

# Programming with TypeScript and the D3 Library



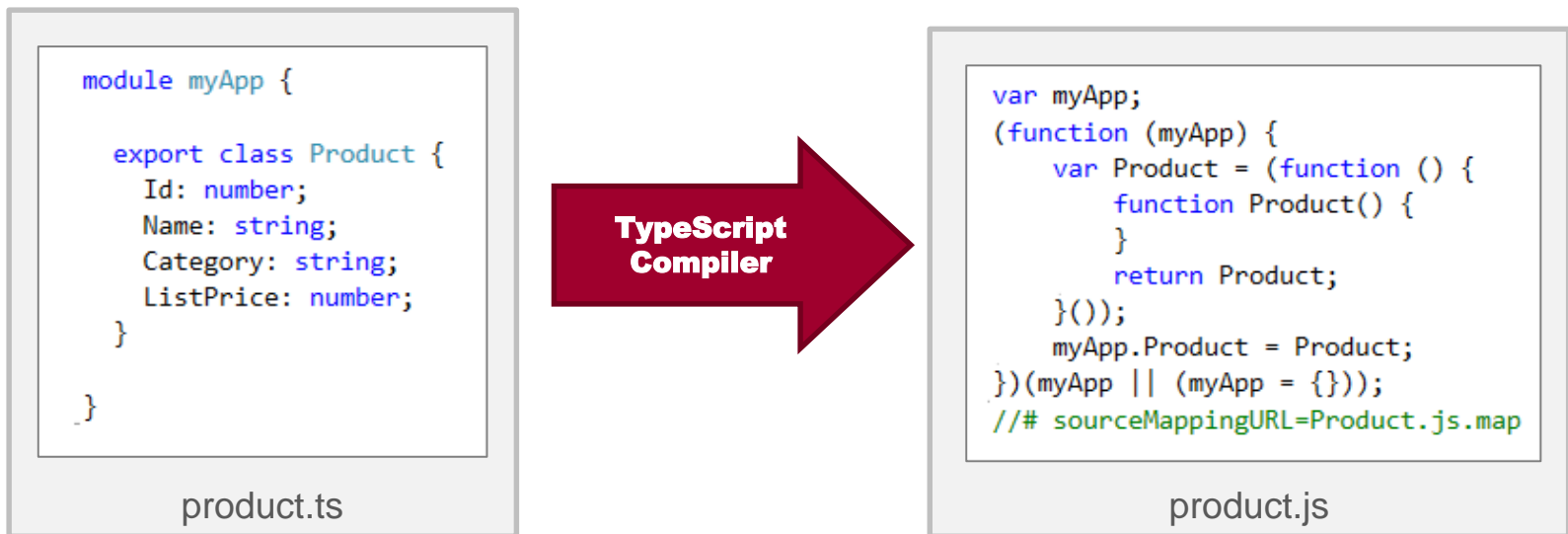
# Agenda

- TypeScript Language Primer
- Getting Started with D3 and SVG Graphics
- Creating Data-driven Visuals
- Enhancing Visuals with Scales and Axes
- Event Handling and Transitions
- Using D3 Layouts



# What is TypeScript?

- A programming language which compiles into plain JavaScript
- A superset of JavaScript that adds a strongly-typed dimension
- It can be compiled into ECMAScript3, ECMAScript3 or ECMAScript 6
- It runs in any browser, in any host and on any OS



# Type Annotation

- TypeScript allows you to annotate types
  - Provides basis for strongly-typed programming
  - Type annotations used by compiler for type checking
  - Type annotations are erased at the end of compile time

```
// define strongly-typed function
var myFunction = function (param1: number): string {
  | return "You passed " + param1;
};

// define strongly-typed variables
var myNumber: number = 2017;
var myMessage: string = myFunction(myNumber);
var myContent: JQuery = $("<p>").text(myMessage);
var contentBox: JQuery = $("#content-box");

contentBox.empty().append(myContent);
```



# Assignment with let versus var

- var does not recognize nor honor scope
- let will recognize and honor scope

```
var x:number = 2016;  
let y: number = 2016;  
  
{  
  var x:number = 2017;  
  let y:number = 2017;  
}  
  
let message = "x=" + x + " and " + "y=" + y;
```



x=2017 and y=2016



# Parameter Arrays

```
// define function with a parameter array using (...) syntax
function createOrderedList(...names: string[]): string{
    let html: string = "<ol>";
    for (let index: number = 0; index < names.length; index++) {
        html += "<li>" + names[index] + "</li>"
    }
    return html += "</ol>";
};

// create a string array
let stooges: string[] = ["Moe", "Curly", "Larry"];

// call function with a parameter array
let stoogesList: string = createOrderedList(...stooges);
```





# Arrow Function Syntax

- TypeScript supports arrow function syntax
  - Concise syntax to define anonymous functions
  - Can be used to retain this pointer in classes

```
// create anonymous function using function arrow syntax
let myFunction = () => {
  console.log("Hello world");
};

// use function arrow syntax with typed parameters
let myOtherFunction = (param1: number, param2: string) : string => {
  return param1 + " - " + param2;
};

// create function to assign to DOM event
window.onresize = (event: Event) => {
  let window: Window = event.target as Window;
  console.log("Window width: " + window.outerWidth);
  console.log("Window height: " + window.outerHeight);
};
```



# Classes

- TypeScript supports defining classes
  - Class defines type for object
  - Export keyword makes class created across files
  - Class can be passed as factory function
  - Default accessibility is public

```
export class Product {  
  Id: number;  
  Name: string;  
  Category: string;  
  ListPrice: number;  
}
```

```
// create new Product instance  
let product1: Product = new Product();  
product1.Id = 1;  
product1.Name = "Batman Action Figure";  
product1.Category = "Action Figure";  
product1.ListPrice = 14.95;
```





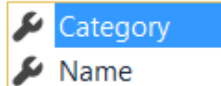
# Class Constructors

- Constructor parameters become fields in class

```
export class Product {  
  
  constructor(private Id: number, public Name: string, public Category: string, private ListPrice: number) {  
    // no need to do anything here  
  }  
  
  MyPublicMethod() {  
    // access to private fields  
    let id: number = this.Id  
    let price: number = this.ListPrice  
  }  
  
}
```

- Client-side code calls constructor using new operator

```
// create new Product instance  
let product1: Product = new Product(1, "Batman Action Figure", "Action Figure", 14.95);  
  
// access public properties  
let product1Name: string = product1.Name;  
let product1Category: string = product1.
```



# Interfaces

- Interface defines a programming contract
  - Classes can implement interfaces

```
export interface IProductDataService {  
  GetAllProducts(): Product[];  
  GetProduct(id: number): Product;  
  AddProduct(product: Product): void;  
  DeleteProduct(id: number): void;  
  UpdateProduct(product: Product): void;  
}
```

```
export class MyProductDataService implements IProductDataService {  
  
  private products: Product[] = [];  
  
  GetAllProducts(): Product[] {  
    return this.products;  
  }  
  
  GetProduct(id: number): Product {  
    return this.products.find(p => p.id === id);  
  }  
  
  AddProduct(product: Product): void {  
    this.products.push(product);  
  }  
  
  DeleteProduct(id: number): void {  
    this.products = this.products.filter(p => p.id !== id);  
  }  
  
  UpdateProduct(product: Product): void {  
    const index = this.products.findIndex(p => p.id === product.id);  
    this.products[index] = product;  
  }  
}
```

