**Phase 1: Installation & Setup**

1. **Introduction to MongoDB**
   * What is MongoDB?
   * NoSQL vs. SQL
   * Features & Use Cases
2. **Installing MongoDB on Windows**
   * Downloading MongoDB
   * Installing MongoDB Community Edition
   * Setting up MongoDB as a Windows Service
3. **MongoDB Compass & Shell**
   * Installing MongoDB Compass
   * Using MongoDB Shell (mongosh)

**Phase 1: Installation & Setup** of MongoDB on **Windows**. 🚀

### **1️⃣ Introduction to MongoDB**

#### **What is MongoDB?**

* MongoDB is a **NoSQL database** that stores data in **JSON-like documents**.
* It is **schema-less**, meaning you don't need to define a rigid structure like in SQL databases.
* It is designed to handle **large-scale applications** with high performance, scalability, and flexibility.

#### **NoSQL vs SQL**

|  |  |  |
| --- | --- | --- |
| Feature | SQL (Relational) | NoSQL (MongoDB) |
| **Data Storage** | Tables & Rows | Collections & Documents |
| **Schema** | Fixed Schema | Flexible Schema |
| **Joins** | Uses Foreign Keys | Embedded Documents & References |
| **Scalability** | Vertical Scaling | Horizontal Scaling (Sharding) |

#### **Use Cases of MongoDB**

✅ Real-time analytics  
✅ Content management systems  
✅ E-commerce applications  
✅ IoT & Big Data applications

### **Comparison: Data Storage in MySQL vs MongoDB**

Let’s compare **how data is stored** in **MySQL (Relational DB)** vs **MongoDB (NoSQL Document DB)** using an **Employee Management** example.

### **1️⃣ MySQL (SQL - Relational Database)**

In MySQL, data is stored in **tables** with predefined **columns and relationships**.

#### **Employee Table (SQL)**

|  |  |  |  |
| --- | --- | --- | --- |
| id | name | email | department\_id |
| 101 | Alice | [alice@example.com](mailto:alice@example.com) | 1 |
| 102 | Bob | [bob@example.com](mailto:bob@example.com) | 2 |

#### **Department Table (SQL)**

|  |  |
| --- | --- |
| department\_id | department\_name |
| 1 | HR |
| 2 | IT |

#### **Retrieving Employee with Department Name (SQL Query)**

SELECT e.id, e.name, e.email, d.department\_name

FROM Employee e

JOIN Department d ON e.department\_id = d.department\_id

WHERE e.id = 101;

**Problem with SQL Approach**

* Data is **split across multiple tables**, requiring **JOINS**.
* Schema is **rigid**, meaning if we want to add a new field (e.g., phone number), we must **alter the table**.

### **2️⃣ MongoDB (NoSQL - Document Database)**

In MongoDB, data is stored as **JSON-like documents** inside **collections** instead of tables.

#### **Employee Collection (MongoDB)**

{

"\_id": 101,

"name": "Alice",

"email": "alice@example.com",

"department": {

"department\_id": 1,

"department\_name": "HR"

}

}

#### **Retrieving Employee with Department (MongoDB Query)**

db.employees.findOne({ \_id: 101 })

**Advantages of MongoDB Approach** ✅ **No Need for JOINS** – The department is stored inside the employee document.  
✅ **Flexible Schema** – We can add new fields (e.g., phone number) **without altering a schema**.  
✅ **Better Performance for Reads** – Since data is stored together, fetching an employee’s department is **faster**.

### **Comparison Summary**

|  |  |  |
| --- | --- | --- |
| Feature | MySQL (SQL) | MongoDB (NoSQL) |
| **Storage Format** | Tables (Rows & Columns) | Collections (JSON Documents) |
| **Schema** | Fixed Schema (Needs ALTER) | Flexible Schema (Dynamic) |
| **Relationships** | Foreign Keys & JOINS | Embedded Documents (No Joins) |
| **Querying** | SQL Queries (JOINs) | JSON-based Queries (BSON) |
| **Scalability** | Vertical Scaling (Single Server) | Horizontal Scaling (Sharding) |

### **🚀 When to Choose What?**

* **Use MySQL** if your data is **highly structured** with **complex relationships** (e.g., banking, ERP).
* **Use MongoDB** if you need **scalability, flexibility**, and work with **large, unstructured data** (e.g., real-time apps, logs, IoT).

