Entwicklung Web-basierter Anwendungen

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Einführung in JavaScript | Wichtige Sprachkonzepte

Outline

- Error Handling using `try...catch`
- ES6 Syntax
- Closures
- Asynchronous Programming
  - Callbacks
  - Promises
  - Async & Await

Error Handling 💣

- **Programm defensively** ⇝ anticipate the things that can go wrong and handle them in your code
  - e.g. Checking parameter types
  - e.g. Checking for `null` or `undefined`
- Surround code that can throw errors with `try / catch`
  - e.g. in node.js, an unhandled error might cause your server to shut down
- Throw `Error` objects in case of unexpected events

Error Handling is a kind of mindset

Prepare your code for things that can go wrong & handle them nicely!

```
// NO Error Handling
const printFirstTwoLetters = (str) => {
    const firstTwo = str.substring(0,2);
    console.log(firstTwo); // will not be executed
}
printFirstTwoLetters(5) // str.substring is not a function
```

```
// WITH Error Handling
const printFirstTwoLetters = (str) => {
    try {
        if (typeof str !== "string")
            throw new Error("Parameter is not a String");
        if (str.length < 2)
            throw new Error("String is less than 2 chars");
        console.log(str.substring(0,2));
    } catch (err) {
        console.log(err)
    }
}
printFirstTwoLetters(5) // Parameter is not a String
printFirstTwoLetters("5") // String is less than 2 chars
```

Some new ES6 Syntax Features

Destructuring

```
let robotA = { name: "Bender" };
let robotB = { name: "Flexo" };

let { name: nameA } = robotA;
let { name: nameB } = robotB;

console.log(nameA); // "Bender"
console.log(nameB); // "Flexo"
```

```
let options = {   title: "Menu",
                  width: 100,
                  height: 200
              };

let {title, width, height} = options;

console.log(title, width, heigth);
```

The Spread Operator

```
let dateFields = [1970, 0, 1];
let d = new Date(...dateFields);
```

```
let obj1 = { foo: 'bar', x: 42 };
let obj2 = { foo: 'baz', y: 13 };
let mergedObj = { ...obj1, ...obj2 };
// Object { foo: "baz", x: 42, y: 13 }
```

Literal Strings

```
const a = 101;
const b = 42;
const quiz = "Sum of " + a + " + " + b +
  " is " + (a + b) + ".";
```

```
// written as template literal
const quiz =
  `Sum of ${a} + ${b} is ${(a + b)}.`;
```

Source: https://www.youtube.com/watch?v=a00NRSFgHsY and https://javascript.info/destructuring-assignment

Closures

- A closure is the combination of outer and inner functions
- A closure provides access to an outer function's scope from an inner function
- Closures are a common way to achieve encapsulation, ie.
  ⇝ hiding data from external and uncontrolled access
- To use a closure, define a function inside another function and expose it – return it or pass it to another function
- The inner function will have access to the lexical scope of the outer function, even after the outer function has returned

Usage Scenarios

- Isolation of protected variables
- Transportation of states to another scope
- Creation of stateful functions

```
function MyProtectedObj(param) {
  const mySecretVariable = Math.floor(4711 * Math.random());
  let name = param;
  return {
    getCode: function() {
      return mySecretVariable;
    },
    setName: function(value) {
      name = value;
    },
    getName: function() {
      return name;
    }
  }
}
```

```
let obj = MyProtectedObj("James");

console.log(mySecretVariable);      // Reference Error
console.log(obj.mySecretVariable);  // outputs 'undefined'

obj.getCode();          //returns the randomly generated number
obj.setName("John");    //ok
obj.getName();          //outputs 'John'
```

Closures – Pitfalls

⚠ Be careful, `this` does not work in closures ⚠

```
function MyProtectedObj(name) {
  this.mySecretVariable = Math.floor(4711 * Math.random());
  this.name = name;

  return {
    getCode: function() {
      return mySecretVariable;
    },
    setCode: function(value) {
      mySecretVariable = value;
    },
    getName: function() {
      return name;
    }
  }
}

let obj = MyProtectedObj("James");

//works since mySecretVariable is bound to the global scope
console.log(mySecretVariable);  // outputs the generated number
```

