FALLING IN LOVE WITH ASYNC-AWAIT

Atishay Jain, Senior Computer Scientist, Adobe

Byetconf JS 2019

JavaScript

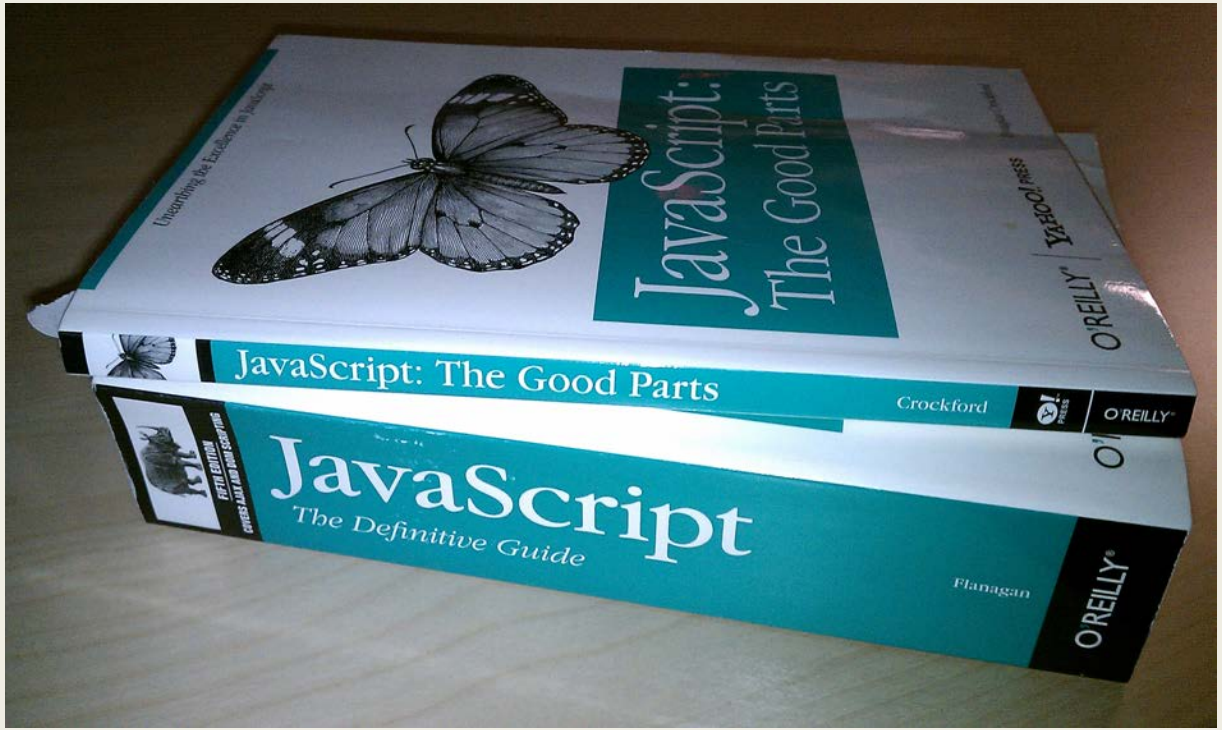

Image by Nathan on Flickr

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Agenda

- About me
- The async-await paradigm
- A beginners walk-through of async await
  - *Callback vs promise vs async await*
  - *The program flow*
- Intermediate async-await
  - *A detour to promises*
  - *Async guarantees*
  - *The program flow*
  - *Wrapping asynchronous functions*
- Advanced async-await
  - *Exploiting the promises underneath*
  - *Exploiting callbacks deep down*
- Conclusion

Image from gyfcat

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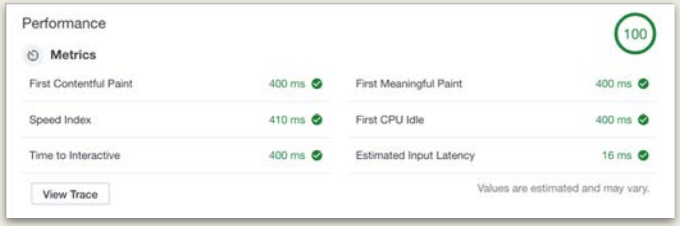
About Me

- Work in San Francisco.
- Crazy about the web
  - *Working on web since the Flash & IE6 days.*
  - *Have worked on Desktop (Adobe InDesign), and on Mobile (Adobe Capture)*
  - *Author of VS Code's "All Autocomplete" plugin*
  - *Rewrote my website for the nth time last year) - https://atishay.me (Perf score 100)*
  - *Guest author at CSS-Tricks*
- Ship node based desktop software to millions of Creative Cloud users
- Use these techniques(& much more) in daily life
- Doing asynchronous node.js since Node 0.6.



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THE ASYNC-AWAIT PARADIGM

The concept of async-await

Serial Dispatch

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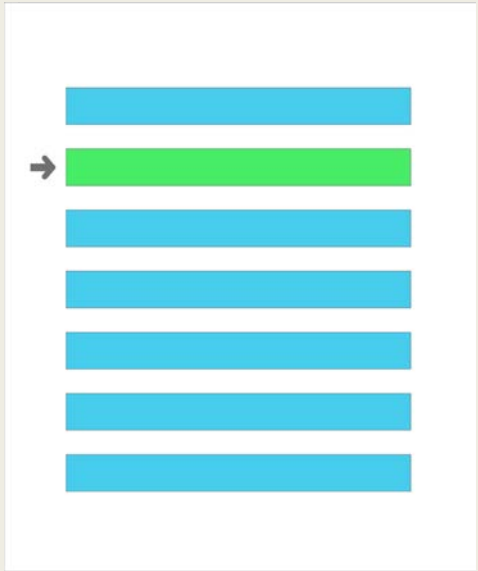
The concept of async-await



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The concept of async-await

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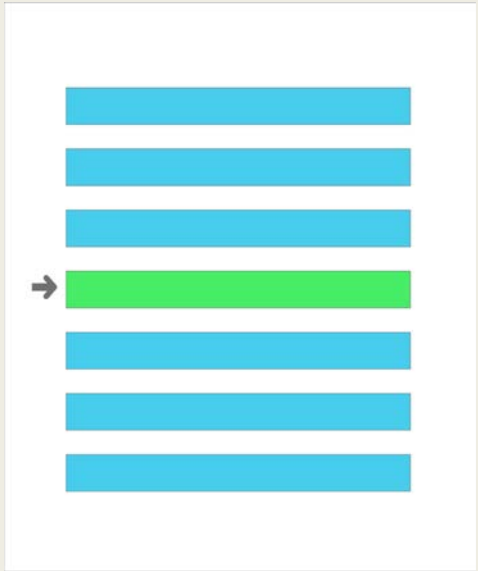

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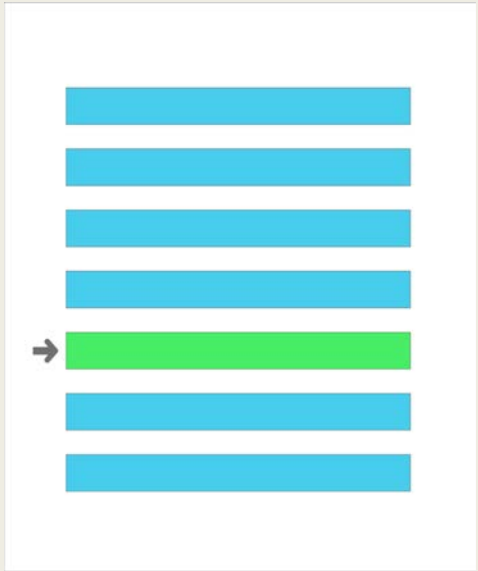

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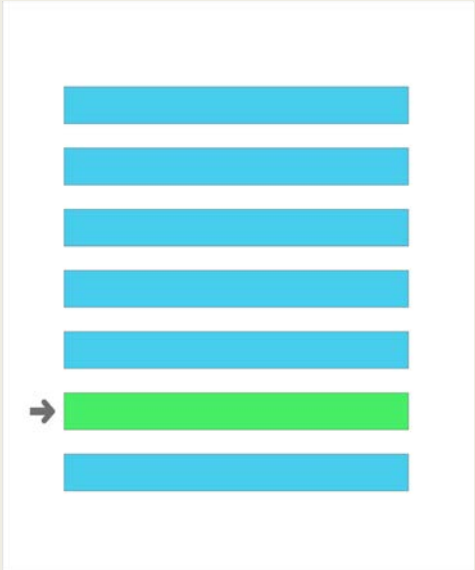

