Node.js Documentation

Module 1: Intro to Node.js

- ### What is Node.js?
  Node.js is a runtime environment that allows you to run JavaScript on the server side. It uses the V8 JavaScript engine, the same engine that powers Google Chrome, to execute code.

- ### PHP vs. Node.js

  PHP and Node.js are both popular choices for server-side development but have different strengths and use cases.

  PHP

  1. **Blocking I/O**: PHP uses a blocking I/O model where each I/O operation (like reading a file, or querying a database) blocks the execution of the script until the operation is completed.

  2. **Synchronous**: PHP scripts are executed in a synchronous manner.

  3. **Common Use Case**: Traditional web development with tools like WordPress, Laravel, etc.

  Node.js

  1. **Non-blocking I/O**: Node.js uses a non-blocking I/O model where operations can be executed without waiting for previous ones to complete.

2. **Asynchronous**: Node.js is designed for asynchronous execution.

3. **Common Use Case**: Real-time applications, API development, and applications requiring high concurrency.

- ## RAM vs. I/O Latency

RAM (Random Access Memory)

RAM is a type of computer memory that can be accessed randomly. It is used to store data that is being actively used or processed by the CPU. Accessing data from RAM is much faster compared to accessing data from a hard drive or SSD.

Key Points:

1. **Fast Access**: Data in RAM can be accessed in nanoseconds, making it extremely fast.

2. **Volatile**: RAM is volatile memory, meaning it loses all stored information when the power is turned off.

3. **Temporary Storage**: RAM is used for temporary storage of data that the CPU needs quick access to.

4. **Limited Size**: RAM is typically smaller in size compared to disk storage but is much faster.

5. **Used for Active Data**: RAM stores data that is actively being used or processed by applications.

6. **Expensive**: RAM is more expensive per byte compared to disk storage.

7. **Performance Impact**: More RAM can significantly improve the performance of applications by reducing the need to access slower storage.

8. **Random Access**: RAM allows for data to be read and written in any order, providing flexibility and speed.

I/O Latency (Input/Output Latency)

I/O latency refers to the time it takes to complete an I/O operation, such as reading from or writing to a disk or network. It is typically measured in milliseconds or microseconds.

Key Points:

- **Slower Access**: I/O operations, such as reading from or writing to a disk or network, have higher latency compared to RAM access.

- **Persistent Storage**: Unlike RAM, data stored in I/O devices (like hard drives and SSDs) is persistent and remains even when the power is off.

- **Physical Limitations**: The speed of I/O operations is limited by the physical properties of the storage medium or network.

- **Measured in Milliseconds**: I/O latency is typically measured in milliseconds or microseconds, which is much slower than nanoseconds for RAM.

- **Blocking Operations**: Synchronous I/O operations can block the execution of a program until the operation is completed.

- **Asynchronous Operations**: Asynchronous I/O operations allow other tasks to continue executing while waiting for the I/O operation to complete, improving efficiency.
- **Used for Long-term Storage**: I/O devices are used for long-term storage of data, including files, databases, and backups.

- **Cost-effective**: I/O devices, especially traditional hard drives, are more cost-effective per byte compared to RAM.

Blocking vs Non-blocking

Blocking Operations

Blocking operations cause the execution of subsequent code to wait until the current operation completes. This means that no other operations can be processed until the blocking operation finishes.

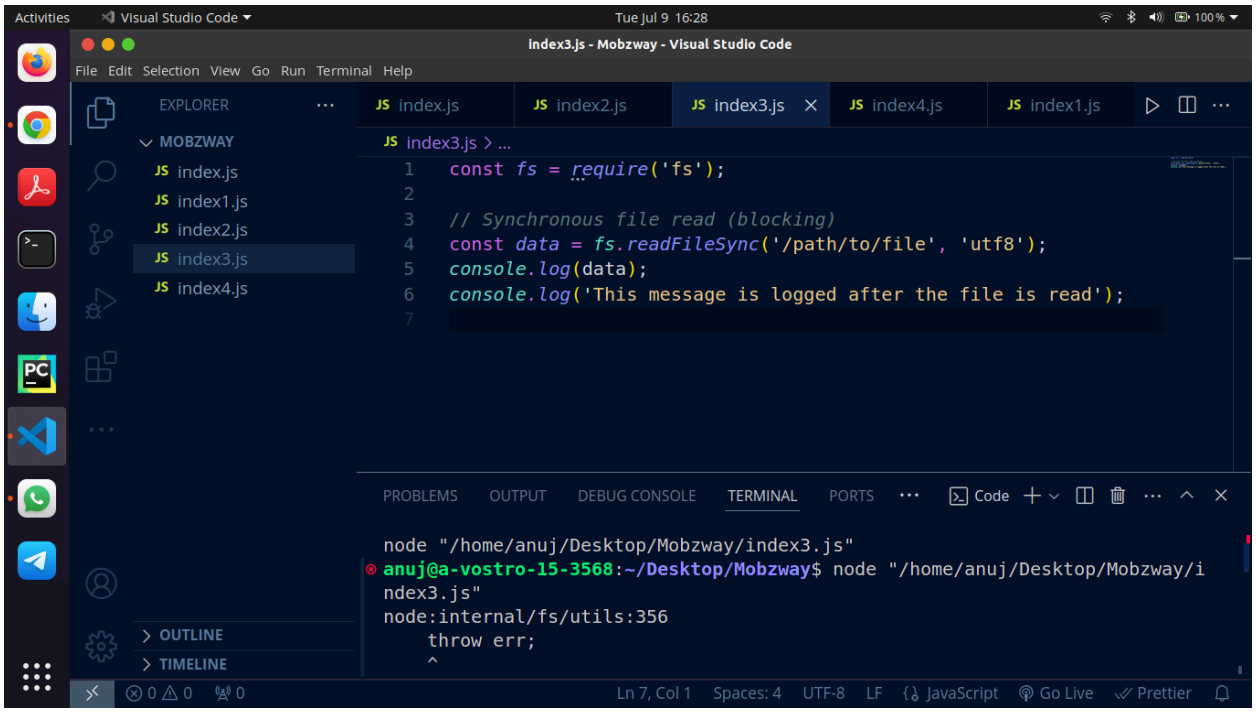
Characteristics of Blocking Operations:

1. **Synchronous Execution:** The code is executed line by line, and each operation must complete before the next one starts.

2. **Potential for Delays:** Long-running operations can cause significant delays, making the application unresponsive.

3. **Simple but Inefficient:** Easy to write and understand but can lead to performance bottlenecks.

Example of Blocking Code:



In this example:

- `fs.readFileSync` is a blocking operation that reads the file synchronously.
- The execution of `console.log (This message is logged after the file is read')` is blocked until the file read operation completes.

Non-Blocking Operations

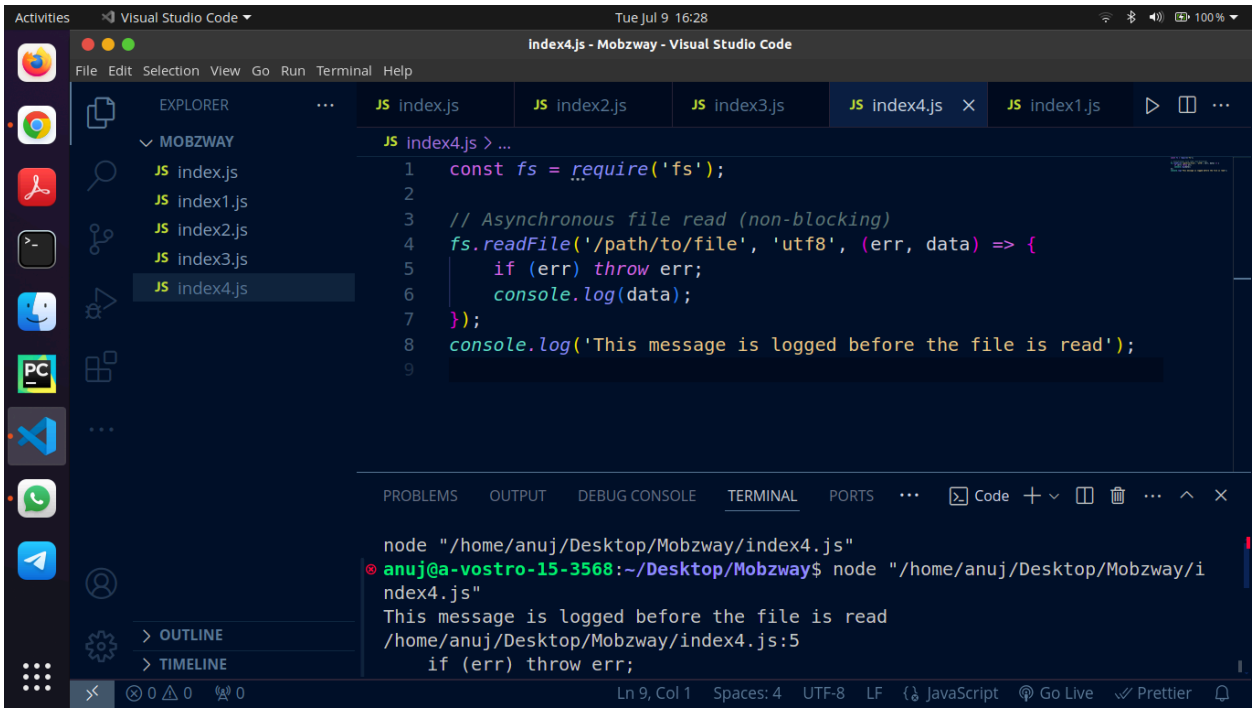
Non-blocking operations allow other tasks to be processed while the current operation is being executed. This approach enables higher concurrency and better performance, especially for I/O-bound tasks.

Characteristics of Non-Blocking Operations:

1. **Asynchronous Execution:** The code continues to execute without waiting for the current operation to complete.

2. **Concurrency:** Multiple operations can be handled concurrently, improving efficiency.
3. **More Complex:** Requires handling callbacks, promises, or async/await, making the code more complex but highly performant.

Example of Non-Blocking Code:



In this example:

- `fs.readFile` is a non-blocking operation that reads the file asynchronously.
- `console.log('This message is logged before the file is read')` is executed immediately without waiting for the file read operation to complete.

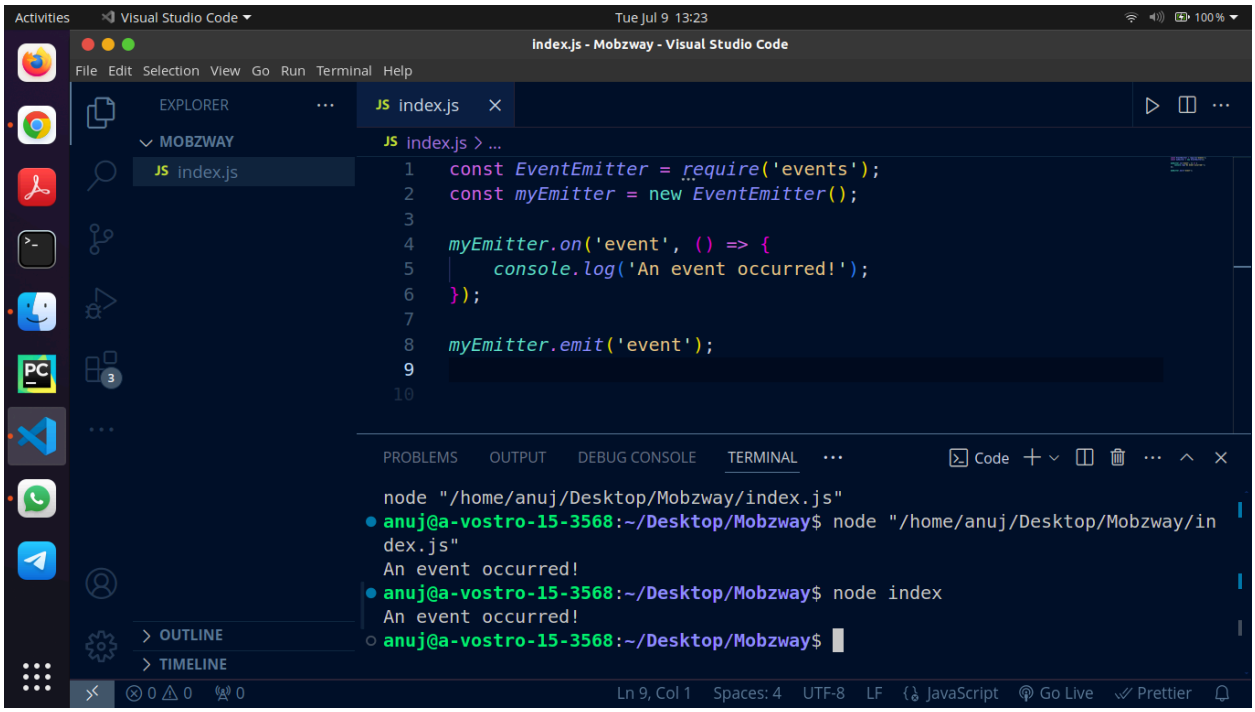
- **Event-Driven Programming**

Event-driven programming means a callback function will be executed when the corresponding event occurs.
For this, we make an object of the EventEmitter class and through this object, we can access any method in this class.
We use .emit method for the occurrence of the event.
.emit method takes the event name as an argument.

.on method has two parameters:

1. Event name
2. Listener: It is a callback function that will be executed when the corresponding event occurs.

Below code is an example of event-driven programming.



In the above code, when an event occurs in line 8, the corresponding callback function, which is in line 4, will be executed.

- **Event Loop**
  The event loop is a fundamental concept in Node.js that allows it to handle asynchronous operations and non-blocking I/O. It is the mechanism that Node.js

uses to manage the execution of multiple pieces of code without the need for multiple threads.

Event Loop Explained

1. **Single-Threaded:** Node.js operates on a single-threaded event loop, which is responsible for executing JavaScript code, handling events, and performing I/O operations asynchronously.

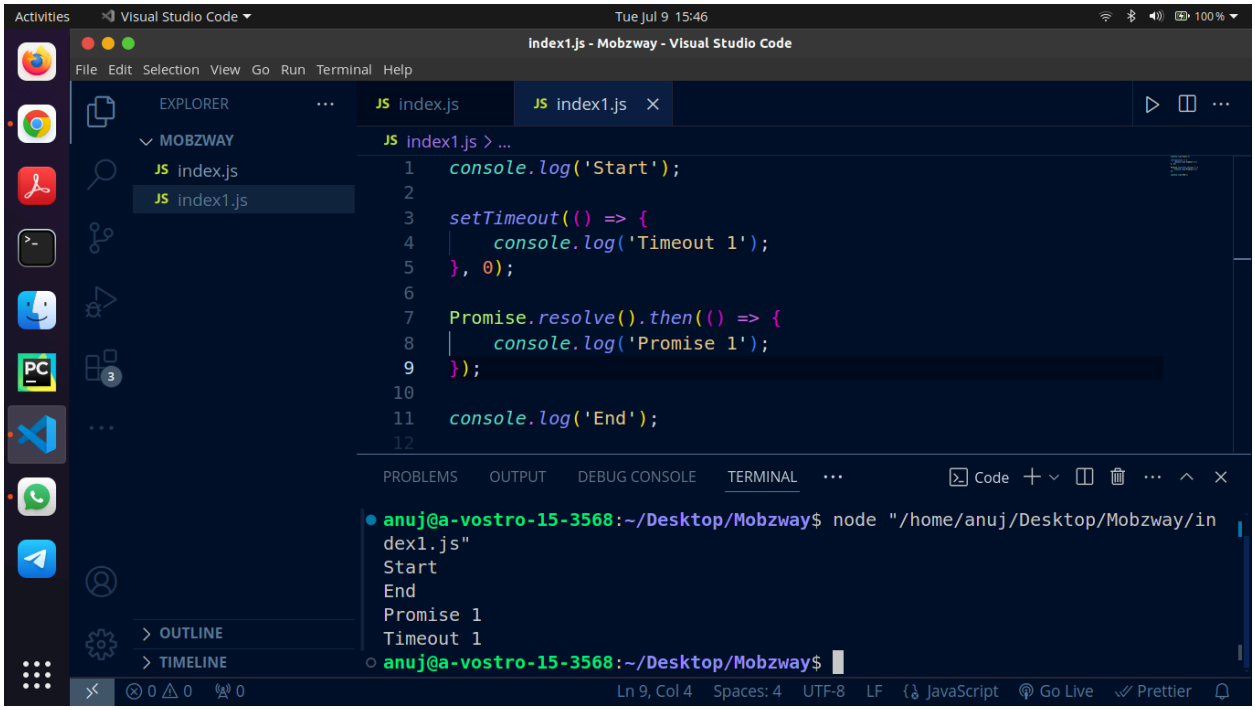
2. **Non-blocking I/O:** The event loop enables Node.js to perform non-blocking I/O operations despite being single-threaded. This means it can handle other tasks while waiting for I/O operations to complete.

3. **Phases of the Event Loop:**

    - **Timers:** Executes callbacks scheduled by `setTimeout` and `setInterval`.
    - **Pending Callbacks:** Executes I/O callbacks deferred to the next iteration of the loop.
    - **Idle, Prepare**: Internal use only.
    - **Poll:** Retrieves new I/O events; executes I/O callbacks (almost all events except close, timers, and setImmediate).
    - **Check**: Executes callbacks scheduled by `setImmediate`.
    - **Close Callbacks:** Executes close event callbacks like `socket.on('close' ...)`.

4. **Microtasks:** Tasks such as `process.nextTick` and resolved Promises have a higher priority than other tasks and are executed immediately after the currently executing script before the event loop continues.

    Example Explanation:



Let's break down the execution of this example step by step.

1. **Synchronous Code Execution:** The code starts executing from the top.
    - `console.log('Start');` is executed, and "Start" is printed to the console.

2. **setTimeout:**
    - `setTimeout` is called with a delay of 0 milliseconds. This means the callback function is added to the Timer phase of the event loop but will only be executed after the current stack and microtasks are completed.

3. **Promise:**
    - `Promise.resolve().then(...)` schedules the callback function to be executed as a microtask (part of the microtask queue).

4. **Synchronous Code Execution Continues:**
    - `console.log('End');` is executed, and "End" is printed to the console.

5. **Microtasks Execution:**
    - After the synchronous code is executed, the event loop checks the microtask queue. The callback from `Promise.resolve().then(...)` is executed, printing "Promise 1" to the console.

6. **Timers Phase:**
    - Once all microtasks are completed, the event loop moves to the Timers phase and executes the `setTimeout` callback, printing "Timeout 1" to the console.

