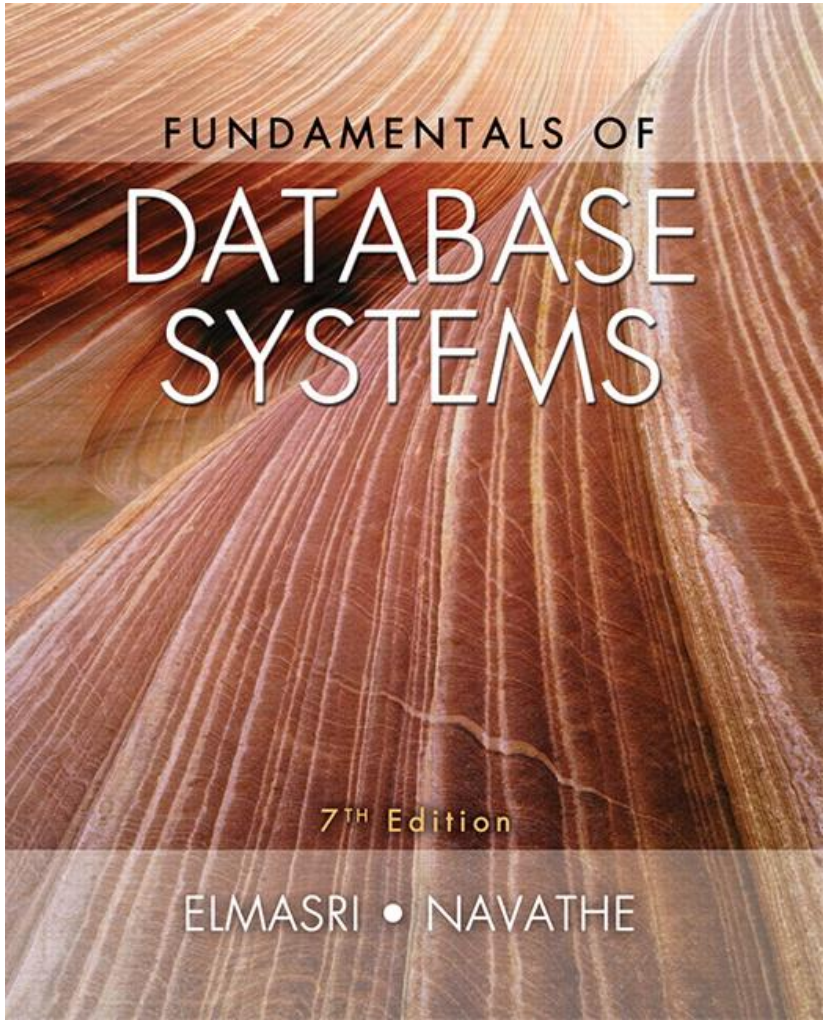


CHAPTER 1

Databases and Database Users

OUTLINE

- Types of Databases and Database Applications
- Basic Definitions
- Typical DBMS Functionality
- Example of a Database (UNIVERSITY)
- Main Characteristics of the Database Approach
- Types of Database Users
- Advantages of Using the Database Approach
- Historical Development of Database Technology
- Extending Database Capabilities
- When Not to Use Databases

What is data, database, DBMS

- Data: Known facts that can be recorded and have an implicit meaning; raw
- Database: a highly organized, interrelated, and structured set of data about a particular enterprise
  - Controlled by a database management system (DBMS)
- DBMS
  - Set of programs to access the data
  - 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

Types of Databases and Database Applications

- Traditional applications:
  - Numeric and textual databases
- More recent applications:
  - Multimedia databases
  - Geographic Information Systems (GIS)
  - Biological and genome databases
  - Data warehouses
  - Mobile databases
  - Real-time and active databases
- First part of book focuses on traditional applications
- *A number of recent applications are described later in the book (for example, Chapters 24,25,26,27,28,29)*

Recent Developments (1)

