ASYNC PATTERNS & STRATEGIES IN JAVASCRIPT

{ Jim Cowart }

Who am I?

- Jim Cowart (a.k.a. - @ifandelse)
- Chief Architect at appendTo
- I act like I write stuff: http://freshbrewedcode.com/jimcowart
- I write stuff: http://github.com/ifandelse

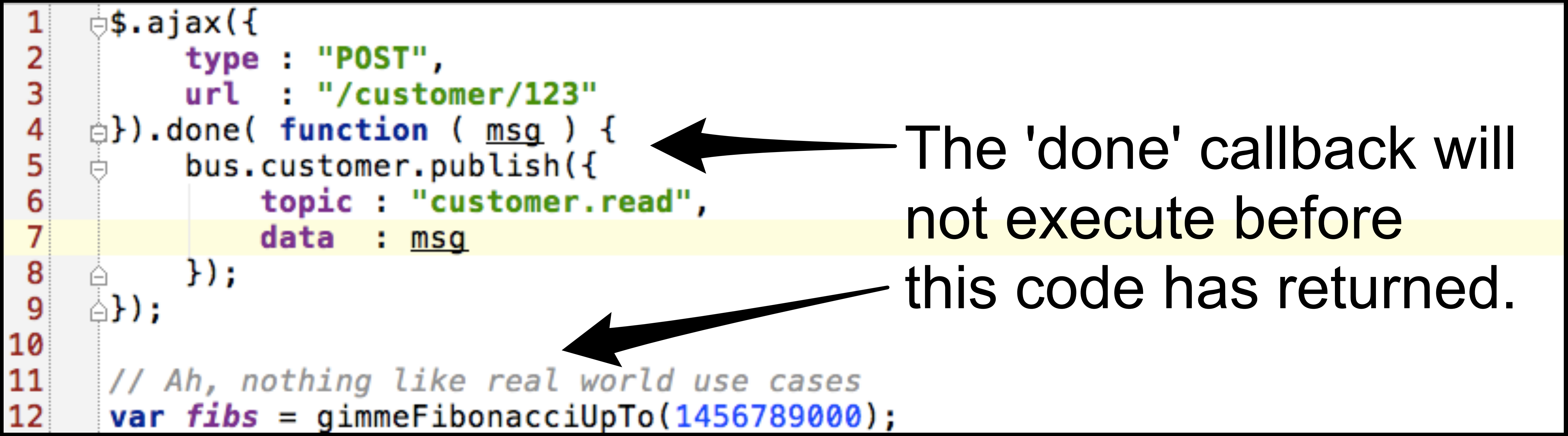
So why are we here?

- “We have a cultural bias towards blocking” code
- Asynchronous is far more than just AJAX response handlers
- What patterns can help us?
- What about good implementations of those patterns in popular libraries?

What does it mean to be asynchronous?

- JavaScript is single-threaded & runs in an event loop
- Events are queued - and will run when the loop is available
- Currently executing code can queue something to run later (but no sooner than the currently executing code has returned)

Obligatory Asynchronous Example



```
$.ajax({
    type : "POST",
    url  : "/customer/123"
}).done( function ( msg ) {
    bus.customer.publish({
        topic : "customer.read",
        data  : msg
    });
});

// Ah, nothing like real world use cases
var fibs = gimmeFibonacciUpTo(1456789000);
```

The 'done' callback will not execute before this code has returned.

"Events can be queued while code is running, but they can't fire until the runtime is free."
- Trevor Burnham (Async JavaScript)

Once you go async, you'll never return...

- Callbacks are the currency of asynchronous code
- Continuation-passing-style vs return values === very different design constraints
- Not safe to assume *how* a 3rd party lib will execute your callback (synchronously? asynchronously?)

Something to keep in mind

“You cannot reduce the complexity of a task beyond a given point. Once you reach that point, you can only shift the burden around.”

Tessler’s Law of Conservation of Complexity

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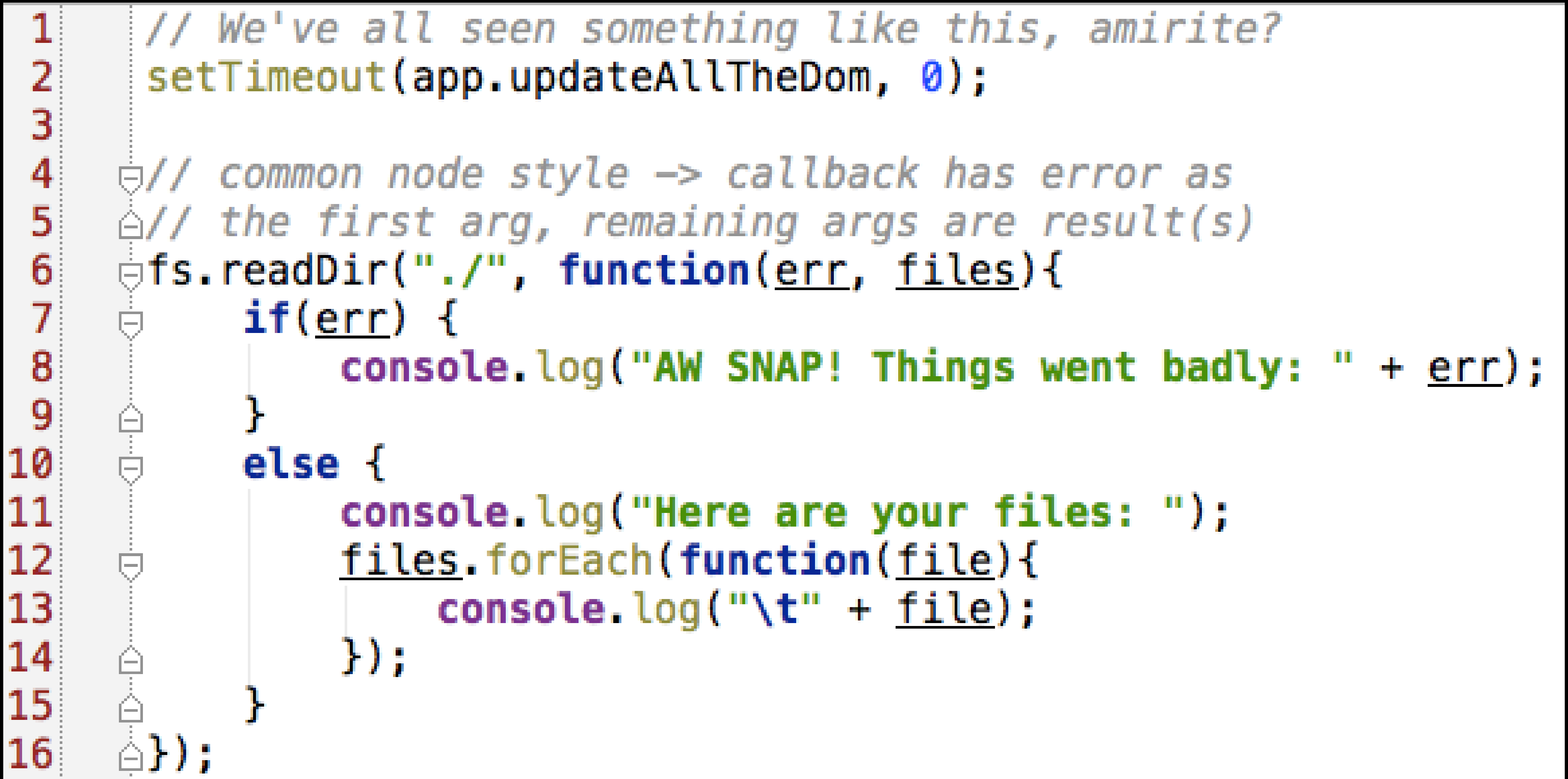
So, to *where* are you shifting the burden?

The Future (of upcoming Examples)

