



Database Basics

A basic introduction to relational databases

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Relational or NoSQL

Relational Databases - data stored in structured format, with data in fields (columns), one record per row, in tables. Tables are similar to tables in a spreadsheet, but columns have fixed size.

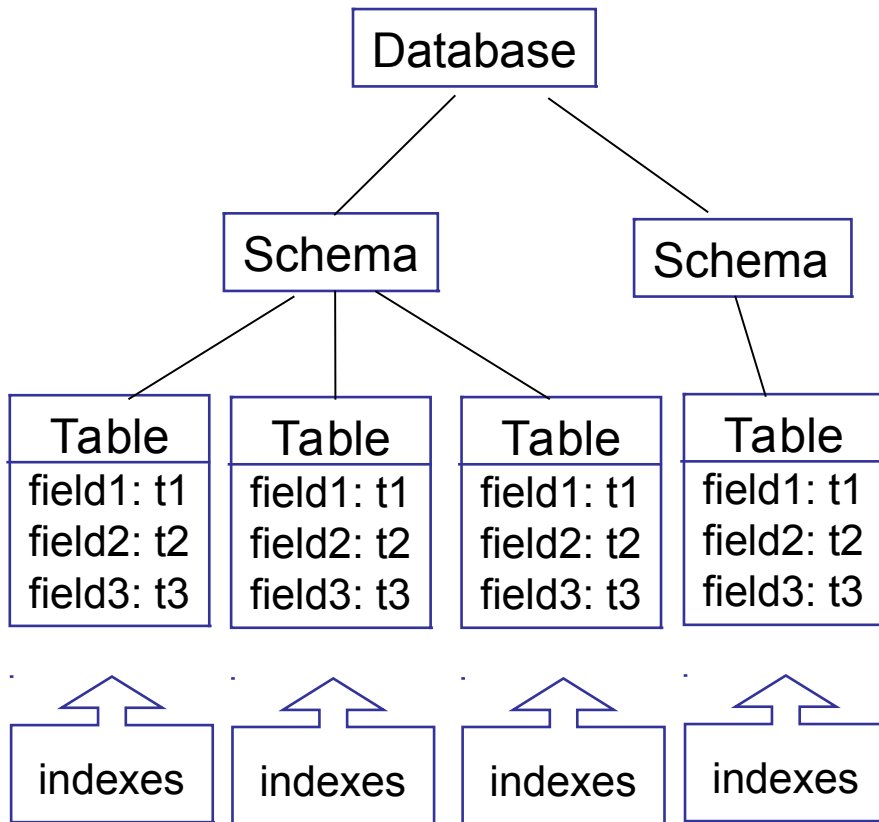
Data in different tables can be related based on common values or expressions.

Examples: Sqlite, MySQL, Oracle, H2

NoSQL Databases - any database not organized like a Relational Database. Some forms are document-oriented and graph databases.

Examples: MongoDB, CouchDB (document),
Neo4j (graph)

Database Structure



A database contains **schema**, which describe its structure.

A **schema** can contain:

tables - containing data

index files - for fast lookup of data in tables

stored procedures, constraints, triggers, and more

*SQLite databases have only **one** schema, so its not shown.*

A Table

- A table contains the actual data in **records** (rows).
- A record is composed of **fields** (columns).
- Each record contains one set of data values.

records
(rows)

ID	Name	CCode	District	Populatn
3320	Bangkok	THA	Bangkok	6320174
3321	Nonthaburi	THA	Nonthaburi	292100
3323	Chiang Mai	THA	Chiang Mai	171100

fields (columns)

Key field to Identify Rows

- A table contains a *primary key* that uniquely identifies a row of data.
- Each record must have a **distinct value** of primary key
- The primary key is used to relate data in tables.

ID is the *primary key* in City table.

