Introduction to Node.js

Overview, Modules, Web Server, Request and Response

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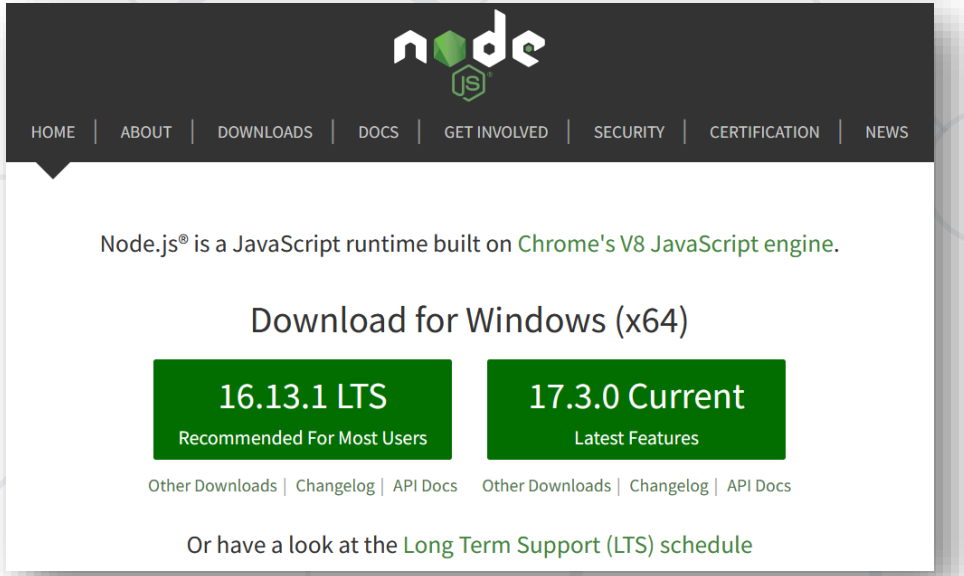
Introduction to Node.js

Node.js Overview

- A runtime environment for JS that runs on the server
- Advantages
  - **One language** for server and client
  - **Asynchronous** and **Event** Driven
  - Very **fast**
  - Efficient **package manager**

Installation

- Go to http://nodejs.org and install the latest version



- To check the currently installed version of the node, type in the **command prompt/terminal**:

```
node -v
```

Environment Setup

- From the **terminal**

```
node        // Starts REPL
let a = 5
let b = 3
a + b       // 8
```

- Interpret code from a **file**
  - Save the script to **index.js**
  - Execute from the terminal:

```
node index.js
```

NPM Packages

Node.js **projects** are usually set up as **NPM packages**

- From the **terminal**, inside the **target directory**

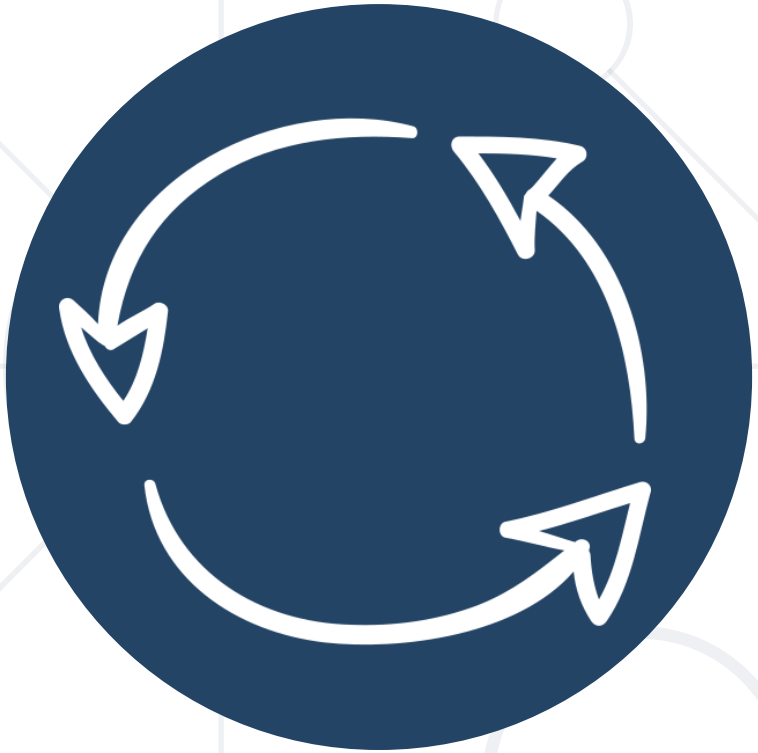
```
npm init
```

- Answer **questions** to initialize the project
- A **package.json** file will be created with initial configuration
- To bypass all questions (take default values):

```
npm init -y
```

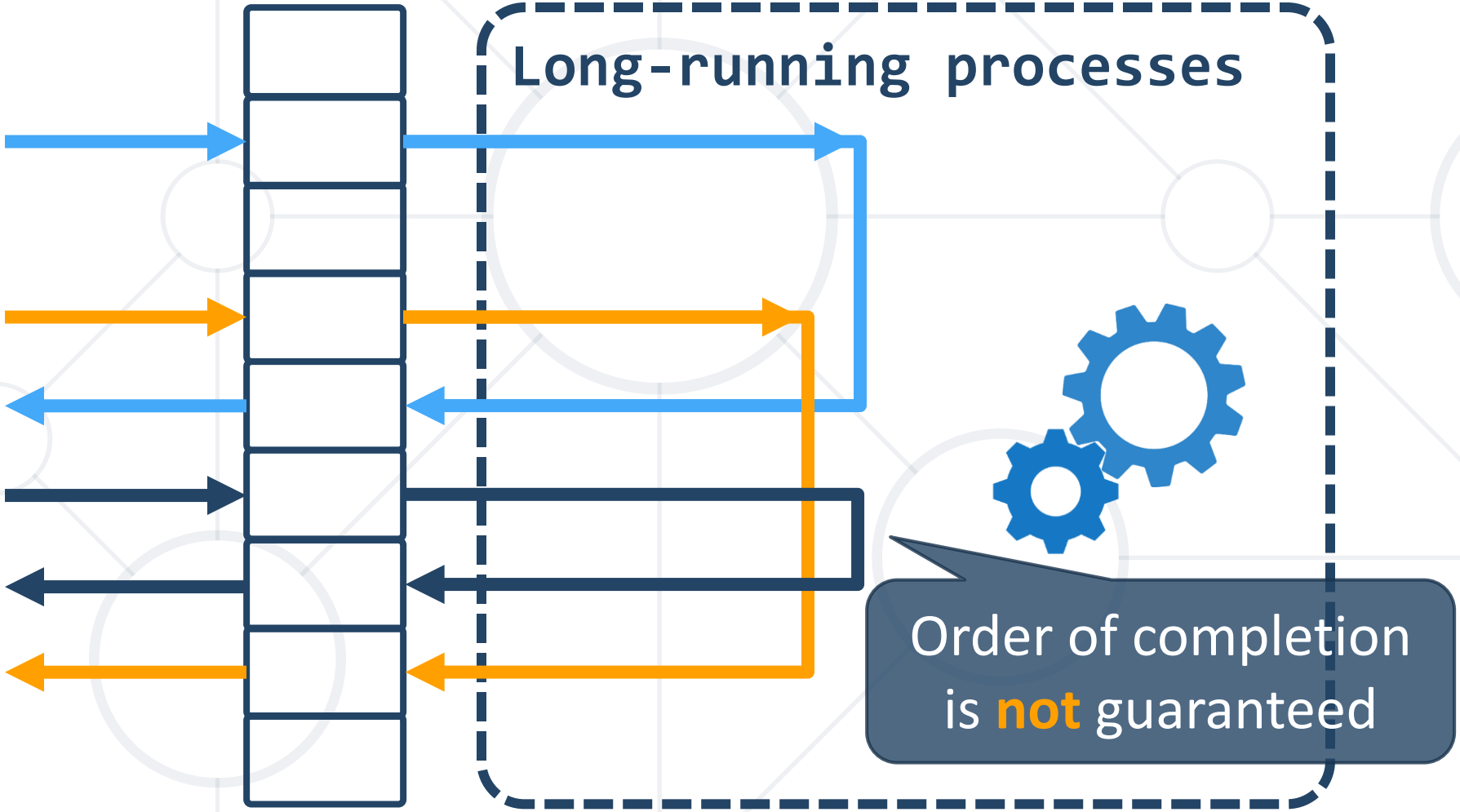
Configuration (Package.json)

```
{
  "name": "demo",
  "version": "1.0.0",
  "description": "Node.js demo project",
  "main": "index.js",
  "engines": {          // Sets versions of Node.js
    "node": ">= 6.0.0",           and other commands
    "npm": ">= 3.0.0" },
  "scripts": {          // Defines a set of node scripts
    "start": "node index.js" },
  "keywords": [],
  "author": "",
  "license": "ISC"
}
```



Event Loop

The Event Loop



Stack calls

```
function foo(x) {
    return x * x;
}
function bar(y) {
    return foo(y + 2);
}

bar(8);
```

Stack

Stack calls

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bar(8)

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Stack

foo(10)

bar(8)

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Stack calls

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function foo(x) {
    return x * x;
}
function bar(y) {
    return foo(y + 2);
}

