Interaction

Start here

Note: *consider treating gender and sex data with more nuance than in these examples [see here]*

Interaction as an aesthetic mapping

- In some cases interaction allows us to simply add another “dimension”: **time**
  - Very limited in scope
  - Not always the right choice!
  - Example

Best practices for interaction

Based on slides from Cody Dunne & Miriah Meyer

- **Benefits** of interaction
    - Enables visualization of large amounts of data
    - Amplifies user cognition (supports sensemaking)
    - Increases engagement (vis becomes personal to user)
    - Increases deep learning and learning transfer

Best practices for interaction

Based on slides from Cody Dunne & Miriah Meyer

- **Drawbacks** of interaction
  - Requires human time and attention
  - Increase perceptual and exploration costs (van Wijk 2005)
  - Interaction costs (Lam 2008)
  - Multiple user studies find no increase in performance in specific situations (Ragan et al. 2012,

“Overview first, zoom and filter, and details on demand.”

- Ben Shneiderman

“The Shneiderman Mantra”

“Overview first, zoom and filter, and details on demand.”

- Ben Shneiderman

“The Shneiderman Mantra”

Overview—provide high-level view/summary

Zoom and Filter—enable data discovery and exploration, support search/tasks

Details on Demand—do not overwhelm the viewer. Provide extra information as needed

“Search, show context, expand on demand”

- van Ham & Perer

“Search, show context, expand on demand”
- van Ham & Perer

Search—pick subset of data to focus on.

Show context—show connected or relevant data for the user’s current interests.

Expand on demand—user chooses to expand the context in a direction of interest.

Taxonomy of interactions

Based on slides from Jeffery Heer

- **Data and view specification**
  - Filter, query, derive
- **View manipulation**
  - Select, Navigate, coordinate, organize
- **Process and provenance**
  - Record annotate, share, guide

Querying and filtering

- Determine a subset of data to highlight by applying *filters*
  - Example: Simple filtering
  - Example: ZIP codes
  - Example: baby names
  - Example: Gapminder DimpVis
  - Example: Segregation in U.S. Cities

Pointing and selection

Select an observation for more details

- Example: tooltips!
- Example: Airports
- Example: College mobility

Brushing and linking

- Select a subset of data using a brush
  - See the selected data in other views
  - Views must be *linked*
  - Example: Stocks and IMDB
  - Example: Brushable scatterplot
  - Example: Crossfiltering
  - Example: Parallel coordinates

Zooming and panning

- Allow user to manipulate the scales
  - Example: maps!
  - Example: Vega-Altair

Sorting

- Allow user to manipulate the scales
  - Example: Sortable bar plot

Scrollytelling

- Update visualization as a reader progresses through a story
  - Example: California fires

Prompting reflection

- Allow user to set their own expectations
  - Example: college mobility

Implementing interaction

How do we implement interaction?

- Bootstrapping applet

wind speed

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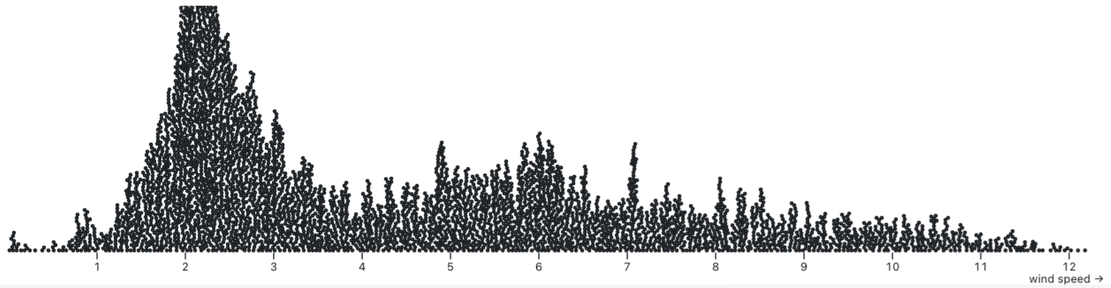


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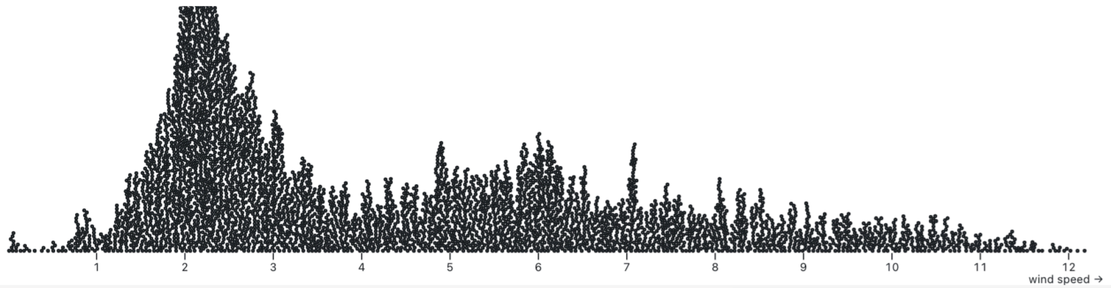


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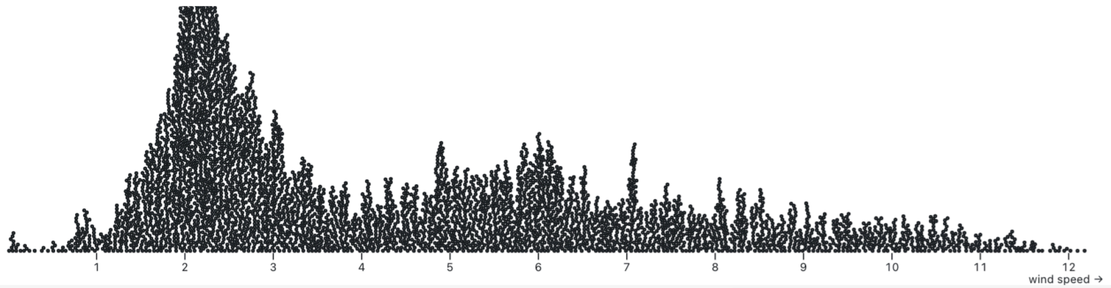


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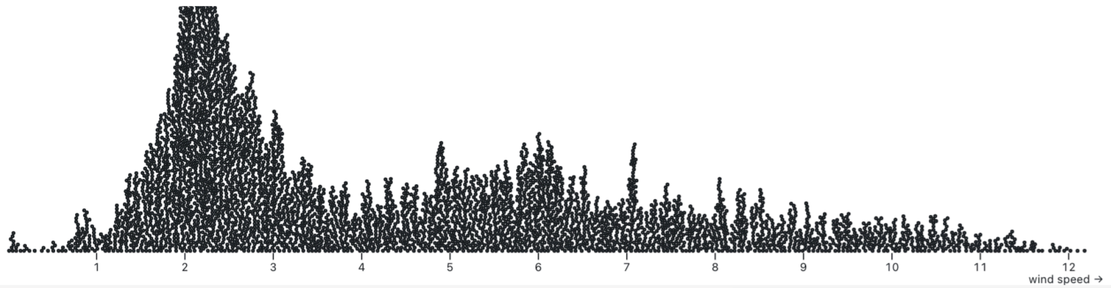


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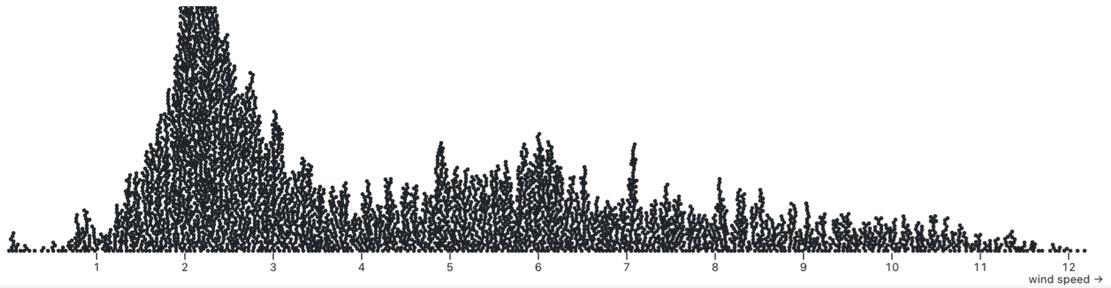


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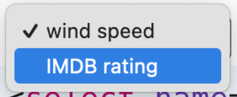


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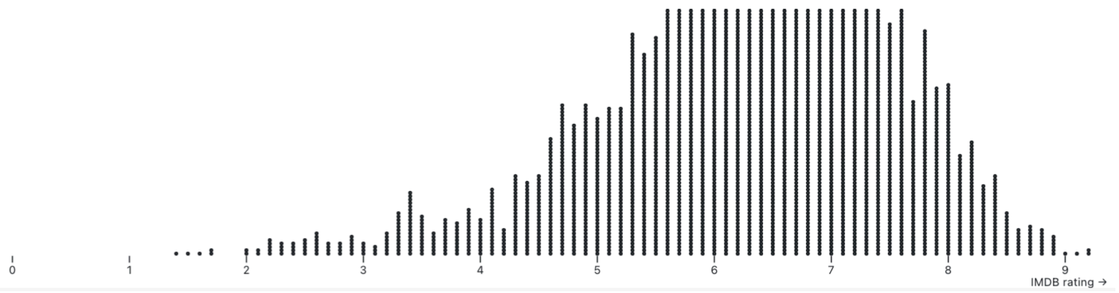


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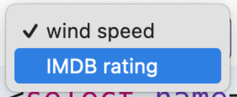


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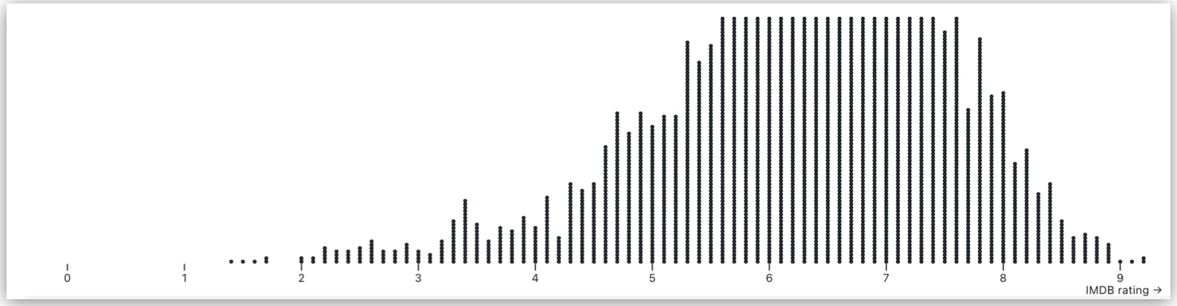


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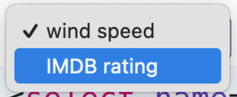


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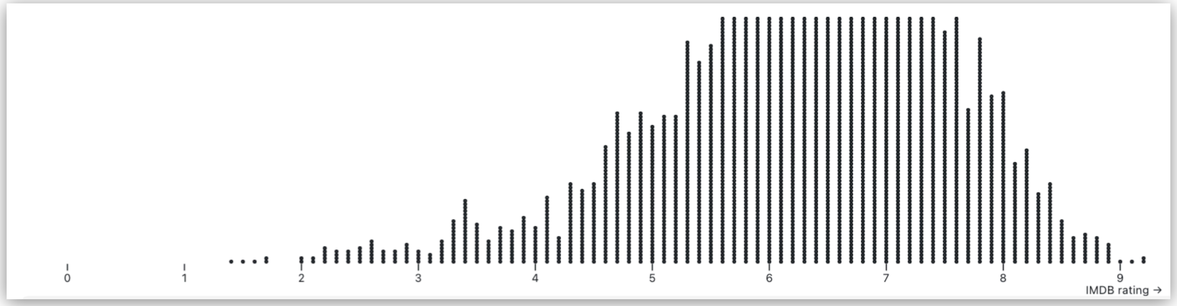


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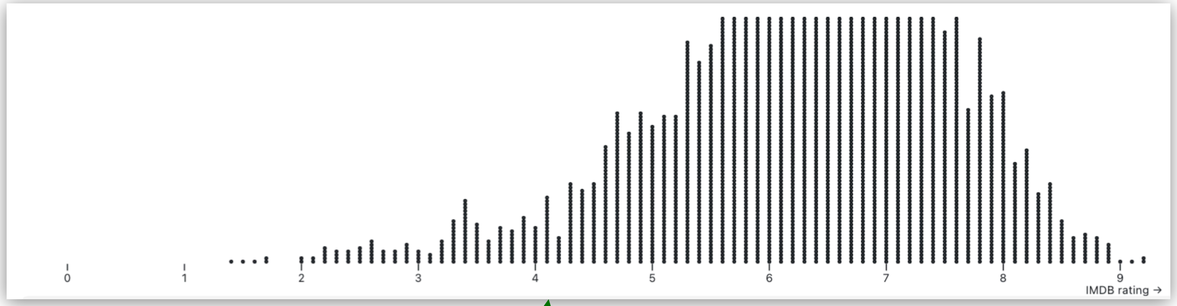
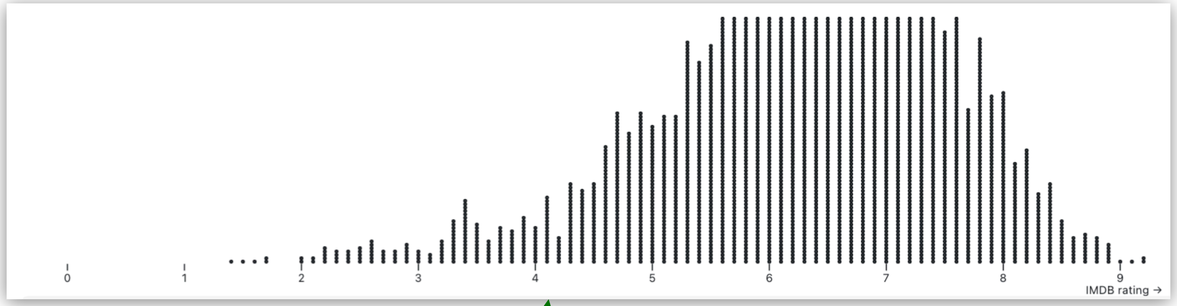
IMDB rating



Updates

IMDB rating



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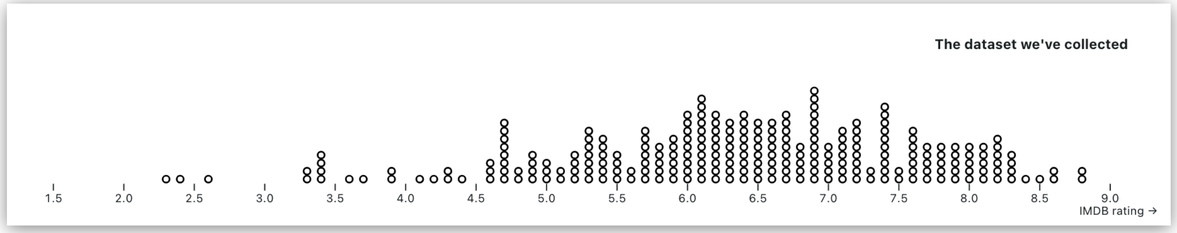
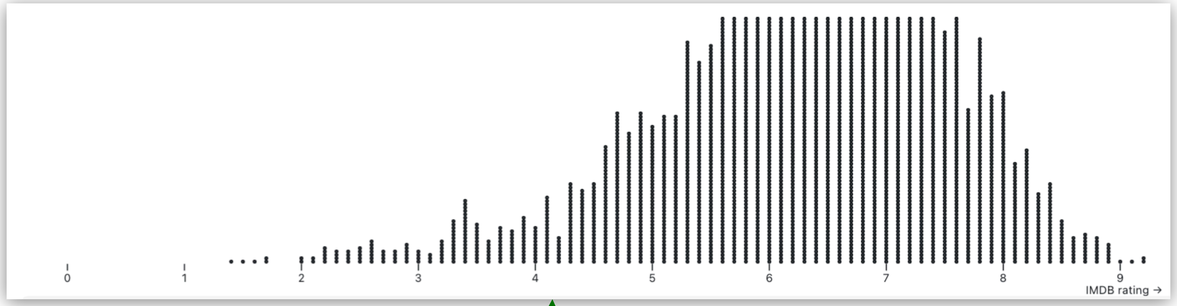
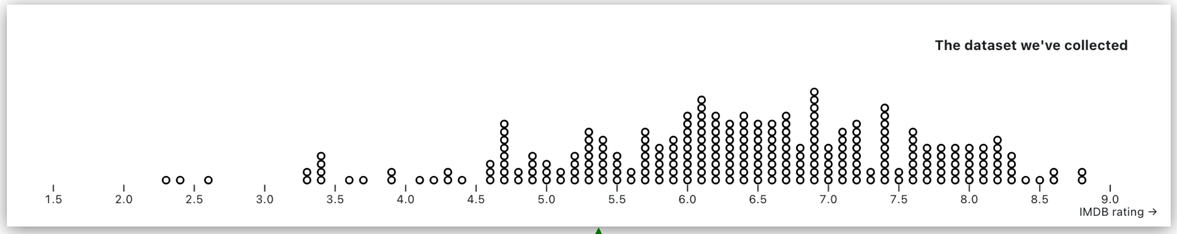


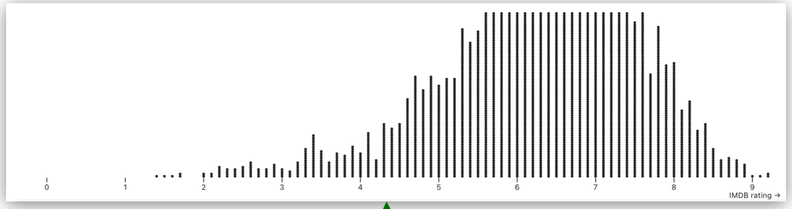


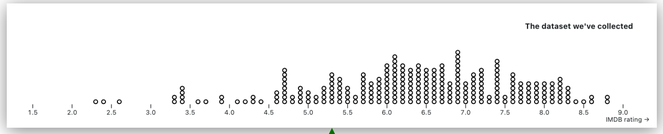


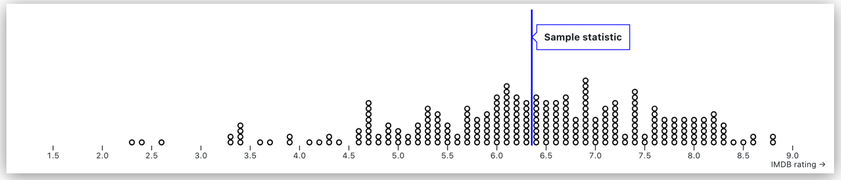
Population

Updates

IMDB rating







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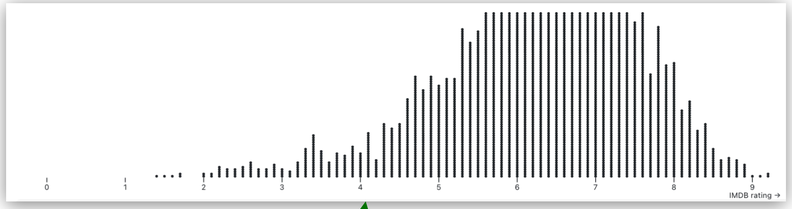
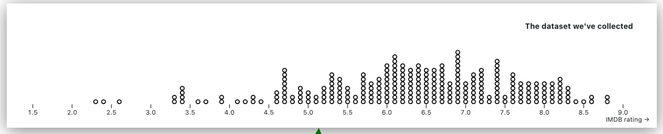
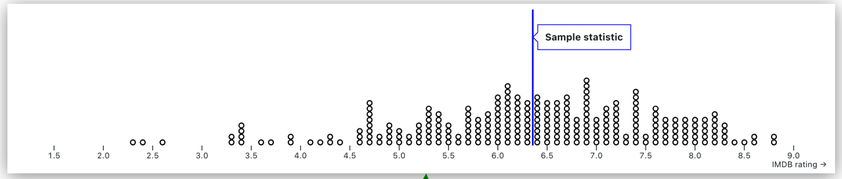




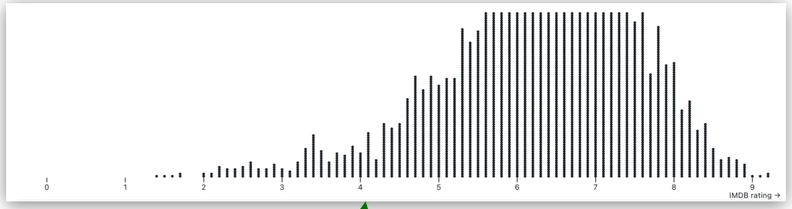


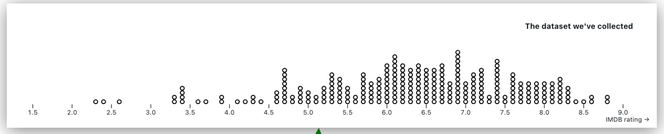
Sample

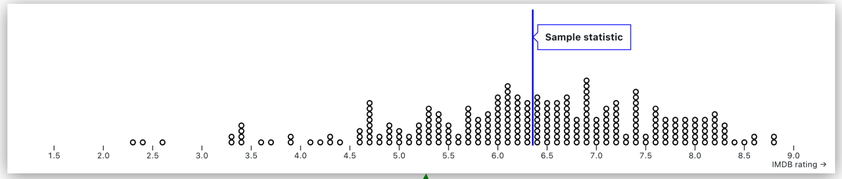
Population

Updates

IMDB rating







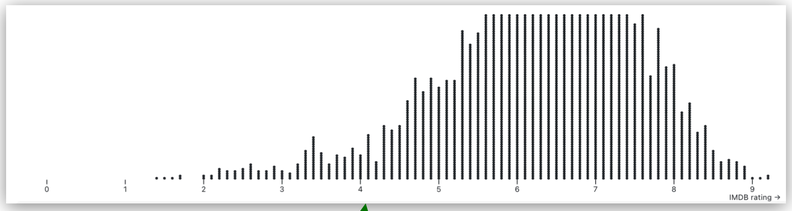
Sample

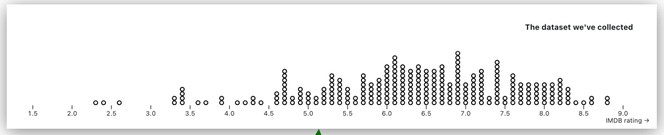
Population

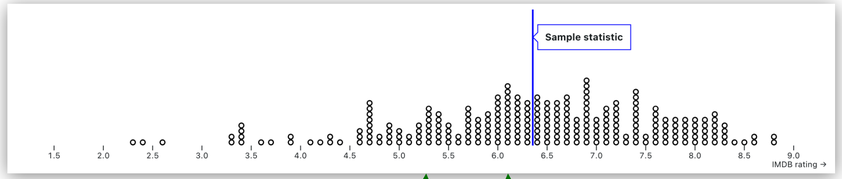
Updates

IMDB rating

Mean







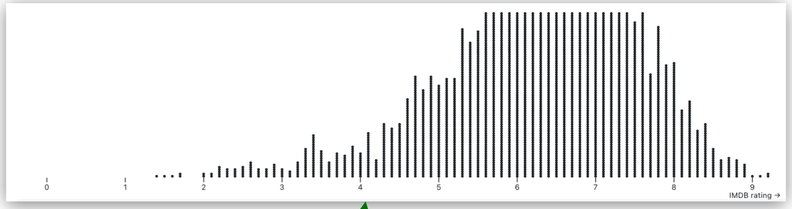
Sample

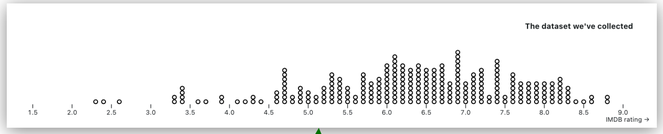
Population

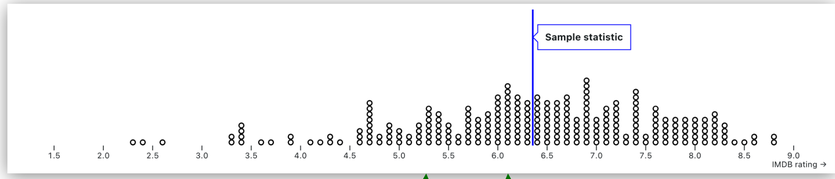
Updates

IMDB rating

Mean







Sample

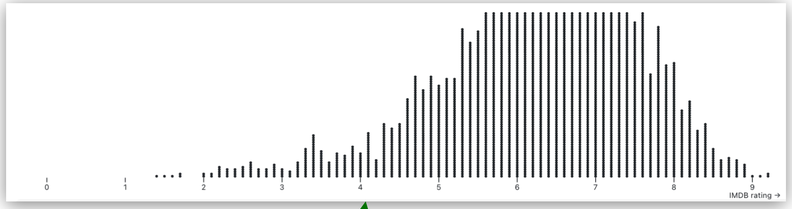
Population

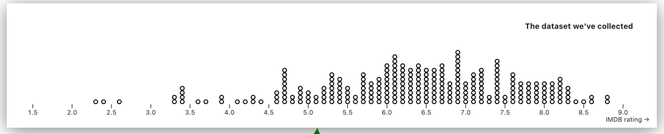
Updates

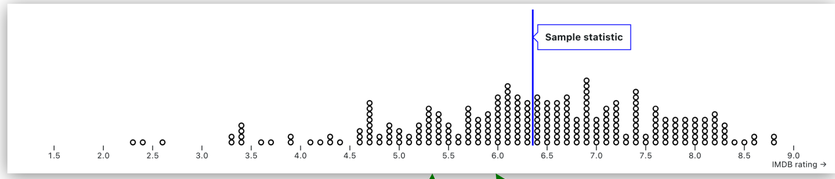
*Here our **Mean** of `IMDB rating` is 6.35*

IMDB rating

Mean







Sample

Statistic

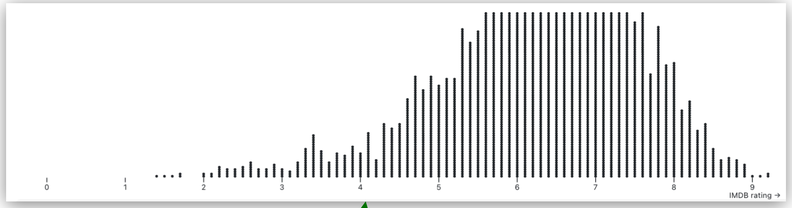
Population

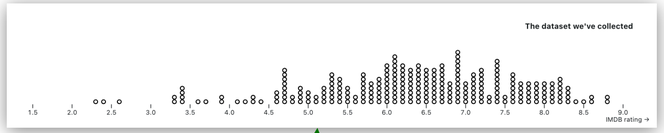
Updates

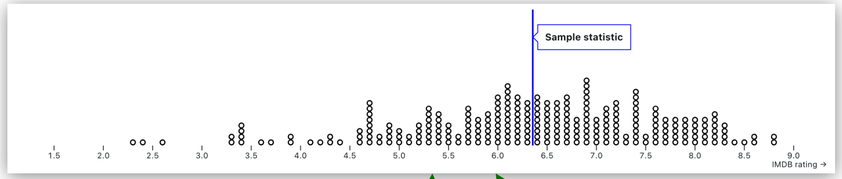
*Here our **Mean** of `IMDB rating` is 6.35*

IMDB rating

Mean







Here we needed to:

- Add *statistic* to our state
- Change *sample* code to update the *statistic*
- Change *statistic type selector* code to update text
- Change *statistic* code to update text
- ...