Strategy #1 - Plain Callbacks



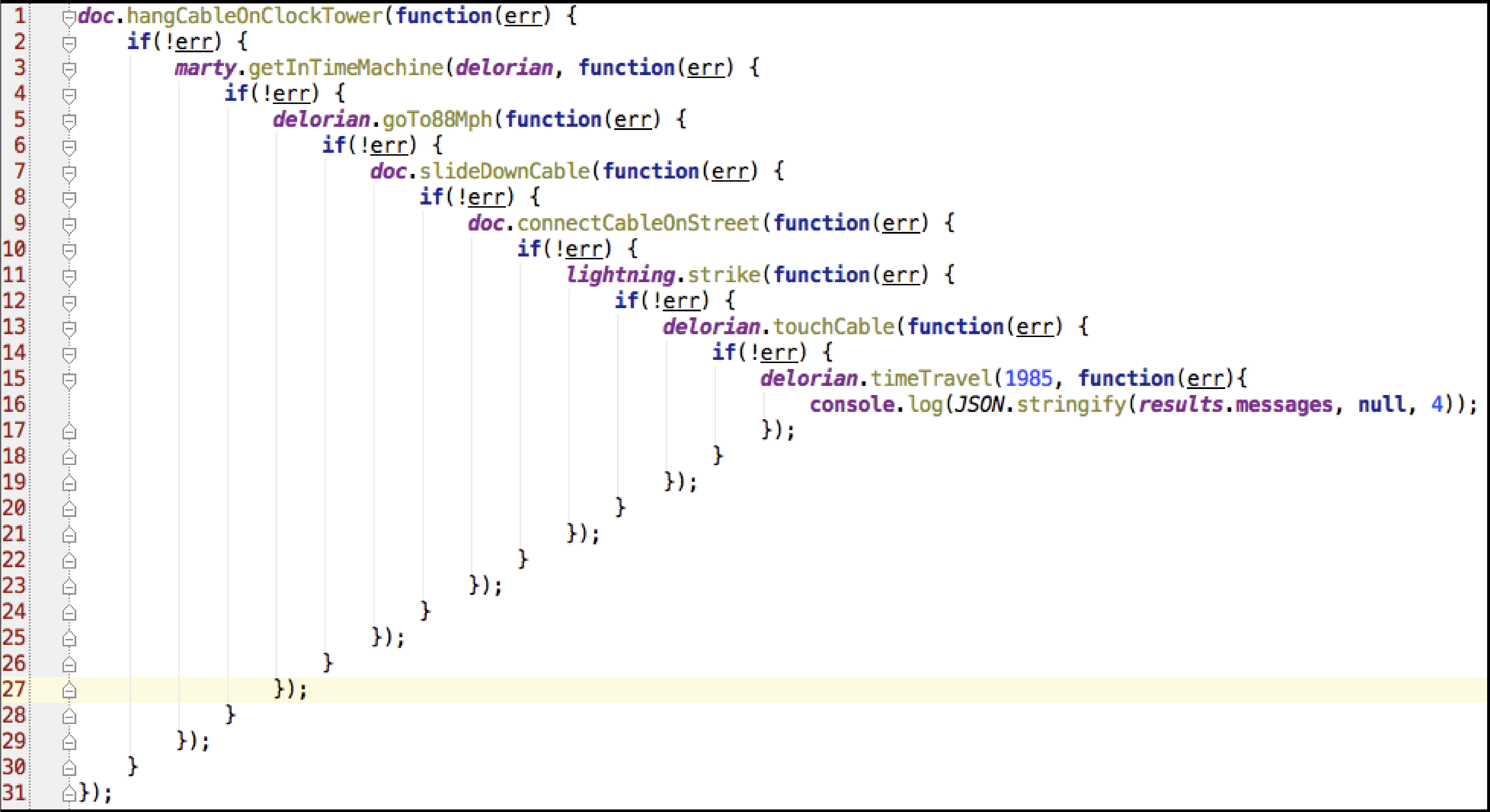
```
// We've all seen something like this, amirite?
setTimeout(app.updateAllTheDom, 0);

// common node style -> callback has error as
// the first arg, remaining args are result(s)
fs.readDir("./", function(err, files){
    if(err) {
        console.log("AW SNAP! Things went badly: " + err);
    }
    else {
        console.log("Here are your files: ");
        files.forEach(function(file){
            console.log("\t" + file);
        });
    }
});
```

It’s simple: Pass a function that will be invoked when the work completes. (Could be synchronous or asynchronous.)

Strategy #1 - Plain Callbacks

Oh, look! Nested ~~facepalms~~ callbacks.



```
doc.hangCableOnClockTower(function(err) {
    if(!err) {
        marty.getInTimeMachine(delorian, function(err) {
            if(!err) {
                delorian.goTo88Mph(function(err) {
                    if(!err) {
                        doc.slideDownCable(function(err) {
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                                doc.connectCableOnStreet(function(err) {
                                    if(!err) {
                                        lightning.strike(function(err) {
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                                                    if(!err) {
                                                        delorian.timeTravel(1985, function(err){
                                                            console.log(JSON.stringify(results.messages, null, 4));
                                                        });
                                                    }
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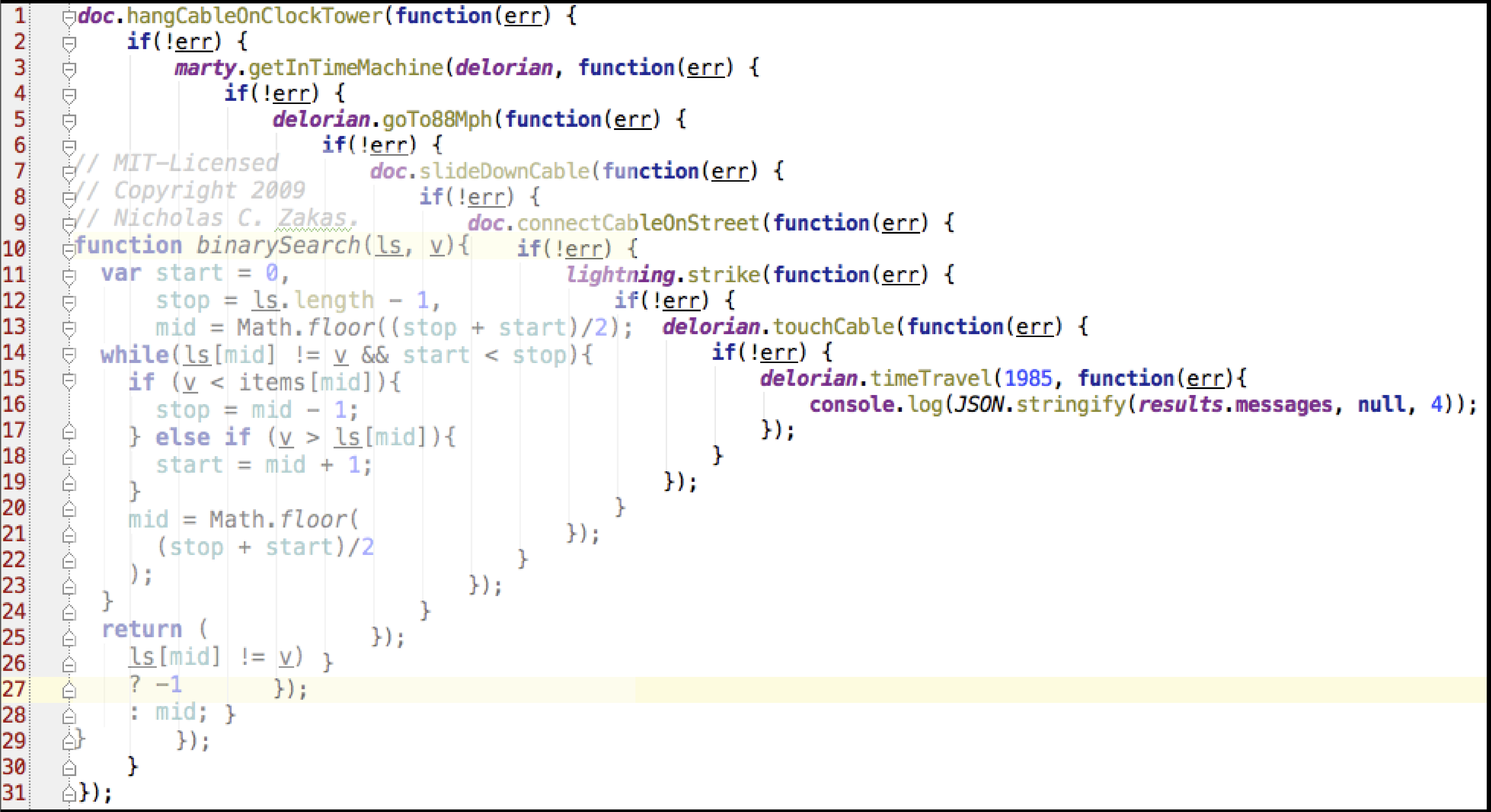

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                                                    }
                                                });
                                            }
                                        });
                                    }
                                });
                            }
                        });
                    }
                });
            }
        });
    }
});
```

```
// MIT-Licensed
// Copyright 2009
// Nicholas C. Zakas.
function binarySearch(ls, v){
  var start = 0,
      stop = ls.length - 1,
      mid = Math.floor((stop + start)/2);
  while(ls[mid] != v && start < stop){
    if (v < items[mid]){
      stop = mid - 1;
    } else if (v > ls[mid]){
      start = mid + 1;
    }
    mid = Math.floor(
      (stop + start)/2
    );
  }
  return (
    ls[mid] != v)
    ? -1
    : mid;
}
```

