FRONTEND DEVELOPMENT

WINTERSEMESTER 2020

ASYNCHRONOUS JAVASCRIPT

SHORT DISCLAIMER

» You'll see es6 arrow functions in the slides

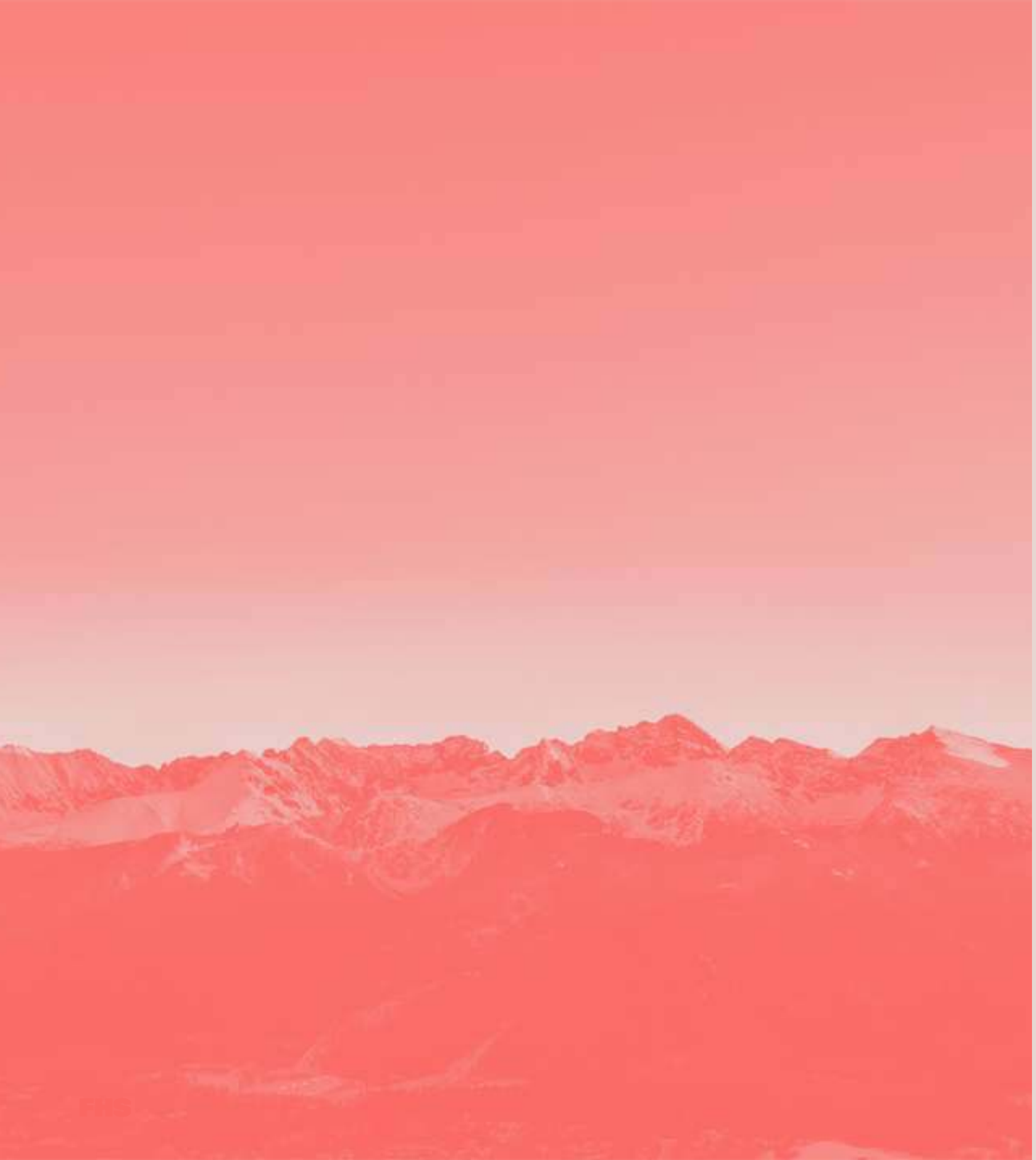
» For now:

  » all 4 variants can be seen as equal

  » we'll look at the difference in the next lecture

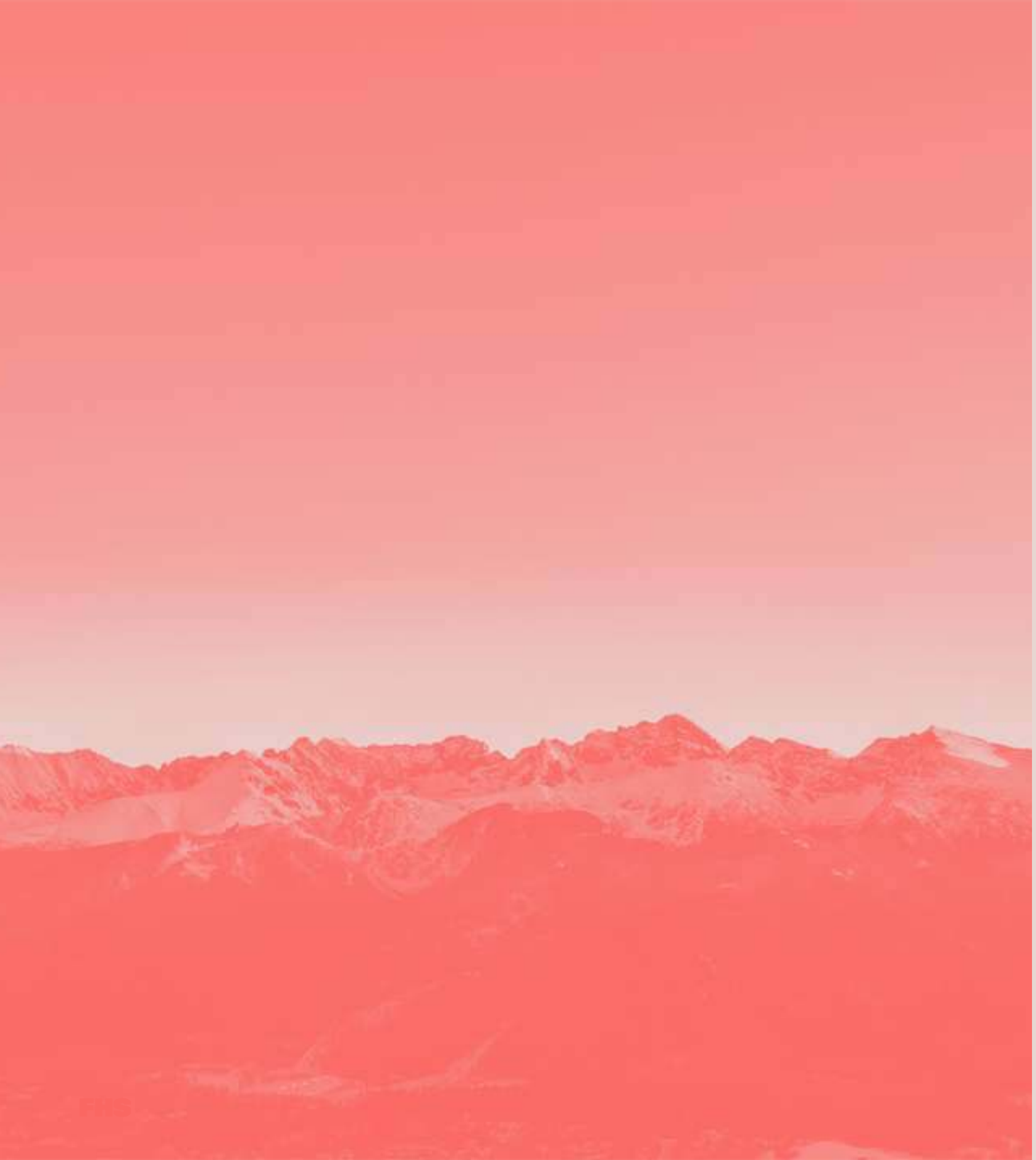
```
function myFunction() { return 'some value' } // function
const myFunction = function () { return 'some value' } // anonymous function
const myFunction = () => { return 'some value' } // es6 arrow functions
const myFunction = () => 'some value' // es6 arrow functions with implicit return
```

ASYNCHRONOUS JAVASCRIPT



JS & CONCURRENCY

- JS is single threaded
- eliminate lots of concurrency issues
- Only one thing can happen at a time
  - long running operations would block execution
  - eg. network requests



JS & CONCURRENCY

- Network requests would block main thread
  - no user interaction would be possible
  - button clicks wouldn't be registered
  - scrolling would not work
  - ...

SYNCHRONOUS CODE

“IN A SYNCHRONOUS PROGRAMMING MODEL, THINGS HAPPEN ONE AT A TIME.[5]”

[5] https://eloquentjavascript.net/11_async.html

JS AND SYNCHRONOUS CODE EXECUTION [3]

```
const second = () => {
  console.log('Hello there!');
}
const first = () => {
  console.log('Hi there!');
  second();
  console.log('The End');
}
```

[3] Visualisation of code execution

ASYNCHRONOUS CODE EXECUTION

“AN ASYNCHRONOUS MODEL ALLOWS MULTIPLE THINGS TO HAPPEN AT THE SAME TIME.[5]”

[5] https://eloquentjavascript.net/11_async.html

ASYNC JS

- multiple non-cpu bound computationscan happen at the same time
  - network requests
  - reading files from disk
  - waiting for a setTimeout

ASYNC JS

- when waiting for network response
  - js continues doing other tasks
  - once the response is there
  - and js has nothing else to do
  - js continues processes network response

CONTINUATION PASSING STYLE

NO PROCEDURE IS ALLOWED TO RETURN TO ITS CALLER--EVER. [1]

[1] pre es6

CONTINUATION PASSING STYLE

» or programming with callbacks

» a callback is a function which is called when something happened

CONTINUATION PASSING STYLE

- real world example:
  - you wait for a package and call the delivery service
  - the delivery service notes your "contact details" (callback)
  - and he'll call you back once he has additional information

CONTINUATION PASSING STYLE

```
function multiplyBy2(x, whenDone) {
  //                    ^^^^^^^^
  // callback is defined which will receive the result
  whenDone(x * 2)
}

function logResult(value) {
  console.log(value)
}

multiplyBy2(4, logResult) // 8 will be logged
```

CONTINUATION PASSING STYLE IN THE BROWSER

» setTimeout does not block js execution

» other scripts can still execute

» after ~1 second callback will be invoced

```
setTimeout(() => {
  // will be called in the future
}, 1000)
```

CONTINUATION PASSING STYLE IN NODE.JS

» fs.readFile does not return to it's caller

» accepts a callback which is invoket once the file was read

```
// in node.js
fs.readFile('file.txt', (err, data) => {
  if (err) throw err; // throws on error (eg. file not found)
  console.log(data); // logs the contents of file.txt
})
```

USECASE:

» fetch function which fetches data from an api

» does a HTTP GET request

» accepts URL and callback

» callback receives server response

```
fetch(url, (err, response) => {})
```

USECASE:

```
function logCurrentUser() {
  fetch('/api/currentUser', (currentUser) => {
    console.log(currentUser)
  })
}
```

WHAT IF ADDITIONAL DATA NEEDS TO BE FETCHED?

