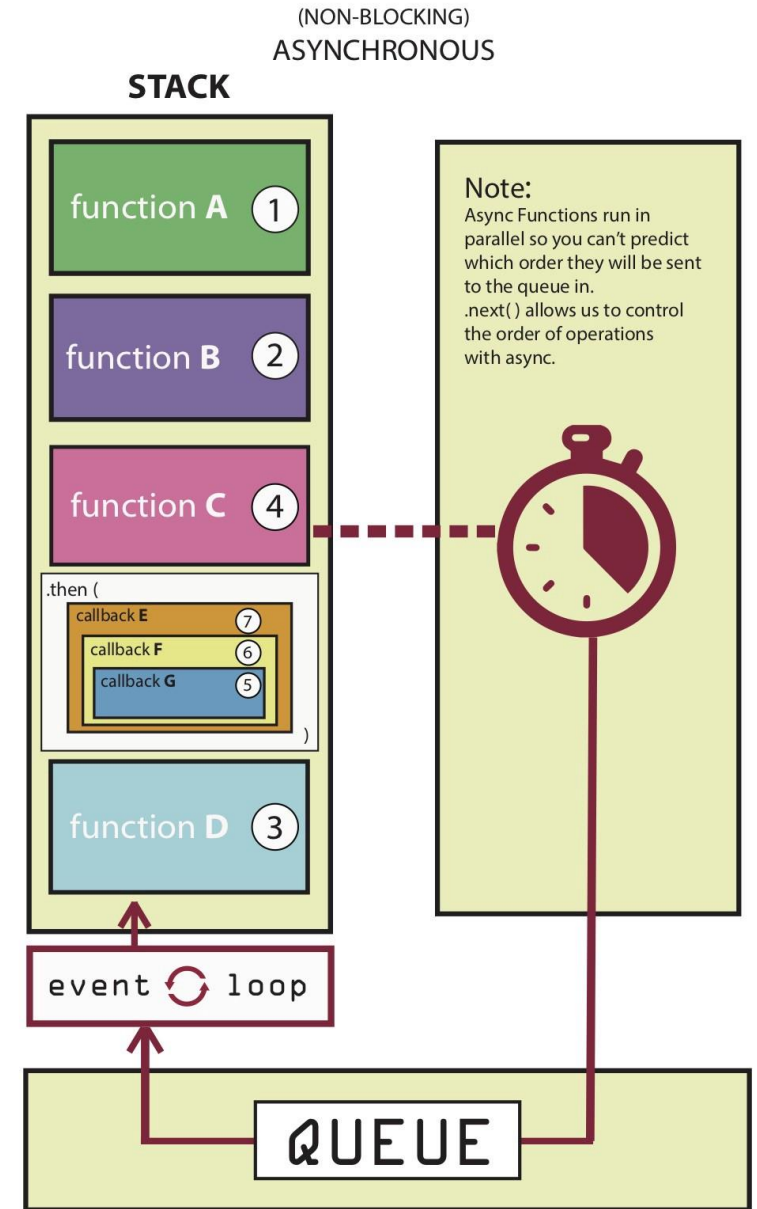# Asynchronous Programming in JS

"The" language of the Web

Fulvio Corno

Luigi De Russis

Outline

- Callbacks
- Functional Programming
- Asynchronous Programming
- Database Access with SQLite
- Promises
- async/await

JavaScript – The language of the Web

CALLBACKS

Callbacks

- A callback function is a function passed into another function as an argument, which is then invoked inside the outer function to complete some kind of routine or action.
  - Synchronous
  - Asynchronous

```
function logQuote(quote) {
    console.log(quote);
}

function createQuote(quote,
callback) {
    const myQuote = `Like I always
say, '${quote}'`;
    callback(myQuote);
}

createQuote("WebApp I rocks!",
logQuote);
```

Synchronous Callbacks

- Used in functional programming
  - e.g., providing the sort criteria for array sorting

```
let numbers = [4, 2, 5, 1, 3];

numbers.sort(function(a, b) {
  return a - b;
});

console.log(numbers);
```

```
let numbers = [4, 2, 5, 1, 3];

numbers.sort((a, b) => a - b);

console.log(numbers);
```

Synchronous Callbacks

- Example: filter according to a criteria
  - filter() creates a **new** array with all elements for which the callback returns true

```
const market = [
  { name: 'GOOG', var: -3.2 },
  { name: 'AMZN', var:  2.2 },
  { name: 'MSFT', var: -1.8 }
];

const bad = market.filter(stock => stock.var < 0);
// [ { name: 'GOOG', var: -3.2 }, { name: 'MSFT', var: -1.8 } ]

const good = market.filter(stock => stock.var > 0);
// [ { name: 'AMZN', var: 2.2 } ]
```

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FUNCTIONAL PROGRAMMING

Functional Programming: A Brief Overview

- A programming paradigm where the developer mostly construct and structure code using *functions*
  - not JavaScript's main paradigm, but JavaScript is well suited
- More "declarative style" rather than "imperative style" (e.g., for loops)
- Can improve program readability:

```
new_array =
 array.filter ( filter_function ) ;
```

```
new_array = [] ;
for (const el of list)
          if ( filter_function(el) )
                    new_array.push(el) ;
```

