Asynchronous JS, Part 2

SWE 432, Fall 2019

Web Application Development

Review: Asynchronous

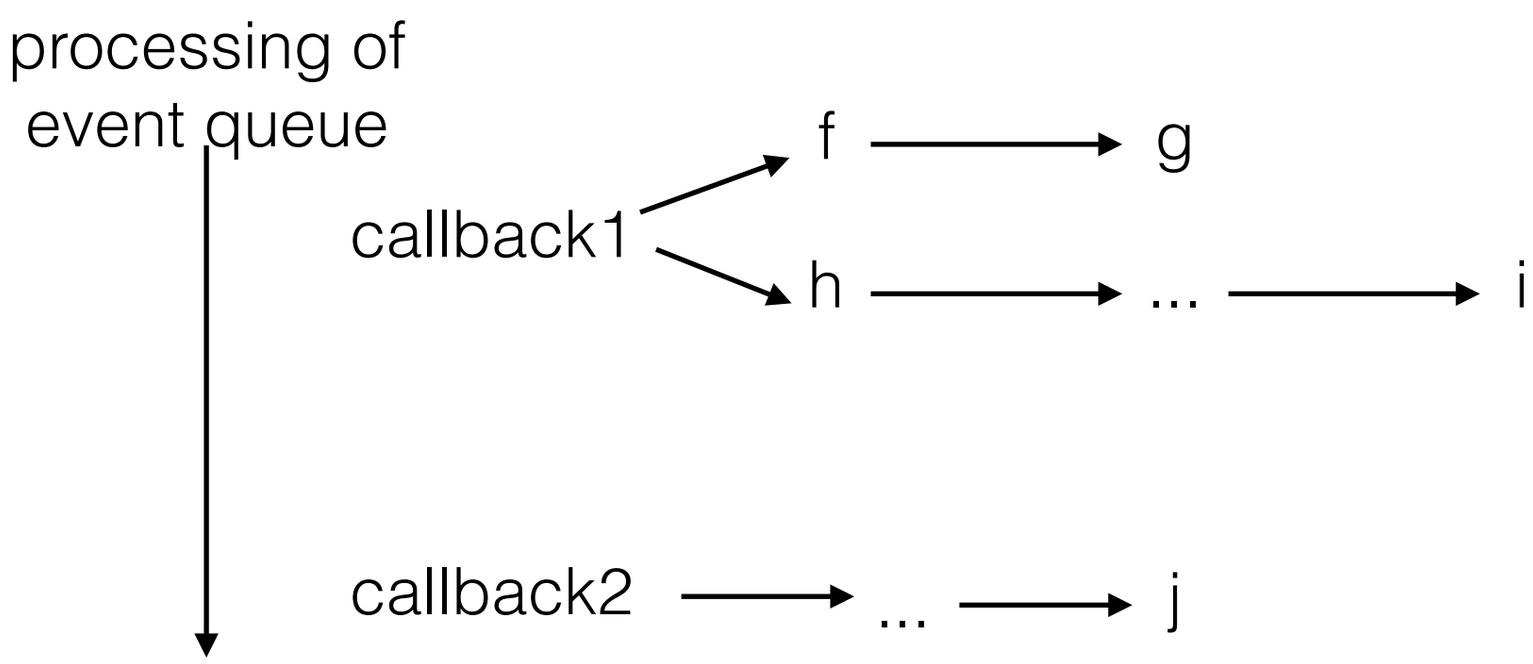
- Synchronous:
  - Make a function call
  - When function call returns, the work is done
- Asynchronous:
  - Make a function call
  - Function returns immediately, before completing work!

