10. Multimedia Database Systems

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10.1 Database Systems

Database Management System (DBMS)
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10.2 Multimedia Database Management System

Main task of Database Management System (DBMS) is to abstract from the details of:

- storage access
- storage management

Location of the MDBMS:

- embedded between the application domain and the device domain

Integration into the system:

- through operating system
- communication components
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10.2 Multimedia Database Management System / Properties

Persistence of Data:
- Data outlive processing programs and technologies, e.g. companies have to keep data in databases for several decades.

Consistent View of Data:
- Synchronisation protocols provide a consistent view of data in a multi-user system.

Security of Data:
- Transaction concepts ensure security and integrity protection in case of system failure. Recovery of lost data.

Query and Retrieval of Data:
- Query languages such as SQL (Structured Query Language) enable formulating database queries.
- Each entry has its state information that can be retrieved correctly.
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10.3 Characteristics of MDBMS

Corresponding Storage Media
- Multimedia data must be stored and managed according to the specific characteristics of the available storage media.

Descriptive Search Methods
- Query of multimedia data should be based on a descriptive and content-oriented search, e.g., “Picture of a woman with a red scarf”.

Device-independent Interface
- Hide details of device control, but offer information on specific characteristics of available storage media (read-only, write-once, write-many).

Format-independent Interface
- DBMS must hide internal storage format and offer conversions to formats requested by the applications (GIF, TIFF, SUN Raster, ....).
- This allows changing to new storage technologies without any impact on MM-applications.
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10.3 Characteristics of MDBMS

View-specific and Simultaneous Data Access
- Allows consistent, multiple and simultaneous data access through different queries of several applications (e.g. shared editing)

Management of Large Amounts of Data
- DBMS must be capable of handling and managing large amounts of data. Need of appropriate referencing mechanism.

Relational Consistency of Data Management
- Relations among data of one or different media must stay consistent corresponding to their specification. MMDBMS manages following relations:
  - Attribute Relation: supports different presentation (audio, video, image) of one object.
  - Component Relation: includes all parts belonging to one data object.
  - Substitution Relation: defines different kinds of presentation of the same information, e.g. equation as tables, graphs, animation.
  - Synchronisation Relation: describes temporal relations between data units, e.g. lip synchronisation of audio and video.
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10.3 Characteristics of MDBMS

**Real-time Data Transfer**
- DBMS must perform read and write operations of continuous data in real-time.
- The data transfer of continuous data has a higher priority than other database management actions.
- Primitives of multimedia operating system should be used to support the real-time transfer of continuous data.

**Long Transactions**
- The transfer of large amount of data will take a long time and must be done in a reliable fashion.
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10.3 Characteristics of MDBMS

Relation between the operating system and MDBMS:

- The operating system provides the management interface for MDBMS to all local devices.
- The MDBMS provides an abstraction of the stored data and their equivalent devices, as is the case in DBMS without multimedia.
- The communication system provides for MDBMS abstractions for communication with entities at remote computers.
- Operating system and communication system can unify all the different abstractions and offer them.
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10.4 Data Structure

Data can be stored in databases as

- unstructured (unformatted): data are presented in a unit where content cannot be retrieved by accessing any structural detail.

  Example: “Mr. Penguin is a student in the seventh term.”

- structured form (formatted): data are stored in variables, fields or attributes with corresponding values.

  Example:

  ```
  o.student.surname = “mustername”
  o.student.name = “hammel”
  o.student.age = 41
  ```
Multimedia data can be stored in databases as raw, registering and descriptive data types.

