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Node.js File System Module

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Introduction to Node.js File System

The Node.js File System module (fs) provides a comprehensive set of methods for working with the file system on your computer.

It allows you to perform file I/O operations in both synchronous and asynchronous ways.

Note: The File System module is a core Node.js module, so no installation is required.

Importing the File System Module

You can import the File System module using CommonJS `require()` or ES modules `import` syntax:

CommonJS (Default in Node.js)

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

ES Modules (Node.js 14+ with "type": "module" in package.json)

Promise-based API

Node.js provides promise-based versions of the File System API in the `fs/promises` namespace, which is recommended for modern applications:

```
// Using promises (Node.js 10.0.0+)
const fs = require('fs').promises;

// Or with destructuring
const { readFile, writeFile } = require('fs').promises;

// Or with ES modules
// import { readFile, writeFile } from 'fs/promises';
```

Common Use Cases

File Operations

- Read and write files
- Create and delete files
- Append to files
- Rename and move files
- Change file permissions

Directory Operations

- Create and remove directories
- List directory contents
- Watch for file changes
- Get file/directory stats
- Check file existence

Advanced Features

- File streams
- File descriptors
- Symbolic links
- File watching
- Working with file permissions

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Performance Tip: For large files, consider using streams (`fs.createReadStream` and `fs.createWriteStream`) to avoid high memory usage.

Reading Files

Node.js provides several methods to read files, including both callback-based and promise-based approaches.

The most common method is `fs.readFile()` .

Note: Always handle errors when working with file operations to prevent your application from crashing.

Reading Files with Callbacks

Here's how to read a file using the traditional callback pattern:

myfile.txt

```
This is the content of myfile.txt
```

Create a Node.js file that reads the text file, and return the content:

Example: Reading a file with callbacks

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

// Read file asynchronously with callback
fs.readFile('myfile.txt', 'utf8', (err, data) => {
  if (err) {
    console.error('Error reading file:', err);
```

```
// For binary data (like images), omit the encoding
fs.readFile('image.png', (err, data) => {
  if (err) throw err;
  // data is a Buffer containing the file content
  console.log('Image size:', data.length, 'bytes');
});
```

Run example »

Reading Files with Promises (Modern Approach)

Using `fs.promises` or `util.promisify` for cleaner async/await syntax:

Example: Reading a file with async/await

```
// Using fs.promises (Node.js 10.0.0+)
const fs = require('fs').promises;

async function readFileExample() {
  try {
    const data = await fs.readFile('myfile.txt', 'utf8');
    console.log('File content:', data);
  } catch (err) {
    console.error('Error reading file:', err);
  }
}

readFileExample();

// Or with util.promisify (Node.js 8.0.0+)
const { promisify } = require('util');
const readFileAsync = promisify(require('fs').readFile);

async function readWithPromisify() {
  try {
    const data = await readFileAsync('myfile.txt', 'utf8');
    console.log(data);
```

```
readWithPromisify();
```

Run example »

Reading Files Synchronously

For simple scripts, you can use synchronous methods, but avoid them in production servers as they block the event loop:

Example: Reading a file synchronously

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

try {
  // Read file synchronously
  const data = fs.readFileSync('myfile.txt', 'utf8');
  console.log('File content:', data);
} catch (err) {
  console.error('Error reading file:', err);
}
```

Best Practice: Always specify the character encoding (like 'utf8') when reading text files to get a string instead of a Buffer.

Creating and Writing Files

Node.js provides several methods for creating and writing to files.

Creates a new file or overwrites an existing file with the specified content:

Example: Writing to a file

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

async function writeFileExample() {
  try {
    // Write text to a file
    await fs.writeFile('myfile.txt', 'Hello, World!', 'utf8');

    // Write JSON data
    const data = { name: 'John', age: 30, city: 'New York' };
    await fs.writeFile('data.json', JSON.stringify(data, null, 2),
'utf8');

    console.log('Files created successfully');
  } catch (err) {
    console.error('Error writing files:', err);
  }
}

writeFileExample();
```

Run example »

2. Using `fs.appendFile()`

Appends content to a file, creating the file if it doesn't exist:

Example: Appending to a file

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

async function appendToFile() {
  try {
    // Append a timestamped log entry
```

```
    console.log('Log entry added');
  } catch (err) {
    console.error('Error appending to file:', err);
  }
}

appendToFile();
```

Run example »

3. Using File Handles

For more control over file operations, you can use file handles:

Example: Using file handles

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

async function writeWithFileHandle() {
  let fileHandle;

  try {
    // Open a file for writing (creates if doesn't exist)
    fileHandle = await fs.open('output.txt', 'w');

    // Write content to the file
    await fileHandle.write('First line\n');
    await fileHandle.write('Second line\n');
    await fileHandle.write('Third line\n');

    console.log('Content written successfully');
  } catch (err) {
    console.error('Error writing to file:', err);
  } finally {
    // Always close the file handle
    if (fileHandle) {
      await fileHandle.close();
    }
```

Run example »

4. Using Streams for Large Files

For writing large amounts of data, use streams to avoid high memory usage:

Example: Writing large files with streams

```
const fs = require('fs');
const { pipeline } = require('stream/promises');
const { Readable } = require('stream');

async function writeLargeFile() {
  // Create a readable stream (could be from HTTP request, etc.)
  const data = Array(1000).fill().map((_, i) => `Line ${i + 1}:
${'x'.repeat(100)}\n`);
  const readable = Readable.from(data);

  // Create a writable stream to a file
  const writable = fs.createWriteStream('large-file.txt');

  try {
    // Pipe the data from readable to writable
    await pipeline(readable, writable);
    console.log('Large file written successfully');
  } catch (err) {
    console.error('Error writing file:', err);
  }
}

writeLargeFile();
```

Run example »

- `'w+'` - Open for reading and writing (file is created or truncated)
- `'a'` - Open for appending (file is created if it doesn't exist)
- `'ax'` - Like 'a' but fails if the path exists
- `'r+'` - Open for reading and writing (file must exist)

Deleting Files and Directories

Node.js provides several methods to delete files and directories.

Here's how to handle different deletion scenarios:

1. Deleting a Single File

Use `fs.unlink()` to delete a file:

Example: Deleting a file

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

async function deleteFile() {
  const filePath = 'file-to-delete.txt';

  try {
    // Check if file exists before deleting
    await fs.access(filePath);

    // Delete the file
    await fs.unlink(filePath);
    console.log('File deleted successfully');
  } catch (err) {
    if (err.code === 'ENOENT') {
      console.log('File does not exist');
    } else {
      console.error('Error deleting file:', err);
    }
  }
```

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2. Deleting Multiple Files

To delete multiple files, you can use Promise.all() with fs.unlink():

Example: Deleting multiple files

```
const fs = require('fs').promises;
const path = require('path');

async function deleteFiles() {
  const filesToDelete = [
    'temp1.txt',
    'temp2.txt',
    'temp3.txt'
  ];

  try {
    // Delete all files in parallel
    await Promise.all(
      filesToDelete.map(file =>
        fs.unlink(file).catch(err => {
          if (err.code !== 'ENOENT') {
            console.error(`Error deleting ${file}:`, err);
          }
        })
      )
    );

    console.log('Files deleted successfully');
  } catch (err) {
    console.error('Error during file deletion:', err);
  }
}

deleteFiles();
```

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3. Deleting Directories

To delete directories, you have several options depending on your needs:

Example: Deleting directories

```
const fs = require('fs').promises;
const path = require('path');

async function deleteDirectory(dirPath) {
  try {
    // Check if the directory exists
    const stats = await fs.stat(dirPath);

    if (!stats.isDirectory()) {
      console.log('Path is not a directory');
      return;
    }

    // For Node.js 14.14.0+ (recommended)
    await fs.rm(dirPath, { recursive: true, force: true });

    // For older Node.js versions (deprecated but still works)
    // await fs.rmdir(dirPath, { recursive: true });

    console.log('Directory deleted successfully');
  } catch (err) {
    if (err.code === 'ENOENT') {
      console.log('Directory does not exist');
    } else {
      console.error('Error deleting directory:', err);
    }
  }
}

// Usage
deleteDirectory('directory-to-delete');
```

Run example »

Example: Emptying a directory

```
const fs = require('fs').promises;
const path = require('path');

async function emptyDirectory(dirPath) {
  try {
    // Read the directory
    const files = await fs.readdir(dirPath, { withFileTypes: true });

    // Delete all files and directories in parallel
    await Promise.all(
      files.map(file => {
        const fullPath = path.join(dirPath, file.name);
        return file.isDirectory()
          ? fs.rm(fullPath, { recursive: true, force: true })
          : fs.unlink(fullPath);
      })
    );

    console.log('Directory emptied successfully');
  } catch (err) {
    console.error('Error emptying directory:', err);
  }
}

// Usage
emptyDirectory('directory-to-empty');
```

Run example »

Security Note: Be extremely careful with file deletion, especially when using recursive options or wildcards. Always validate and sanitize file paths to prevent directory traversal attacks.

