a structure that facilitates the database to complete a transaction
- Four basic properties that a transaction should posses
  - Atomicity: All or nothing property. A transaction is an indivisible unit that is either performed or not
  - Consistency: A transaction must transform the database from one consistent state to another consistent state
  - Independence: Transactions execute independently of one another
  - Durability: The effects of a successfully committed transaction should be permanently recorded in the database
- ACID test of transaction reliability

ACID test

- For a single-user PC database where only one person is carrying out transactions at any one time the circumstances for the ACID test may be irrelevant
- Important for large number of users which access the database at the same time
  - A transaction can than only be achieved by locking the data rows involved to stop other users changing the data
  - Replicated database there may be more than one copy of the data that needs to be updated at the same time
- Architecture of a multi-user database can become complex
- It is not clear which architecture would be the best option for a multimedia database
  - A transaction involving multimedia data will in general be expected to take longer
  - Locks will have to be maintained for longer periods

- Formal database architecture
- Separate user view from the system view
- Three-layer architecture
The external level provides the user's view of the database
- It is a partial view

The conceptual level is the community view of the database
- Logical level as seen by the system administrator
- In a relational database, relational conceptual level

Internal level
- The way the data is physically stored
- In a relational database the internal level must not be relational
  - Records, pointers, etc..

For multimedia objects, performance depends on the rate at which information can be transferred from storage memory for processing
- Block size affects the performance
  - Number of fetch operations
The architecture of the database system is influenced by the underlying computer and network system.

- **Centralized database** system run on a single computer system that does not interact with other computer systems.
- **Client-server system**, networking computers allow a division of work. Task relating to database structure are executed on server, presentation on the client computer.
- **Distributed database systems** have been developed to handle geographically and administratively distributed data spread over multiple computer systems.

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**Figure 8.2** Multimedia databases – user, conceptual and physical storage views
Multimedia Server Requirements

- Often large scale applications
- Take into account:
  - User access behavior
  - Bandwidth
  - Storage requirements
    - (Complex multimedia formats)

Storage hierarchy

- Example, videos on demand:
  - High popular videos are stored in storage media with the highest bandwidth
Characteristics

- Minimal response time
- Reliability and availability
- Ability to sustain *guaranteed number of streams*
- Real-time delivery
- Exploit user access patterns

Distributed Multimedia System

- In a relational database that is distributed a table may be divided into a number of subrelations
- Horizontally - fragments consists of columns but only some rows
- Vertically - fragments consists of all rows but only some columns
- Partitioning of the data
Replicate fragments so that duplicates are stored on several sites

LOBs (video, music) movements to a site, where they are likely to be requested (duplicates)
- Even daily basis!

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**Scalability**

- Increasing number of users
- Size of data objects
- Amount of accessible data
  - Search, access, management
- Non-uniform request distribution
Super server concept

- Distribute load among several servers
  - Problems arise when server selection is mainly based on systems defaults or on the user choice
  - This kind of static selection can cause uneven loads
- Dynamic server selection by alternatively mapping the servers in a local cluster
  - Saves local load problems

Super server concept

- Requests are directed to an appropriate server according to the location and the requested data, the current load of the servers, the location of the servers and the available network bandwidth
- User contacts a multimedia server as a normal server, and it makes the decision which is the most appropriate server
Client-Server Systems

- A special case of distributed systems
  - Certain sites are designated as clients and others as servers

- We will introduce
  - DataLinks as a specific art of SQL3
  - Development of intelligent middleware

DataLinks

- Store large unstructured data objects in a file system near a relational database
- Allows existing applications to incorporate multimedia with no changes to them
- Video and audio objects need to be streamed out to the client
  - Database servers do not have these capabilities
Intelligent Middleware

- Change information across systems developed by different vendors
  - Oracle, Ingres, DB2, MySQL
- Integration of information
- Three-tier systems were developed
  - Gateway to manage connections between the databases
- In large system there will be many servers
  - Data from local and external resources

Figure 8.7 Three-tier systems using mediators
**Peer-to-Peer Networks**

- Type of network in which each workstation has equivalent capabilities and responsibilities
- A peer-to-peer (P2P) application is different from traditional client-server model
  - Applications act both as client and server
- P2P networks are simpler
  - Low performance under heavy load