bar(8);
```

Stack

```
function init(el){
    el.addEventListener(
        "click",
        handler
    );
}
```

Stack calls

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Hidden implementation

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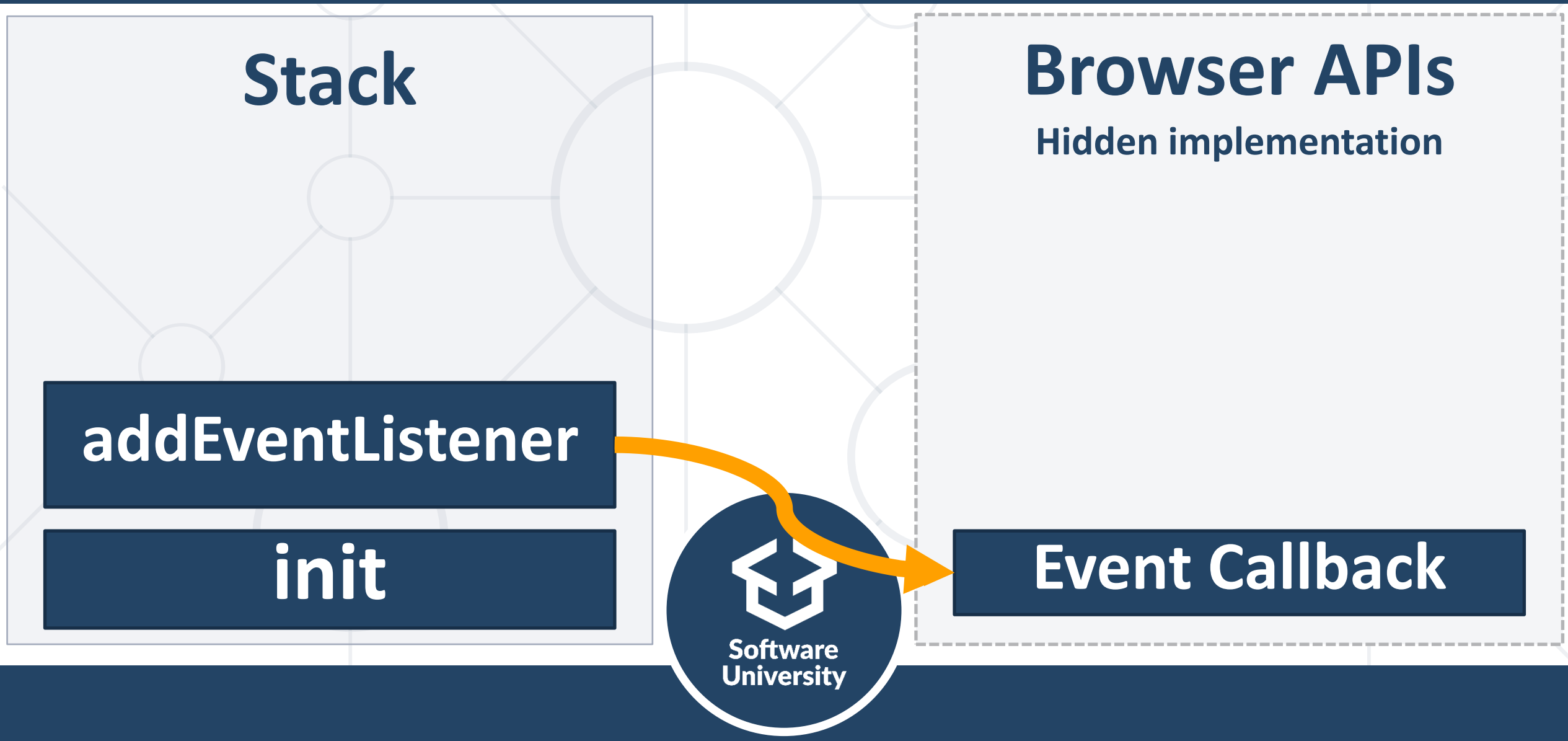
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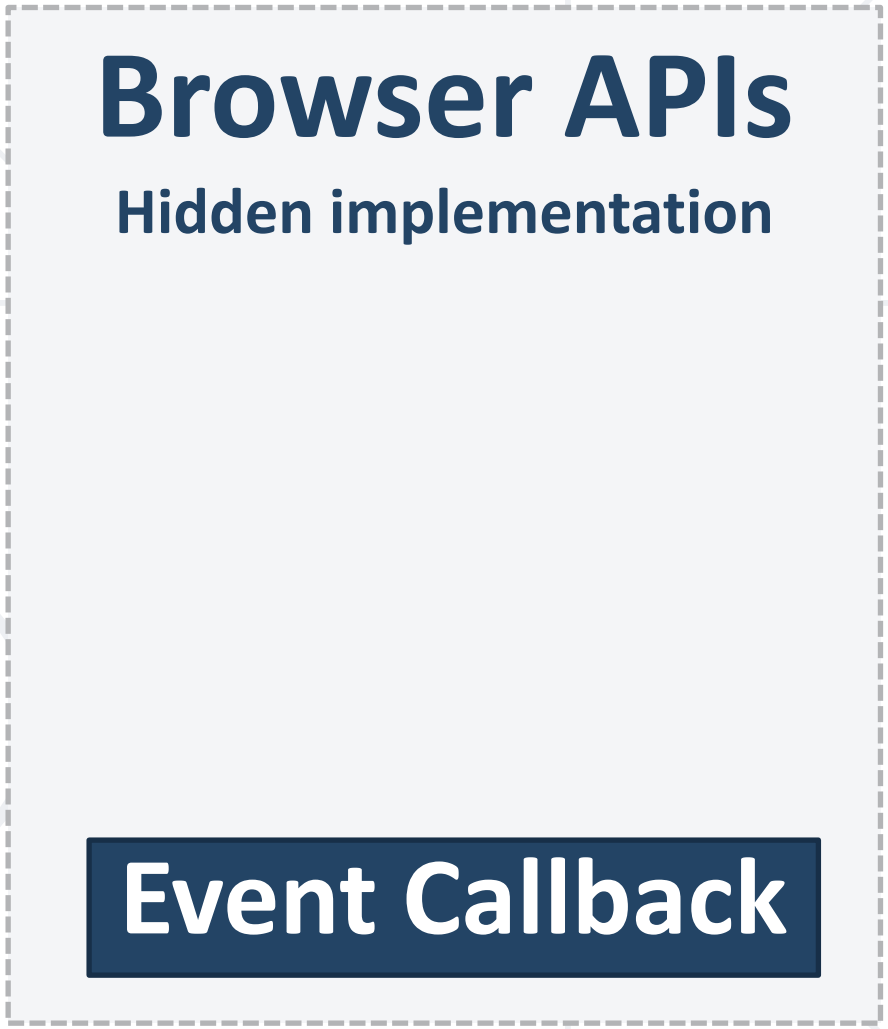

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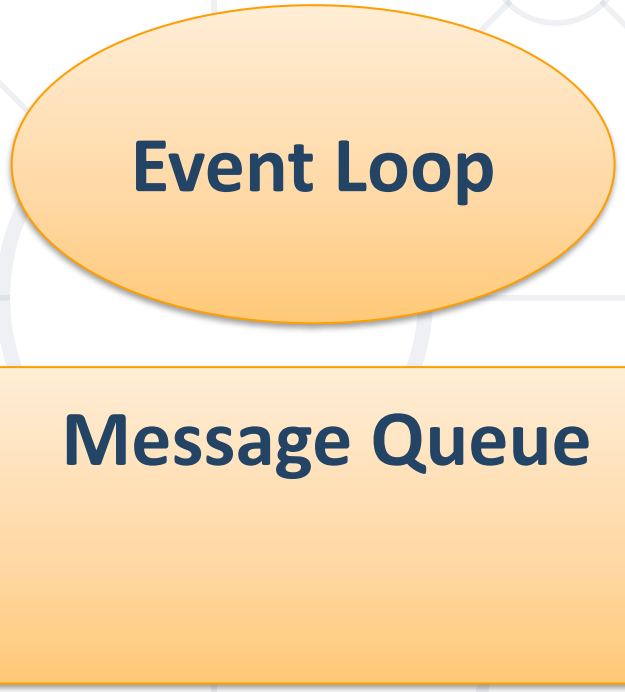

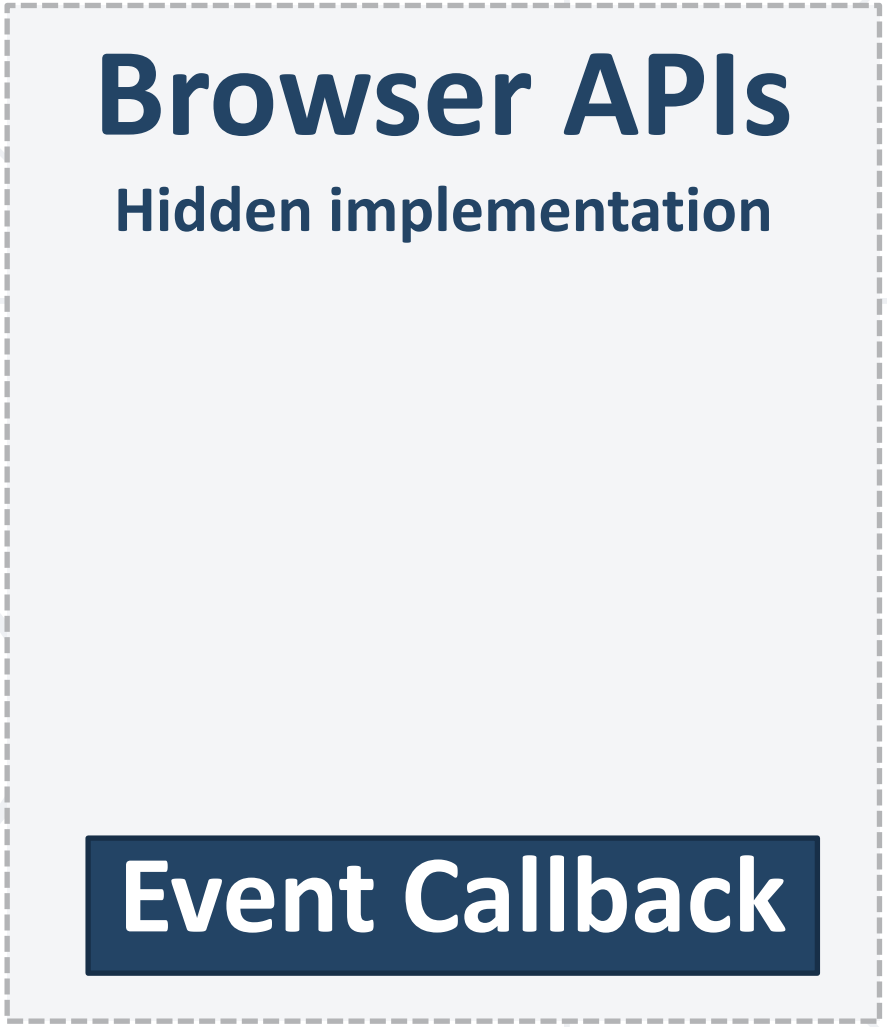

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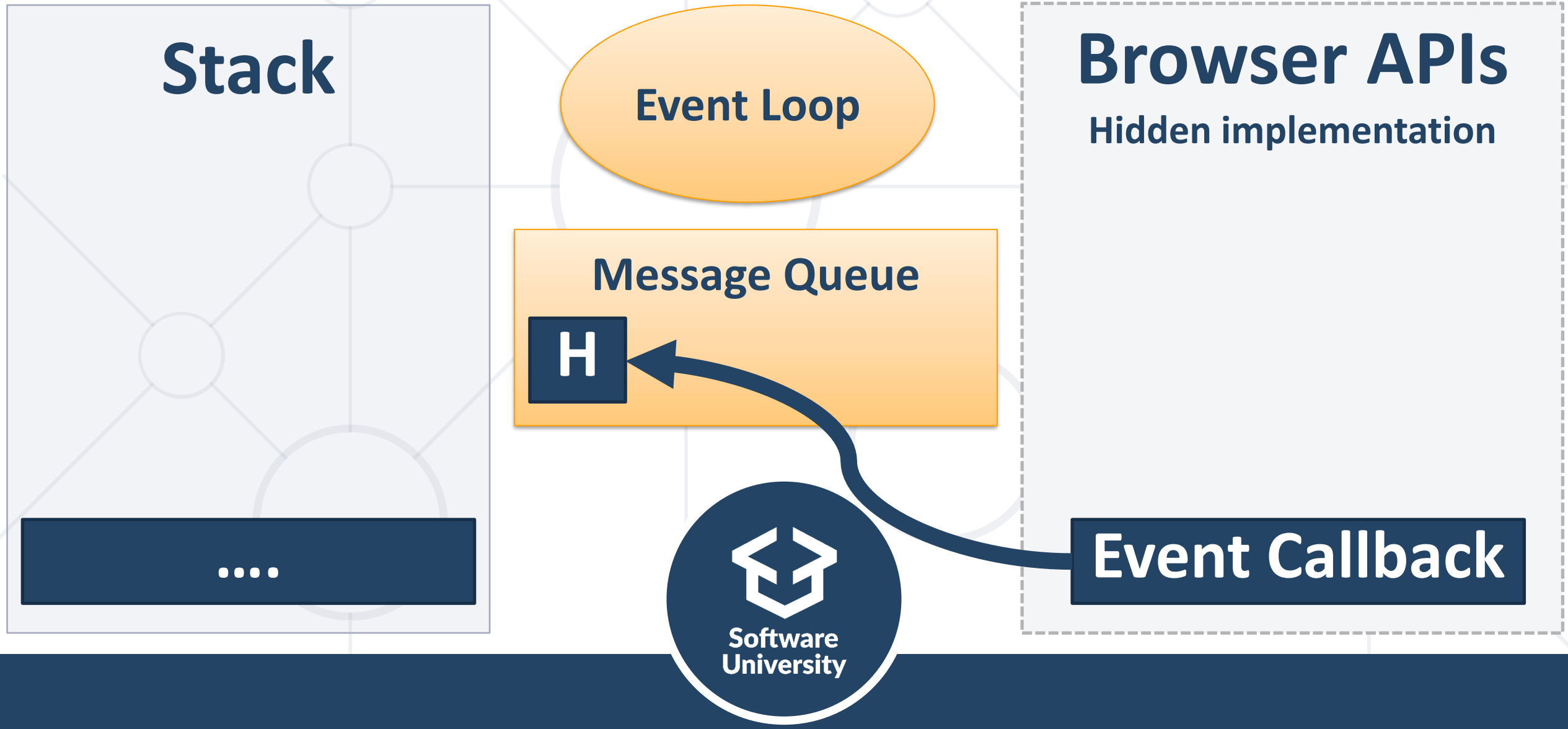
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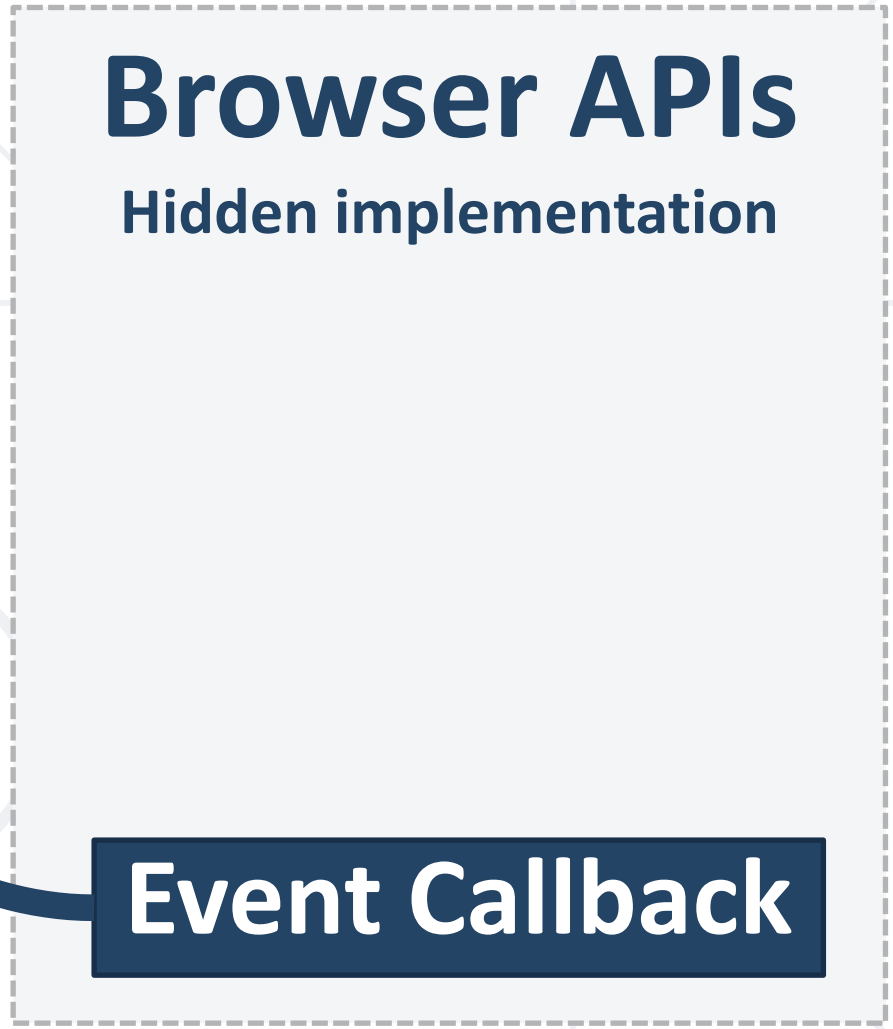
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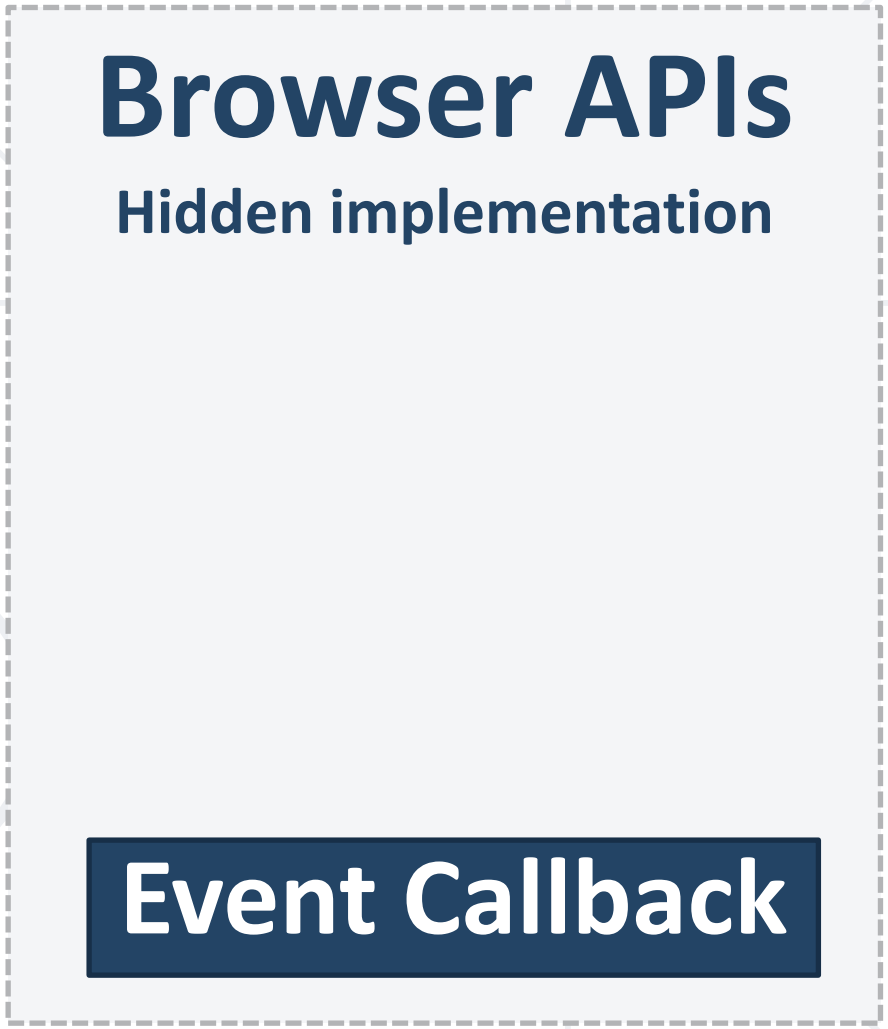
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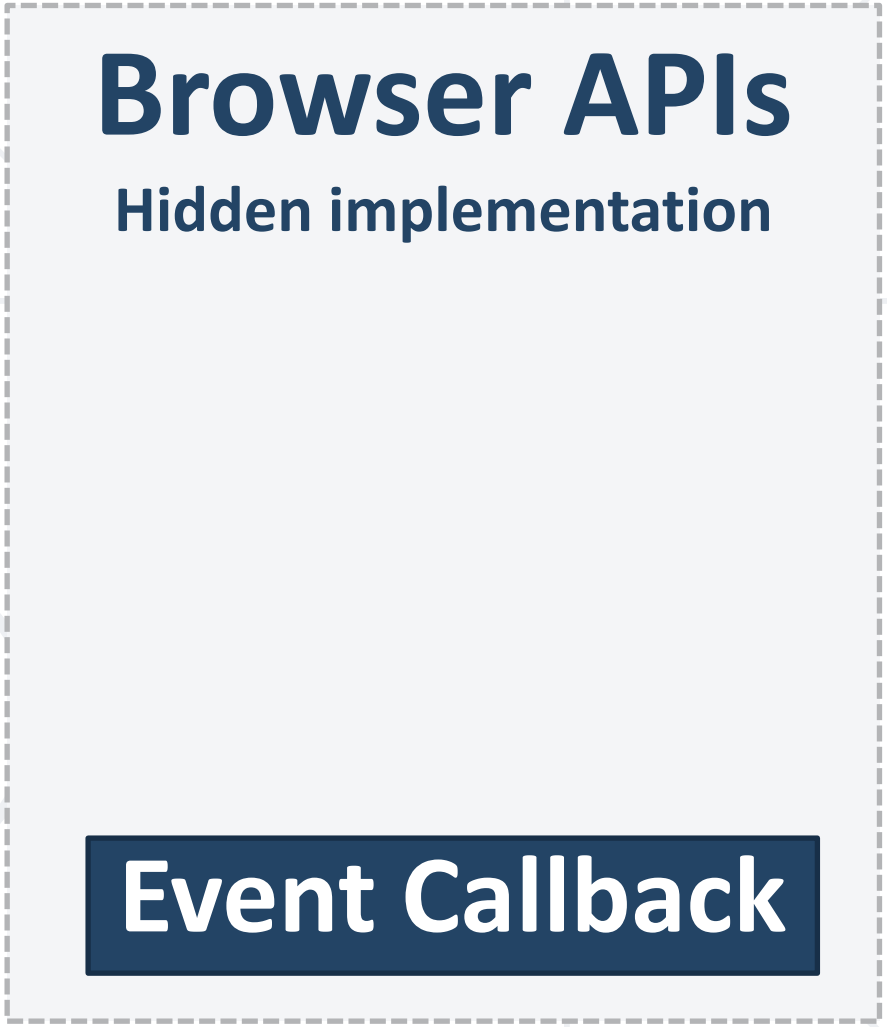
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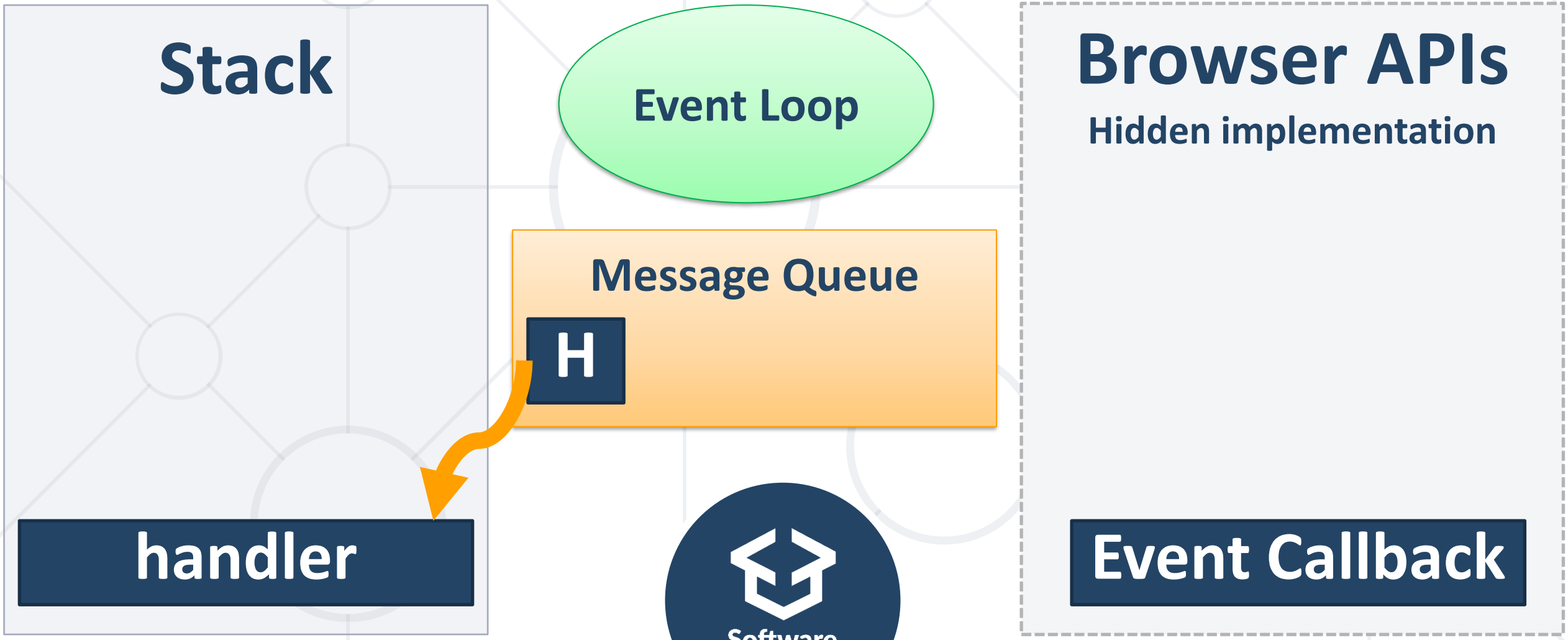
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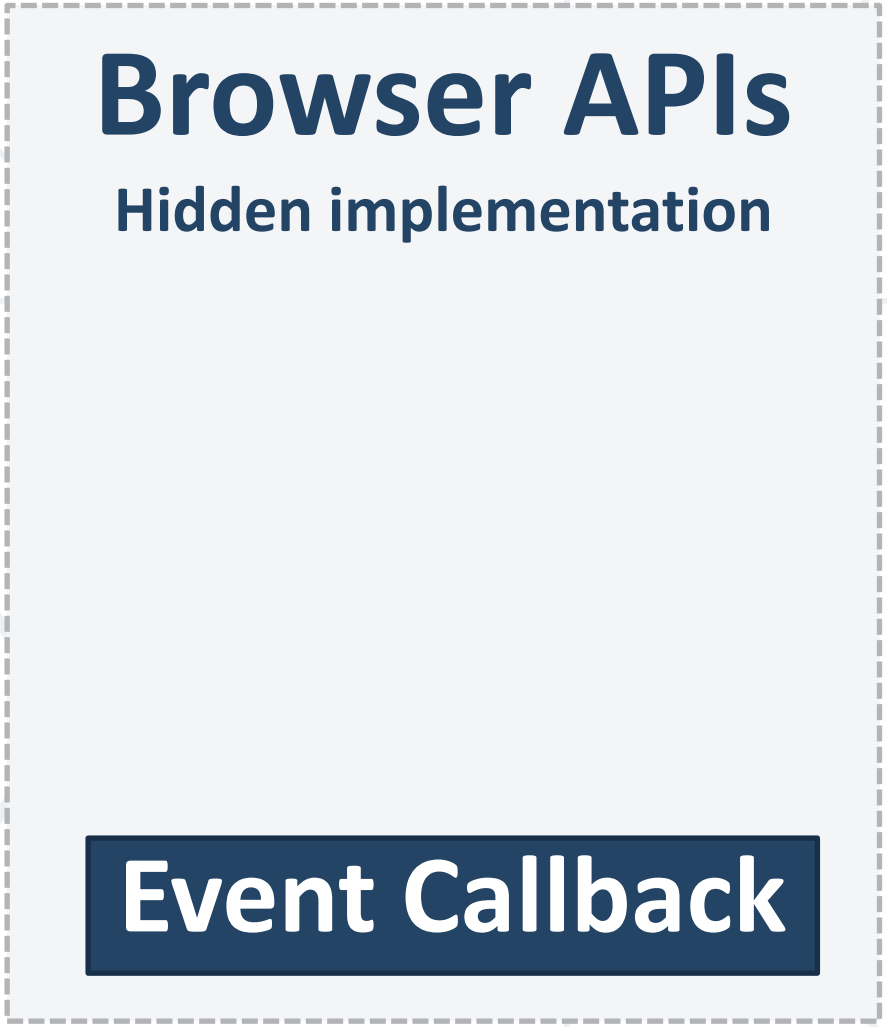
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Modules

Modules

- Allow larger **apps** to be **split** and **organized**
- Each module has its **own context**
  - It **cannot pollute** the **global scope**
- Node.js includes **three types** of modules
  - **Core** Modules
  - **Local** Modules
  - **Third-Party** Modules

Local Modules

- Created **locally** in the Node.js application
- Include **different functionalities** in **separate** folders
- Use `module.exports` to expose a **function**, **object** or **variable**

