Web Application Development

Node.js Fundamentals

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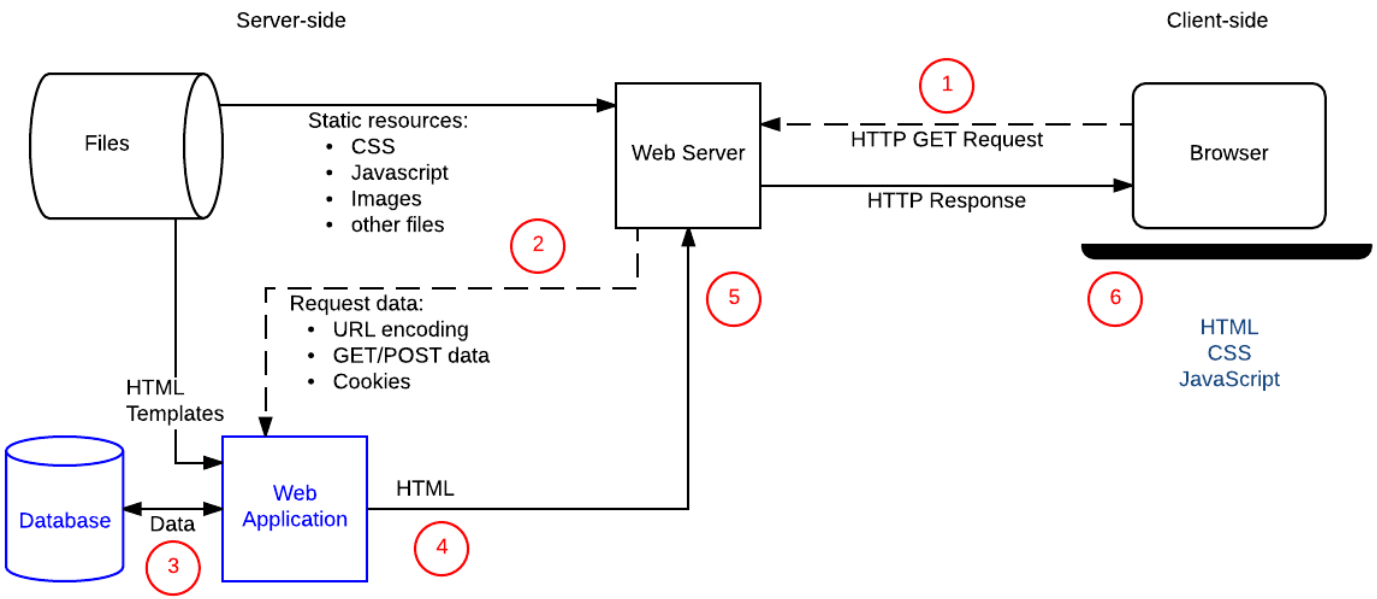


What is Node.js?

- **Definition**:
  - Node.js is a JavaScript runtime built on Chrome's V8 engine that allows JavaScript to be executed on the server.
  - Enables server-side programming with JavaScript.
- **Key Points**:
  - Uses non-blocking, event-driven architecture.
  - Primarily used for building scalable and fast network applications.

What is Node.js? (cont.)