Summary of the Event Loop Execution

1. **Initial Execution**: `console.log('Start');` and `console.log('End');` are executed sequentially.

2. **Scheduling Tasks**: `setTimeout` schedules a callback in the Timers phase, and `Promise.resolve().then(...)` schedules a microtask.

3. **Microtasks**: Microtasks from the microtask queue (like resolved Promises) are executed after the current stack is completed but before moving to the next phase of the event loop.

4. **Timers Phase**: Once all synchronous code and microtasks are executed, the event loop proceeds to execute the `setTimeout` callback in the Timers phase.

- ## Blocking the Event Loop

  Blocking the event loop in Node.js is a critical concept to understand because it directly affects the performance and responsiveness of your application. Node.js is designed to handle many operations concurrently, but blocking the event loop can prevent it from processing other tasks, leading to delays and decreased performance.

  ### What is Blocking the Event Loop?

  Blocking the event loop occurs when a task takes a long time to complete and prevents other tasks from executing. Since Node.js uses a single-threaded event loop to handle all operations, any function that takes a long time to execute will block the event loop and delay the execution of other pending tasks.

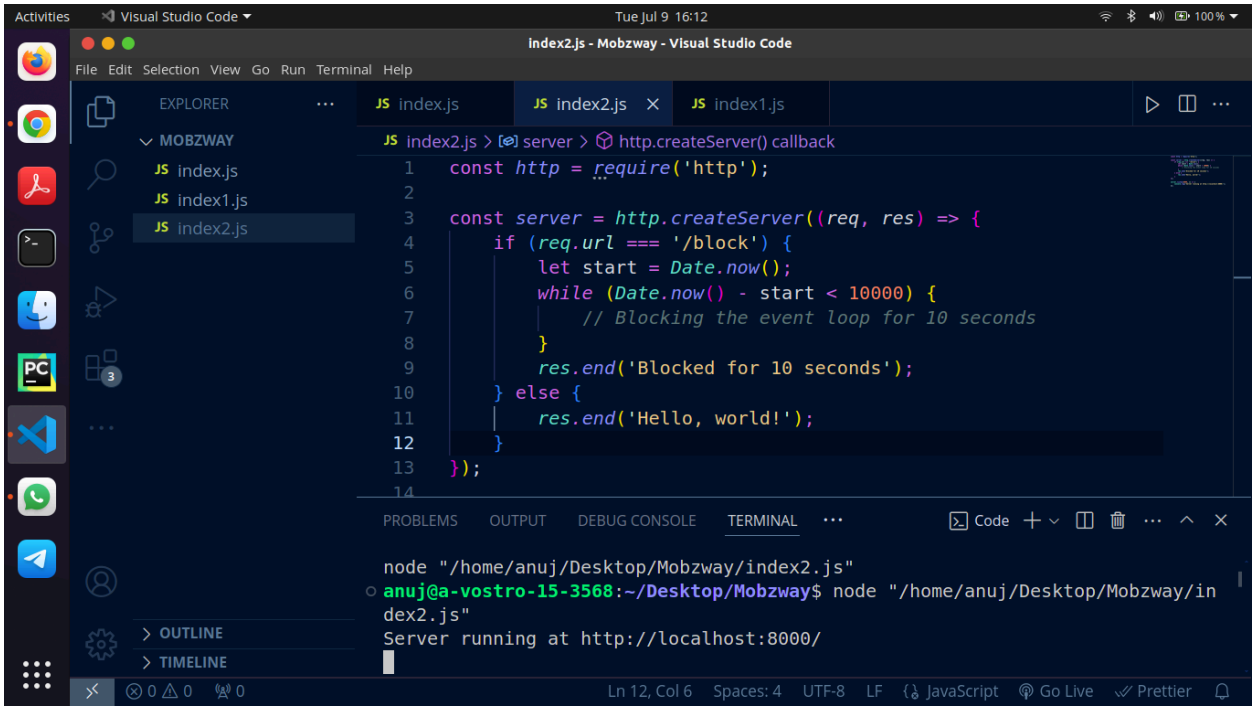
  ### How Does Blocking Happen?

  1. **Synchronous Code**: Any synchronous code that takes a long time to execute will block the event loop. Examples include complex calculations, large loops, or heavy file operations.

  2. **I/O Operations**: While Node.js is designed to handle I/O operations asynchronously, if you use synchronous I/O methods, they will block the event loop.

  3. **Long-Running Operations**: Functions that perform long-running operations without yielding control back to the event loop will cause blocking.

  Example of Blocking Code



Breakdown of the Example

1. **Create HTTP Server:** An HTTP server is created.

2. **Blocking Route:** If the request URL is `/block`, the server will enter a while loop that runs for 10 seconds.

3. **Non-blocking Route**: For any other request URL, the server responds with "Hello, world!".

When a request is made to `/block`, the server will not be able to handle any other requests until the 10-second loop completes. This blocks the event loop and makes the server unresponsive during that time.

How to Avoid Blocking the Event Loop

1. **Use Asynchronous Operations:** Always prefer asynchronous methods over synchronous ones. For example, use `fs.readFile` instead of `fs.readFileSync`.

2. **Break Long-Running Tasks:** Split long-running tasks into smaller chunks and use `setImmediate` or `process.nextTick` to yield control back to the event loop.

3. **Offload Intensive Tasks:** Offload CPU-intensive tasks to worker threads or child processes.

Module 2: Node.js Platform Setup

- ## Node REPL

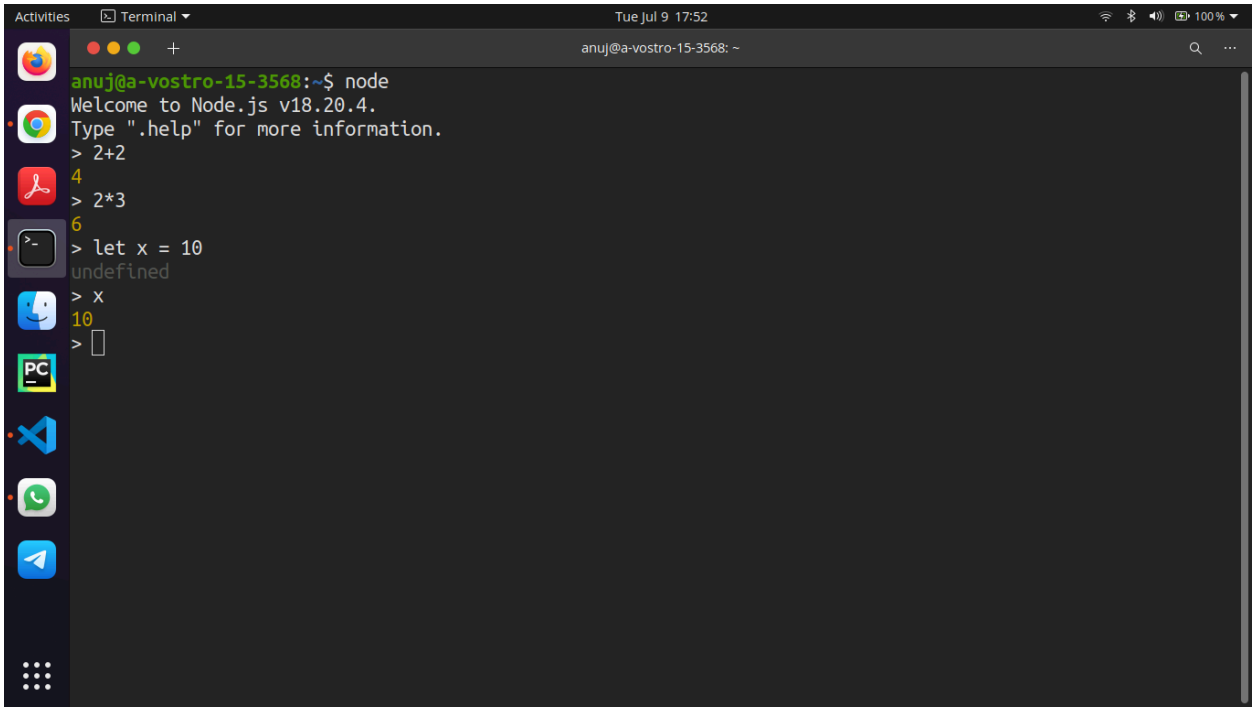
  The Node.js REPL (Read-Eval-Print Loop) is an interactive shell that allows you to enter JavaScript code and immediately see the results. It's a useful tool for testing and experimenting with Node.js code snippets in real-time.

  Starting the Node.js REPL

  To start the Node.js REPL, simply open your terminal or command prompt and type: `node`

  This will start the REPL, and you'll see a prompt (>) where you can start typing JavaScript code.

Basic Operations in the REPL



- ## Download and Install Node.js

To download and install Node.js, follow these steps based on your operating system:

<u>For Windows</u>

1. **Download Node.js Installer:**
    - Go to the Node.js download page.
    - Click the Windows Installer button to download the `.msi` file.

2. **Run the Installer:**
    - Locate the downloaded `.msi` file and double-click to run it.
    - Follow the prompts in the Node.js Setup Wizard. Accept the license agreement and choose the installation options.
    - Make sure to check the box that says "Automatically install the necessary tools" (if available).

3. **Verify Installation:**
    - Open Command Prompt (`cmd`) or PowerShell.
    - Type the following commands to verify the installation: node -v
    - npm -v

For macOS

1. **Download Node.js Installer:**
    - Go to the Node.js download page.
    - Click the macOS Installer button to download the `.pkg` file.

2. **Run the Installer:**
    - Locate the downloaded `.pkg` file and double-click to run it.
    - Follow the prompts in the Node.js Installer. Accept the license agreement and proceed with the installation.

3. **Verify Installation:**
    - Open Terminal.
    - Type the following commands to verify the installation: node -v
    - npm -v

- ## Import Required Modules

In Node.js, you can import required modules using the `require` function for CommonJS modules, which is the module system used by Node.js by default. Here's how you can import some commonly used modules:

Core Modules

```
const fs = require('fs'); // File system module
const http = require('http'); // HTTP module for creating web servers
const path = require('path'); // Path module for working with file and directory paths
```

const os = require('os'); // OS module for getting operating system-related utility methods and properties
const util = require('util'); // Utilities module

External Modules

External modules are installed via npm (Node Package Manager). For example, to use the `express` module, you first need to install it using npm:

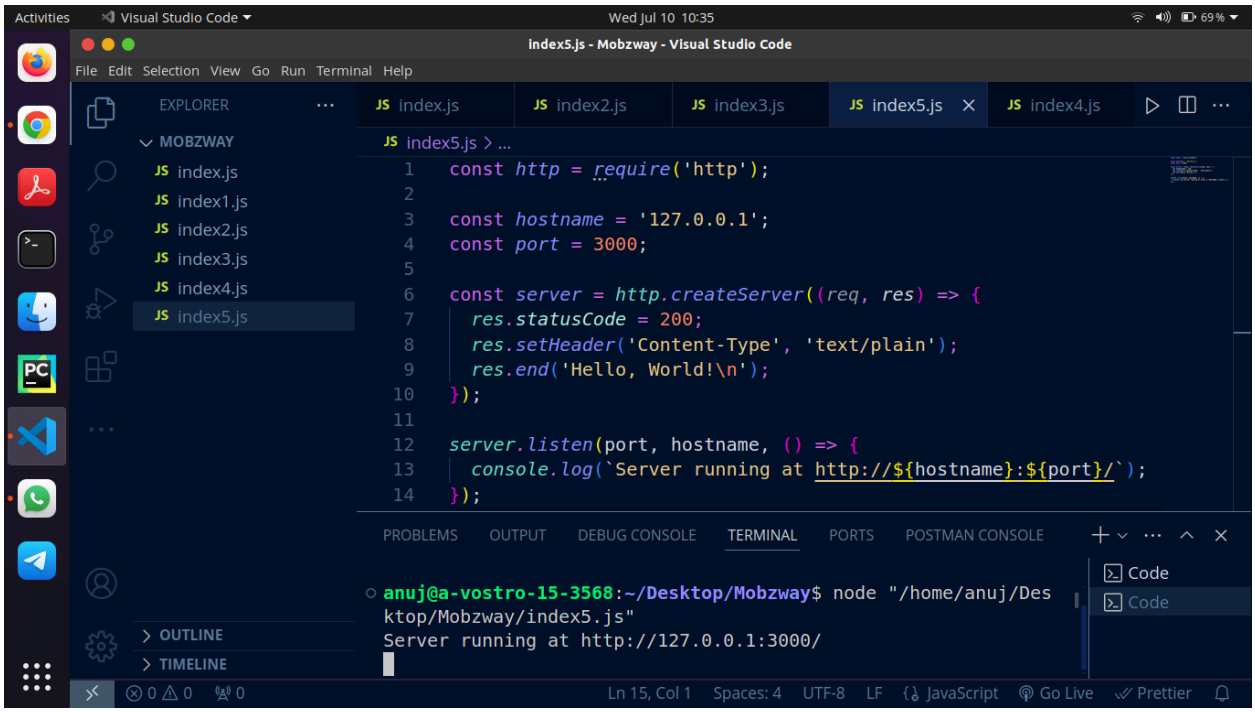
```
npm install express
```

Then, you can import it in your Node.js application.

- ## Creating Web Server

Creating a web server in Node.js is straightforward, I'll show you how to create a web server: using the built-in `http` module.

Using the `http` Module



let's break down this code step by step:

Importing the `http` Module

This will import the built-in `http` module, which provides the functionality to create an HTTP server.

Setting the Hostname and Port

Here, `hostname` is set to `'127.0.0.1'`, which is the loopback IP address (localhost). The `port` is set to `3000`. These are the address and port number where the server will listen for incoming requests.

Creating the Server

1. http.createServer((req, res) => { ... }): This function creates an HTTP server. It takes a callback function as an argument. This callback function is called every time a request is received by the server.

2. (req, res): The callback function takes two arguments:
   - `req`: An object representing the incoming request.
   - `res`: An object representing the response that will be sent to the client.

3. res.statusCode = 200;: This line sets the status code of the response to `200`, which means "OK".

4. res.setHeader('Content-Type', 'text/plain');: This line sets the `Content-Type` header of the response to `text/plain`. This tells the client that the response body is plain text.

5. res.end('Hello, World!\n');: This line ends the response and sends the string `'Hello, World!\n'` to the client.

Starting the Server

1. **server.listen(port, hostname, () => { ... })**: This method starts the server and makes it listen on the specified `port` and `hostname`.

2. **() => { ... }**: This is a callback function that is executed once the server starts successfully.

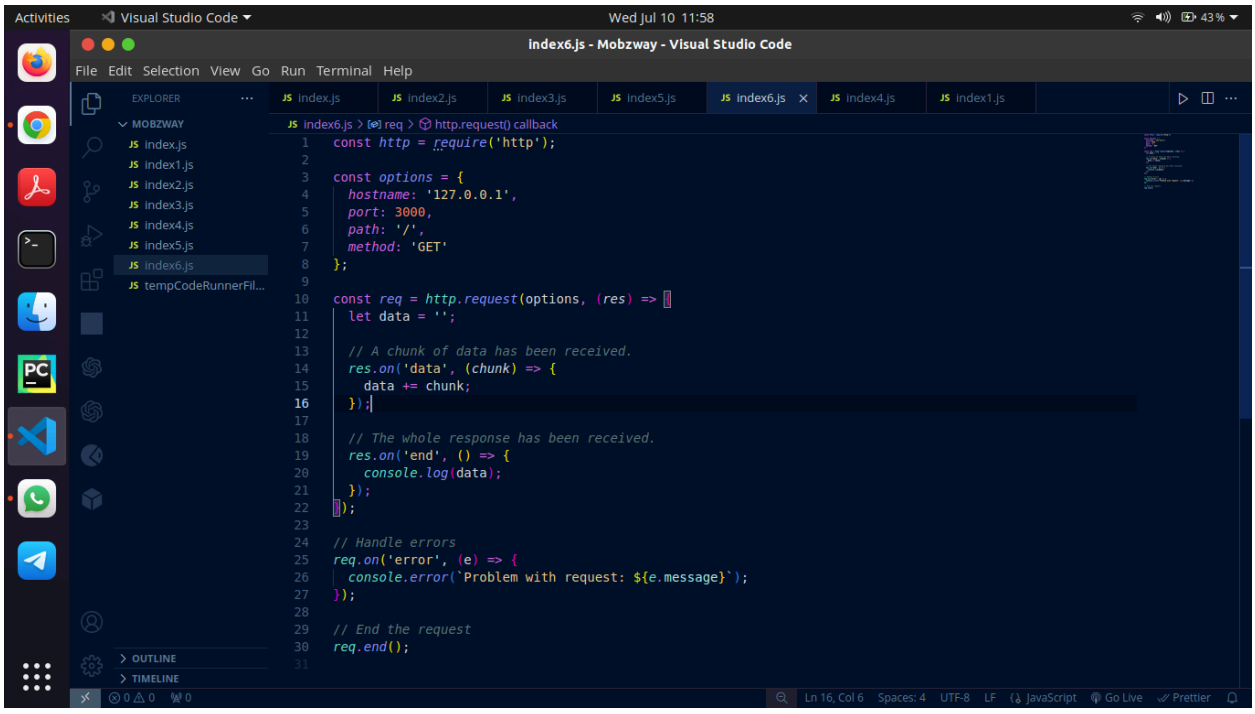
3. **console.log(`Server running at http://${hostname}:${port}/`);**: This line logs a message to the console, indicating that the server is running and providing the URL where it can be accessed.

- ## Sending Request

Here is the example of sending HTTP requests using http module in Node.js:

Using the Built-in `http` Module

Here's an example of how to send a GET request using the `http` module:



Setting Up Request Options

Here, an `options` object is created to specify the details of the HTTP request:

- `hostname`: The server address. In this case, it's the loopback IP address (localhost).
- `port`: The port number to connect to on the server.
- `path`: The URL path to request from the server.
- `method`: The HTTP method to use for the request (GET, in this case).

Making the Request

`http.request(options, callback)`: This function creates a new HTTP request using the provided `options` and a callback function that handles the response.

1. **Callback function `(res) => { ... }`**: This function is called when the server responds. It receives a `res` (response) object.
2. **`res.on('data', (chunk) => { ... })`**: This event listener handles the incoming data chunks. The data received is appended to the `data` variable.
3. **`res.on('end', () => { ... })`**: This event listener is called when the entire response has been received. It logs the complete response data to the console.

Handling Errors

`req.on('error', (callback))`: This event listener is called if there is an error with the request. It logs the error message to the console.

