Comp 324/424 - Client-side Web Design

Spring Semester 2017 - Week 12

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- Data visualisation library - D3.js
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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 `<div>` 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* `<div>` *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 paragraph");
```

- 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(d) { return d; });
```

- 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...

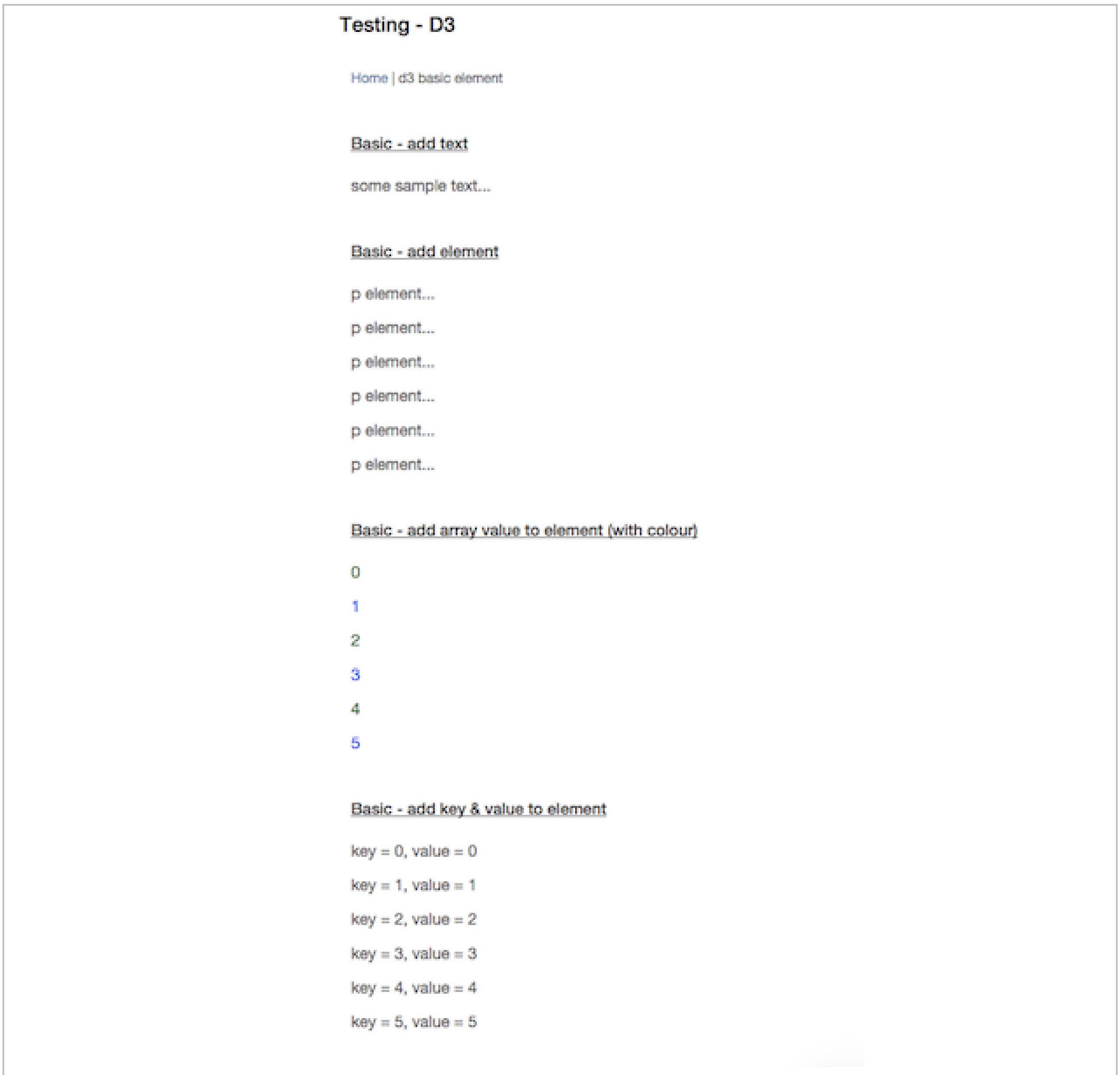
```
.style("color", "blue");
```

- 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



Testing - D3

Home | d3 basic element

Basic - add text

some sample text...

Basic - add element

p element...

p element...

p element...

p element...

p element...

p element...

