Chapter 1: Introduction

Database System Concepts, 6th Ed.

Database Management System (DBMS)

- DBMS contains information about a particular enterprise
  - Collection of interrelated data
  - Set of programs to access the data
  - An environment that is both *convenient* and *efficient* to use
- Database Applications:
  - Airlines: reservations, schedules
  - Universities: registration, grades
  - Sales: customers, products, purchases, order tracking
  - Employee records, salaries,
  - …..
- Databases touch all aspects of our lives

University Database Example

- Application program examples
  - Add new students, instructors, and courses
  - Register students for courses, and generate class rosters
  - Assign grades to students, compute grade point averages (GPA) and generate transcripts
  - Clicker data: record attendance and quiz answers
    - **Quiz Q1: Click 1 now!**
- In the early days, database applications were built directly on top of file systems

Purpose of Database Systems

- Drawbacks of using file systems to store data:
  - **Data redundancy and inconsistency**
    - Multiple file formats, duplication of information in different files
  - **Difficulty in accessing data**
    - Need to write a new program to carry out each new task
  - **Data isolation — multiple files and formats**
  - **Integrity problems**
    - Integrity constraints (e.g. "*dept_name* of student must be a valid department name") become "buried" in program code rather than being stated explicitly
    - Hard to add new constraints or change existing ones

Purpose of Database Systems (Cont.)

- Drawbacks of using file systems (cont.)
  - **Atomicity of updates**
    - Failures may leave database in an inconsistent state with partial updates carried out
    - Example: Transfer of funds from one account to another should either complete or not happen at all
  - **Concurrent access by multiple users**
    - Concurrent accessed needed for performance
    - Uncontrolled concurrent accesses can lead to inconsistencies
      - Example: Two people reading a balance (say 100) and updating it by withdrawing money (say 50 each) at the same time
  - **Security problems**
    - Hard to provide user access to some, but not all, data
- Database systems offer solutions to all the above problems

Instances and Schemas

- Similar to types and variables in programming languages
- **Schema** – the logical structure of the database
  - Analogous to type information of a variable in a program
  - Physical schema: database design at the physical level
    - E.g. data storage structures, indices for fast access
  - Logical schema: database design at the logical level
- **Instance** – the actual content of the database at a particular point in time
  - Analogous to the value of a variable
- **Physical Data Independence** – the ability to modify the physical schema without changing the logical schema
  - Applications depend on the logical schema

Data Models

- A collection of tools for describing
  - Data
  - Data relationships
  - Data semantics
  - Data constraints
- Relational model
- Entity-Relationship data model (mainly for database design)
- Object-based data models (Object-oriented and Object-relational)
- Semistructured data model (XML)
- Other older models:
  - Network model
  - Hierarchical model

Relational Model

- Relational model (Chapter 2)
- Example of tabular data in the relational model

Columns

Rows

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

A Sample Relational Database

instructor

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
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15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

department

dept_name	*building*	*budget*
Comp. Sci.	Taylor	100000
Biology	Watson	90000
Elec. Eng.	Taylor	85000
Music	Packard	80000
Finance	Painter	120000
History	Painter	50000
Physics	Watson	70000

Data Manipulation Language (DML)

- Language for accessing and manipulating the data organized by the appropriate data model
  - DML also known as query language
- Two classes of languages
  - **Procedural** – user specifies what data is required and how to get those data
  - **Declarative (nonprocedural)** – user specifies what data is required without specifying how to get those data
- SQL is the most widely used query language

Data Definition Language (DDL)

- Specification notation for defining the database schema

  Example: **create table** *instructor* (
  ID **char**(5),
  name **varchar**(20),
  dept_name **varchar**(20),
  salary **numeric**(8,2))

- DDL compiler generates a set of tables
- Data dictionary contains metadata (i.e., data about data)
  - Database schema
    - Which tables are present, what are their attributes, …
  - Integrity constraints
    - Which attributes are primary keys, foreign keys, …

Database Design

The process of designing the general structure of the database:

- **Logical Design** – Deciding on the database schema. Database design requires that we find a "good" collection of relation schemas.
  - Business decision – What attributes should we record in the database?
  - Computer Science decision – What relation schemas should we have and how should the attributes be distributed among the various relation schemas?
- **Physical Design** – Deciding on the physical layout of the database

Database Design?

- Is there any problem with this design?

