

# CS 50011: Introduction to Systems II

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## Relational Databases

- You have learned how to store data persistently into files.
- However, when using plain files, you have to write functions to parse the information, to search it etc.
- Relational databases (often simply “databases”) store the information in tables.
- A table is made of many rows and columns, where one row stores a record and a column stores an attribute of the record.
- Databases provide functions to add, delete, and search records in a table.
- SQL (Structured Query Language) is the standard language used to manipulate databases.

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## Relational Databases

- Predominant database idea since 1980s
- Organizes data into sets of two-dimensional tables
- Edgar “Ted” Codd (1923-2003)
- Introduced concept c1970
- Turing Award 1981

## SQL and Relational Databases

## Available SQL databases

MariaDB

<https://mariadb.org/>

Very popular free database

Oracle

<http://www.oracle.com>

Very popular database for enterprise use

Microsoft SQL

<http://www.microsoft.com/sqlserver>

Also very popular. © Gustavo Rodriguez-Rivera

## Structured Query Language (SQL)

All major languages let you communicate with a database using SQL.

There are often GUIs available that help with database administration

You can think of a database as a group of named tables with rows and columns.

Each column has a name and each row contains a set of related data.

## Structuring your information in Tables

- As part of the design of a project, you need to design the tables in a database.
- You may store your information in multiple tables to reduce the amount of repeated information.
- In the example before we could store, all the information in a single table but that would lead to many repeated entries.

## Anatomy

- Database consists of a set of named *relations* (tables)
- Relation
  - Set of *tuples* (rows) with identical column structure
  - Values often uniform “type” (integer, text, date, etc)
- All rows should be distinct
  - Not necessarily enforced

## Schema vs. Instance

- Structure of the database (tables, columns, types, etc) is the *schema*
  - Usually fixed over time
- Instance is a specific collection of data conforming to the schema
  - “Database” usually refers to the latter (“the grades database”)

## Single Table

Title	ISBN	FName	LName	Price	Publisher	URL
A Guide to the SQL Standard	0-201-96426-0	Alexander	Christopher	47.95	Addison-Wesley	www.aw-bc.com
A Pattern Language: Towns, Buildings, Construction	0-19-501919-9	Frederick P.	Brooks	65.00	John Wiley & Sons	www.wiley.com
A Pattern Language: Towns, Buildings, Construction	0-19-501919-9	Smith	Peter	65.00	John Wiley & Sons	www.wiley.com

## SQL Schema

**Authors Table**

Author_ID	Name	Fname
ALEX	Alexander	Christopher
BROO	Brooks	Frederick P.
SMITH	Smith	Peter

**Books Table**

Title	ISBN	Publisher_ID	Price
A Guide to the SQL Standard	0-201-96426-0	0201	47.95
A Pattern Language: Towns, Buildings, Construction	0-19-501919-9	0407	65.00

## SQL by Example (from textbook)

**BookAuthors Table**

ISBN	Author_ID	Seq_No
0-201-96426-0	ALEX	1
0-201-96426-0	BROO	2
0-19-501919-9	DAR	1

**Publishers Table**

Publisher_ID	Name	URL
0201	Addison-Wesley	www.aw-bc.com
0407	John Wiley & Sons	www.wiley.com

## Structured Query Language (SQL)

- Computer language for expressing management, manipulation, and querying of databases
- Supported by almost all RDBs
- Sometimes there are differences
  - Underlying implementation may also be inconsistent

## Primary Keys

- One or more of the columns of the table are defined as “Primary Keys”.
- The value in each column of a primary key must be unique.
- A separate data structure called “B-tree” is created for this “Primary Key” for quick access.
- Searches on this binary key will be at least  $O(\log n)$ , compared to searches in other columns that will be linear.

## SQL by Example

By convention SQL keywords are written in uppercase.

```
SELECT * FROM Books
```

This query returns all rows in the Books table.

SQL statements always require FROM

```
SELECT ISBN, Price, Title  
FROM Books
```

This query returns a table with only the ISBN, price and title columns from the Books table.

## Foreign Keys

- Uniquely identifies row of another table
  - Refers to primary key in another table
- Must be NULL or refer to a row in the other table
  - Referential integrity constraint
- Database normalization
  - Organizing columns and tables to reduce data redundancy

## SQL by Example

```
SELECT ISBN, Price, Title  
FROM Books  
WHERE Price <=29.95
```

This query returns a table with the ISBN, Price and Title from the Books table but only for the books where the price is less or equal to 29.95.

## SQL by Example

```
SELECT ISBN, Price, Title
FROM Books
WHERE Title NOT LIKE "%n_x%"
```

Returns a table with ISBN, Price and Title as columns excluding the books that contain Linux or UNIX in the title.

The “%” character means any zero or more characters. “\_” means any single character.

## SQL by Example (from textbook)

You can also delete rows with SQL

```
DELETE FROM Books
WHERE Title Like "%C++%"
```

This deletes all books that have C++ in the title.

## SQL by Example

```
SELECT Title, Name, URL
FROM Books, Publishers
WHERE Books.Publisher_ID=Publishers.Publisher_ID
```

It returns a table with the Title, Name of publisher, and URL from Books and Publishers.

Title	Name	URL
A Guide to the SQL Standard	Addison-Wesley	www.aw-bc.com
A Pattern Language: Towns, Buildings, Construction	John Wiley & Sons	www.wiley.com

## SQL by Example

Use INSERT to insert a new row in the table.

```
INSERT INTO Books
VALUES ('A Guide to the SQL Standard',
'0-201-96426-0', '0201', 47.95)
```

This inserts a new book in the Books table.

## SQL by Example

You can also use SQL to change data inside a database.

```
UPDATE Books
SET Price = Price - 5.00
WHERE Title Like "%C++%"
```

This reduces the price by \$5.00 for all books that have C++ in the title.

## SQL by Example

You can also create a new table using SQL

```
CREATE TABLE Books
(
TITLE CHAR(60),
ISBN CHAR(13),
Publisher_ID CHAR(6),
Price DECIMAL(10,2)
)
```

## JOIN

- Combine columns from one or more tables using values common to each
- Different types
  - INNER JOIN common
  - LEFT (OUTER) JOIN
    - Always contain left table rows, even if no match on right
  - RIGHT JOIN
  - FULL JOIN

## Running mysql in the sslab machines

```
To run mysql type:
bash> mysql -u root
mysql> CREATE DATABASE menagerie;
mysql> USE menagerie
mysql> SHOW TABLES;
mysql> CREATE TABLE pet (name VARCHAR(20), owner VARCHAR(20),
-> species VARCHAR(20), sex CHAR(1), birth DATE, death DATE);
mysql> SHOW TABLES;
mysql> DESCRIBE pet;
mysql> INSERT INTO pet
-> VALUES ('Puffball', 'Diane', 'hamster', 'f', '1999-03-30', NULL);
mysql> select * from pet;
```

## SQL Tutorials

For more information about SQL, see the SQL tutorial in

<http://www.w3schools.com/sql/default.asp>

You can also run some SQL examples there.

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## Running SQL in the SSLAB machines

- The explanation of how to run mysql inside your account in the sslab machines is in :  
[http://support.cs.purdue.edu/help/MySQL\\_mini-HOWTO\\_Linux](http://support.cs.purdue.edu/help/MySQL_mini-HOWTO_Linux)
- The instructions allow you to run the database in the background but it will allow only to connect clients in the same machine.
- Here is the mysql tutorial. Follow the tutorial to get familiar with mysql.  
<http://dev.mysql.com/doc/refman/5.1/en/tutorial.html>