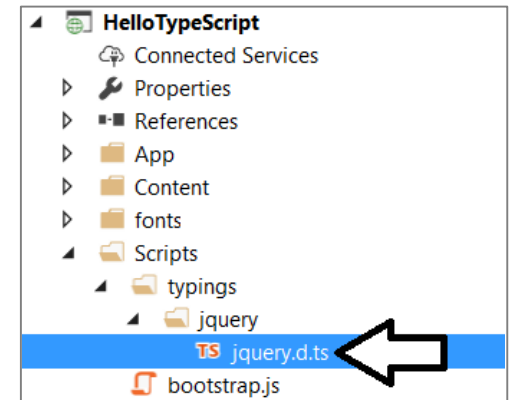
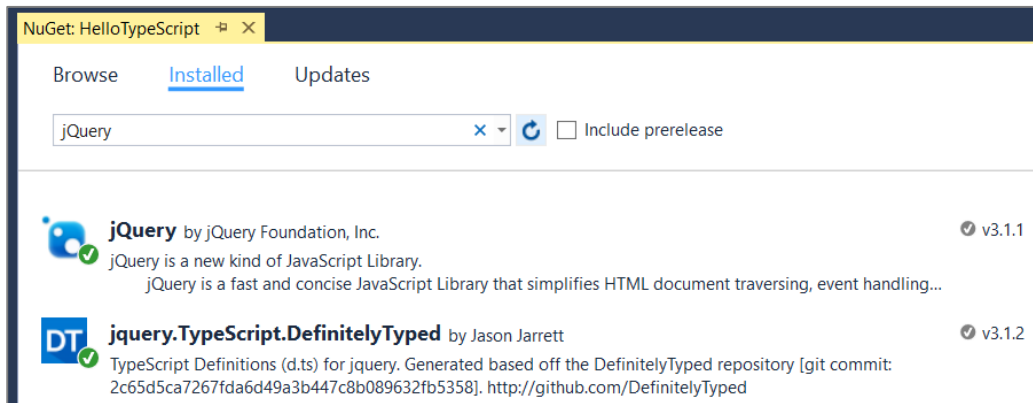
- Client code can be decoupled from concrete classes

```
// program against variables based on interface type  
let productService: IProductDataService = new MyProductDataService();  
  
// client code is decoupled from underlying data access class implementations  
let products: Product[] = productService.GetAllProducts();  
let product1: Product = productService.GetProduct(1);
```



# TypeScript Definition Files (d.ts)

- What are TypeScript definition files
  - Typed definitions for 3rd party JavaScript libraries
  - DefinitelyTyped provides great community resource
  - Typed definition files have a **d.ts** extension



```
// define strongly-typed variables
var myNumber: number = 2017;
var myMessage: string = myFunction(myNumber);
var myContent: JQuery = $("<p>").text(myMessage);
var contentBox: JQuery = $("#content-box");
```



# Interface-based Design

- Interfaces define programming contracts

```
export interface IViewPort {  
  width: number;  
  height: number;  
}
```

```
export interface ICustomVisual {  
  name: string;  
  load(container: HTMLElement): void;  
  update(viewport: IViewPort): void;  
}
```

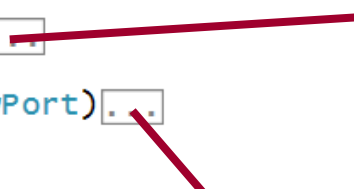
- Application design can use interfaces instead of concrete classes

```
module myApp {  
  
  var leftNavCollapsed: boolean = true;  
  var loadedVisual: ICustomVisual;  
  
  var visuals: ICustomVisual[] = [  
    new Viz01(), new Viz02(), new Viz03(), new Viz04()  
  ];  
  
  function LoadVisual(visual: ICustomVisual) ...  
  
  $(( ) => ...);  
}
```



# Sample Custom Visual using jQuery

```
export class Viz01 implements ICustomVisual {  
    public name: string = "Visual 1: Hello jQuery";  
    private container: JQuery;  
    private message: JQuery;  
  
    load(container: HTMLElement) {  
        ...  
    }  
  
    public update(viewport: IViewport) {  
        ...  
    }  
}
```



```
load(container: HTMLElement) {  
    this.container = $(container);  
    this.message = $("

")  
        .text("Hello jQuery")  
        .css({  
            "display": "table-cell",  
            "text-align": "center",  
            "vertical-align": "middle",  
            "text-wrap": "none",  
            "background-color": "yellow"  
        });  
    this.container.append(this.message);  
}


```

```
public update(viewport: IViewport) {  
    let paddingX: number = 2;  
    let paddingY: number = 2;  
    let fontSizeMultiplierX: number = viewport.width * 0.15;  
    let fontSizeMultiplierY: number = viewport.height * 0.4;  
    let fontSizeMultiplier: number = Math.min(...[fontSizeMultiplierX,  
                                                    fontSizeMultiplierY]);  
  
    this.message.css({  
        "width": viewport.width - paddingX,  
        "height": viewport.height - paddingY,  
        "font-size": fontSizeMultiplier  
    });  
}
```

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# The D3 Library

- What does the D3 library do?
  - Loading data into the browser's memory
  - Binding data to create new set of SVG elements
  - Adding and removing SVG elements as needed
  - Transforming SVG elements by setting properties
  - Transitioning SVG elements in response to user actions