Basic - add array value to element (with colour)

0

1

2

3

4

5

Basic - add key & value to element

key = 0, value = 0

key = 1, value = 1

key = 2, value = 2

key = 3, value = 3

key = 4, value = 4

key = 5, value = 5

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*

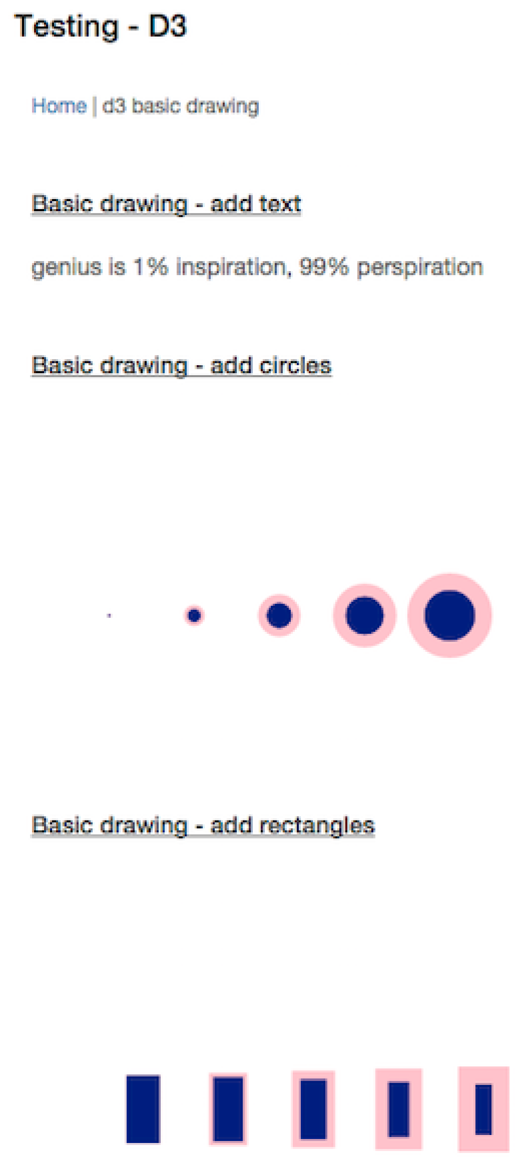
2. create SVG

- 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



Testing - D3

Home | d3 basic drawing

Basic drawing - add text

genius is 1% inspiration, 99% perspiration

Basic drawing - add circles

Basic drawing - add rectangles

D3 - basic drawing

Data visualisation - D3

Drawing - SVG barchart - part I

- 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

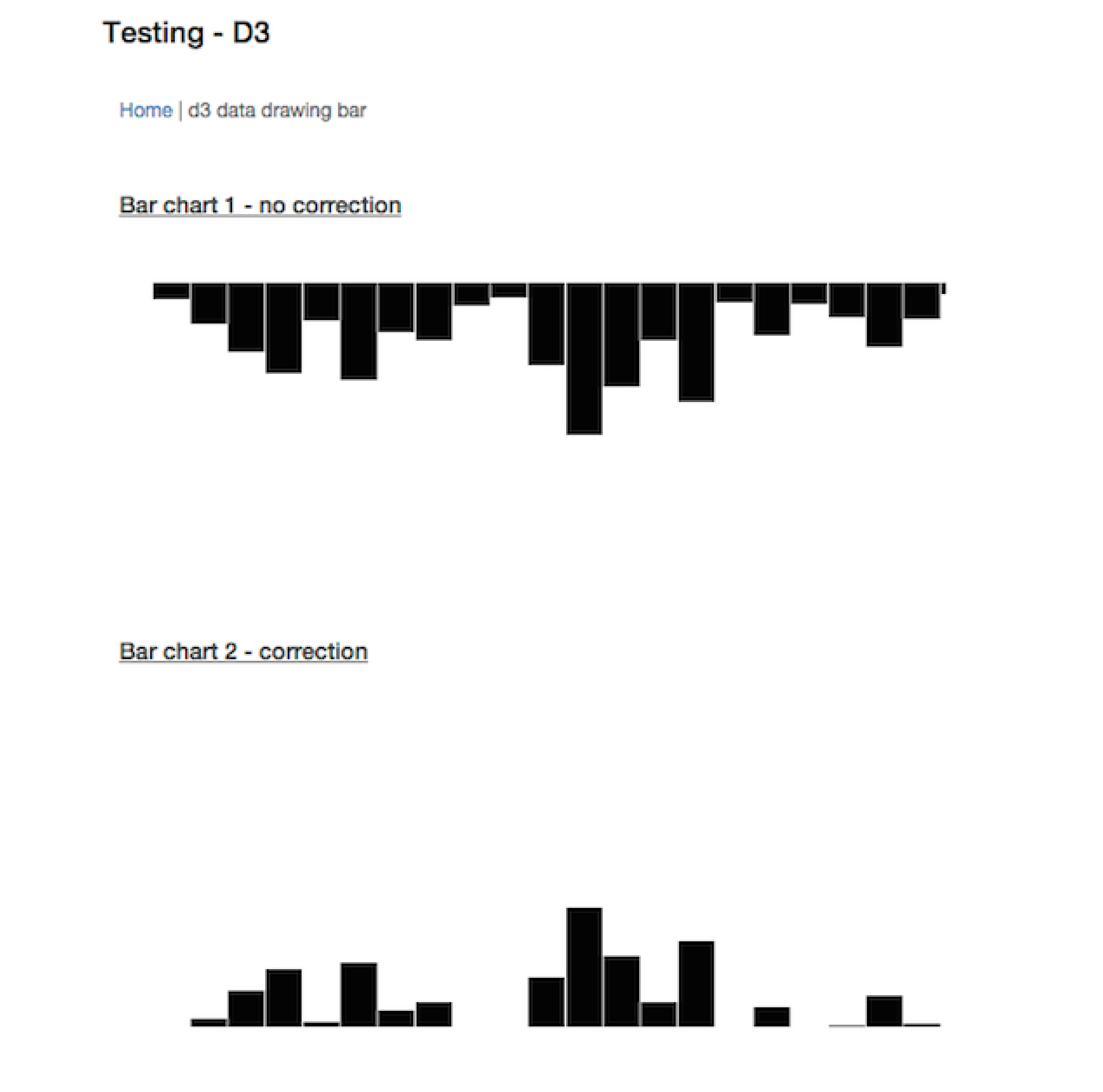
```
.attr("height", function(d) {
    return d * 4;
});
```

