Data Storage and Retrieval

Lecture 2

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What is Data

data	52
information	J Smith’s score on the final exam is 52%
knowledge	I’ve passed!

What is a Database

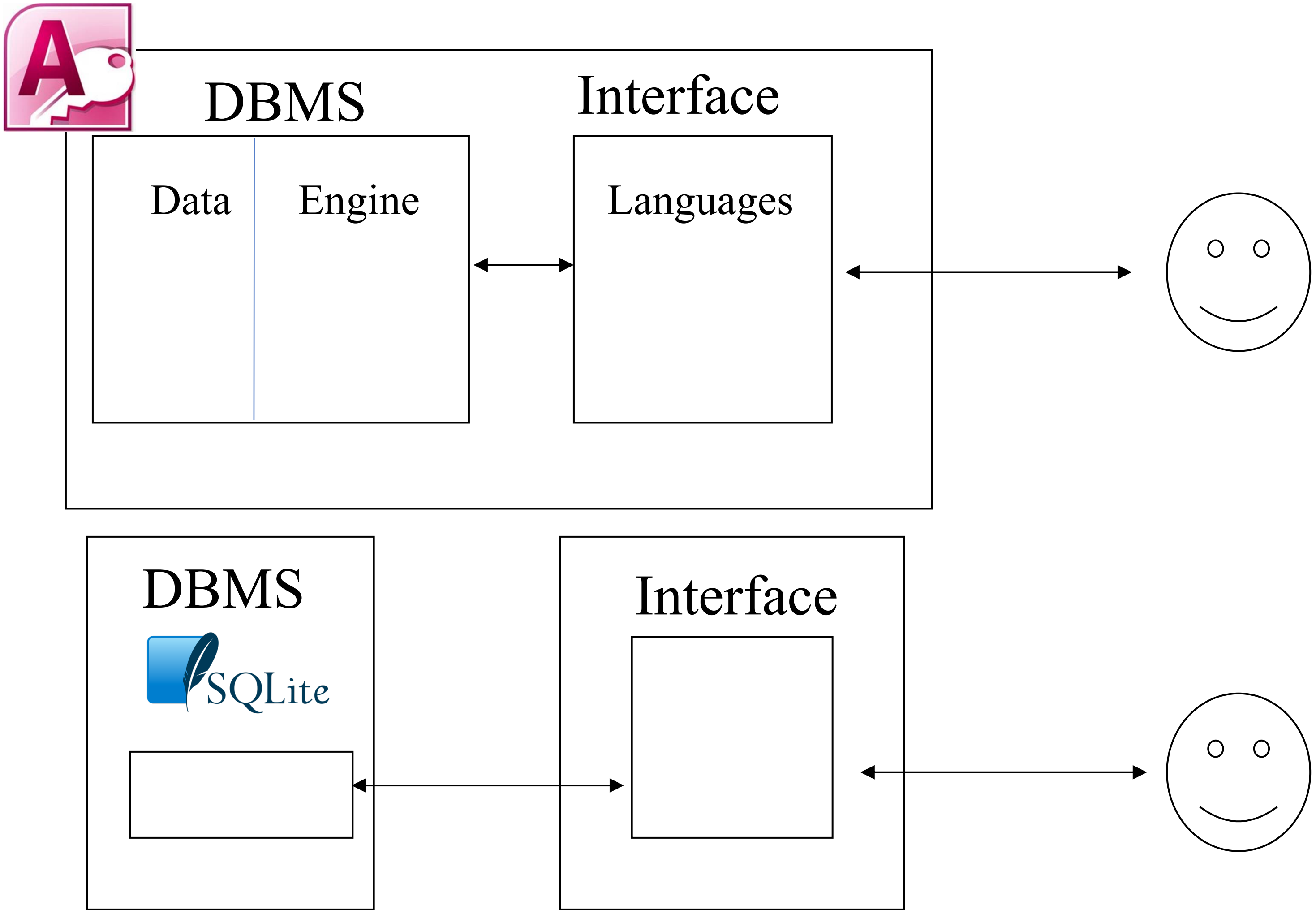
- A database (abbreviated *DB*) is an entity in which data can be stored in a **persistent** and **structured manner**, with as **little redundancy** as possible
- A database centralises users access to data, which they can view, enter, or update
    - within the limits of the access rights granted to them
- It is viewable (and writable) by many users at the same time (**controlled concurrent access**)

What is a Database Management System (DBMS)

