Online Multimedia

Winter Semester 2019/20

Tutorial 03 – Advanced JS

Today's Agenda

- The EventLoop
- JS Modules, Types & OOP
- TypeScript
- Roundup Quiz

The Event Loop

The Event Loop

- JavaScript is inherently single threaded
  - This for example prevents race conditions when modifying the DOM
  - WebWorkers are a way to explicity programm concurrency in JS
- But timeouts, callbacks, promises, etc. somehow happen „while“ other code is being executed
- This is due to very well-defined interleaving in the JavaScript **EventLoop**
- Every browser engine implements their own version based on standardized semantics

The Main Loop

- The Main Loop executes sequential code
- It also delegates when to execute messages and when to render

Adapted from Jake Archibald's Talk: In The Loop

The Message Queue

- The message Queue waits for enqueued messages
- If messages are queued it executes a single message to completion and returns to the main loop
- If a messages takes a long time to complete, the main loop is blocked
  - Do not put long running code in messages, instead split it into multiple messages

Adapted from Jake Archibald's Talk: In The Loop

Blocking with Messages

```
// This blocks the EventLoop
setTimeout(function () {
  while (true) { }
}, 0);

// This does not
setTimeout(function cb () {
  setTimeout(cb, 0);
}, 0);
```

Rendering

- Rendering first calculates the stylesheet and the result layout
- It then paints the WebPage
- Rendering never happens during a message execution, so it always paints the result of all DOM manipulations in a message
- But not every message triggers a re-rendering