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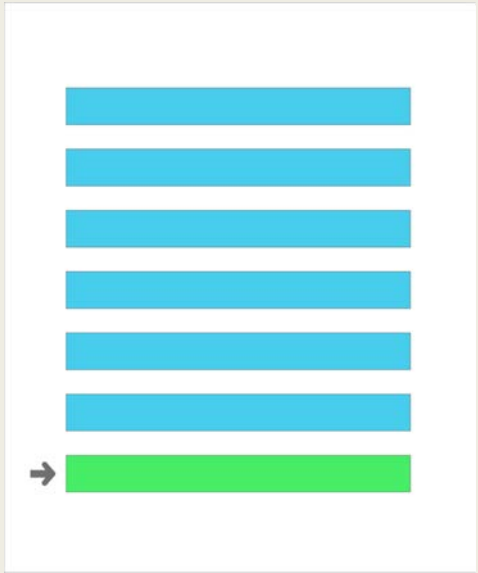

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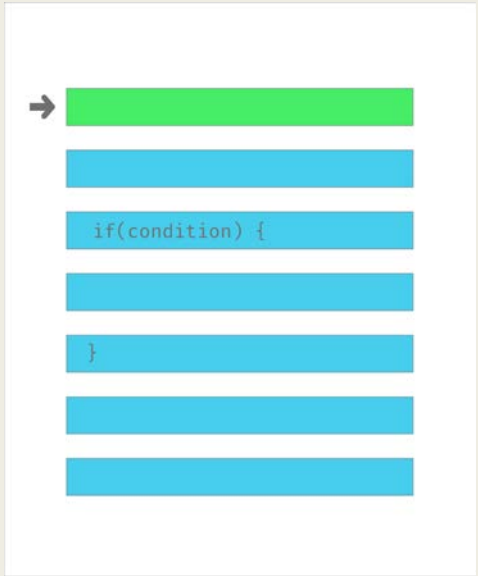

Conditionals Dispatch

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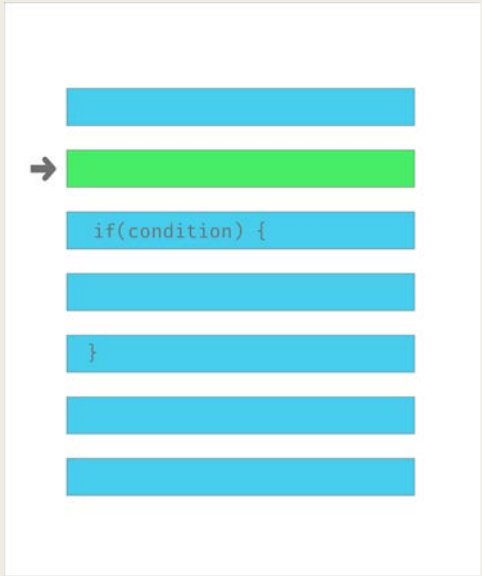

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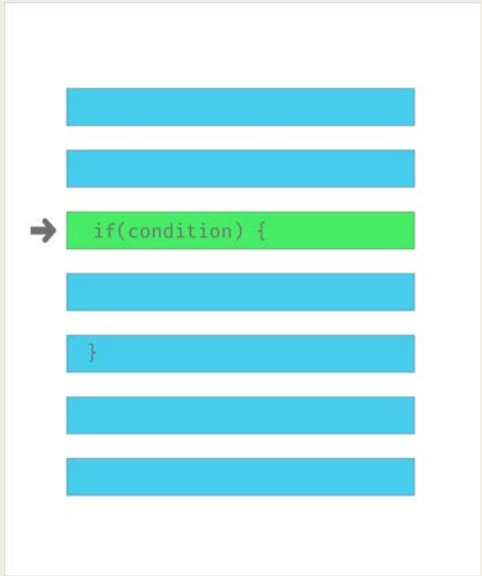

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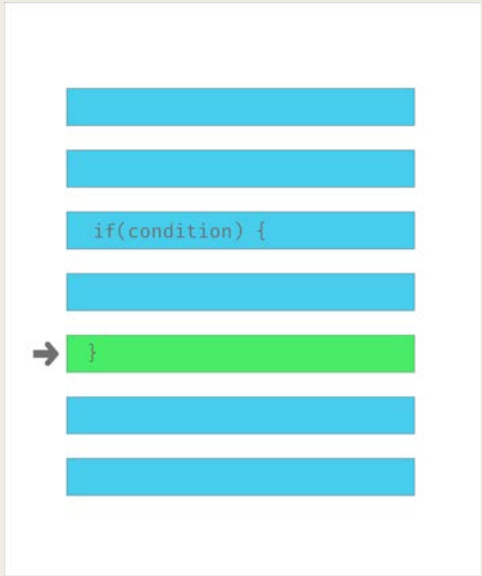

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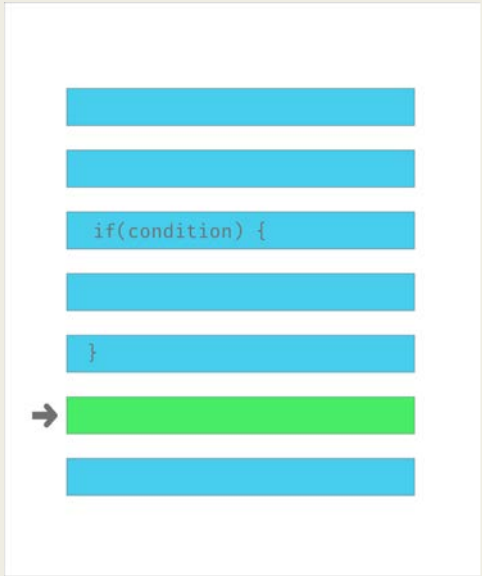

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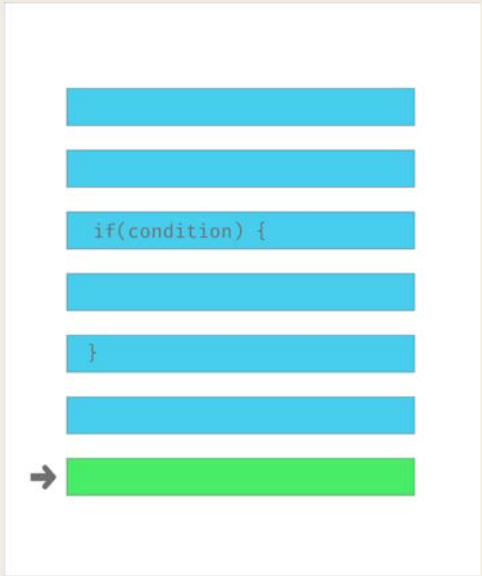

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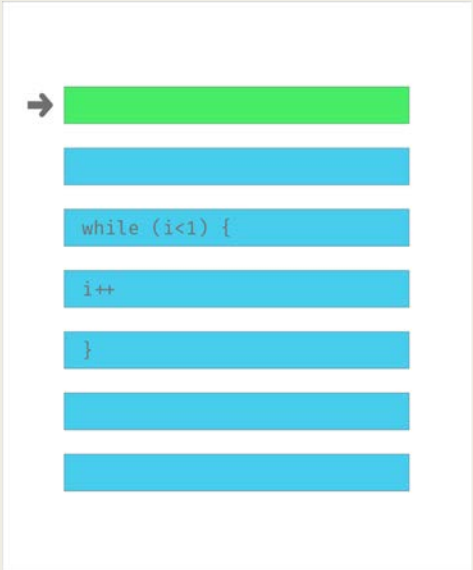

Loop

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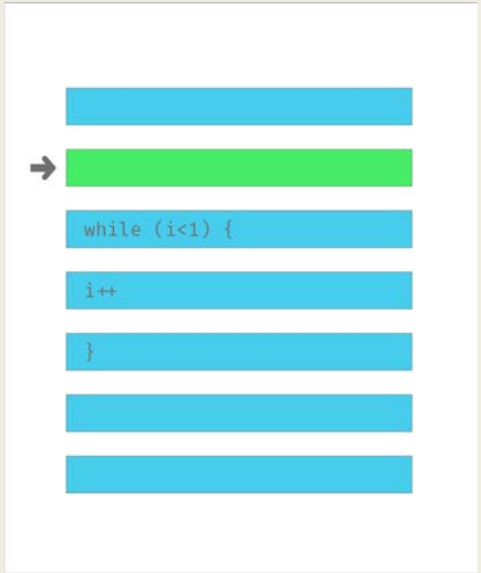