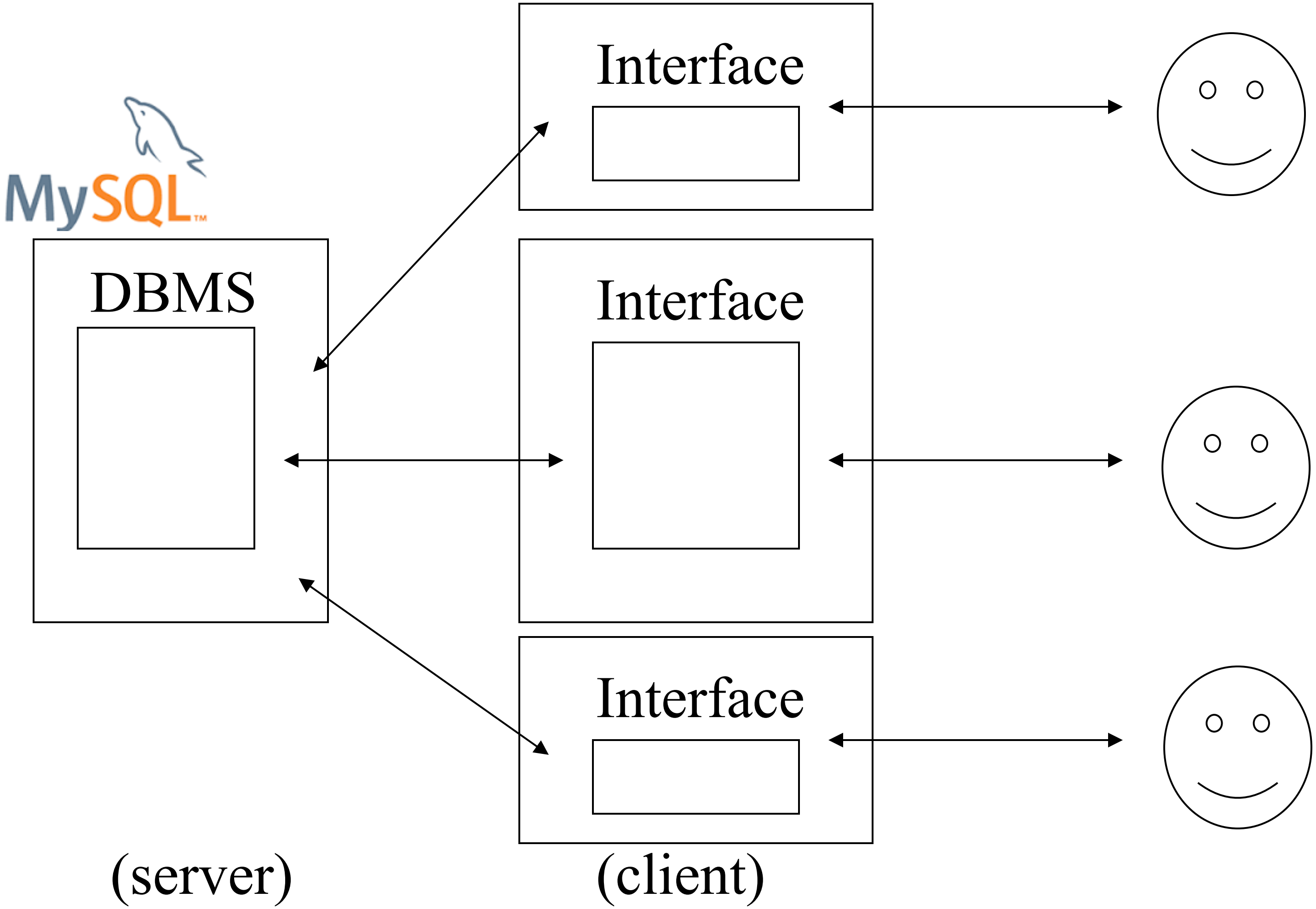
- The DBMS is a suite of services (software applications) for managing (one or more) databases, which involves:
  - enabling simple access to data
  - allowing multiple users access to the information
  - manipulating the data found in the database (inserting, deleting, editing)

- It also controls the **security** and **integrity** of the database
  - The DBMS accepts requests for data from the application program and instructs the operating system to transfer the appropriate data
- Varying forms of data access may be supported by the DBMS

