Databases

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Lec01

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Basic Definitions

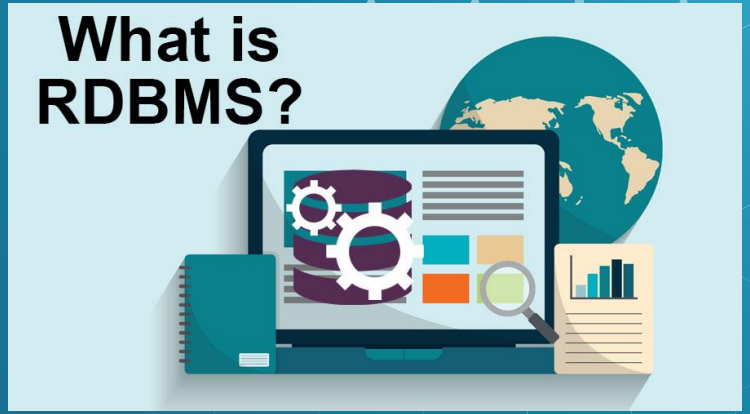
- Database: A collection of related data.
- Data: Known facts that can be recorded and have an implicit meaning.
- Mini-world: Some part of the real world about which data is stored in a database.
- For example, student grades and transcripts at a university.

Impact of Databases and Database Technology

- **Businesses**: Banking, Insurance, Retail, Transportation, Healthcare, Manufacturing
- **Service** Industries: Financial, Real-estate, Legal, Electronic Commerce, Small businesses
- **Education** : Resources for content and Delivery
- More recently: **Social** Networks, Environmental and Scientific Applications, Medicine and Genetics
- **Personalized** Applications: based on smart **mobile** devices

What is RDBMS?

- RDBMS stands for Relational Database Management System.
- RDBMS is the basis for SQL and for all modern database systems like MS SQL Server, IBM DB2, Oracle, MySQL, and Microsoft Access.
- A Relational database management system (RDBMS) is a database management system (DBMS) that is based on the relational model



What is table?

- The data in RDBMS is stored in database objects called tables.
- The table is a collection of related data entries and it consists of columns and rows.
- Following is the example of a Person table:

	BusinessEntityID	PersonType	NameStyle	Title	FirstName	MiddleName	LastName
719	1147	SC	0	Ms.	Jodan	M.	Jacobson
720	1149	SC	0	Ms.	Mary	NULL	Alexander
721	1151	SC	0	Mr.	David	NULL	Jaffe
722	1153	SC	0	Mr.	Jay	NULL	Jamison
723	1155	SC	0	Ms.	Vance	P.	Johns
724	1157	SC	0	Ms.	Joyce	NULL	Jarvis
725	1159	SC	0	Mr.	George	NULL	Jiang
726	1161	SC	0	Mr.	Stephen	Yuan	Jiang

What is field/column?

- The fields in the Person table consist of BusinessEntityID, PersonType, NameStyle, Title, FirstName, MiddleName and LastName.
- A field is a column in a table that is designed to maintain specific information about every record in the table.

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What is record/row?

- A record/row of data, is each individual entry that exists in a table.

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Simplified database system environment

