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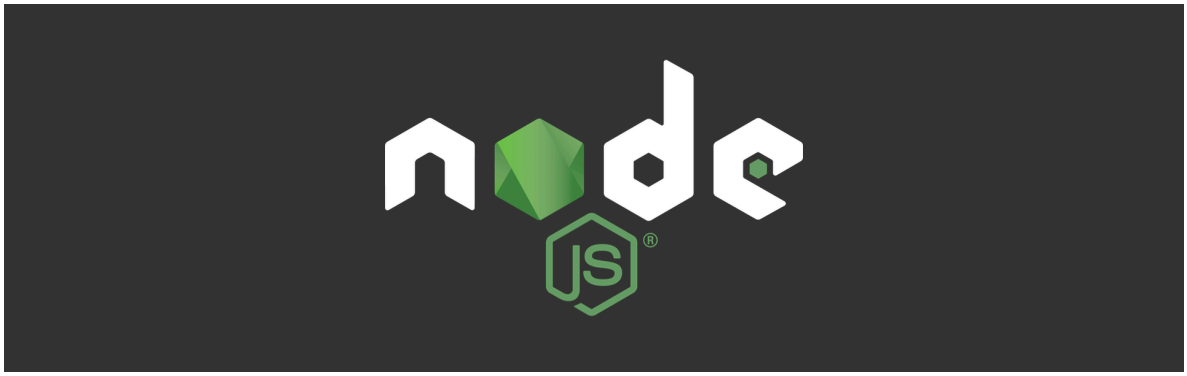
Node.js Curriculum

1. Introduction

What is Node.js?



node_logo.png

Node.js is an open-source, cross-platform JavaScript runtime environment that allows developers to build server-side and network applications using JavaScript. It is built on Chrome's V8 JavaScript engine, enabling fast and scalable development. Unlike traditional JavaScript, which typically runs in the browser, Node.js executes JavaScript code outside of the browser, making it ideal for backend development, real-time applications, and much more.

Key features of Node.js:

- Asynchronous and event-driven
- Non-blocking I/O model
- Lightweight and efficient
- Uses the same language (JavaScript) on both frontend and backend

```
// A simple Node.js server in TypeScript

import * as http from 'http';

const server = http.createServer((req, res) => {
  res.statusCode = 200;
```

```
  res.setHeader('Content-Type', 'text/plain');
  res.end('Hello, World!\n');
});

server.listen(3000, () => {
  console.log('Server running at http://localhost:3000/');
});
```

Why Node.js?

Node.js is widely adopted for a variety of reasons, making it one of the most popular tools for backend development:

1. **Single Language for Fullstack Development**: With Node.js, developers can use JavaScript for both the frontend and backend, making it easier for full-stack development and reducing the context switching between different languages.
2. **Fast Execution with V8 Engine**: The V8 engine, which powers Node.js, compiles JavaScript to native machine code, providing highly efficient execution.
3. **Non-blocking, Asynchronous Model**: Node.js uses an event-driven, non-blocking I/O model, which allows it to handle many connections concurrently without being resource-intensive. This makes Node.js particularly suitable for I/O-heavy applications, like web servers or real-time applications.
4. **Large Ecosystem**: The Node Package Manager (NPM) is the largest ecosystem of open-source libraries, which makes adding functionalities like database interaction, authentication, or real-time communication easy.
5. **Scalability**: Node.js is designed with scalability in mind, allowing developers to build applications that handle numerous requests efficiently.

```
// Demonstrating non-blocking behavior in Node.js
import * as fs from 'fs';

console.log('Start reading file...');
fs.readFile('example.txt', 'utf-8', (err, data) => {
```

```
  if (err) throw err;
  console.log('File content:', data);
});
console.log('Do other work while file is being read.');
```

In the above example, Node.js doesn't block the execution while reading the file, allowing the server to perform other tasks.

What Can Node.js Do?

Node.js can be used for a wide range of applications, making it a versatile tool in modern web development. Here are some common use cases:

1. **Web Servers**: Node.js is commonly used to build web servers. Its ability to handle multiple requests simultaneously with non-blocking I/O makes it highly efficient for web applications.
2. **API Development**: Node.js is an excellent choice for building RESTful APIs and microservices, thanks to its speed and the extensive support for libraries through NPM.
3. **Real-time Applications**: Real-time features such as chat applications, live data streaming, and collaborative tools can be efficiently built using Node.js. Libraries like Socket.io make it easy to implement WebSocket-based communication.
4. **Command Line Tools**: You can use Node.js to write command-line tools and scripts that automate tasks. With access to file systems, processes, and child processes, Node.js can handle various automation tasks.
5. **Serverless Functions**: Many cloud providers offer serverless computing using Node.js as the runtime. This allows you to write lightweight functions that automatically scale and handle HTTP requests.

```
// Simple REST API with Node.js and Express in TypeScript

import express from 'express';
```

```
const app = express();
const port = 3000;

app.get('/', (req, res) => {
  res.send('Hello, World!');
});

app.get('/api', (req, res) => {
  res.json({ message: 'Welcome to the API!' });
});

app.listen(port, () => {
  console.log(`Server is running at http://localhost:${port}`);
});
```

With the above example, you can create a simple web server that responds to different routes. This is a very basic example of how Node.js can power web applications or APIs.

This introduction sets the stage for understanding Node.js by explaining its core concepts, benefits, and practical use cases.

2. Getting Started

Download Node.js

To get started with Node.js, you'll first need to download and install it on your system. Node.js comes with its package manager, **npm** (Node Package Manager), which allows you to install libraries and dependencies for your project.

1. Visit the official Node.js website: https://nodejs.org/ (https://nodejs.org/)
2. You'll see two versions available:
   - **LTS (Long Term Support)**: This version is recommended for most users as it is stable and gets security updates for a longer time.
   - **Current**: This is the latest version with new features, but it may not be as stable as the LTS version.
3. Download the appropriate installer for your operating system (Windows, macOS, or Linux).
4. Run the installer and follow the setup instructions.

Once installed, you can verify the installation by opening your terminal (or Command Prompt) and typing:

```
node -v
```

This should display the version of Node.js installed.

You can also verify npm by running:

```
npm -v
```

This will show the version of npm that was installed alongside Node.js.

Command Line Interface (CLI)

Node.js provides a simple command-line interface (CLI) for running JavaScript and TypeScript code. You can interact with Node.js through your terminal or command prompt.

1. Running Node.js REPL (Read-Eval-Print Loop)

Node.js comes with a REPL, which allows you to execute JavaScript code interactively.

To start the REPL, just type `node` in your terminal and press Enter:

```
$ node
Welcome to Node.js v16.13.0.
Type ".help" for more information.
> console.log('Hello, Node.js!');
Hello, Node.js!
>
```

Here, you can execute any JavaScript code, and Node.js will evaluate it immediately. To exit the REPL, type `.exit` or press `Ctrl + C` twice.

2. Running Node.js Scripts

To execute a JavaScript or TypeScript file with Node.js, you can use the following command:

```
node <filename.js>
```

For example, if you have a file `app.js` that contains:

```
console.log('Hello, World!');
```

You can run it with:

```
node app.js
```

This will output:

```
Hello, World!
```

3. Installing Global Packages

Node.js also uses npm for package management. You can install Node.js packages globally (so they are accessible anywhere) using npm:

```
npm install -g typescript
```

In this example, we installed **TypeScript** globally, allowing you to use the `tsc` (TypeScript Compiler) command.

Initiate the Node.js File

Before creating your first Node.js project, it's a good practice to set up a project directory and initialize it using npm. This will allow you to manage your dependencies and set up your project structure.

1. Create a New Project Directory

Open your terminal and create a new directory for your project:

```
mkdir my-node-app
cd my-node-app
```

2. Initialize the Project with npm

To initialize a new Node.js project, use the following command:

```
npm init
```

This command will ask you several questions about your project (like project name, version, entry point, etc.), but you can skip through them by pressing Enter or manually configure them.

Alternatively, you can use the `-y` flag to accept the default settings:

```
npm init -y
```

This will generate a `package.json` file, which is a configuration file that stores metadata about your project, including dependencies, scripts, and more.

The `package.json` file will look something like this:

```
{
  "name": "my-node-app",
  "version": "1.0.0",
  "description": "",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "keywords": [],
  "author": "",
  "license": "ISC"
}
```

3. Create Your First Node.js File

Now, create a new file called `index.ts` (or `index.js` if you're using plain JavaScript):

```
touch index.ts
```

Inside this file, you can write your first Node.js code using TypeScript:

```
const message: string = 'Hello, TypeScript with Node.js!';
console.log(message);
```

4. Run the TypeScript File

To run TypeScript with Node.js, you need to transpile the TypeScript code into JavaScript using the TypeScript compiler (`tsc`).

First, install TypeScript as a dev dependency:

```
npm install typescript --save-dev
```

You can now compile the `index.ts` file into JavaScript:

```
npx tsc index.ts
```

This will generate a JavaScript file (`index.js`), which can then be executed using Node.js:

```
node index.js
```

The output will be:

```
Hello, TypeScript with Node.js!
```

5. Automate the Compilation and Running (Optional)

To make the process of compiling and running TypeScript easier, you can add a script to your `package.json`:

```
{
  "scripts": {
    "start": "tsc && node index.js"
  }
}
```

Now, you can compile and run your project with one command:

```
npm start
```

This will compile the TypeScript and run the generated JavaScript file.

This section guides you through the process of downloading and setting up Node.js, familiarizing you with the command line interface, and creating your first Node.js project.

3. Node Package managers

Node.js uses various package managers to handle external libraries and dependencies, which are essential for building modern applications. These package managers simplify the process of installing, updating, and managing the libraries your project requires. In this section, we'll cover what a package is, and introduce the most commonly used package managers: **NPM**, **PnPm**, and **Yarn**.

What is a Package?