```
module.exports = myModule
```

- Loaded using the `require()` function

```
const myModule = require('./myModule.js');
```

Third-Party Modules

- Installed from Node Package Manager (**NPM**)
- Run from the terminal

```
npm install express --save-exact
```

- To use in your code

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

- To install globally (for use from the terminal)

```
npm install mocha -g
```


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Core Modules

- Includes all **functionalities** of Node.js
- Load **automatically** when Node.js process starts
- Need to be **imported** in order to be used

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

- Commonly used modules are
  - **http** - used to create Node.js server
  - **url**, **querystring**, **path**, **fs**

URL Module

- Provides utilities for URL **resolution** and **parsing**

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

- Parses an address with the **parse()** function
  - Returns an **object** with **info** about the **url**

```
let urlObj = url.parse(req.url);
```

- **Splits** web address into **readable** parts

URL Parts

- Host '**localhost:8080**'

```
let host = urlObj.host
```

- Path '**/home**'

```
let path = urlObj.pathname
```

- Search/query '**?year=2017&month=february**'

```
let query = urlObj.query
```

```
let search = urlObj.search
```

Query String Module

- Provides utilities for **parsing** and **formatting** URL query strings

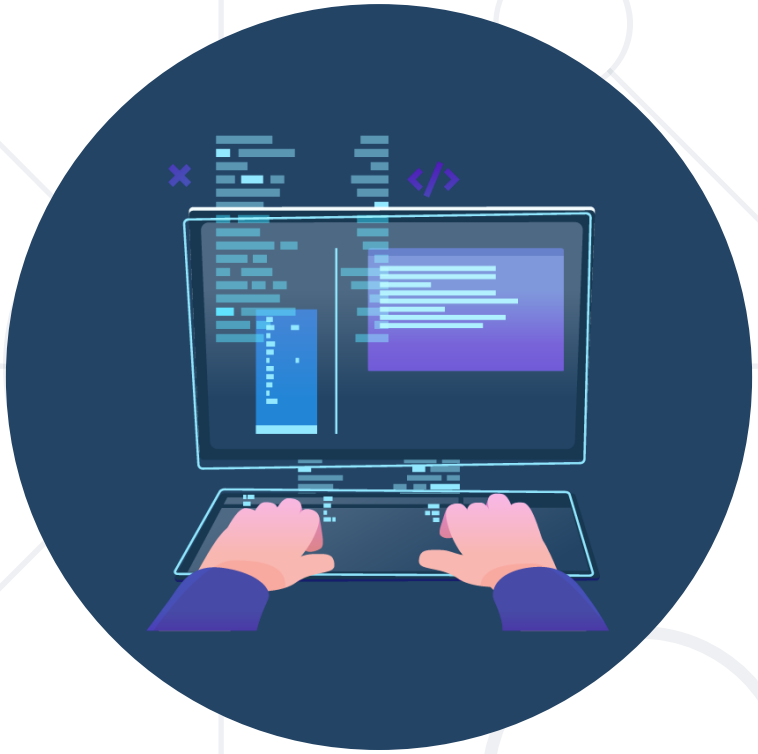
```
const queryString = require('querystring');
```

- Parses a query string into an object

```
const qs = querystring
  .parse('year=2017&month=february');
```

```
const year = qs.year;          // 2017
```

```
const month = qs.month;      // february
```



Node.js Web Server

Web Servers

- All **physical** servers have **hardware**
- The hardware is controlled by the **operating system**
- **Web servers** are **software** products that use the operating system to **handle web requests**
  - Web servers **serve** Web content
- The requests are **redirected to other software** products (ASP.NET, PHP, etc.), depending on the webserver **settings**

Node.js Web Server

- Creating a simple Node.js web server

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

http.createServer((req, res) => {
  res.write('Hi!');
  res.end();
}).listen(1337);

console.log('Node.js server running on port 1337');
```

Request & Response Wrappers

The Request Wrapper

- Used to **handle** incoming http requests
- Properties
  - **httpVersion** - '1.1' or '1.0'
  - **headers** - object for request headers
  - **method** - 'GET', 'POST', etc.
  - **url** - the URL of the request

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Request Wrapper Example

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```
const http = require('http');
const url = require('url');
const port = 1337;

http.createServer((req, res) => {
  let path = url.parse(req['url']).pathname;
  if (path === '/') {
     // TODO: Send 'Welcome to home page!'
  }
}).listen(port);
```

The Response Wrapper

- Used to **retrieve** a **response** to the **client**
- Functions
  - Create **response header**
  - Send the actual **content** to the **client**
  - **End** the response

Response Wrapper Example

```
const http = require('http');
const port = 3000;

http.createServer((req, res) => {
  res.writeHead(200, { // Response Status Code
    'Content-Type': 'text/plain'
  });
  res.write('Hello from Node.js'); // UTF-8 Encoding
  res.end(); // Always End the Response
}).listen(port);
```

Live Exercises

Summary

- Node.js is a **fast** and **asynchronous** efficient **package manager**
- Applications can be **organized** using **module**
- NPM allows quick access to **external modules**
- **Web Servers** transfer resources to the **Client**
- The **Request/Response** Wrappers

Questions?

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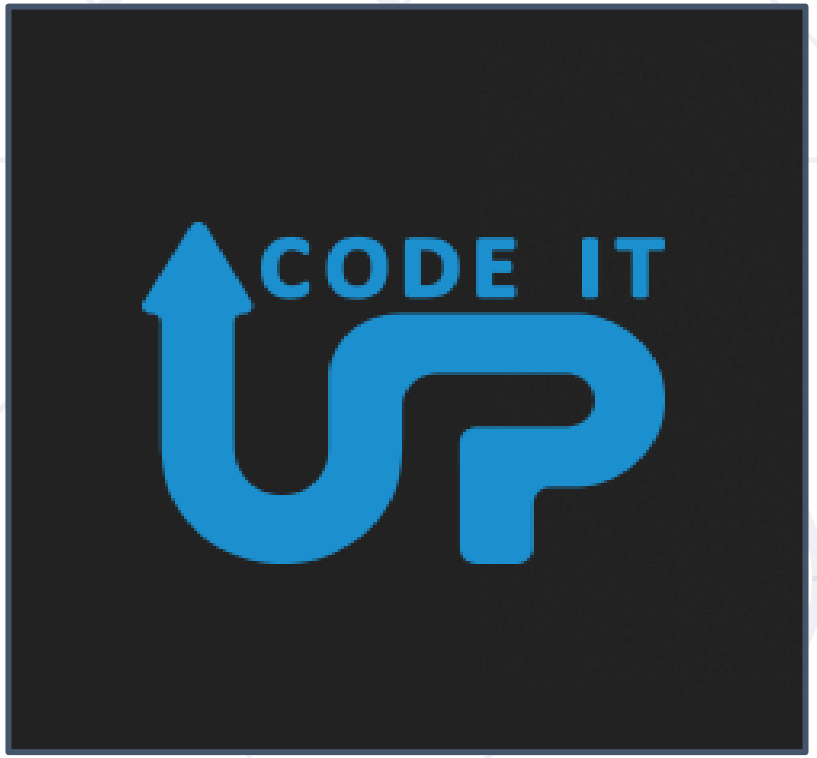

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Streams and Utilities

Streams, Pub/Sub Pattern, Events, FS Module

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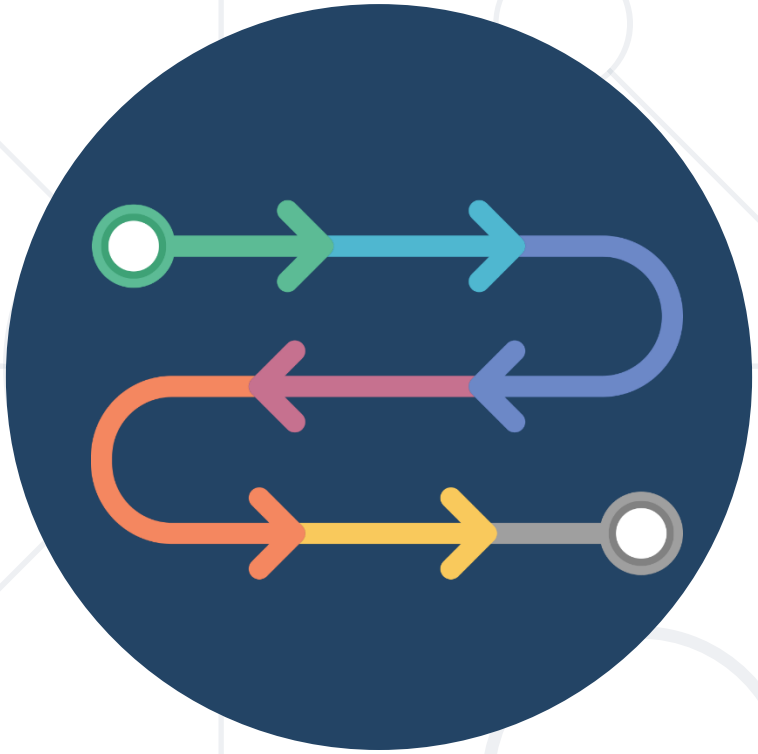


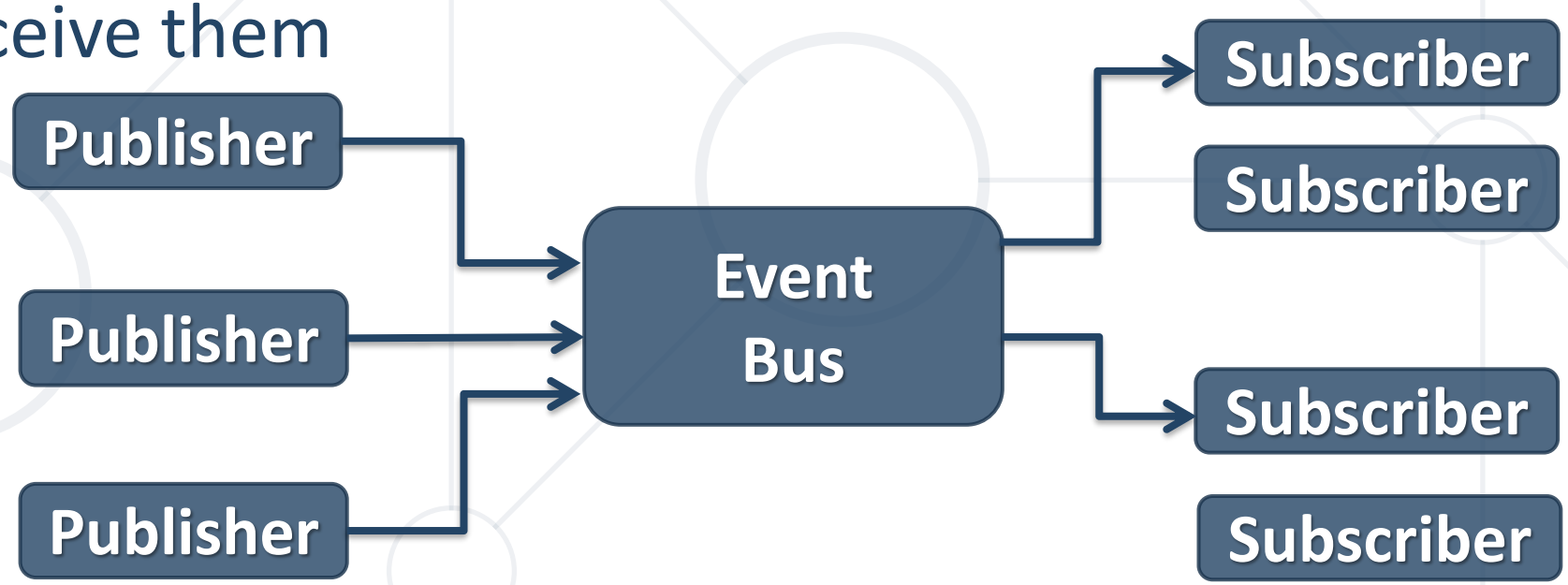
Publish-Subscribe Pattern

What is Pub/Sub?

- Used to **communicate messages** between different system components without them knowing anything about each other's **identity**
  - **Senders** (publishers), do not program the messages to be sent directly to specific **receivers** (subscribers)
  - Subscribers express interest in **one or more events**, and only **receive messages** that are of **interest**

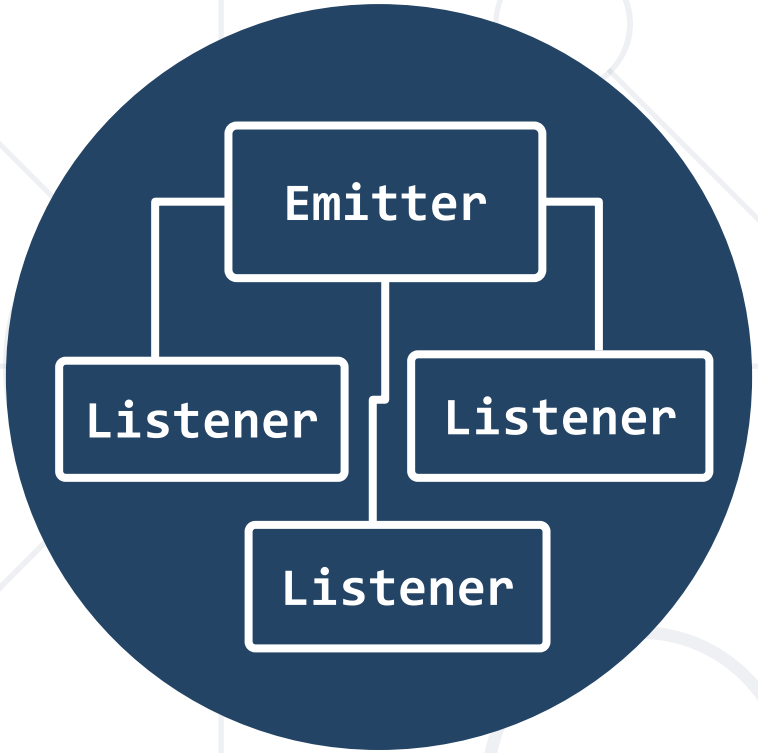
Pub/Sub Example

- An **intermediary** (called a "**message broker**" or "**event bus**")
  - Receives **published** messages
  - Forwards them to the **subscribers** who are registered to receive them



Advantages

- Decouple and Scale Independently
  - Makes software more **flexible**
- Eliminate Polling
  - Promotes **faster response time** and **reduces the delivery latency**
- Simplify Communication
  - Reduces complexity by **removing** all the **point-to-point connections** with a single connection



Events

Events

- Require module "**events**"