**P2P application**

- No central server
  - Napster (original), Freenet
- Discovering other peers
- Querying peers for content
- Sharing content with other peers
Heterogeneous Distributed DBMS

- Homogenous system all the sites use the same DBMS system
- Heterogeneous system different DBMS, different data models
Content Management

- Integration of a number of technologies

- Degree of semantics
  - Artifacts (date, location), content information (sentence, key shape, color histogram), domain concepts like ontologies
  - Decomposition of media into a database in terms of storage of metadata, building an indexing structure
    - should be an automatic process
Media Streams

- An important objective of multimedia systems design is to transfer data at a constant speed.
- Streaming is a technique for transferring data, so that it can be processed as a steady and continuous stream.
- By using streaming, the client browser can display the data before the entire file has been transmitted.

Definitions

- **Media stream**: the output of a sensor device such as a video, audio or motion sensor that produces a continuous or discrete signal.
- **Live multimedia**: the scenario where the multimedia information is captured in a real-life setting.
- **Continuous queries**: persistent queries that are issued once and then logically run continuously over live and unbounded streams.
Media Streams

- If the streaming client receives the data more quickly than required, it needs to be saved in a buffer.
- However, if the data does not arrive quickly enough, the presentation of the data will be not smooth.

MM Networking Applications

Classes of MM applications:

1) Streaming stored audio and video
2) Streaming live audio and video
3) Real-time interactive audio and video
Fundamental characteristics:

- Typically **delay sensitive**
  - end-to-end delay
  - delay jitter

  **Jitter** is the variability of packet delays within the same packet stream

- But **loss tolerant**: infrequent losses cause minor glitches

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**Streaming Stored Multimedia**

- 1. video recorded
- 2. video sent
- 3. video received, played out at client

*streaming:* at this time, client playing out early part of video, while server still sending later part of video
Streaming Multimedia: Client Buffering

- Client-side buffering, playout delay compensate for network-added delay, delay jitter

Streaming Multimedia: Client Buffering

- Client-side buffering, playout delay compensate for network-added delay, delay jitter
Quality-of-service Issue

(1) “Quality of service (QoS) is the collective effect of service performances which determine the degree of satisfaction of a user of the service”.

(ITU-T Recomm. E-800)

(2) A measure of the extent to which a user’s

“Quality of service represents the set of those quantitative and qualitative characteristics of a distributed multimedia system that are necessary to achieve the required functionality of an application.”

(Vogel, et al)
Degree to which some applications are Sensitive to Quality Parameters

<table>
<thead>
<tr>
<th>Application</th>
<th>Reliability</th>
<th>Delay</th>
<th>Jitter</th>
<th>Bandwidth</th>
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</thead>
<tbody>
<tr>
<td>E-mail</td>
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<tr>
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<td>High</td>
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<td>Low</td>
</tr>
<tr>
<td>Videoconferencing</td>
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<td>High</td>
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Bandwidth Requirements for Some Applications

<table>
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<tr>
<th>Application</th>
<th>Bandwidth</th>
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<td>Telephony</td>
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<tr>
<td>Telephony</td>
<td>16 - 32 kbps</td>
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<tr>
<td>Teleconferencing</td>
<td>48 - 64 kbps</td>
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<tr>
<td>2-channel audio</td>
<td>128 - 384 kbps</td>
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<tr>
<td>5-channel audio</td>
<td>320 kbps</td>
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<tr>
<td>Videoconferencing</td>
<td>64 - 153 kbps</td>
</tr>
<tr>
<td>High-Definition TV</td>
<td>17 Mbps</td>
</tr>
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</table>
Characteristics of Multimedia Traffic

- Often consists of continuous streams of digitized video and audio data + bit-mapped images
- Video stream and audio stream are often sent separately
- Streams are broken up into discrete packets
- Packets are transmitted in sequence with uniform latency

Multimedia Network Requirements

- **Throughput Requirements**:  
  - high transmission bandwidth  
  - large buffer capacity  
  - high-bandwidth channels for extended period of time  
  - error control
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