D3 Tutorial

Data Transformation and Scale Functions

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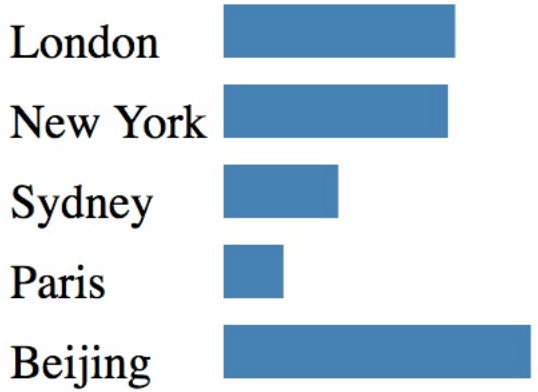
Populations of cities - Scaling



- Scale populations
  - so that we can display bars within the screen

```
var scaleFactor = 1e-5;
var rects =  svg.selectAll("rect")
    .data(cities)
    .enter().append("rect")
    .attr("x", 80)
    .attr("y", function(d, i) {
        return padding + i * (barHeight + padding);
    })
    .attr("width", function(d, i) {
        return d.population * scaleFactor;
    })
    .attr("height", barHeight)
    .style("fill", "steelblue");
```

```
var cities = [
  { name: 'London', population: 8674000},
  { name: 'New York', population: 8406000},
  { name: 'Sydney', population: 4293000},
  { name: 'Paris', population: 2244000},
  { name: 'Beijing', population: 11510000}
];
```

- London: 86.74 pixels
- New York: 84.06 pixels
- Sydney: 42.93 pixels
- Paris: 22.44 pixels
- Beijing: 115.1 pixels

Data Transformation Using Scale Functions

- Scale functions of D3
  - Map from an input domain to an output range
    - Usually, map a dimension/attribute of data to a visual variable
  - Take an input
    - usually a number, date or category
  - Return a value
    - e.g., a coordinate, a color, a length or a radius

Data Transformation

- Scale factor = 10^5
  - Mapping
    - From [0, 11 510 000] (domain)
    - To [0, 115.1] (range)

```
var scaleFactor = 1e-5;
var rects =  svg.selectAll("rect")
    .data(cities)
    .enter().append("rect")
    .attr("x", 80)
    .attr("y", function(d, i) {
        return padding + i * (barHeight + padding);
    })
    .attr("width", function(d, i) {
        return d.population * scaleFactor;
    })
    .attr("height", barHeight)
    .style("fill", "steelblue");
```

```
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];
```

- London: 86.74 pixels
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Scale Function - d3.scaleLinear()

- Mapping
  - From [0, 11 510 000] (domain)
  - To [0, 115.1] (range)
- Extend mapping for more generality
  - From [0, 20 000 000] (domain)
  - To [0, 200] (range)
- pop2width – **Pop**ulation to **Width**
  - d3.scaleLinear()
    - Linear mapping

```
var pop2width = d3.scaleLinear()
    .domain([0, 2*1e7])
    .range([0, 200]);

var rects =  svg.selectAll("rect")
    .data(cities)
    .enter().append("rect")
    .attr("x", 80)
    .attr("y", function(d, i) {
        return padding + i * (barHeight + padding);
    })
    .attr("width", function(d, i) {
        return pop2width(d.population);
    })
    .attr("height", barHeight)
    .style("fill", "steelblue");
```

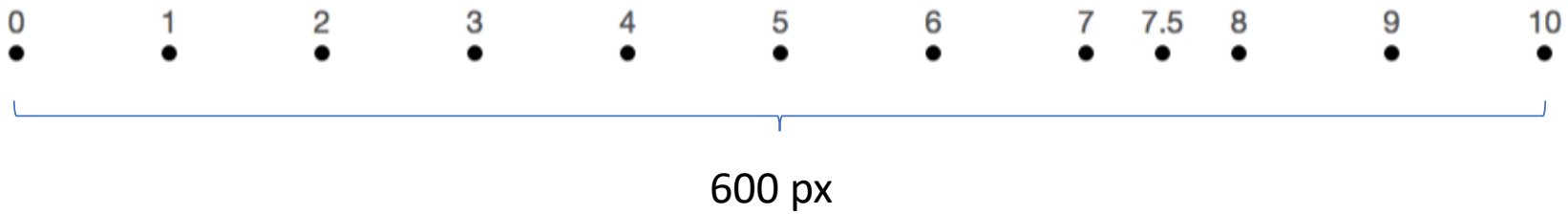
Categories of Scale Functions

- Categories
  - Continuous Input -> Continuous Output
  - Continuous Input -> Discrete Output
  - Discrete Input -> Discrete Output
- We’ll now look at these 3 categories one by one