Review: Asynchronous

- How we do multiple things at a time in JS
- NodeJS magically handles these asynchronous things in the background
- Really important when doing file/network input/output

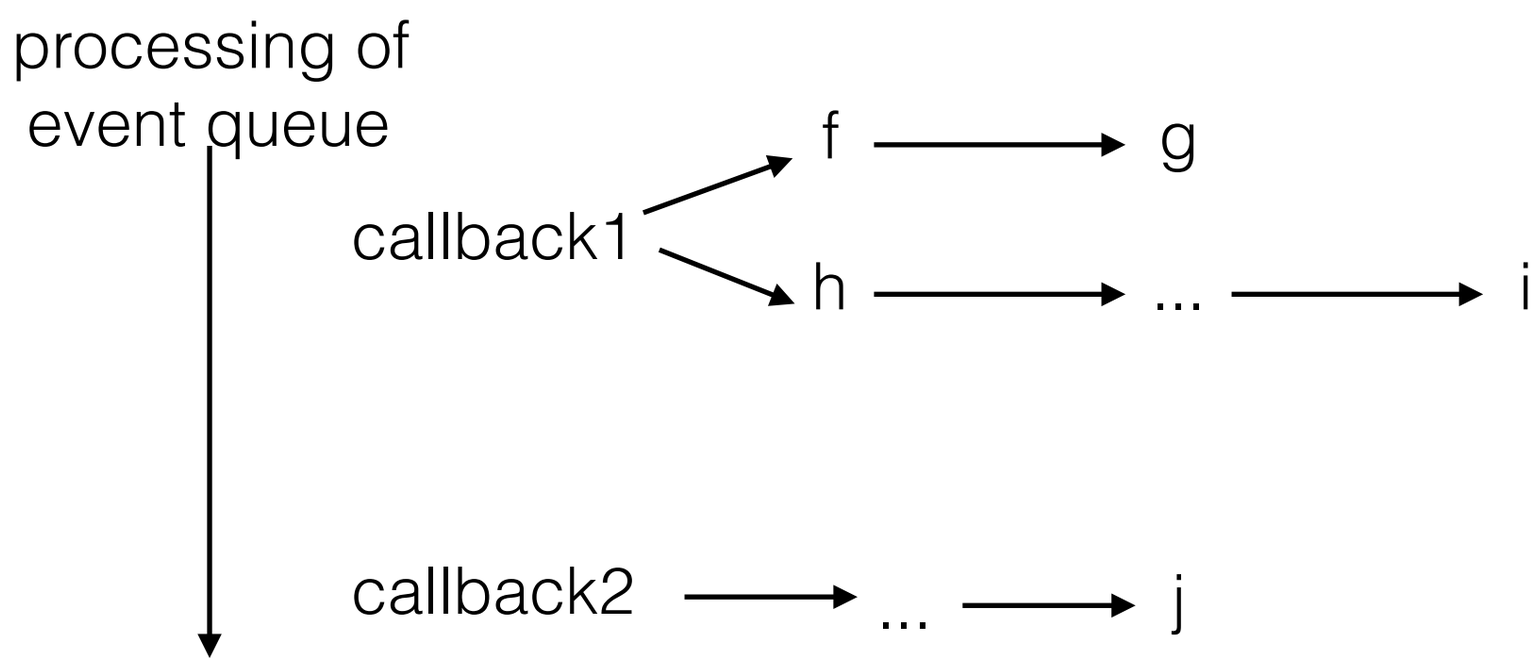
Review: Run-to-completion semantics

- Run-to-completion
  - The function handling an event and the functions that it (transitively) synchronously calls will keep executing until the function finishes.
  - The JS engine will not handle the next event until the event handler finishes.



