Chapter 1: Introduction

Database System Concepts, 7th Ed.

Outline

- Database-System Applications
- Purpose of Database Systems
- View of Data
- Database Languages
- Database Design
- Database Engine
- Database Architecture
- Database Users and Administrators
- History of Database Systems

Database Systems

- DBMS contains information about a particular enterprise
  - Collection of interrelated data
  - Set of programs to access the data 저장.
  - An environment that is both *convenient* and *efficient* to use
- Database systems are used to manage collections of data that are:
  - Highly valuable
  - Relatively large
  - Accessed by multiple users and applications, often at the same time.
- A modern database system is a complex software system whose task is to manage a large, complex collection of data.
- Databases touch all aspects of our lives

Database Applications Examples

- Enterprise Information
  - Sales: customers, products, purchases
  - Accounting: payments, receipts, assets
  - Human Resources: Information about employees, salaries, payroll taxes.
- Manufacturing: management of production, inventory, orders, supply chain.
- Banking and finance
  - customer information, accounts, loans, and banking transactions.
  - Credit card transactions
  - Finance: sales and purchases of financial instruments (e.g., stocks and bonds; storing real-time market data
- Universities: registration, grades

Database Applications Examples (Cont.)

- Airlines: reservations, schedules
- Telecommunication: records of calls, texts, and data usage, generating monthly bills, maintaining balances on prepaid calling cards
- Web-based services
  - Online retailers: order tracking, customized recommendations
  - Online advertisements
- Document databases
- Navigation systems: For maintaining the locations of varies places of interest along with the exact routes of roads, train systems, buses, etc.

Purpose of Database Systems

In the early days, database applications were built directly on top of file systems, which leads to:

- Data redundancy and inconsistency: data is stored in multiple file formats resulting induplication of information in different files
  重複
  重複
  data의 일관성↓
- Difficulty in accessing data 지우기 쉽지 않음.
  - Need to write a new program to carry out each new task
- Data isolation
  - Multiple files and formats
- Integrity problems
  - Integrity constraints (e.g., account balance > 0) become "buried" in program code rather than being stated explicitly
    accident damage to database.
  - Hard to add new constraints or change existing ones

induplication of information
⇒ data의 일반성 떨어짐.

Purpose of Database Systems (Cont.)

中途半端におわらない性質 update が途中でおわったら大変!!

- Atomicity of updates → 끝나든지 안끝나든지.
  - Failures may leave database in an inconsistent state with partial updates carried out ex. Internet shopping 결제가 두번 되면 안돼...
  - Example: Transfer of funds from one account to another should either complete or not happen at all
- Concurrent access by multiple users 同時にお金とっても。
  - Concurrent access needed for performance ちゃんと処理されないといけない。
  - Uncontrolled concurrent accesses can lead to inconsistencies
    - Ex: 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

같은 데이터라도 볼수 있는 범위가 다르다.

Database systems offer solutions to all the above problems

University Database Example

- In this text we will be using a university database to illustrate all the concepts
- Data consists of information about:
  - Students
  - Instructors
  - Classes
- 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

구조

Data Models

Underling $\boxed{\text{the structure}}$ of a database is the data model

- 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)
- Semi-structured data model (XML)
- Other older models:
  - Network model
  - Hierarchical model

1970년대.

conceptual → 설계 ?

mapping ?

data ↔ date

capture

Relational Model

- All the data is stored in various tables.
- Example of tabular data in the relational model

4개의 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

Ted Codd
Turing Award 1981

A Sample Relational Database

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
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(a) The *instructor* table

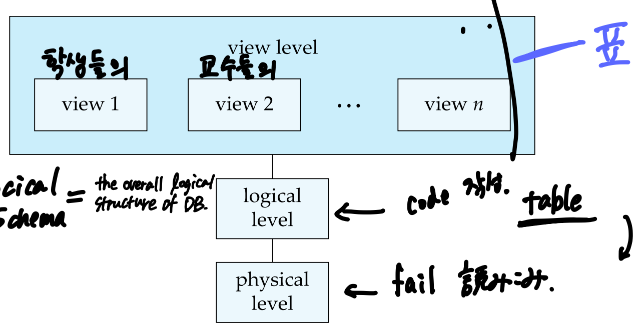
dept_name	*building*	*budget*
Comp. Sci.	Taylor	100000
Biology	Watson	90000
Elec. Eng.	Taylor	85000
Music	Packard	80000
Finance	Painter	120000
History	Painter	50000
Physics	Watson	70000

(b) The *department* table

View of Data

An architecture for a database system

table 형태!



logical schema = the overall logical structure of DB.

code 개념. table

コンピューター 인식 못함.

fail 読みこみ.

