



# Step 1 - Types of Databases



What all we'll learn today -

Simple – SQL vs NoSQL, how to create Postgres Databases,

How to do CRUD on them

Advance – Relationships, Joins, Transactions

There are a few types of databases, all serve different types of use-cases

## NoSQL databases

1. Store data in a **schema-less** fashion. Extremely lean and fast way to store data.
2. Examples – MongoDB,



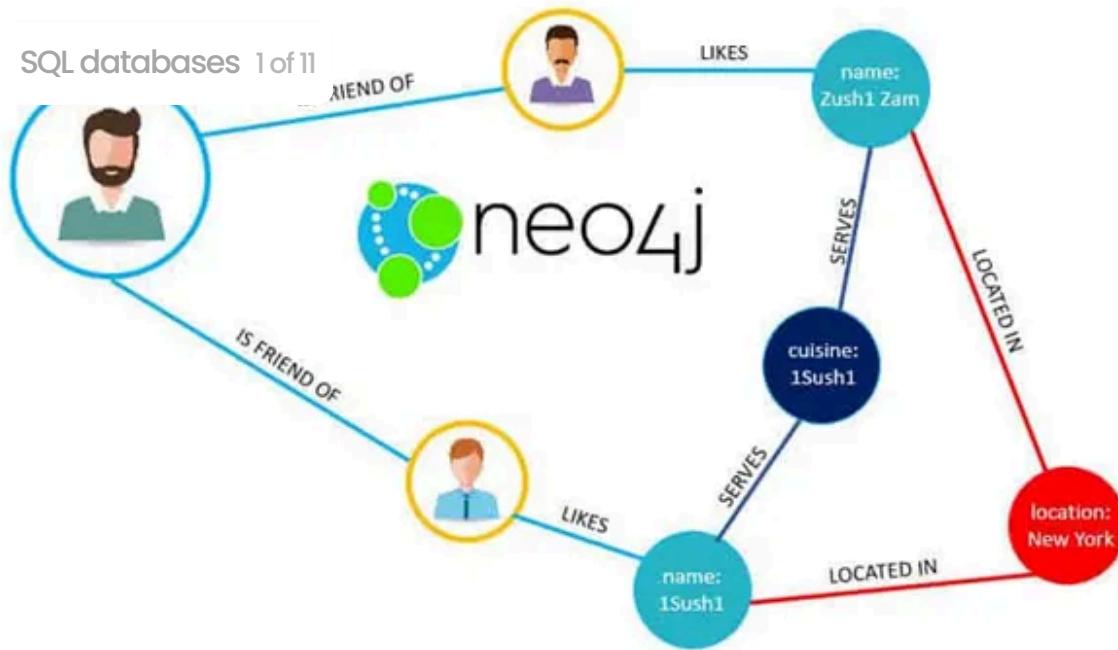
The screenshot shows the MongoDB Compass interface. At the top, there's a header with tabs for 'populations.cities' and 'Documents'. Below the header, the title 'SQL databases 1 of 1' is displayed, followed by a summary table with columns: DOCUMENTS (20), TOTAL SIZE (2.0KB), AVG. SIZE (104B); and INDEXES (1), TOTAL SIZE (4.0KB), AVG. SIZE (4.0KB). Below the summary are tabs for 'Documents' (selected), 'Aggregations', 'Schema', 'Explain Plan', 'Indexes', and 'Validation'. A search bar with a 'FILTER' button and a 'field: value' placeholder is present. To the right of the search bar are buttons for 'OPTIONS', 'FIND', 'RESET', and a three-dot menu. Below the search bar is a toolbar with icons for 'ADD DATA', 'VIEW', and filtering options. The main area displays 20 documents, each represented by a card. The first document's data is shown in the image:

```
_id: ObjectId("617604944e16573d5867039b")
name: "Seoul"
country: "South Korea"
continent: "Asia"
population: 25.674
```

Subsequent documents are partially visible, showing similar fields like name, country, continent, and population.

