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CSCI 4140 – Tutorial 7

Learning the basics of Node.js

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SHB 118

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Outline

- What is Node.js?

- Learning the basics of Node.js: Non-blocking I/O, HTTP

  – Exercises adapted from **`learnyounode`**:
    https://github.com/rvagg/learnyounode

License of `learnyounode`

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learnyounode builds on the excellent work by @substack and @maxogden who created stream-adventure which serves as the original foundation for **learnyounode**.

What is Node.js?

- An **open-source**, **cross-platform** runtime environment for **server-side** and **networking applications**

- Applications are written in **JavaScript**
  - Node.js uses **Google V8 JavaScript engine** to execute code

- Provide an **event-driven architecture** and a **non-blocking I/O** API
  - One process for all **concurrent connections**
  - Optimizes an application's **throughput** and **scalability**
  - For your information, Apache uses **process-/thread-based architecture**, which is relatively inefficient
    - A new process / thread is created per connection

What is Node.js: Event-driven architecture

For those who have taken CSCI/CENG 3150…

Event Emitters
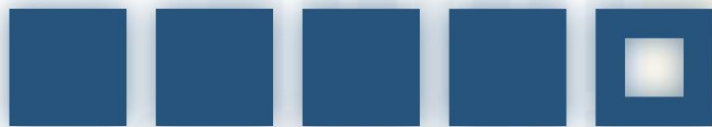
Event Queue

Event Loop (single-threaded)

States

Event Handler
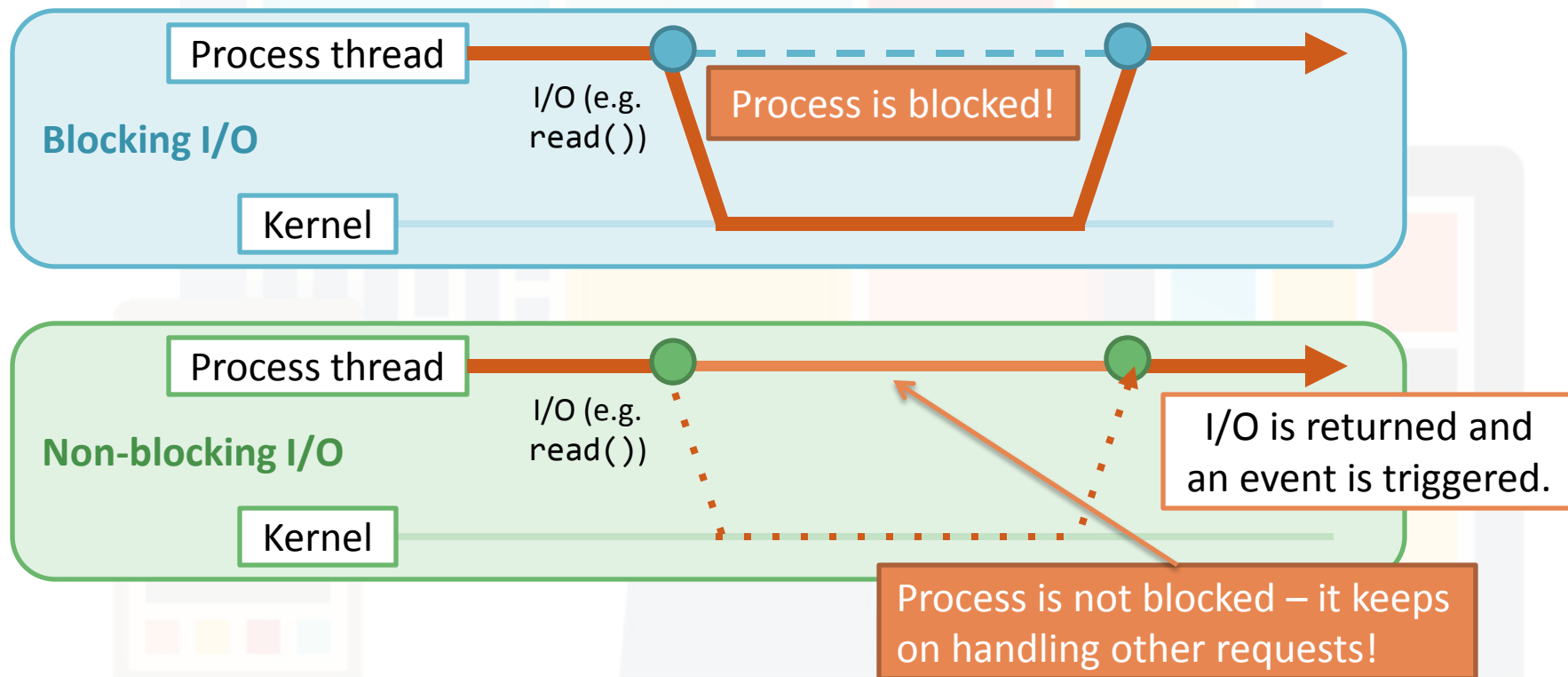
One thread is enough for all connections!