Sample

Statistic

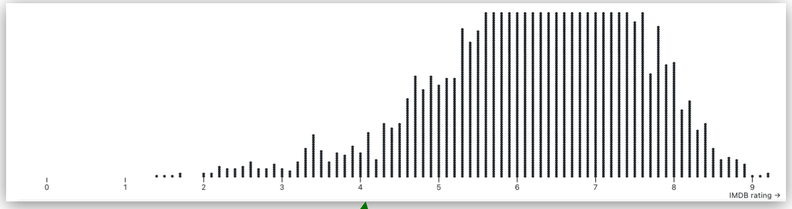
Population

Updates

*Here our **Mean** of `IMDB rating` is 6.35*

IMDB rating

Mean



Adding new components gets very complicated very quickly

Here we needed to:

- Add *statistic* to our state
- Change *sample* code to update the *statistic*
- Change *statistic type selector* code to update text
- Change *statistic* code to update text
- ...

Sample

Statistic

Population

Updates

*Here our **Mean** of `IMDB rating` is 6.35*

IMDB rating

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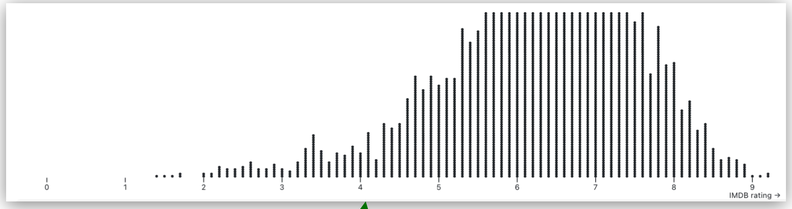
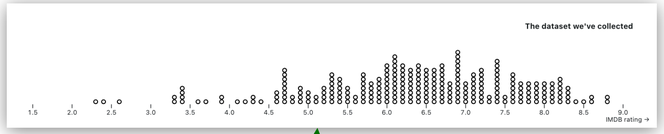
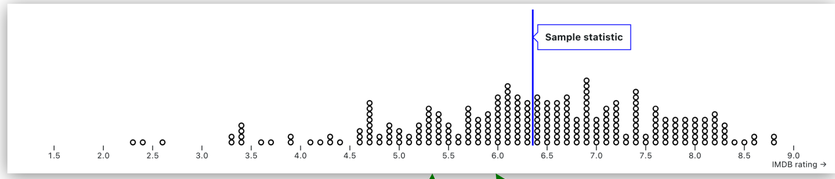






Sample

Statistic

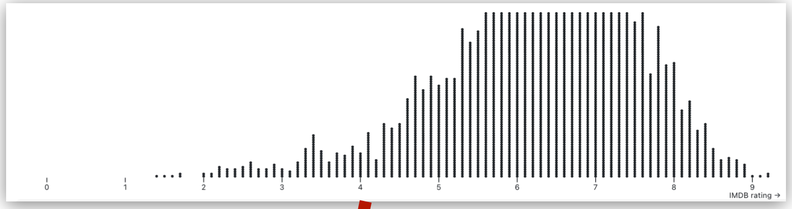
Population

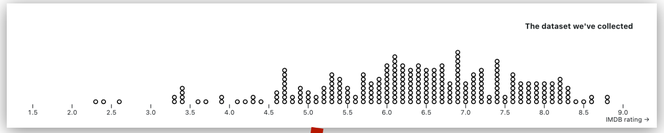
Updates

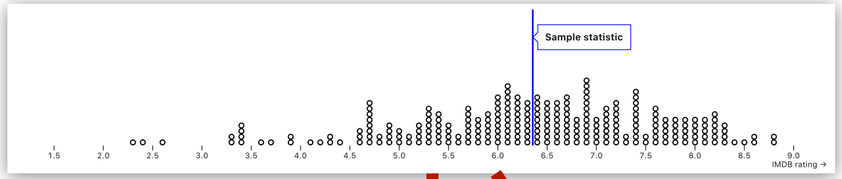
*Here our **Mean** of `IMDB rating` is 6.35*

IMDB rating

Mean







Sample

Statistic

Population

Observes

*Here our **Mean** of `IMDB rating` is 6.35*

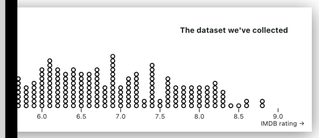
IMDB rating

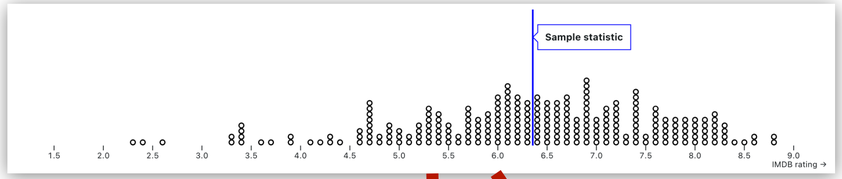
Mean

Observer pattern: *flip responsibility*

Each *component* is responsible for knowing what other pieces of state it depends on

- When parent state changes - *recompute*!





Sample

Statistic

Population

Observes

*Here our **Mean** of `IMDB rating` is 6.35*

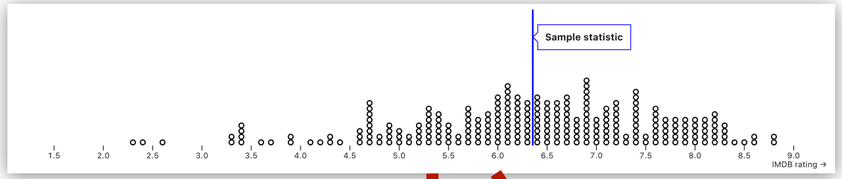
IMDB rating

Mean

Observer pattern: *implementation*

Each component *registers* itself as an observer of its parent

- When parent state changes - *signal all observers*!



Python

```python
class Observable:
    def __init__(self):
        self._observers = []

    def register_observer(self, observer) -> None:
        self._observers.append(observer)

    def notify_observers(self, *args, **kwargs) -> None:
        for observer in self._observers:
            observer.notify(self, *args, **kwargs)


class Observer:
    def __init__(self, observable):
        observable.register_observer(self)

    def notify(self, observable, *args, **kwargs) -> None:
        print("Got", args, kwargs, "From", observable)


subject = Observable()
observer = Observer(subject)
subject.notify_observers("test", kw="python")

# prints: Got ('test',) {'kw': 'python'} From <__main__.Observable object at
0x0000019757826FD0>
```

Javascript

```javascript
let Subject = {
    _state: 0,
    _observers: [],
    add: function(observer) {
        this._observers.push(observer);
    },
    getState: function() {
        return this._state;
    },
    setState: function(value) {
        this._state = value;
        for (let i = 0; i < this._observers.length; i++)
        {
            this._observers[i].signal(this);
        }
    }
};

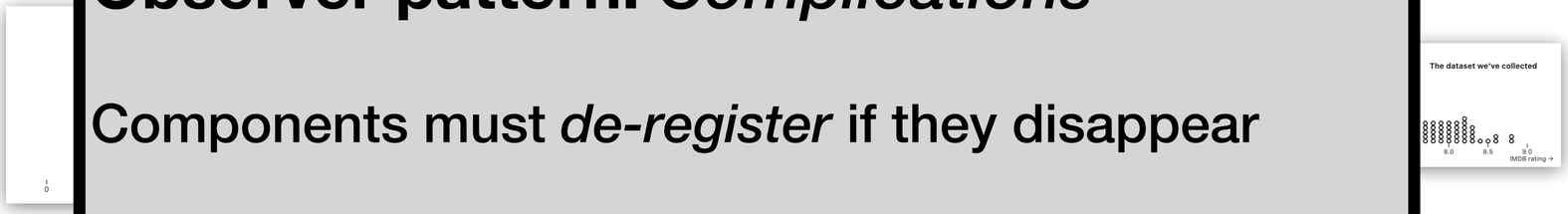
let Observer = {
    signal: function(subject) {
        let currentValue = subject.getState();
        console.log(currentValue);
    }
}

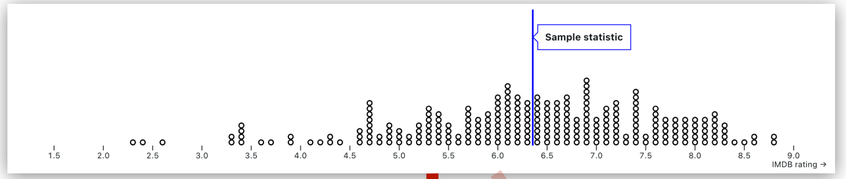
Subject.add(Observer);
Subject.setState(10);
//Output in console.log - 10
```

From Wikipedia

Observer pattern: *Complications*

Components must *de-register* if they disappear





Sample

Statistic

Population

Observes

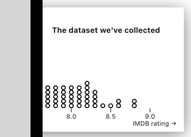
*Here our **Mean** of IMDB rating is 6.35*

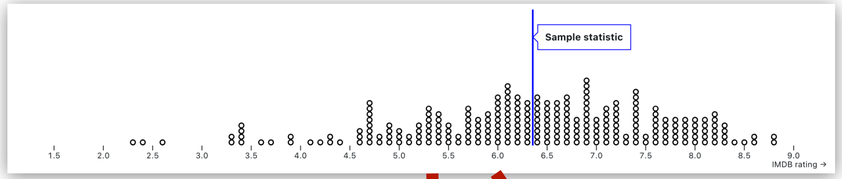
IMDB rating

Mean

Observer pattern: *Complications*

Cycles cannot be allowed!





Sample

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*Here our **Mean** of `IMDB rating` is 6.35*

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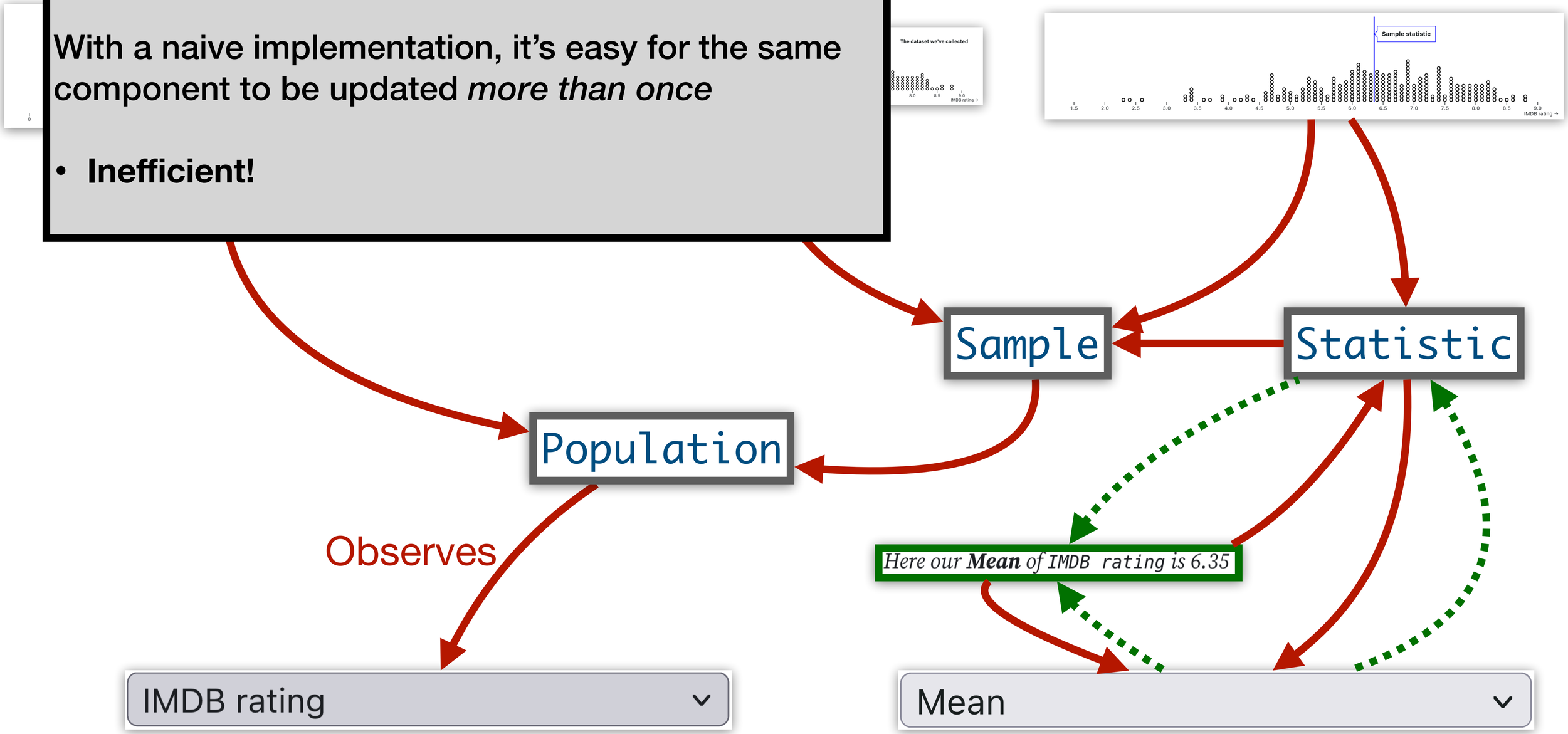
Observer pattern: *Complications*

With a naive implementation, it's easy for the same component to be updated *more than once*

- **Inefficient!**



Observer pattern: *Complications*

With a naive implementation, it's easy for the same component to be updated *more than once*

- **Inefficient!**

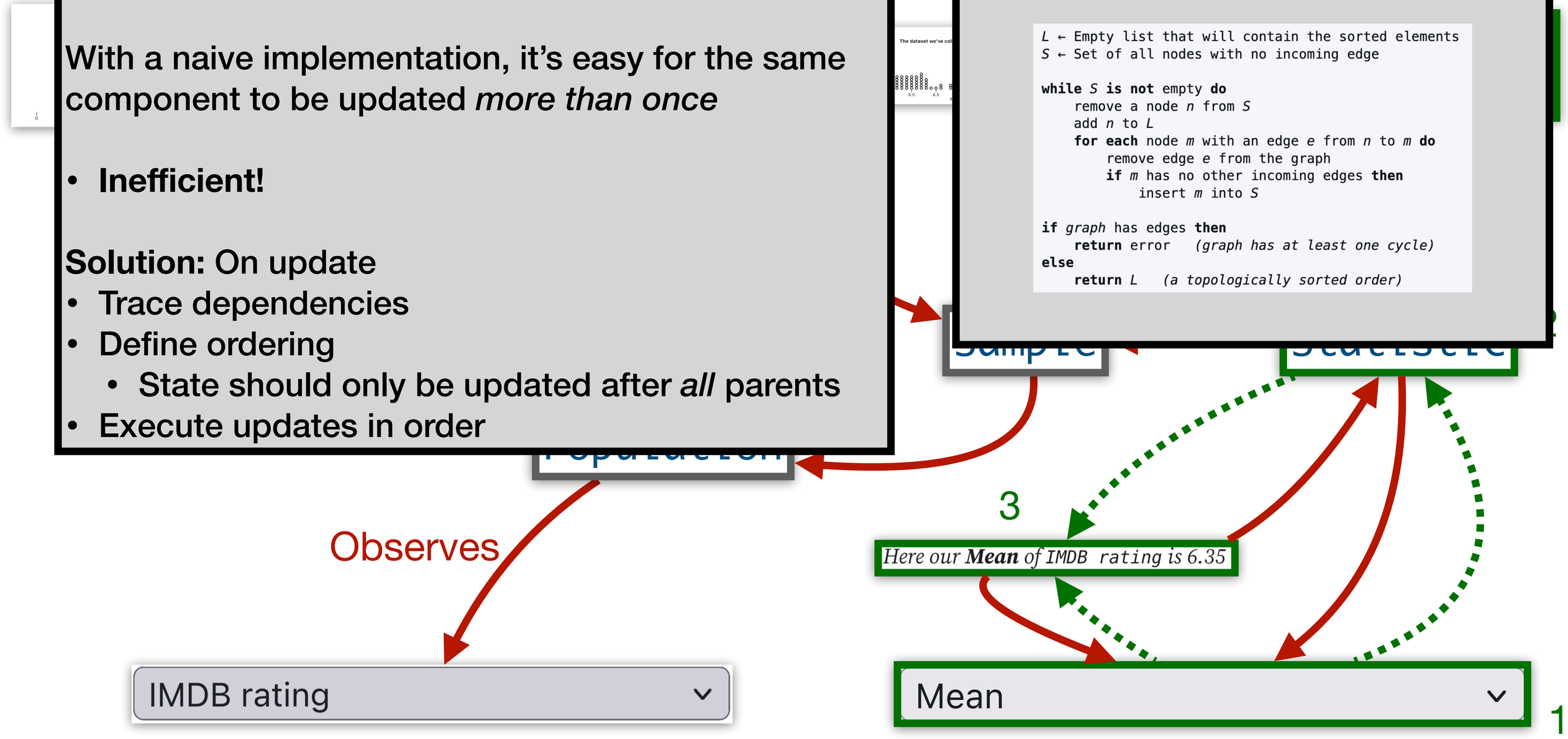
Solution: On update
- Trace dependencies
- Define ordering
  - State should only be updated after *all* parents
- Execute updates in order

Define ordering: *topological sort*

```
L ← Empty list that will contain the sorted elements
S ← Set of all nodes with no incoming edge

while S is not empty do
    remove a node n from S
    add n to L
    for each node m with an edge e from n to m do
        remove edge e from the graph
        if m has no other incoming edges then
            insert m into S

if graph has edges then
    return error   (graph has at least one cycle)
else
    return L   (a topologically sorted order)
```

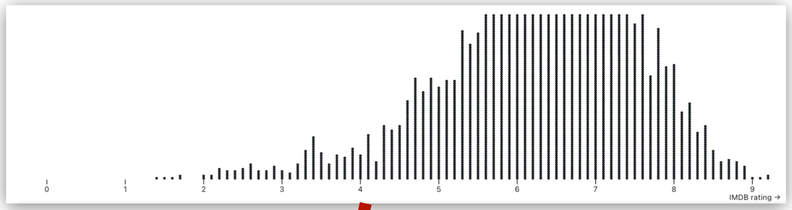


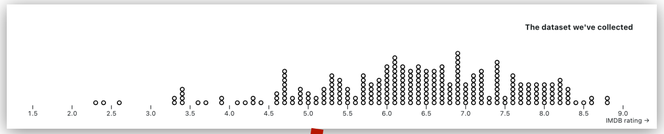
Reactive programming

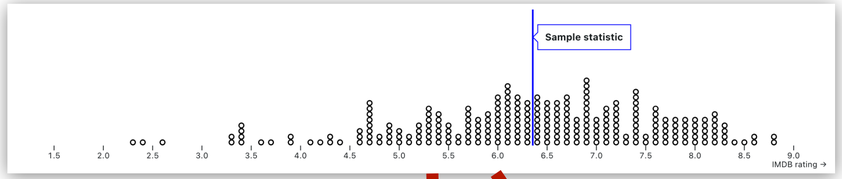
Build observer pattern into core language or framework

Reactive programming

Build observer pattern into core language or framework








```
sample = resample(population)
```

```
stat = computeStat(sample)
```

Sample

Statistic

```
population = (dataset == "wind speed") ? windpopulation : imdbpopulation;
```

Population

```
*Here our **${statistic}** of `${dataset}` is ${estimate}*
```

*Here our **Mean** of IMDB rating is 6.35*

Observes

IMDB rating

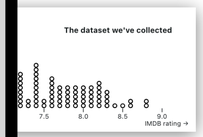
Mean

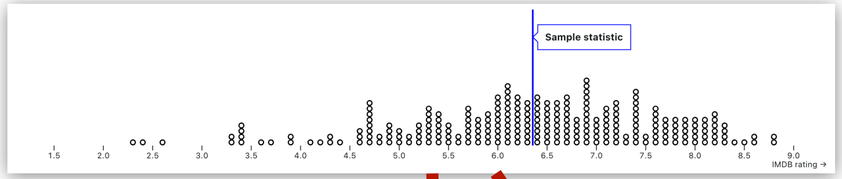
```
viewof dataset = Inputs.select(["wind speed", "IMDB rating"], {label: "Dataset"});
```

```
viewof statistic = Inputs.select(["Mean", "Median"])
```

Reactive framework

Each line re-runs when variables it uses change!



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```

*Here our **Mean** of IMDB rating is 6.35*

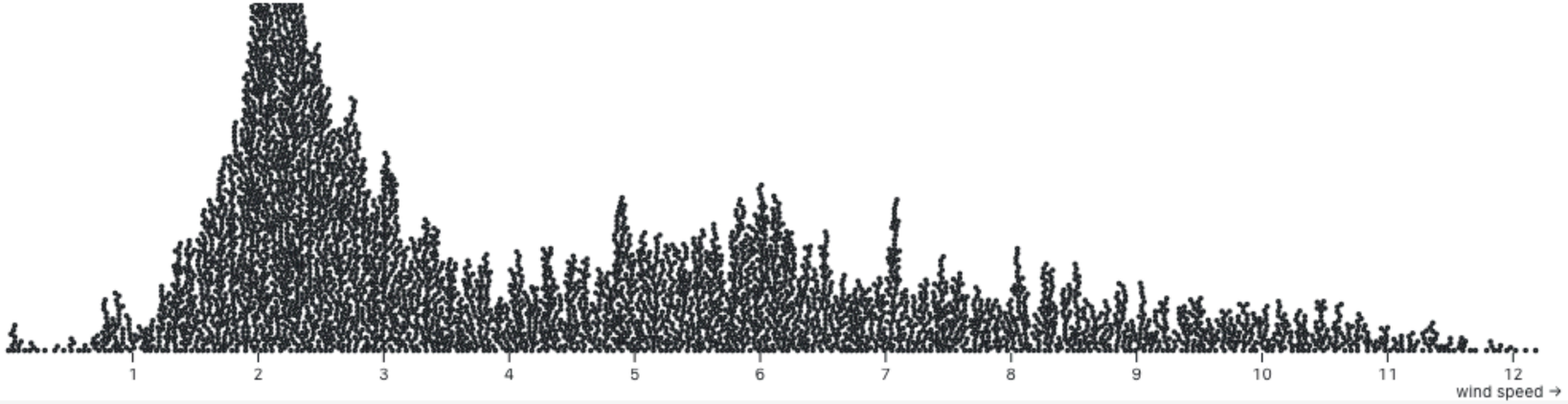
IMDB rating

Mean

```
viewof dataset = Inputs.select(["wind speed", "IMDB rating"], {label: "Dataset"});
```

```
viewof statistic = Inputs.select(["Mean", "Median"])
```

Dataset choice




```
Plot.plot({
  height: 250,
  width: 1000,
  x: {label: dataset, domain: [Math.min(...populations[dataset]),
                               Math.max(...populations[dataset])]},
  marks: [
    Plot.dot(populations[dataset], Plot.dodgeY({x: "0", r:1}))
  ]
})
```

Updated on change!

wind speed

```
viewof dataset = Inputs.select(["wind speed", "IMDB rating"])
```

```
populations = ▸ Object {wind speed: Array(4800), IMDB rating: Array(3201)}
```

```
 populations = ({
      "wind speed": winddata.map(d => [d['speed']]),
      "IMDB rating": imdb.map(d => [d['IMDB Rating']]),
    })
```

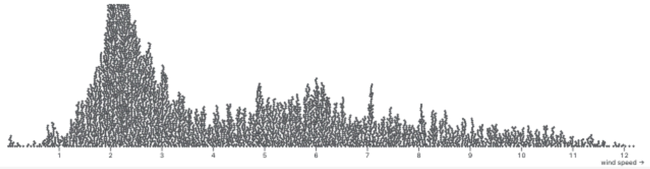
```
▸ Array(3201) [6.1, 6.9, 6.8, null, 3.4, null, 7.7, 3.8, 5.8, 7, 7, 7.5, 8.4, null, 6.8, null, 7, 6.1, 2.5, 8.9, …]
```

```
imdb.map(d => d['IMDB Rating'])
```

```
import {windpopulation, imdbpopulation, imdb, wind, winddata, tf, windspeedDistributionPlot, imdbDistributionPlot} from
"3523e4b3244dbb93"
```

Traditional

Dataset choice




```
<figure id='population-figure'></figure>
```

wind speed

```
<select name="dataset-select" id="dataset-select">
    <option value="wind speed">wind speed</option>
    <option value="IMDB rating">IMDB rating</option>
  </select>
```

```
undefined
```

```
{
  let figure = document.getElementById('population-figure');

  let select = document.getElementById('dataset-select');

  function updatePlot(dataset) {
    let populations = ({
      "wind speed": winddata.map(d => [d['speed']]),
      "IMDB rating": imdb.map(d => [d['IMDB Rating']]),
    })

    let newPlot = Plot.plot({
      height: 250,
      width: 1000,
      x: {label: dataset, domain: [Math.min(...populations[dataset]),
                                   Math.max(...populations[dataset])]},
      marks: [
        Plot.dot(populations[dataset], Plot.dodgeY({x: "0", r:1}))
      ]
    })
    figure.innerHTML = ""; // Clear the current plot
    figure.appendChild(newPlot); // Add in the new plot
  }
  updatePlot(select.value);

  select.addEventListener("change", (d) => updatePlot(d.target.value));
}
```