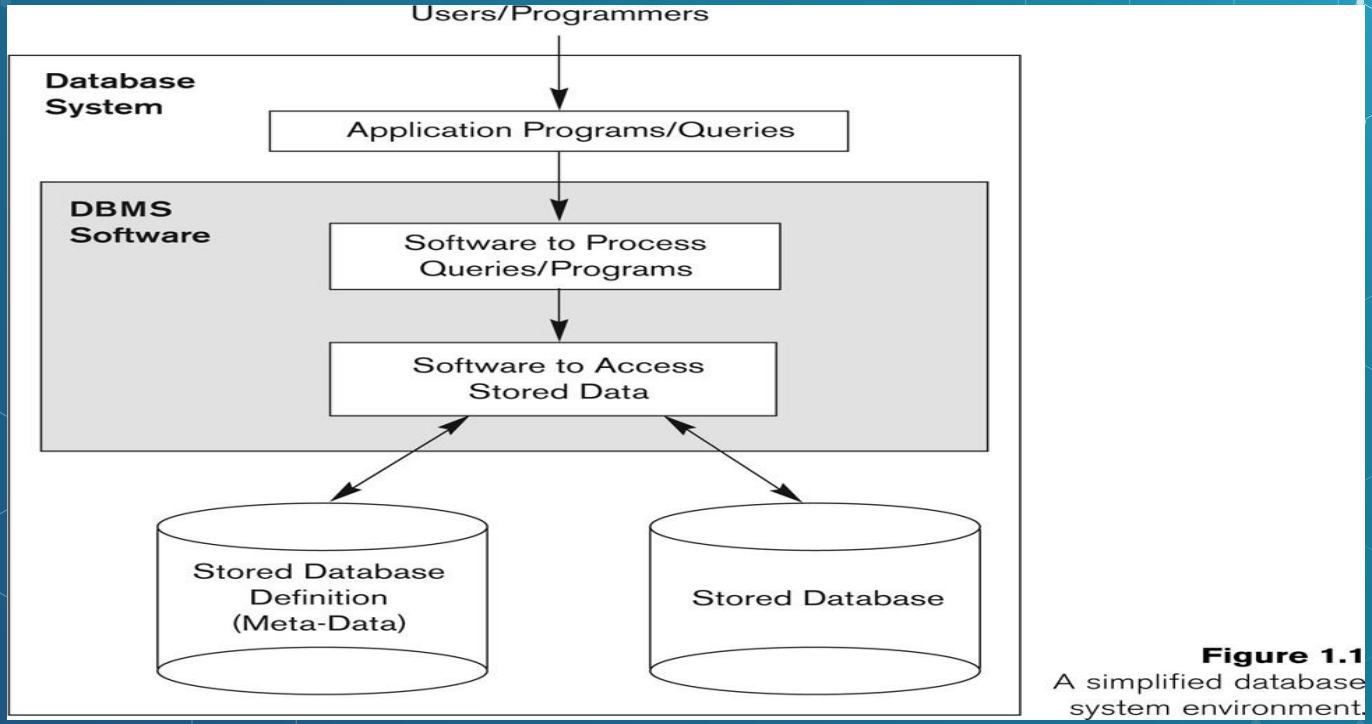

Figure 1.1
A simplified database system environment.

Typical DBMS Functionality

- Define a particular database in terms of its data types, structures, and constraints
- Construct or Load the initial database contents on a secondary storage medium
- Manipulating the database:
- Retrieval: Querying, generating reports
- Modification: Insertions, deletions and updates to its content
- Accessing the database through Web applications
- Processing and Sharing by a set of concurrent users and application programs – yet, keeping all data valid and consistent

Application Activities Against a Database

- Applications interact with a database by generating
- Queries: that access different parts of data and formulate the result of a request
- Transactions: that may read some data and "update" certain values or generate new data and store that in the database
- Applications must not allow unauthorized users to access data
- Applications must keep up with changing user requirements against the database

Additional DBMS Functionality

- DBMS may additionally provide:
- Protection or Security measures to prevent unauthorized access
- “Active” processing to take internal actions on data Presentation and Visualization of data
- Maintenance of the database and associated programs over the lifetime of the database application.

Example of a Database (with a Conceptual Data Model)

- Mini-world for the example:
- Part of a UNIVERSITY environment.
- Some mini-world entities:
- STUDENTs
- COURSEs
- SECTIONs (of COURSEs)
- (academic) DEPARTMENTs
- INSTRUCTORs

Example of a Database (with a Conceptual Data Model)

- Some mini-world relationships:
- SECTIONs are of specific COURSEs
- STUDENTs take SECTIONs
- COURSEs have prerequisite COURSEs
- INSTRUCTORs teach SECTIONs
- COURSEs are offered by DEPARTMENTs
- STUDENTs major in DEPARTMENTs
- Note: The above entities and relationships are typically expressed in a conceptual data model, such as the ENTITY-RELATIONSHIP data model (see Chapters 3, 4)