Reference: http://berb.github.io/diploma-thesis/original/042_serverarch.html

What is Node.js: Non-blocking I/O

- Also called **Asynchronous I/O**
- You are familiar with **blocking I/O** already…

For those who have taken CSCI/CENG 3150…

Blocking I/O

Process thread

I/O (e.g. read())

Process is blocked!

Kernel

Non-blocking I/O

Process thread

I/O (e.g. read())

Kernel

I/O is returned and an event is triggered.

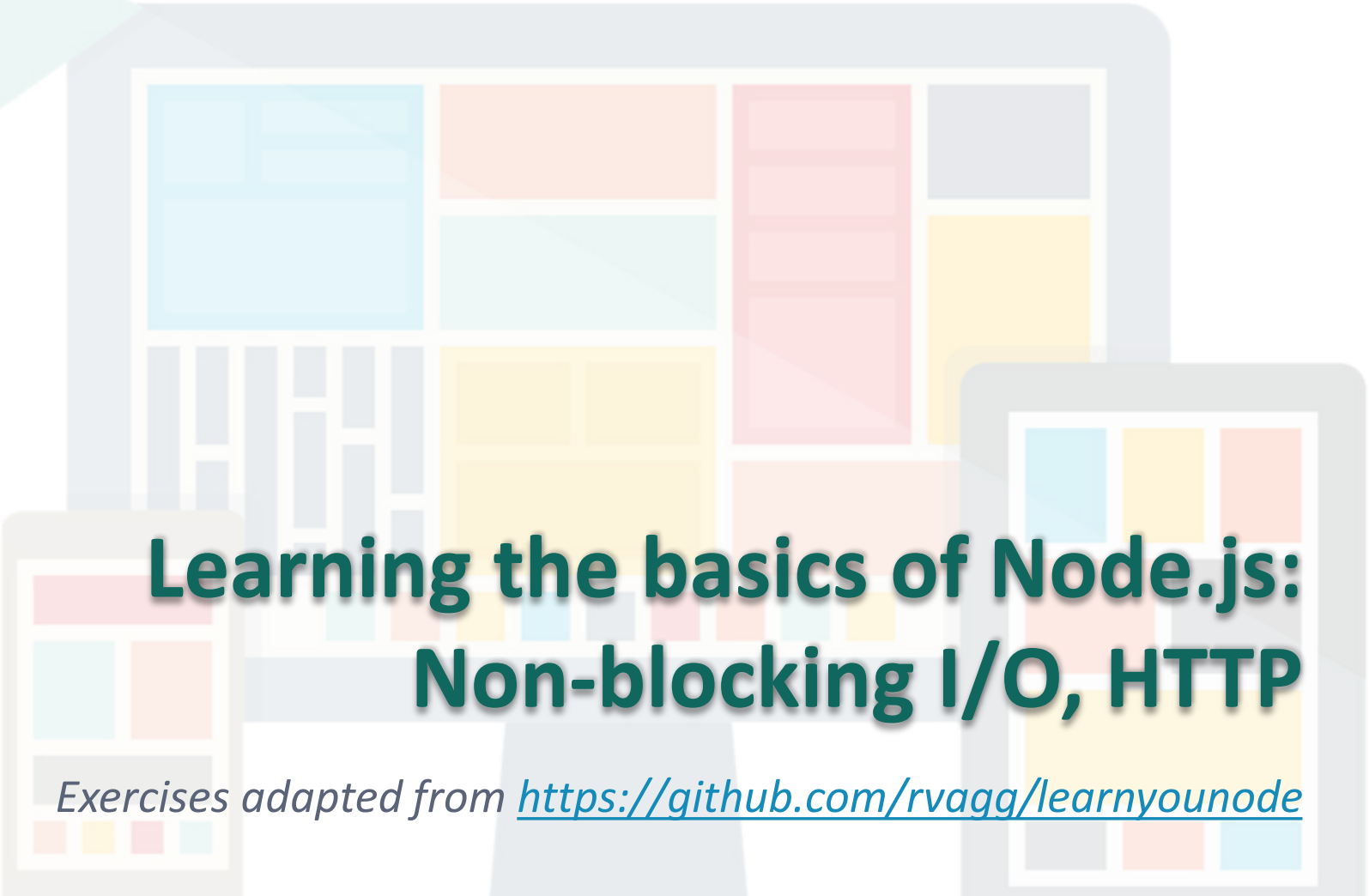Process is not blocked – it keeps on handling other requests!