ID	Name	CCode	District	Populatr
3320	Bangkok	THA	Bangkok	6320174
3321	Nonthaburi	THA	Nonthaburi	292100
3323	Chiang Mai	THA	Chiang Mai	171100

Structure of a Table

Every field has:

- a name
- a data type and length

To view the structure of a table use:

```
DESCRIBE tablename
```

```
sql> DESCRIBE City;
```

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI		auto_increment
Name	char(35)	NO			
CountryCode	char(3)	NO			
District	char(20)	NO			
Population	int(11)	NO		0	

Field types and attributes

Each field (column) has an SQL **data type**, like `char(20)`.
Fields can have **constraints** (`not null`) and **default values**.

```
sql> SHOW columns FROM City;
```

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI		auto_increment
Name	char(35)	NO			
CountryCode	char(3)	NO			
District	char(20)	NO			
Population	int(11)	NO		0	

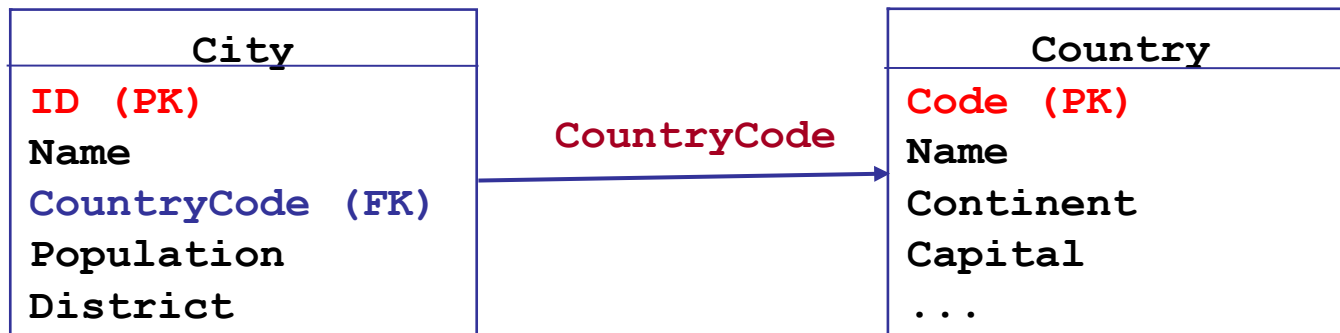
A default value to use if value is not assigned explicitly.

Keys

Every table should have a **primary key** that uniquely identifies each row.