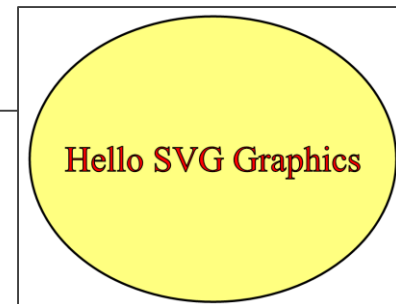




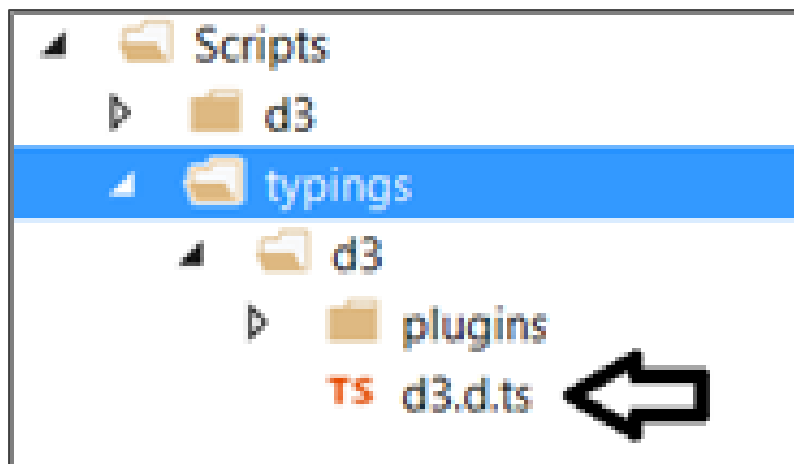
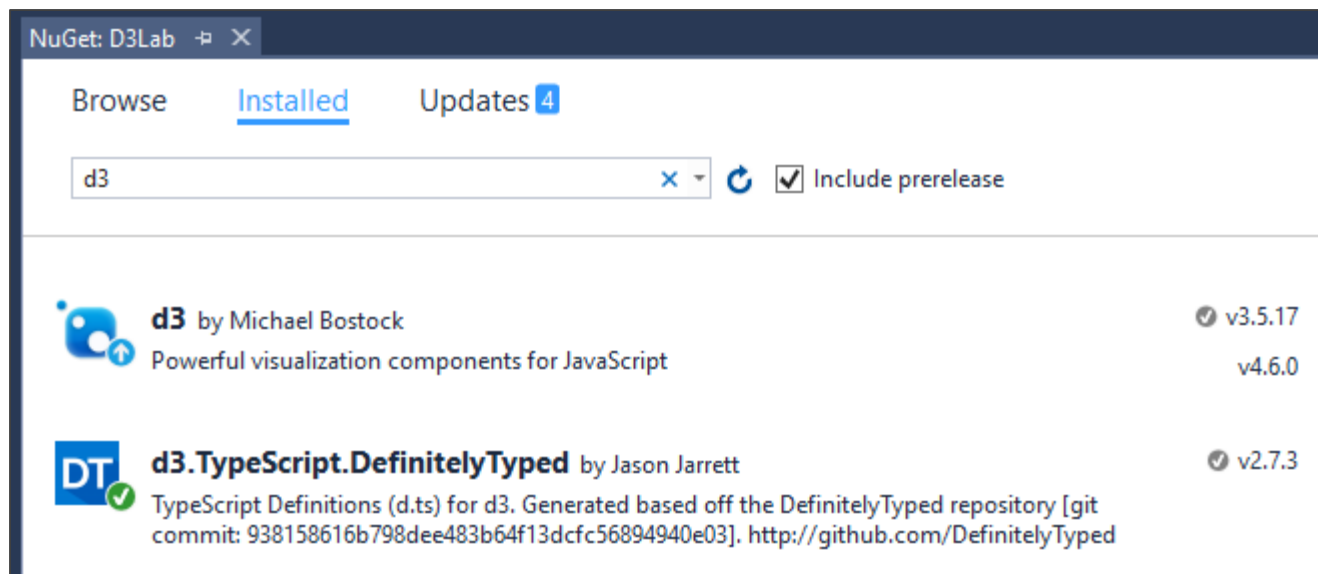
# SVG Graphics

- SVG = Scalable Vector Graphics
  - Specialized type of HTML element
  - More reliable and consistent than other HTML elements

```
<svg width="700" height="550">
  <ellipse cx="350" cy="275" rx="330" ry="256"
    style="fill: rgba(255, 255, 0, 0.498039);
    stroke: rgb(0, 0, 0); stroke-width: 4;">
  </ellipse>
  <text x="350" y="275" width="660" height="512" font-size="132"
    text-anchor="middle" dominant-baseline="central"
    style="fill: rgb(255, 0, 0); stroke: rgb(0, 0, 0); stroke-width: 2;">
    Hello SVG Graphics
  </text>
</svg>
```

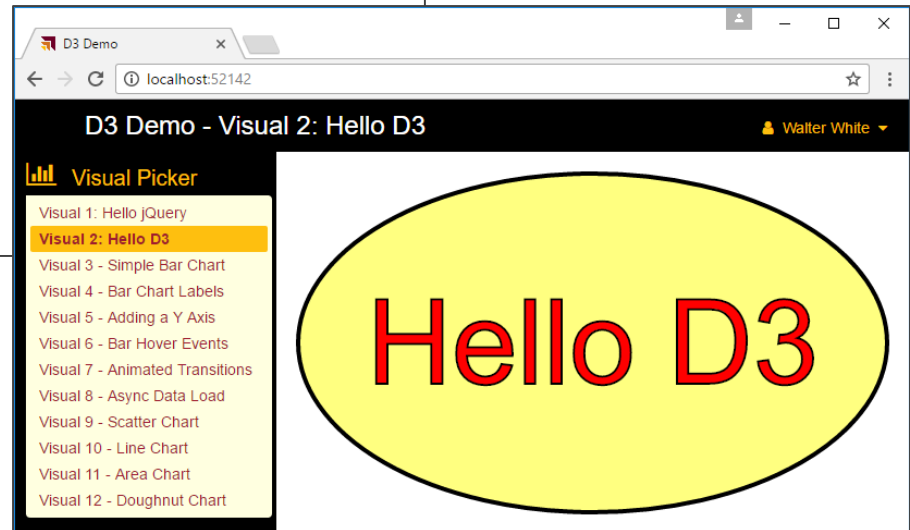


# Adding d3 and d3 typings files



# Designing a D3 Custom Visual

```
export class Viz02 implements ICustomVisual {  
  
  name = "Visual 2: Hello D3";  
  
  private svgRoot: d3.selection<SVGElementInstance>;  
  private ellipse: d3.selection<SVGElementInstance>;  
  private text: d3.selection<SVGElementInstance>;  
  private padding: number = 20;  
  
  load(container: HTMLElement) ...  
  
  update(viewport: IViewport) ...  
  
}
```



# Implementing load

```
load(container: HTMLElement) {  
  this.svgRoot = d3.select(container).append("svg");  
  
  this.ellipse = this.svgRoot.append("ellipse")  
    .style("fill", "rgba(255, 255, 0, 0.5)")  
    .style("stroke", "rgba(0, 0, 0, 1.0)")  
    .style("stroke-width", "4");  
  
  this.text = this.svgRoot.append("text")  
    .text("Hello D3")  
    .attr("text-anchor", "middle")  
    .attr("dominant-baseline", "central")  
    .style("fill", "rgba(255, 0, 0, 1.0)")  
    .style("stroke", "rgba(0, 0, 0, 1.0)")  
    .style("stroke-width", "2");  
}
```



