

# Relational Databases and SQLite

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open.michigan

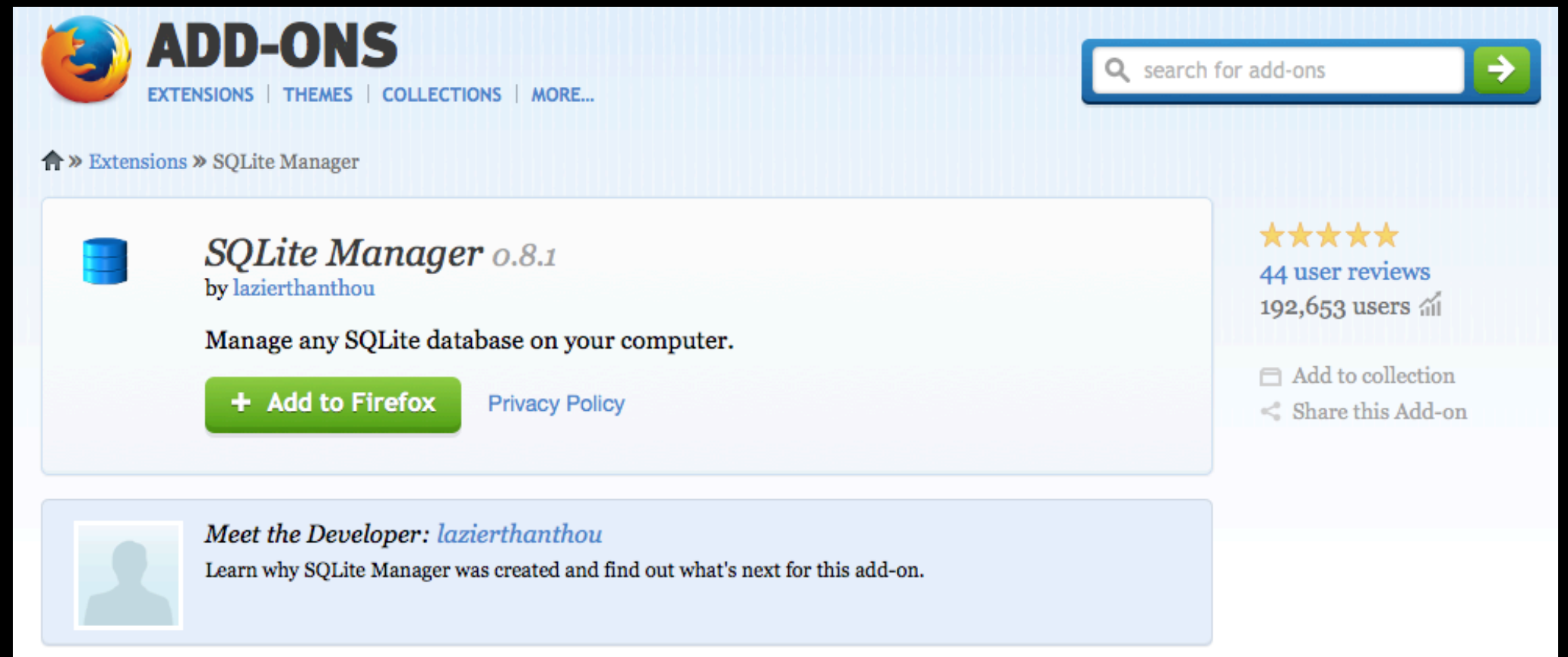
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# SQLite Manager For Firefox



The screenshot shows the Mozilla Add-ons page for the SQLite Manager extension. At the top, there is a search bar with the text "search for add-ons" and a search icon. Below the search bar, the page title "ADD-ONS" is displayed, along with navigation links for "EXTENSIONS", "THEMES", "COLLECTIONS", and "MORE...". The breadcrumb trail shows "Extensions » SQLite Manager". The main content area features a card for the "SQLite Manager 0.8.1" extension by "lazierthanhou". The card includes a database icon, the extension name and version, the developer's name, and a description: "Manage any SQLite database on your computer." Below the description is a green "Add to Firefox" button and a link to the "Privacy Policy". To the right of the card, there are five stars, "44 user reviews", and "192,653 users". Below the stars are two links: "Add to collection" and "Share this Add-on". At the bottom of the card, there is a section titled "Meet the Developer: lazierthanhou" with a placeholder profile picture and the text "Learn why SQLite Manager was created and find out what's next for this add-on."

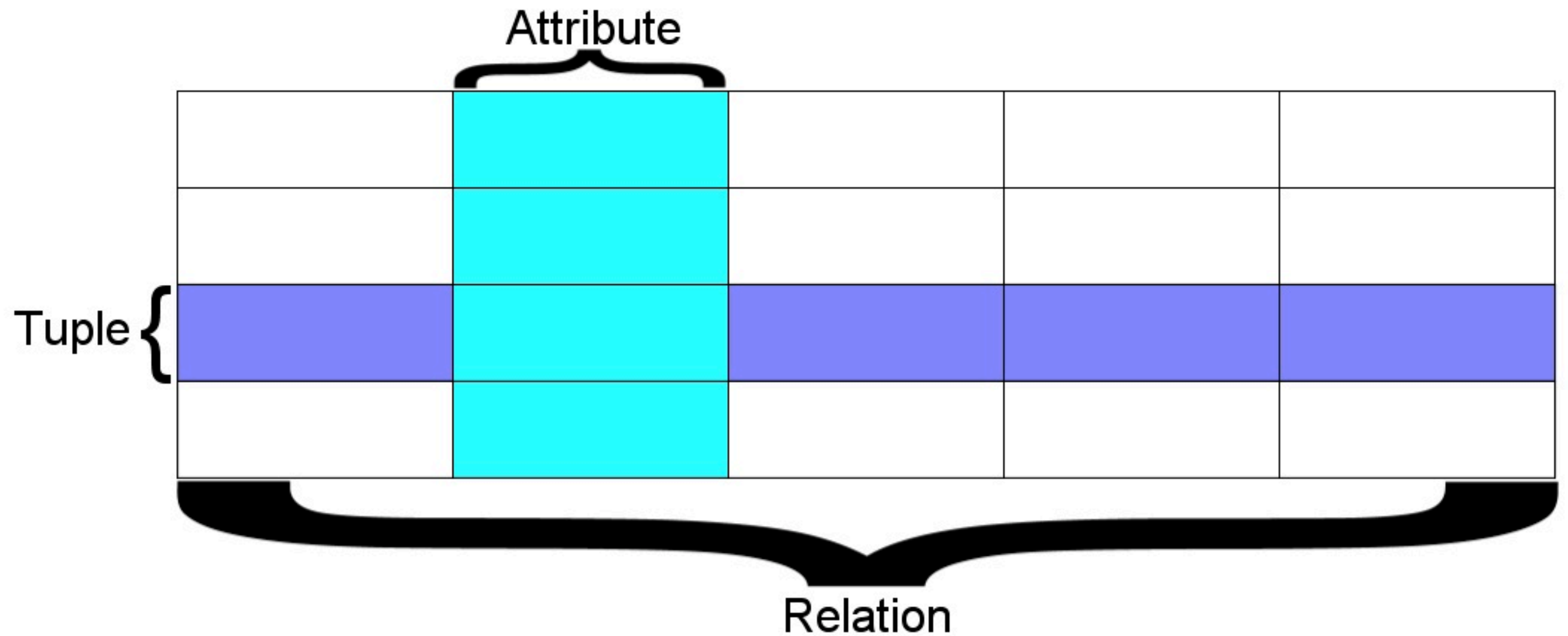
<https://addons.mozilla.org/en-US/firefox/addon/sqlite-manager/>

# Relational Databases

Relational databases model data by storing rows and columns in tables. The power of the relational database lies in its ability to efficiently retrieve data from those tables and in particular where there are multiple tables and the relationships between those tables involved in the query.

# Terminology

- **Database** - Contains many tables
- **Relation (or table)** - contains tuples and attributes
- **Tuple (or row)** - is a set of fields it generally represents an “object” like a person or a music track
- **Attribute (also column or field)** - One of possibly many elements of data corresponding to the object represented by the row



A **relation** is defined as a **set of tuples** that have the same **attributes**. A **tuple** usually represents an **object** and information about that object. **Objects** are typically physical objects or concepts. A **relation** is usually described as a **table**, which is organized into **rows** and **columns**. All the data referenced by an **attribute** are in the same domain and **conform to the same constraints**. (wikipedia)

SI502 - Database

New Open Save Print Import Copy Paste Format Undo Redo AutoSum Sort A-Z Sort Z-A Gallery Toolbox

