**Database Concepts**

**Database & Database Management System**

**Database**
- A shared collection of logically related (and a description of this data), designed to meet the information needs of an organization.

**Database Management System (DBMS)**
- A software system that enables users to define, create, and maintain the database and provides controlled access to this database.

**Application examples**
- Supermarket
- Credit Card
Application examples

- Travel Agent

Application examples

- Library

Application examples

- University

Traditional File-based Processing

- Sales
  - Data entry and reports
  - File handling routines
  - File definition
  - Sales application programs
  - Sales files

- Contracts
  - Data entry and reports
  - File handling routines
  - File definition
  - Contracts application programs
  - Contracts files
Database Approach

Arose because:

- Definition of data was embedded in application programs, rather than being stored separately and independently.
- No control over access and manipulation of data beyond that imposed by application programs.

Result - the database and Database Management System (DBMS).

The Paradigm Shift

File-based approach
- The work of database design was driven by the application needs of individual departments.

Database approach
- To think of the data first and then the application second.

=> The Paradigm Shift

DB and DBMS: An example

The Paradigm Shift

Database

Recall: Database = A shared collection of logically related data (and a description of this data), designed to meet the information needs of an organization.

- System catalog (data dictionary or metadata) provides the description of the data to enable program-data independence.
- Logically related data comprises entities, attributes, and relationships of an organization’s information.
**Logically Related Data**

**entities, attributes, and relationships**

- **Owner**
  - **Name**
  - **Address**
  - **Tel_No**
- **Property**
  - **Property_No**
  - **Owns**

**Database Concepts - 13**

**Functions of a DBMS**

- **Data storage, retrieval, and update**
- **User-accessible catalog**
- **Transaction support**
  - Ensure that either all the updates corresponding to a given transaction are made or that none of them are made.
- **Concurrency control services**
  - Ensure that the database is updated correctly when multiple users are updating the database concurrently.

**Database Concepts - 14**

**The Lost Update Problem:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Transaction&lt;sub&gt;1&lt;/sub&gt;</th>
<th>Transaction&lt;sub&gt;2&lt;/sub&gt;</th>
<th>bal&lt;sub&gt;1&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>t1</td>
<td>Read(bal&lt;sub&gt;1&lt;/sub&gt;)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>t2</td>
<td>Read(bal&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>bal&lt;sub&gt;2&lt;/sub&gt;=bal&lt;sub&gt;1&lt;/sub&gt;+100</td>
<td>100</td>
</tr>
<tr>
<td>t3</td>
<td>bal&lt;sub&gt;1&lt;/sub&gt;=bal&lt;sub&gt;2&lt;/sub&gt;-10</td>
<td>Write(bal&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>200</td>
</tr>
<tr>
<td>t4</td>
<td>Write(bal&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>t5</td>
<td></td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

**Database Concepts - 15**

**Functions of a DBMS**

- **Recovery Services**
- **Authorization Services**
- **Support for data communication**
- **Integrity services**
- **Services to promote data independence**
  - Programs can be written without knowing actual data structure
- **Utility services**
  - Eg. Import data from other formats, monitor database usage and operation, statistical kits, indexing, garbage collection and reallocation.

**Database Concepts - 16**
Database Languages

Recall: DBMS = A software system that enables users to define, create, and maintain the database and provides controlled access to this database.

Data definition language (DDL)
To express database schema (the structure of the database).
Results => System Catalog

Data manipulation language (DML)
To access and manipulate data.

Database Languages

Procedural & non-procedural DMLs

Procedural DML
What data is needed and exactly how to retrieve the data.

Non-Procedural DML
What data is needed.
Eg. Structured Query Language (SQL)

Components of a DBMS

Components of DBMS Environment

- Hardware
- Software
- Data
- Procedures
- People
**DBMS Environment - Hardware**

*Example:*

A Traditional Architecture (Dumb Terminals)

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**DBMS Environment - Hardware**

*Example:*

A File-Server Architecture

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**DBMS Environment - Hardware**

*Example:*

A Client-Server Architecture

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**DBMS Environment - Software**

- DBMS + Application Programs + Operating Systems

- A typical application program embeds SQL statements in C or Cobol codes to access data

- DBMS Tools: reports generators, forms generators, application generators etc.
**DBMS Environment - Data**

- **Data (Operational data)**
- **System Catalog**
  - Examples:
    - Names, types, sizes of data items
    - Relationships
    - Integrity constraints on the data
    - Names of authorized users
    - Types of indexes and storage structures
    - Usage statistics

**DBMS Environment - Procedures**

Procedures refer to the instructions and rules of the design and use of the database, eg.,
- **Logon**
- **Run some programs**
- **Start and stop the DBMS**
- **Backup**
- **Failure handling**
- **Changes on the data structures or physical storage**

**DBMS Environment - People**

- **Data Administrator**
  - Management of the data resource
- **Database Administrators**
  - Responsible for physical aspects such as physical database design and implementation, security, performance
- **Database Designer**
- **Application Programmers**
- **End-Users**

**DB Architecture: 3 Levels of Abstraction**

- **External (User Views)**
  - Each user concerns with only his specific portion of data
- **Conceptual (Logical)**
  - What data are stored and the relationships exist among data
- **Internal (Physical)**
  - The lowest level, describes how data are actually stored
**View Mechanism**

*View mechanism*
- Provides users with only the data they want or need to use.