- Social Networks started capturing a lot of information about people and about communications among people-posts, tweets, photos, videos in systems such as:
  - Facebook
  - Twitter
  - Linked-In
- All of the above constitutes data
- Search Engines, Google, Bing, Yahoo: collect their own repository of web pages for searching purposes

Recent Developments (2)

- New technologies are emerging from the so-called non-SQL, non-database software vendors to manage vast amounts of data generated on the web:
  - **Big data** storage systems involving large clusters of distributed computers (Chapter 25)
  - **NOSQL** (Non-SQL, Not Only SQL) systems (Chapter 24)
- A large amount of data now resides on the "cloud" which means it is in huge data centers using thousands of machines.

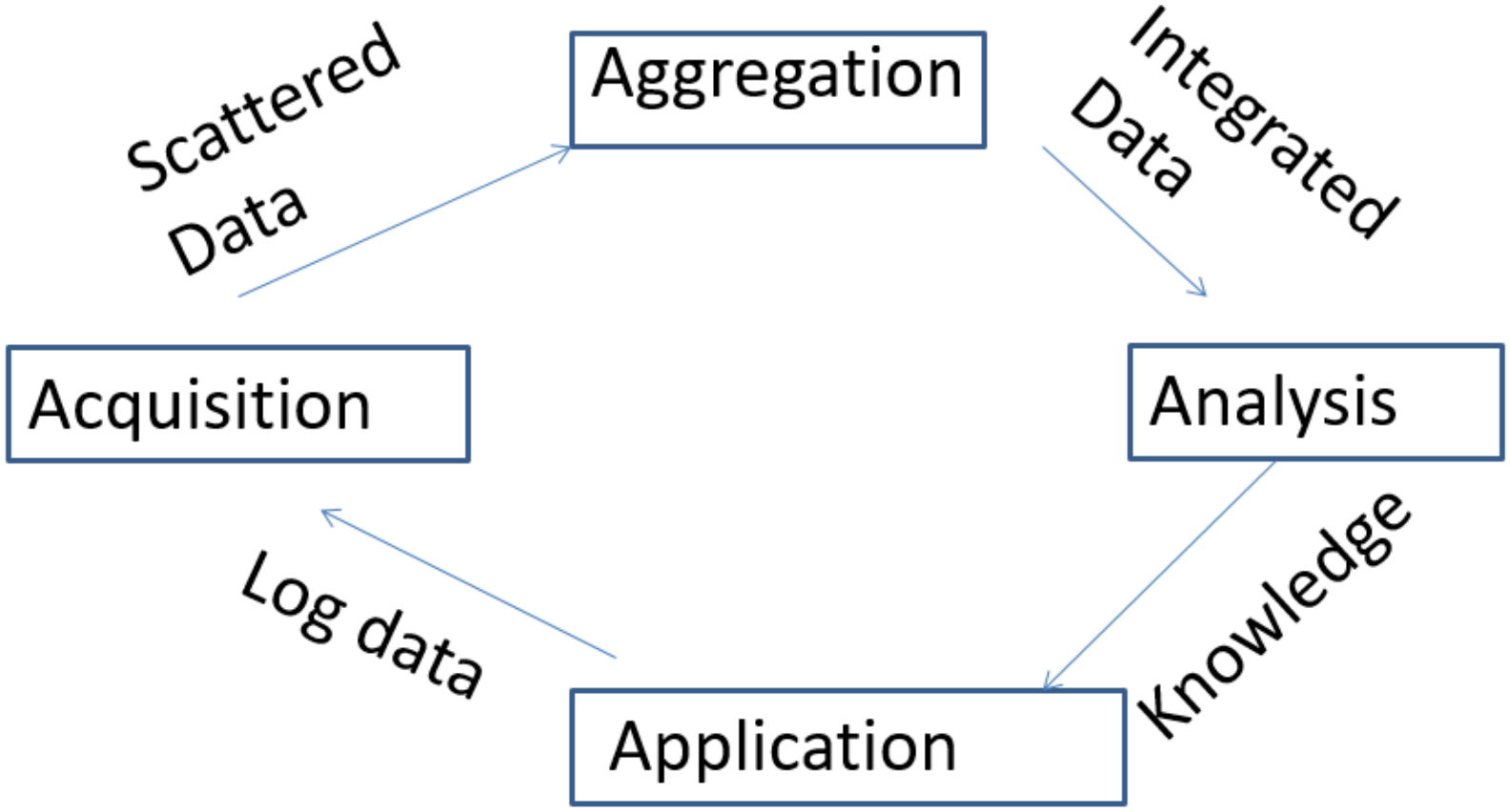
What is “big data”?

