Introduction to Database Systems (1)

SWEN304/ SWEN435

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Engineering and Computer Science

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

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Outline

- Fundamental assumptions
- Databases (DB) and data
- Database management systems (DBMS)
- Database systems (DBS)

- Reading:
  - Chapter 1 of the textbook
  - Lecture slides make use of material provided on the textbook's companion website

Introduction

- Fundamental Assumptions of Data Management:
  - databases provide data for *multiple* application programs
  - data in databases is accessed and manipulated *concurrently*
  - data in databases is *dynamic*, that is, may change over time
  - data in databases is *persistent*
  - the amount of data in databases can be huge

Introduction

- Our Goals:
  - understand the storage and retrieval of persistent data (principles)
  - understand technology for the management of data in databases (foundations, applications)

Some Immediate Consequences

- Integration of data from various sources:
  - completeness and redundancy freeness
  - utilization of secondary storage

- Data integrity:
  - never violate (static and dynamic) integrity constraints
  - constraints determined by the semantics of the data (and application programs)

Some Immediate Consequences

- Data security / safety:
  - protection against loss of data
  - protection against misuse of data

- Concurrent access to data:
  - synchronization
  - concurrent execution of application programs
  - utilize transactions (serializability)

Basic Terminology

- a database (DB) is a collection of related data that is well structured and stored permanently

- a database management system (DBMS) is a general-purpose software system that facilitates the process of *defining*, *constructing*, *manipulating*, and *sharing* databases among various users and applications.

- a database system (DBS) comprises a DBMS plus one or more databases

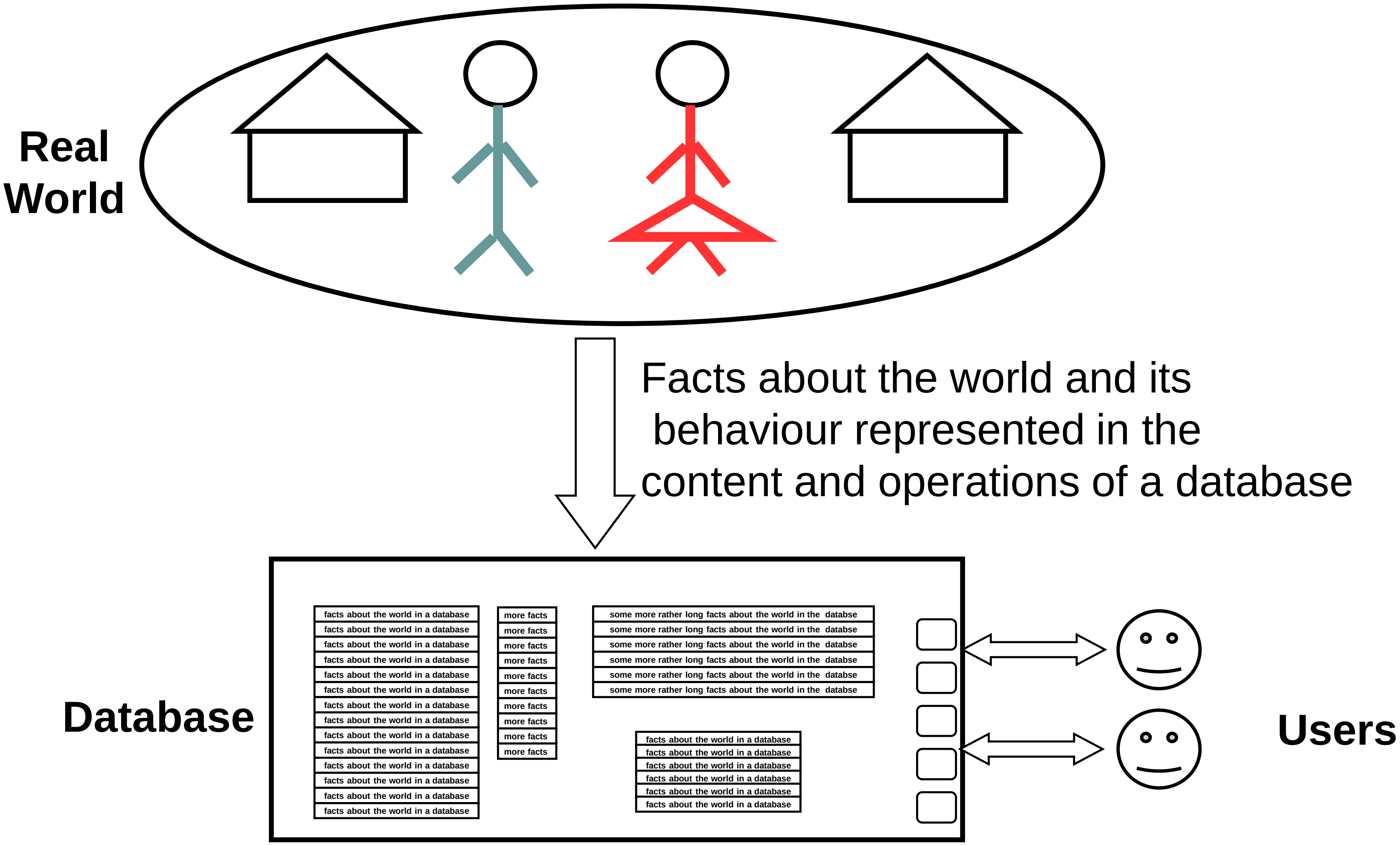
Basic Terminology

- Meta-data
  - Database definition or descriptive information
  - Stored by the DBMS in the form of a database catalog or dictionary
- Manipulating a database
  - Query and update the database of a miniworld
  - Generate reports