Node.js HTTP server

- HTTP is a **first class citizen** in Node
  - Forget about Apache / IIS / Nginx
- Say "Hello World!" with Node.js HTTP server:
  - Execute "**node nodejs/server.js**" in your terminal and visit **http://127.0.0.1:4140/** in your browser

```
var http = require( 'http' );
http.createServer( function( request, response ) {
    response.writeHead( 200, { 'Content-Type' : 'text/plain' } );
    response.end( 'Hello World!\n' );
} ).listen( 4140, '127.0.0.1' );

console.log( 'Server running at http://127.0.0.1:4140/' );
```

nodejs/server.js

Learning the basics of Node.js: Non-blocking I/O, HTTP

Exercises adapted from [*https://github.com/rvagg/learnyounode*](https://github.com/rvagg/learnyounode)

Exercise 1: Hello World

- *Let's learn Node.js by doing exercises!*
- **Problem:** Write a program that prints the text "HELLO WORLD" to the console (`stdout`)
- Use the **console** API: http://nodejs.org/api/console.html

```
console.log( "HELLO WORLD" );
```
nodejs/ex1-hello.js

```
$ node nodejs/ex1-hello.js
```
Terminal

- Useful for debugging
  - Obviously you cannot call "`alert()`"...

Exercise 2: Baby steps

- **Problem:** Write a program that accepts one or more numbers as command-line arguments and prints the sum of those numbers to the console (`stdout`)

- Access **command-line arguments** from the **argv** property of the global **process** object
  - For example, executing "**node program.js 1 2 3**"

| program.js | `console.log(process.argv);` |

| Output | `[ 'node', '/home/mtyiu/program.js', '1', '2', '3' ]` |

- Note that the command-line arguments are strings
  - Convert the string into number with "**Number(<string>)**"

Exercise 2: Baby steps

Solution

```
var sum = 0;
for( var i = 2; i < process.argv.length; i++ )
    sum += Number( process.argv[ i ] );
console.log( sum );
```

nodejs/ex2-baby-steps.js

Exercise 2: Baby steps

Solution

process.argv is an array so you can get its length in the field "length".

```
var sum = 0;
for( var i = 2; i < process.argv.length; i++ )
    sum += Number( process.argv[ i ] );
console.log( sum );
```

nodejs/ex2-baby-steps.js

Parse the command-line arguments into numbers.

Exercise 3: My first I/O

- **Problem:** Write a program that uses a single **synchronous** filesystem operation to read a file and print the **number of newlines** it contains to the console (`stdout`), similar to running `cat file | wc -l`.

- We need the **fs** module from the Node core library
  - http://nodejs.org/api/fs.html
  - Load the `fs` module into a **variable**: `var fs = require( 'fs' );`

- All synchronous (or blocking) filesystem methods end with "Sync", e.g., "**fs.readFileSync(** *<file path>* **)**"
  - This method returns a **Buffer** object containing the complete contents of the file

Exercise 3: My first I/O

- **Buffer** objects are Node's way of efficiently representing arbitrary arrays of data
  - To convert them to strings, call "**toString()**" method on them, e.g.,
    var str = buf.toString()
- To count the number of newlines in a string, you can split it using the "**split()**" method with the "**\n**" character as the delimiter
- Remember that the last line of the input file does not contain a newline

Exercise 3: My first I/O

Solution

```
var fs = require( 'fs' );
var buf = fs.readFileSync( process.argv[ 2 ] );
var str = buf.toString();
console.log( str.split( '\n' ).length - 1 );
```

nodejs/ex3-first-io.js

Exercise 3: My first I/O

Solution

Use the synchronous filesystem API to read the file.

```
var fs = require( 'fs' );
var buf = fs.readFileSync( process.argv[ 2 ] );
var str = buf.toString();
console.log( str.split( '\n' ).length - 1 );
```

nodejs/ex3-first-io.js

The last line does not contain a newline so it is not counted.

Exercise 4: My first asynchronous I/O

- **Problem:** Write a program that uses a single **asynchronous** filesystem operation to read a file and print the number of **newlines** it contains to the console (`stdout`), similar to running `cat file | wc -l`.

- `fs.readFile()` is the asynchronous version of `fs.readFileSync()`

  – This method returns **without blocking**

  – To read the file contents, you need to pass a **callback function** which will be called when the I/O completes

    - This concept is **extremely important** in **JavaScript** programming!

