Comp 324/424 - Client-side Web Design

Fall Semester 2018 - Week 14

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Final Demo and Presentation

- presentation and demo - live working app...
  - *due on Tuesday 4th December 2018 @ 7pm*
  - ***NO** content management systems (CMSs) such as Drupal, Joomla, WordPress...*
  - ***NO** PHP, Python, Ruby, C# & .Net, Go, XML...*
  - ***NO** CSS frameworks, such as Bootstrap, Foundation, Materialize...*
- explain chosen app's logic and structure
  - *data store, API, deferred patterns &c.*
  - *any data visualisations used*
  - *...*
- must implement data from either
  - *self hosted (MongoDB, Redis...)*
  - *APIs*
  - *cloud services, storage (Firebase, Heroku, mLab &c.)*
  - ***NO** SQL...*
- explain design decisions
  - *describe patterns used in design of UI and interaction*
  - *layout choices...*
- show and explain implemented differences from DEV week
  - *where and why did you update the app?*
  - *perceived benefits of the updates?*
- how did you respond to peer review?
- anything else useful for final assessment...
- consider outline of content from final report outline
- ...

All project code must be pushed to a repository on GitHub.

n.b. present your own work contributed to the project, and its development...

Final Report

Report due on 11th December 2018 by 7pm

- final report outline - coursework section of website
  - *PDF*
  - *group report*
  - ***extra individual report*** *- optional*
- include repository details for project code on GitHub

Server-side considerations - Node.js

working with data - post data

- we've seen examples that load JSON data
  - *using jQuery's `.getJSON()` function*
- now consider jQuery's `post` function
  - *allow us to easily send JSON data to the server*
  - *simply called `post`*
- begin our updates by creating a new route in our Express server
  - *one that will handle the `post` route*

```
jsonApp.post("/notes", function(req, res) {
  //return simple JSON object
  res.json({
    "message": "post complete to server"
  });
});
```

Server-side considerations - Node.js

working with data - post data

- may look similar to our earlier `get` routes
  - *difference due to browser restrictions*
  - *can't simply request direct route using our browser*
  - *as we did with `get` routes*
- need to change JS we use for the client-side
  - *allows us to post new route*
  - *then enables view of the returned message*
- update our test app to store data on the server
  - *then initialise our client with this stored data*

Server-side considerations - Node.js

working with data - post data

- start with a simple check that the post route is working correctly
  - *add a button, submit a request to the post route, and then wait for the response*
  - *add event handler for a button*

```
$("#post").on("click", function() {
  $.post("notes", {}, function (response) {
    console.log("server post response returned..." + response.toSource());
  })
});
```

- submit a `post` request
  - *specify the route for the post to the Node.js server*
  - *then specify the data to post - an empty object in this example*
  - *the specify a callback for the server's response*
- test returns the following output to the browser's console,

```
server post response returned...({message:"post complete to server"})
```

Server-side considerations - Node.js

working with data - post data

- now send some data to the server
  - *add new note to our object*
- update the server to handle this incoming object
  - *process the submitted jQuery JSON into a JavaScript object*
  - *ready for use with the server*
- use the **Express** module's `body-parser` plugin
- update `server.js` as follows

```
//add body-parser for JSON parsing etc...
var bodyParser = require("body-parser");
...
//Express will parse incoming JSON objects
jsonApp.use(bodyParser.urlencoded({ extended: false }));
...
```

- as server receives new JSON object
  - *it will now parse, or process, this object*
  - *ensures it can be stored on the server for future use*

Server-side considerations - Node.js

working with data - post data

- now update our test button's event handler
  - *send a new note as a JSON object*
- note will retrieve its new content from the input field
  - *gets the current time from the node server*

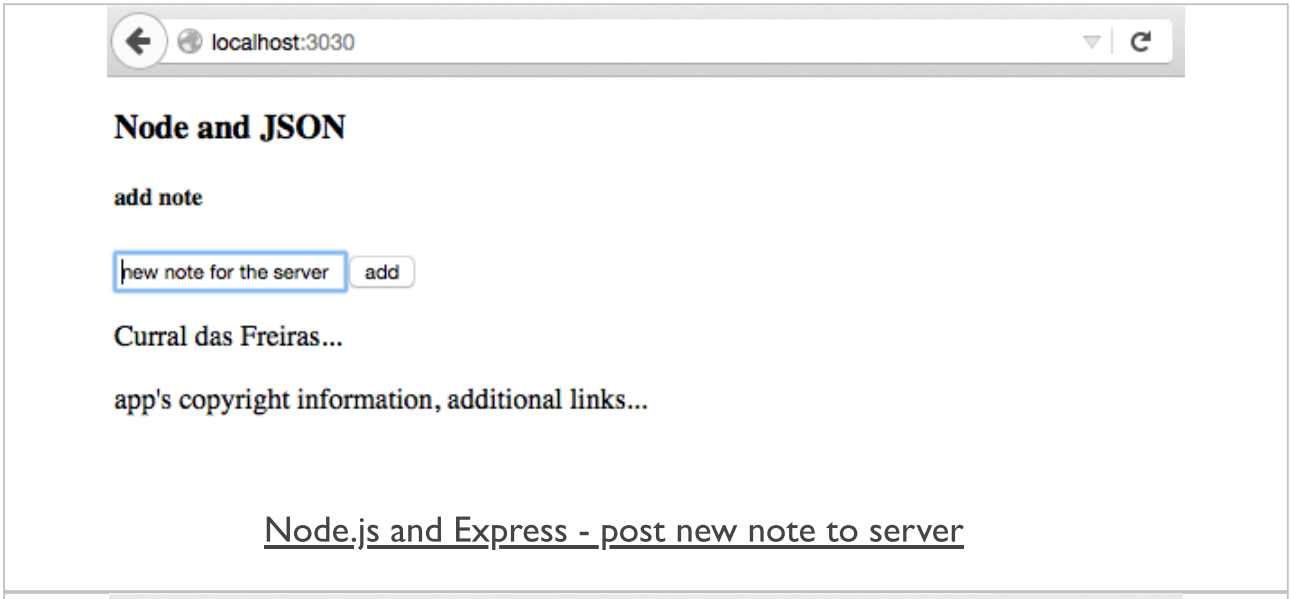
```
$(".note-input button").on("click", function() {
  //get values for new note
  var note_text = $(".note-input input").val();
  var created = new Date();
  //create new note
  var newNote = {"created":created, "note":note_text};
  //post new note to server
  $.post("notes", newNote, function (response) {
    console.log("server post response returned..." + response.toSource());
  })
});
```

- input field and button follow the same pattern as previous examples

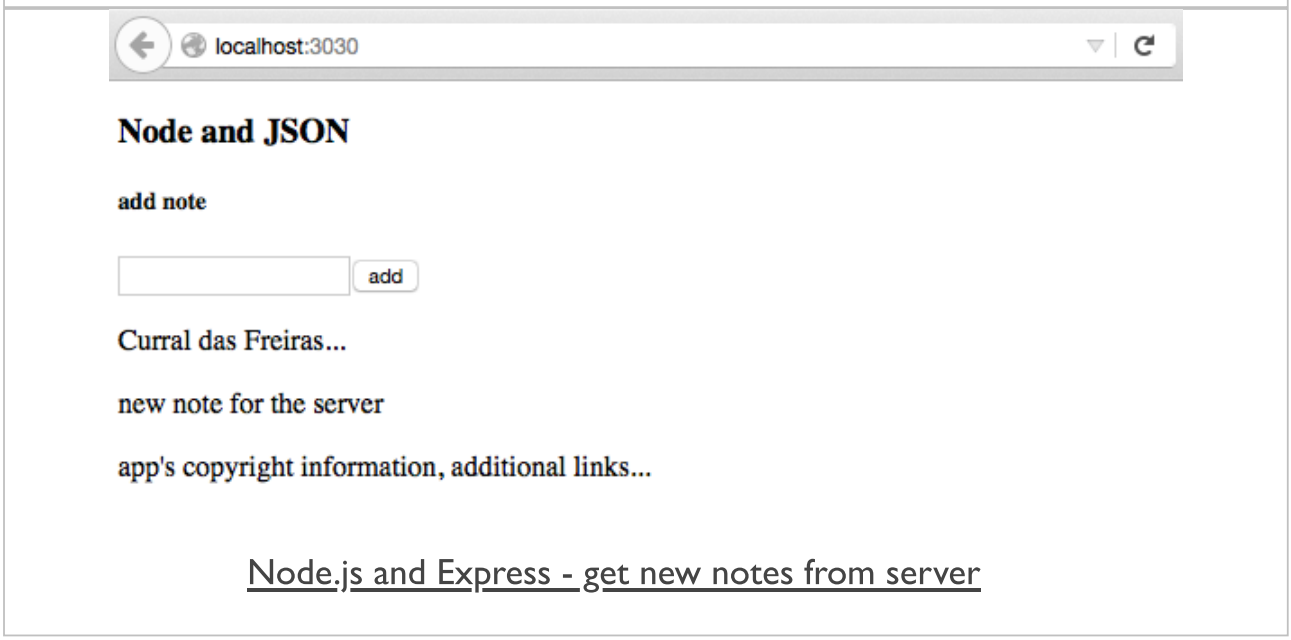
```
<!-- note input -->
<section class="note-input col-6">
    <h5>add note</h5>
    <input><button>add</button>
</section>
```

- DEMO - 424-node-json2

Image - Client-side and server-side computing



Node.js and Express - post new note to server



Node.js and Express - get new notes from server

Server-side considerations - data storage

intro

- tested Node.js, created a server for hosting our files and routes with ExpressJS
  - *read JSON from the server*
  - *updated our JSON on the server-side*
- works well as long as we do not need to restart, repair, update etc our server
- data lost with restart etc...
- need to consider a persistent data storage
  - *independent from the application*
- NoSQL options such as Redis and MongoDB
- integration with Node.js

Server-side considerations - data storage

SQL or NoSQL

- common database usage and storage
  - *often thought solely in terms of SQL, or structured query language*
- SQL used to query data in a relational format
- relational databases, for example MySQL or PostgreSQL, store their data in tables
  - *provides a semblance of structure through rows and cells*
  - *easily cross-reference, or relate, rows across tables*
- a relational structure to map authors to books, players to teams...
  - *thereby dramatically reducing redundancy, required storage space...*
- improvement in storage capacities, access...
  - *led to shift in thinking, and database design in general*
- started to see introduction of non-relational databases
  - *often referred to simply as **NoSQL***
- with NoSQL DBs
  - *redundant data may be stored*
  - *such designs often provide increased ease of use for developers*
- some NoSQL examples for specific use cases
  - *eg: fast reading of data more efficient than writing*
  - *specialised DB designs*

Server-side considerations - data storage

Redis - intro

- Redis provides an excellent example of NoSQL based data storage
- designed for fast access to frequently requested data
- improvement in performance often due to a reduction in perceived reliability
  - *due to in-memory storage instead of writing to a disk*
- able to flush data to disk
  - *performs this task at given points during uptime*
  - *for majority of cases considered an in-memory data store*
- stores this data in a **key-value** format
  - *similar in nature to standard object properties in JavaScript*
- Redis often a natural extension of conventional data structures
- Redis is a good option for quick access to data
  - *optionally caching temporary data for frequent access*

Server-side considerations - data storage

Redis - installation

- On OS X, use the Homebrew package manager to install Redis

```
brew install redis
```

- Windows port maintained by the Microsoft Open Tech Group - Redis
  - *or use Windows package manager - https://chocolatey.org/*
- for Linux - download, extract, and compile Redis

```
$ wget http://download.redis.io/releases/redis-3.0.5.tar.gz
$ tar xzf redis-3.0.5.tar.gz
$ cd redis-3.0.5
$ make
```

Server-side considerations - data storage

Redis - server and CLI

- start the Redis server with the following command,

```
redis-server
```

- interact with our new server directly using the CLI tool,

```
redis-cli
```

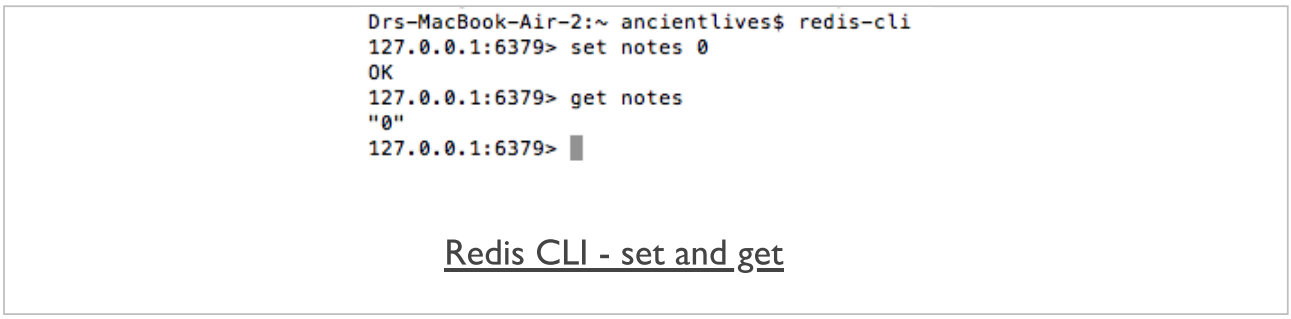
- store some data in Redis using the `set` command
  - *create a new key for `notes`, and then set its value to `0`*
  - *if value is set, Redis returns `OK`*

```
set notes 0
```

- retrieve a value using the `get` command
  - *returns our set value of `0`*

```
get notes
```

Image - Client-side and server-side computing



Redis CLI - set and get

Server-side considerations - data storage

Redis - server and CLI

- also manipulate existing values for a given key
  - *eg: increment and decrement a value, or simply delete a key*
- increment key `notes` value by 1

```
incr notes
```

- decrement key `notes` value by 1

```
decr notes
```

- we can then increment or decrement by a specified amount

```
// increment by 10
incrby notes 10
// decrement by 5
decrby notes 5
```

- delete our key

```
// single key deletion
del notes
// multiple keys deletion
del notes notes2 notes3
```

Image - Client-side and server-side computing

```
Drs-MacBook-Air-2:~ ancientlives$ redis-cli
127.0.0.1:6379> set notes 0
OK
127.0.0.1:6379> get notes
"0"
127.0.0.1:6379> incr notes
(integer) 1
127.0.0.1:6379> incr notes
(integer) 2
127.0.0.1:6379> get notes
"2"
127.0.0.1:6379> decr notes
(integer) 1
127.0.0.1:6379> get notes
"1"
127.0.0.1:6379> incrby notes 10
(integer) 11
127.0.0.1:6379> get notes
"11"
127.0.0.1:6379> decrby notes 5
(integer) 6
127.0.0.1:6379> get notes
"6"
```

Redis CLI - increment and decrement

Server-side considerations - data storage

Redis and Node.js setup

- test Redis with our Node.js app
- new test app called `424-node-redis1`

```
|- 424-node-redis1
   |- app
      |- assets
   |- node_modules
   |- package.json
   |- server.js
```

- create new file, `package.json` to track project
  - *eg: dependencies, name, description, version...*

Server-side considerations - data storage

Redis and Node.js - package.json

```
{
  "name": "424-node-redis1",
  "version": "1.0.0",
  "description": "test app for node and redis",
  "main": "server.js",
  "dependencies": {
    "body-parser": "^1.14.1",
    "express": "^4.13.3",
    "redis": "^2.3.0"
  },
  "author": "ancientlives",
  "license": "ISC"
}
```

- we can write the `package.json` file ourselves or use the interactive option

```
npm init
```

- then add extra dependencies, eg: Redis, using

```
npm install redis --save
```

- use `package.json` to help with app management and abstraction...