Hello D3



# Implementing update

```
update(viewport: IViewport) {  
  
  this.svgRoot  
    .attr("width", viewport.width)  
    .attr("height", viewport.height);  
  
  var plot = {  
    xoffset: this.padding,  
    yoffset: this.padding,  
    width: viewport.width - (this.padding * 2),  
    height: viewport.height - (this.padding * 2),  
  };  
  
  this.ellipse  
    .attr("cx", plot.xoffset + (plot.width * 0.5))  
    .attr("cy", plot.yoffset + (plot.height * 0.5))  
    .attr("rx", (plot.width * 0.5))  
    .attr("ry", (plot.height * 0.5))  
  
  var fontSizeForWidth: number = plot.width * .20;  
  var fontSizeForHeight: number = plot.height * .35;  
  var fontSize: number = d3.min([fontSizeForWidth, fontSizeForHeight]);  
  
  this.text  
    .attr("x", plot.xoffset + (plot.width / 2))  
    .attr("y", plot.yoffset + (plot.height / 2))  
    .attr("width", plot.width)  
    .attr("height", plot.height)  
    .attr("font-size", fontSize);  
}
```



Hello D3



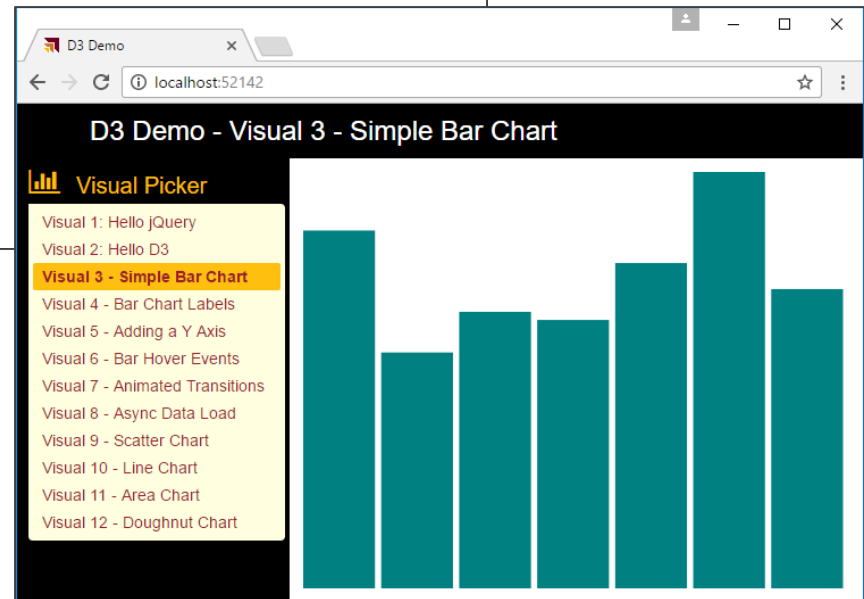
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# Designing a D3 Visual with a Bar Chart

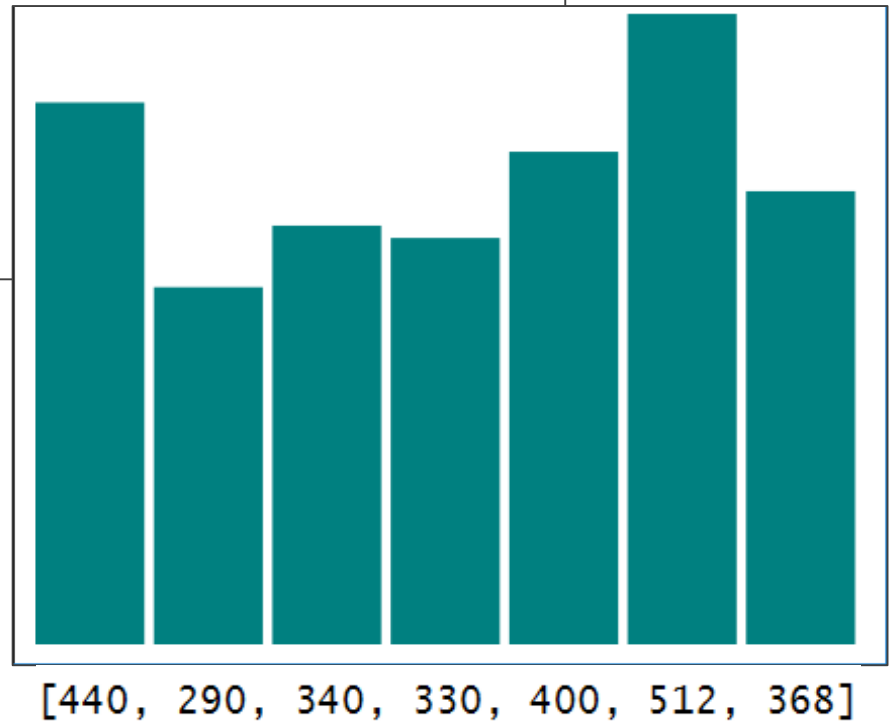
```
export class Viz03 implements ICustomVisual {  
    name = "Visual 3 - Simple Bar Chart";  
  
    private dataset = [440, 290, 340, 330, 400, 512, 368];  
  
    private svgRoot: d3.Selection<SVGElementInstance>;  
    private bars: d3.Selection<number>;  
    private padding: number = 12;  
  
    load(container: HTMLElement) ...  
    update(viewport: IViewport) ...  
}
```





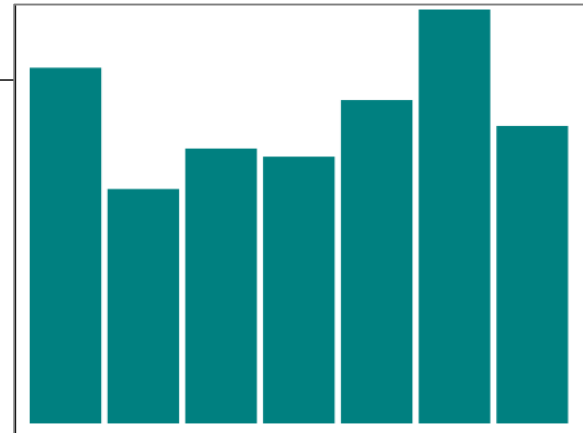
# Implementing load

```
load(container: HTMLElement) {  
  this.svgRoot = d3.select(container).append("svg");  
  this.bars = this.svgRoot  
    .selectAll("rect")  
    .data(this.dataset)  
    .enter()  
    .append("rect");  
}
```



# Implementing update

```
update(viewport: IViewport) {  
  this.svgRoot  
    .attr("width", viewport.width)  
    .attr("height", viewport.height);  
  
  var plot = {  
    xOffset: this.padding,  
    yOffset: this.padding,  
    width: viewport.width - (this.padding * 2),  
    height: viewport.height - (this.padding * 2),  
  };  
  
  var datasetSize = this.dataset.length;  
  var xScaleFactor = plot.width / datasetSize;  
  var yScaleFactor = plot.height / d3.max(this.dataset);  
  var barWidth = (plot.width / datasetSize) * 0.92;  
  
  this.bars  
    .attr("x", (d, i) => { return plot.xOffset + (i * (xScaleFactor)); })  
    .attr("y", (d, i) => { return plot.yOffset + plot.height - (Number(d) * yScaleFactor); })  
    .attr("width", (d, i) => { return barWidth; })  
    .attr("height", (d, i) => { return (Number(d) * yScaleFactor); })  
    .attr("fill", "teal");  
}
```

