Lecture 7: JavaScript on the Server: Node.js

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Karthik Pattabiraman

The University of British Columbia
Department of Electrical and Computer Engineering
Vancouver, Canada

Electrical and Computer Engineering

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Server-side Javascript

→ More events

1. Server-side Javascript
2. Node.js Modules
3. Events
4. Files
5. Network and Http Server

→ Mirror AJAX Server -

History of Server-side JS

- JavaScript evolved primarily on the client-side in the web browser
- However, JavaScript began to be used as a server side language starting in 2008-2009
  - Rhino: JavaScript parser and interpreter written in Java
  - Node.js: V8 JavaScript engine in Chrome (standalone), written in C++

analyze JS code.

↳ Much faster

Server-Side JS: Advantages

Economic

- Same language for both client and server
  - Eases software maintenance tasks
  - Eases movement of code from server to client
- Much easier to exchange data between client and server, and between server and NoSQL DBs
  - Native support for JSON objects in both
- Much more scalable than traditional solutions
  - Due to use of asynchronous methods everywhere

code, programmers

hard to migrate across teams

MONGODB → support for JSON.

- traditional: multiple thread, 1 per conn. slow, consume memory
- Concurrency: by events. clean model.

Comparison with Traditional Solutions

Difficult to maintain multithreaded code -
- concurrency

- Traditional solutions on the server tend to spawn a new thread for each client request
  - Leads to proliferation of threads
  - No control over thread scheduling
  - Overhead of thread creation and context switches
- Server-side JS: Single-threaded nature of JS makes it easy to write code
  - Scalability achieved by asynchronous calls → can do in parallel
  - Composition with libraries is straightforward

↳ invariants not preserved

Node.js Features

- Written in C++ and very fast → Write to file system etc.
- Provides access to low-level UNIX APIs
- Almost all function calls are asynchronous → Default.
  - File systems
  - Network calls
- Module system to manage dependencies → NPM
  - Centralized package manager for modules → dependency
- Implements all standared ECMAScript5 constructors, properties, functions and globals

↳ Consistent interface. → each thing has specialized obj

Node.js Example


```
1  console.log("Hello");  // Same as before
2  setTimeout( function() {  // Same as before
3        console.log("World") }, 1000);
4
5  // New stuff - can't do this in client-side JavaScript
6  var fs = require("fs");  // Load file system object
7  var contents = fs.readFilesync( fileName );
8  console.log(contents);
```

→ Not part of window.

- Can't access DOM - not in Web browser anymore

Node.js Modules

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Node.js

- flexibility in composing modules
- NPM uses modules

- In Node.js, you use modules to package functionality together
- Use the module.exports keyword to export a function or object as part of a module ↪ Keep rel. functionality + encapsul.
- Use the require keyword to import a module and its associated functions or objects

- Choose modules to require - then actually included in final prog. / appl.

Exporting Functions

- Can be used to create one's own modules

Calculator.js

```
1  function sum(a, b) {
2      return a + b;
3  }
4
5  // This exports the sum function
6  module.exports.sum = sum;
```

name. <can be diff^n>

- Can run on command line, node.js.

Exporting Objects (Constructors)

- Can also export entire objects through the module.exports – module is optional below

Shapes.js

```
1  var Point = function(x, y) {
2      this.x = x; this.y = y;
3  };
4
5  module.exports = Point;
```

- require Shapes.JS. ← whole thing.

Using modules: *require*

- Used to express dependency on a certain module's functionality

Shapes.js

```
1  // Imports the Calculator module
2  var calculator = require("Calculator.js");
3  calculator.sum(10, 20);
4
5  // Imports the shapes module
6  var Point = require("Shapes.js");
7  var p = new Point(1, 2);
```

← only Sum can be called, export only 1 thing

← entire file.