Adapted from Jake Archibald's Talk: In The Loop

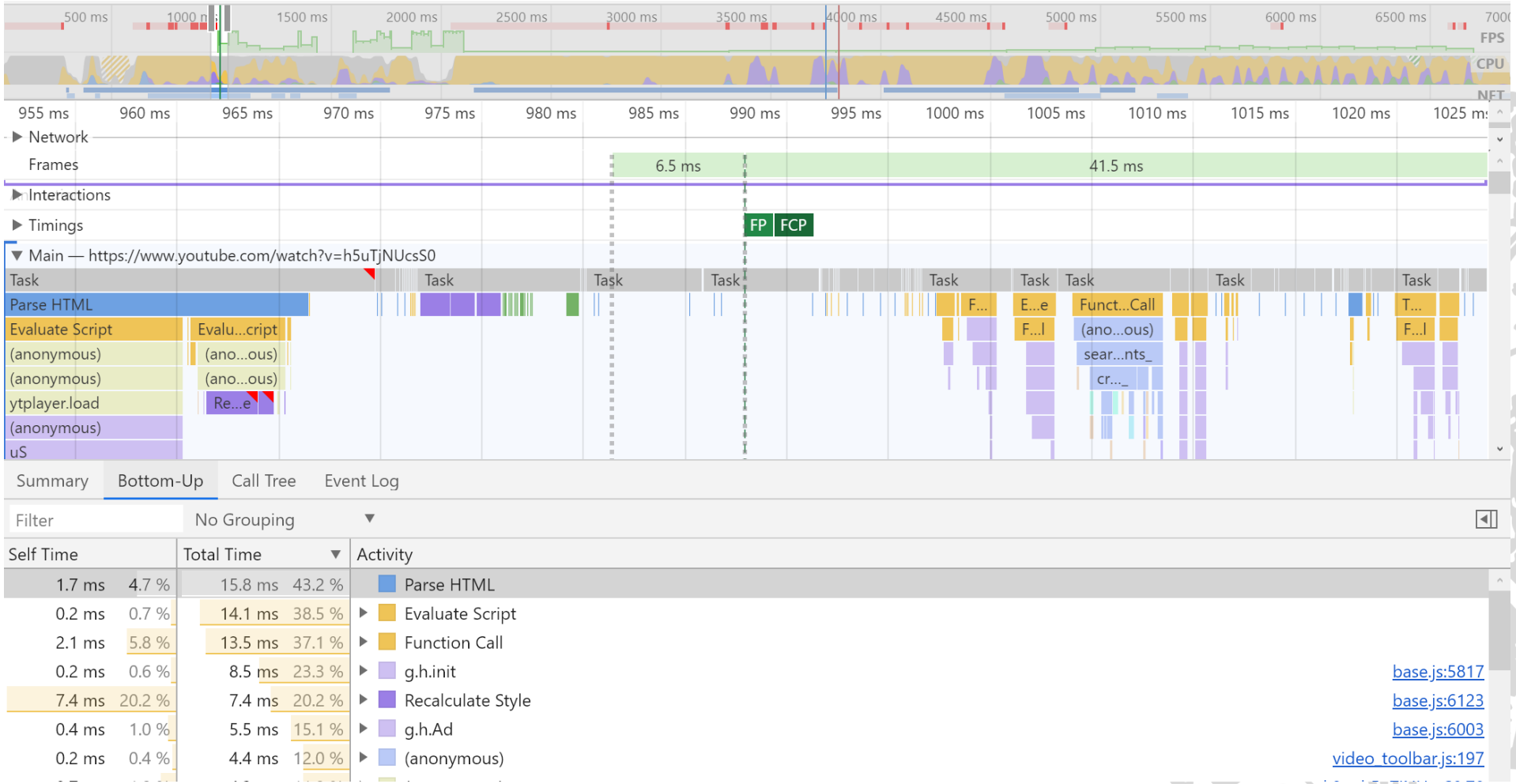
`requestAnimationFrame`

- To make sure you only modify the DOM when it is actually re-rendered, use `requestAnimationFrame`
- All queued RAFs are executed as **part of the rendering** and therefore at the same framerate as the rendering

- *Making sure the EventLoop is not blocked maintains a consistent framerate and therefore responsiveness and user experience*

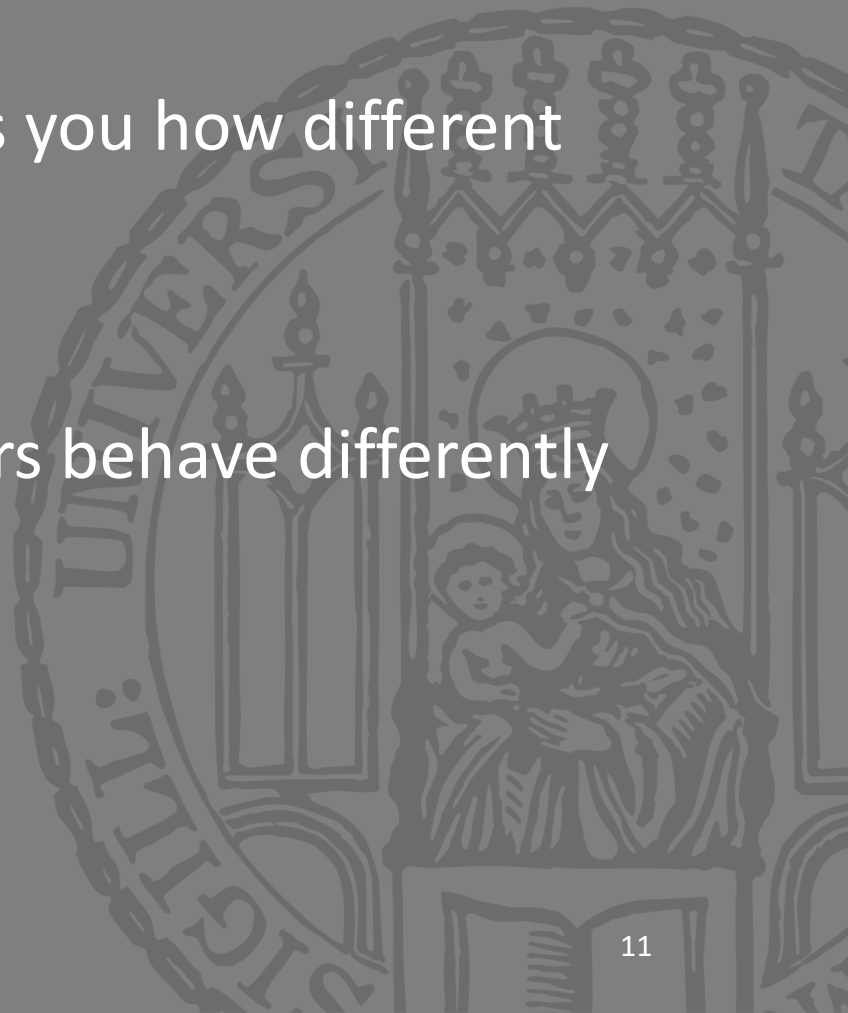
Adapted from Jake Archibald's Talk: In The Loop

