Information Systems

An Overview of Database Management

Temur Kutsia

Research Institute for Symbolic Computation
Johannes Kepler University of Linz, Austria
kutsia@risc.uni-linz.ac.at

Outline

Introduction

What Are Database Systems?

What Is a Database?

Why to Use Database?

Data Independence

Brief Overview of Systems

Summary

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Goal of if this lecture:

- Explain what a database system is and why database systems are desirable.
- Briefly discuss the difference between relational systems and others.

Introduction

- Database system: a computerized record-keeping system.

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- Database: a repository or a container for a collection of computerized data files.

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- Database system: a computerized record-keeping system.
- Database: a repository or a container for a collection of computerized data files.
- Operations on databases:
  - Adding new files to the database
  - Inserting data into existing files
  - Retrieving data from existing files
  - Deleting data from existing files
  - Changing data in existing files
  - Removing existing files from the database
  - etc.

Introduction

Example (The Wine Cellar Database)

BIN#	WINE	PRODUCER	YEAR	BOTTLES	READY
2	Chardonnay	Buena Vista	2001	1	2003
6	Chardonnay	Simi	2000	4	2000
12	Joh. Riesling	Jekel	2002	1	2003
21	Fumè Blanc	Ch. St. Jean	2002	4	2003
43	Cab. Sauv.	Windsor	1995	12	2004
51	Pinot Noir	Fetzer	1997	3	2004
58	Merlot	Clos du Bois	1998	9	2004

File CELLAR

Introduction

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File CELLAR

Retrieval:

```
SELECT      WINE, BIN#, PRODUCER
FROM        CELLAR
WHERE       READY = 2004 ;
```

WINE	BIN#	PRODUCER
Cab. Sauv.	43	Windsor
Pinot Noir	51	Fetzer
Merlot	58	Clos du Bois

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File CELLAR

Inserting new data:

```
INSERT
INTO      CELLAR ( BIN#, WINE, PRODUCER, YEAR, BOTTLES, READY )
VALUES    ( 53, 'Pinot Noir', 'Saintsbury', 2001, 6, 2005 ) ;
```

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File CELLAR

Deleting existing data:

```
DELETE
FROM        CELLAR
WHERE       BIN# = 2 ;
```

Introduction

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2	Chardonnay	Buena Vista	2001	1	2003
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File CELLAR

Changing existing data:

```
UPDATE      CELLAR
SET         BOTTLES = 4
WHERE       BIN# = 43 ;
```

Introduction

- SELECT, INSERT, DELETE, UPDATE are called statements, commands, or operators.
- In the previous example they are expressed in a language called SQL.
- The Term update sometimes refers to the three operators: INSERT, DELETE, UPDATE. Do not confuse!

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- The Term update sometimes refers to the three operators: INSERT, DELETE, UPDATE. Do not confuse!
- Terminology. The same things are referred differently in different contexts:
  - Files, records, fields (when talking about database systems in general).
  - Tables, rows, columns (when talking about SQL systems).
  - Relations, tuples, attributes (in more formal discussions).

Introduction

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- We might extend the CELLAR table to include additional columns:
  - LABEL (photo of the bottle label).
  - REVIEW (review text from some wine magazine).
  - MAP (showing where the wine comes from).
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  - etc.

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  - etc.
- Column data types.

Introduction

- Column BIN# constitutes the primary key for the table CELLAR.
- Meaning: No two CELLAR rows ever contain the same BIN# value.
- We use underlining to indicate primary key columns.

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Brief Overview of Systems

Summary

Database Systems

- Database system: computerized record-keeping system.
- Four major components:
  - data,
  - hardware,
  - software,
  - users.

Data

- Database systems are available on machines of different size and power.
- Systems on large machines tend to be multi-user, on smaller machines – single-user.
- Multi-user systems: many users can access the database at the same time.
- Single-user systems: at most one user can access the database at the same time.
- The distinction is largely irrelevant as far as most of the users are concerned.
- Special problems of multi-user systems mainly are internal to the systems.
- Data in the system can be stored in a single database, or can be split across several databases.

Data

- Data in the database is in general both integrated and shared.
- Integrated database:
  - unification of several distinct files,
  - any redundancy among those files partly or wholly eliminated.
- Shared database:
  - sharing among different users,
  - different users can access the same data, maybe at the same time.

Data

Example (Integrated Database)

- Database containing an EMPLOYEE file and an ENROLLMENT file.
- The EMPLOYEE file contains data about employee names, addresses, salaries, etc:

NAME	ADDRESS	DEPARTMENT	SALARY	. . .