Points to Note

- Need to provide the full path of the module to the requires function
- Need to check the value of requires. if it's undefined, then module was not found.
- Only functions/objects that are exported using export are visible in the line that calls require

Events

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Event Streams

- Node.js code can define events and monitor for the occurrence of events on a stream (e.g., network connection, file etc).
- Associate callback functions to events using the 'on()' or 'addListener()' functions
- Trigger by calling the 'emit' function

Event

- Refer to specific points in the execution
  - Example: exit, before a node process exists
  - Example: data, when data is available on connection
  - Example: end when a connection is closed
- Can be defined by the application and event registers can be added on streams
- Event can be triggered by the streams

Can create new events / emitters

```
1  var EventEmitter = require('events').EventEmitter;
2  if (! EventEmitter) process.exit(1);
3  var myEmitter = new EventEmitter();
4  var connection = function(id) { /* ... */ };
5  var message = function(msg) { /* ... */ };
6  // Add event handlers
7  myEmitter.on("connection", connection);
8  myEmitter.on("message", message);
9  // Emit the events
10 myEmitter.emit("connection", 100);
11 myEmitter.emit("message", "hello");
```

-> Module.
-> check exists
-> constr -> stream, can attach subscribers
-> just strings made up -> DIY events.
-> Attach subscribers
-> anywhere, will get called
-> args

Class Activity

Write a function that takes an event stream and an array of strings as arguments, and counts the number of occurrences of each string in the stream. You should use EventEmitter.on for monitoring the stream, i.e., you should not directly scan the stream for the strings. The function should return a function that prints the count of each string.

Files

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File handling in Node

→ + Streaming file io
- Asynchronous
- More features.

- Node.js supports two ways to read/write files
  - Asynchronous reads and writes ⟨Preferred⟩
  - Synchronous reads and writes
- The asynchronous methods require callback functions to be specified and are more scalable → register callback when rw.
- Synchronous is similar to regular reads and writes in other languages

↳ no context switching.
only when done, does callback execute.

Synchronized Reads and Writes

Least preferred way.

- readFileSync and writeFileSync to read/write files synchronously (operations block JS)
- Not suitable for reading/writing large files
  - Can lead to large performance delays

```
1  var f= fs.readFileSync(fileName);
2  var f = fs.writeFileSync(fineName, data);
```

- No callback reqd.

Asynchronously reading a file


```
1  var fs = require("fs");     // Filesystem module in node.js
2  var length = 0;
3  var fileName = "sample.txt";
4
5  fs.readFile(fileName, function(err, buf) {
6      if (err) throw err;
7      length = buf.length;
8       console.log("Number of characters read = " + length);
9  } );
```

callback fx

- exec asynchronously
- No access to og callstack.
- Diff^n calling context

- Mechanism.
  pass err as 1st param.
  Set err to non-zero value (str messages)

Buf → the read file.

Asynchronous Reads using Streams

- if file long, waste time, otherwise calc can be done in parallel in background.

- It's also possible to start processing a file as and when it is being read. We need to read files as event streams: fs.createReadStream
- Three types of events on files
  - data: There's data available to be read
  - end: The end of the file was reached
  - error: There was an error in reading the data

→ Handler code must store partial progress.

Example of Using Streams

- No callback passed.
- Event handler on Stream.

```
1  var fs = require('fs');
2  var length = 0;
3  var fileName = "sample.txt";
4  var readStream = fs.createReadStream(fileName);;
5
6  readStream.on("data", function(blob) {
7      console.log("Read " + blob.length);
8      length += blob.length;
9  });
10
11 readStream.on("end", function() {
12     console.log("Total number of chars read = " + length);
13 });
14
15 readStream.on("error", function() {
16     console.log("Error occurred when reading from file " +
           fileName);
17 });
```

- cannot ch, predefn

→ cannot make assumption of blob sz / length

Asynchronous Writes

- Like reads, writes can also be asynchronous. Just call fs.writeFile with the callback function

```
1  fs.writeFile( fileName, data, function(err) {
2      if (! err)
3          console.log("Finished writing data");
4      else
5          console.log("Error writing to " + fileName);
6  };
```

Writeable Stream

- Like readStreams, we can define writeStreams and write data to them in blobs
  - Same events as before
  - Useful when combined with readableStreams to avoid buffering in memory
  - Need to call end() when the writing is completed

Example: Copying one file to another


```
1  var fs = require("fs");
2
3  var readStream = fs.createReadStream("sample.txt");
4  var writeStream = fs.createWriteStream("sample-copy.txt");
5
6  readStream.on("data", function(blob) {
7      console.log("Read " + blob.length);
8       writeStream.write(blob);
9  });
10
11 readStream.on("end", function() {
12     console.log("End of stream");
13     writeStream.end();
14 });
```

