Table of Contents

In the first unit, we had a brief intro to some database terms. In this unit and the next few units we will try to explain these types of terms in a bit more depth. This document will seem rather dry, but go though it and come back next week and read it again. After a reading or two (or three) you should be able to understand these terms in context.

1. Terms

Application
Attribute
Base table
Business entity
Client
Column
Data independence
Data integrity
Data type
Database
DBMS
Entity instance
Entity set
Normalization
Primary key
Query optimization
Relation
Relational database
Relationship
Row
Schema
Table
Tuple
User interface
Virtual table

2. Relations and databases

A **database** is a collection of related data organized for some purpose. Some people will use the term database for any type of storage including paper files. Most people will assume that the database is a computer system managed by a collection of programs called a database management system (dbms).

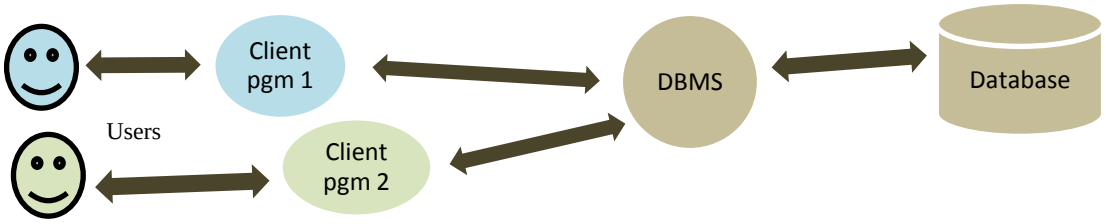
A **relational database** stores data in structures called **relations** which can be thought of two-dimensional tables. A relation is a mathematical concept- but we can think of it as a table.

3. Interface, client, application

These are terms that can have several different definitions. The way I will use them is that the client is a general purpose program that lets us work with the database. The client lets us enter SQL statements and see the results. The client lets us build database objects such as tables. We can also run scripts via the client. But as you will see over the semester, coding SQL statements is not the appropriate way for most end-users to get results from a database. We do not expect students enrolling in classes to do this by coding Insert statements. For an end-user we want to provide a more specialized interface- probably using menus and text boxes and buttons. The way an end-user interacts with a database is generally through a specialized application that provides an interface. We can have an application that handles student enrolling in classes and a different application that allows staff to build the semester schedule of classes. The application program might use SQL statements to work with the database. In this class, we do not build the application level software. We work at the SQL level.

4. DBMS features

The **DBMS** is a collection of programs that manage the database. When we issue an SQL select statement, we enter it in a client program which sends the SQL statement to a translator program which changes our text into a query that can be processed. Then another part of the dbms takes that request and gets the data from the physical data in storage. Now the DBMS send the data back to the **client** program which may need to do some additional steps to format it for our display.



4.1. Physical data independence

One of the advantages of using a dbms is that the end-user and, to a large extent, the developer does not need to know how the data is stored physically on the persistent storage devices - generally hard drives. This is more in the realm of the database administrator (dba). For example, the data stored on the disk might be organized in a particular physical order to make retrieving data more efficient. The SQL to retrieve the data does not logically depend on that ordering. If the physical order of the data in persistent storage is changed, the SQL application does not need to be changed. If a developer wants to store a date value, she should not be concerned about how the data value is sorted in terms of the bit patterns. In reality, a developer often has to know something about the storage of data to write the most efficient queries and to decide on the proper data types to use.

4.2. Logical data independence

With logical data independence we are talking about the ability of the dbms to access data even if the organization of the underlying data is altered. For example, suppose you define a table that stores the student's street address and their zip code as two attributes. It should not make any difference to your code whether the data is stored with the address first in the persistent storage or the zip code first. In a relational database the order of the attributes in the table can have no logical significance. Suppose I decide to add a new column to the zoo table and allow that column to be null; your SQL code for A01 should still work.