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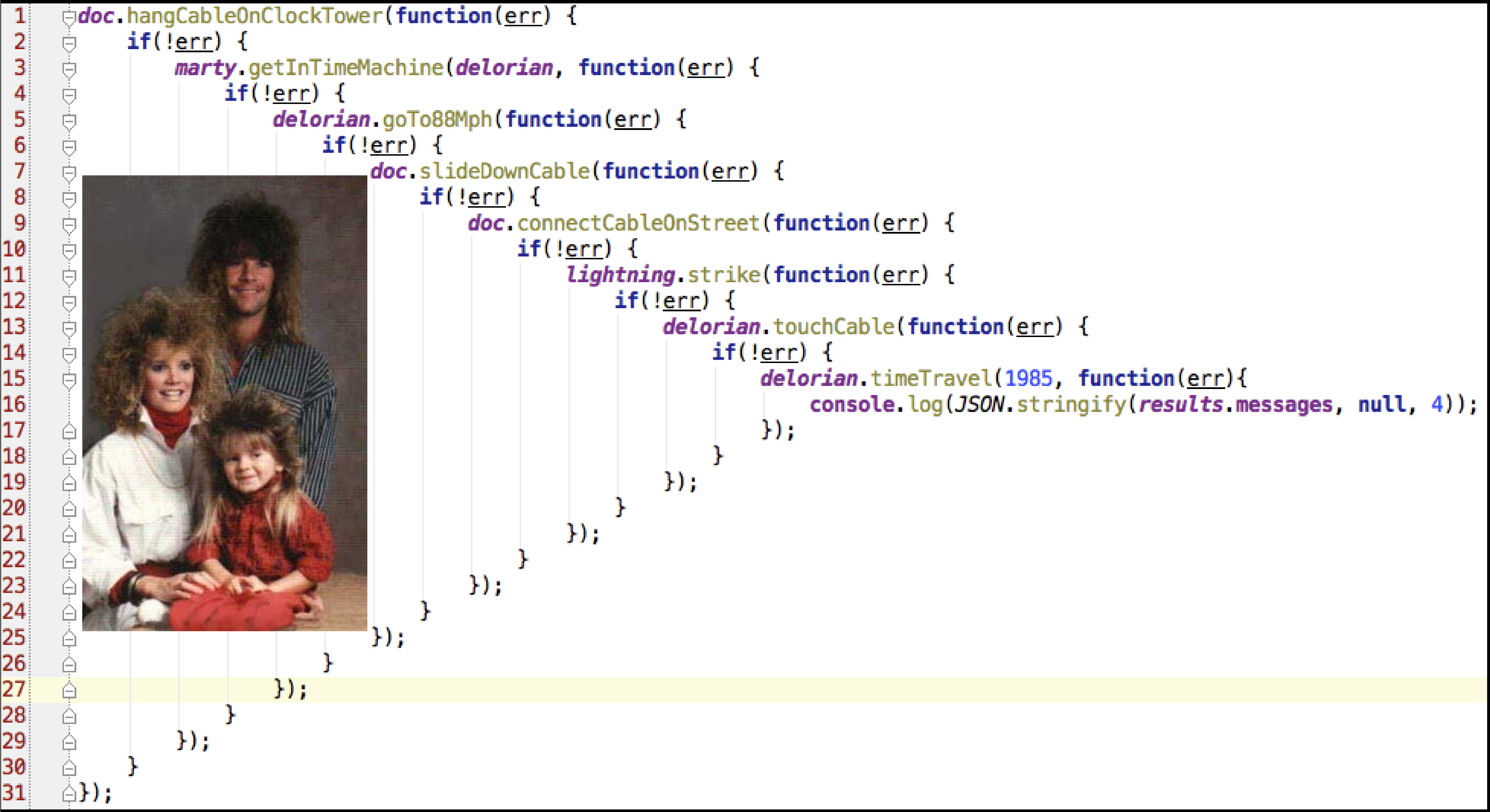

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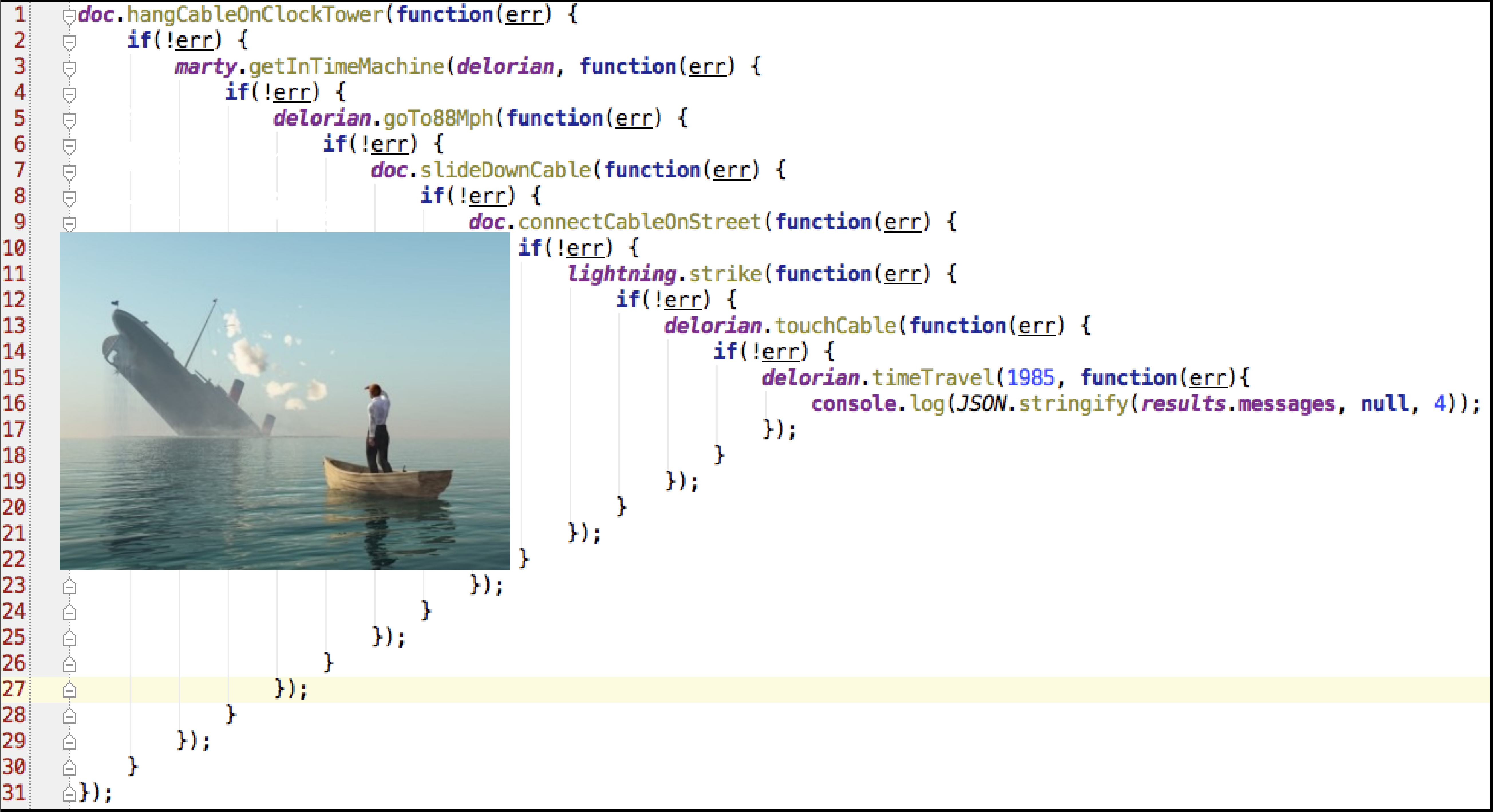

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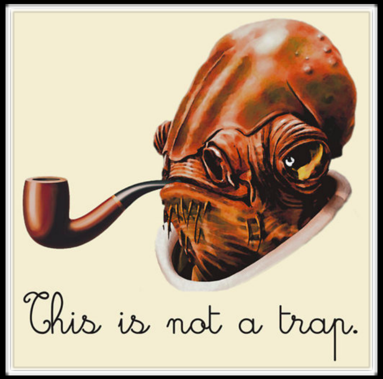
Strategy #1 - Plain Callbacks



PROS:

- Simple
- No extra libs required
- works well for stand-alone concerns

CONS:

- hardens tight coupling
- limited 'visibility' into the operation
- gets complex when nested

Strategy #1 - Plain Callbacks

Recommendations:

- Use for concerns that go 1 or 2 levels deep (at most)
- Use in ‘public API’ (less opinionated that other options)*

Strategy #2 - Events

- EventEmitter (or similar style API):
  - on(“SomeEvent”, callback [, context])
  - off(“SomeEvent” [, callback [, context]])
  - emit(“SomeEvent”, [arg1, arg2, etc...])
- Break components into small pieces that listen for events to occur at any time

{ Code }

Strategy #2 - Events

PROS:

- Better decoupling
- More testable than nested callbacks
- Better at coordinating evented workflow

CONS:

- Despite decoupling, observers still require direct reference to observed

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Libraries to check out:

- jQuery (custom events)
- EventEmitter (node & browser)
- EventEmitter2
- Backbone.Events

Strategy #2 - Events

Recommendations:

- Use where nesting would exceed 2 levels
- Emitting is (usually) superior to continuations. Use in place of plain callbacks where possible
- Use between separate components/

Strategy #3 - Deferreds

- What is a ‘deferred’?
  - “a chainable utility object that can register multiple callbacks into callback queues, invoke callback queues, and relay the success or failure state of any synchronous or asynchronous function” (jQuery API docs: http://api.jquery.com/category/deferred-object/)
- register one or more callbacks with
  - done() (invoked when ‘resolved’)
  - fail() (invoked when ‘rejected’)
  - always() (invoked, er, um...*always*)