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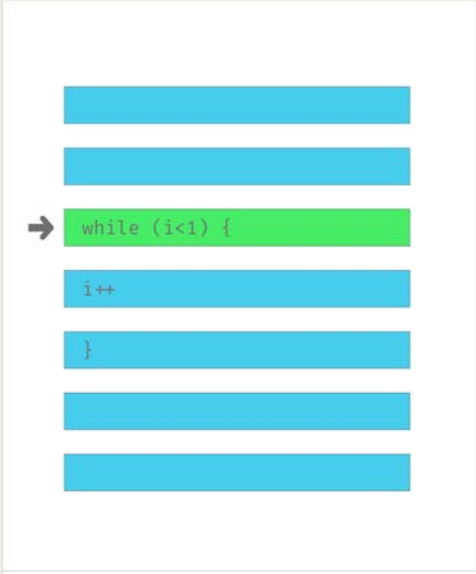

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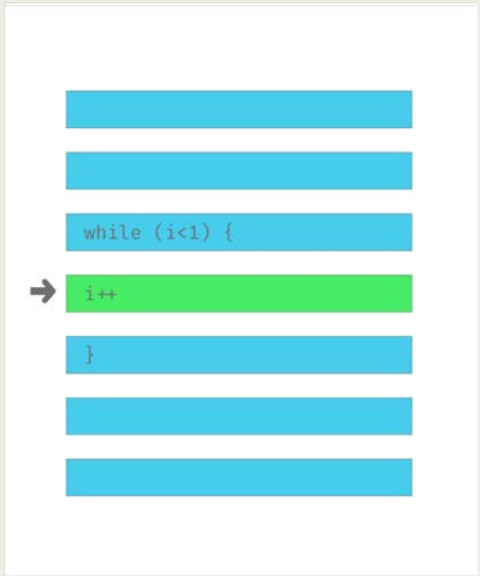

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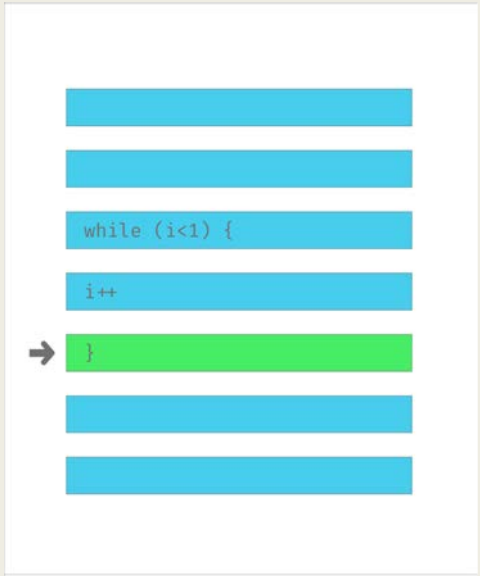

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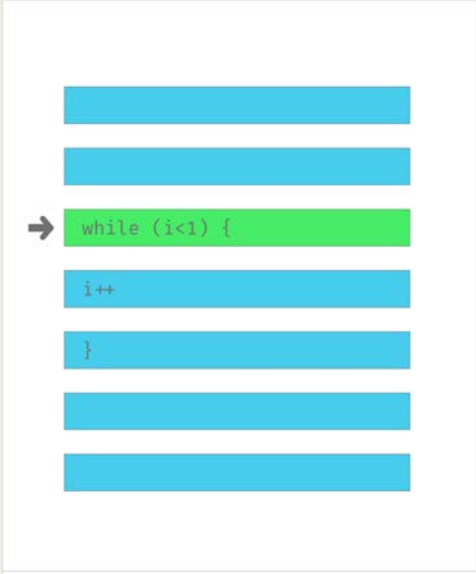

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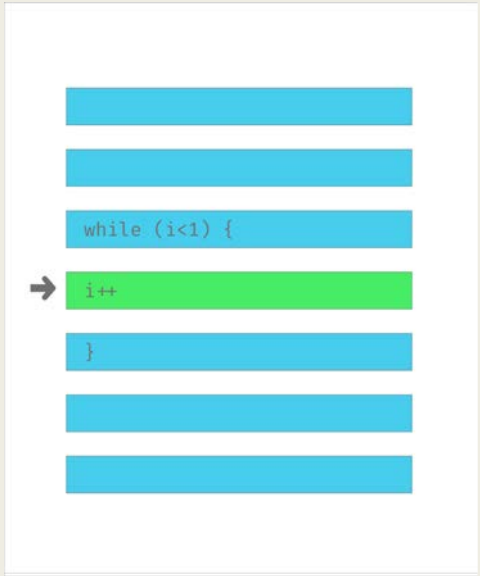

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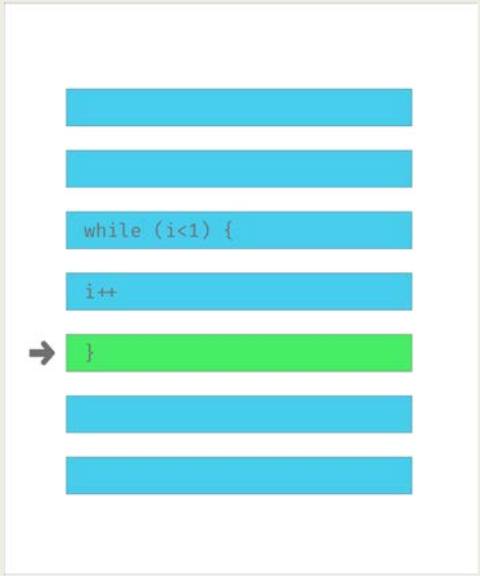

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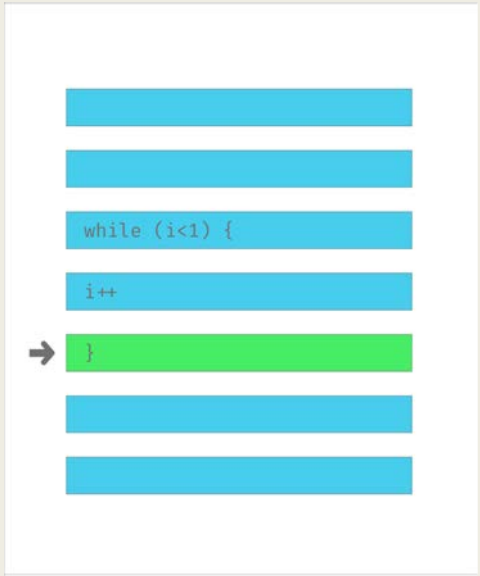

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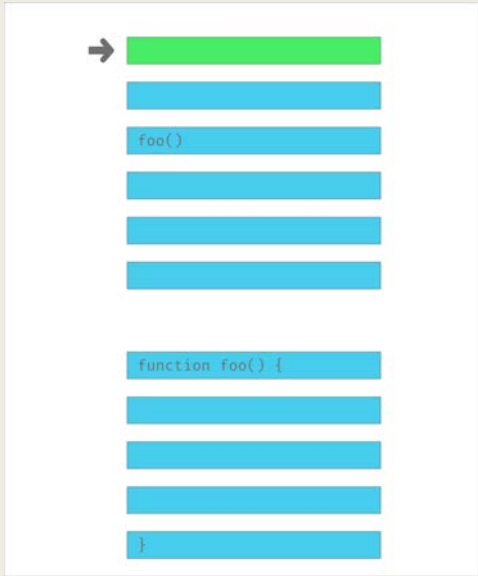

Function

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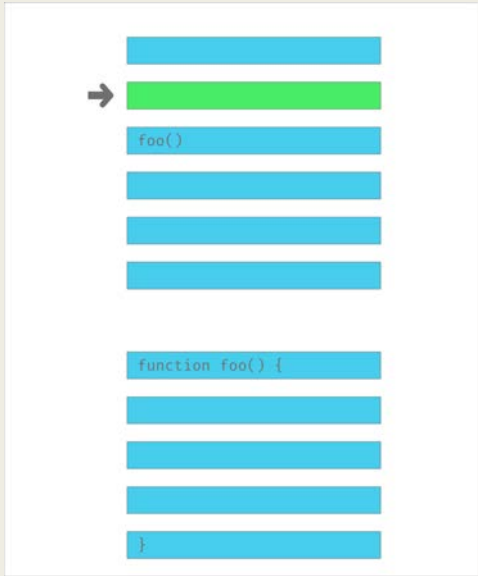

