Databases

Relational and Non-Relational Databases and MySQL

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Databases

Introduction

What is a Database?

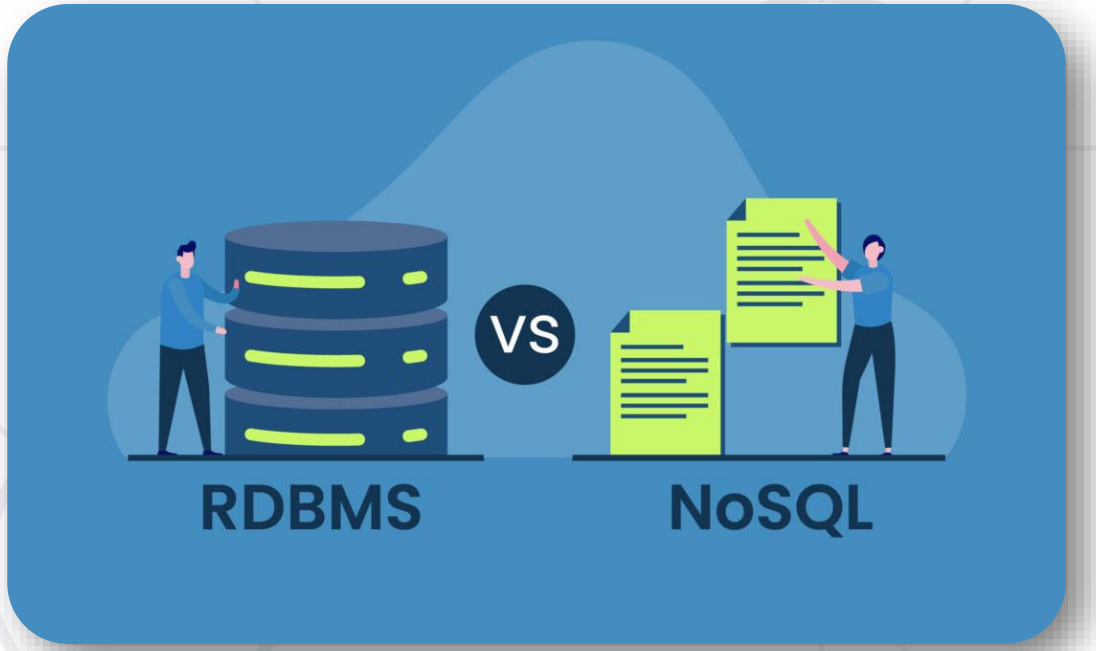
- A **database** is a collection of data, organized to be easily accessed, managed and updated
- Modern databases are managed by **Database Management Systems** (DBMS)
  - Define database **structure**, e.g. tables, collections, columns, relations, indexes
  - Create / Read / Update / Delete data (CRUD operations)
  - Execute **queries** (filter / search data)

Relational and Non-Relational Databases

- Databases hold and manage data in the back-end systems
- **Relational databases** (SQL Databases)
  - Hold data in **tables** + **relationships**
  - Use the **SQL** language to query / modify data
  - Examples: MySQL, PostgreSQL, Web SQL in HTML5
- **Non-Relational databases** (No SQL Databases)
  - Hold **collections** of documents or key-value pairs
  - Examples: MongoDB, IndexedDB in HTML5

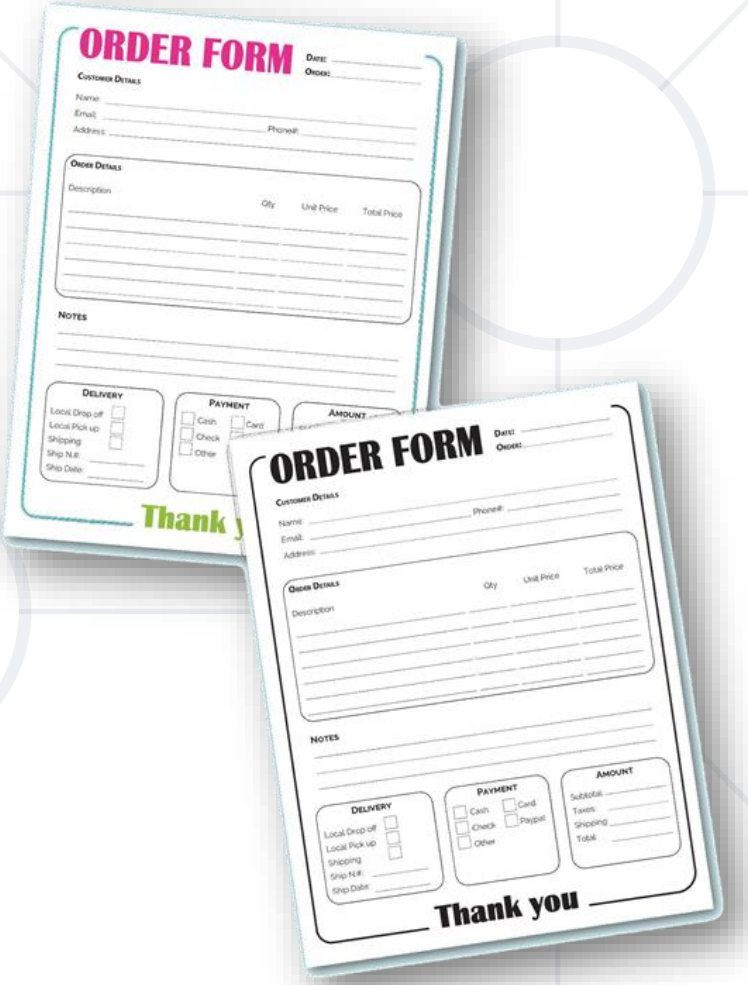
SQL & NoSQL Database

- **RDBMS vs. NoSQL** – **Which is Better**?
  - **RDBMS** focuses on **relational databases**
  - **NoSQL** focuses on **Big Data** and **real-time web applications**