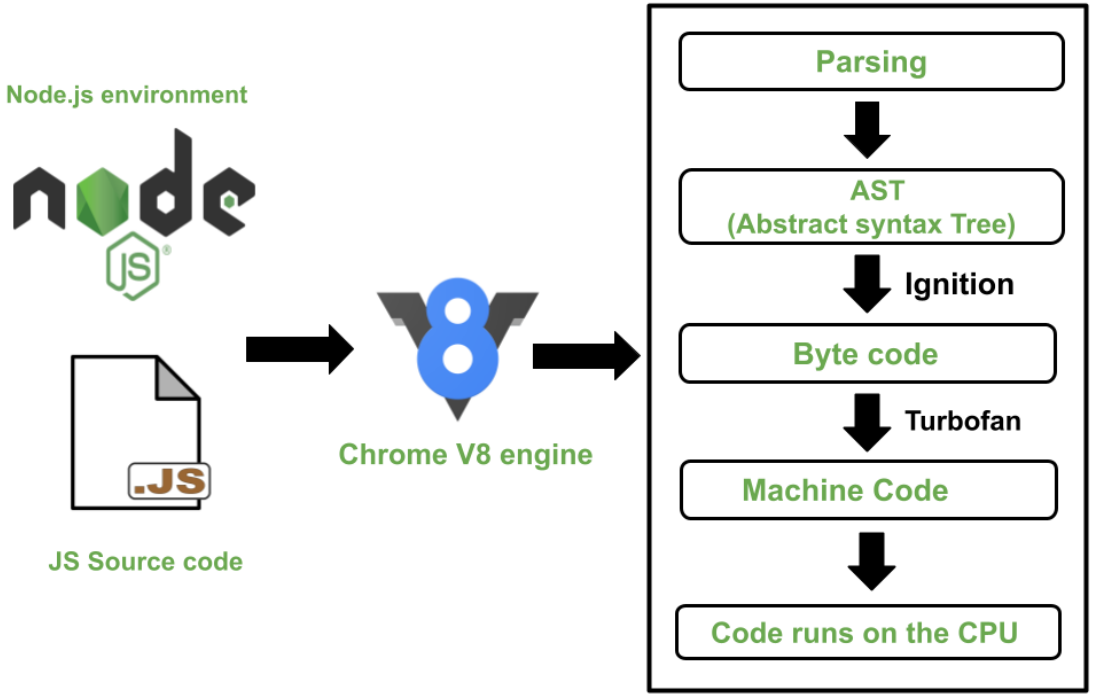
- **Why is it important?**:
  - JavaScript can now be used end-to-end (front-end and back-end), reducing the need for multiple programming languages across an application.

Node.js Architecture

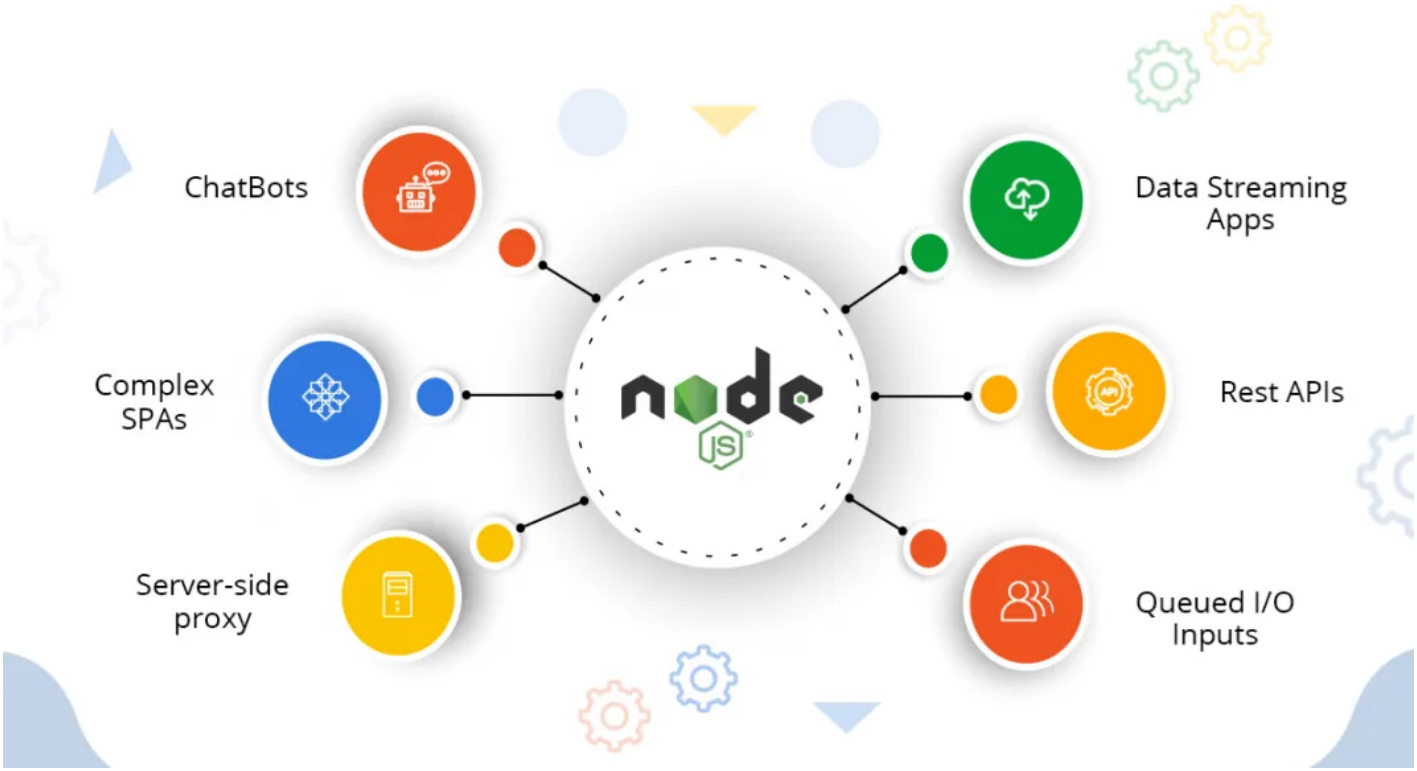
- **Single-threaded, Event-Driven**:
  - Node.js operates on a single thread using the event loop to handle multiple connections concurrently.
  - Unlike traditional multithreaded servers, Node.js is non-blocking, allowing it to efficiently manage multiple requests without creating new threads for each.
- **Event Loop**:
  - Explain the event loop: The core of Node.js' non-blocking architecture.
  - Handles I/O operations asynchronously, queuing up operations and processing them once they're complete.