Continuous Input -> Continuous Output d3.scaleLinear() again

- They use a linear function $y = k \cdot x + b$ to interpolate across the domain (x) and range (y)

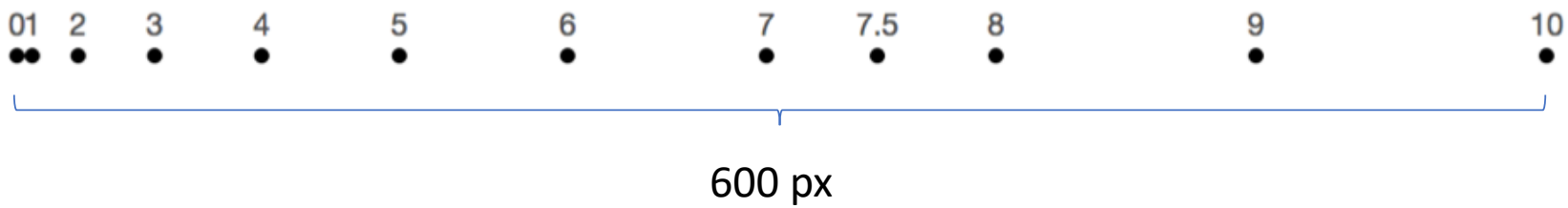
```
var value2width = d3.scaleLinear()
    .domain([0, 10])
    .range([0, 600]);

var data = [ 0, 1, 2, 3, 4, 5, 6, 7, 7.5, 8, 9, 10 ];
```



Continuous Input -> Continuous Output d3.scalePow()

- The pow scale interpolates using a power ($y = m \cdot x^k + b$) function.
  - The exponent *k* is set using .exponent():

```
var value2width = d3.scalePow()
  .exponent(2)
  .domain([0, 10])
      .range([0, 600]);

var data = [ 0, 1, 2, 3, 4, 5, 6, 7, 7.5, 8, 9, 10 ];
```



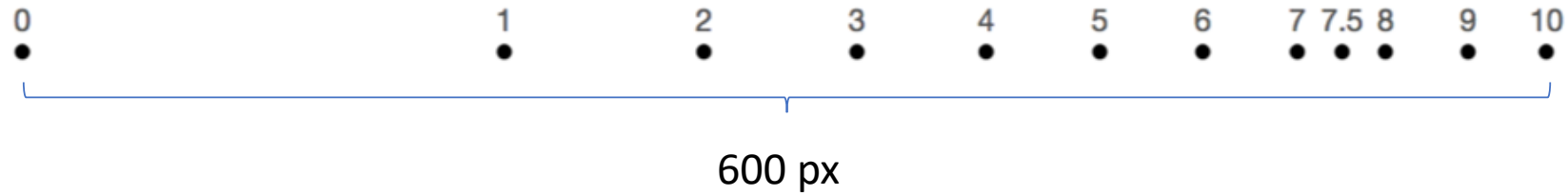
Continuous Input -> Continuous Output d3.scaleSqrt()

- The scaleSqrt scale is a special case of the pow scale (where *k* = 0.5)

```
var value2width = d3.scaleSqrt()
 .domain([0, 10])
     .range([0, 600]);
```

```
var value2width = d3.scalePow()
  .exponent(0.5)
  .domain([0, 10])
      .range([0, 600]);
```

