Three types of information systems:

- Information-Retrieval Systems (IR)
  - Search large bodies of information which are not specifically formatted as formal data bases.
    - Web search engine
    - Keyword search of a text base
  - Typically read-only

- Database Management Systems (DBMS)
  - Relatively small schema
  - Large body of homogeneous data
  - Minor or no deductive capability
  - Extensive formal update capability
  - Shared use for both read and write

- Knowledge-Base Systems (KBS)
  - Relatively small body of heterogeneous information
  - Significant deductive capability
  - Typical use: support of an intelligent application.

Key DBMS issues:

- Efficiency issues:
  - Databases can be very large. Efficient access must be provided despite the size.

- Simplicity issues:
  - Many potential users are not sophisticated programmers, and so simple means of access must be available.
  - Means of more sophisticated access must also be available.

- Multi-user issues:
  - Concurrency
    - Several users may have simultaneous access to the database.
  - Access via views
    - Each user has a limited “window” through which the appropriate part of the database is viewed.
  - Authorization
    - The access privileges of each user will be limited in a specific way.

- Robustness issues:
  - Deadlock must be avoided.
  - A means of recovery from crashes, with minimal loss of data, must be available.

Data Model Evolution:

Model	Devel.	Use	Properties	Analogy
File management	1950’s – 1970’s	1950’s-	Low-level interaction. No data independence.	Assembly language
Navigational models	1950’s – 1960’s	1960’s -	Some data independence, but the model invites dependence. Requires procedural queries.	Procedural languages
Relational model	1970’s -	Late 1980’s -	Simple, easy to use for non-experts. Strong data independence. Standard nonprocedural query language (SQL). Excellent implementations exist. Limited expressive capability.	Declarative languages
Object-oriented models	1980’s -	1990’s -	Powerful expressive capability, but require substantial expertise for use. Popular in niche applications. Standardization not imminent.	Object-oriented languages
Object-relational models	1990’s	1990’s -	Attempt to integrate the simplicity of the relational model with the advanced features of the object-oriented approach. A new standardized query language (SQL:1999) is available, with SQL:20xx on the way. Many “high-end” commercial relational systems embody object-relational features.	?
Semi-structured models	1990's	2000's -	Attempt to integrate data management with markup languages, principally via XML.	?

The course focuses on the relational model. Why?

- The relational model is very widely used.
- The relational model provides a flexible interface which has components appropriate for users at all levels.
- A standard query language, SQL, is used with virtually all commercial products. Thus, applications have a high degree of portability.
- The relational model provides strong data independence: the external product is relatively independent of the internal implementaton.
- The relational model is dominant on microcomputers running Windows operating systems:
  - Office suites:
    - Microsoft Office: Access
    - Lotus SmartSuite: Approach
    - Corel Suite: Paradox
  - Other microcomputer products:
    - dBase
- All have proprietary graphical interfaces, and provide programming-style queries as well.

- The relational model has also been dominant on mainframe database servers, including but not limited to UNIX systems.

- Recently, many of these systems have become available for the PC UNIX system Linux. (Some are free!)
  - Oracle
  - Interbase 7 (Inprise, formerly Borland)
  - Sybase Adaptive Server Enterprise
  - Informix (now owned by IBM)
  - IBM DB2
  - PostgreSQL 7.4, 8.1 (public domain, very good)

- There are even some products from Sweden:
  - MySQL (GPL)
  - Mimer SQL (Upright Database Technology)

In the past, this course had used Microsoft Access.

Since 2002, PostgreSQL has been be used.

Why?

- The dialect of SQL which is supported under Access is much more limited than the dialects of comprehensive systems.
- PostgreSQL has matured greatly in the past few years.
- The Department of Computing Science has an SQL server, which is administered by the support staff.

The following system will also be used:

- Leap
  - A simple relational database system which uses the *relational algebra* as a query language.
  - Although not of commercial importance, use of this alternate query language is very beneficial pedagogically.

- Students are still free to use Microsoft Access, although it will not be discussed in class.

- All final versions of SQL assignments must run under PostgreSQL.

Database access models:

- SQL is the standard query language for the relational model.

- There are many *access models* which are built around SQL.

  - *Direct SQL:* Write and send SQL queries directly to the database system.

  - *Hosting SQL* within a programming language:

    - *Embedded SQL:* SQL statements are embedded in a host programming language, such as C. Generally requires preprocessing.

    - *Proprietary hosting languages:* (e.g., Oracle PL/SQL).

    - *Proprietary hosting systems:* (e.g., within Microsoft VBA).

    - *SQL / CLI ODBC:* A vendor- and OS-independent call-interface system (in principle) for SQL. Embedding may be in any of a variety of languages (C, C++ are the most common.)

- In this course, we will use both direct SQL and ODBC.

