JavaScript Asynchronous Patterns

Frank Walsh

Agenda

- Callbacks
- Promises
- Async Await
- Further/advanced async behaviour

Recap -Javascript Characteristics

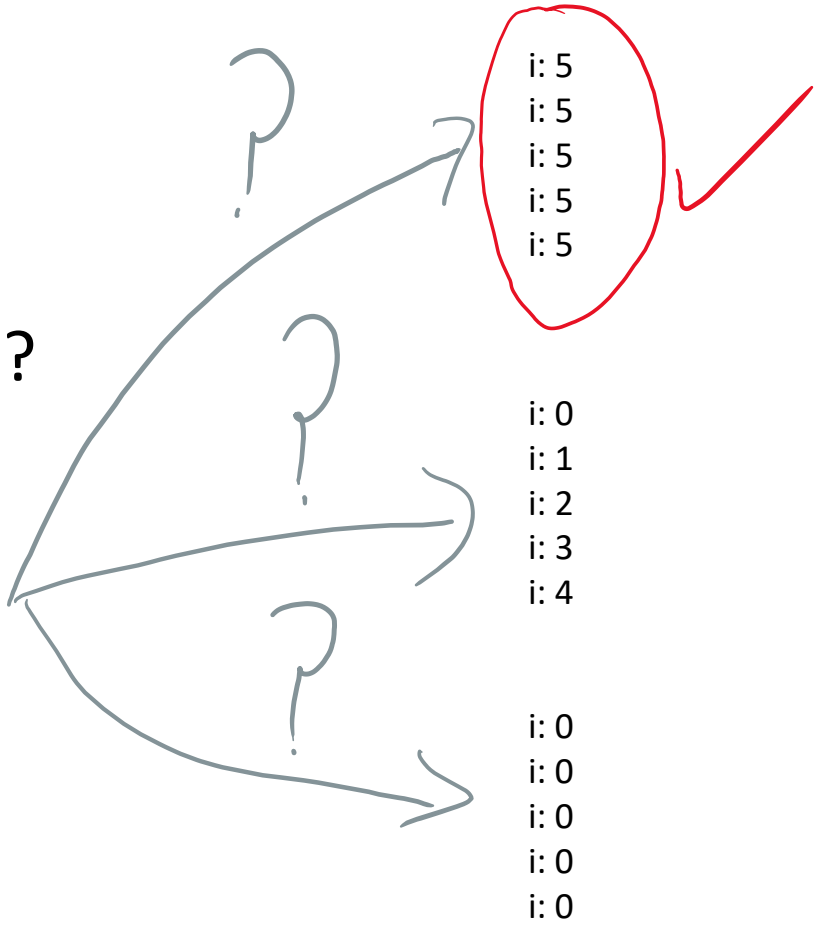
- JavaScript is single threaded
- JavaScript is event driven
  - Events happen – we write code to deal with them
  - Can use callbacks to do this
- JavaScript can be Asynchronous
  - Order of operation results may differ from order they were called…

Callbacks (again)

Recap - The Callback

What will be logged to the console?

```
console.log('setTimeout')
let i=0;
while (i <5) {
  setTimeout(() => {
  console.log('i: ' + i)
  }, 0);
  i++;
}
```



Hint: the while loop will finish before the 1st callback executes.

The Callback

- The traditional way of handling asynchronous events
  - Function that is registered as the event handler for something we're fairly sure will happen in the future

```
componentDidMount : ()=> {
        request.get('http://0.0.0.0:3000/friends')
          .end( (error, response) => { . . . Callback code ...}
    }
    .......
    filterFriends : (event) => { . . . Callback . . . .}
    render: ()=>{
         . . . . . . . .
         <input type="text" …. onChange={this.filterFriends} />
```

What have Callbacks ever done for us…

- Great for things that can happen multiple times
- Great if you don't really care about what happened before you attached the listener
- Great if it's a straight-forward, stand-alone event with a quick resolution time
- Great if callback is not part of sequential process.