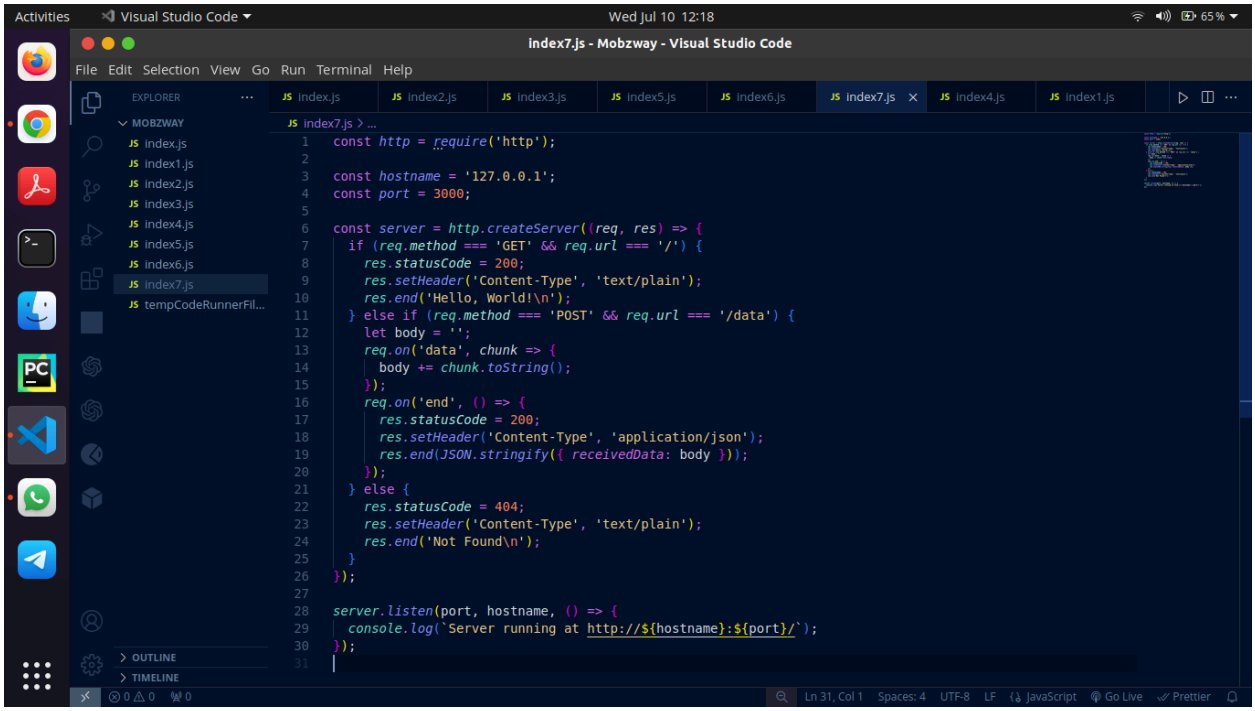
Ending the Request

`req.end()`: This function signals that the request has been completed and no more data will be sent. It is necessary to call `req.end()` to actually send the request.

- ## Handling HTTP requests

  Handling HTTP requests in Node.js typically involves creating a server that listens for incoming requests and responds appropriately. This can be done using the built-in `http` module.

  ### Using the Built-in `http` Module



  ### Handling GET Requests

  1. **Checking the Request Method and URL**: This `if` statement checks if the request method is `GET` and the request URL is `/`.
  2. **Setting the Status Code**: `res.statusCode = 200;` sets the HTTP status code of the response to `200`, which means "OK".
  3. **Setting the Header**: `res.setHeader('Content-Type', 'text/plain');` sets the `Content-Type` header of the response to `text/plain`, indicating that the response body is plain text.
  4. **Ending the Response**: `res.end('Hello, World!\n');` ends the response and sends the string `'Hello, World!\n'` to the client.

Handling POST Requests

Checking the Request Method and URL: This `else if` statement checks if the request method is `POST` and the request URL is `/data`.

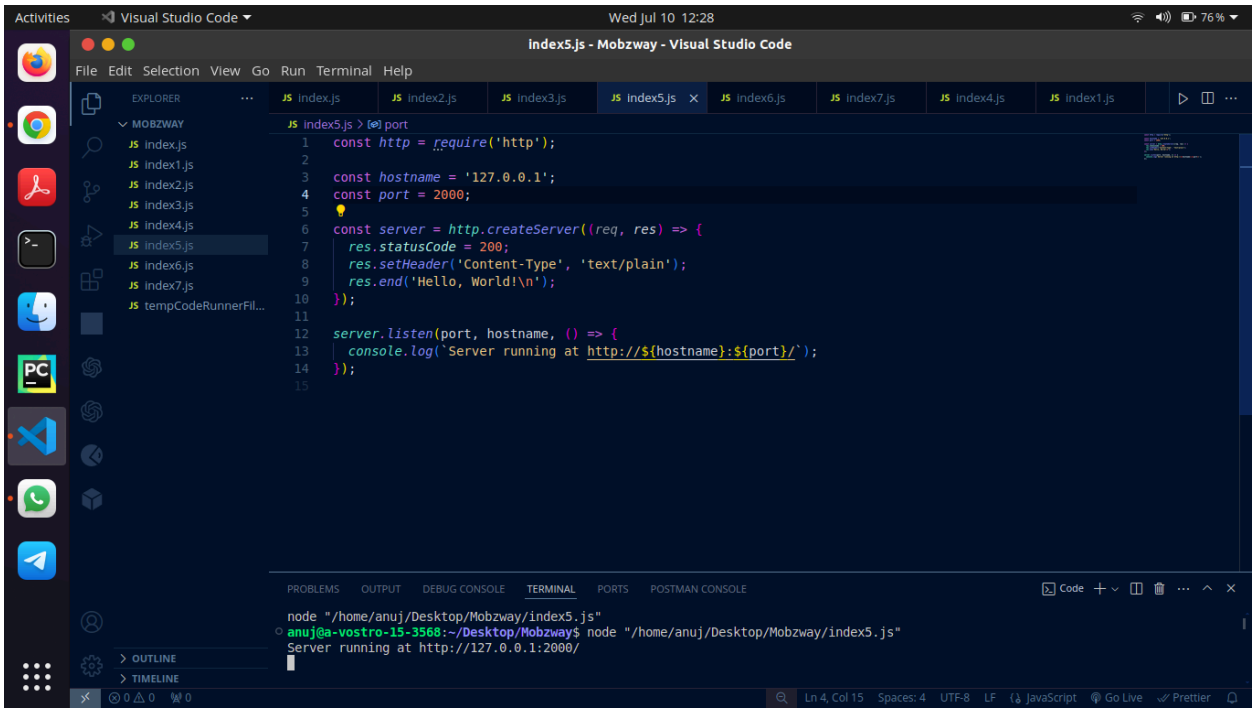
1. **Handling Incoming Data**:
    - `let body = '';` initializes an empty string to accumulate the incoming data chunks.

    - `req.on('data', chunk => { body += chunk.toString(); });` sets up an event listener for the `data` event, which is emitted when a chunk of data is received. The received chunk is converted to a string and appended to the `body` variable.
2. **Handling End of Data**:
    - `req.on('end', () => { ... });` sets up an event listener for the `end` event, which is emitted when all data has been received.
    - Inside the `end` event listener:
        - `res.statusCode = 200;` sets the HTTP status code of the response to `200`, indicating success.

        - `res.setHeader('Content-Type', 'application/json');` sets the `Content-Type` header to `application/json`, indicating that the response body is JSON.

        - `res.end(JSON.stringify({ receivedData: body }));` ends the response and sends a JSON string containing the received data back to the client.

- **Write your First Hello-World Program**



Explanation

1. **Import the `http` Module**: The first line imports the built-in `http` module, which is required to create an HTTP server.
2. **Define the Hostname and Port**: The `hostname` is set to `'127.0.0.1'` (localhost), and the `port` is set to `3000`.
3. **Create the HTTP Server**: The `http.createServer` function creates a new HTTP server. The server takes a callback function that is executed each time a request is received.
4. **Start the Server**: The `server.listen` function starts the server and makes it listen on the specified port and hostname. When the server starts, a message is logged to the console.

- **Deploy your node app on any platform like Heroku, Render and firebase**

Deploying on Heroku

1. **Install Heroku CLI:** If you haven't already, download and install the Heroku CLI.

2. **Login to Heroku:** Open your terminal and run: heroku login

3. **Prepare Your Application**: Ensure your `helloWorld.js` and `package.json` are in the same directory. Your `package.json` should look something like this:

   ```
   {
     "name": "hello-world",
     "version": "1.0.0",
     "main": "helloWorld.js",
     "scripts": {
       "start": "node helloWorld.js"
     }
   }
   ```

4. **Initialize a Git Repository**:

   ```
   git init
   git add .
   git commit -m "Initial commit"
   ```

5. **Create a Heroku App**:

   ```
   heroku create
   ```

6. **Deploy Your Code**:

   git push heroku master

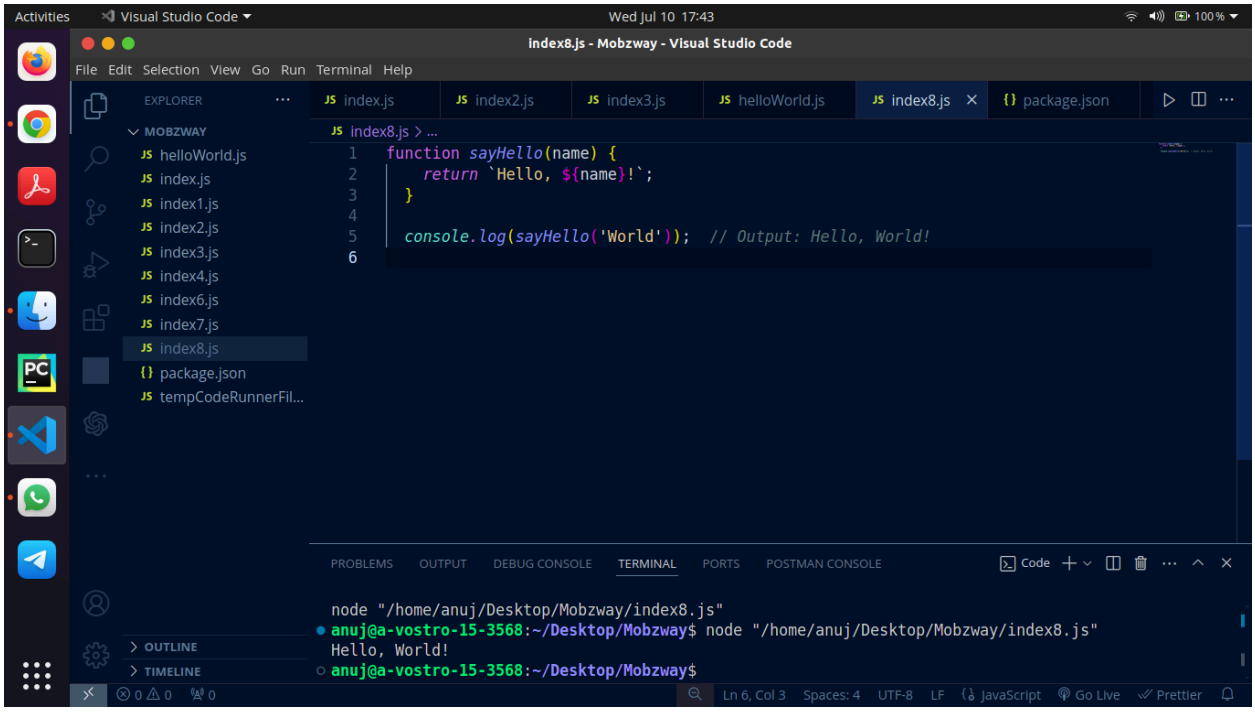
7. **Open Your App**:

   heroku open

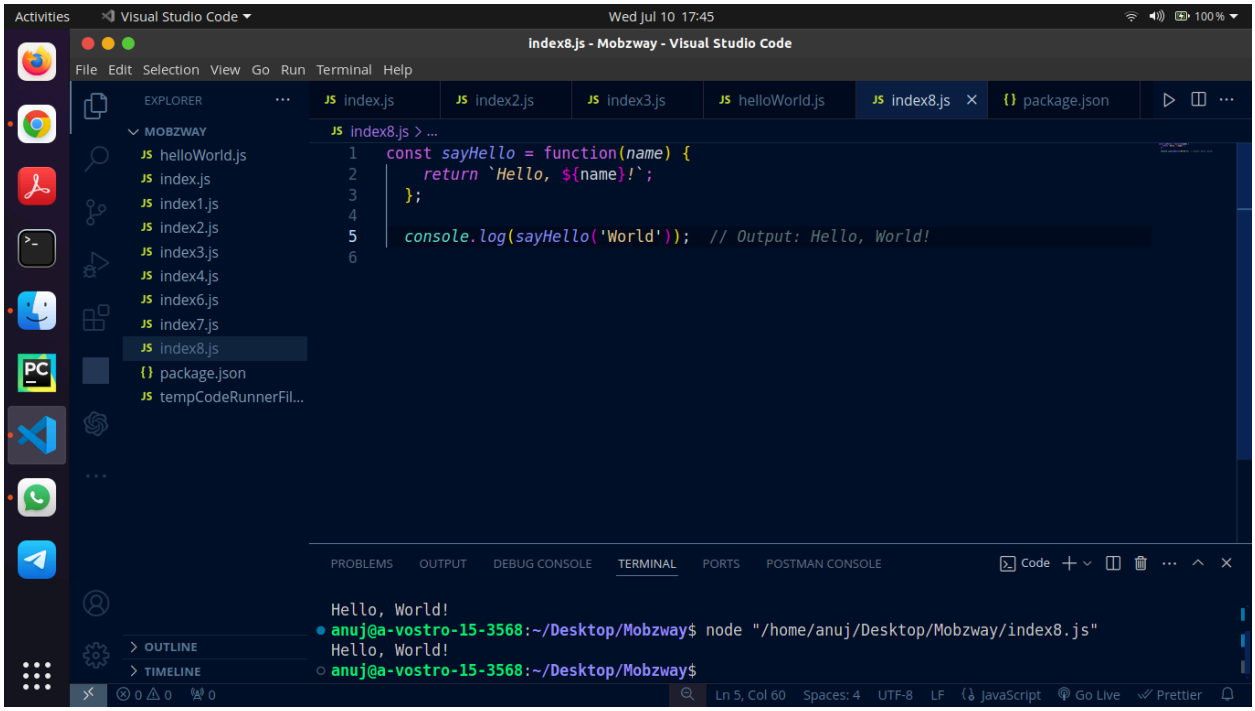
Module 3: Node JS Modules

- **Functions**

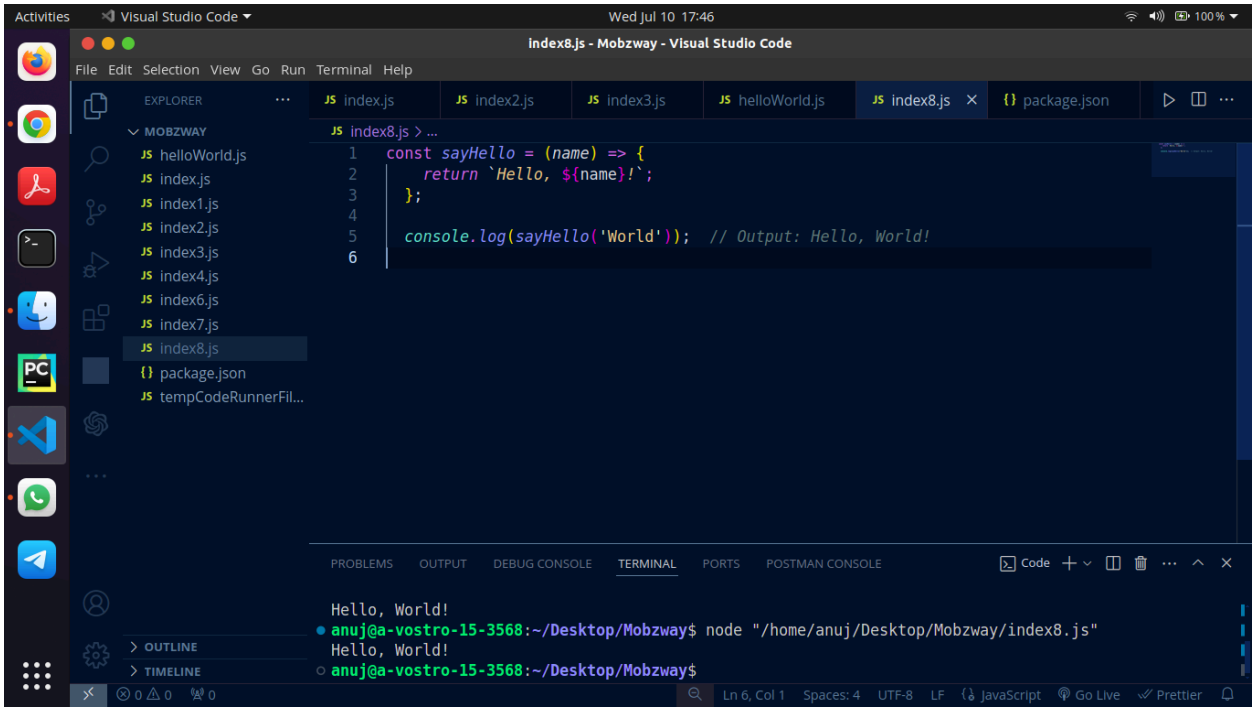
Named Functions



Anonymous Functions

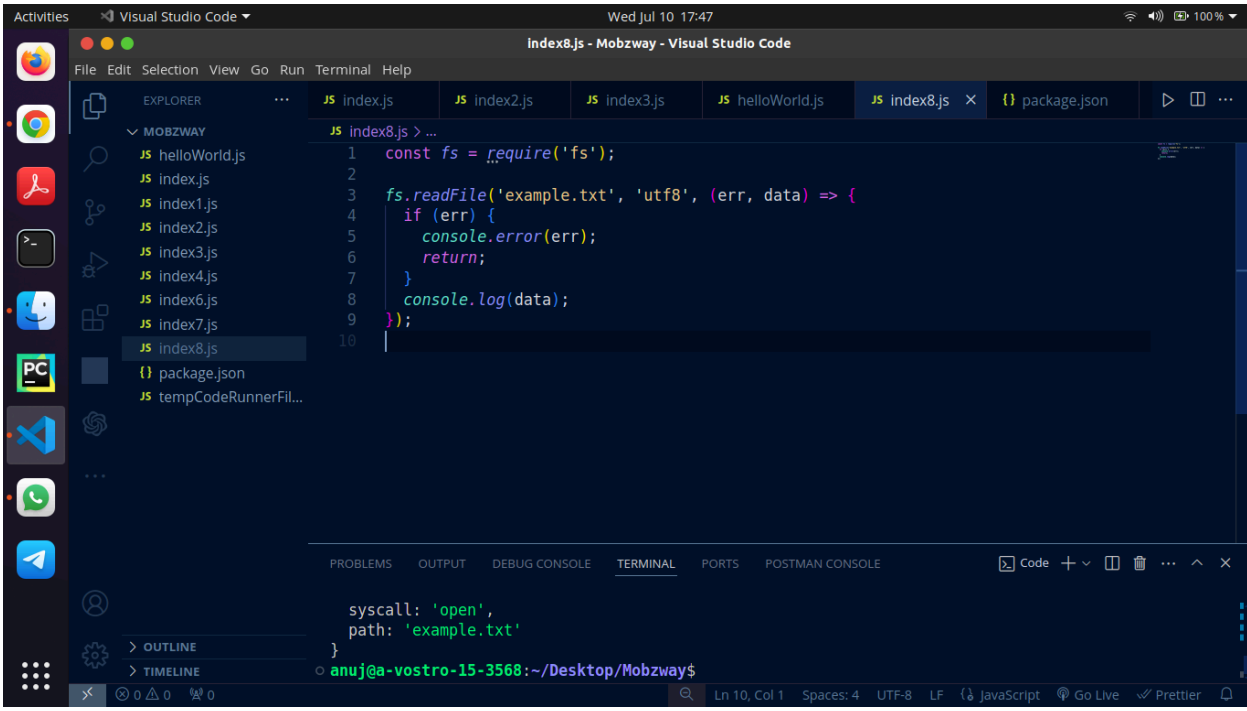


Arrow Functions

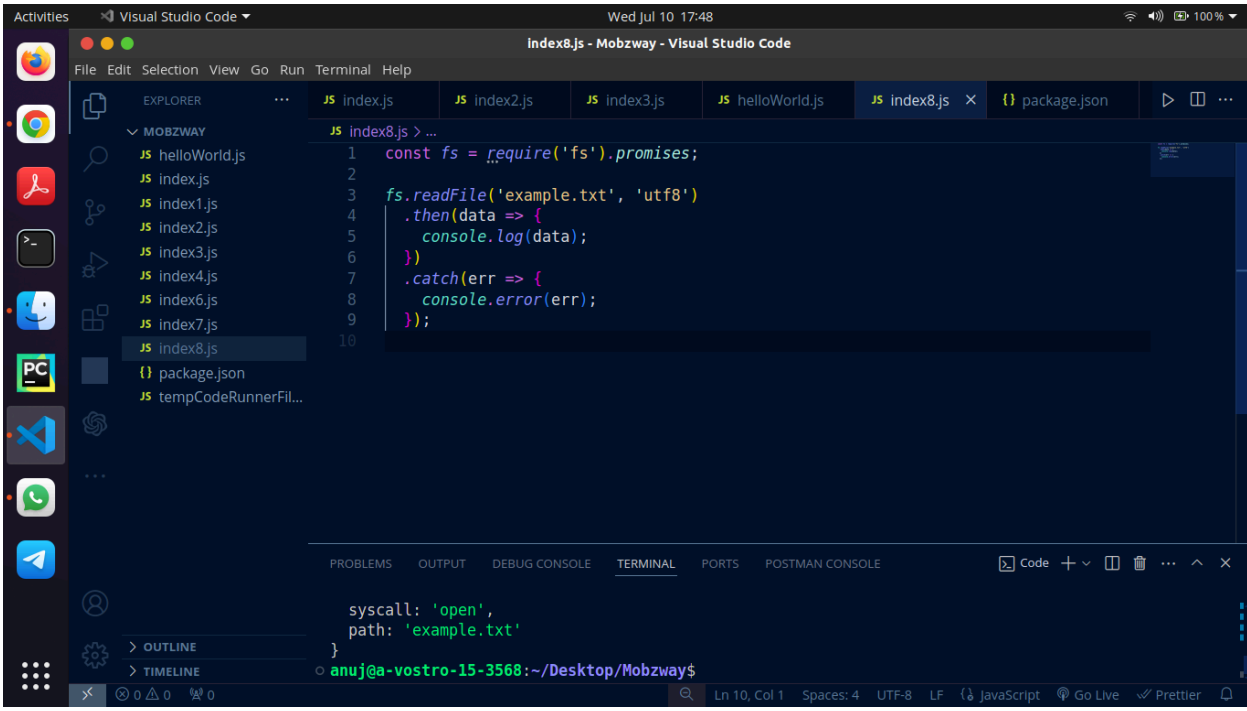


Asynchronous Functions

1. Callbacks

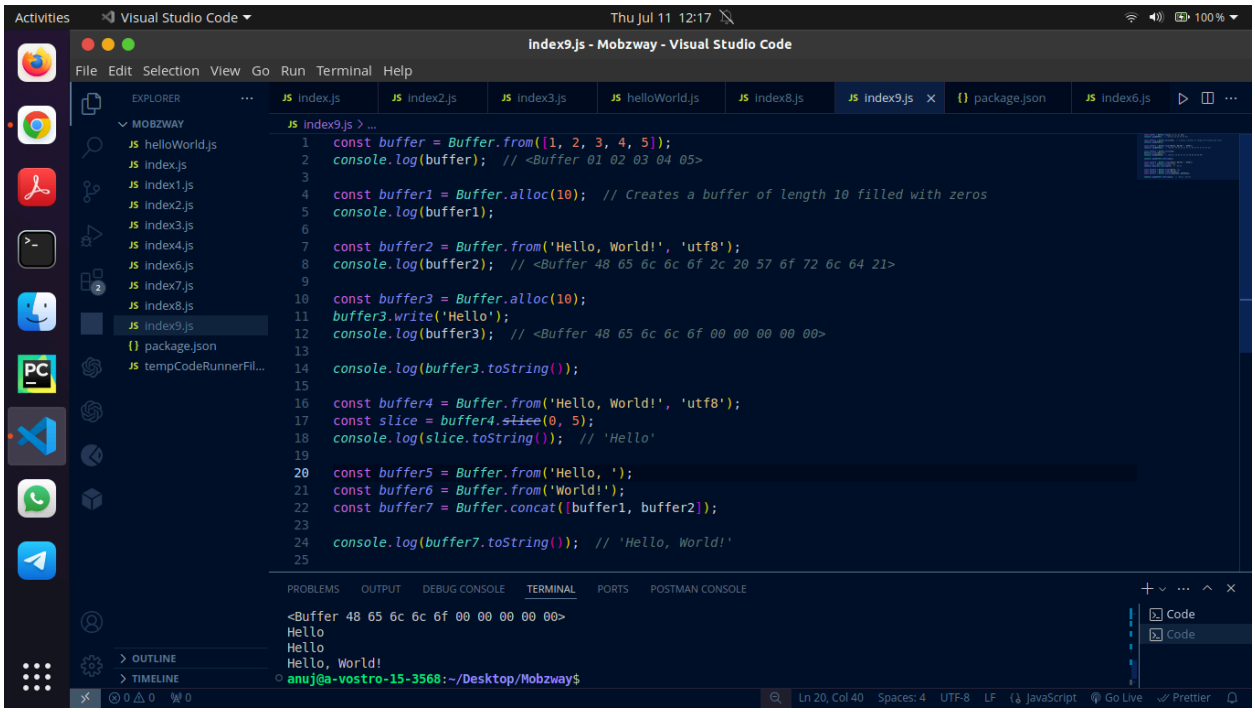


2. Promises



- **Buffer**

  Buffers in Node.js are used to handle binary data. They are particularly useful when dealing with file streams, TCP streams, and other types of data where the encoding is not always UTF-8. Buffers allow for the manipulation and storage of raw binary data.



Allocating a Buffer

You can create a buffer of a specified size using `Buffer.alloc`.

From an Array

You can create a buffer from an array of bytes.

From a String

You can create a buffer from a string.

Writing to a Buffer

Reading from a Buffer

Slicing Buffers

You can create a new buffer that references the same memory as the original buffer but only represents a subset of it.

Concatenating Buffers

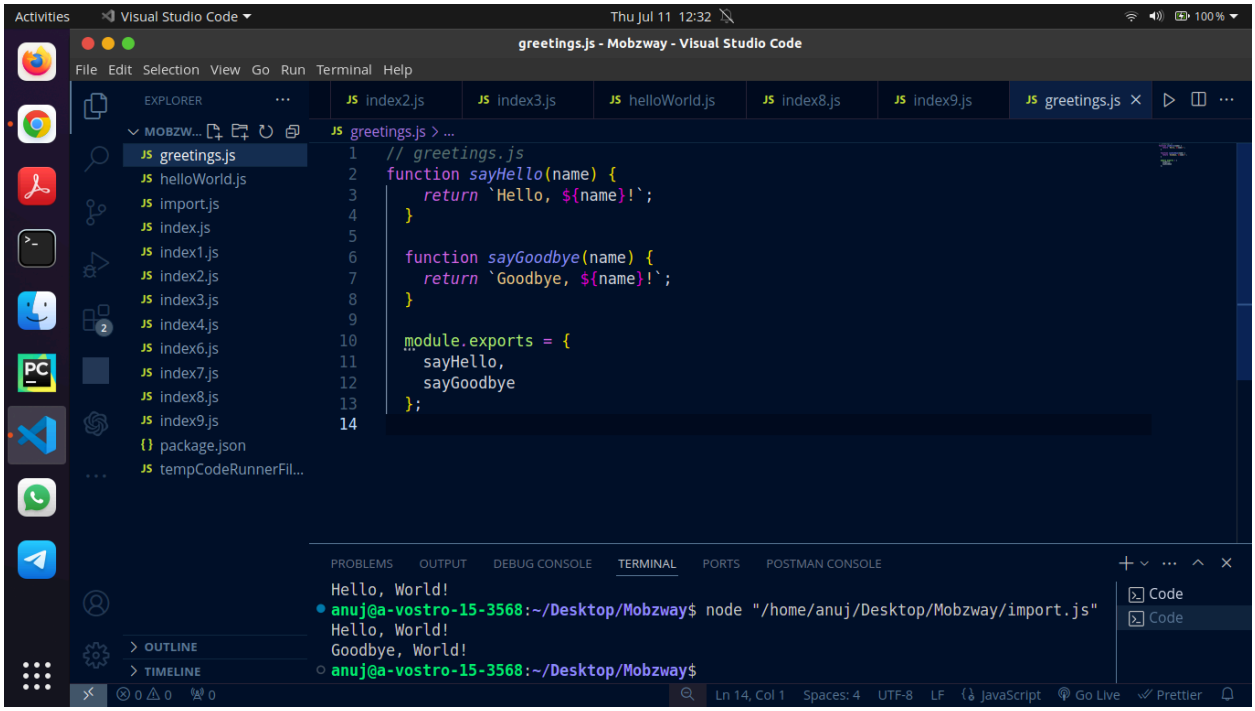
You can concatenate multiple buffers into a single buffer.

- ## Module

Modules in Node.js are a way to organize and encapsulate code into reusable components. Each module in Node.js is treated as a separate file, and you can export and import functions, objects, and values between modules. This modular approach helps in maintaining clean and manageable code.

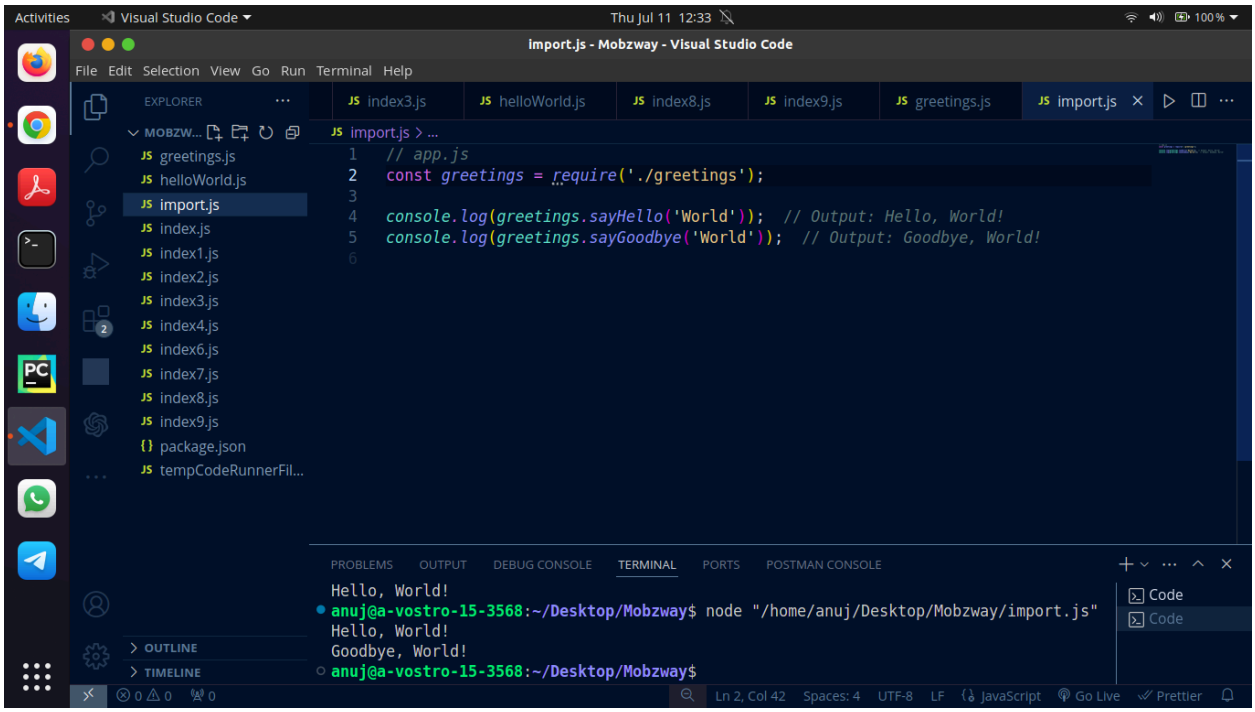
Creating and Exporting a Module

You can create a module by defining functions, objects, or values and exporting them using `module.exports` or `exports`.



Importing a Module

To use the exported functions from a module in another file, you use the `require` function.



- ## Modules Types

Built-in (Core) Modules

Node.js comes with a set of built-in modules that provide essential functionalities for building applications. These modules are part of the Node.js runtime and do not require installation.

Examples of Built-in Modules:

- `fs`: File system operations.
- `http`: HTTP server and client functionality.
- `path`: Utilities for working with file and directory paths.

User-defined Modules

These are modules that you create in your Node.js application. They are useful for organizing and encapsulating your code into reusable components.

Third-party Modules

These modules are created by the community and can be installed using the Node Package Manager (npm). They provide additional functionalities that are not part of the core Node.js library.

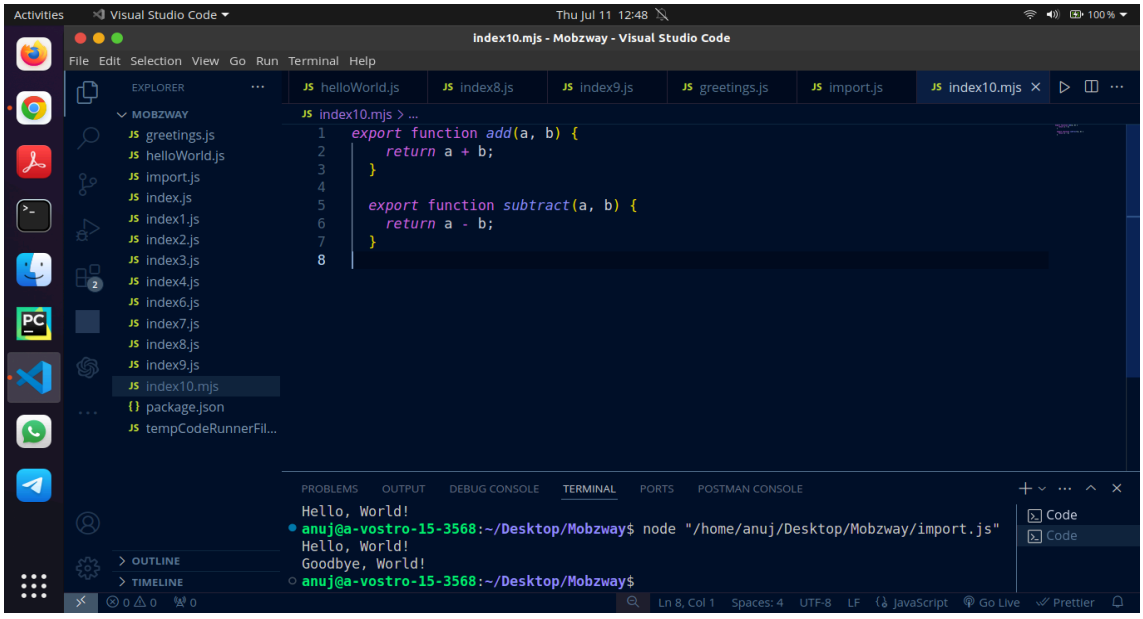
Examples of Popular Third-party Modules:

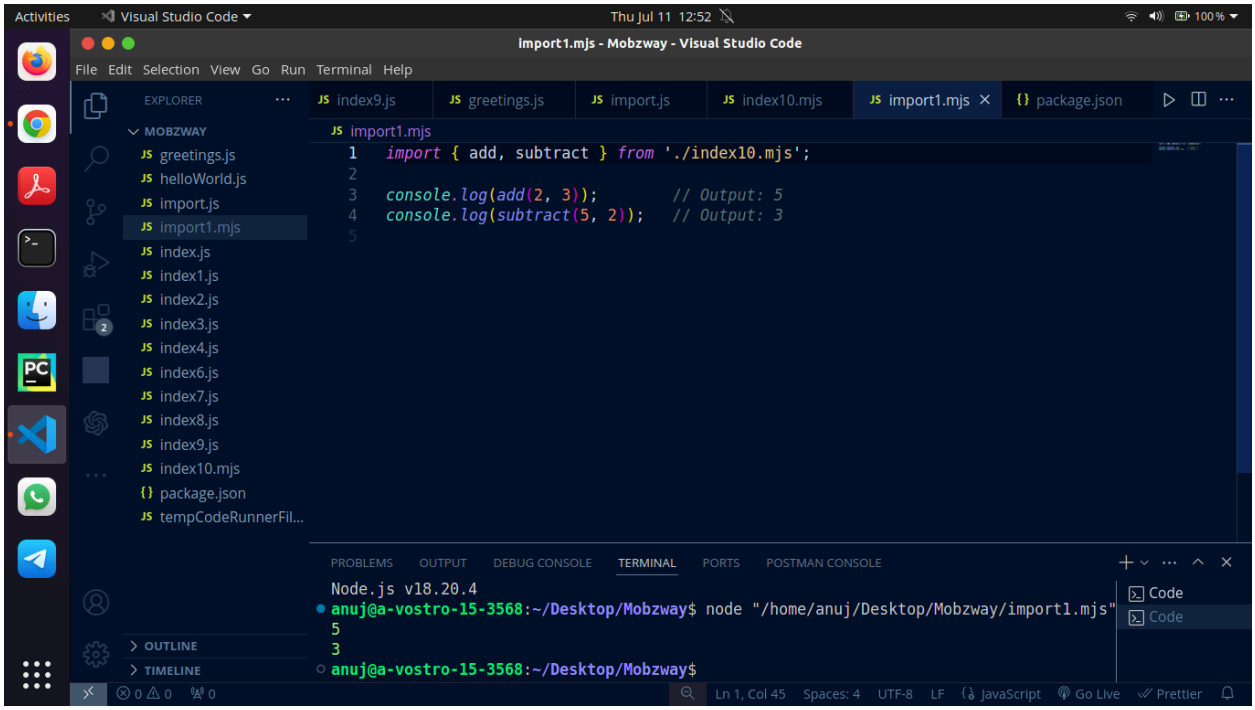
- `express`: Web application framework.
- `lodash`: Utility library for JavaScript.
- `mongoose`: MongoDB object modeling tool.