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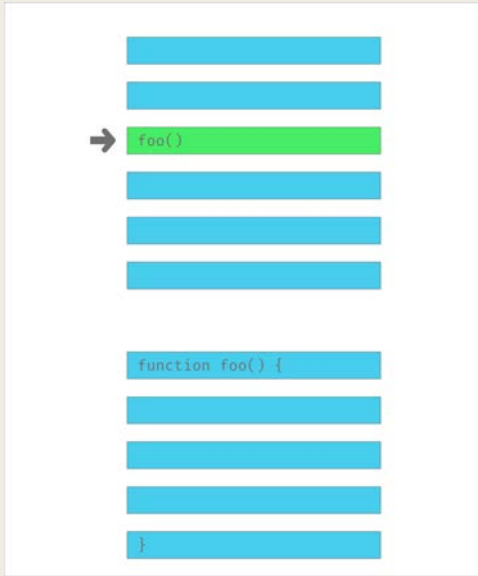

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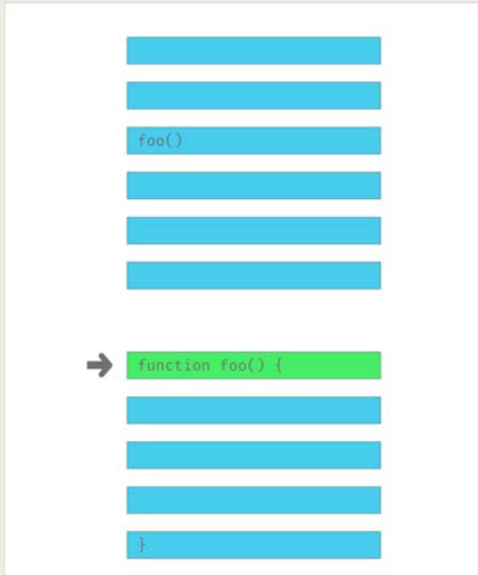

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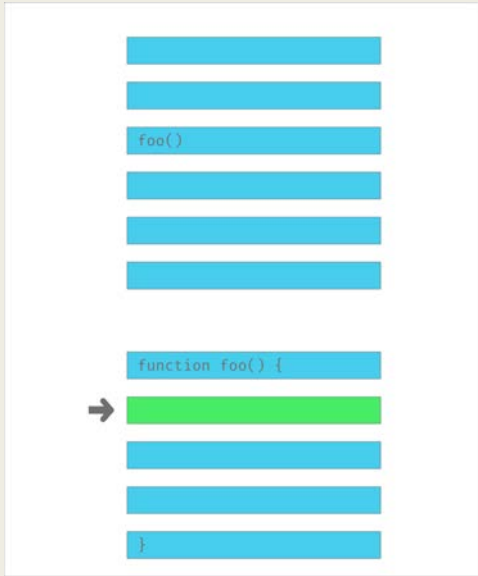

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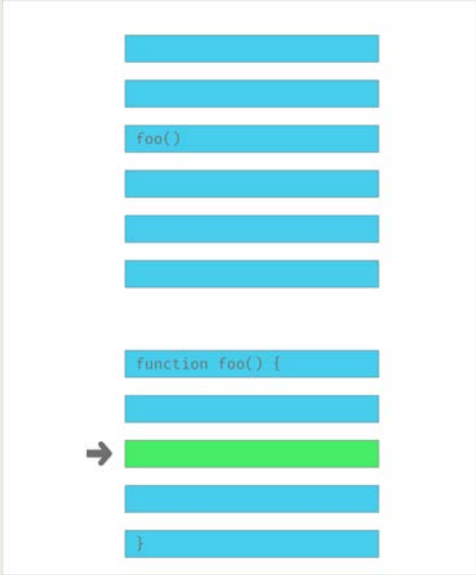

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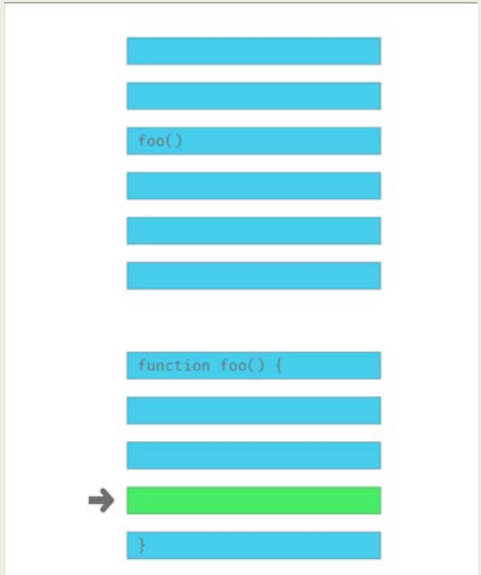

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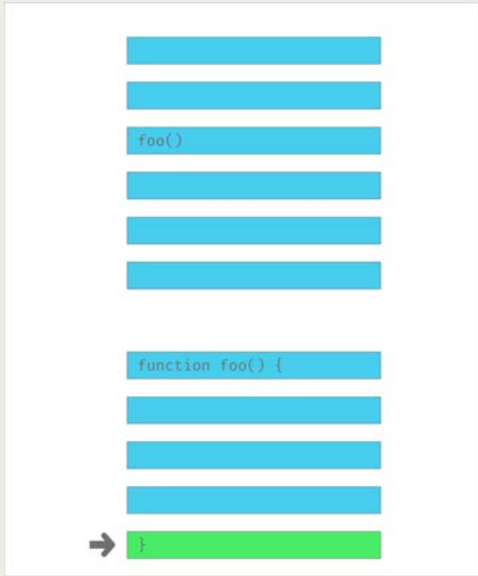

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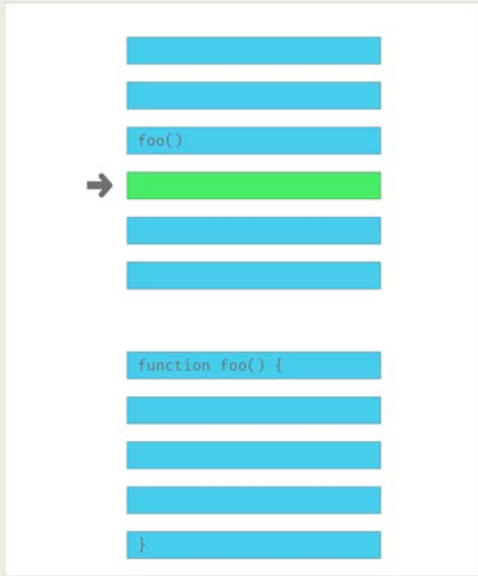

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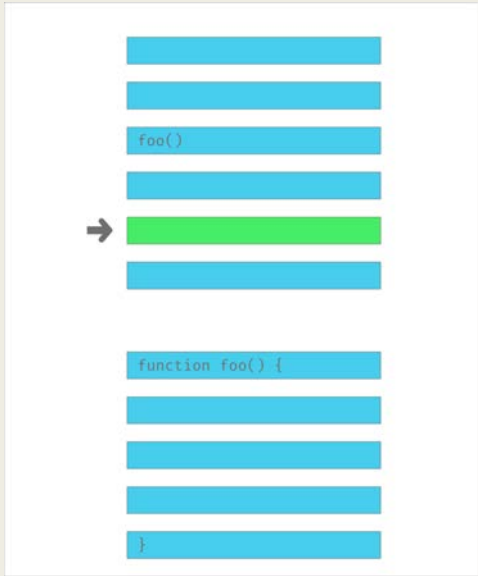

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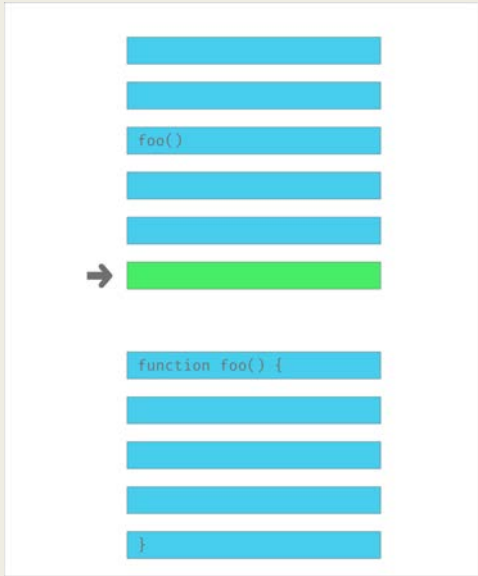