Notable Features of the Functional Paradigm

- Functions are *first-class* citizens
  - functions can be used as if they were variables or constants, combined with other functions and generate new functions in the process, chained with other functions, etc.
- *Higher-order functions*
  - a function that operates on functions, taking one or more functions as arguments and typically returning a new function
- Function *composition*
  - composing/creating functions to simplify and compress your functions by taking functions as an argument and return an output
- Call *chaining*
  - returning a result of the same type of the argument, so that multiple functional operators may be applied consecutively

Functional Programming in JavaScript

- JavaScript supports the features of the paradigm "out of the box"
- Functional programming requires *avoiding mutability*
  - i.e., do not change objects in place!
  - e.g., if you need to perform a change in an array, return a new array

Iterating over Arrays

- Iterators: `for ... of`, `for (..;..;..)`

Functional style

- Iterators: `forEach(f)`
  - Process each element with callback f

- Iterators: `every(f)`, `some(f)`
  - Check whether all/some elements in the array satisfy the Boolean callback `f`

- Iterators that return a new array: `map(f)`, `filter(f)`
  - Construct a new array

- `reduce`: callback function on all items to *progressively* compute a result
  `reduce(callback( accumulator, currentValue[, index[, array]] )[, initialValue])`

.forEach()

- forEach( ) invokes your (synchronous) callback function once for each element of an **iterable**

```
const letters = [..."Hello world"] ;
let uppercase = "" ;
letters.forEach(letter => {
  uppercase += letter.toUpperCase();
});
console.log(uppercase); // HELLO WORLD
```

.forEach()

- `forEach()` invokes your (synchronous) callback function once for each element of an **iterable**
  - The callback may have 3 parameters
    - `currentValue`: The current element being processed in the array.
    - `index` (Optional): The index of `currentValue` in the array
    - `array` (Optional): The array forEach() was called upon.
  - Always **returns *undefined*** and is **<u>not</u> chainable**
  - No way to stop or break a `forEach()` loop other than by throwing an exception
- `forEach()` does not mutate the array on which it is called
  - however, its callback *may* do so

.every()

- every() tests whether **all elements** in the array pass the test implemented by the provided function
  - Callback: Same 3 arguments as forEach
  - It returns a Boolean value (*truthy/falsy*)
  - It executes its callback once for each element present in the array until it finds the one where the callback returns a falsy value
    - If such an element is found, **immediately** returns false

```
let a = [1, 2, 3, 4, 5];
a.every(x => x < 10); // => true: all values are < 10
a.every(x => x % 2 === 0); // false: not all even values
```

.some()

- some() tests whether **at least one** element in the array passes the test implemented by the provided function
  - It returns a Boolean value
  - It executes its callback once for each element present in the array until it finds the one where the callback returns a truthy value
    - if such an element is found, **immediately** returns true

```
let a = [1, 2, 3, 4, 5];
a.some(x => x%2===0); // => true; a has some even numbers
a.some(isNaN);
```

.map()

- `map()` passes each element of the **array** on which it is invoked to the function you specify
  - the callback should return a value
  - `map()` always returns **a *new* array** containing the values returned by the callback

```
const a = [1, 2, 3];


const b = a.map(x => x*x);


console.log(b); // [1, 4, 9]
```

```
const letters = [..."Hello world"];


const uppercase = letters.map(letter
=> letter.toUpperCase());


console.log(uppercase.join(''));
```

.filter()

- `filter()` creates **a *new* array** with all elements that pass the test implemented by the provided function
  - the callback is a function that returns either true or false
  - if no element passes the test, an empty array is returned

```
const a = [5, 4, 3, 2, 1];

a.filter(x => x < 3); // generates [2, 1], values less than 3

a.filter((element, index) => index%2 == 0); // [5, 3, 1]
```

.reduce()

```
reduce(
        callback(accumulator, currentValue[, index[, array]])
        [, initialValue]
)
```

- reduce() combines the elements of an **array**, using the specified function, to produce **a *single* value**
  - this is a common operation in functional programming and goes by the names "inject" and "fold"

- reduce takes two arguments:

1. the *"reducer function"* (callback) that performs the reduction/combination operation (combine or **reduce 2 values into 1**)

2. an (optional) **initialValue** to pass to the function; if not specified, it uses the first element of the array as initial value (and iteration starts from the next element)

.reduce()

- Callbacks used with `reduce()` are different than the ones used with `forEach()` and `map()`
  - the *first* argument is the **accumulated result** of the reduction so far
  - on the first call to this function, its first argument is the initial value
  - on subsequent calls, it is the value returned by the previous invocation of the reducer function

```
const a = [5, 4, 3, 2, 1];

a.reduce( (accumulator, currentValue) =>
accumulator + currentValue,     0);
// 15; the sum of the values

a.reduce((acc, val) => acc*val,  1);
// 120; the product of the values

a.reduce((acc, val) => (acc > val) ? acc
: val);
// 5; the largest of the values
```

Array methods cheatsheet

.map(☐→○)