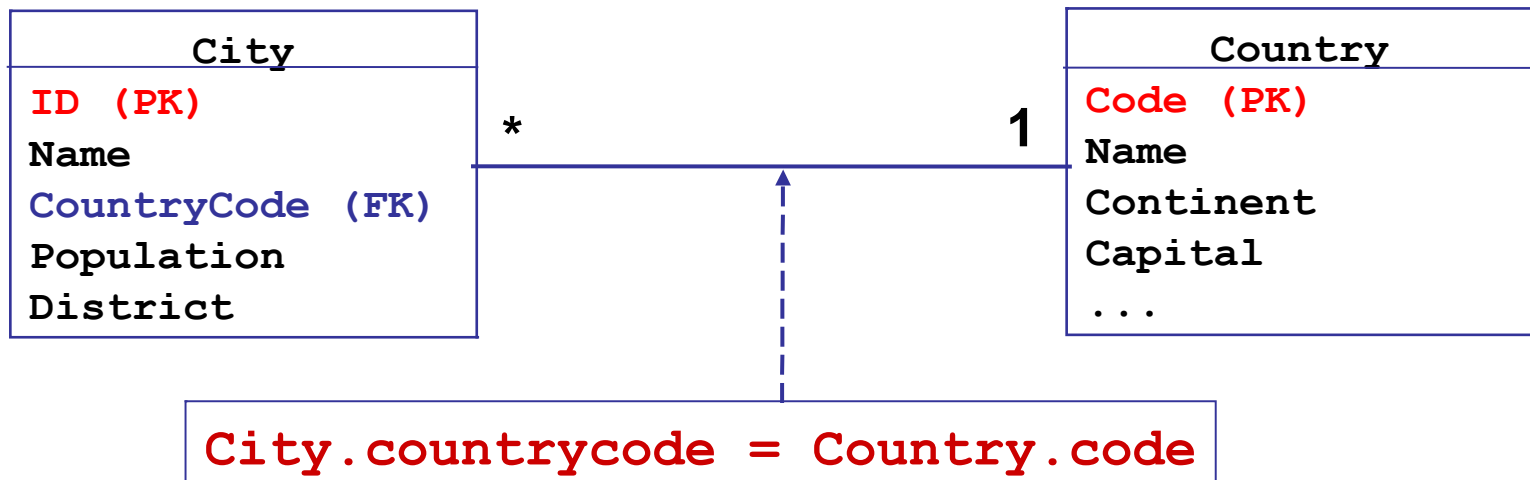
```
sql> DESCRIBE Country;
```

Field	Type	Null	Key	Default	Extra
Code	char(3)	NO	PRI		
Name	char(52)	NO			
...					



Joining Tables

- Relate or "join" data in different tables.
- This is what makes an RDB so powerful and useful.
- City contains the CountryCode for the country it belongs to. This is called a **Foreign Key**.

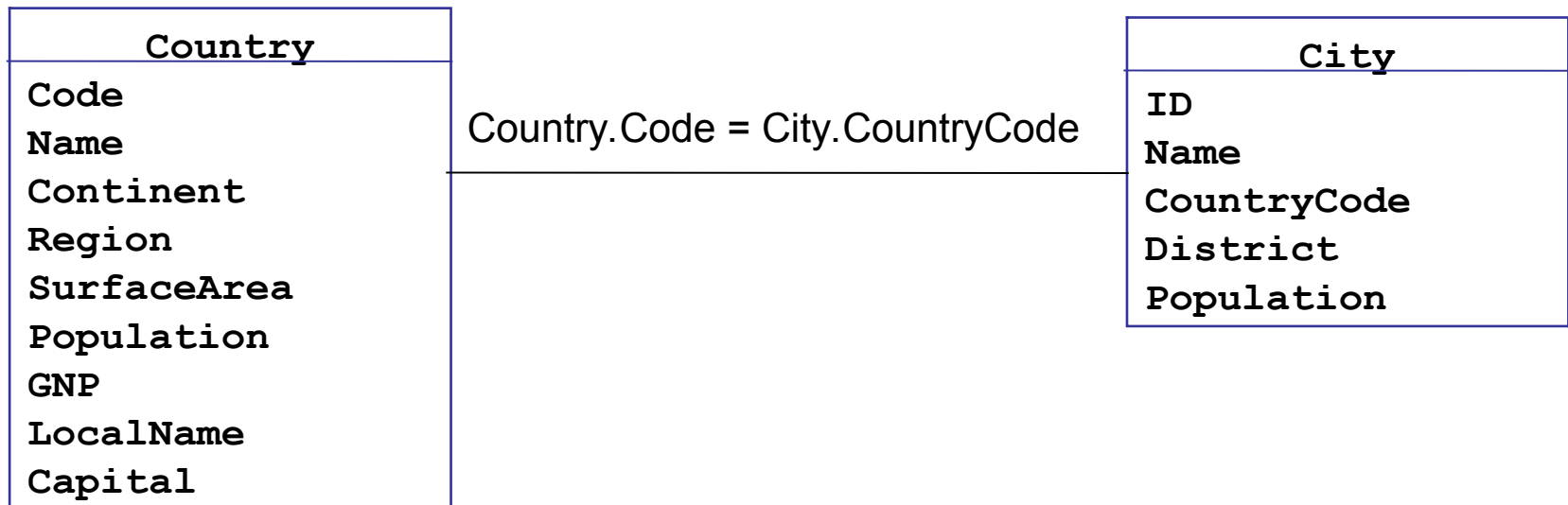


Example: find all cities in SE Asia

Join the Country table and City table.