Sheets Charts SmartArt Graphics WordArt

A B C D

1

1 2 3 4 5 6 7 8

TITLE	RATING	LEN	
About to Rock	3	354	Rows /
Who Made Who	4	252	Tuples

Tracks Albums Artists Genres +

Columns / Attributes

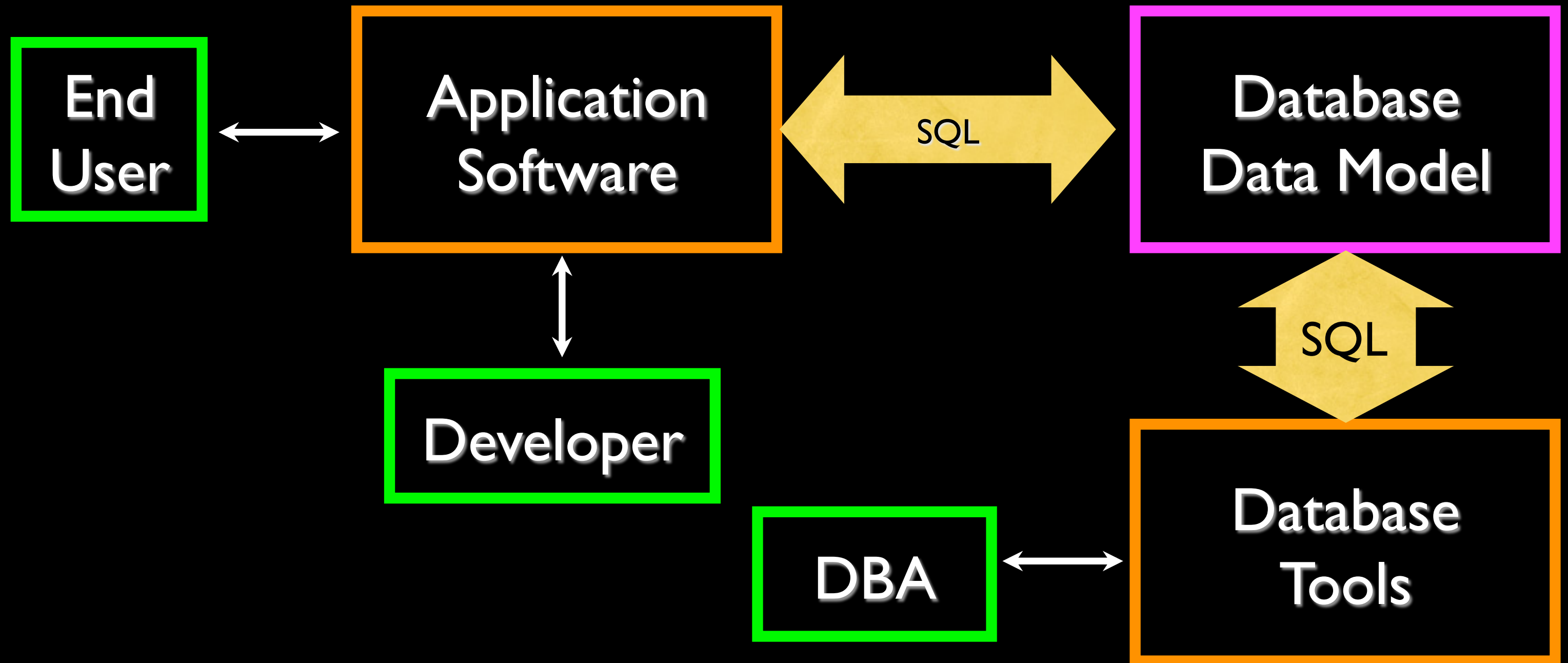
Tables / Relations

# Two Roles in Large Projects

- **Application Developer** - Builds the logic for the application, the look and feel of the application - monitors the application for problems
- **Database Administrator** - Monitors and adjusts the database as the program runs in production
- Often both people participate in the building of the “Data model”



# Application Structure



# Database Administrator (dba)

A database administrator (DBA) is a person responsible for the design, implementation, maintenance and repair of an organization's database. The role includes the development and design of database strategies, monitoring and improving database performance and capacity, and planning for future expansion requirements. They may also plan, co-ordinate and implement security measures to safeguard the database.

[http://en.wikipedia.org/wiki/Database\\_administrator](http://en.wikipedia.org/wiki/Database_administrator)

# Database Model

A **database model** or **database schema** is the **structure or format of a database**, described in a formal language supported by the database management system. In other words, a "database model" is the application of a data model when used in conjunction with a database management system.

[http://en.wikipedia.org/wiki/Database\\_model](http://en.wikipedia.org/wiki/Database_model)

# SQL

- **Structured Query Language** is the language we use to issue commands to the database
  - Create a table
  - Retrieve some data
  - Insert data
  - Delete data

<http://en.wikipedia.org/wiki/SQL>

# Common Database Systems

- Three Major Database Management Systems in wide use
  - **Oracle** - Large, commercial, enterprise-scale, very very tweakable
  - **MySQL** - Simpler but very fast and scalable - commercial open source
  - **SqlServer** - Very nice - from Microsoft (also Access)
- Many other smaller projects, free and open source
  - HSQL, **SQLite**, Postgress, ...

# SQLite Database Manager

- SQLite is a very popular database - it is free and fast and small
- We have a FireFox plugin to manipulate SQLite databases
  - <https://addons.mozilla.org/en-US/firefox/addon/sqlite-manager/>
- SQLite is embedded in Python and a number of other languages

# SQLite is in lots of software...

**symbian**

 python™



**skype™**



**Microsoft®**

**McAfee®**



**A**  
Adobe



**php**

**Google™**

**TOSHIBA**

 **Sun**  
microsystems

<http://www.sqlite.org/famous.html>

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table (1)
- Tables (0)
- Views (0)
- Indexes (0)
- Triggers (0)

TABLE: sqlite\_master

Export

More Info

No. of Records: 0 No. of Indexes: 0 No. of Triggers: 0

Columns (5)

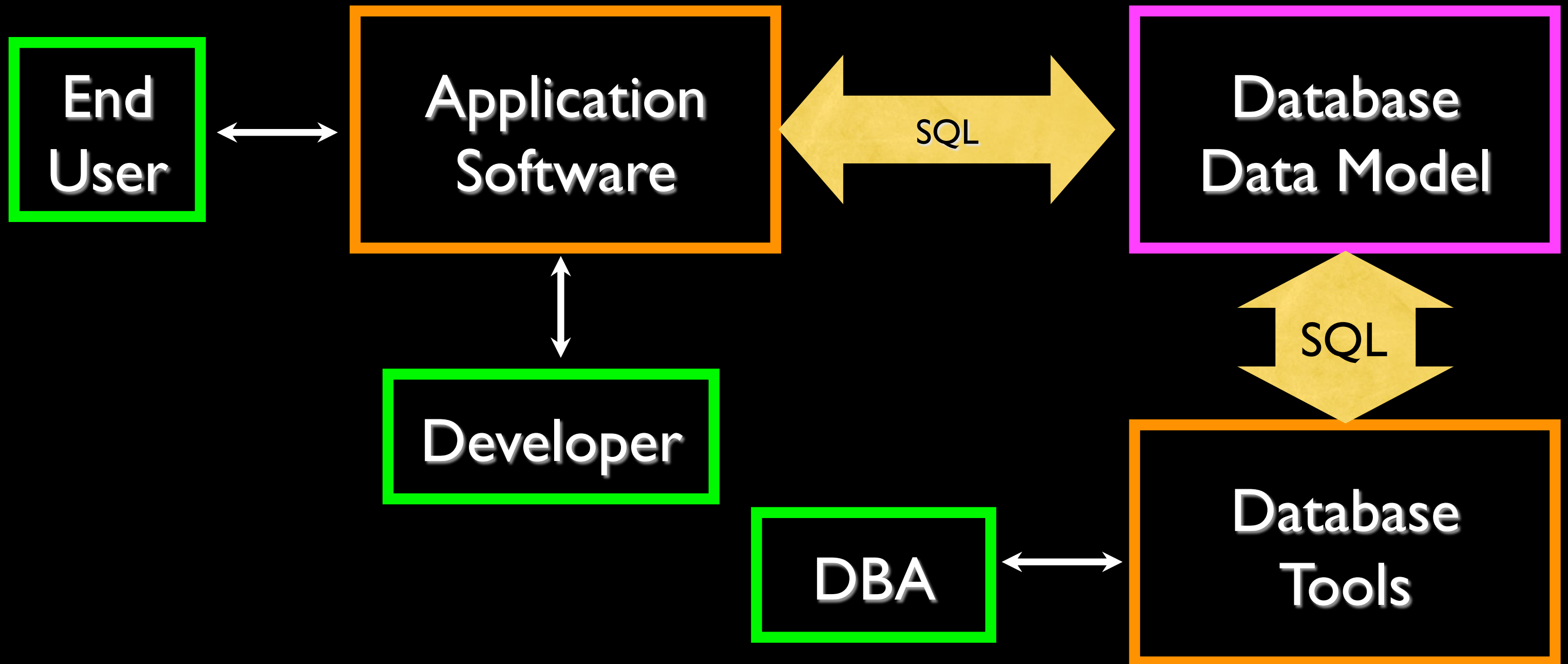
Column ID	Name	Type	Not Null	Default Value	Primary Key
0	type	text	0	null	0
1	name	text	0	null	0
2	tbl_name	text	0	null	0
3	rootpage	integer	0	null	0
4	sql	text	0	null	0

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of files in selected directory: 13