Review: Implications of run-to-completion

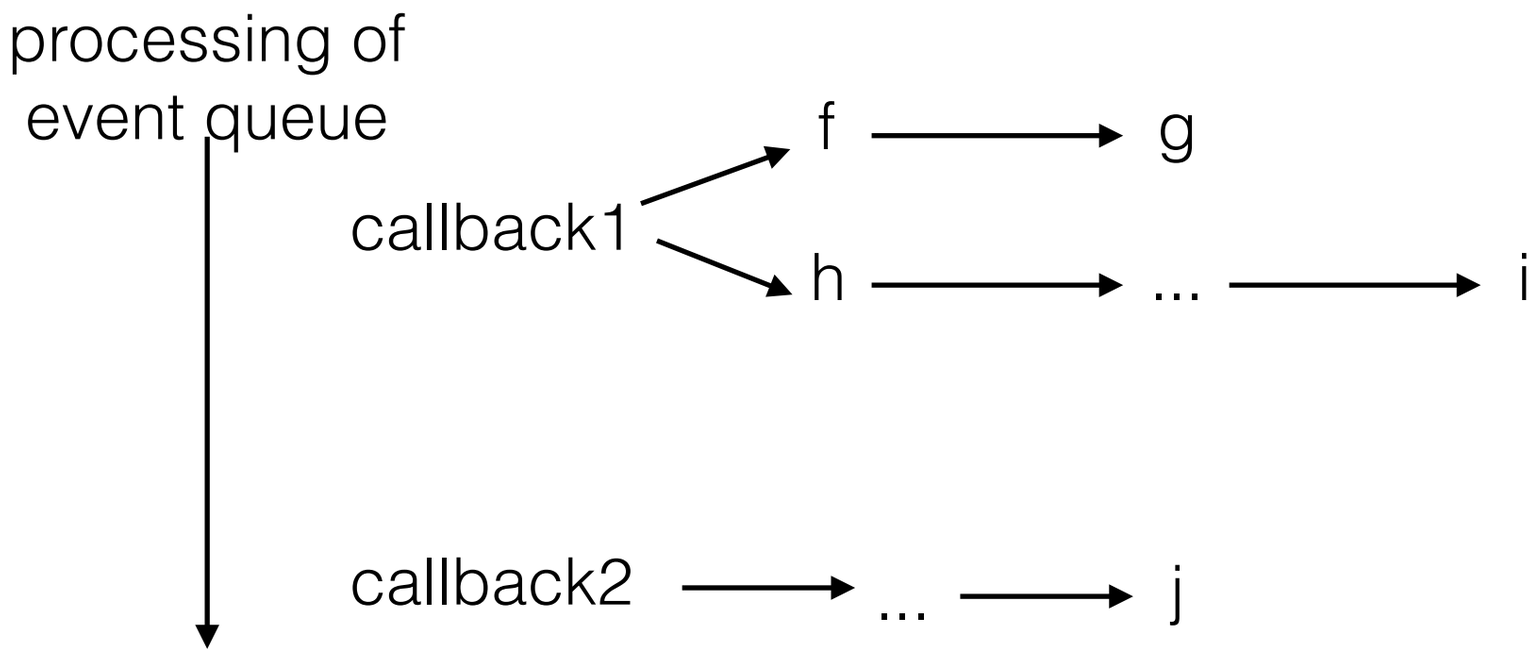
- Good news: no other code will run until you finish (no worries about other threads overwriting your data)



j will not execute until after i

Review: Implications of run-to-completion

- Bad/OK news: Nothing else will happen until event handler returns
  - Event handlers should never block (e.g., wait for input) --> all callbacks waiting for network response or user input are **always** asynchronous
  - Event handlers shouldn't take a long time either



j will not execute until i finishes

Review: Chaining Promises

```
myPromise.then(function(resultOfPromise){
    //Do something, maybe asynchronously
    return theResultOfThisStep;
})
.then(function(resultOfStep1){
    //Do something, maybe asynchronously
    return theResultOfThisStep
})
.then(function(resultOfStep2){
    //Do something, maybe asynchronously
    return theResultOfThisStep
})
.then(function(resultOfStep3){
    //Do something, maybe asynchronously
    return theResultOfThisStep
})
.catch(function(error){

});
```

Review: Promises example

https://jsbin.com/fifihitiku/edit?js,console

Today

- Async/await
- Programming activity

Promising many things

- Can also specify that *many* things should be done, and then something else

- Example: load a whole bunch of images at once:

```
Promise
  .all([loadImage("GMURGB.jpg"), loadImage(“CS.jpg")])
.then(function (imgArray) {
        imgArray.forEach(img => {document.body.appendChild(img)})
    })
.catch(function (e) {
  console.log("Oops");
  console.log(e);
});
```

Async Programming Example

1 second each

Go get a data item | Go get a data item | Go get a data item | Go get a data item | Go get a data item

Go get a data item | Go get a data item | Go get a data item | Go get a data item | Go get a data item