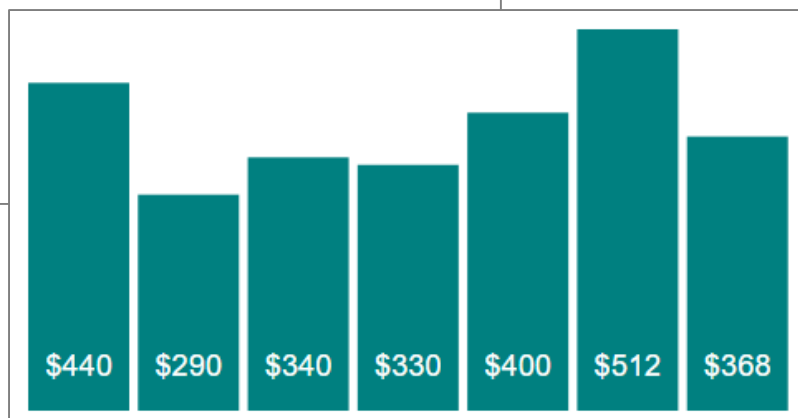


[440, 290, 340, 330, 400, 512, 368]



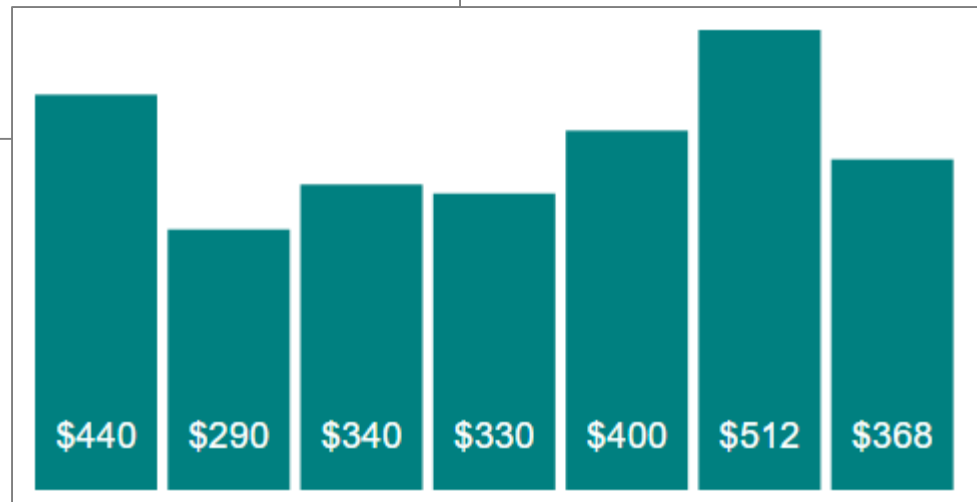
# Adding Labels to the Bar Chart

```
export class Viz04 implements ICustomVisual {  
  name = "Visual 4 - Bar Chart Labels";  
  private dataset = [440, 290, 340, 330, 400, 512, 368];  
  private svgRoot: d3.Selection<SVGElementInstance>;  
  private bars: d3.Selection<number>;  
  private labels: d3.Selection<number>;  
  private padding: number = 12;  
  
  load(container: HTMLElement) ...  
  update(viewport: IViewport) ...  
}
```

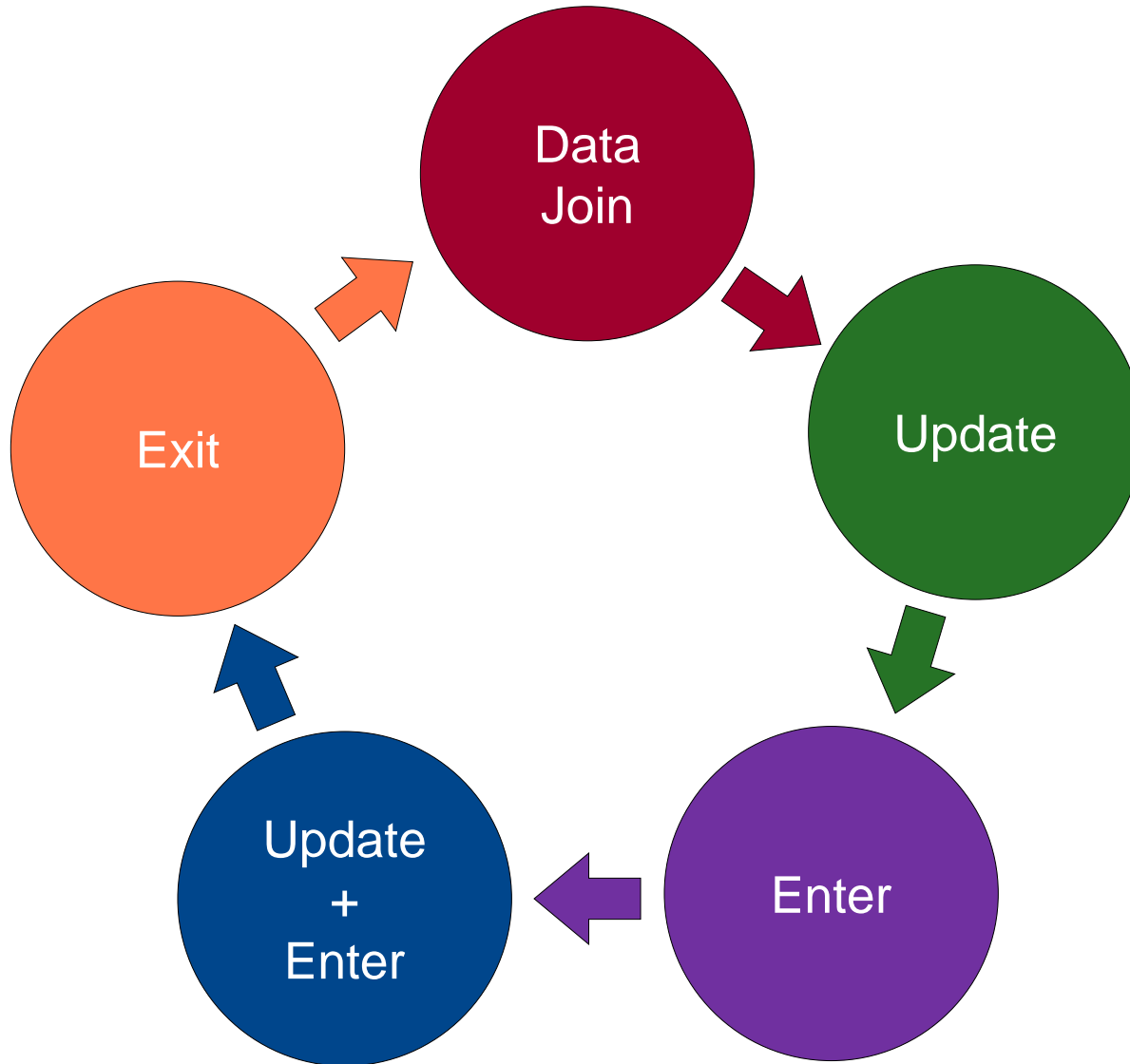


# Implementing load

```
load(container: HTMLElement) {  
  this.svgRoot = d3.select(container).append("svg");  
  
  this.bars = this.svgRoot  
    .selectAll("rect")  
    .data(this.dataset)  
    .enter()  
    .append("rect");  
  
  this.labels = d3.select("svg").selectAll("text")  
    .data(this.dataset)  
    .enter()  
    .append("text");  
}
```