Server-side considerations - data storage

Redis and Node.js - set notes value

- add Redis to our earlier test app
- import and use Redis in the `server.js` file

```
...
var express = require("express"),
    http = require("http"),
    bodyParser = require("body-parser"),
    jsonApp = express(),
    redis = require("redis");
...
```

- create client to connect to Redis from Node.js

```
//create client to connect to Redis
redisConnect = redis.createClient();
```

- then use Redis, for example, to store access total for notes on server

```
redisConnect.incr("notes");
```

- check Redis command line for change in `notes` value

```
get notes
```

Server-side considerations - data storage

Redis and Node.js - get notes value

- now set the counter value for our notes
  - *add our counter to the application to record access count for notes*
- use the `get` command with Redis to retrieve the incremented values for the `notes` key

```
redisConnect.get("notes", function(error, notesCounter) {
  //set counter to int of value in Redis or start at 0
  notesTotal.notes = parseInt(notesCounter,10) || 0;
});
```

- `get` accepts two parameters - `error` and return value
- Redis stores values and strings
  - *convert string to integer using `parseInt()`*
  - *two parameters - return value and `base-10` value of the specified number*
- value is now being stored in a global variable `notesTotal`
  - *declared in `server.js`*

```
var express = require("express"),
    http = require("http"),
    bodyParser = require("body-parser"),
    jsonApp = express(),
    redis = require("redis"),
    notesTotal = {};
```

Server-side considerations - data storage

Redis and Node.js - get notes value

- store notes counter value in Redis
- create new route in `server.js`
  - *monitor the returned JSON for the counter*

```
//json get route
jsonApp.get("/notesTotal.json", function(req, res) {
  res.json(notesTotal);
});
```

- start using it with our application
  - *load by default, within event handler...*
- render to DOM
- store as a internal log record
- link to create note event handler...
- DEMO - 424-node-redis1

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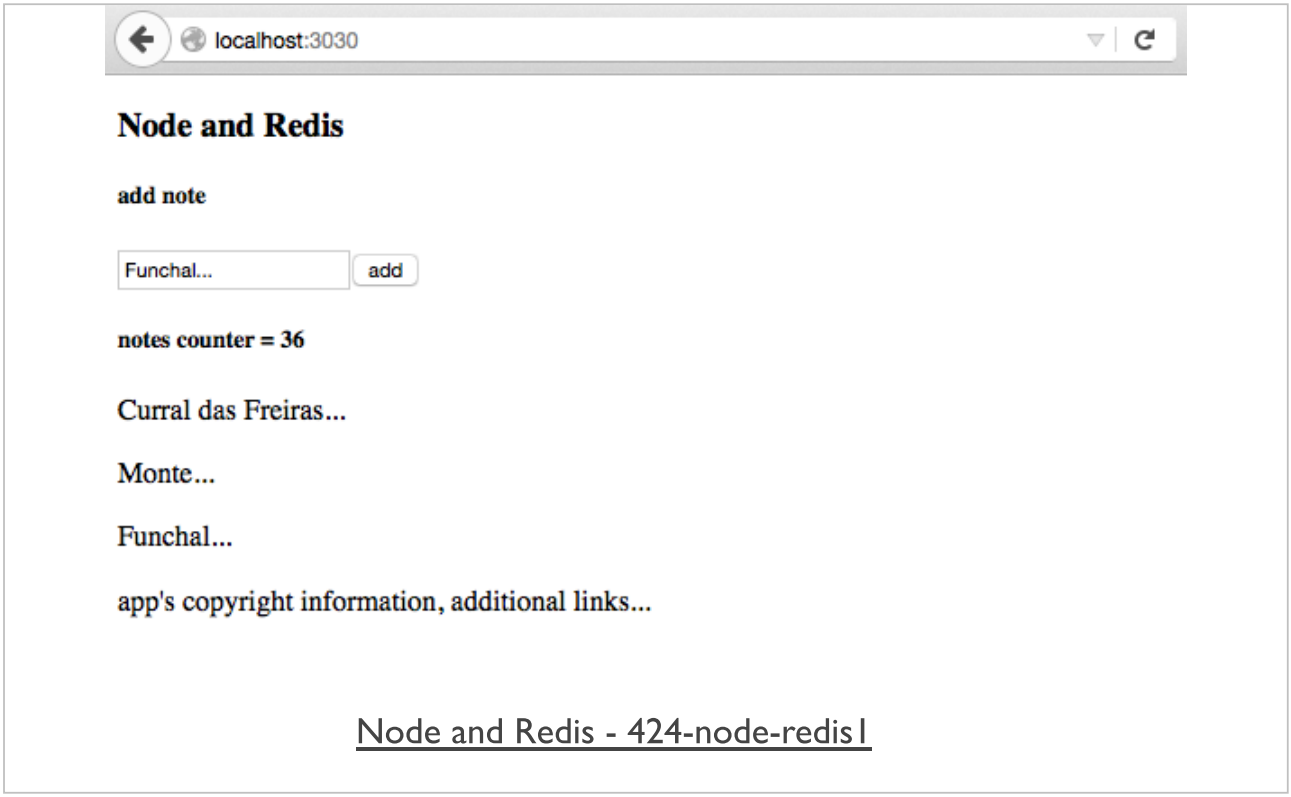


Node and Redis - 424-node-redis1

Server-side considerations - data storage

MongoDB - intro

- MongoDB is another example of a NoSQL based data store
  - *a database that enables us to store our data on disk*
- unlike MySQL, for example, it is not in a relational format
- MongoDB is best characterised as a **document-oriented** database
- conceptually may be considered as storing objects in collections
- stores its data using the BSON format
  - *consider similar to JSON*
  - *use JavaScript for working with MongoDB*

Server-side considerations - data storage

MongoDB - document oriented

- SQL database, data is stored in tables and rows
- MongoDB, by contrast, uses **collections** and **documents**
- comparison often made between a collection and a table
- **NB:** a document is quite different from a table
- a document can contain a lot more data than a table
- a noted concern with this document approach is duplication of data
- one of the trade-offs between NoSQL (MongoDB) and SQL
- SQL - goal of data structuring is to normalise as much as possible
- thereby avoiding duplicated information
- NoSQL (MongoDB) - provision a data store, as easy as possible for the application to use

Server-side considerations - data storage

MongoDB - BSON

- BSON is the format used by MongoDB to store its data
- effectively, JSON stored as binary with a few notable differences
  - *eg: `ObjectId` values - data type used in MongoDB to uniquely identify documents*
  - *created automatically on each document in the database*
  - *often considered as analogous to a primary key in a SQL database*
- `ObjectId` is a large pseudo-random number
- for nearly all practical occurrences, assume number will be unique
- might cease to be unique if server can't keep pace with number generation...
- other interesting aspect of `ObjectId`
  - *they are partially based on a timestamp*
  - *helps us determine when they were created*

Server-side considerations - data storage

MongoDB - general hierarchy of data

- in general, MongoDB has a three tiered data hierarchy

1. database
   - *normally one database per app*
   - *possible to have multiple per server*
   - *same basic role as DB in SQL*
2. collection
   - *a grouping of similar pieces of data*
   - *documents in a collection*
   - *name is usually a noun*
   - *resembles in concept a table in SQL*
   - *documents do not require the same schema*
3. document
   - *a single item in the database*
   - *data structure of field and value pairs*
   - *similar to objects in JSON*
   - *eg: an individual user record*

Server-side considerations - data storage

MongoDB - install and setup

- install on Linux
- install on Mac OS X
  - *again, we can use **Homebrew** to install MongoDB*

```
// update brew packages
brew update
// install MongoDB
brew install mongodb
```

- then follow the above OS X install instructions to set paths...
- install on Windows

Server-side considerations - data storage

MongoDB - a few shell commands

- issue following commands at command line to get started - OS X etc

```
// start MongoDB server - terminal window 1
mongod
// connect to MongoDB - terminal window 2
mongo
```

- switch to, create a new DB (if not available), and drop a current DB as follows

```
// list available databases
show dbs
// switch to specified db
use 424db1
// show current database
db
// drop current database
db.dropDatabase();
```

- DB is not created permanently until data is created and saved
  - *insert a record and save to current DB*
- only permanent DB is the local `test` DB, until new DBs created...

Server-side considerations - data storage

MongoDB - a few shell commands

- add an initial record to a new `424db1` database.

```
// select/create db
use 424db1
// insert data to collection in current db
db.notes.insert({
...    "travelNotes": [{
...    "created": "2015-10-12T00:00:00Z",
...    "note": "Curral das Freiras..."
...    }]
... })
```

- our new DB `424db1` will now be saved in Mongo
- we've created a new collection, `notes`

```
// show databases
show dbs
// show collections
show collections
```

Server-side considerations - data storage

MongoDB - test app

- now create a new test app for use with MongoDB
- create and setup app as before
  - *eg: same setup pattern as Redis test app*
- add **Mongoose** to our app
  - *use to connect to MongoDB*
  - *helps us create a schema for working with DB*
- update our `package.json` file
  - *add dependency for Mongoose*

```
// add mongoose to app and save dependency to package.json
npm install mongoose --save
```

- test server and app as usual from app's working directory

```
node server.js
```

Server-side considerations - data storage

MongoDB - Mongoose schema

- use **Mongoose** as a type of bridge between Node.js and MongoDB
- works as a client for MongoDB from Node.js applications
- serves as a useful data modeling tool
  - *represent our documents as objects in the application*
- a data model
  - *object representation of a document collection within data store*
  - *helps specify required fields for each collection's document*
  - *known as a schema in Mongoose, eg: `NoteSchema`*

```
var NoteSchema = mongoose.Schema({
  "created": Date,
  "note": String
});
```

- using schema, build a model
  - *by convention, use first letter uppercase for name of data model object*

```
var Note = mongoose.model("Note", NoteSchema);
```

- now start creating objects of this model type using JavaScript

```
var funchalNote = new Note({
"created": "2015-10-12T00:00:00Z",
"note": "Curral das Freiras..."
});
```

- then use the Mongoose object to interact with the MongoDB
  - *using functions such as `save` and `find`*

Server-side considerations - data storage

MongoDB - test app

- with our new DB setup, our schema created
  - *now start to add notes to our DB, `424db1`, in MongoDB*
- in our `server.js` file
  - *need to connect Mongoose to `424db1` in MongoDB*
  - *define our schema for our notes*
  - *then model a note*
  - *use model to create a note for saving to `424db1`*

```
...
//connect to 424db1 DB in MongoDB
mongoose.connect('mongodb://localhost/424db1');
//define Mongoose schema for notes
var NoteSchema = mongoose.Schema({
  "created": Date,
  "note": String
});
//model note
var Note = mongoose.model("Note", NoteSchema);
...
```

Server-side considerations - data storage

MongoDB - test app

- then update app's `post` route to save note to `424db1`

```
//json post route - update for MongoDB
jsonApp.post("/notes", function(req, res) {
  var newNote = new Note({
    "created":req.body.created,
    "note":req.body.note
  });
  newNote.save(function (error, result) {
    if (error !== null) {
      console.log(error);
      res.send("error reported");
    } else {
      Note.find({}, function (error, result) {
        res.json(result);
      })
    }
  });
});
```

Server-side considerations - data storage

MongoDB - test app

- update our app's `get` route for serving these notes

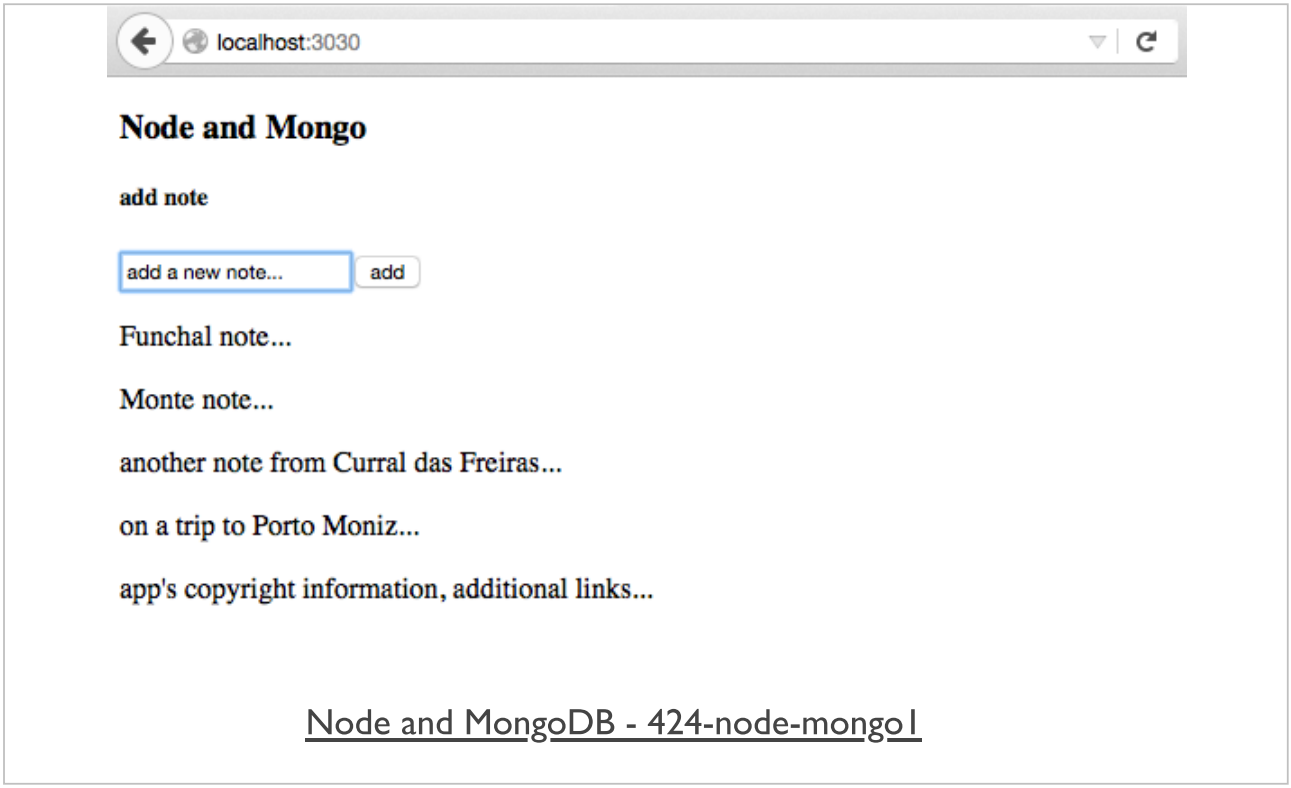
```
//json get route - update for mongo
jsonApp.get("/notes.json", function(req, res) {
  Note.find({}, function (error, notes) {
   //add some error checking...
   res.json(notes);
  });
});
```

- modify `buildNotes()` function in `json_app.js` to get return correctly

```
...
//get travelNotes
var $travelNotes = response;
...
```

- now able to enter, save, read notes for app
- notes data is stored in the `424db1` database in MongoDB
- notes are loaded from DB on page load
- notes are updated from DB for each new note addition
- DEMO - 424-node-mongo1

Image - Client-side and server-side computing



Node and MongoDB - 424-node-mongo1

Client-side - Data - Node, Express, MongoDB &c.