- 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



Testing - D3

Home | d3 data drawing bar

Bar chart 1 - no correction

Bar chart 2 - correction

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

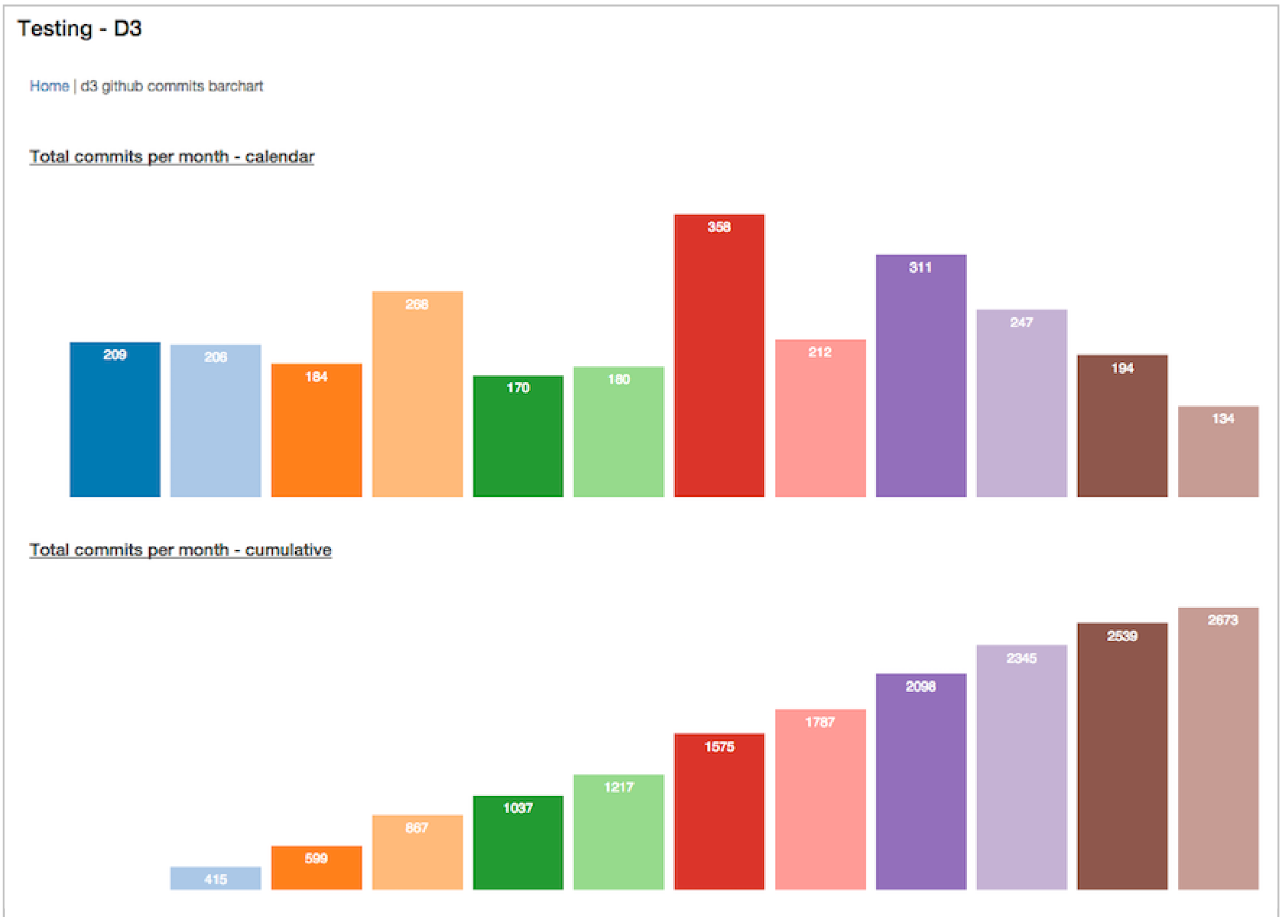
```
.attr("x", function(d, i) {
    return i * (w / dataset.length);
})
.attr("y", function(d, i) {
    return h - (d * 4);
});
```

- 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



