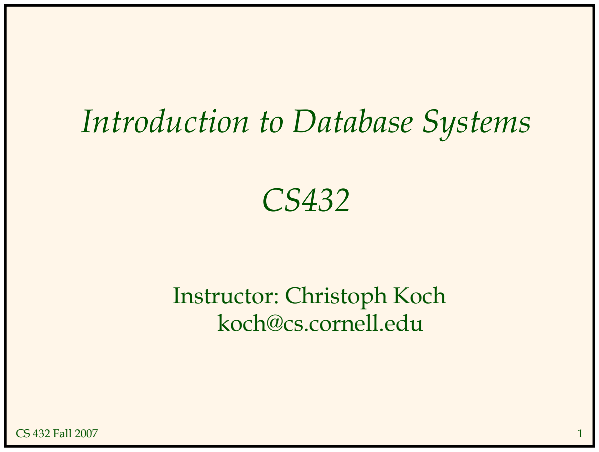
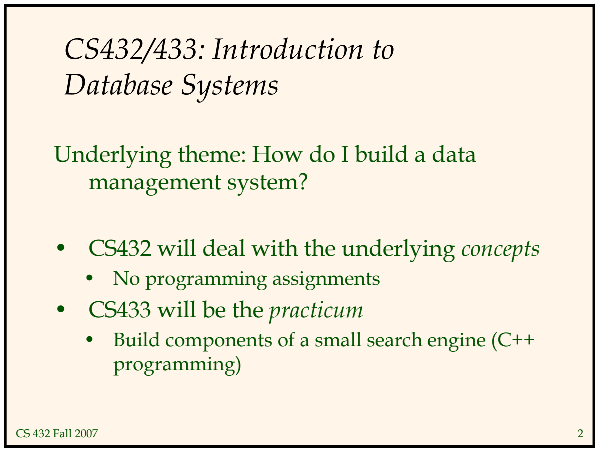


Introduction to Database Systems

CS432

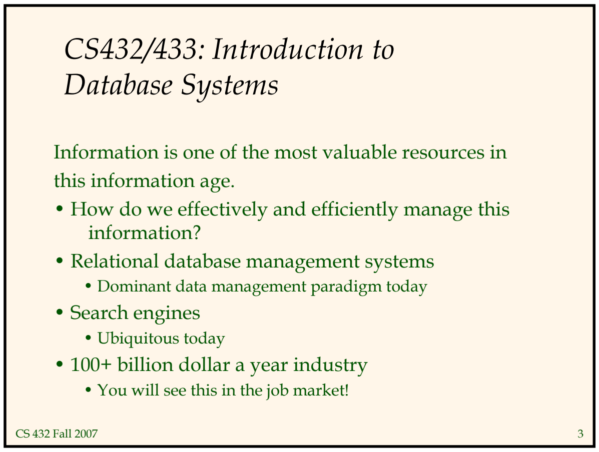
Instructor: Christoph Koch
koch@cs.cornell.edu



CS432/433: Introduction to Database Systems

Underlying theme: How do I build a data management system?

- CS432 will deal with the underlying *concepts*
  - No programming assignments
- CS433 will be the *practicum*
  - Build components of a small search engine (C++ programming)

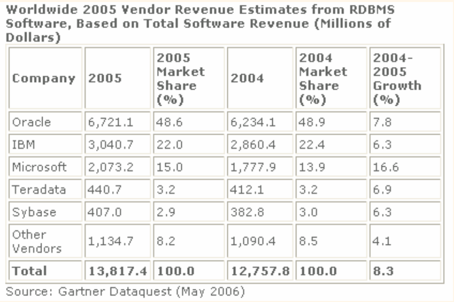


CS432/433: Introduction to Database Systems

Information is one of the most valuable resources in this information age.

- How do we effectively and efficiently manage this information?
- Relational database management systems
  - Dominant data management paradigm today
- Search engines
  - Ubiquitous today
- 100+ billion dollar a year industry
  - You will see this in the job market!