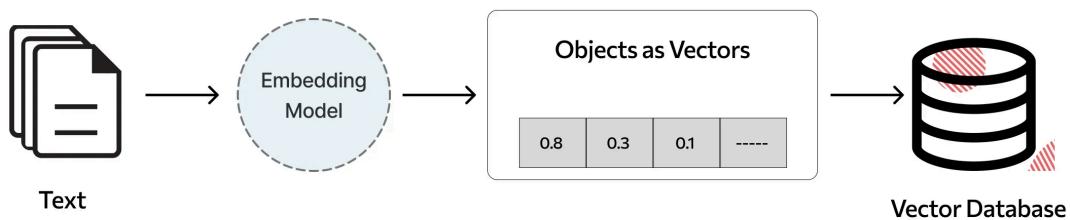
## Graph databases

1. Data is stored in the form of a graph. Specially useful in cases where **relationships** need to be stored (social networks)
2. Examples – Neo4j



## Vector databases

1. Stores data in the form of vectors
2. Useful in Machine learning
3. Examples – Pinecone



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1. Stores data in the form of rows

## Step 2 – Why not NoSQL

You might've used **MongoDB**

It's **schemaless** properties make it ideal to for bootstrapping a project fast.

But as your app grows, this property makes it very easy for data to get **curopted**

### What is schemaless?

Different rows can have different **schema** (keys/types)

### Problems?

1. Can lead to inconsistent database
2. Can cause runtime errors
3. Is too flexible for an app that needs strictness

- 1. Can move very fast
- 2. SQL databases have strict schema very easily



You might think that `mongoose` does add strictness to the codebase because we used to define a schema there. That strictness is present at the Node.js level, not at the DB level. You can still put in erroneous data in the database that doesn't follow that schema.

## Step 3 – Why SQL?

SQL databases have a strict schema. They require you to

1. Define your schema
2. Put in data that follows that schema
3. Update the schema as your app changes and perform migrations

So there are 4 parts when using an SQL database (not connecting it to Node.js, just running it and putting data in it)

1. Running the database

Connect and put data in it.

3. Creating a table and defining its **schema**.

↳ SQL databases 1 of 11  
Create database to interact with the data  
(Insert/Update/Delete)

## Step 4 - Creating a database

You can start a Postgres database in a few ways -

### ▼ Using neondb

<https://neon.tech/> is a decent service that lets you create a server.

## Connection String

`bostaresal://username:password@ep-broken-frost-69135494.us`



## ▼ Using docker locally

SQL databases 1 of 11 name my-postgres -e POSTGRES\_PASSWORD=mysecretpassword



## Connection String

`postgresql://postgres:mysecretpassword@localhost:5432/postgres`



## ▼ Using docker on windows

How to run PostgreSQL in windows terminal(if you have docker installed).

- fist run docker gui application that help in running commands in terminal.
- After that run it with the docker instance by the help of following command .
  - for the first time if the image is not downloaded .
  - `docker run --name my-postgres1 -e POSTGRES_PASSWORD=mysecretpassword -d -p 5432:5432 postgres` .
  - if the docker image is there, prior to use the it can simply be runned by `docker run <image name>` .
- After that ,
  - use `docker exec -it my-postgres1 psql -U postgres -d postgres` this command in terminal .
  - then enter the password and it will connect to localhost Postgress instance .
  - now you will be inside the postress command line that looks like `postgres-#` .
  - U can check it by running `\dt` , (the command to display all the tables.)