---

extra notes

- Heroku
  - *Heroku & Git*
  - *Heroku & MongoDB*
  - *Heroku & Postman*
- Node.js
  - *Node.js outline*
  - *Node.js updating*
- Node.js & Express
  - *Node.js and Express*
  - *Node.js & Express starter*
- Node.js, Express, and MongoDB
  - *Node.js and MongoDB*
- Node.js API
  - *Data stores & APIs - MongoDB and native driver*
  - *Node Todos API*
  - *Testing - Node Todos API*
- Node.js & Web Sockets
  - *Node.js & Socket.io*

Client-side - Data - Firebase

Firebase - intro

- Firebase is hosted platform, acquired by Google
  - *provides options for data starage, authentication, real-time database querying...*
- it provides and API for data access
  - *access and query JavaScript object data stores*
  - *query in real-time*
  - *listeners available for all connected apps and users*
  - *synchronisation in milliseconds for most updates...*
  - *notifications*

Client-side - Data - Firebase

Firebase - authentication

- **authentication** with Firebase provides various backend services and SDKs
  - *help developers manage authentication for an app*
  - *service supports many different providers, including Facebook, Google, Twitter &c.*
  - *using industry standard **OAuth 2.0** and **OpenID Connect** protocols*
- custom solutions also available per app
  - *email*
  - *telephone*
  - *messaging*
  - ...

Client-side - Data - Firebase

Firebase - cloud storage

- **Cloud Storage** used for uploading, storing, downloading files
  - *accessed by apps for file storage and usage...*
  - *features a useful safety check if and when a user's connection is broken or lost*
  - *files are usually stored in a Google Cloud Storage bucket*
  - *files accessible using either Firebase or Google Cloud*
  - *consider using Google Cloud platform for image filtering, processing, video editing...*
  - *modified files may then become available to Firebase again, and connected apps*
  - *e.g. Google's Cloud Platform*

Client-side - Data - Firebase

Firebase - Real-time database

- **Real-time Database** offers a hosted NoSQL data store
  - *ability to quickly and easily sync data*
  - *data synchronisation is active across multiple devices, in real-time*
  - *available as and when the data is updated in the cloud database*
- other services and tools available with Firebase
  - *analytics*
  - *advertising services such as adwords*
  - *crash reporting*
  - *notifications*
  - *various testing options...*

Client-side - Data - Firebase

Firebase - basic setup

- start using Firebase by creating an account with the service
  - *using a standard Google account*
  - *Firebase*
- login to Firebase
  - *choose either Get Started material or navigate to Firebase console*
- at *Console* page, get started by creating a new project
  - *click on the option to* `Add project`
  - *enter the name of this new project*
  - *and select a region*
- then redirected to the *console dashboard* page for the new project
  - *access project settings, config, maintenance...*
- reference documentation for the Firebase Real-Time database,
  - *https://firebase.google.com/docs/reference/js/firebase.database*

Client-side - Data - Firebase

Firebase - create real-time database

- now setup a database with Firebase for a test app
- start by selecting *Database* option from left sidebar on the Console Dashboard
  - *available under the DEVELOP option*
- then select *Get Started* for the real-time database
- presents an empty database with an appropriate name to match current project
- data will be stored in a JSON format in the real-time database
- working with Firebase is usually simple and straightforward for most apps
- get started quickly direct from the Firebase console
  - *or import some existing JSON...*

Image - Firebase

create a database

Firebase - create a database

Client-side - Data - Firebase

Firebase - import JSON data

- we might start with some simple data to help test Firebase
- import JSON into our test database
  - *then query the data &c. from the app*

```
{
  "cards": [
    {
      "visible": true,
      "title": "Abu Simbel",
      "card": "temple complex built by Ramesses II"
    },
    {
      "visible": false,
      "title": "Amarna",
      "card": "capital city built by Akhenaten"
    },
    {
      "visible": false,
      "title": "Giza",
      "card": "Khufu's pyramid on the Giza plateau outside Cairo"
    },
    {
      "visible": false,
      "title": "Philae",
      "card": "temple complex built during the Ptolemaic period"
    }
  ]
}
```

Image - Firebase

JSON import

Firebase - import JSON file

Client-side - Data - Firebase

Firebase - permissions

- initial notification in Firebase console after creating a new database
  - *Default security rules require users to be authenticated*
- permissions with Firebase database
  - *select RULES tab for current database*
- lots of options for database rules
  - *Firebase - database rules*
- e.g. for testing initial app we might remove authentication rules
- change rules as follows

from

```
{
  "rules": {
    ".read": "auth != null",
    ".write": "auth != null"
  }
}
```

to

```
{
  "rules": {
    ".read": "true",
    ".write": "true"
  }
}
```

Client-side - Data - Firebase

add data with plain JS objects

- plain objects as standard Firebase storage
  - *helps with data updating*
  - *helps with auto-increment pushes of data...*


```
{
  "egypt": {
    "code": "eg",
    "ancient_sites": {
      "abu_simbel": {
        "title": "abu simbel",
        "kingdom": "upper",
        "location": "aswan governorate",
        "coords": {
          "lat": 22.336823,
          "long": 31.625532
        },
        "date": {
          "start": {
            "type": "bc",
            "precision": "approximate",
            "year": 1264
          },
          "end": {
            "type": "bc",
            "precision": "approximate",
            "year": 1244
          }
        }
      },
      "karnak": {
        "title": "karnak",
        "kingdom": "upper",
        "location": "luxor governorate",
        "coords": {
          "lat": 25.719595,
          "long": 32.655807
        },
        "date": {
          "start": {
            "type": "bc",
            "precision": "approximate",
```

```
            "year": 2055
          },
          "end": {
            "type": "ad",
            "precision": "approximate",
            "year": 100
          }
        }
      }
    }
  }
}
```

Image - Firebase

JSON import

Firebase - import JSON file

Client-side - Data - Firebase

add to app's `index.html`

- start testing setup with default config in app's `index.html` file
  - e.g.

```
<!-- JS - Firebase app -->
<script src="https://www.gstatic.com/firebasejs/5.5.8/firebase.js"></script>
<script>
  // Initialize Firebase
  var config = {
    apiKey: "YOUR_API_KEY",
    authDomain: "422cards.firebaseapp.com",
    databaseURL: "https://422cards.firebaseio.com",
    projectId: "422cards",
    storageBucket: "422cards.appspot.com",
    messagingSenderId: "282356174766"
  };
  firebase.initializeApp(config);
</script>
```

- example includes initialisation information so the SDK has access to
  - *Authentication*
  - *Cloud storage*
- Realtime Database
- Cloud Firestore

n.b. don't forget to modify the above values to match your own account and database...

Client-side - Data - Firebase

customise API usage

- possible to customise required components per app
- allows us to include only features required for each app
  - *e.g. the only **required** component is*
- `firebase-app` - core Firebase client (required component)

```
<!-- Firebase App is always required and must be first -->
<script src="https://www.gstatic.com/firebasejs/5.5.8/firebase-app.js"></script>
```

- we may add a mix of the following optional components,
- `firebase-auth` - various authentication options
- `firebase-database` - realtime database
- `firebase-firestore` - cloud Firestore
- `firebase-functions` - cloud based function for Firebase
- `firebase-storage` - cloud storage
- `firebase-messaging` - Firebase cloud messaging

Client-side - Data - Firebase

modify JS in app's `index.html`

```
<!-- Add additional services that you want to use -->
<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-auth.js"></script>
<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-database.js"></scr
<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-firestore.js"></sc
<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-messaging.js"></sc
<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-storage.js"></scri

<script src="https://www.gstatic.com/firebasejs/5.5.3/firebase-functions.js"></sc
```

- then define an object for the `config` of the required services and options,

```
var config = {
  // add API key, services &c.
};
firebase.initializeApp(config);
```

Client-side - Data - Firebase

initial app usage - DB connection

- after defining required config and initialisation
  - *start to add required listeners and calls to app's JS*

define DB connection

- we can establish a connection to our Firebase DB as follows,

```
const db = firebase.database();
```

- then use this reference to connect and query our database

Client-side - Data - Firebase

initial app usage - `ref()` method

- with the connection to the database
  - *we may then call the `ref()`, or reference, method*
  - *use this method to read, write &c. data in the database*
- by default, if we call `ref()` with no arguments
  - *our query will be relative to the root of the database*
  - *e.g. reading, writing &c. relative to the whole database*
- we may also request a specific reference in the database
  - *pass a location path, e.g.*

```
db.ref('egypt/ancient_sites/abu_simbel/title').set('Abydos');
```

- allows us to create multiple parts of the Firebase database
- such parts might include,
  - *multiple objects, properties, and values &c.*
- a quick and easy option for organising and distributing data

Client-side - Data - Firebase

write data - intro

- also write data to the connected database
  - *again from a JavaScript based application*
- Firebase supports many different JavaScript datatypes, including
  - *strings*
  - *numbers*
  - *booleans*
  - *objects*
  - *arrays*
  - ...
- i.e. any values and data types we add to JSON
  - *n.b. Firebase may not maintain the native structure upon import*
  - *e.g. arrays will be converted to plain JavaScript objects in Firebase*

Client-side - Data - Firebase

write data - set all data

- `set` data for the whole database by calling the `ref()` method at the *root*
  - e.g.

```
db.ref().set({
  site: 'abu-simbel',
  title: 'Abu Simbel',
  date: 'c.1264 B.C.',
  visible: true,
  location: {
    country: 'Egypt',
    code: 'EG',
    address: 'aswan'
  }
  coords: {
    lat: '22.336823',
    long: '31.625532'
  }
});
```

Client-side - Data - Firebase

write data - set data for a specific data location

- also write data to a specific location in the database
- add an argument to the `ref()` method
  - *specifying required location in the database*
  - *e.g.*

```
db.ref('egypt/ancient_sites/abu_simbel/location').set('near aswan');
```

- `ref()` may be called relative to any depth in the database from the *root*
- allows us to update anything from whole DB to single property value

Client-side - Data - Firebase

Promises with Firebase

- Firebase includes native support for Promises and associated chains
  - *we do not need to create our own custom Promises*
- we may work with a return Promise object from Firebase
  - *using a standard chain, methods...*
- e.g. when we call the `set()` method
  - *Firebase will return a Promise object for the method execution*
- `set()` method will not explicitly return anything except for success or error
  - *we can simply check the return promise as follows,*

```
db.ref('egypt/ancient_sites/abu_simbel/title')
  .set('Abu Simbel')
  .then(() => {
    // log data set success to console
    console.log('data set...');
  })
  .catch((e) => {
    // catch error from Firebase - error logged to console
    console.log('error returned', e);
  });
```

Client-side - Data - Firebase

remove data - intro

- we may also delete and remove data from the connected database
- various options for removing such data, including
  - *specific location*
  - *all data*
  - `set()` *with* `null`
  - *by updating data*
  - ...

Client-side - Data - Firebase

remove data - specify location

- we may also delete data at a specific location in the connected database
  - e.g.

```
db.ref('egypt/ancient_sites/abu_simbel/kingdom')
  .remove()
  .then(() => {
    // log data removed success to console
    console.log('data removed...');
  })
  .catch((e) => {
    // catch error from Firebase - error logged to console
    console.log('error returned', e);
  });
```

Client-side - Data - Firebase

remove data - all data

- also remove all of the data in the connected database
  - e.g.

```
db.ref()
  .remove()
  .then(() => {
    // log data removed success to console
    console.log('data removed...');
  })
  .catch((e) => {
    // catch error from Firebase - error logged to console
    console.log('error returned', e);
  });
```

Client-side - Data - Firebase

remove data - `set()` with null

- another option specified in the Firebase docs for deleting data
  - *by using `set()` method with a `null` value*
  - *e.g.*

```
db.ref('egypt/ancient_sites/abu_simbel/kingdom')
  .set(null)
  .then(() => {
    // log data removed success to console
    console.log('data set to null...');
  })
  .catch((e) => {
    // catch error from Firebase - error logged to console
    console.log('error returned', e);
  });
```

Client-side - Data - Firebase

update data - intro

- also combine setting and removing data in a single pattern
  - *using the `update()` method call to the defined database reference*
- meant to be used to update multiple items in database in a single call
- we must pass an object as the argument to the `update()` method

Client-side - Data - Firebase

update data - existing properties

- to update multiple existing properties
  - e.g.

```
db.ref('egypt/ancient_sites/abu_simbel/').update({
  title: 'The temple of Abu Simbel',
  visible: false
});
```

Client-side - Data - Firebase

update data - add new properties

- also add a new property to a specific location in the database

```
db.ref('egypt/ancient_sites/abu_simbel/').update({
  title: 'The temple of Abu Simbel',
  visible: false,
  date: 'c.1264 B.C.'
});
```

- still set new values for the two existing properties
  - *`title` and `visible`*
- add a new property and value for `data`
- `update()` method will only update the specific properties
  - *does not override everything at the reference location*
  - *compare with the `set()` method...*

Client-side - Data - Firebase

update data - remove properties

- also combine these updates with option to remove an existing property
  - *e.g.*

```
db.ref('egypt/ancient_sites/abu_simbel/').update({
  card: null,
  title: 'The temple of Abu Simbel',
  visible: false,
  date: 'c.1264 B.C.',
});
```

- `null` used to delete specific property from reference location in DB
- at the reference loaction in the DB, we're able to combine
  - *creating new property*
  - *updating a property*
  - *deleting existing properties*

Client-side - Data - Firebase

update data - multiple properties at different locations

- also combine updating data in multiple objects at different locations
  - *locations relative to initial passed reference location*
  - *e.g.*

```
db.ref().update({
  'egypt/ancient_sites/abu_simbel/visible': true,
  'egypt/ancient_sites/karnak/visible': false
});
```

- relative to the root of the dabatase
  - *now updated multiple `title` properties in different objects*
- *n.b.* update is only for child objects relative to specified ref location
  - *due to character restrictions on the property name*
  - *e.g. the name may not begin with `.`, `/` &c.*

Client-side - Data - Firebase

update data - Promise chain

- `update()` method will also return a Promise object
  - *allows us to chain the standard methods*
  - *e.g.*

```
db.ref().update({
  'egypt/ancient_sites/abu_simbel/visible': true,
  'egypt/ancient_sites/karnak/visible': false
}).then(() => {
  console.log('update success...');
}).catch((e) => {
  console.log('error = ', e);
});
```

- as with `set()` and `remove()`
  - *Promise object itself will return success or error for method call*

Client-side - Data - Firebase

read data - intro

- fetch data from the connected database in many different ways, e.g.
  - *all of the data*
  - *or a single specific part of the data*
- also connect and retrieve data once
- another option is to setup a listener
  - *used for polling the database for live updates...*

Client-side - Data - Firebase

read data - all data, once

- retrieve all data from the database a single time

```
// ALL DATA ONCE - request all data ONCE
// - returns Promise value
db.ref().once('value')
  .then((snapshot) => {
    // snapshot of the data - request the return value for the data at the time o
    const data = snapshot.val();
    console.log('data = ', data);
  })
  .catch((e) => {
    console.log('error returned - ', e);
  });
```

Client-side - Data - Firebase

read data - single data, once

- we may query the database once for a single specific value
  - e.g.

```
// SINGLE DATA - ONCE
db.ref('egypt/ancient_sites/abu_simbel/').once('value')
  .then((snapshot) => {
    // snapshot of the data - request the return value for the data at the time o
    const data = snapshot.val();
    console.log('single data = ', data);
  })
  .catch((e) => {
    console.log('error returned - ', e);
  });
```

- returns value for object at the specified location
  - *egypt/ancient_sites/abu_simbel/*

Client-side - Data - Firebase

read data - listener for changes - subscribe

- also setup listeners for changes to the connected database
  - *then continue to poll the DB for any subsequent changes*
  - *e.g.*

```
// LISTENER - poll DB for data changes
// - any changes in the data
db.ref().on('value', (snapshot) => {
  console.log('listener update = ', snapshot.val());
});
```

- `on()` method polls the DB for any changes in `value`
- then get the current snapshot value for the data stored
- any change in data in the online database
  - *listener will automatically execute defined success callback function*

Client-side - Data - Firebase

read data - listener for changes - subscribe - error handling

- also add some initial error handling for subscription callback
  - e.g.

```
// LISTENER - SUBSCRIBE
// - poll DB for data changes
// - any changes in the data
db.ref().on('value', (snapshot) => {
  console.log('listener update = ', snapshot.val());
}, (e) => {
  console.log('error reading db', e);
});
```

Client-side - Data - Firebase

read data - listener - why not use a Promise?