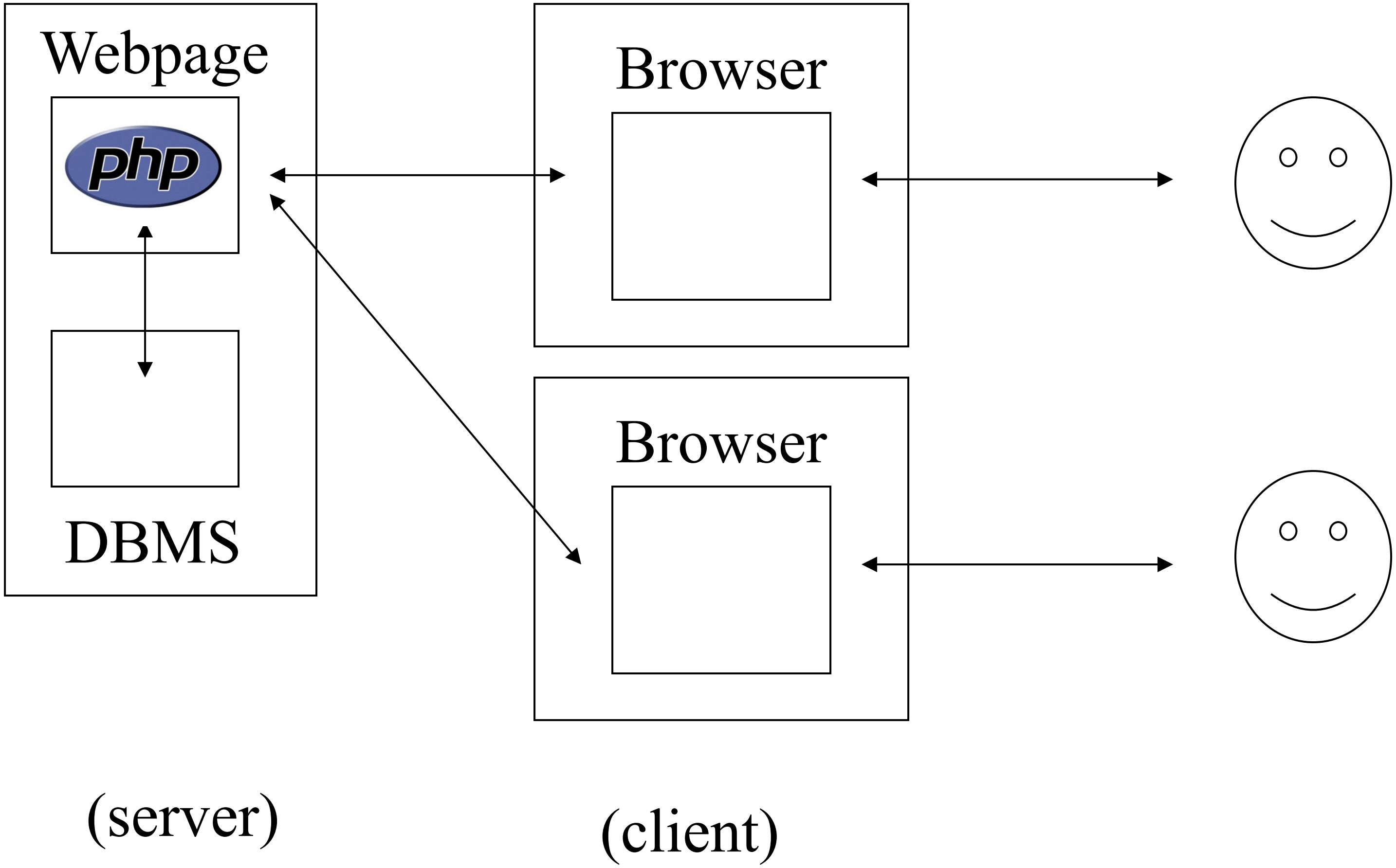
Forms of Data Access: Local Database



Forms of Data Access: Client / Server

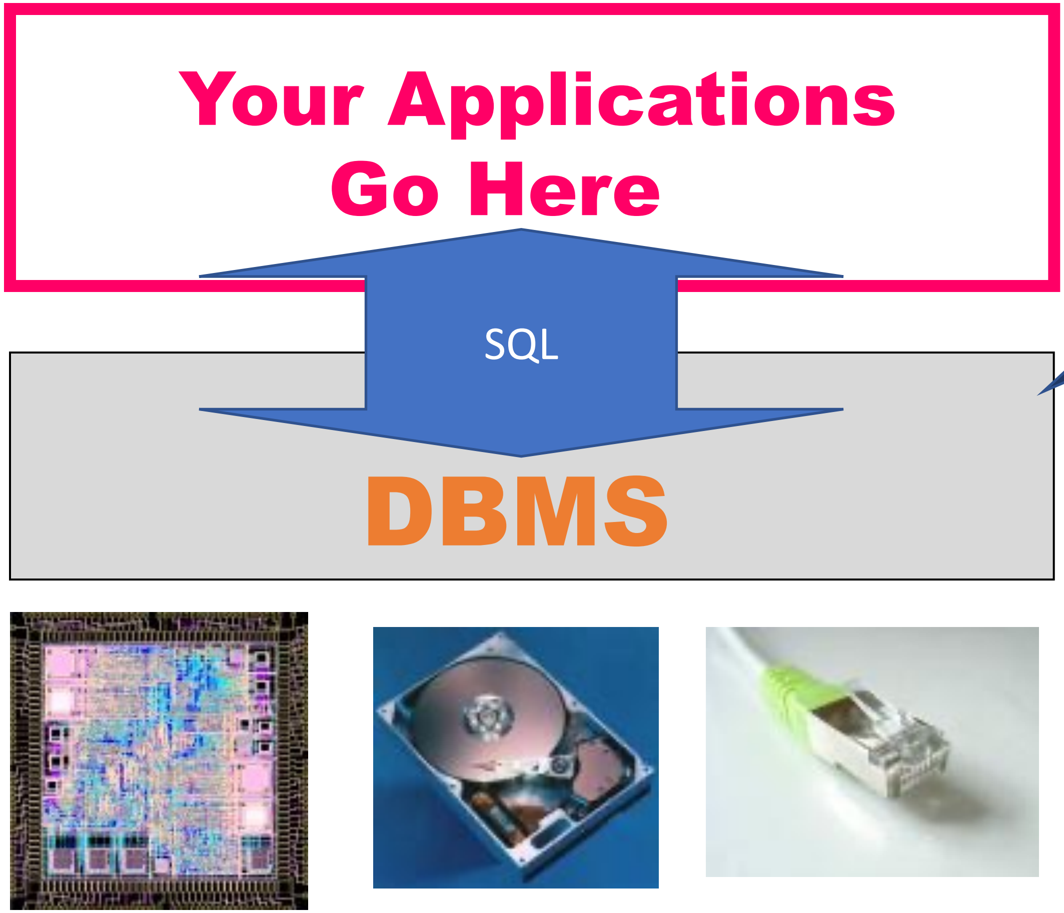


Forms of Data Access: Web-based



Forms of data access – Web-based

Database Management Systems (DBMSs)



Your Applications Go Here

SQL

DBMS

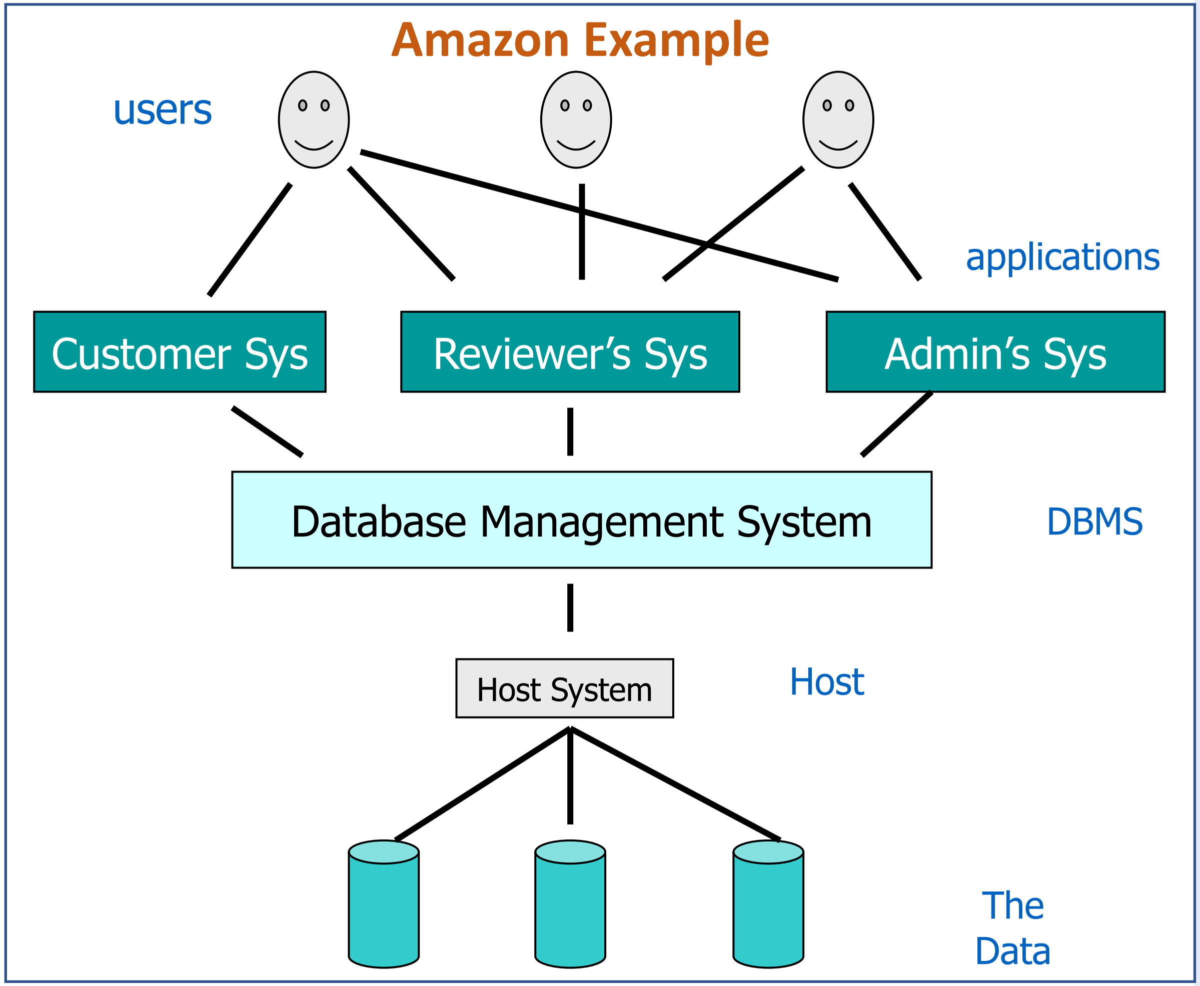
Raw Resources (bare metal)

DBMS abstractions allow this interface to be cleanly defined and this allows applications and data management systems to be implemented separately.