2 seconds each

thenCombine

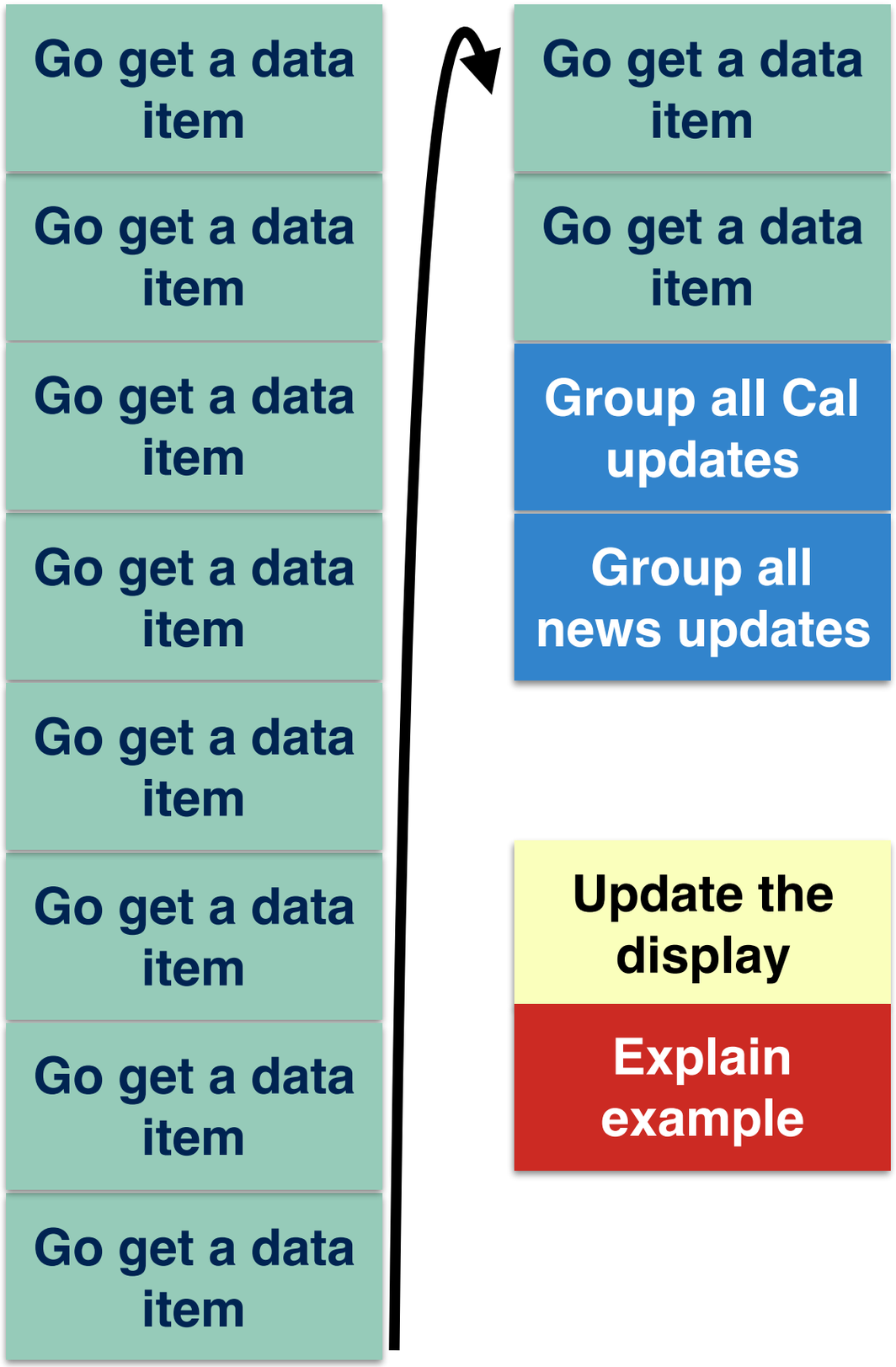
Group all Cal updates | Group all news updates