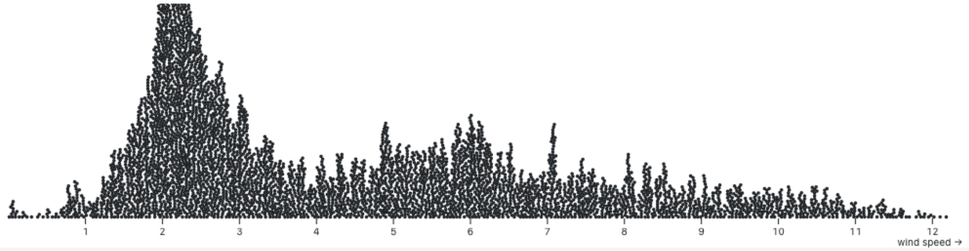
```
▸ Array(3201) [6.1, 6.9, 6.8, null, 3.4, null, 7.7, 3.8, 5.8, 7, 7, 7.5, 8.4, null, 6.8, null, 7, 6.1, 2.5, 8.9, …]
```

```
imdb.map(d => d['IMDB Rating'])
```

```
import {windpopulation, imdbpopulation, imdb, wind, winddata, tf, windspeedDistributionPlot, imdbDistributionPlot} from
"3523e4b3244dbb93"
```

Reactive

Dataset choice

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Plot.plot({
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  marks: [
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  ]
})
```

wind speed

```
viewof dataset = Inputs.select(["wind speed", "IMDB rating"])
```

```
populations = ▸ Object {wind speed: Array(4800), IMDB rating: Array(3201)}
```

```
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      "IMDB rating": imdb.map(d => [d['IMDB Rating']]),
    })
```

```
▸ Array(3201) [6.1, 6.9, 6.8, null, 3.4, null, 7.7, 3.8, 5.8, 7, 7, 7.5, 8.4, null, 6.8, null, 7, 6.1, 2.5, 8.9, …]
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imdb.map(d => d['IMDB Rating'])
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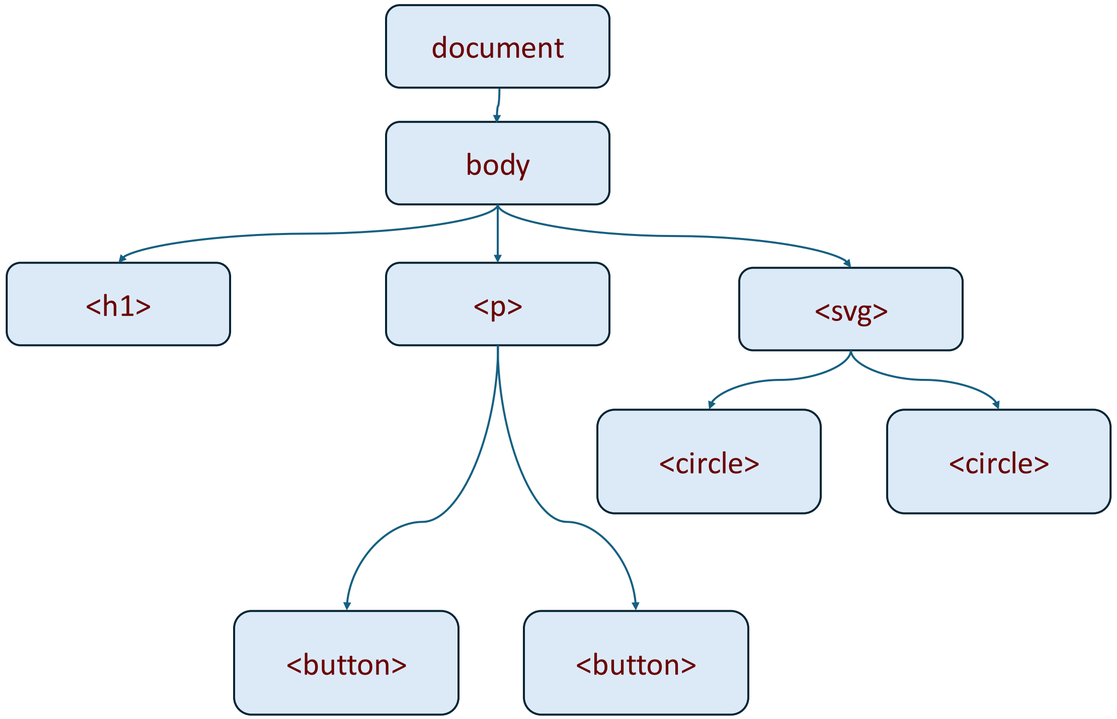
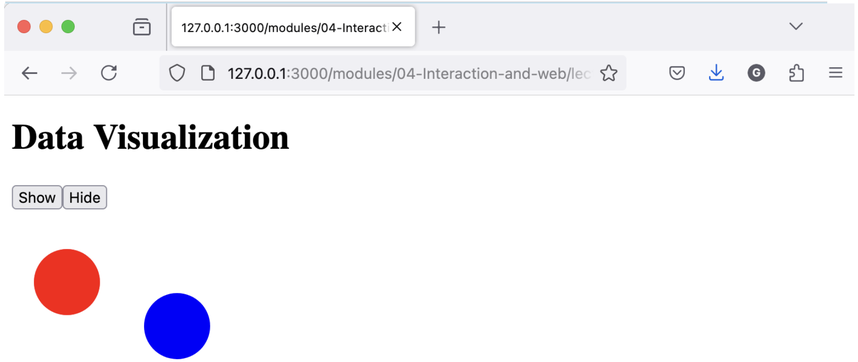
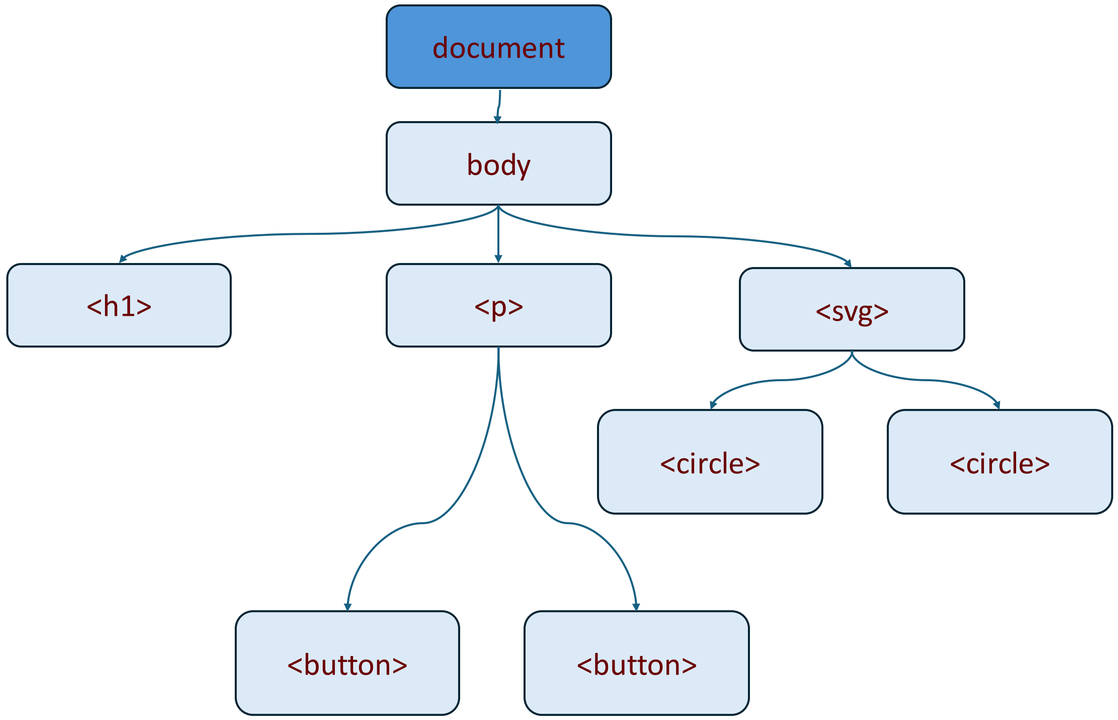
```
import {windpopulation, imdbpopulation, imdb, wind, winddata, tf, windspeedDistributionPlot, imdbDistributionPlot} from
"3523e4b3244dbb93"
```

Website basics

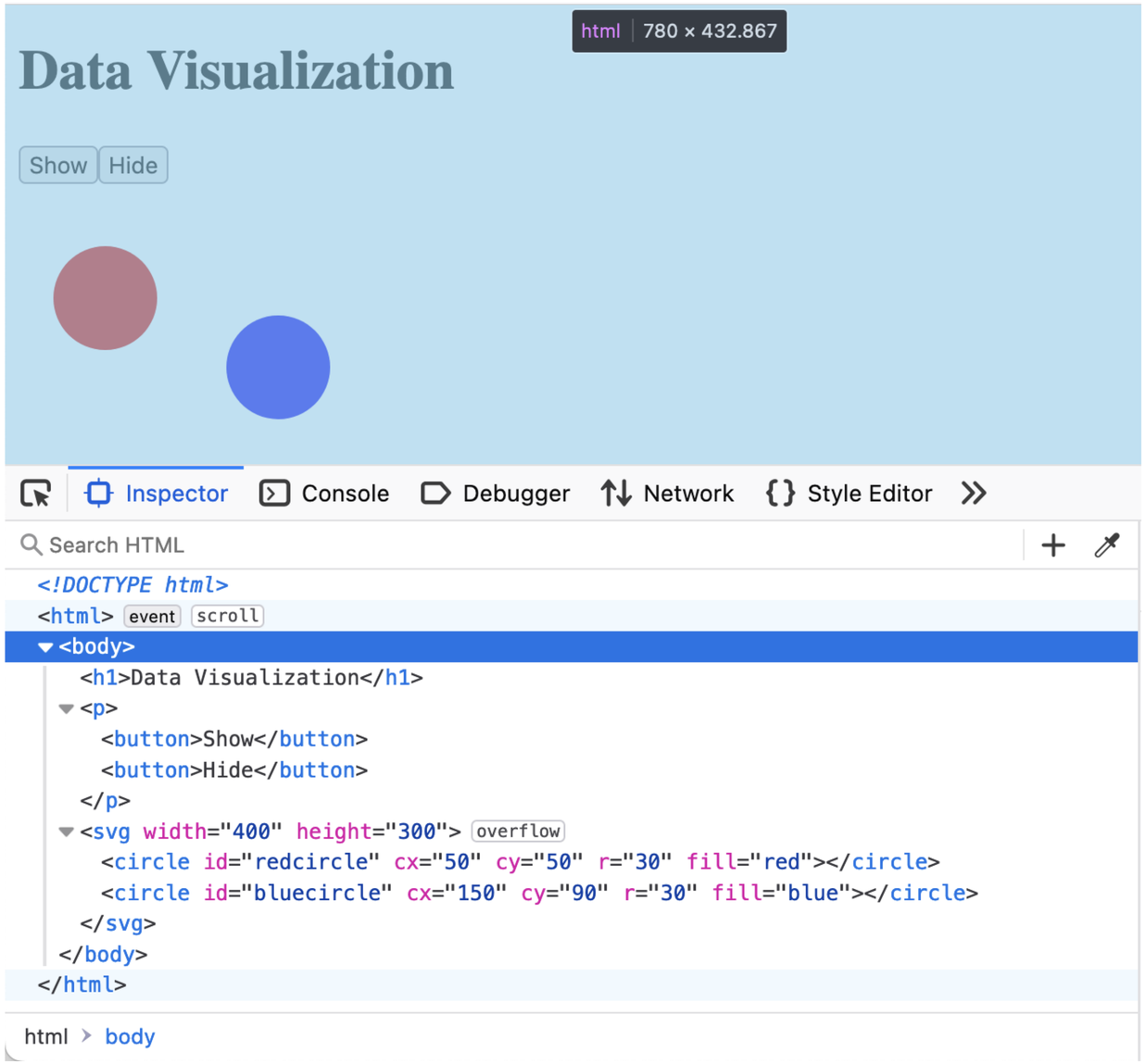
```
<!DOCTYPE html>
<html>
<body>
  <h1>Data Visualization</h1>
  <p>
    <button>Show</button>
    <button>Hide</button>
  </p>
  <svg width="400" height="300">
    <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
    <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
  </svg>
</body>
</html>
```





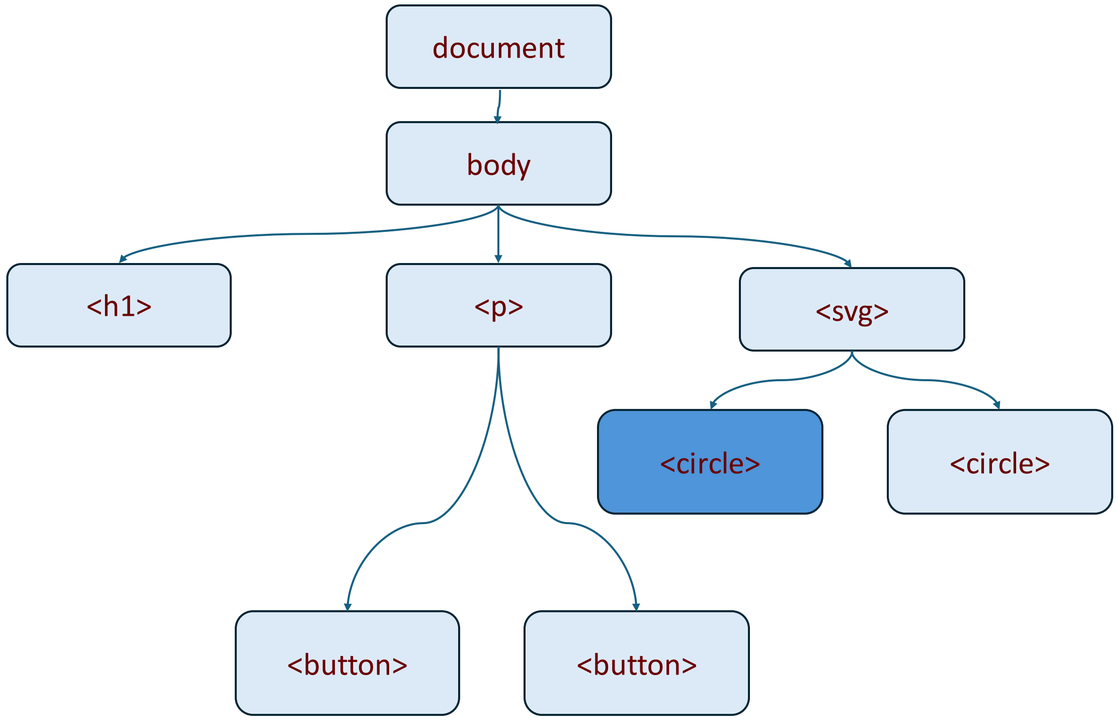

document
body
<h1>

<svg>
<circle>
<circle>
<button>
<button>


html | 780 × 432.867
Data Visualization
Show
Hide
Inspector
Console
Debugger
Network
Style Editor
Search HTML
<!DOCTYPE html>
<html> event scroll
<body>
<h1>Data Visualization</h1>

<button>Show</button>
<button>Hide</button>

<svg width="400" height="300"> overflow
<circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
<circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
</svg>
</body>
</html>
html > body



Data Visualization

Show Hide

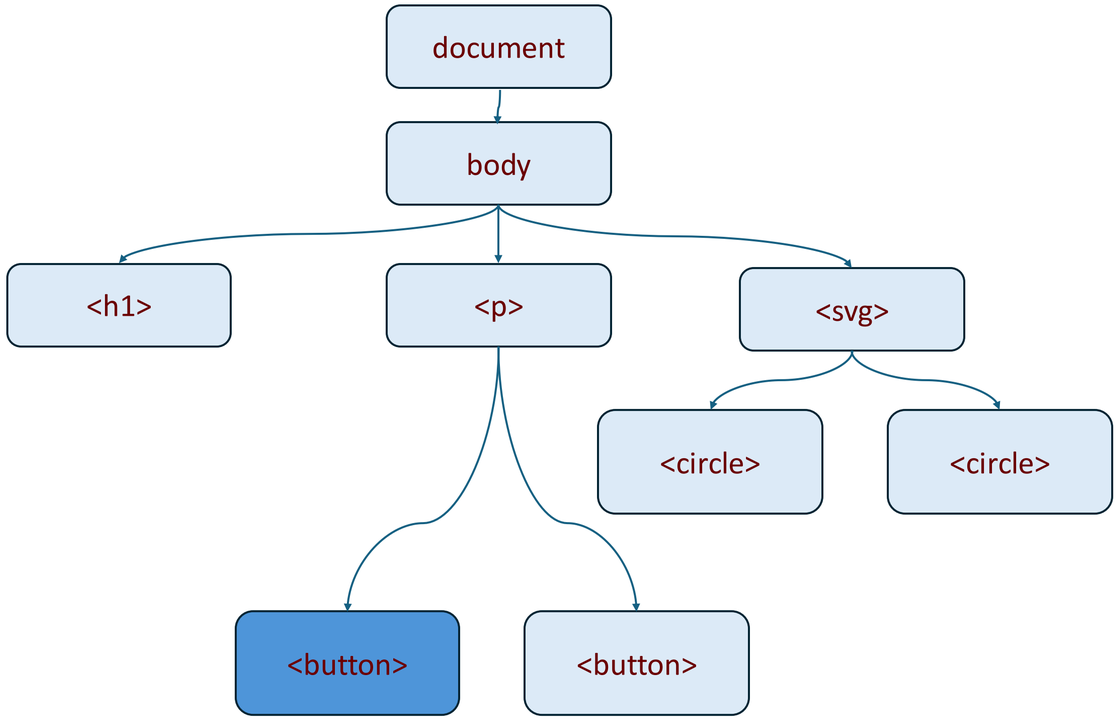
circle#redcircle 60 × 60

Inspector Console Debugger Network Style Editor

Search HTML

```
<!DOCTYPE html>
<html> event scroll
<body>
  <h1>Data Visualization</h1>
  <p>
    <button>Show</button>
    <button>Hide</button>
  </p>
  <svg width="400" height="300"> overflow
    <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
    <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
  </svg>
</body>
</html>
```

html › body › svg › circle#redcircle



Data Visualization

button 45.9 × 22

Show Hide

Inspector Console Debugger Network Style Editor

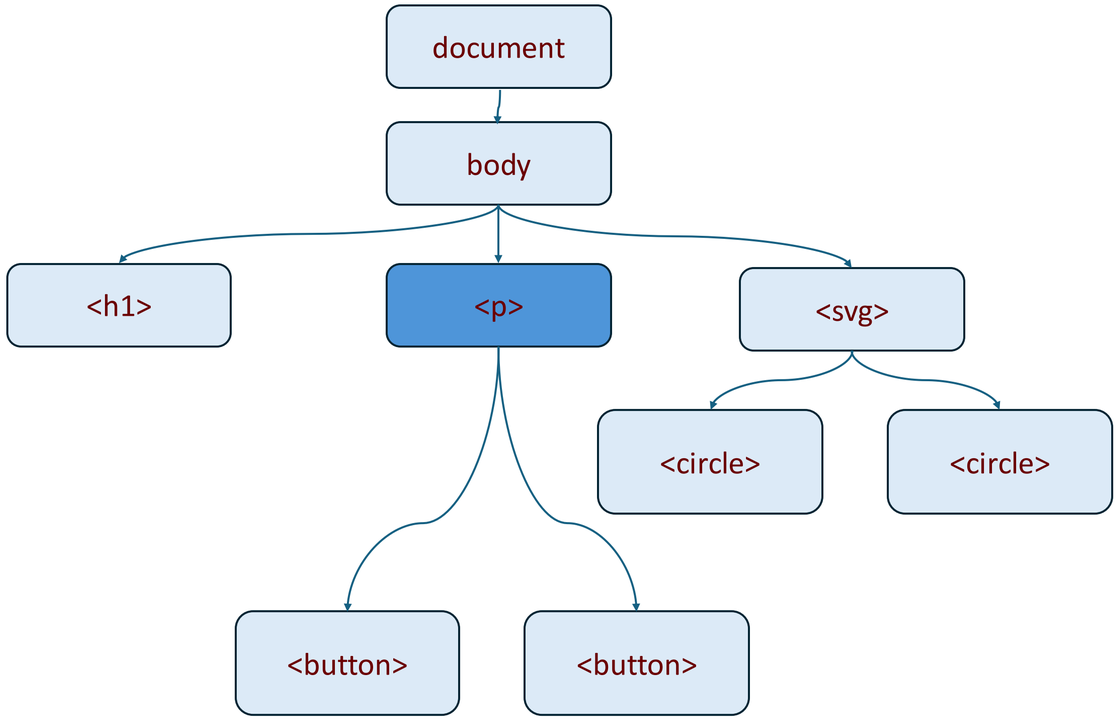
Search HTML

```
<!DOCTYPE html>
<html> event scroll
  <body>
    <h1>Data Visualization</h1>
    <p>
      <button>Show</button>
      <button>Hide</button>
    </p>
    <svg width="400" height="300"> overflow
      <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
      <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
    </svg>
  </body>
</html>
```

html › body › p › button

:hov .cl

element
}



Data Visualization

p | 764 × 22

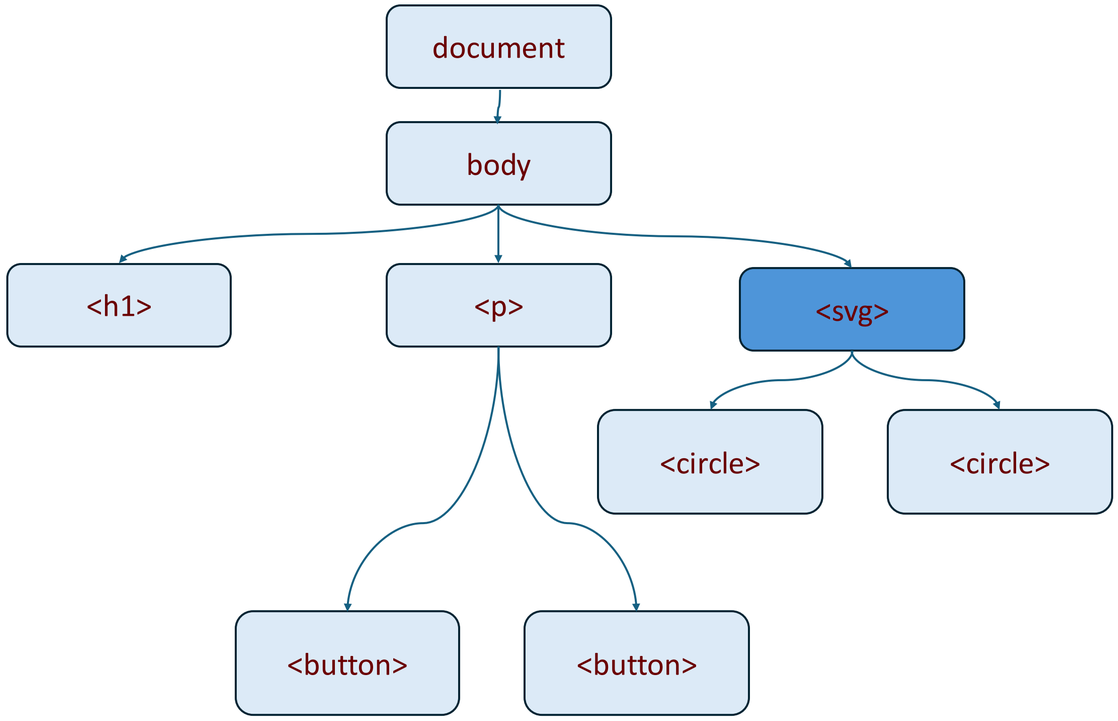
Show Hide

Inspector Console Debugger Network Style Editor

Search HTML

```
<!DOCTYPE html>
<html> event scroll
<body>
  <h1>Data Visualization</h1>
  <p>
    <button>Show</button>
    <button>Hide</button>
  </p>
  <svg width="400" height="300"> overflow
    <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
    <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
  </svg>
</body>
</html>
```

html › body › p



Data Visualization

Show Hide

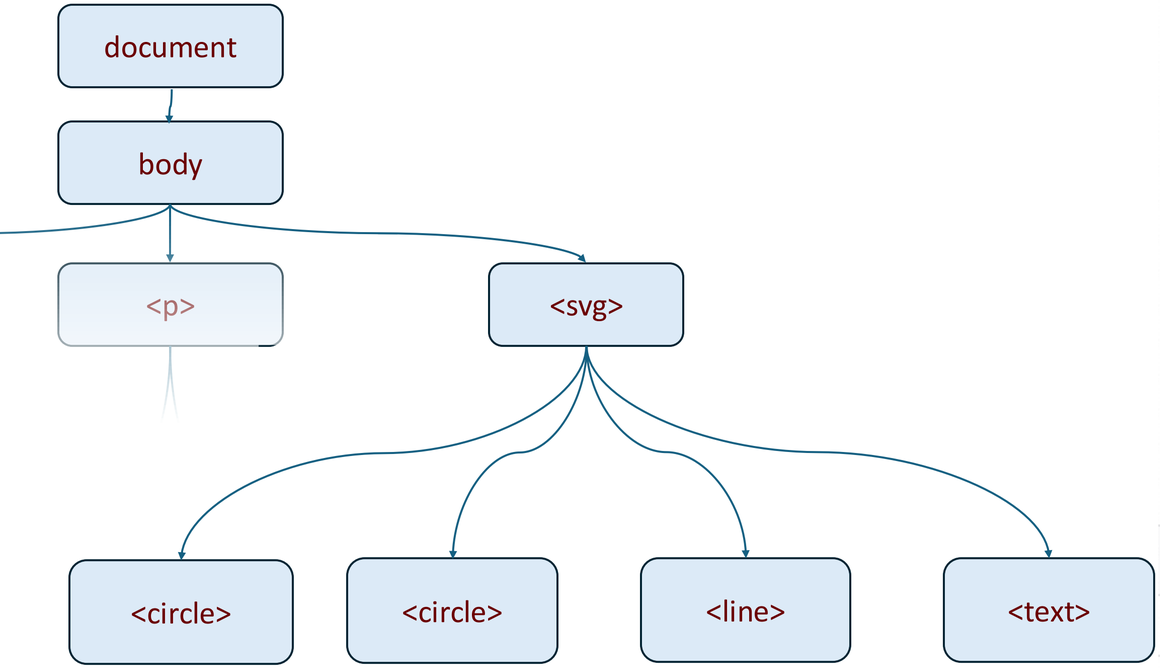
svg | 400 × 300

Inspector Console Debugger Network Style Editor

Search HTML

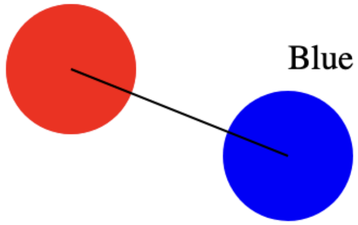
```
<!DOCTYPE html>
<html> event scroll
  <body>
    <h1>Data Visualization</h1>
    <p>
      <button>Show</button>
      <button>Hide</button>
    </p>
    <svg width="400" height="300"> overflow
      <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
      <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
    </svg>
  </body>
</html>
```