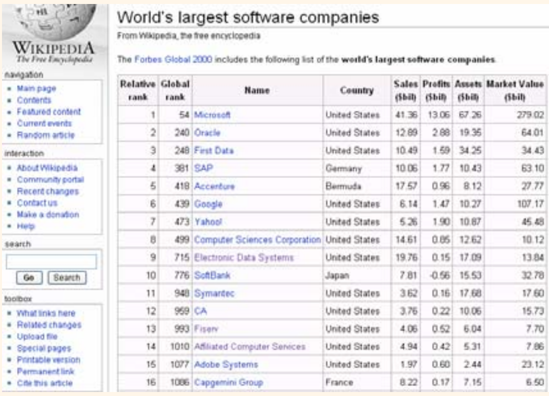
RDBMS Market



Worldwide 2005 Vendor Revenue Estimates from RDBMS Software, Based on Total Software Revenue (Millions of Dollars)

Company	2005	2005 Market Share (%)	2004	2004 Market Share (%)	2004-2005 Growth (%)
Oracle	6,721.1	48.6	6,234.1	48.9	7.8
IBM	3,040.7	22.0	2,860.4	22.4	6.3
Microsoft	2,073.2	15.0	1,777.9	13.9	16.6
Teradata	440.7	3.2	412.1	3.2	6.9
Sybase	407.0	2.9	382.8	3.0	6.3
Other Vendors	1,134.7	8.2	1,090.4	8.5	4.1
Total	**13,817.4**	**100.0**	**12,757.8**	**100.0**	**8.3**

Source: Gartner Dataquest (May 2006)



World's largest software companies

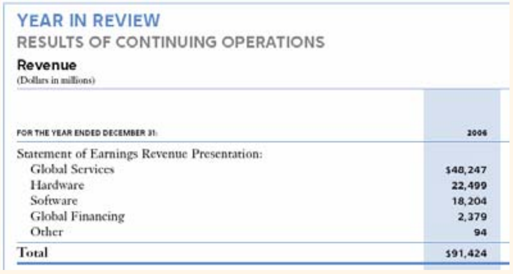
From Wikipedia, the free encyclopedia

The Forbes Global 2000 includes the following list of the **world's largest software companies**.

Relative rank	Global rank	Name	Country	Sales ($bil)	Profits ($bil)	Assets ($bil)	Market Value ($bil)
1	54	Microsoft	United States	41.36	13.06	67.26	279.02
2	240	Oracle	United States	12.89	2.88	19.35	64.01
3	248	First Data	United States	10.49	1.59	34.25	34.43
4	381	SAP	Germany	10.06	1.77	10.43	63.10
5	418	Accenture	Bermuda	17.57	0.96	8.12	27.77
6	439	Google	United States	6.14	1.47	10.27	107.17
7	473	Yahoo!	United States	5.26	1.90	10.87	45.48
8	499	Computer Sciences Corporation	United States	14.61	0.85	12.62	10.12
9	715	Electronic Data Systems	United States	19.76	0.15	17.09	13.84
10	776	SoftBank	Japan	7.81	-0.56	15.53	32.78
11	948	Symantec	United States	3.62	0.16	17.68	17.60
12	959	CA	United States	3.76	0.22	10.06	15.73
13	993	Fiserv	United States	4.06	0.52	6.04	7.70
14	1010	Affiliated Computer Services	United States	4.94	0.42	5.31	7.86
15	1077	Adobe Systems	United States	1.97	0.60	2.44	23.12
16	1086	Capgemini Group	France	8.22	0.17	7.15	6.50

„Note: The above list does not include companies like IBM whose software/services part is bigger than Microsoft. In the Forbes2000 report IBM and HP were listed as Technology Hardware companies.“