E.g. key press event on control.

document.getElementById("demo").addEventListener("keypress", myFunction);

- **But...**

Multiple Callbacks

I want this to happen sequentially… but order of callback events is indeterminate.

```
console.log("about to read...");
fs.readFile("test-1.txt", "utf8", (err, contents) => {
    console.log(contents);
});
fs.readFile("test-2.txt", "utf8", (err, contents) => {
    console.log(contents);
});
fs.readFile("test-3.txt", "utf8", (err, contents) => {
    console.log(contents);
});
console.log("...done");
```

Possible Result

```
about to read...
...done
- 4
- 5
- 6
- 7
- 8
- 9
- 1
- 2
- 3
```

Possible Result

```
about to read...
...done
- 1
- 2
- 3
- 7
- 8
- 9
- 4
- 5
- 6
```

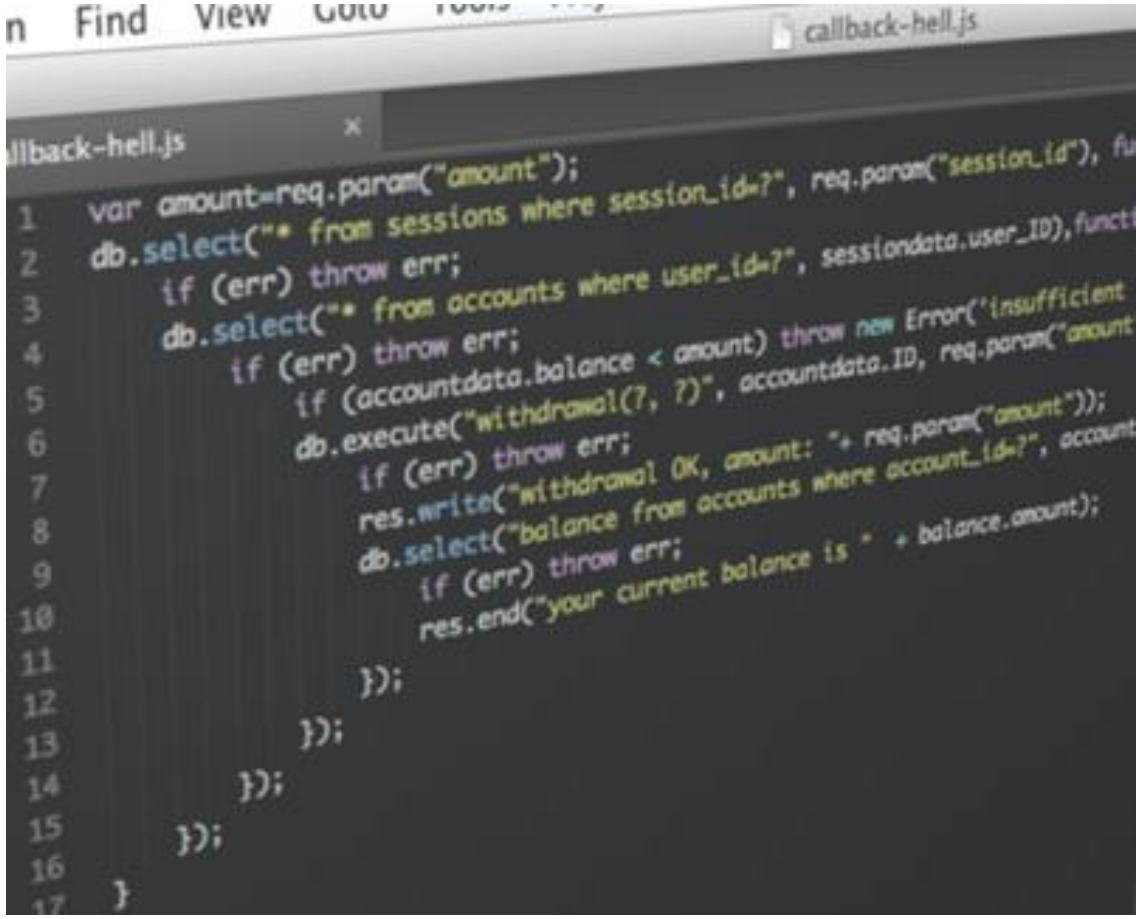
Sequential callbacks.

```
console.log("about to read...");
fs.readFile("test-1.txt", "utf8", (err, contents) => {
    if (err) throw err;
    console.log(contents);
    fs.readFile("test-2.txt", "utf8", (err, contents) => {
        if (err) throw err;
        console.log(contents);
        fs.readFile("test-3.txt", "utf8", (err, contents) => {
            if (err) throw err;
            console.log(contents);
        });
    });
});
```