Exercise 4: My first asynchronous I/O

Updated

- The callback function should have the following signature:

```
function callback ( err, data ) { /* ... */ }
```

Represent an error

The Buffer object / string containing the file contents

- **fs.readFile()** function accepts two or three arguments:

```
fs.readFile( filename[, options], callback )
```

Pass "utf8" for the options argument to get a string instead of an Buffer object

Exercise 4: My first asynchronous I/O

Solution

```
var fs = require( 'fs' );
fs.readFile(
    process.argv[ 2 ],
    'utf8',
    function( err, data ) {
        console.log( data.split( '\n' ).length - 1 );
    }
);
```

nodejs/ex4-first-async-io.js

Exercise 4: My first asynchronous I/O

Solution

```
var fs = require( 'fs' );
fs.readFile(
    process.argv[ 2 ],
    'utf8',
    function( err, data ) {
        console.log( data.split( '\n' ).length - 1 );
    }
);
```

nodejs/ex4-first-async-io.js

This function is only executed after the I/O operation completes.
The `readFile()` call will not be blocked.

Exercise 5: Filtered `ls`

- **Problem:** Create a program that prints a list of files in a given directory to the console using **asynchronous I/O**, filtered by the **extension** of the files

  - *1st argument*: A directory name

  - *2nd argument*: A file extension to filter by

- Similar to Exercise 4, but with **`fs.readdir()`**

  - http://nodejs.org/api/fs.html#fs_fs_readdir_path_callback

- You will also need **`path.extname()`** in the **path** module

  - http://nodejs.org/api/path.html#path_path_extname_p

Exercise 5: Filtered `ls`

Solution

```
var fs = require( 'fs' );
var path = require( 'path' );
var ext = '.' + process.argv[ 3 ];

fs.readdir( process.argv[ 2 ], function( err, data ) {
    data.forEach( function( i ) {
        if ( path.extname( i ) == ext )
            console.log( i );
    } );
} );
```

nodejs/ex5-filtered-ls.js

Exercise 5: Filtered `ls`

Solution

```javascript
var fs = require( 'fs' );
var path = require( 'path' );
var ext = '.' + process.argv[ 3 ];

fs.readdir( process.argv[ 2 ], function( err, data ) {
    data.forEach( function( i ) {
        if ( path.extname( i ) == ext )
            console.log( i );
    } );
} );
```

nodejs/ex5-filtered-ls.js

For `fs.readdir()`, `data` is an array of the names of the files in the directory excluding '`.`' and '`..`'.

Instead of the ordinary for-loop which iterates from 0 to `data.length`, we use **`data.forEach()`** to iterate over all values in the array.
You need to provide a callback function which takes three optional arguments: (1) Current value, (2) Index & (3) The array `forEach()` was called upon.

Exercise 6: Make it modular

- **Problem:** Same as Exercise 5, but you need to make it **modular**

- Write a **module file** to do most of the work
  - The module should **export a function** which takes 3 arguments:
    1. The directory name
    2. The filename extension string (identical to the corresponding command-line argument)
    3. A callback function
  - The callback function should use the idiomatic node `(err, data)` convention
    - **err** is `null` if there is no errors; return the errors from `fs.readdir()` otherwise
    - **data** is the filtered list of files, as an Array
  - Nothing should be printed from your module file
    - Only print from the original program

Exercise 6: Make it modular

- From the problem statement, we induce the four requirements of a module:
  - **Export** a single function that takes exactly the **arguments** described
  - Call the **callback** exactly **once** with an error or some data as described
  - **Don't change anything** else, like global variables or `stdout`
  - Handle all the **errors** that may occur and pass them to the callback
    - Do **early-returns** within callback functions if there is an error

- A good Node.js developer should follow these rules!

Exercise 6: Make it modular

- In the module file (e.g., `module.js`), assign a function to the **`module.exports`** object to define a **single function export**:

```
module.exports = function (args) { /* ... */ }
```

- In your program, load the module (`module.js`) using the **`require()`** call ("`./`" indicates that it is a local module):

```
var module = require( './module' );
```

  – **Note:** "`.js`" can be omitted

- The `require()` call returns what you export in the module file
  – In this example, it returns a function that you can call directly!

Exercise 6: Make it modular

Solution

```js
var fs = require( 'fs' );
var path = require( 'path' );

module.exports = function( dirname, ext, callback ) {
    var ext = '.' + ext;
    fs.readdir( dirname, function( err, data ) {
        if ( err )
            return callback( err );

        var ret = data.filter( function( i ) {
            return ( path.extname( i ) == ext );
        } );
        callback( null, ret );
    } );
};
```

nodejs/ex6-make-it-modular-module.js *(Module file)*

Exercise 6: Make it modular

Solution

```
var fs = require( 'fs' );
var path = require( 'path' );

module.exports = function( dirname, ext, callback ) {
    var ext = '.' + ext;
    fs.readdir( dirname, function( err, data ) {
        if ( err )
            return callback( err );

        var ret = data.filter( function( i ) {
            return ( path.extname( i ) == ext );
        } );
        callback( null, ret );
    } );
};
```

Early-return

The `filter()` method creates a new array with all elements that pass the test implemented by the provided function.