From the IBM 2006 Annual Report



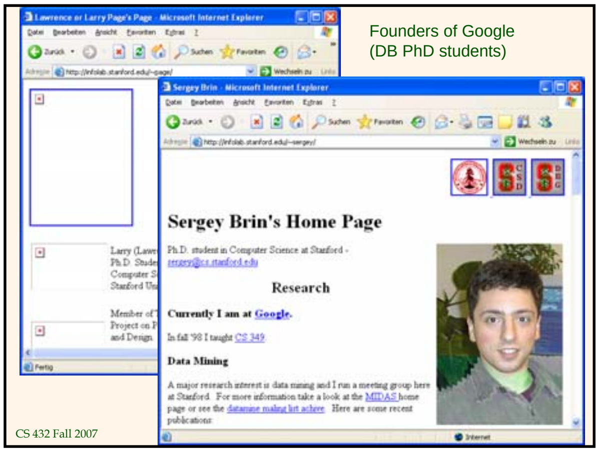
YEAR IN REVIEW

RESULTS OF CONTINUING OPERATIONS

Revenue

(Dollars in millions)

FOR THE YEAR ENDED DECEMBER 31:	2006
Statement of Earnings Revenue Presentation:	
Global Services	$48,247
Hardware	22,499
Software	18,204
Global Financing	2,379
Other	94
Total	$91,424


Lawrence or Larry Page's Page - Microsoft Internet Explorer
Datei Bearbeiten Ansicht Favoriten Extras ?
Zurück Suchen Favoriten
Adresse http://infolab.stanford.edu/~page/
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Fertig
Sergey Brin - Microsoft Internet Explorer
Datei Bearbeiten Ansicht Favoriten Extras ?
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and Design

Sergey Brin's Home Page

Ph.D. student in Computer Science at Stanford - sergey@cs.stanford.edu

Research

Currently I am at Google.

In fall '98 I taught CS 349

Data Mining

A major research interest is data mining and I run a meeting group here at Stanford. For more information take a look at the MIDAS home page or see the datamine mailing list achive. Here are some recent publications:

Founders of Google
(DB PhD students)

CS432 Prerequisites

Courses

- CS212 (Computers and Programming)
- CS312 (Structure and Interpretation of Computer Programs)

People

- Instructor:
  - Christoph Koch
- TAs:
  - Ethan Feldman
  - Parvati Iyer
  - James Lenfestey

Access to Instructor and TAs

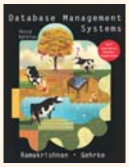
- Office hours
  - Posted on course web site http://www.cs.cornell.edu/courses/cs432
- TA mailing list
  - cs432ta-l@cs.cornell.edu
  - Do not directly email TAs
  - Questions should be answered within 24 hours during week, 48 hours on weekends.

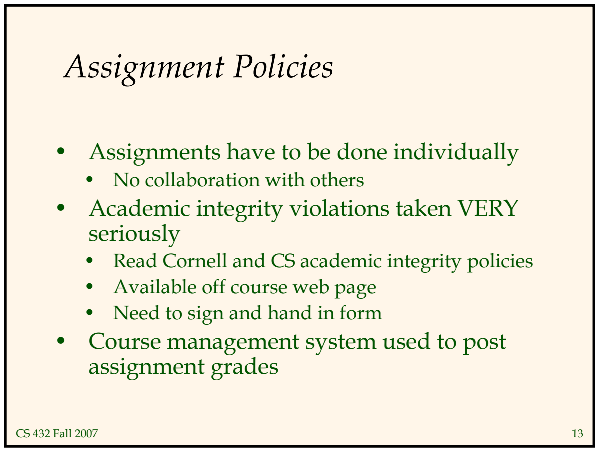
Course Structure

- Two components
  - Assignments (50%)
    - Five assignments
    - Each assignment worth 10% of total grade.
  - Two examinations (50%)
- No programming assignments in CS432
  - CS433 will have all programming assignments