The connection strina is similar to the string we had in

## Connection String

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where does harkirat live  $\Rightarrow [1, 2, 2, 2, 3001, 100]$

Harkirat lives in INdia  $\Rightarrow [1, 2, 2, 2, 2, 2]$

Harkirat is from chandigarh  $\Rightarrow [1, 2, 2, 2, 3]$

Harkirat has been living in india, chandigarh  $\Rightarrow [1, 2, 2, 2, 2, 3]$

The world is round  $\Rightarrow [1, 2, 10001, 1001, 001001]$

Pacman is such a good game  $\Rightarrow [100, 10001, 20020, 1-001, 100]$

# Step 5 – Using a library that let's you connect and put data in it.

## 1. psql

**psql** is a terminal-based front-end to PostgreSQL. It provides an interface to the PostgreSQL (or

TimescaleDB) database. With psql, you can type in queries

SQL databases 1 of 11 rem to PostgreSQL, and see the query results.

## How to connect to your database?

psql Comes bundled with postgresql. You don't need it for this tutorial. We will directly be communicating with the database from Node.js

```
psql -h p-broken-frost-69135494.us-east-2.aws.neon.tech -d datab
```



## 2. pg

pg is a `Node.js` library that you can use in your backend app to store data in the Postgres DB (similar to `mongoose`). We will be installing this eventually in our app.

# Step 6 – Creating a table and defining its **schema** .

A single database can have multiple tables inside. Think of them

☰ ↴ SQL databases 1 of 11 MongoDB database.

Until now, we have a database that we can interact with. The next step in case of postgres is to define the **schema** of your tables.

SQL stands for **Structured query language**. It is a language in which you can describe what/how you want to put data in the database.

To create a table, the command to run is -

```
CREATE TABLE users (
    id SERIAL PRIMARY KEY,
    username VARCHAR(50) UNIQUE NOT NULL,
    email VARCHAR(255) UNIQUE NOT NULL,
    password VARCHAR(255) NOT NULL,
    created_at TIMESTAMP WITH TIME ZONE DEFAULT CURRENT_TIMESTAMP
);
```



There are a few parts of this SQL statement, let's decode them one by one

## 1. CREATE TABLE users

**CREATE TABLE users** : This command initiates the creation of a new table in the database named **users**.

## 2. id SERIAL PRIMARY KEY

- **id** : The name of the first column in the **users** table, typically used as a unique identifier for each row (user). Similar to **\_id** in mongodb
- **SERIAL** : A PostgreSQL-specific data type for creating an auto-incrementing column. When a new row is inserted, this

value automatically increments, ensuring each user has a

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- **PRIMARY KEY** : This constraint specifies that the `id` column is the primary key for the table, meaning it uniquely identifies each row. Values in this column must be unique and not null.

### 3. email VARCHAR(255) UNIQUE NOT NULL,

- `email` : The name of the second column, intended to store the user's username.
- **VARCHAR(50)** : A variable character string data type that can store up to 50 characters. It's used here to limit the length of the username.
- **UNIQUE** : This constraint ensures that all values in the `username` column are unique across the table. No two users can have the same username.
- **NOT NULL** : This constraint prevents null values from being inserted into the `username` column. Every row must have a username value.

### 4. password VARCHAR(255) NOT NULL

Same as above, can be non unique

### 5. created\_at TIMESTAMP WITH TIME ZONE DEFAULT CURRENT\_TIMESTAMP

- `created_at` : The name of the fifth column, intended to store the timestamp when the user was created.
- **TIMESTAMP WITH TIME ZONE** : This data type stores both a timestamp and a time zone, allowing for the precise tracking of events regardless of the user's or server's time zone.

- **DEFAULT CURRENT\_TIMESTAMP** : This default value automatically SQL databases 1of11 .at column to the date and time at which the row is inserted into the table, using the current timestamp of the database server.