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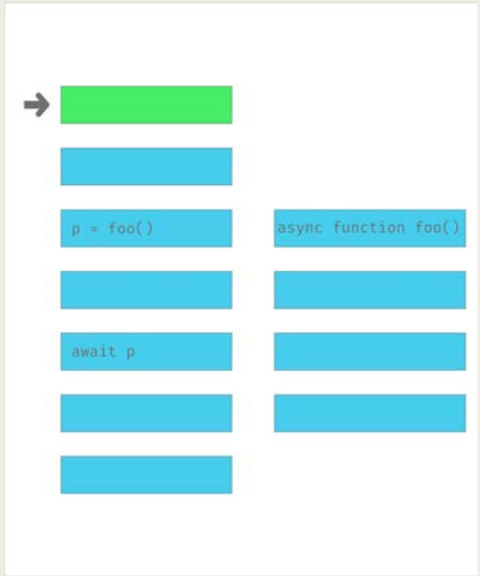

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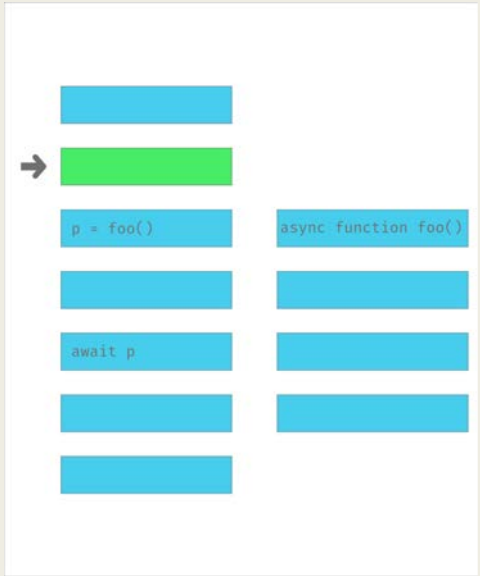

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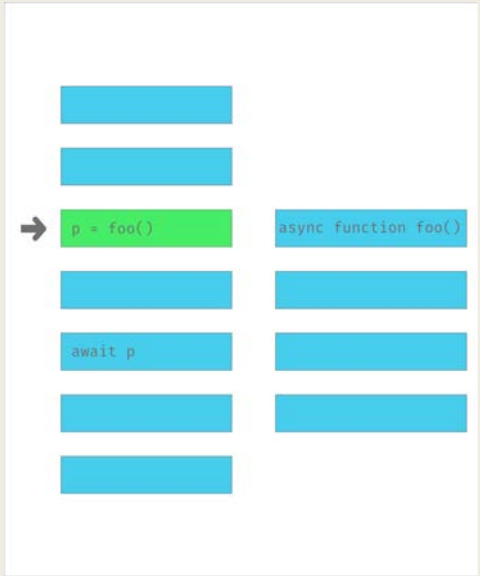

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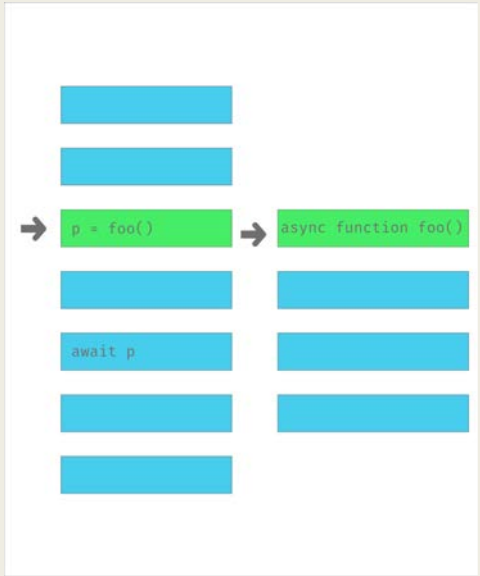

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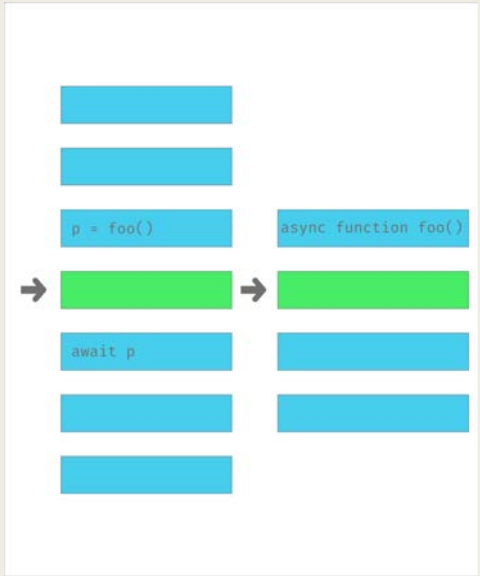

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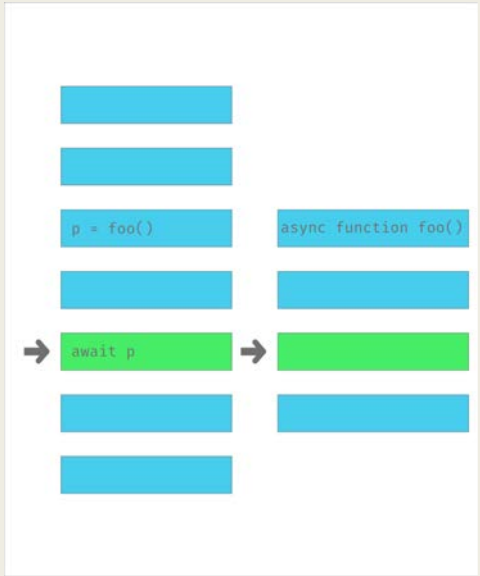

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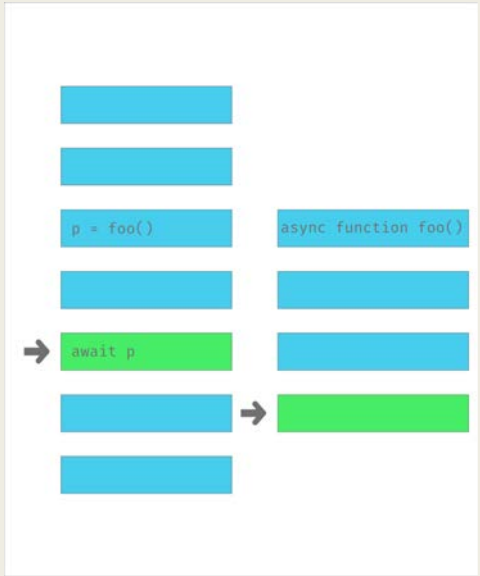

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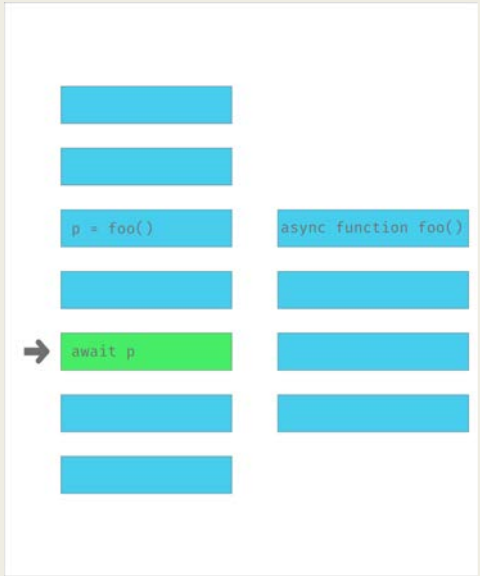

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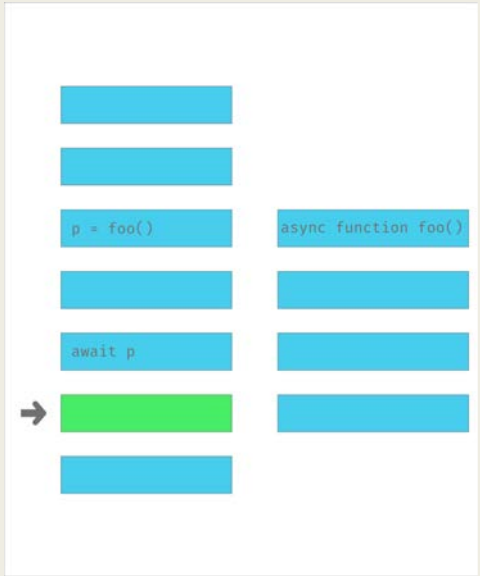