Instances and Schemas

- Similar to types and variables in programming languages
- **Logical Schema** – the overall logical structure of the database
  - Example: The database consists of information about a set of customers and accounts in a bank and the relationship between them
    - Analogous to type information of a variable in a program
- **Physical schema** – the overall physical structure of the database
- **Instance** – the actual content of the database at a particular point in time
  - Analogous to the value of a variable

類似.

Physical Data Independence

저장구조를 바꿔도 파일(logical) 안 바꿔도 됨.

- **Physical Data Independence** – the ability to modify the physical schema without changing the logical schema
  - Applications depend on the logical schema
  - In general, the interfaces between the various levels and components should be well defined so that changes in some parts do not seriously influence others.

Physical Data は 独立してるので

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 table templates stored in a ***data dictionary***
- Data dictionary contains metadata (i.e., data about data)
  - Database schema
  - Integrity constraints
    - Primary key (ID uniquely identifies instructors)
  - Authorization
    - Who can access what

Data Manipulation Language (DML)

- Language for accessing and updating the data organized by the appropriate data model
  - DML also known as query language
- There are basically two types of data-manipulation language
  - **Procedural DML** -- require a user to specify what data are needed and how to get those data.
  - **Declarative DML** -- require a user to specify what data are needed without specifying how to get those data. [illegible] 条件にあった.
- Declarative DMLs are usually easier to learn and use than are procedural DMLs.
- Declarative DMLs are also referred to as non-procedural DMLs
- The portion of a DML that involves information retrieval is called a **query** language.

query：データベースの検索で、指定された条件を満たす情報を取り出すために行われる処理の要求.

SQL Query Language

- SQL query language is nonprocedural. A query takes as input several tables (possibly only one) and always returns a single table.
- Example to find all instructors in Comp. Sci. dept

  select *name*
  from *instructor* ← table
  where *dept_name* = 'Comp. Sci.'

tableがinput
tableの中から何が必要か
&
tableとして出る.

- SQL is **NOT** a Turing machine equivalent language
- To be able to compute complex functions SQL is usually embedded in some higher-level language

組み込み型の

- Application programs generally access databases through one of
  - Language extensions to allow embedded SQL
  - Application program interface (e.g., ODBC/JDBC) which allow SQL queries to be sent to a database

Database Access from Application Program

- Non-procedural query languages such as SQL are not as powerful as a universal Turing machine.
- SQL does not support actions such as input from users, output to displays, or communication over the network.
- Such computations and actions must be written in a **host language**, such as C/C++, Java or Python, with embedded SQL queries that access the database.
- **Application programs** -- are programs that are used to interact with the database in this fashion.

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.
  table 설계
  - Business decision – What attributes should we record in the database? 어떤 정보가 필요?. 市場調査
  - 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

어떤 파일을 保存할지?.

Database Engine

- A database system is partitioned into modules that deal with each of the responsibilities of the overall system.
- The functional components of a database system can be divided into
  - The storage manager,
  - The query processor component,
  - The transaction management component.

Storage Manager

- A program module that provides the interface between the low-level data stored in the database and the application programs and queries submitted to the system.
- The storage manager is responsible to the following tasks:
  - Interaction with the OS file manager
  - Efficient storing, retrieving and updating of data

사용자한테 줄까 말까

- The storage manager components include:
  - Authorization and integrity manager
  - Transaction manager
  - File manager
  - Buffer manager

Storage Manager (Cont.)

実行する.

- The storage manager implements several data structures as part of the physical system implementation:
  - Data files -- store the database itself
  - Data dictionary -- stores metadata about the structure of the database, in particular the schema of the database.
  - Indices -- can provide fast access to data items. A database index provides pointers to those data items that hold a particular value.

indexをファイルにつけると → 検索が、早い.