In the Node.js ecosystem, a **package** refers to a reusable piece of code or library that performs a specific task or provides specific functionality. Packages are distributed as modules, which can include utilities, frameworks, middleware, or even entire applications.

A typical package may consist of:

- JavaScript/TypeScript code
- A `package.json` file containing metadata (name, version, dependencies, etc.)
- Additional resources like README files, license agreements, and configuration files

Packages can be installed locally (only available to the project) or globally (available system-wide). They are often hosted in package registries like the official **npm registry**.

Example of a `package.json` file:

```
{
  "name": "my-node-app",
  "version": "1.0.0",
  "description": "A simple Node.js app",
  "main": "index.js",
  "dependencies": {
    "express": "^4.17.1"
  },
  "devDependencies": {
    "typescript": "^4.4.3"
  },
```

```
  "scripts": {
    "start": "node index.js",
    "build": "tsc"
  }
}
```

In this example, the `express` package is listed as a runtime dependency, while `typescript` is a development dependency.

NPM (Node Package Manager)

NPM (Node Package Manager) is the default package manager for Node.js, and it comes pre-installed when you install Node.js. NPM allows developers to easily share and reuse code and manage dependencies.

Key Features:

- **Largest Package Registry**: NPM has the largest repository of open-source Node.js libraries available for installation.
- **Dependency Management**: It manages both direct and transitive dependencies through a `package.json` file.
- **Scripts**: NPM allows you to define custom scripts in `package.json` to automate tasks like testing, building, or deploying.
- **Versioning**: NPM makes it easy to update or lock dependencies to specific versions, ensuring that your project uses stable versions of packages.

Common NPM Commands:

- Install a package locally:

  ```
  npm install <package-name>
  ```

- Install a package globally:

```
npm install -g <package-name>
```

- Add a package as a development dependency:

```
npm install <package-name> --save-dev
```

- Install all dependencies listed in `package.json`:

```
npm install
```

- Remove a package:

```
npm uninstall <package-name>
```

- Running a custom script defined in `package.json`:

```
npm run <script-name>
```

Example:

```
npm install express
```

This command installs `express`, a web framework, and updates `package.json` with the new dependency.

c. PnPm

PnPm is an alternative package manager for Node.js that aims to optimize disk space and speed. It addresses some of the inefficiencies of NPM and Yarn by storing package dependencies in a shared, central directory, and linking them into each project. This can significantly reduce disk usage, especially when multiple projects have similar dependencies.

Key Features:

- **Efficient Disk Usage**: PnPm uses a content-addressable storage to store every package only once, even if multiple projects depend on different versions of the

package.

- **Performance**: It is often faster than both NPM and Yarn, especially for monorepo projects.
- **Strict Dependency Management**: PnPm ensures that the dependency tree is more predictable, catching issues like missing or incompatible peer dependencies early on.

Installing PNPM

PNPM is a fast, disk space-efficient package manager for Node.js. More information on https://pnpm.io/installation (https://pnpm.io/installation)

1. **Install PNPM**:

- Using Powershell:

```
Invoke-WebRequest https://get.pnpm.io/install.ps1 -UseBasicParsing |
Invoke-Expression
```

- On POSIX systems, you can use curl or wget:

```
curl -fsSL https://get.pnpm.io/install.sh | sh -
```

If you don't have curl installed, you would like to use wget:

```
wget -qO- https://get.pnpm.io/install.sh | sh -
```

2. **Verify Installation**: After the installation completes, verify it by typing:

```
pnpm -v
```

This should display the installed PNPM version.

3. **Updating pnpm**: To update pnpm, run the `self-update` command:

```
pnpm self-update
```

To install Node.js with PNPM on your system, follow the steps below:

Installing Node.js

Node.js is a JavaScript runtime that allows you to run JavaScript code on your server or local machine. Here's how to install it:

use

- Install and use the specified version of Node.js. Install the LTS version of Node.js:

```
pnpm env use --global lts
```

- Or if you prefer a specific Install Node.js v16:

```
pnpm env use --global 16
```

Common PnPm Commands:

- Install a package locally:

  ```
  pnpm install <package-name>
  ```

- Install a package globally:

  ```
  pnpm add -g <package-name>
  ```

- Add a development dependency:

  ```
  pnpm add <package-name> --save-dev
  ```

- Install all dependencies listed in `package.json`:

  ```
  pnpm install
  ```

Example:

```
pnpm install express
```

This command installs `express`, just like NPM, but PnPm will link the dependencies in an optimized way, saving disk space.

Advantages:

- Faster installation times in larger projects.
- Prevents projects from installing unnecessary duplicate dependencies.
- Strictness in dependency resolution ensures fewer conflicts.

d. Yarn

Yarn is another package manager that was originally created by Facebook to address some performance and security concerns they found in NPM. Yarn improves on speed and consistency, offering a lockfile system and better offline support.

Key Features:

- **Fast Installation**: Yarn caches every package it downloads, so it never needs to download the same package again.
- **Lockfile for Consistency**: Yarn generates a `yarn.lock` file to ensure that all developers working on a project install exactly the same package versions.
- **Parallel Installations**: Yarn installs packages in parallel, which can significantly reduce installation times.
- **Offline Mode**: Once a package is installed, it can be reinstalled without an internet connection, thanks to Yarn's caching system.

Common Yarn Commands:

- Install a package locally:

  ```
  yarn add <package-name>
  ```

- Install a package globally:

```
yarn global add <package-name>
```

- Add a development dependency:

```
yarn add <package-name> --dev
```

- Install all dependencies listed in `package.json`:

```
yarn install
```

Example:

```
yarn add express
```

This command adds `express` as a dependency to your project using Yarn.

Advantages:

- **Faster** than NPM due to parallel package installation.
- **Offline Mode** allows reinstallation of previously installed packages without an internet connection.
- **Deterministic**: The `yarn.lock` file ensures that every installation will result in the same file structure.

Comparison

Common Commands

COMMAND	NPM	PNPM	YARN
init	`npm init`	`pnpm init`	`yarn init`
install from package.json	`npm install`	`pnpm install`	`yarn`
add package	`npm install <package> [--location=global]`	`pnpm add <package> [--global]`	`yarn add <package>`
add package as devDependencies	`npm install <package> --save-dev`	`pnpm add <package> --save-dev`	`yarn add <package> --dev`
remove package	`npm uninstall <package> [--location=global]`	`pnpm uninstall <package> [--global]`	`yarn [global] remove <package>`
remove package as devDependencies	`npm uninstall <package> --save-dev`	`pnpm uninstall <package> --save-dev`	`yarn remove <package> --dev`
audit vulnerable dependencies	`npm list --depth 0 [--location=global]`	`pnpm list --depth 0 [--global]`	`yarn [global] list --depth 0`
Run	`npm run <script-name>`	`pnpm run <script-name>`	`yarn run <script-name>`
build	`npm build`	`pnpm build`	`yarn build`
test	`npm test`	`pnpm test`	`yarn test`

Features

Feature	NPM	PnPm	Yarn
Speed	Standard	Very fast	Fast
Disk Usage	Can be heavy on disk space	Optimized with central storage	Efficient with cachi ng
Offline Mode	Limited	No, but faster for cach ed files	Yes
Dependency Tree	Standard	Strict	Flexible but with lo ckfiles
Parallel Instal ls	No	Yes	Yes

In conclusion, NPM, PnPm, and Yarn all have their strengths and weaknesses, and your choice of package manager depends on your specific needs. **NPM** is the default and easiest to use, **PnPm** optimizes disk space and speed for large projects, and **Yarn** offers performance improvements and more deterministic installs.

3.1 PnPm Cheatsheet

Here's a cheat sheet for using PNPM to perform common tasks. PNPM is a fast and efficient package manager for Node.js projects, and this guide will help you get started with some of the most frequently used commands.

1. Initialization

- **Initialize a new project (create `package.json`):**

```
pnpm init
```

2. Installing Packages

- **Install all dependencies listed in `package.json`:**

```
pnpm install
```

- **Install a specific package (e.g., `lodash`):**

```
pnpm add lodash
```

- **Install a package as a development dependency:**

```
pnpm add eslint --save-dev
```

  or

```
pnpm add -D eslint
```

- **Install a specific version of a package:**

```
pnpm add lodash@4.17.20
```

- **Install dependencies without modifying `package.json` (useful for CI/CD):**

```
pnpm install --frozen-lockfile
```

3. Removing Packages

- **Uninstall a package:**

```
pnpm remove lodash
```

4. Running Scripts

- **Run a script defined in `package.json`:**

```
pnpm run <script_name>
```

Example:

```
pnpm run build
```

- **Run a package binary without installing it globally:**

```
pnpm dlx <package_name>
```

Example:

```
pnpm dlx create-react-app my-app
```

5. Working with Global Packages

- **Install a package globally:**

```
pnpm add -g eslint
```

- **List globally installed packages:**

```
pnpm list -g --depth 0
```

6. Managing Dependencies

- **Update all dependencies to the latest versions:**

```
pnpm update --latest
```

- **Install dependencies without running `preinstall` and `postinstall` scripts:**

```
pnpm install --ignore-scripts
```

7. Managing the PNPM Cache

- **Clear the PNPM cache:**

```
pnpm cache clean
```

8. Workspaces

- **Create a new workspace:**

```
pnpm init
```

- **Add a package to a workspace:**

```
pnpm add <package_name> -w
```

- **Run a command in all workspace packages:**

```
pnpm -r <command>
```

  Example:

```
pnpm -r build
```

9. Linking Packages

- **Link a package globally:**

```
pnpm link
```

- **Link a package locally within a project:**

```
pnpm link <package_name>
```

10. Miscellaneous

- **Check for outdated packages:**

```
pnpm outdated
```

- **List all installed packages:**

```
pnpm list
```

4. Typescript Configuration

TypeScript Configuration for a Node.js App with tsx

To configure TypeScript in a Node.js project, and add `tsx` (a tool that allows running TypeScript files without needing to transpile manually), we need to make sure the project has the appropriate dependencies and configurations in place. Additionally, we'll create scripts for starting, developing, and building the app.

