COMP9311 DATABASE SYSTEMS

- Xuemin Lin
- School of Computer Science and Engineering
- Office: K17-503
- E-mail: lxue@cse.unsw.edu.au
- Ext: 6493
- http://www.cse.unsw.edu.au/~lxue

- **www home address of 9311:**
- http://www.cse.unsw.edu.au/~cs9311

Course Information

Lectures:

18:00 - 20:00 (Tue)	week 1 – 10
15:00 - 17:00 (Fri)	week 1 – 8

- Location: Physics Theatre (K-K14-19)

9 weeks lectures in total.

Lab: week 3 – 10

Consultation: 16:00 – 17:00 (Tue)

- Location : K17-201B

Q&A Forum: https://groups.google.com/group/comp9311-19s1

Course Email: comp9311unsw@gmail.com

For normal questions, we recommend you to use the Q&A forums. You are also welcome to contact us via course email if something is urgent.

Course Information(cont)

3 assignments, 1 project, final exam

Assignments (60%):

- Ass 1: Data Modelling + Relational Algebra (20%) (week 2-4)
- Ass 2: DB Design Theory (20%) (week 5-7)
- Ass 3: Database Storage Structures + Transaction (20%) (week 8-10)

Penalty for later submissions: No late submission will be accepted. 0 mark will be given to any later submission.

Projects (40%)

- Proj 1: 40% (week 5-8)

Penalty for later submissions: *10% reduction for the 1st day, then 30% reduction per day*.

Course Information(cont)

Exam: 100%

- If you are ill on the day of the exam, **do not attend** the exam.
- I will not accept medical special consideration claims from people who have already attempted the exam.

Final Mark by Harmonic Mean:

- Final mark = $\frac{2*(ass1+ass2+ass3+proj1)*final\ exam}{ass1+ass2+ass3+proj1+final\ exam}$

Course Information(cont)

Text Book:

- Elmasri & Navathe, *Fundamentals of Database Systems*, Benjamin/Cummings, 6th Edition, 2010.

Reference Books:

- J. D. Ullman & J. Widom, *A First Course in Database Systems*, Prentice Hall, 1997.
- R. Ramakrishan, *Database Management Systems*, McGRAW-HILL, 1997.
- D. Maier, *The Theory of Relational Databases*, Computer Science Press, 1983.

Course Outline

Time	Tuesday	Friday
Week 1	Subject Introduction, Conceptual DB Design (ER)	Conceptual DB Design (continue), Relational Data Model
Week 2	Relational Data Model(continue), Relational Algebra	SQL
Week 3	SQL(continue), PLpgSQL	Functional Dependencies
Week 4	Functional Dependencies (continue), Normal Forms	Normal Forms (continue)
Week 5	Relational DB design	Relational DB design (continue)
Week 6	Disks, Files	Index
Week 7	Transaction Management	Transaction Management (continue)
Week 8	Graph Data and Graph Database	Distributed Graph Processing
Week 9	Towards Big Graph Processing: applications and challenges	No lecture
Week 10	Revision	No lecture

Introduction

Database Applications:

- Banking System,
- Stock Market,
- Transportation,
- Social Network,
- Marine Data Analysis,
- Criminal Analysis and Control,
- Now, BIG DATA....