Textbook

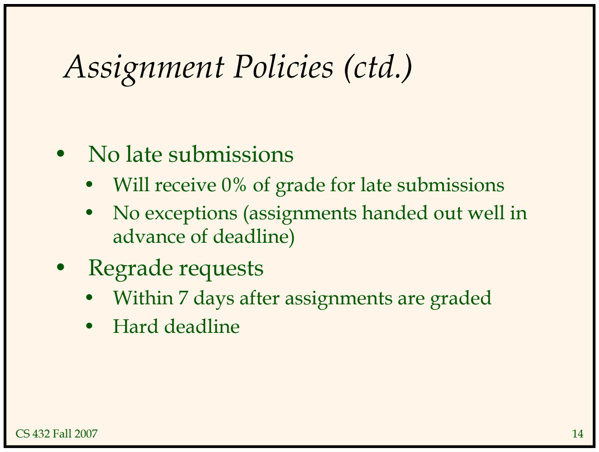
- Textbook: "Database Management Systems" (3rd Edition)
  - By R. Ramakrishnan and J. Gehrke
  - Required textbook
- Syllabus
  - Defined by class lectures
  - Not defined by textbook





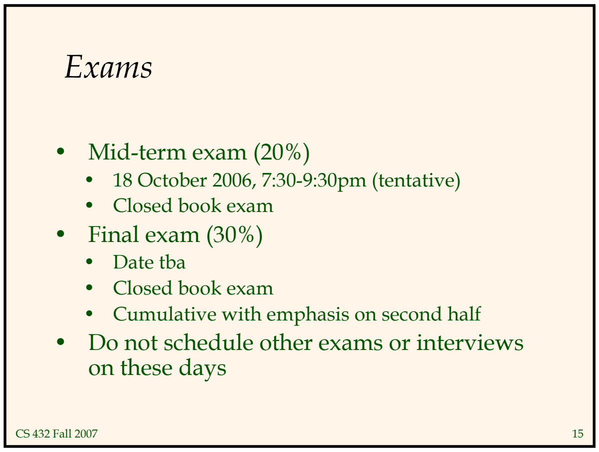
Assignment Policies

- Assignments have to be done individually
  - No collaboration with others
- Academic integrity violations taken VERY seriously
  - Read Cornell and CS academic integrity policies
  - Available off course web page
  - Need to sign and hand in form
- Course management system used to post assignment grades



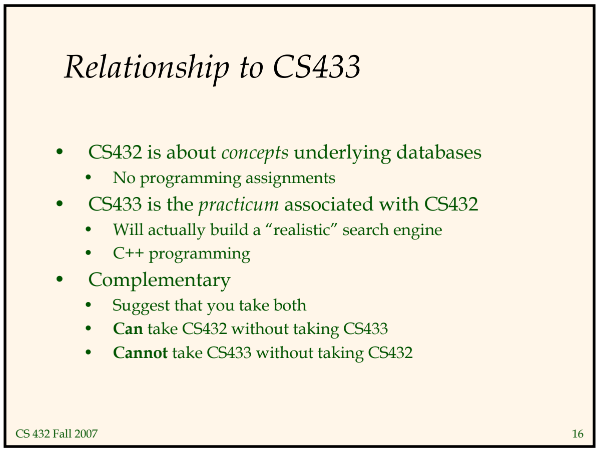
Assignment Policies (ctd.)

- No late submissions
  - Will receive 0% of grade for late submissions
  - No exceptions (assignments handed out well in advance of deadline)
- Regrade requests
  - Within 7 days after assignments are graded
  - Hard deadline