- as listener is notified of updates to the online database
  - *we need the callback function to be executed*
- callback may need to be executed multiple times
  - *e.g. for many updates to the stored data*
- a Promise may only be resolved a single time
  - *with either* `resolve` *or* `reject`
- to use a Promise in this context
  - *we would need to instantiate a new Promise for each update*
  - *would not work as expected*
  - *therefore, we use a standard callback function*
- a callback may be executed as needed
  - *each and every time there is an update to the DB*

Client-side - Data - Firebase

read data - listener for changes - unsubscribe

- need to *unsubscribe* from all or specific changes in online database
  - e.g.

```
db.ref().off();
```

- removes *all* current subscriptions to defined DB connection

Client-side - Data - Firebase

read data - listener for changes - unsubscribe

- also *unsubscribe* a specific subscription by passing callback
  - *callback as used for the original subscription*
- abstract the callback function
  - *pass it to both `on()` and `off()` methods for database `ref()` method*
  - *e.g.*

```
// abstract callback
const valChange = (snapshot) => {
  console.log('listener update = ', snapshot.val());
};
```

Client-side - Data - Firebase

read data - listener for changes - unsubscribe

- then pass this variable as callback argument
  - *for both subscribe and unsubscribe events*
  - *e.g.*

```
// subscribe
db.ref().on('value', valChange);
// unsubscribe
db.ref().off(valChange);
```

- allows our app to maintain the DB connection
  - *and unsubscribe a specific subscription*

Client-side - Data - Firebase

working with arrays

- Firebase does not explicitly support array data structures
  - *converts array objects to plain JavaScript objects*
- e.g. import the following JSON with an array

```
{
  "cards": [
    {
      "visible": true,
      "title": "Abu Simbel",
      "card": "temple complex built by Ramesses II"
    },
    {
      "visible": false,
      "title": "Amarna",
      "card": "capital city built by Akhenaten"
    },
    {
      "visible": false,
      "title": "Giza",
      "card": "Khufu's pyramid on the Giza plateau outside Cairo"
    },
    {
      "visible": false,
      "title": "Philae",
      "card": "temple complex built during the Ptolemaic period"
    }
  ]
}
```

Image - Firebase

JSON import with array

Firebase - import JSON file

Client-side - Data - Firebase

working with arrays - index values

- each index value will now be stored as a plain object
  - *with an auto-increment value for the property*
  - *e.g.*

```
cards: {
  0: {
    card: "temple complex built by Ramesses II",
    title: "Abu Simbel",
    visible: "true"
  }
}
```

Client-side - Data - Firebase

working with arrays - access index values

- we may still access each index value from the original array object
  - *without easy access to pre-defined, known unique references*
- e.g. to access the title value of a given card
  - *need to know its auto-generated property value in Firebase*

```
db.ref('cards/0')
```

- reference will be the path to the required object
  - *then access a given property on the object*
- even if we add a unique reference property to each card
  - *still need to know assigned property value in Firebase*

Client-side - Data - Firebase

working with arrays - `push()` method

- add new content to an existing Firebase datastore
- we may use the `push()` method to add this data
- a unique property value will be auto-generated for pushed data
  - e.g.

```
// push new data to specific reference in db
db.ref('egypt/ancient_sites/').push({
  "philae": {
    "kingdom": "upper",
    "visible": false
  }
});
```

- new data created with auto-generated ID for parent object
  - e.g.

```
LPcdS31H_u9NOdIn27_
```

- may be useful for dynamic content pushed to a datastore
- e.g. notes, tasks, calendar dates &c.

Client-side - Data - Firebase

working with arrays - Firebase `snapshot` methods

- various data snapshot methods in the Firebase documentation
- commonly used method with `snapshot` is the `val()` method
- many additional methods specified in API documentation for *DataSnapshot*
  - *e.g. `forEach()` - iterator for plain objects from Firebase*
  - *Firebase Docs - DataSnapshot*

Client-side - Data - Firebase

working with arrays - create array from Firebase data

- as we store data as plain objects in Firebase
  - *need to consider how we may work with array-like structures*
  - *i.e. for technologies and patterns that require array data structures*
  - *e.g. Redux*
- need to get data from Firebase, then prepare it for use as an array
- to help us work with Firebase object data and arrays
  - *we may call `forEach()` method on the return `snapshot`*
  - *provides required iterator for plain objects stored in Firebase*
  - *e.g.*

```
// get ref in db once
// call forEach() on return snapshot
// push values to local array
// unique id for each DB parent object is `key` property on snapshot
db.ref('egypt/ancient_sites')
  .once('value')
  .then((snapshot) => {
    const sites = [];
    snapshot.forEach((siteSnapshot) => {
      sites.push({
        id: siteSnapshot.key,
        ...siteSnapshot.val()
      });
    });
    console.log('sites array = ', sites);
  });
```

Image - Firebase

snapshot `forEach()` - creating a local array

Firebase - local array

- we now have a local array from the Firebase object data
  - *use with options such as Redux...*

Client-side - Data - Firebase

add listeners for value changes

- as we modify objects, properties, values &c. in Firebase
  - *set listeners to return notifications for such updates*
  - *e.g. add a single listener for any update relative to full datastore*

```
// LISTENER - SUBSCRIBE - v.2
// - get all data & then push return data to local array...
db.ref('egypt').on('value', (snapshot) => {
  const sites = [];
  snapshot.forEach((siteSnapshot) => {
    sites.push({
      id: siteSnapshot.key,
      ...siteSnapshot.val()
    });
  });
  console.log('sites array after update = ', sites);
});
```

- the on( ) method does not return a Promise object
  - *we need to define a callback for the return data*

Client-side - Data - Firebase

listener events - intro

- for subscriptions and updates
  - *Firebase provides a few different events*
- for the `on()` method, we may initially consult the following documentation
- Firebase docs - `on()` events
- need to test various listeners for datastore updates

Client-side - Data - Firebase

listener events - `child_removed` event

- add a subscription for event updates
  - *as a child object is removed from the data store.*
- `child_removed` event may be added as follows,

```
// - listen for child_removed event relative to current ref path in DB
db.ref('egypt/ancient_sites/').on('child_removed', (snapshot) => {
  console.log('child removed = ', snapshot.key, snapshot.val());
});
```

Client-side - Data - Firebase

listener events - `child_changed` event

- also listen for the `child_changed` event
  - *relative to the current path passed to `ref()`*
  - *e.g.*

```
// - listen for child_changed event relative to current ref path in DB
db.ref('egypt/ancient_sites/').on('child_changed', (snapshot) => {
  console.log('child changed = ', snapshot.key, snapshot.val());
});
```

Client-side - Data - Firebase

listener events - `child_added` event

- another common event is adding a new child to the data store
  - *a user may create and add a new note or to-do item...*
  - *e.g. new child added to specified reference*

```
// - listen for child_added event relative to current ref path in DB
db.ref('egypt/ancient_sites/').on('child_added', (snapshot) => {
  console.log('child added = ', snapshot.key, snapshot.val());
});
```

Client-side - Data - Firebase

extra notes

- Firebase - authentication
- Firebase - setup & usage

Data visualisation

intro - part 1

- data visualisation - study of how to visually communicate and analyse data
- covers many disparate aspects
  - *including infographics, exploratory tools, dashboards...*
- already some notable definitions of data visualisation
- one of the better known examples,

> *"Data visualisation is the representation and presentation of data that exploits our visual perception in order to amplify cognition."*
>
> *(Kirk, A. "Data Visualisation: A successful design process." Packt Publishing. 2012.)*

- several variants of this general theme exist
  - *the underlying premise remains the same*
- simply, data visualisation is a visual representation of the underlying data
- visualisation aims to impart a better understanding of this data
  - *by association, its relevant context*

Data visualisation

intro - part 2

- an inherent flip-side to data visualisation
- without a correct understanding of its application
  - *it can simply impart a false perception, and understanding, on the dataset*
- run the risk of creating many examples of standard **areal unit** problem
  - *perception often based on creator's base standard and potential bias*
- inherently good at seeing what we want to see
- without due care and attention visualisations may provide false summations of the data

Data visualisation

types - part 1

- many different ways to visualise datasets
  - *many ways to customise a standard infographic*
- some standard examples that allow us to consider the nature of visualisations
  - *infographics*
  - *exploratory visualisations*
  - *dashboards*
- perceived that data visualisation is simply a variation between
  - *infographics, exploratory tools, charts, and some data art*

1. infographics
   - *well suited for representing large datasets of contextual information*
   - *often used in projects more inclined to exploratory data analysis,*
   - *tend to be more interactive for the user*
   - *data science can perceive infographics as improper data visualisation because*
   - *they are designed to guide a user through a story*
   - *the main facts are often already highlighted*
   - ***NB:*** *such classifications often still only provide tangible reference points*

Data visualisation

types - part 2

2. exploratory visualisations
   - *more interested in the provision of tools to explore and interpret datasets*
   - *visualisations can be represented either static or interactive*
   - *from a user perspective these charts can be viewed*
   - *either carefully*
   - *simply become interactive representations*
   - *both perspectives help a user discover new and interesting concepts*
   - *interactivity may include*
   - *option for the user to filter the dataset*
   - *interact with the visualisation via manipulation of the data*
   - *modify the resultant information represented from the data*
   - *often perceived as more objective and data oriented than other forms*
3. dashboards
   - *dense displays of charts*
   - *represent and understand a given issue, domain...*
   - *as quickly and effectively as possible*
   - *examples of dashboards*
   - *display of server logs, website users, business data...*

Data visualisation

Dashboards - intro

- dashboards are dense displays of charts
- allow us to represent and understand the key **metrics** of a given issue
  - *as quickly and effective as possible*
  - *eg: consider display of server logs, website users, and business data...*
- one definition of a dashboard is as follows,

> *"A dashboard is a visual display of the most important information needed to achieve one or more objective; consolidated and arranged on a single screen so the information can be monitored at a glance."*
>
> *Few, Stephen. Information Dashboard Design: The Effective Visual Communication of Data. O'Reilly Media. 2006.*

- dashboards are visual displays of information
  - *can contain text elements*
  - *primarily a visual display of data rendered as meaningful information*

Data visualisation

Dashboards - intro

- information needs to be consumed quickly
- often simply no available time to read long annotations or repeatedly click controls
- information needs to be visible, and ready to be consumed
- dashboards are normally presented as a complementary environment
- an option to other tools and analytical/exploratory options
- design issues presented by dashboards include effective distribution of available space
- compact charts that permit quick data retrieval are normally preferred
- dashboards should be designed with a purpose in mind
- generalised information within a dashboard is rarely useful
- display most important information necessary to achieve their defined purpose
- a dashboard becomes a central view for collated data
- represented as meaningful information

Data visualisation

Dashboards - good practices

- to help promote our information
  - *need to design the dashboard to fully exploit available screen space*
- need to use this space to help users absorb as much information as possible
- some visual elements more easily perceived and absorbed by users than others
- some naturally convey and communicate information more effectively than others
- such attributes are known as **pre-attentive attributes of visual perception**
- for example,
  - *colour*
  - *form*
  - *position*

Data visualisation

Dashboards - visual perception

- pre-attentive attributes of visual perception

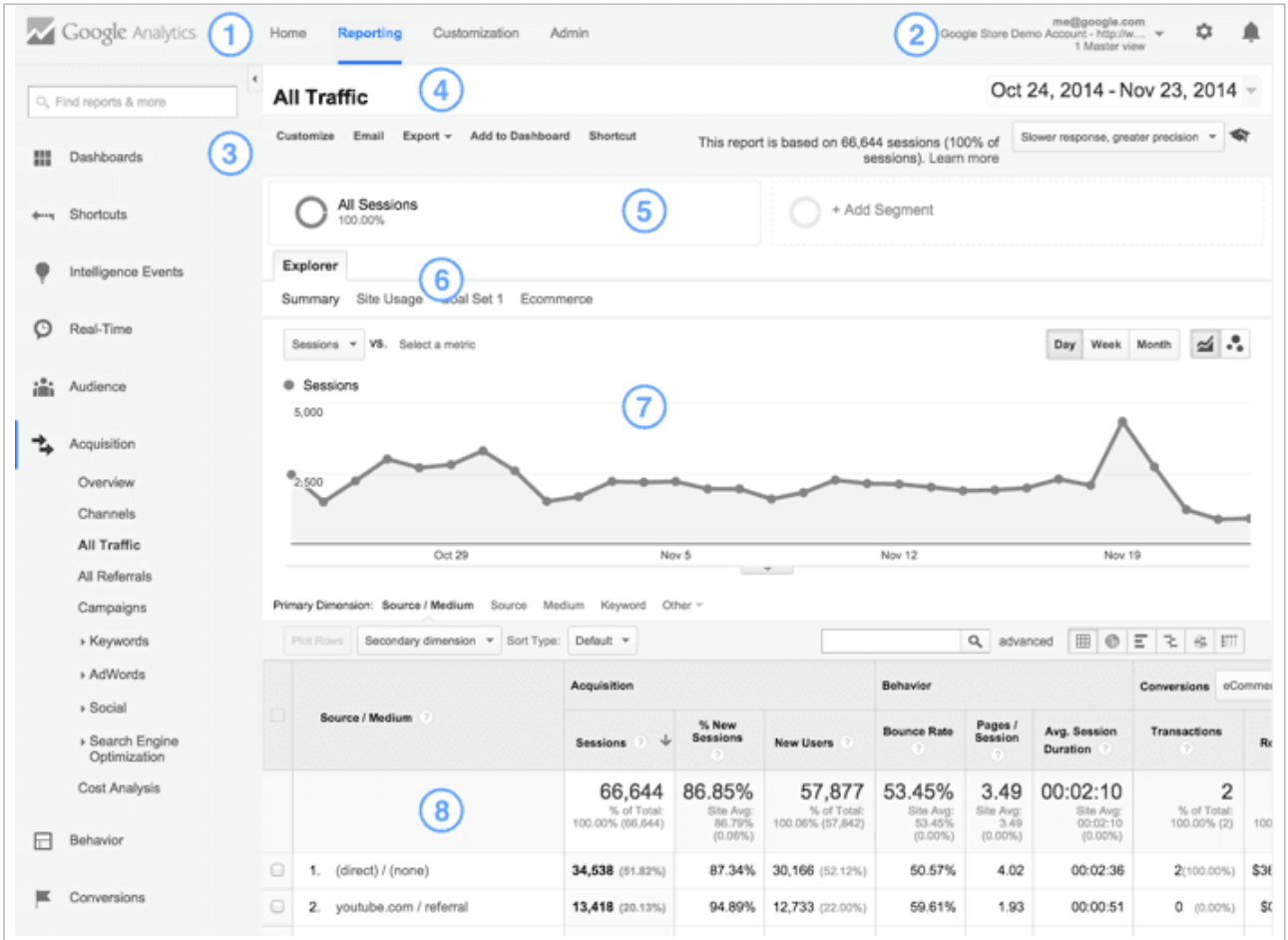
1. *Colour*
   - *many different colour models currently available*
   - *most useful relevant to dashboard design is the HSL model*
   - *this model describes colour in terms of three attributes*
     - *hue*
     - *saturation*
     - *lightness*
   - *perception of colour often depends upon context*
2. *Form*
   - *correct use of length, width, and general size can convey quantitative dimensions*
   - *each with varying degrees of precision*
   - *use the Laws of Prägnanz to manipulate groups of similar shapes and designs*
   - *thereby easily grouping like data and information for the user*
3. *Position*
   - *relative positioning of elements helps communicate dashboard information*
   - *laws of Prägnanz teach us*
   - *position can often infer a perception of relationship and similarity*
   - *higher items are often perceived as being better*
   - *items on the left of the screen traditionally seen first by a western user*

