ICS 321 Spring 2012

# Introduction to Database Systems

Asst. Prof. Lipyeow Lim

Information & Computer Science Department

University of Hawaii at Manoa

# Data, Database, DBMS

- A **database** : a collection of related data.
  - Represents some aspect of the real world (aka universe of discourse).
  - Logically coherent collection of data
  - Designed and built for specific purpose
- **Data** are known facts that can be recorded and that have implicit meaning.
- A **data model** is a collection of concepts for describing data.
- A **schema** is a description of a particular collection of data, using the a given data model.

# DBMS

- A **database management system (DBMS)** is a *collection of programs* that enables users to
  - Create new DBs and specify the structure using data definition language (DDL)
  - Query data using a query language or data manipulation language (DML)
  - Store very large amounts of data
  - Support durability in the face of failures, errors, misuse
  - Control concurrent access to data from many users

# Types of Databases

- On-line Transaction Processing (OLTP)
  - Banking
  - Airline reservations
  - Corporate records
- On-line Analytical Processing (OLAP)
  - Data warehouses, data marts
  - Business intelligence (BI)
- Specialized databases
  - Multimedia
  - XML
  - Geographical Information Systems (GIS)
  - Real-time databases (telecom industry)
- Special Applications
  - Customer Relationship Management (CRM)
  - Enterprise Resource Planning (ERP)
- Hosted DB Services
  - Amazon, Salesforce

# A Bit of History

- 1970 Edgar F Codd  (aka "Ted") invented the relational model in the seminal paper "A Relational Model of Data for Large Shared Data Banks"
  - Main concept: *relation* = a table with rows and columns.
  - Every relation has a *schema*, which describes the columns.
- Prior 1970, no standard data model.
  - Network model used by Codasyl
  - Hierarchical model used by IMS
- After 1970, IBM built System R as proof-of-concept for relational model and used **SQL** as the query language. SQL eventually became a standard.

# Files vs DBMS

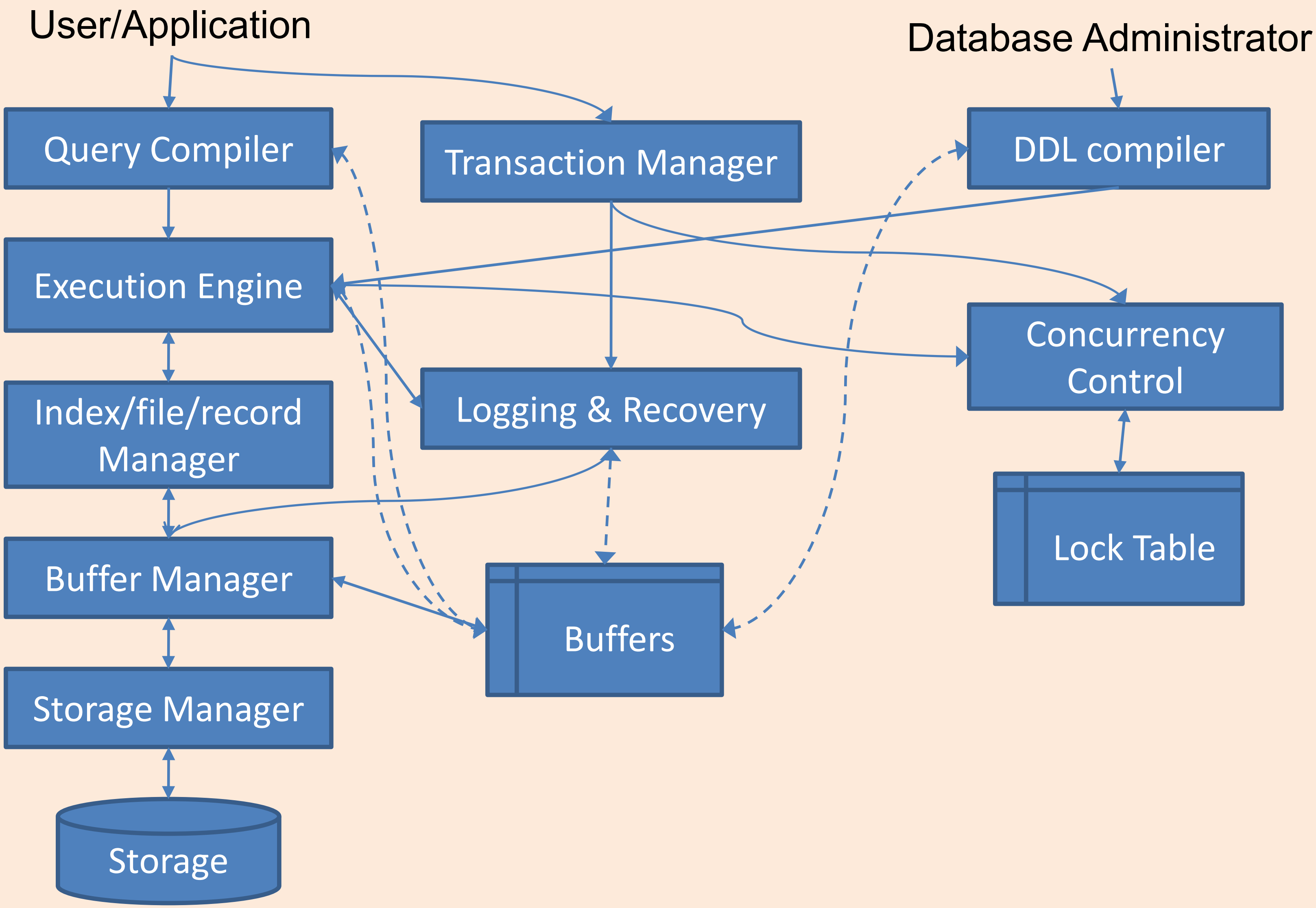
- Swapping data between memory and files
- Difficult to add records to files
- Security & access control
- Do optimization manually
- Good for small data/files