html › body › svg



Data Visualization

Show Hide

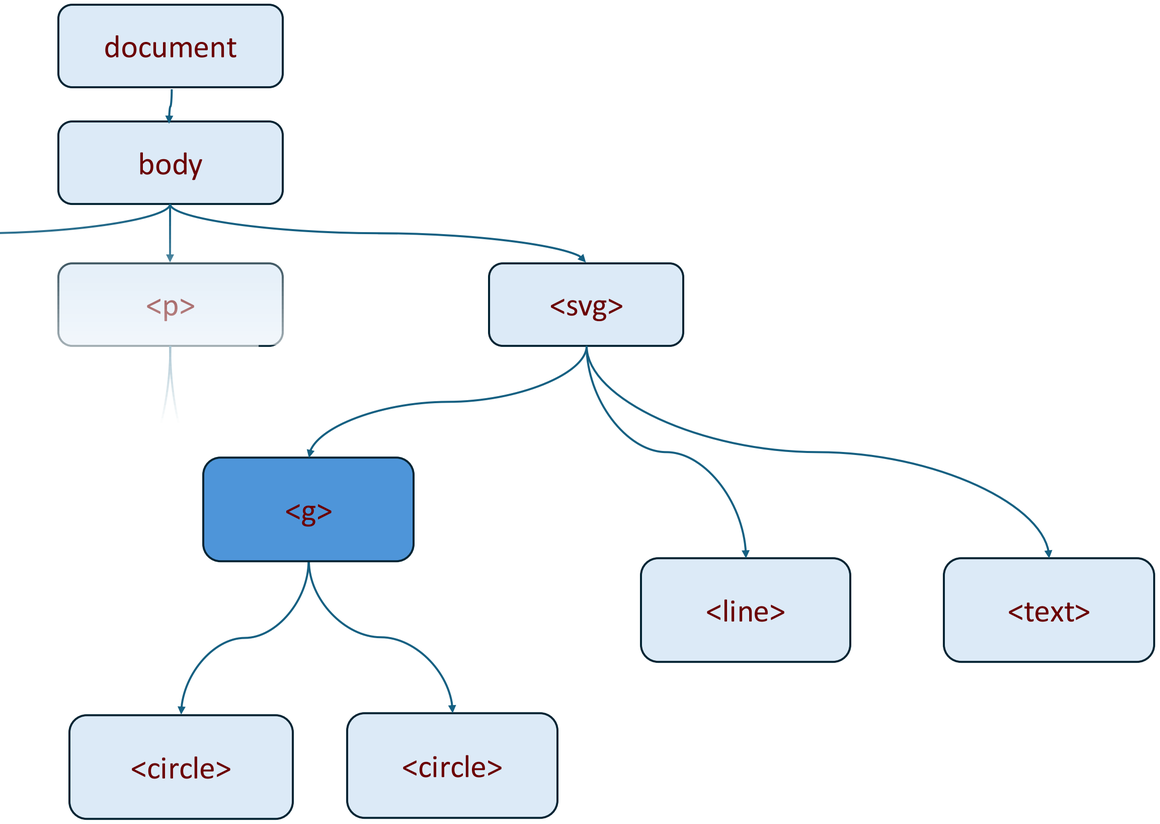


Inspector Console Debugger Network Style Editor

Search HTML

```
<!DOCTYPE html>
<html> event scroll
  <head></head>
  <body>
    <script type="text/javascript" src="/___vscode_livepreview_injected_script"></
    script>
    <h1>Data Visualization</h1>
    <p> ··· </p>
    <svg width="400" height="300"> overflow
      <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
      <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
      <text id="label" x="150" y="50">Blue</text>
      <line x1="50" y1="50" x2="150" y2="90" stroke="black"></line>
    </svg>
```

html › body › svg



Data Visualization

Show Hide

g#circles | 160 × 100

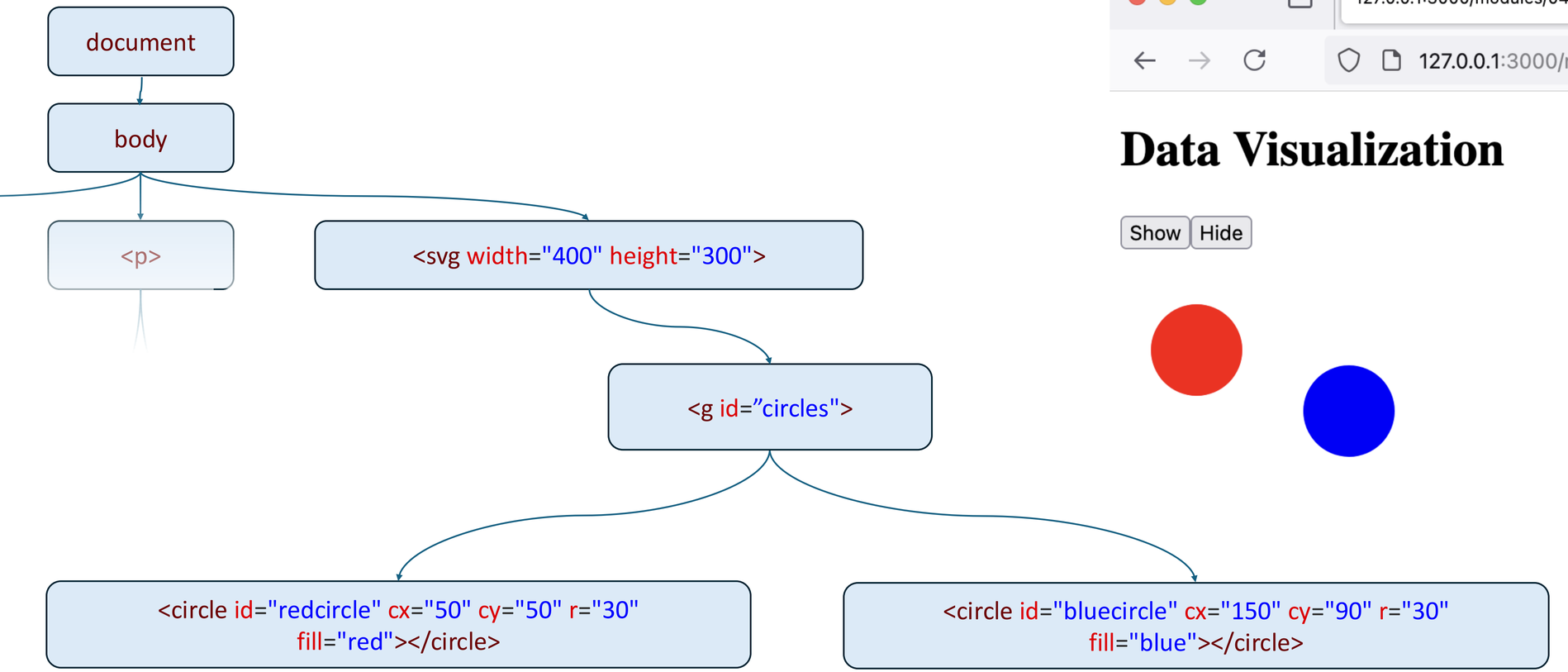
Blue

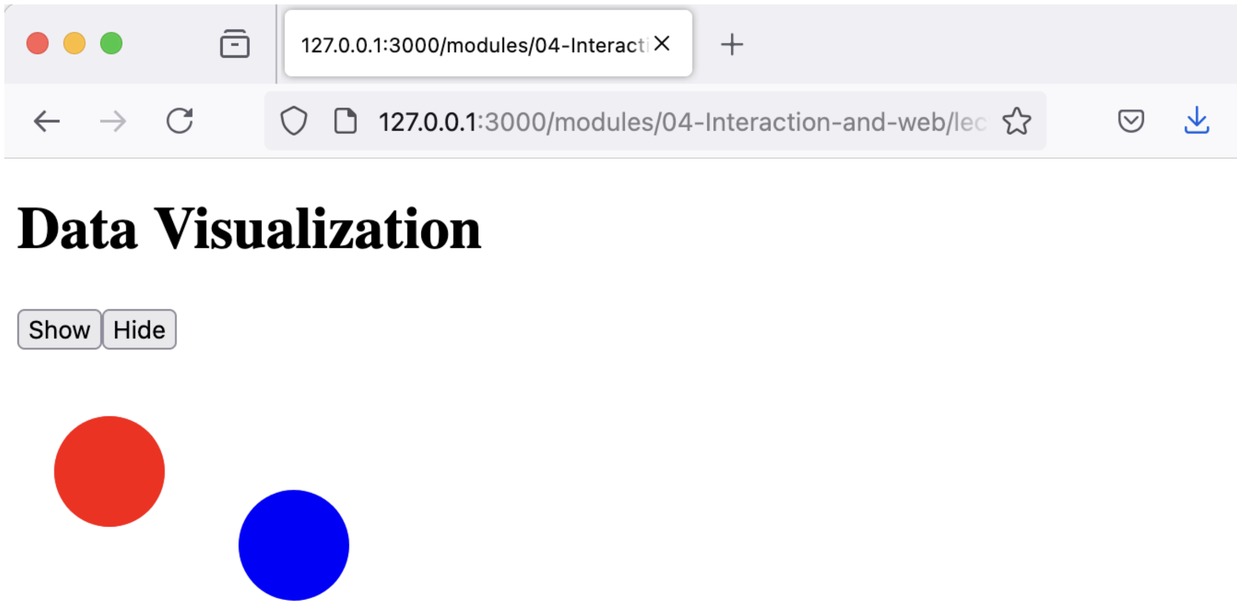
Inspector Console Debugger Network Style Editor

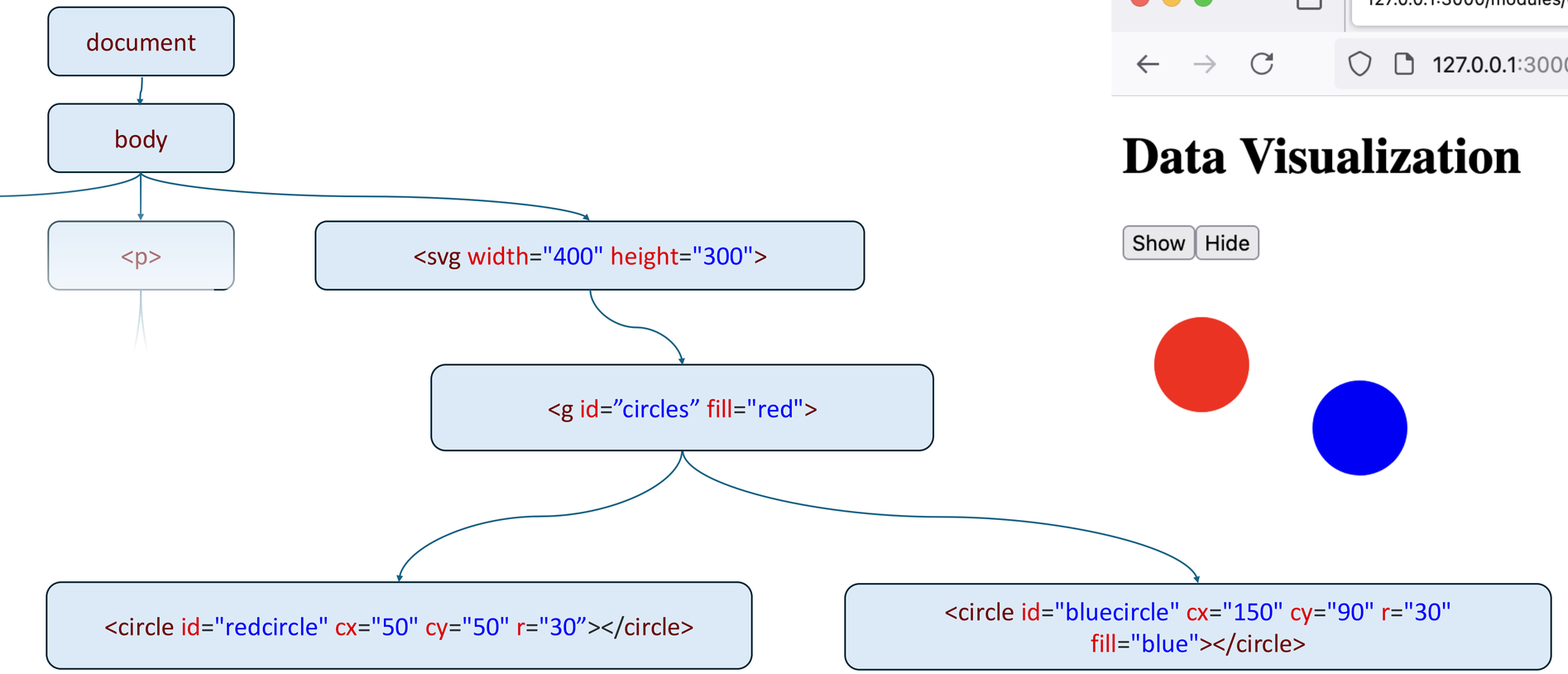
Search HTML

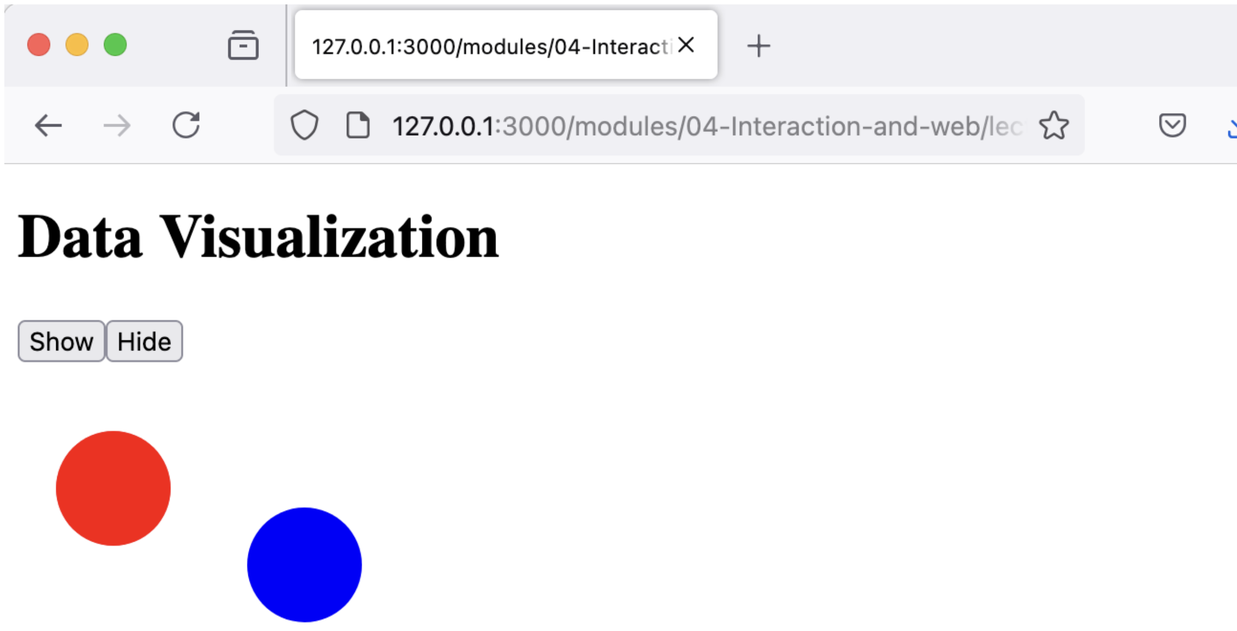
```
<body>
  <script type="text/javascript" src="/___vscode_livepreview_injected_script"></
  script>
  <h1>Data Visualization</h1>
  <p> ··· </p>
  <svg width="400" height="300"> overflow
    <g id="circles">
      <circle id="redcircle" cx="50" cy="50" r="30" fill="red"></circle>
      <circle id="bluecircle" cx="150" cy="90" r="30" fill="blue"></circle>
    </g>
    <text id="label" x="150" y="50">Blue</text>
    <line x1="50" y1="50" x2="150" y2="90" stroke="black"></line>
  </svg>
 </body>
</html>
```

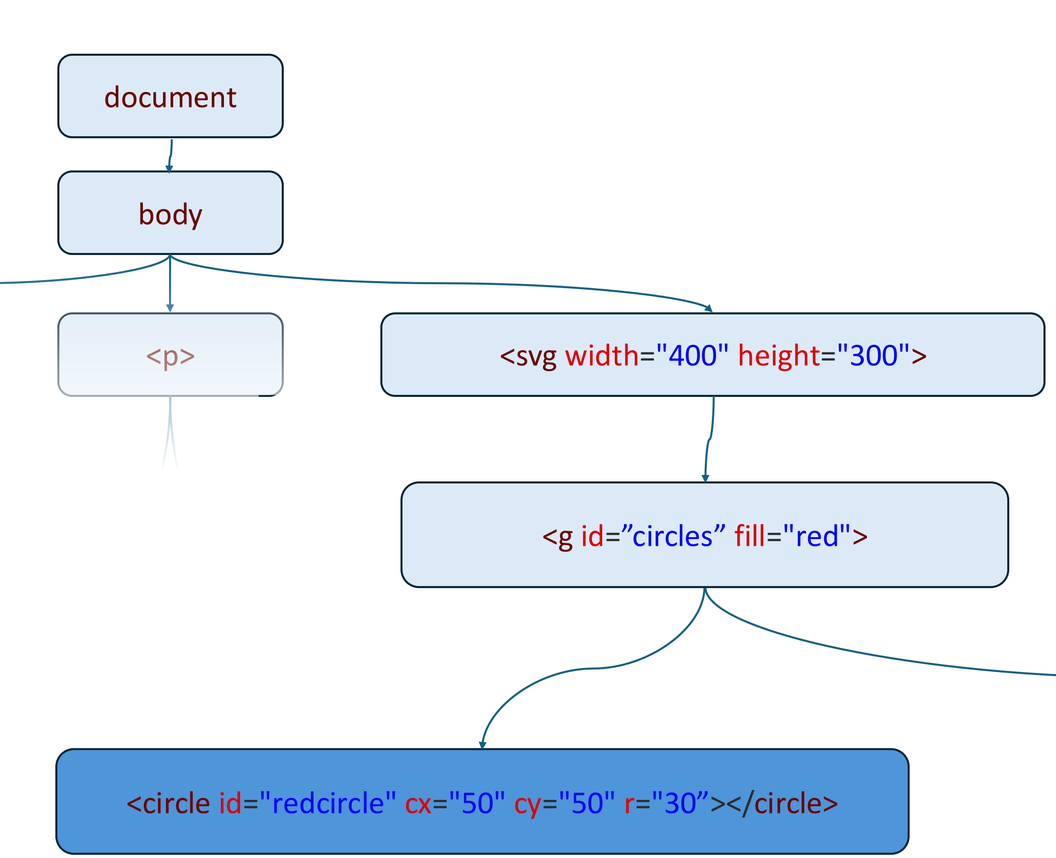
html › body › svg › g#circles

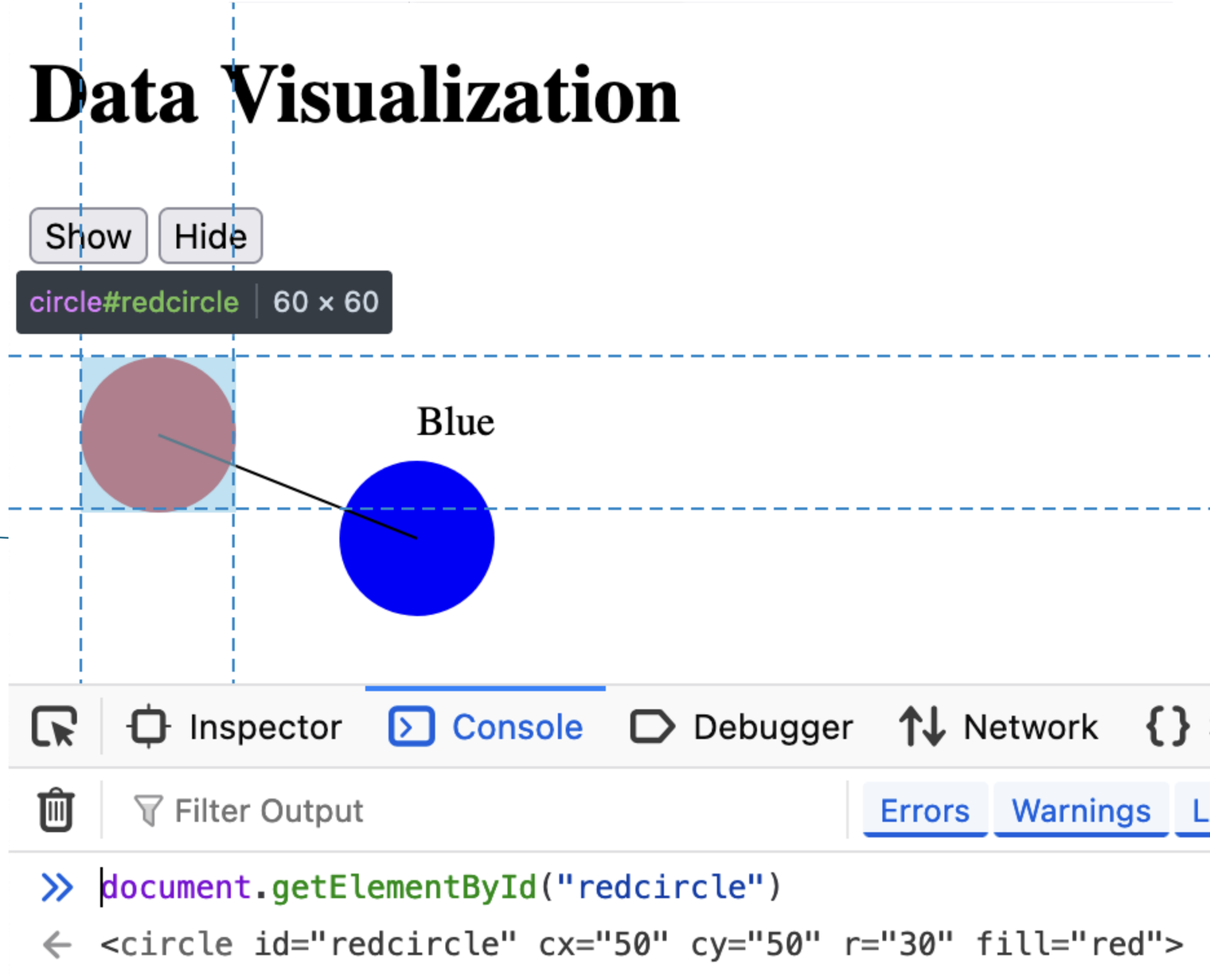

document
body
<p>
<svg width="400" height="300">
<g id=”circles">
<circle id="redcircle" cx="50" cy="50" r="30"
fill="red"></circle>
<circle id="bluecircle" cx="150" cy="90" r="30"
fill="blue"></circle>

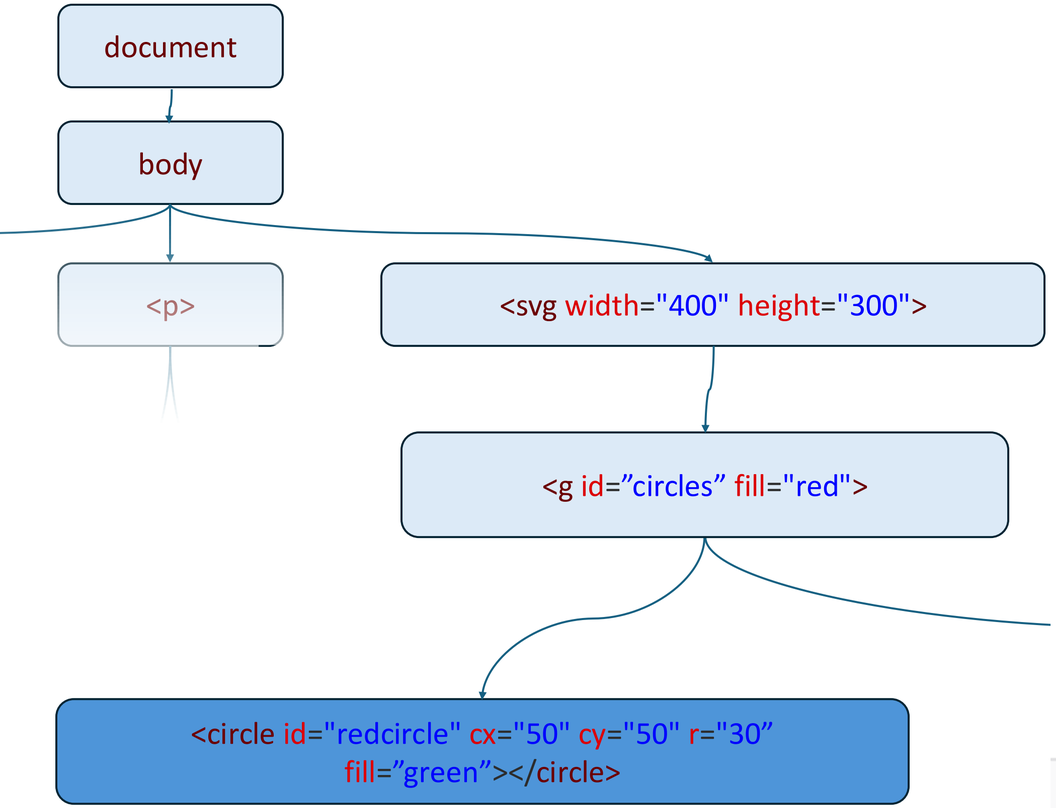

127.0.0.1:3000/modules/04-Interact
127.0.0.1:3000/modules/04-Interaction-and-web/lec
Data Visualization
Show
Hide


document
body
<p>
<svg width="400" height="300">
<g id=”circles” fill="red">
<circle id="redcircle" cx="50" cy="50" r="30”></circle>
<circle id="bluecircle" cx="150" cy="90" r="30"
fill="blue"></circle>


127.0.0.1:3000/modules/04-Interact
127.0.0.1:3000/modules/04-Interaction-and-web/lec
Data Visualization
Show
Hide