<https://addons.mozilla.org/en-US/firefox/addon/sqlite-manager/>

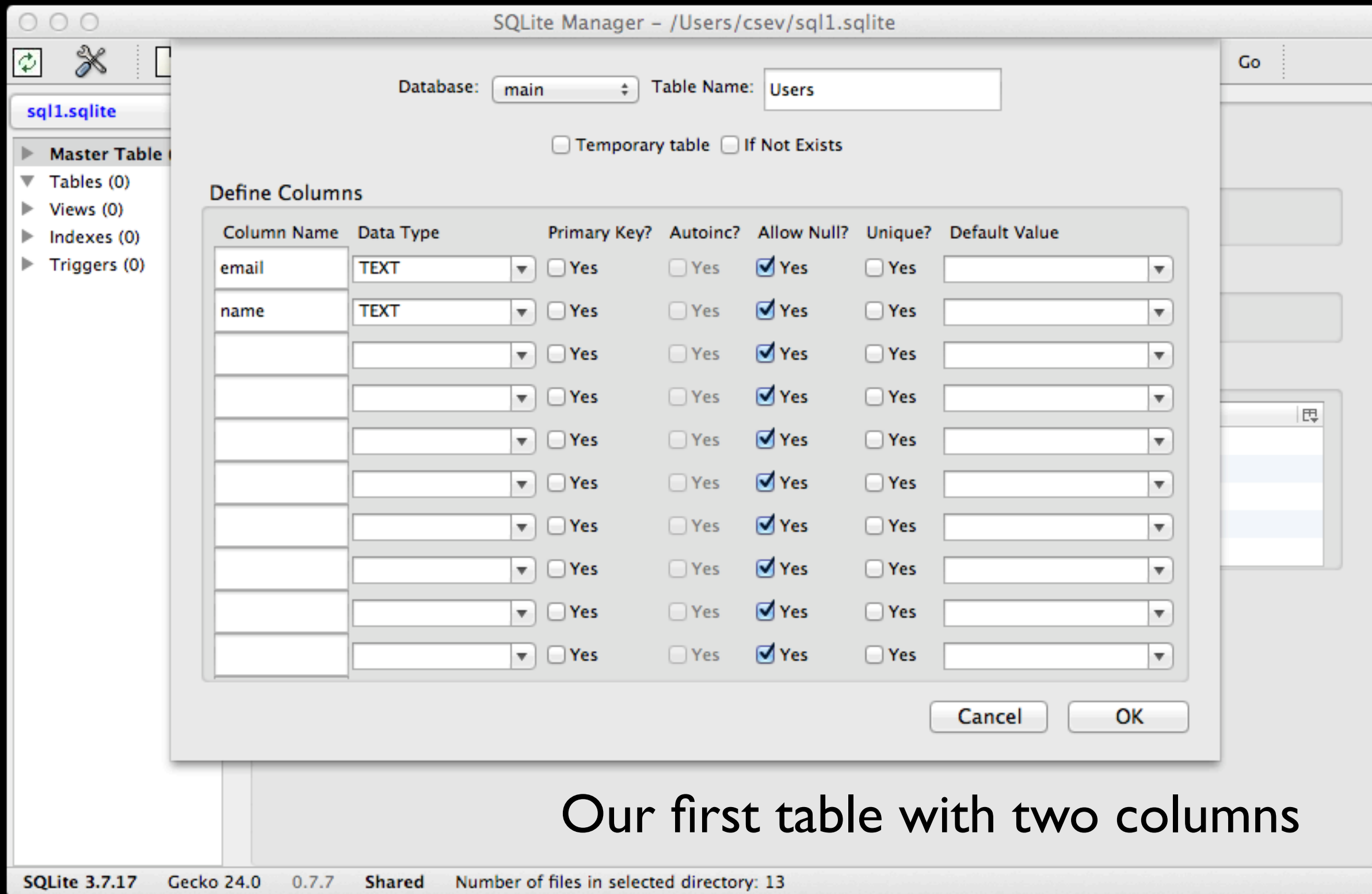


# Application Structure



# Start Simple - A Single Table

- Lets make a table of People - with a Name and an E-Mail using the "wizard" user interface...



Our first table with two columns

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table (1)
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

TABLE Users Search Show All Add Duplicate Edit Delete

rowid	email	name
1	csev@umich.edu	Chuck
2	olga@umich.edu	Olga
3	gab@umich.edu	Gab
4	gaurav@umich.edu	Gaurav

1 to 4 of 4

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of files in selected directory: 13 ET: 0 ms

Our table with four rows

# SQL

- **Structured Query Language** is the language we use to issue commands to the database
  - Create a table
  - Retrieve some data
  - Insert data
  - Delete data

<http://en.wikipedia.org/wiki/SQL>

# SQL Insert

- The Insert statement inserts a row into a table

```
INSERT INTO Users (name, email) VALUES ('Ted', 'ted@umich.edu')
```

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

Enter SQL

```
insert into Users (name, email) values ('Ted', 'ted@umich.edu')
```

Run SQL Actions Last Error:

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of files

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

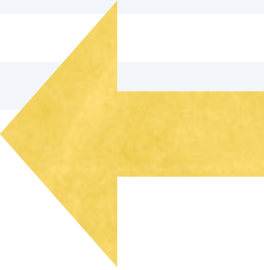
sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

TABLE Users Search Show All Add Duplicate Edit Delete

rowid	email	name
1	csev@umich.edu	Chuck
2	olga@umich.edu	Olga
3	gab@umich.edu	Gab
4	gaurav@umich.edu	Gaurav
5	ted@umich.edu	Ted

<< < 1 to 5 of 5 > >>



# SQL Delete

- Deletes a row in a table based on a selection criteria

```
DELETE FROM Users WHERE email='ted@umich.edu'
```



SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

Enter SQL

```
delete from Users where email='ted@umich.edu'
```

Run SQL Actions Last Error: not an error

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows F

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

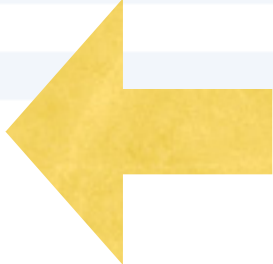
Structure Browse & Search Execute SQL DB Settings

TABLE Users Search Show All Add Duplicate Edit Dele

rowid	email	name
1	csev@umich.edu	Chuck
2	olga@umich.edu	Olga
3	gab@umich.edu	Gab
4	gaurav@umich.edu	Gaurav

1 to 4 of 4

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 0 ET: 0 ms



# SQL: Update

- Allows the updating of a field with a where clause

```
UPDATE Users SET name='Charles' WHERE email='csev@umich.edu'
```

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

Enter SQL

```
update Users set name='Charles' where email='csev@umich.edu'
```

Run SQL Actions Last Error: not an error

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

TABLE Users Search Show All Add Duplicate Edit Delete

rowid	email	name
1	csev@umich.edu	Charles
2	olga@umich.edu	Olga
3	gab@umich.edu	Gab
4	gaurav@umich.edu	Gaurav

<< < 1 to 4 of 4 > >>

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 0 ET: 0 ms

# Retrieving Records: Select

- The select statement retrieves a group of records - you can either retrieve all the records or a subset of the records with a WHERE clause

```
SELECT * FROM Users
```

```
SELECT * FROM Users WHERE email='csev@umich.edu'
```

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

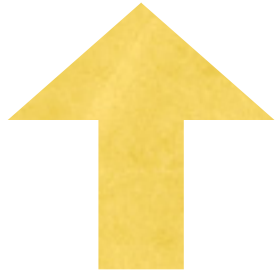
Enter SQL

```
select * from Users
```

Run SQL Actions Last Error: not an error

email	name
csev@umich.edu	Charles
olga@umich.edu	Olga
gab@umich.edu	Gab
gaurav@umich.edu	Gaurav

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned:



SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite


- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

Enter SQL

```
select * from Users where email='csev@umich.edu'
```

Run SQL Actions Last Error: not an error

email	name
csev@umich.edu	Charles



# Sorting with ORDER BY

- You can add an **ORDER BY** clause to **SELECT** statements to get the results sorted in ascending or descending order

```
SELECT * FROM Users ORDER BY email
```

```
SELECT * FROM Users ORDER BY name
```

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- Master Table...
- Tables (1)
  - Users
- Views (0)
- Indexes (0)
- Triggers (0)

Enter SQL

```
select * from Users order by email
```

Run SQL Actions Last Error: not an error

email	name
csev@umich.edu	Charles
gab@umich.edu	Gab
gaurav@umich.edu	Gaurav
olga@umich.edu	Olga

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 4 ET: 0 ms

# SQL Summary

```
insert into Users (name, email) values ('Ted', 'ted@umich.edu')
```

```
delete from Users where email='ted@umich.edu'
```

```
update Users set name="Charles" where email='csev@umich.edu'
```

```
select * from Users
```

```
select * from Users where email='csev@umich.edu'
```

```
select * from Users order by email
```



# This is not too exciting (so far)

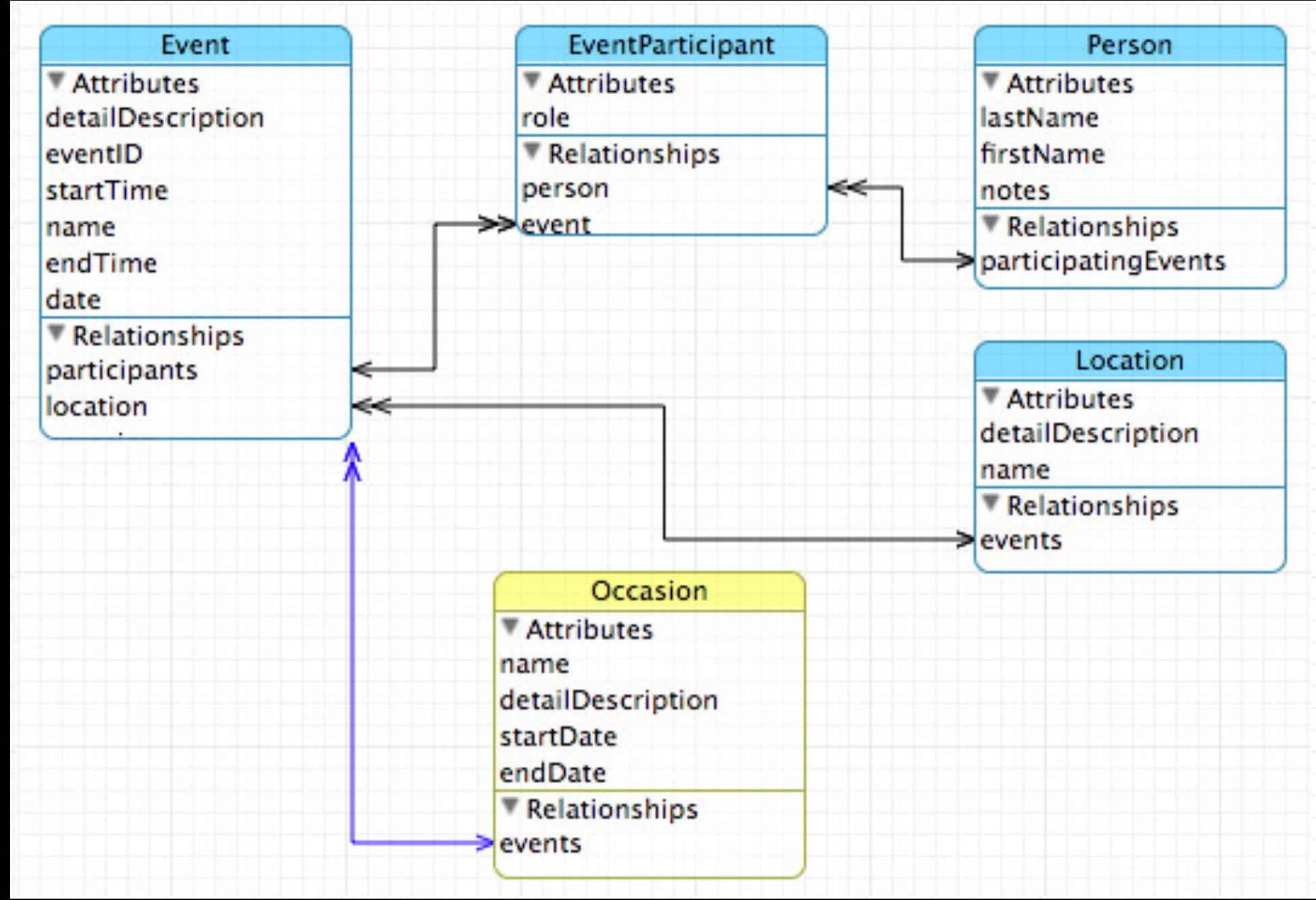
- Tables pretty much look like big fast programmable spreadsheet with rows, columns, and commands
- The power comes when we have more than one table and we can exploit the relationships between the tables