Example of a simple database

COURSE

Course_name	Course_number	Credit_hours	Department
Intro to Computer Science	CS1310	4	CS
Data Structures	CS3320	4	CS
Discrete Mathematics	MATH2410	3	MATH
Database	CS3380	3	CS

SECTION

Section_identifier	Course_number	Semester	Year	Instructor
85	MATH2410	Fall	04	King
92	CS1310	Fall	04	Anderson
102	CS3320	Spring	05	Knuth
112	MATH2410	Fall	05	Chang
119	CS1310	Fall	05	Anderson
135	CS3380	Fall	05	Stone

GRADE_REPORT

Student_number	Section_identifier	Grade
17	112	B
17	119	C
8	85	A
8	92	A
8	102	B
8	135	A

PREREQUISITE

Course_number	Prerequisite_number
CS3380	CS3320
CS3380	MATH2410
CS3320	CS1310

Figure 1.2
A database that stores student and course information.

Main Characteristics of the Database Approach

- Self-describing nature of a database system:
- A DBMS catalog stores the description of a particular database (e.g. data structures, types, and constraints)
- The description is called meta-data*.
- This allows the DBMS software to work with different database applications.
- *

Main Characteristics of the Database Approach

- Insulation between programs and data:
- Called program-data independence.
- Allows changing data structures and storage organization without having to change the DBMS access programs.

Example of a simplified database catalog

RELATIONS

Relation_name	No_of_columns
STUDENT	4
COURSE	4
SECTION	5
GRADE_REPORT	3
PREREQUISITE	2

COLUMNS

Column_name	Data_type	Belongs_to_relation
Name	Character (30)	STUDENT
Student_number	Character (4)	STUDENT
Class	Integer (1)	STUDENT
Major	Major_type	STUDENT
Course_name	Character (10)	COURSE
Course_number	XXXXNNNN	COURSE
….	….	…..
….	….	…..
….	….	…..
Prerequisite_number	XXXXNNNN	PREREQUISITE

Note: Major_type is defined as an enumerared type with all known majors. XXXXNNNN is used to define a type with four alpha characters followed by four digits

Figure 1.3
An example of a database catalog for the database in Figure 1.2.

Main Characteristics of the Database Approach (continued)

- Data Abstraction:
  - ✓ A data model is used to hide storage details and present the users with a conceptual view of the database.
  - ✓ Programs refer to the data model constructs rather than data storage details
- Support of multiple views of the data:
  - ✓ Each user may see a different view of the database, which describes only the data of interest to that user.

Main Characteristics of the Database Approach (continued)

- Sharing of data and multi-user transaction processing:
  - ✓ Allowing a set of concurrent users to retrieve from and to update the database.
- Concurrency control within the DBMS guarantees that each transaction is correctly executed or aborted
- Recovery subsystem ensures each completed transaction has its effect permanently recorded in the database
- OLTP (Online Transaction Processing) is a major part of database applications. This allows hundreds of concurrent transactions to execute per second.

Database Users

- Users may be divided into
- Those who actually use and control the database content, and those who design, develop and maintain database applications (called "Actors on the Scene"), and
- Those who design and develop the DBMS software and related tools, and the computer systems operators (called "Workers Behind the Scene").

Database Users – Actors on the Scene

- Database administrators:
- Responsible for authorizing access to the database, for coordinating and monitoring its use, acquiring software and hardware resources, controlling its use and monitoring efficiency of operations.
- Database Designers:
- Responsible to define the content, the structure, the constraints, and functions or transactions against the database. They must communicate with the end-users and understand their needs.

Database End Users **Actors on the scene (continued)**

- End-users: They use the data for queries, reports and some of them update the database content.
- End-users can be categorized into:
- Casual: access database occasionally when needed

Database End Users **Actors on the scene (continued)**

- Naïve or Parametric: they make up a large section of the end-user population.
  - ✓ They use previously well-defined functions in the form of "canned transactions" against the database.
  - ✓ Users of Mobile Apps mostly fall in this category
  - ✓ Bank-tellers or reservation clerks are parametric users who do this activity for an entire shift of operations.
  - ✓ Social Media Users post and read information from websites

Database End Users (continued)

- **Sophisticated:**
  - ✓ These include business analysts, scientists, engineers, others thoroughly familiar with the system capabilities.
  - ✓ Many use tools in the form of software packages that work closely with the stored database.