Debugging the EventLoop



Breakout #1

- Use the `breakout-01.html` skeleton
- There are three versions of a spinner that shows you how different animation methods perform
- Complete these implementations
- Observe and try to explain why the three spinners behave differently



Modules

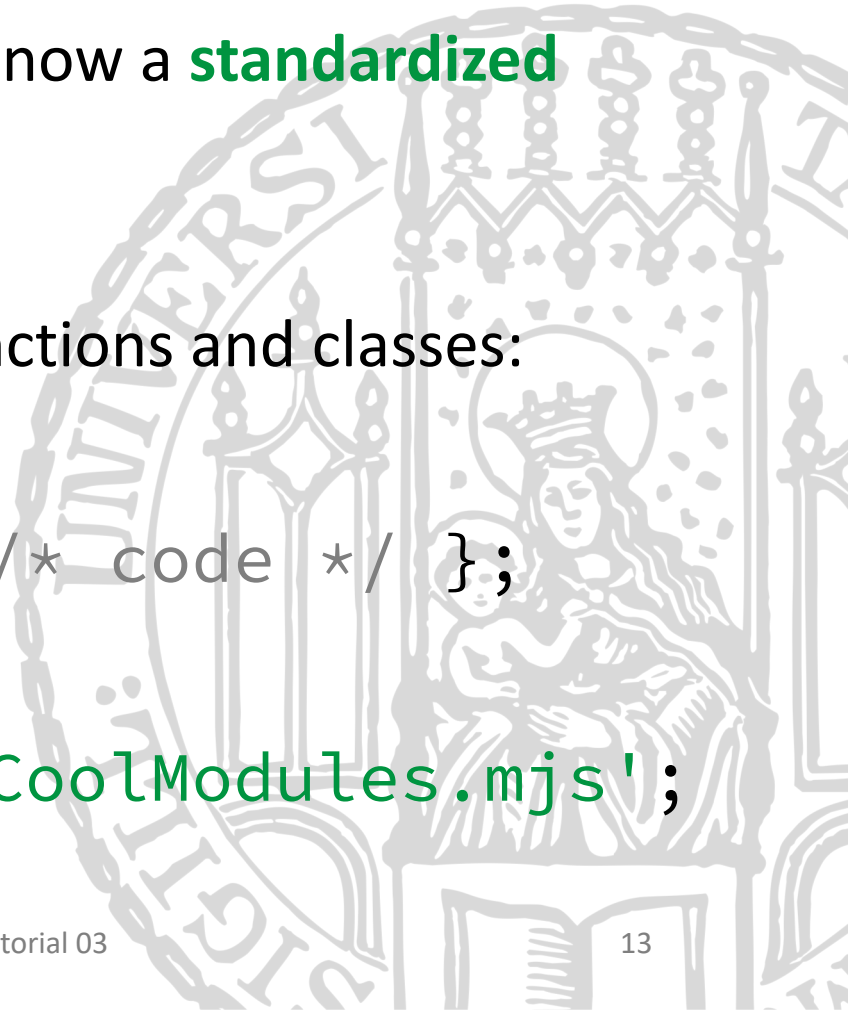
ES6 Modules

- Modules allow splitting code into functionally distinct parts
- After many custom module implementations, there is now a **standardized** module system

- This allows `exporting` and `importing` of values, functions and classes:

```
export function myCoolFunction () { /* code */ };
```

```
import { myCoolFunction } from './myCoolModules.mjs';
```



ES6 Modules

- When using modules in HTML the script must specify that it is a module:
  ```
  <script type="module" src="myScript.mjs"></script>
  ```
- `<script nomodule>` can be used as fallback for old browsers.