```
const events = require('events');
let eventEmitter = new events.EventEmitter();

eventEmitter.on('click', (a, b) => {
  console.log('A click has been detected!');
  console.log(a + ' ' + b); // outputs 'Hello world'
});

eventEmitter.emit('click', 'Hello', 'world');
```

- Events are **not** asynchronous

Streams

Streams

- **Collections of data** that is not available at once
  - Data may come **continuously** in **chunks**
- Types
  - **Readable** - can only be read (process.stdin)
  - **Writeable** - can only be written to (process.stdout)
  - **Duplex** - both Readable and Writeable (TCP sockets)
  - **Transform** - the output is computed from the input (zlib, crypto)

Readable Stream

- Functions
  - `read()` - get chunks from the stream
  - `pause()` - switch to **paused** mode
  - `resume()` - switch to **flowing** mode
- Events - used when the stream is **flowing**
  - `data` - chunk is available for reading
  - `end` - no more data
  - `error` - an exception has occurred

Readable Stream (2)

- **HTTP Request** is a readable stream

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

http.createServer((req, res) => {
  if (req.method === 'POST') {
    let body = '';
    req.on('data', data => { body += data });
    req.on('end', () => {
      console.log(body);
    });
  }
}).listen(5000);
```

Writable Stream

- Functions
  - `write()` - send chunks to the stream
  - `end()` - close the stream
- Events
  - `drain` - stream can receive more data
  - `finish` - all data has been flushed (buffer is empty)
  - `error` - an exception has occurred

Writable Stream (2)

- **HTTP Response** is a writeable stream

```
const fs = require('fs');
const server = require('http').createServer();

server.on('request', (req, res) => {
  const src = fs.createReadStream('./bigfile.txt');
  src.on('data', data => res.write(data));
  src.on('end', () => res.end());
});

server.listen(5000);
```

Piping Streams

- The `pipe()` function allows a readable stream to **output directly** to a writable stream
  - **Event listeners** are automatically added

```
const fs = require('fs');
const server = require('http').createServer();

server.on('request', (req, res) => {
  const src = fs.createReadStream('./bigfile.txt');
  src.pipe(res);
});
server.listen(5000);
```

Duplex and Transform Streams

- **Duplex** stream
  - Implements both the **Readable** and **Writeable** interfaces
  - Example - a TCP socket
- **Transform** stream
  - A special kind of duplex stream where the output is a **transformed** version of the input
    - http://codewinds.com/blog/2013-08-20-nodejs-transform-streams.html

Streams

- Transforms with Gzip

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

let readStream = fs.createReadStream('index.js');
let writeStream = fs.createWriteStream('index.js.gz');

let gzip = zlib.createGzip();

readStream.pipe(gzip).pipe(writeStream);
```

- https://nodejs.org/api/zlib.html

FS Module

Working with the File System

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- The `fs` module gives you access to the **file system**

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

- All functions have **synchronous** and **asynchronous** variants

```
const data = fs.readFileSync('./package.json', 'utf8');
console.log(data);
```

```
const data = fs.readFile('./package.json', 'utf8',
(err, data) => {  // Handle possible errors
  console.log(data); });
```

Working with the File System (2)

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- List files in a directory

```
let data = fs.readdirSync('./myDir', 'utf8');
console.log(data);
```

```
let data = fs.readdir('./myDir', 'utf8', (err,
data) => {
  if (err) {
    console.log(err);
    return;
  }
  console.log(data);
});
```

The result is an **array of strings**, containing all filenames

Working with the File System (3)

- `Create` a directory

```
fs.mkdirSync('./myDir');
```

```
fs.mkdir('./myDir', err => {
  if (err) {
    console.log(err);
    return;
  }
});
```

Working with the File System (4)

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- **Delete** directory

```
fs.rmdirSync('./myDir');
```

```
fs.rmdir('./myDir', err => {
  if (err) {
    console.log(err);
    return;
  }
});
```

- Full API docs: https://nodejs.org/api/fs.html

Working with the File System (5)

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- Rename file or directory

```
fs.renameSync('./oldName', './newName');
```

```
fs.rename('./oldName', './newName', err => {
  if (err) {
    console.log(err);
    return;
  }
});
```

Working with the File System (6)

- `Write` a file

```
const fs = require('fs');
let filePath = './data.txt';
let data = 'Some text';
```

```
fs.writeFileSync(filePath, data);
```

```
fs.writeFile(filePath, data, err => {
  if (err) {
    console.log(err);
    return;
  }
});
```

Working with the File System (7)

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- **Delete** file

```
fs.unlinkSync('./target.txt');
```

```
fs.unlink('./target.txt', err => {
  if (err) {
    console.log(err);
    return;
  }
});ч
```

Debugging

Debugging & Watching in Node.js

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- Debugging in Node.js
  - The V8 **debug protocol** is a **JSON** based protocol
- **IDEs** with a debugger
  - Webstorm
  - Visual Studio
  - Node-inspector (not working with latest version)
- Watching with **Nodemon**

Live Exercises

Summary

- Node.js has various useful **utility** modules
- **Streams** allow working with **big data**
- **Events** simplify **communication** within a large application
- **Pub/Sub** pattern is used to **communicate messages**
- The `fs` module gives you access to the **file system**

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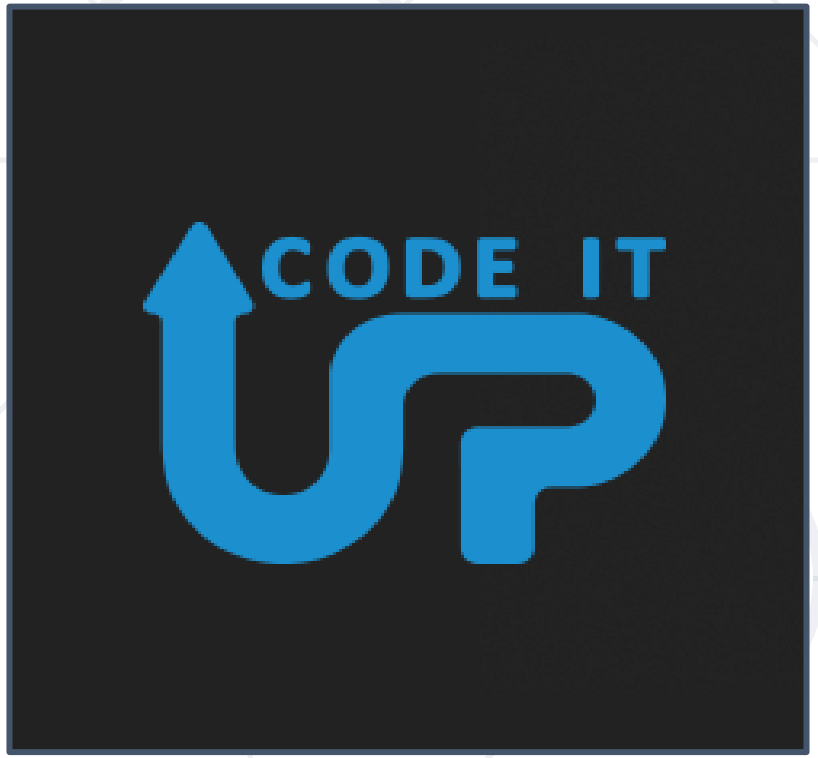

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Intro to Express.js and View Engines

Router, Static Files, Middleware, Handlebars

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#js-web

Introduction to Express.js

Introduction to Express.js

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```
npm install express
```

```
const express = require('express')
const app = express();
const port = 3000;
app.get('/', (req, res) => {
  res.status(200);
  res.send('Welcome to Express.js!');
})
app.listen(port, () => console.log(`Express running
on port: ${port}...`));
```

Create a new **instance** of the **application**

Router in Express.js

Router

- Routing has the following syntax

```
app.METHOD(PATH, HANDLER)
```

- Where
  - **app** is an **instance** of express
  - **METHOD** is an HTTP **request** method, in **lowercase**
  - **PATH** is a path on the **server**
  - **HANDLER** is the function **executed** when the route is **matched**

Route Methods

```
// GET method route
app.get('/', (req, res) => {
  res.send('GET request to the homepage')
})
// POST method route
app.post('/', (req, res) => {
  res.send('POST request to the homepage')
})
// PUT method route
app.put('/', (req, res) => {
  res.send('PUT request to the homepage')
})
```

Route Methods

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```
// All methods route
app.all('/about', (req, res, next) => {
  console.log('Middleware execution..')
  next()
}, (req, res) => {
  res.send('Show about page.')
})
```

The next **handler** to be **called**

Shows the **about** page **after** middleware **execution**

Router Paths

- Paths can **contain** special characters:

```
app.get('*',(req, res) => {
  res.send('Matches everything')
})
app.get('/ab*cd', (req, res) => {
  res.send('abcd, abANYTHINGcd')
})
app.get(/.*fly$/, (req, res) => {
  res.send('butterfly, dragonfly')
})
```

Based on string **patterns**

Based on **regular expressions**

Extracting Parameters

- Paths can have **parameters**

```
app.get('/users/:userId', (req, res) => {
  const paramsObj = req.params
  res.send(paramsObj) })
```

- You can also **validate** parameters with **regular expressions** (it is not recommended)

```
app.get('/users/:userId(\\d+)', (req, res) => {
  const paramsObj = req.params
  res.send(paramsObj) })
```

Chainable Routes

- You can create **chainable** route handlers using '**app.route()**'

```
app.route('/home')
  .get((req, res) => {
    res.send('GET home page') })
  .post((req, res) => {
    res.send('POST home page') })
  .all((req, res) => {
    res.send('Everything else')
  })
```

Better for **ordering** routes

Always place '**all**' as a **final** method

Router Responses

- Responses
  - res.**download** - **prompt** a file to be **downloaded**

```
app.get('/pdf', (req, res) => {
  res.download('FULL PATH TO PDF') })
```

  - res.**end** - end the response **process**
  - res.**json** - send a **JSON** response

Router Responses

- res.**redirect** - redirect a request (to **another** page)

```
app.get('/about/old', (req, res) => {
  res.redirect('/about') })
```

- res.**sendFile** - send a **file** as an **octet**-stream

```
app.get('/file/:fileName', (req, res) => {
  const fileName = req.params.fileName
  res.sendFile("PATH TO FILE" + fileName) })
```

- res.**render** - render a **view template**

Modular Routers

- You can use `express.Router` for modular route handlers
  - **Mounted** on a route (e.g. '/about')
  - Can use middleware, specific **only** to that router

```
const express = require('express')
const router = express.Router()
router.use(/* add middleware */)
router.get(/* define route handlers */)
app.use('/about', router)
```

Middleware

Middleware

- **Function** that has **access** to
  - The **request** and **response** object
  - The **next** middleware in the application's **request-response cycle**
- Different **kinds** of middleware exist
  - Application, route, error

```
const app = express()
app.use((req, res, next) => {
  console.log('Time:', Date.now())
  next() })
```

Next **handler** to be called

Custom Middleware

- Middleware can be for **specific** path

```
app.use('/user/:userId', (req, res, next) => {
  const userId = req.params.userId
  // TODO: Check if user exists in db/session
  let userExists = true
  if (!userExists) { res.redirect('/login') }
  else { next() }
})
app.get('/user/:userId', (req, res) => {
  res.send('User home page!')
})
```

Custom Middleware

- Can be on Application-level:

```
app.use(function (req, res, next) {
  console.log('Time:', Date.now()) next()
});
```

- Can be used for error-handling

```
app.use(function (err, req, res, next) {
  console.error(err.stack)
  res.status(500).send('Something broke!')
});
```

Third-Party Middleware

```
app.set('view engine', 'pug');
app.set('views', __dirname + '/views');
app.use(cookieParser());
app.use(session({secret: 'magic unicorns'}));
app.use(passport.initialize());
app.use(passport.session());
app.use(express.static(config.rootPath +'/public'));
```

Static Files

Static Files

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- Serving static files