Database End Users (continued)

- Stand-alone:
  - ✓ Mostly maintain personal databases using ready-to-use packaged applications.
  - ✓ An example is the user of a tax program that creates its own internal database.
  - ✓ Another example is a user that maintains a database of personal photos and videos.

Database Users – Actors on the Scene (continued)

- System Analysts and Application Developers
  - ✓ This category currently accounts for a very large proportion of the IT work force.

- System Analysts: They understand the user requirements of naïve and sophisticated users and design applications including canned transactions to meet those requirements.

Database Users – Actors on the Scene (continued)

- System Analysts and Application Developers
- Application Programmers: Implement the specifications developed by analysts and test and debug them before deployment.
- Business Analysts: There is an increasing need for such people who can analyze vast amounts of business data and real-time data ("Big Data") for better decision making related to planning, advertising, marketing etc.

Database Users – Actors behind the Scene

- System Designers and Implementors: Design and implement DBMS packages in the form of modules and interfaces and test and debug them. The DBMS must interface with applications, language compilers, operating system components, etc.

- Tool Developers: Design and implement software systems called tools for modeling and designing databases, performance monitoring, prototyping, test data generation, user interface creation, simulation etc. that facilitate building of applications and allow using database effectively.

Database Users – Actors behind the Scene

- Operators and Maintenance Personnel: They manage the actual running and maintenance of the database system hardware and software environment.

Advantages of Using the Database Approach

- Controlling redundancy in data storage and in development and maintenance efforts.
- Sharing of data among multiple users.
- Restricting unauthorized access to data. Only the DBA staff uses privileged commands and facilities.
- Providing Storage Structures (e.g. indexes) for efficient Query Processing – see Chapter 17.

Advantages of Using the Database Approach (continued)

- Providing optimization of queries for efficient processing.
- Providing backup and recovery services.
- Providing multiple interfaces to different classes of users.
- Representing complex relationships among data.
- Enforcing integrity constraints on the database.
- Drawing inferences and actions from the stored data using deductive and active rules and triggers.

Additional Implications of Using the Database Approach

- Potential for enforcing standards:
  - ✓ This is very crucial for the success of database applications in large organizations.
  - ✓ Standards refer to data item names, display formats, screens, report structures, meta-data (description of data), Web page layouts, etc.
- Reduced application development time:
  - ✓ Incremental time to add each new application is reduced.

Additional Implications of Using the Database Approach (continued)

- **Flexibility** to change data structures:
  - ✓ Database structure may evolve as new requirements are defined.
- **Availability** of current information:
  - ✓ Extremely important for on-line transaction systems such as shopping, airline, hotel, car reservations.
- **Economies** of scale:
  - ✓ **Wasteful** overlap of **resources** and **personnel** can be avoided by consolidating data and applications across departments.

When not to use a DBMS

- Main inhibitors (costs) of using a DBMS:
  - ✓ High initial investment and possible need for additional hardware.
- When a DBMS may be unnecessary:
  - ✓ If the database and applications are simple, well defined, and not expected to change.
  - ✓ If access to data by multiple users is not required.
- When a DBMS may be infeasible:
  - ✓ In embedded systems where a general purpose DBMS may not fit in available storage

When not to use a DBMS

- When no DBMS may suffice:
  - ✓ If there are stringent real-time requirements that may not be met because of DBMS overhead (e.g., telephone switching systems)
  - ✓ If the database system is not able to handle the complexity of data because of modeling limitations (e.g., in complex genome and protein databases)
  - ✓ If the database users need special operations not supported by the DBMS (e.g., GIS and location based services).

THANKS!

ANY QUESTIONS?

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