ES6 Modules (ECMAScript Modules)

Node.js supports ES6 modules, which use `import` and `export` syntax. This is different from the CommonJS module system that uses `require` and `module.exports`.

An MJS file is a source code file containing an ES Module (ECMAScript Module) for use with a Node.js application.





To run ES6 modules, you need to use the `.mjs` extension or set `"type": "module"` in your `package.json`.

Local Modules

Local modules are user-defined modules that are stored locally in your project and used within the project. They can be reused across different files of the same project.

- **Core Modules**

Node.js comes with a set of built-in modules that provide essential functionalities for building applications. These modules are part of the Node.js runtime and do not require installation.

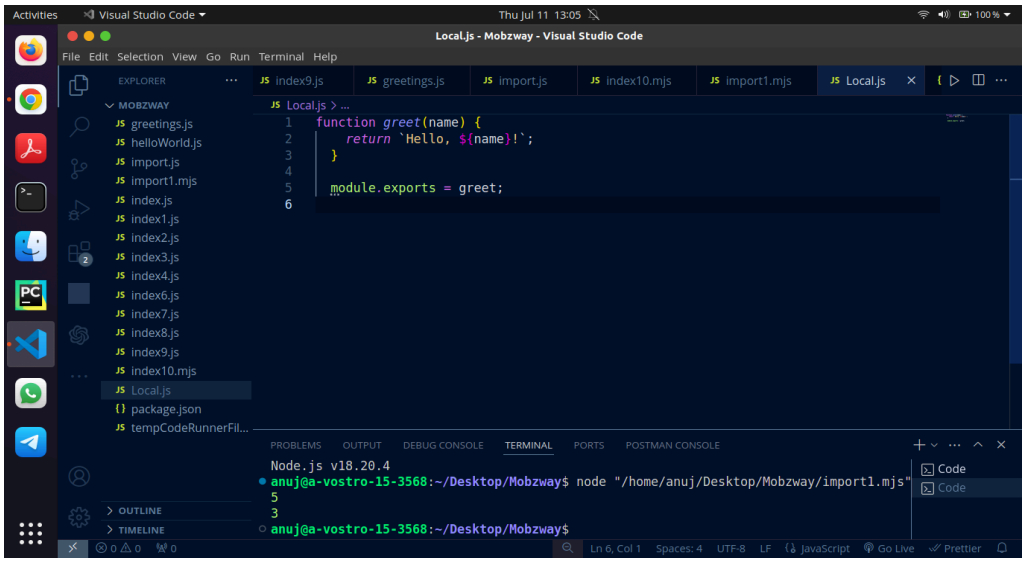
Examples of Built-in Modules:

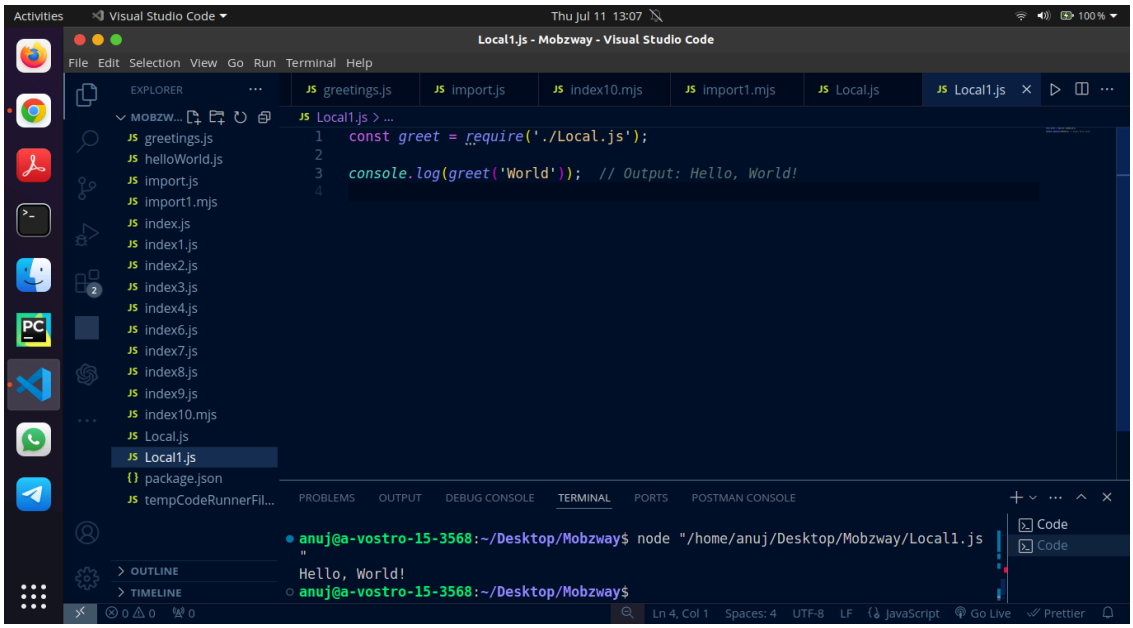
- `fs`: File system operations.
- `http`: HTTP server and client functionality.
- `path`: Utilities for working with file and directory paths.
- `os`: Information about the operating system.

- `events`: Event-driven programming support.
- `util`: Utilities for various tasks like debugging, deprecation, and inheritance.

- **Local Modules**

  Local modules are user-defined modules that are stored locally in your project and used within the project. They can be reused across different files of the same project.





- ## Modules Exports

  In Node.js, the `module.exports` object is used to define what a module exports and makes available for other modules to import. This allows you to organize your code into reusable components.

  Here's a detailed explanation of how `module.exports` works and various ways to use it:

  Basic Usage

  Exporting a Single Function or Object

  When you want to export a single function or object, you can assign it directly to `module.exports`.

  Exporting Multiple Functions or Objects

  If you need to export multiple functions or objects, you can add them as properties of the `module.exports` object.

Module 4: Node Package Manager

- ## What is NPM

  npm (Node Package Manager) is a package manager for JavaScript, primarily used for managing dependencies of Node.js projects. It is the default package manager for the Node.js runtime environment and allows developers to share and reuse code. npm also provides a command-line interface (CLI) for interacting with the npm ecosystem.

- ## Installing Packages Locally

  To install a package locally, use the `npm install` command followed by the package name. This installs the package into the `node_modules` directory and adds it to the `dependencies` section of your `package.json` file.

  npm install <package-name>

- ## Installing Package globally

  To install packages globally using npm, you use the `-g` flag with the `npm install` command. Global installation makes the package available system-wide, meaning it can be used from any directory on your system, which is particularly useful for command-line tools.

  To install a package globally, use the `-g` flag:

  npm install -g <package-name>

- ## Adding dependencies in package.json

  When you install a package using `npm install`, it automatically adds the package to the `dependencies` or `devDependencies` section of your `package.json` file, depending on the flags you use.

  Adding a Dependency:

  npm install <package-name> --save

  The `--save` flag is actually the default behavior and can be omitted. This command installs the package and adds it to the `dependencies` section.

- ## Updating Packages

  Updating packages in a Node.js project can involve different approaches depending on the specific needs. Here's how you can update packages to the latest versions or to specific versions.

  Using npm Update Command

  The `npm update` command updates all the packages listed in the `package.json` file to their latest versions, respecting the version constraints specified.

  npm update

  Updating Specific Packages

  To update a single package to the latest version:

  npm install <package-name>@latest

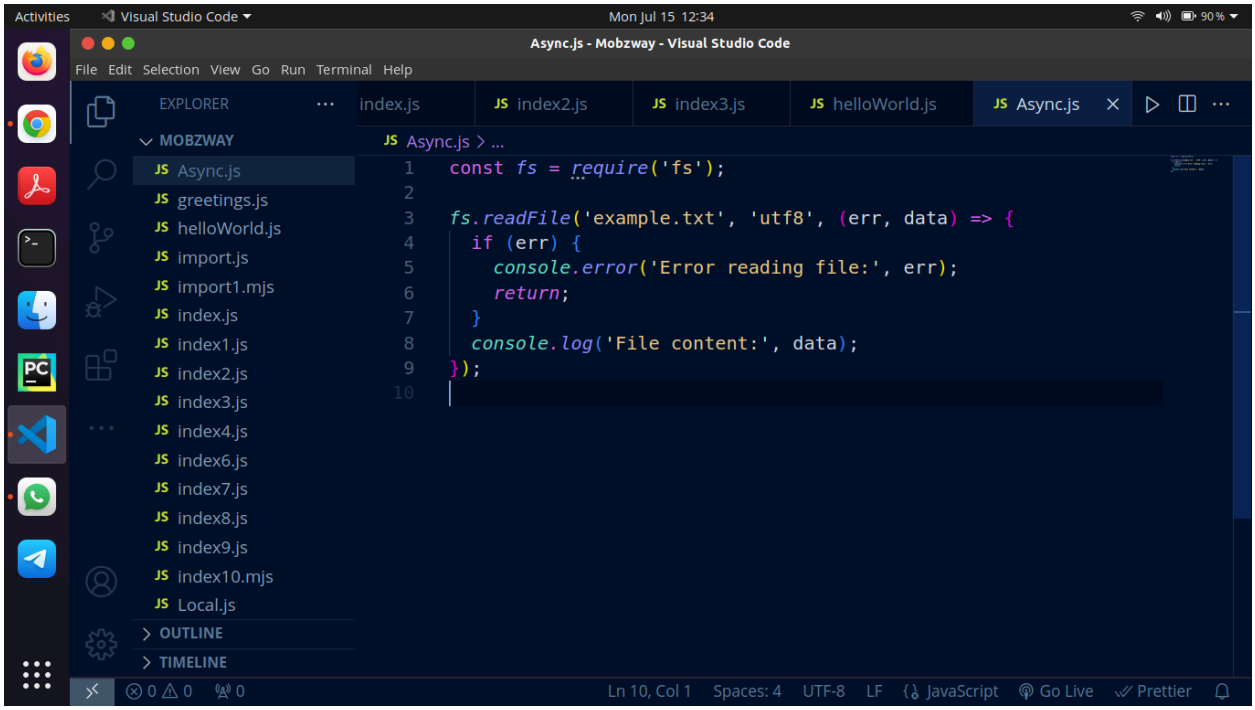
Module 5: File System

- ## Read File

  In Node.js, you can read files using the built-in `fs` (File System) module. There are multiple ways to read files, including synchronous and asynchronous methods. Here's how you can read files using both approaches:

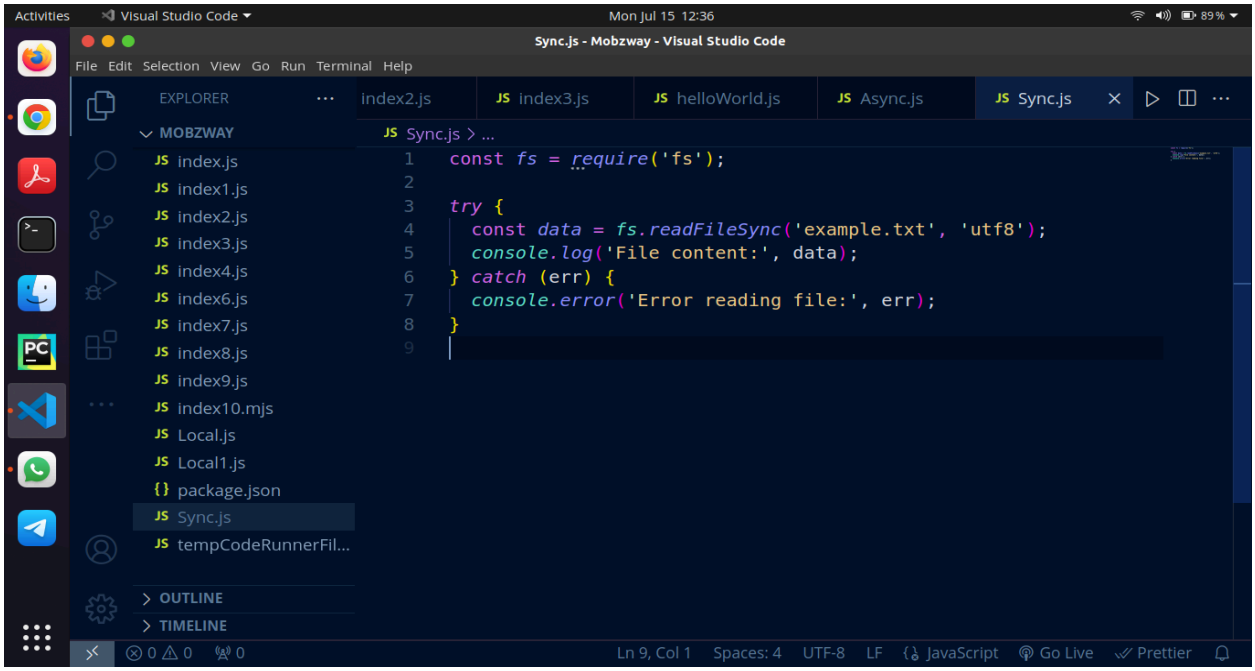
  Asynchronous File Reading

  Using the asynchronous method is generally preferred for non-blocking code execution, which is crucial for performance in a Node.js environment.



Synchronous File Reading

Synchronous methods are simpler but can block the event loop, making them less suitable for performance-critical applications.

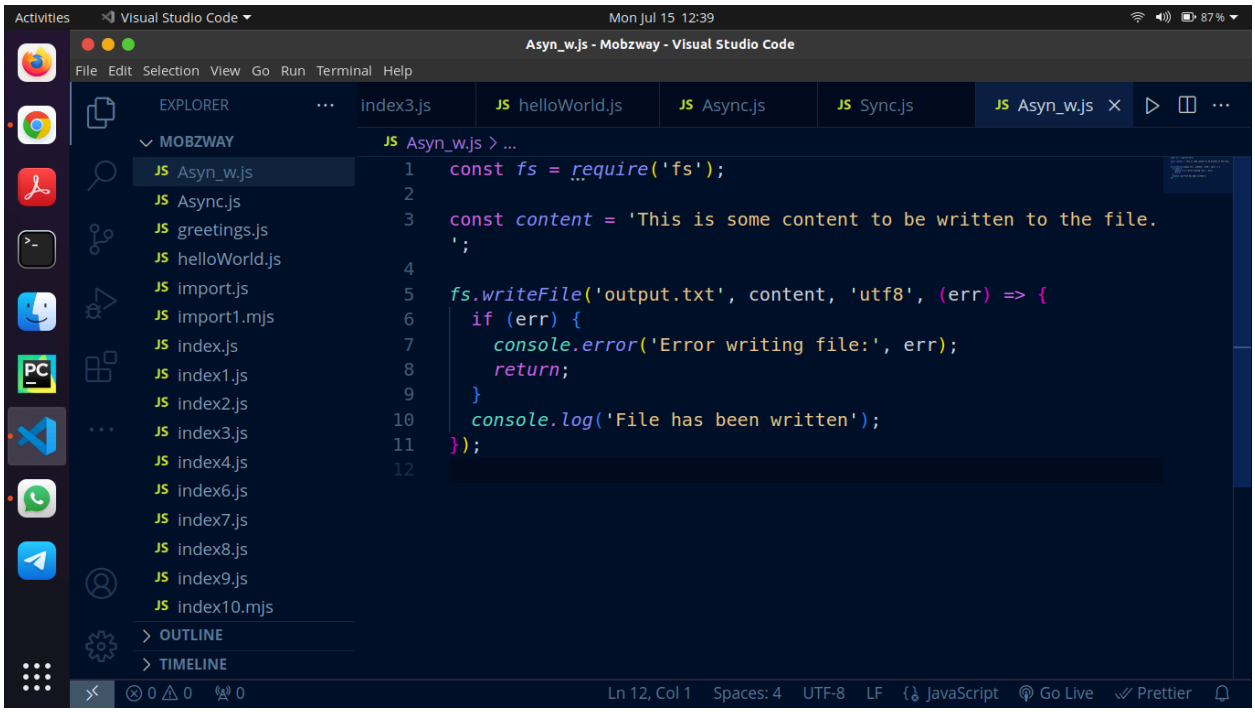


- **Writing a File**

  Writing a file in Node.js can be done using the built-in `fs` (File System) module. Like reading files, you have multiple options to write files, including synchronous and asynchronous methods. Here's how you can write files using both approaches:

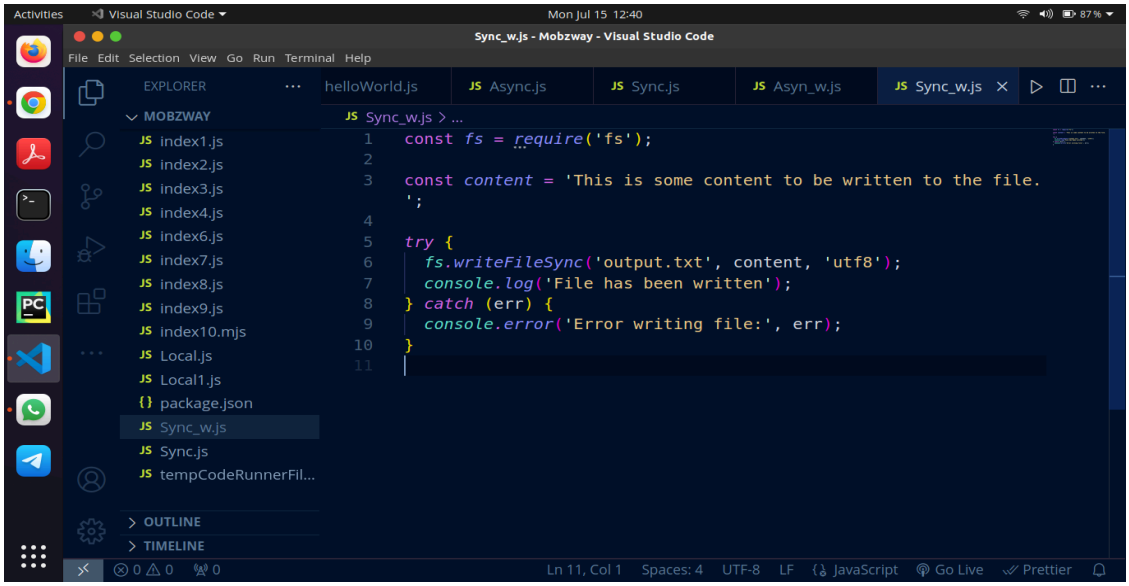
  Asynchronous File Writing

  Asynchronous file writing is preferred to avoid blocking the event loop.