Data Storage

- Conventional **data storage**
  - Orders
  - Receipts



From Data Storage to Databases

- We can **group related pieces of data** into separate columns:

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	TOTAL
WM2536	Women's Tall - M	10	$10.00	$100.00
GH2403	Men's Tall - M	5	$20.00	$100.00
NC2267	Children's - S	10	$5.00	$50.00
YX6278	Men's - XL	5	$10.00	$50.00

- Thus, we keep data in **tables** (like in Excel)
- Tables may be **related** (e. g. Products and Orders)

Why Do We Need Databases?

- **Data storage and processing** is **a common need** in the tech industry
- Data storage needs:
  - Ease of searching
  - Ease of updating
  - Performance
  - Accuracy and consistency
  - Security and access control
  - Redundancy

Relational Databases

Tables, Relationships and SQL

SQL Databases (Relational Databases)

- Relational (**SQL**) databases organize data in **tables**
  - Tables have strict structure (**columns** of certain **data types**)
  - Can have **relationships** to other tables
- Relational databases use the **structured query language** (**SQL**) for defining and manipulating data
  - Extremely powerful for complex queries
- **Relational databases** are the most widely used data management technology

The Relational DB Model

- Relational DB model organizes data into one or more **tables** of columns and rows with a **unique key** identifying each row and **foreign keys** defining **relationships**

Items

ID	Order ID	Name	Quantity	Price
5	1	Table	1	200.00
6	1	Chair	1	123.12

Customers

ID	Name	Email
5	Peter	peter@gmail.com
6	Jayne	jayne@gmail.com

Orders

ID	Customer ID	Date	Total Price
1	5	11/1/17	323.12
2	1	11/15/17	13.99

Non-Relational Databases

NoSQL Databases and JSON Documents

NoSQL (Non-Relational) Databases

- A **NoSQL** databases have dynamic schema for **unstructured** data
- Data may be stored in several ways:
  - **Document-oriented** (JSON store)
  - **Column-oriented** (table store)
  - **Graph-based**
  - **Key-value store**

NoSQL Databases

- **NoSQL databases** don't use tables
  - Instead, use **document collections** or **key-value pairs**
- More **scalable** and **high performance**
- Examples: **MongoDB**, **Cassandra**, **Redis**, etc.

Example of JSON document in MongoDB

```
{
  "_id": ObjectId("59d3fe7ed81452db0933a871"),
  "email": "peter@gmail.com",
  "age": 22
}
```

Database Management Systems

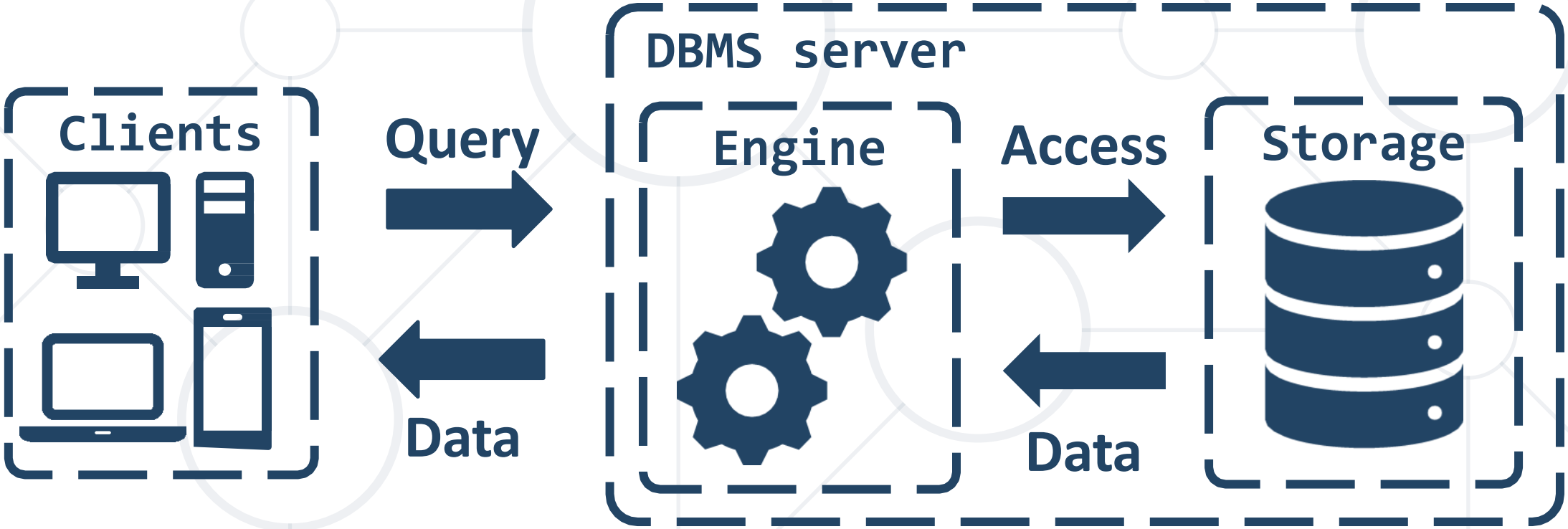
(DBMS)