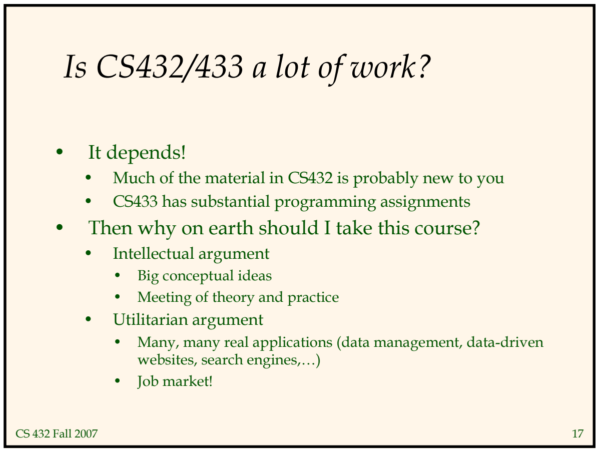
Exams

- Mid-term exam (20%)
  - 18 October 2006, 7:30-9:30pm (tentative)
  - Closed book exam
- Final exam (30%)
  - Date tba
  - Closed book exam
  - Cumulative with emphasis on second half
- Do not schedule other exams or interviews on these days



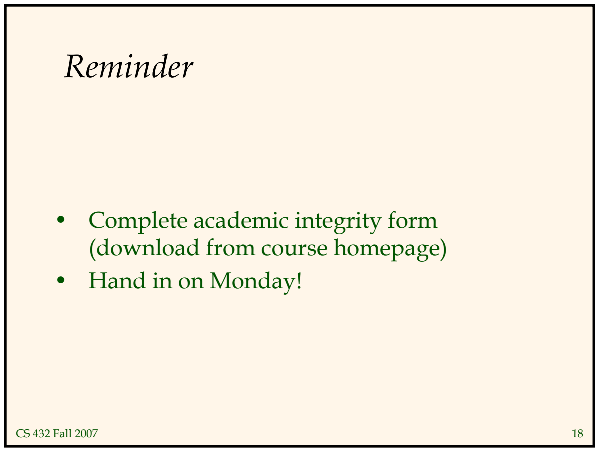
Relationship to CS433

- CS432 is about *concepts* underlying databases
  - No programming assignments
- CS433 is the *practicum* associated with CS432
  - Will actually build a “realistic” search engine
  - C++ programming
- Complementary
  - Suggest that you take both
  - **Can** take CS432 without taking CS433
  - **Cannot** take CS433 without taking CS432



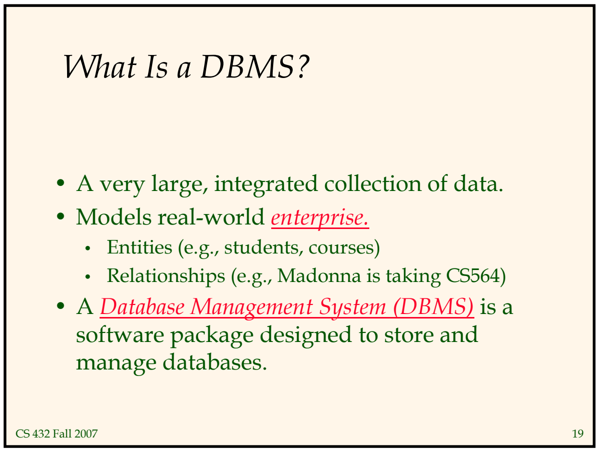
Is CS432/433 a lot of work?

- It depends!
  - Much of the material in CS432 is probably new to you
  - CS433 has substantial programming assignments
- Then why on earth should I take this course?
  - Intellectual argument
    - Big conceptual ideas
    - Meeting of theory and practice
  - Utilitarian argument
    - Many, many real applications (data management, data-driven websites, search engines,…)
    - Job market!