Testing - D3

Home | d3 github commits barchart

Total commits per month - calendar

Total commits per month - cumulative

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*

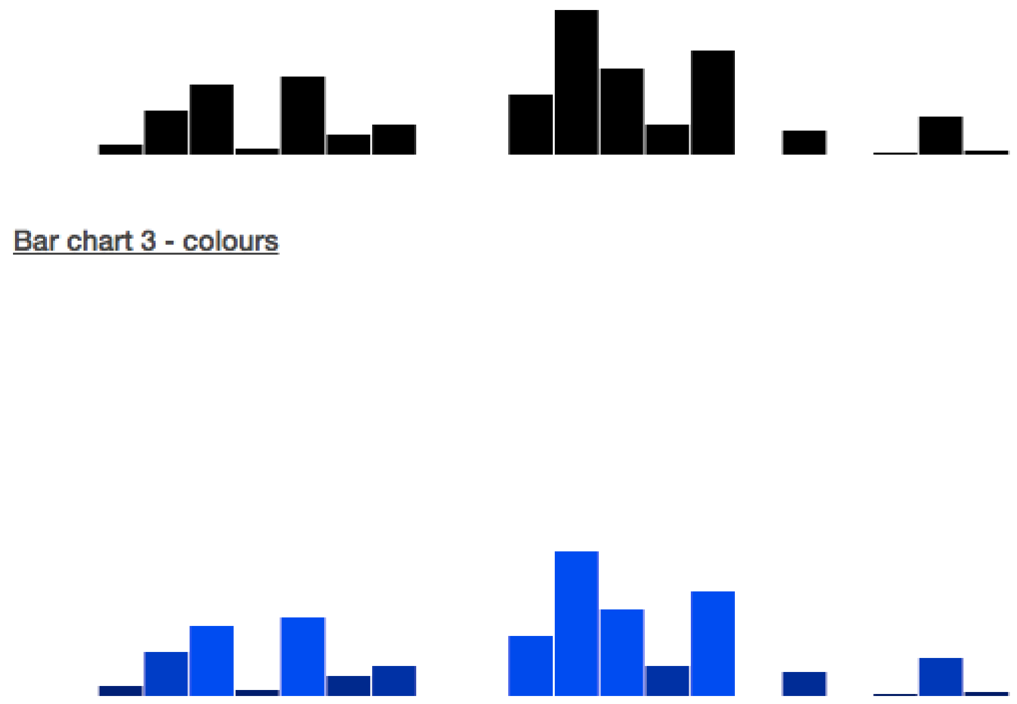
```
d3.select("p")
    .on("click", function() {

    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



Bar chart 3 - colours

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();
```