Databases

- Essential database characteristics are:
  - Represents an aspect of the real world, called miniworld or the universe of discourse (UoD),
  - Reflects (or should reflect) current state of the UoD,
  - We shall suppose it is well structured (even has a strict regular structure),
  - Has users and applications, and
  - Stored in a permanent (persistent) computer memory,
  - Managed by a Database Management System (DBMS)
- All these characteristics have to be met

What is a Database?


Real World
Database
Users
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Facts about the world and its behaviour represented in the content and operations of a database

Example Commercial Database

- Amazon.com
  - 20 million books, CDs, videos, DVDs, electronices, apparel and other items
  - Occupies over 42 terabytes (1 terabytes = 1024GB)
  - Stored on 200 different computers
  - 15 million visitors access Amazon.com each day
  - the database is continually updated as new books/items are added to the inventory and purchases are transacted
  - 100 people are responsible for keeping the database up-to-date

A Simple Sample Database

- University database: information concerning students, courses, and grades in a university environment

STUDENT

id	lname	fname	major
300111	Smith	Susan	COMP
300121	Bond	James	MATH
300132	Smith	Susan	COMP

COURSE

course_id	cname	points	dept
SWEN304	DB sys	15	Engineering
COMP301	softEng	20	Engineering
MATH214	DisMat	15	Math

GRADE

id	course_id	grade
300111	SWEN304	A+
300111	COMP301	A
300111	MATH314	A
300121	COMP301	B
300132	COMP301	C
300121	SWEN304	B+
300132	SWEN304	C+

Questions for You

1. Is a book (like "Fundamentals of Database Systems") a database?
2. Is an old style library card catalog a database?
3. Is a bank statement a database?
4. Is a spreadsheet, containing contact information, a database?

Definition of Data (Datum)

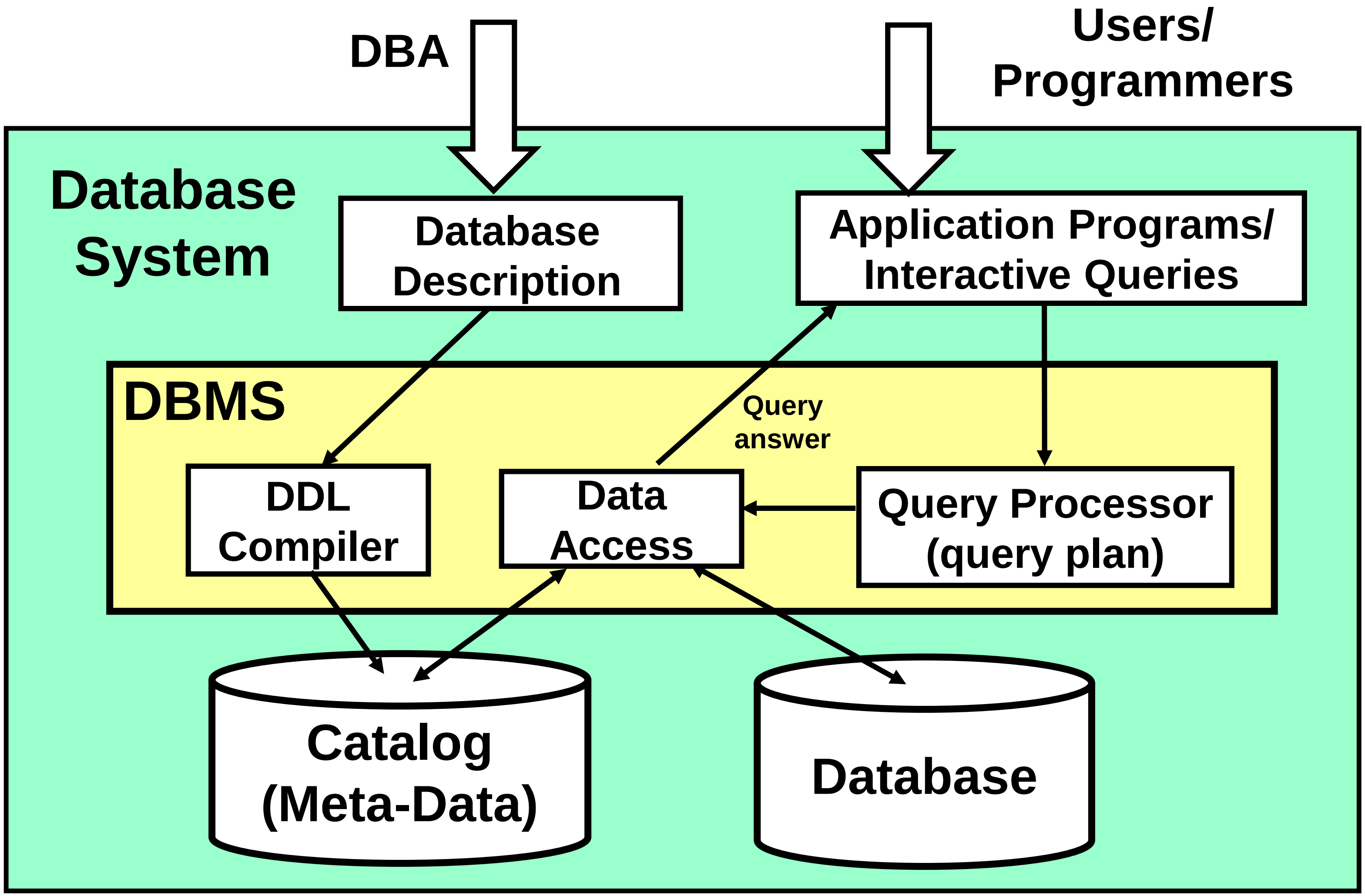
- **Data** is a value of
  - a *property* of an individual UoD object or
  - a *relationship* (between two UoD objects)