Database Management Systems (DBMS)

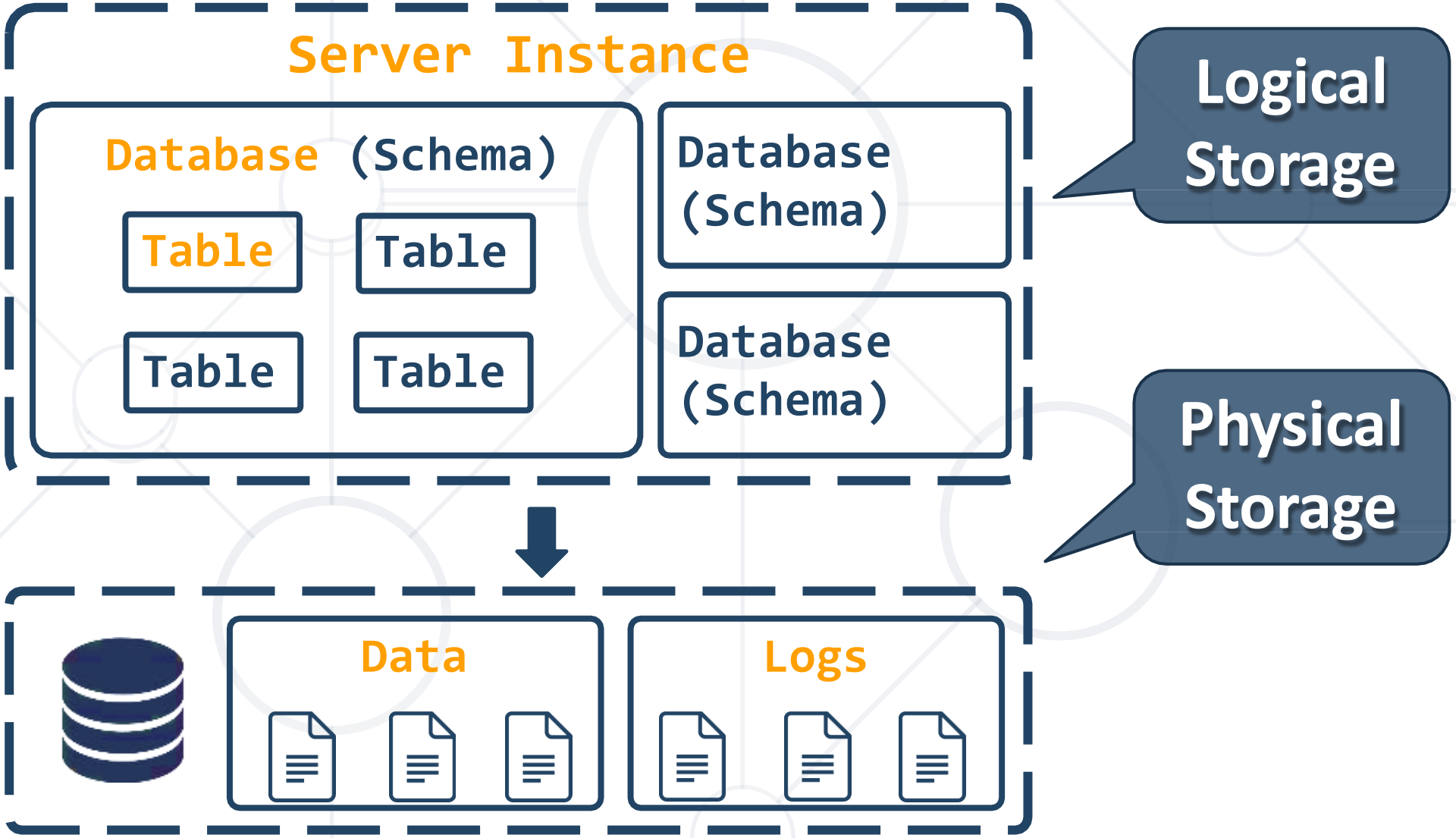
- A **D**ata**b**ase **M**anagement **S**ystem (**DBMS**) is a software, used to **define**, **manipulate**, **retrieve** and **manage** data in a database
  - DBMS **stores and manages** the data itself, the data format, field names and data types, record structure and file structure
- DBMS **examples** (database servers):
  - MySQL, MS SQL Server, Oracle, PostgreSQL
  - MongoDB, Cassandra, Redis, HBase
  - Amazon DynamoDB, Azure Cosmos DB

DBMS Systems and Data Flow

- **DBMS servers** use the **client-server model**:



DBMS Server Architecture



Structured Query Language

SQL Language

Structured Query Language

- Query language designed for managing data in a relational database
- Developed at **IBM** in the early 1970s
- To communicate with the DB engine we use **SQL**

Structured Query Language

- **SQL** == query language designed for managing data in **relational** databases (RDBMS)
  - Used to communicate with the database engine
- Logically, SQL is divided into four sections:
  - **Data definition**: describe the **structure** of data
  - **Data manipulation**: **store** and **retrieve data**
  - **Data control**: define who can **access the data**
  - **Transaction control**: bundle **operations** together and perform **commit** / **rollback**

Database Table Elements

- The **table** is the main **building block** in the relational databases

Column

Row

ID	FirstName	BirthDate	CityId
1	August	03/12/1975	101
2	Bejnamin	04/04/1984	102
3	Denis	15/10/1988	103
4	Linda	07/01/1984	104