If you have access to a database right now, try running this command to create a simple table in there

```
CREATE TABLE users (
    id SERIAL PRIMARY KEY,
    username VARCHAR(50) UNIQUE NOT NULL,
    email VARCHAR(255) UNIQUE NOT NULL,
    password VARCHAR(255) NOT NULL,
    created_at TIMESTAMP WITH TIME ZONE DEFAULT
    CURRENT_TIMESTAMP
);
```

Then try running

```
\dt;
```

to see if the table has been created or not

# Step 7 – Interacting with the database

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There are 4 things you'd like to do with a database

## 1. INSERT

```
INSERT INTO users (username, email, password)  
VALUES ('username_here', 'user@example.com', 'user_password');
```



Notice how you didn't have to specify the `id` because it auto increments

## 2. UPDATE

```
UPDATE users  
SET password = 'new_password'  
WHERE email = 'user@example.com';
```

## 3. DELETE

```
DELETE FROM users  
WHERE id = 1;
```

## 4. Select

```
SELECT * FROM users  
WHERE id = 1;
```

💡 Try running all 4 of these in your terminal if you have `psql`

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If not, that's fine we'll eventually be doing these through the `pg` library

## Step 8 – How to do queries from a Node.js app?

In the end, postgres exposes a protocol that someone needs to talk to be able to send these commands (update, delete) to the database.

`psql` is one such library that takes commands from your terminal and sends it over to the database.

To do the same in a Node.js , you can use one of many `Postgres clients`

### pg library

<https://www.npmjs.com/package/pg>

Non-blocking PostgreSQL client for Node.js.

Documentation – <https://node-postgres.com/>

Connecting –

```
import { Client } from 'pg'  
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const client = new Client({  
  host: 'my.database-server.com',  
  port: 5334,  
  database: 'database-name',  
  user: 'database-user',  
  password: 'secretpassword!!',  
})  
  
client.connect()
```

## Querying -

```
const result = await client.query('SELECT * FROM USERS;')  
console.log(result)
```

```
// write a function to create a users table in your database.  
import { Client } from 'pg'  
  
const client = new Client({  
  connectionString: "postgresql://postgres:mysecretpassword@local  
});  
  
async function createUsersTable() {  
  await client.connect()  
  const result = await client.query(`  
    CREATE TABLE users (  
      id SERIAL PRIMARY KEY,  
      username VARCHAR(50) UNIQUE NOT NULL,  
      email VARCHAR(255) UNIQUE NOT NULL,  
      password VARCHAR(255) NOT NULL,  
      created_at TIMESTAMP WITH TIME ZONE DEFAULT CURRENT_TIM  
    );  
  `);  
}
```

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# Step 9 – Creating a simple Node.js app

1. Initialise an empty typescript project

```
npm init -y  
npx tsc --init
```

1. Change the `rootDir` and `outDir` in `tsconfig.json`

```
"rootDir": "./src",  
"outDir": "./dist",
```

1. Install the `pg` library and its types (because we're using TS)

```
npm install pg  
npm install @types/pg
```

at lets you put data

Create a function that let's you insert data into a table. Make it

c SQL databases 1 of 11 `client.connect` resolves before u do the insert

▼ Answer

```
import { Client } from 'pg';

// Async function to insert data into a table
async function insertData() {
  const client = new Client({
    host: 'localhost',
    port: 5432,
    database: 'postgres',
    user: 'postgres',
    password: 'mysecretpassword',
  });

  try {
    await client.connect(); // Ensure client connection is established
    const insertQuery = "INSERT INTO users (username, email, password) VALUES ('user1', 'user1@example.com', 'password1')";
    const res = await client.query(insertQuery);
    console.log('Insertion success:', res); // Output insertion result
  } catch (err) {
    console.error('Error during the insertion:', err);
  } finally {
    await client.end(); // Close the client connection
  }
}

insertData();
```



This is an `insecure` way to store data in your tables.

When you expose this functionality eventually via `HTTP`, someone can do an `SQL INJECTION` to get access to your data/delete your data.

Update the code so you don't put `user provided fields` in the `SQL`

## string

### ▼ SQL databases 1 of 11 provided strings?

In your final app, this insert statement will be done when a user signs up on your app.