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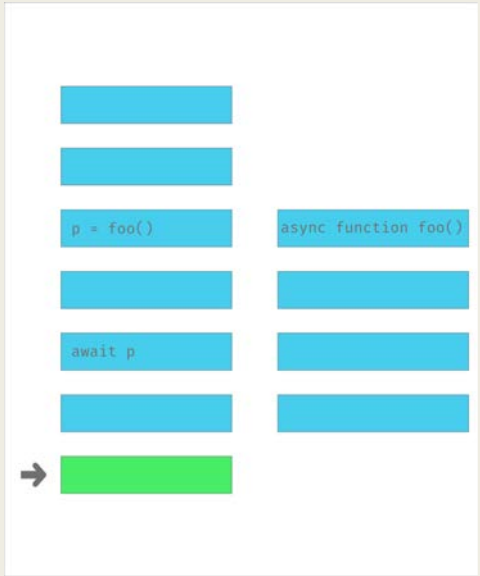

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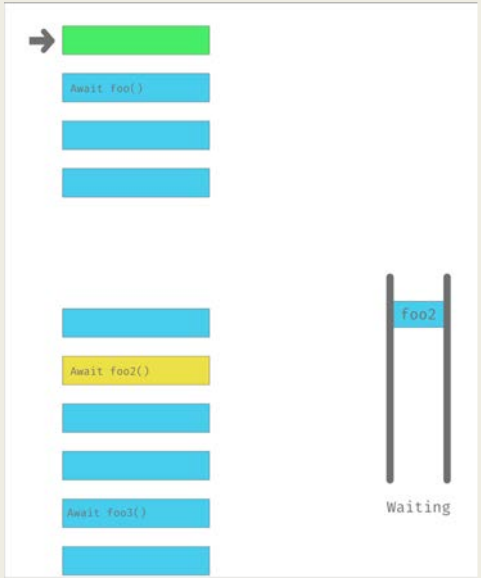

Event Dispatch

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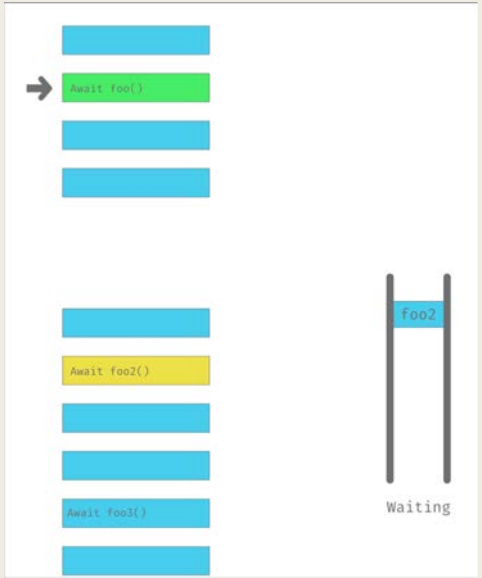

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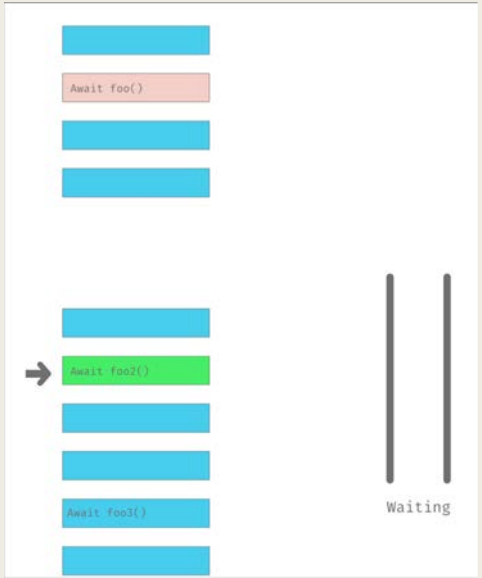

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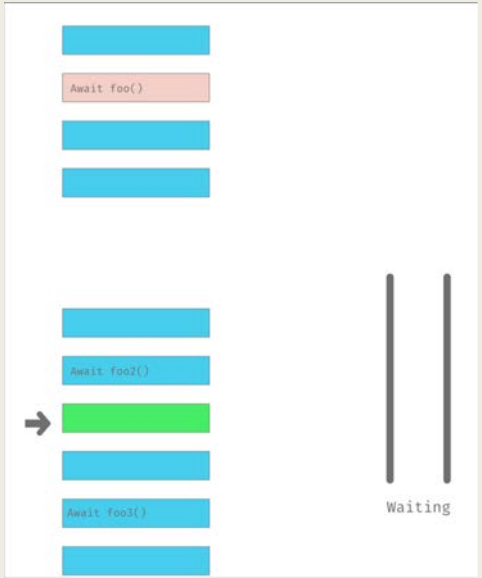

Event Dispatch

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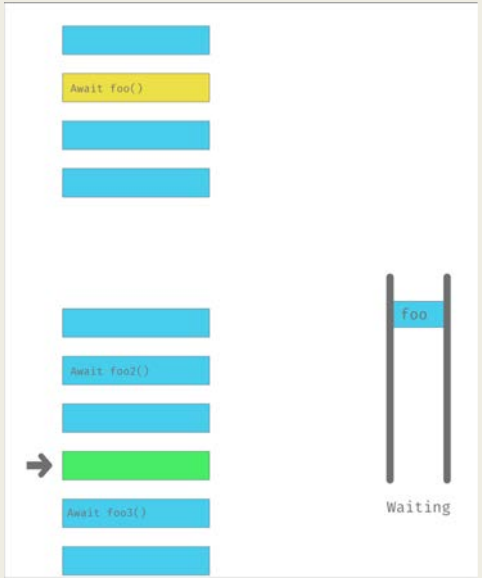
The concept of async-await



Event Dispatch

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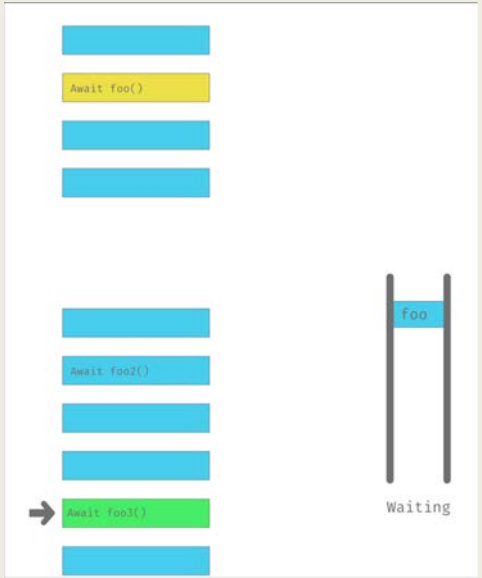
The concept of async-await



Event Dispatch

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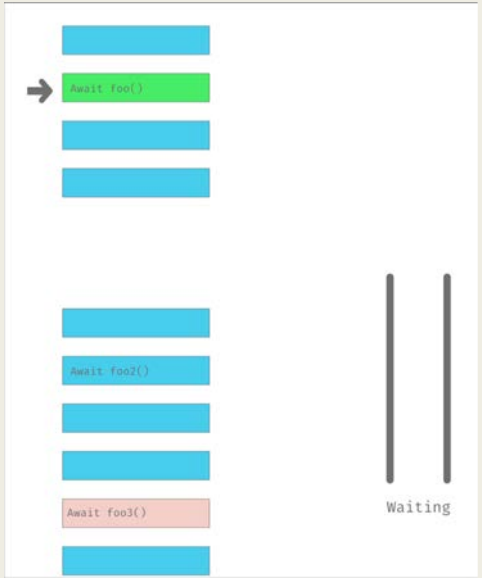
The concept of async-await



Event Dispatch

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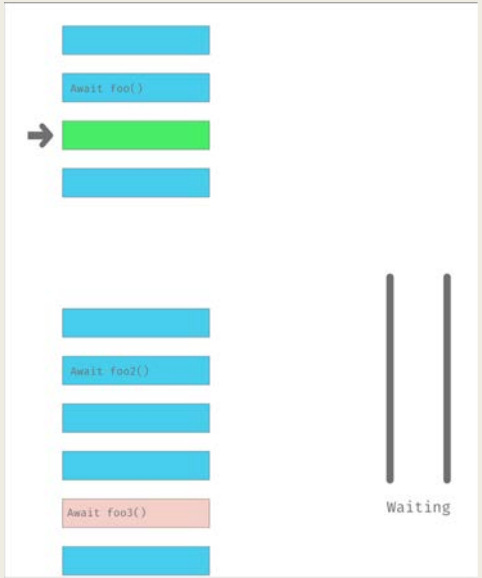
The concept of async-await