CALLBACKS:

```
function myBestFriendsAddress() {
  fetch('/api/currentUser', (currentUser) => {
    // will be executed once we get a response from `currentUser`
    fetch(`/api/user/${currentUser.id}/bestFriend`, (bestFriend) => {
      // will be executed once we get a response from `bestFriend`
      fetch(`/api/user/${bestFriend.id}/address`, (bestFriendsAddress) => {
        // ...
      })
    })
  })
}
```

CALLBACK HELL:

```
function hell(win) {
 // for listener purpose
 return function() {
   loadLink(win, REMOTE_SRC+'/assets/css/style.css', function() {
     loadLink(win, REMOTE_SRC+'/lib/async.js', function() {
       loadLink(win, REMOTE_SRC+'/lib/easyXDM.js', function() {
         loadLink(win, REMOTE_SRC+'/lib/json2.js', function() {
           loadLink(win, REMOTE_SRC+'/lib/underscode.min.js', function() {
             loadLink(win, REMOTE_SRC+'/lib/backbone.min.js', function() {
               loadLink(win, REMOTE_SRC+'/dev/base_dev.js', function() {
                 loadLink(win, REMOTE_SRC+'/assets/js/deps.js', function() {
                   loadLink(win, REMOTE_SRC+'/src/' + win.loader_path + '/loader.js', function() {
                     async.eachSeries(SCRIPTS, function(src, callback) {
                       loadScript(win, BASE_URL+src, callback);
                     });
                   });
                 });
               });
             });
           });
         });
       });
     });
   });
 };
}
```

HOW COULD WE FLATTEN THIS TREE?

ES6 PROMISES TO RESCUE


IT WILL BE FUN
I PROMISE
memegenerator.net

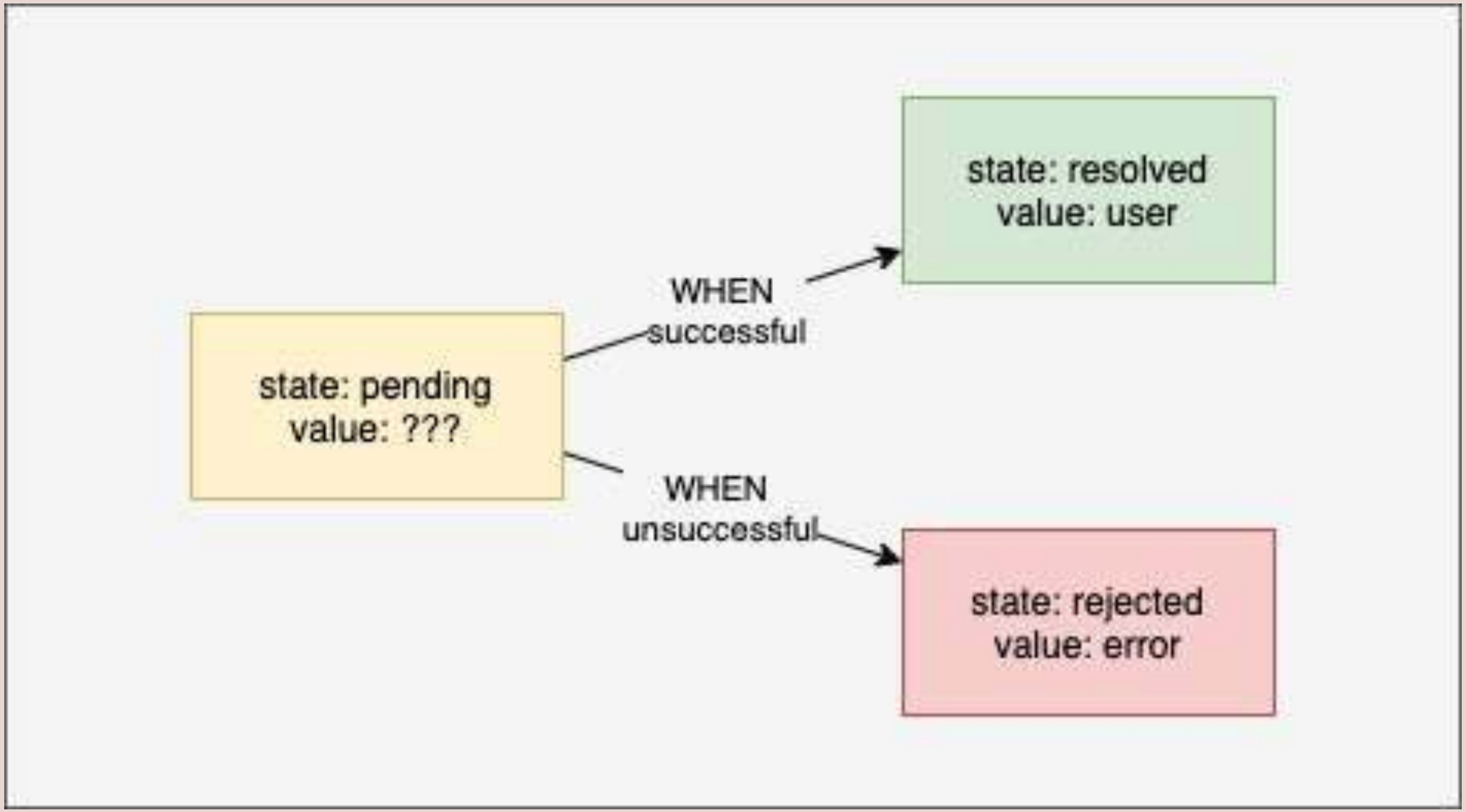
PROMISES

The Promise object represents the eventual completion (or failure) of an asynchronous operation and its resulting value.