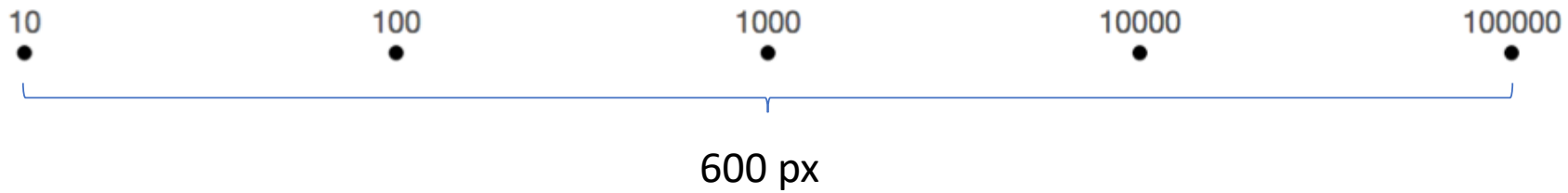
```
var data = [ 0, 1, 2, 3, 4, 5, 6, 7, 7.5, 8, 9, 10 ];
```



Continuous Input -> Continuous Output d3.scaleLog()

- Log scales interpolate using a log function ($y = m \cdot \log(x) + b$)
  - useful when the data has an exponential nature to it

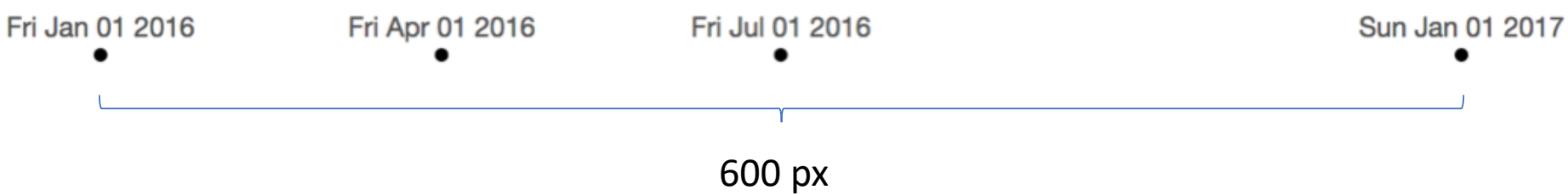
```
var value2width = d3.scaleLog()
 .domain([10, 100000])
     .range([0, 600]);

var data = [10, 100, 1000, 10000, 100000];
```



Continuous Input -> Continuous Output d3.scaleTime()

- scaleTime is similar to scaleLinear
  - The domain is expressed as an array of dates
  - useful when dealing with time series data

```
var time2width = d3.scaleLog()
    .domain([new Date(2016, 0, 1), new Date(2017, 0, 1)])
    .range([0, 600]);

var data = [new Date(2016, 0, 1), new Date(2016, 3, 1), new Date(2016, 6, 1), new Date(2017, 0, 1)];
```



Continuous Input -> Continuous Output Multiple Segments

- The domain and range of scale functions usually consists of two values, but if we provide 3 or more values the scale function is subdivided into multiple segments

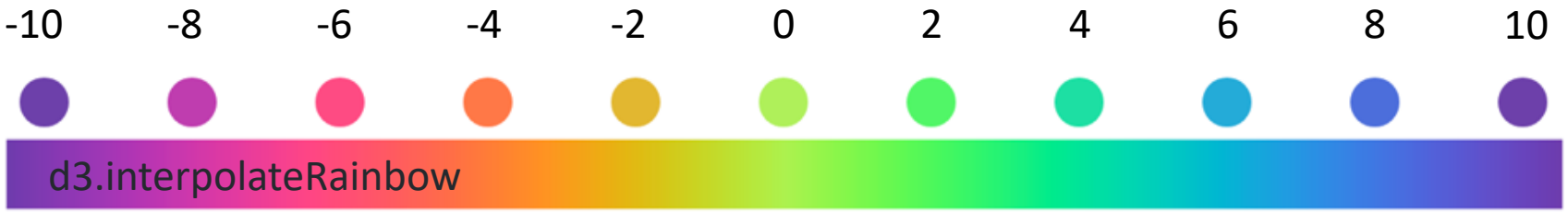
```
var value2color = d3.scaleLinear()
    .domain([-10, 0, 10])
    .range(['red', '#ddd', 'blue']);
```

#ddd is hexadecimal representation of *rgb(221, 221, 221)*
Light Grey

Continuous Input -> Continuous Output d3.scaleSequential(*interpolator*)