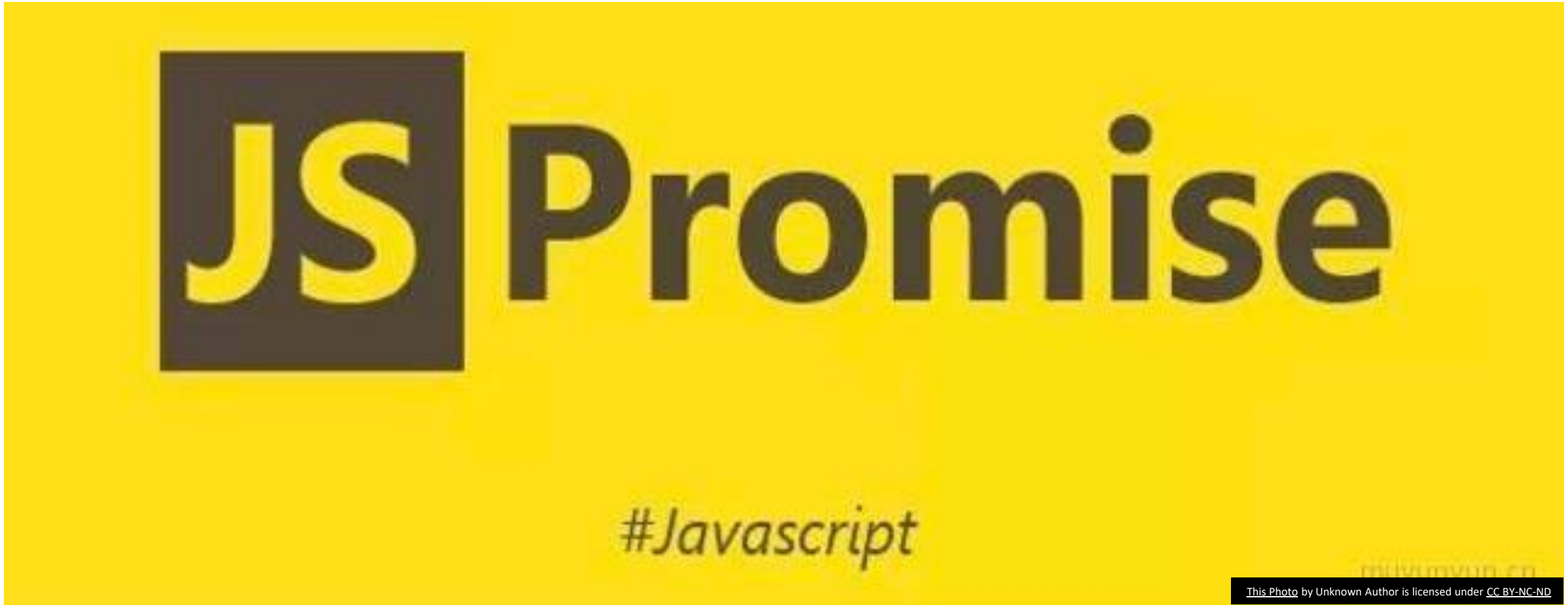
- A callback in a callback in a callback!
- Sequential callbacks are difficult to read / understand
- Sequential callbacks cause many level of indentation in source code
- And this is typically just the “success path”
    - It gets more complicated if you want to handle errors

```
about to read...
...done
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
```

Callback Hell – Multiple sequential requests




```
function loadUppThatApplication() {
    request("/api/getCustomer", function(response){
        var customerId = response.customer.id;
        request("/api/customer/accounts/"+customerId, function (response2) {
            request("http://facebook/pics/"+response2.faceBookUserName, function (response3) {
                showTheUserThatBeautifulUI(response3, function () {
                    byeByeSpinner();
                });
            });
        });
    });
}
```



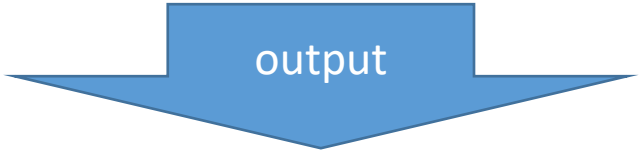
Promises

Promises

- A promise is the eventual result of an asynchronous operation or computation.
- Promises are:
  - an abstraction useful in async programming
  - an associated API that allows us to use this abstraction in our programs.
- A promise can be:
  - **fulfilled** - The action relating to the promise succeeded
  - **rejected** - The action relating to the promise failed
  - **pending** - Hasn't fulfilled or rejected yet
  - **settled** - Has fulfilled or rejected

fs using promises (experimental)

```
import {promises as fs} from 'fs';

console.log("about to read...");
fs.readFile("test-1.txt", "utf8").then((contents) => {
    console.log(contents);
});

console.log("...done");
```




```
about to read...
...done
- 1
- 2
- 3
```