Introduction

Intelligent Transportation

Business Services

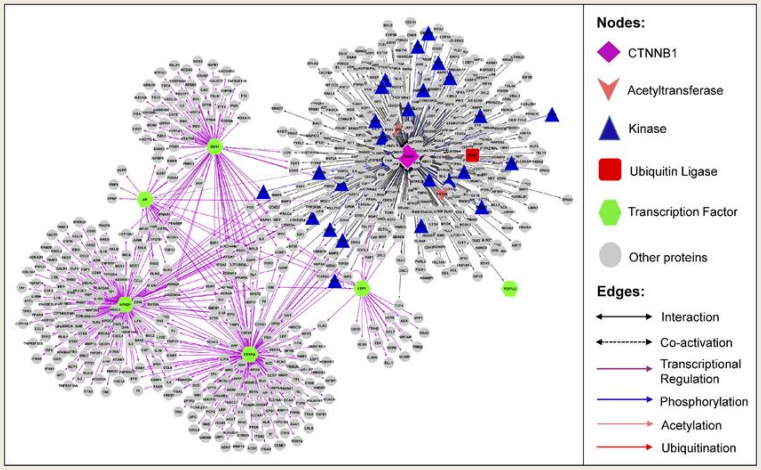
Natural Disasters

Public Health

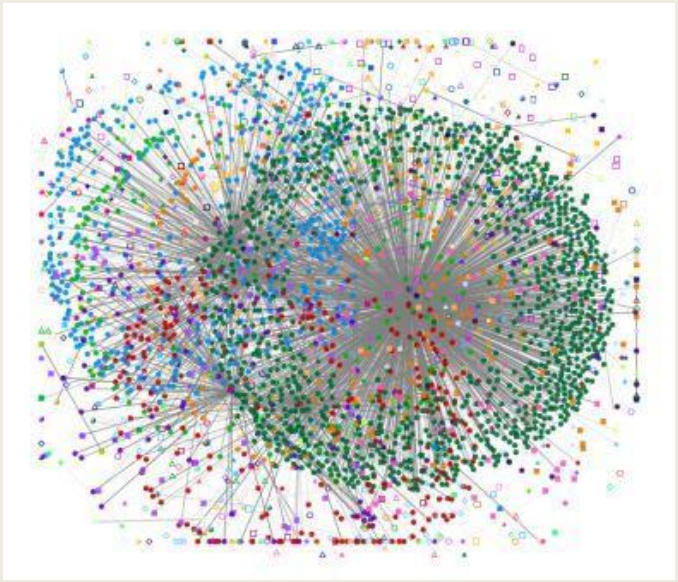
Modern Military

Tourism Development

Introduction

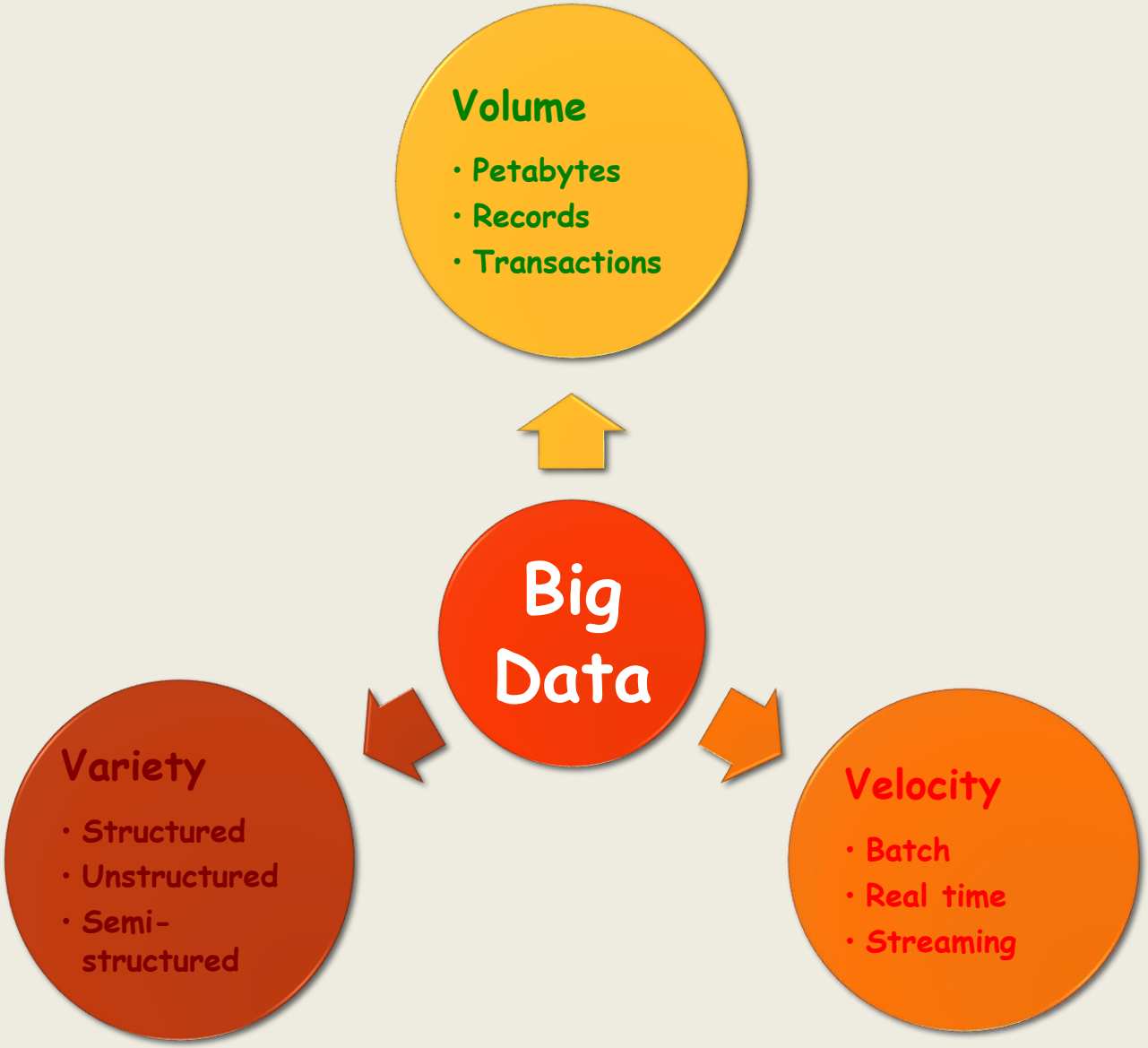


Beta-Catenin Biological Network



Web Graph

Social Network


Volume
• Petabytes
• Records
• Transactions
Big Data
Variety
• Structured
• Unstructured
• Semi-structured
Velocity
• Batch
• Real time
• Streaming

Major Research Issues

New Computing Platform/Architecture

New Graph Analytics Models

New Processing Algorithms & Indexing Techniques

Graph Processing System

- **Primitive operators**
- **Query language**
- **Distributed techniques**
- **Storage**
- **etc**

Introduction(cont)

Develop a *good* database system:

- Effectively organize data (database design).
- Efficiently execute users queries (transaction management).

These are even more important in modern applications, e.g. internet:

- Huge unstructured information is available in the internet.
- Must access the information efficiently and effectively

Item	Type of data	Stored as
Family name	String	Character strings?
Birthdate	Date	3 integers?
Weight	Real number	Floating point number?
…		

What is data?

Data - (Elmasri/Navathe):

- known facts that can be recorded and have explicit meaning . . .

Example - a student records database:

Contents - Information identifying students, courses they are enrolled in, results from past courses . . .

What is a database?

Elmasri/Navathe:

- . . . a collection of related data . . .