.filter(☐)

.find(☐)

.findIndex(☐) → 3

.fill(1, ○)

.copyWithin(2, 0)

.some(☐) → true

.every(☐) → false

.reduce(acc + curr)

20

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Chapter 11. Asynchronous JavaScript

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- Web technology for developers » JavaScript » Concurrency model and the event loop
- Web technology for developers » JavaScript » JavaScript Guide » Using Promises

JavaScript – The language of the Web

ASYNCHRONOUS PROGRAMMING

Asynchronicity

- JavaScript is single-threaded and inherently synchronous
  - i.e., code cannot create threads and run in parallel in the JS engine
- Callbacks are the most fundamental way for writing asynchronous JS code
- How can they work asynchronously?
  - e.g., how can setTimeout() or other async callbacks work?
- Thanks to the Execution Environment
  - e.g., browsers and Node.js
- and the Event Loop

```
const deleteAfterTimeout = (task) =>
{
   // do something
}
// runs after 2 seconds
setTimeout(deleteAfterTimeout, 2000,
task)
```

Execution Environment

Allocated Objects

Running function calls

Pending event handlers

Memory Heap

Call Stack

Web APIs

DOM (document)

AJAX (XMLHttpRequest)

Timeout (setTimeout)

Event Loop

Callback Queue

onClick   onLoad   onDone
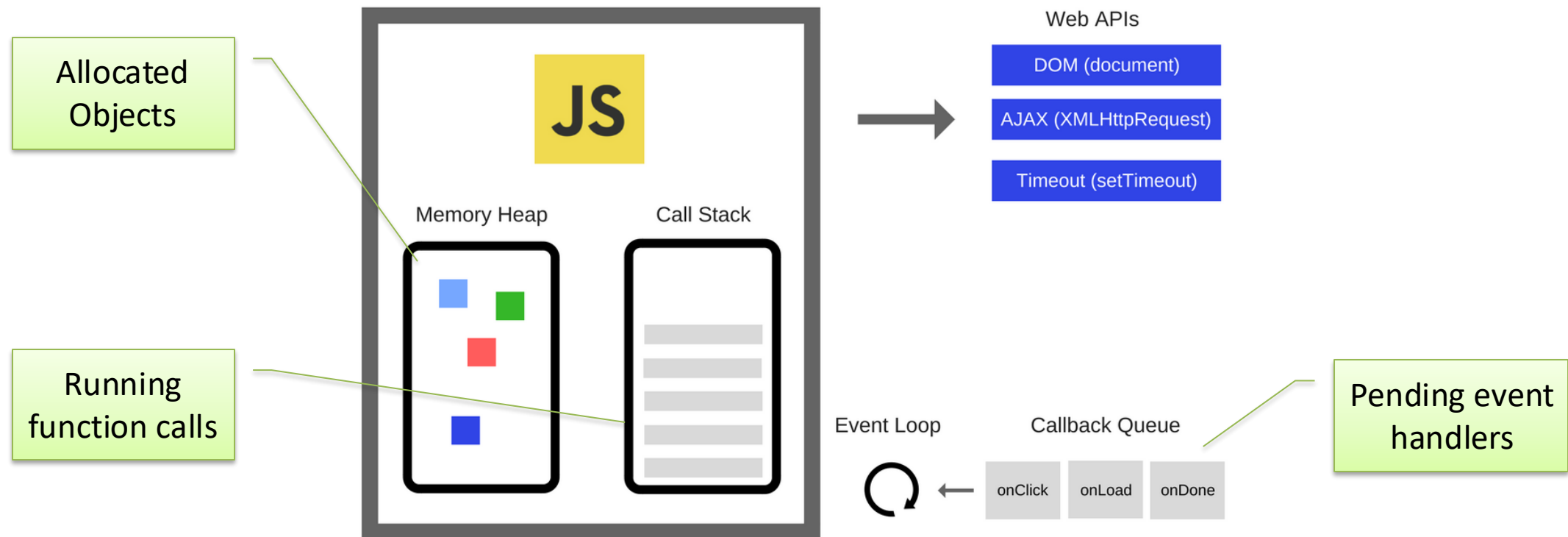
Event Loop

- During code execution you may
  - Call functions → the function call is pushed to the call stack
  - Schedule events → the call to the event handler is put in the Message Queue
    - Events may be scheduled also by external events (user actions, I/O, network, timers, …)
- At any step, the JS interpreter:
  - If the call stack is not empty, pop the top of the call stack and executes it
  - If the call stack is empty, pick the head of the Message Queue and executes it
- A function call / event handler is **never** interrupted
  - Avoid blocking code!

https://developer.mozilla.org/en-US/docs/Web/JavaScript/EventLoop

https://nodejs.org/en/docs/guides/event-loop-timers-and-nexttick/#what-is-the-event-loop

Non-Blocking Code!