- "Big data are high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization” (Gartner 2012)
  - Three Vs? Other Vs?
    - Veracity: refers to the trustworthiness of the data
    - Value: will data lead to the discovery of a critical causal effect?
- Bottom line: Any data that exceeds our current capability of processing can be regarded as “big”
  - Complicated (intelligent) analysis of data may make a small data “appear” to be “big”

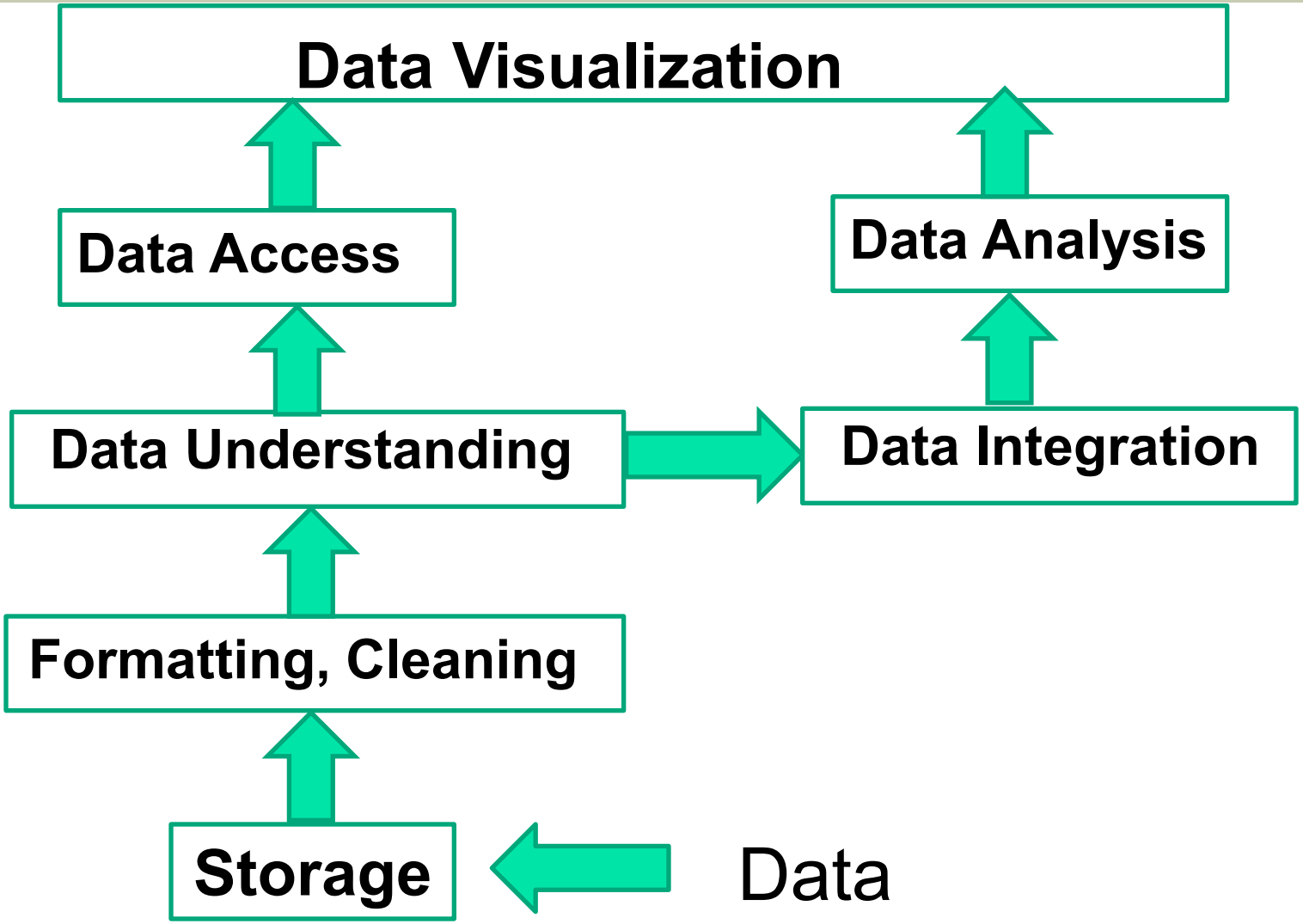
Why is “big data” a “big deal”?