Data items alone are relatively useless.

We need the data to have some structure.

Database can be manipulated by a database management system.

What is a database management system (DBMS)?

Elmasri/Navathe:

- *DBMS*: . . . a collection of programs that enables users to create and maintain a database . . .
- *Database system*: . . . The database and DBMS together . . .

Database requirements

Database system provides facilities to:

- *Define a database* - specifying the data items to be stored and their types,
- *Construct a database* - loading the data items and storing them on some storage medium (usually disk),
- *Manipulate a database*
  - querying - i.e. retrieving relevant data,
  - updating - i.e. adding, deleting or modifying data items:
    - from one “correct” state to another “correct” state,
- *reporting*

Database requirements(cont)

Database system must be

- *Timely* - e.g. an airline database (fast response), a CAD system (must be interactive),
- *Multi-user* - e.g. trading system,
- *Modifiable* - must be able to be extended or reorganised, e.g. to cope with new laws, requirements, business conditions,
- *Secure* - different classes of users may need different levels of access,
- *No redundancy*,
- *Robust* - e.g. power failure during an update - must be able to recover to a consistent state.

Database requirements(cont)

A database system must address these issues and provide solutions - DBMS:

- *a special purpose DBMS,*
- *a general DBMS.*

The DBMS solution vs meta-data

To allow a general DBMS to be applied to a particular database application, we need **meta-data**.

