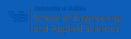
Programming and Database Fundamentals for **Data Scientists**

Database Fundamentals

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Outline

Introduction

Overview

Data Model

Schemas

SQL Basics

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Databases

Why?

- ▶ Why not store everything in files?
- ▶ Use Python to manipulate files

What?

▶ What is a Database, a Database Management System, Data Model?

How?

- ► How to load data into a database?
- ► How to *interact* with the data?

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Overview

- Design of databases
 - Entity Relationship Model
 - ► Chapters 2, 4 (until section 4.5)
- Database programming
 - ▶ SQL
 - ► Chapters 6,7, and 8
- ► SQL in a server environment
 - Embedding SQL in Python
 - Chapter 9 (partly)

Book

Database Systems, The Complete Book (2nd Ed.), Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom (2009), Prentice Hall.

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What is a Data Model?

- Mathematical representation of data
 - Examples: Relational, Semi-structured, Hierarchical, Network
- Operations on data
- Constraints

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Relational Model - A Relation is a Table

- ▶ Data arranged as rows in a table, each row has related information about one data entity
- Consider the following relation (or table) Movies

title	year	length	genre
Gone with the wind	1939	231	drama
Star wars	1977	124	sciFi
Wayne's world	1992	95	comedy

- Attributes (column headers)
- ► Tuples (rows)
- Relation name (movies)

Schemas

- Relation schema Relation name and attribute list
 - ► Type of each attribute
 - E.g., title String, year Integer, etc.
- ▶ A **Database** is a collection of relations (tables).
- The collection of all relation schemas in the database is the database schema

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Why Relational Model

- ► Most popular simple and limited
- ▶ Allows for highly efficient implementations to operate on the data
 - Allows implement high-level languages, such as SQL

Relational Model Basics

- ► Relation
- Attributes
- ▶ Tuples
- Schemas
- Domains
- Relation instance
- ► Relation keys

title	year	length	genre
Gone with the wind	1939	231	drama
Star wars	1977	124	sciFi
Wayne's world	1992	95	comedy

A Simple Database – Movies

Movies

title: string,

year: int,

length: int,

genre: string,

studioName: string,

producerCertificateNum:

int

Studio

name: string,

address: string

presidentCertificateNum:

int

StarsIn

movieTitle:

string,

movieYear: int,

starName: string

MovieStar

name: string,

birthdate: date,

address: string,

gender: string

MovieExecutive

name: string,

certificateNum:
int.

int,

address: string,

netWorth: int

Starting with SQL

- ► **Structure Query Language** or SQL is the language to interact with a relational database management system
- ► Has two uses
 - 1. Data definition creating database schemas, etc.
 - 2. Data manipulation querying, modifying database tables

Creating a Database

CREATE DATABASE moviedb;

Creating/Deleting Tables

```
-- create movies table
CREATE TABLE movies (
   title VARCHAR(128) NOT NULL,
   year INT,
   length INT,
   studioname VARCHAR(128),
   executivenumber INT
);
-- deleting a table
DROP TABLE movies;
```

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SQL Types - Numeric

Туре	Storage	Min	Max
		Signed/Unsigned	Signed/Unsigned
TINYINT	1	-128	127
		0	255
SMALLINT	2	-2 ¹⁵	$2^{15}-1$
		0	$2^{1}6-1$
MEDIUMINT	3	-2^{23}	$2^{23}-1$
		0	$2^{24}-1$
INT	4	-2^{31}	$2^{31}-1$
		0	$2^{32}-1$
BIGINT	8	-2^{63}	$2^{63}-1$
		0	$2^{64}-1$

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SQL Types - Optional Width Argument

► One can optionally set the display width - INT(4)

SQL Types - Floating Points

► FLOAT and DOUBLE keywords to specify fields with single and double precision values, respectively.

SQL Types - Date and Time Types

- DATE Only date and no time.
 - DATE values are displayed as 'YYYY-MM-DD'
 - ► The supported range is '1000-01-01' to '9999-12-31'.
- ► DATETIME Both date and time
 - DATETIME values are displayed as 'YYYY-MM-DD HH:MM:SS'
 - ► The supported range is '1000-01-01 00:00:00' to '9999-12-31 23:59:59'.
- TIMESTAMP Full timestamp (stored as UTC but displayed using current time zone)
 - TIMESTAMP values are displayed as 'YYYY-MM-DD HH:MM:SS'
 - The supported range is '1970-01-01 00:00:01' UTC to '2038-01-19 03:14:07' UTC.

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SQL Types - Text

- CHAR and VARCHAR are declared with a length specifying the maximumum length string that can be stored in that field
- Difference between the two
 - Maximum length for a CHAR field is 255 bytes, while maximum length for a VARCHAR field is 65,535 bytes
 - CHAR(4) will always use 4 bytes (shorter strings are padded with empty space)
 - VARCHAR(4) will use one byte to store the length of the stored string but only use the exact length
 - Example: The string 'ab' will use 4 bytes when stored as CHAR(4) and 3 bytes when stored as VARCHAR(4)
 - Example: The string 'abcd' will use 4 bytes when stored as CHAR(4) and 5 bytes when stored as VARCHAR(4)

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SQL Types - More Text

- ▶ BINARY and VARBINARY For binary data (length specified as number of bytes)
- ► TEXT and BLOB For very long strings and binary data, respectively

Modifying Schema

- ▶ DROP already seen
- Adding or deleting columns
- add a new column to an existing table ALTER TABLE movies ADD genre VARCHAR(16);
- change type of an existing column ALTER TABLE movies MODIFY genre VARCHAR(32);
- delete an existing column from a table
 ALTER TABLE movies DROP genre;

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Defining Keys

- ► An attribute or list of attributes (say S) may be declared PRIMARY KEY or UNIQUE.
- ► For UNIQUE, two tuples cannot agree on all of the attributes in *S*, unless the values for *S* in one of the tuple is NULL
- ► For PRIMARY KEY, attributes in *S* are not allowed to have NULL as a value for their components

Example

```
— create movies table with UNIQUE attribute
CREATE TABLE movies (
  title VARCHAR(128) UNIQUE,
 year INT.
  length INT,
 studioname VARCHAR(128),
 executivenumber INT
— create movies table with primary key as (title, year)
CREATE TABLE movies (
  title VARCHAR(128),
 year INT,
  length INT,
 studioname VARCHAR(128),
 executivenumber INT.
 PRIMARY KEY (title, year)
);
```

References