1. Setting Up the Node.js App

Start by initializing a new Node.js project if you haven't done so already:

```
mkdir my-node-app
cd my-node-app
npm init -y
```

2. Installing Dependencies

Next, you'll need to install TypeScript, `tsx`, and types for Node.js:

```
npm install typescript tsx @types/node --save-dev
```

- **typescript**: The TypeScript compiler (to compile `.ts` files to JavaScript).
- **tsx**: A package that allows you to run TypeScript and JSX (React) files directly without needing to compile.
- **@types/node**: Provides TypeScript definitions for Node.js modules (like `http`, `fs`, etc.).

3. Creating the tsconfig.json

TypeScript requires a `tsconfig.json` file for configuration. This file tells the TypeScript compiler how to transpile the `.ts` files. You can create it by running the following command:

```
npx tsc --init
```

Then, modify the `tsconfig.json` file to suit a typical Node.js environment:

`tsconfig.json`:

```
{
  "compilerOptions": {
    "target": "ES6",                    // Target ES6 or later to
support modern JavaScript features
    "module": "CommonJS",                // Use CommonJS modules for
Node.js
    "rootDir": "./src",                  // Source files location
    "outDir": "./dist",                  // Output directory for
compiled files
    "esModuleInterop": true,             // Enables support for
`import` in CommonJS
    "strict": true,                      // Enables strict type-
checking options
    "skipLibCheck": true,                // Skips type checking of
declaration files
    "moduleResolution": "node",          // For resolving node modules
    "resolveJsonModule": true,           // Enable importing `.json`
files
    "allowSyntheticDefaultImports": true, // Allow default imports from
modules
    "forceConsistentCasingInFileNames": true // Ensure consistent casing
in file names
  },
  "include": ["src/**/*.ts"],            // Include all TypeScript
files in the `src` folder
  "exclude": ["node_modules"]            // Exclude `node_modules`
}
```

4. Project Structure

Here's an example of how your project structure should look:

```
/my-node-app
  ├── /src
  │     ├── index.ts
  ├── /dist                  # Will be generated after build
  ├── package.json
  ├── tsconfig.json
  └── node_modules
```

5. Creating Scripts for Start, Dev, and Build

Next, let's modify the `package.json` file to include scripts for starting, developing, and building the app:

`package.json`:

```
{
  "name": "my-node-app",
  "version": "1.0.0",
  "main": "dist/index.js",
  "scripts": {
    "start": "node dist/index.js",             // Start the compiled
JavaScript code
    "dev": "tsx watch src/index.ts",           // Start the app in
development mode with hot-reloading
    "build": "tsc"                             // Compile TypeScript
files to JavaScript
  },
  "devDependencies": {
    "@types/node": "^18.0.0",
    "tsx": "^3.12.7",
    "typescript": "^4.4.3"
  }
}
```

Explanation of the scripts:

- `start`: This runs the app using `node` after the TypeScript files have been compiled to JavaScript (found in the `dist` directory).
- `dev`: This runs the app directly with `tsx`, allowing you to start the TypeScript app in development mode without needing to compile first. `tsx watch` enables hot-reloading so that the server automatically reloads whenever you make changes.
- `build`: This runs the TypeScript compiler (`tsc`), which compiles the TypeScript files from the `src` directory into JavaScript in the `dist` directory.

6. Example TypeScript File

Now, let's create a simple `index.ts` file in the `src` folder to demonstrate the setup:

`src/index.ts`:

```
import http from 'http';

const hostname = 'localhost';
const port = 3000;

const server = http.createServer((req, res) => {
  res.statusCode = 200;
  res.setHeader('Content-Type', 'text/plain');
  res.end('Hello, TypeScript with Node.js!\n');
});

server.listen(port, hostname, () => {
  console.log(`Server running at http://${hostname}:${port}/`);
});
```

7. Running the App

Development Mode:

To run the app in development mode with hot-reloading (using `tsx`), run:

```
npm run dev
```

This will start the server, and any changes made to your TypeScript files will automatically restart the server.

Build and Start:

To compile your TypeScript code to JavaScript and then run the app:

1. First, build the app:

   ```
   npm run build
   ```

   This will transpile the TypeScript files and output them to the `dist` directory.

2. Then, run the app:

   ```
   npm start
   ```

This will execute the compiled JavaScript files in the `dist` directory.

Summary

1. **Install Dependencies**: Install `typescript`, `tsx`, and `@types/node` to set up TypeScript and run TypeScript files in Node.js without manual compilation.
2. **`tsconfig.json`**: Configure TypeScript settings for a Node.js project with `"module": "CommonJS"` and `"target": "ES6"`.
3. **Scripts**:
   - `start`: Runs the compiled app using `node`.
   - `dev`: Runs the app directly in TypeScript with `tsx` in watch mode.
   - `build`: Compiles TypeScript files to JavaScript.
4. **Project Structure**: Keep TypeScript source files in a `src` directory and output compiled files into a `dist` directory.

This setup provides an efficient workflow for TypeScript development in a Node.js environment, leveraging `tsx` for development and `tsc` for building production-ready

code.

5. Modules

Here's the updated version of the **Modules** documentation that uses **TypeScript** to illustrate how to work with modules in both **CommonJS** and **ES6** formats.

Node.js supports two module systems: **CommonJS** (the original module system used by Node.js) and **ES6 Modules** (the standardized modern module system). This document illustrates how to use modules in **TypeScript**, with examples for both module systems.

What is a Module in Node.js?

A **module** in Node.js is a reusable block of code that can be imported into other parts of your application. Modules can contain functions, objects, or entire classes that are encapsulated for reuse across multiple files.

Key points:

- **CommonJS**: The traditional module system for Node.js.
- **ES6 Modules**: A modern, standardized JavaScript module system.
- **TypeScript**: TypeScript adds static typing to JavaScript, enhancing modules with strong types.

Built-in Modules

Node.js provides built-in modules that offer useful utilities such as working with files, creating HTTP servers, handling paths, and more. You can include and use these modules directly in TypeScript.

Here's how you can use built-in modules in TypeScript:

```
import * as http from 'http';
import * as fs from 'fs';

const server = http.createServer((req, res) => {
  fs.readFile('index.html', (err, data) => {
    if (err) {
      res.writeHead(404, { 'Content-Type': 'text/plain' });
```

```
      res.end('File Not Found');
    } else {
      res.writeHead(200, { 'Content-Type': 'text/html' });
      res.end(data);
    }
  });
});

server.listen(8080, () => {
  console.log('Server running at http://localhost:8080/');
});
```

Include Modules

TypeScript supports both CommonJS and ES6 module systems. Here's how to include modules in each system.

1. CommonJS Syntax in TypeScript

You can use `require()` to import modules in a **CommonJS** format:

```
const http = require('http');  // CommonJS syntax
```

2. ES6 Module Syntax in TypeScript

You can use `import` in TypeScript to leverage **ES6 Modules**:

```
import * as http from 'http';  // ES6 module syntax
```

TypeScript automatically understands the syntax and compiles it into appropriate module systems based on your configuration.

Create Your Own Modules

In TypeScript, you can create custom modules in both **CommonJS** and **ES6** formats. When using TypeScript, you'll also benefit from static typing and type definitions for better clarity and error-checking.

1. Create a CommonJS Module in TypeScript

In **CommonJS**, you define and export functions or objects using `module.exports`. TypeScript supports this syntax and compiles it accordingly.

Example: CommonJS Module in TypeScript

mathOperations.ts:

```
function add(a: number, b: number): number {
  return a + b;
}

function subtract(a: number, b: number): number {
  return a - b;
}

module.exports = {
  add,
  subtract
};
```

In this example, the `add` and `subtract` functions are defined and exported using `module.exports`. You can include these functions in other files using `require()`.

2. Create an ES6 Module in TypeScript

With **ES6 modules**, TypeScript allows you to use the `export` keyword to export functionality. This is more modern and aligns with JavaScript's ES6 standards.

Example: ES6 Module in TypeScript

mathOperations.ts:

```
export function add(a: number, b: number): number {
  return a + b;
}

export function subtract(a: number, b: number): number {
```

```
  return a - b;
}
```

Here, the `export` keyword is used to expose the `add` and `subtract` functions to other files.

Include Your Own Module

Once you've created your custom module, you can include it in other files. TypeScript supports importing both **CommonJS** and **ES6** modules.

1. Including a CommonJS Module in TypeScript

To include a **CommonJS** module in TypeScript, use `require()`:

app.ts:

```
const math = require('./mathOperations');

const result = math.add(10, 5);
console.log(`Addition result: ${result}`);
```

In this example, we use `require()` to import the `mathOperations.ts` file and then use the `add` function from the imported module.

2. Including an ES6 Module in TypeScript

To include an **ES6 module** in TypeScript, use `import`:

app.ts:

```
import { add, subtract } from './mathOperations';

console.log(`Addition: ${add(10, 5)}`);
console.log(`Subtraction: ${subtract(10, 5)}`);
```

Here, we use the `import` syntax to bring in the `add` and `subtract` functions from `mathOperations.ts`. TypeScript's static typing ensures that only the exported members are accessible, and type checking is enforced.

Folder Structure:

Your project might have the following folder structure when working with modules in TypeScript:

```
/my-project
  ├── /modules
  │     └── mathOperations.ts
  ├── app.ts
  └── tsconfig.json
```

In this structure, you can import your custom modules like this:

```
import { add } from './modules/mathOperations';  // ES6
```

```
const math = require('./modules/mathOperations');  // CommonJS
```

tsconfig.json Configuration:

To ensure TypeScript compiles your code correctly, you'll need a `tsconfig.json` file, which defines TypeScript compiler options, including how to handle modules.