Node.js Architecture (cont.)

- **V8 Engine**:
  - Node.js uses Google's V8 JavaScript engine to convert JavaScript code into machine code.



Use Cases of Node.js



Use Cases of Node.js (cont.)

- **Real-Time Applications**: Suitable for chat applications, online collaboration tools, and multiplayer games.
- **API Servers**: Commonly used to build RESTful APIs and microservices.
- **Single-Page Applications (SPAs)**: Works well with frameworks like React or Vue.js to handle dynamic content.
- **Data Streaming Applications**: Ideal for audio/video streaming due to its event-driven nature.
- **IoT Applications**: Handles large amounts of data from IoT devices efficiently.

Recap: Why Node.js?

- Node.js allows JavaScript to run on the server.
- Uses a **single-threaded, event-driven architecture** to handle multiple connections concurrently.
- Powered by the **V8 JavaScript engine** for fast execution.
- Ideal for real-time, API-based, and data-heavy applications.

Key takeaway: Node.js excels in non-blocking, asynchronous operations.

Installing Node.js & NPM

Steps to Install:

1. Go to `https://nodejs.org/` and download the appropriate installer for your OS.
2. Install Node.js along with npm (Node Package Manager).
3. Verify installation:

```
node -v
npm -v
```

Installing Node.js & NPM (cont.)

Command Prompt

```
Microsoft Windows [Version 10.0.22631.4169]
(c) Microsoft Corporation. All rights reserved.

C:\Users\USTH>node -v
v18.12.1

C:\Users\USTH>npm -v
8.19.2

C:\Users\USTH>
```

Setting Up a Basic Node.js Project

Steps to Set Up:

1. Create a new project directory:

```
mkdir nodejs-fundamentals
cd nodejs-fundamentals
```

2. Initialize the project using npm:

```
npm init -y
```

3. This creates a `package.json` file to manage the project.

Setting Up a Basic Node.js Project (cont.)

Command Prompt

```
C:\Users\USTH\nodejs-fundamentals>npm init -y
Wrote to C:\Users\USTH\nodejs-fundamentals\package.json:

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

Understanding `package.json`

What is `package.json`?

- Contains metadata about your project.
- Tracks dependencies for libraries and packages.
- Defines custom **scripts** (e.g., commands to start a server).

Key Fields:

- `"name"`: Name of the project.
- `"version"`: Current version of the project.
- `"dependencies"`: Lists installed npm packages.
- `"scripts"`: Commands such as `"start": "node app.js"`.

Writing and Running the First Node.js Program

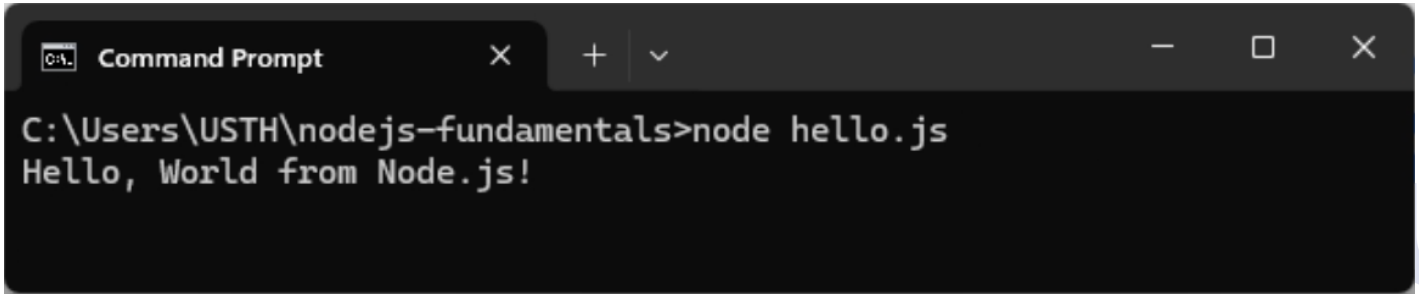
Create a file `hello.js`:

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

Run the script in the terminal:

```
node hello.js
```

Output: `Hello, World from Node.js!`



Node.js as a JavaScript Runtime

What is Node.js?

- Node.js is a **JavaScript runtime** that allows JS to be executed on the server-side.
- Built on Chrome's V8 JavaScript engine.
- Provides an environment for building network applications, using non-blocking I/O operations.

Overview of Modules and `require()` Function

What are Modules?

- Modules in Node.js are independent blocks of reusable code.
- Node.js uses the `require()` function to load modules.

Example: Loading the `fs` Module

```
const fs = require('fs');
```

Built-in Modules: `fs`, `http`, `url`, etc.

Example: Using the fs (File System) Module

Reading a File Synchronously:

```
const fs = require('fs');
let data = fs.readFileSync('file.txt', 'utf8');
console.log(data);
```

Explanation:

- `fs.readFileSync()` reads a file synchronously, blocking execution until reading is complete.
- `console.log()` outputs the file content.

Creating Custom Modules

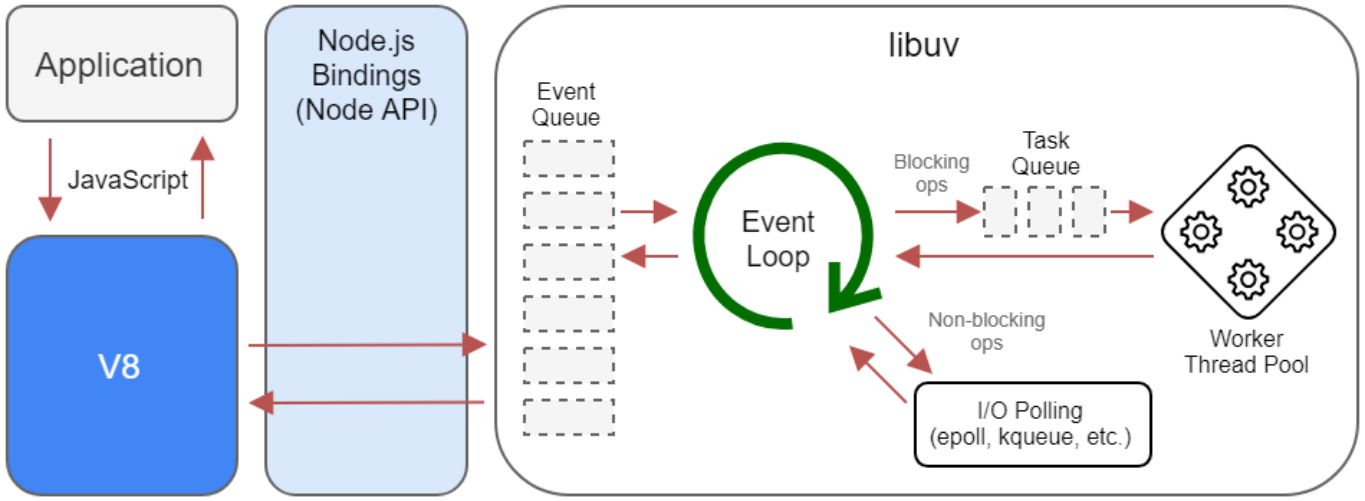
Creating and Exporting a Module:

```
// file: myModule.js
module.exports.sayHello = function() {
    console.log('Hello from myModule!');
};
```

Importing and Using the Custom Module:

```
const myModule = require('./myModule');
myModule.sayHello(); // Outputs: Hello from myModule!
```

Event-Driven Architecture in Node.js



What is Event-Driven Programming?

- Node.js uses an event-driven architecture, where actions trigger events.
- The **Event Loop** processes events asynchronously without blocking.

Example: Using EventEmitter

Creating an Event Listener:

```
const EventEmitter = require('events');
const emitter = new EventEmitter();

// Register a listener
emitter.on('event', () => {
    console.log('An event occurred!');
});