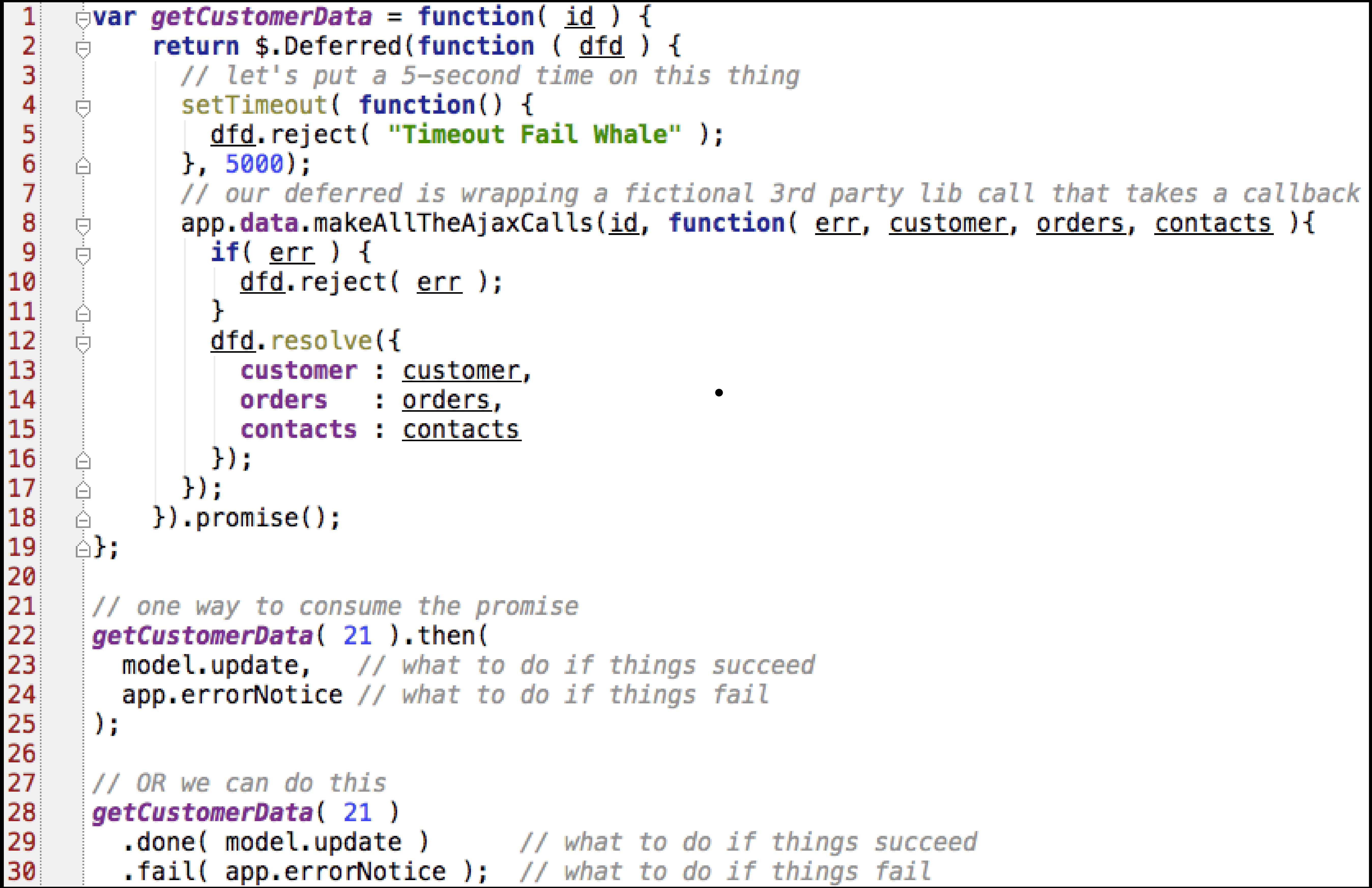
Strategy #3 - Deferreds

- Code that created/owns the deferred calls resolve() or reject()
- callbacks registered after a deferred has resolved/rejected get immediately invoked
- deferreds can be chained via pipe()
- can send progress notifications

Strategy #3 - Deferreds

- But is it a ‘deferred’ or a ‘promise’?
- In jQuery, a deferred can return a promise
- promises:
  - allow callbacks to be registered
  - allow state to only be *examined*
  - do <u>not</u> provide ability to resolve/reject, notify, etc. (no state mutation)