- The ENROLLMENT file contains data about the enrollment of employees in training courses:

NAME	COURSE	. . .

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- The ENROLLMENT file contains data about the enrollment of employees in training courses:

NAME	COURSE	. . .

- Assume the courses administration needs to know the department for each enrolled student.
- No need to include this information in the ENROLLMENT file. Can be discovered in the EMPLOYEE file.

Data

In integrated and shared databases

- any given user is concerned with a small portion of the total database,
- different users' portions will overlap in various ways,
- even if two users share the same portion of the database, their views might be different.

Hardware

Hardware components of a database system:

- The secondary storage volumes, together with the associated I/O devices, device controllers, etc.
- The hardware processor(s) and associated main memory.

Not considered in this course.

Software

- The Database management system (DBMS): a layer of software between the physical database and the users.
- DBMS
  - handles all requests to the database,
  - shields users from hardware-level details,
  - is the most important software component of the system.
- Other software components: utilities, application development tools, design aids, transaction manager, etc.

Sometimes people use the term *database* instead of *DBMS*. Do not confuse!

Users

Three classes of users:

- Application programmers:
- End users:
- Database administrator.

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Users

Three classes of users:

- Application programmers: Write applications in some programming language, which then access the database by issuing a request (SQL statement) to the DBMS.
- End users: Access the database interactively, via online application or using a system interface.
  - Most systems include at least one built-in application, query language processor.
  - Most systems provide additional built-in interfaces, to help end users choose items from a menu or fill in a form, in contrast of issuing explicit database requests: menu- or forms-driven interfaces vs command-driven interfaces.
- Database administrator.

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Persistent Data

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Database

A database is a collection of persistent data that is used by the application systems of some given enterprize.

Entities and Relationships

Example

Manufacturing company records information about:

- its *projects*,
- the *parts* that are used in those projects,
- the *suppliers* who supply parts,
- the *warehouses* where the parts are stored,
- the *employees* who work in the projects,
- etc.

Projects, parts, suppliers, warehouses, employees: basic entities.

Entities and Relationships

Example (Cont.)

In addition to basic entities, the company keeps information about relationships linking those basic entities together:

- each supplier *supplies* certain parts,
- each part is *supplied* by some supplier,
- parts are *used* in projects,
- projects *use* parts,
- etc.

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Binary (and bidirectional) relationships.

- Ternary relationship: each supplier supplies certain parts to certain projects.
- Not equivalent to three binary relationships: supplier supplies parts, parts are used in projects, and projects are supplied by suppliers. (Why?)

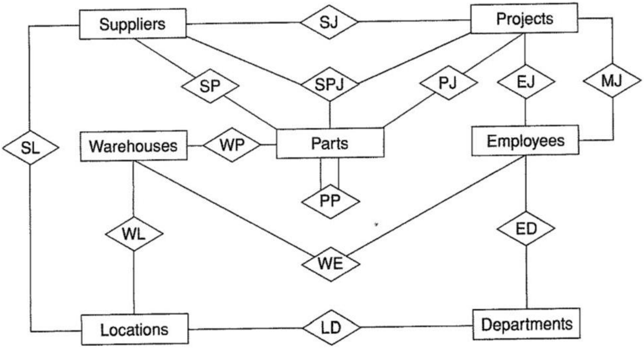
Entities and Relationships

Important:

- Relationships are just as much a part of the data as are the basic entities.
- They must be represented in the database, like the basic entities.
- A relationship can be regarded as an entity in its own right.

Entities and Relationships

Entity/Relationship (E/R) diagram from the previous example:



Representation:

- Entities by rectangles.
- Relationships by diamonds and connecting lines.

Properties

- Entities (relationships included) can be regarded as having properties.
- Properties correspond to the information we wish to record about entities.
- Examples of properties: weight of a part, priority of a project, location of a supplier, plan of a warehouse, etc.

Data and Data Models

Another view what data and databases are:

- Data: given facts from which additional facts can be inferred (by DBMS responding to a request).
- Logically, given facts correspond to true propositions.
- Database: collection of true propositions.

Data and Data Models

SQL products are based on a the relational model of data.

In the relational model

- data is represented by means of rows in tables,
- rows are interpreted as true propositions,
- operators are provided for operating on rows,
- operators support the process of inferring additional true propositions from the given ones.

Data and Data Models

Data Model

- An abstract, self-contained, logical definition of the objects, operators, etc. that together constitute the abstract machine with which users interact.
- The objects allow us to model the structure of data.
- The operators allow us to model its behavior.

Model vs Implementation:

- Model is what the users have to know about,
- Implementation is what the users do not have to know about.