Data visualisation

Building a dashboard

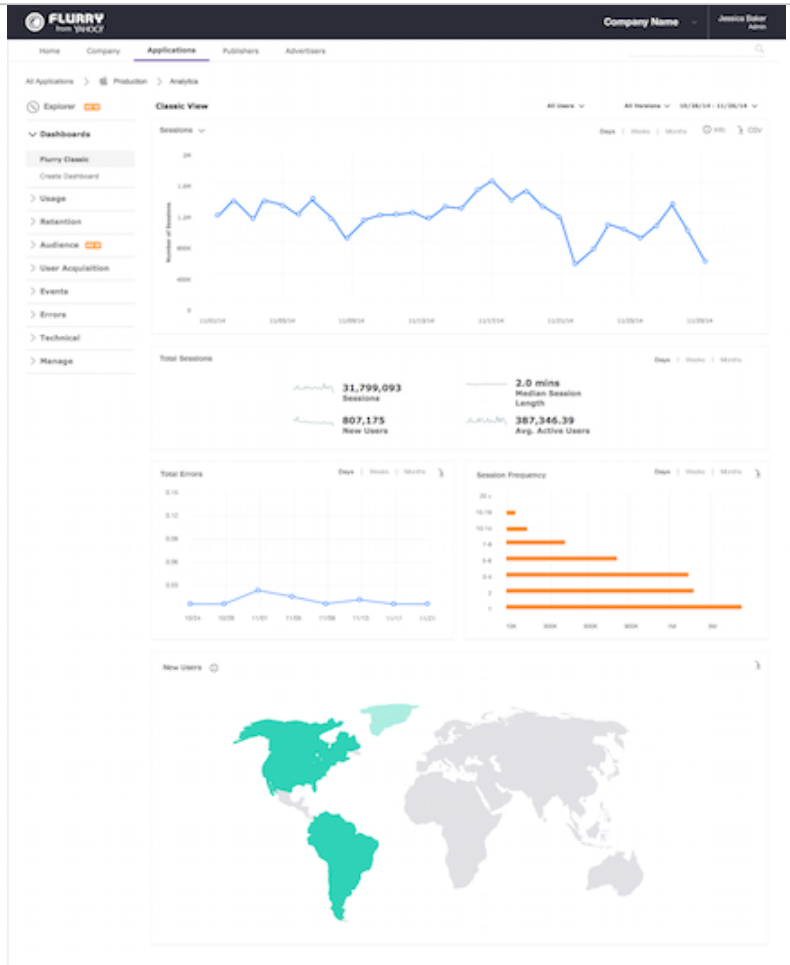
- need to clearly determine the questions that need to be answered
  - *given the information collated and presented within the dashboard*
- need to ensure that any problems can be detected on time
- be certain why we actually need a dashboard for the current dataset
- then begin to collect the requisite data to help us answer such questions
  - *data can be sourced from multiple, disparate datasets*
- chosen visualisations help us tell this story more effectively
- present it in a manner appealing to our users
- need to consider information visualisations familiar to our users
  - *helps reduce any potential user's cognitive overload*
- carefully consider organisation of data and information
- organise the data into logical units of information
  - *helps present dashboard information in a meaningful manner*
- dashboard sections should be organised
  - *to help highlight and detect any underlying or prevailing issues*
  - *then present them to the user*

Image - Google Analytics



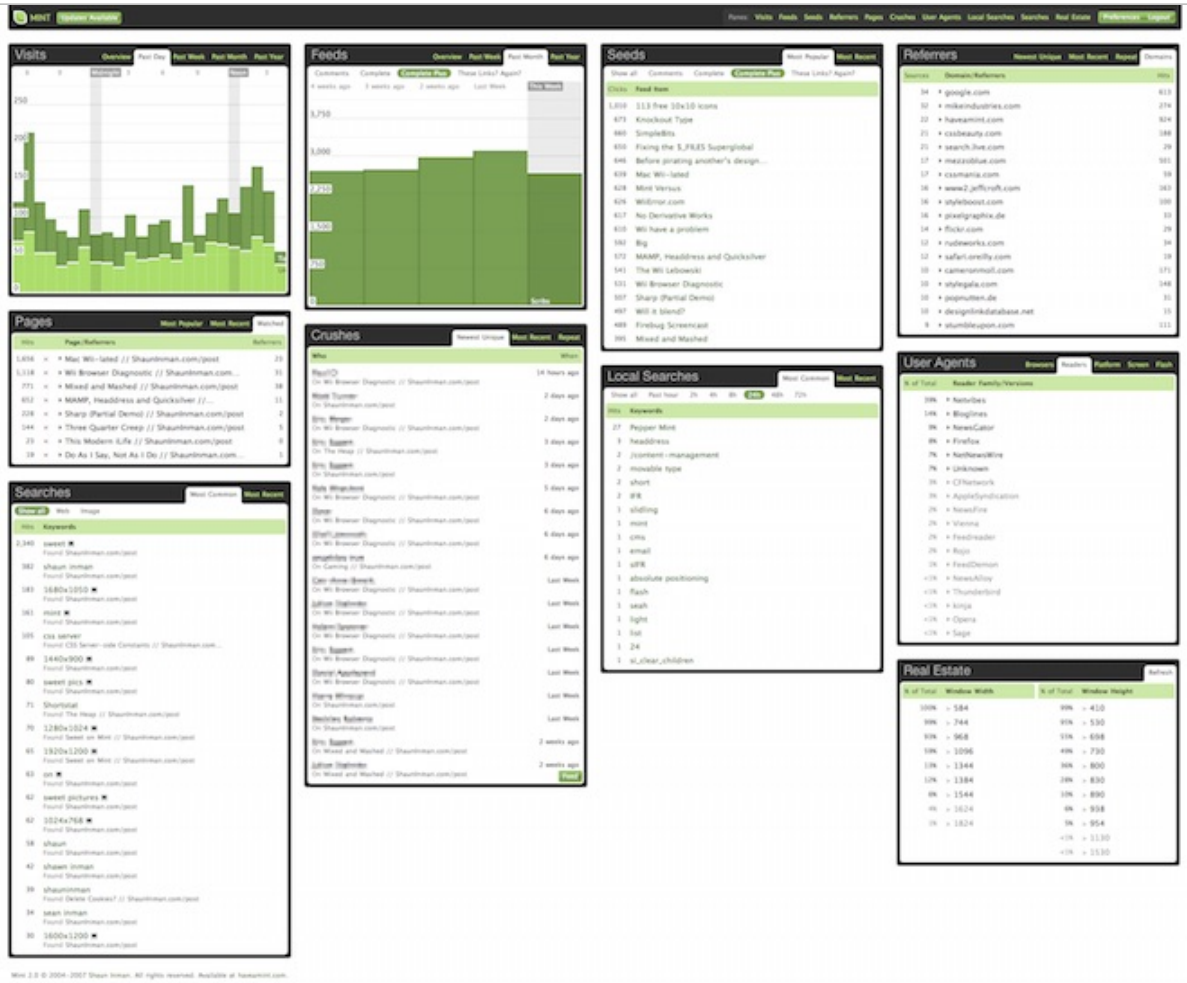
Dashboard - Google Analytics

Image - Yahoo Flurry



Dashboard - Yahoo Flurry

Image - Mint



Dashboard - Mint

Data visualisation - D3

Intro - part 1

- D3 is a custom JavaScript library
  - *designed for the manipulation of data centric documents*
  - *uses a custom library with HTML, CSS, and SVG*
  - *creates graphically rich, informative documents for the presentation of data*
- D3 uses a data-driven approach to manipulate the DOM
- Setup and configuration of D3 is straightforward
  - *most involved aspect is the configuration of a web server*
- D3.js works with standard HTML files
  - *requires a web server capable of parsing and rendering HTML...*
- to parse D3 correctly we need
  - *UTF-8 encoding reference in a meta element in the head section of our file*
  - *reference D3 file, CDN in standard script element in HTML*

Data visualisation - D3

intro - part 2

- D3 Wiki describes the underlying functional concepts as follows,

> *D3's functional style allows code reuse through a diverse collection of components and plugins.*
>
> *D3 Wiki*

- in JS, functions are objects
  - *as with other objects, a function is a collection of a name and value pair*
- real difference between a function object and a regular object
  - *a function can be invoked, and associated, with two hidden properties*
  - *include a function context and function code*
- variable resolution in D3 relies on variable searching being performed locally first
- if a variable declaration is not found
  - *search will continue to the parent object*
  - *continue recursively to the next static parent*
  - *until it reaches global variable definition*
  - *if not found, a reference error will be generated for this variable*
- important to keep this static scoping rule in mind when dealing with D3

Data visualisation - D3

Data Intro - part 1

- Data is structured information with an inherent perceived potential for meaning
- consider data relative to D3
  - *need to know how data can be represented*
  - *both in programming constructs and its associated visual metaphor*
- what is the basic difference between data and information?

> *Data are raw facts. The word raw indicates that the facts have not yet been processed >>> to reveal their meaning...Information is the result of processing raw data to reveal >>> its meaning.*
>
> *Rob, Morris, and Coronel. 2009*

- a general concept of data and information
- consider them relative to visualisation, impart a richer interpretation
- information, in this context, is no longer
  - *the simple result of processed raw data or facts*
  - *it becomes a visual metaphor of the facts*
- same data set can generate any number of visualisations
  - *may lay equal claim in terms of its validity*
- visualisation is communicating creator's insight into data...

Data visualisation - D3

Data Intro - part 2

- relative to development for visualisation
  - *data will often be stored simply in a text or binary format*
- not simply textual data, can also include data representing
  - *images, audio, video, streams, archives, models...*
- for D3 this concept may often simply be restricted to
  - *textual data, or text-based data...*
  - *any data represented as a series of numbers and strings containing alpha numeric characters*
- suitable textual data for use with D3
  - *text stored as a comma-separated value file (.csv)*
  - *JSON document (.json)*
  - *plain text file (.txt)*
- data can then be *bound* to elements within the DOM of a page using D3
  - *inherent pattern for D3*

Data visualisation - D3

Data Intro - Enter-Update-Exit Pattern

- in D3, connection between data and its visual representation
  - *usually referred to as the **enter-update-exit** pattern*
- concept is starkly different from the standard imperative programming style
- pattern includes
  - *enter mode*
  - *update mode*
  - *exit mode*

Data visualisation - D3

Data Intro - Enter-Update-Exit Pattern

Enter mode

- `enter()` function returns all specified data that not yet represented in visual domain
- standard modifier function chained to a selection method
  - *create new visual elements representing given data elements*
  - *eg: keep updating an array, and outputting new data bound to elements*

Update mode

- `selection.data(data)` function on a given selection
  - *establishes connection between data domain and visual domain*
- returned result of intersection of data and visual will be a **data-bound** selection
- now invoke a modifier function on this newly created selection
  - *update all existing elements*
  - *this is what we mean by an **update** mode*

Exit mode

- invoke `selection.data(data).exit` function on a data-bound selection
  - *function computes new selection*
  - *contains all visual elements no longer associated with any valid data element*
- eg: create a bar chart with 25 data points
  - *then update it to 20, so we now have 5 left over*
  - ***exit mode** can now remove excess elements for 5 spare data points*

Data visualisation - D3

Data Intro - binding data - part 1

- consider standard patterns for working with data
- we can iterate through an array, and then bind the data to an element
  - *most common option in D3 is to use the **enter-update-exit** pattern*
- use same basic pattern for binding object literals as data
- to access our data we call the required attribute of the supplied data

```
var data = [
    {height: 10, width: 20},
    {height: 15, width: 25}
];

function (d) {
    return (d.width) + "px";
}
```

- then access the **height** attribute per object in the same manner
- we can also bind functions as data
  - *D3 allows functions to be treated as data...*

Data visualisation - D3

Data Intro - binding data - part 2

- D3 enables us to bind data to elements in the DOM
  - *associating data to specific elements*
  - *allows us to reference those values later*
  - *so that we can apply required mapping rules*
- use D3's `selection.data()` method to bind our data to DOM elements
  - *we obviously need some data to bind, and a selection of DOM elements*
- D3 is particularly flexible with data
  - *happily accepts various types*
- D3 also has a built-in function to handle loading JSON data

```
d3.json("testdata.json", function(json) {
    console.log(json); //do something with the json...
});
```

Data visualisation - D3

Data Intro - working with arrays - options

- min and max = return the min and max values in the passed array

```
d3.select("#output").text(d3.min(ourArray));
d3.select("#output").text(d3.max(ourArray));
```

- extent = retrieves both the smallest and largest values in the the passed array

```
d3.select("#output").text(d3.extent(ourArray));
```

- sum

```
d3.select("#output").text(d3.sum(ourArray));
```

- median

```
d3.select("#output").text(d3.median(ourArray));
```

- mean

```
d3.select("#output").text(d3.mean(ourArray));
```

- asc and desc

```
d3.select("#output").text(ourArray.sort(d3.ascending));
d3.select("#output").text(ourArray.sort(d3.descending));
```

- & many more...