nodejs/ex6-make-it-modular-module.js *(Module file)*

Exercise 6: Make it modular

Solution

```
var module = require( './ex6-make-it-modular-module' );
module( process.argv[ 2 ], process.argv[ 3 ], function( err, data ) {
    if ( err )
        console.error( "Error: " + err );

    data.forEach( function( i ) {
        console.log( i );
    } );
} );
```

nodejs/ex6-make-it-modular.js *(Main program)*

Exercise 6: Make it modular

Solution

Load a local module

```
var module = require( './ex6-make-it-modular-module' );
module( process.argv[ 2 ], process.argv[ 3 ], function( err, data ) {
    if ( err )
        console.error( "Error: " + err );

    data.forEach( function( i ) {
        console.log( i );
    } );
} );
```

Report errors

nodejs/ex6-make-it-modular.js *(Main program)*

Exercise 7: HTTP client

- **Problem:** Write a program that performs an **HTTP GET request** to a URL provided to you as the first command-line argument. Write the `String` contents of each "`data`" event from the response to a new line on the console (`stdout`).
  - **Note:** There is a sample scenario in Assignment 2 – retrieving video title from YouTube server using an HTTP GET request

- Use the **`http.get()`** method in the **`http`** module
  - http://nodejs.org/api/http.html#http_http_get_options_callback
  - *1st argument*: The URL you want to GET
  - *2nd argument*: A callback with the following signature:

    ```
    function callback ( response ) { /* ... */ }
    ```

Exercise 7: HTTP client

- The **response** object is a **Node Stream** object
  - It is an object that emits events
  - Register an **event listener** (`.on(*, callback)`) to handle the event
    - This is the core of "**event-driven architecture**"
  - For `http.get()`, the three events that are of most interests are: "**data**", "**error**" and "**end**"
    - See http://nodejs.org/api/http.html#http_http_incomingmessage and http://nodejs.org/api/stream.html#stream_class_stream_readable

- The `response` object has a **setEncoding()** method
  - If you call this method with "`utf8`", the **data** events emit `Strings` instead of the standard Node **Buffer** objects

Exercise 7: HTTP client

Solution

```
var http = require( 'http' );
http.get( process.argv[ 2 ], function( response ) {
    response.setEncoding( 'utf8' );
    response
        .on( 'data', console.log )
        .on( 'error', console.error );
} );
```

nodejs/ex7-http-client.js

Exercise 7: HTTP client

Solution

```
var http = require( 'http' );
http.get( process.argv[ 2 ], function( response ) {
    response.setEncoding( 'utf8' );
    response
        .on( 'data', console.log )
        .on( 'error', console.error );
} );
```

nodejs/ex7-http-client.js

`console.log()` and `console.error()` are functions! You don't need to wrap it in your own functions as the event listener.

The "`.on( <event name>, <listener/callback> )`" method returns the emitter (e.g., `response` in this example). Therefore this call can be chained.

Exercise 8: HTTP collect

- **Problem:** Write a program that performs an HTTP GET request to a URL provided to you as the first command-line argument. Collect **all data** from the server (not just the first "`data`" event) and then write two lines to the console (`stdout`).
    - *1st line*: The **number of characters** received from the server
    - *2nd line*: The **complete `String` of characters** sent by the server
- Two approaches:
    - Collect and append data across multiple "`data`" events. Write the output when an "end" event is emitted
    - Use a **third-party package** to abstract the difficulties involved in collecting an entire stream of data, e.g., `bl` and `concat-stream`

Exercise 8: HTTP collect

- Let's try the second approach to explore an important component in Node.js: **npm** – the **package manager** for node
  - FYI, the package manager for Python is **pip**

- To install the Node package `bl`, type in the terminal:

  ```
  $ npm install bl
  ```

  - npm will download and install the latest version of the package into a subdirectory named **node_modules**

- When you write "**var bl = require('bl');**" in your program, Node will first look in the **core modules**, and then in the **node_modules** directory where the package is located.

- Read https://www.npmjs.com/package/bl for its usage

Exercise 8: HTTP collect

Solution

```
var http = require( 'http' );
var bl = require( 'bl' );
http.get( process.argv[ 2 ], function( response ) {
    response.pipe(
        bl(
            function( err, data ) {
                if ( err )
                    return console.error( "Error: " + err );
                data = data.toString();
                console.log( data.length );
                console.log( data );
            }
        )
    );
} );
```

nodejs/ex8-http-collect.js

Note that `data` is a Buffer object so you need to convert it to `String` with `toString()`.