- Asynchronous techniques are very useful, particularly for web development
- For instance: when a web app runs executes an intensive chunk of code without returning control to the browser, the browser can appear to be frozen
  - this is called blocking, and it should be the exception!
    - the browser is blocked from continuing to handle user input and perform other tasks until the web app returns control of the processor
- This may happen outside browsers, as well
  - e.g., reading a long file from the disk/network, accessing a database and returning data, accessing a video stream from a webcam, etc.
- Most of the JS execution environments are, therefore, deeply asynchronous
  - with non-blocking primitives
  - JavaScript programs are event-driven, typically

Asynchronous Callbacks

- The most fundamental way for writing asynchronous JS code

- Great for "simple" things!

- Handling user actions
  - e.g., button click

- Handling I/O operations
  - e.g., fetch a document

- Handling time intervals
  - e.g., timers

- Interfacing with databases

```
import readline from 'readline';

const rl = readline.createInterface({
    input: process.stdin,
    output: process.stdout
});

rl.question('How old are you? ', (answer) => {
    let description = answer;

    rl.close();
});
```

Timers

- To delay the execution of a function:
  - `setTimeout()` runs the callback function after a given period of time
  - `setInterval()` runs the callback function periodically

```
const onesec = setTimeout(()=> {
    console.log('hey') ; // after 1s
}, 1000) ;


console.log('hi') ;
```

Note: timeout value in ms, < 2^{31}-1 (about 24 days)

```
const myFunction = (firstParam,
secondParam) => {
  // do something
}
// runs after 2 seconds
setTimeout(myFunction, 2000,
firstParam, secondParam) ;
```

Timers

- `clearInterval()`: for stopping the periodical invocation of `setInterval`

```
const id = setInterval(() => {}, 2000) ;
// «id» is a handle that refers to the timer

clearInterval(id) ;
```

Handling Errors in Callbacks

- No "official" ways, only best practices!
- Typically, the first parameter of the callback function is for storing any error, while the second one is for the result of the operation
  - this is the strategy adopted by Node.js, for instance

```
fs.readFile('/file.json', (err, data) => {
  if (err !== null) {
    console.log(err);
    return;
  }
  //no errors, process data
  console.log(data);
});
```

Data Persistence

DATABASE ACCESS WITH SQLITE

Server-Side Persistence

- A web server should normally store data into a persistent database

- Node supports most databases
  - Cassandra, Couchbase, CouchDB, LevelDB, MySQL, MongoDB, Neo4j, Oracle, PostgreSQL, Redis, SQL Server, SQLite, Elasticsearch

- An easy solution for simple and small-volume applications is **SQLite**
  - in-process on-file relational database

SQLite

- Uses the '`sqlite`' npm module
- Documentation: https://github.com/mapbox/node-sqlite3/wiki

```
npm install sqlite3
```

```
import sqlite from 'sqlite3';
const db = new sqlite.Database('exams.sqlite', // DB filename
  (err) => { if (err) throw err; });

...
db.close();
```

SQLite: Queries

```
rows.forEach((row) => {
    console.log(row.name);
});
```

- const sql = "*SELECT…*";

- db.all(sql, [params], (err, rows) => { })
  - Executes sql and returns all the rows in the callback
  - If err is true, some error occurred. Otherwise, rows contains the result
  - rows is an array. Each item contains the fields of the result

https://www.sqlitetutorial.net/sqlite-nodejs/

SQLite: Queries

```
rows.forEach((row) => {
    console.log(row.name);
});
```

- ## db.get(sql, [params], (err, row) => { })
  - Get only the first row of the result (e.g., when the result has 0 or 1 elements: primary key queries, aggregate functions, ...)

- ## db.each(sql, [params], (err, row) => { })
  - Executes the callback once per each result row (no need to store all of them)

https://www.sqlitetutorial.net/sqlite-nodejs/

SQLite: Other Queries

- `db.run(sql, [params], function (err) { } )`
  - For statement that do not return a value
  - CREATE TABLE
  - INSERT
  - UPDATE
  - In the callback function
    - `this.changes` == number of affected rows
    - `this.lastID` == number of inserted row ID (for INSERT queries)
    - Note: To make `this` work correctly in the callback, the arrow function syntax cannot be used here

https://www.sqlitetutorial.net/sqlite-nodejs/

Parametric Queries

- The SQL string may contain parameter placeholders: ?
- The placeholders are replaced by the values in the [params] array
  - in order: one param per each ?

```
const sql = 'SELECT * FROM course WHERE code=?';
db.get(sql, [code], (err, row) => {
```

- Always use parametric queries – never string+concatenation nor `template strings`

Example

Table: course

	code	name	CFU
	Filter	Filter	Filter
1	01TYMOV	Information systems security	6
2	02LSEOV	Computer architectures	10
3	01SQJOV	Data Science and Database Technology	8
4	01OTWOV	Computer network technologies and services	6
5	04GSPOV	Software engineering	8
6	01TXYOV	Web Applications I	6
7	01NYHOV	System and device programming	10

Table: score

	coursecode	score	laude	datepassed
	Filter	Filter	Filter	Filter
1	02LSEOV	25	0	2021-02-01

Example

```
import sqlite from 'sqlite3';
const db = new sqlite.Database('transcript.sqlite',
    (err) => { if (err) throw err; });

let sql = "SELECT * FROM course LEFT JOIN score ON course.code=score.coursecode" ;
db.all(sql, (err,rows)=>{
    if(err) throw err ;
    for (let row of rows) {
        console.log(row);
    }
});
```