Event Dispatch

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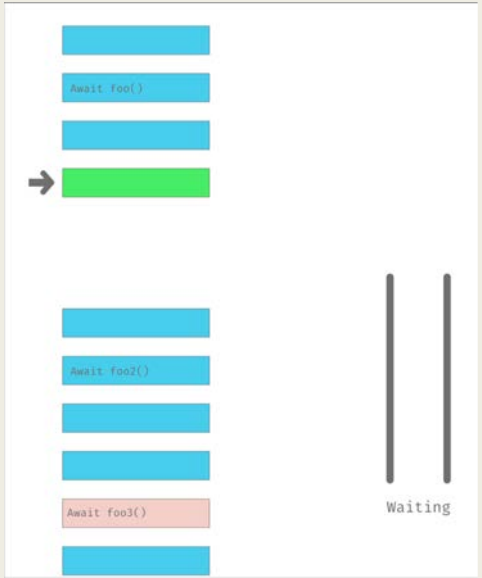
The concept of async-await



Event Dispatch

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BEGINNING ASYNC-AWAIT

A callback vs promise vs async await

A callback vs promise vs async await

```
function work(data, cb) {
      db.connect((err) => {
            if(err) {return cb(err);}
            db.query(query1, (err, result1) =>
            {
                  if(err) { return cb(err) }
                  db.query(query2, cb);
            });
      });
}
```

Callback

```
function work() {
      return db.connect()
      .then(() => {
            return db.query(query1);
      })
      .then((result1)=> {
            return db.query(query2);
      });
}
```

Promises

```
async function work() {
      await db.connect();
      result1 = await db.query(query1);
      return await db.query(query2);
}
```

async await

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BEGINNING ASYNC-AWAIT

The Program Flow

The program flow

```
async function foo() {
     ...
     await foo1();
     ...
     if(await foo2()) {
          ...
          await foo3()
          ...
     }
     for(...) {
          await foo4(...);
     }
     ...
}
```

The natural waterfall model

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The program flow

```
x = [...]
x.forEach(async y => {
     await foo(y);
});
```


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The program flow

```
// Wrong will return promise to
// forEach and not wait
x = [...]
x.forEach(async y => {
     await foo(y);
});
```

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The program flow

```
// Wrong will return promise to
// forEach and not wait
x = [...]
x.forEach(async y => {
     await foo(y);
});
```

```
// Right – will wait for each
// await in sequential order
x= [...];
for(y of x) {
     await foo(y)
}
```

Using for-of

Note: for..in does not make it to the JavaScript Good parts and should be avoided in the favor of for..of where possible.

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INTERMEDIATE ASYNC-AWAIT

A detour to promises

A detour to promises

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A detour to promises

- Promises have a then/catch/finally.

```
async function f() {...}
await f()
    .then((resp) => doSomething(resp))
    .catch((e) => handleError(e))
    .finally(() => cleanup());
```


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A detour to promises

- There is a concept of unhandled rejection.

```
process.on("unhandledRejection",...);

window.addEventListener("unhandledrejection", ...);
```


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A detour to promises

- Use Promises to convert a callback based method to async

```
function x(data, callback) {
      y.doSomething(data, (err, z) => {
            if (err) { return callback(err); }
            processed = somePostProcessing(z);
            callback(null, processed)
      });
}
```

```
x(data, (err, processed) => { });
```

Conversion guide: https://atishay.me/blog/2018/08/25/from-callbacks-to-async-await/

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A detour to promises

- Use Promises to convert a callback based method to async

```
function x(data, callback) {
      y.doSomething(data, (err, z) => {
            if (err) { return callback(err); }
            processed = somePostProcessing(z);
            callback(null, processed)
      });
}
```

```
function x(data) {
      return new Promise((resolve, reject) => {
            y.doSomething(data, (err, z) => {
                  if (err) {return reject(err);}
                  processed = somePostProcessing(z);
                  resolve(processed);
            });
});
```

```
x(data, (err, processed) => { });
```

```
const processed = await x(data);
```

Conversion guide: https://atishay.me/blog/2018/08/25/from-callbacks-to-async-await/

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A detour to promises

- Use Promises to convert a callback based method to async

```
function x(data, callback) {
      y.doSomething(data, (err, z) => {
            if (err) { return callback(err); }
            processed = somePostProcessing(z);
            callback(null, processed)
      });
}
```

```
async function x(data) {
      return new Promise((resolve, reject) => {
            y.doSomething(data, (err, z) => {
                  if (err) {return reject(err);}
                  processed = somePostProcessing(z);
                  resolve(processed);
            });
});
```

```
x(data, (err, processed) => { });
```

```
const processed = await x(data);
```

Conversion guide: https://atishay.me/blog/2018/08/25/from-callbacks-to-async-await/

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INTERMEDIATE ASYNC-AWAIT

The Program Flow

The program flow

```
async foo() {
      ...
      await fetch()
      ...
}

const p = foo();
// Do some parallel tasks
...
await p;
```

Delayed await

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The program flow

```
const tasks = [
     fetch(p1),
     fetch(p2),
     fetch(p3)
];

responses = await Promise.all(tasks);
```

Running stuff in parallel

Note: This will return quickly in case of exceptions. There are ways to workaround this, while the standards committee is working on Promise.allSettled to provide the easy solution.

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The program flow

```
await Promise.all([...].map(async x => {
    ...
    await foo(x);
    ...
}));
```

Using array.map

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The program flow

```
// setTimeout async version
const timeout = async (time) => new Promise(resolve => setTimeout(resolve, time));


// Adding a timeout to fetch
await Promise.race([fetch(...), timeout(2000)]);
```

Racing functions

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The program flow

```
function handleError(error) {
    console.log(error);
    return fallbackFoo2Response;
}

await foo1(...);
await foo2(...).catch(handleError);
await foo3(...)
```

```
await Promise.all([]
    .map(async () => {
        ...
    })
    .map(x => x.catch(e => e))
);
```

Errors without try...catch

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ADVANCED ASYNC-AWAIT

Async guarantees

Async guarantees

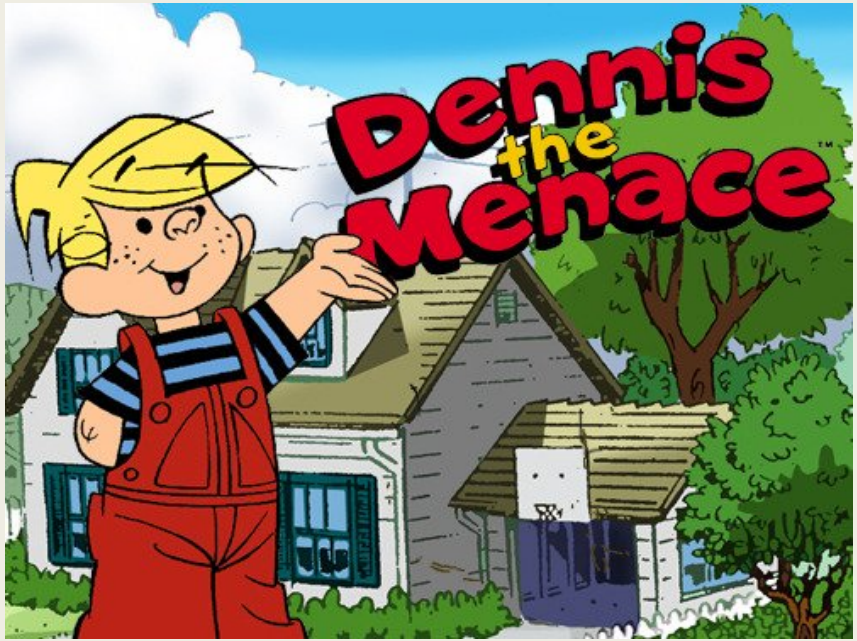

Image from
IMDB

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Async guarantees

```
undefined = true;
```

```
foo.apply(window, arguments)
```

```
function(cb) {
    x((err) => {
        if(err) { callback(err); }
        callback(true);
    })
}
```


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Async guarantees

- It always returns once
- There is only one return value
- It is always a promise

```
undefined = true;
```

```
foo.apply(window, arguments)
```

```
function(cb) {
    x((err) => {
        if(err) { callback(err); }
        callback(true);
    })
}
```