Sources: https://medium.com/javascript-scene/master-the-javascript-interview-what-is-a-closure-b2f0d2152b36 and https://www.computerbase.de/forum/threads/warum-sind-closures-so-wichtig.1906523/

Asynchronous JavaScript

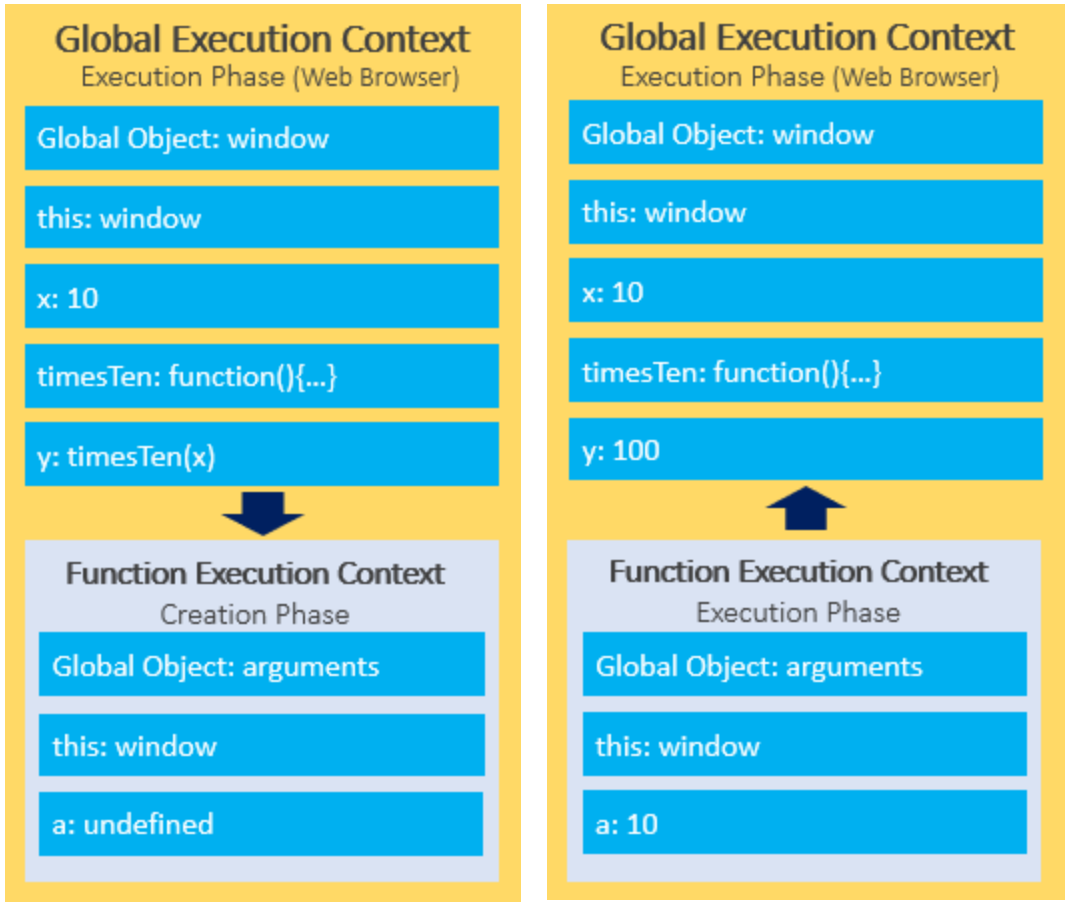
How JavaScript executes Code 🏃 – The Execution Context

The JavaScript engine executes code in **execution contexts**

1. the global exection context or
2. function execution contexts

Each execution context has two phases:

1. Creation Phase
   - Creation of `this`-object and binding it to the exection context
   - Memory heap setup to store variables and function declarations
   - Initializing variables
2. Execution Phase
   - Code is executed line-by-line (ie sychronously)
   - Values are assigned to variables
   - Function calls are executed



For each function call, the JavaScript engine creates a new function execution context.