4.3. Data integrity

The dbms is responsible for protecting the integrity of the data. This has several aspects. If the developer defines an enrollment date as a date value, the dbms should reject an attempt to store a value such as Feb 31, 2009 since

that is not a valid date. If the developer defines an attribute as an integer number between 1 and 15, then the dbms should reject an attempt to store a value such as 51 since it is out of range.

Systems vary in the proper response in some situations. Suppose the developer defines a last name attribute as a string field with a maximum of 15 characters. What should the dbms do with an attempt to enter a value that is longer than 15 characters? One approach is to reject that value and another approach is to store only the first 15 characters of that value.

4.4. Query optimization

It might be that our query is rewritten in some way by the translator program to make it more efficient. This is one of the jobs of the dbms (optimization) and the dbms should not change the logic of your request. The dbms generates a plan of execution as to how it will get the data from the tables. For our first sets of queries this will be a pretty simple plan- but as we work with queries that get data from several different tables and as our tables get bigger, this execution plan will become more important. We do not focus on query efficiency in this class as our job to create a query to return a correct result set; but in a database with tables with thousands of rows of data, efficiency is much more important.

4.5. Concurrency control

In our class assignments you will be the only user accessing your tables; in more realistic situations a dbms will have to handle multiple users working with the data at the same time. For example, we might have two students trying to enroll in the last open seat for a class. The dbms handles this but the way that a developer writes code can affect this situation. This feature, concurrency control, is only briefly discussed in this class. We discuss this topic more in the database programming classes.

4.6. Database security

Database security- in terms of user access, is handled by authentication and authorization. Authentication means identifying a user- generally via a login and password. Authorization deals with a set of privileges that the user has been granted.

When we log into the database, the dbms checks our user name and password to see if we have the right to login. Then it checks what types of work we are allowed to do- can we create tables? Or just read tables that already exist? Can we change the data in the tables?

4.7. Backup and recovery

This is another topic that is more dba oriented. Our tables for class are not storing mission critical data (except for your turning in assignments on time). We have a set of SQL statements to build the database and load the tables with preset data. So you can rebuild the database if needed. Hopefully you will save your scripts for the queries you create.

But for an online real time system, backup and recovery is critical; CCSF would be in trouble if the enrollment system failed and we had to ask students to enroll in their classes again. You would not be happy if your bank's database failed and you had no way to determine the status of your bank accounts. A major dbms will include features to do backups of data while the system is running and help with recovery of the data. For a mission critical system this has to be a lossless recovery- not a backup from the last day of the previous month.

5. Business entities and database components

When we use a database in a company there is always some purpose for which the database was constructed. A **business entity** is something for which we want to keep data. Examples of entities are: students, customers, books in a library. For a business entity, the pieces of data we stored can be called **attributes**. Examples of

attributes for a book in a library may include the book title, the ISBN, the number of pages, the author(s), the year published, purchase price, and publisher. One of the early steps in designing a database is to decide on

- the entities that are important to our company
- the attributes we need to save for these entities
- what type of data the attributes store
- how the data values for one entity are related to other entities
- what rules we have about the data

For example a student at CCSF needs to give us a state of residence so that we can calculate tuition correctly. So the state of residence is a required attribute. But people should be able to register as students even if they do not have a phone number; the phone number is not required. Then we might need to decide if we should store more than one phone number for a student- do we need multiple values?

The attributes are stored in **columns** and each **row** (**tuple** is the term used in more theoretical discussions of databases) in the table includes the attribute values for a specific entity (an **entity instance**). A column in a table has a name and a **data type**. For the library-book example, we could have the following
book title (character), ISBN (character), page count (integer), year published (integer), purchase price (number allowing a decimal point), publisher (character).

We can also define rules for the data, called **constraints** which limit the data values that can be entered. We might want a rule that the purchase price cannot be a negative number.