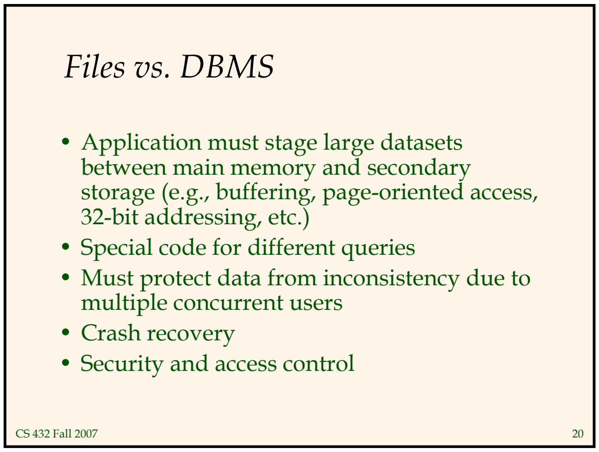
Reminder

- Complete academic integrity form (download from course homepage)
- Hand in on Monday!



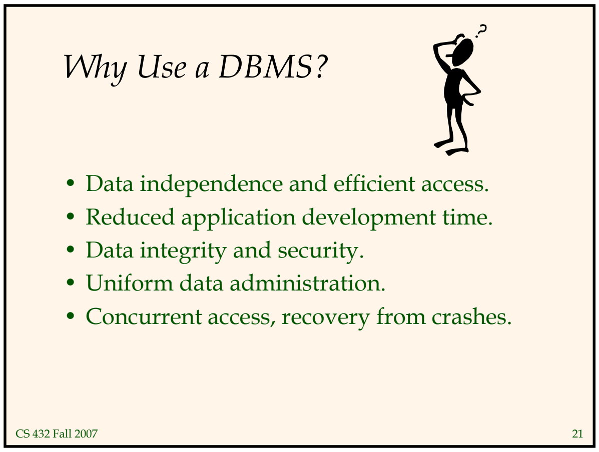
What Is a DBMS?

- 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.



Files vs. DBMS

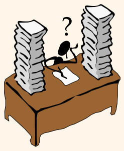
- Application must stage large datasets between main memory and secondary storage (e.g., buffering, page-oriented access, 32-bit addressing, etc.)
- Special code for different queries
- Must protect data from inconsistency due to multiple concurrent users
- Crash recovery
- Security and access control



Why Use a DBMS?

- Data independence and efficient access.
- Reduced application development time.
- Data integrity and security.
- Uniform data administration.
- Concurrent access, recovery from crashes.

Why Study Databases??



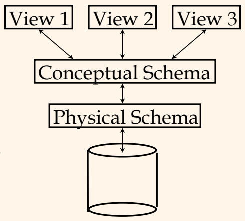
- Shift from *computation* to *information*
  - at the “low end”: scramble to webspace (a mess!)
  - at the “high end”: scientific applications
- Datasets increasing in diversity and volume.
  - Digital libraries, interactive video, Human Genome project, EOS project
  - ... need for DBMS exploding
-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

Data Models

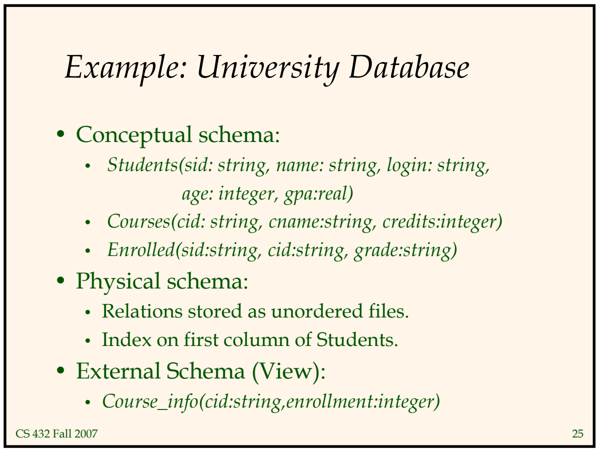
- A *data model* is a collection of concepts for describing data.
- A *schema* is a description of a particular collection of data, using the a given data model.
- The *relational model of data* is the most widely used model today.
  - Main concept: *relation*, basically a table with rows and columns.
  - Every relation has a *schema*, which describes the columns, or fields.

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.