when done

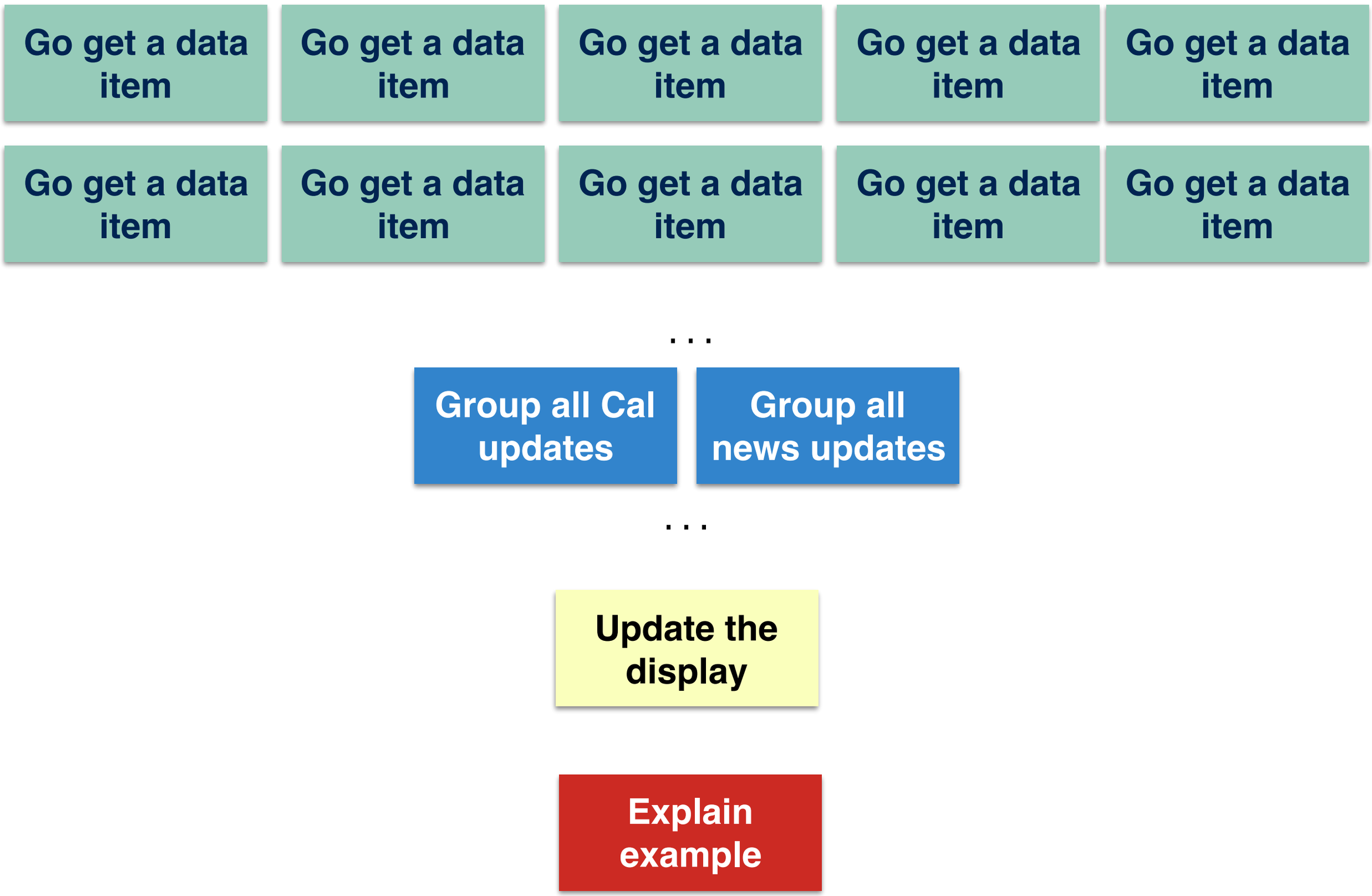
Update display

Explain example

Synchronous Version



Asynchronous Version



Async Programming Example (Sync)

```
let lib = require("./lib.js");

let thingsToFetch = ['t1','t2','t3','s1','s2','s3','m1','m2','m3','t4'];
let stuff = [];
for(let thingToGet of thingsToFetch)
{
    stuff.push(lib.getSync(thingToGet));
    console.log("Got a thing");
}
//Got all my stuff
let ts = lib.groupSync(stuff,"t");
console.log("Grouped");
let ms = lib.groupSync(stuff,"m");
console.log("Grouped");
let ss = lib.groupSync(stuff,"s");
console.log("Grouped");

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

Async Programming Example (Callbacks, no parallelism)