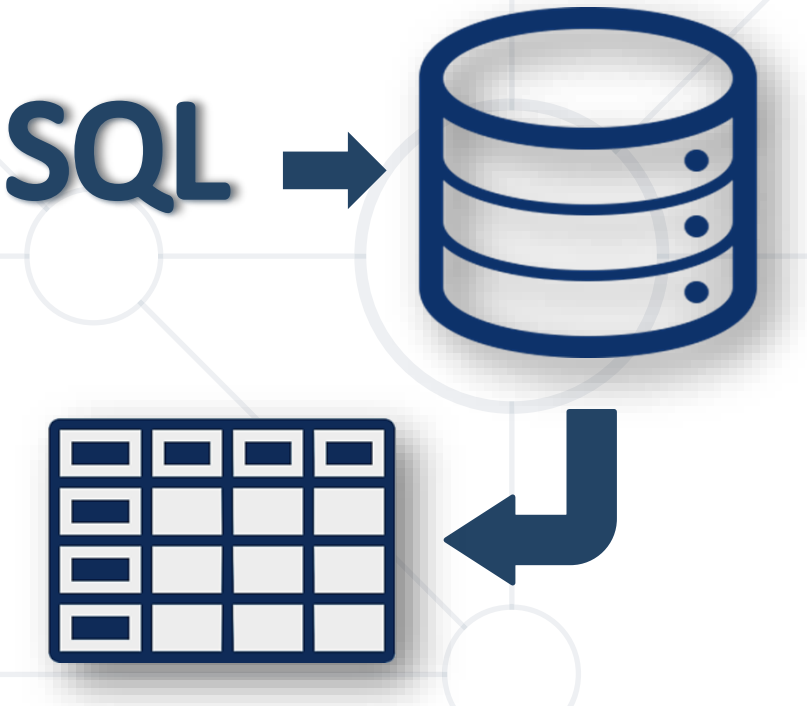
Cell

- Each **row** is called a **record** or **entity**
- Columns (**fields**) define the **type** of data they contain

SQL – Example

- Example of SQL query:

```
SELECT * FROM people
```



- The query is executed by the DBMS system
  - It returns a sequence of data rows, e.g.

id	email	first_name	last_name
1	smith@yahoo.co.uk	John	Smith
2	pwh@gmail.com	Peter	White
3	anne@anne.com	Anne	Green
4	jason.jj@gmail.com	Jason	Anderson

SQL Query

- Subdivided into several language elements
  - Queries
  - Clauses
  - Expressions
  - Predicates
  - Statements

Update command

Expression

Statement

```
UPDATE employees
SET   salary = salary * 1.1
WHERE job_title = "Cashier";
```

Predicate

MySQL

Working with Relational Database

MySQL

- **Open-source** relational database management system
- Used in many **large-scale websites** including Google, Facebook, YouTube etc.
- Works on **many** system platforms – macOS, Windows, Linux
- Download **MySQL Community Server**
  - **Windows**: https://dev.mysql.com/downloads/mysql/
  - **Ubuntu/Debian**: https://dev.mysql.com/downloads/repo/apt/

Related Tables

- We split the data and introduce **relationships** between the tables to **avoid** repeating information

user_id	first	last	registered
203	David	Rivers	05/02/2016
204	Sarah	Thorne	07/17/2016
205	Michael	Walters	11/23/2015

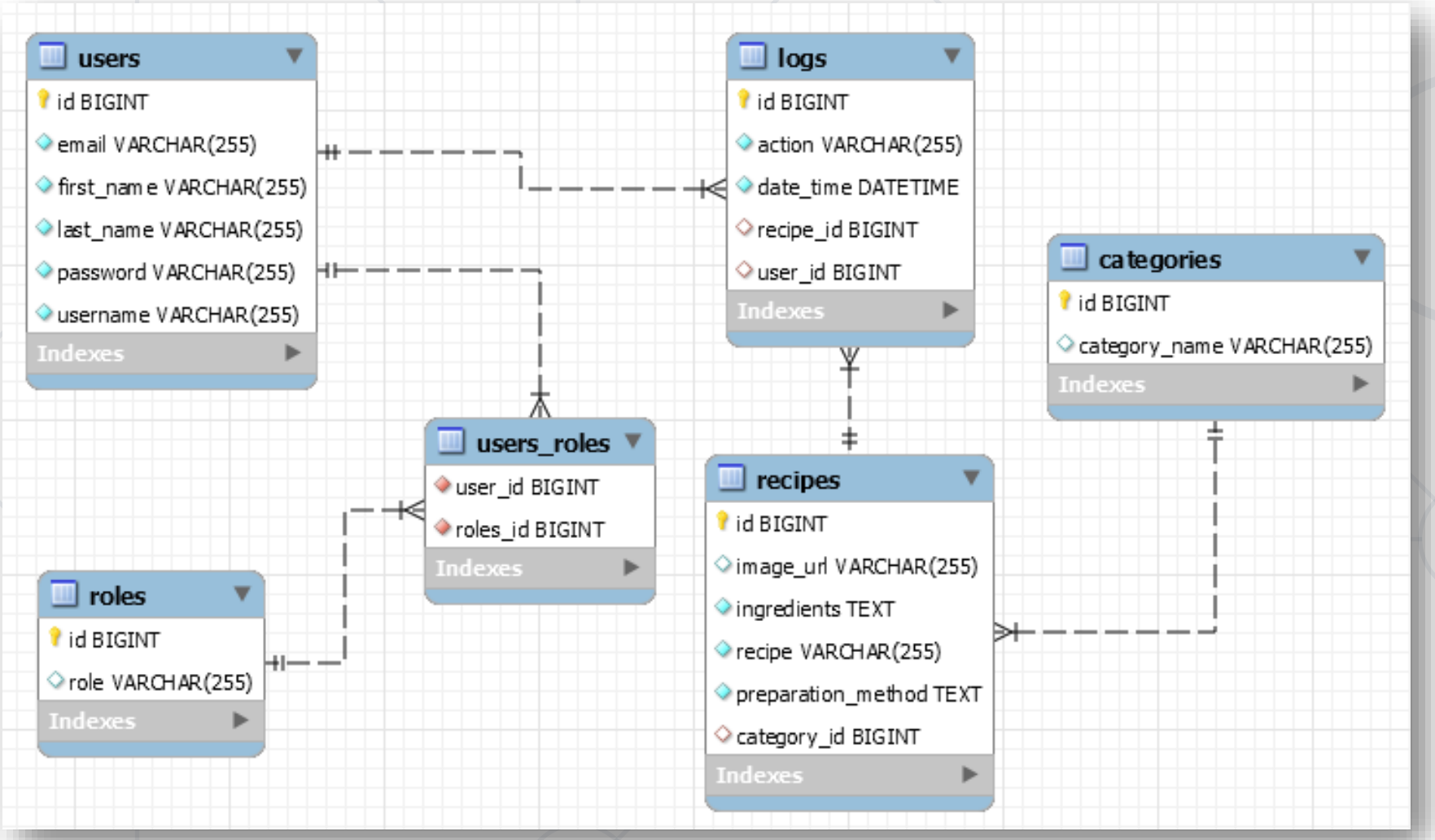
user_id	email
203	drivers@mail.cx
204	sarah@mail.cx
205	walters_michael@mail.cx
203	david@homedomain.cx