PROMISES

- A promise is in one of 3 states
  - pending
  - fulfilled
  - rejected
- Other languages call it futures

PROMISES


state: resolved
value: user
WHEN
successful
state: pending
value: ???
WHEN
unsuccessful
state: rejected
value: error

TRANSFORM CALLBACKS TO PROMISES

```
function myBestFriendsAddress() {
  fetch('/api/currentUser', (currentUser) => {
    // will be executed once we get a response from `currentUser`
    fetch(`/api/user/${currentUser.id}/bestFriend`, (bestFriend) => {
      // will be executed once we get a response from `bestFriend`
      fetch(`/api/user/${bestFriend.id}/address`, (bestFriendsAddress) => {
        // ...
      })
    })
  })
}
```

TRANSFORM CALLBACKS TO PROMISE
WRAP FETCH FUNCTION IN PROMISE

```
const fetchAsPromise = (url) => {
  return new Promise((resolve) => { // create a new promise
    // call the fetch function and *WHEN* the request is done, resolve the promise
    fetch(url, resolve)
  })
}
```

TRANSFORM CALLBACKS TO PROMISE
USE FETCHASPROMISE

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

fetchAsPromise('/api/currentUser')
  .then((currentUser) => fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`))
  .then((bestFriend) => fetchAsPromise(`/api/user/${bestFriend.id}/address`))
  .then((bestFriendsAddress) => console.log(bestFriendsAddress))
```

TRANSFORM CALLBACKS TO PROMISE
USE FETCHASPROMISE

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

fetchAsPromise('/api/currentUser')
  .then((currentUser) => fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`))
  .then((bestFriend) => fetchAsPromise(`/api/user/${bestFriend.id}/address`))
  //     ^^^^^^^^^^
  // value of previous result is the first argument
  .then((bestFriendsAddress) => console.log(bestFriendsAddress))
```

PROMISES ERROR HANDLING

```
const fetchAsPromise = (url) => new Promise((resolve, reject) => {
  //                                          ^^^^^^
  // enhance previous fetchAsPromise with reject param

  fetch(url, (data) => {
    if (data.status === 200) { resolve(data) }
    else { reject(data) }
  })
})
```

PROMISES ERROR HANDLING

```
const fetchAsPromise = (url) => new Promise((resolve, reject) => {
  fetch(url, (data) => {
    if (data.status === 200) { resolve(data) }
    else { reject(data) }
  })
})

fetchAsPromise('/api/currentUser')
  .then((currentUser) => fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`))
  // ...
  .catch(() => alert('something went wrong 😥'))
// ^^^^^
// catch all promise rejections
```

PROMISES ERROR HANDLING

» remember promise has 3 states (pending, resolved, rejected)

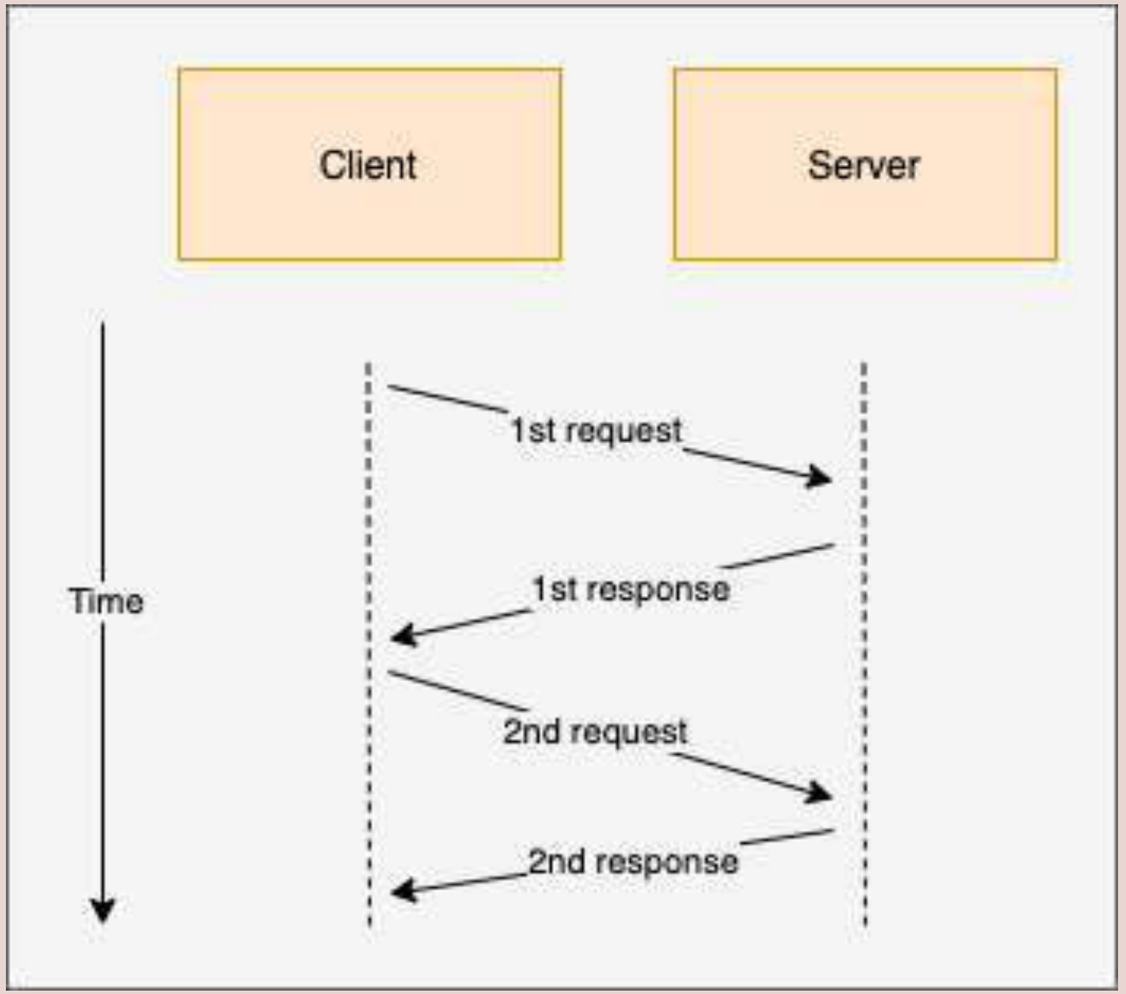
» .catch converts a rejected promise to a resolved one

```
fetchAsPromise('/api/currentUser')
  // state: resolved
  .then(() => fetchAsPromise(`/api/someUnknownURL`))
  // state: rejected
  .catch(() => alert('something went wrong 😢'))
  // state: resolved
  .then(() => console.log('will be logged'))
```