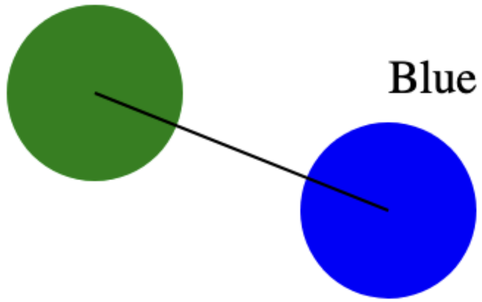

document
body
<p>
<svg width="400" height="300">
<g id=”circles” fill="red">
<circle id="redcircle" cx="50" cy="50" r="30”></circle>

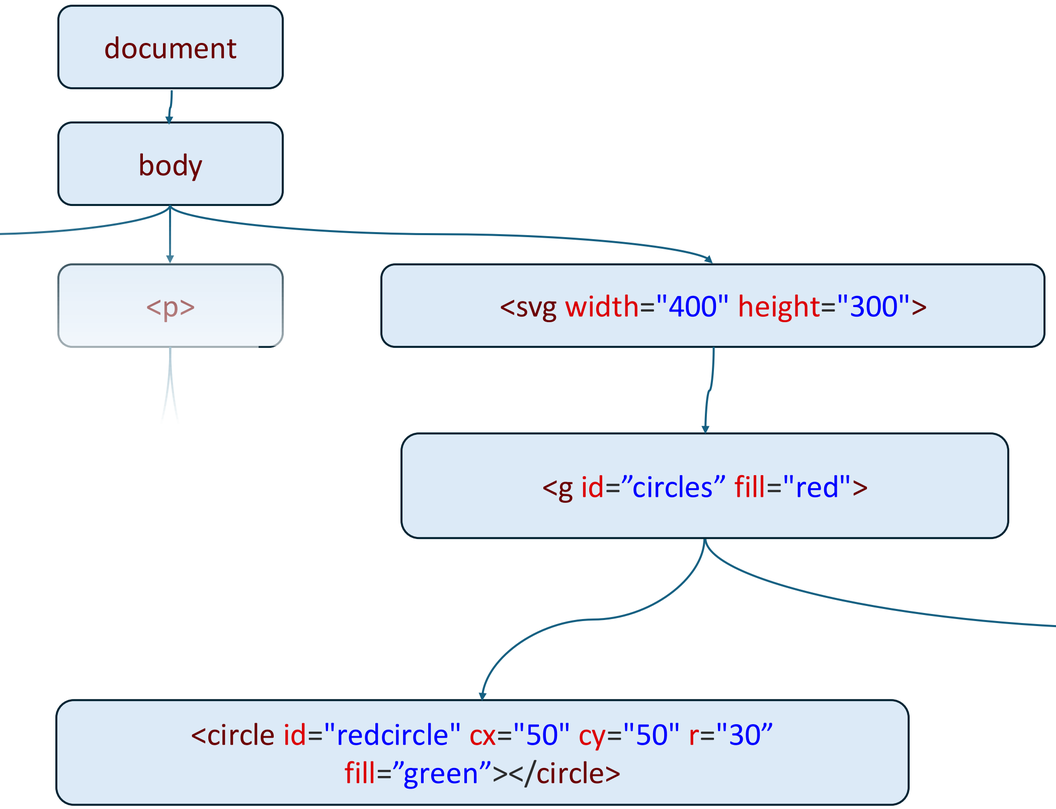

Data Visualization
Show
Hide
circle#redcircle
60 × 60
Blue
Inspector
Console
Debugger
Network
Filter Output
Errors
Warnings
document.getElementById("redcircle")
<circle id="redcircle" cx="50" cy="50" r="30" fill="red">



Data Visualization

Show Hide

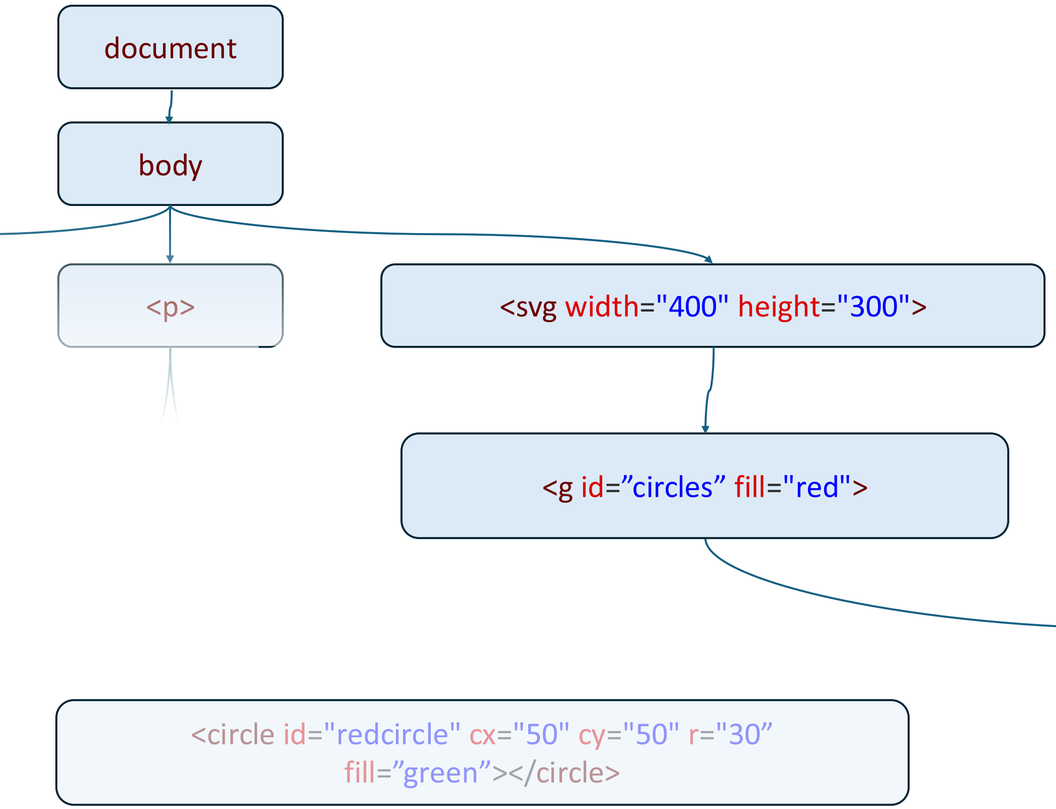





```
let redcircle = document.getElementById('redcircle');
let circles = document. getElementById(circles');

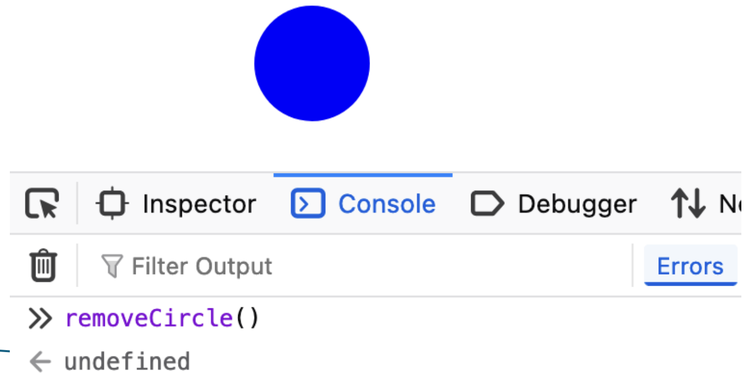
function removeCircle() {
    redcircle.remove()
}

function addCircle() {
    svg.appendChild(redcircle);
}
```



Data Visualization

Show Hide

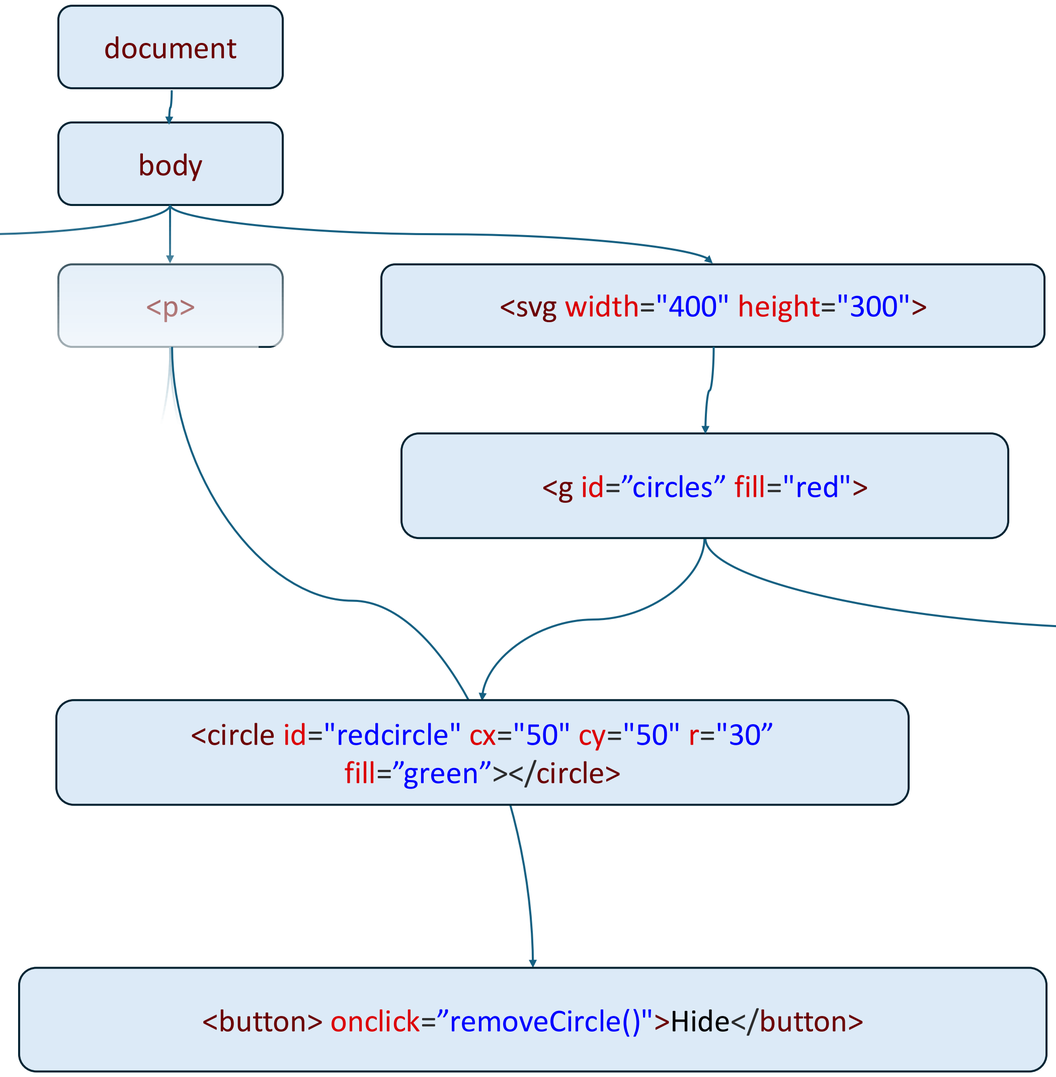



```
let redcircle = document.getElementById('redcircle');
let circles = document. getElementById(circles');

function removeCircle() {
    redcircle.remove()
}

function addCircle() {
    svg.appendChild(redcircle);
}
```

Data Visualization

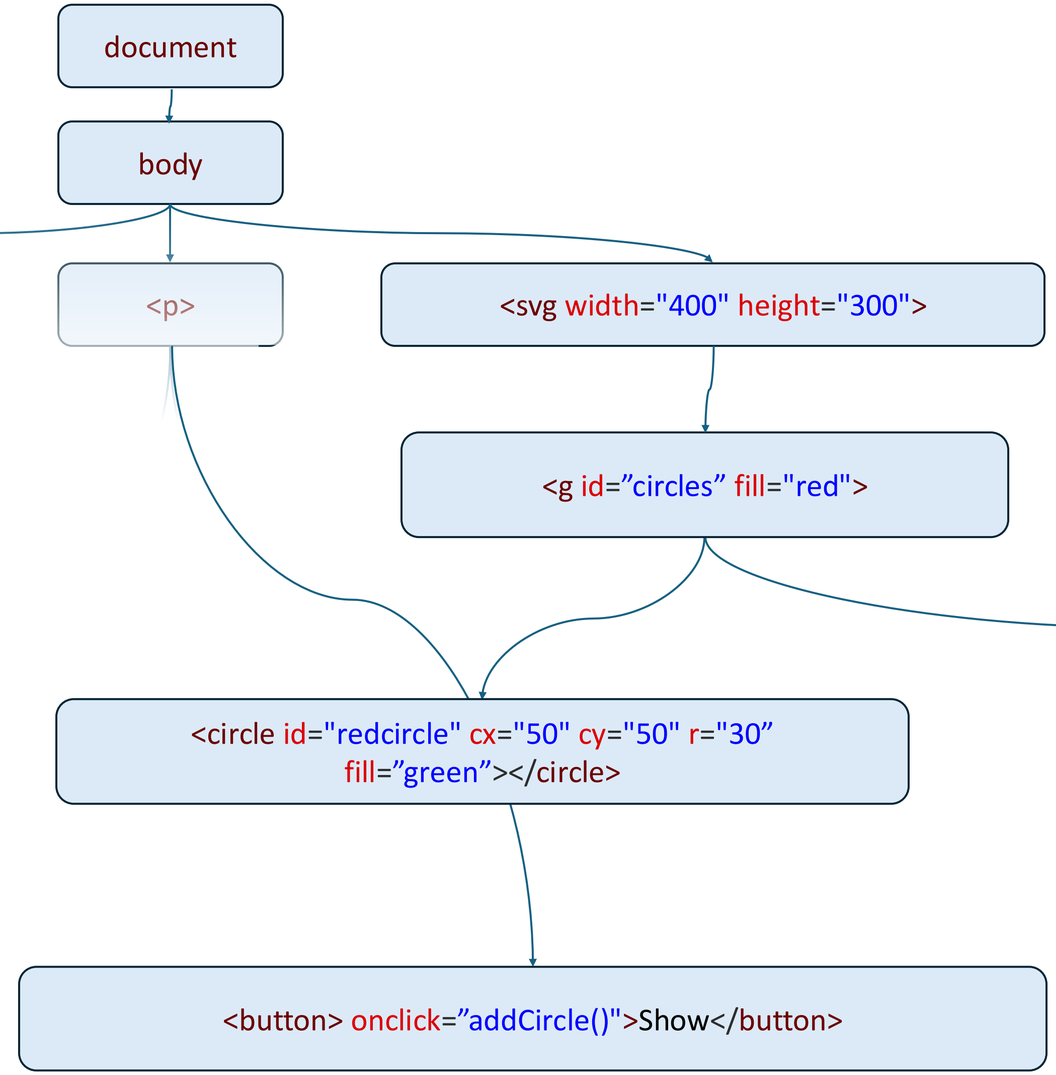


Show Hide

```
let redcircle = document.getElementById('redcircle');
let circles = document. getElementById(circles');

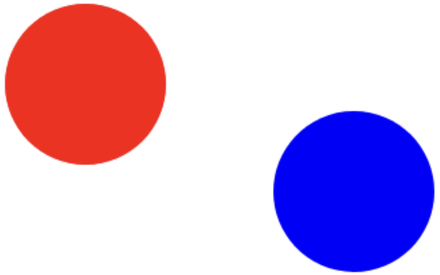
function removeCircle() {
    redcircle.remove()
}

function addCircle() {
    svg.appendChild(redcircle);
}
```



Data Visualization

Show Hide

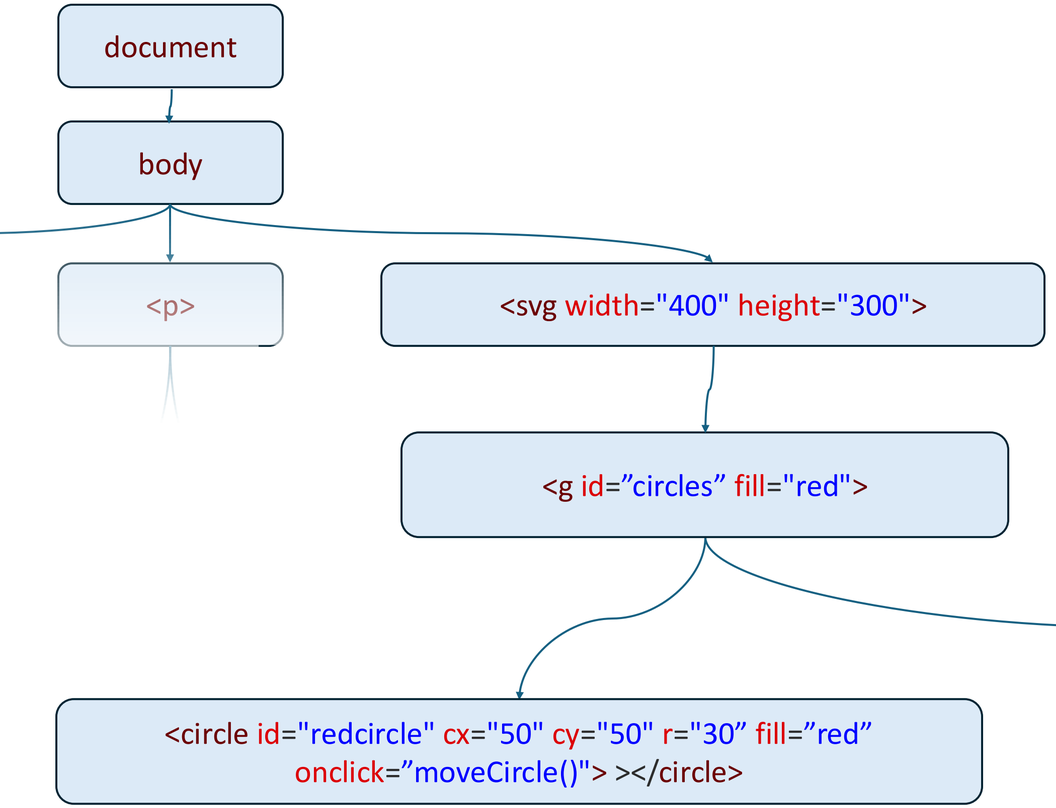



```
let redcircle = document.getElementById('redcircle');
let circles = document. getElementById(circles');

function removeCircle() {
    redcircle.remove()
}

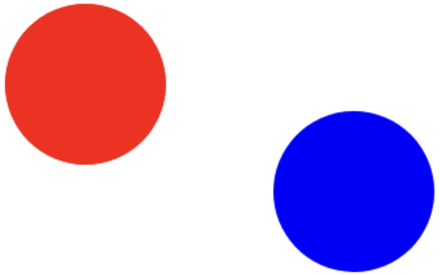
function addCircle() {
    svg.appendChild(redcircle);
}
```

Basic Animation



Data Visualization

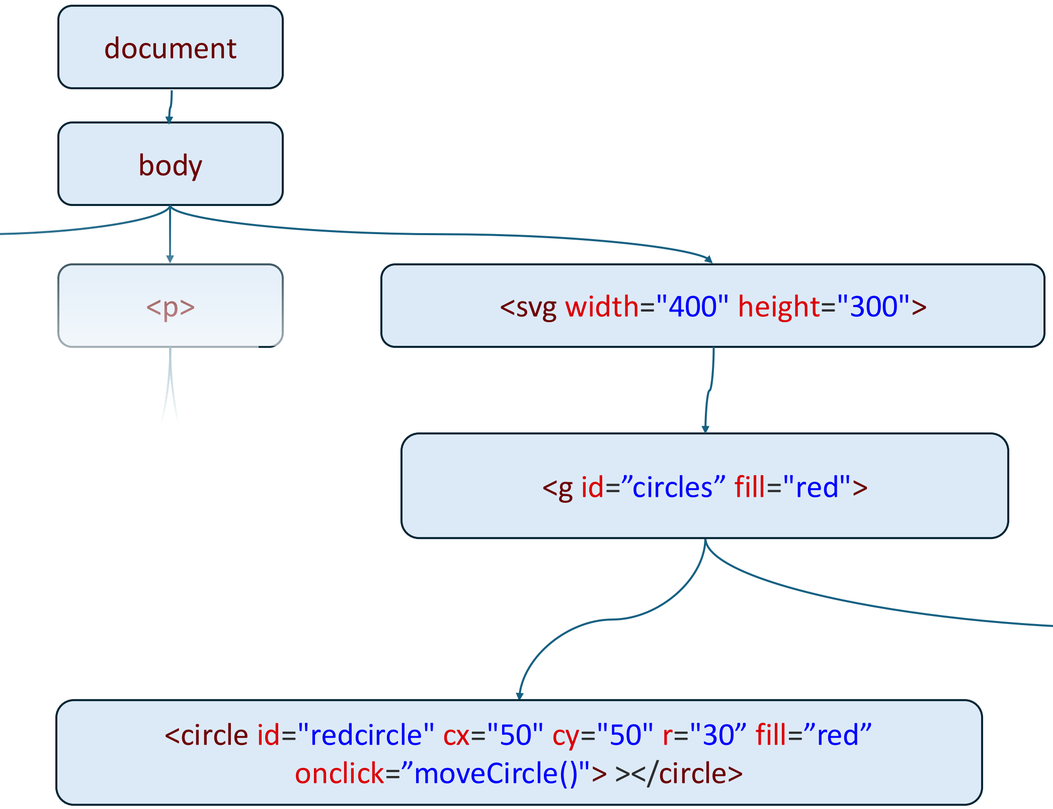
Show Hide



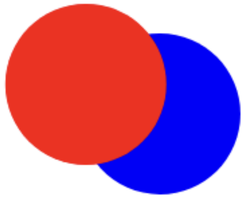
```
function moveCircle() {
    const duration = 1000;
    let i = 0;
    setInterval(() => {
        const t = Math.min(i++ / duration, 1);
        redcircle.setAttribute('cx', t * 150 + (1 - t) * 50);
        redcircle.setAttribute('cy', t * 90 + (1 - t) * 50);
        }, 1)
        }

redcircle.addEventListener('click', moveCircle);
```

Data Visualization



Show Hide



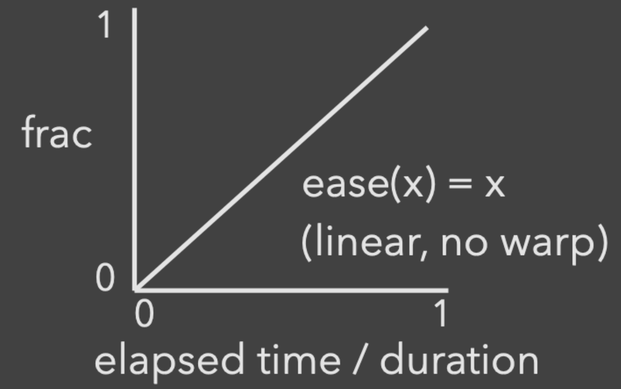
```
function moveCircle() {
    const duration = 1000;
    let i = 0;
    setInterval(() => {
        const t = Math.min(i++ / duration, 1);
        redcircle.setAttribute('cx', t * 150 + (1 - t) * 50);
        redcircle.setAttribute('cy', t * 90 + (1 - t) * 50);
        }, 1)
        }

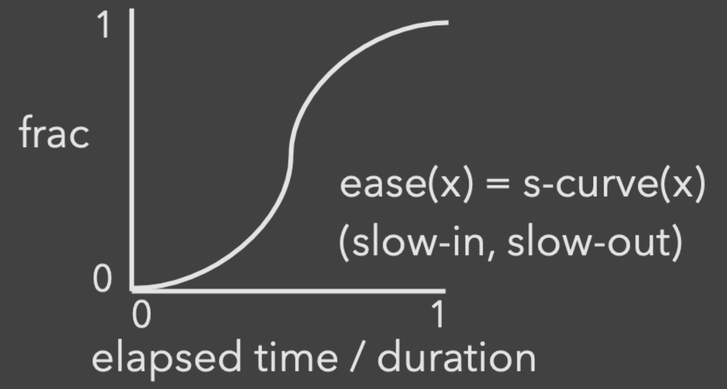
redcircle.addEventListener('click', moveCircle);
```

Easing (or “Pacing”) Functions

Goals: stylize animation, improve perception.

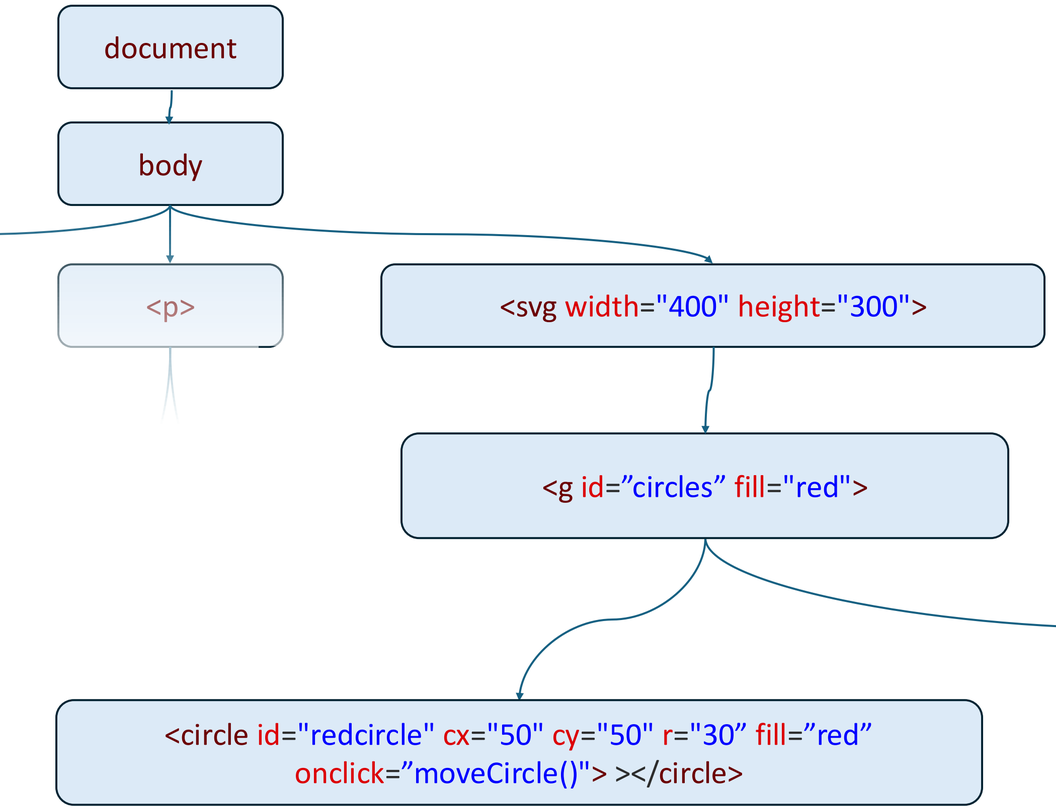
Basic idea is to warp time: as *duration* goes from start (0%) to end (100%), dynamically adjust the *interpolation fraction* using an **easing function**.