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ADVANCED ASYNC-AWAIT

Wrapping asynchronous functions

Wrapping asynchronous functions

Image from Pixabay

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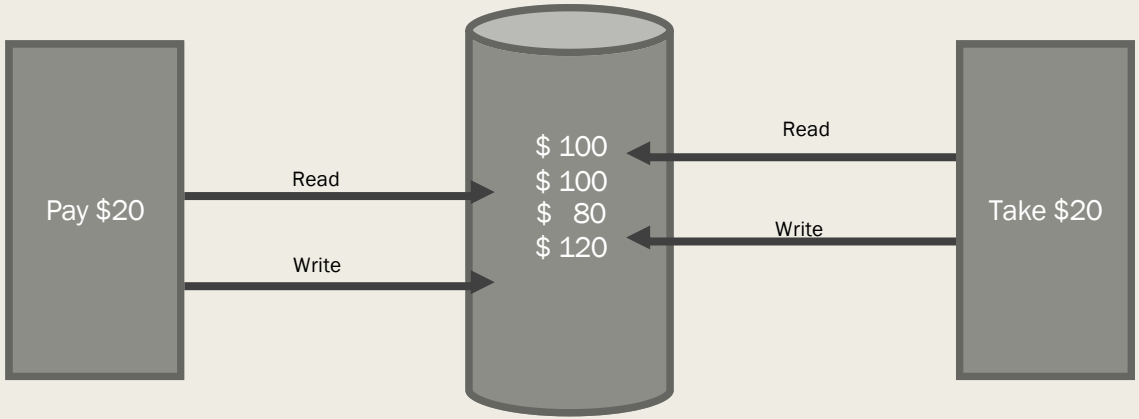
Wrapping asynchronous functions



Shared data problem

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Wrapping asynchronous functions

```
async a() {
     await lock();
     await fs.readFile(file);
     await fs.writeFile(file);
     unlock()
}

async b() {
     await lock()
     await fs.readFile(file);
     await fs.writeFile(file);
     unlock();
}
```

```
let mutex = false;

async lock() {
     while(mutex) { await timeout(100);}
     mutex = true;
}

unlock() {
     mutex = false;
}
```

Shared data and locks

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Wrapping asynchronous functions

```
async a() {
     await lock();
     await fs.readFile(file);
     await fs.writeFile(file);
}
```

Fixing forgotten lock call problem

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Wrapping asynchronous functions

```
async a() {
     await lock();
     await fs.readFile(file);
     await fs.writeFile(file);
}
```

```
async a() {
     return await transaction(async () =>
{
          await fs.readFile(file);
          await fs.writeFile(file);
     });
}
```

Fixing forgotten lock call problem

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Wrapping asynchronous functions

```
async transaction(method) {
    await lock();
    const value = await method().catch(e => {
        unlock();
        throw e;
    });
    unlock();
    return value;
}
```

The transaction wrapper

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Wrapping asynchronous functions

```
async time(key, method) {
     console.time(key);
     return await method().finally(() => {
          console.timeEnd(key);
     });
}

// Usage
await time('myMethod', async ()=> {
     //do your work
})
```

A better way - the time wrapper

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Wrapping asynchronous functions

```
async time(key, method) {
     const context = {};
     console.time(key);
     return await method(context).finally(() => {
          console.timeEnd(key);
          fetch(url, {body: context});
     });
}

// Usage
await time(async (context)=> {
     //do your work
     context.x = "some result;
});
```

Include context

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ADVANCED ASYNC-AWAIT

Exploiting the promises underneath

Exploiting promises in async

Image from gifer

The Parallel calls problem

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Exploiting promises in async

```
function get(cb) {
     if (data) {
          cb(data);
     } else {
          callbacks.push(cb);
     }
     if (callbacks.length === 1) {
          ...
          callbacks.forEach(cb => cb(data));
     }
}
```

Doing it once

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Exploiting promises in async

```
let get = memoize(async () => {
    ...
    return data;
});
```

Memoize method

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Exploiting promises in async

```
1    function memoize(func, resolver) {
2         const memoized = function(...args) {
3              const key = resolver ? resolver.apply(this, args) : args[0]
4              const cache = memoized.cache
5
6              if (cache.has(key)) {
7                   return cache.get(key)
8              }
9              const result = func.apply(this, args)
10             memoized.cache = cache.set(key, result) || cache
11             return result
12        }
13        memoized.cache = new Map();
14        return memoized
15   }
```

Lodash - Memoize method

https://github.com/lodash/lodash/blob/master/memoize.js

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Exploiting promises in async

```
9.1       if (result instanceof Promise) {
9.2             result.state = 'pending';
9.3             result.then(() => result.state = 'resolved')
9.4                     .catch(() => result.state = 'rejected');
9.5       }
```

```
6         if (cache.has(key)) {
6.1           let x = cache.get(key);
6.2           if (x instanceof Promise) {
6.3                 if (x.state === 'pending') {
7                       return x;
7.1                 }
7.2           }
8         }
```

Reuse the promise only if pending

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Exploiting promises in async

```
// Convert to ES6 Decorator
function Memoize() {
     return function (target, functionName, descriptor) {
          descriptor.value = memoize(target[functionName]);
     };
}

@Memoize
async get() {
     ...
     return data;
}
```

Creating decorator for memoize

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ADVANCED ASYNC-AWAIT

Exploiting callbacks deep down

Exploiting callbacks deep down

Reader-Writer Problem

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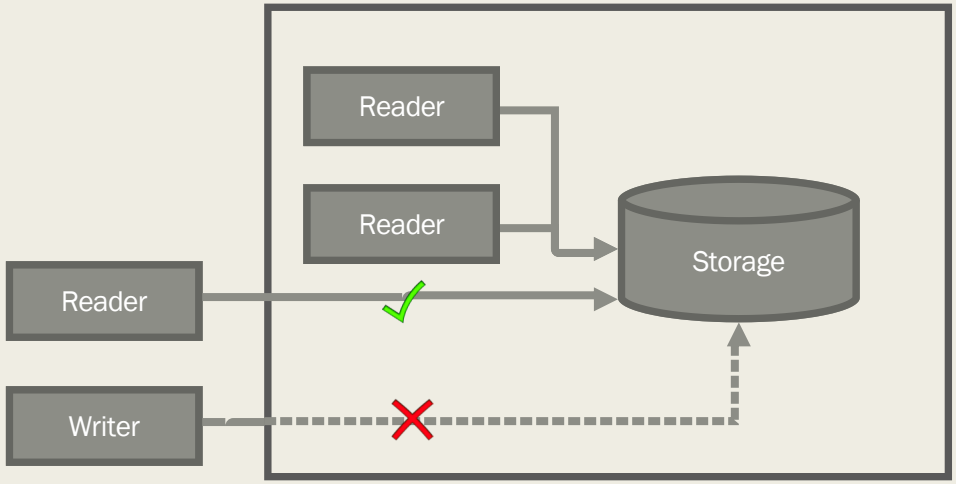
Exploiting callbacks deep down



Reader-Writer Problem

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Exploiting callbacks deep down

```
await lock.read(async ()=> {
    // Do reading
});

await lock.write(async () => {
    // Do writing
});
```

Read-Write Lock API

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Exploiting callbacks deep down

```
class Lock {
    pendingReads = []
    pendingWrites = []
    async read(func) {   // Cannot use await here
        return new Promise(resolve => {
            pendingReads.push({func, cb:resolve});
            this.perform();
        });
    }
    async write(func) { // Cannot use await here
        return new Promise(resolve => {
            pendingWrites.push({func, cb: resolve});
            this.perform();
        }
    }
    perform() {
        ...
    }
}
```

Structure of the Lock class

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Exploiting callbacks deep down

```
perform() {
	if (this.state === 'None' && this.pendingWrites.length > 0) {
		this.state = 'Write';
		const {func, cb} = this.pendingWrites.shift();
		func().finally(() => {
			cb(); this.state = 'None'; this.perform();
		}
	}

	if (this.state !== 'Write' && this.pendingReads.length > 0) {
		this.pendingReads.forEach(({func, cb})=> {
			this.state = 'Read';
			this.readInProgess++;
			func().finally(() => {
				cb();
				this.readInProgess--;
				if (this.readInProgess === 0) { this.state === 'None'; }
				this.perform();
			})
		});
	}

}
readInProgess = 0
state = 'None'
```

Structure of the Lock class

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CONCLUSION

Conclusion

- Where callbacks rule:
  - *addEventListener*
  - *Method Wrappers (can be @decorators as well).*
- Where Promises rule
  - *Short hands with async*
- Where async await rule
  - *Everywhere else*

Image from giphy

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THANK YOU

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