# D3 Update Pattern



# D3 Update Pattern Details

- D3 Data Operator provides 3 virtual selections
  - Three sections include Update, Enter and Exit

```
// update => d3.selection.data(...);  
// enter  => d3.selection.data(...).enter();  
// exit   => d3.selection.data(...).exit();
```

- Update selection contains all of the existing DOM elements that had their data attributes updated
- Enter selection contains placeholder elements for data not yet bound to DOM elements
- Exit selection contains all of the existing DOM elements which did not have their data attributes updated



# Generating Labels in update

```
var yTextOffset = (d3.min(this.dataset) * yScaleFactor) * 0.2;
var textSize = (barWidth * 0.3) + "px";

this.labels.text((d, i) => { return "$" + d; })
  .attr("x", (d, i) => { return plot.xOffset + (i * (xScaleFactor)) + (barWidth / 2); })
  .attr("y", (d, i) => { return plot.yOffset + plot.height - yTextOffset; })
  .attr("fill", "white")
  .attr("font-size", textSize)
  .attr("text-anchor", "middle")
  .attr("alignment-baseline", "middle");
```





# Agenda

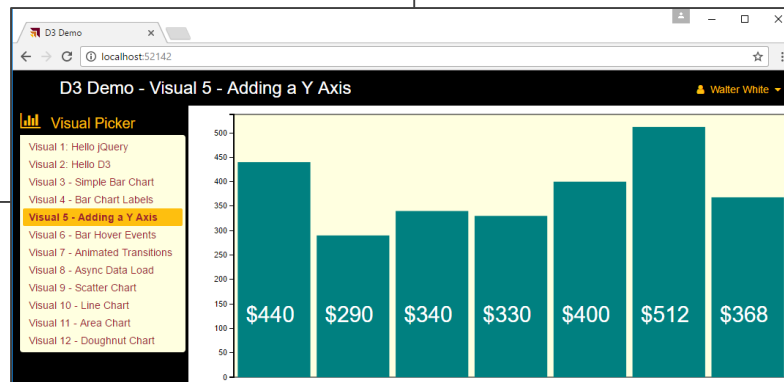
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# Adding a Scale and an Axis

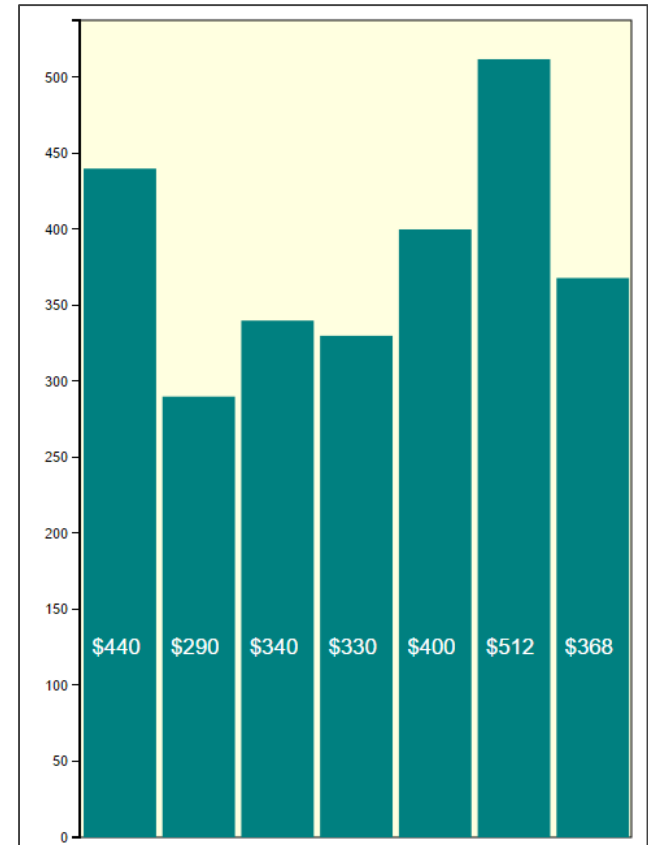
- **Scale** is a function that maps input domain to output range
- **Axis** is a function used to generate the HTML elements of visual axis

```
export class Viz05 implements ICustomVisual {  
    name = "Visual 5 - Adding a Y Axis";  
  
    private dataset = [440, 290, 340, 330, 400, 512, 368];  
  
    private svgRoot: d3.Selection<SVGELEMENT>;  
    private plotArea: d3.Selection<SVGELEMENT>;  
    private axisGroup: d3.Selection<SVGELEMENT>;  
    private bars: d3.Selection<number>;  
    private labels: d3.Selection<number>;  
    private padding: number = 12;  
    private xAxisOffset: number = 50;  
    private yScale: d3.scale.Linear<number, number>;  
    private yAxis: d3.svg.Axis;  
  
    load(container: HTMLElement) ...  
    update(viewport: IViewport) ...  
}
```



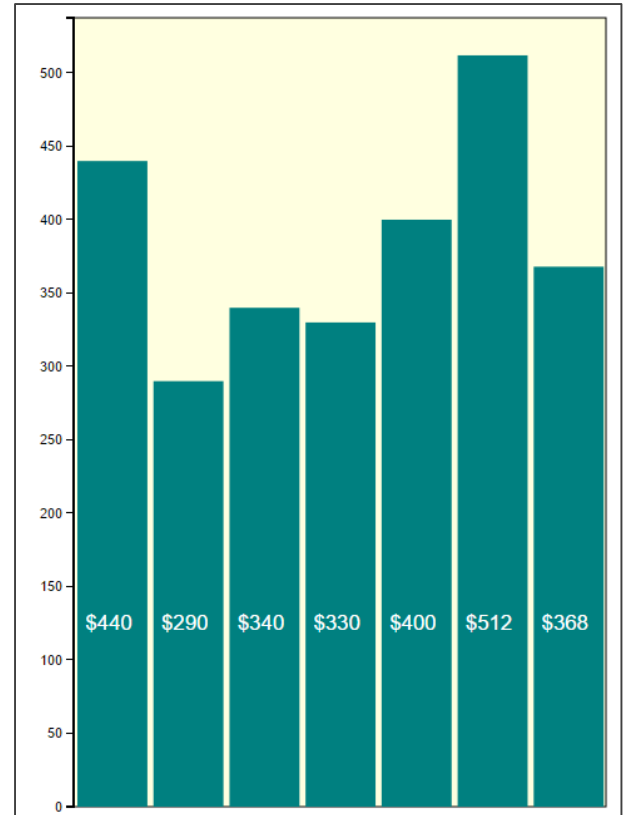
# Implementing load

```
load(container: HTMLElement) {  
  this.svgRoot = d3.select(container).append("svg");  
  
  this.plotArea = this.svgRoot.append("rect")  
    .attr("fill", "lightyellow")  
    .attr("stroke", "black")  
    .attr("stroke-width", 1);  
  
  this.bars = this.svgRoot.append("g")  
    .selectAll("rect")  
    .data(this.dataset)  
    .enter()  
    .append("rect");  
  
  this.labels = this.svgRoot  
    .selectAll("text")  
    .data(this.dataset)  
    .enter()  
    .append("text");  
  
  this.axisGroup = this.svgRoot.append("g");  
  this.yScale = d3.scale.linear();  
  this.yAxis = d3.svg.axis();  
}
```