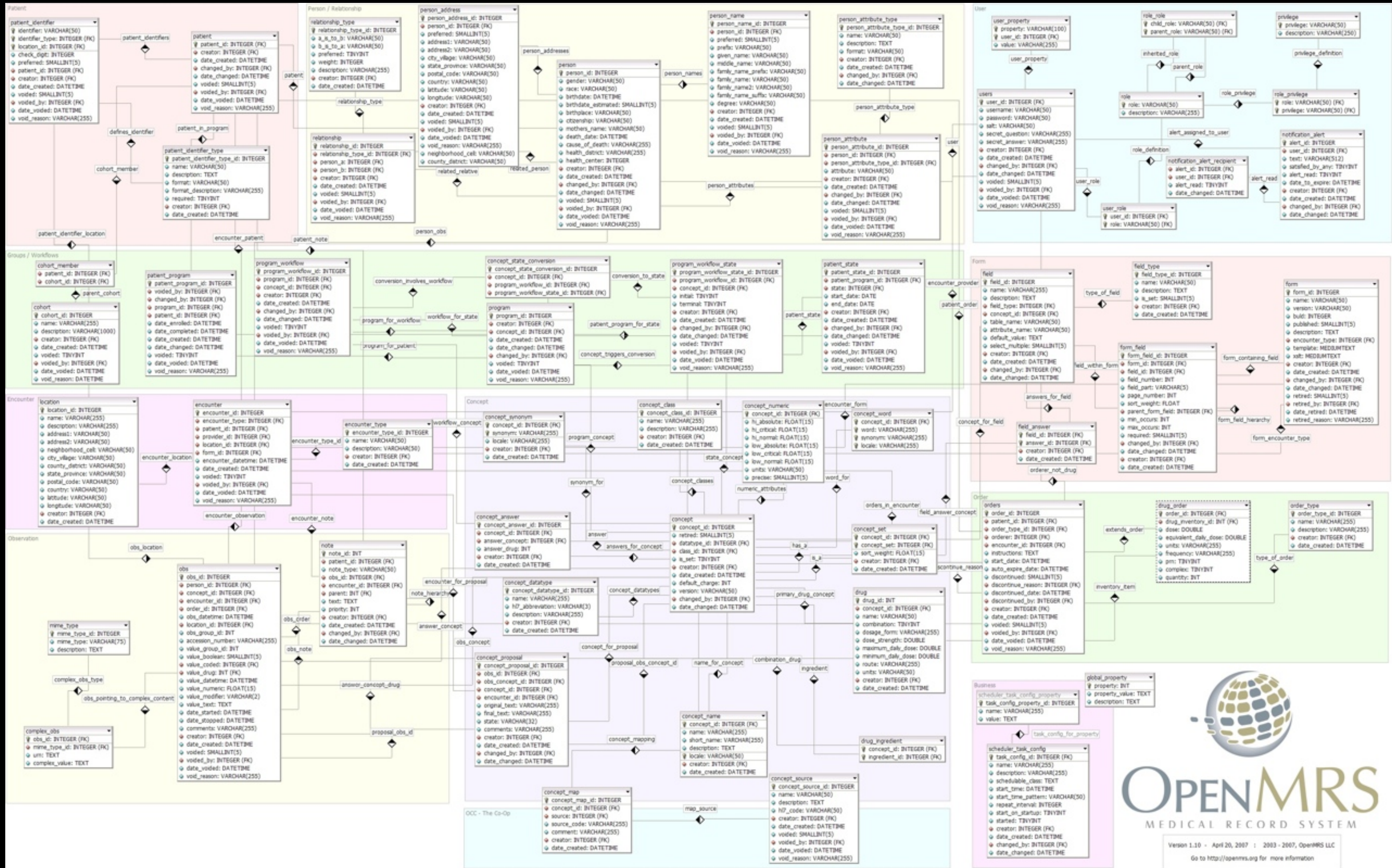
# Complex Data Models and Relationships

[http://en.wikipedia.org/wiki/Relational\\_model](http://en.wikipedia.org/wiki/Relational_model)

# Database Design

- Database design is an **art form** of its own with particular skills and experience
- Our goal is to avoid the really bad mistakes and design clean and easily understood databases
- Others may performance tune things later
- Database design starts with a picture...





**OPENMRS**  
MEDICAL RECORD SYSTEM

# Building a Data Model

- Drawing a picture of the data objects for our application and then figuring out how to represent the objects and their relationships
- Basic Rule: Don't put the same string data in twice - use a relationship instead
- When there is one thing in the "real world" there should be one copy of that thing in the database

Track	Len	Artist	Album	Genre	Rating	Count
<input checked="" type="checkbox"/> Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/> Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/> For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/> Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/> Tin Man	3:30	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Sister Golden Hair	3:22	America	Greatest Hits	Easy Listen...	★★★★★	24
<input checked="" type="checkbox"/> Track 01	4:22	Billy Price	Danger Zone	Blues/R&B	★★★★★	26
<input checked="" type="checkbox"/> Track 02	2:45	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/> Track 03	3:26	Billy Price	Danger Zone	Blues/R&B	★★★★★	22
<input checked="" type="checkbox"/> Track 04	4:17	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/> Track 05	3:50	Billy Price	Danger Zone	Blues/R&B	★★★★★	21
<input checked="" type="checkbox"/> War Pigs/Luke's Wall	7:58	Black Sabbath	Paranoid	Metal	★★★★★	25
<input checked="" type="checkbox"/> Paranoid	2:53	Black Sabbath	Paranoid	Metal	★★★★★	22
<input checked="" type="checkbox"/> Planet Caravan	4:35	Black Sabbath	Paranoid	Metal	★★★★★	25
<input checked="" type="checkbox"/> Iron Man	5:59	Black Sabbath	Paranoid	Metal	★★★★★	26
<input checked="" type="checkbox"/> Electric Funeral	4:53	Black Sabbath	Paranoid	Metal	★★★★★	22
<input checked="" type="checkbox"/> Hand of Doom	7:10	Black Sabbath	Paranoid	Metal	★★★★★	23
<input checked="" type="checkbox"/> Rat Salad	2:30	Black Sabbath	Paranoid	Metal	★★★★★	31
<input checked="" type="checkbox"/> Jack the Stripper/Fairies Wear ...	6:14	Black Sabbath	Paranoid	Metal	★★★★★	24
<input checked="" type="checkbox"/> Bomb Squad (TECH)	3:28	Brent	Brent's Album			1
<input checked="" type="checkbox"/> clay techno	4:36	Brent	Brent's Album			2
<input checked="" type="checkbox"/> Heavy	3:08	Brent	Brent's Album			1
<input checked="" type="checkbox"/> Hi metal man	4:20	Brent	Brent's Album			1
<input checked="" type="checkbox"/> Mistro	2:58	Brent	Brent's Album			1

# For each “piece of info” ...

- Is the column an object or an attribute of another object?
- Once we define objects we need to define the relationships between objects.