- Run out of pointers (32bit)
- Code your own search algorithm
  - Search on different fields is difficult
- Must protect data from inconsistency due to concurrency
- Fault tolerance – crash recovery

# Why use a DBMS ?

- Large datasets
- Concurrency/ multi-user
- Crash recovery
- Declarative query language
- No need to figure out what low level data structure
- Data independence and efficient access.
- Reduced application development time.
- Data integrity and security.
- Uniform data administration.

# DBMS Components



# Transaction: An Execution of a DB Program

- A *transaction* an *atomic* sequence of database actions (reads/writes).
- Each transaction, executed completely, must leave the DB in a *consistent state* if DB is consistent when the transaction begins.
- Concurrent execution of transactions is essential for good DBMS performance.
  - Because disk accesses are frequent, and relatively slow, it is important to keep the cpu humming by working on several user programs concurrently.
- Interleaving actions of different transactions can lead to inconsistency: e.g., check is cleared while account balance is being computed.
- DBMS ensures such problems don't arise: users can pretend they are using a single-user system.

# ACID Properties

- **Atomicity** : all-or-nothing execution of transactions
- **Consistency**: constraints on data elements is preserved
- **Isolation**: each transaction executes as if no other transaction is executing concurrently
- **Durability**: effect of an executed transaction must never be lost

# Ensuring Isolation

- Scheduling concurrent transactions
- DBMS ensures that execution of {T1, ... , Tn} is equivalent to some *serial* execution T1' ... Tn'.
- Idea: use locks to serialize access to shared objects
- Strict 2 Phase locking protocol:
  - Before reading/writing an object, a transaction requests a lock on the object, and waits till the DBMS gives it the lock.
  - All locks are released at the end of the transaction.
  - What if Tj already has a lock on Y and Ti later requests a lock on Y? (Deadlock!) Ti or Tj is aborted and restarted!

# Ensuring Atomicity

- DBMS ensures *atomicity* even if system crashes in the middle of a Xact.
- Idea: Keep a *log* (history) of all actions carried out by the DBMS while executing a set of Xacts.
- Write Ahead Log (WAL) protocol
  - Before a change is made to the database, the corresponding log entry is forced to disk.
  - After a crash, the effects of partially executed transactions are *undone* using the log.
  - WAL property: if log entry wasn't saved before the crash, corresponding change was not applied to database!

# Summary

- Definitions of data, databases, data models, schema
- When to use or not use a DBMS
- DBMS major components
- Transactions and concurrency
- ACID properties of transactions
- Techniques for ensuring ACID properties in DBMSs.