```
let lib = require("./lib.js");

let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
let stuff = [];
let ts, ms, ss;
let outstandingStuffToGet = thingsToFetch.length;

lib.getASync(thingsToFetch[0],(v)=>{
    stuff.push(v);
    console.log("Got a thing")
    lib.getASync(thingsToFetch[1],(v)=>{
        stuff.push(v);
        console.log("Got a thing")
        lib.getASync(thingsToFetch[2],(v)=>{
            stuff.push(v);
            console.log("Got a thing")
            lib.getASync(thingsToFetch[3],(v)=>{
                stuff.push(v);
                console.log("Got a thing")
                lib.getASync(thingsToFetch[4],(v)=>{
                    stuff.push(v);
                    console.log("Got a thing")
                    lib.getASync(thingsToFetch[5],(v)=>{
                        stuff.push(v);
                        console.log("Got a thing")
                        lib.getASync(thingsToFetch[6],(v)=>{
                            stuff.push(v);
                            console.log("Got a thing")
                            lib.getASync(thingsToFetch[7],(v)=>{
                                stuff.push(v);
                                console.log("Got a thing")
                                lib.getASync(thingsToFetch[8],(v)=>{
                                    stuff.push(v);
                                    console.log("Got a thing")
                                    lib.getASync(thingsToFetch[9],(v)=>{
                                        stuff.push(v);
                                        console.log("Got a thing")
                                        lib.groupAsync(stuff, "t", (t) => {
                                            ts = t;
                                            console.log("Grouped");
                                            lib.groupAsync(stuff, "m", (m) => {
                                                ss = s;
                                                console.log("Grouped");
```

Async Programming Example (Callbacks)

```
let lib = require("./lib.js");

let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
let stuff = [];
let ts, ms, ss;
let outstandingStuffToGet = thingsToFetch.length;
for (let thingToGet of thingsToFetch) {
    lib.getASync(thingToGet, (v) => {
        stuff.push(v);
        console.log("Got a thing")
        outstandingStuffToGet--;
        if (outstandingStuffToGet == 0) {
            let groupsOfStuffTogetStill = 3;
            lib.groupAsync(stuff, "t", (t) => {
                ts = t;
                console.log("Grouped");
                groupsOfStuffTogetStill--;
                if (groupsOfStuffTogetStill == 0)
                    console.log("Done");

            });
            lib.groupAsync(stuff, "m", (m) => {
                ms = m;
                console.log("Grouped");
                groupsOfStuffTogetStill--;
                if (groupsOfStuffTogetStill == 0)
                    console.log("Done");
            });
            lib.groupAsync(stuff, "s", (s) => {
                ss = s;
                console.log("Grouped");
                groupsOfStuffTogetStill--;
                if (groupsOfStuffTogetStill == 0)
                    console.log("Done");
            })
        }
    });
}
```

Async Programming Example (Promises, no parallelism)

```
let lib = require("./lib.js");

let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
let stuff = [];
let ts, ms, ss;
let outstandingStuffToGet = thingsToFetch.length;
lib.getPromise(thingsToFetch[0]).then(
    (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[1]);
    }
).then(
     (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[1]);
    }
).then(
    (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[1]);
    }
).then(
    (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[2]);
    }
).then(
    (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[3]);
    }
).then(
    (v)=>{
        stuff.push(v);
        console.log("Got a thing");
        return lib.getPromise(thingsToFetch[4]);
    }
```

Async Programming Example (Promises)