Database requirements(cont)

Meta-data: a definition and description of the stored database, such as structure of each file, type and storage format of each data item, constraints etc.

Stored in the system *catalog*.

Benefits of meta-data

program-data independence - DBMS access programs may be written independent of file structures and storage formats,

data abstraction - information hiding.

- Users are provided with a *conceptual representation* of the data using a high level *data model*.

support for views - different users can have different views of the database. e.g.

- salary details may be hidden from some users,
- statistical summaries may be derived and appear as stored data for some users.

Database personnel

Database Administrator(DBA) - This person is responsible for the centralised control of the database:

- authorising access
- monitoring usage,
- recovery,
- identifying the data,
- choosing appropriate structures to represent and store the data,
- managing definitions of views . . .

Database personnel(cont)

End user - People requiring access to the database for querying, updating, reporting etc.

- Naive (parametric) user - typically use the database via “canned transactions” - standardised queries and updates, often through a menu system of some kind,
- Online user - has an understanding of the database system. May be capable of designing their own queries etc.

Database personnel(cont)

Systems analyst:

- determine end users requirements,
- develop specifications for canned transactions and reports,
- may also take part in database design.

Application programmer - Implements the specifications given by analyst:

- tests,
- debugs,
- maintains the resulting programs.

DBMS concepts

Data model: a set of concepts that is used to describe the allowed structure of a database. i.e. the structure of the meta-data.

May be classified as:

- High-level or conceptual (e.g. ER model – concerns entities, attributes and relationships)
- Implementation or record-based (e.g. Relational, Network, Hierarchical - suggests a physical implementation)
- Low-level or physical (concerns record formats, access paths etc)

DBMS concepts(cont)

Database Schema: An instance of a data model, that is, a description of the structure of a particular database in the formalism of the data model. (Intention)

Database Instance (or State): The data in the database at a particular time. (Extension)

In these terms:

- We define a database by specifying its schema.
- The state is then an empty instance of the schema.
- To create the initial instance we load in data.
- After this, each change in state is an update.