```
app.use(express.static('public'))
app.use('/static', express.static('public'))
app.use('/static', express.static(__dirname + '/public'))
```

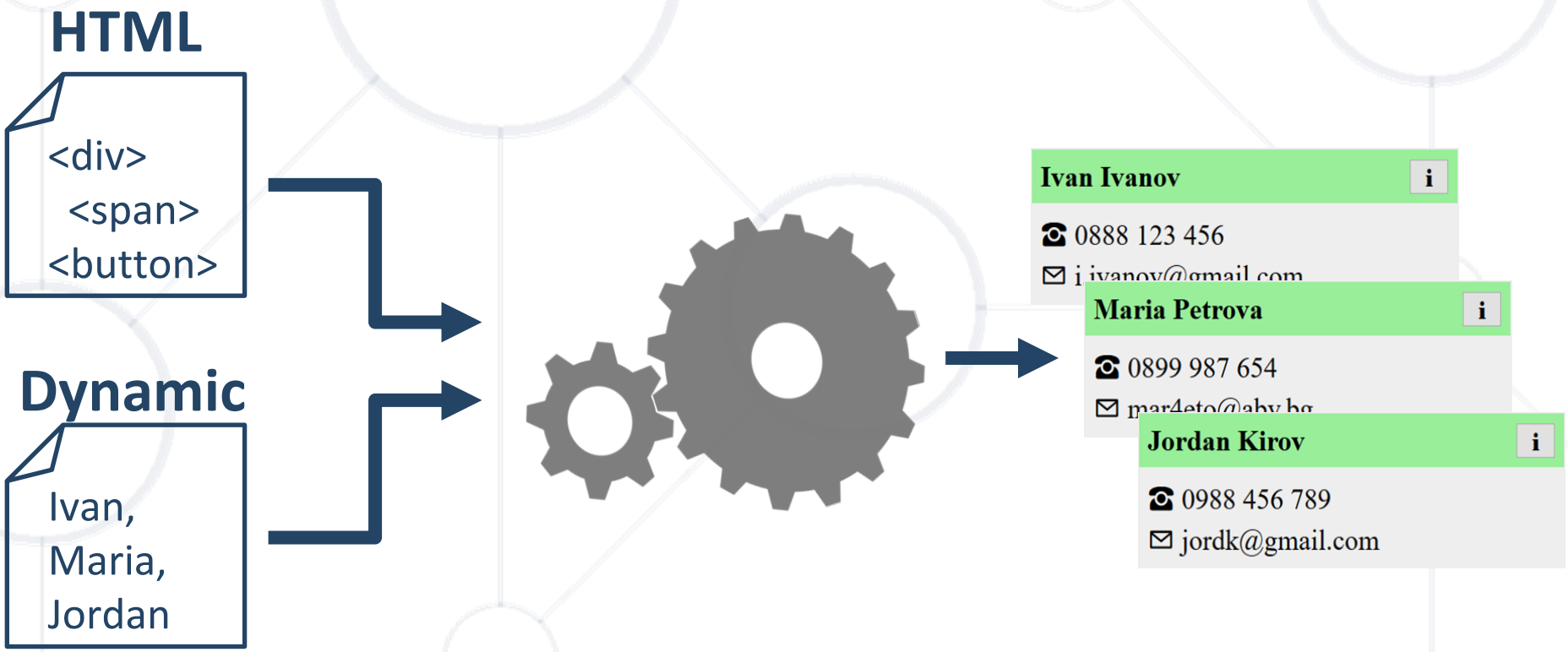
- And all **files** from the directory will be **public**

```
http://localhost:3000/images/kitten.jpg
http://localhost:3000/css/style.css
http://localhost:3000/js/app.js
http://localhost:3000/images/bg.png
http://localhost:3000/hello.html
```

Templating Concepts

Templating

- Allows similar content to be **replicated** in a web page, **without repeating** the corresponding markup everywhere



Templating Concepts

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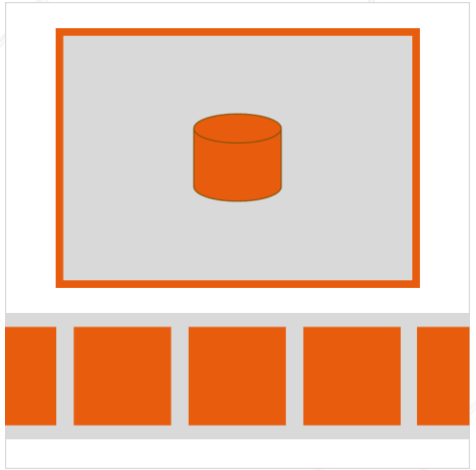
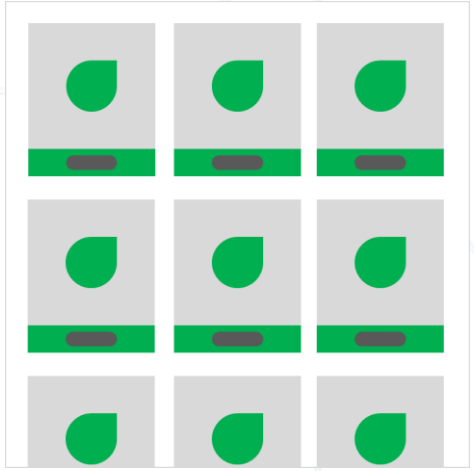
- The **static parts** of a webpage are stored as **templates**
- The **dynamic content** is kept separately (e.g. in a **database**)
- A **view engine** combines the two
- Benefits
  - **Productivity** - avoid writing the same markup over and over
  - **Easier upkeep** - only change the code in one place
  - **Composability** - a single element can be used on multiple pages

Examples

- Display articles in a blog
- Display a gallery of photos
- Visualize user profiles
- Show items in a catalog





Server View Engines

- Server view engines **return** ready-to-use **HTML** to the **client** (the browser)
  - They parse the **data** to **HTML** on the **server**
  - Web applications, created with **server** view engines are **not** real **SPA** apps (In **most** cases)
- Famous View Engines
  - Pug, Mustache, Handlebars, EJS, Vash

Templating with Handlebars

Handlebars

- Based on **Mustache** specification
- Expressions are **initialized** with '{{' and finish with '}}'

```
<div class="entry">
 <h1>{{title}}</h1>
  <div class="body">
   {{body}}
  </div>
</div>
```

```
<div class="entry">
  <h1>My New Post</h1>
  <div class="body">
    This is my first post!
  </div>
</div>
```

Integration in Express

```
npm install express-handlebars
```

```
const app = require('express')()
const exphbs= require('express-handlebars')
const handlebars = exphbs.create({ extname: '.hbs'});

app.engine('.hbs', handlebars.engine)
app.set('view engine', '.hbs')
```

```
app.get('/', function (req, res) {
  res.render('home');
})
```

Call the template

Handlebars directory structure

- Must have a **views** folder containing all the Handlebars templates:

- The **layouts** folder inside the views folder will contain the layouts or the template wrappers.
- The **main.hbs** file is the main layout.
- ***Note:*** The default name of the folders can be changed with an appropriate setting

For-Loops

- A template can be **repeated** for every entry in an **array**

```
const context = {
  contacts: [
    { name: 'Maria Petrova', email: 'mar4eto@abv.bg'},
    { name: 'Jordan Kirov', email: 'jordk@gmail.com'} ]};
```

```
<ul id="contacts">
  {{#each contacts}}
    <li>{{name}}: {{email}}</li>
  {{/each}}
</ul>
```

The expression inside the loop uses each **entry as context**

Conditional Statements

```
{{#if sunny}}
  The sky is clear
{{else}}
  The sky is overcast
{{/if}}
```

Variable to check for **truthiness**

Will be shown if the array is **empty**

```
<ul id="contacts">
  {{#each contacts}}
    <li>{{name}}: {{email}}</li>
  {{else}}
    <i>(empty)<i>
  {{/each}}
</ul>
```

Partials

- **Templates** that can be **inserted into** other templates

```
<div id="contacts">
  {{#each contacts}}
    {{> contact}}
  {{else}}
    <i>(empty)<i>
  {{/each}}
</div>
```

HTML Escaping

- By default, any strings that are evaluated will be **HTML-escaped**
- To prevent this, use the "**triple-stash**"

```
title: "All about <p> Tags"
body: "<p>This is a post about &lt;p&gt; tags</p>"
```

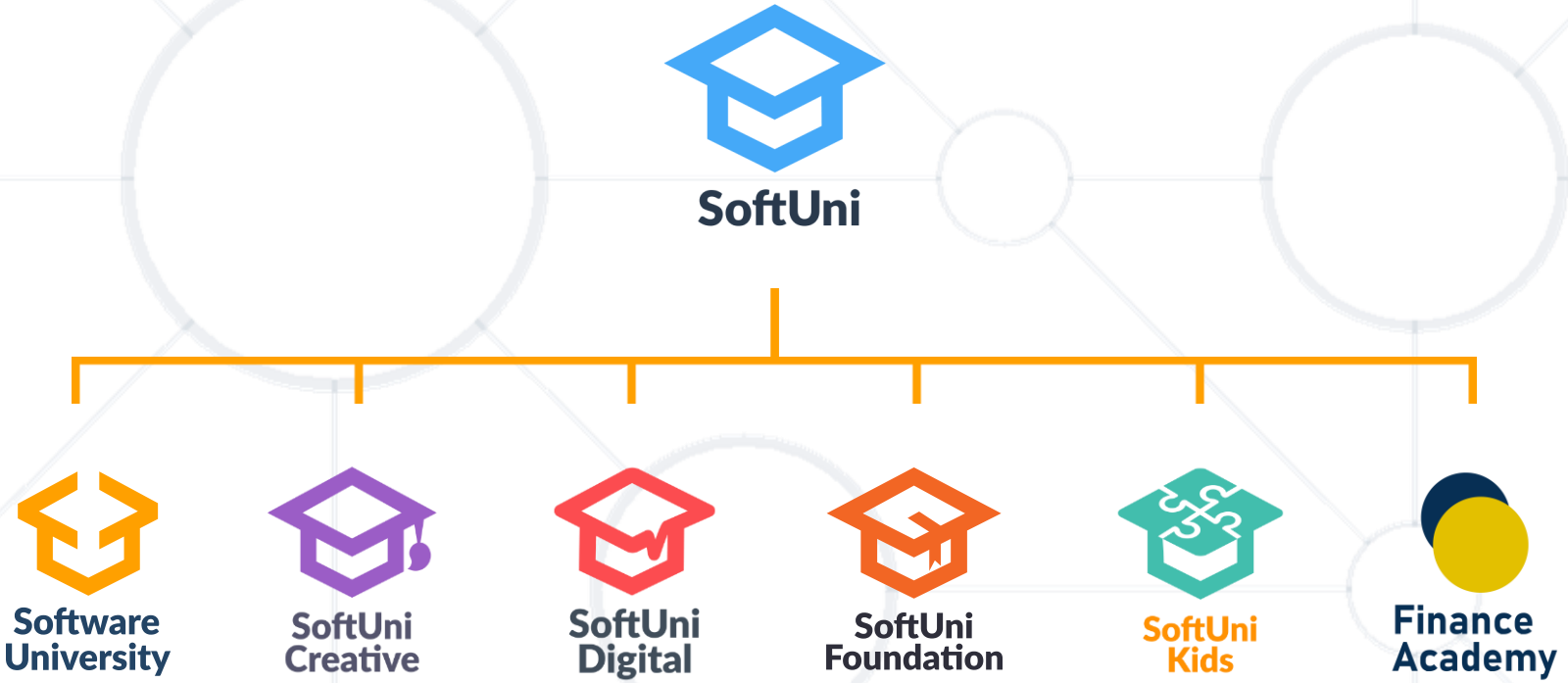
```
<h1>{{title}}</h1>
  <div class="body">
    {{{body}}}
  </div>
```

```
<h1>All About &lt;p&gt; Tags</h1>
  <div class="body">
    <p>This is a post about &lt;p&gt; tags</p>
  </div>
```

Summary

- Express.js is a **fast** web **framework** for Node.js
- **Middlewares** can **manipulate** requests and responses
- Templates **speed up** and **simplify** development
- View Engines **render templates**
- **Handlebars** offers effective templates and simple helper functions

Questions?



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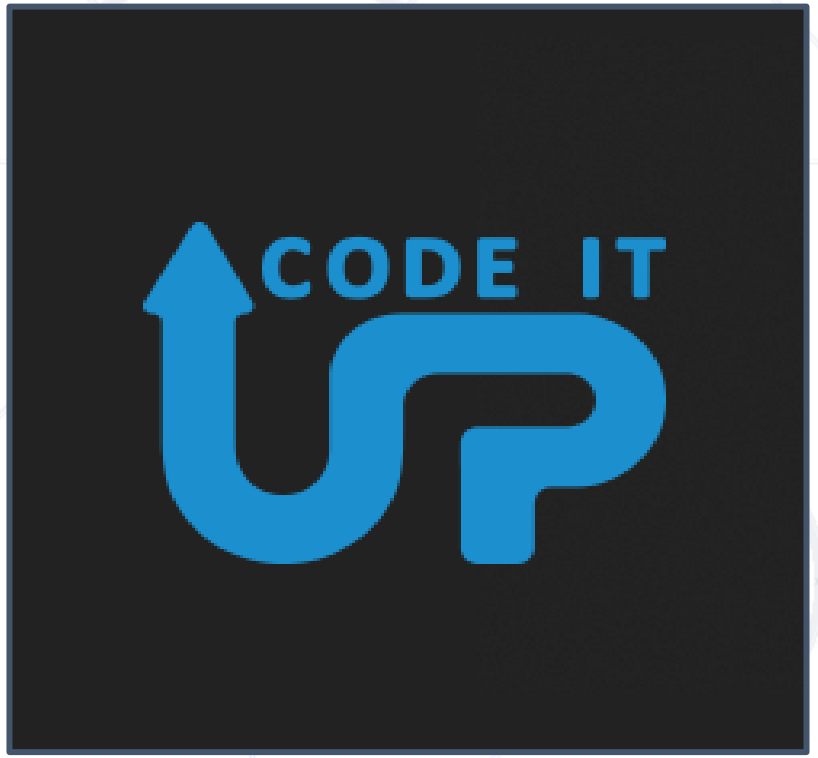

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NoSQL and MongoDB

NoSQL vs SQL, MongoDB, Mongoose

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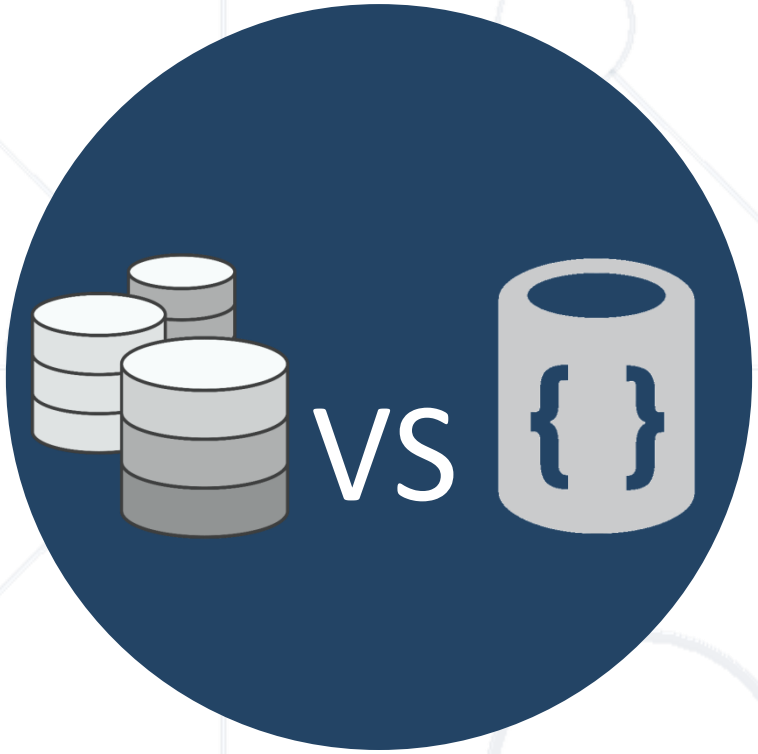

Relational and NoSQL Databases

Relational Database

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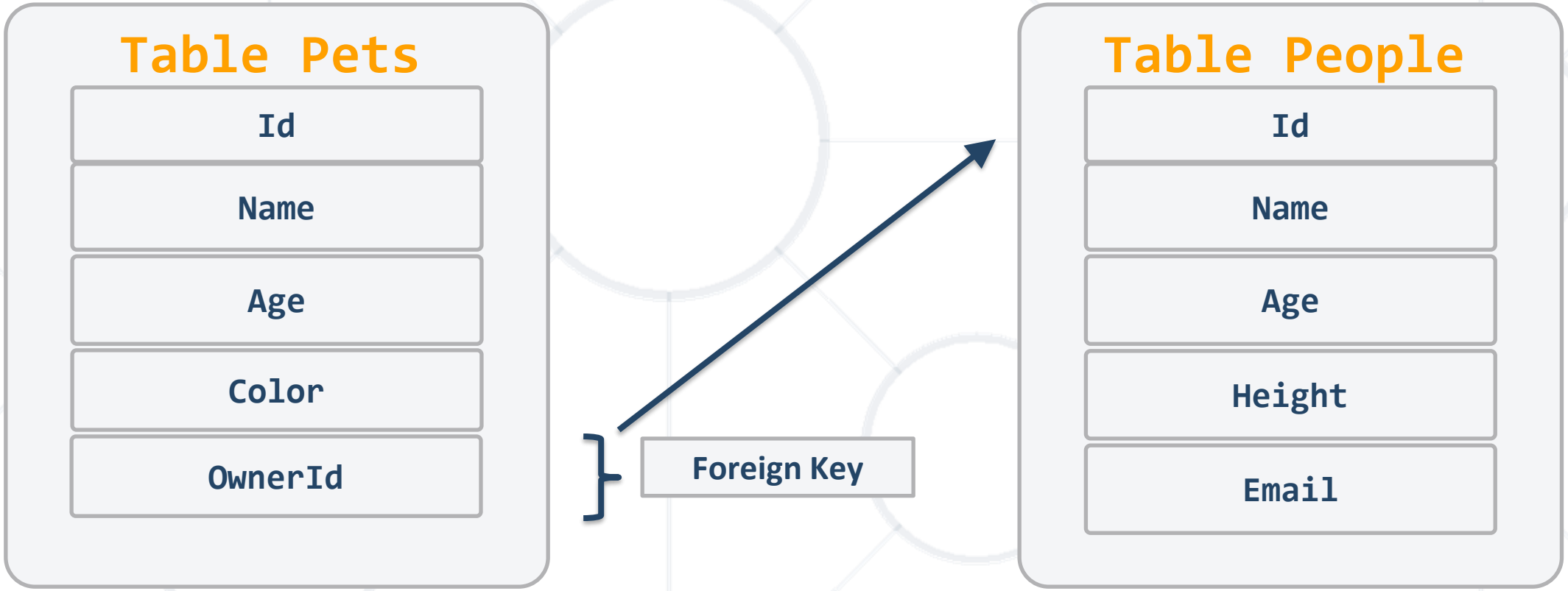
- Organize data into one or more **tables** of **columns** and **rows**
- Unique **key** identifying each **row** of data
- Almost all relational databases use **SQL** to **extract** data