**Advantages:**
- Provides a level of security
- Allows to customize the appearance of the database
- Presents a consistent, unchanging picture of the structure of the database

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**Data Independence**

*Data Independence*: Upper levels are unaffected by changes to lower levels.

**Physical Data Independence**
- the ability to modify the physical scheme without causing application programs to be rewritten

**Logical Data Independence**
- the ability to modify the conceptual scheme without causing application programs to be rewritten
Data Models

Data Model = an integrated collection of concepts for describing data, relationships and constraints on the data in an organization.

3 types of Data Models:
- Record-Based Data Models
  - Relational (tables)
  - Network (graphs)
  - Hierarchical (trees)
- Object-Based Data Models
  - Entity-Relationship
  - Object-Oriented
- Physical Data Models (few in use)
  - Unifying Model: Frame memory

Database Design

The process of database design involves 3 steps:
- Conceptual Database Design => Conceptual Model
  Modelling of the information used in an enterprise, independent of all physical considerations (the DBMS, application programs and languages, hardware platform etc.)
- Logical Database Design => Logical Model
  Refine and map the conceptual model into a logical model according to the target data model for the database (e.g. Relational data model)
- Physical Database Design => How to implement on secondary storage (structures and access methods)

Don’t be confused

Database Architecture (3 Levels of abstraction):
External / Conceptual / Internal (Physical) Levels

External / Conceptual / Internal Schemas

Data Independence:
Logical / Physical Data Independences

Types of data models:
Record-Based / Object-Based / Physical Data Models

Database Design Steps:
- Conceptual Database Design => Conceptual Model
- Logical Database Design => Logical Model
- Physical Database Design => Physical implementation plan

Advantages of DBMS

- Sharing of Data (& Data Access)
- Control of Redundancy
- Data Consistency
- Improved Data Standard
- Better Data Security
- Higher Data Integrity
- Balance of Conflicting Requirements
- Faster Development of New Applications
- Control over concurrency
- Backup & Recovery
### Disadvantages of DBMS

- High cost of DBMS
- May involve more expensive hardware
- Specific programming skill
- Database files conversion
- Slower processing of less critical applications
- Increased vulnerability as resources are centralized
- More sophisticated recovery required when concurrent updates allowed

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#### Case Study - DreamHome

**Organization:**
- **Branches**
  - **Staff of each branch:**
    - One Manager
    - Supervisors
    - 5-10 General Staff + 1 secretary under a supervisor

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### Case Study – DreamHome (Forms)

#### Staff Details Form

<table>
<thead>
<tr>
<th>First Name</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Name</td>
<td>White</td>
</tr>
<tr>
<td>Address</td>
<td>19 Taylor St, Cranford, London</td>
</tr>
<tr>
<td>Tel No</td>
<td>0171-884-5112</td>
</tr>
</tbody>
</table>

**Personal Details**
- Sex
- Date of Birth
- NIN

**Next-of-Kin Details**
- Relationship
- Address
- Tel No

**General Work Details**
- Position
- Manager
- Date Appointed
- 19-Sep-86
- Salary
- 30,000
- Car Allowance
- 2,000
- Bonus Payment
- 340

**Managerial Staff**
- Secretary Staff
- Typing Speed

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#### Case Study - DreamHome

**Services provided by DreamHome:**
- Advertising the property (Flat or House)
- Interview prospective renters
- Organize visits
- Negotiate lease agreement
- Inspect the property regularly (6 months)
Case Study – DreamHome (Reports)

Property Inspection Report

<table>
<thead>
<tr>
<th>Property Number</th>
<th>Address</th>
<th>Allocated to Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG21</td>
<td>18 Dale Rd, Hyndland, Glasgow G12</td>
<td>163 Main St, Partick, Glasgow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Staff Name</th>
<th>Inspection Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susan Brand</td>
<td>12-Apr-95</td>
<td>No problems</td>
</tr>
<tr>
<td>Susan Brand</td>
<td>30-Sep-96</td>
<td>Cracked ceiling in living room, Requires urgent repair</td>
</tr>
<tr>
<td>Ann Beech</td>
<td>01-Jul-97</td>
<td>Crockery needs to be replaced</td>
</tr>
</tbody>
</table>

Case Study - DreamHome

Other data:
- Advertisement details
- Appropriate newspapers

Policies:
- Retain information of withdrawn properties: 3 years
- Retain information of expired leases: 3 years
- Lease period: 3 months – 1 year
- Each staff manages not more than 10 properties

Case Study - DreamHome

Transaction Requirements:
- Maintain records of staff details, properties, prospective renters, viewing by prospective renters, adverts, lease agreements, property inspections
- Produce staff details listing at a branch
- Produce listing of staff under a a supervisor
- Produce listing of supervisors at a branch
- Produce listing of properties at a branch
- Produce listing of properties managed by a staff
- Produce listing of prospective renters at a branch
- Search for properties satisfying a prospective renter
- Produce a report of viewing comments of a property
- Produce listing of adverts for a property
- Produce listing of adverts placed in a newspaper
- Produce report of lease agreement for a property
- Produce listing of inspections of a property