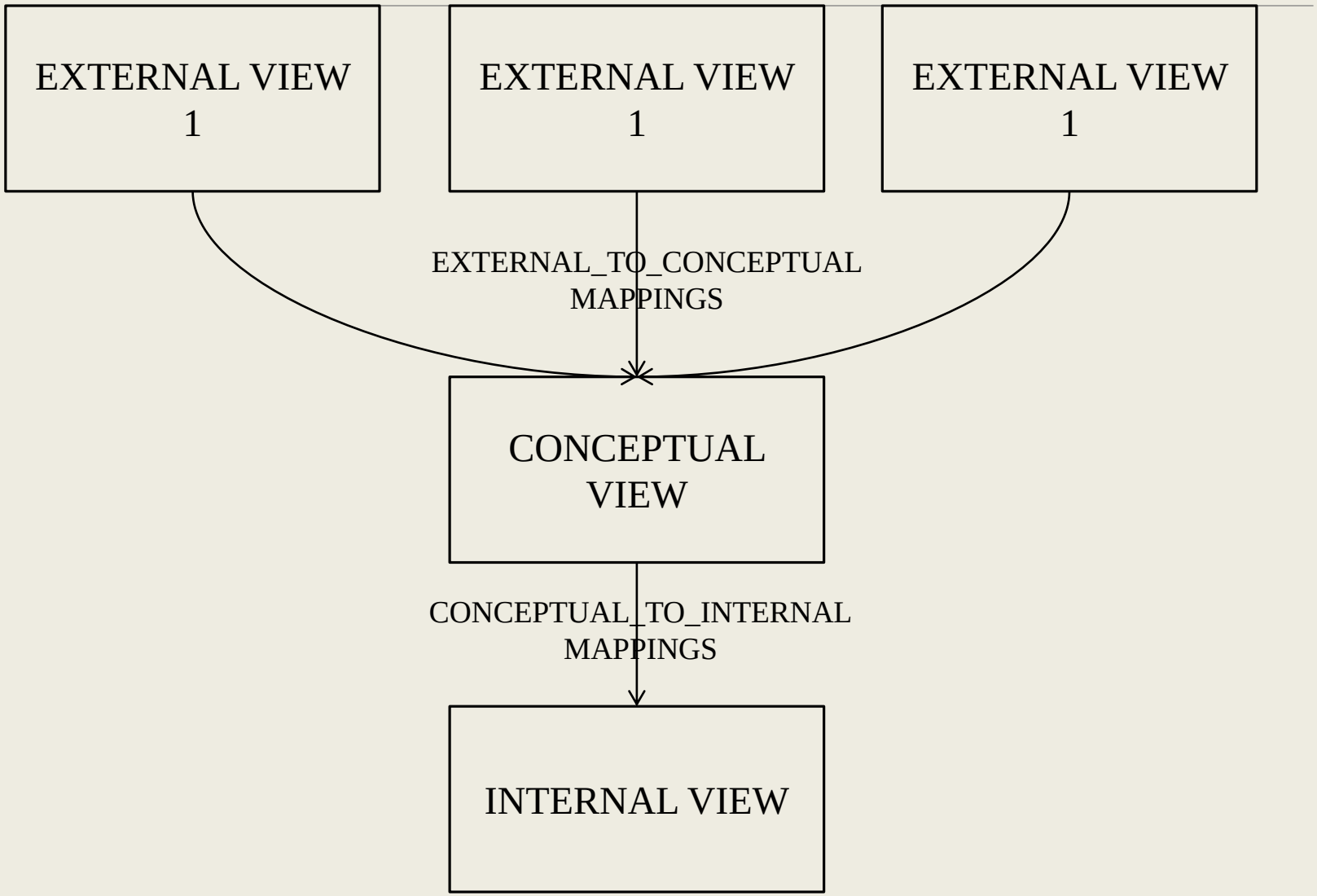
ANSI-SPARC three level architecture

ANSI: American National Standard Institute.

SPARC: Standards Planning and Requirements Committee.

ANSI-SPARC three level architecture (1975-1977):

- The *external* or *view level* includes a number of external schemas or user views.
- The *conceptual level* has a conceptual schema, which describes the structure of the whole database for a community of users.
- The *internal level* has an internal schema, which describes the physical storage structure of the database.


EXTERNAL VIEW 1
EXTERNAL VIEW 1
EXTERNAL VIEW 1
EXTERNAL_TO_CONCEPTUAL MAPPINGS
CONCEPTUAL VIEW
CONCEPTUAL_TO_INTERNAL MAPPINGS
INTERNAL VIEW

ANSI-SPARC three level architecture(cont)

3 levels of abstraction => 2 levels of data independence:

- *logical data independence*: the ability to change the conceptual schema without changing external views. Must change the external-to-conceptual mapping though.
- *physical data independence*: the ability to change physical storage paths and access structures without changing the conceptual view. Must change the conceptual-to-internal mapping though.

Database languages

In the three level architecture:

- *Data definition language (DDL):* used to define the conceptual schema.
- *View definition language (VDL):* used to define external schemas.
- *Storage definition language (SDL):* used to define the internal schemas.

In DBMS where conceptual and internal levels are mixed up, DDL is used to define both schemas.

Database languages(cont)

Data manipulation language (DML): used to construct retrieval requests (queries) and update requests:

- Low-level or procedural
  - embedded in a general purpose language,
  - record at a time
- High-level or non-procedural
  - interactive and/or embedded
  - set at a time/ set oriented.

In most current DBMSs, a comprehensive integrated language is used; for example SQL.

Database components

See Fig2.3 in Elmasri/Navathe.

Run-time database processor - Receives retrieval and update requests and carries them out with the help of the stored data manager.