MS Access
MS SQL
mySQL
PostgreSQL
Oracle

Main Components of a Database

- Users
- Applications
- DBMS
- The Data (& the Database)
- The Host system



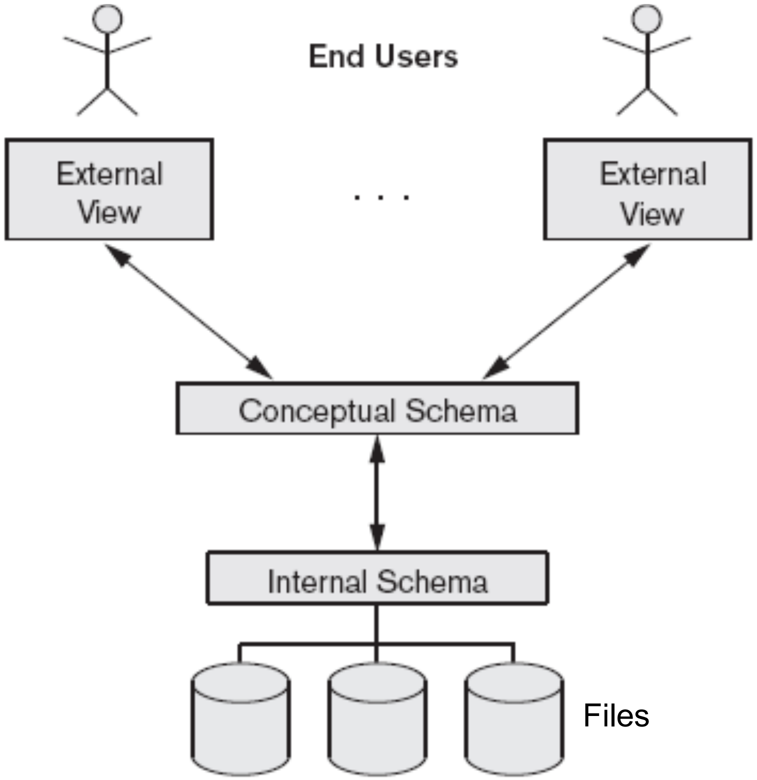
DESIGNING DATABASE SYSTEMS

Who will use this database?

What will they see?

What data will we store?

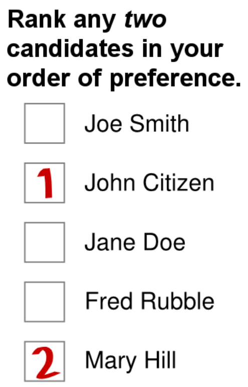
Database Systems: Three-Level Architecture



- We can think about a database system at three levels, called “schemas”:
  - External: how users view data
  - Conceptual: how programmers model and implement the database in the database
  - Internal: how the DBMS stores the data
- In designing a database, we take an **external schema,** and *design* a corresponding **conceptual schema.** The DBMS handles the **internal schema,** with hints from the designer.

Three-Level Architecture: Election Example

External Schema



Rank any *two* candidates in your order of preference.

□ Joe Smith

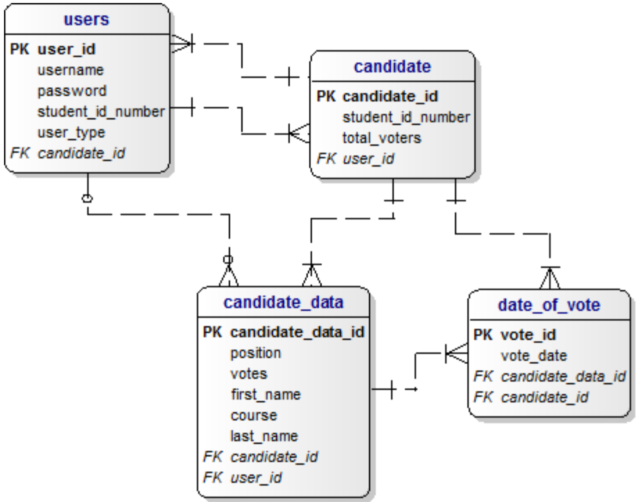
1 John Citizen

□ Jane Doe

□ Fred Rubble

2 Mary Hill

Conceptual Schema



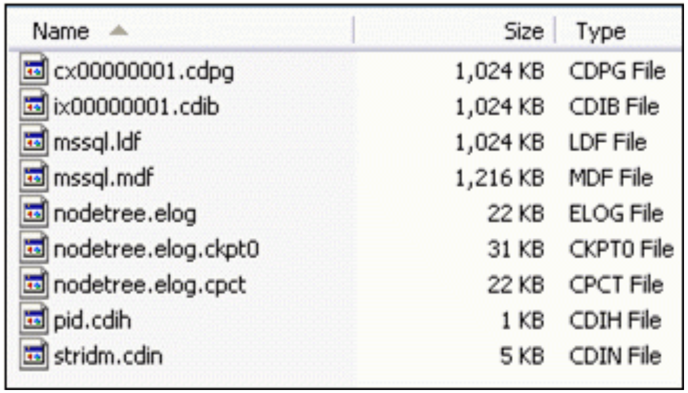
users
PK user_id
username
password
student_id_number
user_type
FK candidate_id

candidate
PK candidate_id
student_id_number
total_voters
FK user_id

candidate_data
PK candidate_data_id
position
votes
first_name
course
last_name
FK candidate_id
FK user_id