Email, username, password are all user provided strings

### ▼ What is the SQL string ?

```
const insertQuery = "INSERT INTO users (username, email, passwo
```



### ▼ Hint

```
const insertQuery = 'INSERT INTO example_table(column1, column2, column3) VALUES ($1, $2, $3);'
const res = await client.query(insertQuery, [column1Value, column2Value, column3Value]);
```



### ▼ Solution

```
import { Client } from 'pg';

// Async function to insert data into a table
async function insertData(username: string, email: string, password: string) {
  const client = new Client({
    host: 'localhost',
    port: 5432,
    database: 'postgres',
    user: 'postgres',
    password: 'mysecretpassword',
  });

  try {
    await client.connect(); // Ensure client connection is established
    // Use parameterized query to prevent SQL injection
    const insertQuery = "INSERT INTO users (username, email, password) VALUES ($1, $2, $3)";
    const values = [username, email, password];
    await client.query(insertQuery, values);
    console.log(`Success! Inserted ${values[0]} with ID ${res.insertId}`);
  } catch (err) {
    console.error(`Error: ${err.message}`);
  }
}
```

```

        console.error('Error during the insertion:', err);
    }

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} catch (err) {
    console.error('An error occurred while inserting data:', err);
}

// Example usage
insertData('username5', 'user5@example.com', 'user_password').then()

```

## 1. Query data

Write a function `getUser` that lets you fetch data from the database given a `email` as input.

```

import { Client } from 'pg';

// Async function to fetch user data from the database given an email
async function getUser(email: string) {
    const client = new Client({
        host: 'localhost',
        port: 5432,
        database: 'postgres',
        user: 'postgres',
        password: 'mysecretpassword',
    });

    try {
        await client.connect(); // Ensure client connection is established
        const query = 'SELECT * FROM users WHERE email = $1';
        const values = [email];
        const result = await client.query(query, values);

        if (result.rows.length > 0) {
            console.log('User found:', result.rows[0]); // Output user data
            return result.rows[0]; // Return the user data
        } else {
            console.log(`No user found for the given email.`);
        }
    } catch (err) {
        console.error('An error occurred while fetching user data:', err);
    }
}

```

```
        } catch (err) {
            // Error during fetching user:, err);
SQL databases 1 of 11 Throw or handle error appropriately
        } finally {
            await client.end(); // Close the client connection
        }
    }

// Example usage
getUser('user5@example.com').catch(console.error);
```

# Step 10 – Relationships and Transactions

Relationships let you store data in different tables and relate it with each other.

## Relationships in Mongodb

Since `mongodb` is a NoSQL database, you can store any shape of data in it.

If I ask you to store a users details along with their address, you tie address details.

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## Relationships in SQL

Since SQL can not store `objects` as such, we need to define two different tables to store this data in.

This is called a `relationship`, which means that the `Address` table is related to the `Users` table.

When defining the table, you need to define the `relationship`

```
CREATE TABLE users (
    id SERIAL PRIMARY KEY,
    username VARCHAR(50) UNIQUE NOT NULL,
    email VARCHAR(255) UNIQUE NOT NULL,
    password VARCHAR(255) NOT NULL,
    created_at TIMESTAMP WITH TIME ZONE DEFAULT CURRENT_TIMESTAMP
);
```

```
CREATE TABLE addresses (
    id SERIAL PRIMARY KEY,
    user_id INTEGER NOT NULL,
    city VARCHAR(100) NOT NULL,
    country VARCHAR(100) NOT NULL,
    street VARCHAR(255) NOT NULL,
    pincode VARCHAR(20),
    created_at TIMESTAMP WITH TIME ZONE DEFAULT CURRENT_TIMESTAMP
    FOREIGN KEY (user_id) REFERENCES users(id) ON DELETE CASCADE
);
```



To insert the address of a user –

```
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addresses (user_id, city, country, street, pincode)  
VALUES (1, 'New York', 'USA', '123 Broadway St', '10001');
```

Now if you want to get the address of a user given an **id**, you can run the following query –

```
SELECT city, country, street, pincode  
FROM addresses  
WHERE user_id = 1;
```

## Extra – Transactions in SQL

 Good question to have at this point is what queries are run when the user signs up and sends both their information and their address in a single request.