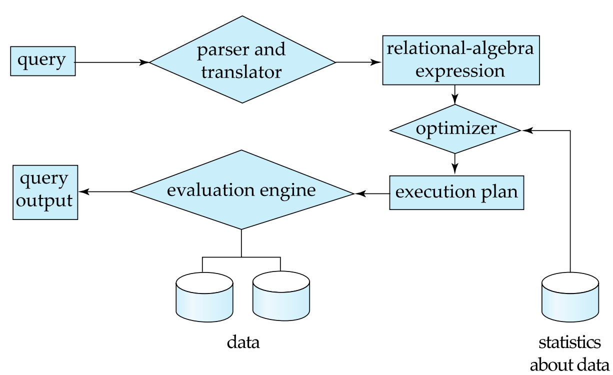
コンピューターで高水準プログラム言語で記述されたソース・プログラムを直接解釈して実行するためのプログラム。

Query Processor

- The query processor components include:
  - DDL interpreter -- interprets DDL statements and records the definitions in the data dictionary.
  - DML compiler -- translates DML statements in a query language into an evaluation plan consisting of low-level instructions that the query evaluation engine understands.
    - The DML compiler performs query optimization; that is, it picks the lowest cost evaluation plan from among the various alternatives.
  - Query evaluation engine -- executes low-level instructions generated by the DML compiler.

Query Processing

1. Parsing and translation
2. Optimization
3. Evaluation



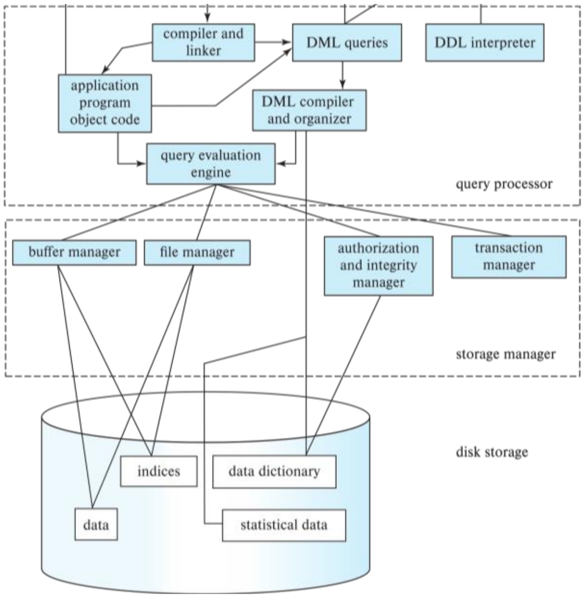
Transaction Management

- A **transaction** is a collection of operations that performs a single logical function in a database application
- **Transaction-management component** ensures that the database remains in a consistent (correct) state despite system failures (e.g., power failures and operating system crashes) and transaction failures.
- **Concurrency-control manager** controls the interaction among the concurrent transactions, to ensure the consistency of the database.

Database Architecture

- Centralized databases
  - One to a few cores, shared memory
- Client-server,
  - One server machine executes work on behalf of multiple client machines.
- Parallel databases
  - Many core shared memory
  - Shared disk
  - Shared nothing
- Distributed databases
  - Geographical distribution
  - Schema/data heterogeneity

Database Architecture (Centralized/Shared-Memory)

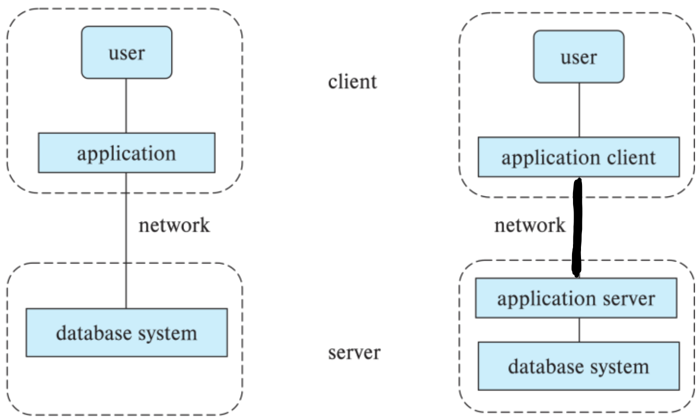


Database Applications

Database applications are usually partitioned into two or three parts

- Two-tier architecture -- the application resides at the client machine, where it invokes database system functionality at the server machine
- Three-tier architecture -- the client machine acts as a front end and does not contain any direct database calls.
  - The client end communicates with an application server, usually through a forms interface.
  - The application server in turn communicates with a database system to access data.