- If you return a value to a ***then()***,
  the next then() is called with that value.
- If you return a promise, the next ***then()*** waits on it, and is only called when that promise settles
  (i.e. either succeeds/rejects).

fs sequential using promises (chaining)

```
import {promises as fs} from 'fs';

console.log("about to read...");
fs.readFile("test-1.txt", "utf8").then((contents) => {
    console.log(contents);
    return fs.readFile("test-2.txt", "utf8")
}).then((contents) => {
    console.log(contents);
    return fs.readFile("test-3.txt", "utf8")
}).then((contents) => {
    console.log(contents)
}), (error) => {
    console.error('File read failed', error)
};

console.log("...done");
```

output

```
about to read...
...done
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
```

Async Functions

using async/await

Async/Await !

- **async/await** and **promises** are essentially the same under the hood
- **async** is a keyword
  - Used in function declaration
- **await** is used during the promise handling
  - must be used within an **async function**
- **async** functions return a promise, regardless of what the return value is within the function.
- **Available now!** in most good browsers as well as Node.js

```
import {promises as fs} from 'fs';

console.log("about to read...");

readFiles()

console.log("...doing other stuff")


async function readFiles() {
    console.log("starting sequential read...");
    const contents1 = await fs.readFile("test-1.txt", "utf8");
    console.log(contents1);
}
```

Async/Await Sequential read

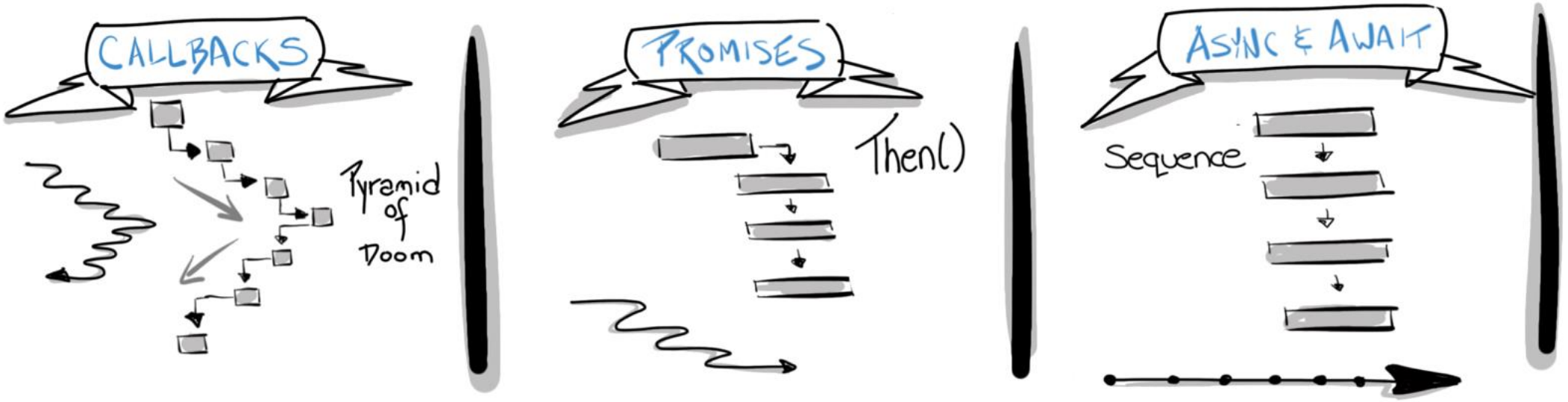
```
console.log("about to read...");

readFiles()

console.log("...doing other stuff")


async function readFiles() {
    console.log("starting sequential read...");
    const contents1 = await fs.readFile("test-1.txt", "utf8");
    console.log(contents1);
    const contents2 = await fs.readFile("test-2.txt", "utf8");
    console.log(contents2);
    const contents3 = await fs.readFile("test-3.txt", "utf8");
    console.log(contents3);
    console.log("...done sequential read");
}
```

output

```
about to read...
starting sequential read...
...doing other stuff
(node:1988) ExperimentalWarning:
- one
- two
- three
- four
- five
- six
- seven
- eight
- nine
...done sequential read
```

