Information Policy

Database

C02. Database

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Contents

01. Database

- Database
  - A very large, integrated collection of data
- Models real-world enterprise.
  - Entities (e.g., students, courses)
  - Relationships (e.g., Madonna is taking CS564)
- A Database Management System (DBMS) is a software package designed to store and manage databases.

01. Database

- Characteristics of Database
  - Data independence
  - Efficient access
  - Reduced application development time
  - Data integrity and security
  - Uniform data administration
  - Concurrent access
  - Recovery from crashes

01. Database

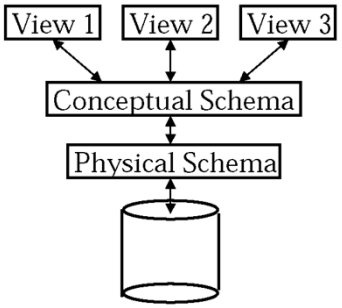
- Why Study Databases?
  - Shift from computation to information
    - at the “low end”: scramble to webspace (a mess!)
    - at the “high end”: scientific applications
  - Datasets increasing in diversity and volume.
    - Digital libraries, interactive video, Human Genome project, EOS project
    - ... need for DBMS exploding
  - DBMS encompasses most of CS
    - OS, languages, theory, AI, multimedia, logic

02. Data Models

- Data Models
  - 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.
  - The relational model of data is the most widely used model today.
  - Main concept: relation, basically a table with rows and columns.
  - Every relation has a schema, which describes the columns, or fields.

02. Data Models

- Levels of Abstraction
  - Many views, single conceptual (logical) schema and physical schema.
    - Views describe how users see the data.
    - Conceptual schema defines logical structure
    - Physical schema describes the files and indexes used.
  - Schemas are defined using DDL
  - Data is modified/queried using DML.



02. Data Models

- Example: Univ. Database
  - Conceptual schema:
    - Students(sid: string, name: string, login: string, gpa:real)
    - Courses(cid: string, cname:string, credits:integer)
    - Enrolled(sid:string, cid:string, grade:string)
  - Physical schema:
    - Relations stored as unordered files.
    - Index on first column of Students.
  - External Schema (View):
    - Course_info(cid:string,enrollment:integer)

03. Features of Database

- Data Independence
  - Applications insulated from how data is structured and stored.
  - Logical data independence:
    - Protection from changes in logical structure of data.
  - Physical data independence:
    - Protection from changes in physical structure of data.
  - One of the most important benefits of using a DBMS!

03. Features of Database

- Concurrency Control
  - Concurrent execution of user programs 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 user programs 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.

03. Features of Database

- Transaction: An Execution of a DB Program
  - Key concept is transaction, which is 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.
    - Users can specify some simple integrity constraints on the data, and the DBMS will enforce these constraints.
    - Beyond this, the DBMS does not really understand the semantics of the data. (e.g., it does not understand how the interest on a bank account is computed).
    - Thus, ensuring that a transaction (run alone) preserves consistency is ultimately the user's responsibility!

03. Features of Database

- Scheduling Concurrent Transactions
  - DBMS ensures that execution of {T1, ... , Tn} is equivalent to some serial execution T1' ... Tn'.
    - 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.
  - Strict 2PL locking protocol
    - Idea: If an action of Ti (say, writing X) affects Tj (which perhaps reads X), one of them, say Ti, will obtain the lock on X first and Tj is forced to wait until Ti completes; this effectively orders the transactions.
    - 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!

03. Features of Database

- Ensuring Atomicity
  - DBMS ensures atomicity (all-or-nothing property) 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:
    - Before a change is made to the database, the corresponding log entry is forced to a safe location.
    - (WAL protocol; OS support for this is often inadequate.)
    - After a crash, the effects of partially executed transactions are undone using the log. (Thanks to WAL, if log entry wasn't saved before the crash, corresponding change was not applied to database!)

03. Features of Database

- The Log
  - The following actions are recorded in the log:
    - Ti writes an object: the old value and the new value.
    - Log record must go to disk before the changed page!
    - Ti commits/aborts: a log record indicating this action.
  - Log records chained together by Xact id, so it's easy to undo a specific Xact (e.g., to resolve a deadlock).
  - Log is often duplexed and archived on "stable" storage.
  - All log related activities (and in fact, all CC related activities such as lock/unlock, dealing with deadlocks etc.) are handled transparently by the DBMS.

03. Features of Database

- Database Makes This Folk Happy.
  - End users and DBMS vendors
    - DB application programmers
    - E.g. smart webmasters
    - Database administrator (DBA)
    - Designs logical /physical schemas
  - Handles security and authorization
  - Data availability, crash recovery
  - Database tuning as needs evolve
  - Must understand how a DBMS works!

03. Features of Database

- Structure of DBMS
  - A typical DBMS has a layered architecture.
  - The figure does not show the concurrency control and recovery components.
  - This is one of several possible architectures;
    - each system has its own variations.