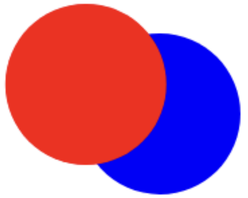


From Jeff Heer

Data Visualization



Show Hide



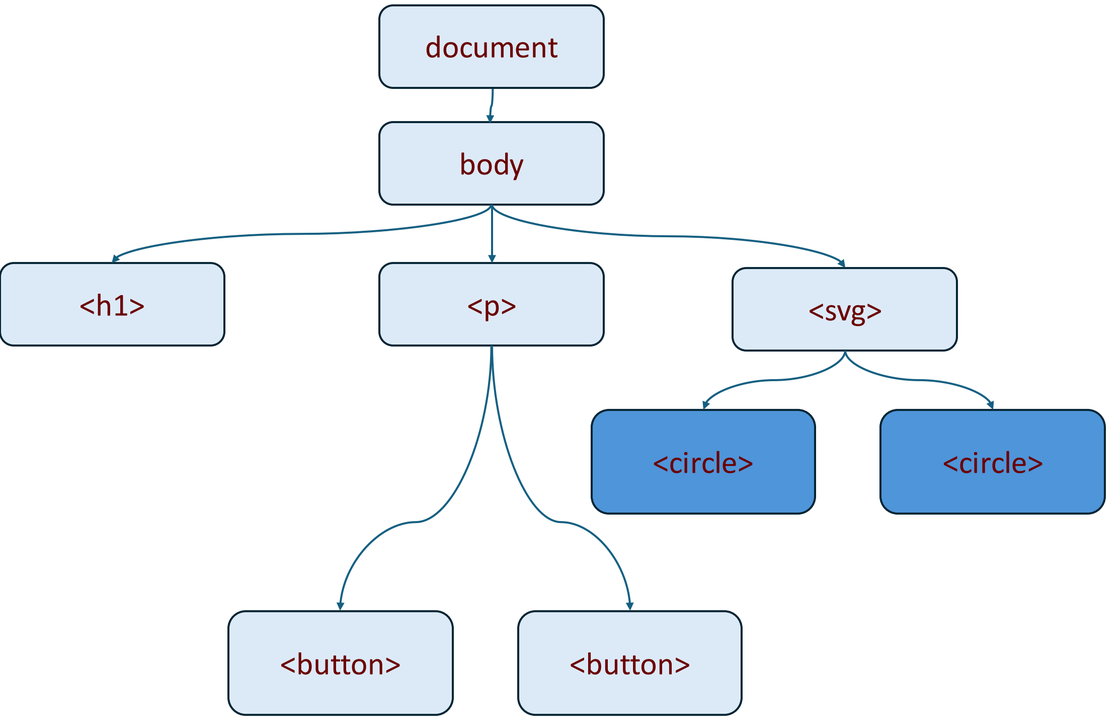
https://easings.net/

```
function moveCircle() {
    const duration = 1000;
    let i = 0;
    setInterval(() => {
        const t = Math.min(i++ / duration, 1);

        t = ease(t); //
        redcircle.setAttribute('cx', t * 150 + (1 - t) * 50);
        redcircle.setAttribute('cy', t * 90 + (1 - t) * 50);
        }, 1)
        }

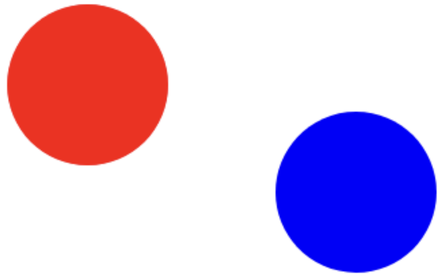
redcircle.addEventListener('click', moveCircle);
```

Selecting Elements



Data Visualization

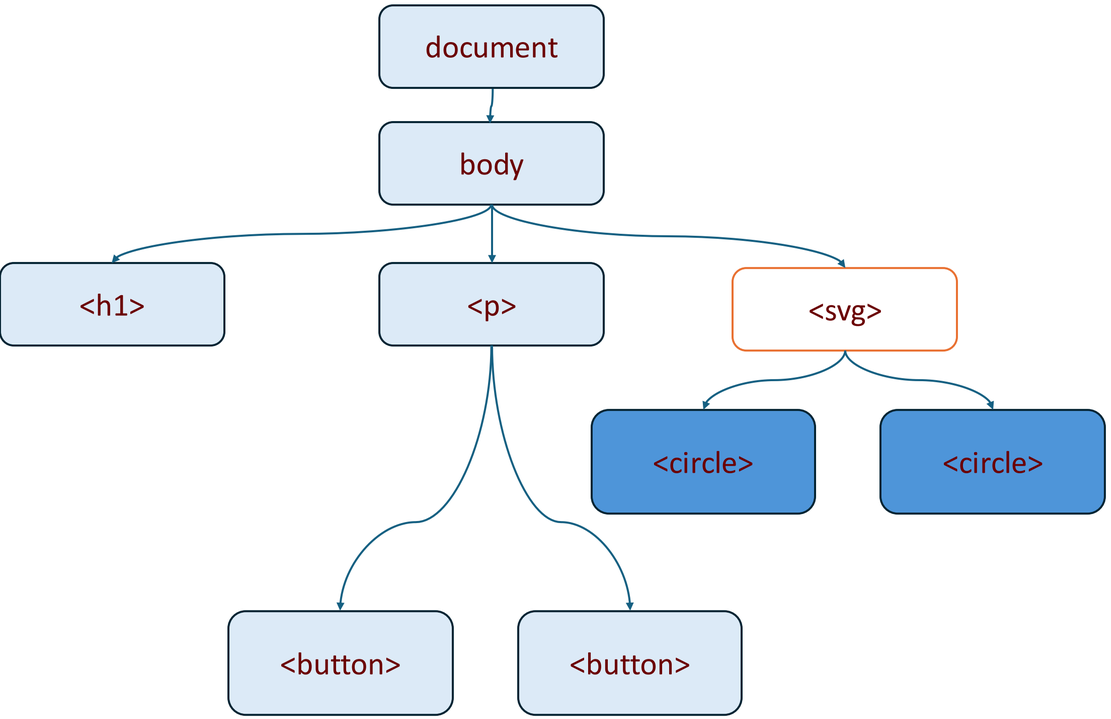
Show Hide



Inspector Console Debugger Network

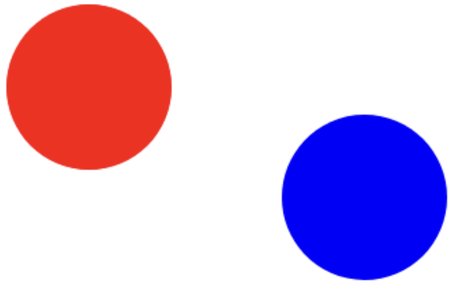
Filter Output Errors Warnings

```
document.querySelectorAll('circle')
NodeList [ circle#redcircle , circle#bluecircle ]
```



Data Visualization

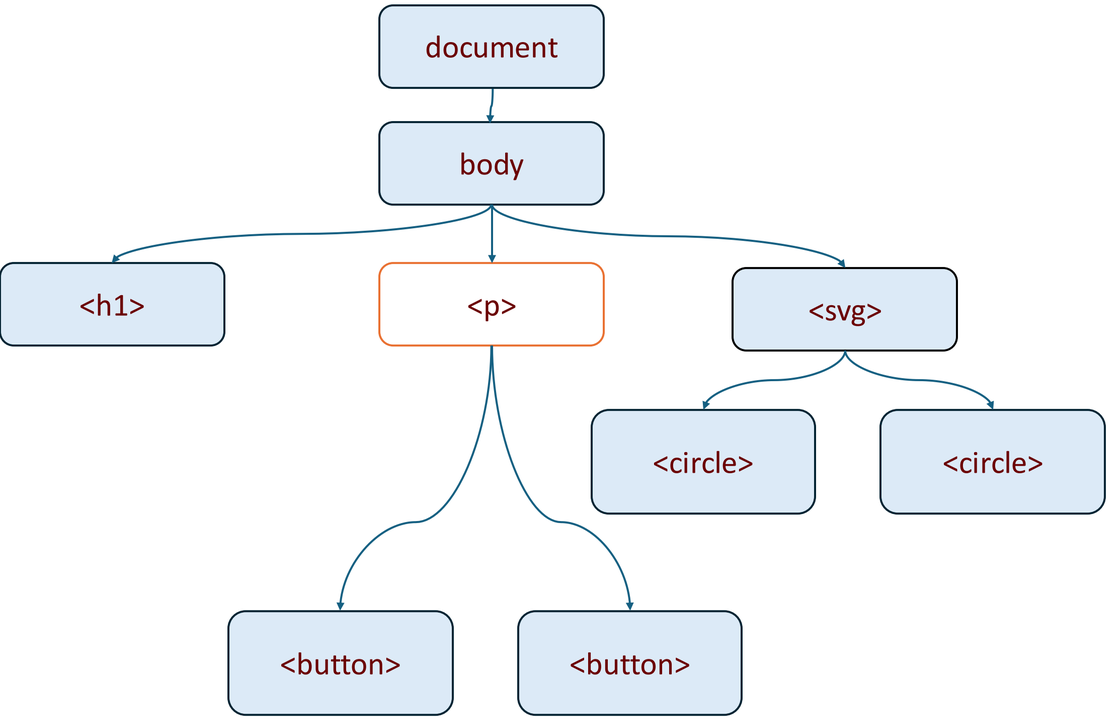
Show Hide



Inspector Console Debugger Network

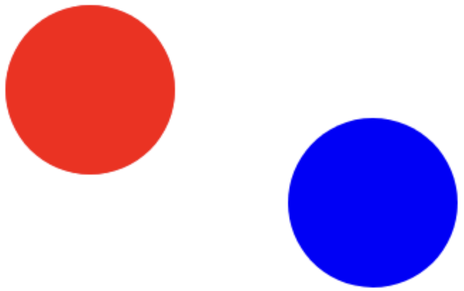
Filter Output Errors Warnings

```
>> svg.querySelectorAll('circle')
<- NodeList [ circle#redcircle , circle#bluecircle ]
```



Data Visualization

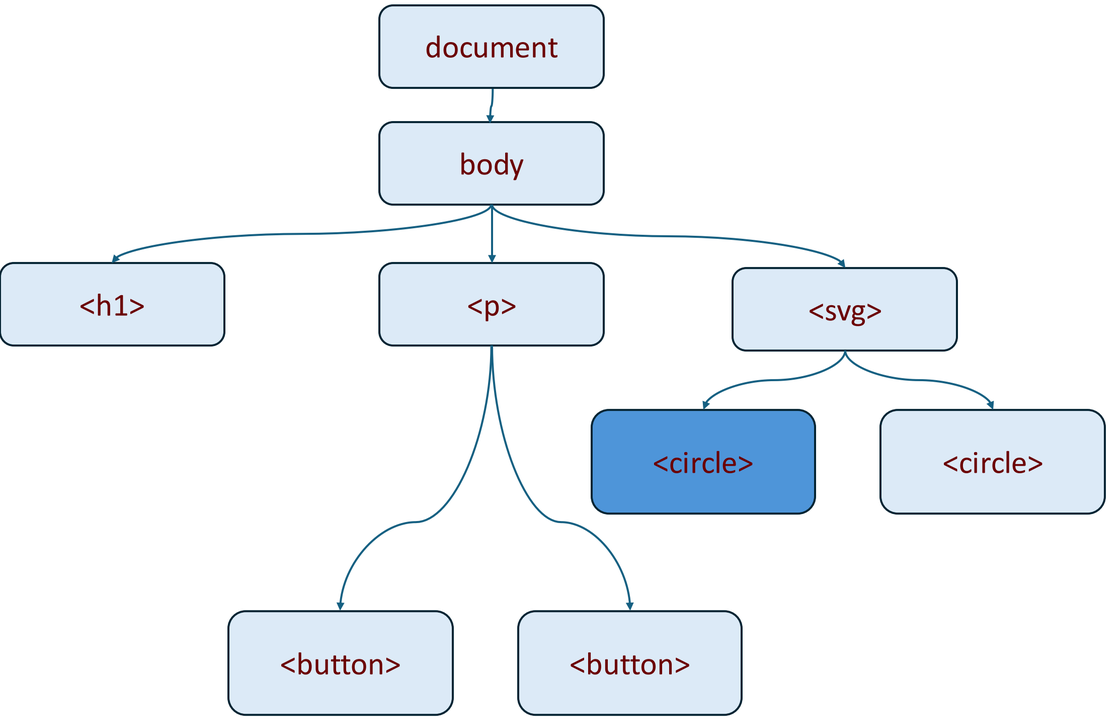
Show Hide

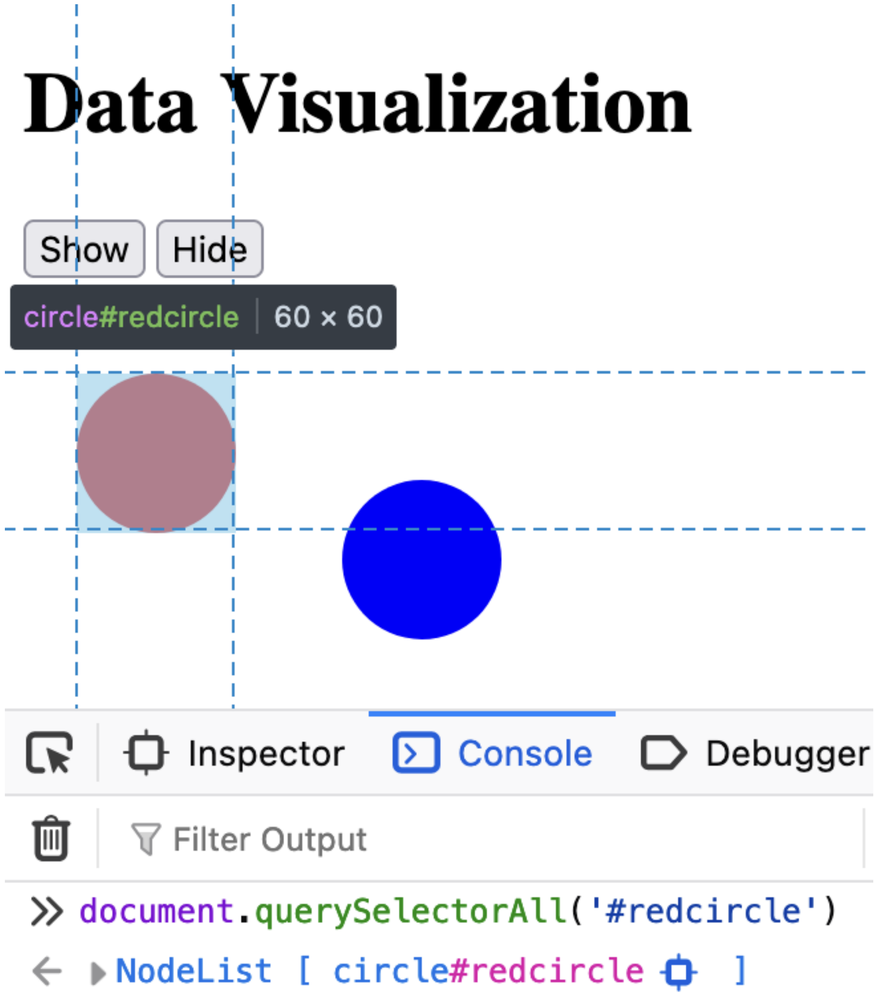


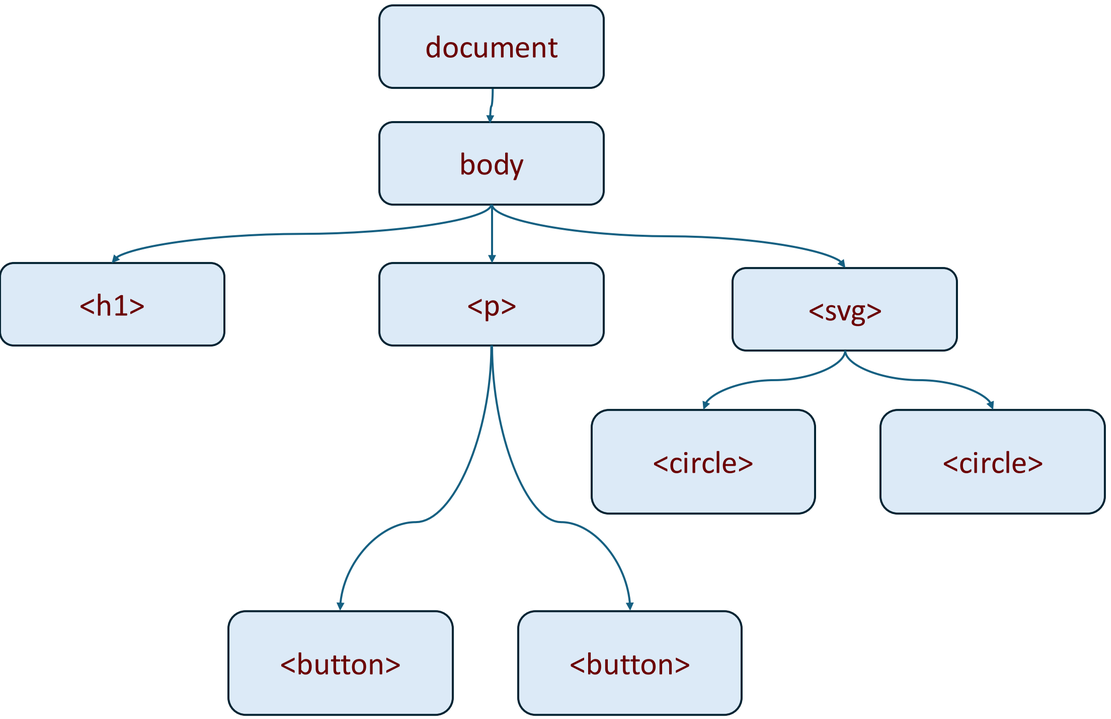
Inspector Console Debugger Network {

Filter Output Errors Warnings

```
p.querySelectorAll('circle')
NodeList []
```

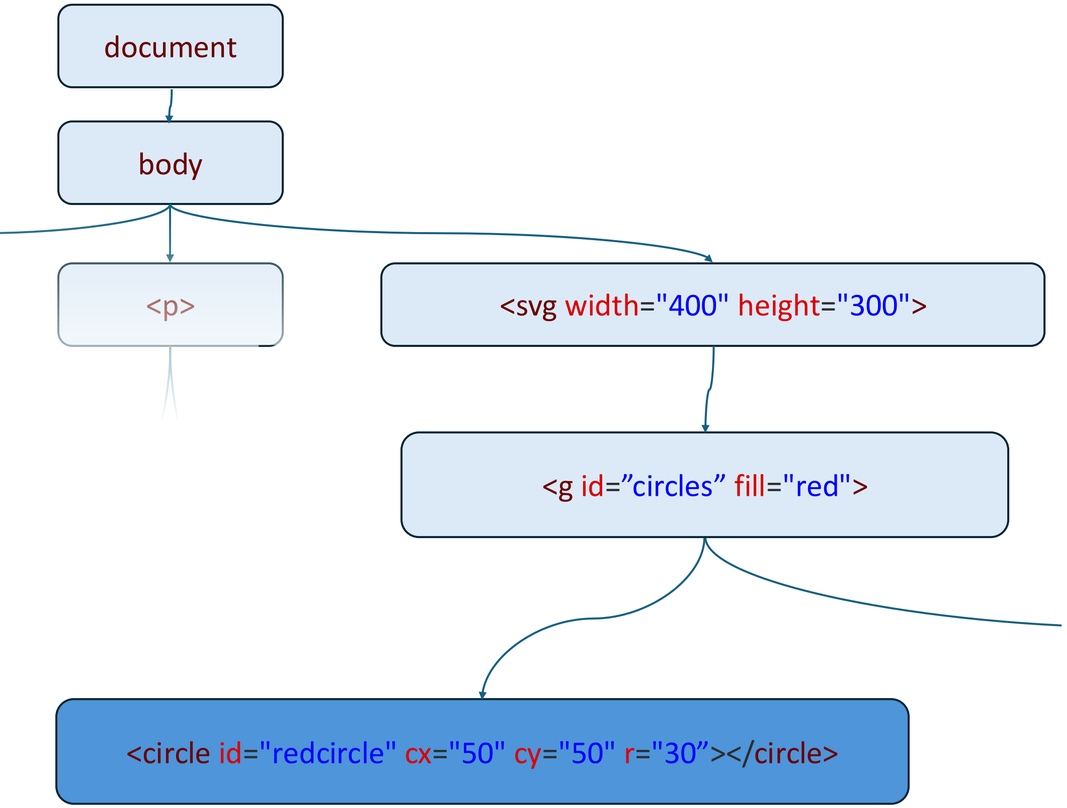

document
body
<h1>
<p>
<svg>
<circle>
<circle>
<button>
<button>


Data Visualization
Show
Hide
circle#redcircle
60 × 60
Inspector
Console
Debugger
Filter Output
document.querySelectorAll('#redcircle')
NodeList [circle#redcircle]



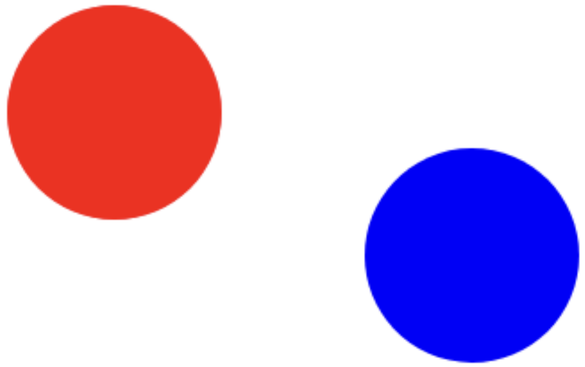

```
#foo        // <any id="foo">
foo         // <foo>
.foo        // <any class="foo">
[foo=bar]     // <any foo="bar">
foo bar     // <foo><bar></foo>
```