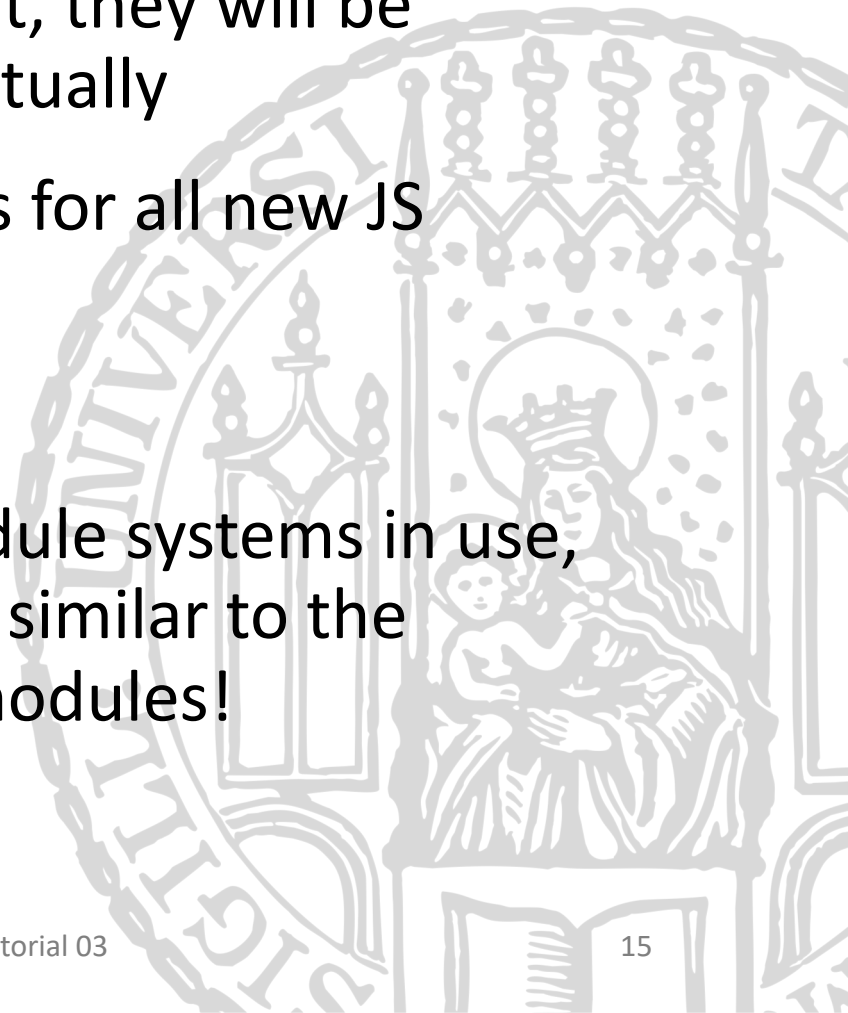
- By convention, JS files with modules have the *.mjs file extension

- Modules can also be loaded dynamically:
  ```
  const { foo } = await import('./myScript.mjs');
  ```

Module Systems

- With modules officially introduced into JavaScript, they will be adopted by major frameworks and libraries eventually
- Browser support will still be tricky though, as it is for all new JS features.

- Currently there are still a lot of custom-built module systems in use, e.g. in NodeJS. So beware: Justs because it looks similar to the standardized ES6 modules, it might not be ES6 modules!