To keep track of all the execution contexts, the JavaScript engine uses the **call stack**.

Source: https://www.javascripttutorial.net/javascript-execution-context/

The Call Stack

The call stack works based on the LIFO principle

When executing a script, the JavaScript engine creates a global execution context and pushes it on top of the call stack

Whenever a function is called, the JavaScript engine creates a function execution context for the function, pushes it on top of the call stack, and starts executing the function.

If a function calls another function, the JavaScript engine creates a new function execution context for the function being called and pushes it on top of the call stack.

When the current function completes, the JavaScript engine pops it off the call stack and resumes the execution where it left off.

The script will stop when the call stack is empty.

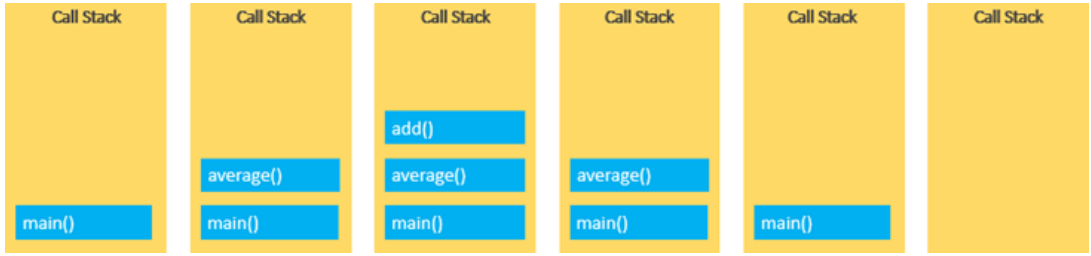
JavaScript uses a call stack to manage execution contexts:

- Global execution context
- function execution contexts

```
function add(a, b) {
    return a + b;
}

function average(a, b) {
    return add(a, b) / 2;
}

let x = average(10, 20);
```



Source: https://www.javascripttutorial.net/javascript-call-stack/

JavaScript is a Single-Threaded, Non-Blocking, Asynchronous PL

Function Execution Stack (aka Call Stack)

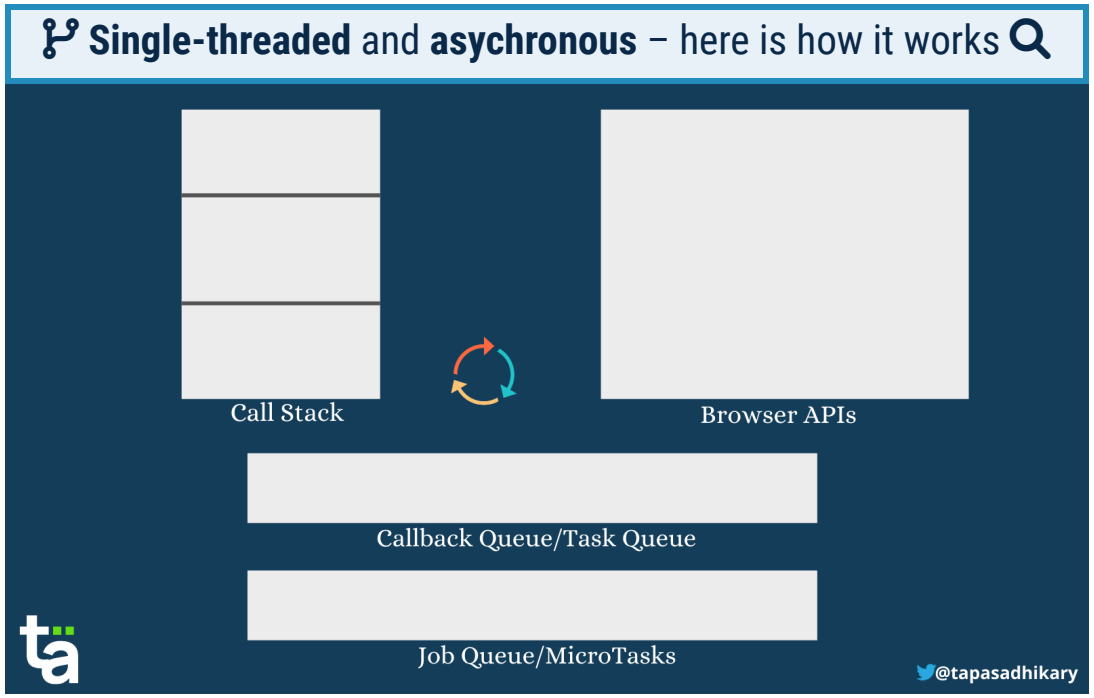
- All invoked functions are added to the call stack
- Completed functions are removed until the stack is empty
- Functions are executed synchronously one-by-one