Strategy #3 - Deferreds



```
var getCustomerData = function( id ) {
    return $.Deferred(function ( dfd ) {
      // let's put a 5-second time on this thing
      setTimeout( function() {
        dfd.reject( "Timeout Fail Whale" );
      }, 5000);
      // our deferred is wrapping a fictional 3rd party lib call that takes a callback
      app.data.makeAllTheAjaxCalls(id, function( err, customer, orders, contacts ){
        if( err ) {
          dfd.reject( err );
        }
        dfd.resolve({
          customer : customer,
          orders   : orders,
          contacts : contacts
        });
      });
    }).promise();
};

// one way to consume the promise
getCustomerData( 21 ).then(
  model.update,   // what to do if things succeed
  app.errorNotice // what to do if things fail
);

// OR we can do this
getCustomerData( 21 )
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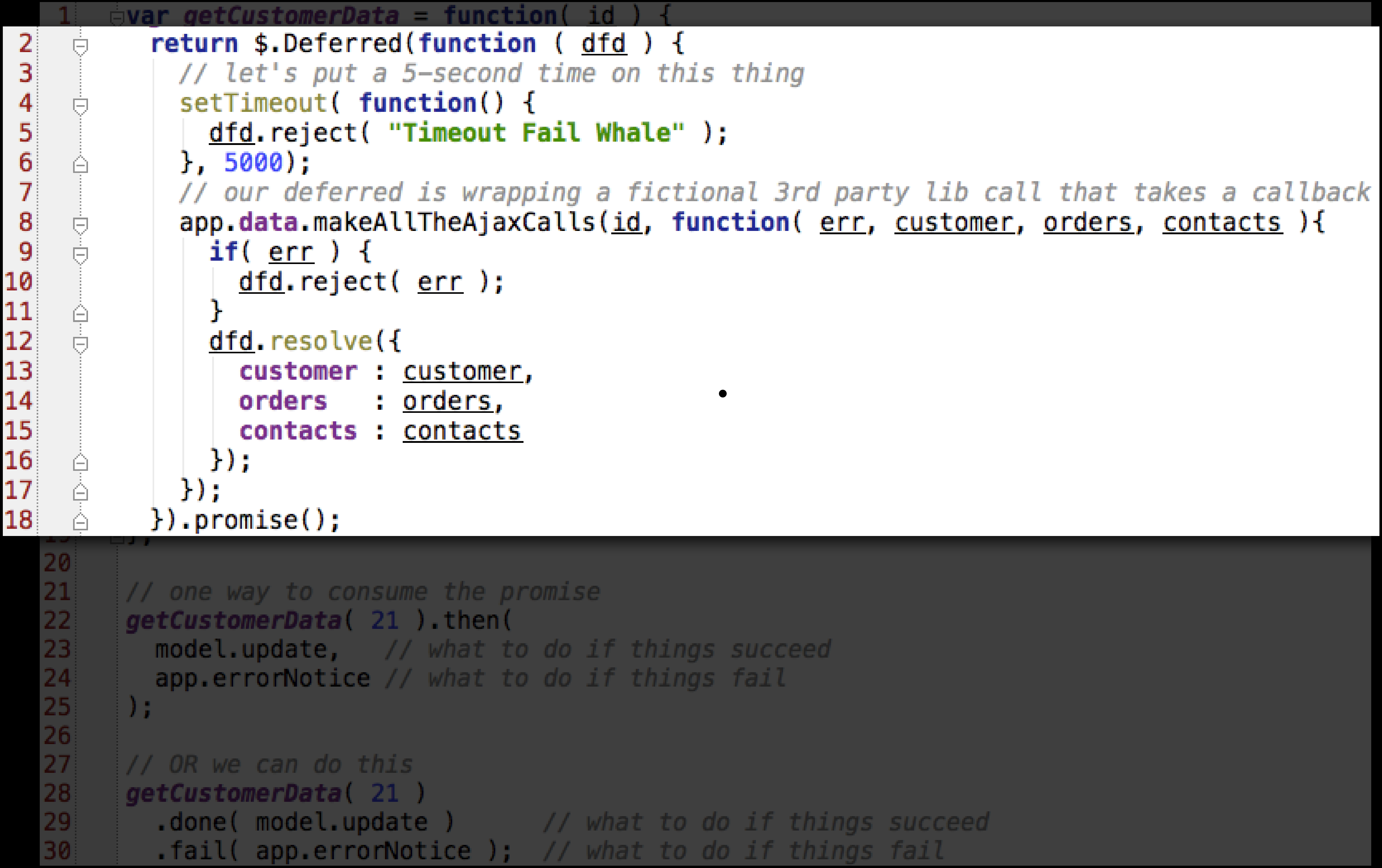

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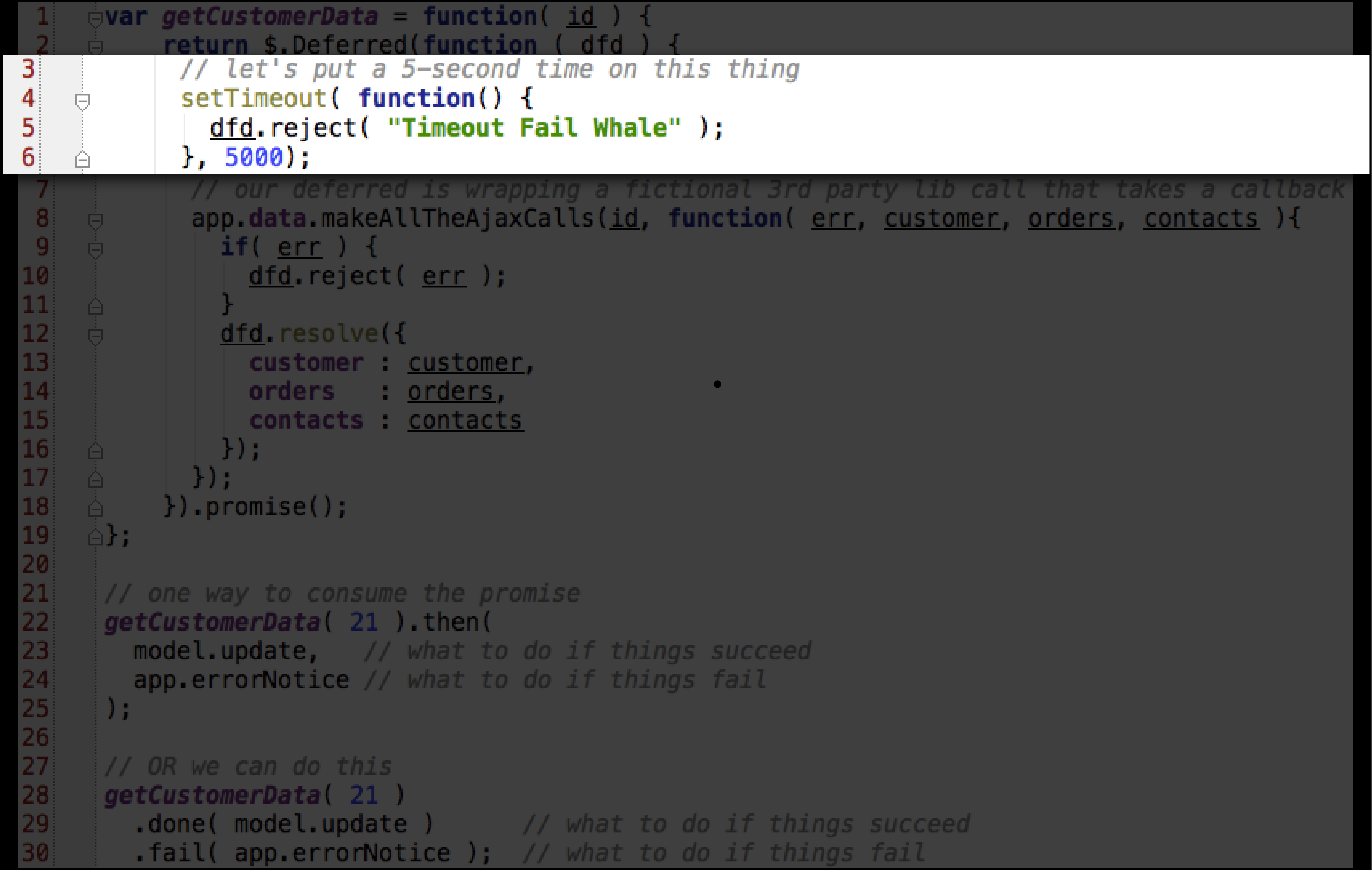

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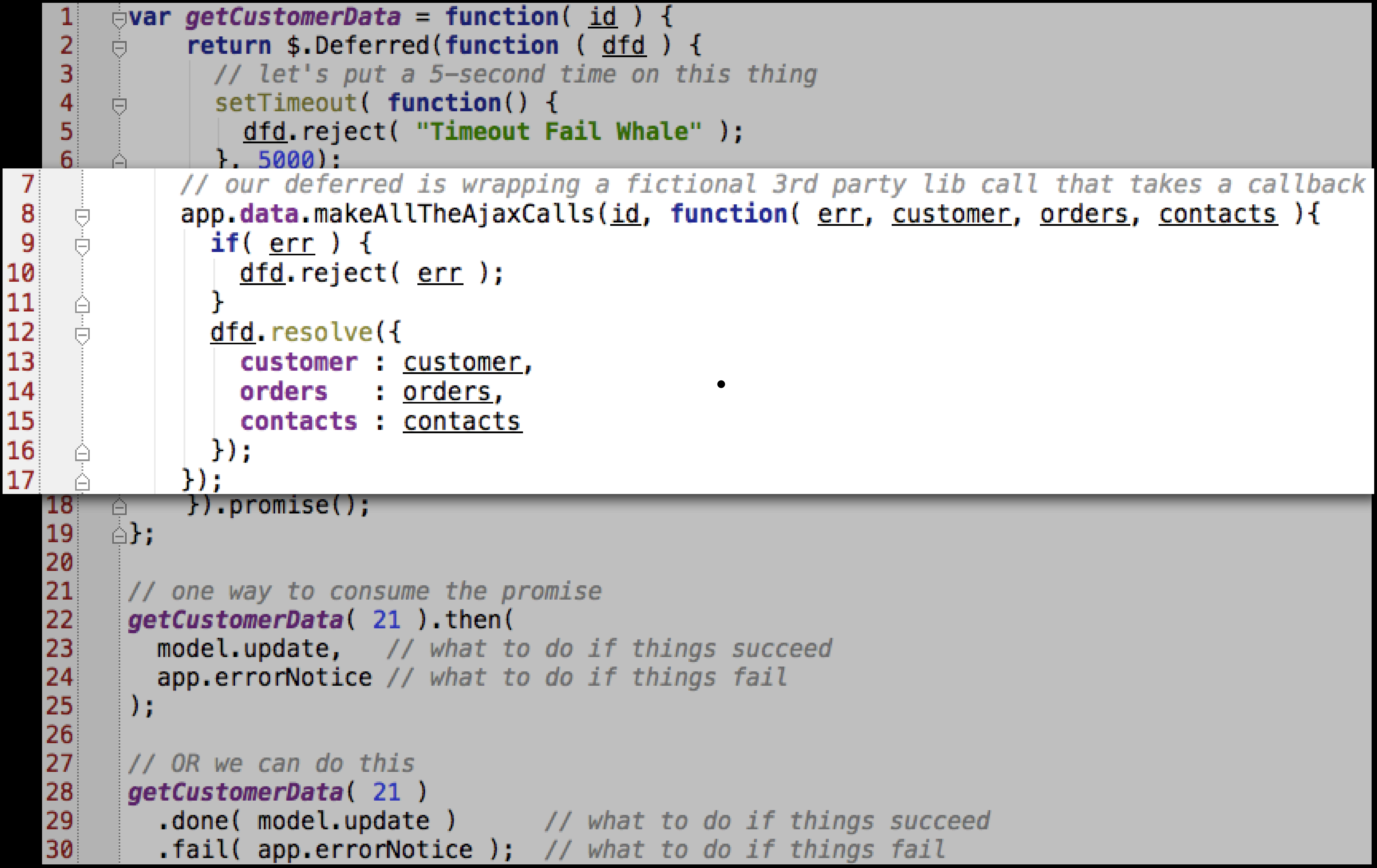

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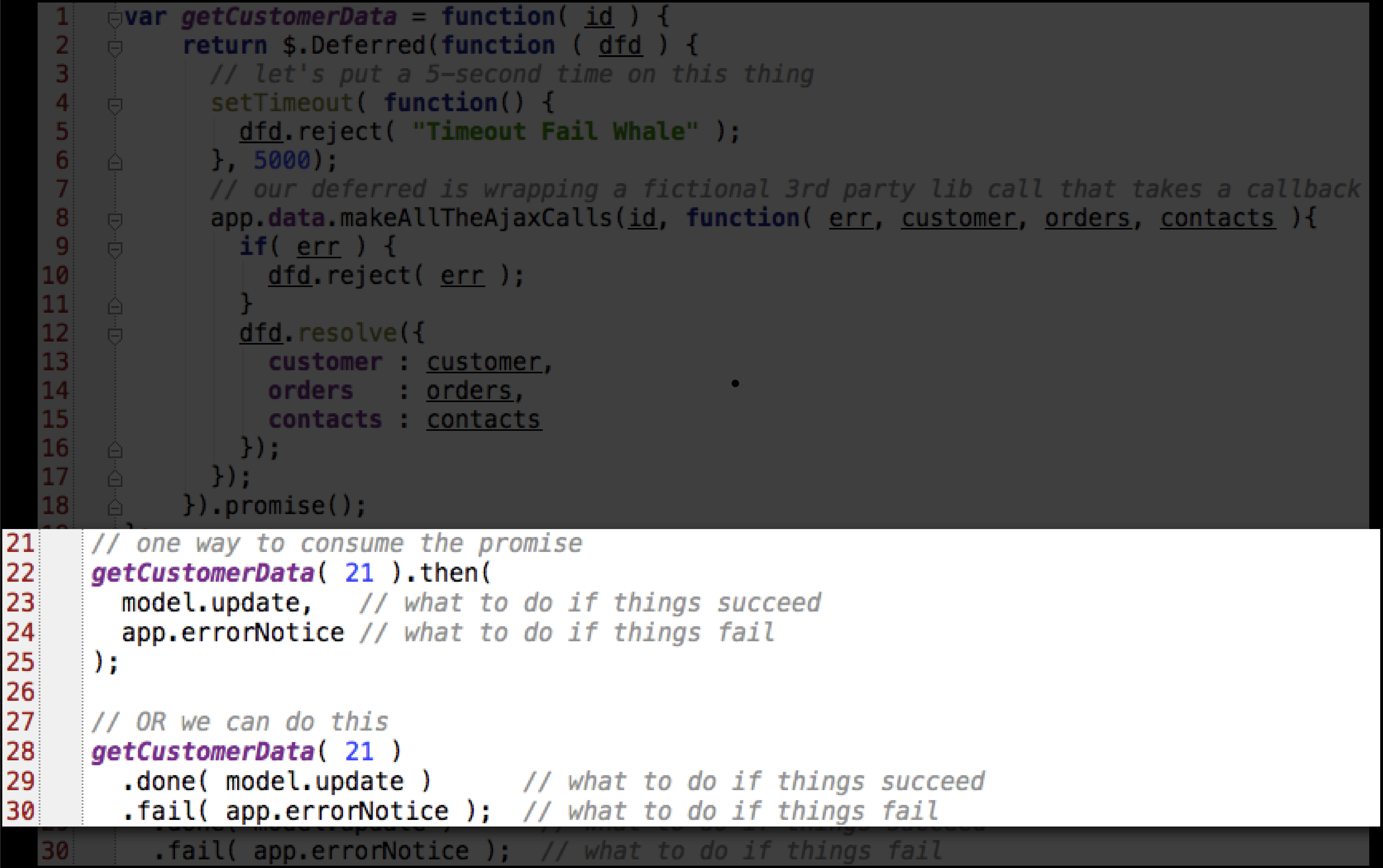

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{ Code }

Strategy #3 - Deferreds

PROS:

- Can flatten ‘nested callback hell’
- Results can be cached*
- Great for aggregating results of multiple *related* async functions

CONS:

- Returning promises on a public API is a *highly* opinionated constraint on developers
- Deferreds often trash the narrative of the code
- Can be *very* difficult to test/debug

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Libraries to check out:

- jQuery 1.5 or greater
- async.js https://github.com/fjakobs/async.js