Types & OOJS

JavaScript Types

- While JavaScript is not type checked, types *do* exist
  - `undefined`
  - `number`
  - `string`
  - `boolean`
  - `Object`
  - `Symbol`
  - `any`
- A good editor or IDE can give code completion and warnings based on type information

```
/** @type {Object} */
const x = { };

/** @type {{ a: number }} */
const x = { a: 5 };

/** @param {{ foo: string }[]} x */
function f (x) {x.map((i) => i.foo); }

/** @type {(any) => number} */
const f = function (x) { return 5; }
```

JavaScript Types

- `typeof` and `instanceof` can be used to determine the type of a value but their behaviour can be counter-intuitive
- `typeof` more or less returns the JavaScript type
- `instanceof` is concerned with the inheritance hierarchy

```
const obj = { };
const arr = [ ];
const fun = function () { };

typeof obj // "object"
typeof arr // "object"
typeof fun // "function"
typeof null // "object"

arr instanceof Object // true
arr instanceof Array // true
fun instanceof Object // true
fun instanceof Function // true
```

OO in JS

- JavaScript supports **Prototype-based** Object Orientation

- Classes are defined by their **constructor functions**:

```
function Animal (name) {
  this.name = name;
}
```

and instantiated with the new keyword

```
new Animal('Lion');
```

OO in JS – Inheritance

- Inheritance in JS happens via **Prototype**
- Each constructor function has a prototype object
- The prototype contains all inherited members, usually functions and constants

```
Animal.prototype.greeting =
  function () { return this.name + 'says hello!'; }

(new Animal('Lion')).greeting() // 'Lion says hello!'
```

- To inherit members one must establish a prototype chain along which members are inherited

OO in JS – Inheritance

```
function Animal (name) { this.name = name; }
Animal.prototype.greeting = function () { return this.name + '
says hello!'; }

function Lion () {
  Animal.call(this, 'Lion'); // ~ super call
  this.maneLength = Math.random();
}

Lion.prototype = Object.create(Animal.prototype); // "Lion extends
Animal"
Lion.prototype.roar = function () { return 'ROOAAAAR!'; }
```

OO in JS – Inheritance

```
// Lion extends Animal
Lion.prototype = Object.create(Animal.prototype);

// MountainLion extends Lion
MountainLion.prototype =
Object.create(Lion.prototype);

// Prototype Chain:
// MountainLion.__proto__               -> Lion
// MountainLion.__proto__.__proto__ -> Animal
```

OO in JS – Inheritance – ES6 classes

```
class Animal {
  constructor (name) {
    this.name = name;
  }

  greeting () { return this.name + ' says hello!'; }
}

class Lion extends Animal {
  constructor () {
    super('Lion');
    this.maneLength = Math.random();
  }

  roar () { return 'ROOOAAAR!'; }
}
```

OO in JS – ES3 vs. ES6

Old function syntax	New ES6 class syntax
Greater flexibility	Familiar syntax
Better information hiding, quasi-private values	Easier to define static members and inheritance
Closer to the actual JS behaviour	Hides weird JS details
Full browser support	Good support in modern browsers
No real private members	No real private members

WTH is `this`?

