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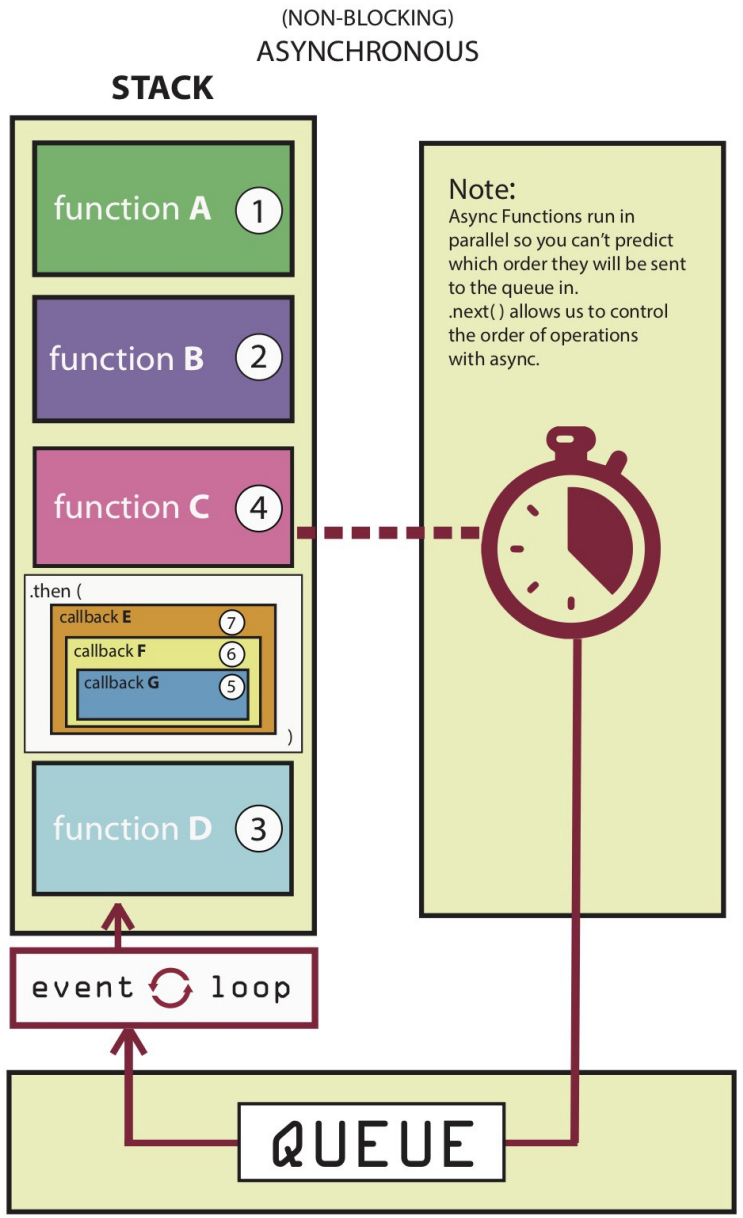
Asynchronous Programming in JS

"The" language of the Web

Fulvio Corno
Luigi De Russis
Enrico Masala



Outline

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

JavaScript: The Definitive Guide, 7th Edition
11.1 Asynchronous Programming with Callbacks

JavaScript – The language of the Web

CALLBACKS

Callbacks

https://developer.mozilla.org/en-US/docs/Glossary/Callback_function

- 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 } ]
```

JavaScript: The Definitive Guide, 7th Edition
Chapter 6. Array
Chapter 7.8 Functional Programming

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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 stile” rather than “imperative style” (e.g., for loops)
- Can improve program readability:

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

```
new_array = [] ;
for (const el in 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 (..;..;..)`
- 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])
```

Functional style

.forEach()

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Array/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()

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Array/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 **not 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

.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
```

Example: average price of all SUVs

```
const vehicles = [
  { make: 'Honda',  model: 'CR-V',     type: 'suv',   price: 24045 },
  { make: 'Honda',  model: 'Accord',   type: 'sedan', price: 22455 },
  { make: 'Mazda',  model: 'Mazda 6',  type: 'sedan', price: 24195 },
  { make: 'Mazda',  model: 'CX-9',     type: 'suv',   price: 31520 },
  { make: 'Toyota', model: '4Runner',  type: 'suv',   price: 34210 },
  { make: 'Toyota', model: 'Sequoia',  type: 'suv',   price: 45560 },
  { make: 'Toyota', model: 'Tacoma',   type: 'truck', price: 24320 },
  { make: 'Ford',   model: 'F-150',    type: 'truck', price: 27110 },
  { make: 'Ford',   model: 'Fusion',   type: 'sedan', price: 22120 },
  { make: 'Ford',   model: 'Explorer', type: 'suv',   price: 31660 }
];

const averageSUVPrice = vehicles
  .filter(v => v.type === 'suv')
  .map(v => v.price)
  .reduce( (sum, price, i, array) => sum + price / array.length, 0);

console.log(averageSUVPrice); // 33399
```

https://opensource.com/article/17/6/functional-javascript

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Chapter 11. Asynchronous JavaScript