Search for `Country.region = 'Southeast Asia'`

```
SELECT City.Name, City.Population
FROM Country, City
WHERE Country.Code = City.CountryCode
AND Country.Region = 'Southeast Asia';
```



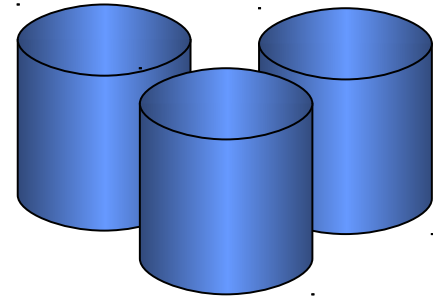
Structure of a Database

- A **database system** may contain **many databases**.
- Each database is composed of **schema** and **tables**.

```
sql> SHOW databases;
```

```
+-----+  
| Database |  
+-----+  
| mysql   |  
| test    |  
| bank    |  
| world   |  
+-----+
```

"shows databases" only shows db that the user has permission to access.

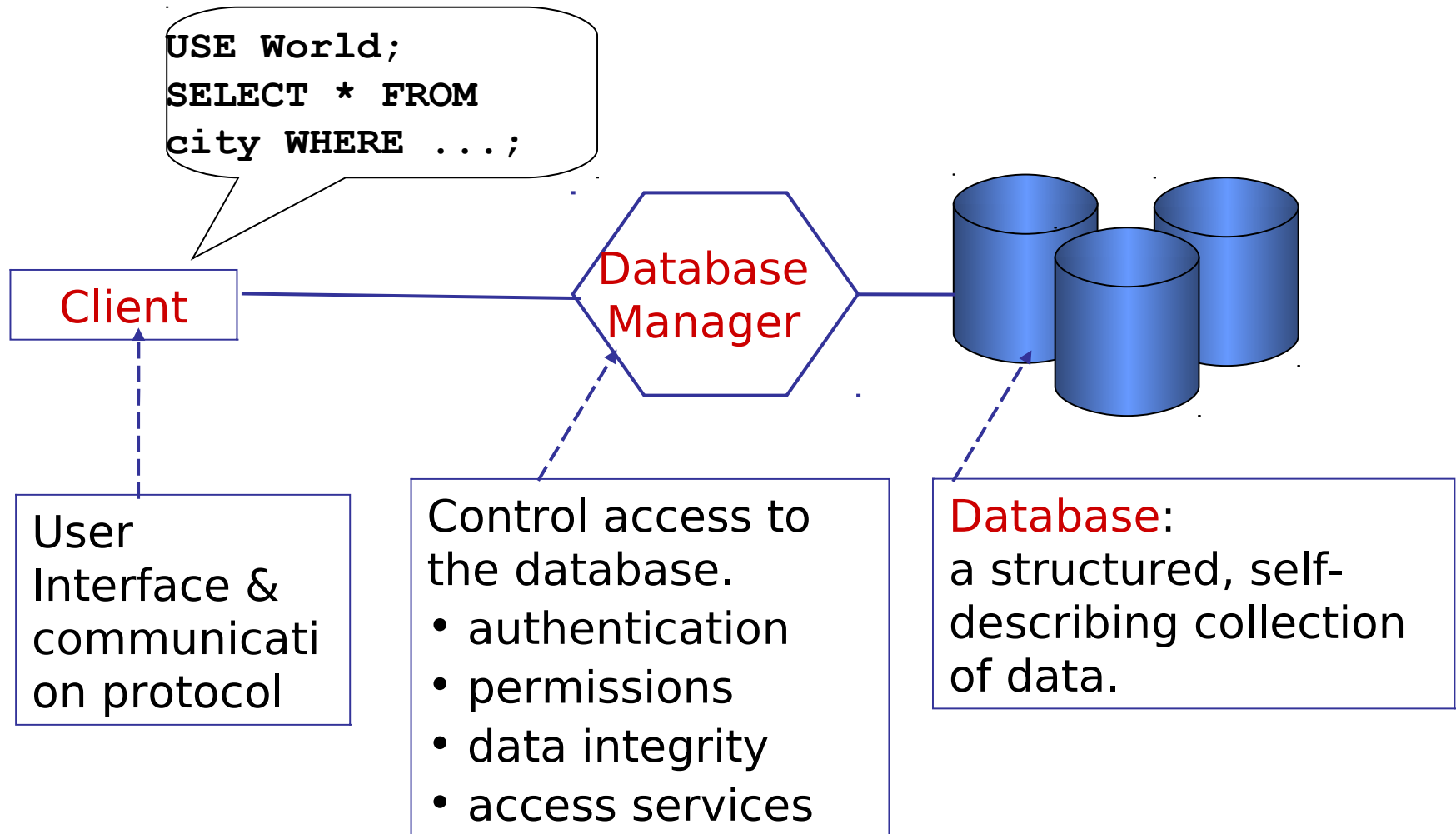


```
sql> USE world;
```

```
sql> SHOW tables;
```