Do we send two SQL queries into the database? What if one of the queries (address query for example) fails?

This would require **transactions** in SQL to ensure either both the user information and address goes in, or neither does

### ▼ SQL Query

```
BEGIN; -- Start transaction
```

```
INSERT INTO users (username, email, password)  
VALUES ('john_doe', 'john_doe@example.com', 'securepassword1')
```

```
INSERT INTO addresses (user_id, city, country, street, pincode)  
VALUES (currval('users_id_seq'), 'New York', 'USA', '123 Broadway St')
```

```
COMMIT;
```

```
import { Client } from 'pg';
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async function insertUserAndAddress(
    username: string,
    email: string,
    password: string,
    city: string,
    country: string,
    street: string,
    pincode: string
) {
    const client = new Client({
        host: 'localhost',
        port: 5432,
        database: 'postgres',
        user: 'postgres',
        password: 'mysecretpassword',
    });

    try {
        await client.connect();

        // Start transaction
        await client.query('BEGIN');

        // Insert user
        const insertUserText = `
            INSERT INTO users (username, email, password)
            VALUES ($1, $2, $3)
            RETURNING id;
        `;
        const userRes = await client.query(insertUserText, [username, email, password]);
        const userId = userRes.rows[0].id;

        // Insert address using the returned user ID
        const insertAddressText = `
            INSERT INTO addresses (user_id, city, country, street, pincode)
        `;

        await client.query(insertAddressText, [userId, city, country, street, pincode]);
    }
}
```

```
    "transaction"
SQL databases 1 of 11   t.query('COMMIT');

        console.log('User and address inserted successfully');
    } catch (err) {
        await client.query('ROLLBACK'); // Roll back the transaction or
        console.error('Error during transaction, rolled back.', err);
        throw err;
    } finally {
        await client.end(); // Close the client connection
    }
}

// Example usage
insertUserAndAddress(
    'johndoe',
    'john.doe@example.com',
    'securepassword123',
    'New York',
    'USA',
    '123 Broadway St',
    '10001'
);
```

# Step 11 – Joins

Defining relationships is easy.

Two (or more) tables together.

For example, if I ask you to fetch me a user's details and their

☰ SQL databases ↴ would you run?

▼ Approach 1 (Bad)

-- Query 1: Fetch user's details

```
SELECT id, username, email  
FROM users  
WHERE id = YOUR_USER_ID;
```

-- Query 2: Fetch user's address

```
SELECT city, country, street, pincode  
FROM addresses  
WHERE user_id = YOUR_USER_ID;
```

▼ Approach 2 (using joins)

```
SELECT users.id, users.username, users.email, addresses.city, addre  
FROM users  
JOIN addresses ON users.id = addresses.user_id  
WHERE users.id = '1';
```

◀ ▶

```
SELECT u.id, u.username, u.email, a.city, a.country, a.street, a.pincc  
FROM users u  
JOIN addresses a ON u.id = a.user_id  
WHERE u.id = YOUR_USER_ID;
```