Example

```javascript
import sqlite from 'sqlite3';
const db = new sqlite.Database('transcript.sqlite',
    (err) => { if (err) throw err; });

let sql = "SELECT * FROM course LEFT JOIN score ON cou
db.all(sql, (err,rows)=>{
    if(err) throw err ;
    for (let row of rows) {
        console.log(row);
    }
});
```

```javascript
{
  code: '01TYMOV',
  name: ' Information systems security ',
  CFU: 6,
  coursecode: null,
  score: null,
  laude: null,
  datepassed: null
}
{
  code: '02LSEOV',
  name: ' Computer architectures ',
  CFU: 10,
  coursecode: '02LSEOV',
  score: 25,
  laude: 0,
  datepassed: '2021-02-01'
}
```

But…

```
import sqlite from 'sqlite3';
const db = new sqlite.Database('transcript.sqlite', (err) => { if (err) throw err; });

let result = [];
let sql = "SELECT * FROM course LEFT JOIN score ON course.code=score.coursecode" ;
db.all(sql, (err,rows)=>{
    if(err) throw err ;
    for (let row of rows) {
        console.log(row);
        result.push(row);
    }
});
console.log('*************');
for (let row of result) {
    console.log(row);
}
```
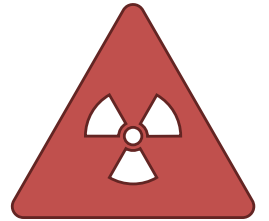
Queries Are Executed **Asynchronously**

```
CREATE TABLE IF NOT EXISTS "numbers" (
    "number"    INTEGER
);
INSERT INTO "numbers" ("number") VALUES (1);
```

number
1

```
insert into numbers(number) values(1);
-- Add a new line
```

```
select count(*) as tot from numbers;
-- Count how many lines we have
```

Queries Are Executed Asynchronously

```js
import sqlite from 'sqlite3';
const db = new sqlite.Database('data.sqlite',
    (err) => { if (err) throw err; });

for(let i=0; i<100; i++) {
    db.run('insert into numbers(number) values(1)',
        (err) => { if (err) throw err; });

    db.all('select count(*) as tot from numbers',
    (err, rows) => {
        if(err) throw err;
        console.log(rows[0].tot);
    }) ;

}
db.close();
```

queries.js

```
…
389
390
391
392
396
396
396
397
398
399
399
400
400
…
```
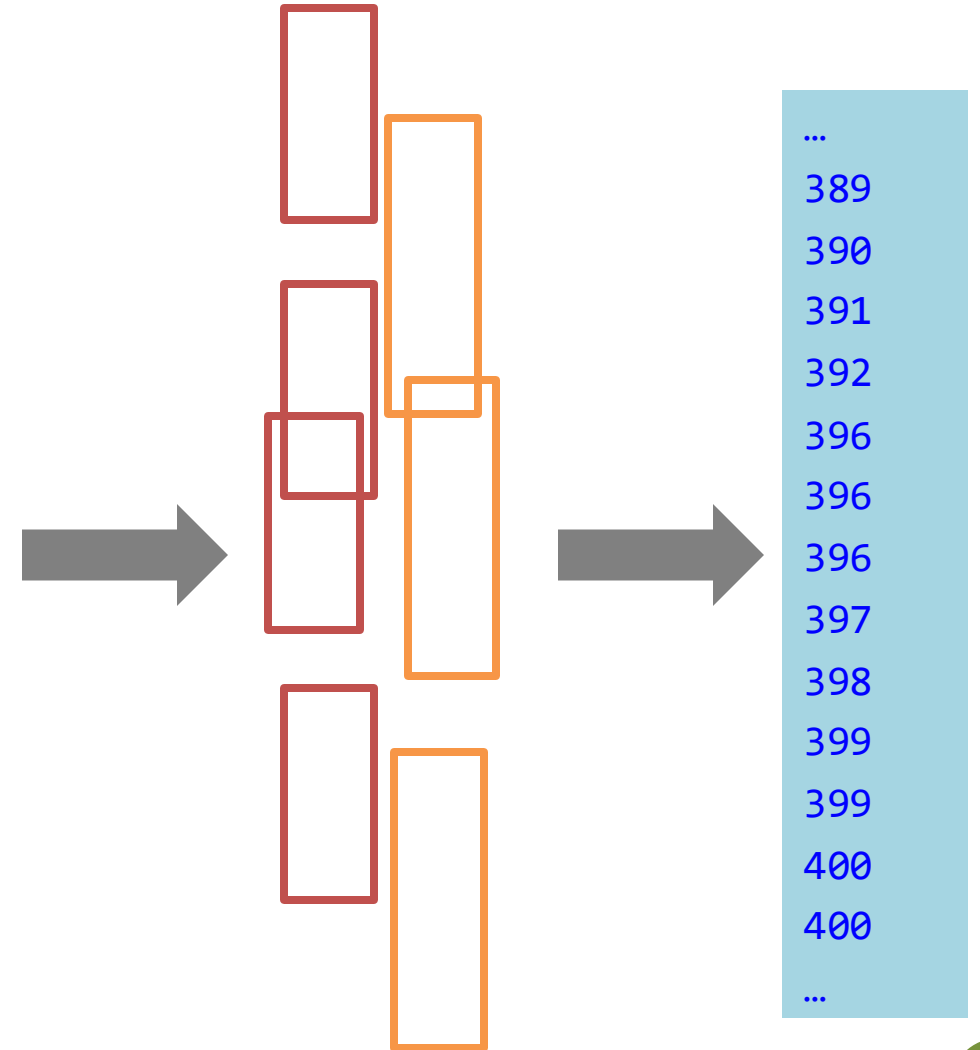
Queries are Executed Asynchronously

```
import sqlite from 'sqlite3';
const db = new sqlite.Database('data.sqlite',
    (err) => { if (err) throw err; });

for(let i=0; i<100; i++) {
    db.run('insert into numbers(number) values(1)',
        (err) => { if (err) throw err; });

    db.all('select count(*) as tot from numbers',
    (err, rows) => {
        if(err) throw err;
        console.log(rows[0].tot);
    }) ;

}
db.close();
```