CREATING PROMISES OUT OF STATIC VALUES

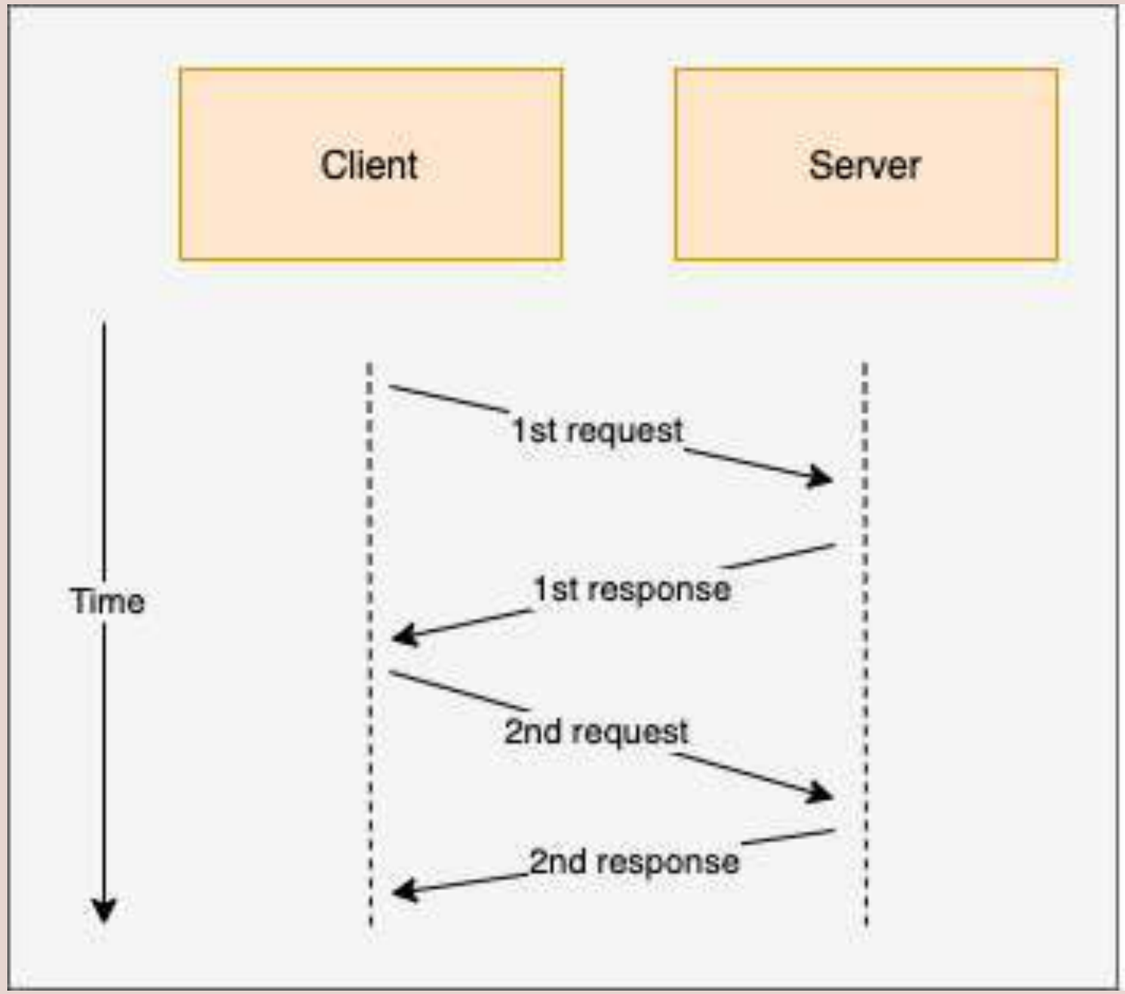
```
Promise.resolve(1)
  .then((value) => { console.log(value) }) // 1 will be logged

Promise.reject(1)
  .catch((value) => { console.log(value) }) // 1 will be logged
```