# Implementing update (part 1)

```
update(viewport: IViewport) {  
  
  this.svgRoot  
    .attr("width", viewport.width)  
    .attr("height", viewport.height);  
  
  var plot = {  
    xOffset: this.padding + this.xAxisOffset,  
    yOffset: this.padding,  
    width: viewport.width - this.xAxisOffset - (this.padding * 2),  
    height: viewport.height - (this.padding * 2),  
  };  
  
  var yDomainStart: number = d3.max(this.dataset) * 1.05;  
  var yDomainStop: number = 0;  
  var yRangeStart: number = 0;  
  var yRangeStop: number = plot.height;  
  
  this.yScale  
    .domain([yDomainStart, yDomainStop])  
    .range([yRangeStart, yRangeStop]);  
  
  var datasetSize = this.dataset.length;  
  var xScaleFactor = plot.width / datasetSize;  
  var barXStart = (plot.width / datasetSize) * 0.05;  
  var barWidth = (plot.width / datasetSize) * 0.92;  
  var yScaleFactor = plot.height / d3.max(this.dataset);  
  
  // to be continued...  
}
```



# Implementing update (part 2)

```
// to be continued...

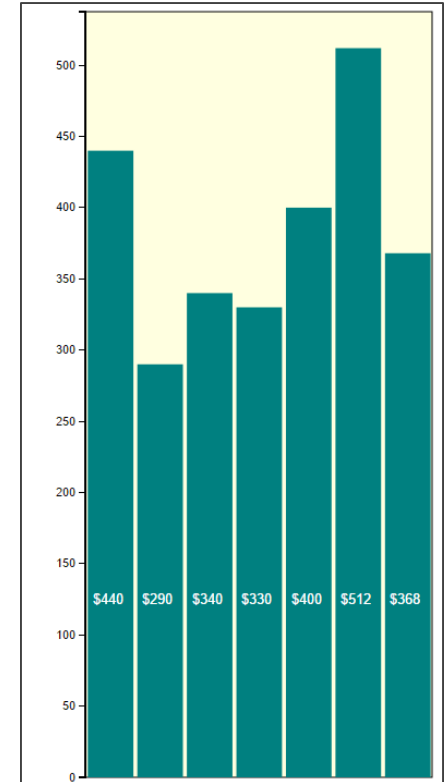
this.plotArea
  .attr("x", plot.xOffset)
  .attr("y", plot.yOffset)
  .attr("width", plot.width)
  .attr("height", plot.height);

this.bars
  .attr("x", (d, i) => { return plot.xOffset + barXStart + (i * (xScaleFactor)); })
  .attr("y", (d, i) => { return plot.yOffset + this.yScale(Number(d)); })
  .attr("width", (d, i) => { return barWidth; })
  .attr("height", (d, i) => { return (plot.height - this.yScale(Number(d))); })
  .attr("fill", "teal");

var yTextOffset = this.yScale(d3.min(this.dataset)) * 0.5;
var textSize = (barWidth * 0.3) + "px";

this.labels
  .text((d, i) => { return "$" + d; })
  .attr("x", (d, i) => { return plot.xOffset + (i * (xScaleFactor)) + (barWidth / 2); })
  .attr("y", (d, i) => { return plot.yOffset + plot.height - yTextOffset; })
  .attr("fill", "white")
  .attr("font-size", textSize)
  .attr("text-anchor", "middle")
  .attr("alignment-baseline", "middle");

this.yAxis.scale(this.yScale).orient('left').ticks(10);
var transform = "translate(" + (this.padding + this.xAxisOffset) + "," + this.padding + ")";
this.axisGroup.attr("class", "axis").call(this.yAxis).attr({ 'transform': transform });
}
```



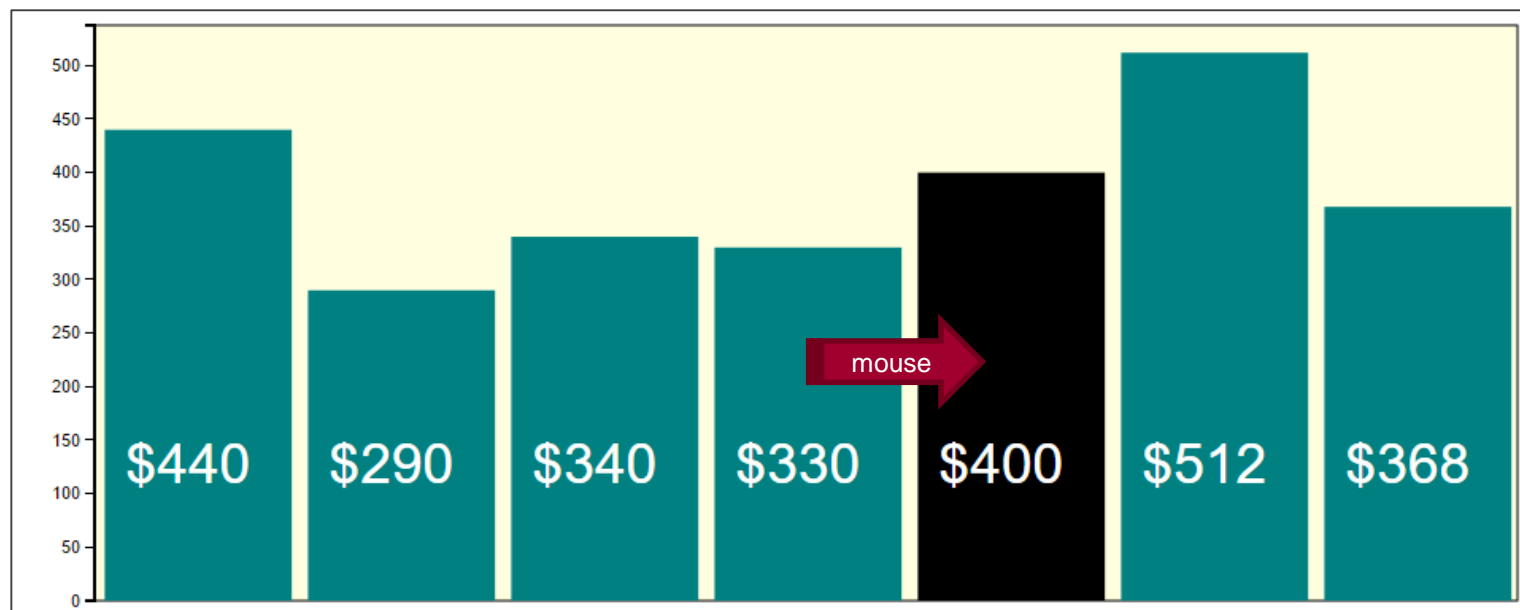
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- Event Handling and Transitions
  - Using D3 Layouts