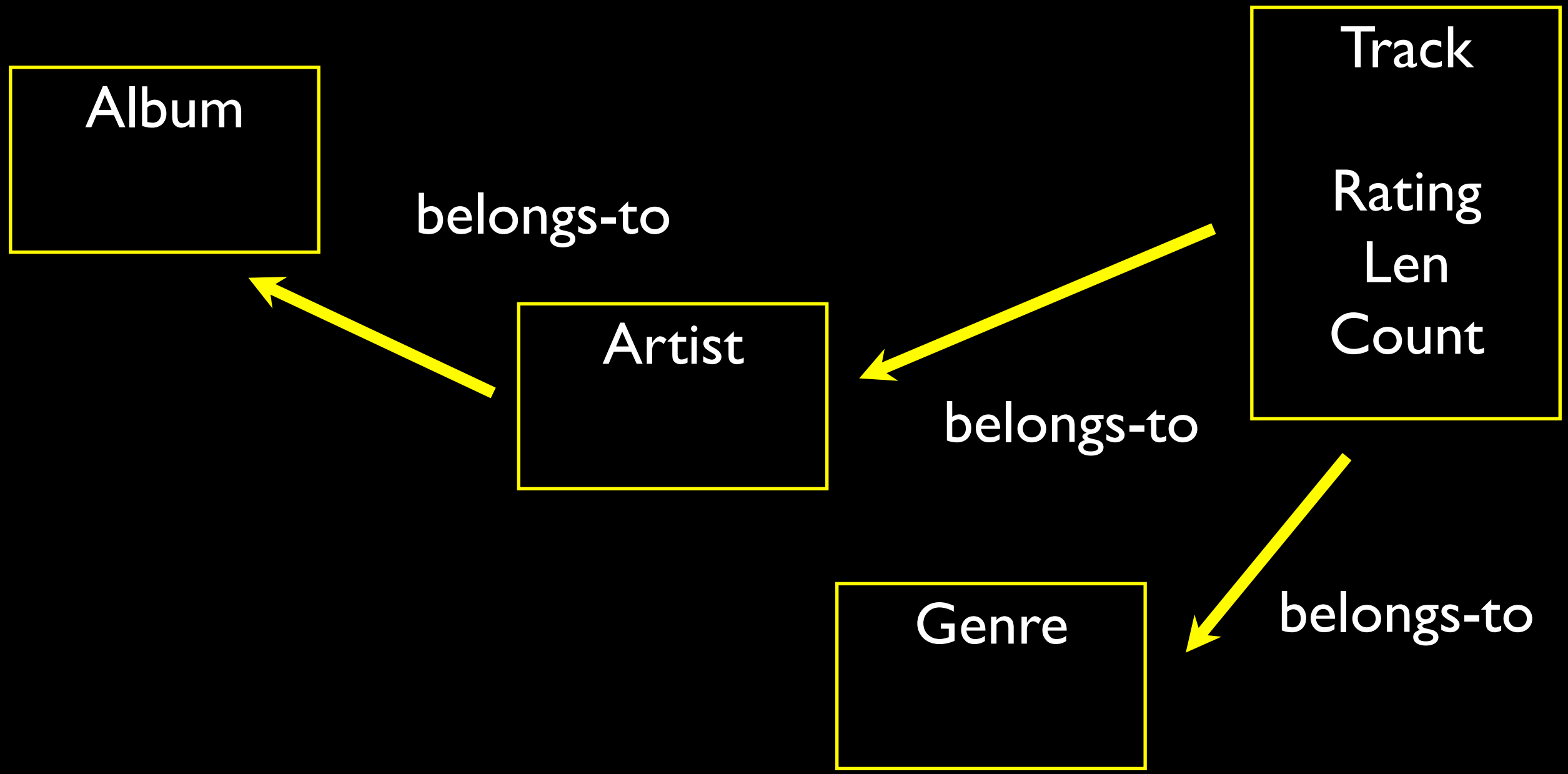
Len Album  
Genre

Artist Rating  
Track Count

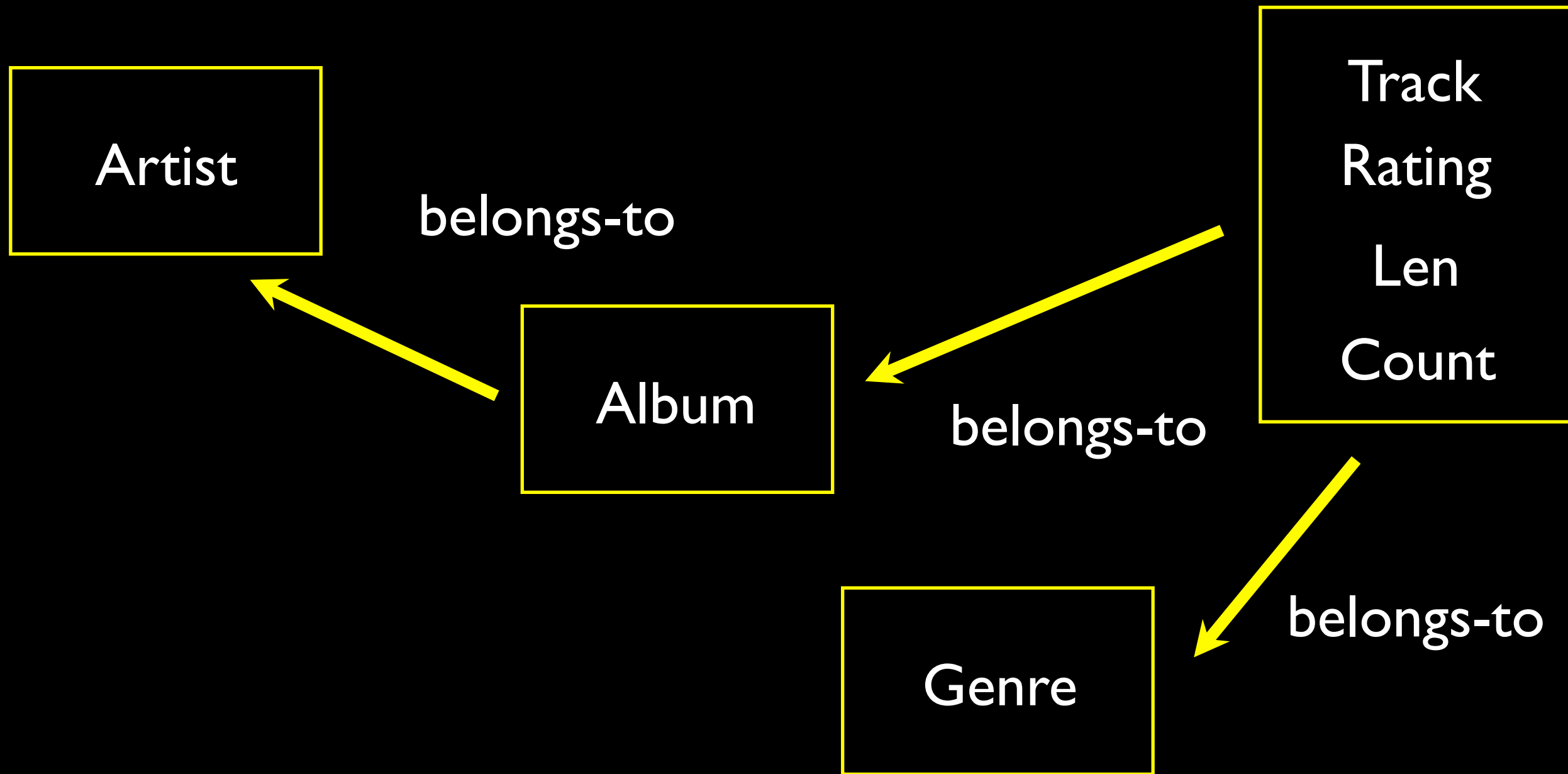
<input checked="" type="checkbox"/> Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/> Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/> For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/> Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/> Tip Man	2:20	America	Greatest Hits	Easy Listen...	★★★★★	22



Track  
Artist  
Album  
Genre  
Rating  
Len  
Count



<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tip Man	2:20	America	Greatest Hits	Easy Listen...	★★★★★	22



<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tip Man	2:20	America	Greatest Hits	Easy Listen...	★★★★★	22

# Representing Relationships in a Database

<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...)	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tip Man	3:20	America	Greatest Hits	Easy Listen...	★★★★★	22

We want to keep track of which band is the “creator” of each music track...

What album does this song “belong to”??

Which album is this song related to?

# Database Normalization (3NF)

- There is \*tons\* of database theory - way too much to understand without excessive predicate calculus
- Do not replicate data - reference data - point at data
- Use integers for keys and for references
- Add a special “key” column to each table which we will make references to. By convention many programmers call this column “id”

[http://en.wikipedia.org/wiki/Database\\_normalization](http://en.wikipedia.org/wiki/Database_normalization)

# Integer Reference Pattern

We use integers to reference rows in another table.

id	
1	Led Zeppelin
2	AC/DC

Artist

Use 'control + ;' to execute the query.

id	artist_id	title
1	2	Who Made Who
2	1	IV

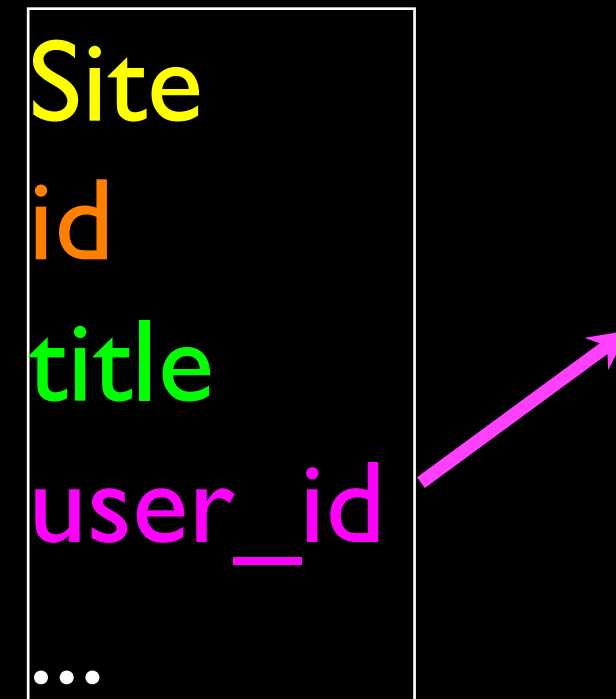
Album

# Keys

Finding our way around...

# Three Kinds of Keys

- **Primary key** - generally an integer auto-increment field
- **Logical key** - What the outside world uses for lookup
- **Foreign key** - generally an integer key point to a row in another table





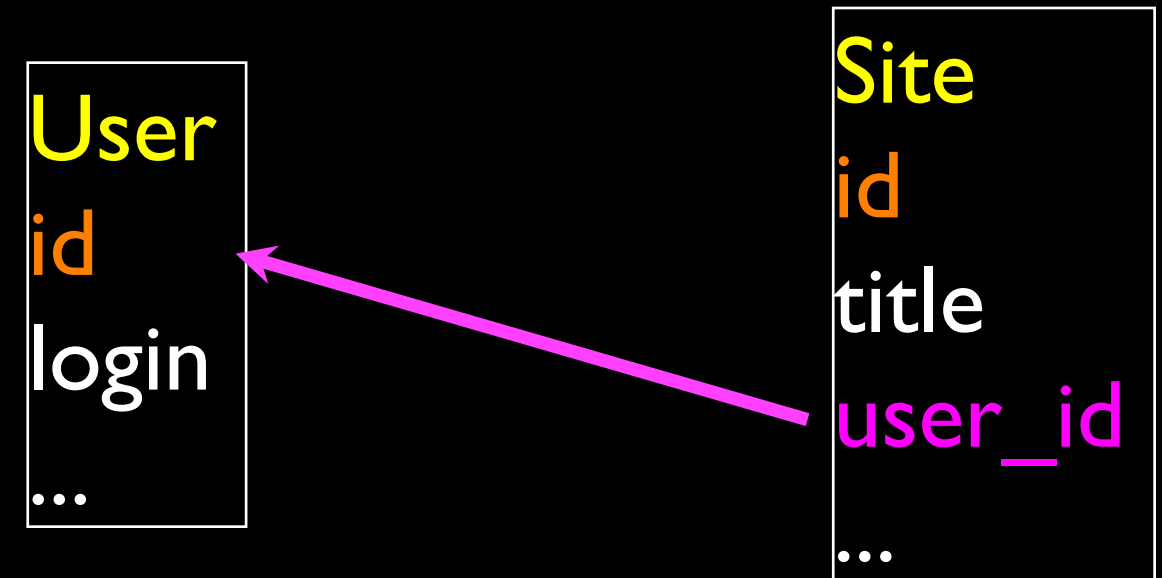
# Primary Key Rules

- Best practices
- Never use your **logical key** as the **primary key**
- **Logical keys** can and do change albeit slowly
- **Relationships** that are based on matching string fields are far less efficient than integers performance-wise