- Mapping continuous values to an output range determined by a preset (or custom) *interpolator*
  - Useful to create a continuous colormap
- Usage
  - d3.scaleSequential(*interpolator*);
    - Domain is [0, 1]
  - Or, d3.scaleSequential().domain(*domain*).interpolator(*interpolator*);

```
var value2color = d3.scaleSequential()
    .domain([-10, 10])
    .interpolator(d3.interpolateRainbow);
```



Continuous Input -> Continuous Output d3.scaleSequential(*interpolator*)

- D3 provides a great many interpolators
  - https://github.com/d3/d3-scale-chromatic
- Diverging

- Single Hue

- Multi-Hue

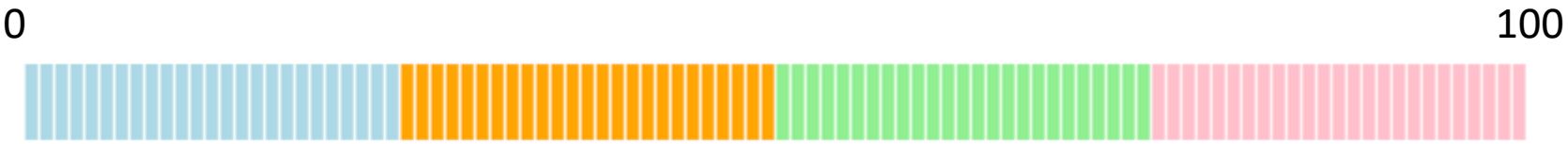
- Cyclical

Continuous Input -> Discrete Output d3.scaleQuantize()

- **Discrete** output
- scaleQuantize accepts continuous input and outputs a number of discrete quantities defined by the range

```
var value2color = d3.scaleQuantize()
    .domain([0, 100])
    .range(['lightblue', 'orange', 'lightgreen', 'pink']);
```

- *value* < 25 is mapped to ‘lightblue’
- 25 ≤ *value* <50 is mapped to ‘orange’
- 50 ≤ *value* <75 is mapped to ‘lightgreen’
- *value* ≥ 75 is mapped to ‘pink’



Continuous Input -> Discrete Output d3.scaleQuantile()

- Quantile scales map a sampled input domain to a discrete range
  - Domain accepts a set of sample values

```
var myData = [0, 1, 2, 3, 4, 30, 35, 40, 60, 62, 65, 70, 80, 90, 100];

var value2color = d3.scaleQuantile()
    .domain(myData)
    .range(['lightblue', 'orange', 'lightgreen']);
```

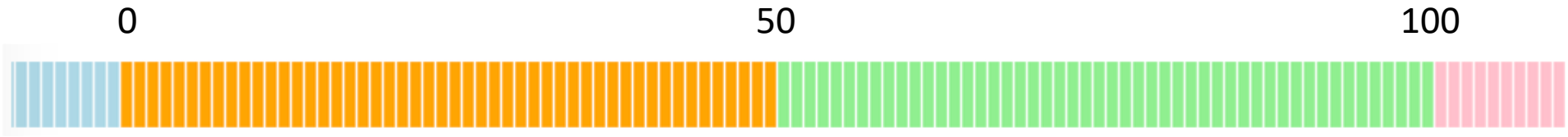
- *the first 5 values are mapped to 'lightblue'*
- *the next 5 values to 'orange'*
- *the last 5 values to 'lightgreen'.*

Continuous Input -> Discrete Output d3.scaleThreshold()

- Map arbitrary subsets of the domain to discrete values in the range

```
var value2color = d3.scaleThreshold()
    .domain([0, 50, 100])
    .range(['lightblue', 'orange', 'lightgreen', 'pink']);
```

- *value* < 0 is mapped to ‘lightblue’
- 0 ≤ *value* <50 is mapped to ‘orange’
- 50 ≤ *value* <100 is mapped to ‘lightgreen’
- *value* ≥ 100 is mapped to ‘pink’



Discrete Input -> Discrete Output d3.scaleOrdinal()

- **Discrete** input and **discrete** output
- scaleOrdinal maps discrete values (specified by an array) to discrete values (also specified by an array)
  - The range array will repeat if it's shorter than the domain array.

```
var data = ['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec']
```

```
var month2color = d3.scaleOrdinal()
    .domain(data)
    .range(['black', 'grey', 'lightgrey']);
```