Data visualisation - D3

Data Intro - working with arrays - nest

- D3's nest function used to build an algorithm
  - *transforms a flat array data structure into a hierarchical nested structure*
- function can be configured using the key function chained to **nest**
- nesting allows elements in an array to be grouped into a hierarchical tree structure
  - *similar in concept to the group by option in SQL*
  - ***nest** allows multiple levels of grouping*
  - *result is a tree rather than a flat table*
- levels in the tree are defined by the *key* function
- leaf nodes of the tree can be sorted by value
- internal nodes of the tree can be sorted by key

Data visualisation - D3

Selections - intro

- **Selection** is one of the key tasks required within D3 to manipulate and visualise our data
- simply allows us to target certain visual elements on a given page
- Selector support is now standardised upon the W3C specification for the Selector API
  - *supported by all of the modern web browsers*
  - *its limitations are particularly noticeable for work with visualising data*
- Selector API only provides support for selector and not selection
  - *able to select an element in the document*
  - *to manipulate or modify its data we need to implement a standard loop etc*
- D3 introduced its own selection API to address these issues and perceived shortcomings
  - *ability to select elements by ID or class, its attributes, set element IDs and class, and so on...*

Data visualisation - D3

Selections - single element

- select a single element within our page

```
d3.select("p");
```

- now select the first <p> element on the page, and then allow us to modify as necessary
  - *eg; we could simply add some text to this element*

```
d3.select("p")
.text("Hello World");
```

- selection could be a generic element, such as <p>
  - *or a specific element defined by targeting its ID*
- use additional modifier functions, such as `attr`, to perform a given modification on the selected element

```
//set an attribute for the selected element
d3.select("p").attr("foo");
//get the attribute for the selected element
d3.select("p").attr("foo");
```

- also add or remove classes on the selected element

```
//test selected element for specified class
d3.select("p").classed("foo")
//add a class to the selected element
d3.select("p").classed("goo", true);
//remove the specified class from the selected element
d3.select("p").classed("goo", function(){ return false; });
```

Data visualisation - D3

Selections - multiple elements

- also select all of the specified elements using D3

```
d3.selectAll("p")
.attr("class", "para");
```

- use and implement multiple element selection
  - *same as single selection pattern*
- also use the same modifier functions
- allows us to modify each element's attributes, style, class...

Data visualisation - D3

Selections - iterating through a selection

- D3 provides us with a selection iteration API
  - *allows us to iterate through each selection*
  - *then modify each selection relative to its position*
  - *very similar to the way we normally loop through data*

```
d3.selectAll("p")
.attr("class", "para")
.each(function (d, i) {
    d3.select(this).append("h1").text(i);
});
```

- D3 selections are essentially like arrays with some enhancements
  - *use the iterative nature of Selection API*

```
d3.selectAll('p')
.attr("class", "para2")
.text(function(d, i) {
    return i;
});
```

Data visualisation - D3

Selections - performing sub-selection

- for selections - often necessary to perform specific scope requests
  - *eg: selecting all <p> elements for a given element*

```
//direct css selector (selector level-3 combinators)
d3.select("div > p")
    .attr("class", "para");

//d3 style scope selection
d3.select("div")
    .selectAll("p")
    .attr("class", "para");
```

- both examples produce the same effect and output, but use very different selection techniques
  - *first example uses the CSS3, level-3, selectors*
  - *`div > p` is known as combinators in CSS syntax*

Data visualisation - D3

Selections - combinators

Example combinators..

1. descendant combinator

- uses the pattern of `selector selector` - describing loose parent-child relationship
- loose due to possible relationships - parent-child, parent-grandchild...

```
d3.select("div p");
```

- select the <p> element as a child of the parent `<div>` element
  - *relationship can be generational*

2. child combinator

- uses same style of syntax, `selector > selector`
- able to describe a more restrictive **parent-child** relationship between two elements

```
d3.select("div > p");
```

- finds <p> element if it is a direct child to the `<div>` element

Data visualisation - D3

Selections - D3 sub-selection

- sub-selection using D3's built-in selection of child elements
- a simple option to select an element, then chain another selection to get the child element
- this type of chained selection defines a scoped selection within D3
  - *eg: selecting a <p> element nested within our selected element*
  - *each selection is, effectively, independent*
- D3 API built around the inherent concept of function chaining
  - *can almost be considered a Domain Specific Language for dynamically building HTML/SVG elements*
- a benefit of chaining = easy to produce concise, readable code

```
var body = d3.select("body");

body.append("div")
    .attr("id", "div1")
  .append("p")
    .attr("class", "para")
  .append("h5")
    .text("this is a paragraph heading...");
```

Data visualisation - D3

Data Intro - page elements

- generation of new DOM elements normally fits
  - *either circles, rectangles, or some other visual form that represents the data*
- D3 can also create generic structural elements in HTML, such as a <p>
  - *eg: we can append a standard p element to our new page*

```
d3.select("body").append("p").text("sample text...");
```

- used D3 to select `body` element, then append a new <p> element with text "new paragraph"
- D3 supports *chain syntax*
  - *allowed us to `select`, `append`, and add `text` in one statement*

Data visualisation - D3

Data Intro - page elements

```
d3.select("body").append("p").text("sample text...");
```

- `d3`
  - *references the D3 object, access its built-in methods*
- `.select("body")`
  - *accepts a CSS selector, returns first instance of the matched selector in the document's DOM*
  - *`.selectAll()`*
  - ***NB:** this method is a variant of the single `select()`*
  - *returns all of the matched CSS selectors in the DOM*
- `.append("p")`
  - *creates specified new DOM element*
  - *appends it to the end of the defined select CSS selector*
- `.text("new paragraph")`
  - *takes defined string, "new paragraph"*
  - *adds it to the newly created <p> DOM element*

Data visualisation - D3

Binding data - making a selection

- choose a selector within our document
  - *eg: we could select all of the paragraphs in our document*

```
d3.select("body").selectAll("p");
```

- if the element we require does not yet exist
  - *need to use the method `enter()`*

```
d3.select("body").selectAll("p").data(dataset).enter().append("p").text("new para
```

- we get new paragraphs that match total number of values currently available in the **dataset**
  - *akin to looping through an array*
  - *outputting a new paragraph for each value in the array*
- create new, data-bound elements using `enter()`
  - *method checks the current DOM selection, and the data being assigned to it*
- if more data values than matching DOM elements
  - *`enter()` creates a new placeholder element for the data value*
  - *then passes this placeholder on to the next step in the chain, eg: `append()`*
- data from dataset also assigned to new paragraphs
- **NB:** when D3 binds data to a DOM element, it does not exist in the DOM itself
  - *it does exist in the memory*

Data visualisation - D3

Binding data - using the data

- change our last code example as follows,

```
d3.select("body").selectAll("p").data(dataset).enter().append("p").text(function(
```

- then load our HTML, we'll now see dataset values output instead of fixed text
- anytime in the chain after calling the `data()` method
  - *we can then access the current data using d*
- also bind other things to elements with D3, eg: CSS selectors, styles...

```
.style("color", "blue");
```

- chain the above to the end of our existing code
  - *now bind an additional css style attribute to each <p> element*
  - *turning the font colour blue*
- extend code to include a conditional statement that checks the value of the data
  - *eg: simplistic striped colour option*

```
.style("color", function(d) {
if (d % 2 == 0) {
return "green";
} else {
 return "blue";
}
});
```

- DEMO - D3 basic elements

Image - D3 Basic Elements

D3 - basic elements

Data visualisation - D3

Drawing - intro - part 1

1. drawing divs

- one of the easiest ways to draw a rectangle, for example, is with a HTML `<div>`
- an easy way to start drawing a bar chart for our stats
- start with standard HTML elements, then consider more powerful option of drawing with SVG
- semantically incorrect, we could use `<div>` to output bars for a bar chart
  - *use of an empty `<div>` for purely visual effect*
- using D3, add a class to an empty element using `selection.attr()` method

2. setting attributes

- `attr()` is used to set an HTML attribute and its value on an element
- After selecting the required element in the DOM
  - *assign an attributes as follows*

```
.attr("class", "barchart")
```

Data visualisation - D3

Drawing - intro - part 2

- use D3 to draw a set of bars in divs as follows

```
var dataset = [ 1, 2, 3, 4, 5 ];

d3.select("body").selectAll("div")
    .data(dataset)
    .enter()
    .append("div")
    .attr("class", "bar");
```

- above sample outputs the values from our dataset with no space between them
  - *effectively as a bar chart of equal height*
- modify the height of each representative bar
  - *by setting height of each bar as a function of its corresponding data value*
  - *eg: append the following to our example chain*

```
.style("height", function(d) {
    return d + "px";
});
```

- make each bar in our chart more clearly defined by modifying `style`

```
.style("height", function(d) {
    var barHeight = d * 3;
    return barHeight + "px";
});
```

Data visualisation - D3

Drawing - intro - part 3

1. drawing SVGs

- properties of SVG elements are specified as **attributes**
- represented as property/value pairs within each element tag

```
<element property="value">...</element>
```

- SVG elements exist in the DOM
  - *we can still use D3 methods `append()` and `attr()`*
  - *create new HTML elements and set their attributes*

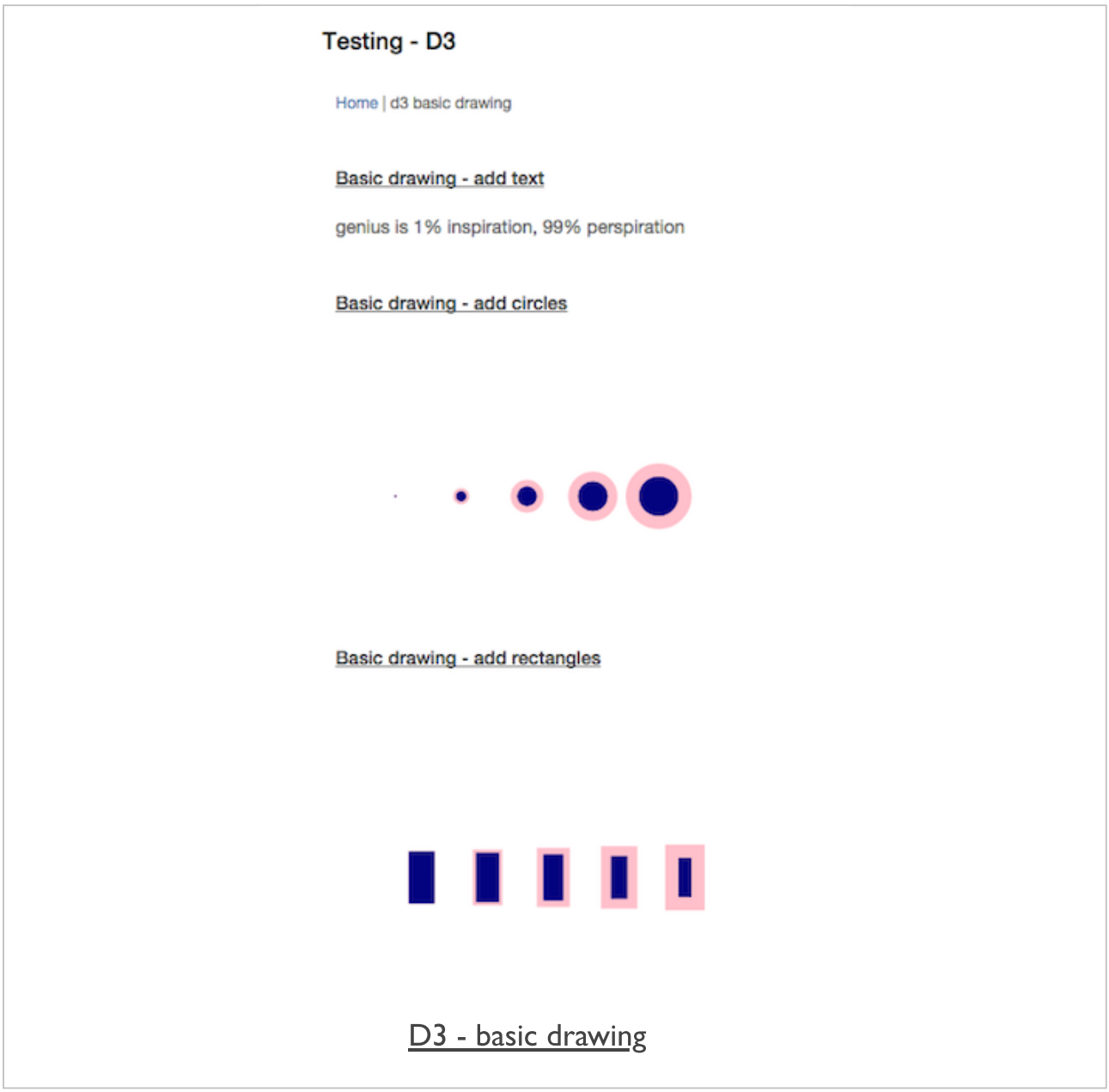
2. create SVG

- need to create an element for our SVG
- allows us to draw and output all of our required shapes

```
d3.select("body").append("svg");
```

- variable effectively works as a reference
  - *points to the newly created SVG object*
  - *allows us to use this reference to access this element in the DOM*
- DEMO - Drawing with SVG

Image - D3 Basic Drawing



D3 - basic drawing

Data visualisation - D3

Drawing - SVG barchart - part 1

- create a new barchart using SVG, need to set the required size for our SVG output

```
//width & height
var w = 750;
var h = 200;
```

- then use D3 to create an empty SVG element, and add it to the DOM

```
var svg = d3.select("body")
    .append("svg")
    .attr("width", w)
    .attr("height", h);
```

- instead of creating DIVs as before, we generate *rects* and add them to the *svg* element.

```
svg.selectAll("rect")
    .data(dataset)
    .enter()
    .append("rect")
    .attr("x", 0)
    .attr("y", 0)
    .attr("width", 10)
    .attr("height", 50);
```

Data visualisation - D3

Drawing - SVG barchart - part 2

- this code selects all of the `rect` elements within `svg`
- initially none, D3 still needs to select them before creating them
- `data()` then checks the number of values in the specified dataset
  - *hands those values to the `enter` method for processing*
- `enter` method then creates a placeholder
  - *for each data value without a corresponding `rect`*
  - *also appends a rectangle to the DOM for each data value*
- then use `attr` method to set `x, y, width, height` values for each rectangle
- still only outputs a single bar due to an overlap issue
- need to amend our code to handle the width of each bar
  - *implement flexible, dynamic coordinates to fit available SVG width and height*
  - *visualisation scales appropriately with the supplied data*

```
.attr("x", function(d, i) {
    return i * (w / dataset.length);
})
```

Data visualisation - D3

Drawing - SVG barchart - part 3

- now linked the `x` value directly to the width of the SVG `w`
  - *and the number of values in the dataset, `dataset.length`*
  - *the bars will be evenly spaced regardless of the number of values*
- if we have a large number of data values
  - *bars still look like one horizontal bar*
  - *unless there is sufficient width for parent SVG and space between each bar*
- try to solve this as well by setting the bar width to be proportional
  - *narrower for more data, wider for less data*

```
var w = 750;
var h = 200;
var barPadding = 1;
```

- now set each bar's width
  - *as a fraction of the SVG width and number of data points, minus our padding value*

```
.attr("width", w / dataset.length - barPadding)
```