Here's an example configuration:

tsconfig.json:

```
{
  "compilerOptions": {
     "target": "ES6", /* Set the JavaScript language version for emitted
JavaScript and include compatible library declarations. */
     "module": "CommonJS", /* Specify what module code is generated. */
     "rootDir": "./src", /* Specify the root folder within your source
files. */
     "outDir": "./dist", /* Specify an output folder for all emitted
files. */
     "forceConsistentCasingInFileNames": true, /* Ensure that casing is
correct in imports. */
     "esModuleInterop": true, /* Emit additional JavaScript to ease
support for importing CommonJS modules. This enables
'allowSyntheticDefaultImports' for type compatibility. */
     "strict": true, /* Enable all strict type-checking options. */
```

```
    "skipLibCheck": true /* Skip type checking all .d.ts files. */
  },
  "include": ["./**/*.ts"],
  "exclude": ["node_modules", "dist"]
}
```

This configuration ensures that TypeScript compiles `.ts` files into the `dist` directory, and it compiles based on the module system you specify (`commonjs` or `esnext` for ES6).

Summary:

1. **What is a Module?**
   - A reusable block of code in Node.js. Modules help organize code efficiently.
2. **Built-in Modules**:
   - Node.js provides various built-in modules like `http`, `fs`, and `path`.
3. **Include Modules**:
   - Use `require()` for **CommonJS** modules.
   - Use `import` for **ES6** modules.
4. **Create Your Own Modules**:
   - **CommonJS**: Use `module.exports` to export code.
   - **ES6**: Use the `export` keyword to export code.
5. **Include Your Own Module**:
   - **CommonJS**: Use `require()` to import modules.
   - **ES6**: Use `import` to bring in modules.
6. **TypeScript Integration**:
   - TypeScript adds static typing to both **CommonJS** and **ES6** modules.

- Use `tsconfig.json` to configure the TypeScript compiler based on your preferred module system.

6. Node.js Globals

Node.js provides several built-in global objects. These are available globally and don't require importing any modules. They can be accessed from any part of your application. Understanding these global objects is crucial for writing effective and efficient Node.js applications.

What are Globals?

In Node.js, **Globals** are objects or functions that are available throughout the entire runtime without the need to import or require any additional modules. They can be accessed directly within any module or file without needing to reference them explicitly.

However, it's important to note that Node.js aims to minimize the use of global objects as it encourages modularity and explicit dependencies. Using global objects should be done with caution to avoid issues with maintainability and scope.

Common Node.js Global Objects

The following are some of the most commonly used global objects in Node.js:

i. __dirname

The `__dirname` global object represents the directory name of the current module (i.e., the file containing the running code). It provides the absolute path to the directory where the currently executing file is located.

This is especially useful for handling file paths dynamically. For example, you may need to access resources or files relative to your module, no matter where your application is being run from.

```
import * as path from 'path';
import * as fs from 'fs';

// Example: Use __dirname to handle file paths dynamically
const filePath = path.join(__dirname, 'data', 'example.txt');

// Checking if the file exists before reading
if (fs.existsSync(filePath)) {
```

```
  const fileContent = fs.readFileSync(filePath, 'utf-8');
  console.log('File Content:', fileContent);
} else {
  console.log(`File not found at ${filePath}`);
}

// Output __dirname value
console.log('Current directory:', __dirname);
```

- **Use case**: File path operations that need the relative path from the current module's directory, such as reading or writing files within the application.

ii. __filename

The `__filename` global object provides the absolute path of the current file being executed, including the file name itself. It can be useful in logging, debugging, or when you need to dynamically work with the path of the current script.

```
import * as path from 'path';

// Example: __filename in action
console.log('Full file path:', __filename);

// Extract directory name from __filename
const currentDir = path.dirname(__filename);
console.log('Directory name:', currentDir);

// Extract base file name (e.g., 'index.js') from __filename
const baseFileName = path.basename(__filename);
console.log('Base file name:', baseFileName);

// Extract file extension (e.g., '.js')
const fileExtension = path.extname(__filename);
console.log('File extension:', fileExtension);

// Construct a path relative to this file
```

```
const relativePath = path.join(currentDir, 'config', 'settings.json');
console.log('Relative file path:', relativePath);
```

- **Use case**: Dynamic operations involving the file path of the current file, like logging its location, or performing actions based on the current file's directory.

iii. exports

In Node.js, `exports` is an object that is used to expose functionalities from a module to other files. It's used to define the public interface of the module. You can export variables, functions, or classes to be available for other files using the `exports` object.

```
// Example: Using exports in a module
export const sayHello = () => {
  console.log('Hello, World!');
};
```

In another file, you can import this function as follows:

```
import { sayHello } from './moduleFile';
sayHello();  // Output: Hello, World!
```

- **Use case**: Sharing functions, variables, or classes from one file to be used in other parts of your application.

iv. module

The `module` object represents the current module and provides information about it. It's an object that contains properties like `exports` (for exporting the module's content) and `filename` (to get the absolute path of the module file).

```
// Example: Inspecting the module object
console.log(module);  // Output: Module details (such as exports, id,
filename)
```

Using `module.exports`, you can overwrite the default exports object.

v. require()

`require()` is a built-in function used to include modules. It is used to load and use modules from other files or node modules. In TypeScript, you typically use the `import` syntax, but `require()` is still relevant in some use cases like when working with older JavaScript modules.

```
// Example: Using require() to load a module
const fs = require('fs');
const data = fs.readFileSync('example.txt', 'utf8');
console.log(data);
```

In TypeScript, the equivalent of `require()` is typically:

```
import * as fs from 'fs';
const data = fs.readFileSync('example.txt', 'utf8');
console.log(data);
```

ES Global Objects

In addition to the Node.js-specific global objects, Node.js also exposes many of the ECMAScript (ES) global objects that are part of the JavaScript language itself. These objects are available in all JavaScript environments (browser, server-side, etc.), and they include objects like:

- **`console`**: Used for printing information, warnings, or errors to the terminal.

  ```
  console.log('This is a message');
  console.error('This is an error');
  ```

- **`setTimeout()`/`setInterval()`**: Used to execute a function after a specified delay or repeatedly at intervals.

  ```
  setTimeout(() => {
    console.log('This message appears after 2 seconds');
  }, 2000);

  setInterval(() => {
  ```

```
  console.log('This message repeats every 3 seconds');
}, 3000);
```

- **Promise**: A global object that represents an asynchronous operation that may complete at some point in the future.

```
const promise = new Promise((resolve, reject) => {
  setTimeout(() => {
    resolve('Promise resolved!');
  }, 1000);
});

promise.then(message => {
  console.log(message);  // Output: Promise resolved!
});
```

- **Buffer**: Available globally in Node.js, the `Buffer` class is used to handle binary data.

```
const buffer = Buffer.from('Hello, world!', 'utf8');
console.log(buffer.toString());  // Output: Hello, world!
```

- **process**: A Node.js-specific object that provides information about the current process, as well as methods for controlling it.

```
console.log(process.env);  // Outputs environment variables
process.exit(1);  // Terminates the process with an error code
```

These objects are available globally in Node.js as part of the underlying JavaScript language and the Node.js runtime.

This section on **Node.js Globals** introduces developers to essential global objects they will frequently encounter when building applications in Node.js. It provides a solid foundation for understanding the Node.js environment and its integration with ECMAScript features.

7. HTTP Module

The HTTP module in Node.js provides the functionality to create web servers and handle HTTP requests and responses. Additionally, Node.js supports HTTP/2 and HTTPS for improved performance and secure communication. Each protocol offers unique features and is widely used to handle web traffic.

HTTP

The HTTP (Hypertext Transfer Protocol) module in Node.js is used to create and manage basic web servers. It provides functionality to create a server, listen for incoming requests, and respond with data. This is one of the core modules in Node.js, allowing developers to set up a web server with minimal setup.

Key Features:

- Handling basic HTTP requests and responses (GET, POST, PUT, DELETE, etc.)
- Managing request headers and response data
- Easy access to URL and query parameters

Example: Basic HTTP Server in Node.js with TypeScript

```
import * as http from 'http';

// Create a basic HTTP server
const server = http.createServer((req, res) => {
  // Set the response header and status code
  res.writeHead(200, { 'Content-Type': 'text/plain' });

  // Send a response based on the URL
  if (req.url === '/') {
    res.end('Welcome to the homepage!');
  } else if (req.url === '/about') {
    res.end('About us page');
  } else {
    res.end('404 - Page not found');
```

```
  }
});

// Listen on port 3000
server.listen(3000, () => {
  console.log('Server is running on http://localhost:3000');
});
```

Explanation:

- `http.createServer()`: Creates an HTTP server that listens for incoming requests.
- `req.url`: Captures the URL of the incoming request, which allows routing to different responses.
- `res.writeHead()`: Sets the HTTP status code and headers before sending the response.
- `res.end()`: Ends the response and sends it to the client.

Use Cases:

- Lightweight web servers for testing or small applications.
- Handling basic APIs and static file serving.

HTTP/2

HTTP/2 is a major revision of the HTTP protocol that introduces several improvements over HTTP/1.1, including better performance and reduced latency. Node.js provides native support for HTTP/2 via the `http2` module. Key benefits include multiplexing (allowing multiple requests and responses to be sent over a single connection), header compression, and server push.

Key Features:

- **Multiplexing**: Multiple requests and responses over a single TCP connection.
- **Header Compression**: Compresses HTTP headers to reduce overhead.

- **Server Push**: The server can push resources (like CSS, JS files) to the client before the client even requests them.