The collection of all of the rows in the current table is called the **entity set.** An individual row can be considered an **entity instance**. We need to be able to distinguish the individual rows in our table, so each table should have a **primary key**- an attribute or collection of attributes that uniquely identifies that entity instance. No two rows in the same table can have the same value for the primary key and no row can be missing a primary key value.

Traditional **normalization** rules say that each attribute should store a single value; this is often interpreted as storing a single simple scalar value. Normalization rules say that all attributes in a row should be determined by the primary key of that entity instance. We will come back to the concept of normalization later in the semester.

Part of normalization is deciding how many tables we have and what data is stored in each table. When we store data in tables, we need to organize it efficiently. Often this means that we split the data into several tables and then build **relationships** between the tables.

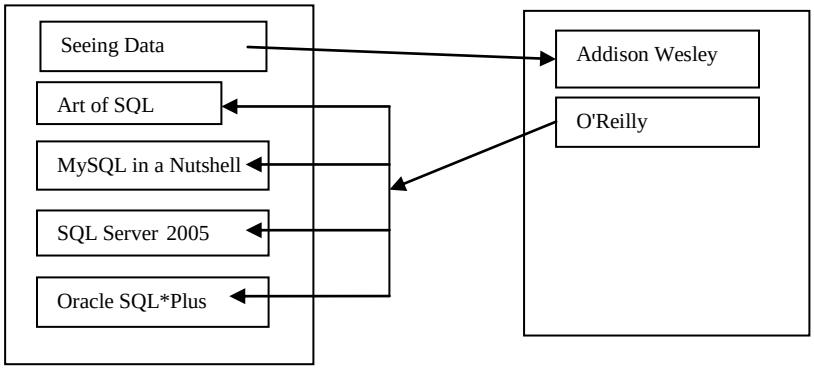
The term **base table** refers to a table that we define with the Create Table statement. Base tables hold data values. The term **virtual table** refers an in-memory data structure that appears to hold the data.

6. Relational databases and relations and relationships

The relational database model has been used for more than 40 years (a very long time for a computer model). The relational database model was developed by Dr Codd in the late 1960's and is the underlying model for the majority of database systems in use.

In the relational model, we think of the data as being stored in **tables** (relations) - with data being stored as a series of rows and columns. A relation stores a set of values that are related to the same entity. The attributes for a book in our library (book title, ISBN, page count, year published, purchase price, publisher) are related to the book entity so these attributes are stored in a book relation.

The data in one table will usually be associated with data in other tables in the database. The association between two tables is called a **relationship**. Relationships are implemented by the two related tables having data values in common. In a library database we would want to keep information about the publishers of our books. "Publishers" is really another business entity with its own attributes (the publisher name, address, phone number, etc.). So we could have two tables: one for books and one for publishers. The publisher table would have a publisher-identifier attribute. The book table would include an attribute which stores the **identifier value** (primary key) for the publisher of that book; that attribute is called a foreign key. Then we can navigate from a particular book in the book table to the related publisher in the publishers table. We can also navigate from a particular publisher in the publishers table to the books in the book table for that publisher.



If I set this up as two tables and store the value of the publisher identifier in the books tables, then I need to store the publisher data values only once per publisher. (In Amazom.com if I do a search for book publisher by Addison Wesley, I get 73,133 hits. I would not want to store contact information for that publisher 73,133 times!)

Book Table

book id	title	publisher id	year published	page count	price
1	Seing Data	101			
2	Art of SQL	102			
3	MySQL in a Nutshell	102			
4	SQL Server 2005	102			
5	Oracle SQL*Plus	102			

Publisher Table

publisher id	publisher name	address	phone	webpage url
101	Addison Wesley			
102	O'Reilly			

When we talk about a database as a logical thing, we think of a collection of tables that are logically related to each other. We may include other types of objects with the database- such as views and processing routines.

In summary: data values are stored in columns. Columns are grouped together into a row that represents an entity instance. Rows are grouped together into a table which represents a business entity that we care about. Tables are grouped together into a schema- a collection of tables. Schemas can be grouped together into a database.