Discrete Input -> Discrete Output d3.scaleOrdinal(*colorScheme*)

- Use D3 built-in color schemes
  - d3.scaleOrdinal(*colorScheme*)
  - d3.schemeCategory10: map 0 ~ 9 to nine colors

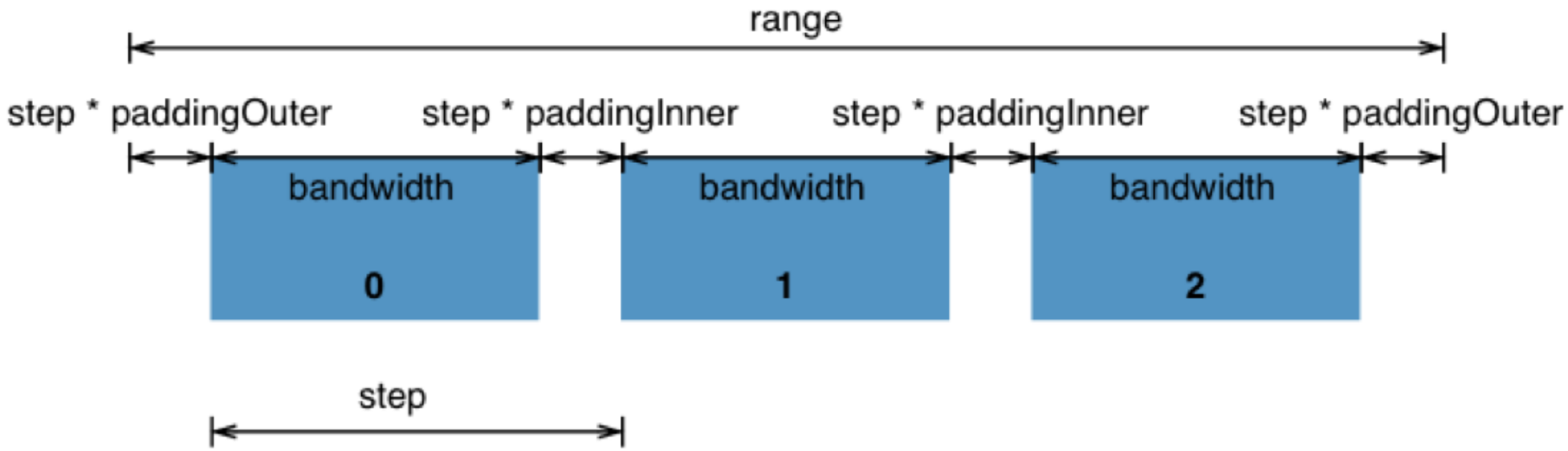
```
var value2color = d3.scaleOrdinal(d3.schemeCategory10);
```

- D3 also provides a great many ordinal color schemes
  - https://github.com/d3/d3-scale-chromatic

Discrete Input -> Discrete Output d3.scaleBand()

- Discrete output values are automatically computed by the scale by dividing the continuous range into uniform bands
  - Band scales are typically used for bar charts with an ordinal or categorical dimension

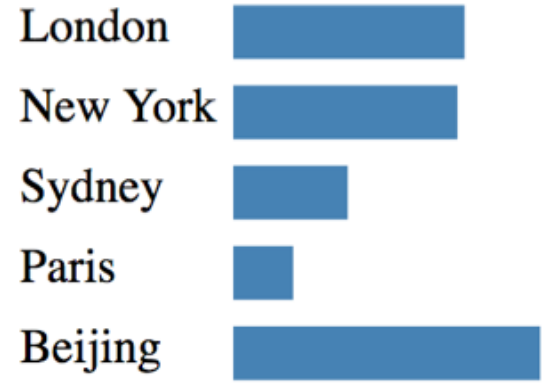
- *paddingOuter* and *paddingInnter* are **ratios**



Discrete Input -> Discrete Output d3.scaleBand()

- Data
  - Populations of Cities
- d3.scaleBand()
  - Domain is the names of cities