- Government
- Private Sector
  - Walmart handles more than 1 million customer transactions every hour, which is imported into databases estimated to contain more than 2.5 petabytes of data
  - Facebook handles 40 billion photos from its user base
  - Falcon Credit Card Fraud Detection System protects 2.1 billion active accounts world-wide
- Science
  - Large Synoptic Survey Telescope will generate 140 Terabyte of data every 5 days
  - Biomedical computation like decoding human Genome and personalized medicine

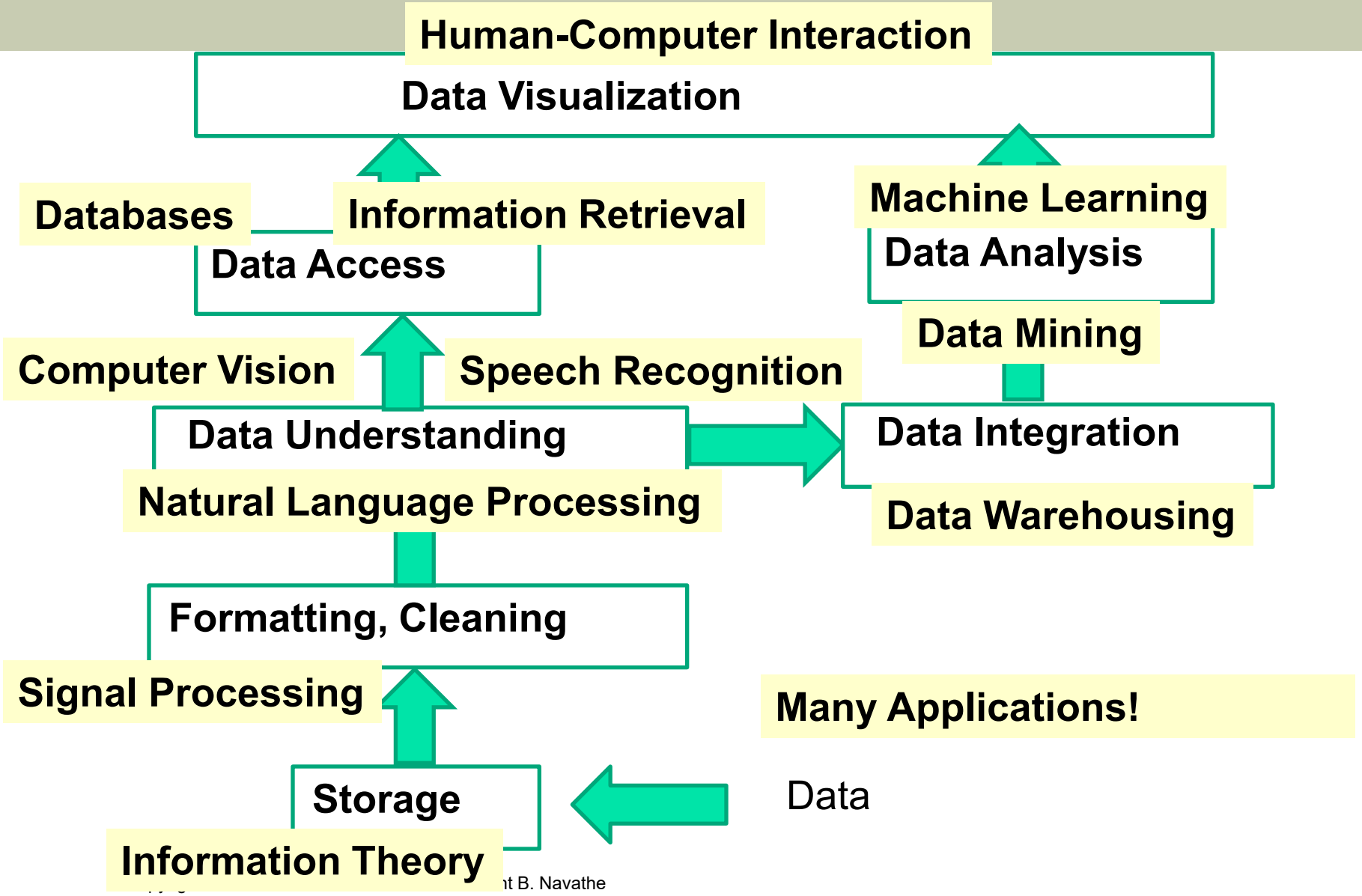
Lifecycle of Data: 4 "A"s



Computational View of Big Data