Primary Key

Foreign Key

- Connection via **Foreign Key** in one table pointing to the **Primary Key** in another

E/R Diagrams


users
id BIGINT
email VARCHAR(255)
first_name VARCHAR(255)
last_name VARCHAR(255)
password VARCHAR(255)
username VARCHAR(255)
Indexes
logs
id BIGINT
action VARCHAR(255)
date_time DATETIME
recipe_id BIGINT
user_id BIGINT
Indexes
categories
id BIGINT
category_name VARCHAR(255)
Indexes
users_roles
user_id BIGINT
roles_id BIGINT
Indexes
recipes
id BIGINT
image_url VARCHAR(255)
ingredients TEXT
recipe VARCHAR(255)
preparation_method TEXT
category_id BIGINT
Indexes
roles
id BIGINT
role VARCHAR(255)
Indexes

SQL Commands

- We can **communicate** with the database engine via **SQL**
- SQL commands provide greater **control** and **flexibility**
- To **create** a database in MySQL:

```
CREATE DATABASE employees;
```

Database name

- **Display** all databases in MySQL:

```
SHOW DATABASES;
```

Creating Table

- **Creating** tables

Column name

Table name

```
CREATE TABLE people (
    id INT NOT NULL PRIMARY KEY AUTO_INCREMENT,
    email VARCHAR(40) NOT NULL,
    first_name VARCHAR(40) NOT NULL,
    last_name VARCHAR(40) NOT NULL
);
```

Primary key definition

Data type

Inserting Values

- **Inserting** values

Table name

Column name

```
INSERT INTO people (email, first_name, last_name)
VALUES
  ('john@gmail.com', 'John', 'Smith'),
  ('smith@yahoo.co.uk', 'John', 'Smith'),
  ('peter@gmail.com', 'Peter', 'White'),
  ('anne@anne.com', 'Anne', 'Green'),
  ('jason.jj@gmail.com', 'Jason', 'Anderson’);
```

Values for each column

Retrieving Records

- **Retrieve** all records from a table

```
SELECT * FROM people;
```

* retrieves all columns

- You can **pick** (select) **the columns** to retrieve

```
SELECT first_name, last_name FROM people;
```

List of columns

- You can **limit the number of rows**

```
SELECT first_name, last_name FROM people
LIMIT 3;
```

Number of rows to return

Filtering Data

- Retrieve all records, matching a **filter**

```
SELECT * FROM people
WHERE email = 'peter@gmail.com’;
```

Filter the returned rows by a condition

- **Filter** and **sort** data

```
SELECT * FROM people
WHERE id > 2 AND id < 5
ORDER BY id;
```

Filter by multiple conditions

Sort by given column / expression

Filtering the Selected Rows

- Use **DISTINCT** to eliminate **duplicate** results

```
SELECT DISTINCT last_name
  FROM people;
```

- Filter rows by specific **conditions** using the **WHERE** clause

```
SELECT first_name, email
  FROM people
 WHERE last_name = 'Smith';
```

- Other **logical operators** can be used for greater control

```
SELECT first_name, last_name
FROM people WHERE id <= 3;
```

Sorting Result Sets

- Sort rows with the **ORDER BY** clause
  - **ASC**: ascending order, default

```
  SELECT first_name, last_name
    FROM people
ORDER BY last_name;
```

first_name	last_name
Jason	Anderson
Anne	Green
John	Smith
John	Smith
Peter	White

  - **DESC**: descending order

```
  SELECT first_name, last_name
    FROM people
ORDER BY last_name DESC;
```

first_name	last_name
Peter	White
John	Smith
John	Smith
Anne	Green
Jason	Anderson

Updating Records

- **Updating** rows

```
UPDATE people
SET last_name = 'Adams'
WHERE first_name = 'Anne';
```

