COMP9311 DATABASE SYSTEMS

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- http://www.cse.unsw.edu.au/~cs9311

Course Information

Lectures: lectures will be delivered live online. Recorded video will be made available.

4PM – 6PM (Monday)	week 1 – 3, 5, 7 – 10
1PM – 3PM (Tueday)	week 1 – 5, 7-10

Lab: Detailed lab notes will be provided and you are expected to follow the guide using your own computer. Tutors during the online lab sessions will help with any questions. Lab sessions will not be recorded.

week 2-5, 7-10.

Consultation: course admin will answer questions regarding the course

week 2-5, 7-10. 3PM – 4PM (Monday)

Q&A Forum: https://webcms3.cse.unsw.edu.au/COMP9311/20T3/forums/

Course Email: comp9311unsw@gmail.com

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

Course Information

- Lecturer-in-Charge (LiC)
  - A/Prof. Wenjie Zhang
  - Office: K17 502, Phone: 93857799
  - Email: wenjie.zhang@unsw.edu.au
- Tutors
  - A group of PhD students in the *Data and Knowledge Research Group*
  - COMP9311 in T3 has ~250 students, each tutor looks after 1-2 labs.
- Course Website
  - http://www.cse.unsw.edu.au/~cs9311

Why study databases

Every significant modern computer application has Large Data.

This needs to be:

- stored (typically on a disk device)
- manipulated (efficiently, usefully)
- shared (by many users, concurrently)
- transmitted (all around the Internet)

Red stuff handled by databases; brown by networks.

Challenges in building effective databases: efficiency, security, scalability, maintainability, availability, integration, new media types (e.g., music, video), ...

Syllabus Overview

Data modelling and database design (Week 1 to Week 2)

- ER model, ODL, ER-to-relational
- Relational model (relational algebra), mapping of ER to relational model

Database application development (Week 3 to Week 4)

- SQL, views, stored procedures, triggers, aggregates
- PostgreSQL: PLpgSQL (procedural)

Formal database design theory and database system architecture (Week 5 – Week 8)

- Normalisation, functional dependencies
- Storage and indexing, data access operations
- Query processing: translation, optimisation, evaluation
- Transaction processing: transactions, concurrency control, recovery

Research Topics of Databases (Week 9)

- Cutting-edge technologies for database management

Revision (Week 10)

Course Outline

Time	Monday	Tuesday
Week 1	Subject Introduction, Conceptual DB Design (ER)	Relational Data Model
Week 2	ER to Relational Model Mapping	Relational Algebra
Week 3	SQL	SQL (continue)
Week 4	Public Holiday No Lecture	PLpgSQL
Week 5	Functional Dependencies, Normal Forms	Relational Database Design
Week 6	No lecture	No lecture
Week 7	Relational Database Design (continue)	Disk, File, Index
Week 8	Transaction Management	Transaction Management (continue)
Week 9	Research Topics I	Research Topics II
Week 10	Revision	No lecture

Textbook

Lecture notes are sufficient but the following text books are good:

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.

Teaching/Learning Approaches

What we do to support your learning:

- Online support sessions in labs
  - *Lab exercises (starting Week 2, every week)*: guides you through the practical skills on the database application programming part of the course
  - We run consultations in the lab: tutors will answer all sorts of questions related to the course.
- Extra exercise questions with answers: available in the course website
- Weekly course admin consultations (every Monday before the class)

- How to access labs and consultation: log into Moodle (https://moodle.telt.unsw.edu.au/), find out course (COMP9311 – Database Systems 2020 T3), click "Lectures and Recordings", click the corresponding lab or consultation session to join.

Teaching / Learning Approaches

- Other support
  - course *forums* (You may post questions in the forum and answer the questions from fellow students. Tutors will visit the forum regularly to answer qustions.)
  - send an email to comp9311unsw@gmail.com (regularly monitored)
  - If urgent: send an email to me wenjie.zhang@unsw.edu.au

Teaching/Learning Approaches

Things that we expect you to **do**:

- Follow the lecture content
- *Practice the exercise questions:* exercise questions with solutions covering the key topics. Try to solve them first and before checking the answers
- *Practical* work: lab exercises. Attending labs is strongly encouraged.