### **2️⃣ Installing MongoDB on Windows**

#### **Step 1: Download MongoDB**

1. Go to the [MongoDB Download Center](https://www.mongodb.com/try/download/community).
2. Select **Windows**, then choose **MSI package**.
3. Click **Download**.

#### **Step 2: Install MongoDB**

1. Open the downloaded .msi file.
2. Follow the installation wizard:
   * Select **Complete Installation**.
   * Enable **MongoDB as a Windows Service** (Recommended).
   * Keep default paths unless you prefer custom installation.

#### **Step 3: Verify Installation**

1. Open **Command Prompt (cmd)** and type:
2. mongod --version

If installed correctly, it should display the MongoDB version.

### **3️⃣ Starting & Stopping MongoDB**

#### **Start MongoDB as a Service**

MongoDB runs as a background service automatically.  
If not running, start it manually:

net start MongoDB

#### **Stop MongoDB Service**

net stop MongoDB

#### **Run MongoDB Manually**

1. Open a terminal and type:
2. mongod
3. Open a new terminal and type:
4. mongosh

If successful, you’ll enter the MongoDB shell.

### **4️⃣ MongoDB Compass & Shell**

#### **MongoDB Compass (GUI)**

* **MongoDB Compass** is a GUI tool to visualize your database.
* Download it from [MongoDB Compass](https://www.mongodb.com/products/compass) and install it.
* Open Compass and **connect to MongoDB** (mongodb://localhost:27017).

#### **MongoDB Shell (**mongosh**)**

* The command-line interface for MongoDB.
* Run:
* mongosh

and start interacting with MongoDB.

**Phase 2: Basic MongoDB Operations**

1. **Understanding MongoDB Database & Collections**
   * Creating & Dropping Databases
   * Creating & Dropping Collections
2. **CRUD Operations**
   * Insert Documents
   * Read (Find) Documents
   * Update Documents
   * Delete Documents
3. **MongoDB Query Operators**
   * Comparison Operators ($eq, $ne, $gt, $lt, etc.)
   * Logical Operators ($and, $or, $not, etc.)
   * Projection & Sorting
4. **Indexing in MongoDB**
   * What is an Index?
   * Creating & Managing Indexes

### **Understanding MongoDB Databases & Collections**

MongoDB organizes data into **databases**, and each database contains multiple **collections** (like tables in SQL, but without a strict schema). Each collection stores **documents** (JSON-like objects).

#### **1️⃣ Creating & Dropping Databases** (**Real-World Banking Example)**

In a banking system, we might need a database called **bankDB** to store customer, account, and transaction details.

##### **📌 Creating a Database**

To create or switch to a new database, use:

use bankDB

📌 **MongoDB will create the database only when you insert data into it.**

##### **📌 Checking Available Databases**

show dbs

💡 **Note:** If bankDB is empty, it won’t appear in show dbs.

##### **📌 Dropping a Database**

To delete the bankDB database:

use bankDB

db.dropDatabase()

🚨 **Warning:** This removes all collections and data inside the database!

#### **2️⃣ Creating & Dropping Collections**

Collections in MongoDB store related documents.

##### **📌 Creating Collections**

We need collections like customers, accounts, and transactions for our banking system.

1️⃣ **Create a customers collection manually:**

db.createCollection("customers")

2️⃣ **Insert data into accounts (collection auto-created):**

db.accounts.insertOne({ accountNumber: "1234567890", type: "Savings", balance: 5000 })

💡 **MongoDB creates the collection automatically when you insert a document.**

##### **📌 Viewing Collections**

show collections

##### **📌 Dropping Collections**

To remove the customers collection:

db.customers.drop()

🚨 **Warning:** This removes all documents in the collection!

### **CRUD Operations in MongoDB** 🏦

Now that we have the bankDB database with collections like customers, accounts, and transactions, let's perform **CRUD (Create, Read, Update, Delete) operations**.

## ****1️⃣ Insert Documents (CREATE Operation)****

We insert data into collections using insertOne() (single document) and insertMany() (multiple documents).