Exercise 9: Juggling async

- **Problem:** Same as Exercise 8, but this time you will be provided with **3 URLs** as the first 3 command-line arguments
  - Print the complete content provided by each of the URLs to the console (`stdout`), one line per URL
  - No need to print out the length
  - The content must be printed out in the **same order** as the URLs are provided to you as command-line arguments

- **This exercise is tricky!**
  - `http.get()` is an asynchronous call
  - The callback function is executed when any of the servers response
  - The responses will probably be **out of order**!
    - You need to **queue the results** and print the data when all data is ready

Exercise 9: Juggling async

Solution

Modifying from the solution of Exercise 8...

```javascript
var http = require( 'http' );
var bl = require( 'bl' );



    http.get( process.argv[ 2 ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            data = data.toString();
            console.log( data.length );
            console.log( data );



        } ) );
    } );
```

nodejs/ex9-juggling-async-wrong.js

Exercise 9: Juggling async

Solution

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            ret[ i - 2 ] = data.toString();
            count++;




        } ) );
    } );
}
```

Modifying from the solution of Exercise 8...

Iterate over the 3 URLs and save the responses to the `ret` array. Count the number of responses received in `count`.

nodejs/ex9-juggling-async-wrong.js

Solution

Exercise 9: Juggling async

Modifying from the solution of Exercise 8...

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            ret[ i - 2 ] = data.toString();
            count++;

            if ( count == 3 ) {
                for ( var j = 0; j < 3; j++ )
                    console.log( ret[ j ] );
            }
        } ) );
    } );
}
```

Print the data to the console when all 3 responses are received.

nodejs/ex9-juggling-async-wrong.js

Exercise 9: Juggling async

Wrong Solution

```javascript
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            ret[ i - 2 ] = data.toString();
            count++;

            if ( count == 3 ) {
                for ( var j = 0; j < 3; j++ )
                    console.log( ret[ j ] );
            }
        } ) );
    } );
}
```

Sorry...this solution is wrong! Why?

nodejs/ex9-juggling-async-wrong.js

Exercise 9: Juggling async

Wrong Solution

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            ret[ i - 2 ] = data.toString();
            count++;

            if ( count == 3 ) {
                for ( var j = 0; j < 3; j++ )
                    console.log( ret[ j ] );
            }
        } ) );
    } );
}
```
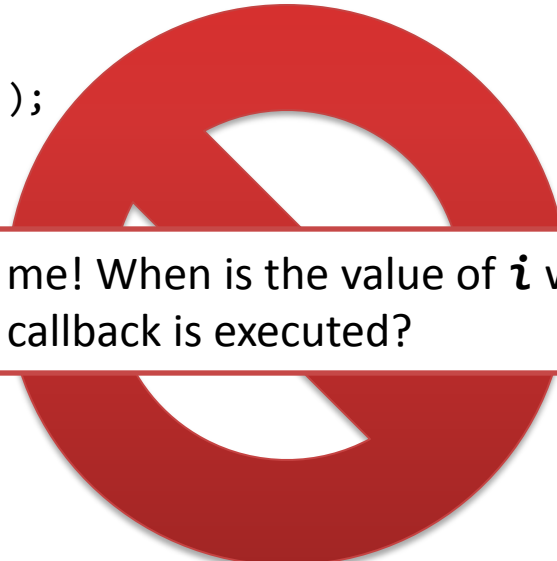
Tell me! When is the value of i when the callback is executed?

nodejs/ex9-juggling-async-wrong.js

Exercise 9: Juggling async

Wrong Solution

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function( response ) {
        response.pipe( bl( function( err, data ) {
            if ( err )
                return console.error( "Error: " + err );
            ret[ i - 2 ] = data.toString();
            count++;

            if ( count == 3 ) {
                for ( var j = 0; j < 3; j++ )
                    console.log( ret[ j ] );
            }
        } ) );
    } );
}
```

The value of i is **evaluated** only **when the callback is executed**. Since the for-loop has probably completed, i **= 5 no matter which callback is executed**.

nodejs/ex9-juggling-async-wrong.js

Exercise 9: Juggling async

Right Solution

Modifying from the wrong solution…

```javascript
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ],

            function( response ) {
            response.pipe( bl( function( err, data ) {
                if ( err )
                    return console.error( "Error: " + err );
                ret[    i - 2 ] = data.toString();
                count++;

                if ( count == 3 ) {
                    for ( var j = 0; j < 3; j++ )
                        console.log( ret[ j ] );
                }
            } ) );
        }
    );
}
```

nodejs/ex9-juggling-async-right.js

Exercise 9: Juggling async

Right Solution

Modifying from the wrong solution…

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function() {

        return function( response ) {
            response.pipe( bl( function( err, data ) {
                if ( err )
                    return console.error( "Error: "
                ret[    i - 2 ] = data.toString();
                count++;

                if ( count == 3 ) {
                    for ( var j = 0; j < 3; j++ )
                        console.log( ret[ j ] );
                }
            } ) );
        }
    }() );
}
```

To save the current value of i, we need a **closure**.
"Closures are functions that refer to independent (free) variables. In other words, the function defined in the closure 'remembers' the environment in which it was created."

nodejs/ex9-juggling-async-right.js

Exercise 9: Juggling async

Right Solution

Modifying from the wrong solution…