You will show us your progress/learning outcomes through:

- *2 Assignments*: extended exercises
- 1 *Project*: practical questions in SQL and PLpgSQL
- *Final exam*: paper-based

Assignment and Project

2 assignments, 1 project. All individual work !

Assignments (50%):

- Ass 1: Data Modelling + Relational Algebra (25%) (week 2-4)
- Ass 2: DB Design Theory + Database Storage Structures + Transaction (25%) (week 8-10)

Projects (50%)

- Proj 1: SQL PLpgSQL (50%) (week 4-7)

Penalty for later submissions: *20% reduction per day*.

Exam and Marks

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

Database related courses in CSE

COMP9311 introduces foundations & technology of databases

- skills: how to build database-backed applications
- theory: how do you know that what you built was good

After COMP9311 you can go on to study ...

- COMP9315: how to build relational DBMSs (write your own PostgreSQL or Oracle)
- COMP9318: techniques for data mining (discovering patterns in DB)
- COMP9319: Web data compression and search (dealing with a large amount of Web data)
- COMP6714: information retrieval, web search (dealing with text data)
- COMP932[1|2|3]: service-oriented computing, which relies on DB background

Beyond the courses …

Research Degrees: PhD (3 – 3.5 years), Master by Research or Master of Philosophy (1.5 – 2 years) . https://research.unsw.edu.au/higher-degree-research-programs

- To deeply explore on research problems
- Feel free to contact me if you are interested in obtaining a research degree