```
SELECT * FROM Students
```

- **Relations** between tables are done using **Foreign Keys (FK)**
- Such databases are **Oracle**, **MariaDB**, **SQL Server**, etc…

Relational Database – Example



Non-relational Database (NoSQL)

- Key-value **stores**

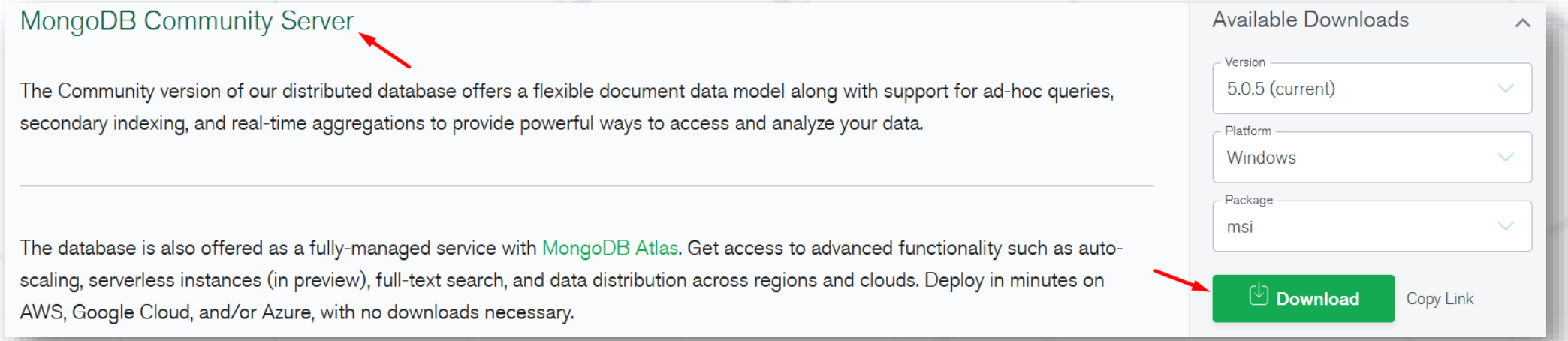
```
{
    "_id": ObjectId("59d3fe7ed81452db0933a871"),
    "email": "peter@gmail.com",
    "age": 22
}
```

- **SQL** query is **not** used in NoSQL systems
- More **scalable** and **provide** superior **performance**
- Such databases are **MongoDB**, **Cassandra**, **Redis**, etc..

MongoDB Overview

Install MongoDB

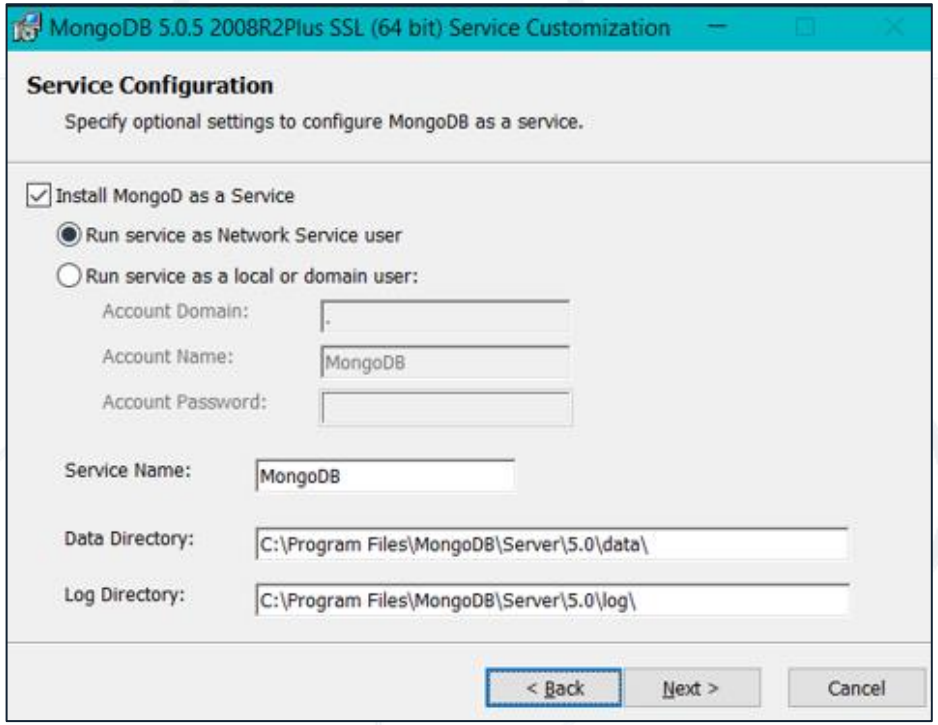
- Download from: mongodb.com/try/download/community



- The package includes **MongoDB Compass**
- When **installed**, MongoDB needs a **driver** (for every project)
  - Install MongoDB **driver** for Node.js `npm install mongodb`
  - We will be using **Mongoose** (includes a driver)

MongoD Windows Service

- During installation, configure the **MongoDB service**:



Manual Service Configuration

- Required if you **skipped** the service installation (and for Linux)
  - Go to installation folder and **run** a command prompt as an **administrator**
  - Type the following command

Usually in C:\Program Files\MongoDB\Server\3.4\bin

```
<path to mongod.exe> mongod --dbpath <path to store data>
```

  - Additional information at https://docs.mongodb.com/manual/tutorial/

Working with MongoDB Shell Client

- Start the shell from **another** CLI
  - Type the command **mongo**

```
show dbs
```

```
use mytestdb
```

```
db.mycollection.insertOne({"name":"George"})
```

```
db.mycollection.find({"name":" George"})
```

```
db.mycollection.find({})
```

  - Additional information at
    - https://docs.mongodb.com/manual/reference/mongo-shell/

Working with MongoDB GUI

- Choose one of the many (**Compass** is included in the installer)
- For example
  - Compass- https://www.mongodb.com/products/compass
  - Robo 3T- https://robomongo.org/download
  - NoSQLBooster- https://nosqlbooster.com

Working with MongoDB from Node.js – Example

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```
const mongodb = require('mongodb');
const MongoClient = mongodb.MongoClient;
const connectionStr = 'mongodb://localhost:27017';
const client = new MongoClient(connectionStr,
{useUnifiedTopology: true});
client.connect(function(err) {
  const db = client.db('testdb');
  const people = db.collection('people');
  people.insertOne({ 'name': 'Ivan' }, (err, result) => {
    people.find({ name: 'Ivan' }).toArray((err, data) => {
      console.log(data);
    });
  });
});
```

Mongoose Overview

Mongoose Overview

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- Mongoose is an object-document **model** module in Node.js for MongoDB
  - It **provides** a straight-forward, **schema-based** solution to **model** your application data
  - Includes build-in type **casting** and **validation**
  - **Extends** the native **queries** (much **easier** to use)
  - To **install** type in terminal/CMD (for every project)

```
npm install mongoose --save
```

Working with Mongoose in Node.js

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- Load the following module

```
const mongoose = require('mongoose')
```

- **Connecting** to the database

```
async function main(){
    await mongoose.connect('mongodb://localhost:27017/testdb', {
          useNewUrlParser: true,
          useUnifiedTopology: true
    });
    console.log("Database connected")
}
main();
```

MongoDB Hosting

- Host a **database** in the largest MongoDB **cloud** service
- Go to '**mongo atlas**' and register - https://www.mongodb.com/cloud/atlas
- You can **store** up to 500 MB of **content**

Mongoose Models

Mongoose Models

- Mongoose **supports** models
  - Fixed **types** of documents
    - Used like object **constructors**
  - Needs a **mongoose.Schema** call

```
const mongoose = require('mongoose');
const studentSchema = new mongoose.Schema({
    firstName: String,
    lastName: String,
    facultyNumber: { type: String, required: true },
    age: Number
});

const Student= mongoose.model('Student', studentSchema);
```

Mongoose Models - Example

```
const myPerson = new Student({
        firstName: "John",
        lastName: "Peterson",
        facultyNumber: "5014sa",
        age: 25
    });

await myPerson.save();
const data = await Student.find({});
console.log(data); /* [{_id: new ObjectId("6139c6faf79365e5e54645bf"),
                        firstName: 'John',
                        lastName: 'Peterson',
                        facultyNumber: '5014sa',
                        age: 25, __v: 0}] */
```

Model Methods

- Since Mongoose models are just JavaScript **object constructors,** they can have **methods**

```
const studentSchema = new mongoose.Schema({…});

studentSchema.methods.getInfo = function() {
   return `I am ${this.firstName} ${this.lastName}`;
};
```

Do **not** use arrow functions

Model Virtual Properties

- Not all properties **need** to be **persisted** in the **database**
- Mongoose provides a way to **create** properties, that are accessible on all models, but are **not persisted** to the database
  - And they have both **getters** and **setters**

```
studentSchema.virtual('fullName').get(function () {
  return this.firstName + ' ' + this.lastName
});
```

Property Validation (1)

- With Mongoose developers can **define** custom **validation** on their **properties**
  - Validate records when trying to **save**

```
studentSchema.path('firstName')
  .validate(function () {
      return this.firstName.length >= 2
      && this.firstName.length <= 10
}, 'First name must be between 2 and 10 symbols long!')
```

Error message as second param

Property Validation (2)

- Mongoose has several built-in validators.
  - All **Schema-**Types have the built-in required validator.
  - Numbers have **min** and **max** validators.
  - Strings have **enum**, **regex**, **minLength**, and **maxLength** validators.

```
facultyNumber: {
   type: String,
   required: [true, 'FacultyNumber is required']
 }
```

Error message

- You can configure the error message for individual validators in your schema.

Exemplary validations

- Mongoose replaces **{VALUE}** with the value being validated.

```
const studentSchema = new mongoose.Schema({
  age: {
     type: Number,
     min: [0, 'Must be at least 0, got {VALUE}'],
     max: 50 }
});
```

Error message as second param

```
const studentSchema = new mongoose.Schema({
  facultyNumber: {
     type: String,
     enum: {
      values: ['50121', '50122', '50123'],
      message: '{VALUE} is not valid'
    } }
});
```

Exporting Modules

- Having all model definitions in the **main** module is **no** good
  - That is the reason Node.js has **modules** in the first place
  - In folder **models**, file **Student.js**

```
const mongoose = require('mongoose');
const studentSchema = new mongoose.Schema({
    firstName: { type: String, required: true },
    age: { type: Number }
});

module.exports = mongoose.model('Student', studentSchema);
```

Exporting and Using Modules

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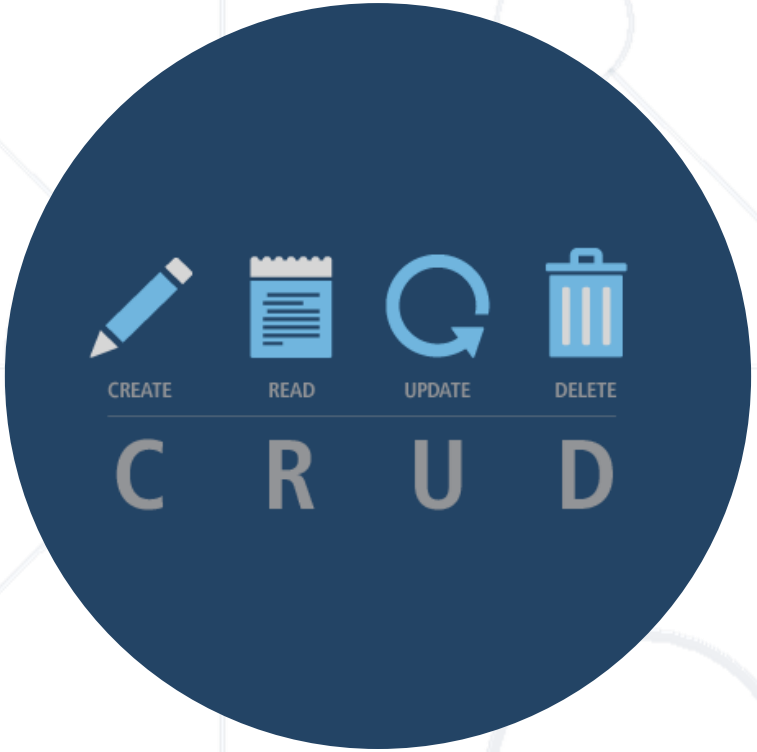
- Export the model definition:

```
const mongoose = require('mongoose');
const studentSchema = new mongoose.Schema({ /* … */ });

module.exports = mongoose.model('Student', studentSchema);
```

- We can put each **model** in a different **module**, and **load** all models where they are needed

```
const Student = require('./models/Student');
```



CRUD with Mongoose

CRUD with Mongoose

Software University

- Mongoose supports **all** CRUD operations
  - Create (Persist data)

```
new Student({}).save(callback)
```

  - Read (Extract data)

```
Student.find({})
Student.findOne({conditions}, {options}, callback)
Student.findById(id, {options}, callback)
```

CRUD with Mongoose

Software University

- Update (Modify data)

```
Student
  .findByIdAndUpdate(id, {$set: {prop: newVal}}, callback)
Student
  .updateOne({filter}, {$set: {prop: newVal}}, callback)
Student
  .updateMany({filter}, {$set: {prop: newVal}}, callback)
```

- Delete (Remove data)

```
Student.findByIdAndDelete(id, callback)
Student.deleteOne({conditions}, {options}, callback)
Student.deleteMany({conditions}, {options}, callback)
```

Create Example

```
const mongoose = require('mongoose');
const connectionStr = 'mongodb://localhost:27017/unidb';
const studentSchema = new mongoose.Schema({
  name: { type: String, required: true, minlength: 3 },
  age: Number
});
const Student = mongoose.model('Student', studentSchema);
mongoose.connect(connectionStr).then(() => {
  new Student({ name: 'Petar', age: 21 })
    .save()
    .then(student => {
      console.log(student._id)
    });
});
```

You can also use Student.create()

Read Example

```
Student
    .find({})
    .then(students => console.log(students))
    .catch(err => console.error(err))
Student
    .find({name: 'Petar'})
    .then(students => console.log(students))
Student
    .findOne({name: 'Petar'})
    .then(student => console.log(student))
```

Always handle errors

Update Example

```
Student
    .findById('57fb9fe1853ab747b0f692d1')
    .then((student) => {
      student.name = 'Stamat'
      student.save()
    });
Student
    .findByIdAndUpdate('57fb9fe1853ab747b0f692d1', {
      $set: { name: 'Petar' }
    }).then(students => console.log(students))
Student
    .updateOne(
      { name: 'Petar' },
      { $set: { name: 'Kiril' } }). then(students =>
console.log(students))
```