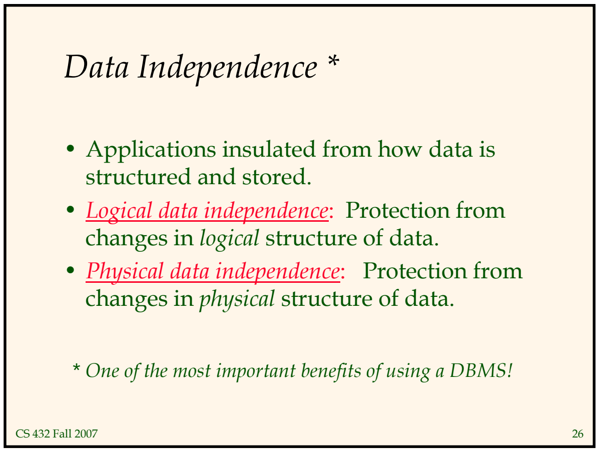


** Schemas are defined using DDL; data is modified/queried using DML.*



Example: University Database

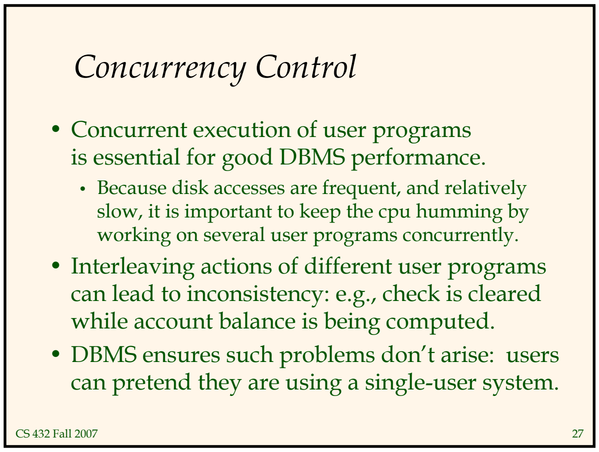
- Conceptual schema:
  - *Students(sid: string, name: string, login: string, age: integer, gpa:real)*
  - *Courses(cid: string, cname:string, credits:integer)*
  - *Enrolled(sid:string, cid:string, grade:string)*
- Physical schema:
  - Relations stored as unordered files.
  - Index on first column of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



*Data Independence **

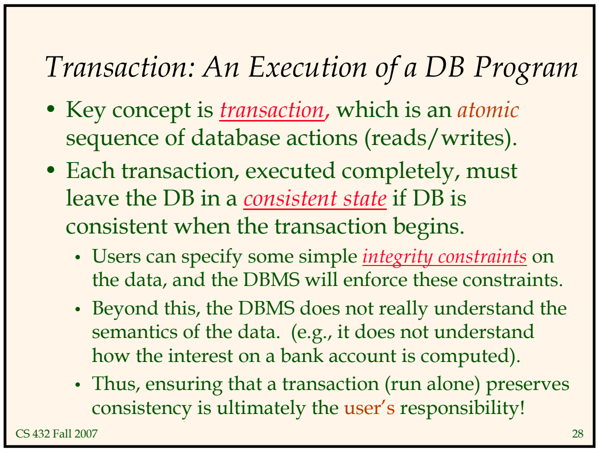
- Applications insulated from how data is structured and stored.
- *Logical data independence*: Protection from changes in *logical* structure of data.
- *Physical data independence*: Protection from changes in *physical* structure of data.