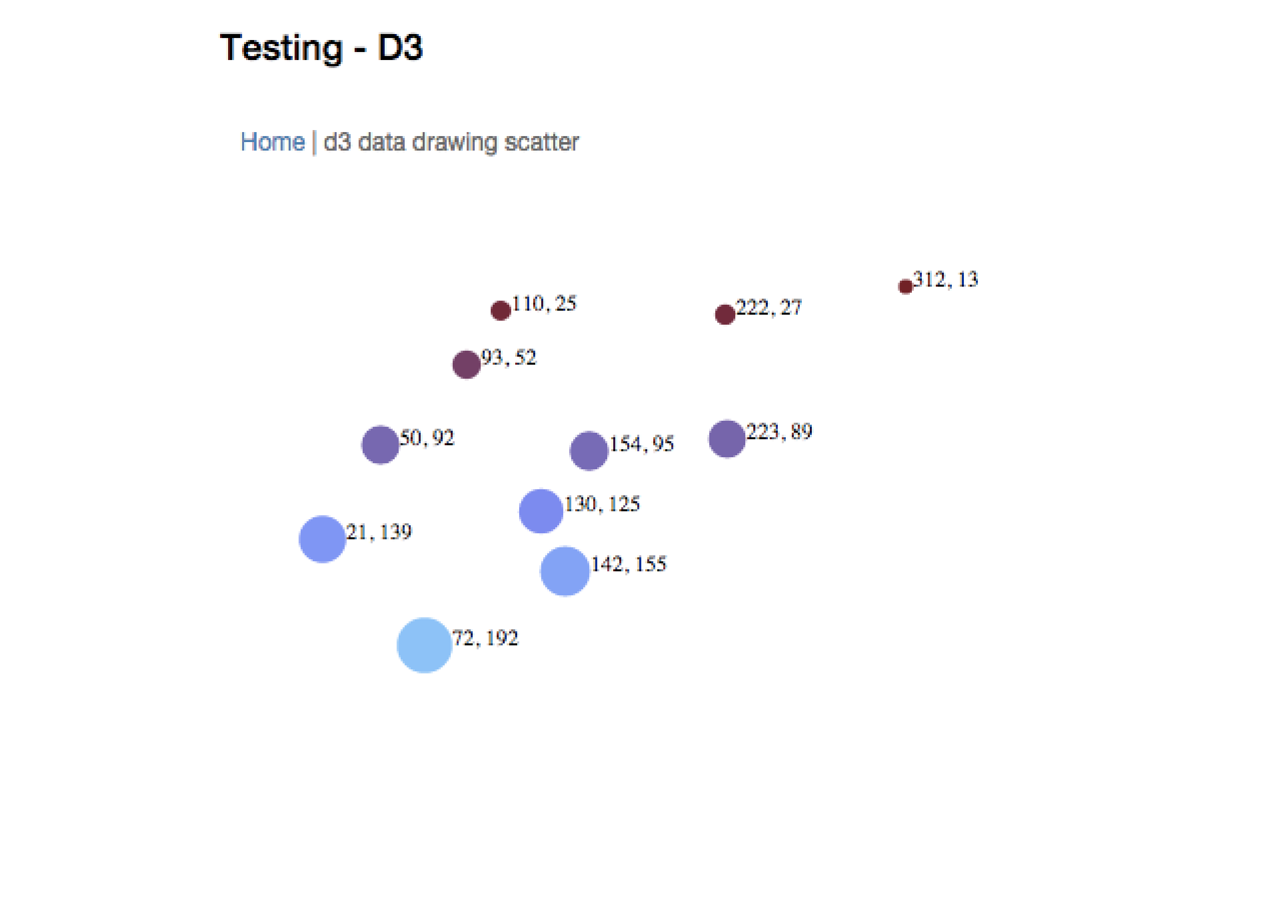
- `remove()` is a special transition method that awaits until transition is complete
- then deletes element from DOM forever
  - *to get it back, we'd need to rebuild it again*