- Q - https://github.com/kriskowal/q/

Strategy #3 - Deferreds

Recommendations:

- Use for aggregating results of async calls that should always resolve together
- Use when the 3rd party lib author left you no choice but to use their promises

Strategy #4 - Message Bus

- Similar to custom events, but no direct reference to observed subject
- Great option to adapt existing APIs, extending the reach of their events/messages
- “Several small apps” that communicate via message passing

Strategy #4 - Message Bus

- The "bus" is the only common reference
- Typical API includes:
  - subscribe
  - unsubscribe
  - publish
- An 'envelope' is published (unlike event emitting's 0-n args)

{ Code }

Strategy #4 - Message Bus

PROS:

- Clean SoC
- Very testable
- Very extendable

CONS:

- Prone to “boilerplate proliferation”
- Can be difficult to follow

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Libraries to check out:

- postal.js (shameless plug!)
- amplify.js

Strategy #4 - Message Bus

Recommendations:

- Use between modules (wrap existing APIs with message endpoints)
- Use between components that do not (or should not) need a direct reference to each other, but might be interested in data published

Strategy #5 - Finite State Machine

- Exists in one of a finite number of states.
- Responds to input based on the current state.
- Can transition to a different state under defined condition(s)

Strategy #5 - Finite State Machine

100k-foot-view Concepts

- **States** - define states in which machine can exist *(states affect how a machine responds to input/events)*
- **Transitions** - moving from one state to another
- **Input/Events** - behavior (internal or external) that can produce output and/or cause state transitions