Big Data & Related Disciplines



Basic Definitions

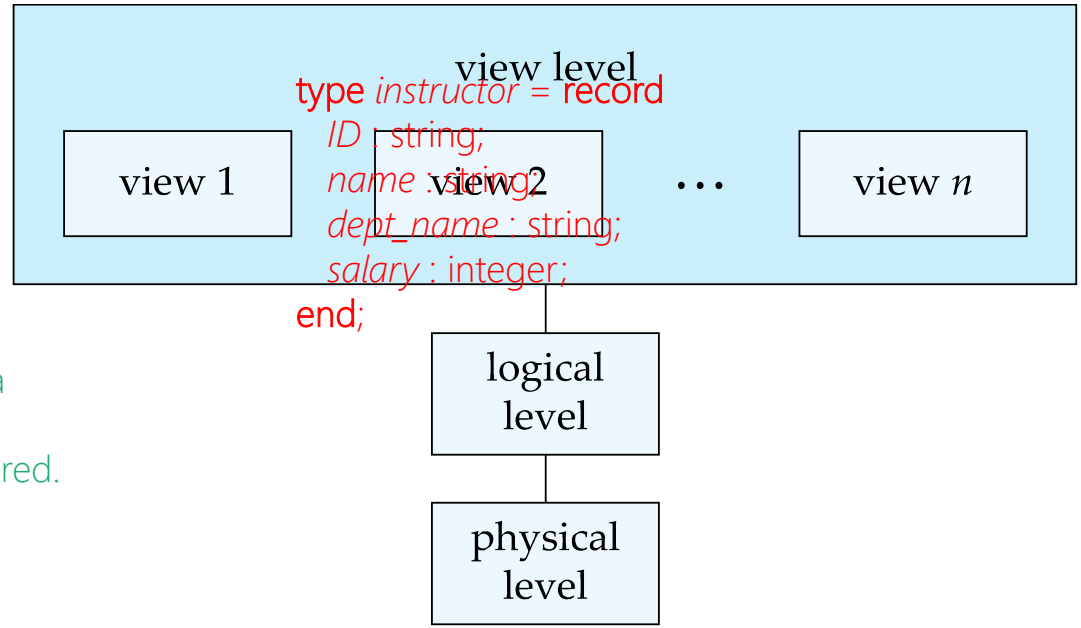
- Database:
  - A collection of related data.
- Data:
  - Known facts that can be recorded and have an implicit meaning.
- Mini-world:
  - Some part of the real world about which data is stored in a database. For example, student grades and transcripts at a university.
- Database Management System (DBMS):
  - A software package/system to facilitate the creation and maintenance of a computerized database.
- Database system:
  - The DBMS software together with the data itself. Sometimes, the applications are also included.