  Synchronous File Writing

  Synchronous methods are simpler but can block the event loop.

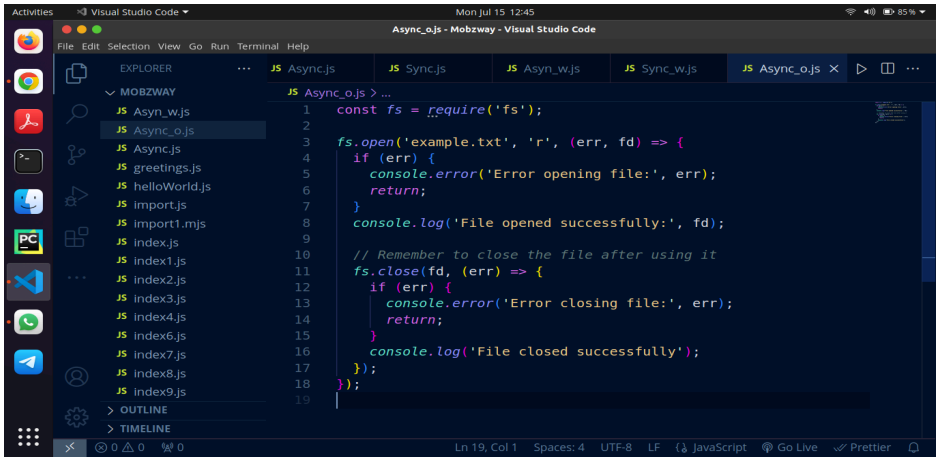


- **Opening a File**

  In Node.js, opening a file involves using the built-in `fs` (File System) module. You can open a file to read from or write to it using asynchronous or synchronous methods. Opening a file provides you with a file descriptor, which you can then use for various file operations.

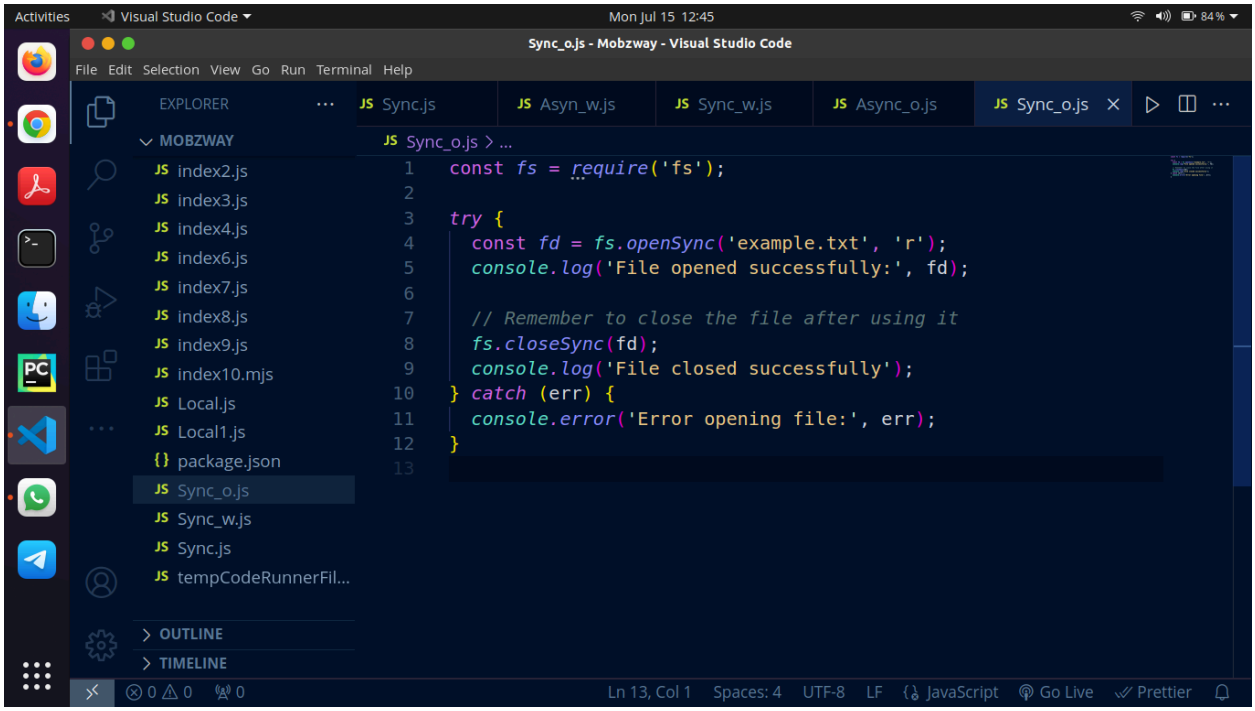
  Asynchronous File Opening

  Using the asynchronous method is preferred for non-blocking code execution, which is crucial for performance in a Node.js environment.



Synchronous File Opening

Synchronous methods are simpler but can block the event loop, making them less suitable for performance-critical applications.

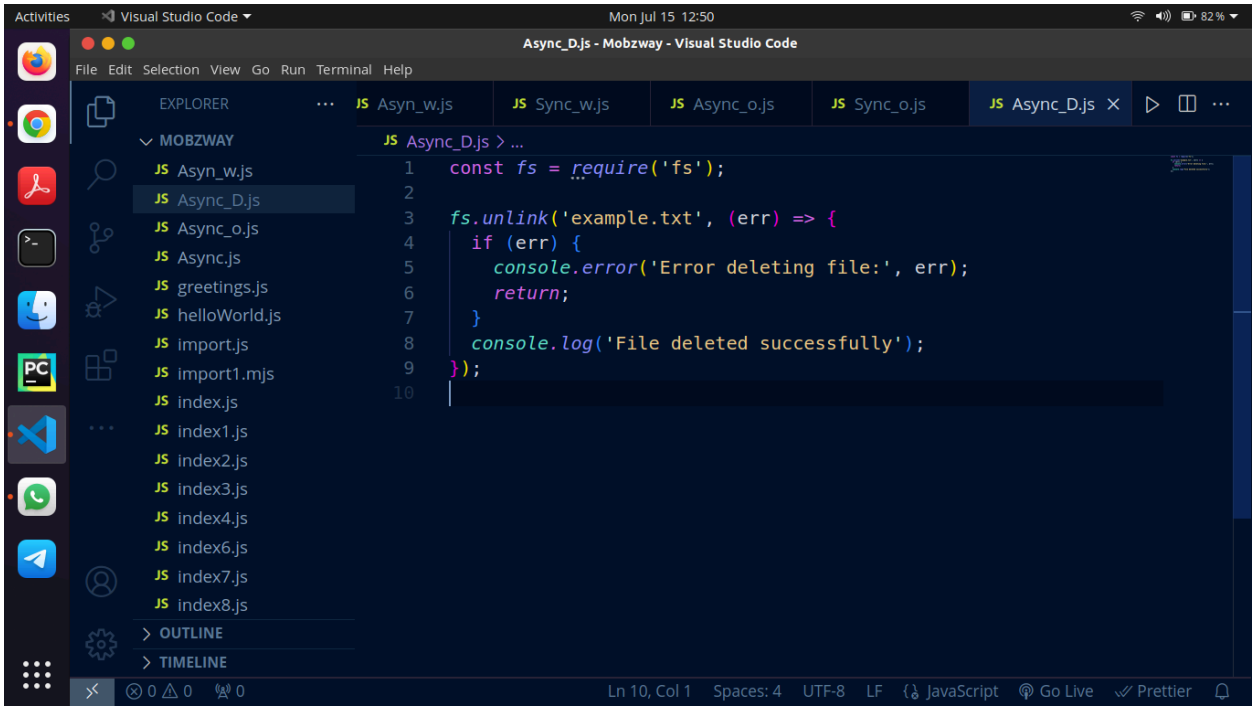


- ## Deleting a File

Deleting a file in Node.js can be done using the `fs` (File System) module. There are both asynchronous and synchronous methods available for this task.

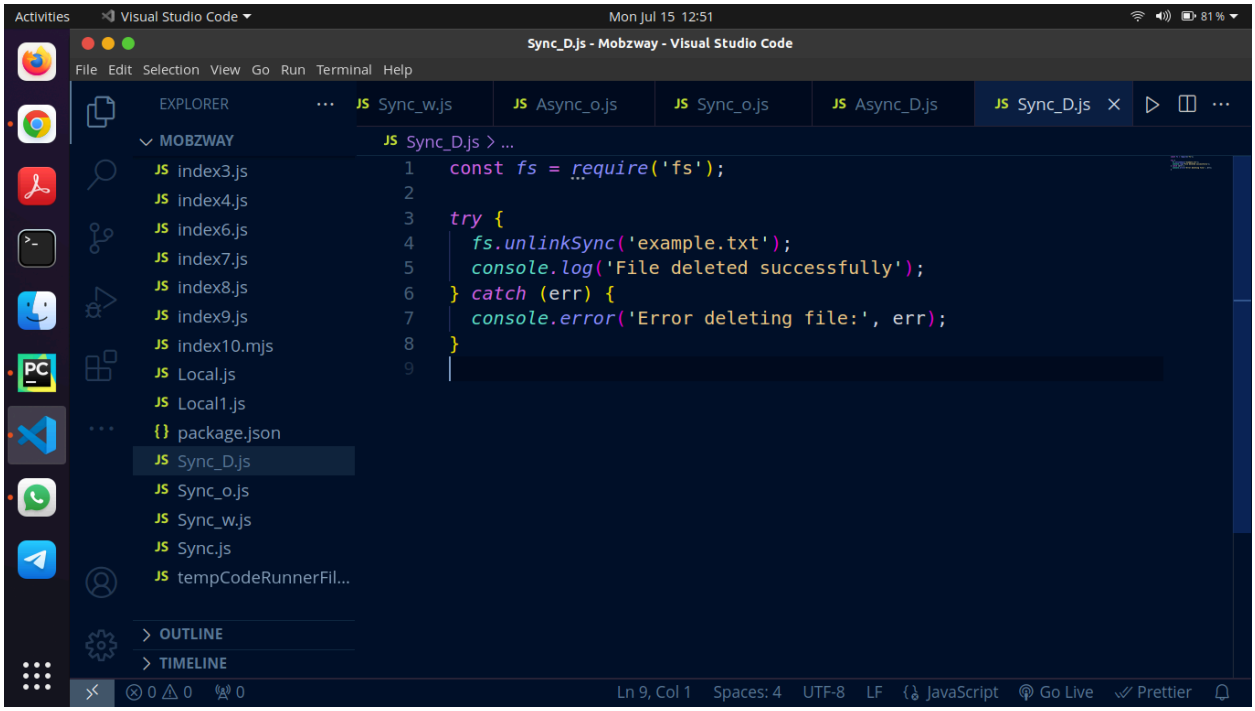
Asynchronous File Deletion

The asynchronous method is preferred to avoid blocking the event loop.



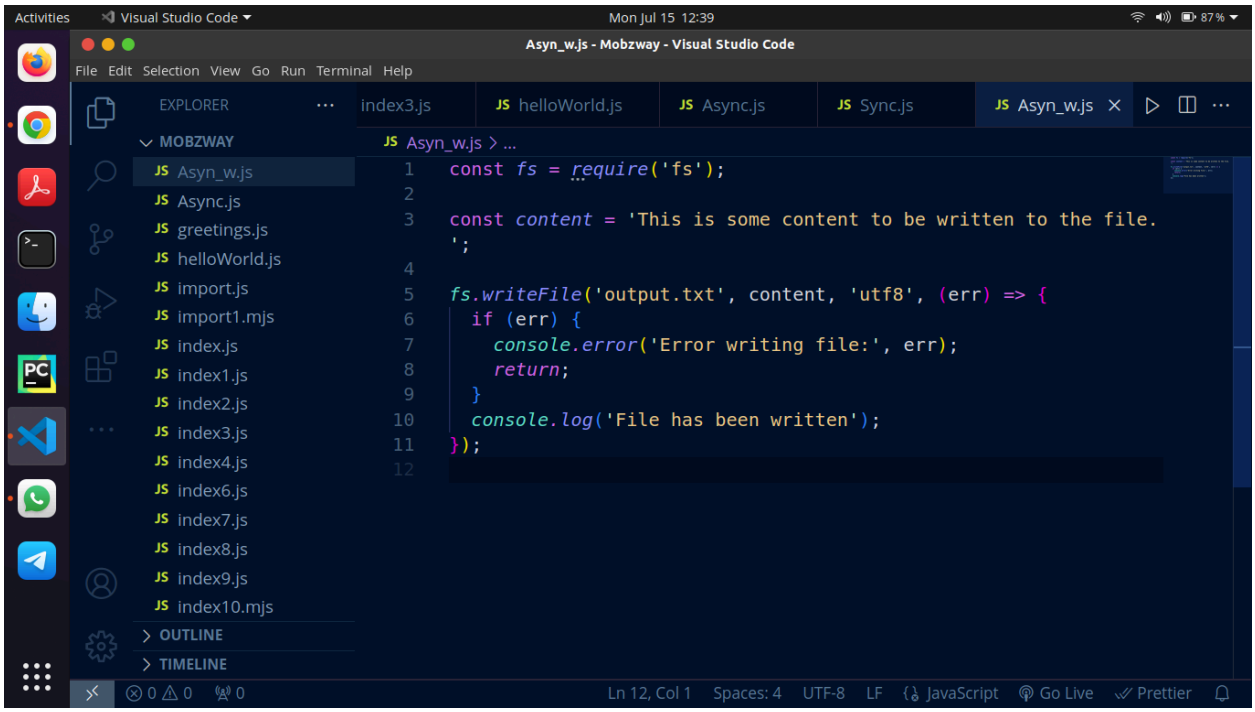
Synchronous File Deletion

The synchronous method is simpler but can block the event loop.



- **Writing a file asynchronously**

  Asynchronous file writing is preferred to avoid blocking the event loop.



  In this example:

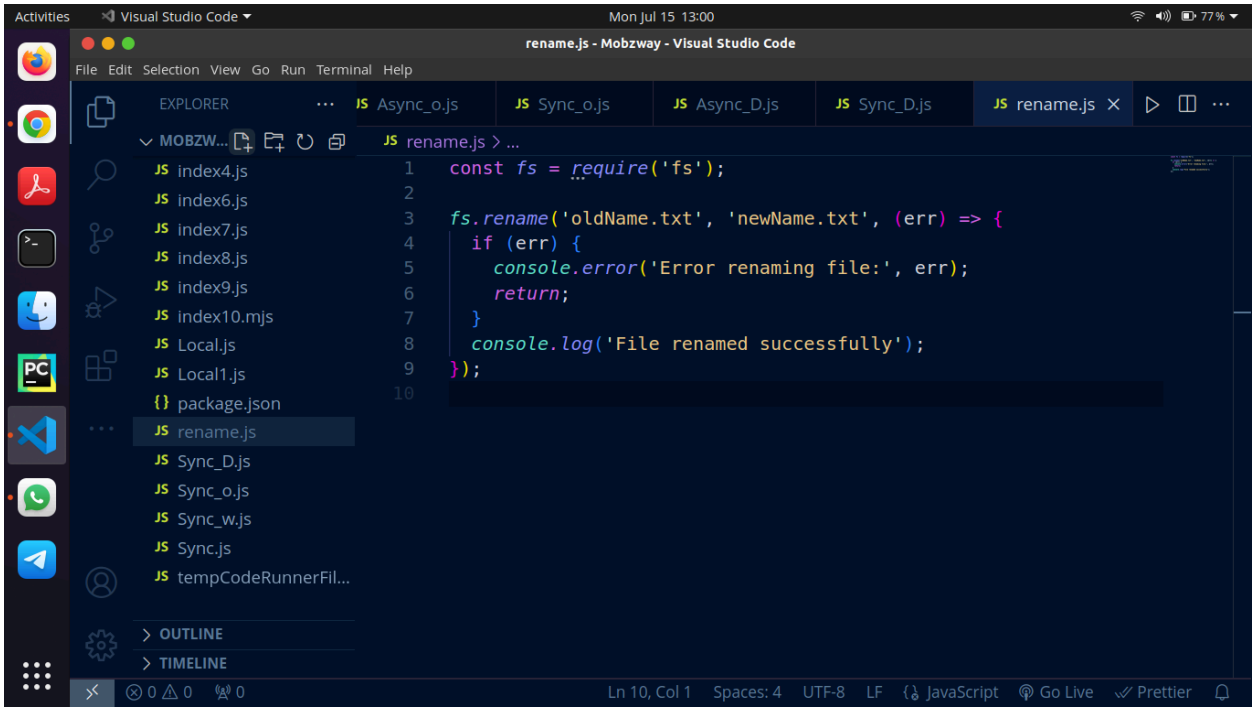
  - `fs.writeFile` writes the file asynchronously.
  - The first argument is the path to the file.
  - The second argument is the content to be written.
  - The third argument is the encoding (optional, but `utf8` is commonly used).
  - The fourth argument is a callback function that handles any error that occurs.