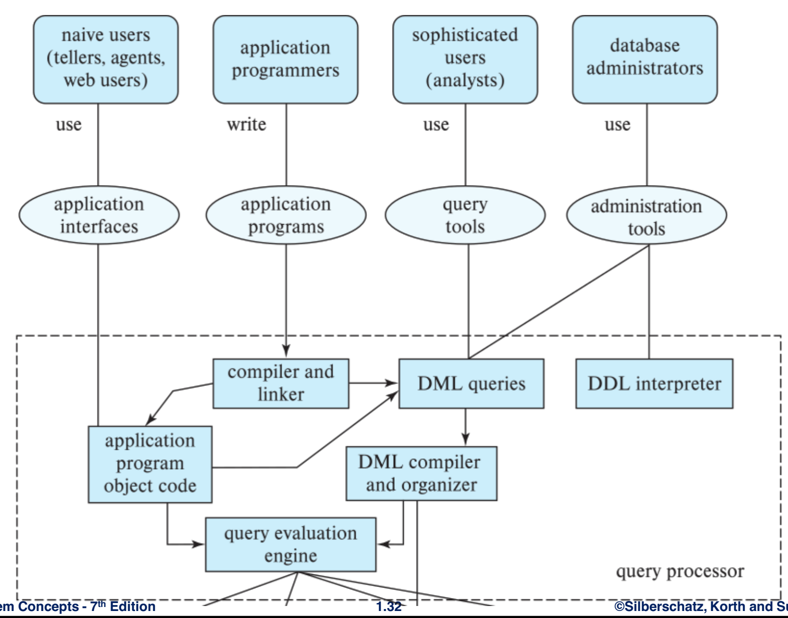
Two-tier and three-tier architectures



(a) Two-tier architecture (b) Three-tier architecture

超好 security good!

Database Users



Database Administrator

A person who has central control over the system is called a **database administrator (DBA).** Functions of a DBA include:

- Schema definition
- Storage structure and access-method definition
- Schema and physical-organization modification
- Granting of authorization for data access
- Routine maintenance
- Periodically backing up the database
- Ensuring that enough free disk space is available for normal operations, and upgrading disk space as required
- Monitoring jobs running on the database

History of Database Systems

- 1950s and early 1960s:
  - Data processing using magnetic tapes for storage
    - Tapes provided only sequential access
  - Punched cards for input
- Late 1960s and 1970s:
  - Hard disks allowed 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 (Michael Stonebraker) begins Ingres prototype
    - Oracle releases first commercial relational database
  - High-performance (for the era) transaction processing

필요한 사람 책

History of Database Systems (Cont.)

- 1980s:
  - Research relational prototypes evolve into commercial systems
    - SQL becomes industrial standard
  - Parallel and distributed database systems
    - Wisconsin, IBM, Teradata
  - Object-oriented database systems
- 1990s:
  - Large decision support and data-mining applications
  - Large multi-terabyte data warehouses
  - Emergence of Web commerce

History of Database Systems (Cont.)

- 2000s
  - Big data storage systems
    - Google BigTable, Yahoo PNuts, Amazon,
    - “NoSQL” systems.
  - Big data analysis: beyond SQL
    - Map reduce and friends
- 2010s
  - SQL reloaded
    - SQL front end to Map Reduce systems
    - Massively parallel database systems
    - Multi-core main-memory databases

End of Chapter 1

<1.6 Purpose of Database Systems>

DB app. were built directly on top of file systems.

- Data redundancy and inconsistency:
  data is stored in multiple file formats resulting induplication of information in different files.

- Difficulty in accessing data

- Data isolation
  multiple files and formats.

- Integrity problems

(Cont.) Purpose of DB.

- Atomicity of updates.

- Concurrent access by multiple users.

- Security Problems.

View of Data

An architecture for a DB.

View Level

ex. 학생들의 view1. 교수들의 view2....

logical Level .... code를 작성

physical level ... Fail 읽어오기

<Instances and Schemas>

<Physical Data Independence>.

-

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<Storage Manager>

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