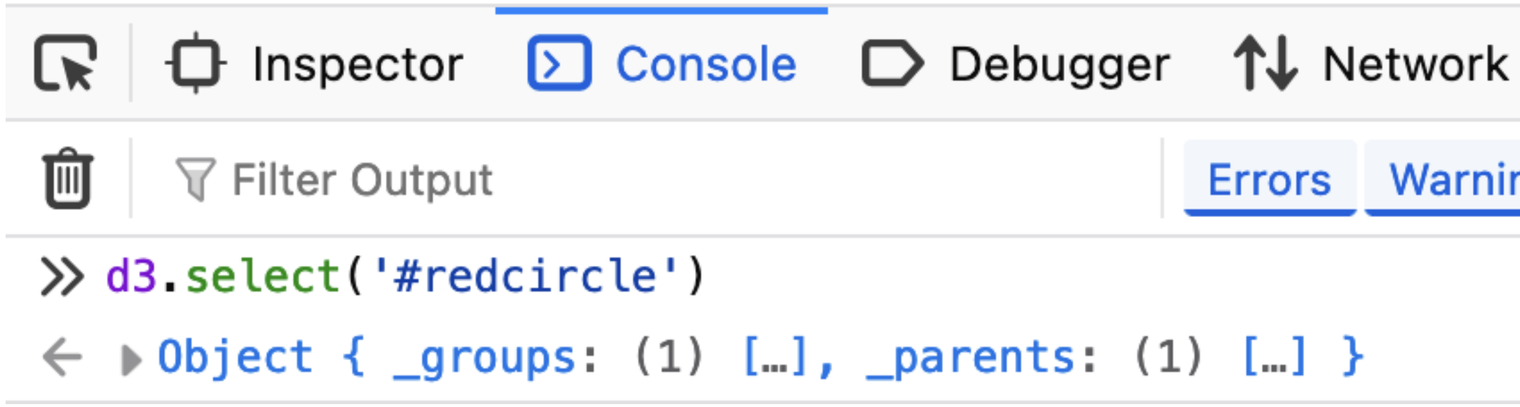
D3.js



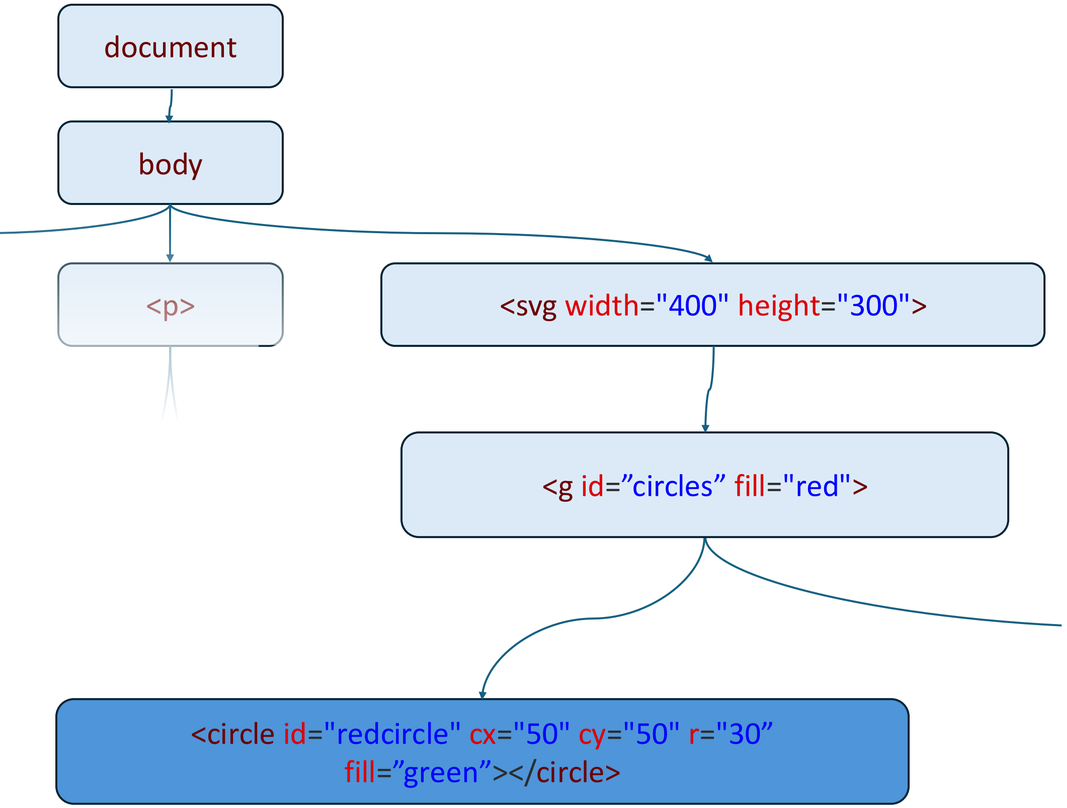
Data Visualization

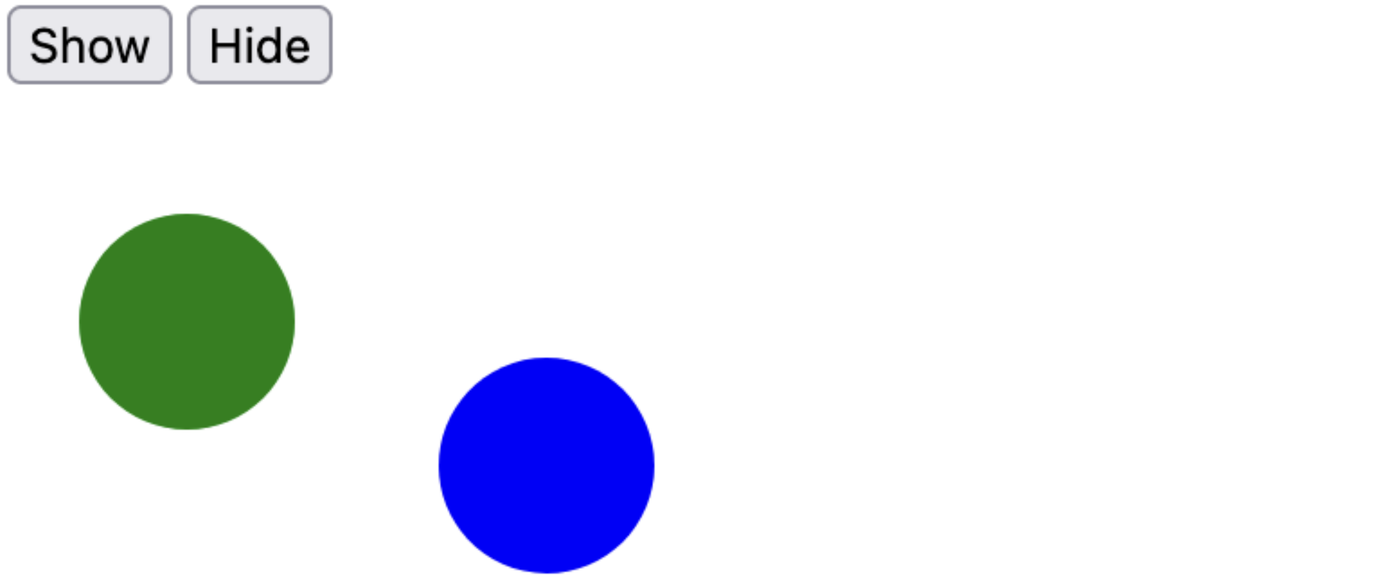
Show Hide

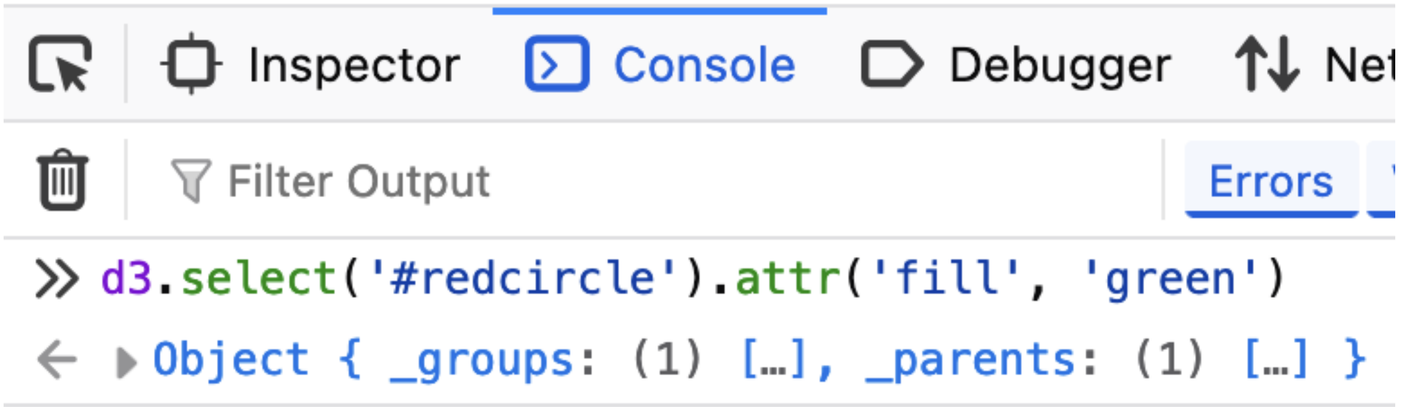


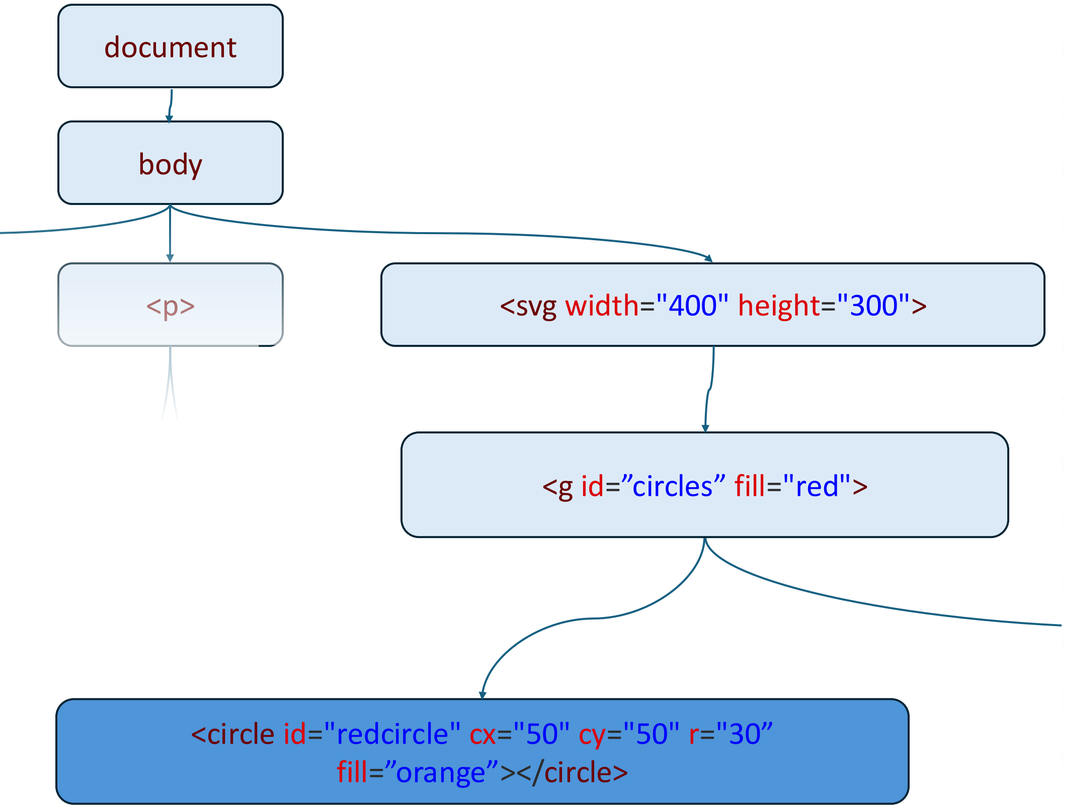


Data Visualization



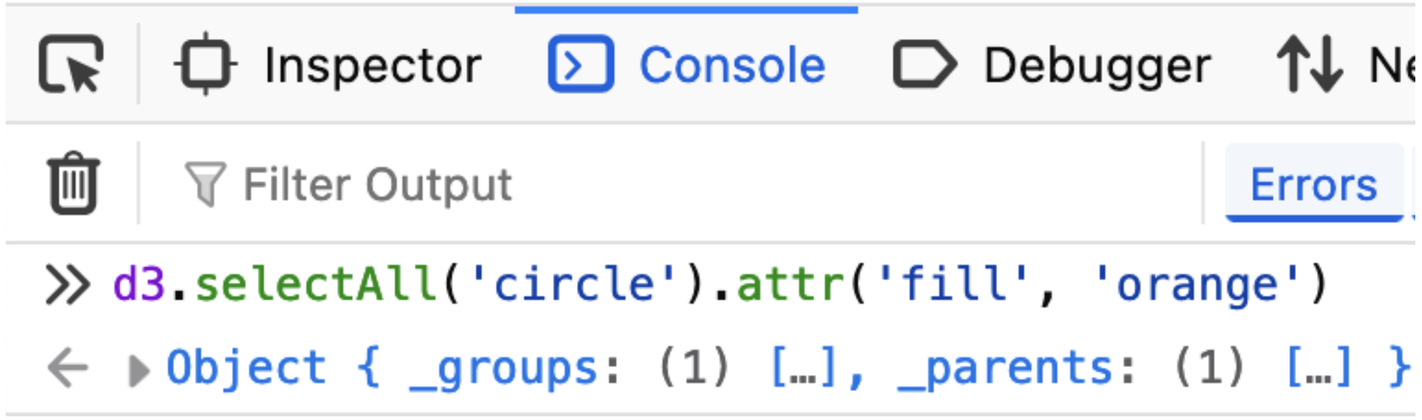


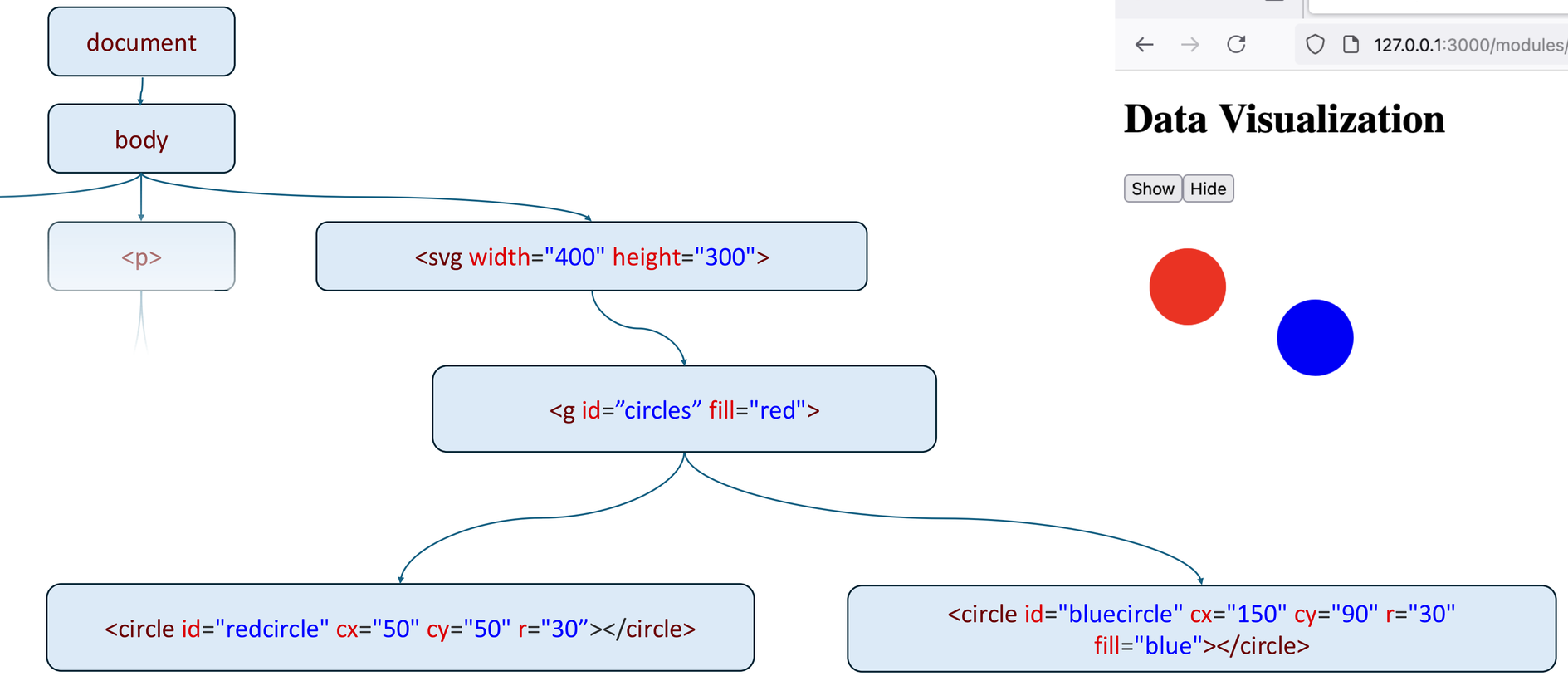




Data Visualization

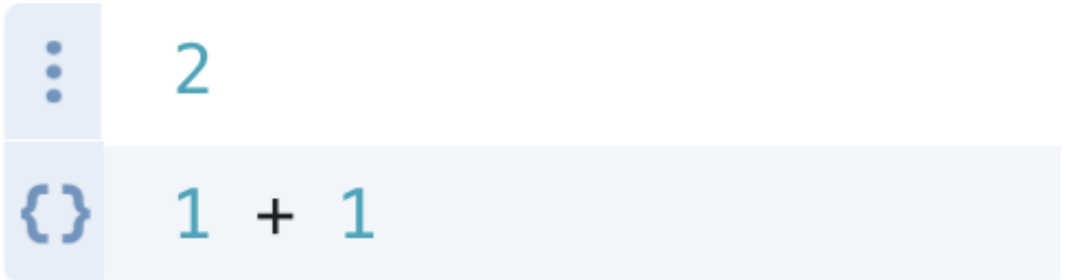
Show Hide

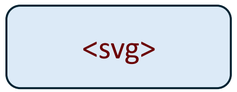



document
body
<p>
<svg width="400" height="300">
<g id=”circles” fill="red">
<circle id="redcircle" cx="50" cy="50" r="30”></circle>
<circle id="bluecircle" cx="150" cy="90" r="30"
fill="blue"></circle>

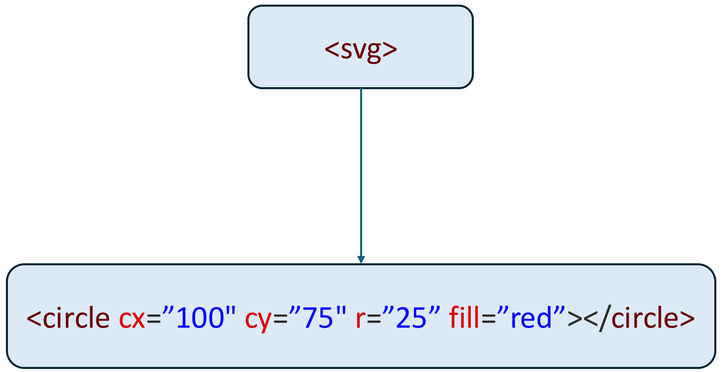

127.0.0.1:3000/modules/04-Interact
127.0.0.1:3000/modules/04-Interaction-and-web/lec
Data Visualization
Show
Hide

Observable

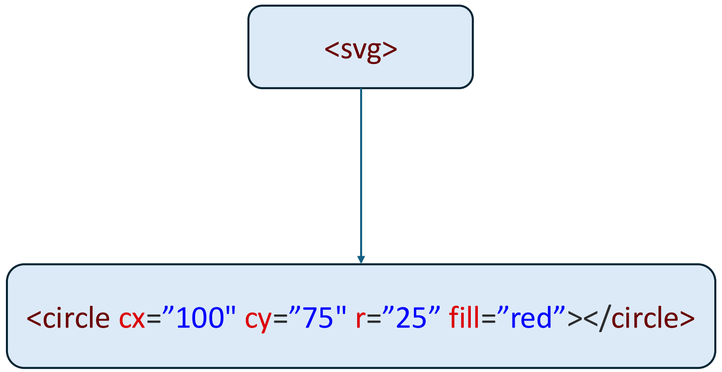

2
1 + 1




```
{
  const svg = d3.create("svg");
  return svg.node();
}
```

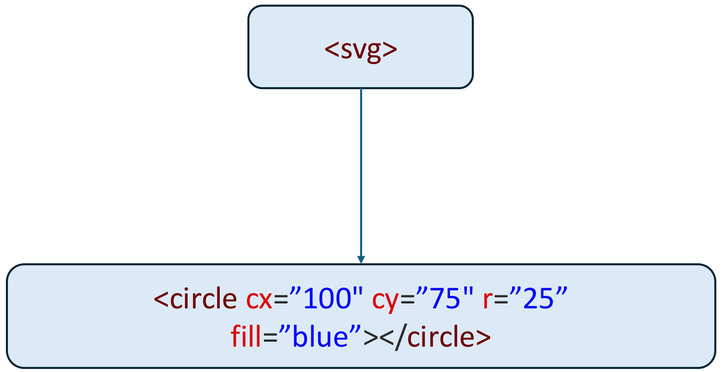


```
{
  const svg = d3.create("svg");
  const circle = svg.append('circle')
                    .attr('cx', '100')
                    .attr('cy', '75')
                    .attr('r', '25')
                    .attr('fill', 'red');
  return svg.node();
}
```



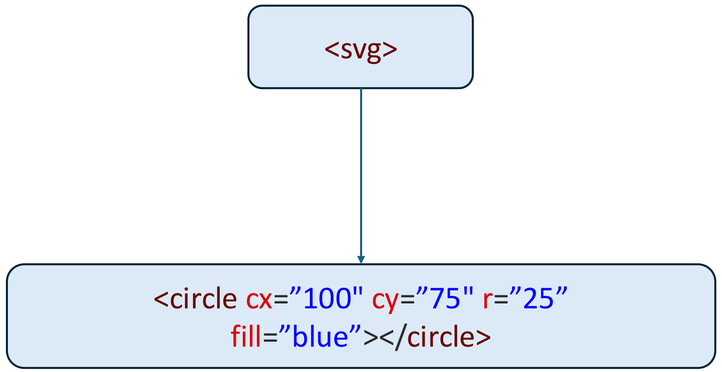
```
{
  const svg = d3.create("svg");
  const circle = svg.append('circle')
                    .attr('cx', '100')
                    .attr('cy', '75')
                    .attr('r', '25')
                    .attr('fill', 'red');

  circle.on('click',
            () => circle.attr('fill', 'blue')
            );
  return svg.node();
}
```



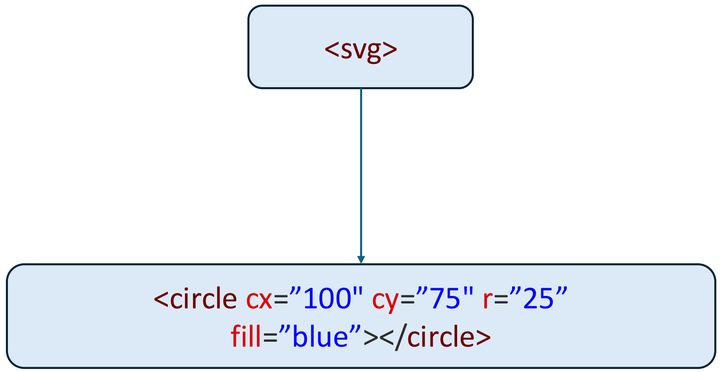
```
{
  const svg = d3.create("svg");
  const circle = svg.append('circle')
                    .attr('cx', '100')
                    .attr('cy', '75')
                    .attr('r', '25')
                    .attr('fill', 'red');

  circle.on('click',
            () => circle.attr('fill', 'blue')
            );
  return svg.node();
}
```



```
{
  const svg = d3.create("svg");
  const circle = svg.append('circle')
                    .attr('cx', '100')
                    .attr('cy', '75')
                    .attr('r', '25')
                    .attr('fill', 'red');

  circle.on('click',
            () => circle
              .transition().duration(10000)
              .attr('fill', 'blue')
              .attr('cx', '200')
            );
  return svg.node();
}
```



```
{
  const svg = d3.create("svg");
  const circle = svg.append('circle')
                    .attr('cx', '100')
                    .attr('cy', '75')
                    .attr('r', '25')
                    .attr('fill', 'red');

  circle.on('click',
            () => circle
              .transition().duration(10000)
              .attr('fill', 'blue')
              .attr('cx', '200')
            );
  return svg.node();
}
```

Cars dataset

name	economy (mpg)	cylinders	displacement (cc)	power (hp)	weight (lb)	0-60 mph (s)
AMC Ambassador ...	13	8	360	175	3,821	11
AMC Ambassador ...	15	8	390	190	3,850	8.5
AMC Ambassador ...	17	8	304	150	3,672	11.5
AMC Concord DL 6	20.2	6	232	90	3,265	18.2
AMC Concord DL	18.1	6	258	120	3,410	15.1
AMC Concord DL	23	4	151		3,035	20.5
AMC Concord	19.4	6	232	90	3,210	17.2
AMC Concord	24.3	4	151	90	3,003	20.1
AMC Gremlin	18	6	232	100	2,789	15
AMC Gremlin	19	6	232	100	2,634	13
AMC Gremlin	20	6	232	100	2,914	16

```
Inputs.table(cars)
```

```
▶ Array(406) [Object, Object, Object, Object,
```

```
cars
```

```
▼ Object {
    name: "AMC Ambassador Brougham"
    economy (mpg): 13
    cylinders: 8
    displacement (cc): 360
    power (hp): 175
    weight (lb): 3821
    0-60 mph (s): 11
    year: 73
  }
```

```
cars[0]
```

```
{
  const width = 640;
  const height = 400;
  const margin = {top: 20, right: 30, bottom: 30, left: 40};

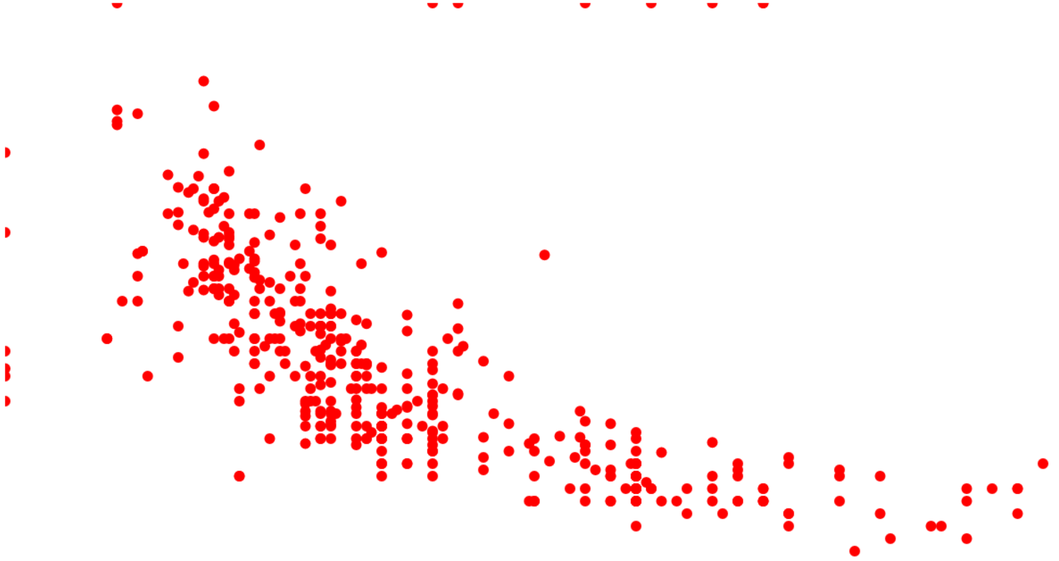
  const svg = d3.create("svg")
      .attr("width", width)
      .attr("height", height);

  const x = d3.scaleLinear()
      .domain([40, 240])
      .range([margin.left, width - margin.right]);

  const y = d3.scaleLinear()
      .domain([0, 50])
      .range([height - margin.bottom, margin.top]);

  svg.selectAll('circle')
      .data(cars)
      .enter().append('circle')
      .attr("fill", "red")
      .attr("cx", (d) => x(d["power (hp)"]))
      .attr("cy", (d) => y(d["economy (mpg)"]))
      .attr("r", 3)

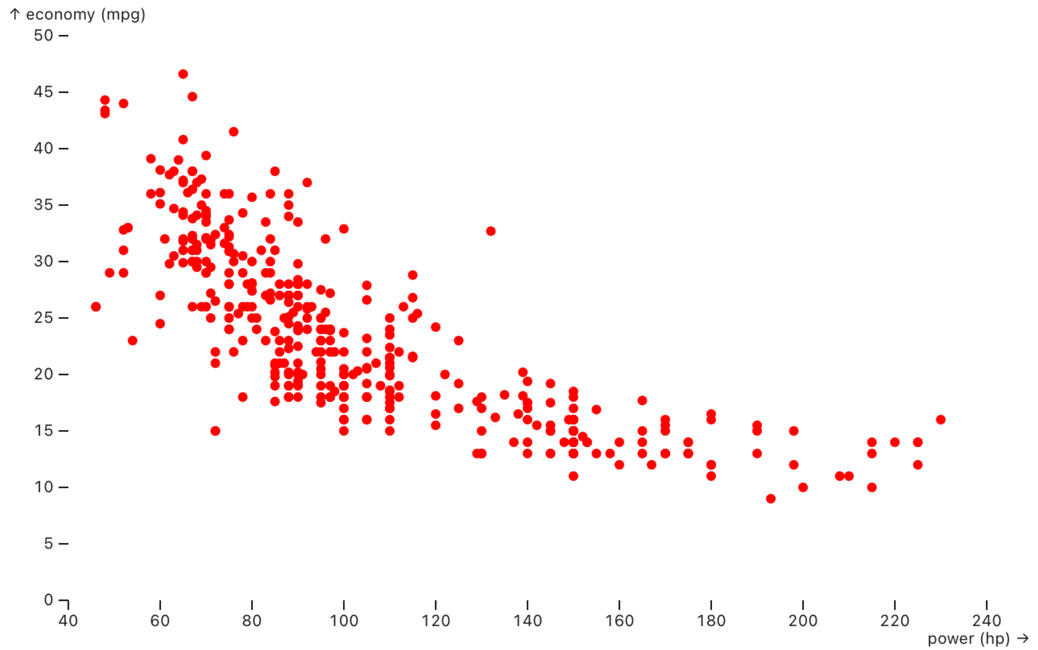
  return svg.node();
}
```



```d3
{
  const width = 640;
  const height = 400;
  const margin = {top: 20, right: 30, bottom: 30, left: 40};

  const svg = d3.create("svg")
      .attr("width", width)
      .attr("height", height);

  const x = d3.scaleLinear()
      .domain([40, 240])
      .range([margin.left, width - margin.right]);

  const y = d3.scaleLinear()
      .domain([0, 50])
      .range([height - margin.bottom, margin.top]);

  svg.selectAll('circle')
      .data(cars)
      .enter().append('circle')
      .attr("fill", "red")
      .attr("cx", (d) => x(d["power (hp)"]))
      .attr("cy", (d) => y(d["economy (mpg)"]))
      .attr("r", 3)

  return svg.node();
}
```

```plot
{}  Plot.plot({
      width: 640,
      height: 400,
      marginTop: 20, marginRight: 30, marginBottom: 30, marginLeft: 40,

      x: {domain: [40, 240]},
      y: {domain: [0, 50]},
      marks: [
        Plot.dot(cars, {x: "power (hp)",
                        y: "economy (mpg)",
                        r: 3,
                        fill: 'red'
                       }),
      ]
    })
```