- **Rules/Constraints** - used to determine if the machine can transition to new state

Strategy #5 - Finite State Machine

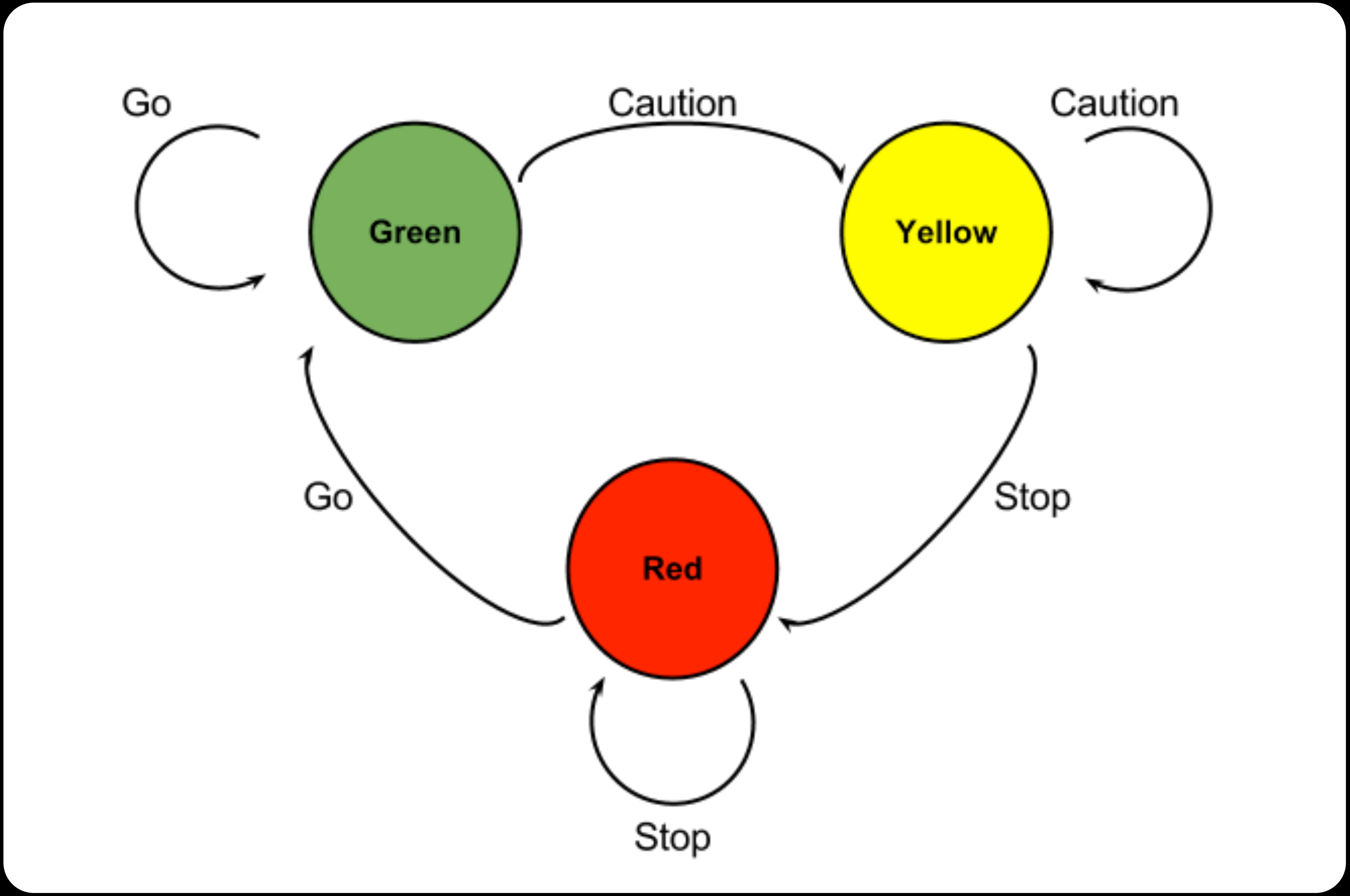
WARNING: FSM Minutia Ahead

Strategy #5 - Finite State Machine

- General Types of FSMs:
  - Acceptor
  - Transducer
    - **Moore machine** - output depends on state (entry actions)
    - **Mealy machine** - output depends on state ***and*** input
- **Deterministic** - only one transition possible for each state
- **Non-deterministic** - zero or more transitions possible from each state

Strategy #5 - Finite State Machine

Traffic Light FSM



Strategy #5 - Finite State Machine

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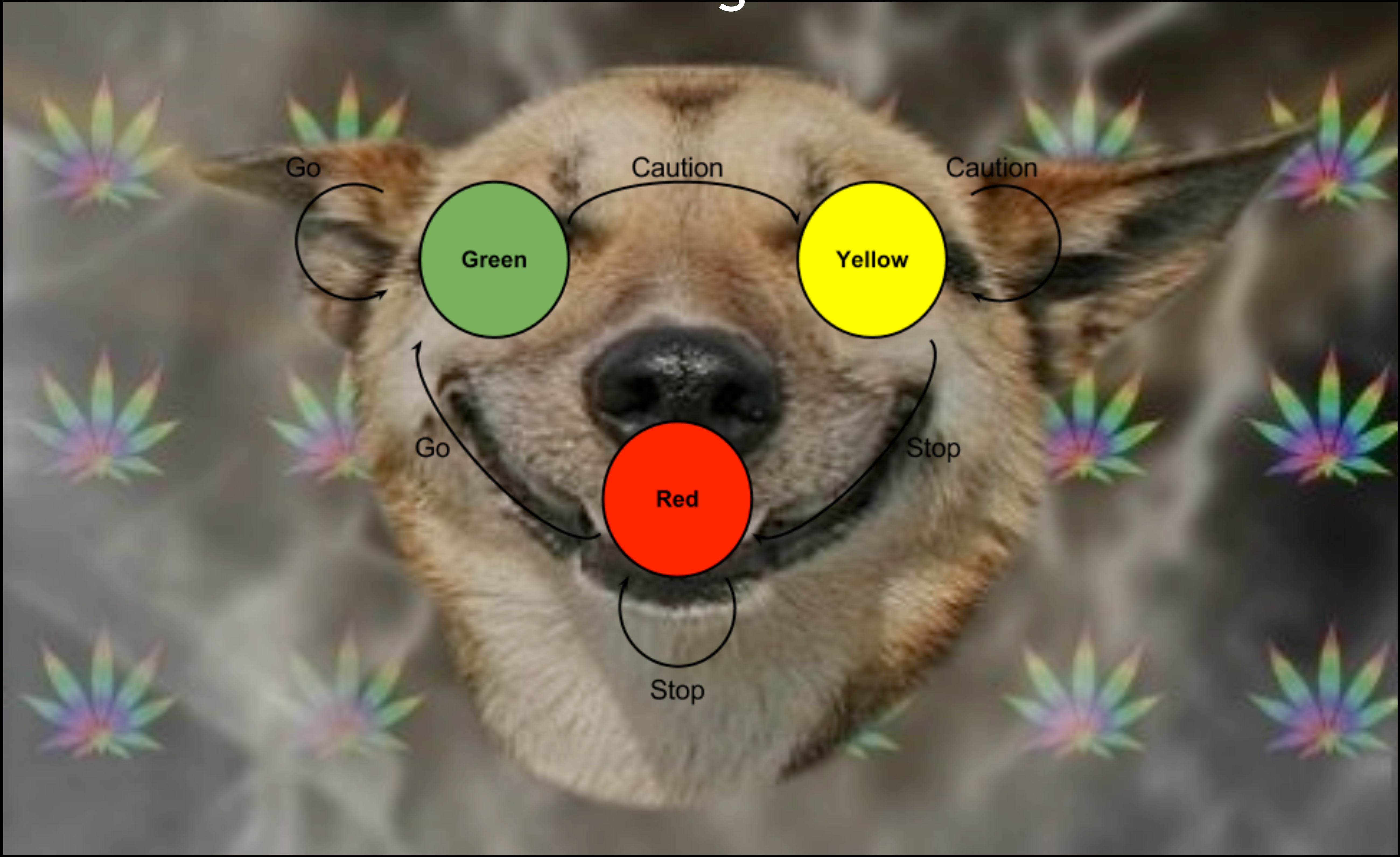

Strategy #5 - Finite State Machine

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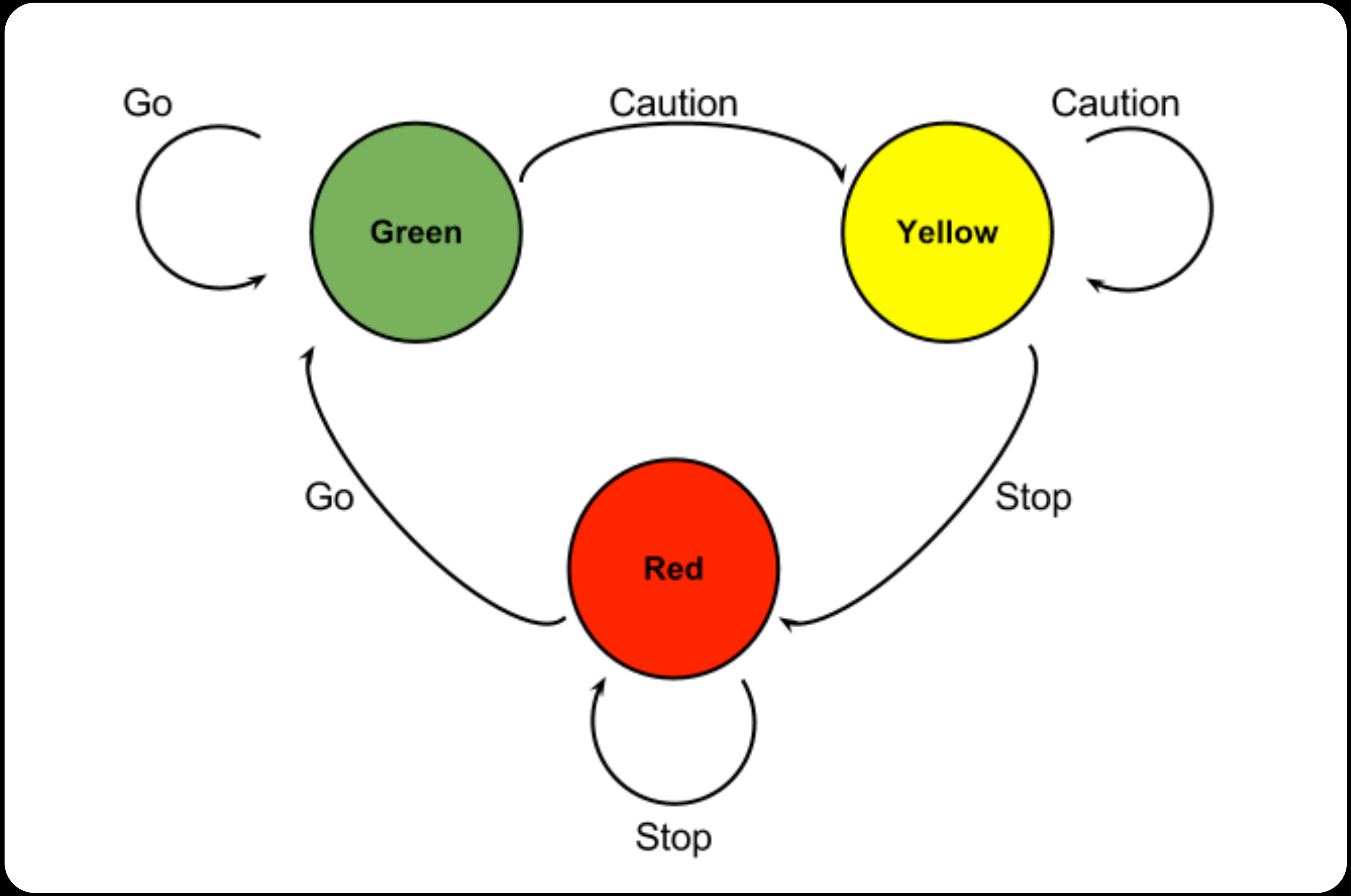
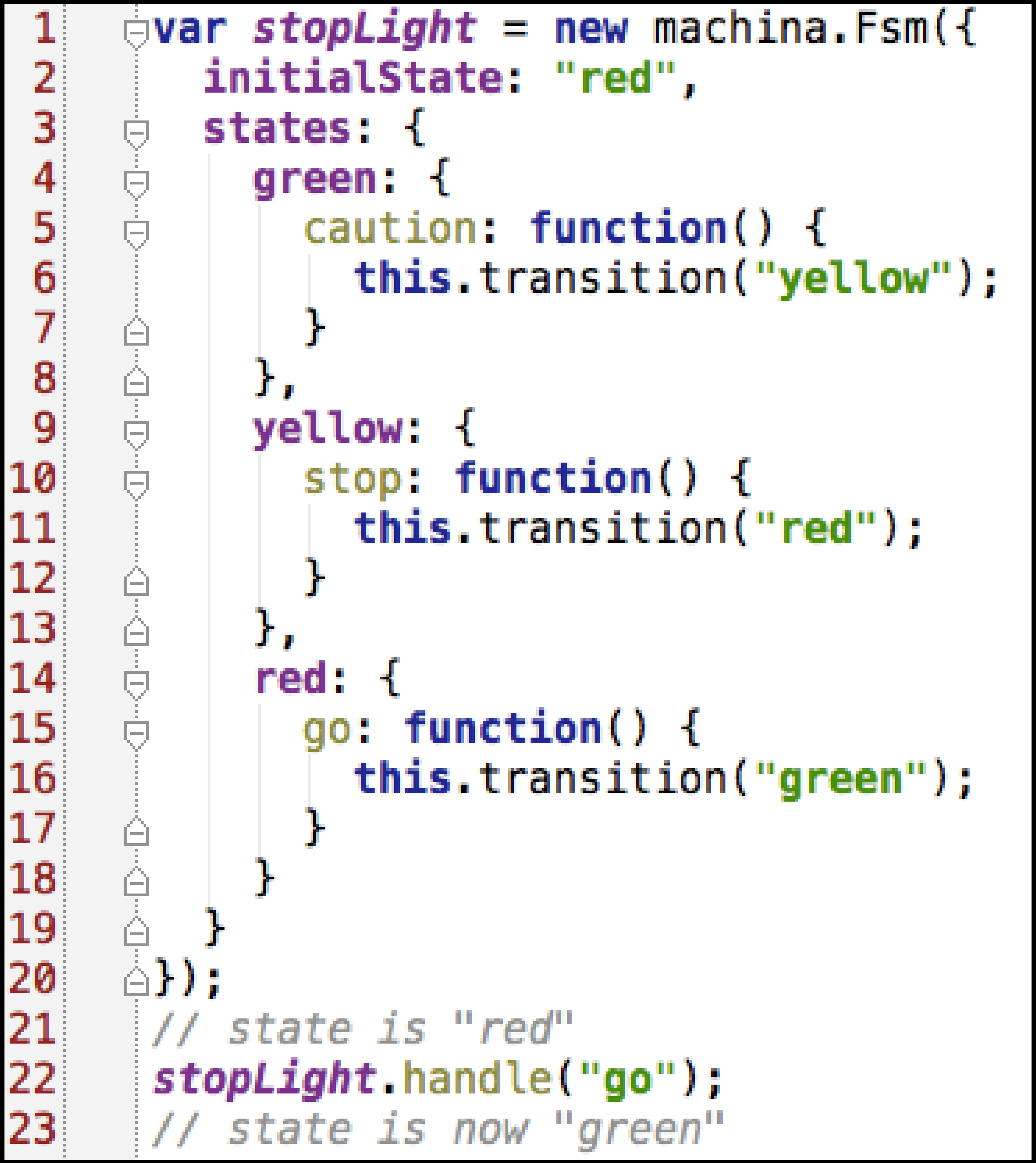


Strategy #5 - Finite State Machine

- machina.js - helper lib for FSMs in JavaScript
- Using machina.js to drive FSMs:
  - Control is *yours* (low level)
  - Acceptor...Transducer...Franken-FSM
  - Leans towards Mealy, but supports Moore or *both*
  - You determine determinism
    (preferably with determination....*yo, dawg, I hear you like determinism...*)

Strategy #5 - Finite State Machine



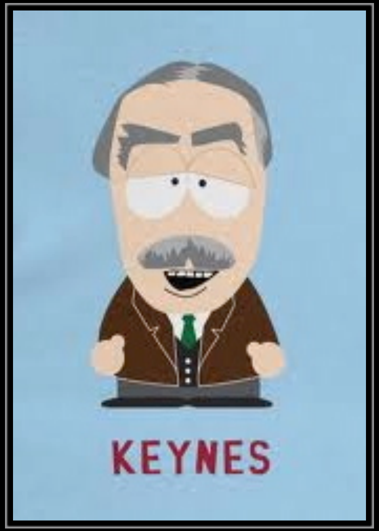
```
var stopLight = new machina.Fsm({
    initialState: "red",
    states: {
        green: {
            caution: function() {
                this.transition("yellow");
            }
        },
        yellow: {
            stop: function() {
                this.transition("red");
            }
        },
        red: {
            go: function() {
                this.transition("green");