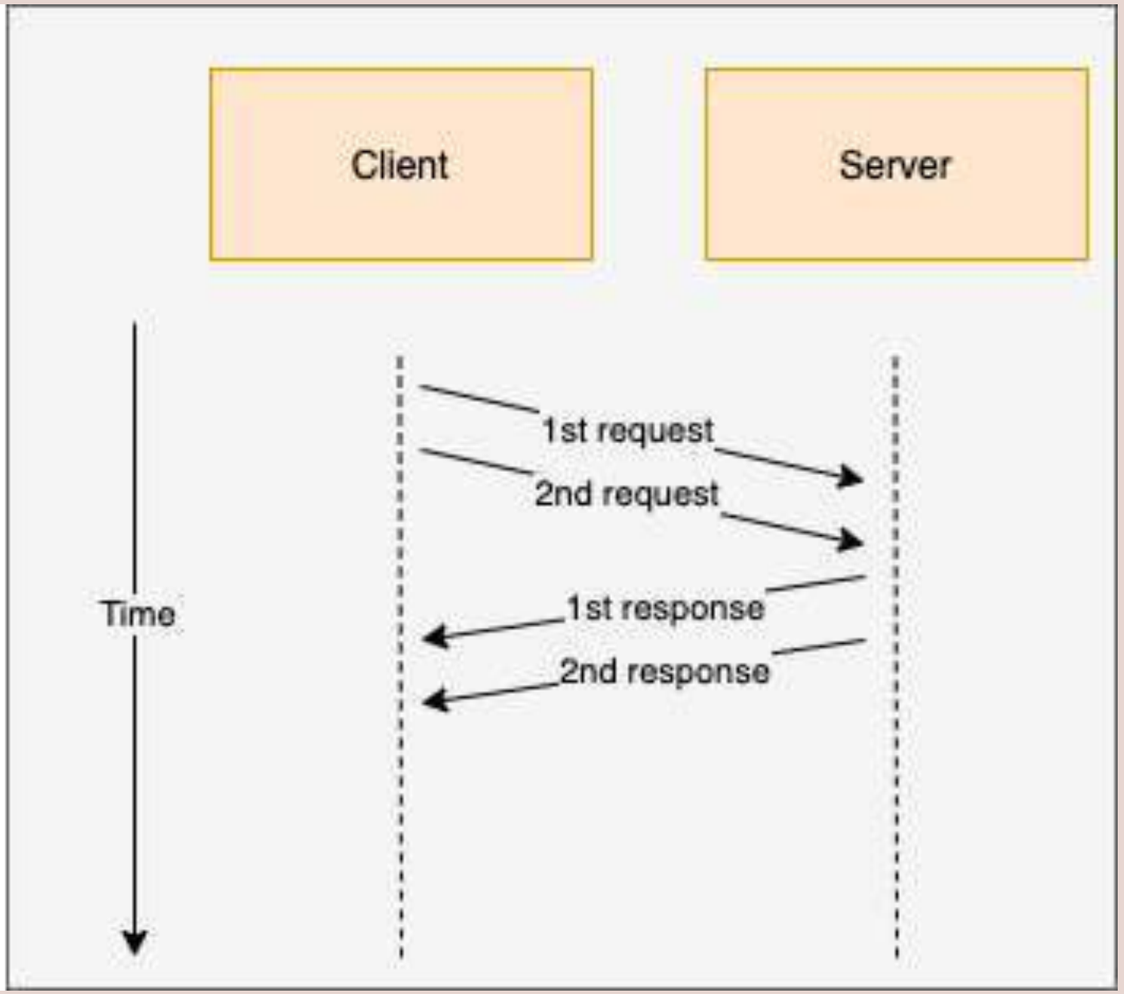
WAITING FOR MULTIPLE PROMISES



DIDN'T YOU SAY NETWORK REQUESTS CAN BE DONE CONCURRENTLY?

WAITING FOR MULTIPLE PROMISES





WAITING FOR MULTIPLE PROMISES

- waiting for each request before doing the next one is slow
- Promise.all makes it possible to run and wait for multiple promises concurrently
  - if possible try to parallelize promises via Promise.all

WAITING FOR MULTIPLE PROMISES

```
Promise.all([
  fetchAsPromise(`/api/currentUser`),
  fetchAsPromise(`/api/weather`)
]).then(([ currentUser, weather ]) => {
  console.log(currentUser)
  console.log(weather)
})
```