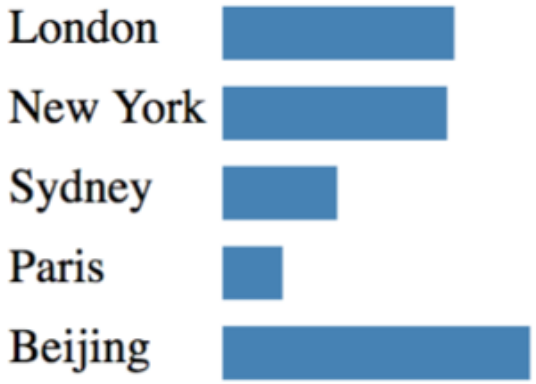
```
var cityNames = cities.map(function(d) {return d.name});
var bandScale = d3.scaleBand()
    .domain(cityNames)
    .range([0, 160])
    .paddingOuter(0.33)
    .paddingInner(0.33);
```



Discrete Input -> Discrete Output d3.scaleBand()

- Draw bars by *scaleBand*

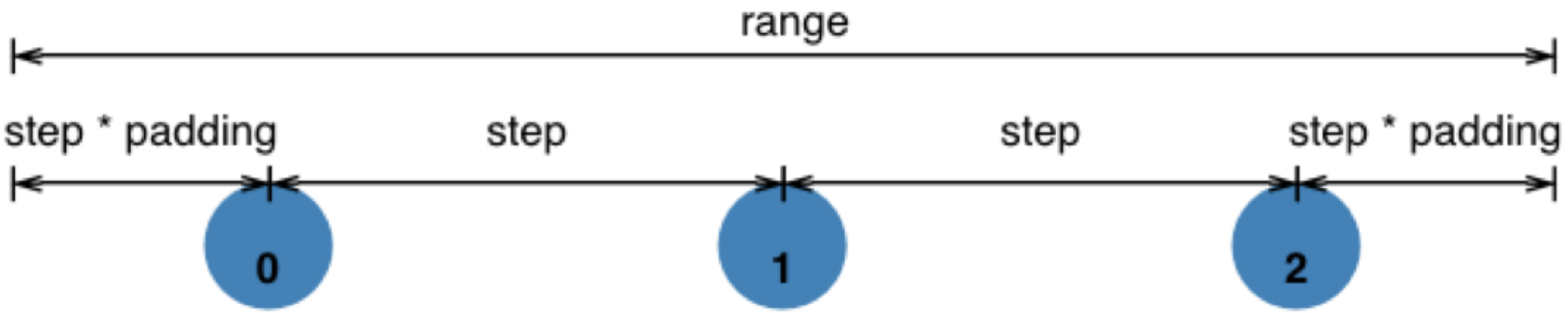
```
var rects =  svg.selectAll("rect")
    .data(cities)
    .enter().append("rect")
    .attr("x", 80)
    .attr("y", function(d) {
        return bandScale(d.name)
    })
    .attr("width", function(d, i) {
        return pop2width(d.population);
    })
    .attr("height", bandScale.bandwidth())
    .style("fill", "steelblue");
```



Discrete Input -> Discrete Output d3.scalePoint()

- Point scales are a variant of band scales with the bandwidth fixed to zero
  - Point scales are typically used for scatterplots with an ordinal or categorical dimension

- *padding* *is a* **ratio**



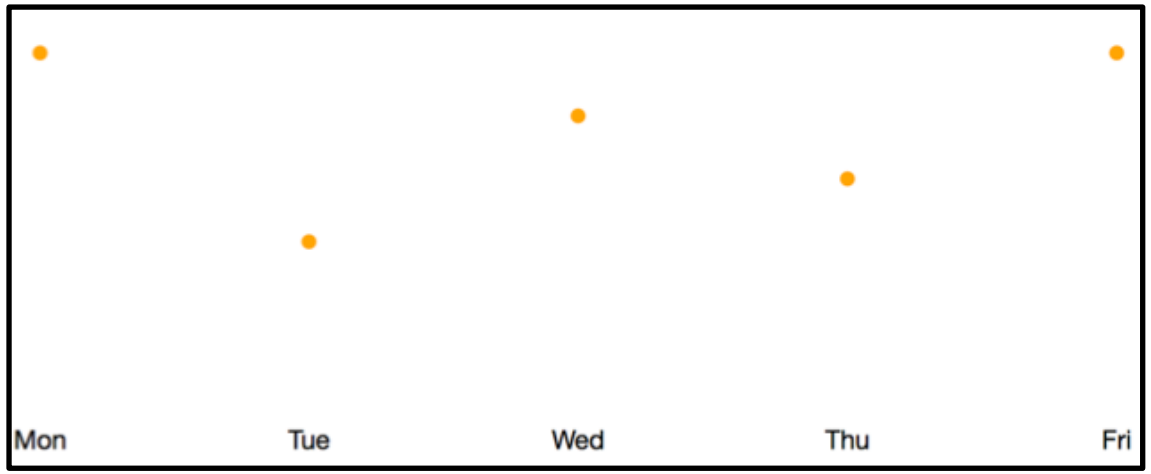
Discrete Input -> Discrete Output d3.scalePoint()