...
389
390
391
392
396
396
396
397
398
399
399
400
400
...

Solution?

```
for(let i=0; i<100; i++) {

    db.run('insert into numbers(number) values(1)',
        (err) => { if (err) throw err;
                        else                                    })

    db.all('select count(*) as tot from numbers',
    (err, rows) => {
        if(err) throw err;
        console.log(rows[0].tot);

    }) ;

}
```

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- Web technology for developers » JavaScript » JavaScript Guide » Using Promises

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PROMISES

Beware: *Callback Hell*!

- If you want to perform multiple asynchronous actions in a row using callbacks, you must keep passing new functions to handle the continuation of the computation after the previous action
  - every callback adds a level of nesting
  - when you have lots of callbacks, the code starts to be complicated very quickly

```
import readline from 'readline';
const rl = readline.createInterface({
    input: process.stdin,
    output: process.stdout
});

rl.question('Task description: ', (answer) => {
  let description = answer;

  rl.question('Is the task important? (y/n)', (answer) => {
    let important = answer;

    rl.question('Is the task private? (y/n)', (answer) => {
      let privateFlag = answer;

      rl.question('Task deadline: ', (answer) => {
        let date = answer;
        ...
        rl.close();
      })
    })
  })
});
```

Promises

- A core language feature to "**simplify**" **asynchronous programming**
  - a possible solution to callback hell, too!
  - a fundamental building block for "newer" functions (`async`, ES2017)
- It is an **object** representing the eventual **completion** (or **failure**) of an asynchronous operation
  - i.e., an asynchronous function returns *a promise to supply the value* at some point in the future, instead of returning immediately a final value
- Promises standardize a way to handle errors and provide a way for errors to propagate correctly through a chain of promises

Promises

- Promises can be created or consumed
  - many Web APIs expose Promises to be consumed!

- When consumed:
  - a Promise starts in a pending state
    - the caller function continues the execution, while it waits for the Promise to do its own processing, and give the caller function some "responses"
  - then, the caller function waits for it to either return the promise in a fulfilled state or in a rejected state

Creating a Promise

- A Promise object is created using the **new** keyword
- Its constructor takes an *executor function*, as its parameter
- This function takes two *functions* as parameters:
  - resolve, called when the asynchronous task completes successfully and returns the results of the task as a value
  - reject, called when the task fails and returns the reason for failure (an error object, typically)

```
const myPromise =
  new Promise((resolve, reject) => {

    // do something asynchronous which
    eventually call either:

        resolve(someValue); // fulfilled

    // or

        reject("failure reason"); // rejected

});
```

Creating a Promise

- You can also provide a function with "promise functionality"

- Simply have it return a promise!

```
function waitPromise(duration) {
  // Create and return a new promise
  return new Promise((resolve, reject) => {
      // If the argument is invalid,
      // reject the promise
    if (duration < 0) {
      reject(new Error('Time travel not yet
implemented'));
    } else {
      // otherwise, wait asynchronously and then
      // resolve the Promise; setTimeout will
      // invoke resolve() with no arguments:
      // the Promise will fulfill with
      // the undefined value
      setTimeout(resolve, duration);
    }
  });
}
```