### **🏦 Example: Insert Customers**

db.customers.insertOne({

customerId: "C1001",

name: "Dineshkumar Thangavel",

email: "dk@example.com",

phone: "+919876543210",

address: { city: "Chennai", zip: "600001" }

})

✅ **A new customer is added to the customers collection.**

### **🏦 Insert Multiple Customers**

db.customers.insertMany([

{

customerId: "C1002",

name: "Divya Dineshkumar",

email: "dd@example.com",

phone: "+919812345678",

address: { city: "Chennai", zip: "600001" }

},

{

customerId: "C1003",

name: "Darwin Divya Dinesh",

email: "ddd@example.com",

phone: "+919700123456",

address: { city: "Chennai", zip: "600001" }

}

])

✅ **Now we have three customers in the database.**

## ****2️⃣ Read Documents (READ Operation)****

To **fetch data**, we use find().

### **🏦 Retrieve All Customers**

db.customers.find()

📌 **This returns all documents.**

### **🏦 Retrieve a Specific Customer**

db.customers.findOne({ customerId: "C1002" })

✅ **Finds Bob Williams' details.**

### **🏦 Retrieve Only Names & Emails (Projection)**

db.customers.find({}, { name: 1, email: 1, \_id: 0 })

📌 **This returns only name and email, excluding \_id.**

## ****3️⃣ Update Documents (UPDATE Operation)****

We use updateOne() and updateMany().

### **🏦 Update a Customer's Email**

db.customers.updateOne(

{ customerId: "C1001" },

{ $set: { email: "dk.new@example.com" } }

)

✅ **Alice's email is updated.**

### **🏦 Update Multiple Customers in the Same City**

db.customers.updateMany(

{ "address.city": "Hyderabad" },

{ $set: { "address.zip": "60602" } }

)

✅ **All customers in Chicago get their ZIP code updated.**

🏦 Rename a Field Name

db.customers.updateOne(

{ customerId: "C1001" },

{ $rename: { "nickname": "alias", "cell": "mobile" } }

)

✅ Customer's fields are renamed.

🏦 Rename the Collection

db.customers.renameCollection("clients")

✅ The `customers` collection is renamed to `clients`.

## ****4️⃣ Delete Documents (DELETE Operation)****

We use deleteOne() and deleteMany().

### **🏦 Delete a Specific Customer**

db.customers.deleteOne({ customerId: "C1003" })

✅ **Charlie Brown is removed.**

### **🏦 Delete All Customers in a Specific City**

db.customers.deleteMany({ "address.city": "Chennai" })

✅ **All customers from Los Angeles are deleted.**

## ****MongoDB Query Operators with Real-Time Banking Example**** 🏦

Now, let's explore **Comparison Operators, Logical Operators, Projection, and Sorting** using the bankDB database.

## ****1️⃣ Comparison Operators**** 🔍

These help filter documents based on conditions.

### **📌** $in **– Match Any Value in an Array**

Find all customers in **New York or Los Angeles**.

db.customers.find({ "address.city": { $in: ["New York", "Los Angeles"] } })

✅ Returns customers from New York or LA.

### **📌** $nin **– Not in the Given Values**

Find customers **NOT** in Chicago or Houston.

db.customers.find({ "address.city": { $nin: ["Chicago", "Houston"] } })

✅ Excludes customers from these cities.

### **📌** $gt **(Greater Than) &** $gte **(Greater Than or Equal To)**

Find all **accounts with a balance greater than $5000**.

db.accounts.find({ balance: { $gt: 5000 } })

✅ Only returns accounts with balance above $5000.

Find **accounts with balance at least $5000**.

db.accounts.find({ balance: { $gte: 5000 } })

✅ Includes accounts with balance = $5000 too.

### **📌** $lt **(Less Than) &** $lte **(Less Than or Equal To)**

Find **transactions below $1000**.

db.transactions.find({ amount: { $lt: 1000 } })

✅ Retrieves transactions with amount < 1000.

Find **transactions of $1000 or less**.

db.transactions.find({ amount: { $lte: 1000 } })

✅ Includes $1000 transactions.

### **📌** $eq **(Equal) &** $ne **(Not Equal)**

Find all **savings accounts**.

db.accounts.find({ accountType: { $eq: "Savings" } })

✅ Returns all Savings accounts.

Find all **non-Savings accounts**.

db.accounts.find({ accountType: { $ne: "Savings" } })

✅ Returns all except Savings accounts.

## ****2️⃣ Logical Operators**** 🧠

These help combine multiple conditions.