date_of_vote
PK vote_id
vote_date
FK candidate_data_id
FK candidate_id

Internal Schema



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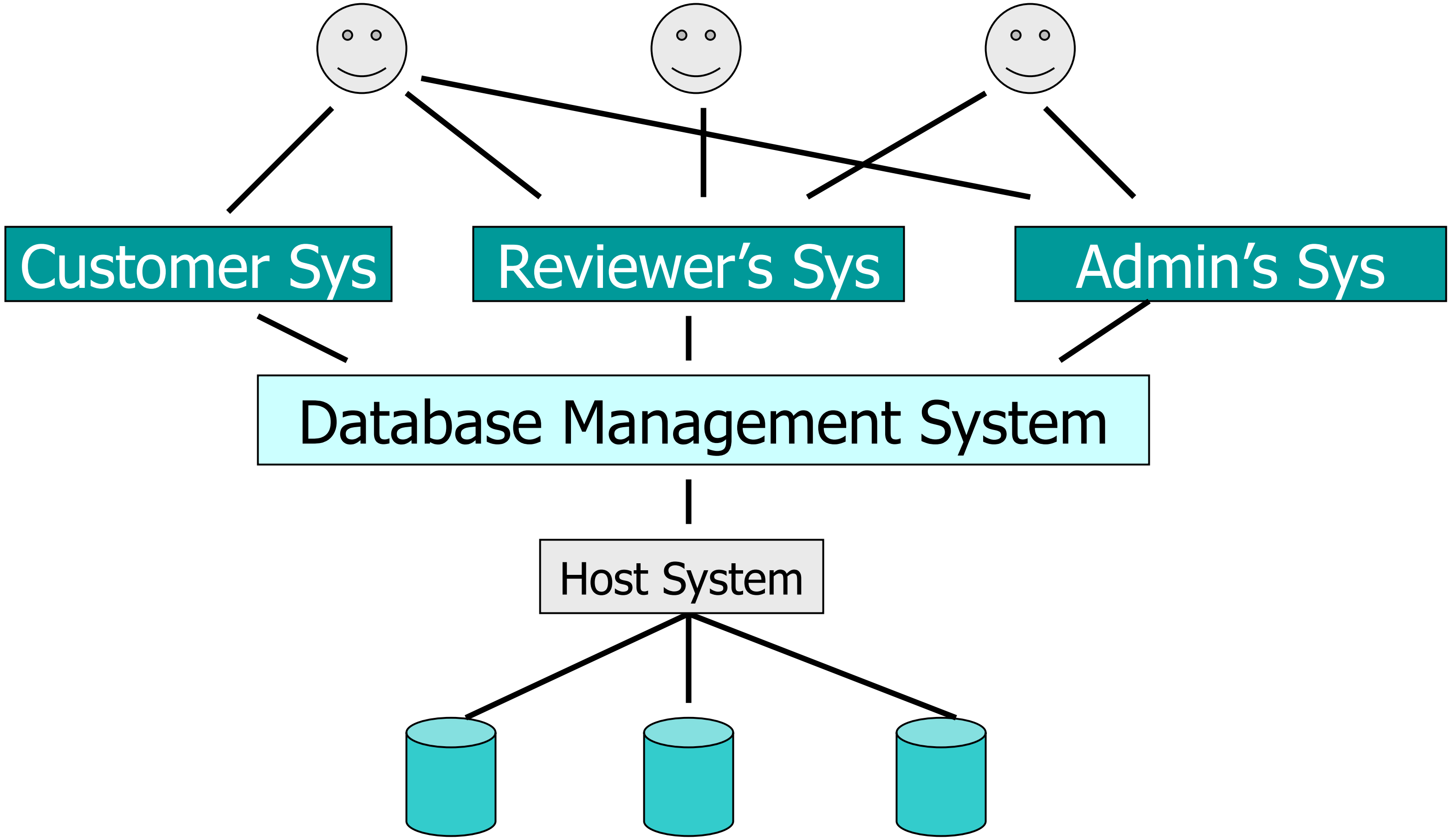
mssql.mdf	1,216 KB	MDF File
nodetree.elog	22 KB	ELOG File
nodetree.elog.ckpt0	31 KB	CKPT0 File
nodetree.elog.cpct	22 KB	CPCT File
pid.cdih	1 KB	CDIH File
stridm.cdin	5 KB	CDIN File

Example: Amazon

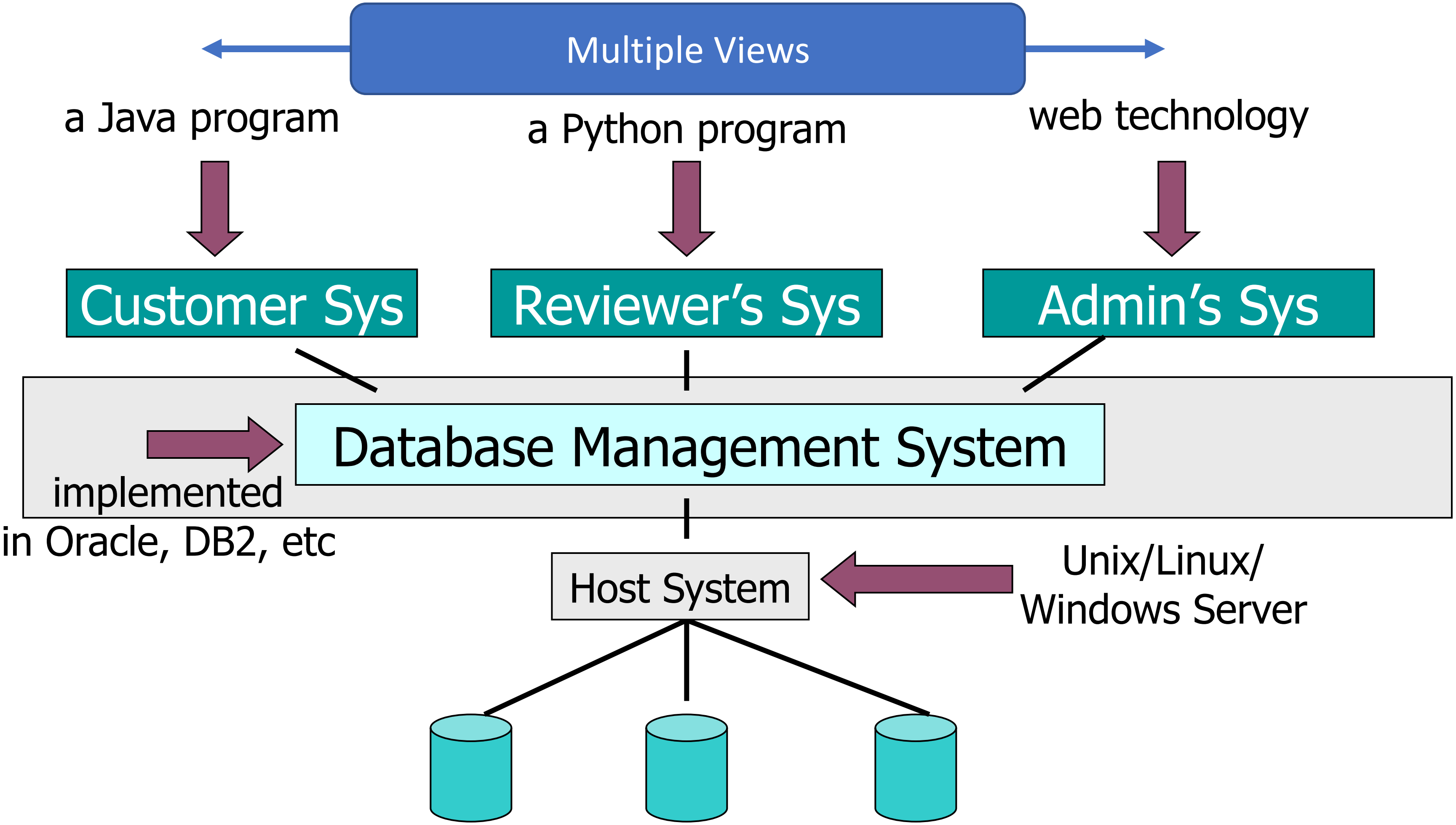
- Stores data about products and their related details (name, price, colour, product code…….)