```
let lib = require("./lib.js");

let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
let stuff = [];
let ts, ms, ss;

let promises = [];
for (let thingToGet of thingsToFetch) {
    promises.push(lib.getPromise(thingToGet));
}
Promise.all(promises).then((data) => {
    console.log("Got all things");
    stuff = data;
    return Promise.all([
            lib.groupPromise(stuff, "t"),
            lib.groupPromise(stuff, "m"),
            lib.groupPromise(stuff, "s")
        ]
    )
}).then((groups) => {
    console.log("Got all groups");
    ts = groups[0];
    ms = groups[1];
    ss = groups[2];
    console.log("Done");
});
```

Problems with Promises

```
const makeRequest = () => {
    try {
        return promise1()
            .then(value1 => {
                // do something
            }).catch(err => {
                //This is the only way to catch async errors
                console.log(err);
            })
    }catch(ex){
        //Will never catch async errors!!
    }
}
```

Async/Await

- The latest and greatest way to work with async functions

- A programming pattern that tries to make async code look more synchronous

- Just “await” something to happen before proceeding

- https://javascript.info/async-await

Async keyword

```
async function hello() { return "Hello" };
hello();
```

- Denotes a function that can block and resume execution later
- Automatically turns the return type into a Promise

Async/Await Example

```
function resolveAfter2Seconds() {
    return new Promise(resolve => {
        setTimeout(() => {
            resolve('resolved');
        }, 2000);
    });
}

async function asyncCall() {
    console.log('calling');
    var result = await resolveAfter2Seconds();
    console.log(result);
    // expected output: 'resolved'
}

asyncCall();
```

https://jsbin.com/jivacodefo/edit?js,console

Async/Await -> Synchronous

```
let lib = require("./lib.js");

async function getAndGroupStuff() {
    let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
    let stuff = [];
    let ts, ms, ss;

    let promises = [];
    for (let thingToGet of thingsToFetch) {
        stuff.push(await lib.getPromise(thingToGet));
        console.log("Got a thing");
    }
    ts = await lib.groupPromise(stuff,"t");
    console.log("Made a group");
    ms = await lib.groupPromise(stuff,"m");
    console.log("Made a group");
    ss = await lib.groupPromise(stuff,"s");
    console.log("Made a group");
    console.log("Done");
}

getAndGroupStuff();
```

Async/Await

- Rules of the road:
  - You can only call **await** from a function that is **async**
  - You can only **await** on functions that return a **Promise**

- Beware: await makes your code synchronous!

```
async function getAndGroupStuff() {
...
    ts = await lib.groupPromise(stuff,"t");
...
}
```

Async/Await Activity

Rewrite this code so that all of the things are fetched (in parallel) and then all of the groups are collected

```
let lib = require("./lib.js");

async function getAndGroupStuff() {
    let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
    let stuff = [];
    let ts, ms, ss;

    let promises = [];
    for (let thingToGet of thingsToFetch) {
        stuff.push(await lib.getPromise(thingToGet));
        console.log("Got a thing");
    }
    ts = await lib.groupPromise(stuff,"t");
    console.log("Made a group");
    ms = await lib.groupPromise(stuff,"m");
    console.log("Made a group");
    ss = await lib.groupPromise(stuff,"s");
    console.log("Made a group");
    console.log("Done");
}

getAndGroupStuff();
```

download lib.js: https://bit.ly/2QvyrOu

download this code: https://bit.ly/2OvsWhq

Async/Await

```
async function getAndGroupStuff() {
    let thingsToFetch = ['t1', 't2', 't3', 's1', 's2', 's3', 'm1', 'm2', 'm3', 't4'];
    let stuff = [];
    let ts, ms, ss;

    let promises = [];
    for (let thingToGet of thingsToFetch) {
        promises.push(lib.getPromise(thingToGet));
    }
    stuff = await Promise.all(promises);
    console.log("Got all things");
    [ts, ms, ss] = await Promise.all([lib.groupPromise(stuff, "t"),
lib.groupPromise(stuff, "m"), lib.groupPromise(stuff, "s")]);
    console.log("Got all groups");
    console.log("Done");
}

getAndGroupStuff();
```