- our bar widths and x positions scale correctly regardless of data values

Data visualisation - D3

Drawing - SVG barchart - part 4

- encode our data as the *height* of each bar

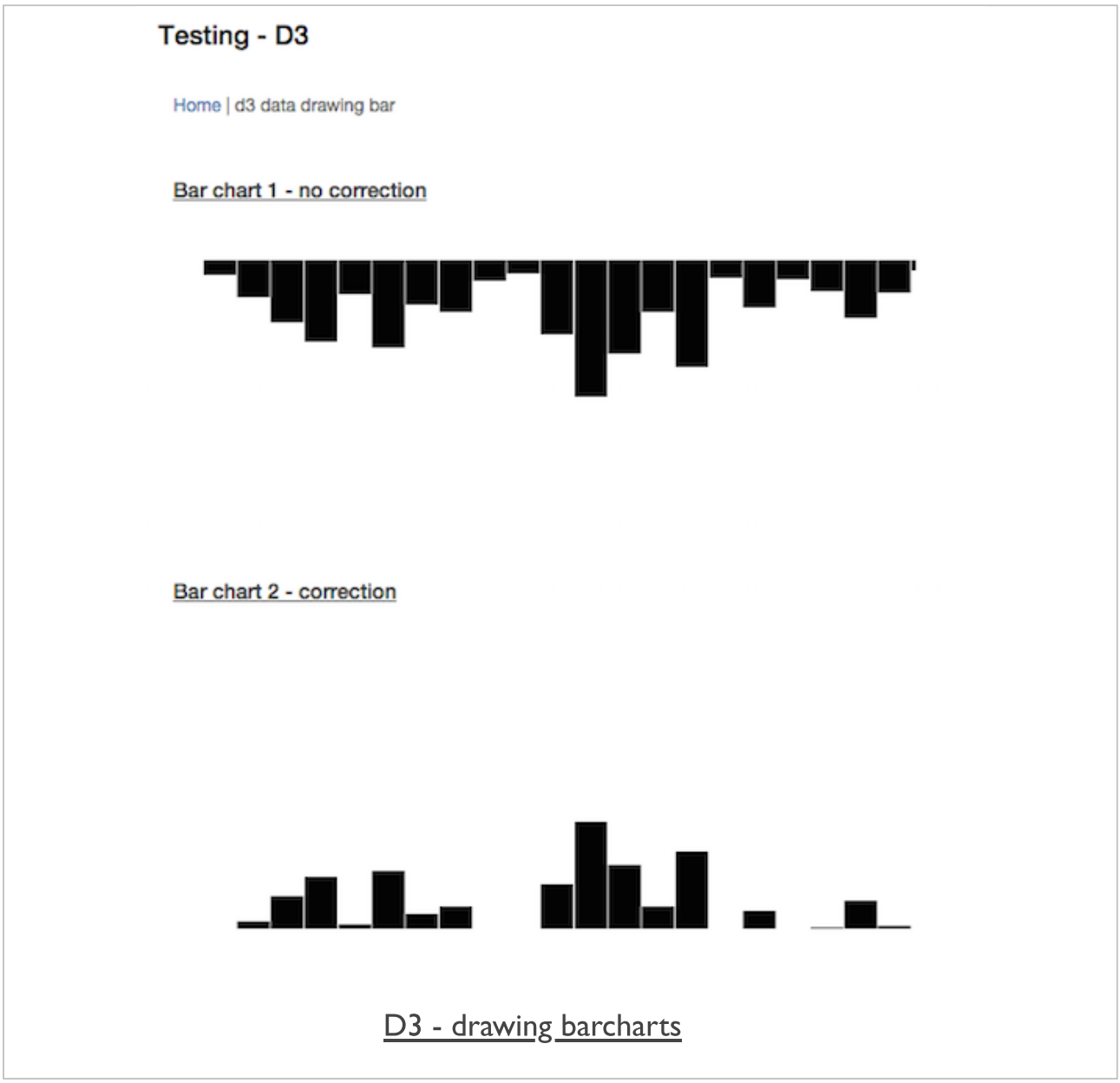
```
.attr("height", function(d) {
    return d * 4;
});
```

- our bar chart will size correctly, albeit from the top down
  - *due to the nature of SVG*
  - *SVG adheres to a top left pattern for rendering shapes*
- to correct this issue
  - *need to calculate the top position of our bars relative to the SVG*
- top of each bar expressed as a relationship
  - *between the height of the SVG and the corresponding data value*

```
.attr("y", function(d) {
    //height minus data value
    return h - d;
})
```

- bar chart will now display correctly from the bottom upwards
- DEMO - Drawing with SVG - barcharts

Image - D3 Barcharts



D3 - drawing barcharts

Data visualisation - D3

Drawing - SVG barchart - part 5

1. add some colour

- adding a colour per bar simply a matter of setting an attribute for the fill colour

```
.attr("fill", "blue");
```

- set many colours using the data itself to determine the colour

```
.attr("fill", function(d) {
    return "rgb(0, 0, " + (d * 10) + ")";
});
```

2. add text labels

- also set dynamic text labels per bar, which reflect the current dataset

```
svg.selectAll("text")
.data(dataset)
.enter()
.append("text")
```

- extend this further by positioning our text labels

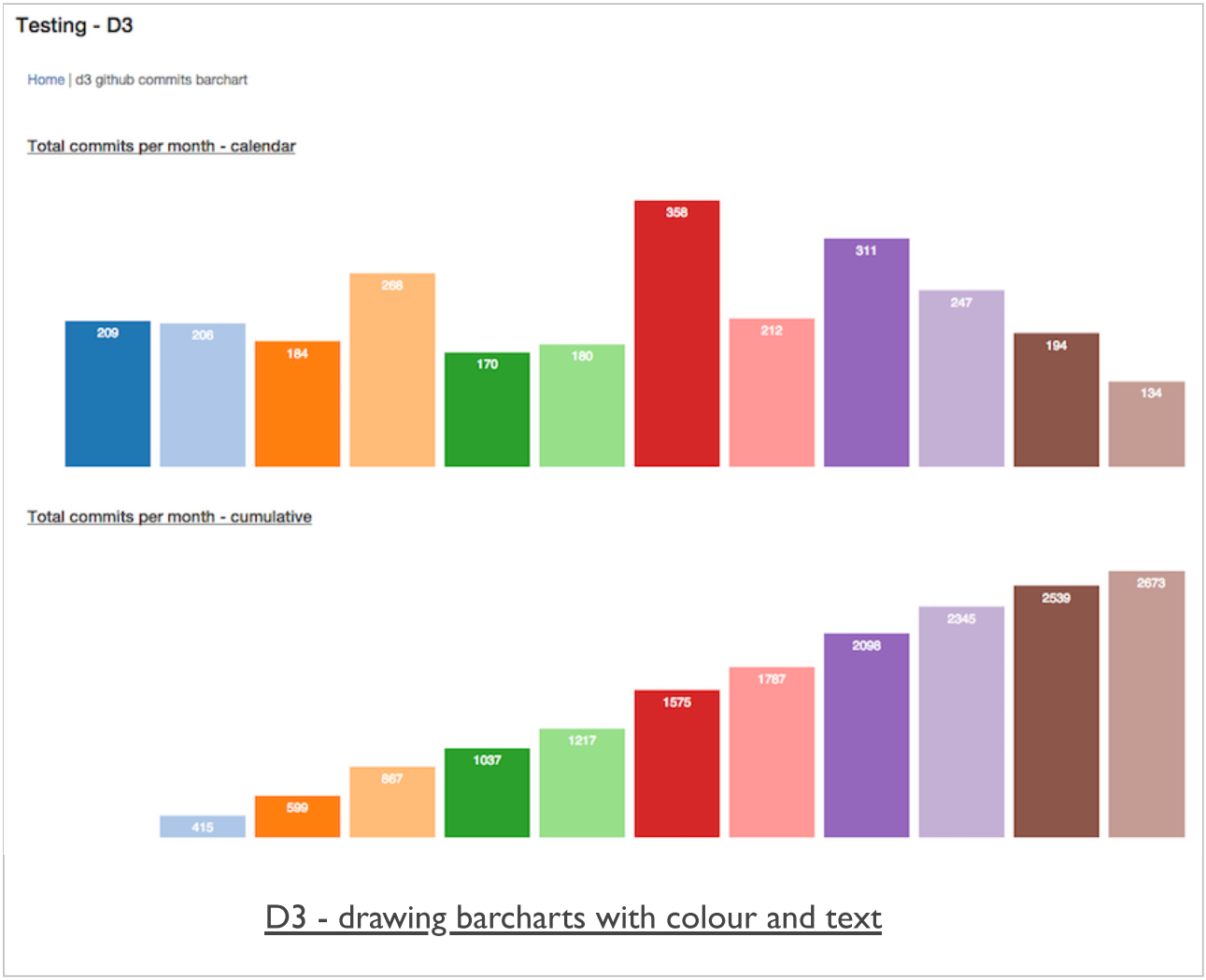
```
.attr("x", function(d, i) {
    return i * (w / dataset.length);
})
.attr("y", function(d, i) {
    return h - (d * 4);
});
```

- then position them relative to the applicable bars, add some styling, colours...

```
.attr("font-family", "sans-serif")
.attr("font-size", "11px")
.attr("fill", "white");
```

- DEMO - Drawing with SVG - barcharts, colour, and text labels

Image - D3 Barcharts



D3 - drawing barcharts with colour and text

Data visualisation - D3

Drawing - add interaction - listeners

- event listeners apply to any DOM element for interaction
  - *from a button to a <p> with the body of a HTML page*

```
<p>this is a HTML paragraph...</p>
```

- add a listener to this DOM element

```
d3.select("p")
    .on("click", function() {
    //do something with the element...
    });
```

- above sample code selects the <p> element
  - *then adds an event listener to that element*
- *event listener* is an anonymous function
  - *listens for `.on` event for a specific element or group of elements*
- in our example,
  - *`on()` function takes two arguments*

Data visualisation - D3

Drawing - add interaction - update visuals

- achieved by combining
  - *event listener*
  - *modification of the visuals relative to changes in data*

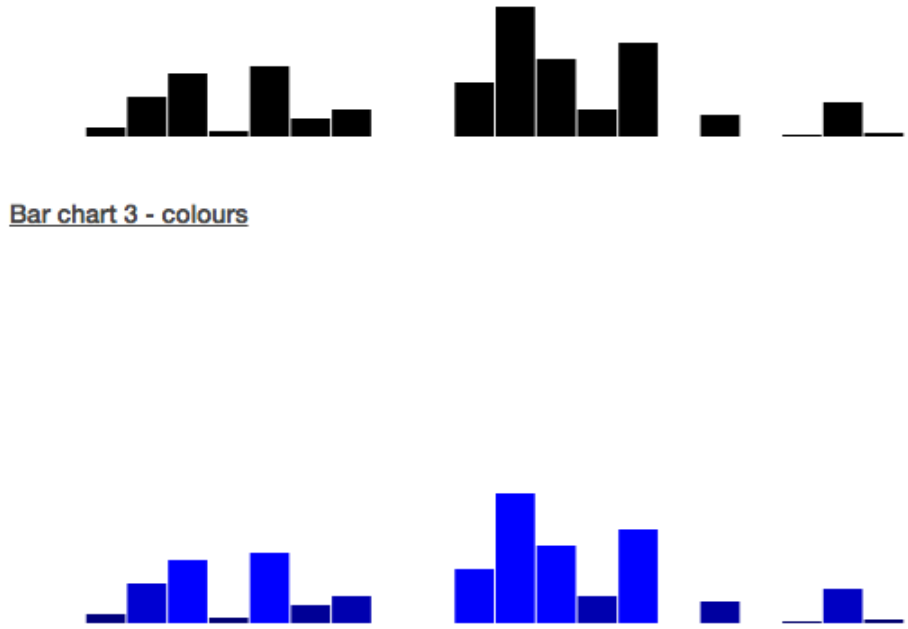
```
d3.select("p")
    .on("click", function() {

    dataset = [....];

    //update all of the rects
    svg.selectAll("rect")
    .data(dataset)
    .attr("y", function(d) {
    return h - yScale(d);
    });
    .attr("height", function(d) {
    return yScale(d);
    });
});
```

- above code triggers a change to visuals for each call to the event listener
- eg: change the colours
  - *add call to `fill()` to update bar colours*

```
.attr("fill", function( d) {
    return "rgb( 0, 0, " + (d * 10) + ")";
});
```

- DEMO - update bar colours

Image - D3 Barcharts



D3 - drawing colour updates for barcharts

Data visualisation - D3

Drawing - add interaction - transitions

- adding a fun transition in D3 is as simple as adding the following,

```
.transition()
```

- add this to above code chain to get a fun and useful transition in the data
- animation reflects the change from the old to the new data
- add a call to the `duration()` function
  - *allows us to specify a time delay for the transition*
  - *quick, slow...we can specify each based upon time*
- chain the `duration()` function after `transition()`

```
.transition().duration(1000)
```

- if we want to specify a constant easing to the transition
  - *use `ease()` with a `linear` parameter*

```
.ease(linear)
```

- other built-in options, including
  - *circle - gradual ease in and acceleration until elements snap into place*
  - *elastic - best described as springy*
  - *bounce - like a ball bouncing, and then coming to rest...*

Data visualisation - D3

Drawing - add interaction - transitions

- add a delay using the `delay()` function

```
.transition()
.delay(1000)
.duration(2000)
```

- also set the `delay()` function dynamically relative to the data,

```
.transition()
.delay( function( d, i) {
return i * 100;
})
.duration( 500)
```

- when passed an anonymous function
  - *datum bound to the current element is passed into `d`*
  - *index position of that element is passed into `i`*
- in the above code example, as D3 loops through each element
  - *delay for each element is set to `i * 100`*
  - *meaning each subsequent element will be delayed 100ms more than preceding element*
- DEMO - transitions - interactive sort

Data visualisation - D3

Drawing - add interaction - adding values and elements

- select all of the bars in our chart
  - *we can rebind the new data to those bars*
  - *and grab the new update as well*

```
var bars = svg.selectAll("rect")
    .data(dataset);
```

- if more new elements, bars in our example, than original length
  - *use `enter()` to create references to those new elements that do not yet exist*
- with these reserved elements
  - *we can use `append()` to add those new elements to the DOM*
  - *now updates our bar chart as well*
- now made the new `rect` elements
  - *need to update all visual attributes for our `rects`*
  - *set x, and y position relative to new dataset length*
  - *set width and height based upon new xScale and yScale*
  - *calculated from new dataset length*

Data visualisation - D3

Drawing - add interaction - removing values and elements

- more DOM elements than provided data values
  - *D3's **exit** selection contains references to those elements without specified data*
  - ***exit** selection is simply accessed using the `exit()` function*
- grab the *exit* selection
- then transition exiting elements off the screen
  - *for example to the right*
- then finally remove it

```
bars.exit()
.transition()
.duration(500)
.attr("x", w)
.remove();
```

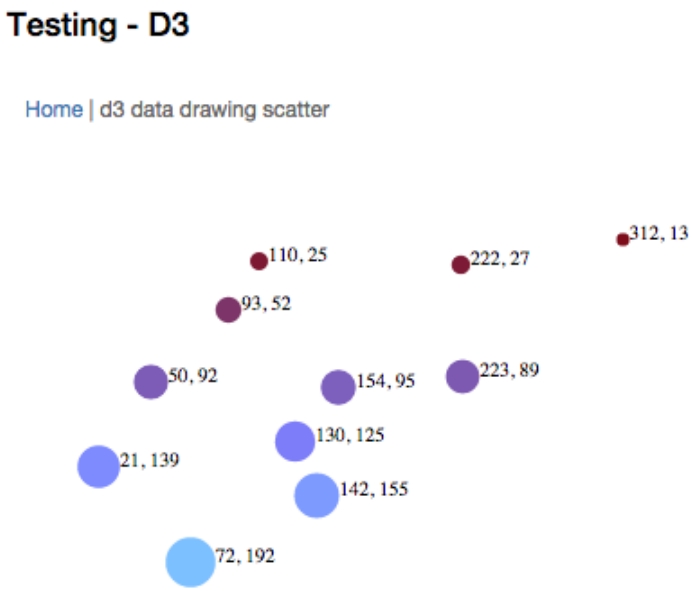
- `remove()` is a special transition method that awaits until transition is complete
- then deletes element from DOM forever
  - *to get it back, we'd need to rebuild it again*