RACING MULTIPLE PROMISES

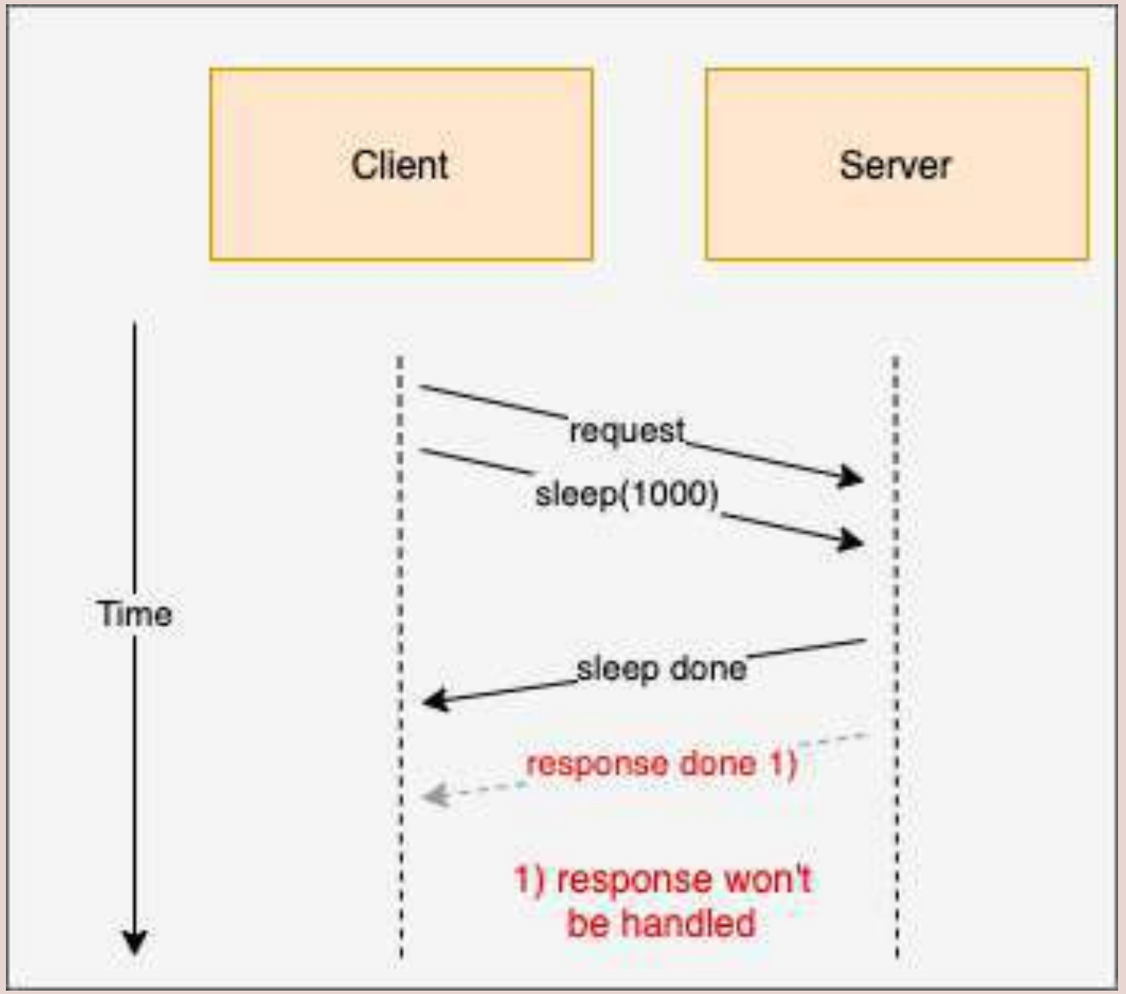
» Promise.race returns the fastest promise [2]

» can be used to implement a timeout for slow requests

```
const sleep = (timeout) => new Promise((resolve) => setTimeout(resolve, timeout))

Promise.race([
  fetchAsPromise(`/api/currentUser`),
  sleep(1000).then(() => ({ error: 'timeout' }))
]).then((result) => {
  if (result.error) {
    throw new Error('Timeout')
  }
  return result;
})
```

[2] I personally only used it once

RACING MULTIPLE PROMISES



PROMISE IN THE WILD
FETCH API

» Promise based Browser API for HTTP requests

» replaces/enhances XHR Request

» based on promises

```
// Getting data via fetch

fetch('/api/users')
  .then((httpResult) => httpResult.json())
  //                              ^^^^^^
  // required as fetch resolves when HTTP headers are sent
  .then((data) => console.log(data))
```

PROMISE IN THE WILD
POSTING DATA VIA FETCH

```
// Posting data via fetch

fetch('/api/users', {
  method: 'POST',                              // specify HTTP method
  headers: {
      'Content-Type': 'application/json'  // setting the content type
  },
  body: JSON.stringify({ my: 'payload' }) // adding payload
})
  .then((httpResult) => httpResult.json())
  .then((data) => console.log(data))
```

ASYNC/AWAIT

ASYNC/AWAIT

- Syntactic Sugar for Promises
- 2 new keywords
  - async marks a function to be async
  - await pauses execution inside an async function
- await can't be used outside an async function

ASYNC/AWAIT

```
async function someAsyncFunction () {
// ^^
// async keyword defines an async function
// in here we can use await

  const response = await myHTTPRequest()
  //               ^^^^^
  // wait until the http request is done and the promise resolves/rejects
  console.log(response)
}
```

ASYNC/AWAIT
PROMISE EXAMPLE

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

function bestFriendsAddress() {
  return fetchAsPromise('/api/currentUser')
    .then((currentUser) => fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`))
    .then((bestFriend) => fetchAsPromise(`/api/user/${bestFriend.id}/address`))
    .then((bestFriendsAddress) => console.log(bestFriendsAddress))
}
```

ASYNC/AWAIT
PROMISE EXAMPLE

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

async function bestFriendsAddress() {
  const currentUser = await fetchAsPromise('/api/currentUser')
  const bestFriend = await fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`)
  const bestFriendsAddress = await fetchAsPromise(`/api/user/${bestFriend.id}/address`)
  console.log(bestFriendsAddress)
}
```

ASYNC/AWAIT
PROMISE EXAMPLE

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

// define an async function
async function bestFriendsAddress() {
  const currentUser = await fetchAsPromise('/api/currentUser')
  //                  ^^^^^
  // wait until the promise is resolved and continue once it is done
  const bestFriend = await fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`)
  const bestFriendsAddress = await fetchAsPromise(`/api/user/${bestFriend.id}/address`)
  console.log(bestFriendsAddress)
}
```

ASYNC/AWAIT
ERROR HANDLING PROMISES