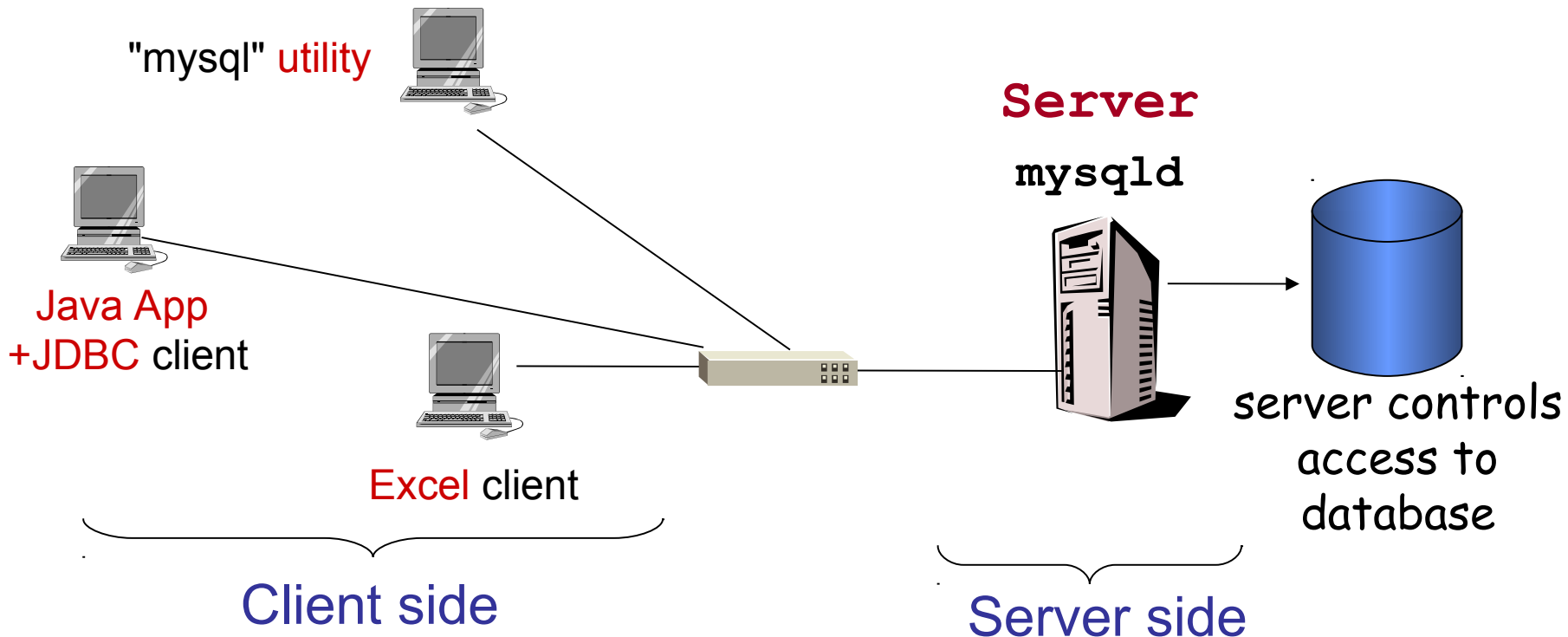
```
+-----+  
| Tables_in_world |  
+-----+  
| countries       |  
| city            |  
+-----+
```