Callback Queue (aka Task Queue)

- Callbacks are stored in this separate (FIFO) queue
- The JS engine periodically looks for new entries in the task queue and once the call stack is empty it shifts the first entry to the call stack and executes it synchronously (⇒ event loop)

Job Queue (⟶ Micro Tasks)

- Promise executor functions are stored in the job queue
- For each loop of the event loop, one macro task is completed out of the callback queue
- Once that task is complete, the event loop visits the job queue and completes all micro-tasks in the job queue before it continues.

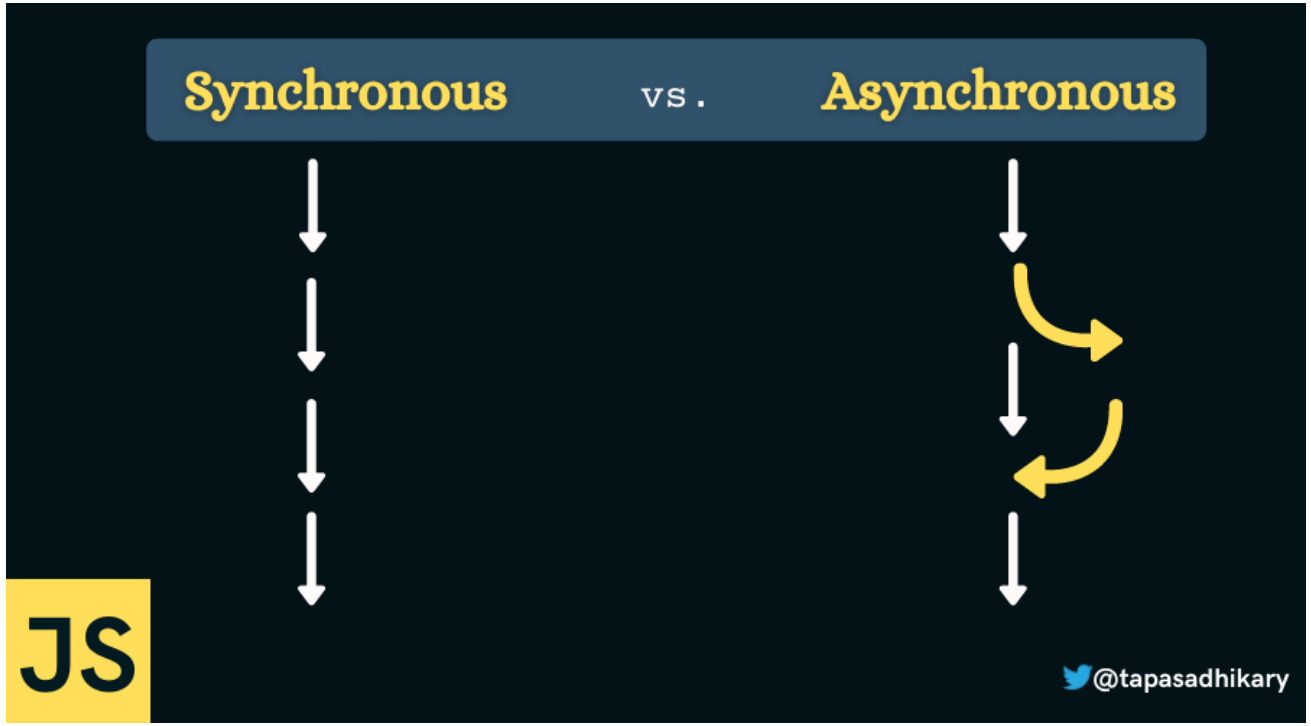


Source: https://www.freecodecamp.org/news/synchronous-vs-asynchronous-in-javascript/

Asynchronous Programming

- Javascript is a single-threaded, non-blocking, asychronous, dynamically, and weakly-typed programming language
- JavaScript has some unique features for the asynchronous execution of code
- The 3 most important concepts are

1.) **Callbacks**
2.) **Promises**
3.) **Async & Await**



Callbacks

- Callbacks are a central element in asynchronous JavaScript
- Callbacks are (mostly anonymous) functions that will be called when a previously defined event occurs
- Callbacks are implement as handler functions; they are called asynchronously by the JavaScript engine
- Callbacks are most commonly used to ...
  - handle input events
  - process recieved JSON data from AJAX requests
- Callbacks can become problematic → ☢ Callback-Hell

```
//************ Example #1: A Simple Callback ************
console.log("Hallo Welt - jetzt");

setTimeout(() => {
    console.log("Hallo Welt - nach 1 Sek.")
}, 1000 );

console.log(
    "Dieser Code wird vor dem asynchronen Code ausgeführt...");

// Output:
// "Hallo Welt - jetzt"
// "Dieser Code wird vor dem asynchronen Code ausgeführt..."
// "Hallo Welt - nach 1 Sek."


//******* Example #2: Event Handler for DOM Elements *******