Consuming a Promise

- When a Promise is fulfilled, the `then()` callback is used
- If a Promise is rejected, instead, the `catch()` callback will handle the error
- `then()` and `catch()` are instance methods defined by the Promise object
  - each function registered with then() is invoked only once
- You can omit catch(), if you are interested in the result, only

```
waitPromise().then((result) => {
  console.log("Success: ", result);
}).catch((error) => {
  console.log("Error: ", error);
});


// if a function returns a Promise...
waitPromise(1000).then(() => {
  console.log("Success!");
}).catch((error) => {
  console.log("Error: ", error);
});
```
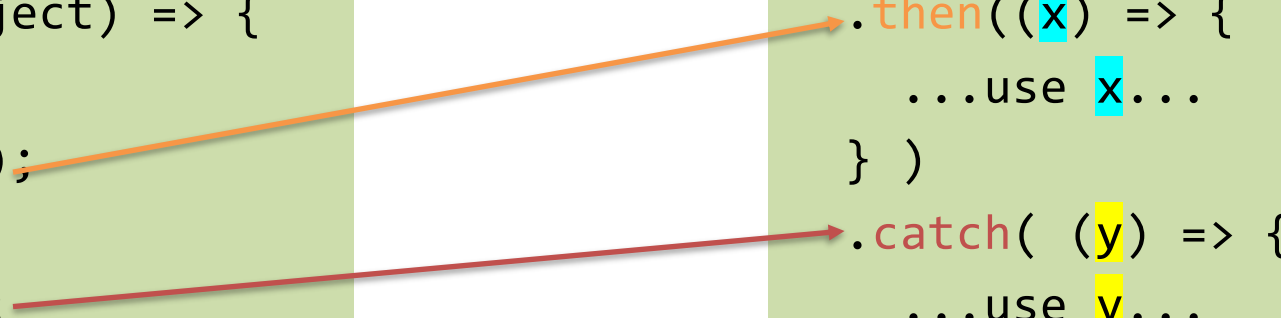
Consuming a Promise

- `p.then(onFulfilled[, onRejected]);`
  - Callbacks are executed asynchronously (inserted in the event loop) when the promise is either fulfilled (success) or rejected (optional)
- `p.catch(onRejected);`
  - Callback is executed asynchronously (inserted in the event loop) when the promise is rejected
  - Short for `p.then(null, failureCallback)`
- `p.finally(onFinally);`
  - Callback is executed in any case, when the promise is either fulfilled or rejected
  - Useful to avoid code duplication in then and catch handlers
- All these methods return Promises, too! ⇒ They can be chained

Promise: Create & Consume

```
const prom = new Promise(
    (resolve, reject) => {
        ...
        resolve(x);
        ...
        reject(y);
        ...
    }
)
```

```
prom
.then((x) => {
    ...use x...
} )
.catch( (y) => {
    ...use y...
} ) ;
```

Chaining Promises

- One of the most important benefits of Promises
- They provide a natural way to express a sequence of asynchronous operations as a linear chain of `then()` invocations
  - without having to nest each operation within the callback of the previous one
    - the "callback hell" seen before
  - If the error handling code is the same for all steps, you can attach `catch()` to the end of the chain
- **Important:** always return results, otherwise callbacks won't get the result of a previous promise

```
getRepoInfo()
  .then(repo => getIssue(repo))
  .then(issue => getOwner(issue.ownerId))
  .then(owner => sendEmail(owner.email,
'Some text'))
  .catch(e => {
    // just log the error
    console.error(e)
  })
  .finally(_ => logAction());
});
```

Example: Chaining

- Useful, for instance, with I/O API such as `fetch()`, which returns a Promise

```
const status = (response) => {
  if (response.status >= 200 && response.status < 300) {
    return Promise.resolve(response)   // static method to return a fulfilled Promise
  }
  return Promise.reject(new Error(response.statusText))
}
const json = (response) => response.json()

fetch('/todos.json')
  .then(status)
  .then(json)
  .then((data) => { console.log('Request succeeded with JSON response', data) })
  .catch((error) => { console.log('Request failed', error) })
```

Promises… in Parallel

```
Promise.all(promises)
    .then(results => console.log(results))
    .catch(e => console.error(e));
```

- What if we want to execute several asynchronous operations in parallel?
- `Promise.all()`
  - takes an array of Promise objects as its input and returns a Promise
  - the returned Promise will be rejected if at least one of the input Promises is rejected
  - otherwise, it will be fulfilled with an array of the fulfillment values for each of the input promises
  - the input array can contain non-Promise values, too: if an element of the array is not a Promise, it is simply copied unchanged into the output array
- `Promise.race()`
  - returns a Promise that is fulfilled or rejected when the first of the Promises in the input array is fulfilled or rejected
  - if there are any non-Promise values in the input array, it simply returns the first one

JavaScript: The Definitive Guide, 7th Edition
Chapter 11. Asynchronous JavaScript

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- Web technology for developers » JavaScript » Concurrency model and the event loop
- Web technology for developers » JavaScript » JavaScript Guide » Using Promises

JavaScript – The language of the Web

ASYNC/AWAIT

Simplifying Writing With async / await

- ECMAScript 2017 (**ES8**) introduces two new keywords, **async** and **await**

  – write promise-based asynchronous code that looks like synchronous code

- Prepend the async keyword to any function means that it will return a Promise

- Prepend await when calling an async function (or a function returning a Promise) makes the calling code stop until the promise is resolved or rejected

```
const sampleFunction = async () => {
  return 'test'
}
sampleFunction().then(console.log) // This will log 'test'
```