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

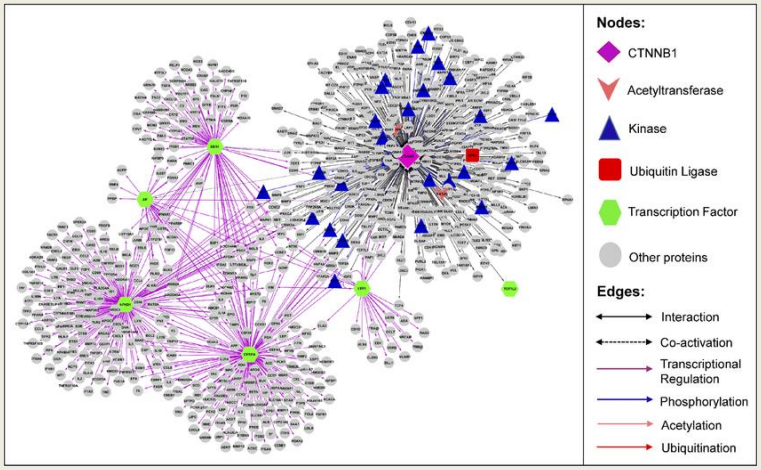
Natural Disasters

Public Health

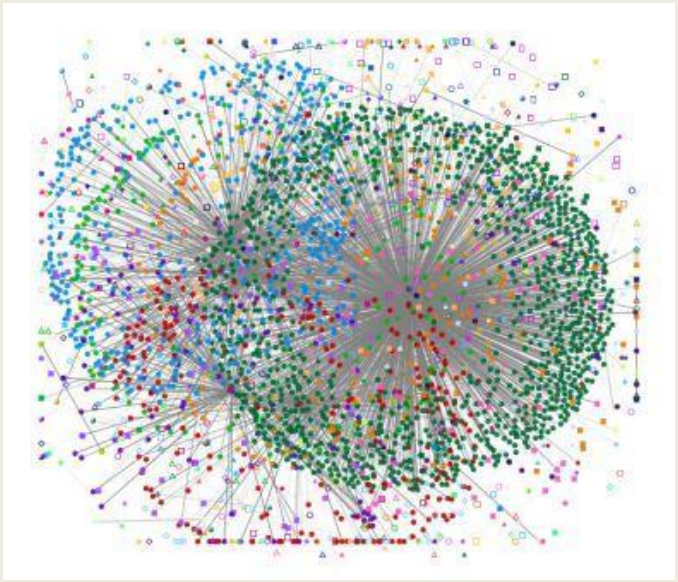
Modern Military

Tourism Development

Introduction



Beta-Catenin Biological Network



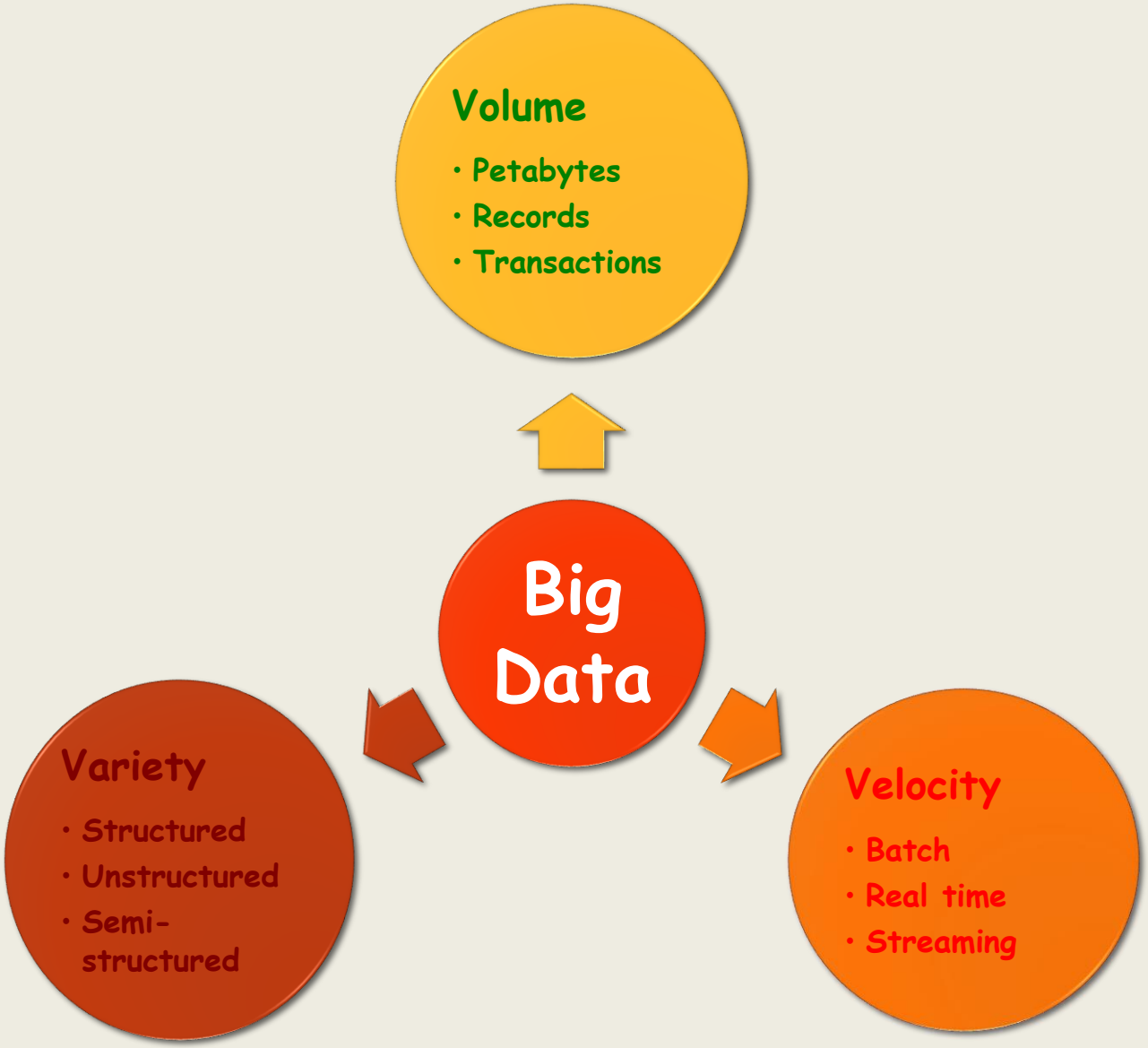
Web Graph

Social Network

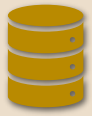
Databases: Important Themes

The field of *databases* deals with:

- *data* ... representing application scenarios
- *relationships* ... amongst data items
- *constraints* ... on data and relationships
- *redundancy* ... one source for each data item
- *data manipulation* ... declarative, procedural
- *transactions* ... multiple actions, atomic effect
- *concurrency* ... multiple users sharing data
- *scale* ... massive amounts of data


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

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.*

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.