const btn = document.querySelector('#btn');
btn.addEventListener("click", () => {     });
```

Callback-Hell

The ☢ **callback-hell** denotes a christmas-tree-like pattern of nested callback handlers

```
let i = 0;
let stop = false;

setTimeout(() => {
    console.log("rot - " + i);
    setTimeout(() => {
        console.log("gelb - " + i);
        setTimeout(() => {
            console.log("grün - " + i);
            stop = true;
        }, 2000);
    }, 2000);
}, 2000);

const inc = setInterval(() => {
    i = i + 1;
    if (stop === true) {
        clearInterval(inc);
    }
}, 500);
```

Output

```
// rot - 3
// gelb - 7
// grün - 11
```

Promises

- A Promise is an object that represents the completion or failure of an asynchronous operation
  - a value is created in a success case
  - an error is created if the promise does not complete
- The promise constructor expects an executor function with two callback functions as arguments:
  - `resolve` indicates a successful completion of the task
  - `reject` indicates the occurence of an error
- The callback functions are provided by JavaScript and announce the outcome
- They can hold individial data objects
- Promises have three handler methods
  - `.then()` accepts `result` and `error` as arguments
  - `.catch()` used to handle error cases
  - `.finally()` used to perform cleanup work

```
// Example
const myPromise = new Promise((resolve, reject) => {
    const rand = Math.floor(Math.random() * 2); // '0' or '1'
    if (rand === 1) {
        resolve(rand); // resolve can hold individal data
    } else {
        reject(new Error("Fehlerfall - " + rand));
    }
} );

// Promises can be chained instead of nested
// ie., no christmas-tree-pattern
myPromise
    .then((rand) => console.log("Success - " + rand))
    .then(() => console.log("2. Ausgabe nur im Erfolgsfall"))
    .catch((err) => console.error(err));
```

