Introduction to Database Systems (1)

SWEN 304

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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.

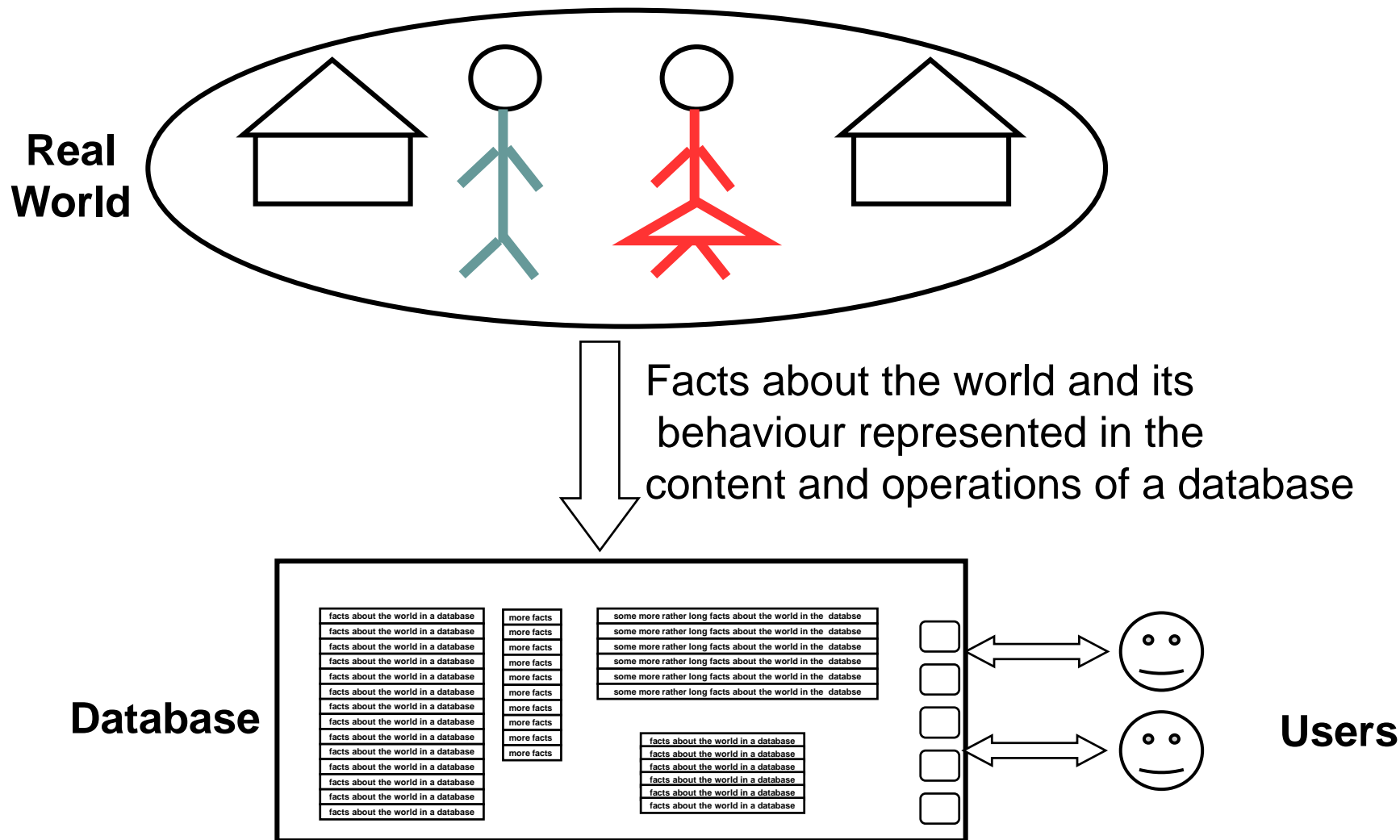- a database system (DBS) comprises a DBMS plus one or more databases

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

Facts about the world and its behaviour represented in the content and operations of a database