  at a particular period of time

- Example

UoD object(s)	James	James & CompSci
Property	Age	Number of Points
Time	July 2008	July 2008
Value	21	240

A Simplified Database System Layout



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
- **Processing** and **Sharing** by a set of concurrent users and application programs
  - keeping all data valid and consistent

Typical DBMS Functionality

- Protection or Security measures to prevent unauthorized access

- Maintaining the database and associated programs over the life time of the database application

- Presentation and Visualization of data

Data Definition Example

Defining a table in SQL:

```
CREATE TABLE COURSE (
        course_id   CHR(4)    CONSTRAINT cspk PRIMARY KEY,
        cname       CHR(15)   NOT NULL,
        points      INT       NOT NULL CHECK (Points >= 0),
        dept        CHR(25)
    );
```

Query and Update Examples

- Retrieve a list of all surnames, course names and grades of 'James'

```
SELECT     lname AS SURNAME, cname, grade
 FROM      STUDENT s, GRADE g, COURSE p
 WHERE     FName = 'James'
 AND       s.id = g.id
 AND       p.course_id = g.course_id;
```

- Insert two records into STUDENT

```
INSERT INTO STUDENT (fname, lname, id)
 VALUES    ('Ann', 'Bole', 111111),
           ('Sharon', 'King' 121212);
```

Essential Roles in Data Management

- The database administrator (DBA) ‘owns’ the DBMS and is responsible for
  - authorizing access to the database
  - the maintenance of the physical schema
  - the decision on the physical storage structures and access methods
  - physical optimization and tuning

- The data engineer (or data administrator or database designer) ‘owns’ the database and is responsible for
  - the design of conceptual/logical and external schemata
  - specification of interfaces to application programs (queries, transactions)
  - liaison with current or potential users

Advantages of Using the Database Approach

- Controlling redundancy in data storage and in development and maintenance efforts
  - Data normalization
  - Denomalization: sometimes it is necessary to use **controlled** redundancy to improve the performance of queries
- Sharing of data among multiple users
- Restricting unauthorized access to data

Advantages of Using the Database Approach

- Providing persistent storage for program Objects (in Object-oriented DBMS’s)
  - Complex object in C++ can be stored permanently in an object-oriented DBMS
  - Impedance mismatch problem: object-oriented database system typically offer data structure compatibility
- Providing storage structures for efficient query processing
  - Index
  - Buffering and catch
  - Query processing and optimisation

Advantages of Using the Database Approach

- Providing backup and recovery services
- Providing multiple interfaces to different classes of users
- Representing complex relationships among data
- Enforcing integrity constraints on the database
  - Referential integrity constraint
  - Key or uniqueness constraint
- Drawing inferences and actions using rules
  - E.g. triggers and stored procedures

Summary

- A database is a collection of related data that is well structured and stored permanently
- A data (datum) is a value of an real object’s (or of a relationship between two objects) property in a perceived moment of time
- A DBMS is a set of programs that allows a comfortable database usage:
  - Defining
  - Populating by data,
  - Querying,
  - Preserving consistency,
  - Protecting from misuse,
  - Recovering from failure, and
  - Concurrent using

Plan for the next lecture

- Data models
- Schemas and instances
- The three schema architecture
- Data independence
- Database users and languages

- *Reading:*
    - *chapter 2 of the textbook*