Remove & Count Example

```
Student
    .findByIdAndDelete('57fb9fe1853ab747b0f692d1').then()
Student
    .deleteOne({ name: 'Stamat' }).then()
Student
    .countDocuments()
    .then(console.log)
Student
    . countDocuments({ age: { $gt: 19 } })
    .then(console.log)
```

Remove by criteria

Get the count by criteria

Mongoose Queries

Mongoose Queries

Software University

- Mongoose defines **all** queries of the native MongoDB driver in a more **clear** and **useful** way
  - Instead of

```
{
  $or: [
    {conditionOne: true},
    {conditionTwo: true}
  ]
}
```

  - Do

```
.where({ conditionOne: true })
.or({ conditionTwo: true })
```

Mongoose Queries Example

- Mongoose supports **many** queries
  - For equality/non-equality

```
Student.findOne({'lastName':'Petrov'})
```

```
Student.find({}).where('age').gt(7).lt(14)
```

```
Student.find({}).where('facultyNumber').equals('12399')
```

  - Selection of some properties

```
Student.findOne({'lastName':'Kirilov'}).select('name age')
```

Mongoose Queries Example 2

- Sorting

```
Student.find({}).sort({age:-1})
```

- Limit & skip

```
Student.find({}).sort({age:-1}).skip(10).limit(10)
```

- Different methods could be **stacked** one upon the other

```
Student.find({})
       .where('firstName').equals('gosho')
       .where('age').gt(18).lt(65)
       .sort({age:-1})
       .skip(10)
       .limit(10)
```

Model Population

Population Definition

- Population is the process of **automatically replacing** the **specified paths** in the document with document(s) from **other** collection(s)
- We may **populate** a single document, multiple documents, plain object, multiple plain objects, or all objects returned from a query

Example

- We create **two models** that **reference** each other

```
const studentSchema = new mongoose.Schema({
  name: String,
  age: Number,
  facultyNumber: String,
  teacher: { type: Schema.Types.ObjectId, ref: 'Teacher' },
  subjects: [{ type: Schema.Types.ObjectId, ref: 'Subject' }]
});
const subjectSchema = new mongoose.Schema({
  title: String,
  students: [{ type: Schema.Types.ObjectId, ref: 'Student' }]
});
const Student = mongoose.model('Student', studentSchema);
const Subject = mongoose.model('Subject', subjectSchema);
```

Population

- To load all the data **referenced** with the entity use **populate()**

```
Student.findOne({ name: 'Peter' })
   .populate('subjects')
   .then(student => {
      console.log(student.subjects)
    })
```

Will return an array of **objects** and **NOT** Id's

- You can also load **multiple** paths

```
Student.findOne({ name: 'Peter' })
    .populate('subjects')
    .populate('teacher')
    .then(student => {
       console.log(student.teacher)
       console.log(student.subjects)
    })
```

Query Conditions

- Populate based on a **condition**

```
Subject.
  find({})
  .populate({
    path: 'students',
    match: { age: { $gte: 19 }},
    select: 'name facultyNumber',
    options: { limit: 3 }
  })
```

- More on populate here - mongoosejs.com/docs/populate.html

Summary

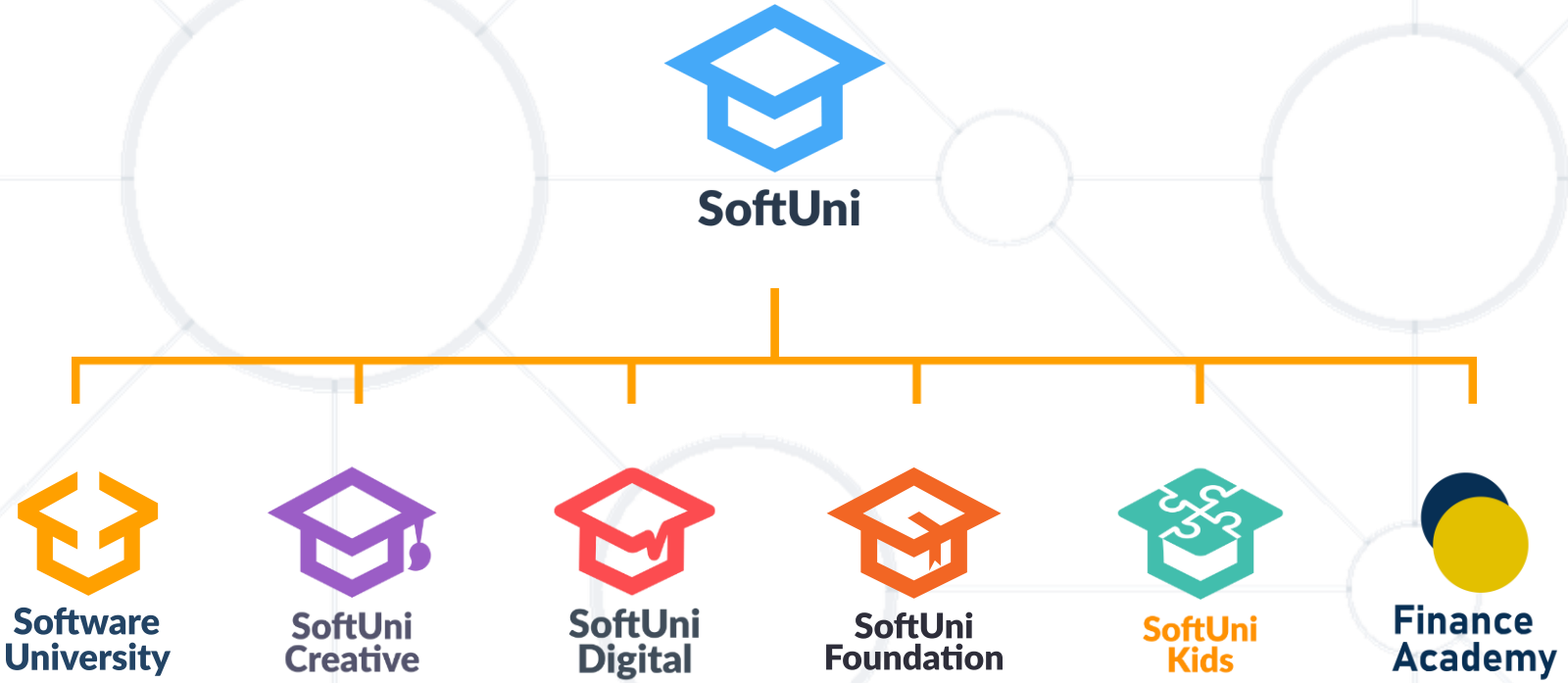
- NoSQL databases provide **superior** performance
- Mongoose gives us a **schema-based** solution

```
const modelSchema = new mongoose.Schema({
   propString: String
});
```

- Mongoose supports all **CRUD** operations
- Chaining queries with Mongoose is possible

```
Student.find({}).where('firstName').equals('gosho')
.where('age').gt(18).lt(65).sort({age:1}).skip(10)
.limit(10)
```

Questions?



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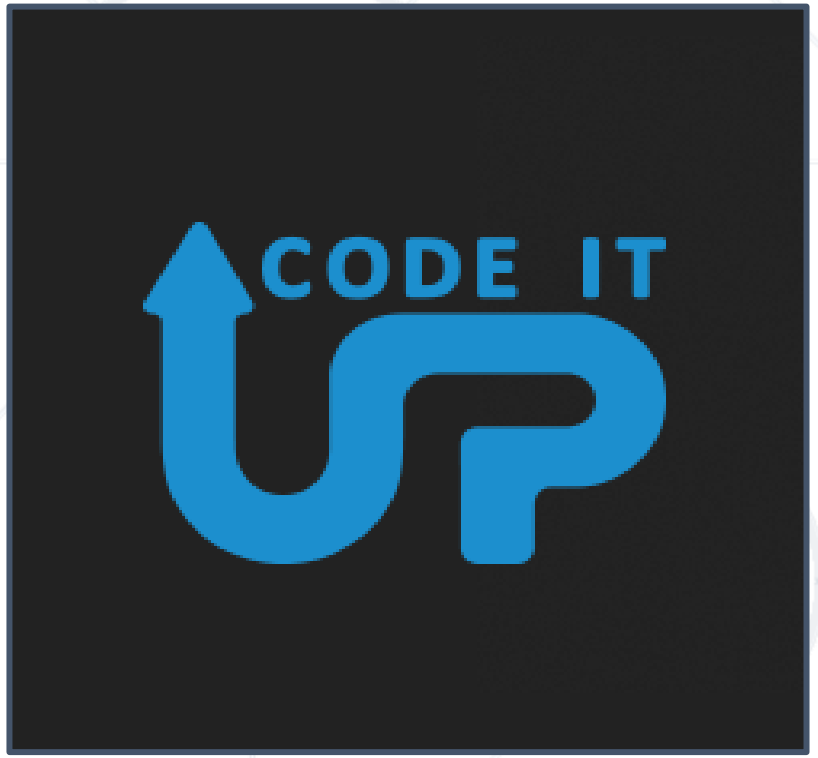

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Sessions and Authentication

State Persistence and Application Security

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Cookies and Sessions

HTTP Communication

- HTTP is **stateless**
  - The Server and Client **don't remember** each other across requests
- To preserve state, **cookies** are stored on the **Client**
- **Session cookie** - exists on the **Server**
  - It can **store information** about a Client
  - Used to **persist state** across requests
  - Matched to a Client by their **cookie**

Session vs Cookie

- **Session** is preferred when you need to store **short-term** information/values
- **Cookies** are preferred when you need to store **long-term** information/values
- Session is **safer** because is stored on the server
- Cookies are not very safe. Expiration **can be set**, and it can last for years

Using Cookies

- You can use **cookie-parser** middleware for Express

```
npm install cookie-parser --save-exact
```

```
// use in an express app
const cookieParser = require('cookie-parser')
app.use(cookieParser())

app.get('/setCookie', (req, res) => {
  res.cookie("message", "hello")
  res.end('Cookie set')
})

app.get('/readCookie', (req, res) => {
  res.json(req.cookies)
})
```

Using Sessions

- You can use **express-session** middleware for Express

```
npm install express-session --save-exact
```

```
// use in an express app
const session = require('express-session')
app.use(session({ secret: 'my secret',
                  resave: false,
                  saveUnitialized: true,
                  cookie: {secure: true } }))
app.get('/setSession', (req, res) => {
  req.session.message = "hello"
  res.end('Session set')
})

app.get('/readSession', (req, res) => {
  res.json(req.session)
})
```

Live Demo

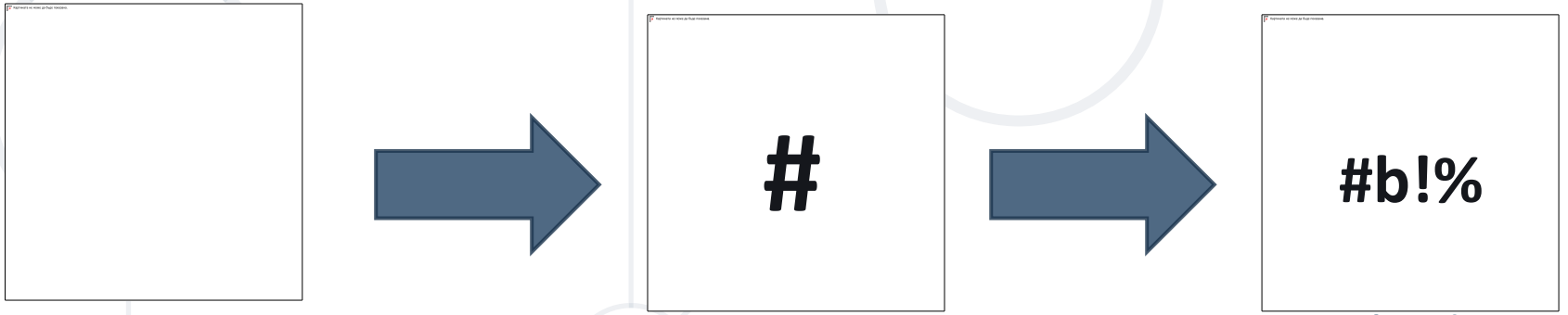
Authentication Concepts

Application Security

- **Authentication** is an important part of **application security**
- It serves to verify whether the **client** is who or what it declares itself to be
- It's built on several **layers of abstraction**
  - Cookies → Sessions → Security
- Authentication is **a cross-cutting concern**, best handled away from business logic
  - Request → Authentication → Business Logic → Response

Bcrypt

- **Bcrypt** is a password hashing function
  - Besides incorporating **salt** to protect against **rainbow table** attacks, **bcrypt** is an adaptive function
    - Over time, the iteration count can be increased to make it slower, so it remains resistant to **brute-force search attacks** even with increasing computation power



Bcrypt

- Installation

```
npm install bcrypt
```

- Hash password

```
const bcrypt = require('bcrypt');
const saltRounds = 9;
const myPlainTextPassword = "password123";

bcrypt.genSalt(saltRounds, (err, salt) => {
    bcrypt.hash(myPlainTextPassword, salt, (err, hash) => {
        console.log(hash);
        // $2b$09$pdhUAoT4qE0tmku.ZkXWROeLcJCy.LDRq.1I4IVImjrUTGuUbYQMi
    })});
```

Bcrypt

Software University

- Check password

```
const myPlainTextPassword = "password123";
const hash = "$2b$09$pdhUAoT4qE0tmku.ZkXWROeLcJCy.LDRq.1I4IVImjrUTGuUbYQMi";

bcrypt.compare(myPlainTextPassword, hash, (err, res) => {
    console.log(res); // true
});
```

- **Async** way is **recommended** to **hash** and **check** password

Authentication vs. Authorization

- **Authentication**
  - The process of **verifying the identity** of a user or computer
  - Questions: "**Who are you?**", "**How do you prove it?** "
  - Credentials can be a password, smart card, external token, etc...
- **Authorization**
  - The process of determining what a user is **permitted** to do on a computer or network
  - Questions: " **What are you allowed to do?**", "**Can you see this page?**"

Live Demo

JSON Web Token

What is JWT?

- **JSON Web Token** (**JWT**) is an open standard that defines a compact and self-contained way for securely transmitting information between parties as a JSON object
- This information can be verified and trusted because it is digitally signed
- JWTs can be signed using a secret or a public/private key pair using **RSA** or **ECDSA**

When Should You Use JWT?