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async Functions

- The `async` function declaration defines an asynchronous function
- Asynchronous functions operate in a separate order than the rest of the code (via the event loop), returning an **implicit Promise** as their result
  - but the syntax and structure of code using async functions looks like standard synchronous functions.

```
async function name([param[, param[, ...param]]]) {
    statements
}
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Statements/async_function

await

- The `await` operator can be used to wait for a Promise. It can *only be used inside an async function*
- await **blocks** the code execution within the async function **until the Promise is resolved**
- When resumed, the value of the await expression is that of the fulfilled Promise
- If the Promise is rejected, the await expression throws the rejected value
  - If the value of the expression following the await operator is not a Promise, it's converted to a resolved Promise

```
returnValue = await expression ;
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Operators/await

Example: async / await

```
function resolveAfter2Seconds() {
  return new Promise(resolve => {
    setTimeout(() => {
      resolve('resolved');
    }, 2000);
  });
}
async function asyncCall() {
  console.log('calling');
  const result = await resolveAfter2Seconds();
  console.log(result);
}

asyncCall();
```

Return a promise

`async` is needed to use `await`

Looks like sequential code

```
> "calling"
//... 2 seconds
> "resolved"
```

Example: async / await

```javascript
function resolveAfter2Seconds() {
  return new Promise(resolve => {
    setTimeout(() => {
      resolve('resolved');
    }, 2000);
  });
}
async function asyncCall() {
  console.log('calling');
  const result = await resolveAfter2Seconds();
  return 'end';
}

asyncCall().then(console.log);
```

Implicitly returns a `Promise`

Can use Promise methods

```
> "calling"
//... 2 seconds
> "end"
```

Examples… Before and After

```
const makeRequest = () => {
  return getAPIData()
    .then(data => {
      console.log(data);
      return "done";
    }
  );
}


let res = makeRequest();
```

```
const makeRequest = async () => {
  console.log(await getAPIData());
  return "done";
};

let res = makeRequest();
```

Examples... Before and After

```
function getData() {
  return getIssue()
    .then(issue => getOwner(issue.ownerId))
    .then(owner => sendEmail(owner.email, 'Some text'));
}


// assuming that all the 3 functions above return a Promise
```

```
async function getData = {
  const issue = await getIssue();
  const owner = await getOwner(issue.ownerId);
  await sendEmail(owner.email, 'Some text');
}
```

Chaining with async/await

- Simpler to read, easier to debug
  - debugger would not stop on asynchronous code

```
const getFirstUserData = async () => {
  const response = await fetch('/users.json'); // get users list
  const users = await response.json(); // parse JSON
  const user = users[0]; // pick first user
  const userResponse = await fetch(`/users/${user.name}`); // get user data
  const userData = await user.json(); // parse JSON
  return userData;
}
getFirstUserData();
```

Promises or async/await? Both!

- If the output of `function2` is dependent on the output of `function1`, use `await`.

- If two functions can be run in parallel, create two different async functions and then run them in parallel `Promise.all(promisesArray)`

- Instead of creating huge async functions with many await asyncFunction() in it, it is better to create **smaller** async functions (not too much blocking code)

- If your code contains blocking code, it is better to make it an async function. The callers can decide on the level of asynchronicity they want.

https://medium.com/better-programming/should-i-use-promises-or-async-await-126ab5c98789

SQLite… revisited

```javascript
function insertOne() {
    return new Promise( (resolve, reject) => {
        db.run('insert into numbers(number) va
lues(1)', (err) => {
            if (err) reject(err);
            else resolve('Done');
        });
    }) ;
}
```

```javascript
function printCount() {
    return new Promise( (resolve, reject) => {
        db.all('select count(*) as tot from nu
mbers',
            (err, rows) => {
                if(err)
                    reject(err);
                else {
                    console.log(rows[0].tot);
                    resolve(rows[0].tot);
                }
            }) ;
    }) ;
}
```

SQLite… revisited

```
function insertOne() {
    return new Promise( (resolve, reject) => {
        db.run('insert into numbers(number) va
lues(1)', (err) => {
            if (err) reject(err);
            else resolve('Done');
        });
    }) ;
}
```

```
function printCount() {
    return new Promise( (resolve, reject) => {
        db.all('select count(*) as tot from nu
mbers',
            (err, rows) => {
                if(err)
                    reject(err);
                else {
                    console.log(rows[0].tot);
                    resolve(rows[0].tot);
                }
            }) ;
    ) ;
```

```
async function main() {
    for(let i=0; i<100; i++) {
        await insertOne();
        await printCount();
    }
    db.close();
}

main() ;
```

Beware The Bug!

```
async function main() {
    for(let i=0; i<100; i++) {
        await insertOne();
        await printCount();
    }
    db.close();
}

main() ;
```

```
async function main() {
    for(let i=0; i<100; i++) {
        await insertOne();
        await printCount();
    }
}

main() ;
db.close();
```

SQLite Libraries: Various Options

- `sqlite3`: the basic SQLite interface (JS wrapper of the SQLite C library)
- `sqlite`: This module has the same API as the original sqlite3 library, except that all its API methods **return ES6 Promises**.
  - internally, it wraps sqlite3; written in TypeScript
- `sqlite-async`: ES6 **Promise-based** interface to the sqlite3 module.
- `better-sqlite3`: Easy-to-use **synchronous** API (they say it's faster...)

- ... search on https://www.npmjs.com/

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