```
const fetchAsPromise = (url) => new Promise((resolve) => {
  fetch(url, resolve)
})

async function bestFriendsAddress() {
  try {
    const currentUser = await fetchAsPromise('/api/currentUser')
    const bestFriend = await fetchAsPromise(`/api/user/${currentUser.id}/bestFriend`)
    const bestFriendsAddress = await fetchAsPromise(`/api/user/${bestFriend.id}/address`)
    console.log(bestFriendsAddress)
  } catch (e) {
    console.error('something went wrong')
  }
}
```

ASYNC/AWAIT PITFALLS

ASYNC/AWAIT PITFALLS
await IN LOOPS

» API is called sequentially

» waits until promise is resolved before continuing

» each iteration waits until the promise is done

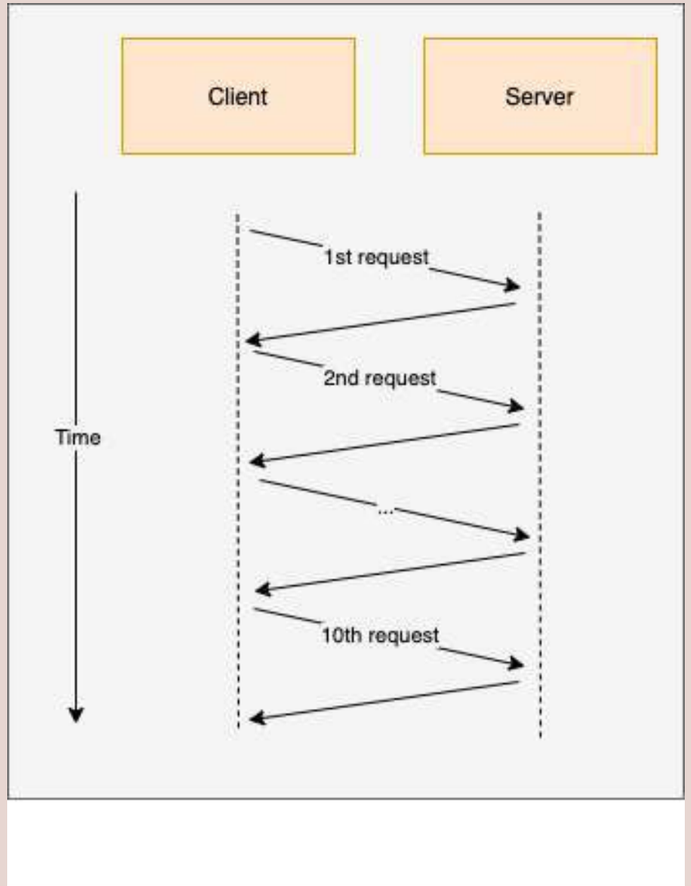
» user needs to wait longer until all data is present

ASYNC/AWAIT PITFALLS
await IN LOOPS

```
async function awaitInLoops() {
  for (let userId; userId < 10; userId++) {
    const user = await fetchAsPromise(`/api/user/${userId}`)
    //             ^^^^^
    // for each user we have to wait until http request is done
    console.log(user)
  }
}
```

ASYNC/AWAIT PITFALLS

`await` IN LOOPS

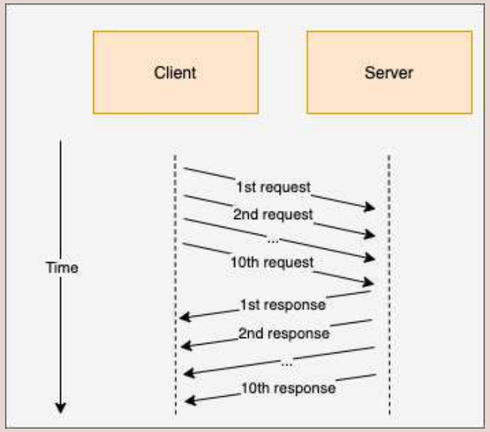


ASYNC/AWAIT PITFALLS
`await` IN LOOPS

» Promise.all can fix this

» requests to the backend are executed in parallel

» client waits until all promises resolve



ASYNC/AWAIT PITFALLS
await IN LOOPS

```
async function awaitInLoops() {
  const promises = [] // declare a list of promises

  for (let userId; userId < 10; userId++) {
    promises.push(fetchAsPromise(`/api/user/${userId}`))
    // ^^^^^^^^^^
    // start the promise and add it to the promises
  }

  await Promise.all(promises)
  // wait for all promises to finish
}
```

ASYNC/AWAIT PITFALLS
ERROR HANDLING WITHOUT AWAIT

```
async function fetchBestFriend(id) {
  try {
    return fetchAsPromise(`/api/user/${id}/bestFriend`)
    // ^^^^^
    // return promise without awaiting its result
  } catch (e) {
    console.error('something went wrong')
    // ^^^^^
    // when promise fails this error handler won't be called
  }
}
```

ASYNC/AWAIT PITFALLS
ERROR HANDLING WITHOUT AWAIT

» Remember:

» A promise is a value which might be available in the future

```
async function fetchBestFriend(id) {
  try {
    return fetchAsPromise(`/api/user/${id}/bestFriend`)
    // ^^^^^
    // returning without an await makes the function return
    // without waiting for the response and a possible error
    // when the promise gets rejected the JS engine already
    // went into a different execution context
  } catch (e) {
    console.error('something went wrong')
    // ^^^^^
    // when promise fails this error handler won't be called
  }
}
```

ASYNC/AWAIT PITFALLS
ERROR HANDLING WITHOUT AWAIT

```
async function fetchBestFriend(id) {
  try {
    return await fetchAsPromise(`/api/user/${id}/bestFriend`)
    //     ^^^^^
    // we wait for the promise to be resolved inside the function
    // and handle the error internally => catch block will be called
  } catch (e) {
    console.error('something went wrong')
  }
}
```

ASYNC/AWAIT PITFALLS
ERROR HANDLING WITHOUT AWAIT

```
async function fetchBestFriend(id) {
  try {
    return await fetchAsPromise(`/api/user/${id}/bestFriend`)
    //     ^^^^^
    // we wait for the promise to be resolved inside the function
    // and handle the error internally => catch block will be called
  } catch (e) {
    console.error('something went wrong')
  }
}
```

HOMEWORK

» please see wiki

FEEDBACK

» Questions: tmayrhofer.lba@fh-salzburg.ac.at

» Feedback Link