Example: Basic HTTP/2 Server in Node.js with TypeScript

```
import * as http2 from 'http2';
import * as fs from 'fs';

// Load SSL certificates for secure connection
const options = {
  key: fs.readFileSync('server-key.pem'),
  cert: fs.readFileSync('server-cert.pem')
};

// Create an HTTP/2 server
const server = http2.createSecureServer(options);

server.on('stream', (stream, headers) => {
  // Respond to HTTP/2 requests
  const path = headers[':path'];

  if (path === '/') {
    stream.respond({
      'content-type': 'text/html',
      ':status': 200
    });
    stream.end('<h1>Welcome to the HTTP/2 Server</h1>');
  } else if (path === '/about') {
    stream.respond({
      'content-type': 'text/html',
      ':status': 200
    });
    stream.end('<h1>About Us</h1>');
  } else {
    stream.respond({
      ':status': 404
    });
    stream.end('404 - Not Found');
```

```
  }
});

// Listen on port 8443
server.listen(8443, () => {
  console.log('HTTP/2 server is running on https://localhost:8443');
});
```

Explanation:

- `http2.createSecureServer()`: Creates a secure HTTP/2 server using SSL certificates.
- `stream.respond()`: Sends headers and status code for each incoming request.
- `stream.end()`: Ends the response and sends data to the client.

Use Cases:

- Modern web applications that require faster loading times and efficient resource loading.
- Applications that need to support Server Push for improved user experience.

HTTPS

HTTPS (Hypertext Transfer Protocol Secure) is an extension of HTTP that provides secure communication over the network using SSL/TLS encryption. In Node.js, the `https` module is used to create secure servers. HTTPS ensures that all data exchanged between the server and the client is encrypted, protecting sensitive information from being intercepted.

Key Features:

- **SSL/TLS Encryption**: Secure communication using certificates.
- **Secure Data Transmission**: Protects sensitive information (like login credentials, payment info).

Example: Basic HTTPS Server in Node.js with TypeScript

```
import * as https from 'https';
import * as fs from 'fs';

// Load SSL certificates
const options = {
  key: fs.readFileSync('server-key.pem'),
  cert: fs.readFileSync('server-cert.pem')
};

// Create a basic HTTPS server
const server = https.createServer(options, (req, res) => {
  res.writeHead(200, { 'Content-Type': 'text/plain' });

  // Respond to requests based on URL
  if (req.url === '/') {
    res.end('Welcome to the secure homepage!');
  } else if (req.url === '/about') {
    res.end('About us page (secure)');
  } else {
    res.end('404 - Secure page not found');
  }
});

// Listen on port 443 (default for HTTPS)
server.listen(443, () => {
  console.log('HTTPS server is running on https://localhost');
});
```

Explanation:

- **SSL Certificates**: The `options` object includes the private key and certificate required for secure connections.
- **`https.createServer()`**: Creates an HTTPS server using SSL/TLS encryption.

- **Port 443**: The standard port for HTTPS, ensuring that all communication is encrypted.

Use Cases:

- Websites or APIs that need to handle sensitive data securely, such as login systems, financial transactions, or private communications.
- Any application that wants to ensure security and privacy by default.

Summary

- **HTTP**: Ideal for building simple web servers or APIs where performance and security are not primary concerns. However, it is commonly used for local development and testing.
- **HTTP/2**: Offers significant performance improvements over HTTP/1.1, including multiplexing and server push, which makes it ideal for modern web applications.
- **HTTPS**: Provides a secure communication layer with SSL/TLS encryption, essential for any application handling sensitive user data. It ensures the integrity and privacy of data exchanged between client and server.

These modules enable developers to create flexible, high-performance, and secure applications for various use cases.

7.1 Install OpenSSL on Windows

You can generate the `server-key.pem` and `server-cert.pem` files on Windows using OpenSSL. Here's a step-by-step guide to generate the self-signed certificates on Windows.

Step 1: Install OpenSSL on Windows

If you don't have OpenSSL installed on Windows, follow these steps:

1. Download the OpenSSL Windows installer from this link (https://slproweb.com/products/Win32OpenSSL.html).
2. Install OpenSSL, and during the installation, ensure that you add OpenSSL to the system PATH.

After installation, you should be able to use `openssl` commands from the Command Prompt or PowerShell.

Step 2: Open Command Prompt or PowerShell

Once OpenSSL is installed, open a **Command Prompt** or **PowerShell** with administrative privileges.

Step 3: Generate the Private Key and Self-Signed Certificate

1. Generate the Private Key (server-key.pem)

Run the following command to generate a 2048-bit RSA private key:

```
openssl genrsa -out server-key.pem 2048
```

This command will create the `server-key.pem` file, which contains the private key.

2. Generate the Certificate Signing Request (CSR)

Next, generate a Certificate Signing Request (CSR) using the private key:

```
openssl req -new -key server-key.pem -out server-csr.pem
```

When prompted, enter the required information. Here's an example:

```
Country Name (2 letter code) [AU]:US
State or Province Name (full name) [Some-State]:California
Locality Name (eg, city) []:San Francisco
Organization Name (eg, company) [Internet Widgits Pty Ltd]:MyCompany
Organizational Unit Name (eg, section) []:Development
Common Name (e.g. server FQDN or YOUR name) []:localhost
Email Address []:admin@mycompany.com
```

For the **Common Name**, use `localhost` if you're generating the certificate for local development.

3. Generate the Self-Signed Certificate (server-cert.pem)

Finally, generate a self-signed certificate using the CSR and the private key:

```
openssl x509 -req -in server-csr.pem -signkey server-key.pem -out
server-cert.pem -days 365
```

This will create the `server-cert.pem` file, which is valid for 365 days.

Step 4: Use the Certificates in Your Node.js Application

You should now have the following files in your working directory:

- `server-key.pem`: The private key.
- `server-cert.pem`: The self-signed certificate.

These files can be used in your Node.js HTTPS and HTTP/2 applications. Here's how to use them:

```
import * as https from 'https';
import * as http2 from 'http2';
import * as fs from 'fs';
```

```
// Load the certificate and key files
const options = {
  key: fs.readFileSync('server-key.pem'),
  cert: fs.readFileSync('server-cert.pem'),
};

// HTTPS server example
const httpsServer = https.createServer(options, (req, res) => {
  res.writeHead(200);
  res.end('Hello, secure HTTPS world!');
});
httpsServer.listen(443, () => {
  console.log('HTTPS server running at https://localhost');
});

// HTTP/2 server example
const http2Server = http2.createSecureServer(options);
http2Server.on('stream', (stream, headers) => {
  stream.respond({ ':status': 200 });
  stream.end('Hello, HTTP/2 world!');
});
http2Server.listen(8443, () => {
  console.log('HTTP/2 server running at https://localhost:8443');
});
```

Final Notes:

- You can use these certificates for local development. When using them in a browser, it will show a security warning because the certificates are self-signed and not trusted by default.
- In production, you'll need to obtain SSL certificates from a trusted Certificate Authority (CA), such as Let's Encrypt or a paid provider like DigiCert or GlobalSign.

8. File System Module

Node.js provides a built-in module called `fs` (File System), which allows you to interact with the file system on your server. With this module, you can perform various file operations such as reading, writing, updating, deleting, and renaming files. You can also use Node.js as a file server to handle file requests from clients.

Node.js as a File Server

Using Node.js as a file server, you can read and serve files to users, or allow file manipulations like creating, updating, deleting, or renaming files. The `fs` module provides both asynchronous and synchronous methods for these operations. It's important to use asynchronous methods whenever possible to prevent blocking the event loop.

Below are some common operations you can perform with the `fs` module:

i. Read Files

To read the contents of a file, you can use the `fs.readFile()` method asynchronously. This method reads the entire file into memory.

Example: Reading a File Asynchronously

```
import * as fs from 'fs';
import * as http from 'http';

// Example: Serving a file using Node.js
const server = http.createServer((req, res) => {
  // Reading the requested file asynchronously
  fs.readFile('example.txt', 'utf-8', (err, data) => {
    if (err) {
      res.writeHead(404, { 'Content-Type': 'text/plain' });
      res.end('File not found');
    } else {
      res.writeHead(200, { 'Content-Type': 'text/plain' });
      res.end(data);
    }
  });
```

```
});

// Listen on port 3000
server.listen(3000, () => {
  console.log('Server is running at http://localhost:3000');
});
```

Explanation:

- **`fs.readFile()`**: Reads the contents of the `example.txt` file asynchronously.
- **Error Handling**: If the file does not exist, an error message is sent back to the client.

Use Case:

- Serve files like HTML, CSS, JavaScript, or other resources to clients in a web server.

ii. Create Files

You can create new files in Node.js using `fs.writeFile()` or `fs.appendFile()`. The `writeFile()` method creates a new file and writes content to it, overwriting the file if it already exists, while `appendFile()` adds data to the end of an existing file or creates the file if it doesn't exist.

Example: Creating a New File

```
import * as fs from 'fs';

// Example: Creating and writing to a file
fs.writeFile('newfile.txt', 'Hello, this is a newly created file!',
(err) => {
  if (err) throw err;
  console.log('File created and written successfully');
});
```

Example: Appending Data to a File

```
import * as fs from 'fs';

// Example: Appending data to an existing file
fs.appendFile('newfile.txt', '\nAppending more content to the file.',
(err) => {
  if (err) throw err;
  console.log('Content appended successfully');
});
```

Use Case:

- Creating new files for logging, storing data, or dynamically generating files.

iii. Update Files

You can update a file by either writing to it again (overwriting the content) using `fs.writeFile()` or appending new content to the existing file using `fs.appendFile()`.

Example: Overwriting a File

```
import * as fs from 'fs';

// Example: Overwriting the content of a file
fs.writeFile('newfile.txt', 'This content replaces the old one.', (err)
=> {
  if (err) throw err;
  console.log('File content overwritten successfully');
});
```

Example: Appending to a File

```
import * as fs from 'fs';

// Example: Appending content to a file
fs.appendFile('newfile.txt', '\nMore content being added.', (err) => {
  if (err) throw err;
```

```
  console.log('File updated with new content');
});
```

Use Case:

- Updating logs, modifying data files, or appending new data to reports.

iv. Delete Files

You can delete files using `fs.unlink()` method.