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

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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)
```

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

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

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

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

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

Timers

- Useful to delay the execution of a function. Two possibilities from the runtime environment
  - `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
```

```
const sqlite = require('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

transcript.js

```
const sqlite = require('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

```
const sqlite = require('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);
    }
});
```

```
{
  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…

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

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

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

number
1

Queries Are Executed Asynchronously

```
const sqlite = require('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
…
```

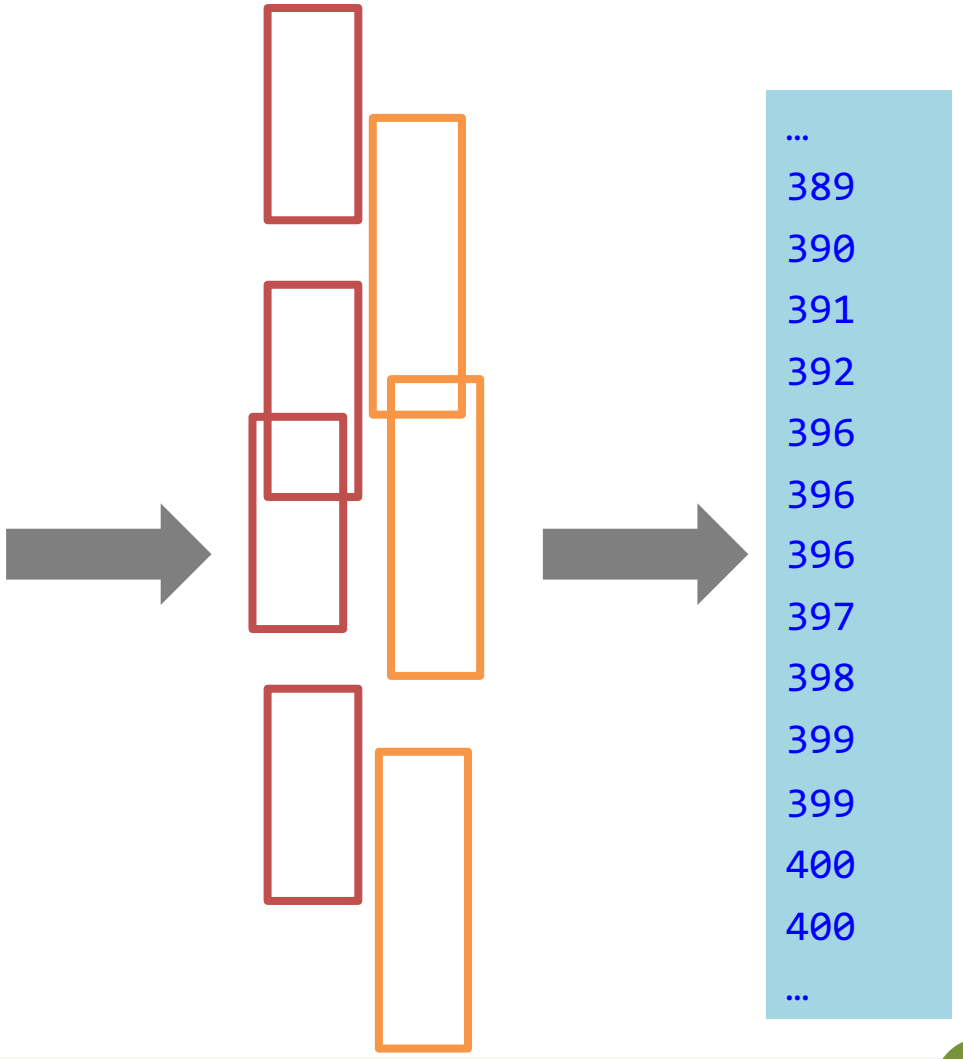
Queries are Executed Asynchronously

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



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);

    }) ;

}
```

A possible solution is in `queries_sync.js`, but it's **not** recommended

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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

```
const readline = require('readline');
const rl = readline.createInterface(...);

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 private = 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 wait(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...
wait(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
- `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
- **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

Mozilla Developer Network

- Learn web development JavaScript » Dynamic client-side scripting » Asynchronous JavaScript
- 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'
```

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

```
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

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

```
async 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

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

```
async 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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