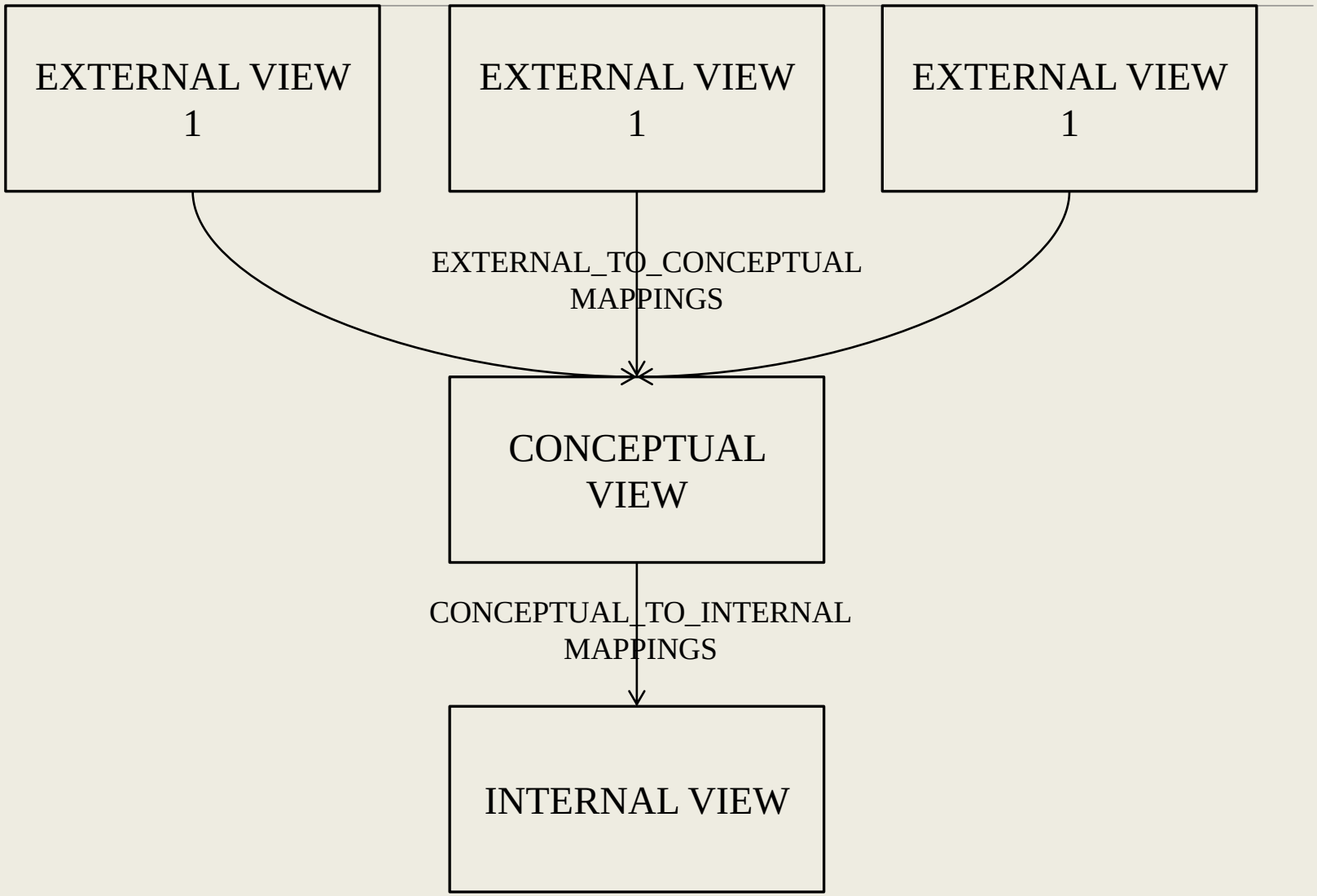
ANSI-SPARC three level architecture

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

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

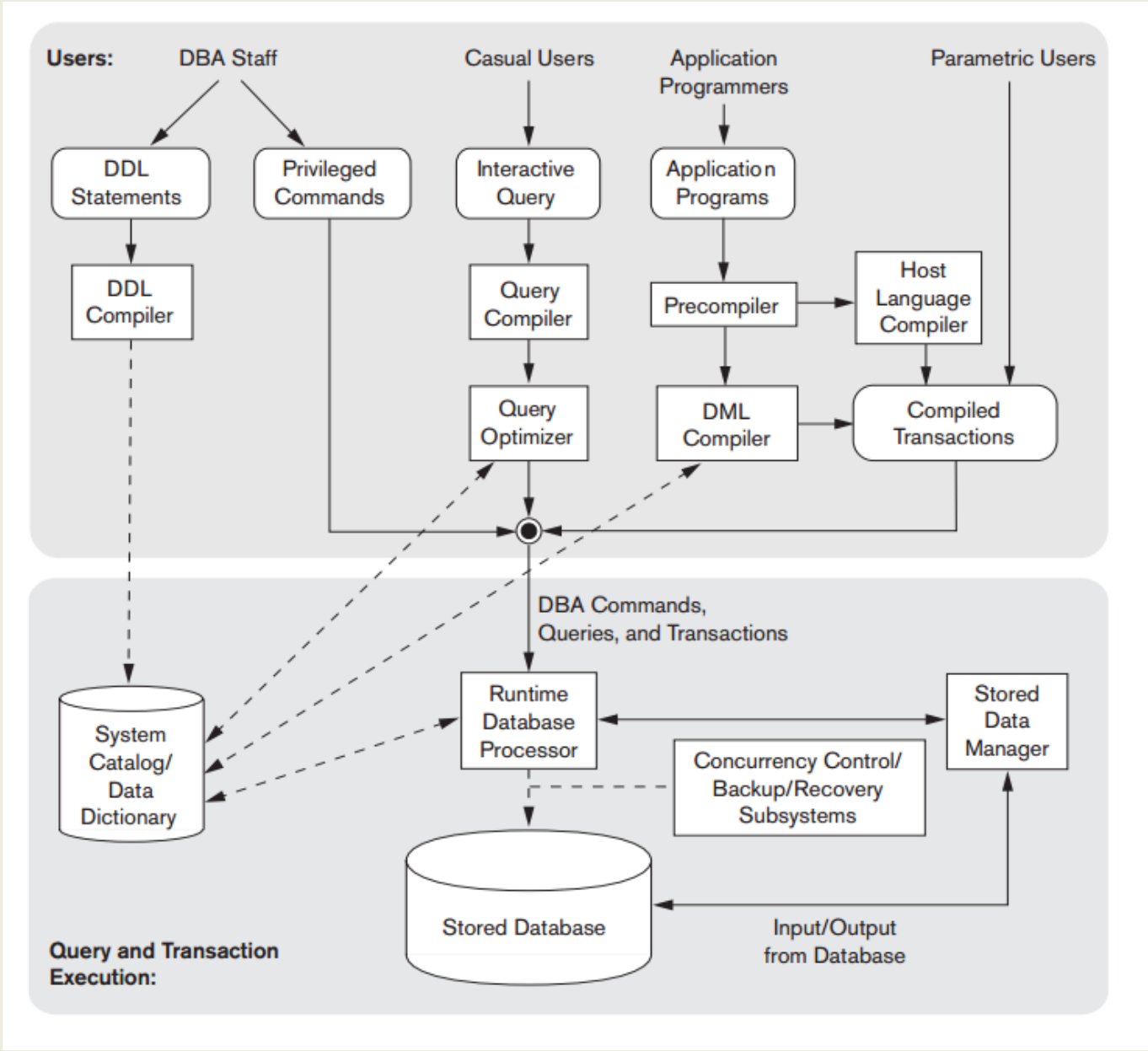
Stored data manager or file manager - Controls access to the DBMS information stored on disk:

- 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.

Learning Outcomes:

- Introduction of the course

- General understanding of terms in databases, details will be found in later part of the course.