Source: https://blog.greenroots.info/javascript-promises-explain-like-i-am-five

Fetch with Promises

- The **Fetch API** interface allows web browser to make asynchronous HTTP requests without `XMLHttpRequest`
- The `fetch()` method allows to fetch resources asynchronosly
  - it takes at least one argument: the URL to fetch
  - it does not directly return the data but a promise that resolves with a `Response` object
- The `Response` object contains the entire HTTP response
  - `.json()` needs to be called to retrieve the JSON data
- The promise object returned won't be rejected in case of HTTP status codes `404` or `500`

```
const fetch = require('node-fetch');  // not needed in browser

fetch("https://randomuser.me/api/")
    .then((response) => response.json())
    .then((data) => console.log(data.results) )
    .catch((err) => console.error(err));

// Output
[
  {
    gender: 'male',
    name: { title: 'Mr', first: 'Maël', last: 'Da Silva' },
    location: {
      street: [Object],
      city: 'Poitiers',
      state: 'Guadeloupe',
      country: 'France',
      postcode: 54475,
      coordinates: [Object],
      timezone: [Object]
    }, [...]
  }
]
```

Sources: https://developer.mozilla.org/en-US/docs/Web/API/Fetch_API/Using_Fetch

Async & Await – The Preferred Way to handle Promises and Asynchronous Operations

- Async & Await work on top of promises
- We use `async` to return a promise
  - `async` declares an asychronous function
  - transforms a function into a `Promise`
  - enable the use of `await`
  - resolve with whatever is returned by its body
- We use `await` to wait and handle a promise
  - `await` pauses the execution of asynchronous functions
    - until a promise is settled (either resolved or rejected)
    - and a value/error is returned/thrown
  - `await` is used in front on promises
  - only works with promises, not callbacks
  - can only be used inside `async` functions

```
const fetchUserWithErrorHandling = async () => {
    try {
        const res = await fetch(url);
        const data = await res.json();
        console.log("finished");
    } catch(err) {
        console.error(err);
    }
}

fetchUserWithErrorHandling();
```

- If the promise rejects, it throws an error that is handled by the `catch`-block
- `async` / `await` enables standard error handling with `try...catch`

If you do not return a promise explicitly from an async function, JavaScript automatically wraps the value in a Promise and returns it.

Await must be Invoked in an async Function

```
const fetchUserDetails = async (userId) => {
    // pretend we make an asynchronous call
    // and return the user details
    return {'name': 'Robin', 'likes': ['toys', 'pizzas']};
}
```

```
// not working
const user = await fetchUserDetails();
console.log(user);
```

```
// correct solution via IIFE
(async () => {
    const user = await fetchUserDetails();
    console.log(user);
})();
```

Remember

An async function always encapsulates its return value in a promise

Remember

`await` can only be called inside an async function

Remember

In order to use `await` regardless of an async function, it need to be wrapped in an async IIFE

Source: https://blog.greenroots.info/javascript-async-and-await-in-plain-english-please

JavaScript Modules – Comming soon...

- Modules are used to separte code into files
- Modules are self-contained units of code, stored in files
- more to come...

```
Code
```

Sources:

- https://www.freecodecamp.org/news/javascript-modules-explained-with-examples/
- https://www.freecodecamp.org/news/javascript-modules-beginners-guide/
- https://www.freecodecamp.org/news/javascript-modules-a-beginner-s-guide-783f7d7a5fcc/

Summary

Points to Remember

- Unsafe code should always be wrapped in a `try-catch()`-block
- Closures allow to hide data from external and uncontrolled access through a combination of inner and outer function
- Closures work both when executed as function as well as constructors
- JavaScript employs different language structures in order to enable asynchronocity
  - Functions are put to and executed in the call stack
  - Callbacks are so-called macro-tasks and processed in the Callback or Task Queue
  - Promises are micro-tasks and processed in the Job Queue
- The event loop priorizes micro tasks over macro tasks which are executed only when the call stack is empty
- Callback functions, Promises, and functions encapsulated in `async` and `await` are executed asynchronously