Example: Deleting a File

```
import * as fs from 'fs';

// Example: Deleting a file
fs.unlink('newfile.txt', (err) => {
  if (err) throw err;
  console.log('File deleted successfully');
});
```

Use Case:

- Removing temporary files or cleaning up old data files that are no longer needed.

v. Rename Files

To rename a file, use the `fs.rename()` method.

Example: Renaming a File

```
import * as fs from 'fs';

// Example: Renaming a file
fs.rename('oldfile.txt', 'newfile.txt', (err) => {
  if (err) throw err;
```

```
  console.log('File renamed successfully');
});
```

Use Case:

- Organizing files, managing file versions, or moving files within the same directory.

Complete Example: Node.js File Server with File Operations

Below is an example of how you can create a basic file server in Node.js that handles reading, creating, updating, and deleting files dynamically.

```
import * as fs from 'fs';
import * as http from 'http';

// Example: Node.js File Server
const server = http.createServer((req, res) => {
  const url = req.url;

  // Read file
  if (url === '/read') {
    fs.readFile('example.txt', 'utf-8', (err, data) => {
      if (err) {
        res.writeHead(404, { 'Content-Type': 'text/plain' });
        res.end('File not found');
      } else {
        res.writeHead(200, { 'Content-Type': 'text/plain' });
        res.end(data);
      }
    });

  // Create file
  } else if (url === '/create') {
    fs.writeFile('example.txt', 'This is a newly created file!', (err)
=> {
      if (err) {
```

```
        res.writeHead(500, { 'Content-Type': 'text/plain' });
        res.end('Error creating file');
      } else {
        res.writeHead(200, { 'Content-Type': 'text/plain' });
        res.end('File created successfully');
      }
    });

  // Update file
  } else if (url === '/update') {
    fs.appendFile('example.txt', '\nAppending new content to the file.',
(err) => {
      if (err) {
        res.writeHead(500, { 'Content-Type': 'text/plain' });
        res.end('Error updating file');
      } else {
        res.writeHead(200, { 'Content-Type': 'text/plain' });
        res.end('File updated successfully');
      }
    });

  // Delete file
  } else if (url === '/delete') {
    fs.unlink('example.txt', (err) => {
      if (err) {
        res.writeHead(404, { 'Content-Type': 'text/plain' });
        res.end('File not found');
      } else {
        res.writeHead(200, { 'Content-Type': 'text/plain' });
        res.end('File deleted successfully');
      }
    });

  // Rename file
  } else if (url === '/rename') {
    fs.rename('example.txt', 'renamedfile.txt', (err) => {
      if (err) {
        res.writeHead(500, { 'Content-Type': 'text/plain' });
```

```
        res.end('Error renaming file');
      } else {
        res.writeHead(200, { 'Content-Type': 'text/plain' });
        res.end('File renamed successfully');
      }
    });

  // Default route
  } else {
    res.writeHead(200, { 'Content-Type': 'text/plain' });
    res.end('Use /read, /create, /update, /delete, or /rename to
interact with the file system.');
  }
});

// Start the server
server.listen(3000, () => {
  console.log('File server is running at http://localhost:3000');
});
```

Explanation:

- **Routes**: Each URL (`/read`, `/create`, `/update`, `/delete`, `/rename`) corresponds to different file operations.
- **Error Handling**: Each operation checks for errors and responds with the appropriate message.

9. Node.js Events

Node.js is built around an **event-driven architecture**, which is one of its core strengths. Events play a significant role in Node.js by enabling asynchronous and non-blocking communication between different parts of an application. The `EventEmitter` class, part of the `events` module, allows you to create, emit, and listen for events in a Node.js application.

In this section, we'll explore how Node.js events work, how to create and use custom events, and practical examples of their usage.

What are Events in Node.js?

In Node.js, an event refers to a specific action or occurrence, such as a user request, a timer completion, or the availability of data. The system "emits" these events, and functions called **listeners** or **handlers** react to them.

Node.js provides the `events` module, which includes the `EventEmitter` class. Objects created from `EventEmitter` can trigger and handle various events. This allows asynchronous, event-based programming, where actions happen in response to certain triggers rather than sequential execution.

The EventEmitter Class

The `EventEmitter` class is the core of event handling in Node.js. It allows you to:

- Register event listeners
- Emit (trigger) events
- Remove event listeners

The basic pattern for working with `EventEmitter` involves creating an event emitter instance, defining listeners for specific events, and emitting those events when needed.

Example: Basic Usage of EventEmitter

```
import { EventEmitter } from 'events';
```

```
// Create an instance of EventEmitter
const eventEmitter = new EventEmitter();

// Define a listener for the 'greet' event
eventEmitter.on('greet', (name) => {
  console.log(`Hello, ${name}!`);
});

// Emit the 'greet' event
eventEmitter.emit('greet', 'Alice');  // Output: Hello, Alice!
```

Explanation:

- `eventEmitter.on()`: Registers a listener for the `greet` event.
- `eventEmitter.emit()`: Emits (triggers) the `greet` event, causing the registered listener to execute.

Registering Multiple Event Listeners

You can register multiple listeners for the same event. Each listener will be executed in the order in which it was registered.

Example: Multiple Event Listeners

```
import { EventEmitter } from 'events';

const eventEmitter = new EventEmitter();

// Register multiple listeners for the same event
eventEmitter.on('greet', (name) => {
  console.log(`Listener 1: Hello, ${name}!`);
});

eventEmitter.on('greet', (name) => {
  console.log(`Listener 2: How are you, ${name}?`);
});
```

```
// Emit the 'greet' event
eventEmitter.emit('greet', 'Bob');

// Output:
// Listener 1: Hello, Bob!
// Listener 2: How are you, Bob?
```

Handling Event with Arguments

When emitting an event, you can pass additional arguments to the listeners. The arguments can be used to customize the event's behavior.

Example: Passing Arguments to Event Handlers

```
import { EventEmitter } from 'events';

const eventEmitter = new EventEmitter();

// Register a listener with multiple arguments
eventEmitter.on('status', (code, message) => {
  console.log(`Status Code: ${code}, Message: ${message}`);
});

// Emit the 'status' event with arguments
eventEmitter.emit('status', 200, 'OK');  // Output: Status Code: 200,
Message: OK
```

One-Time Event Listeners

Sometimes, you may want a listener to respond to an event only once. The `once()` method allows you to register a listener that is automatically removed after it is triggered for the first time.

Example: One-Time Event Listener

```
import { EventEmitter } from 'events';
```

```
const eventEmitter = new EventEmitter();

// Register a one-time listener for the 'greet' event
eventEmitter.once('greet', (name) => {
  console.log(`Hello for the first and only time, ${name}!`);
});

// Emit the 'greet' event twice
eventEmitter.emit('greet', 'Charlie');  // Output: Hello for the first
and only time, Charlie!
eventEmitter.emit('greet', 'Charlie');  // No output, listener is
removed after the first emit
```

Removing Event Listeners

To remove a specific event listener, use the `removeListener()` or `off()` methods. These methods allow you to remove a previously registered listener.

Example: Removing Event Listeners

```
import { EventEmitter } from 'events';

const eventEmitter = new EventEmitter();

const greetListener = (name: string) => {
  console.log(`Hello, ${name}!`);
};

// Register the listener
eventEmitter.on('greet', greetListener);

// Emit the 'greet' event
eventEmitter.emit('greet', 'David');  // Output: Hello, David!

// Remove the listener
eventEmitter.off('greet', greetListener);
```

```
// Emit the 'greet' event again (no output this time)
eventEmitter.emit('greet', 'David');
```

EventEmitter Inheritance

You can inherit from the `EventEmitter` class to create custom classes that emit events. This is useful when you want to add event-driven behavior to your own objects.

Example: Custom Class Inheriting EventEmitter

```
import { EventEmitter } from 'events';

class MyEmitter extends EventEmitter {
  log(message: string) {
    console.log(message);
    this.emit('logged', { message });
  }
}

const myEmitter = new MyEmitter();

// Register a listener for the 'logged' event
myEmitter.on('logged', (data) => {
  console.log(`Event emitted with message: ${data.message}`);
});

// Call the custom method which emits the 'logged' event
myEmitter.log('This is a custom event');  // Output:
                                          // This is a custom event
                                          // Event emitted with message:
This is a custom event
```

Handling Errors in Event Emitters

When an error occurs within an event emitter, it's a common practice to emit an `'error'` event. If there are no listeners for the `'error'` event, Node.js will throw the error and crash

the program. Always ensure there is a listener for error events when emitting errors.

Example: Emitting and Handling Errors

```
import { EventEmitter } from 'events';

const eventEmitter = new EventEmitter();

// Register an error event listener
eventEmitter.on('error', (err) => {
  console.error('Error occurred:', err);
});

// Emit an error event
eventEmitter.emit('error', new Error('Something went wrong!'));

// Output: Error occurred: Error: Something went wrong!
```

Built-in Node.js Event Emitters

Many Node.js core modules use the `EventEmitter` class internally to handle asynchronous operations. Some examples include:

- **`http`**: The HTTP module uses events to handle incoming requests and responses.
- **`net`**: The Networking module uses events for managing socket connections.
- **`fs`**: The File System module emits events when files are opened, read, or closed.

Example: Using Events in the http Module

```
import * as http from 'http';

const server = http.createServer((req, res) => {
  res.writeHead(200, { 'Content-Type': 'text/plain' });
  res.end('Hello, Event-Driven World!');
});

// Register a listener for the 'connection' event
```

```
server.on('connection', () => {
  console.log('New connection established');
});

// Start the server
server.listen(3000, () => {
  console.log('Server listening on http://localhost:3000');
});
```

10. Node.js Errors

Error handling is an essential part of building reliable applications, and Node.js provides several mechanisms for dealing with errors in an efficient way. By understanding the different types of errors and how to handle them, you can write more robust applications.