Database

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Users

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?
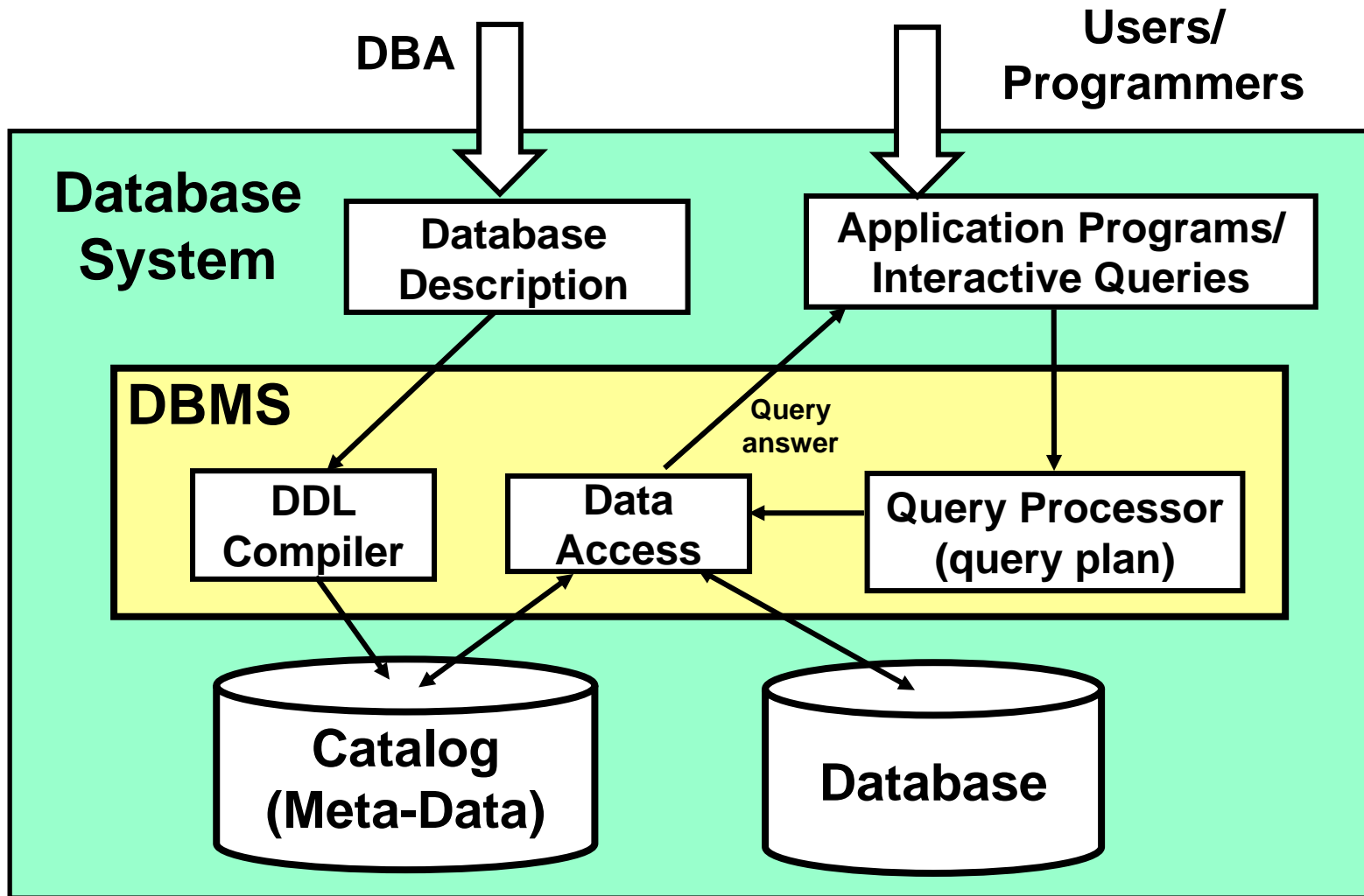
Definition of Data (Datum)

- **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 lifetime 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*