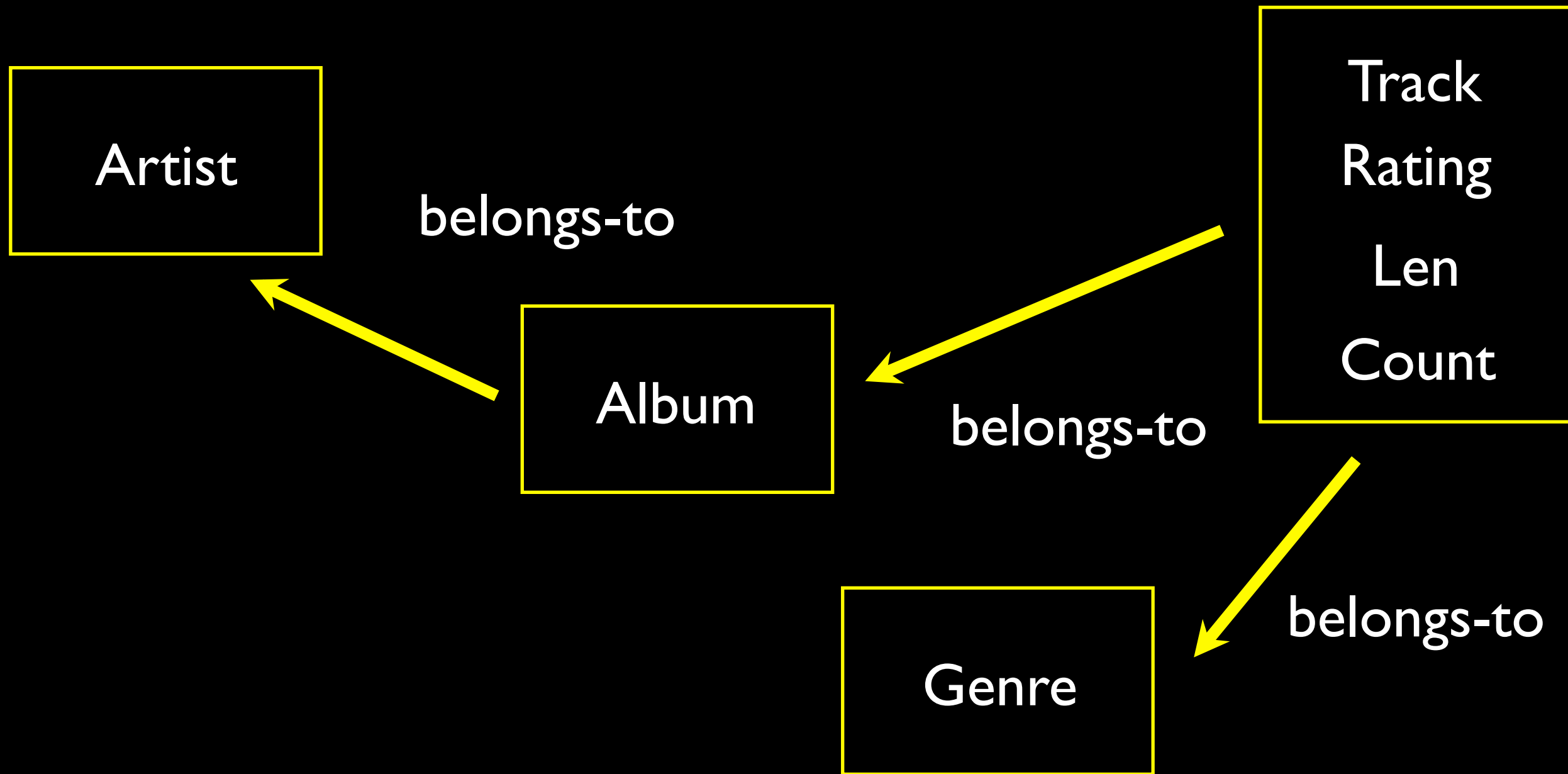
```
User
id
login
password
name
email
created_at
modified_at
login_at
```

# Foreign Keys

- A **foreign key** is when a table has a column that contains a key which points the **primary key** of another table.
- When all primary keys are integers, then all foreign keys are integers - this is good - very good
- If you use strings as foreign keys - you show yourself to be an uncultured swine



# Relationship Building (in tables)



<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tip Man	2:20	America	Greatest Hits	Easy Listen...	★★★★★	22

Album

belongs-to

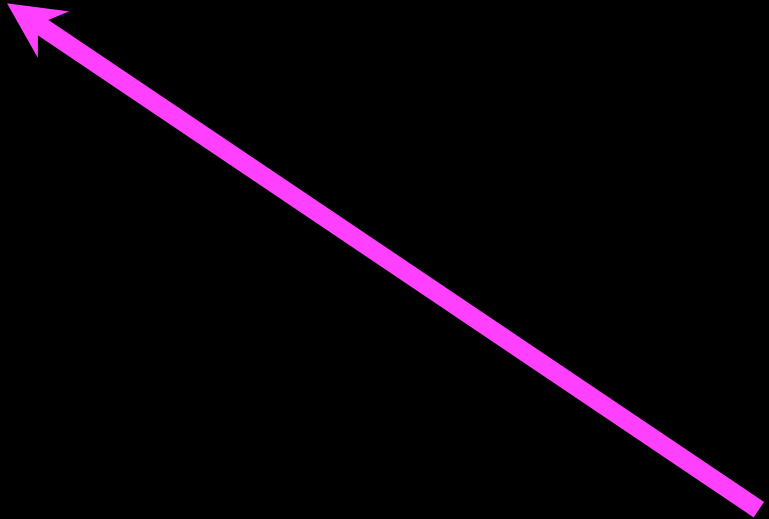


Track  
Title  
Rating  
Len  
Count

Table  
Primary key  
Logical key  
Foreign key

Album
id
title

Track
id
title
rating
len
count
album_id



Artist
id
name

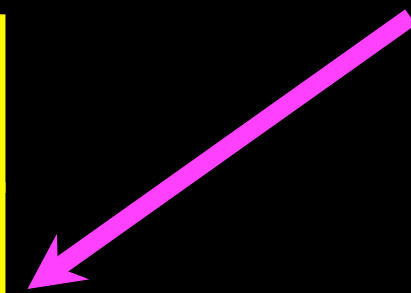
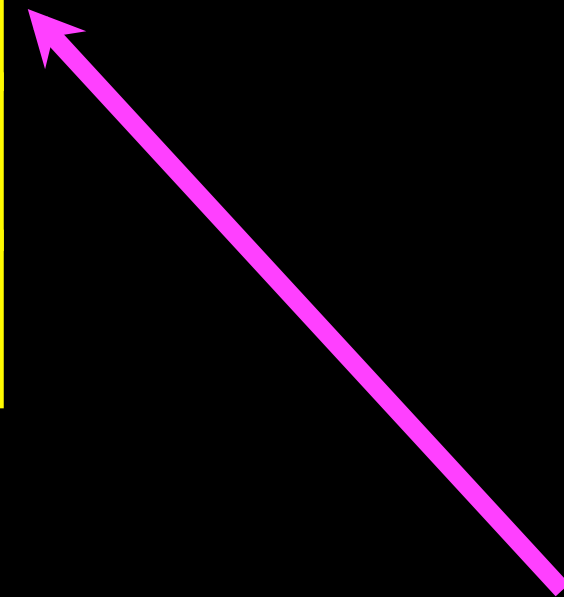
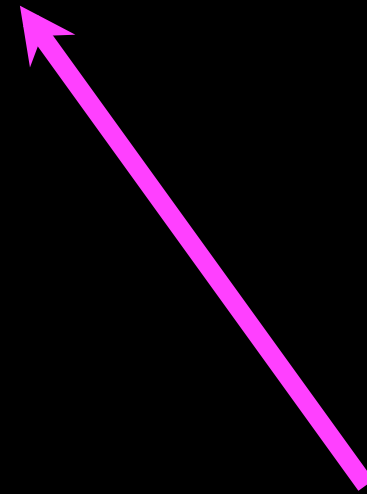
Album
id
title
artist_id

Track
id
title
rating
len
count
album_id
genre_id

Genre
id
name

Table  
Primary key  
Logical key  
Foreign key

Naming FK artist\_id is a convention.



Database:  Table Name:

Temporary table  If Not Exists

Define Columns

Column Name	Data Type	Primary Key?	Autoinc?	Allow Null?	Unique?	Default Value
id	INTEGER	<input checked="" type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="text"/>
name	TEXT	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>
		<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="text"/>

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- ▶ Master Table (1)
- ▼ Tables (5)
  - ▶ Album
  - ▶ Artist
  - ▶ Genre
  - ▶ Track
  - ▶ sqlite\_sequence
- ▶ Views (0)
- ▶ Indexes (4)
- ▶ Triggers (0)

TABLE: Genre

Drop Empty Rename Reindex Copy Export

Create statement

```
CREATE TABLE "Genre" ("id" INTEGER PRIMARY KEY AUTOINCREMENT NOT NULL UNIQUE , "name" TEXT)
```

More Info

No. of Records: 0 No. of Indexes: 1 No. of Triggers: 0

Columns (2)

Column ID	Name	Type	Not Null	Default Value	Primary Key
0	id	INTEGER	1	null	1
1	name	TEXT	0	null	0

Name Type Not Null Default

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 0 ET: 0 ms



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sql1.sqlite

- ▶ Master Table (1)
- ▼ Tables (5)
  - ▶ Album
  - ▶ Artist
  - ▶ Genre
  - ▶ Track
  - ▶ sqlite\_sequence
- ▶ Views (0)
- ▶ Indexes (4)
- ▶ Triggers (0)

**TABLE: Album**

Drop Empty Rename Reindex Copy Export

Create statement

```
CREATE TABLE "Album" ("id" INTEGER PRIMARY KEY AUTOINCREMENT NOT NULL UNIQUE , artist_id INTEGER,"title" TEXT)
```

More Info

No. of Records: 0 No. of Indexes: 1 No. of Triggers: 0

Columns (3)

Column ID	Name	Type	Not Null	Default Value	Primary Key
0	id	INTEGER	1	null	1
1	artist_id	INTEGER	0	null	0
2	title	TEXT	0	null	0