** One of the most important benefits of using a DBMS!*



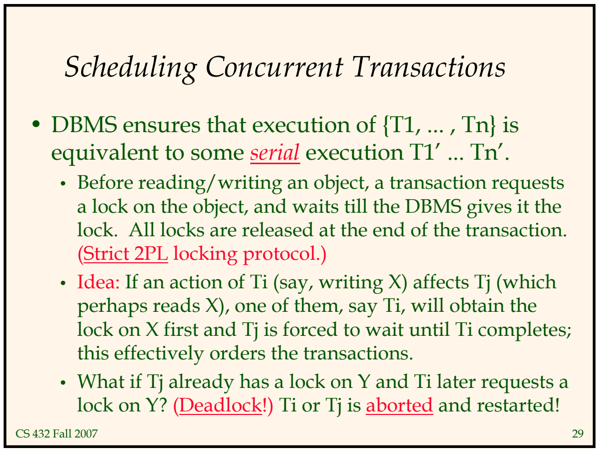
Concurrency Control

- 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.



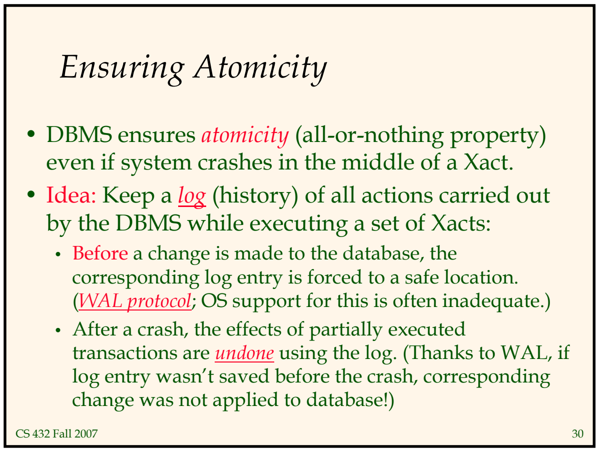
Transaction: An Execution of a DB Program

- 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!



Scheduling Concurrent Transactions

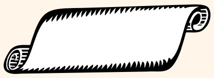
- DBMS ensures that execution of {T1, ... , Tn} is equivalent to some *serial* execution T1' ... Tn'.
  - Before reading/writing an object, a transaction requests a lock on the object, and waits till the DBMS gives it the lock. All locks are released at the end of the transaction. (Strict 2PL locking 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!



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!)

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.

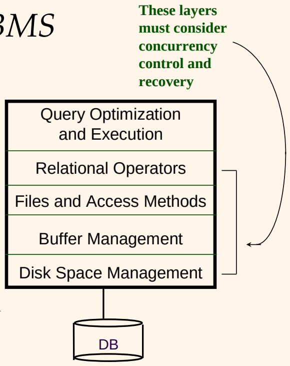
Databases make these folks happy ...

- 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!

Structure of a 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.



These layers must consider concurrency control and recovery

Query Optimization and Execution

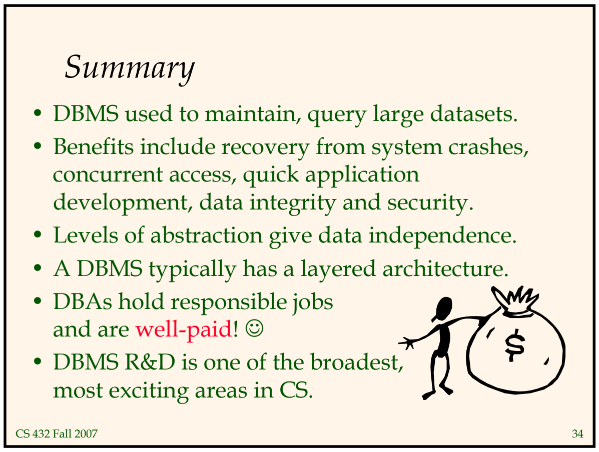
Relational Operators

Files and Access Methods

Buffer Management

Disk Space Management

DB



Summary

- DBMS used to maintain, query large datasets.
- Benefits include recovery from system crashes, concurrent access, quick application development, data integrity and security.
- Levels of abstraction give data independence.
- A DBMS typically has a layered architecture.
- DBAs hold responsible jobs and are well-paid! ☺
- DBMS R&D is one of the broadest, most exciting areas in CS.