# Adding Mouse Event Handlers

```
this.bars
.attr("x", (d, i) => { return plot.xOffset + barXStart + (i * (xScaleFactor)); })
.attr("y", (d, i) => { return plot.yOffset + this.yScale(Number(d)); })
.attr("width", (d, i) => { return barWidth; })
.attr("height", (d, i) => { return (plot.height - this.yScale(Number(d))); })
.attr("fill", "teal")
.on("mouseover", function () { d3.select(this).attr("fill", "black") })
.on("mouseout", function () { d3.select(this).attr("fill", "teal") });
```





# Programming D3 Animation

```
.on("mouseover", function () { d3.select(this).attr("fill", "black") })
.on("mouseout", function () { d3.select(this).attr("fill", "teal") })
.on("click", function (d, i) {
  // get reference to current bar
  var currentBar = d3.select(this);
  // determine current bar Y position and height
  var currentY: number = parseInt(currentBar.attr("y"));
  var currentHeight: number = parseInt(currentBar.attr("height"));
  // transition bar to height of zero
  currentBar.transition().duration(1000)
    .attr("y", currentY + (currentHeight))
    .attr("height", 0)
    .each("end", () => {
      // transition bar back to previous height
      currentBar.transition().duration(500).delay(100)
        .attr("y", currentY)
        .attr("height", currentHeight);
    });
});
```



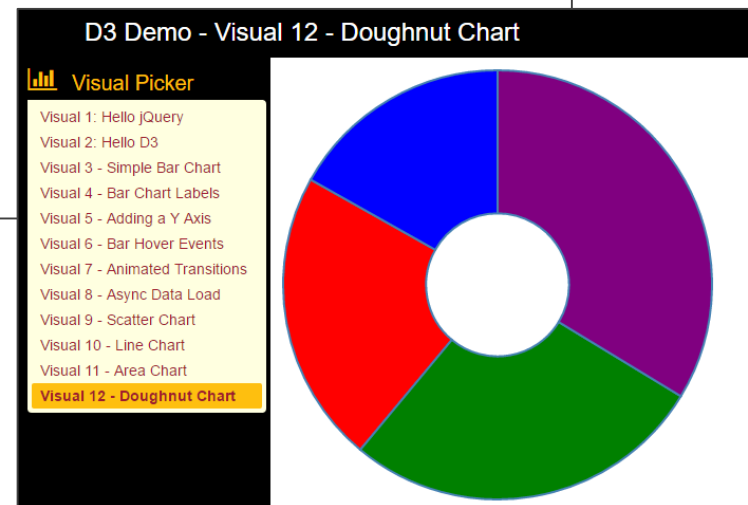
# Agenda

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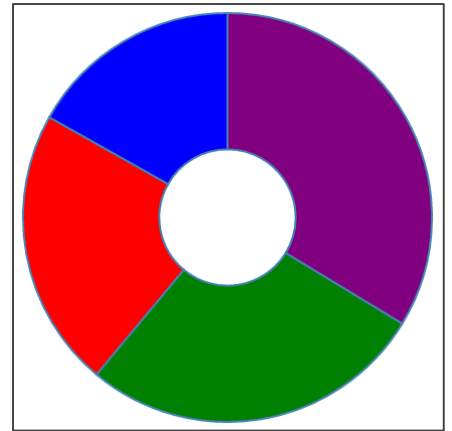
# Using a D3 Layout

```
export class Viz12 implements ICustomVisual {  
    name = "Visual 12 - Doughnut Chart";  
    dataset = [21, 26, 16, 32];  
  
    private svgRoot: d3.Selection<SVGElementInstance>;  
    private plotArea: d3.Selection<SVGElementInstance>;  
  
    private arc: d3.svg.Arc<d3.layout.pie.Arc<number>>;  
    private pie: d3.layout.Pie<number>;  
    private pieDataset: d3.layout.pie.Arc<number>[];  
    private arcSelection: d3.Selection<d3.layout.pie.Arc<number>>;  
    private arcSelectionPath: d3.Selection<d3.layout.pie.Arc<number>>;  
  
    private padding: number = 12;  
  
    load(container: HTMLElement) ...  
  
    update(viewport: IViewport) ...  
}
```



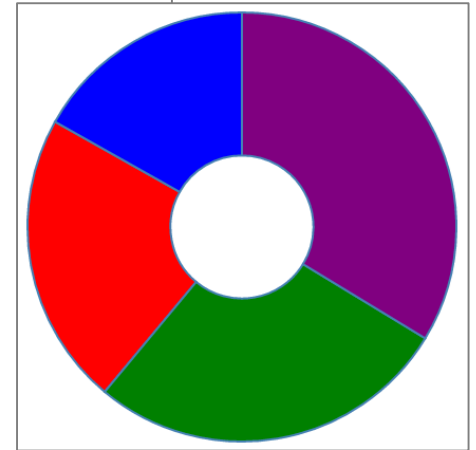
# Implementing load

```
load(container: HTMLElement) {  
  this.svgRoot = d3.select(container).append("svg");  
  this.arc = d3.svg.arc<d3.layout.pie.Arc<number>>();  
  this.pie = d3.layout.pie();  
  
  this.arcSelection = this.svgRoot.selectAll("arc")  
    .data(this.pie(this.dataset))  
    .enter()  
    .append("g")  
    .attr("class", "arc");  
  
  this.arcSelectionPath = this.arcSelection.append("path");  
}
```



# Implementing Update

```
update(viewport: IViewport) {  
  
  this.svgRoot  
    .attr("width", viewport.width)  
    .attr("height", viewport.height);  
  
  var plot = {  
    xOffset: this.padding,  
    yOffset: this.padding,  
    width: viewport.width - (this.padding * 2),  
    height: viewport.height - (this.padding * 2),  
  };  
  
  var outerRadius = d3.min([plot.width / 2, plot.height / 2]);  
  var innerRadius = outerRadius / 3;  
  
  this.arc  
    .innerRadius(innerRadius)  
    .outerRadius(outerRadius);  
  
  this.arcSelection  
    .attr("transform", "translate(" + (outerRadius + this.padding) + ", " +  
      (outerRadius + this.padding) + ")");  
  
  var color = ["red", "green", "blue", "purple", "Yellow"];  
  
  this.arcSelectionPath  
    .attr("fill", (d, i) => { return color[i]; })  
    .attr("d", this.arc);  
  
}
```



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