Name Type Not Null Default

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 0 ET: 0 ms

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- ▶ Master Table (1)
- ▼ Tables (5)
  - ▶ Album
  - ▶ Artist
  - ▶ Genre
  - ▶ Track
  - ▶ sqlite\_sequence
- ▶ Views (0)
- ▶ Indexes (4)
- ▶ Triggers (0)

**TABLE: Track**

Drop Empty Rename Reindex Copy Export

Create statement

```
CREATE TABLE "Track" ("id" INTEGER PRIMARY KEY AUTOINCREMENT NOT NULL UNIQUE , album_id INTEGER, genre_id INTEGER, len INTEGER, rating INTEGER, "title" TEXT, "count" INTEGER)
```

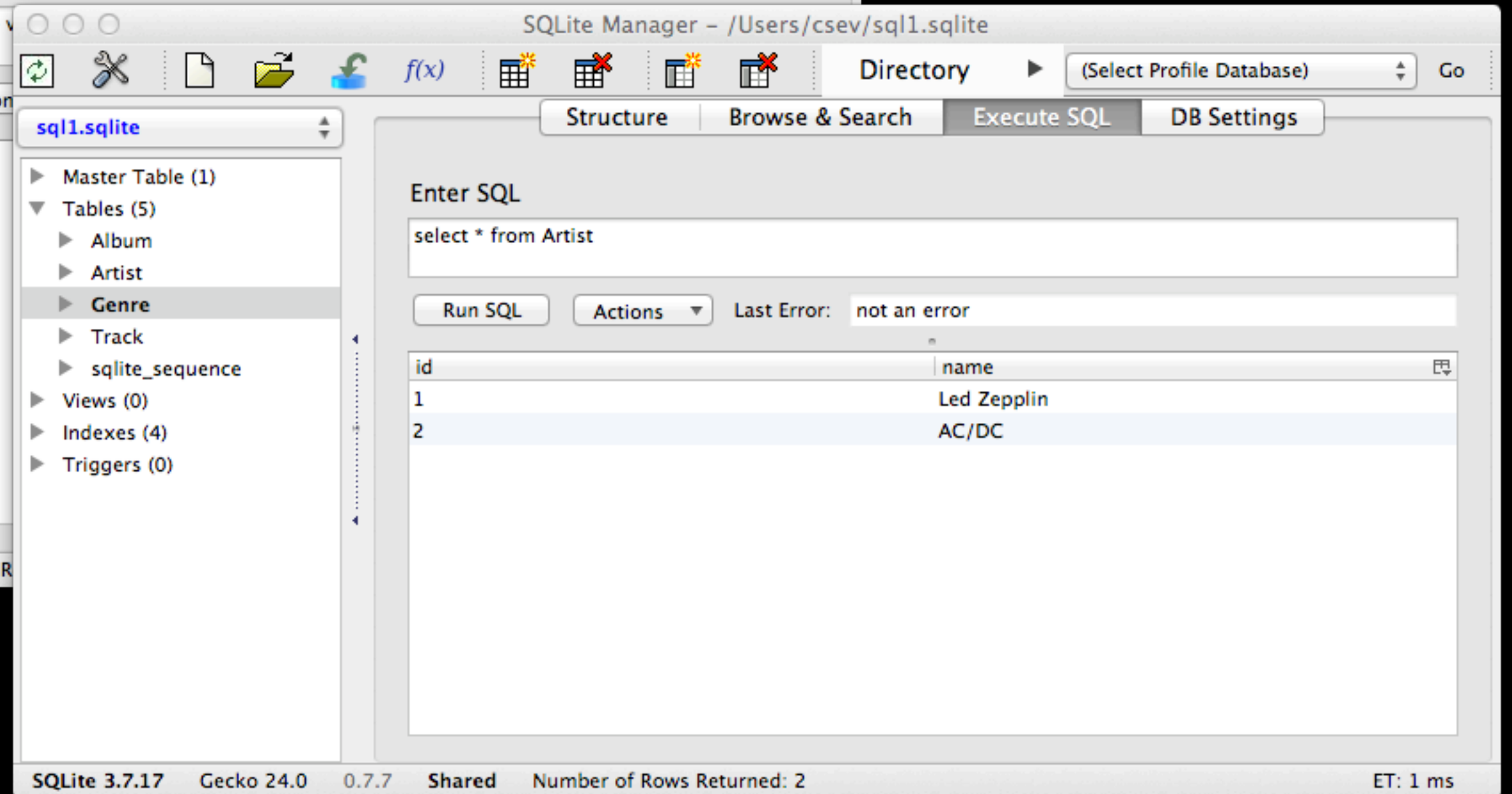
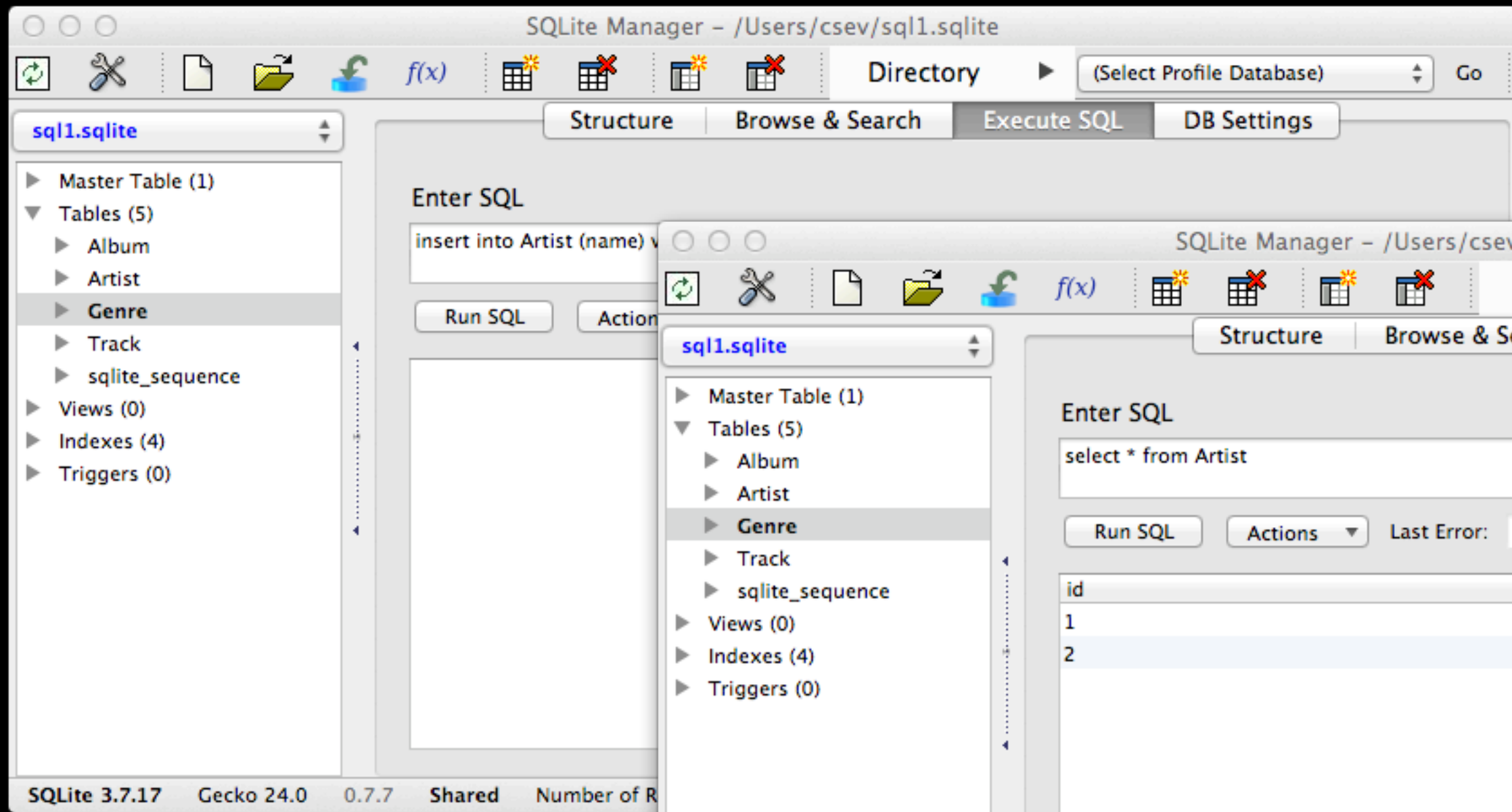
More Info