Updates the last name of person

```
UPDATE people
SET first_name = 'Peter',
    last_name = 'Black',
    email = 'pw@email.com'
WHERE id = 3;
```

Updates multiple fields

Deleting Data and Objects

- **Deleting** table rows

```
DELETE FROM people WHERE id = 4;
```

- Deleting (**dropping**) database objects
  - Table

Delete all records in a table

```
TRUNCATE TABLE people;
```

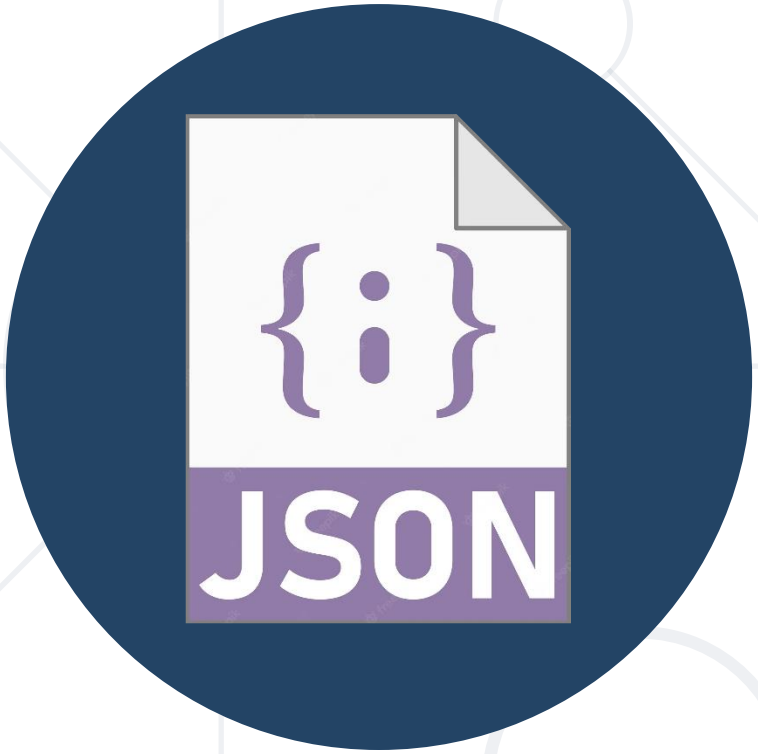
Delete the table itself

```
DROP TABLE people;
```

  - Entire database

```
DROP DATABASE employees;
```

  - These actions **cannot be undone**



JSON Data Format

Definition and Syntax

JSON Data Format

- **JSON** (**J**ava**S**cript **O**bject **N**otation) is a lightweight data format
  - Human and machine-readable plain text
  - Based on **JavaScript** objects
  - Independent of development platforms and languages
  - JSON data consists of:
    - Key-value pairs: **`{ key : value }`**
    - Values (**`strings`**, **`numbers`**, etc.)
    - Arrays: **`[value1, value2, …]`**

```
{
  "firstName": "Peter",
  "courses": ["C#", "JS", "ASP.NET"]
  "age": 23,
  "hasDriverLicense": true,
  "date": "2012-04-23T18:25:43.511Z",
  // ...
}
```

JSON Data Format

- The **JSON** data format follows the rules of object creation in JS
  - **Strings**, **numbers** and **Booleans**:

```
"this is a string and is valid JSON"
```

```
3.14
```

```
true
```

  - **Arrays**:

```
[5, "text", true]
```

  - **Objects** (key-value pairs):

```
{
  "firstName": "Svetlin", "lastName": "Nakov",
  "jobTitle": "Technical Trainer", "age": 30
}
```

Mongo DB

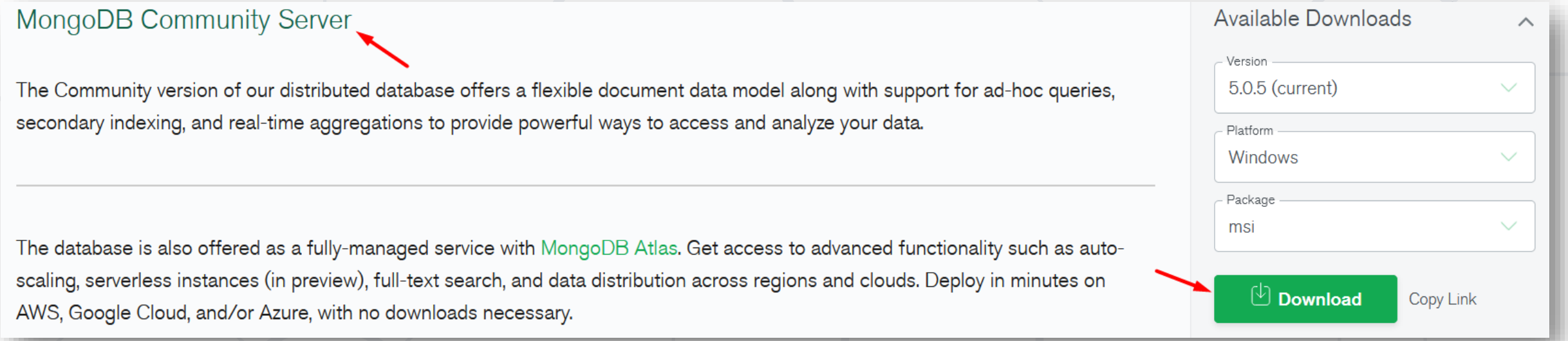
Working with Non-Relational Database

MongoDB

- **MongoDB** == free **open-source** cross-platform **document-oriented database**
  - Keeps collections of **JSON** documents (with or without schema)
- Sample usages: **mobile app** backend, product **catalog**, **poll** system, **blog** system, Web content management system (**CMS**)
- Supports evolving data requirements
  - The DB structure **may change** over the time
- Supports **indexing** for increased performance