Node.js uses both synchronous and asynchronous error handling mechanisms. Since Node.js is event-driven and non-blocking, errors can occur in both synchronous code (where they can be caught immediately) and asynchronous code (where error handling is more complex).

In this section, we will cover:

- Common types of errors in Node.js
- Error handling in both synchronous and asynchronous code
- The `Error` object and custom error classes
- Best practices for error handling

a. Types of Errors in Node.js

In Node.js, errors can generally be categorized into several types:

1. **Operational Errors**: Errors that occur during the normal operation of a program. These include network issues, file not found errors, permission errors, etc.
2. **Programmer Errors**: Errors caused by bugs in the code, such as accessing an undefined variable or calling a function that doesn't exist.
3. **System Errors**: Errors that occur due to issues outside of the application, such as hardware failures or network problems.

b. The Error Object

In Node.js, all errors are represented as instances of the built-in `Error` class. The `Error` object provides information about what went wrong and can be thrown and caught

using the `try/catch` mechanism in synchronous code.

Example: Throwing and Catching Errors

```
try {
  throw new Error('Something went wrong!');
} catch (err) {
  console.error('Caught an error:', err.message);
}
```

Properties of the Error Object:

- **`message`**: A human-readable description of the error.
- **`name`**: The name of the error (defaults to `'Error'`).
- **`stack`**: A stack trace that shows where the error occurred in the code.

c. Handling Synchronous Errors

Synchronous code runs in a blocking fashion, so errors can be caught immediately using `try/catch` blocks.

Example: Handling Synchronous Errors

```
try {
  // Some synchronous code that could throw an error
  const result = JSON.parse('{ malformed JSON }');
} catch (err) {
  console.error('Error occurred during parsing:', err.message);
}
```

In synchronous code, `try/catch` blocks are straightforward to use and help to prevent the application from crashing.

d. Handling Asynchronous Errors

Handling errors in asynchronous code is more challenging because of Node.js's non-blocking nature. There are several patterns for handling errors in asynchronous

operations, such as callbacks, promises, and `async/await`.

1. Error Handling in Callbacks

When working with callbacks, errors are typically passed as the first argument to the callback function. This is often referred to as the "error-first" callback pattern.

```
import * as fs from 'fs';

// Example: Handling errors in a callback
fs.readFile('nonexistentfile.txt', 'utf-8', (err, data) => {
  if (err) {
    console.error('Error reading file:', err.message);
    return;
  }
  console.log('File content:', data);
});
```

2. Error Handling in Promises

When using promises, errors can be caught using `.catch()`.

```
// Example: Handling errors in a promise
const asyncOperation = new Promise((resolve, reject) => {
  const errorOccurred = true;
  if (errorOccurred) {
    reject(new Error('Something went wrong!'));
  } else {
    resolve('Operation succeeded');
  }
});

asyncOperation
  .then((result) => {
    console.log(result);
  })
  .catch((err) => {
```

```
    console.error('Error in promise:', err.message);
  });
```

3. Error Handling with async/await

With `async/await`, error handling is similar to synchronous code. You can use `try/catch` blocks to handle errors in asynchronous code.

```
async function readFileAsync() {
  try {
    const data = await fs.promises.readFile('nonexistentfile.txt', 'utf-
8');
    console.log('File content:', data);
  } catch (err) {
    console.error('Error reading file:', err.message);
  }
}

readFileAsync();
```

e. Custom Error Classes

Node.js allows you to create custom error classes that extend the built-in `Error` class. This can be useful for defining specific error types and improving error categorization.

Example: Creating a Custom Error Class

```
class ValidationError extends Error {
  constructor(message: string) {
    super(message);
    this.name = 'ValidationError';
  }
}

try {
  throw new ValidationError('Invalid input data');
} catch (err) {
  if (err instanceof ValidationError) {
```

```
    console.error('Caught a validation error:', err.message);
  }
}
```

Explanation:

- `ValidationError`: This custom error class inherits from the `Error` class and can be used to signal validation errors.

f. Uncaught Exceptions

When an error occurs but is not caught by any error-handling code, Node.js emits an `uncaughtException` event. Unhandled errors can cause the application to crash. You can listen for `uncaughtException` events to log the error, clean up resources, and exit the application gracefully.

Example: Handling Uncaught Exceptions

```
process.on('uncaughtException', (err) => {
  console.error('Uncaught exception:', err.message);
  process.exit(1);  // Exit the process after handling the error
});

// Simulate an uncaught exception
throw new Error('This is an uncaught exception');
```

Warning:

- Catching `uncaughtException` should be done cautiously. It's better to handle errors locally in the code, rather than relying on this global handler, as catching an uncaught exception could leave your application in an inconsistent state.

g. Unhandled Promise Rejections

In Node.js, when a promise is rejected and no `.catch()` handler is provided, the runtime emits an `unhandledRejection` event. Failing to handle promise rejections can lead to

memory leaks or unintended behavior.

Example: Handling Unhandled Promise Rejections

```
process.on('unhandledRejection', (reason, promise) => {
  console.error('Unhandled promise rejection:', reason);
  // Optionally exit the process
  process.exit(1);
});

// Simulate an unhandled promise rejection
new Promise((_, reject) => reject(new Error('This promise was rejected
but not handled')));
```

h. Best Practices for Error Handling in Node.js

1. **Handle Errors Explicitly**: Always handle errors explicitly in your code using `try/catch`, `.catch()`, or callbacks.
2. **Fail Fast**: When encountering critical errors, especially programmer errors (like referencing an undefined variable), fail fast by crashing the application and logging the issue.
3. **Graceful Shutdown**: When handling errors, especially in production, gracefully shut down the application after logging the error to avoid further corruption or inconsistent states.
4. **Use Custom Error Classes**: Create custom error classes for specific categories of errors to make it easier to catch and handle them appropriately.
5. **Log Errors**: Log errors in a consistent and informative format to help with debugging and post-mortem analysis.
6. **Avoid Using `process.exit()` Recklessly**: Exiting the process abruptly without proper cleanup (e.g., closing database connections) can cause issues. Always ensure a graceful shutdown when exiting due to errors.

11. Node intergration with Databases

Introduction to Node.js Integration with Databases

Node.js is a powerful, event-driven JavaScript runtime that excels in building fast and scalable network applications. One of its core strengths lies in its ability to seamlessly integrate with a variety of databases, both relational (SQL-based) and non-relational (NoSQL-based). Databases are fundamental to almost every application, as they store, retrieve, and manipulate the data that powers web services, APIs, and applications.

Integrating Node.js with databases is crucial for building robust applications that require data persistence, user authentication, analytics, and more. Whether you're developing a simple CRUD (Create, Read, Update, Delete) application or a complex enterprise-grade system, understanding how to work with databases in Node.js is essential.

Why Use Node.js with Databases?

Node.js's non-blocking, asynchronous nature makes it an excellent choice for database integration, especially for I/O-heavy tasks like querying databases, where it can handle many concurrent operations without being bogged down by waiting for responses. Here's why Node.js pairs well with databases:

1. **Asynchronous Operations**: Node.js's asynchronous design allows multiple database queries to run in parallel without blocking the main event loop, resulting in faster performance and scalability.
2. **Support for Multiple Databases**: Node.js supports a wide variety of databases, including:
    - **Relational Databases** (SQL): MySQL, PostgreSQL, Microsoft SQL Server (MSSQL), SQLite, etc.
    - **Non-relational Databases** (NoSQL): MongoDB, Redis, CouchDB, etc.
3. **Active Ecosystem**: The Node.js ecosystem has many libraries and ORM (Object Relational Mapping) tools that make it easier to interact with databases, such as

`mongoose` for MongoDB, `sequelize` for SQL databases, and `TypeORM` for various databases.

4. **JSON and JavaScript Compatibility**: With JSON as a common data format and JavaScript used across the stack, integration between Node.js and NoSQL databases (like MongoDB) is often seamless, reducing the need for complex data transformation.

Types of Databases You Can Use with Node.js

1. Relational Databases (SQL-based)

Relational databases store data in structured formats like tables with predefined schemas. SQL (Structured Query Language) is used to interact with the data.

- **MySQL**: One of the most popular open-source databases used for web applications. It is known for its reliability and scalability.
- **PostgreSQL**: A powerful, open-source object-relational database known for its extensibility, standards compliance, and strong support for complex queries.
- **Microsoft SQL Server (MSSQL)**: A robust enterprise-grade relational database management system from Microsoft, commonly used in large organizations.
- **SQLite**: A lightweight, self-contained SQL database engine often used for local storage in smaller applications or development environments.

2. Non-relational Databases (NoSQL-based)

NoSQL databases are designed to handle unstructured or semi-structured data and are known for their flexibility, scalability, and high performance.

- **MongoDB**: A document-based NoSQL database where data is stored in flexible, JSON-like documents. It is highly scalable and ideal for handling large volumes of unstructured data.
- **Redis**: An in-memory key-value store known for its blazing-fast read/write performance, often used for caching and real-time data processing.
- **CouchDB**: Another document-based NoSQL database, CouchDB uses a distributed architecture and stores data as JSON documents, making it suitable for distributed

systems.

Node.js Database Integration Approaches

There are two main approaches for integrating Node.js with databases:

1. Using Query Builders and Raw Queries

For developers who prefer greater control over SQL queries or who need to work directly with database-specific features, raw queries or query builders like **Knex.js** are great options. These allow developers to write SQL queries directly or through a builder that generates SQL dynamically.