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Why to Use Database

The advantages of a database system over paper-based methods of bookkeeping:

- Compactness: No need in paper files.
- Speed: Machine is faster in retrieval than a human.
- Less drudgery: Mechanical tasks (maintaining files etc.) are better done by machines.
- Currency: Up-to-date information is available on demand at any time.
- Protection: The data can be better protected against unintentional loss and unlawful access.

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One more advantage in a multi-user environment:

- The database system provides the enterprize with centralized control of its data.

Data Administration and Database Administration

- Data administrator

- Database administrator (DBA)

Data Administration and Database Administration

- Data administrator
  - A person who has the central responsibility for the data.
  - Senior manager, not a technician (although familiar with the database system capabilities at a technical level).
  - Decides what data should be stored, establishes policies for maintaining and dealing with data.
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Data Administration and Database Administration

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  - A person who has the central responsibility for the data.
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  - Decides what data should be stored, establishes policies for maintaining and dealing with data.
- Database administrator (DBA)
  - A technical person responsible for implementing data administrator’s decisions.
  - An IT specialist.
  - Creates databases, puts in place the technical controls needed to enforce data administrator’s policy decisions.
  - May have a staff of programmers and technical assistants.

Advantages of Centralized Control

- Redundancy can be reduced.
- The data can be shared.
- Inconsistency can be avoided (to some extent).
- Transition support can be provided.
- Integrity can be maintained.
- Security can be enforced.
- Conflicting requirements can be balanced.
- Standards can be enforced.
- Data independence can be provided.

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Data Independence

- Two kinds of data independence: Physical and logical.
- Only physical data independence in this lecture.

Data Dependence

- An application is data-dependent, if the physical representation of the data and (physical) access techniques can not be changed without affecting the application.
- Extremely undesirable property.

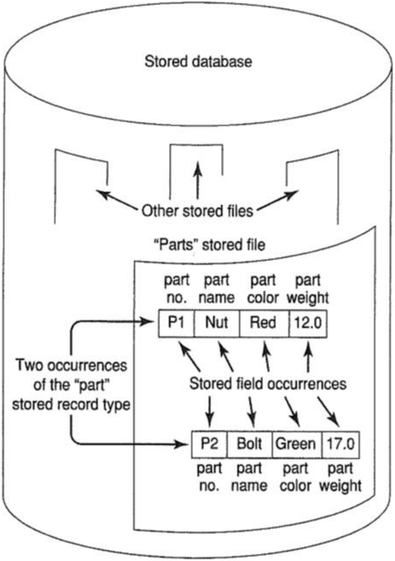
Data Independence

- Data independence: the immunity of applications to change in physical representation and access techniques.
- What kind of changes we wish applications to be immune to?

Data Independence

- Stored fields: smallest unit of stored data.
  - The database will contain many occurrences of each of several types of stored field.
  - Example: a database containing information about different kinds of parts might include a stored field type “part number”, and one occurrence of that stored field for each kind of part.
- Stored record: collection of stored fields.
  - A stored record occurrence consists of related stored field occurrences.
  - Database might contain many occurrences of stored record type.
- Stored file: collection of all currently existing occurrences of one type of stored record.

Data Independence



part no.	part name	part color	part weight
P1	Nut	Red	12.0

P2	Bolt	Green	17.0
part no.	part name	part color	part weight

Data Independence

- In database systems the DBA might change the stored representation of data—stored fields, records, and files.
- Data as seen by applications does not change.

Data Independence

Some aspects of the stores representation that might be subject to change:

- Representation of numerical data.
- Representation of character data.
- Units for numeric data.
- Data coding.
- Data materialization.
- Structure of stored records.
- Structure of stored files.

Data Independence

- Database should be able to grow without impairing existing applications.
- Data independence is one of the reasons to separate data model from data implementation.

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Relational Systems and Others

- Relational system is a system in which
  - the data is perceived by the user as tables,
  - the operators available to the user derive “new” tables from “old” ones.
- Relation is basically a mathematical term for a table.
- Other systems:
  - Inverted list systems.
  - Hierarchical systems.
  - Network systems.
  - Object and object-relational systems.
  - Multi-dimensional systems.
  - Logic-based (deductive) systems.
  - Semistructured systems.

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- It involves the data (stored in the database), hardware, software (in particular, DBMS) and users.
- Users can be divided into application programmers, end users, and the DBA.
- DBA is responsible for administering the database and the database system with policies established by DA.

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- They are used to store persistent data representing entities and relationships among entities.
- One of the most important benefit of database systems is data independence.
- Data independence requires a sharp distinction between the data model and its implementation.
- Relational systems are based on the relational model.