It's a versatile method for file system operations that involve changing file paths.

1. Basic File Renaming

To rename a file in the same directory:

Example: Renaming a file

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

async function renameFile() {
  const oldPath = 'old-name.txt';
  const newPath = 'new-name.txt';

  try {
    // Check if source file exists
    await fs.access(oldPath);

    // Check if destination file already exists
    try {
      await fs.access(newPath);
      console.log('Destination file already exists');
      return;
    } catch (err) {
      // Destination doesn't exist, safe to proceed
    }

    // Perform the rename
    await fs.rename(oldPath, newPath);
    console.log('File renamed successfully');
  } catch (err) {
    if (err.code === 'ENOENT') {
      console.log('Source file does not exist');
    } else {
      console.error('Error renaming file:', err);
    }
  }
}
```

2. Moving Files Between Directories

You can use `fs.rename()` to move files between directories:

Example: Moving a file to a different directory

```
const fs = require('fs').promises;
const path = require('path');

async function moveFile() {
  const sourceFile = 'source/file.txt';
  const targetDir = 'destination';
  const targetFile = path.join(targetDir, 'file.txt');

  try {
    // Ensure source file exists
    await fs.access(sourceFile);

    // Create target directory if it doesn't exist
    await fs.mkdir(targetDir, { recursive: true });

    // Move the file
    await fs.rename(sourceFile, targetFile);

    console.log('File moved successfully');
  } catch (err) {
    if (err.code === 'ENOENT') {
      console.log('Source file does not exist');
    } else if (err.code === 'EXDEV') {
      console.log('Cross-device move detected, using copy+delete
fallback');
      await moveAcrossDevices(sourceFile, targetFile);
    } else {
      console.error('Error moving file:', err);
    }
  }
}
```

```
    // Copy the file
    await fs.copyFile(source, target);

    // Delete the original
    await fs.unlink(source);

    console.log('File moved across devices successfully');
  } catch (err) {
    // Clean up if something went wrong
    try { await fs.unlink(target); } catch (e) {}
    throw err;
  }
}

// Usage
moveFile();
```

Run example »

3. Batch Renaming Files

To rename multiple files matching a pattern:

Example: Batch renaming files

```
const fs = require('fs').promises;
const path = require('path');

async function batchRename() {
  const directory = 'images';
  const pattern = /^image(\d+)\.jpg$/;

  try {
    // Read directory contents
    const files = await fs.readdir(directory);

    // Process each file
    for (const file of files) {
```

```
        const oldPath = path.join(directory, file);
        const newPath = path.join(directory, newName);

        // Skip if the new name is the same as the old name
        if (oldPath !== newPath) {
          await fs.rename(oldPath, newPath);
          console.log(`Renamed: ${file} - ${newName}`);
        }
      }
    }

    console.log('Batch rename completed');
  } catch (err) {
    console.error('Error during batch rename:', err);
  }
}

batchRename();
```

Run example »

4. Atomic Rename Operations

For critical operations, use a temporary file to ensure atomicity:

Example: Atomic file update

```
const fs = require('fs').promises;
const path = require('path');
const os = require('os');

async function updateFileAtomic(filePath, newContent) {
  const tempPath = path.join(
    os.tmpdir(),
    `temp-${Date.now()}-${Math.random().toString(36).substr(2, 9)}`
  );

  try {
```

```
    const stats = await fs.stat(tempPath);
    if (stats.size === 0) {
      throw new Error('Temporary file is empty');
    }

    // 3. Rename (atomic on most systems)
    await fs.rename(tempPath, filePath);

    console.log('File updated atomically');
  } catch (err) {
    // Clean up temp file if it exists
    try { await fs.unlink(tempPath); } catch (e) {}

    console.error('Atomic update failed:', err);
    throw err;
  }
}

// Usage
updateFileAtomic('important-config.json', JSON.stringify({ key:
'value' }, null, 2));
```

Cross-Platform Note: The `fs.rename()` operation is atomic on Unix-like systems but may not be on Windows.

For cross-platform atomic operations, consider using a temporary file approach as shown in the example above.

Exercise ?

Drag and drop the correct word to complete the sentence.

Node.js provides both and asynchronous methods for file

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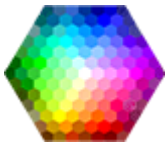

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