### **📌** $and **– Both Conditions Must be True**

Find **transactions above $5000** made by a customer from **New York**.

db.transactions.find({

$and: [{ amount: { $gt: 5000 } }, { "customer.city": "New York" }]

})

✅ Returns high-value transactions from NY customers.

### **📌** $or **– Either Condition Can be True**

Find **customers from New York or customers with a balance above $10,000**.

db.customers.find({

$or: [{ "address.city": "New York" }, { balance: { $gt: 10000 } }]

})

✅ Returns either NY customers or customers with a high balance.

### **📌** $not **– Negate a Condition**

Find customers **NOT from New York**.

db.customers.find({ "address.city": { $not: { $eq: "New York" } } })

✅ Returns everyone except New Yorkers.

### **📌** $exists **– Check if a Field Exists**

Find **all customers who have an email address**.

db.customers.find({ email: { $exists: true } })

✅ Only customers with an email will be returned.

## ****3️⃣ Projection – Return Specific Fields**** 📜

By default, MongoDB returns full documents. **Projection** lets us return only specific fields.

### **📌 Show Only Name and Email (Exclude** \_id**)**

db.customers.find({}, { name: 1, email: 1, \_id: 0 })

✅ Returns documents with **only** name and email.

### **📌 Hide Address Field**

db.customers.find({}, { address: 0 })

✅ Returns everything **except** address.

## ****4️⃣ Sorting – Order Results**** 🔽🔼

### **📌 Sort by Balance in Descending Order**

db.accounts.find().sort({ balance: -1 })

✅ Highest balance first.

### **📌 Sort by Name in Ascending Order**

db.customers.find().sort({ name: 1 })

✅ Alphabetical order (A-Z).

### **📌 Sort by City Ascending, then Balance Descending**

db.customers.find().sort({ "address.city": 1, balance: -1 })

✅ Groups customers by **city**, and within each city, sorts by **highest balance first**.

**Phase 3: Advanced MongoDB Concepts**

1. **Indexing**
2. **Aggregation Framework**
   * Understanding Aggregations
   * Using $match, $group, $sort, $project, $limit
3. **Relationships in MongoDB**
   * Embedded vs. Referenced Documents
   * Implementing One-to-One, One-to-Many, and Many-to-Many
4. **Transactions in MongoDB**

* ACID Transactions in MongoDB
* Multi-document Transactions

### **📌 Step 1: Indexing in MongoDB**

#### **What is Indexing?**

* **Indexing** in MongoDB is similar to an **index in a book**—it speeds up data retrieval.
* Without indexes, MongoDB must scan every document in a collection, which is **slow** for large datasets.
* Indexes store a **sorted** list of values from a field, making lookups faster.

#### **Types of Indexes in MongoDB**

1. **Single Field Index** – Index on a single field.
2. **Compound Index** – Index on multiple fields.
3. **Text Index** – For searching text efficiently.
4. **Hashed Index** – Distributes values for sharding.
5. **Geospatial Index** – For location-based queries.

### **🛠 Practical Example: Indexing on Banking Data**

Let's **create an index** on the phone field in the **customers collection** to speed up customer lookups.

#### **1️⃣ Create a Single Field Index**

db.customers.createIndex({ "phone": 1 })

📌 **This will create an index on the phone field in ascending order (1 = ascending, -1 = descending).**

#### **2️⃣ Check Existing Indexes**

db.customers.getIndexes()

🔍 **This will list all indexes in the customers collection.**

#### **3️⃣ Create a Compound Index**

Suppose we often search for customers using both **city** and **state**. We can optimize this with a compound index.

db.customers.createIndex({ "address.city": 1, "address.state": 1 })

📌 **Now MongoDB can efficiently search for customers in a specific city & state.**

#### **4️⃣ Use Index in Queries**

**Without an index:**

db.customers.find({ "phone": "+919876543210" }).explain("executionStats")

**With an index:** 🔥

db.customers.find({ "phone": "+919876543210" }).hint({ "phone": 1 }).explain("executionStats")

📌 **You will notice a significant performance improvement!**

#### **5️⃣ Delete an Index**

db.customers.dropIndex("phone\_1")

📌 **This removes the index on the phone field.**

### **✅ Summary**

* **Indexes improve query performance** by reducing scan time.
* **Use Single & Compound indexes** based on query patterns.
* **Check & manage indexes** using getIndexes(), explain(), and dropIndex().