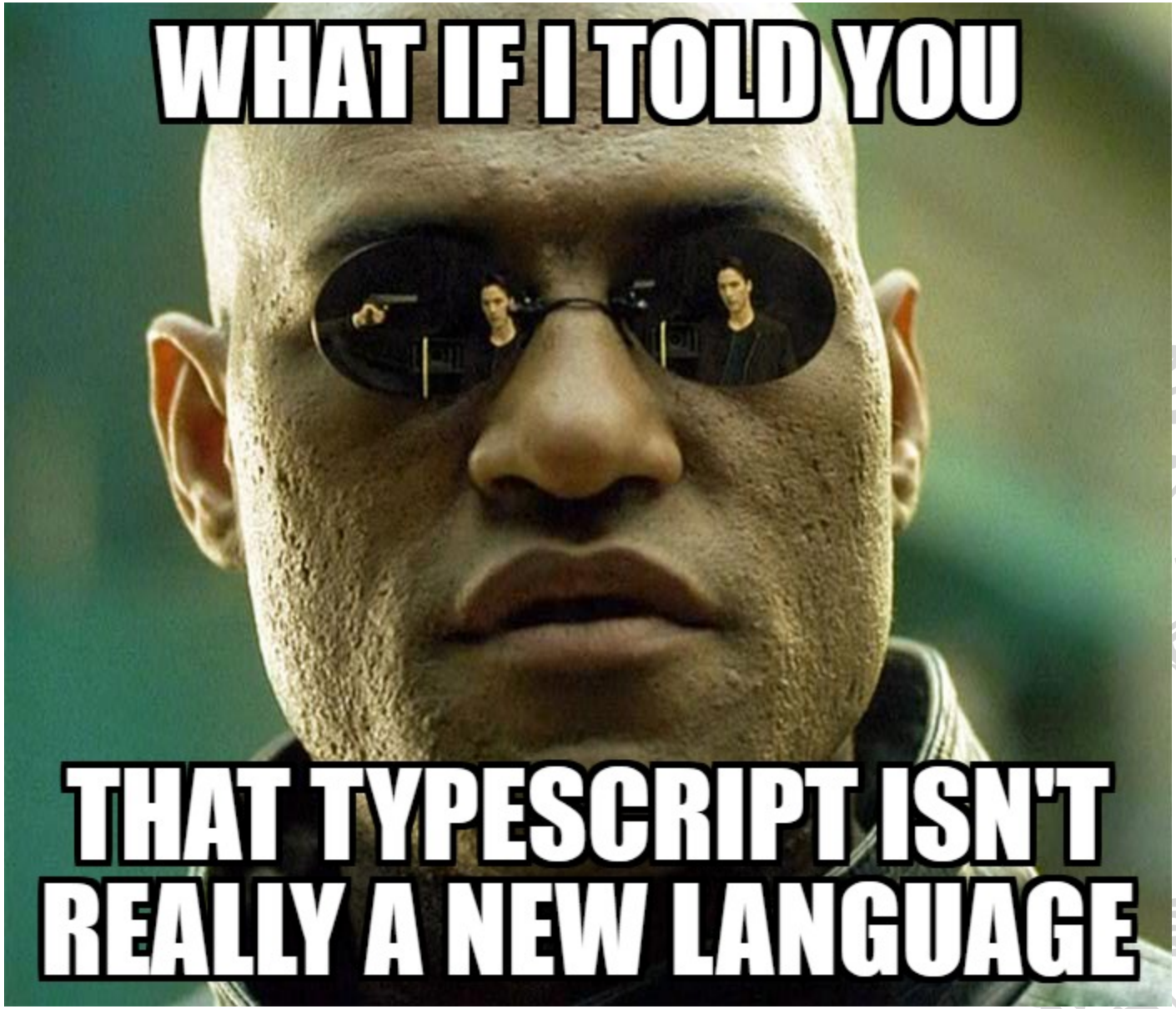
- You may have noticed that we used `function` instead of fat arrow for defining member functions
- That is because fat arrow does bind the `this` reference from the object instance, so `this` would be whatever it was when defining the member function

WTH is `this`?

```
Animal.prototype.greeting =
  function () { return this.name + '...'; }

new Animal('Lion').greeting() // 'Lion ...'

Animal.prototype.greeting =
  () => this.name + '...';

new Animal('Lion').greeting() // ' ...'
```

TypeScript


ANOTHER LANGUAGE
YEAH, SURE, WHATEVER


WHAT IF I TOLD YOU
THAT TYPESCRIPT ISN'T REALLY A NEW LANGUAGE

TypeScript

- TypeScript is a super-set of JavaScript

- It essentially is JavaScript with type-annotations and some other features, like
  - Class-member visibility
  - Interfaces
  - Enums
  - etc.