A Rough Course Outline:

- Introduction to DBMS's

- Knowledge Representation for DBMS's (10%)
  - Entity-Relationship Modelling
  - The Relational Model

- Query Processing and Constraints (40%)
  - Query Languages
    - Relational Algebra
    - Relational Calculus
    - SQL
  - Views
  - Database Programming and the CLI/ODBC Interface
  - Dependencies and Normalization

- Implementation Issues (40%)
  - Physical Database Design
  - Database System Architecture
  - Query Optimization
  - Transaction Processing and Concurrency Control
  - Recovery
  - Security and Authorization

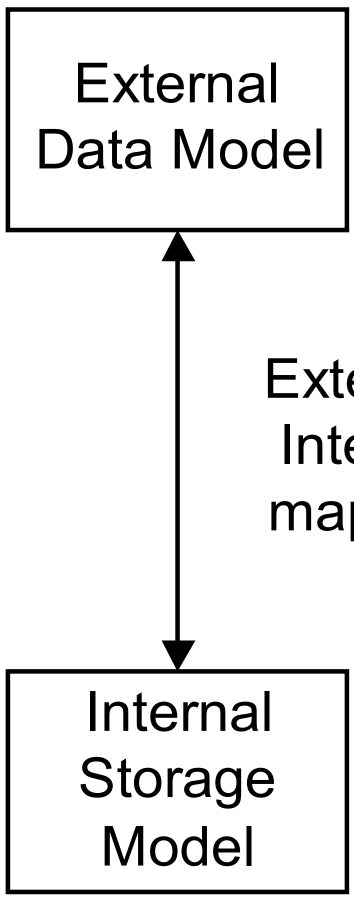
- Special Topics (10%)
  - Object-Oriented and Object-Relational Approaches

Database System Architecture:

- Early approach: one-level

- The user interacted directly with the storage model.
- Analogy: assembly-language programming
- Disadvantages:
- Impossible to use for non-experts.
- Difficult to use and error-prone even for experts.
- Evolution of storage model, or migration to a new architecture, requires a total rebuild of all application programs.

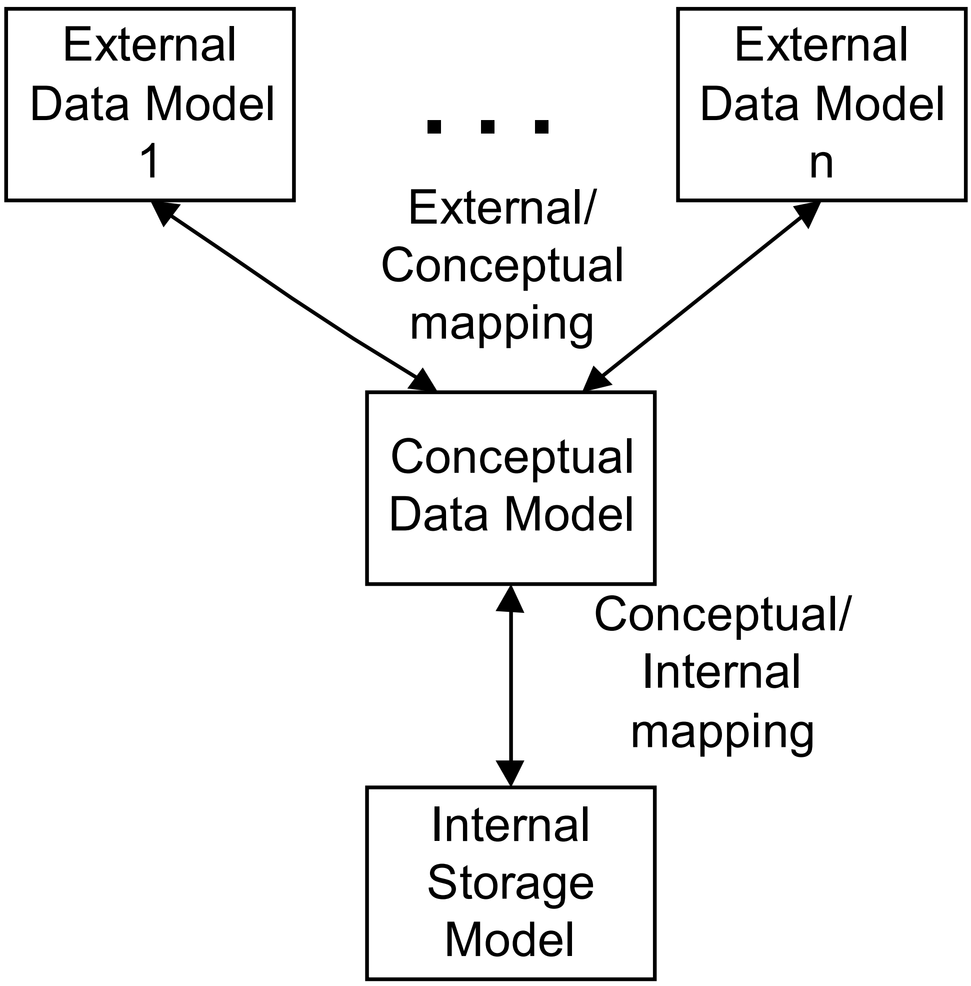
A more modern approach: two-level



- Advantages:
  - Internal model and/or target architecture may be changed without requiring a rebuild of applications.
  - Analogy: A high-level programming language.

- Disadvantages:
  - There is a single external model for all.

The ANSI/SPARC three-level architecture:



- Advantages:
  - Provides two levels of independence:
  - The internal storage model is isolated from the conceptual component, as in the two-level architecture.
  - Many external views are possible.
  - The conceptual model may be re-designed without requiring rebuilds of application programs.

Data independence:

- <u>Data independence</u> refers to the idea that a more internal level of a database system may be re-engineered, or moved to a different architecture, without requiring a total rebuild of the more external layers.

- The ANSI/SPARC architecture provides two levels of data independence.

- It is often, however, something of an ideal, even with the systems of today.

- Usually, in a relational system, both the conceptual schema and the external schemata are relational.

- Still, the conceptual schema is often *designed* using a more general tool than the relational model.