- A customer can view products, search products, buy a product and rate reviews
- An admin person can upload products & edit product info
- A reviewer can write reviews
- ……….

An Example Database System: Amazon



An Example Database System: Amazon



Multiple Views

a Java program

a Python program

web technology

Customer Sys

Reviewer’s Sys

Admin’s Sys

Database Management System

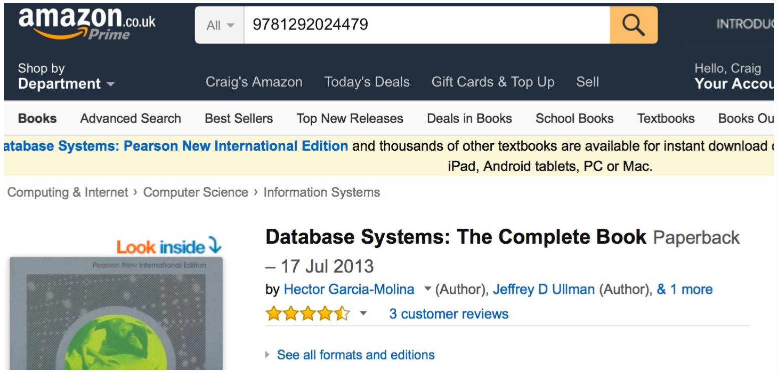
implemented in Oracle, DB2, etc

Host System

Unix/Linux/ Windows Server

Three-level Architecture: Amazon Example

External Schema



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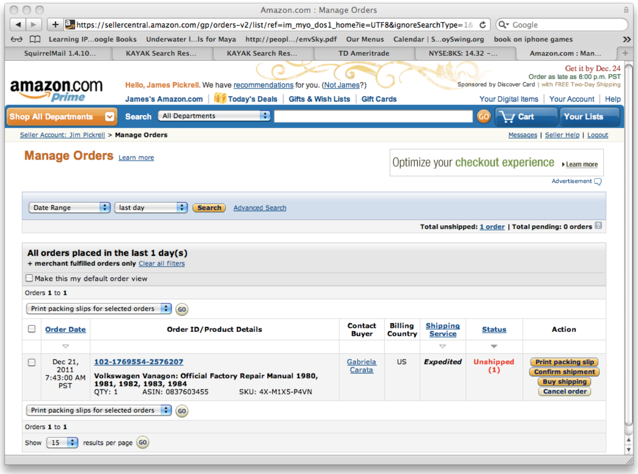

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Get it by Dec. 24
Order as late as 8:00 p.m. PST
Sponsored by Discover Card | with FREE Two-Day Shipping

Hello, James Pickrell. We have recommendations for you. (Not James?)

Seller Account: Jim Pickrell > Manage Orders

Manage Orders

Optimize your checkout experience

Date Range: last day

Total unshipped: 1 order | Total pending: 0 orders

All orders placed in the last 1 day(s)
+ merchant fulfilled orders only

□ Make this my default order view

Orders 1 to 1

Print packing slips for selected orders

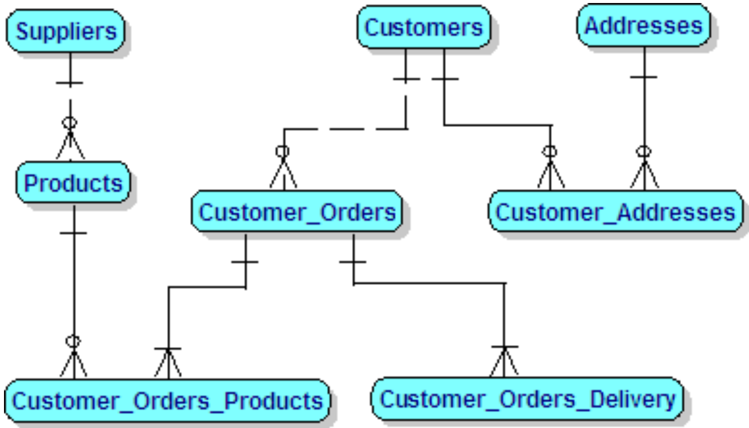
□	Order Date	Order ID/Product Details	Contact Buyer	Billing Country	Shipping Service	Status	Action
□	Dec 21, 2011 7:43:00 AM PST	102-1769554-2576207 **Volkswagen Vanagon: Official Factory Repair Manual 1980, 1981, 1982, 1983, 1984** QTY: 1 ASIN: 0837603455 SKU: 4X-M1X5-P4VN	Gabriela Carata	US	*Expedited*	Unshipped (1)	Print packing slip Confirm shipment Buy shipping Cancel order