- Data
  - Daily sales of fruit Apricots

```
var data = [
    {day : 'Mon', value: 120},
    {day : 'Tue', value: 60},
    {day : 'Wed', value: 100},
    {day : 'Thu', value: 80},
    {day : 'Fri', value: 120}
];
```

Discrete Input -> Discrete Output d3.scalePoint()

- Create scales
  - d3.scalePoint()
    - Map day of week to *x* coordinate
  - d3.scaleLinear()
    - Map daily sales to *y* coordinate



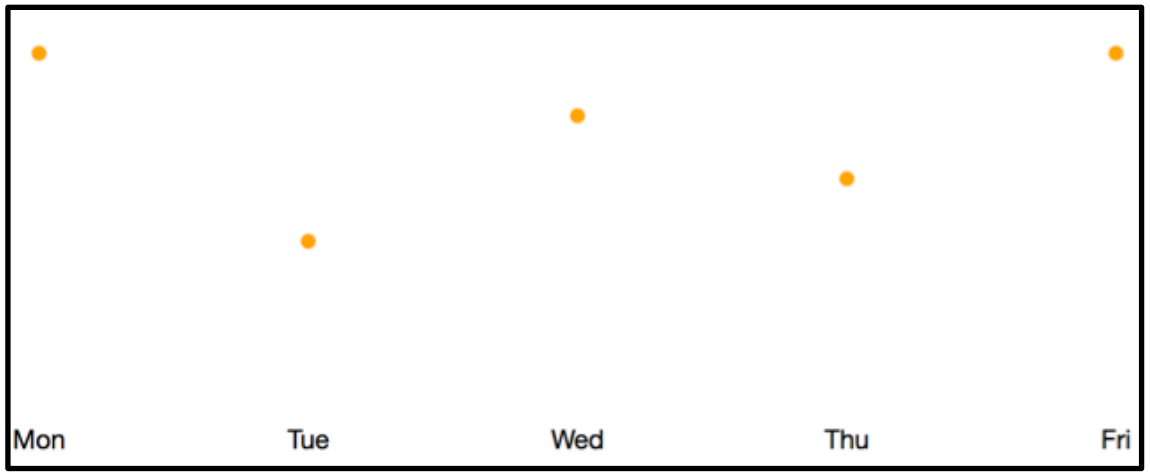

```
var pointScale = d3.scalePoint()
    .domain(['Mon', 'Tue', 'Wed', 'Thu', 'Fri'])
    .range([0, 600])
    .padding(0.1);

var value2height = d3.scaleLinear()
    .domain([0, d3.max(data, function(d) {return d.value;})])
    .range([200, 0]);
```

```
var data = [
    {day : 'Mon', value: 120},
    {day : 'Tue', value: 60},
    {day : 'Wed', value: 100},
    {day : 'Thu', value: 80},
    {day : 'Fri', value: 120}
];
```

Discrete Input -> Discrete Output d3.scalePoint()

- Draw points

```
var circles = d3.select('#wrapper')
    .selectAll('circle')
    .data(data)
    .enter()
    .append('circle')
    .attr('cx', function(d) {
        return pointScale(d.day);
    })
    .attr('cy', function(d) {
        return value2height(d.value);
    })
    .attr('r', 4);
```




```
var data = [
    {day : 'Mon', value: 120},
    {day : 'Tue', value: 60},
    {day : 'Wed', value: 100},
    {day : 'Thu', value: 80},
    {day : 'Fri', value: 120}
];
```