Callbacks vs Promises vs Async-Await

Asynchronous Javascript



Error Handling

Error Handling - Promises

- **then()** function can take **2 arguments**, one for fulfillment(success), one for rejection(failure)

```
fs.readFile("test-12.txt", "utf8").then((contents) => {
    console.log(contents);
}, (error)=>{console.error("Failed to read file!",error)});
```

Error Handling - catch(...)

- You can also use catch() to handle promise rejects:
- Reacts slightly different to previous.
  - Useful in sequential async processes

```
fs.readFile("test-1.txt", "utf8").then((contents) => {
    console.log(contents);
    return fs.readFile("test-2.txt", "utf8")
}).then((contents) => {
    console.log(contents);
    return fs.readFile("test-3.txt", "utf8")
}).then((contents) => {
    console.log(contents)
}).catch ((error) => {
    console.error('File read failed', error)
});
```

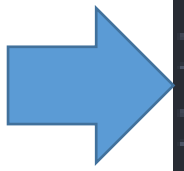
Error Handling – async await

Use **try -catch**

```
async function readFiles() {
    try{
    console.log("starting sequential read...");
    const contents1 = await fs.readFile("test-1.txt", "utf8");
    console.log(contents1);
    const contents2 = await fs.readFile("test-22.txt", "utf8");
    console.log(contents2);
    const contents3 = await fs.readFile("test-3.txt", "utf8");
    console.log(contents3);
    }catch (error){
        console.error("failed to read a file!",error)
    }
    console.log("...done sequential read");
}
```

JavaScript promise dummy implementation

```
1    const promise = new Promise((resolve, reject)=> {
2      // do a thing, possibly async, then…
3    console.log('setTimeout');
4      setTimeout(()=> {
5        if (doSomethingThatMightFail()) {
6          resolve( 'Stuff worked!');
7        } else {
8          reject(Error('It broke'));
9        }
10   }, 1000);
11   }
12   );
13
```



```
14     promise.then((result) => {
15       console.log(result); // "S
16     }, (err)=>{
17       console.log(err); // Error
18     });
19
```