- JSON Web Tokens are useful for
  - **Authorization** (a most common scenario) - Once the user is logged in, each subsequent request will include JWT, allowing the user to access routes, services, and resources that are permitted with that token
  - **Information Exchange** - JSON Web Tokens are good way of securely transmitting information between parties. Because they are signed digitally

JWT Structure

- In its compact form, JSON Web Tokens consist of three parts separated by dots (.)
  - **Header**
  - **Payload**
  - **Signature**

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.
eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4
gRG9lIiwiaXNTb2NpYWwiOnRydWV9.
4pcPyMD09olPSyXnrXCjTwXyr4BsezdI1AVTmud2fU4
```

JWT Usage

- Installation

```
npm install jsonwebtoken
```

- Encode token

```
const jwt = require('jsonwebtoken');

const payloads = { _id, username };
const options = { expiresIn: '2d'};
const secret = 'MySuperPrivateSecret';
const token = jwt.sign(payload, secret, options);

console.log(token);
//eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJwYXkiOiIxMjM0NTY3ODkwIiwibmFtZSI6
IkpvaG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.xzK8LJQz0lDkJqsng04BYxcUQzxWngyEBP
```

JWT Usage

- Decode token

```
const token = req.cookies['token'] || sessionStorage.getItem('token');
// Depends where you store the token..

const decodedToken = jwt.verify(token, secretKey);

console.log(decodedToken); // { _id: ..., username: ... }
```

- More about JWT, you can find
  - https://jwt.io/
  - https://www.npmjs.com/package/jsonwebtoken

Live Demo

Summary

- Cookies and Sessions
  - Definitions and Usage
  - Cookies vs Sessions
- Authentication Concepts
  - Application Security with bcrypt
- JSON Web Token
  - What is JWT?
  - Structure and Usage

Questions?

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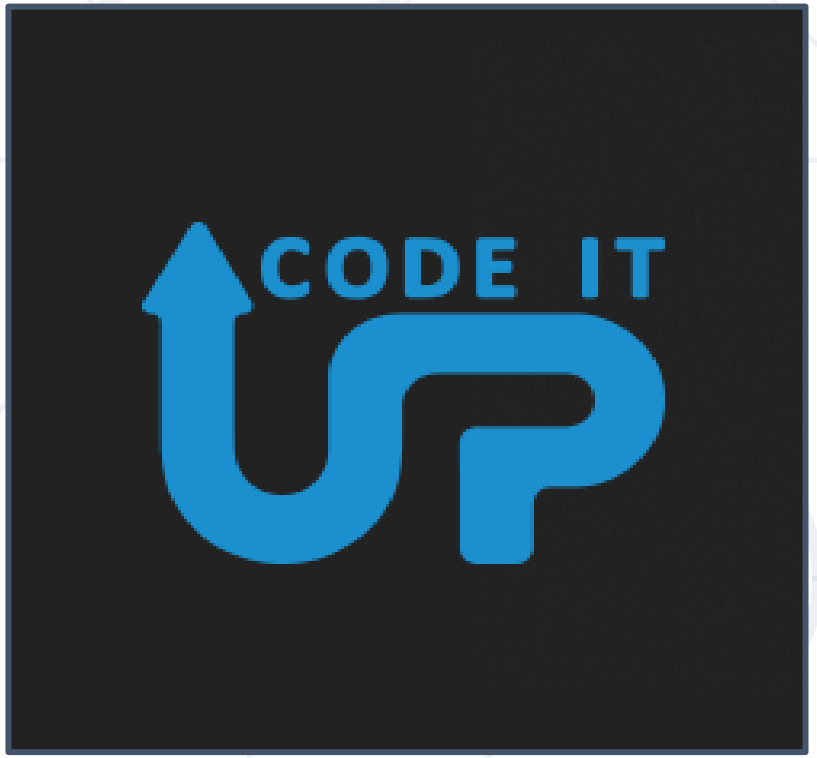

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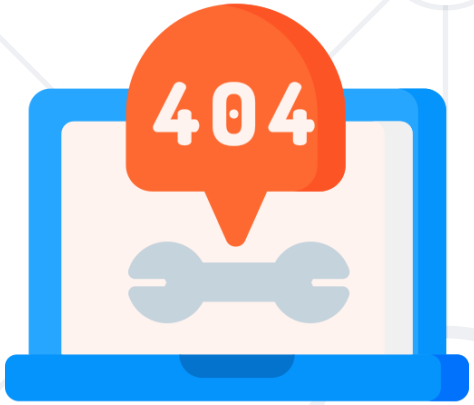
Validation and Error Handling

Validating User Input and Handle Different Type of Errors



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Validation

Validation

- Why validate?
  - **Bigger app** === **more data** you will need from your users at some point of time
  - You should prevent the user from entering something **incorrect**
  - The validation can
    - either **succeed and allow** the data to be written to the database
    - **reject** the input and **return some information**

Validation

- How to validate?
  - **Client-Side**
    - Before any request is sent, we can use **HTML** or **JS** to approve the UX
    - It's optional because the user **can see**, **change** and **disable** the code in the browser
    - This is **not** a protection that secures you against incorrect data being sent to your server

Validation

- How to validate?
  - **Server-side**
    - The code **can't** be **seen**, **changed** or **disabled**, because it happens on the server, not in the browser.
    - **The server** is the place where you should add validation and filter out the invalid data
    - After that, you will be sure you only work with valid data and store the correct information into the database

Validation

- How to validate?
  - **Database**
    - For most database engines there is a **build-in validation** which you can turn on
    - It's **not required**, because there should be no scenario where your database work with invalid data
    - Make sure you have proper **server-side validation** and your database works with correct data

Validation

- **validator.js** - Is a library of string validators and sanitizers
  - Installation and Usage

```
npm install validator
```

    - Server-side usage

```
const validator = require('validator');
const body = req.body;
validator.isEmail(body.email); // true or false
```

    - Client-side usage

```
<script type="text/javascript" src="validator.min.js"></script>
<script type="text/javascript">
  validator.isEmail($('#email').val()); // true or false
</script>
```

Validation

- **express-validator** - Is a set of express.js middlewares that wraps **validator.js** validator and sanitizer functions
  - Installation and usage `npm install express-validator`

```
const { check, validationResult } = require('express-validator');

check('email').isEmail()
check('password').isLength({ min: 5 });

const errors = validationResult(req);

if(!errors.isEmpty()) // Return 422 status and export errors

// Create user...
```

Validation

- **Sanitizers** are functions that implement **sanitization** which is
  - Make sure that the data is in the right format
  - Removing any illegal character from the data
    - **normalizeEmail**: canonicalizes an email address
    - **trim**: trim characters from both sides of the input
    - **blacklist**: remove characters that appear on the blacklist
    - and more...

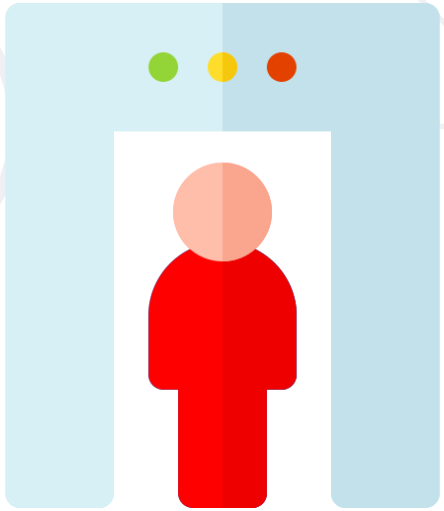
Validation

- **Sanitizing** input is also something that makes sense to be done
  - You can do it in one step by validating

```
const { body } = require('express-validator');
body('email')
      .isEmail() // check if the string is an email (validation)
      .normalizeEmail(), // canonicalizes an email address (sanitization)
body('password')
      .isLength({ min: 5 })
      .isAlphanumeric()
      .trim() // trim characters (whitespace by default) - sanitization
```

Validation

- The sanitization **mutates** the request
- This means that if **req.body.email** was sent
  - with the value "**PeteR@ood.bg**"
  - after the sanitization, its value will be "**peter@ood.bg**"



Validation

- Express-validators allows you to create **custom validations** and that send **custom messages**
- **Custom validator**

```
const { body } = require('express-validator');

app.post('/user', body.('email').custom(value => {
    return User.findUserByEmail(value)
        .then(user => {
            if(user){
                return Promise.reject('E-mail already in use');
            }
        });
}));
```

Validation

- **Custom Sanitizer**
  - Can be implemented by using the method `.customSanitizer()`

```
const { sanitizeParam } = require('express-validator');

app.post('/object/:id', sanitizeParam('id').customSanitizer(value => {
  return ObjectId(value);
}), (req, res) => {
  // Handle the request...
});
```

Mongoose Validation

- Validation is defined in the **SchemaType**
- Validation is middleware
  - Mongoose registers validation as a `pre('save')` hook
  - It's **asynchronously recursive**
  - can be customizable
- **A unique** option for schemas is not a validator
  - It's a convenient helper for building MongoDB unique indexes

Mongoose Save/Validate Hooks

- The **save()** function triggers **validate()** hook
  - all **pre('validate')** and **post('validate')** hooks get called before any **pre('save')** hook

```
schema.pre('validate', function() {
  console.log('this gets printed first');
});
schema.post('validate', function() {
  console.log('this gets printed second');
});
schema.pre('save', function() {
  console.log('this gets printed third');
});
schema.post('save', function() {
  console.log('this gets printed fourth');
});
```

Mongoose Built-in Validators

- All **SchemaTypes** have built-in required validator
  - **Numbers** have min and max validators
  - **Strings** have **enum**, **regex**, **minLength** and **maxLength**

```
const userSchema = new Schema({
    username: {
        type: String,
        required: true,
        unique: true,
        minLength: 4,
        maxLength: 20
    }
});
```

Mongoose Custom Validators

- If the build-in validators aren't enough, you can define **custom validators** to suit your needs

```
const userSchema = new Schema({
  phone: {
    type: String,
    validate: {
      validator: function(v) {
        return /\d{3}-\d{3}-\d{4}/.test(v);
      },
      message: props => `${props.value} is not a valid phone number!`
    },
    required: [true, 'User phone number required']
  }
});
```

Mongoose Validation Errors

- Errors returned after failed validation contain an **error object** whose values are **ValidatorError** object
  - has a **kind**, **path**, **value** and **message** properties

```
toy.save((err) => {
      assert.equal(err.errors.color.message, 'Color');
      assert.equal(err.errors.color.kind, 'Invalid color');
      assert.eqial(err.errors.color.path, 'color');
      assert.equal(err.errors.color.value, 'Green');
      ...
});
```

Validation

- No matter which approaches you choose, in the end, some of the validations can fail
  - You should **always return** a helpful error **message** to the user
  - **Never reload** the page but always keep the user data inserted because that is a bad user experience
- More info
  - https://express-validator.github.io/docs/
  - https://mongoosejs.com/docs/validation.html

Validation Demo

Error Handing

Error Handling

- Errors in your code should be handled properly
- These errors can be different types
  - **Technical**/**Network** Errors
  - "**Usual**"/"**Expected**" Errors
  - **Bugs**/**Logical** Errors

Error Handling

- **Technical**/**Network** errors
  - MongoDB server might be down
- "**Usual**"/"**Expected**" Errors
  - File can't be read or some database operation fails
- **Bugs**/**Logical**
  - User object used when it doesn't exist
    - These errors are our fault
    - They should be fixed during development

Working with Errors

- An error is a **technical object** in a node application. This built-in error object can be thrown
  - Synchronous code
    - **try-catch**
  - Asynchronous code
    - **then()-catch()**
- In the end in both scenarios, you have to choice
  - Directly handle the error
  - Use **ExpressJS** functionality

Error Handling

- There is a scenario where you **can't continue**, but there is **no technical error**
  - If some user tries to login, but the username does not exist
  - You must check the values and decide what to do
    - Throw an error
    - Directly handle the "error"

Error Handling

- Handling errors synchronously

```
const User = require('../models/User/');

async (req, res, next) => {
    const { username, password } = req.body;
    try{
      const currentUser = await User.findOne({ username });
      // Login...
    } catch (e) {
      // Handle error properly...
    }
};
```

Error Handling

- Handling errors asynchronously

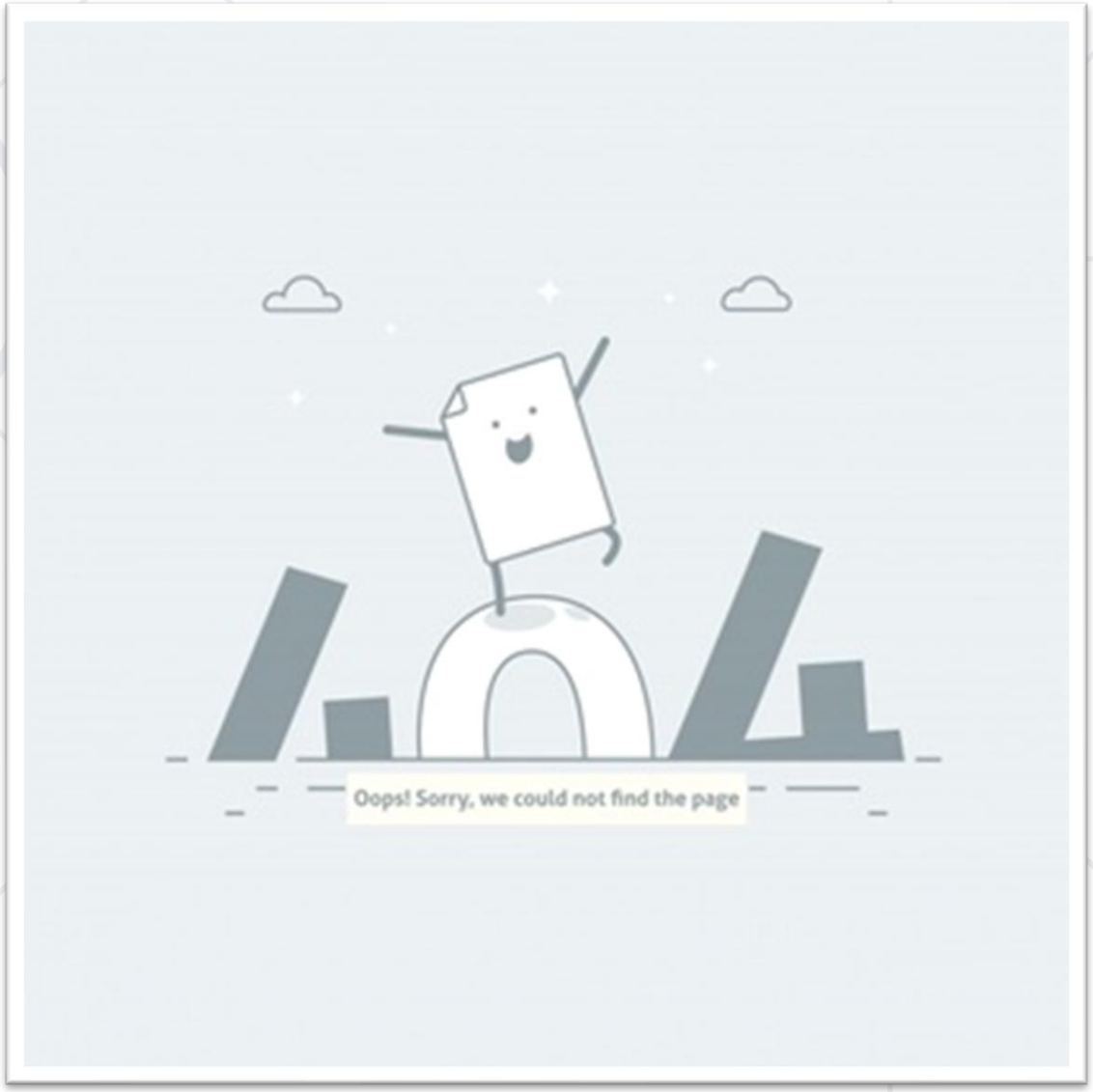
```
Post.findById(postId)
  .then((post) => {
    // Delete post
  })
  .catch(error => {
    if (!error.statusCode) {
       error.statusCode = 500;
    }
    next(error);
  })
```

If status code is missing, then something went wrong with the server

The error is sent to the middleware

Error Handling

- In all cases, you can
  - Return an **error page**
  - Return a response with **error information**
  - **Redirect**



Error Handling Demo

Summary

- Validation
  - Why and how validate data?
  - Validating and sanitization data with express-validator
  - Mongoose validator
- Error Handling
  - Different types of errors

Questions?

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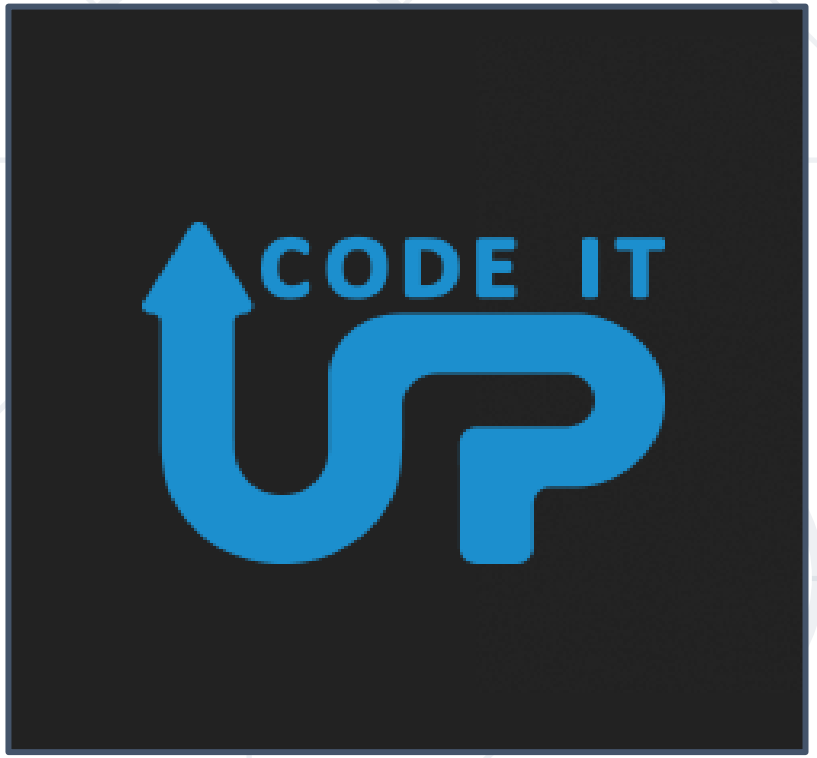

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