Install MongoDB

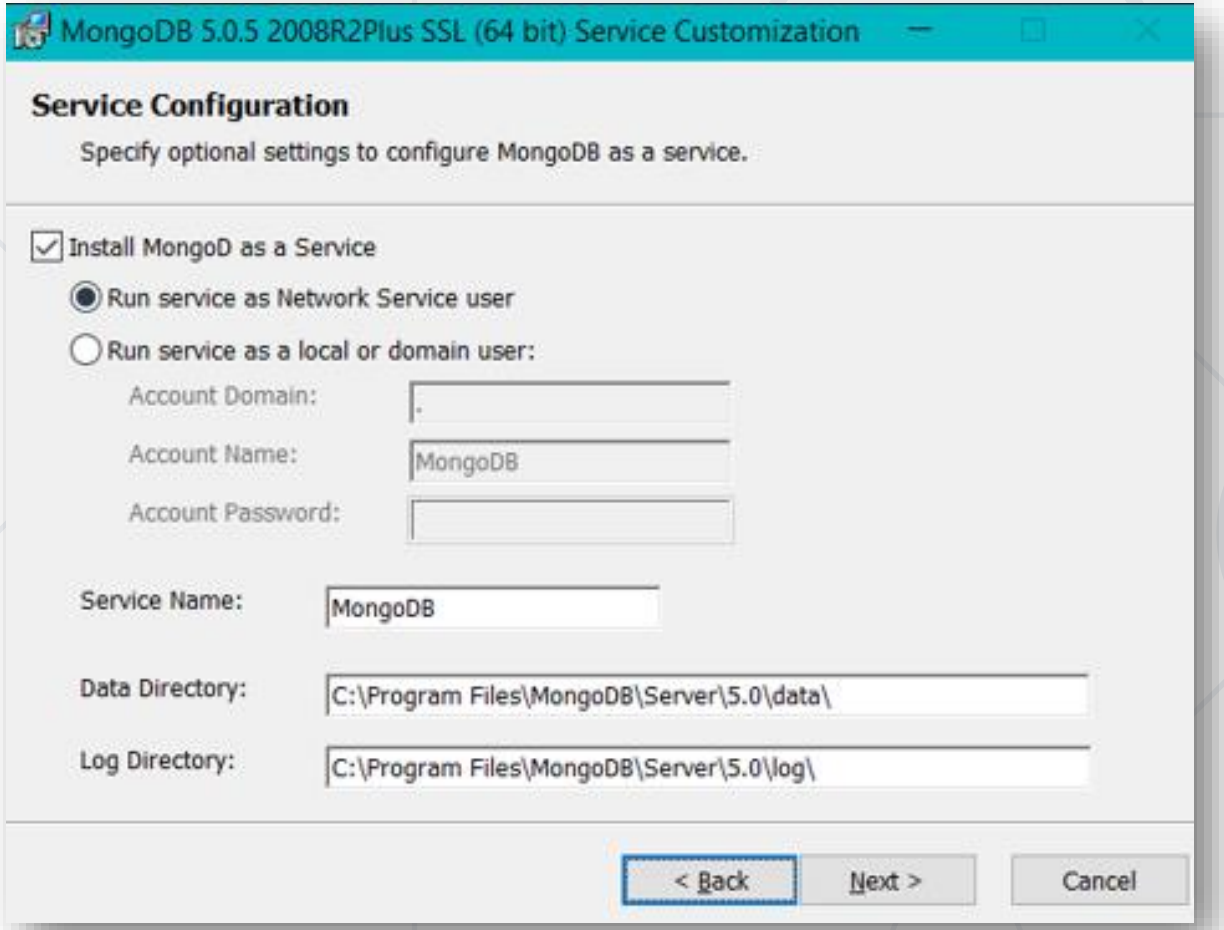
- Download from: mongodb.com/try/download/community



- The package includes **MongoDB Compass**

MongoD Windows Service

- During installation, configure the **MongoDB service**:



Working with MongoDB GUI

- Choose one of the many
  - **MongoDB Compass** is included in the installer
- For example
  - Compass – https://www.mongodb.com/products/compass
  - Robo 3T – https://robomongo.org/download
  - NoSQLBooster – https://nosqlbooster.com

MongoDB Compass

MongoDB Compass - localhost:27017/blog.articles

Connect Edit View Collection Help

localhost:27017

Documents
blog.articles

My Queries

Databases

Search

- admin
- blog
  - articles
  - books
  - students
- config
- local

blog.articles

3 DOCUMENTS

1 INDEXES

Documents | Aggregations | Schema | Explain Plan | Indexes | Validation

Filter | Type a query: { field: 'value' } | Reset | Find | More Options

ADD DATA | EXPORT DATA | 1 – 3 of 3

```
{
  "_id": {
    "$oid": "647f46e611e023152797a3e5"
  },
  "title": "AutoGPT",
  "readTimes": 31,
  "body": "AutoGPT is a tool to automate ChatGPT with Internet searches for solving more comp
}
```

```
{
  "_id": {...},
  "title": "Playground AI",
  "readTimes": 112,
  "body": "Playground AI is an image generator based on stable diffusion"
```