No. of Records: 0 No. of Indexes: 1 No. of Triggers: 0

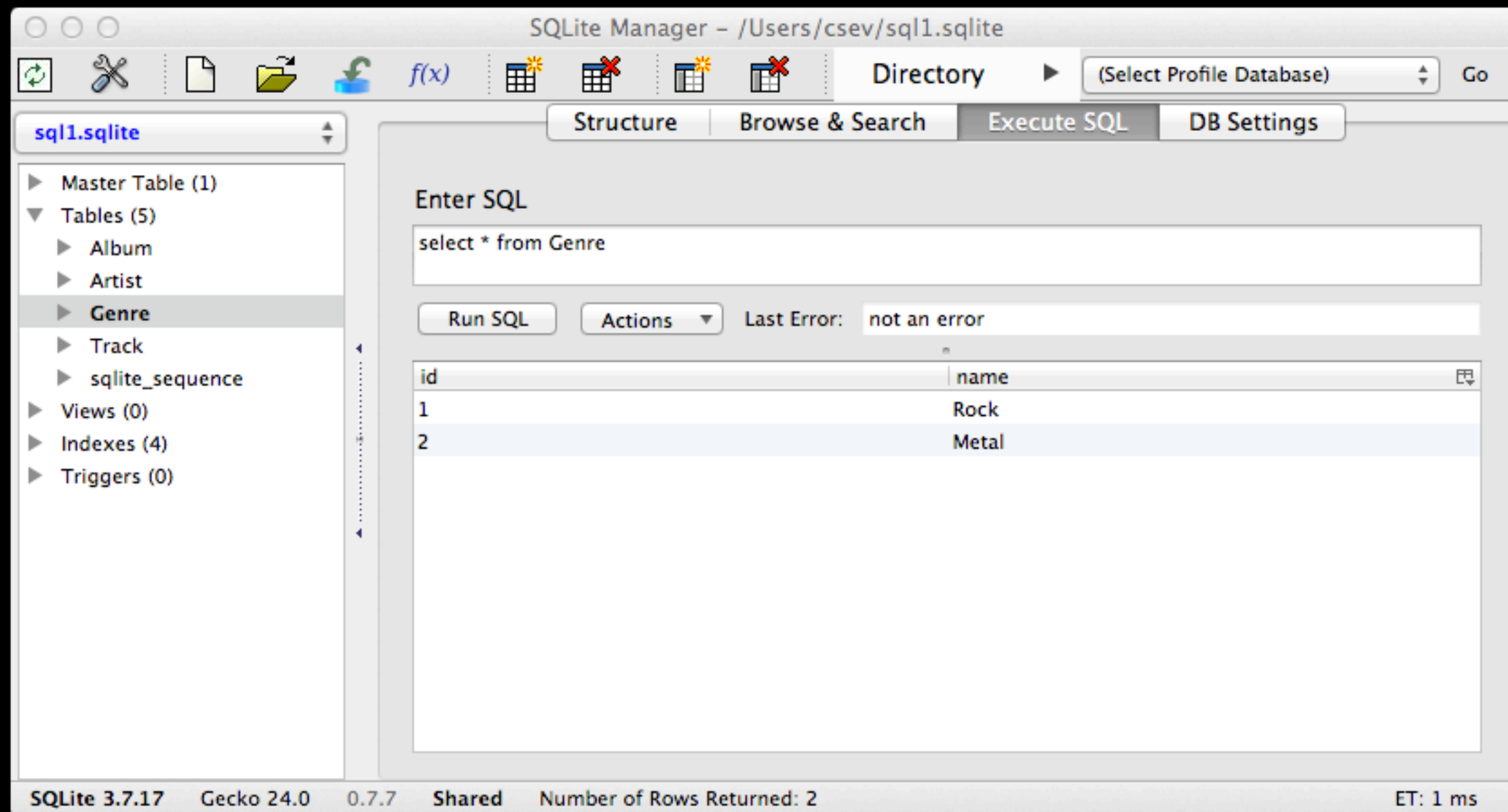
Columns (7)

Column ID	Name	Type	Not Null	Default Value	Primary Key
0	id	INTEGER	1	null	1
1	album_id	INTEGER	0	null	0
2	genre_id	INTEGER	0	null	0
3	len	INTEGER	0	null	0
4	rating	INTEGER	0	null	0
5	title	TEXT	0	null	0
6	count	INTEGER	0	null	0

Name Type Not Null Default



insert into Artist (name) values ('Led Zeppelin')  
insert into Artist (name) values ('AC/DC')



insert into Genre (name) values ('Rock')  
insert into Genre (name) values ('Metal')

SQLite Manager - /Users/csev/sql1.sqlite

Directory (Select Profile Database) Go

Structure Browse & Search Execute SQL DB Settings

sql1.sqlite

- ▶ Master Table (1)
- ▼ Tables (5)
  - ▶ Album
  - ▶ Artist
  - ▶ Genre
  - ▶ Track
  - ▶ sqlite\_sequence
- ▶ Views (0)
- ▶ Indexes (4)
- ▶ Triggers (0)

Enter SQL

```
select * from Album;
```

Run SQL Actions Last Error: not an error

id	artist_id	title
1	2	Who Made Who
2	1	IV

SQLite 3.7.17 Gecko 24.0 0.7.7 Shared Number of Rows Returned: 2 ET: 0 ms

insert into Album (title, artist\_id) values ('Who Made Who', 2)  
insert into Album (title, artist\_id) values ('IV', 1)

```
insert into Track (title, rating, len, count, album_id, genre_id)
values ('Black Dog', 5, 297, 0, 2, 1)
insert into Track (title, rating, len, count, album_id, genre_id)
values ('Stairway', 5, 482, 0, 2, 1)
insert into Track (title, rating, len, count, album_id, genre_id)
values ('About to Rock', 5, 313, 0, 1, 2)
insert into Track (title, rating, len, count, album_id, genre_id)
values ('Who Made Who', 5, 207, 0, 1, 2)
```

id	album_id	genre_id	len	rating	title	count
1	2	1	297	5	Black Dog	0
2	2	1	482	5	Stairway	0
3	1	2	313	5	About to Rock	0
4	1	2	207	5	Who Made W...	0

# We have relationships!

id	album_id	genre_id	len	rating	title	count
1	2	1	297	5	Black Dog	0
2	2	1	482	5	Stairway	0
3	1	2	313	5	About to Rock	0
4	1	2	207	5	Who Made W...	0

Track

id	artist_id	title
1	2	Who Made Who
2	1	IV

Album

id	name
1	Rock
2	Metal

Genre

id	name
1	Led Zeppelin
2	AC/DC

Artist

Use 'control + ;' to execute the query.

# Using Join Across Tables

[http://en.wikipedia.org/wiki/Join\\_\(SQL\)](http://en.wikipedia.org/wiki/Join_(SQL))



# Relational Power

- By removing the replicated data and replacing it with references to a single copy of each bit of data we build a “web” of information that the relational database can read through very quickly - even for very large amounts of data
- Often when you want some data it comes from a number of tables linked by these foreign keys

# The JOIN Operation

- The JOIN operation **links across several tables** as part of a select operation
- You must tell the JOIN **how to use the keys** that make the connection between the tables using an **ON clause**

id	artist_id	title
1	2	Who Made Who
2	1	IV

title	name
Who Made Who	AC/DC
IV	Led Zeppelin

id	title
1	Led Zeppelin
2	AC/DC

Use 'control + ;' to execute the query.

`select Album.title, Artist.name from Album join Artist on Album.artist_id = Artist.id`

What we want  
to see

The tables which  
hold the data

How the tables  
are linked

id	artist_id	title
1	2	Who Made Who
2	1	IV

id	name
1	Led Zeppelin
2	AC/DC

Use 'control + ;' to execute the query.

Album.title      Album.artist\_id      Artist.id      Artist.name

title	artist_id	id	name
Who Made Who	2	2	AC/DC
IV	1	1	Led Zeppelin

```
select Album.title, Album.artist_id, Artist.id, Artist.name
from Album join Artist on Album.artist_id = Artist.id
```

id	album_id	genre_id	len	rating	title	count
1	2	1	297	5	Black Dog	0
2	2	1	482	5	Stairway	0
3	1	2	313	5	About to Rock	0
4	1	2	207	5	Who Made W...	0

title	name
Black Dog	Rock
Stairway	Rock
About to Rock	Metal
Who Made Who	Metal

id	name
1	Rock
2	Metal

`select Track.title, Genre.name from Track join Genre on Track.genre_id = Genre.id`

What we want  
to see

The tables which  
hold the data

How the tables  
are linked

# It can get complex...

```
select Track.title, Artist.name, Album.title, Genre.name from
Track join Genre join Album join Artist on Track.genre_id =
Genre.id and Track.album_id = Album.id and Album.artist_id
= Artist.id
```

title	name	title	name
Black Dog	Led Zeppelin	IV	Rock
Stairway	Led Zeppelin	IV	Rock
About to Rock	AC/DC	Who Made Who	Metal
Who Made Who	AC/DC	Who Made Who	Metal

What we want  
to see

The tables which  
hold the data

How the tables  
are linked

<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tin Man	3:30	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Sister Golden Hair	3:22	America	Greatest Hits	Easy Listen...	★★★★★	24
<input checked="" type="checkbox"/>	Track 01	4:22	Billy Price	Danger Zone	Blues/R&B	★★★★★	26
<input checked="" type="checkbox"/>	Track 02	2:45	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/>	Track 03	3:26	Billy Price	Danger Zone	Blues/R&B	★★★★★	22
<input checked="" type="checkbox"/>	Track 04	4:17	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/>	Track 05	3:50	Billy Price	Danger Zone	Blues/R&B	★★★★★	21
<input checked="" type="checkbox"/>	War Pigs/Luke's Wall	7:58	Black Sabbath	Paranoid	Metal	★★★★★	25
<input checked="" type="checkbox"/>	Paranoid	2:53	Black Sabbath	Paranoid	Metal	★★★★★	22
<input checked="" type="checkbox"/>	Planet Caravan						
<input checked="" type="checkbox"/>	Iron Man						
<input checked="" type="checkbox"/>	Electric Funeral						
<input checked="" type="checkbox"/>	Hand of Doom						
<input checked="" type="checkbox"/>	Rat Salad						
<input checked="" type="checkbox"/>	Jack the Stripper/Fa						
<input checked="" type="checkbox"/>	Bomb Squad (TECH)						
<input checked="" type="checkbox"/>	clay techno						
<input checked="" type="checkbox"/>	Heavy						
<input checked="" type="checkbox"/>	Hi metal man	4:20	Brent	Brent's Album			1
<input checked="" type="checkbox"/>	Mistro	2:58	Brent	Brent's Album			1

title	name	title	name
Black Dog	Led Zeppelin	IV	Rock
Stairway	Led Zeppelin	IV	Rock
About to Rock	AC/DC	Who Made Who	Metal
Who Made Who	AC/DC	Who Made Who	Metal

# Complexity Enables Speed

- Complexity makes speed possible and allows you to get very fast results as the data size grows.
- By **normalizing the data and linking it with integer keys**, the overall **amount of data** which the relational database must **scan** is far lower than if the data were simply flattened out.
- It might seem like a **tradeoff** - spend some time designing your database so it continues to be fast when your application is a success



# Additional SQL Topics

- **Indexes** improve access performance for things like string fields
- **Constraints** on data - (cannot be NULL, etc..)
- **Transactions** - allow SQL operations to be grouped and done as a unit
- See SI664 - Database Design (All Semesters)

# Summary

- Relational databases allow us to **scale** to very large amounts of data
- The key is to have **one copy of any data** element and use relations and joins to link the data to multiple places
- This greatly **reduces the amount of data which much be scanned** when doing complex operations across large amounts of data
- Database and SQL design is a bit of an **art-form**