→ No error handling

writeStream.on("error", function()

Alternate method: Using Pipe

Skip the middleman

```
1  var fs = require("fs");
2
3  // Open the read and write streams
4  var readStream = fs.createReadStream("sample.txt");
5  var writeStream = fs.createWriteStream("sample-copy.txt");
6
7  // Copies contents of read stream to write stream
8  readStream.pipe( writeStream );
```

Class Activity

- Write a function that searches for a given string in a large text file in node.js. The file should be read using streams and asynchronous I/O, and should not be buffered in memory all at once (as it's too large).
- NOTE: You may get multiple calls to the callback function as file data comes in chunks. Your method must search between chunks.

Network and Http Server

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Network Server

- Node.js has built in modules for servers
  - 'net' module for general-purpose servers
  - 'http' module for http servers
- To create a http server
  - new http.Server
  - createServer(foo): foo is called when a request arrives, with request & response parameters

Method 1: Handling Http connections


```
1  var http = require('http');
2
3  // Create a simple function to serve a request
4  var serveRequest = function(request, response) {
5     console.log( request.headers );
6     response.write("Welcome to node.js");
7     response.end();
8  };
9
10 // Start the server on the port and setup response
11 var port = 8080;
12 var server = http.createServer(serveRequest);
13 server.listen(port);
```

Async handling

end · Send response.

Stream

Accept conn. from port.

Main exits, wait for conn.

Method 2: Using Streams

echo Server.

```
1  var http = require('http');
2
3  // Create a simple function to serve a request
4  var serveRequest = function(request, response) {
5     console.log("Received request " + request);
6     response.writeHeader(200, { "Content-type":"text/htm"});
7     response.write("Received: " + request.url);
8     response.end();
9  };
10
11 // Start the server on the port and setup response
12 var port = 8080;
13 var server = http.createServer();
14 server.on("request", serveRequest);
15 server.listen(port);
```

listen on Stream.

request handler.

Inside serveRequest

- Both request and response are streams
- You can add listeners on both request and response as you do on streams
  - Call end on response when you're done
- Can retrieve the headers and url of request
  - request.url
  - request.headers

AJAX Server

- Let's write a simple AJAX server for the AJAX client we wrote earlier
- If the client requests a JS or html file, serve it from the "./client" directory
- If the client sends a message with the prefix 'hello-', send back a response 'world-' with the same suffix as that of the request
  - Add a delay of 3000 for each request

AJAX Server - Solution

Part 1

```
1  var serveRequest = function(request, response) {
2     if ( request.url.startsWith("/hello") ) {
3        // If it's an AJAX request, return world
4        console.log( "Received " + request.url );
5          setTimeout( function() {
6              var count = request.url.split("-")[1];
7              response.write("world-" + count);
8              response.statusCode = 200;
9              response.end();
10         }, 3000);  // delay of 3 seconds
11    }
```

AJAX Server - Solution

Part 2

```
1     else if ( request.url.endsWith(".html") ||
          request.url.endsWith(".js")) {
2         // If it's a HTML or JS file, retrieve the
              file in the request
3         response.statusCode = 200;
4         var fileName = path + request.url;
5         var rs = fs.createReadStream(fileName);
6         s.on("error", function(error) {
7             console.log(error);
8             response.write("Unable to read file : " +
                  fileName);
9             response.statusCode = 404;
10        });
11        rs.on("data", function(data) {
12            response.write(data);
13        });
14        rs.on("end", function() {
15            response.end();
16        });
17    }
```

AJAX Server - Solution

Part 3

```
1      } else {
2          response.write("Unknown request " + request.
               url);
3          response.statusCode = 404;
4          response.end();
5      }
6  };
7
8  // Start the server on the port and setup response
9  var port = 8080;
10 var server = http.createServer(serveRequest);
11 server.listen(port);
12 console.log("Starting server on port " + port);
```

Can use Pipes too

Class Activity

- Extend the AJAX server application to log the set of all requests received from the client to a text file. The logging should be done asynchronously and right after the request is received. You should also be able to handle connections from more than 1 client (HINT: Use a separate text file for each client).

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