## ****📌 Advanced Indexing Concepts in MongoDB****

### **1️⃣ Unique Index**

* Ensures that **duplicate values** are not inserted in a specific field.
* Useful for fields like **phone numbers, email IDs, account numbers, etc.** in a banking system.

#### **✅ Create a Unique Index**

db.customers.createIndex({ "phone": 1 }, { unique: true })

🔹 **Now, MongoDB will prevent duplicate phone numbers from being inserted.**

#### **⛔ Trying to Insert a Duplicate Phone Number**

db.customers.insertOne({ "name": "Rahul", "phone": "+919876543210" })

📌 **If a document with this phone already exists, MongoDB will throw an error!**

### **2️⃣ Naming an Index**

* By default, MongoDB assigns index names like {fieldname}\_1, but we can give **custom names**.

#### **✅ Create an Index with a Custom Name**

db.customers.createIndex({ "email": 1 }, { name: "UniqueEmailIndex" })

🔹 **Easier to manage and drop later!**

#### **Check Existing Indexes**

db.customers.getIndexes()

📌 **You'll see your index with the custom name.**

### **3️⃣ TTL (Time-to-Live) Index**

* **Automatically deletes documents** after a certain period.
* Useful for **temporary records**, such as **OTP verifications, session data, or logs**.

#### **✅ Create a TTL Index**

db.otp\_requests.createIndex({ "createdAt": 1 }, { expireAfterSeconds: 300 })

🔹 **Documents in otp\_requests will be deleted after 5 minutes (300 seconds).**

### **4️⃣ Partial Filter Index**

* **Indexes only documents that meet a condition.**
* Saves storage and improves performance for specific queries.

#### **✅ Create a Partial Index**

db.transactions.createIndex({ "status": 1 }, { partialFilterExpression: { "status": { $eq: "Pending" } } })

🔹 **Only transactions with "status": "Pending" will be indexed.**  
🔹 **This speeds up searches on pending transactions while reducing index size.**

### **5️⃣ Wildcard Index**

* Useful when the **fields are dynamic** (e.g., JSON-based schemas in NoSQL).
* Instead of defining **specific fields**, we can index **all fields**.

#### **✅ Create a Wildcard Index**

db.logs.createIndex({ "$\*\*": 1 })

🔹 **Indexes all fields dynamically.**  
🔹 Useful for **searching in flexible, schema-less collections.**

### **6️⃣ Custom Collation (Case-Insensitive Indexing)**

* Used for **sorting & searching case-insensitively**.
* In banking apps, we may want **case-insensitive email lookups**.

#### **✅ Create a Case-Insensitive Index**

db.customers.createIndex(

{ "email": 1 },

{ collation: { locale: "en", strength: 2 } }

)

🔹 **Now searches on email will be case-insensitive.**  
🔹 "JohnDoe@gmail.com" and "johndoe@gmail.com" are treated as the same.

### **7️⃣ Sparse Index**

* **Skips indexing null or missing values**, reducing index size.
* Useful for **optional fields** (e.g., PAN Card numbers in customer profiles).

#### **✅ Create a Sparse Index**

db.customers.createIndex({ "pan\_card": 1 }, { sparse: true })

🔹 **Documents without pan\_card won't be indexed.**  
🔹 **Saves space & improves efficiency for optional fields.**

## ****✅ Summary****

|  |  |
| --- | --- |
| Index Type | Use Case Example |
| **Unique Index** | Prevents duplicate emails or phone numbers. |
| **Named Index** | Easier index management with custom names. |
| **TTL Index** | Auto-delete expired OTPs or session data. |
| **Partial Filter Index** | Index only pending transactions for faster queries. |
| **Wildcard Index** | Index all fields dynamically in logs or flexible schemas. |
| **Custom Collation** | Case-insensitive email lookups. |
| **Sparse Index** | Saves space by indexing only non-null values. |

**Phase 4: MongoDB with Spring Boot**

1. **Spring Boot MongoDB Integration**

* Setting up MongoDB with Spring Boot
* Configuring application.properties
* Using MongoRepository

1. **Performing CRUD with Spring Boot & MongoDB**

* Implementing REST API with MongoDB

1. **Querying MongoDB in Spring Boot**

* Custom Queries using @Query
* Aggregation Queries

1. **Exception Handling & Transactions in Spring Boot with MongoDB**

* Handling Errors Gracefully
* Implementing Transactions