```
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function() {

        return function( response ) {
            response.pipe( bl( function( err, data ) {
                if ( err )
                    return console.error( "Error: " + err );
                ret[    i - 2 ] = data.toString();
                count++;

                if ( count == 3 ) {
                    for ( var j = 0; j < 3; j++ )
                        console.log( ret[ j ] );
                }
            } ) );
        }
    }() );
}
```

This returned function defines a closure.

nodejs/ex9-juggling-async-right.js

Exercise 9: Juggling async

Right Solution

Modifying from the wrong solution…

```javascript
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function() {
        var my_i = i;
        return function( response ) {
            response.pipe( bl( function( err, data ) {
                if ( err )
                    return console.error( "Error: " + err );
                ret[ my_i - 2 ] = data.toString();
                count++;

                if ( count == 3 ) {
                    for ( var j = 0; j < 3; j++ )
                        console.log( ret[ j ] );
                }
            } ) );
        }() );
    }
}
```

Save and use the current value of *i* inside the closure.

nodejs/ex9-juggling-async-right.js

Exercise 9: Juggling async

Right Solution

```javascript
var http = require( 'http' );
var bl = require( 'bl' );
var ret = [];
var count = 0;
for ( var i = 2; i < 5; i++ ) {
    http.get( process.argv[ i ], function() {
        var my_i = i;
        return function( response ) {
            response.pipe( bl( function( err, data ) {
                if ( err )
                    return console.error( "Error: " + err );
                ret[ my_i - 2 ] = data.toString();
                count++;

                if ( count == 3 ) {
                    for ( var j = 0; j < 3; j++ )
                        console.log( ret[ j ] );
                }
            } ) );
        }
    }() );
}
```

nodejs/ex9-juggling-async-right.js

Exercise 10: Time server

- **Problem:** Write a TCP time server!
  - Your server should listen to **TCP connections** on the port provided by the first argument to your program
  - For each connection you must write the **current date & 24 hour time** in the format: "**YYYY-MM-DD hh:mm**", followed by a newline character
  - Month, day, hour and minute must be zero-filled to 2 integers
    - For example: "2013-07-06 17:42"

- This exercise demonstrates the power of Node.js!
  - Challenge to CSCI 4430 students: Solve this problem in **C/C++ socket programming**!

Exercise 10: Time server

- To create a **raw TCP server**, use the **net** module
  - Use the method named **net.createServer()**
    - It returns an instance of your server
    - To start listening on a particular port, use **server.listen(*<port>*)**
    - It takes a callback function with the following signature:

      ```
      function callback ( socket ) { /* ... */ }
      ```

  - The **socket** object passed into the callback function contains a lot of metadata regarding the connection
  - To write data to the **socket**: `socket.write( data );`
  - To close the **socket**: `socket.end();`

    `socket.end( data );`

    Can be combined

  - **Ref.:** http://nodejs.org/api/net.html

Exercise 10: Time server

- To create the date, you will need to create a custom format from a **new Date()** object

- The following methods will be useful:

  - `date.getFullYear()`
  - `date.getMonth()        // starts at 0`
  - `date.getDate()        // returns the day of month`
  - `date.getHours()`
  - `date.getMinutes()`

Exercise 10: Time server

```
var net = require( 'net' );
var server = net.createServer( function( socket ) {
    var date = new Date();
    var zerofill = function( val ) {
        return ( val <= 9 ? '0' : '' ) + val;
    };

    socket.end( date.getFullYear() + '-'
                + zerofill( date.getMonth() + 1 ) + '-'
                + zerofill( date.getDate() ) + ' '
                + zerofill( date.getHours() ) + ':'
                + zerofill( date.getMinutes() ) + '\n' );

} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex10-time-server.js

Exercise 11: HTTP file server

- *Now we are ready to learn how to use Node.js to implement server-side program!*

- **Problem:** Write an **HTTP server** that **serves the same text file** for each request it receives
  - *1st argument*: **Port number** that the server listens on
  - *2nd argument*: The **location** of the file to serve

- You must use the `fs.createReadStream()` method to stream the file contents to the response
  - It creates a **stream** representing the file
  - Use `src.pipe( dst )` to pipe data from the **src** stream to the **dst** stream

Exercise 11: HTTP file server

- Use the **http** module to create an HTTP server
  - **http.createServer()** take a callback that is called once for each connection received by your server

    ```
    function callback ( request, response ) { /* ... */ }
    ```

  - The two arguments are **Node stream** objects representing the HTTP request and the corresponding response
    - Request is used for **fetch properties**, e.g., the header and query string
    - Response is for **sending data to the client**, both headers and body
  - *Ref.:* http://nodejs.org/api/http.html