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



Testing - D3

Home | d3 data drawing scatter

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) + ')';
});
```

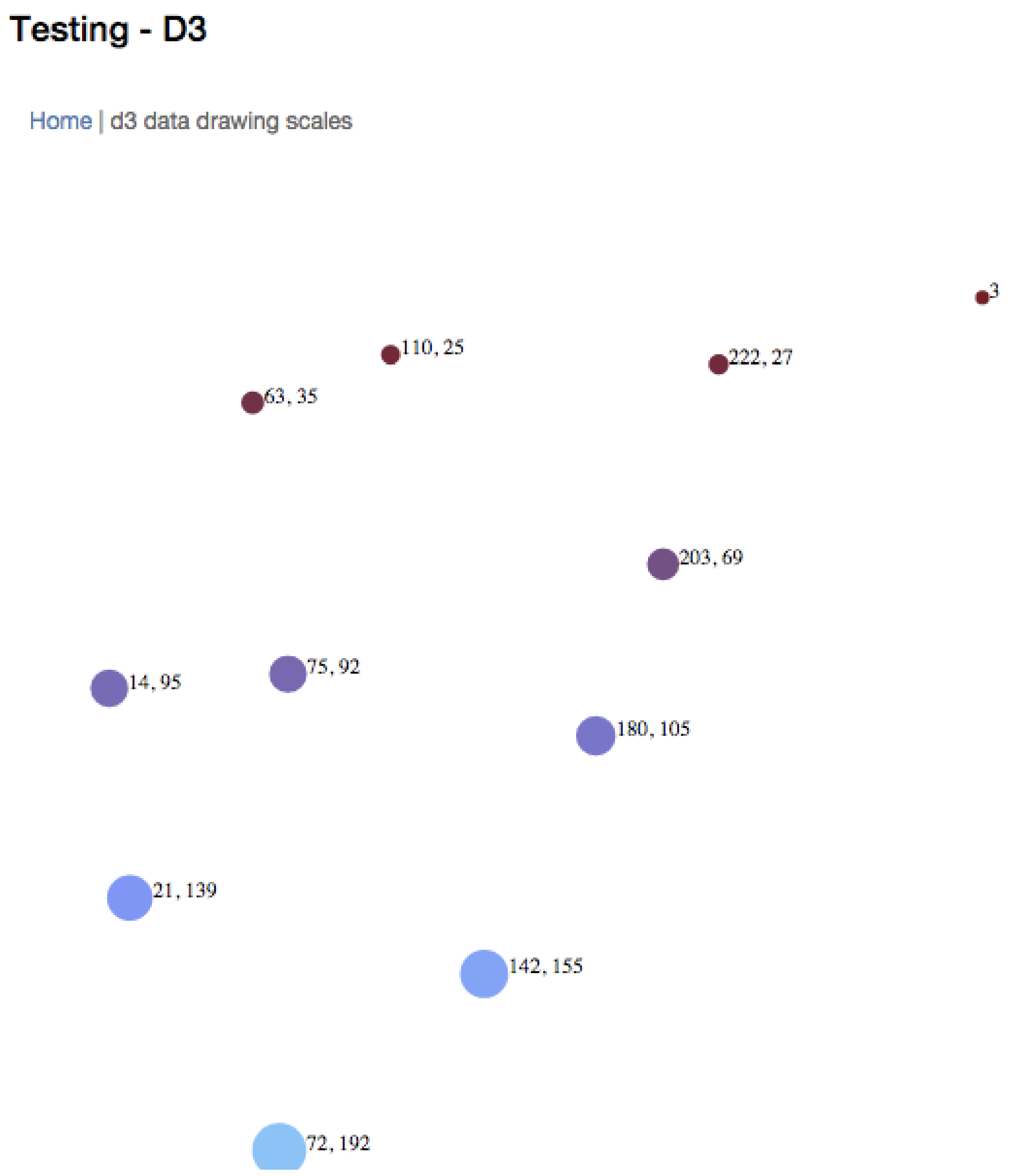
Data visualisation - D3

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



Testing - D3

Home | d3 data drawing scales

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*

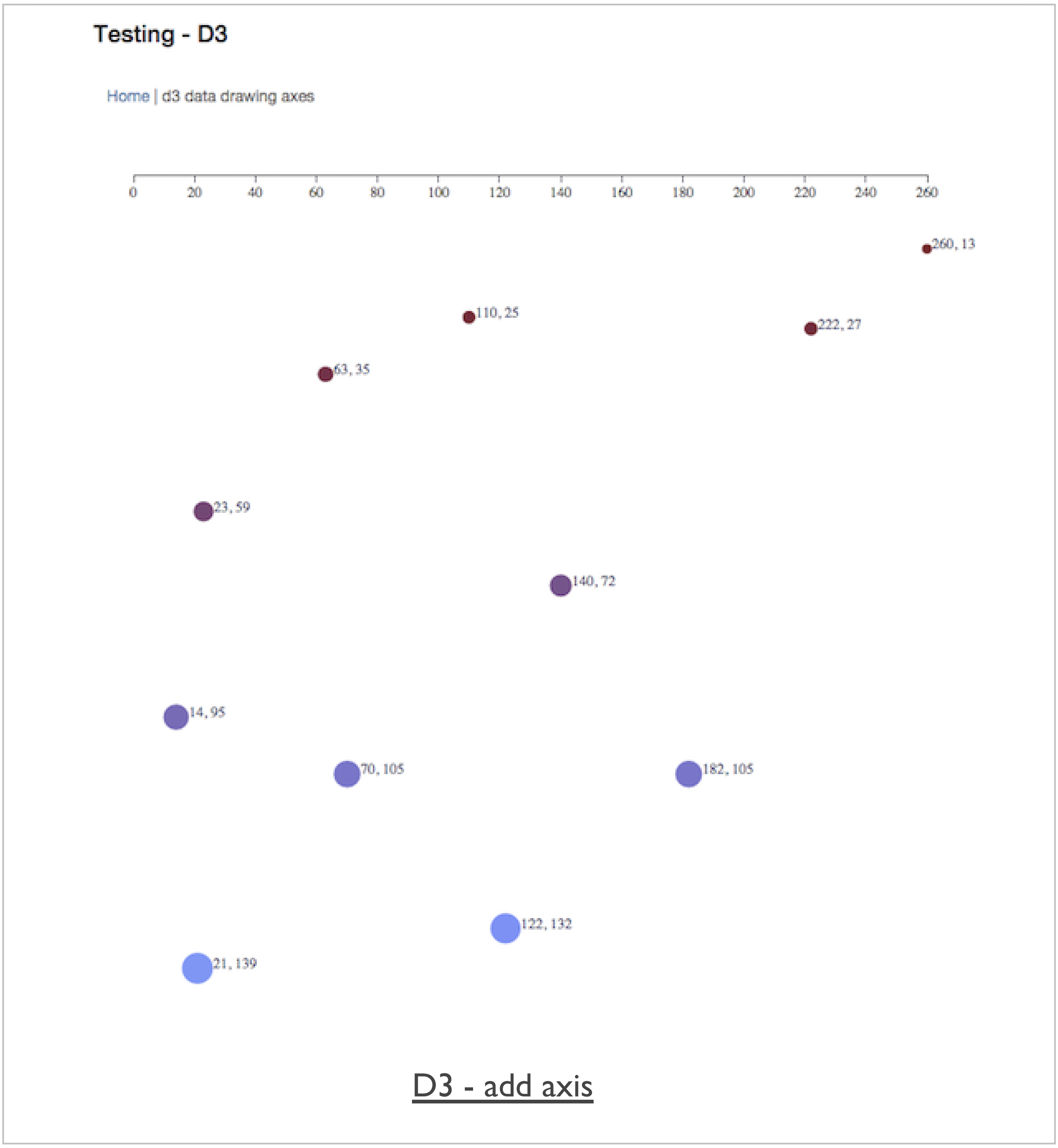
```
d3.max(dataset, function(d) {
    return d[0];
});
```

- 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



Testing - D3

Home | d3 data drawing axes

D3 - add axis

Data visualisation - D3

Drawing - SVG - adding dynamic scales

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

Demos

D3.js

- D3 basic elements
- Drawing with SVG
- Drawing with SVG - barcharts
- Drawing with SVG - barcharts, colour, and text labels

References

- D3.js
  - *D3 - API reference*
  - *D3 - Easing*
  - *D3 - Scales*
  - *D3 - Wiki*
- Homebrew for OS X
  - *Homebrew - the missing package manager for OS X*
- Kirk, A. *Data Visualisation: A successful design process*. Packt Publishing. 2012.
- W3 Selector API