Example: Raw Query with MySQL

```
const mysql = require('mysql2/promise');

async function fetchTodos() {
  const connection = await mysql.createConnection({ /* connection
details */ });
  const [rows] = await connection.execute('SELECT * FROM todos');
  return rows;
}
```

11.1 Node.js Database Integration Approaches

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details */ });
  const [rows] = await connection.execute('SELECT * FROM todos');
  return rows;
}
```

2. Using ORM (Object-Relational Mapping)

ORMs abstract database interactions, allowing developers to work with objects and models instead of raw SQL queries. This approach is particularly useful for those who want to avoid writing raw SQL and focus on the business logic.

Popular Node.js ORMs:

- **Drizzle**: It's the only ORM with both relational and SQL-like query APIs, providing you the best of both worlds when it comes to accessing your relational data.
- **Sequelize**: A promise-based ORM for MySQL, PostgreSQL, and SQLite that provides a comprehensive set of features, including model definition, associations, and transactions.

- **TypeORM**: A versatile ORM that supports a wide variety of databases, including MySQL, PostgreSQL, SQLite, and MongoDB. It works well with TypeScript and supports decorators for defining models.
- **Mongoose**: A popular ODM (Object Data Modeling) library for MongoDB that allows for defining schemas, models, and relationships in a simple and efficient way.

11.1.1 Using Query Builders and Raw Queries

1. MySQL Todo CRUD App

Step 1: Install Dependencies

```
npm install mysql2 typescript @types/node
```

Step 2: MySQL Connection and CRUD Functions

Create a file `mysql-todo.ts`.

```
import { createConnection } from 'mysql2/promise';

// MySQL Connection
const connection = createConnection({
  host: 'localhost',
  user: 'root',
  password: 'password',
  database: 'todo_db',
});

async function createTodo(title: string) {
  const conn = await connection;
  const [result] = await conn.execute('INSERT INTO todos (title) VALUES
(?)', [title]);
  console.log('Todo Created:', result);
}

async function fetchAllTodos() {
  const conn = await connection;
  const [todos] = await conn.query('SELECT * FROM todos');
  console.log('All Todos:', todos);
}
```

```
async function fetchTodoById(id: number) {
  const conn = await connection;
  const [todo] = await conn.query('SELECT * FROM todos WHERE id = ?',
[id]);
  console.log('Todo by ID:', todo[0]);
}

async function deleteTodoById(id: number) {
  const conn = await connection;
  await conn.execute('DELETE FROM todos WHERE id = ?', [id]);
  console.log('Todo deleted with ID:', id);
}

// Execute CRUD operations
(async () => {
  await createTodo('Learn TypeScript');
  await fetchAllTodos();
  await fetchTodoById(1);
  await deleteTodoById(1);
})();
```

Step 3: Run the App

```
tsc mysql-todo.ts && node mysql-todo.js
```

2. PostgreSQL Todo CRUD App

Step 1: Install Dependencies

```
npm install pg typescript @types/node
```

Step 2: PostgreSQL Connection and CRUD Functions

Create a file `postgres-todo.ts`.

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

```
// PostgreSQL Connection
const pool = new Pool({
  user: 'postgres',
  host: 'localhost',
  database: 'todo_db',
  password: 'password',
  port: 5432,
});

async function createTodo(title: string) {
  const result = await pool.query('INSERT INTO todos (title) VALUES ($1)
RETURNING *', [title]);
  console.log('Todo Created:', result.rows[0]);
}

async function fetchAllTodos() {
  const result = await pool.query('SELECT * FROM todos');
  console.log('All Todos:', result.rows);
}

async function fetchTodoById(id: number) {
  const result = await pool.query('SELECT * FROM todos WHERE id = $1',
[id]);
  console.log('Todo by ID:', result.rows[0]);
}

async function deleteTodoById(id: number) {
  await pool.query('DELETE FROM todos WHERE id = $1', [id]);
  console.log('Todo deleted with ID:', id);
}

// Execute CRUD operations
(async () => {
  await createTodo('Learn PostgreSQL');
  await fetchAllTodos();
  await fetchTodoById(1);
```

```
  await deleteTodoById(1);
})();
```

Step 3: Run the App

```
tsc postgres-todo.ts && node postgres-todo.js
```

3. MongoDB Todo CRUD App

Step 1: Install Dependencies

```
npm install mongoose typescript @types/node
```

Step 2: MongoDB Connection and CRUD Functions

Create a file `mongo-todo.ts`.

```
import mongoose from 'mongoose';

// MongoDB Connection
mongoose.connect('mongodb://localhost:27017/todo_db', {
  useNewUrlParser: true,
  useUnifiedTopology: true,
});

const todoSchema = new mongoose.Schema({
  title: String,
});

const Todo = mongoose.model('Todo', todoSchema);

async function createTodo(title: string) {
  const todo = new Todo({ title });
  await todo.save();
  console.log('Todo Created:', todo);
}
```

```
async function fetchAllTodos() {
  const todos = await Todo.find();
  console.log('All Todos:', todos);
}

async function fetchTodoById(id: string) {
  const todo = await Todo.findById(id);
  console.log('Todo by ID:', todo);
}

async function deleteTodoById(id: string) {
  await Todo.findByIdAndDelete(id);
  console.log('Todo deleted with ID:', id);
}

// Execute CRUD operations
(async () => {
  await createTodo('Learn MongoDB');
  await fetchAllTodos();
  const todo = await Todo.findOne(); // Assuming one exists
  if (todo) {
    await fetchTodoById(todo._id.toString());
    await deleteTodoById(todo._id.toString());
  }
})();
```

Step 3: Run the App

```
tsc mongo-todo.ts && node mongo-todo.js
```

4. MSSQL Todo CRUD App

Step 1: Install Dependencies

```
npm install mssql typescript @types/node
```

Step 2: MSSQL Connection and CRUD Functions

Create a file `mssql-todo.ts`.

```
import sql from 'mssql';

// MSSQL Connection
const config = {
  user: 'sa',
  password: 'password',
  server: 'localhost',
  database: 'todo_db',
  options: {
    encrypt: false, // for local dev
  },
};

const poolPromise = sql.connect(config);

async function createTodo(title: string) {
  const pool = await poolPromise;
  const result = await pool.request().query(`INSERT INTO todos (title)
VALUES ('${title}')`);
  console.log('Todo Created:', result);
}

async function fetchAllTodos() {
  const pool = await poolPromise;
  const result = await pool.request().query('SELECT * FROM todos');
  console.log('All Todos:', result.recordset);
}

async function fetchTodoById(id: number) {
  const pool = await poolPromise;
  const result = await pool.request().query(`SELECT * FROM todos WHERE
id = ${id}`);
  console.log('Todo by ID:', result.recordset[0]);
}
```

```
async function deleteTodoById(id: number) {
  const pool = await poolPromise;
  await pool.request().query(`DELETE FROM todos WHERE id = ${id}`);
  console.log('Todo deleted with ID:', id);
}

// Execute CRUD operations
(async () => {
  await createTodo('Learn MSSQL');
  await fetchAllTodos();
  await fetchTodoById(1);
  await deleteTodoById(1);
})();
```

Step 3: Run the App

```
tsc mssql-todo.ts && node mssql-todo.js
```

Summary

In each of the examples above:

- We defined connection configurations for each database.
- Implemented CRUD operations (`createTodo`, `fetchAllTodos`, `fetchTodoById`, `deleteTodoById`).
- The functions are called with dummy data, and the operations are printed to the console.

These examples are basic and do not involve Express.js or routing. Instead, they are designed to be standalone scripts that perform CRUD operations directly on the respective databases. You can adapt this structure to your needs, including adding error handling, more detailed data validation, and additional features.

11.2 Using ORM (Object-Relational Mapping)

ORMs abstract database interactions, allowing developers to work with objects and models instead of raw SQL queries. This approach is particularly useful for those who want to avoid writing raw SQL and focus on the business logic.

Popular Node.js ORMs:

- **Sequelize**: A promise-based ORM for MySQL, PostgreSQL, and SQLite that provides a comprehensive set of features, including model definition, associations, and transactions.
- **TypeORM**: A versatile ORM that supports a wide variety of databases, including MySQL, PostgreSQL, SQLite, and MongoDB. It works well with TypeScript and supports decorators for defining models.
- **Mongoose**: A popular ODM (Object Data Modeling) library for MongoDB that allows for defining schemas, models, and relationships in a simple and efficient way.

Example: Using Sequelize with PostgreSQL

```
import { Sequelize, DataTypes } from 'sequelize';

const sequelize = new Sequelize('database', 'username', 'password', {
  host: 'localhost',
  dialect: 'postgres'
});

const Todo = sequelize.define('Todo', {
  title: {
    type: DataTypes.STRING,
    allowNull: false,
  },
});
```

```
async function fetchTodos() {
  const todos = await Todo.findAll();
  return todos;
}
```

Common CRUD Operations in Node.js with Databases

CRUD (Create, Read, Update, Delete) operations are the foundation of interacting with databases. These operations allow you to store, retrieve, update, and delete data.

- **Create**: Inserting new records into a table (SQL) or collection (NoSQL).
- **Read**: Querying records from a database.
- **Update**: Modifying existing records in the database.
- **Delete**: Removing records from the database.

Example: CRUD with MongoDB (Mongoose)

```
import mongoose from 'mongoose';

const todoSchema = new mongoose.Schema({ title: String });
const Todo = mongoose.model('Todo', todoSchema);

// Create a new Todo
async function createTodo() {
  const todo = new Todo({ title: 'Learn Node.js with MongoDB' });
  await todo.save();
  console.log('Todo created:', todo);
}

// Read all Todos
async function fetchTodos() {
  const todos = await Todo.find();
```

```
  console.log('All Todos:', todos);
}
```

Best Practices for Database Integration with Node.js

1. **Connection Pooling**: Use connection pools to reuse connections efficiently rather than creating a new one for each request, which can improve performance and resource usage.
2. **Error Handling**: Ensure proper error handling for database queries and connections to avoid application crashes. Implement retry logic or graceful shutdown in case of failures.
3. **Security**: Always secure database credentials using environment variables and avoid hardcoding sensitive information in your codebase. Additionally, ensure SQL queries are parameterized to prevent SQL injection attacks.
4. **Query Optimization**: For large datasets, optimize queries to reduce latency. This can involve using indexing, caching frequently accessed data, and minimizing the use of `SELECT *` queries.