- This is good because it allows
  - More concise code
  - More developer control
  - Static checking

TypeScript – Examples

```
const x: number = 5;

function joinString (x: string[]): string { … }

// There are    interfaces in TS
interface Engine {
  horsePower: number;
  ignite (): number;
}

// Classes can   have member-visibility
class Car {
  private engine: Engine;
  public start (): void { … }
}
```

TypeScript – Comparison

```
const x: number = 5;

function joinString (x: string[]): string { … }

// There are no interfaces in JS D=
interface Engine {
  horsePower: number;
  ignite (): number;
}

// Classes can't have member-visibility
class Car {
  private engine: Engine;
  public start (): void { … }
}
```

The JS/TS Ecosystem

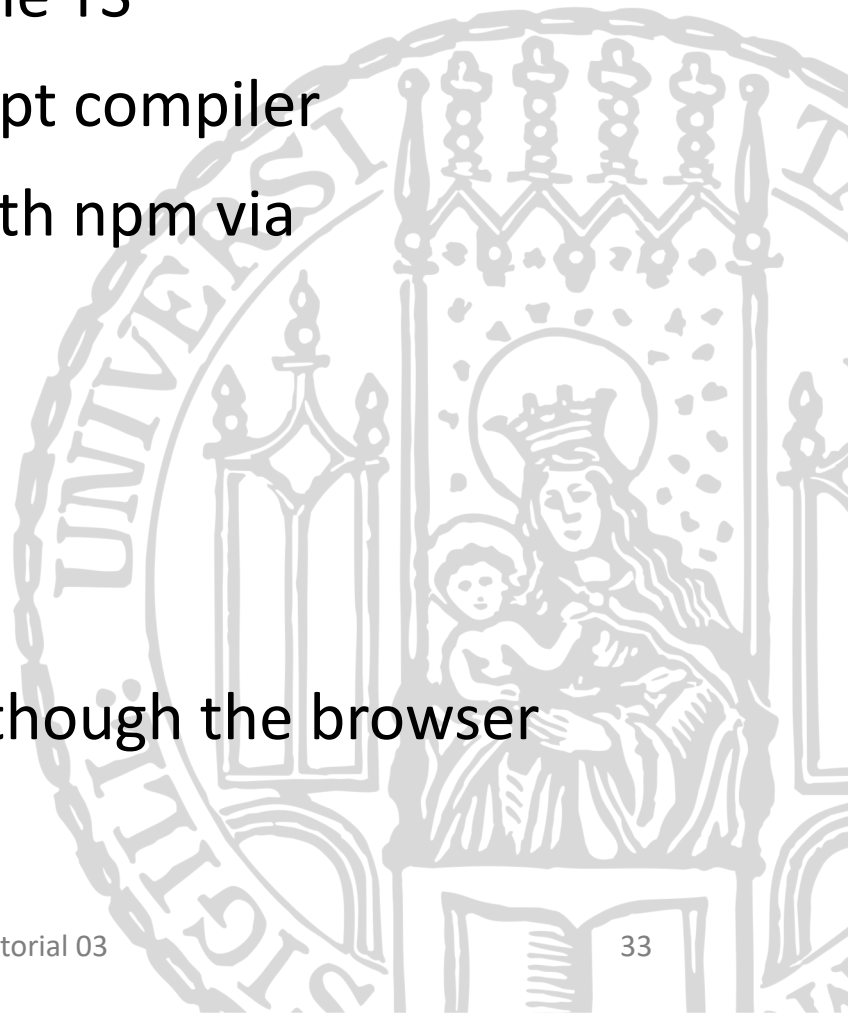
- Obviously your browser does not know how to handle TS
- It has to be transpiled into JS with `tsc`, the TypeScript compiler
- This, and many many more tools, can be installed with npm via

```
npm install -g typescript
```

  - The –g is to install it globally so you can use it as CLI
- Now you can compile *.ts files to *.js files:

```
tsc my-file.ts
```

- **Source-maps** allow you to debug the TS code, even though the browser uses the generated JS.



Breakout #2

- In the breakout skeleton, a small and buggy Javascript web application is given
- Improve the code‘s data structures by applying OO-programming patterns through TypeScript, so that one recognized the bugs at compilation time

brand	model	type
BMW	i3	car
Tesla	Model 3	car
Opel	Astra	car
VW	Golf	car
Embraer	E190	airplane
Airbus	A220	airplane
Airbus	A380	airplane

Roundup Quiz

1. Why does it make sense to keep JS single-threaded?
2. How do you convert between a float and an int in JS?
3. Is a static private value in Javascript part of the prototype or the constructor function?
4. What does the –g flag do for npm?