            }
        }
    }
});
// state is "red"
stopLight.handle("go");
// state is now "green"
```

{ Code }

Strategy #5 - Finite State Machine

PROS:

- Very useful for coordinating long-running async workflows
- Expressive intent
- Extremely versatile



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- Can involve more lines of code*

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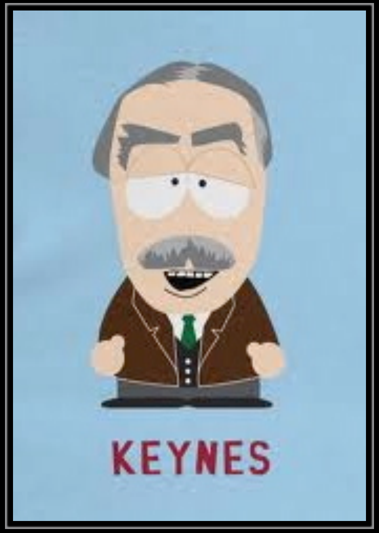

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Libraries to check out:

- machina.js (shameless plug!)
- state.js - https://github.com/nickfargo/state

Strategy #5 - Finite State Machine

Recommendations:

- look for workflow applications!
- deterministic FSM can help with initialization
- consider an FSM for managing offline/online concerns
- consider an FSM to abstract “enabled/disabled” type concerns

Be kind to your API consumers

- Avoid deeply nested callbacks
- Don’t let your abstractions leak
  - Beware of what you bake into your API
  - Avoid forcing dependencies where possible
  - Consider offering plain callback alternatives alongside more opinionated API approaches

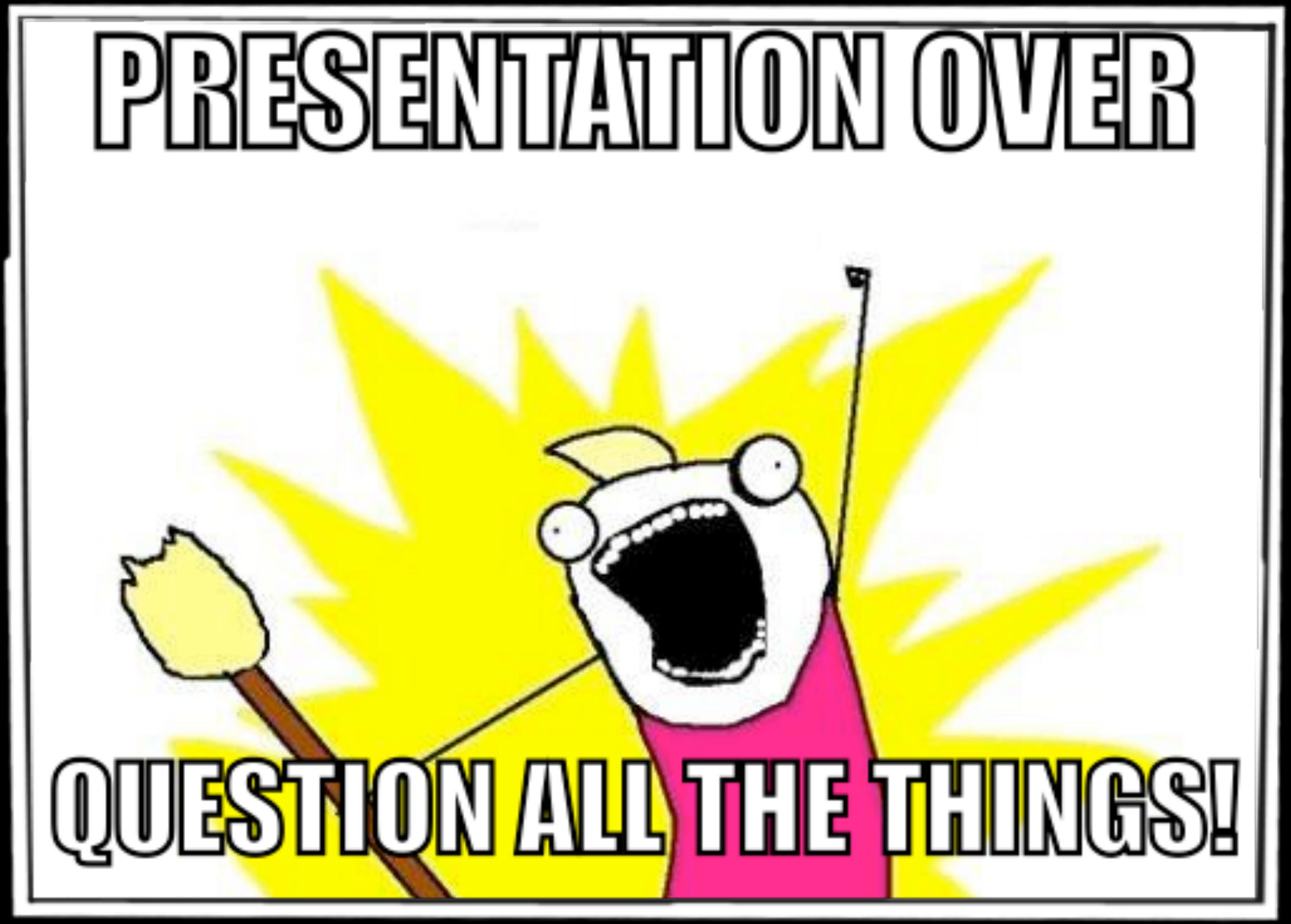
Further Reading

- Async JavaScript
  by Trevor Burnham

  fantastic treatment of jQuery deferreds + async.js

- Finite State Machines:
  - http://blog.markwshead.com/869/state-machines-computer-science/
  - http://machina-js.org/ (shameless plug!)
  - http://www.ibm.com/developerworks/library/wa-finitemach1/
    - (Great further reading suggestions on this one!)
- Other good stuff:
  - http://www.2ality.com/2012/06/continuation-passing-style.html
  - http://www.erichynds.com/jquery/using-deferreds-in-jquery/

Code/Slides for this presentation - http://bit.ly/async-js-patterns



Q & A