Print packing slips for selected orders

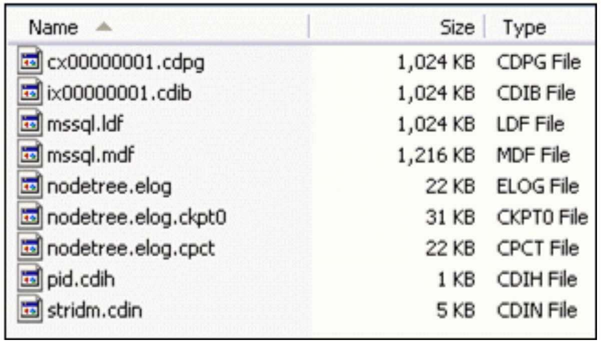
Orders 1 to 1

Show 15 results per page

Conceptual Schema



Internal Schema



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nodetree.elog.cpct	22 KB	CPCT File
pid.cdih	1 KB	CDIH File
stridm.cdin	5 KB	CDIN File

Summary

- Databases are used by people… to perform particular tasks, obtain views on the data
- Databases therefore need interfaces to allow people access to the data
- Many people may need to access the same database
    - Web pages / mApps are just one way of implementing an interface to a database
- We must consider the needs of the users when designing a database … our next focus.
- Database design: taking external schemas to identify the conceptual scheme. The DBMS will handle the internal schema

Database Design Lifecycle

- Requirements analysis
  - User needs; what must database do?
- Conceptual design
  - High-level description; often using E/R model
- Logical design
  - Translate E/R model into (typically) relational schema
- Schema refinement
  - Check schema for redundancies and anomalies
- Physical design/tuning
  - Consider typical workloads, and further optimise

Today

Lecture 3

Database Design

- How do we go about designing a database from scratch?

Firstly Some Terminology

- A **data model**:
  - Description of the objects that could be represented by a computer system together with their properties and relationships
  - Typically "real world" objects, e.g. products, suppliers, customers, and orders

WE DO THESE IN ORDER!

- A **schema**:
  - Description of how a database can be designed to represent a *data model*
  - *E.g. tables with columns definitions: Suppliers have names, addresses, etc*
- A **database**:
  - Instance of a schema with corresponding data
  - E.g. Amazon’s suppliers/customers/orders.

Database Design

- Creating a database involves:
  - **(1) Capturing user requirements**
  - **(2) Representing them in a MODEL**
  - **(3) Converting the model into a SCHEMA**
  - **(4) Implementation of the schema on a DBMS**

- Many different ways to implement a database
- Many different models and tools you can use
  - All require the stages above

People Involved

- Users
  - access the data only (casual vs. expert)
  - need an effective means of accessing the data
- Database designers:
  - specify schema and content
- (web) Application developers:
  - extend functionality; provide means of data access for a particular application
- Database administrators
  - Maintain accuracy, speed and integrity
- Web-site designers

All involved in the design process need to think about the final users

1 – Identifying **User** Requirements

- Talk to client
  - E.g. CEO of the bank, the chief of BT…..
- Talk to customers
  - End users of the system
  - Those that might view the data
- Talk to different levels of users
  - Admin, programmers, technical staff….
  - People who might need to add/update/query data

Users

1 – Identifying **Data** Requirements

- Write down all the different ‘**THINGS**’ that you need to store data about
  - Customers, branches, accounts…..
  - What do we need to know about these things? i.e., what are the **attributes** that describe the things?
- Take note of any **relationships** between the things talked about
  - All customers must belong to one branch only
  - All accounts must only have one account number

Organising into Data Objects

Customer

- Name
- address
- overdraft limit
- address
- ID

Branch

- name
- address
- manager
- ID

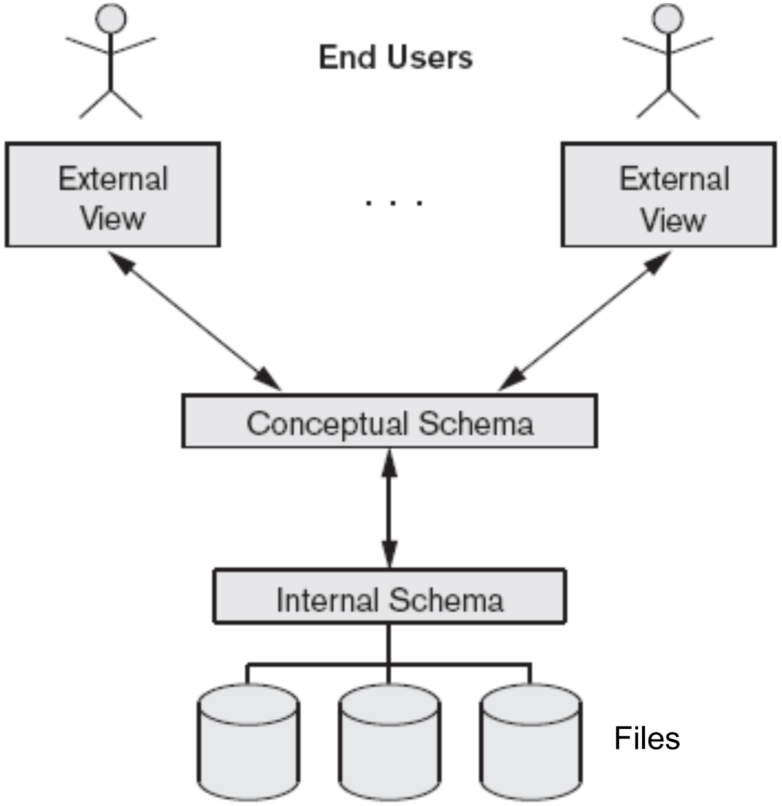
This could start to get quite complicated if there are lots of things to store information about in the database

2 – Data Modelling

- We need a way to represent all the data we have captured relating to what we want to store in our database
  - Helps us during design and implementation
  - Helps to communicate ideas to other members of the team

Remember the three-level Architecture?