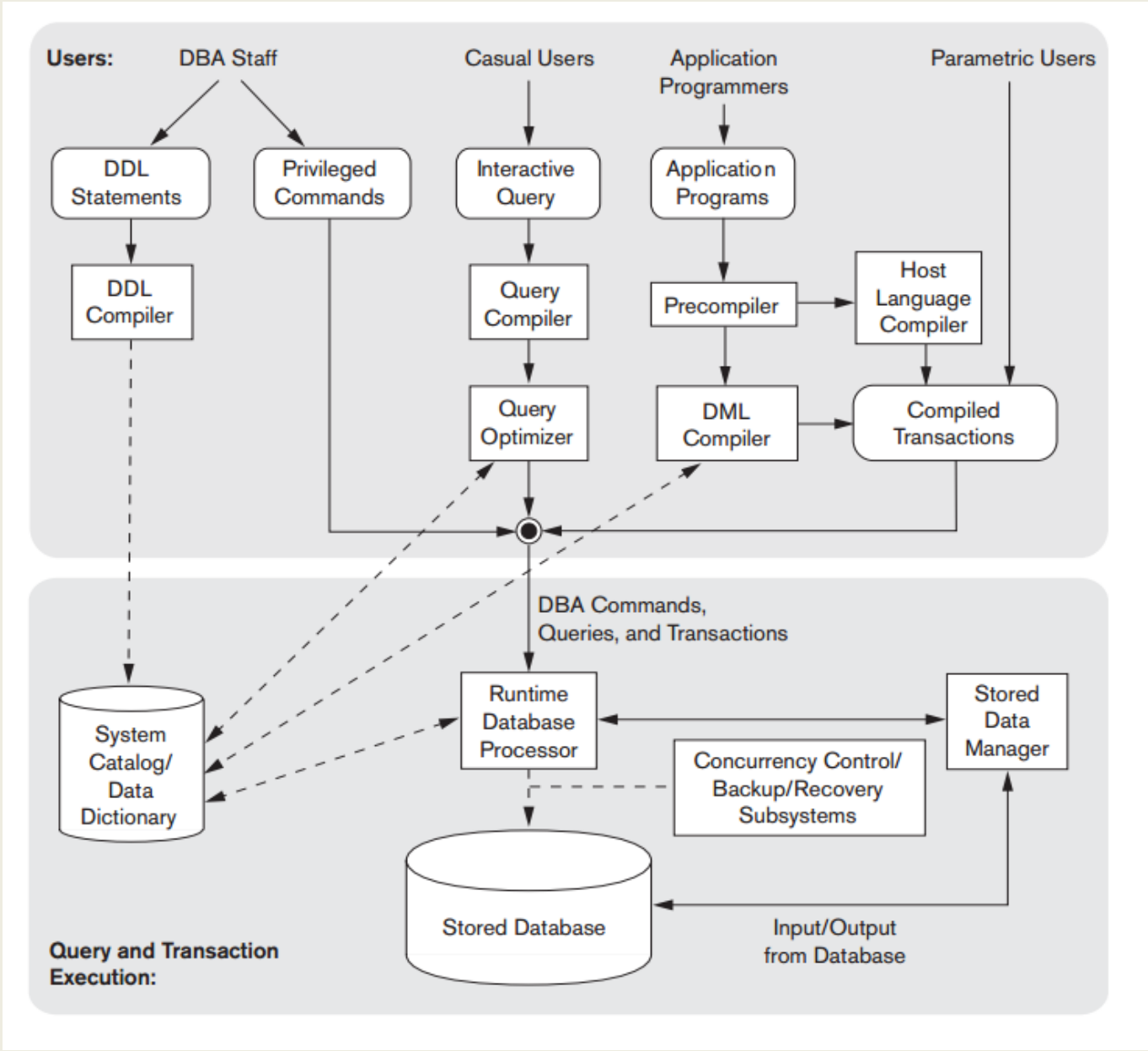
Stored data manager or file manager - Controls access to the DBMS information stored on disk:

- may use the OS for disk access,
- controls other aspects of data transfer, such as handling buffers.

Pre-compiler - Extracts DML commands from the host language program.

- These are compiled by the DML compiler, the rest is compiled by the host language compiler, then they are linked to produce executable code with calls to the data manager.

Query processor (or Complier) - Parses high-level queries and converts them into calls to be executed by the data manager.



Component modules of a DBMS and their interactions.