Exercise 11: HTTP file server

Solution

```
var http = require( 'http' );
var fs = require( 'fs' );

var server = http.createServer( function( request, response ) {
    response.writeHead( 200, { 'Content-Type' : 'text/plain' } );
    fs.createReadStream( process.argv[ 3 ] ).pipe( response );
} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex11-http-file-server.js

Exercise 11: HTTP file server

Solution

```
var http = require( 'http' );
var fs = require( 'fs' );

var server = http.createServer( function( request, response ) {
    response.writeHead( 200, { 'Content-Type' : 'text/plain' } );
    fs.createReadStream( process.argv[ 3 ] ).pipe( response );
} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex11-http-file-server.js

Write the status code and headers using the **response.writeHead()** method.

Pipe the data from the stream representing the file to the `response` stream.

Exercise 12: HTTP uppercaserer

- **Problem:** Write an HTTP server that **receives only POST requests** and converts incoming **POST body characters** to **upper-case** and returns it to the client
  - *1ˢᵗ argument*: **Port number** that the server listens on
- You can use the "**through2-map**" module to create a **transform stream** using only a single function that takes a **chunk of data** and returns a chunk of data
  - Install **through2-map** using **npm**
  - Read https://www.npmjs.com/package/through2-map for its usage

Exercise 12: HTTP uppercaserer

Solution

```
var http = require( 'http' );
var map = require( 'through2-map' );

var server = http.createServer( function( request, response ) {
    if ( request.method != 'POST' )
        return response.end( 'Only POST requests are accepted' );

    request
        .pipe( map( function( chunk ) {
            return chunk.toString().toUpperCase();
        } ) )
        .pipe( response );
} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex12-http-uppercaserer.js

Exercise 12: HTTP uppercaserer

Solution

```
var http = require( 'http' );
var map = require( 'through2-map' );

var server = http.createServer( function( request, response ) {
    if ( request.method != 'POST' )
        return response.end( 'Only POST requests are accepted' );

    request
        .pipe( map( function( chunk ) {
            return chunk.toString().toUpperCase();
        } ) )
        .pipe( response );
} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex12-http-uppercaserer.js

Check is the request is a **POST** request.

Pipe the data from the **request** stream to the **transform stream**.

Pipe the data from the **transform stream** to the **response** stream.

Exercise 13: HTTP JSON API server

- **Problem:** Write an HTTP server that serves **JSON data** when it
  - Receives a GET request to the path "**/api/parsetime**"
    - The JSON response should contain only '**hour**', '**minute**' and '**second**' properties
  - Receives a GET request to the path "**/api/unixtime**"
    - The JSON response should contain the **UNIX epoch time in milliseconds** (the number of milliseconds since 1 Jan 1970 00:00:00 UTC) under the property '**unixtime**'
  - Both requests accept a query string with a key '**iso**' and an ISO-format time as the value
  - *1ˢᵗ argument of the program*: **Port number** that the server listens on

Exercise 13: HTTP JSON API server

- Use the **`url.parse()`** method in the **`url`** module to parse the URL and query string
  - *Ref.:* http://nodejs.org/api/url.html

- Use **`JSON.stringify()`** to convert an object into JSON string format

- To parse a date in **ISO format**, use **`new Date(`** *`<ISO date string>`* **`)`**

- Use **`date.getTime()`** to get the **UNIX epoch time in milliseconds**

Exercise 13: HTTP JSON API server

Solution

```
var http = require( 'http' );
var url = require( 'url' );

var server = http.createServer( function( request, response ) {
    var parsedUrl = url.parse( request.url, true );
    var ret = {};

    switch( parsedUrl.pathname ) {
        case '/api/parsetime':
            var date = new Date( parsedUrl.query.iso );
            ret.hour = date.getHours();
            ret.minute = date.getMinutes();
            ret.second = date.getSeconds();
            break;
```

Check the URL to determine the endpoints.

Read the **iso** property in the query string.

nodejs/ex13-http-json-api-server.js

Exercise 13: HTTP JSON API server

(Continued)

```
        case '/api/unixtime':
            var date = new Date( parsedUrl.query.iso );
            ret.unixtime = date.getTime();
            break;
        default:
            return response.writeHead( 404 ).end();
    }

    response.writeHead( 200, { 'Content-Type' : 'application/json' } );
    response.end( JSON.stringify( ret ) );
} );
server.listen( Number( process.argv[ 2 ] ) );
```

nodejs/ex13-http-json-api-server.js

Congratulations!

- You have learnt the fundamental concepts involved in Node.js development!

- To develop web applications even faster, we will use a **web framework** called **Express**

  – Please refer to the corresponding tutorial slides

– End –