- *External:* how users view data
- *Conceptual*: how programmers plan and implement the database in the database
- *Internal*: how the DBMS stores the data



Data Modelling
External → Conceptual → Internal

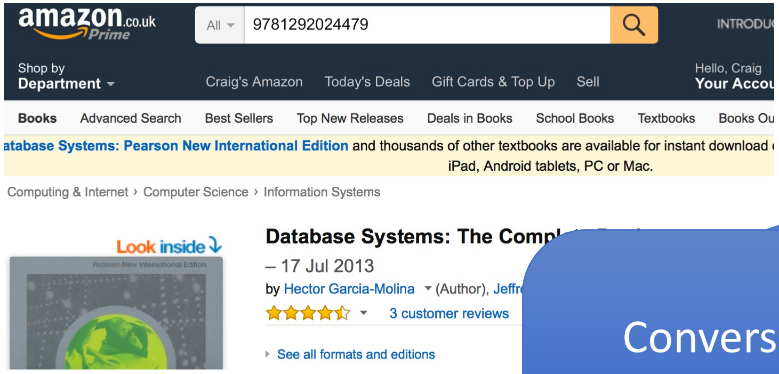
- We develop a **conceptual** data model, based on talking to users and considering existing external views
  - High-level description of data, i.e. close to their real world (**external**) meaning - entity types, attributes & relationships

- The conceptual data model can then be converted into a **conceptual schema** describing how data is stored
  - For instance as tables and records
  - These are **Implementation-level/logical Data Models**

- **Low-level** or **Physical Data Models** describe how data is **internally** stored on the computer:
  - files, storage structures, etc.
  - This is handled by the DBMS, with *occasional* help from the DBA

Back to the Amazon Example

1. External Schema (aka User Needs)



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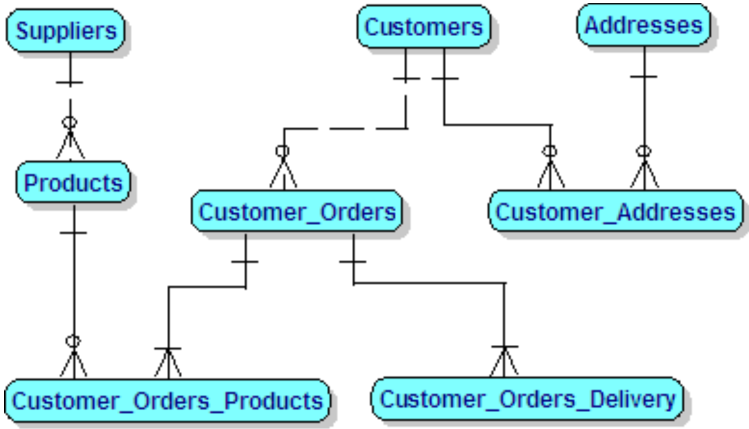
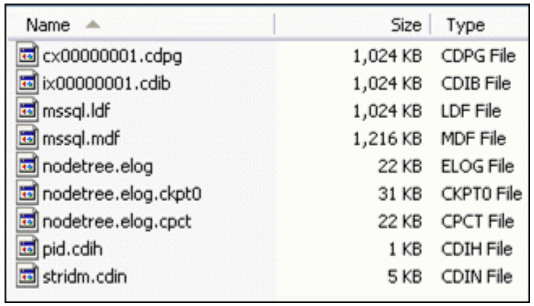
2. Conceptual *Model*



Conversion depends on Database Model used by DBMS

4. Internal Schema



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nodetree.elog.ckpt0	31 KB	CKPT0 File
nodetree.elog.cpct	22 KB	CPCT File
pid.cdih	1 KB	CDIH File
stridm.cdin	5 KB	CDIN File

3. Implementation Model: Conceptual *Schema*

```
Supplier(ID, Name, Address, Postcode)
Product(ID, Supplier, Title)
Customer_Orders_Products(
…
```

What are the *concepts* involved?

How can we represent these in a database?

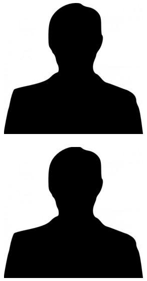
Chosen by DBMS

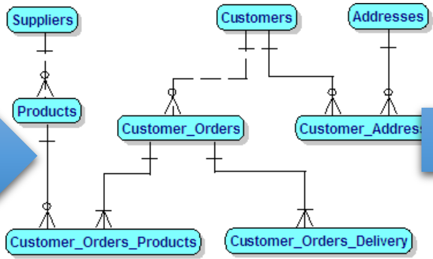
External

Conceptual Data Model

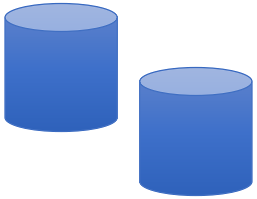
Implementation/ Logical Model

Physical Model





```
Suppliers(ID, Name, Address)
Products(Id, Supplier, Title)
Customer_Orders_Products()
…
```



Conceptual **Schema**

Internal **Schema**

Real World (users)

Database Designer

DBMS

Why Use Data Modelling?

A **data model** is:

- An abstract representation of the data we wish to store
- A convention for the specification of the logical structure of real-world information

The choice of **data model** depends on the type of database…

- We will use the Entity Relationship Model
  - Entities, relationships and attributes (Chen, 1976)
- …which easily maps to the Relational DBMS

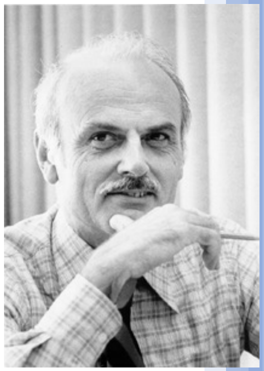
Once we have a conceptual data model for a problem in terms of an *Entity Relationship diagram*, we can easily generate a conceptual schema for the database

Relational DBMS

- In older DBMS, the code for data management and application were all tangled together
  - Hard to modify, hard to generalise
  - Data manipulation code written with little *abstraction*

- Instead many modern DBMS follow the *relational* model (RDBMS)
  - Data is stored in relational *tables*
  - It links very well with **Entity/Relationships (E/R)** form of Conceptual Data Modelling

- E/R modelling and corresponding Relational DBMS will be the focus of the next lectures



E.F. Codd
1923-2003

Next Lecture: E/R Modelling

1. We identify THINGS - entities
   - these are typically "real world" objects such as products, suppliers, customers, and orders
2. We identify what we know *about* each kind of THINGS
   - Attributes of an object, such as name, address
3. We identify relationships *between* types of THINGS
   - One bank branch has many customers
4. We follow rules to make a database schema

Next Lecture: E/R Modelling

- How to construct an ER diagram
- More on relationships and attributes