- **Other I/O Operations**

  In Node.js, the `fs` (File System) module provides various I/O operations for working with the file system. Here are some common I/O operations apart from reading, writing, and deleting files:

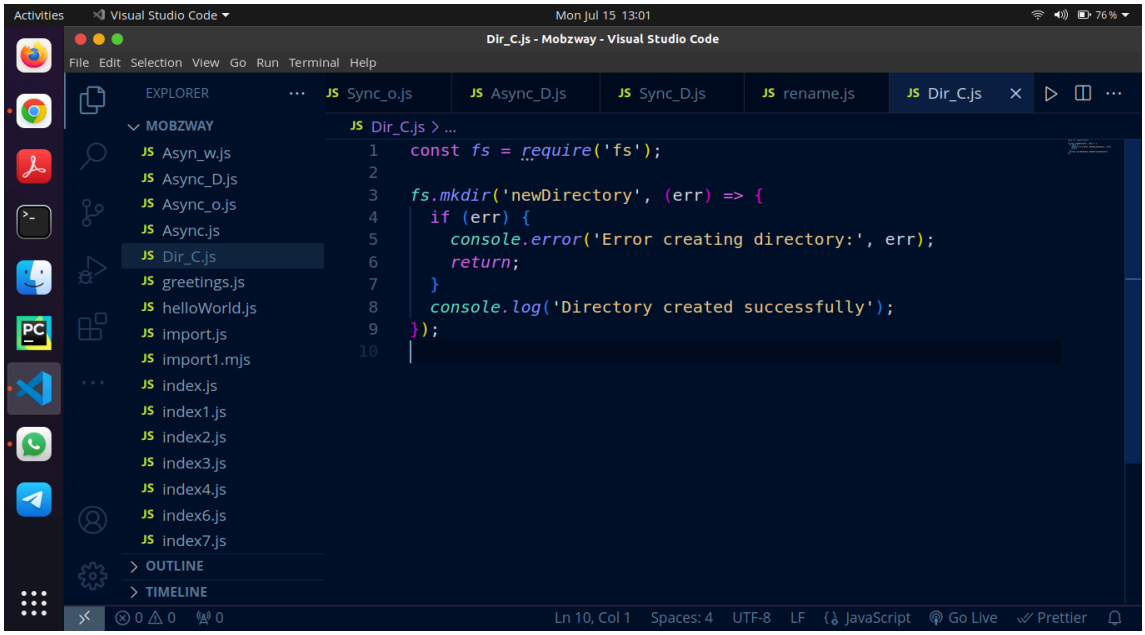
Renaming a File

You can rename or move a file using the `fs.rename` method.



Creating a Directory

You can create a new directory using the `fs.mkdir` method.



Module 6: Buffers

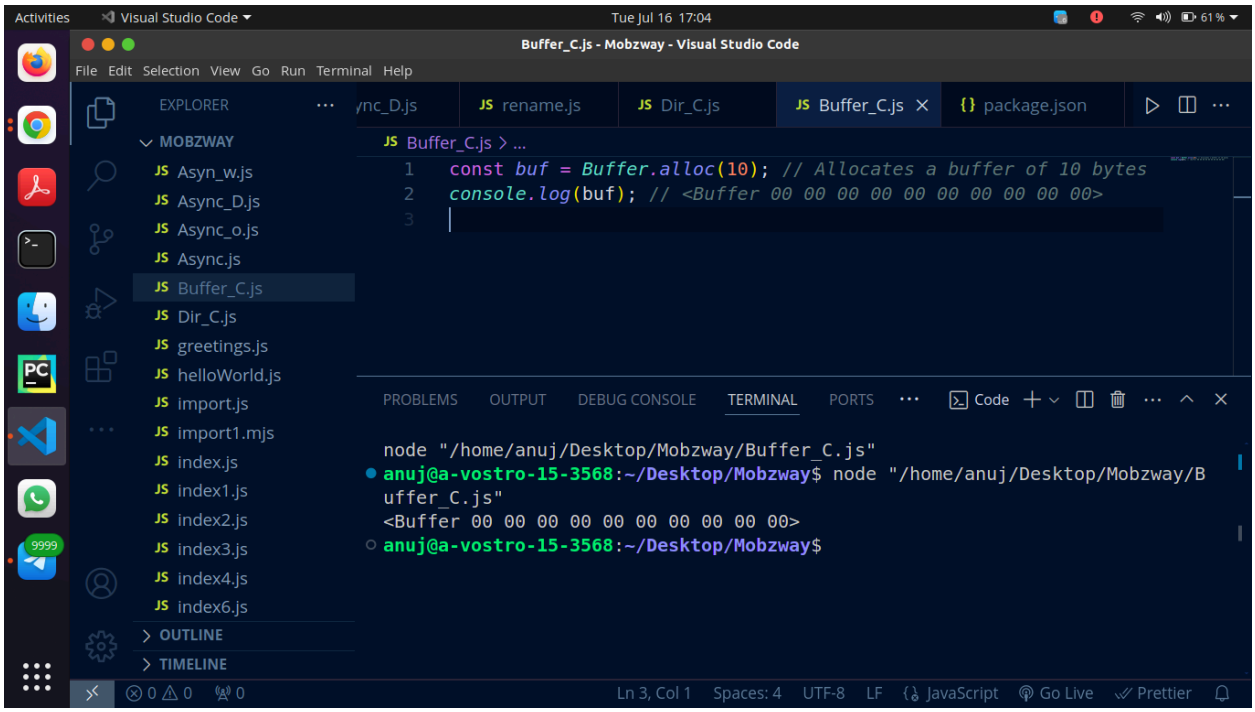
- ## Why Buffers exist

  Buffers in Node.js are designed to handle binary data directly, allowing you to work with raw memory and perform operations on binary data. Here's a detailed explanation of why buffers exist and their importance:

  Reasons for Buffers in Node.js

  1. **Handling Binary Data**:
     - JavaScript, the language in which Node.js is written, primarily handles strings and doesn't have a built-in way to handle binary data. Buffers provide a mechanism to work with binary data directly, enabling operations on raw bytes.
  2. **Efficient Data Manipulation**:
     - Buffers are essential for performance-critical applications. They allow efficient data manipulation without converting data between binary and string formats, which can be costly in terms of performance.
  3. **Networking**:
     - Networking protocols often require dealing with streams of binary data. For instance, when sending or receiving data over TCP or UDP sockets, buffers allow you to manage these streams efficiently.
  4. **File I/O**:
     - When reading from or writing to files, data is often handled in binary form. Buffers enable direct reading and writing of binary data to and from files, making file I/O operations more efficient.
  5. **Compatibility with C/C++ Libraries**:
     - Node.js can interface with C/C++ libraries using the Node-API (formerly N-API). Buffers provide a way to exchange binary data between JavaScript and native modules, ensuring seamless integration and performance.
  6. **Stream Handling**:
     - Buffers are used internally by Node.js streams. They help manage data flow in a stream, handling chunks of binary data, which is crucial for processing large data sets efficiently (e.g., handling large files, streaming media).

- **Creating Buffers**



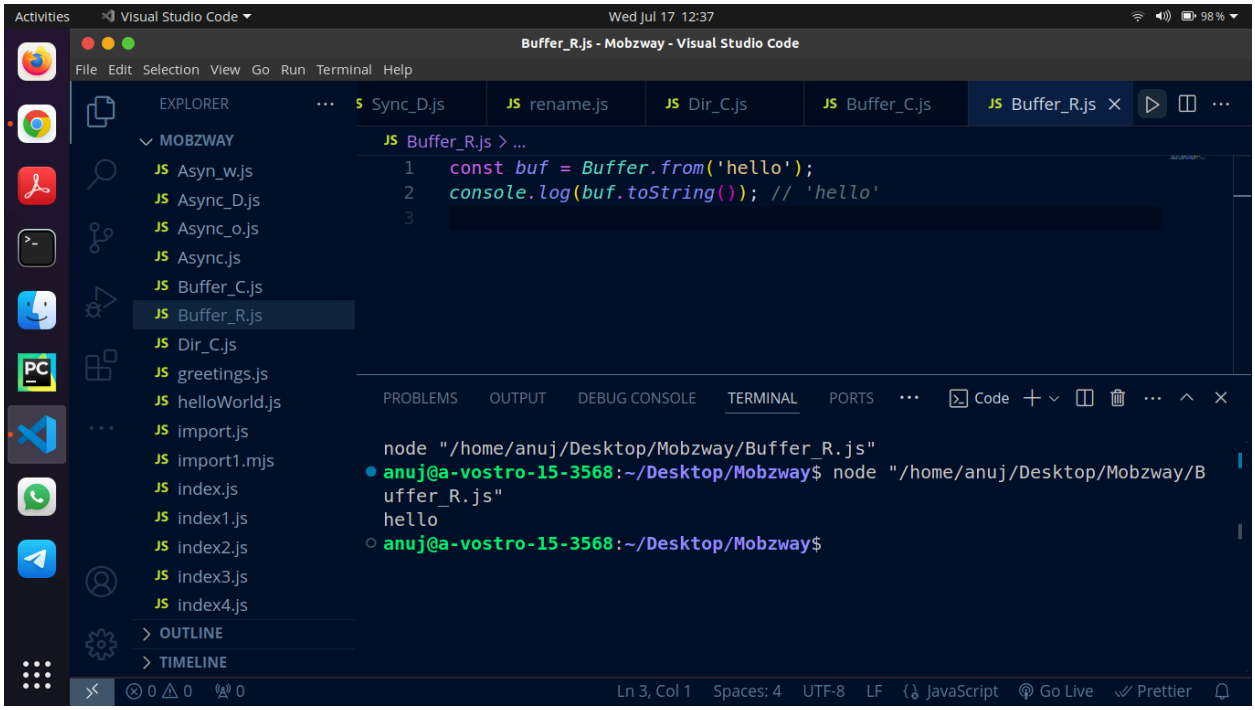
`Buffer.alloc(size)`: This method allocates a new buffer of the specified size in bytes. In this case, `size` is 10, so a buffer of 10 bytes is allocated.

Initialization: The `Buffer.alloc` method initializes all bytes in the buffer to `0`. This means every byte in the buffer will have a value of `0` upon allocation.

- **Reading and Writing Buffers**

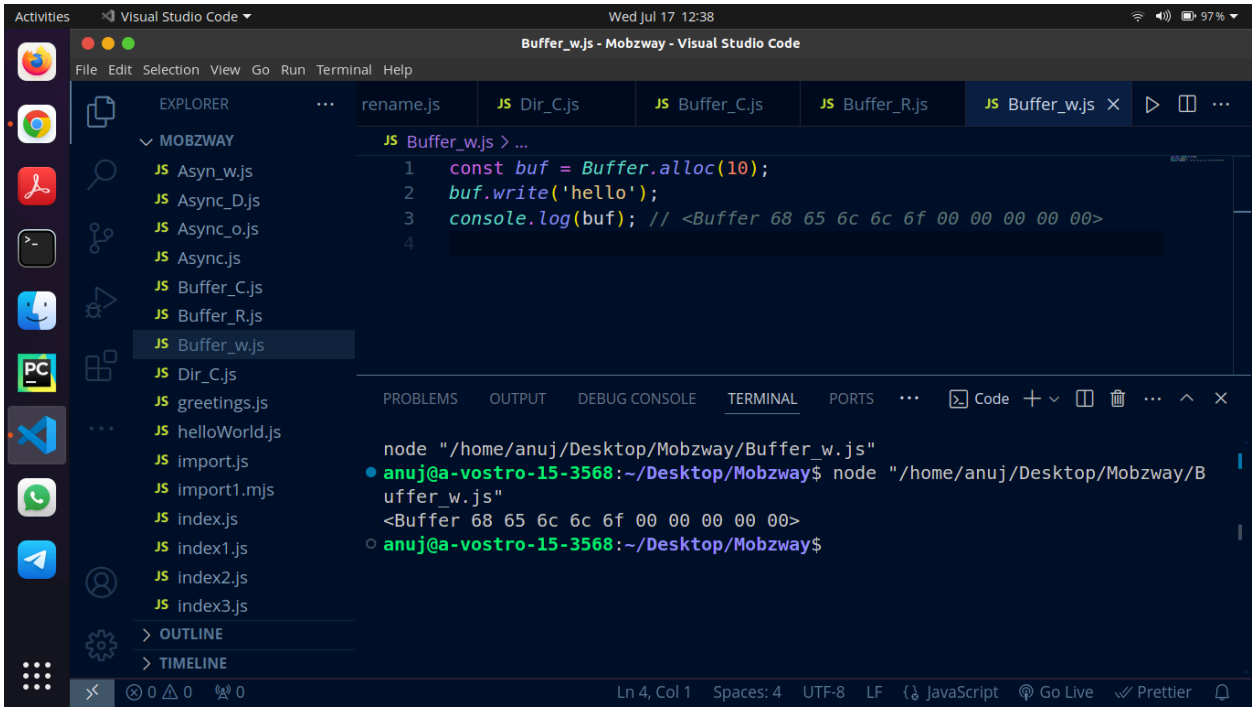
  Reading from a Buffer

  You can read data from a buffer using methods like `toString` or by accessing individual bytes directly.



Writing to a Buffer

You can write data to a buffer using the `write` method or by directly setting the buffer's values.

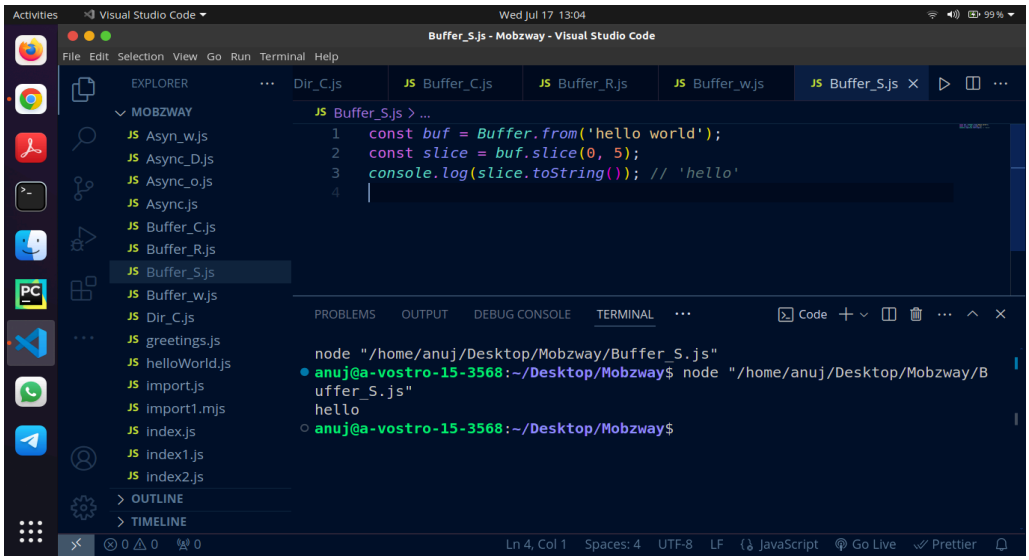


- **Manipulating Buffers**

  Manipulating buffer data in Node.js involves performing operations such as reading, writing, slicing, copying, and filling buffers.

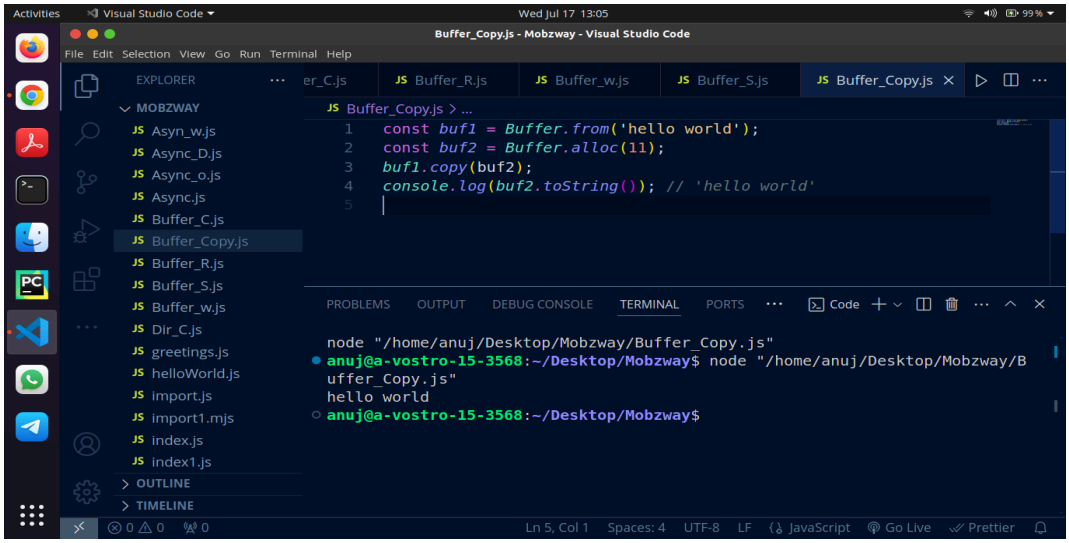
  ### Slicing a Buffer

  You can create a new buffer that references a subset of the original buffer's memory using the `slice` method:



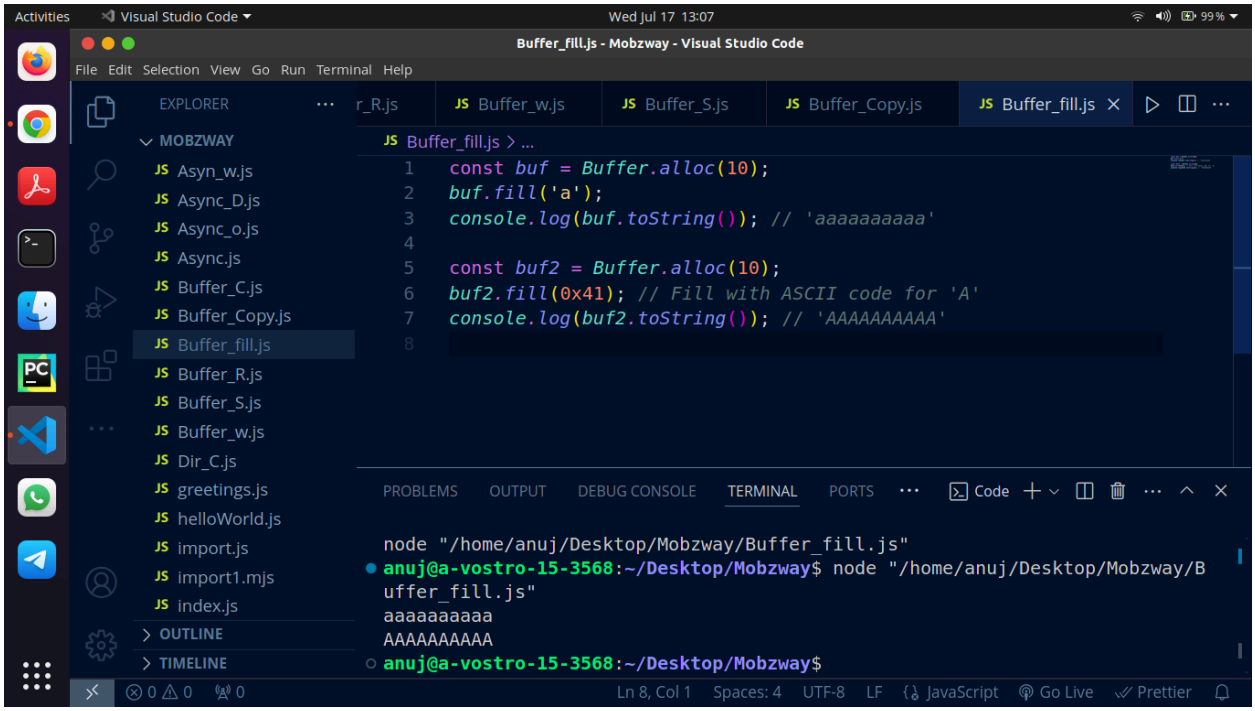
  ### Copying a Buffer

  You can copy data from one buffer to another using the `copy` method:



Filling a Buffer

You can fill a buffer with a specific value using the `fill` method:



Module 7: Streams

- ## What are Streams

  Streams are a fundamental concept in Node.js for handling I/O operations efficiently. They provide a way to read and write data in a continuous, sequential manner, which is particularly useful for working with large data sets, such as files,

network requests, and real-time communication. Streams are an instance of the `EventEmitter` class and allow you to process data piece by piece (chunks), rather than loading the entire data into memory at once.