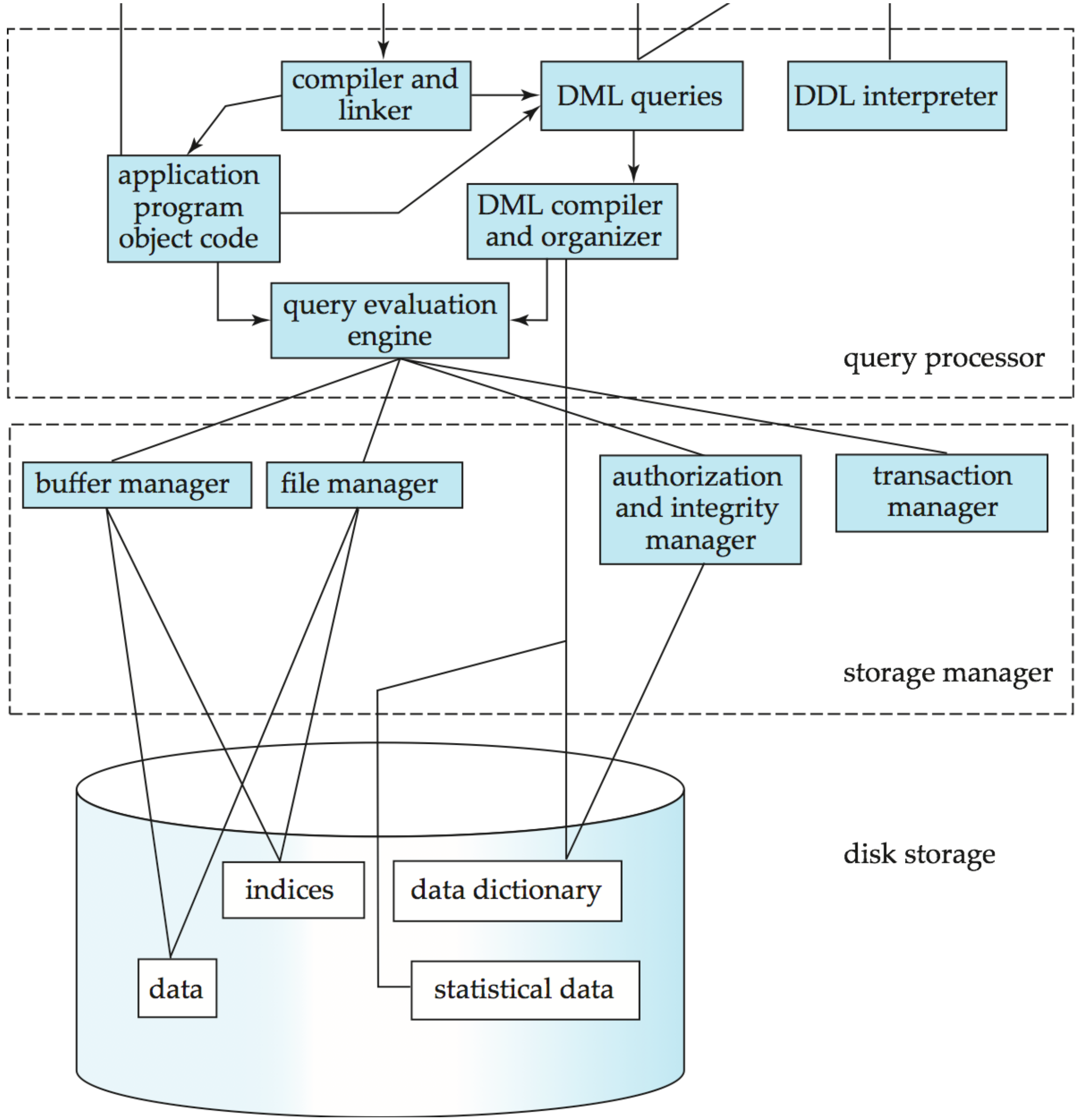
ID	*name*	*salary*	*dept_name*	*building*	*budget*
22222	Einstein	95000	Physics	Watson	70000
12121	Wu	90000	Finance	Painter	120000
32343	El Said	60000	History	Painter	50000
45565	Katz	75000	Comp. Sci.	Taylor	100000
98345	Kim	80000	Elec. Eng.	Taylor	85000
76766	Crick	72000	Biology	Watson	90000
10101	Srinivasan	65000	Comp. Sci.	Taylor	100000
58583	Califieri	62000	History	Painter	50000
83821	Brandt	92000	Comp. Sci	Taylor	100000
15151	Mozart	40000	Music	Packard	80000
33456	Gold	87000	Physics	Watson	70000
76543	Singh	80000	Finance	Painter	120000

Quiz Q2: The problem is: (1) missing information (2) repeated information (3) there is no problem (4) these instructor salaries are too low

Design Approaches

- Normalization Theory (Chapter 8)
  - Formalize what designs are bad, and test for them
- Entity Relationship Model (Chapter 7)
  - Models an enterprise as a collection of *entities* and *relationships*
    - Entity: a "thing" or "object" in the enterprise that is distinguishable from other objects
      - Described by a set of *attributes*
    - Relationship: an association among several entities
  - Represented diagrammatically by an *entity-relationship diagram:*

Database System Internals



Query Processor

Storage Manager

Storage

History of Database Systems

- 1950s and early 1960s:
  - Data processing using magnetic tapes for storage
    - Tapes provide only sequential access
  - Punched cards for input
- Late 1960s and 1970s:
  - Hard disks allow direct access to data
  - Network and hierarchical data models in widespread use
  - Ted Codd defines the relational data model
    - Would win the ACM Turing Award for this work
    - IBM Research begins System R prototype
    - UC Berkeley begins Ingres prototype
  - High-performance (for the era) transaction processing

History (cont.)

- 1980s:
  - Research relational prototypes evolve into commercial systems
    - SQL becomes industrial standard
  - Parallel and distributed database systems
  - Object-oriented database systems
- 1990s:
  - Large decision support and data-mining applications
  - Large multi-terabyte parallel data warehouses
  - Emergence of Web commerce
- Early 2000s:
  - XML and XQuery standards
  - Automated database administration
- Later 2000s: Big Data
  - massively parallel storage systems
    - Google BigTable, Yahoo PNuts, Amazon, ..
  - Parallel data analysis, using MapReduce

End of Chapter 1

Database Users and Administrators