◀ ▶

Now try converting the same to your node app

▼ Approach 1 (Bad)

```
import { Client } from 'pg';
```

```
// Async function to fetch user details and address separately  
async function getUserDetailsAndAddressSeparately(userId: string) {
```

```
    const client = new Client({
```

```

    database: 'postgres',
    port: 5432,
    user: 'postgres',
    password: 'mysecretpassword',
  });

try {
  await client.connect();

  // Fetch user details
  const userDetailsQuery = 'SELECT id, username, email FROM users WHERE id = $1';
  const userDetails = await client.query(userDetailsQuery, [userId]);

  // Fetch user address
  const userAddressQuery = 'SELECT city, country, street, pincode FROM addresses WHERE id = $1';
  const userAddress = await client.query(userAddressQuery, [userDetails.rows[0].address_id]);

  if (userDetails.rows.length > 0) {
    console.log('User found:', userDetails.rows[0]);
    console.log('Address:', userAddress.rows.length > 0 ? userAddress.rows[0] : null);
    return { user: userDetails.rows[0], address: userAddress.rows[0] };
  } else {
    console.log('No user found with the given ID.');
    return null;
  }
} catch (err) {
  console.error('Error during fetching user and address:', err);
  throw err;
} finally {
  await client.end();
}
}

getUserDetailsAndAddressSeparately("1");

```

## ▼ Approach 2 (using joins)

```
import { Client } from 'pg';
```

```

data and their address together
/ithAddress(userId: string) {
  const client = new Client({

```

```
host: 'localhost',  
      -  
SQL databases 1 of 11 'postgres',  
    user: 'postgres',  
    password: 'mysecretpassword',  
  );  
  
try {  
  await client.connect();  
  const query = `  
    SELECT u.id, u.username, u.email, a.city, a.country, a.street, c  
    FROM users u  
    JOIN addresses a ON u.id = a.user_id  
    WHERE u.id = $1  
  `;  
  const result = await client.query(query, [userId]);  
  
  if (result.rows.length > 0) {  
    console.log('User and address found:', result.rows[0]);  
    return result.rows[0];  
  } else {  
    console.log('No user or address found with the given ID.');//  
    return null;  
  }  
} catch (err) {  
  console.error('Error during fetching user and address:', err);  
  throw err;  
} finally {  
  await client.end();  
}  
}  
getUserDetailsWithAddress("1");
```

No



## Benefits of using a join -

## 1. Reduced Latency

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## 3. Transactional Integrity

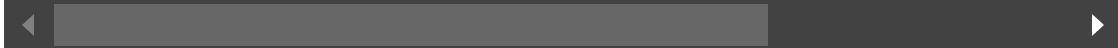
# Types of Joins

## 1. INNER JOIN

Returns rows when there is at least one match in both tables. If there is no match, the rows are not returned. It's the most common type of join.

**Use Case: Find All Users With Their Addresses. If a user hasn't filled their address, that user shouldn't be returned**

```
SELECT users.username, addresses.city, addresses.country, addresses.state  
FROM users  
INNER JOIN addresses ON users.id = addresses.user_id;
```



## 2. LEFT JOIN

Returns all rows from the left table, and the matched rows from the right table.

Use case - To list all users from your database along with their address information (if they've provided it), you'd use a LEFT JOIN. Users without an address will still appear in your query result, but the address fields will be NULL for them.

```
SELECT users.username, addresses.city, addresses.country, addresses.state  
FROM users  
LEFT JOIN addresses ON users.id = addresses.user_id;
```



## 3. RIGHT JOIN

Returns all rows from the right table, and the matched rows from

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Use case - Given the structure of the database, a RIGHT JOIN would be less common since the **addresses** table is unlikely to have entries not linked to a user due to the foreign key constraint. However, if you had a situation where you start with the **addresses** table and optionally include user information, this would be the theoretical use case.

```
SELECT users.username, addresses.city, addresses.country, addresses.state  
FROM users  
RIGHT JOIN addresses ON users.id = addresses.user_id;
```



## 4. FULL JOIN

Returns rows when there is a match in one of the tables. It effectively combines the results of both LEFT JOIN and RIGHT JOIN.

Use case - A FULL JOIN would combine all records from both **users** and **addresses**, showing the relationship where it exists. Given the constraints, this might not be as relevant because every address should be linked to a user, but if there were somehow orphaned records on either side, this query would reveal them.

```
SELECT users.username, addresses.city, addresses.country, addresses.state  
FROM users  
FULL JOIN addresses ON users.id = addresses.user_id;
```





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