Database Management System



Client - Server Databases

- Database **Server** is a separate *process* on a host.
- **Clients** can be on *any machine*.
- Many programs may be *clients* using a **standard API**.



4 Basic Database Operations

The 4 most common operations:

SELECT query (search & retrieve) data

INSERT add new records to a table(s)

UPDATE modify existing record(s)

DELETE delete record(s) from a table

What is CRUD?

Programmers call these operations "**CRUD**".

What does **CRUD** stand for?

Exercise: O-O Analogy of a Table?

Database

Object Oriented Construct

table

record (row)

fields (columns)

ID	Name	District	Popula..}
3320	Bangkok	Bangkok	6320174
3321	Nonthaburi	Nonthaburi	292100
3323	Chiang Mai	Chiang Mai	171100

records
(rows)

fields (columns)

Exercise: O-O Analogy of a Table?

Database

table

record (row)

fields (columns)

Object Oriented Construct

class

instance of class (object)

attributes

UML for
City class

City

name: String

district: String

population: long

Exercise

The database for the Django Polls project is db.sqlite3.

Use a database browser to answer some questions (separate file).

Tools

- [sqlite3](#) command line tool, included with Sqlite
- [sqlitebrowser](#) free GUI tool. Works on all platforms.
- [DBeaver](#) popular database editor/browser that works with (almost) any database. Uses Java.

SQL Field Types are Different

SQL field types only *partially* match the data types in most programming languages.

SMALLINT (16-bit)	-32,768 - 32,767
INTEGER or INT	32-bit same as <code>int</code> in C, Java
DECIMAL(m, d) DECIMAL(6, 2)	Decimal with m digits, n digits after decimal point. 1234.56
REAL or FLOAT	8-byte floating point, like " <code>double</code> " in Java or C.
BOOLEAN	True (1) or False (0). Not standard.

SQL Date, Time, and String Types

SQL has a **lot more types** than shown here.

Not all databases support all types, and details differ.

DATE	yyyy-mm-dd
TIME	HH:MM:SS
DATETIME	yyyy-mm-dd HH:MM:SS Python datetime.datetime is more accurate.
TIMESTAMP	Stores number of seconds since 1970-01-01 00:00:00 (the unix "epoch")
CHAR(n)	Character data with fixed length n. n <= 8000.
VARCHAR(n)	Variable length character string. n <= 8000
TEXT	Variable length string storage, maximum 2GB (varies)
NCHAR(n) NVARCHAR(n)	Character data stored as Unicode (likely 2-byte/char)

Why Should You Care?

> Appropriate data type can **improve code & accuracy**.

Example:

Use `Decimal(10,2)` for Thai money.

> **Save storage**, especially when you have lots of data.