// Emit the event
emitter.emit('event'); // Outputs: An event occurred!
```

Explanation:

- `emitter.on()` registers an event listener.
- `emitter.emit()` triggers the event.

Blocking vs Non-Blocking I/O

Blocking I/O:

- Operations execute in sequence, one after the other.
- Blocks further execution until the current operation is complete.

Non-Blocking I/O:

- Operations can be initiated without waiting for the previous operation to complete.
- Node.js excels in handling non-blocking, asynchronous operations.

Example of Blocking Code

Synchronous File Reading:

```
const fs = require('fs');

let data = fs.readFileSync('file.txt');
console.log(data);
console.log('File reading complete.');
```

Output Order:

- File content is printed first.
- "File reading complete" is printed only after file is fully read.

Example of Non-Blocking Code

Asynchronous File Reading:

```
const fs = require('fs');

fs.readFile('file.txt', (err, data) => {
    if (err) throw err;
    console.log(data);
});
console.log('File reading initiated.');
```

Output Order:

- "File reading initiated" is printed first.
- File content is printed later when reading is complete.

What are Callbacks?

Definition:

- A **callback** is a function passed as an argument to another function.
- It is executed after an asynchronous operation completes.

Callback Syntax:

```
function fetchData(callback) {
    // Simulate async operation
    setTimeout(() => {
        console.log('Data fetched!');
        callback();
    }, 1000);
}

fetchData(() => {
    console.log('Callback executed.');
});
```

Example: Callback Function

Asynchronous Operation with Callback:

```
function doSomething(callback) {
    console.log('Doing something...');
    callback();
}

function onComplete() {
    console.log('Task complete.');
}

doSomething(onComplete); // Outputs: Doing something... Task complete.
```

Error Handling in Callbacks

Handling Errors in Asynchronous Functions:

```
fs.readFile('file.txt', (err, data) => {
    if (err) {
        console.error('Error reading file:', err);
        return;
    }
    console.log(data);
});
```

Explanation:

- Check if `err` exists before proceeding.
- Use `return` to stop further execution if an error occurs.

Recap of Asynchronous Programming

Key Takeaways:

- Node.js uses non-blocking I/O operations to handle multiple requests concurrently.
- Callbacks are functions passed to asynchronous operations, executed when the task is complete.
- Proper error handling in callbacks is crucial for robust code.

Introducing the HTTP Module

The HTTP Module in Node.js:

- The built-in `http` module allows Node.js to create a basic web server.
- Provides functionality for handling HTTP requests and responses.
- No need for external libraries—just import and use.

Key Features:

- Create an HTTP server with `http.createServer()`.
- Listen for requests on a specific port.

Code Example: Basic HTTP Server in Node.js

Example Code:

```javascript
const http = require('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/');
});
```

Explanation: This code creates a simple HTTP server that listens on port 3000.

Running the Server

Steps to Run the Server:

1. Save the code as `server.js` in your project folder.
2. In the terminal, navigate to the folder and run the server with:

```
node server.js
```

3. You should see a message like:

```
Server running at http://localhost:3000/
```

4. Open your browser and navigate to `http://localhost:3000/` to see the output.

Breakdown of the HTTP Server Code

Key Sections of the Code:

- `http.createServer()`: Creates the HTTP server and handles incoming requests.
- `res.statusCode = 200`: Sets the status code to 200, indicating a successful request.
- `res.setHeader('Content-Type', 'text/plain')`: Specifies the content type of the response as plain text.
- `res.end('Hello, World!')`: Ends the response and sends the data to the client.
- `server.listen(3000)`: Instructs the server to listen on port 3000.

Console Output: Displays when the server starts successfully.

Recap of Key Concepts

What We've Covered:

- Introduction to the Node.js HTTP module and its role in building a server.
- Writing a simple Node.js server to handle HTTP requests.
- Running and testing the server on `localhost`.
- Understanding the key components of an HTTP server in Node.js.

Next Steps: Preparing to integrate front-end with back-end using HTTP endpoints.

Questions and Next Steps

Any Questions?

Next Steps:

- Review the code examples we covered in class.
- Begin thinking about how to integrate front-end components with this HTTP server.
- The hand-on assignment will help solidify your understanding.

Hand-on Assignment

- Build a simple Node.js server that handles different types of requests:
  - Serve different types of content (e.g., HTML, JSON).
  - Set up different routes to respond to GET and POST requests.
- Use the concepts covered in class to break down the HTTP server code.
- Submit the project by the end of the week.

Tip: Start by expanding the basic server example and adding routes for different paths (e.g., `/`, `/about`, `/data`).

Thank you for listening!