Data visualisation - D3

Drawing - SVG scatterplot - intro

- scatterplot allows us to visualise two sets of values on two different axes
  - *one set of data against another*
- plot one set of data on *x* axis, and the other on the *y* axis
- often create dimensions from our data
  - *helps us define patterns within our dataset*
  - *eg: date against age, or age against fitness...*
- dimensions will also be represented relative to *x* and *y* axes
- create our scatterplot using SVG
  - *add our SVG to a selected element*

Image - D3 Scatterplot



D3 - drawing a basic scatterplot

Data visualisation - D3

Drawing - SVG scatterplot - data

- data for the scatterplot is normally stored as a multi-dimensional representation
  - *comparison x and y points*
- eg: we could store this data in a multi-dimensional array

```
var dataset = [
        [10, 22], [33, 8], [76, 39], [4, 15]
      ];
```

- in such a multi-dimensional array
  - *inner array stores the comparison data points for our scatterplot*
  - *each inner array stores x and y points for scatterplot diagram*
- we can also stroe such data in many different structures
  - *eg: JSON...*

Data visualisation - D3

Drawing - SVG scatterplot - create SVG

- need to create an element for our SVG
  - *allows us to draw and output all of our required shapes*

```
d3.select("body").append("svg");
```

- appends to the body an SVG element
  - *useful to encapsulate this new DOM element within a variable*

```
var svg = d3.select("body").append("svg");
```

- variable effectively works as a reference
  - *points to the newly created SVG object*
  - *allows us to use this reference to access element in the DOM*

Data visualisation - D3

Drawing - SVG scatterplot - build scatterplot

- as with our barchart, we can set the width and height for our scatterplot,

```
//width & height
var w = 750;
var h = 200;
```

- we will need to create circles for use with scatterplot instead of rectangles

```
svg.selectAll('circle')
   .data(dataset)
   .enter()
   .append('circle');
```

- corresponding to drawing circles
  - *set `cx`, the x position value of the centre of the circle*
  - *set `cy`, the y position value of the centre of the circle*
  - *set `r`, the radius of the circle*

Data visualisation - D3

Drawing - SVG scatterplot - adding circles

- draw circles for scatterplot

```
.attr('cx', function(d) {
    return d[0]; //get first index value for inner array
})
.attr('cy', function(d) {
    return d[1]; //get second index value for inner array
})
.attr('r', 5);
```

- outputs simple circle for each inner array within our supplied multi-dimensional dataset
- start to work with creating circle sizes relative to data quantities
- set a dynamic size for each circle
  - *representative of the data itself*
  - *modify the circle's area to correspond to its y value*
- as we create SVG circles, we cannot directly set the area
  - *so we need to calculate the radius* `r`
  - *then modify that for each circle*

Data visualisation - D3

Drawing - SVG scatterplot - calculate dynamic area

- assuming that `d[1]` is the original area value of our circles
  - *get the square root and set the radius for each circle*
- instead of setting each circle's radius as a static value
  - *now use the following*

```
.attr('r', function(d) {
    return Math.sqrt(d[1]);
});
```

- use the JavaScript `Math.sqrt()` function to help us with this calculation

Data visualisation - D3

Drawing - SVG scatterplot - add colour

- as with a barchart
- also set a dynamic colour relative to a circle's data

```
.attr('fill', function (d) {
    return 'rgb(125,' + (d[1]) + ', ' + (d[1] * 2) + ')';
});
```

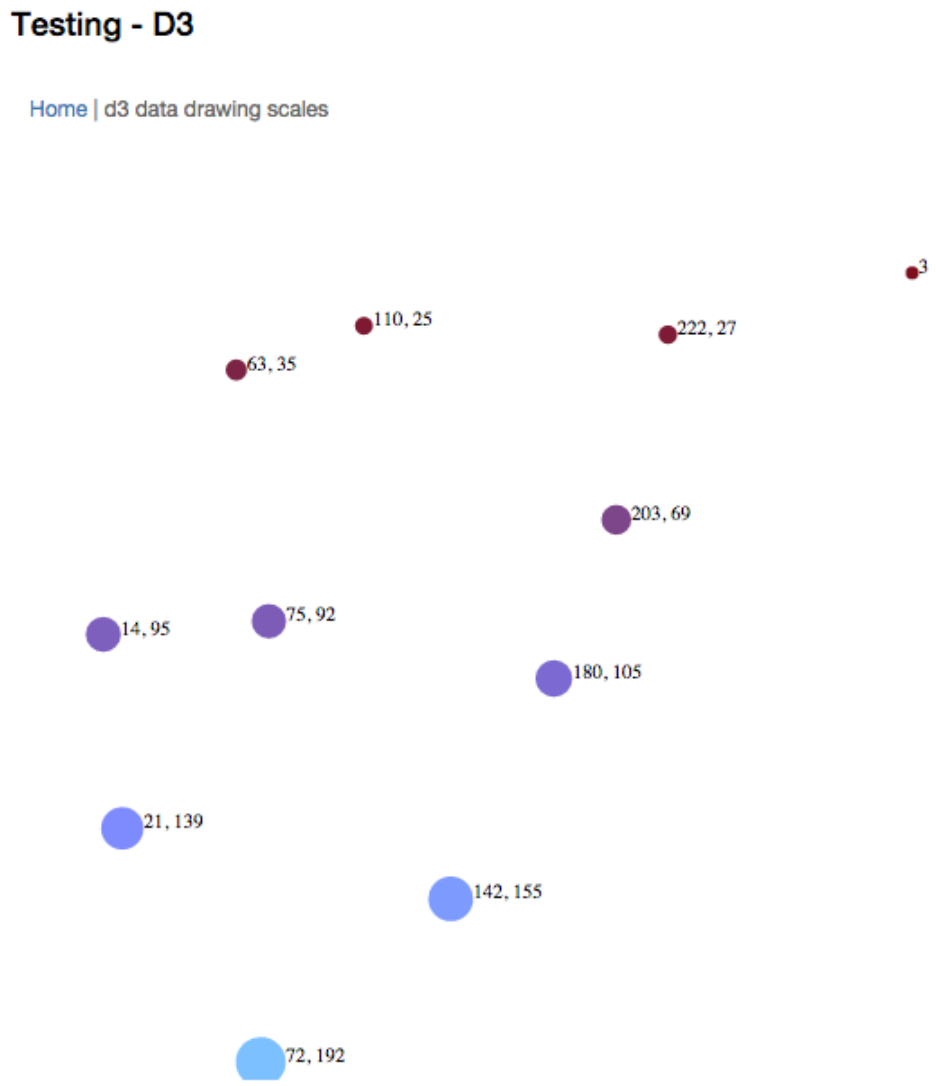
Data visualisation - D3

Drawing - SVG scatterplot - add labels

```
//add labels for each circle
svg.selectAll('text')
   .data(dataset)
   .enter()
   .append('text')
   .text(function(d) {
    return d[0] + ', ' + d[1];//set each data point on the text label
   })
   .attr('x', function(d) {
    return d[0];
   })
   .attr('y', function(d) {
    return d[1];
   })
   .attr('font-family', 'serif')
   .attr('font-size', '12px')
   .attr('fill', 'navy');
```

- start by adding text labels for our data
  - *adding new text elements where they do not already exist*
- then set the text label itself for each circle
  - *using the data values stored in each inner array*
- make the label easier to read
  - *set x and y coordinates relative to data points for each circle*
- set some styles for the labels

Image - D3 Scatterplot



D3 - drawing a basic scatterplot 2

Data visualisation - D3

Drawing - SVG - scales

- in D3, *scales* are defined as follows,

> *"Scales are functions that map from an input domain to an output range"*
>
> *Bostock, M.*

- you can specify your own scale for the required dataset
  - *eg: to avoid massive data values that do not translate correctly to a visualisation*
  - *scale these values to look better within you graphic*
- to achieve this result, you simply use the following pattern.
  - *define the parameters for the scale function*
  - *call the scale function*
  - *pass a data value to the function*
  - *the scale function returns a scaled output value for rendering*
- also define and use as many scale functions as necessary for your visualisation
- important to realise that a scale has no direct relation to the visual output
  - *it is a mathematical relationship*
- need to consider scales and axes
  - *two separate, different concepts relative to visualisations*

Data visualisation - D3

Drawing - SVG - domains and ranges

- *input domain* for a scale is its possible range of input data values
  - *in effect, initial data values stored in your original dataset*
- *output range* is the possible range of output values
  - *normally use as the pixel representation of the data values*
  - *a personal consideration of the designer*
- normally set a minimum and maximum *output range* for our scaled data
- scale function then calculates the scaled output
  - *based upon original data and defined range for scaled output*
- many different types of scale available for use in D3
- three primary types
  - *quantitative*
  - *ordinal*
  - *time*
- *quantitative* scale types also include other built-in scale types
- many methods available for the scale types

Data visualisation - D3

Drawing - SVG - building a scale

- start building our scale in D3
  - *use `d3.scale` with our preferred scale type*

```
var scale = d3.scale.linear();
```

- to use the scale effectively, we now need to set our input domain

```
scale.domain([10, 350]);
```

- then we set the output range for the scale

```
scale.range([1, 100]);
```

- we can also chain these methods together

```
var scale = d3.scale.linear()
          .domain([10, 350])
              .range([1, 100]);
```

Data visualisation - D3

Drawing - SVG - adding dynamic scales

- we could pre-define values for our scale relative to a given dataset
- makes more sense to abstract these values relative to the defined dataset
- we can now use the D3 array functions to help us set these scale values
  - *eg; find highest number in array dataset*

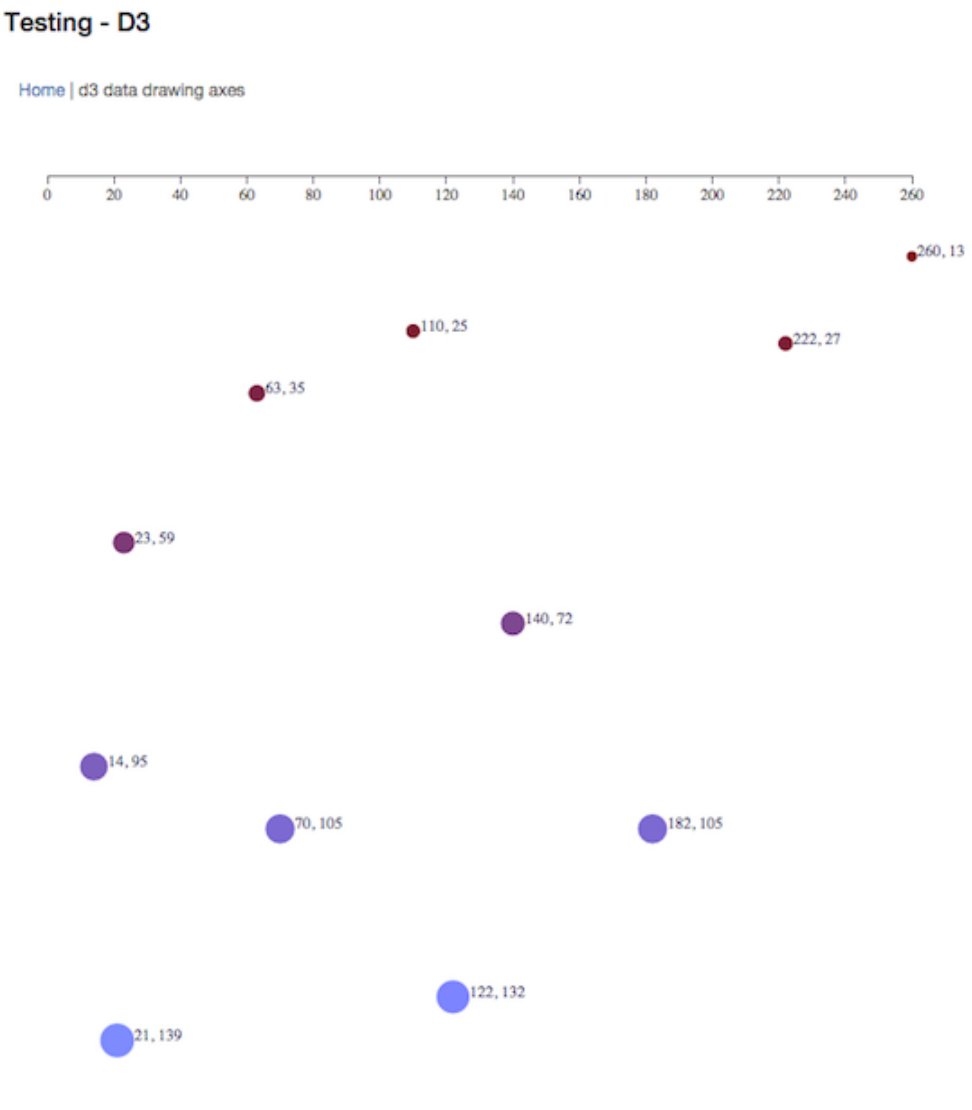
```
d3.max(dataset, function(d) {
    return d[0];
});
```

- returns highest value from the supplied array
- getting minimum value in array works in the same manner
  - *with `d3.min()` being called instead*
- now create a scale function for `x` and `y` axes

```
var scaleX = d3.scale.linear()
        .domain([0, d3.max(dataset, function(d) { return d[0]; })])
        .range([0, w]);//set output range from 0 to width of svg
```

- Y axis scale modifies above code relative to provided data, `d[1]`
  - *range uses height instead of width*
- for a scatterplot we can use these values to set `cx` and `cy` values

Image - D3 Scatterplot



D3 - add axis

Data visualisation - D3

Drawing - SVG - adding dynamic scales

- a few data visualisation examples
- Tests 1
- Tests 2

Data Visualisation

general examples

Sample dashboards and visualisations

- gaming dashboard
- schools and education
- students and grades
- D3 examples

Example datasets

- Chicago data portal

Article example

- dashboard designs
- replace jQuery with D3

projects examples

A few examples from recent projects,

- GitHub API tests
- check JSON return
- early test examples
- metrics test examples

Demos

- D3.js
  - *D3 basic elements*
  - *Drawing with SVG*
  - *Drawing with SVG - barcharts*
  - *Drawing with SVG - barcharts, colour, and text labels*
- MongoDB
- 424-node-mongo1
- Redis
- 424-node-redis1

Resources

- D3.js
  - *D3 - API reference*
  - *D3 - Easing*
  - *D3 - Scales*
  - *D3 - Wiki*
- Kirk, A. *Data Visualisation: A successful design process*. Packt Publishing. 2012.
- MongoDB
- MongoDB - For Giant Ideas
- MongoDB - Getting Started (Node.js driver edition)
- MongoDB - Getting Started (shell edition)
- Mongoose
- MongooseJS Docs
- Node.js
  - *Node.js home*
  - *ExpressJS body-parser*
- Redis
  - *redis.io*
  - *redis commands*
  - *redis - npm*
  - *try redis*
  - *Windows support*
- Various
  - *Create your own AJAX loader*
  - *W3 Selector API*