Types of Streams

Node.js provides four main types of streams:

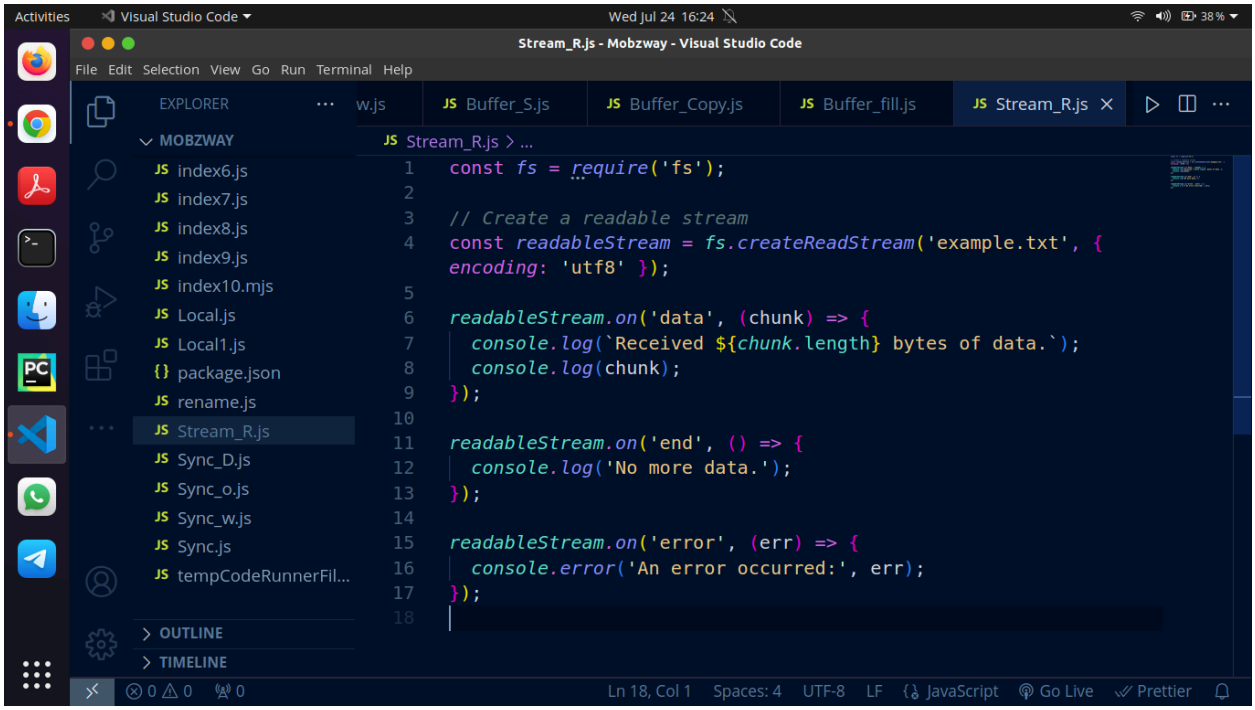
1. **Readable Streams**:
   - Used for reading data.
   - Examples: `fs.createReadStream`, `http.IncomingMessage` (for HTTP requests).
2. **Writable Streams**:
   - Used for writing data.
   - Examples: `fs.createWriteStream`, `http.ServerResponse` (for HTTP responses).
3. **Duplex Streams**:
   - Both readable and writable.
   - Examples: `net.Socket`, `zlib.createDeflate`.
4. **Transform Streams**:
   - A type of duplex stream where the output is computed based on the input.
   - Examples: `zlib.createGzip`, `crypto.createCipher`.

● Read and Write Stream API

The Read and Write Stream API in Node.js provides a way to handle reading from and writing to streams in a more efficient manner, especially for large amounts of data. Here's a comprehensive guide on how to use the Read and Write Stream API with examples.

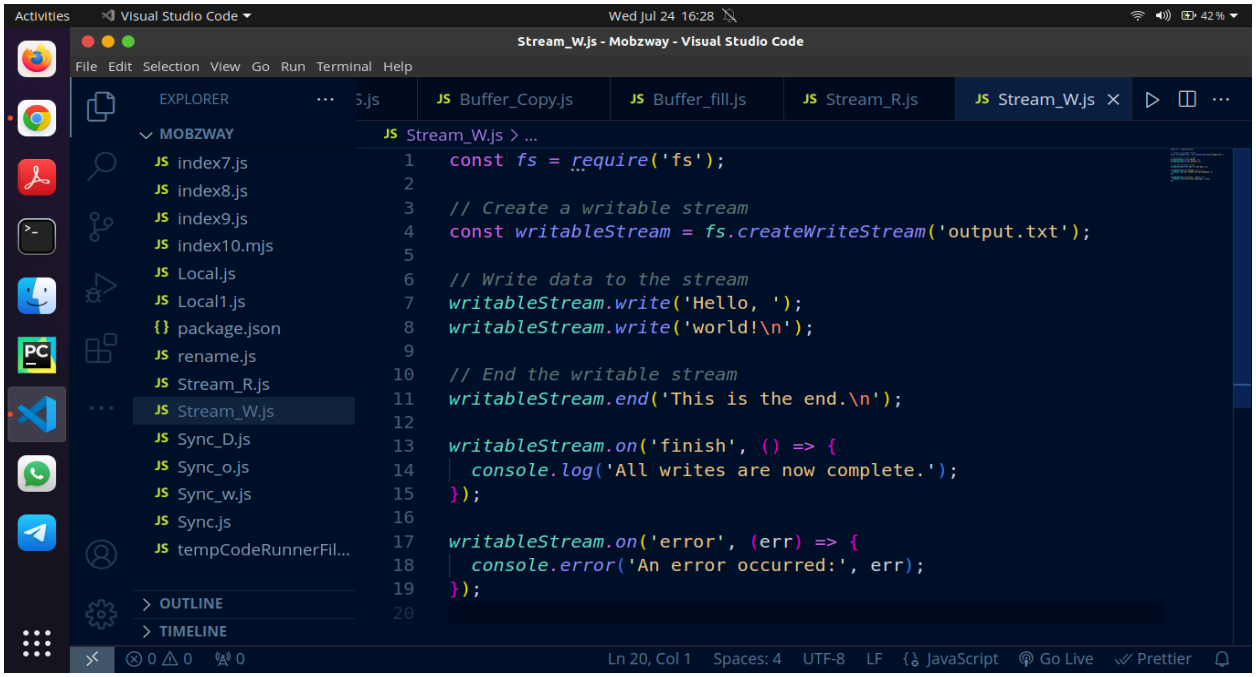
Readable Streams

Readable streams are used to read data from a source in a sequential manner.



Writable Streams

Writable streams are used to write data to a destination sequentially



- ## Flow Control

  Flow control in Node.js streams is essential for managing the rate at which data is read from a source and written to a destination, ensuring that neither the readable stream nor the writable stream becomes overwhelmed. This is especially important when dealing with large data sets or when the speed of the source and destination are mismatched.

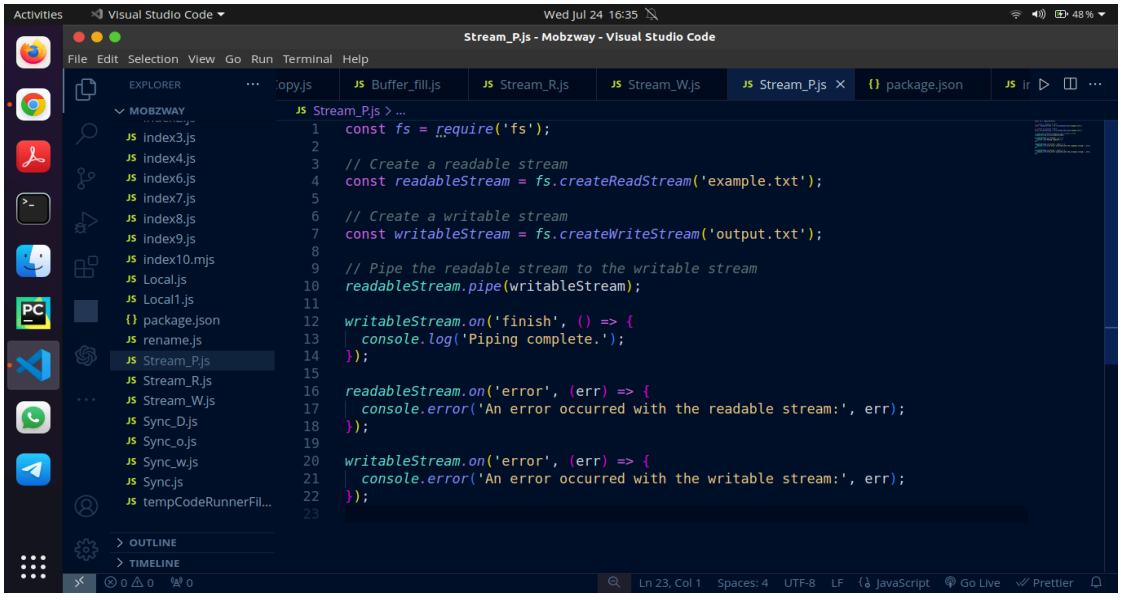
  ### Understanding Flow Control

  When working with streams, flow control mechanisms help balance the flow of data. Key aspects include:

  1. **Readable Stream**: Emits data as it is read from the source.
  2. **Writable Stream**: Writes data to the destination at its own pace.
  3. **Backpressure**: Occurs when the writable stream can't handle the rate at which the readable stream is providing data.

- ## Piping

  Piping streams is a powerful feature that allows you to connect a readable stream to a writable stream. This automatically handles the flow of data from the source to the destination.



- ## Duplex Stream

  A duplex stream in Node.js is a type of stream that implements both the Readable and Writable interfaces. This means that it can read and write data, making it suitable for use cases where you need to perform both operations, such as in network protocols, file handling, or transformation streams.

  ### Creating a Duplex Stream

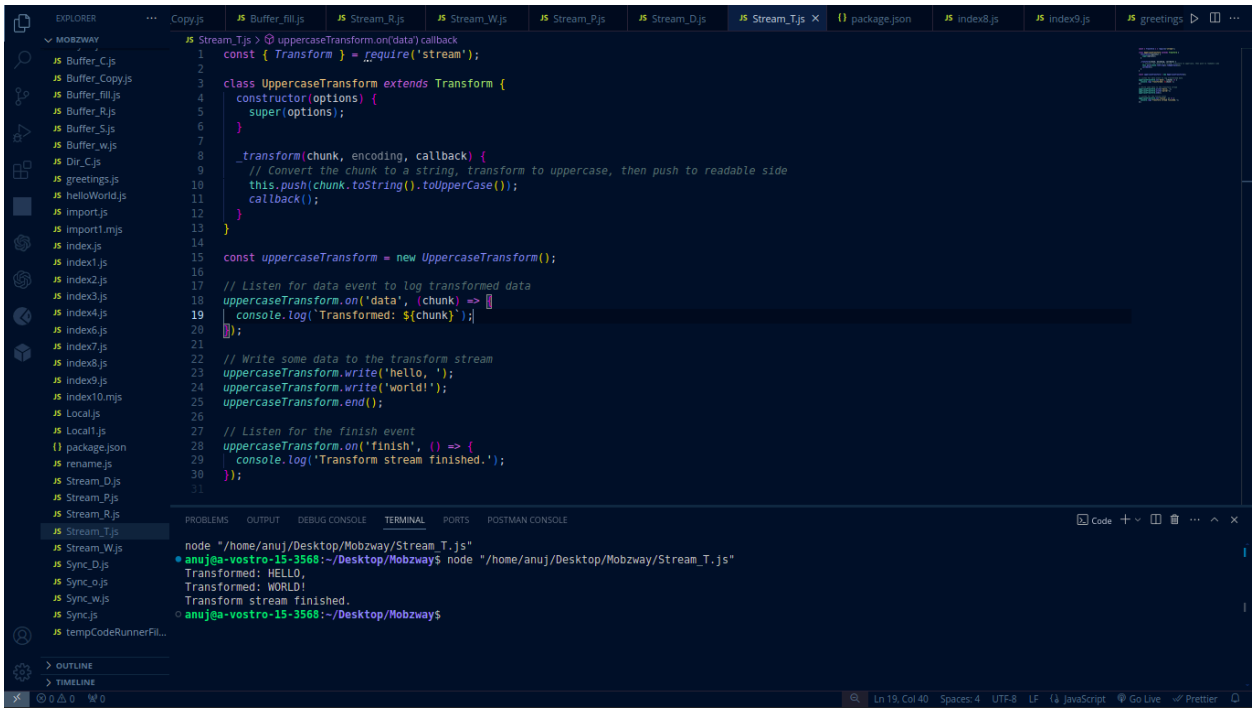
  To create a duplex stream, you can extend the `stream.Duplex` class and implement the `_read` and `_write` methods. Here is an example of how to create a custom duplex stream.

- ## Transform Stream

  A transform stream is a type of duplex stream where the output is computed based on the input. This allows you to transform data as it is being read and

written. Node.js provides a `Transform` class in the `stream` module for creating such streams.

Here's a simple example of a transform stream that converts all input text to uppercase.

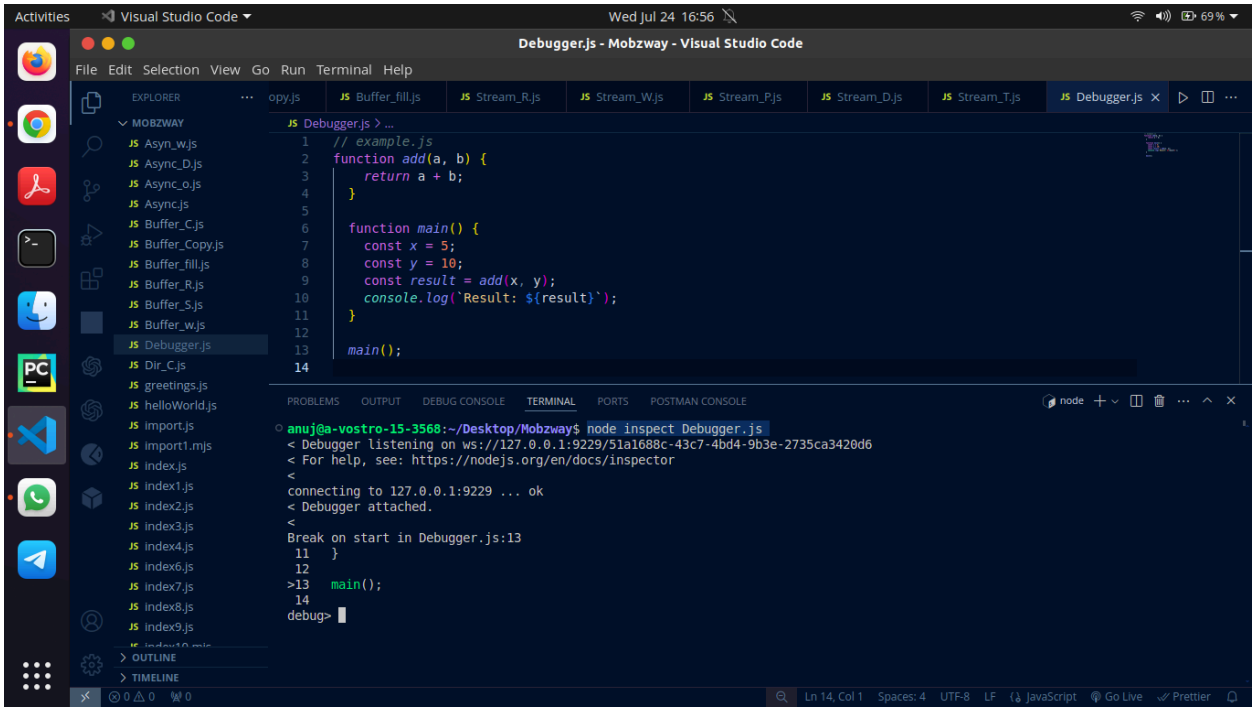


Module 8: Debugging Node JS Application

- **Core Node JS Debugger**

  The core Node.js debugger allows you to debug your Node.js applications directly from the command line. This is useful for inspecting your code, setting

breakpoints, and stepping through your code to understand its behavior. The debugger can be accessed using the built-in `inspect` command.



1. Start the Debugger: Run your script with the `inspect` flag.

```
node inspect example.js
```

2. **Running and Stepping Through Code**:

- `cont` or `c`: Continue execution until the next breakpoint.
- `next` or `n`: Step to the next line of code.
- `step` or `s`: Step into a function call.
- `out` or `o`: Step out of the current function.
- `repl`: Open a REPL session to inspect variables and execute code.

3. Setting Breakpoints:

- `setBreakpoint()` or `sb()`: Set a breakpoint at a specific line.
- `clearBreakpoint()` or `cb()`: Clear a breakpoint.

- ## Callbacks: Error-first

  Error-first callbacks are a common pattern in Node.js and JavaScript programming, especially when dealing with asynchronous operations. This pattern ensures that the first argument of the callback function is reserved for an error object (if any error occurs), and subsequent arguments are used for successful results. This approach helps to consistently handle errors and makes the code more predictable and easier to maintain.

  ### Structure of an Error-first Callback