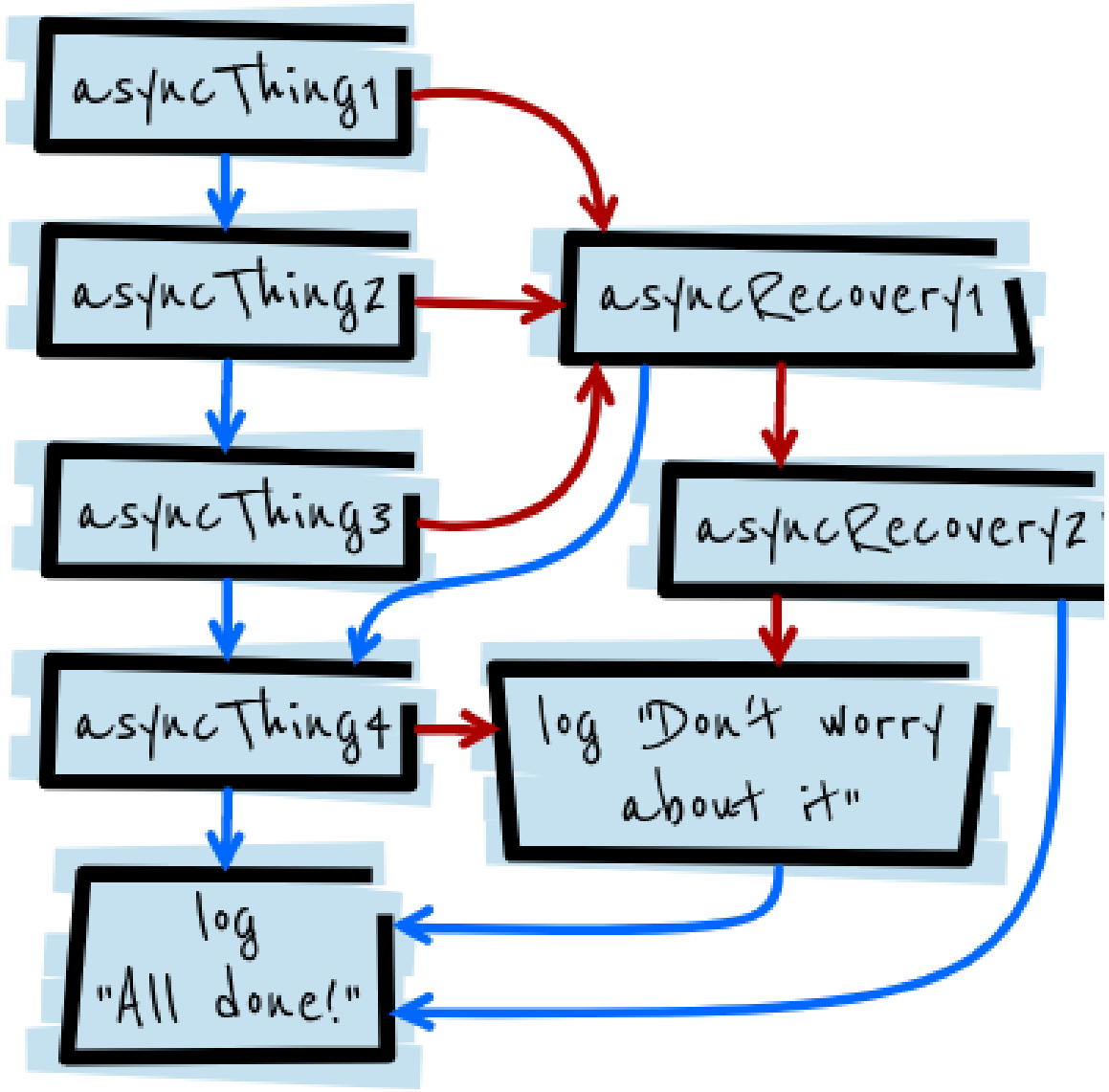
```
20   const doSomethingThatMightFail = ()=>{
21     return result = (Math.random()>.5)? true:false;
22   };
```

Further Asynchronous features…

Rejection forwarding

- A Promise rejection will skip forward to the next then() with a rejection callback (or catch()):

```
asyncThing1().then(function() {
    return asyncThing2();
}).then(function() {
    return asyncThing3();
}).catch(function(err) {
    return asyncRecovery1();
}).then(function() {
    return asyncThing4();
}, function(err) {
        return asyncRecovery2();
}).catch(function(err) {
        console.log("Don't worry about it");
}).then(function() {
        console.log("All done!");
})
```



https://developers.google.com/web/fundamentals/primers/promises#error_handlingck to add text

Wrapper Function

- As an Async function always returns a Promise.
  - can *wrap* the async function to catch errors...
  - Can drop try/catch.
- Makes code more readable.

```
const asyncWrapper = fn => {
    return Promise.resolve(fn)
      .catch(err => {return err.message});
};

async function doSomethingAsync() {
    const result = await asyncWrapper(promise());
    console.log(result);
}
```

Chaining

- you can chain then's together to transform values or run additional async actions one after another.

```
1   const promise = new Promise((resolve, reject) => {
2     resolve(1);
3   });
4
5   promise.then((val) => {
6     console.log(val); // 1
7     return val + 2;
8   }).then((val) => {
9     console.log(val); // 3
10  });
```

Parallelism //

- Some processes need to be sequential
  - Eg. Had to get data back from API **BEFORE** getting link URL
- REMEMBER: Should only be sequential if you need to be...

Takes 1000ms

```
async function series() {
  await wait(500); // Wait 500ms…
  await wait(500); // …then wait another 500ms.
  return "done!";
}
```

Takes ~500ms

```
async function parallel() {
  const wait1 = wait(500); // Start a 500ms timer asynchronously…
  const wait2 = wait(500); // this timer happens in parallel.
  await wait1; // Wait 500ms for the first timer…
  await wait2; // …by which time this timer has already finished.
  return "done!";
}
```

Sources

- https://developers.google.com/web/fundamentals/primers/promises
- https://stackoverflow.com/questions/2069763/difference-between-event-handlers-and-callbacks
- https://medium.com/@Abazhenov/using-async-await-in-express-with-node-8-b8af872c0016