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

A simplified architecture for a database system

View level: what application programs see; views can also hide information (such as an instructor's salary) for security purposes.



Physical level: describes how a record (e.g., instructor) is stored.

A simplified architecture for a database system

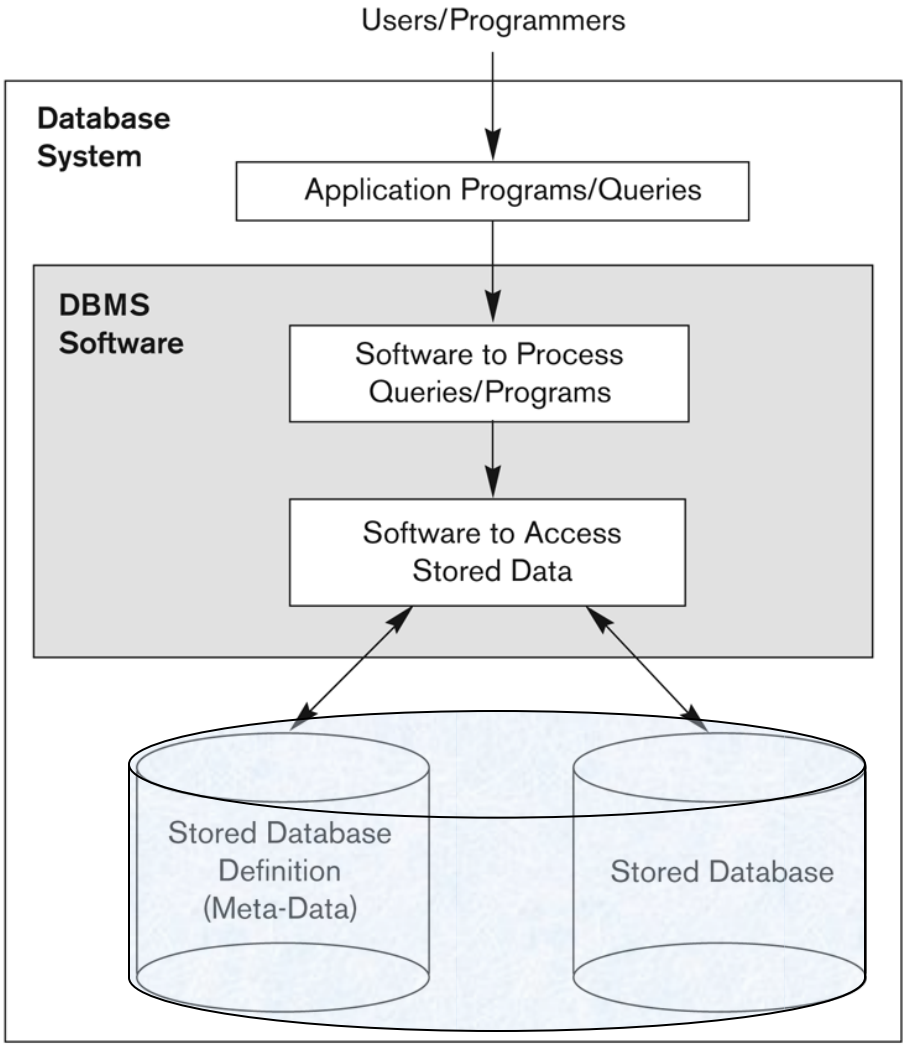
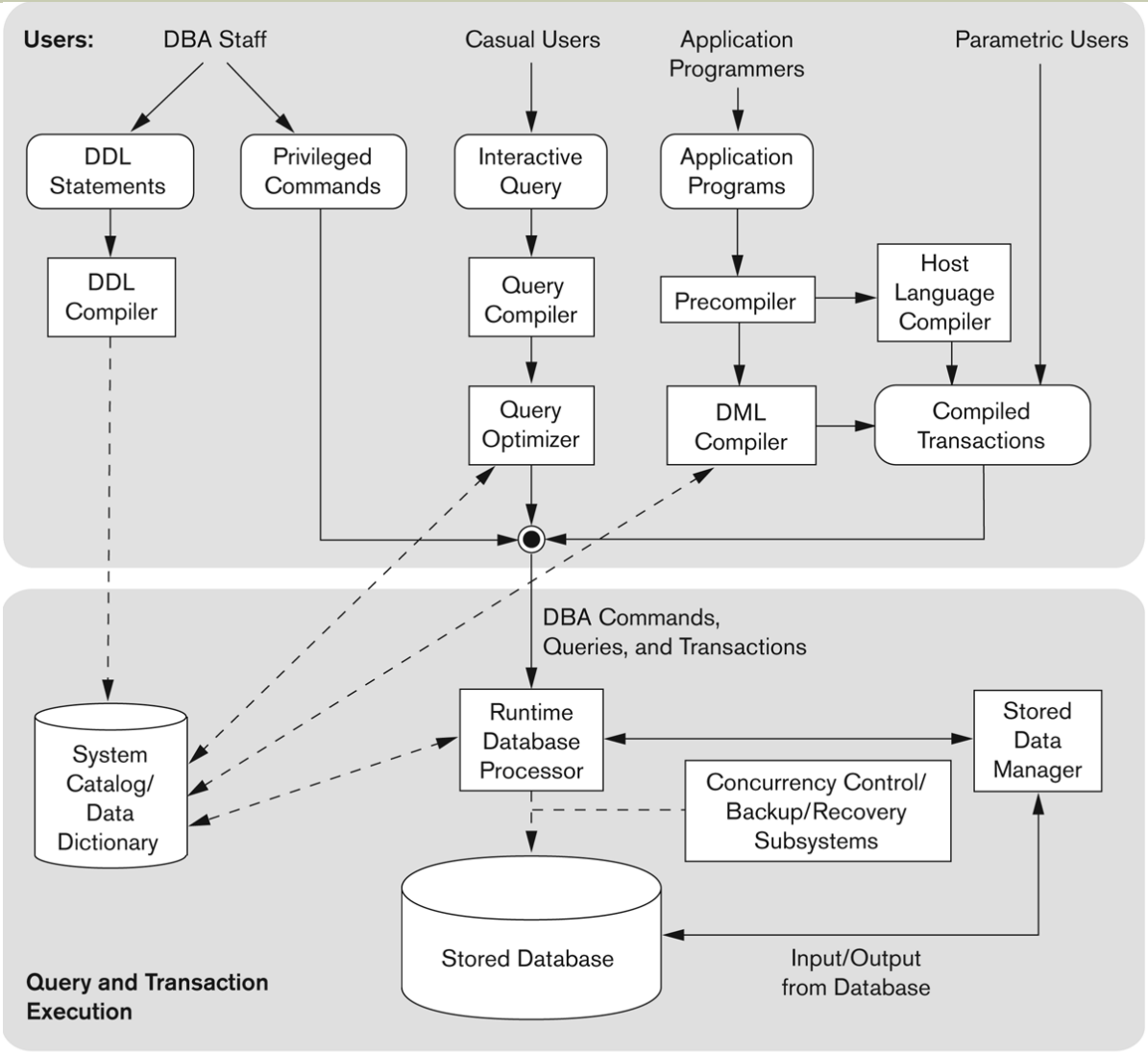
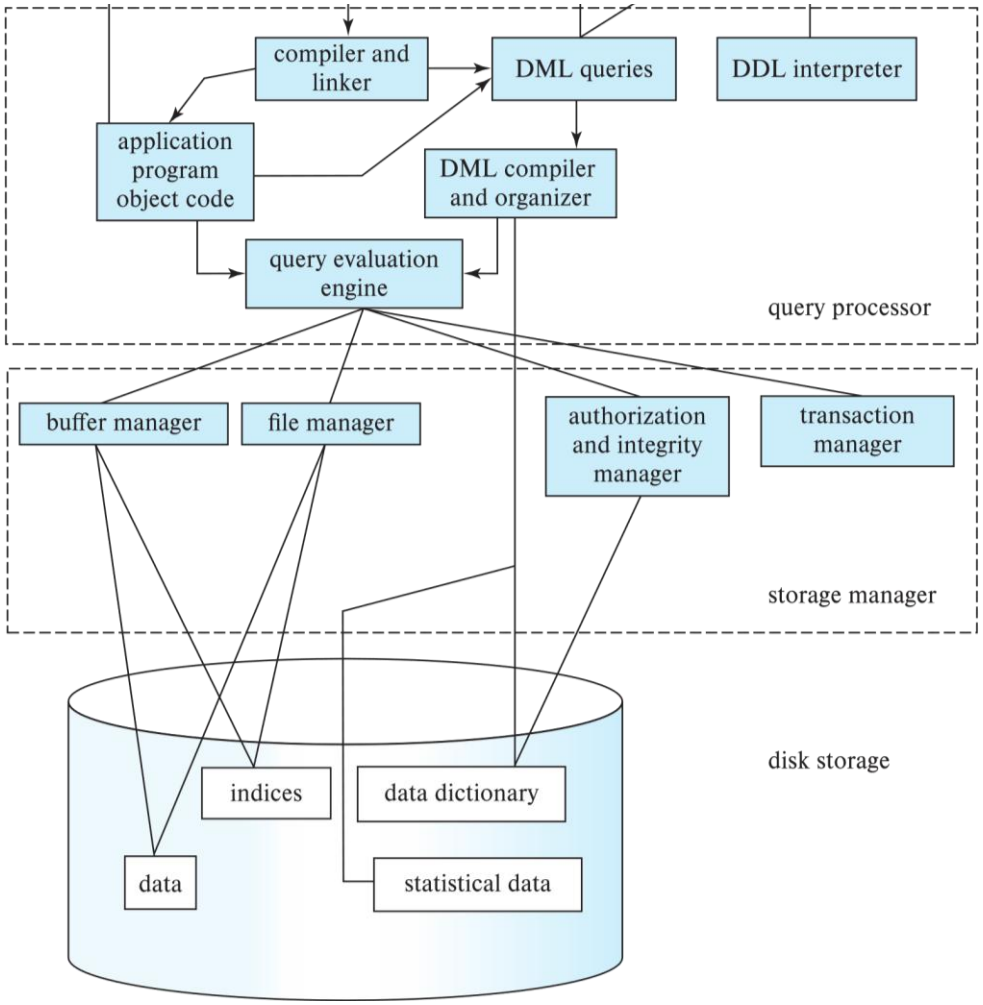


Figure 1.1
A simplified database system environment.

A simplified architecture for a database system



A simplified architecture for a database system



What a DBMS Facilitates

- *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

Other DBMS Functionalities

- 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

Application Programs and DBMS

- 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

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 (ER) data or UML class 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

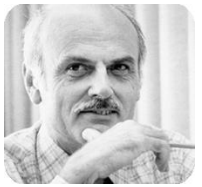
Figure 1.2
A database that stores student and course information.

The relational model

Columns

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

Rows



E.F. "Ted" Codd

Chapter Summary

- Types of databases and database applications
- Basic definitions
- Typical DBMS functionality
- Example of a database (UNIVERSITY)
- Main characteristics of the database Approach
- Types of database users
- Advantages of using the database approach
- Historical development of database technology
- Extending database capabilities
- When not to use databases