- **Raw Data**: represent the unformatted information content, e.g. letters, pixel, values.
- **Registering data**: necessary for correct interpretation and identification of the data; usually concealed in the header. For example: format-description (GIF, TIFF, SUN-Raster, ASCII, EBCDIC, ...), compressed/uncompressed data, etc.
- **Descriptive data**: information about content and structure of SMO to make use easier and faster, e.g. semantic search.
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10.4 Data Structure / Data Types - Examples

Text

- Characters represent raw data
- Registering data describe the coding (e.g., ASCII)
- Descriptive data may include information for layout and logical structuring of the text or keywords

Image

- Pixels represent raw data
- Registering data include the height and width of the picture.
- Descriptive data are individual lines, surfaces and subjects
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10.4 Data Structure / Data Types - Examples

Video sequence

– Pixel matrices represent the raw data
– Registering data provides, in addition to other information, the number of images per second.
– Descriptive data provide a scene description, e.g. ”Jan‘s birthday party”.

Audio sequence

– The digital sample values created by a simple PCM coding represent the raw data
– Registering data represent the properties of the audio coding.
– Descriptive data represent the content of the audio.
An MDBMS must offer, for all data types corresponding operations for:

- archival and
- retrieval

The media related operations will be handled as part of or an extension of query languages, e.g. SQL

Different classes of operations are needed:

- input
- output
- modification
- deletion
- comparison
- evaluation
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10.5 Operations on Data

Input (insert / record) operation:
- data will be written to the database
- the raw and registering data are always needed, descriptive data can be attached later

Output (play) operation:
- reads the raw data from the database according to the registering data

Modification:
- changing of raw, registering and descriptive data
- Modification can also be understood as a data conversion from one format to another.

Deletion operation:
- removes an entry from the database
- the consistency of the data must be preserved
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10.5 Operations on Data

Comparison:
- Many queries to the MDBMS consist of a search and retrieval of the stored data
- Queries are based on comparison information
- Individual patterns in the particular medium are compared with the stored raw data → not succesfull enough
  ➔ Pattern matching, search in descriptive data, etc.

Evaluation:
- generation of the corresponding descriptive data from the raw and registering data
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10.6 Integration in a Database Model

Design of multimedia database system based on two different kinds of DBMS:

**ERDBMS (Extensible Relational Database Management System):**
- Definition of additional, application-dependent datatypes as domains for attributes.
- Definition of new functions to control behaviour and access to the data.
- Embedding new types and functions into existing RDMBS.

**OODBMS (Object-Oriented Database Management System):**
- Different media are represented by classes, whose instance variables include the data as internal state.
- Class hierarchy allows objects relations, offer well information navigation and flexible presentation possibilities.
Simplest possibility to implement a multimedia database is to use the relational database model.

The attributes of different media in relational databases are defined

Attributes can specify

- text
- audio
- video

Advantage

- compatibility with existent database applications
A relation “student” is given

Student (  
  Admission_Number Integer,  
  Name String,  
  Picture Image,  
  Exercise_Device_1 Video,  
  Exercise_Device_2 Video  
)

A relation’s attributes can be specified through different media types

  – picture  
  – exercise  
  – video

Other entries are ”athletics”, ”swimming” and ”analysis”

Athletics (  
  Admission_Number Integer,  
  Qualification Integer,  
  The_High_Jump Video,  
  The_Mile_Run Video  
)

Swimming(  
  Admission_Number Integer,  
  Crawl Video  
)

Analysis (  
  Qualification Integer,  
  Error_Pattern String,  
  Comment Audio  
)
Type 1 Relational Model
- Value of a certain attribute can be fixed over the particular set of the corresponding attribute types, e.g. the frame rate of the video can be fixed
- In the example, the videos from the exercise davesies 1 and 2 will play at the fixed rate defined by the type 1 specification

Type 2 Relational Model
- A variable number of entries can be defined through the type 2 relational model
- In the example, the individual disciplines of each admitted student are identified through their admission numbers

Type 3 Relational Model
- Additionally, an entry can simultaneously belong to several relations
- In the example, a video entry of a student can be assigned to the relation "athletics" as well as to the relation "analysis"
In object-oriented databases
- classes with objects are defined
- objects can be put in relations via a class hierarchy
- a semantic specialization of classes and objects can follow

Example
- Main class: sport institute
- Subclass: athletics, swimming
- Objects: students

Advantage:
- These system offer good information navigation and flexible presentation possibility

Desadvantage
- Query operations are incompletely supported