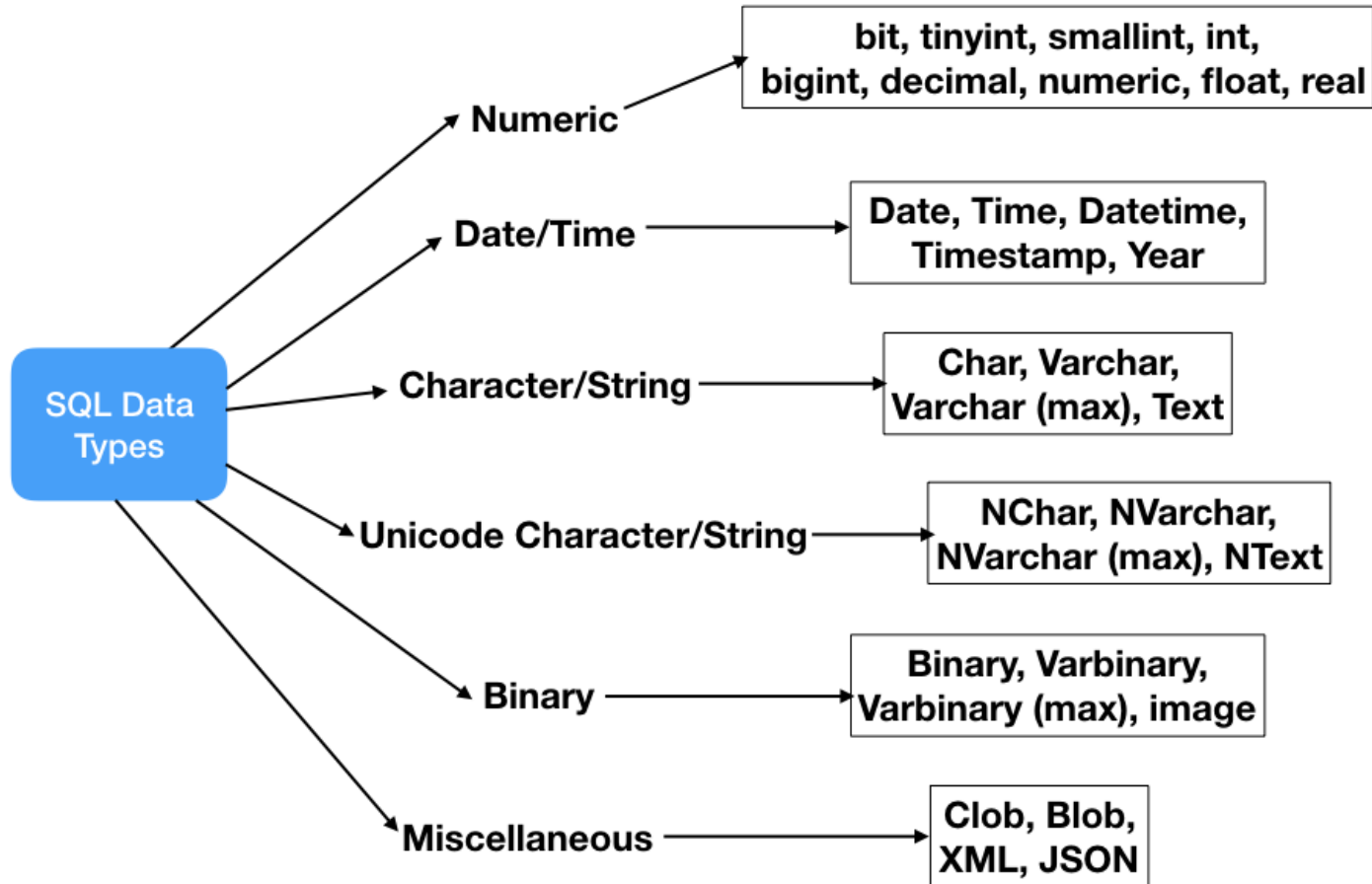
Example:

You have 1 billion temperature measurements.

If you store them as `Float`, you need 8GB.

If you store them as 2-byte `Int` (maybe scaled), you need 2GB.

Data Type Hierarchy



Django Model Field types

Fields in a Django Model subclass are saved to the database.

For list of Field types in Django:

<https://docs.djangoproject.com/en/2.2/ref/models/fields/>