>_MONGOSH

MongoDB Queries Example

- Mongoose supports **many** queries
  - For equality/non-equality

```
Student.findOne({'lastName':'Petrov'})
```

```
Student.find({}).where('age').gt(7).lt(14)
```

```
Student.find({}).where('facultyNumber').equals('12399')
```

  - Selection of some properties

```
Student.findOne({'lastName':'Kirilov'}).select('name age')
```

Mongoose Queries Example

- Sorting

```
Student.find({}).sort({age:-1})
```

- Limit & skip

```
Student.find({}).sort({age:-1}).skip(30).limit(10)
```

- Different methods could be **stacked** one upon the other

```
Student.find({})
        .where('firstName').equals('gosho')
        .where('age').gt(18).lt(65)
        .sort({age:-1})
        .skip(10)
        .limit(10)
```

Working with MongoDB Shell Client

- Install "**MongoDb Shell**" and run it from the command line:
  - Type the command "**mongo**"

```
show dbs
```

```
use mytestdb
```

```
db.mycollection.insertOne({"name":"George"})
```

```
db.mycollection.find({"name":" George"})
```

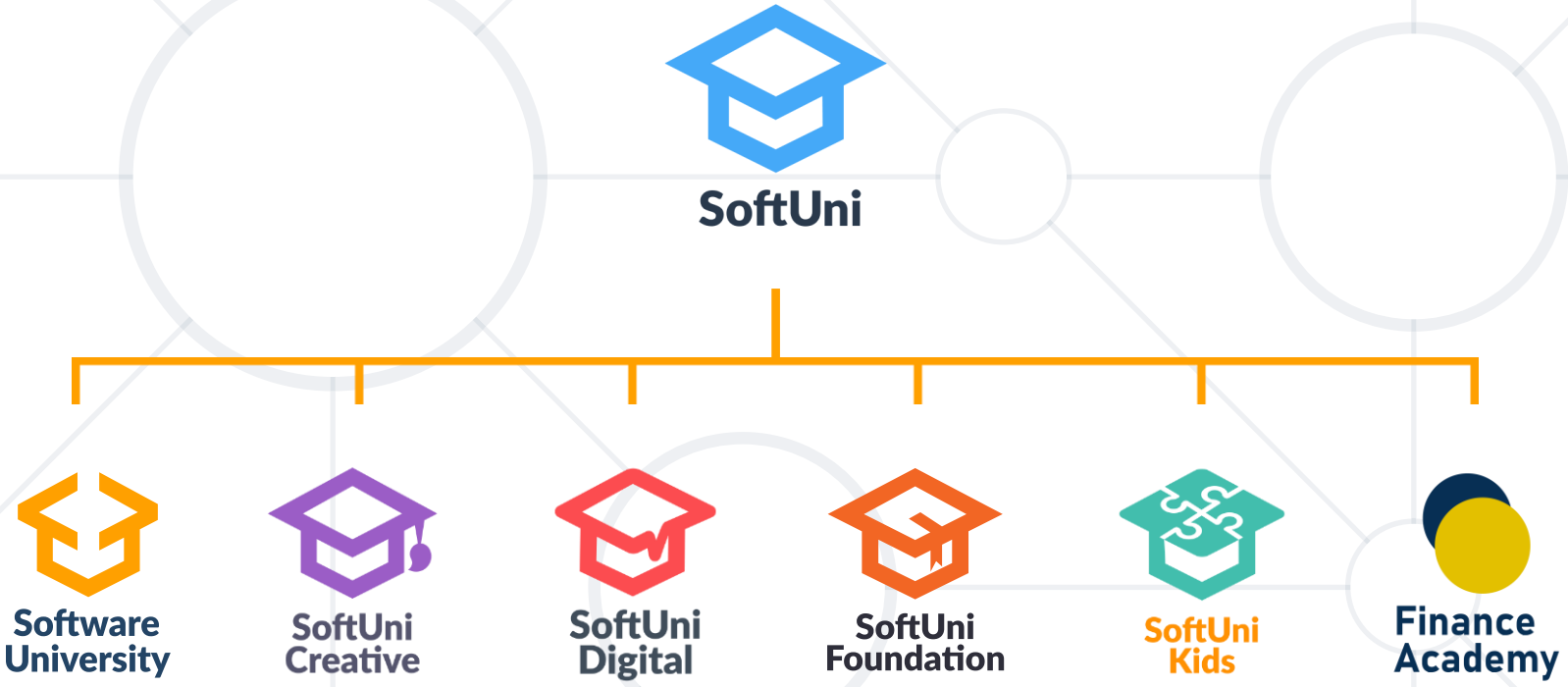
```
db.mycollection.find({})
```

  - Additional information at: https://www.mongodb.com/try/download/shell

Summary

- **Databases**: store data tables and collections
- **Relational databases**: tables and relationships
- **Non-Relational**: document collections
- **DBMS** (database servers), e.g. MySQL, MongoDB
- **SQL** commands: SELECT, INSERT, UPDATE, DELETE, …
- **JSON** document: {"name":"Joe", "age":25}
- Working with **MySQL** + **Workbench**
- Working with **Mongo DB** + **Compass**

Questions?



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