<svg width=”640" height=”400” >

```
{
  const width = 640;
  const height = 400;
  const margin = {top: 20, right: 30, bottom: 30, left: 40};

  const svg = d3.create("svg")
      .attr("width", width)
      .attr("height", height);
```

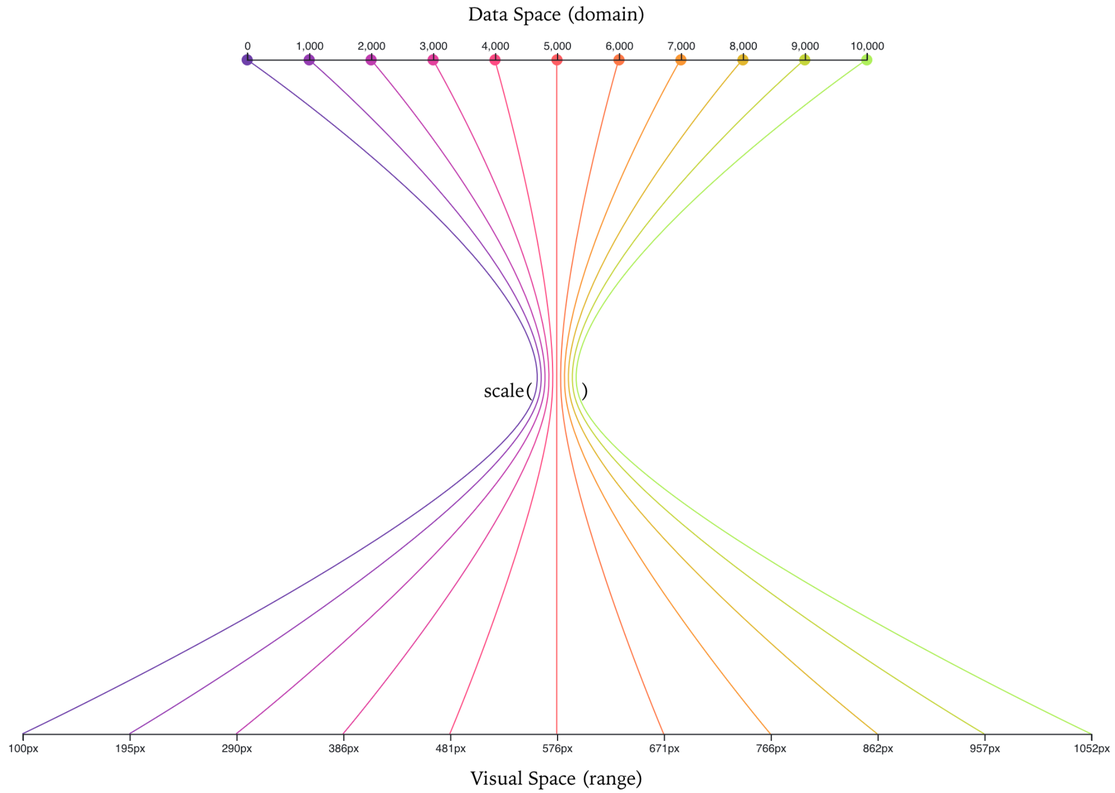
```
Plot.plot({
  width: 640,
  height: 400,
  marginTop: 20, marginRight: 30, marginBottom: 30, marginLeft: 40,
```

```
const x = d3.scaleLinear()
    .domain([40, 240])
    .range([margin.left, width - margin.right]);

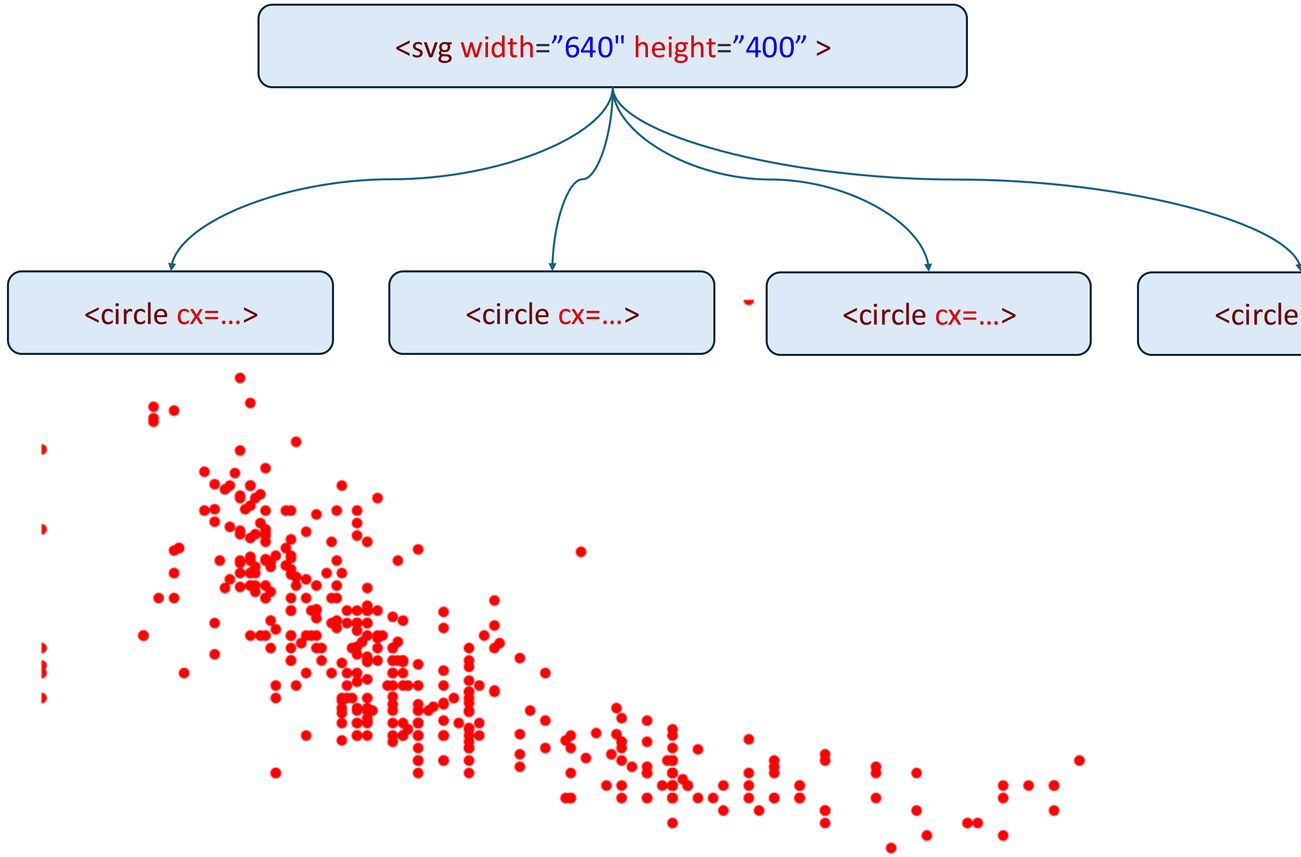
const y = d3.scaleLinear()
    .domain([0, 50])
    .range([height - margin.bottom, margin.top]);
```

```
x: {domain: [40, 240]},
y: {domain: [0, 50]},
marks: [
```

Transition

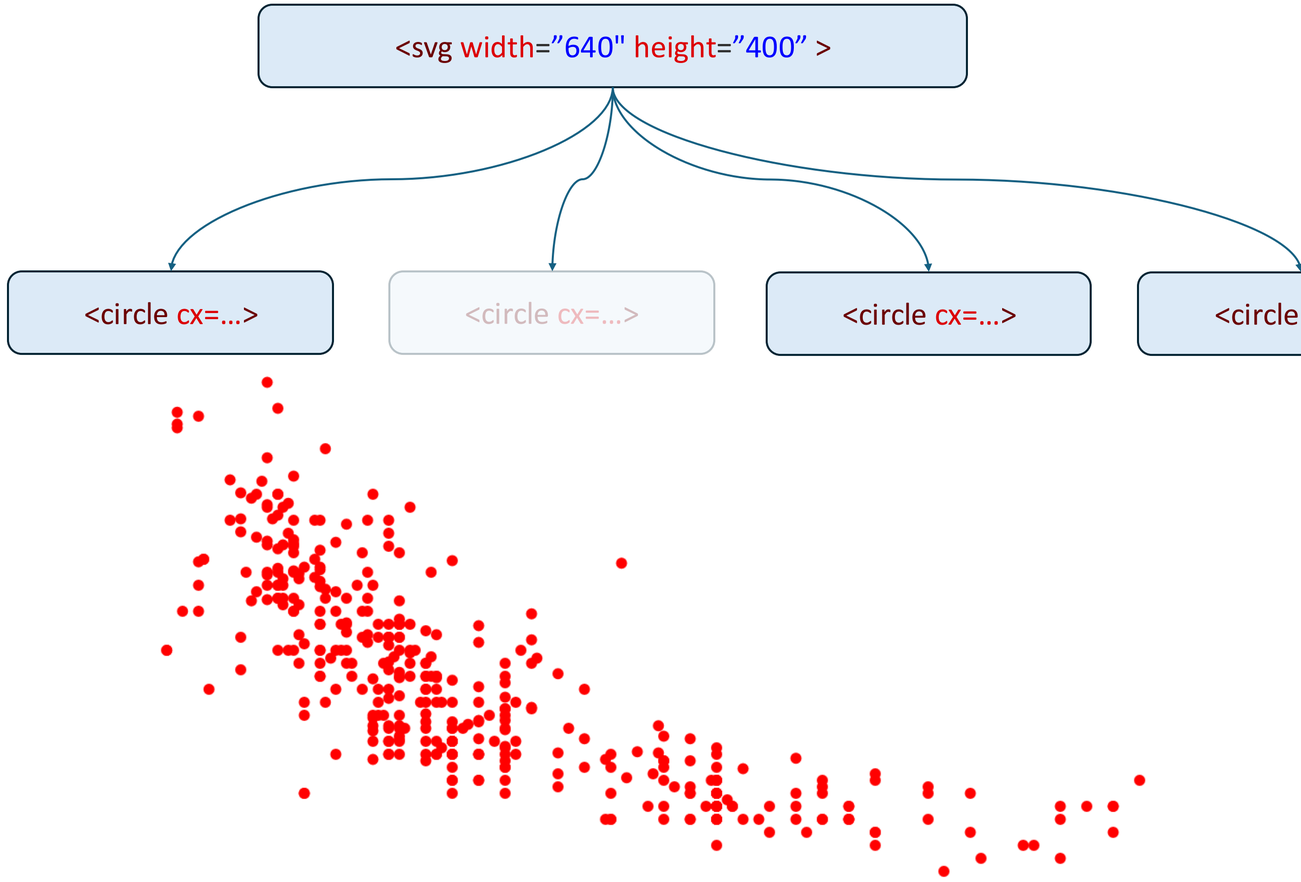


```
svg.selectAll('circle')
    .data(cars)
    .enter().append('circle')
    .filter((d) => d["power (hp)"] > 0 && d["economy (mpg)"] > 0)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```



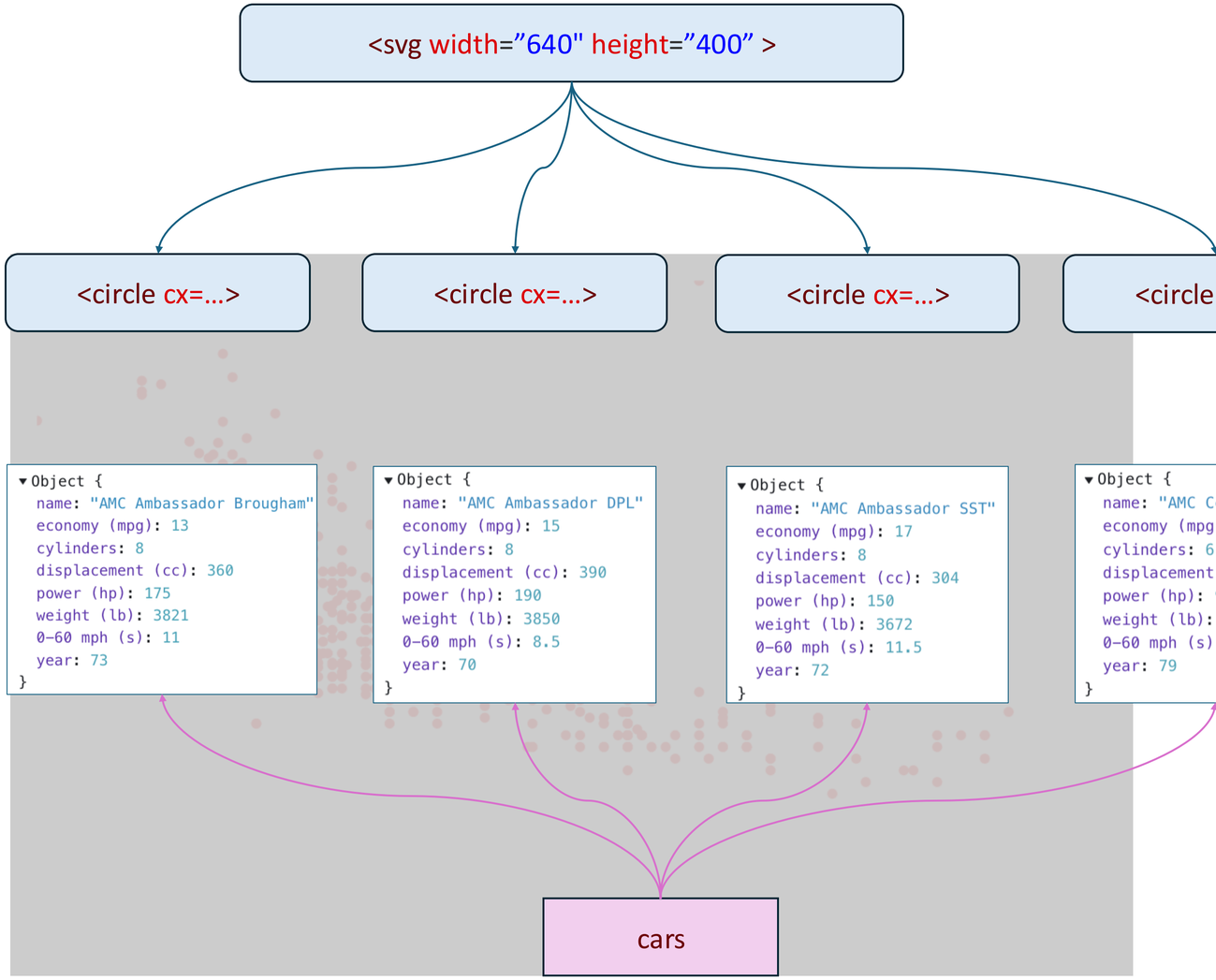

```
  marks: [
    Plot.dot(cars, {x: "power (hp)",
                    y: "economy (mpg)",
                    r: 3,
                    fill: 'red'
                   }),
  ]
```

```
svg.selectAll('circle')
    .data(cars)
    .enter().append('circle')
    .filter((d) => d["power (hp)"] > 0 && d["economy (mpg)"] > 0)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```



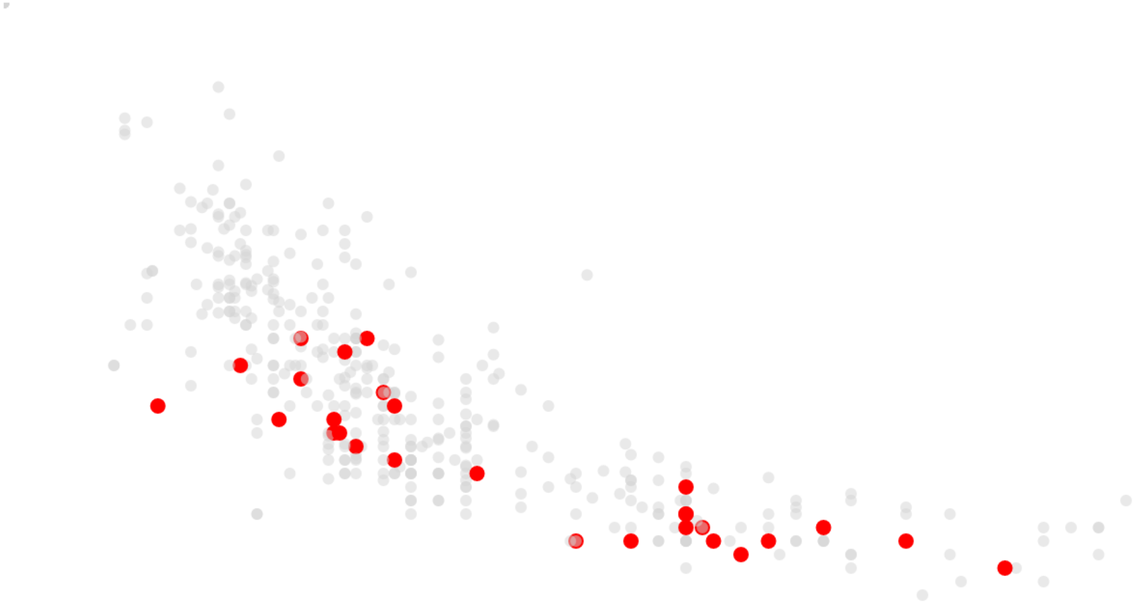
```
svg.selectAll('circle')
    .data(cars)
    .enter().append('circle')
    .filter((d) => d["power (hp)"] > 0 && d["economy (mpg)"] > 0)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

```
  marks: [
    Plot.dot(cars, {x: "power (hp)",
                    y: "economy (mpg)",
                    r: 3,
                    fill: 'red'
                   }),
  ]
```

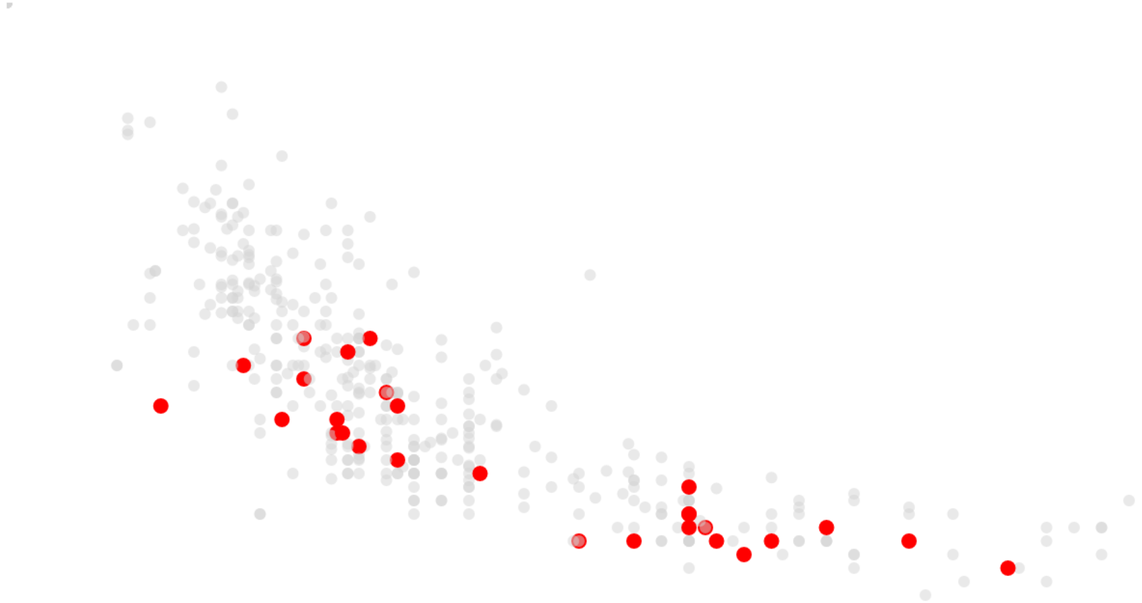


Interaction with D3

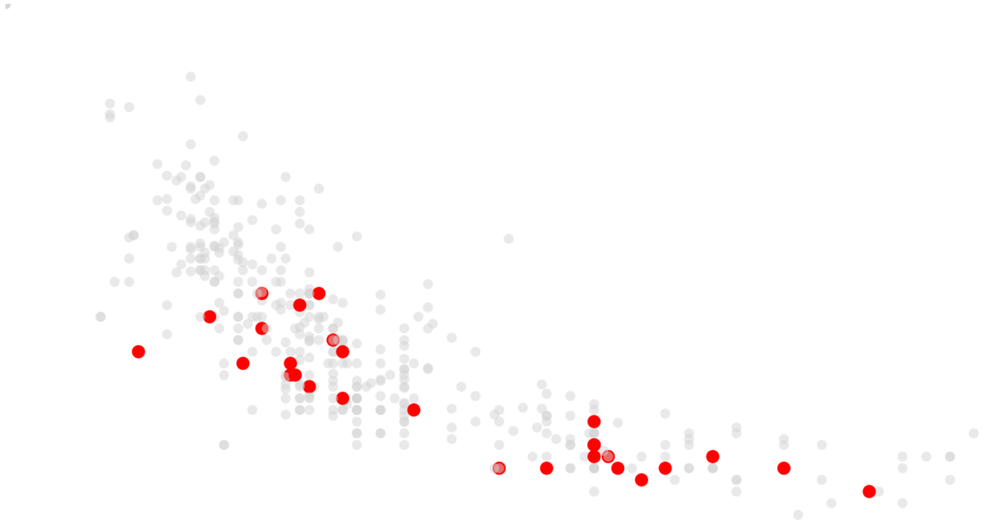
```
function onclick(event, datum) {
    svg.selectAll('circle')
      .attr('opacity', 0.5)
      .attr('fill', 'lightgrey')
      .attr('r', 3)
      .filter((d) => d.year == datum.year)
      .attr('fill', 'red')
      .attr('opacity', 1.)
      .attr('r', 4);
}
```



```
function onclick(event, datum) {
    svg.selectAll('circle')
      .attr('opacity', 0.5)
      .attr('fill', 'lightgrey')
      .attr('r', 3)
      .filter((d) => d.year == datum.year)
      .attr('fill', 'red')
      .attr('opacity', 1.)
      .attr('r', 4);
}
```



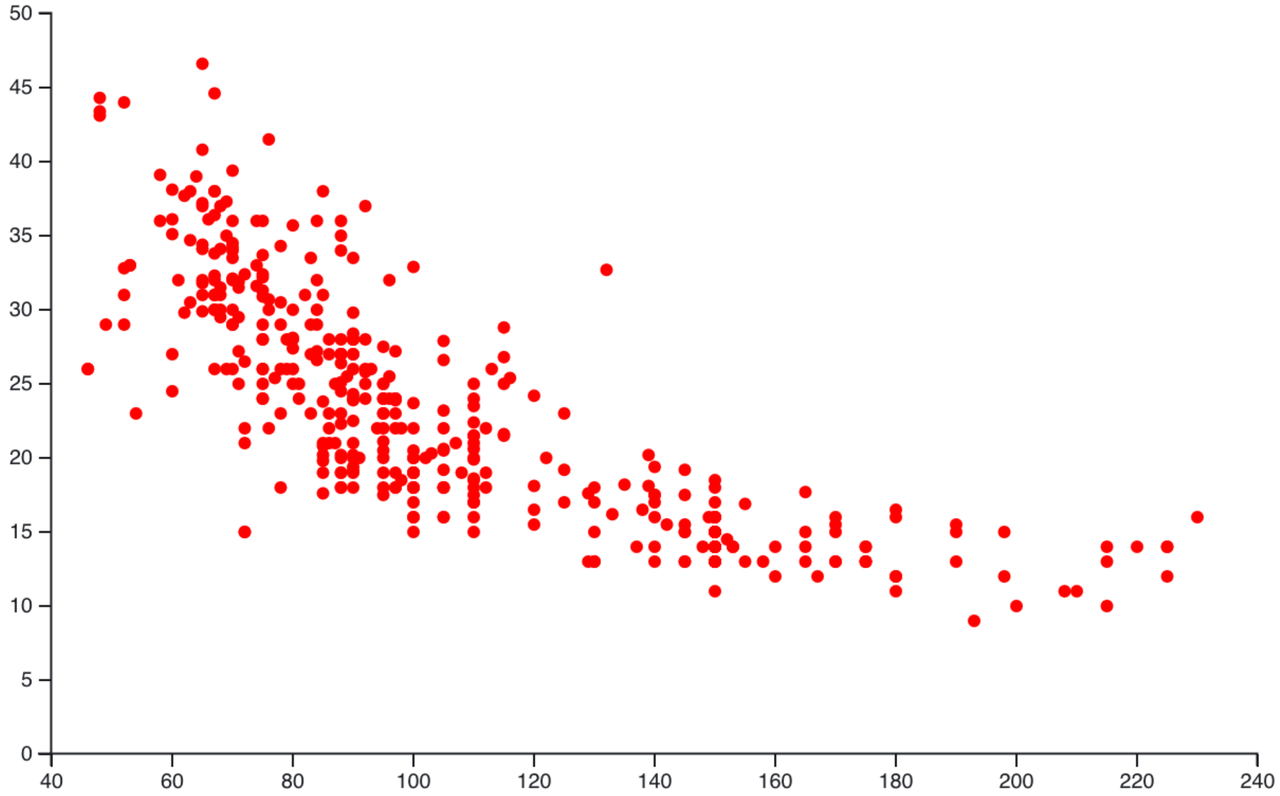
```
svg.selectAll('circle')
    .data(cars)
    .join('circle')
    .filter((d) => d["power (hp)"] > 0 && d["economy (mpg)"] > 0)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
    .on('click', onclick)
```



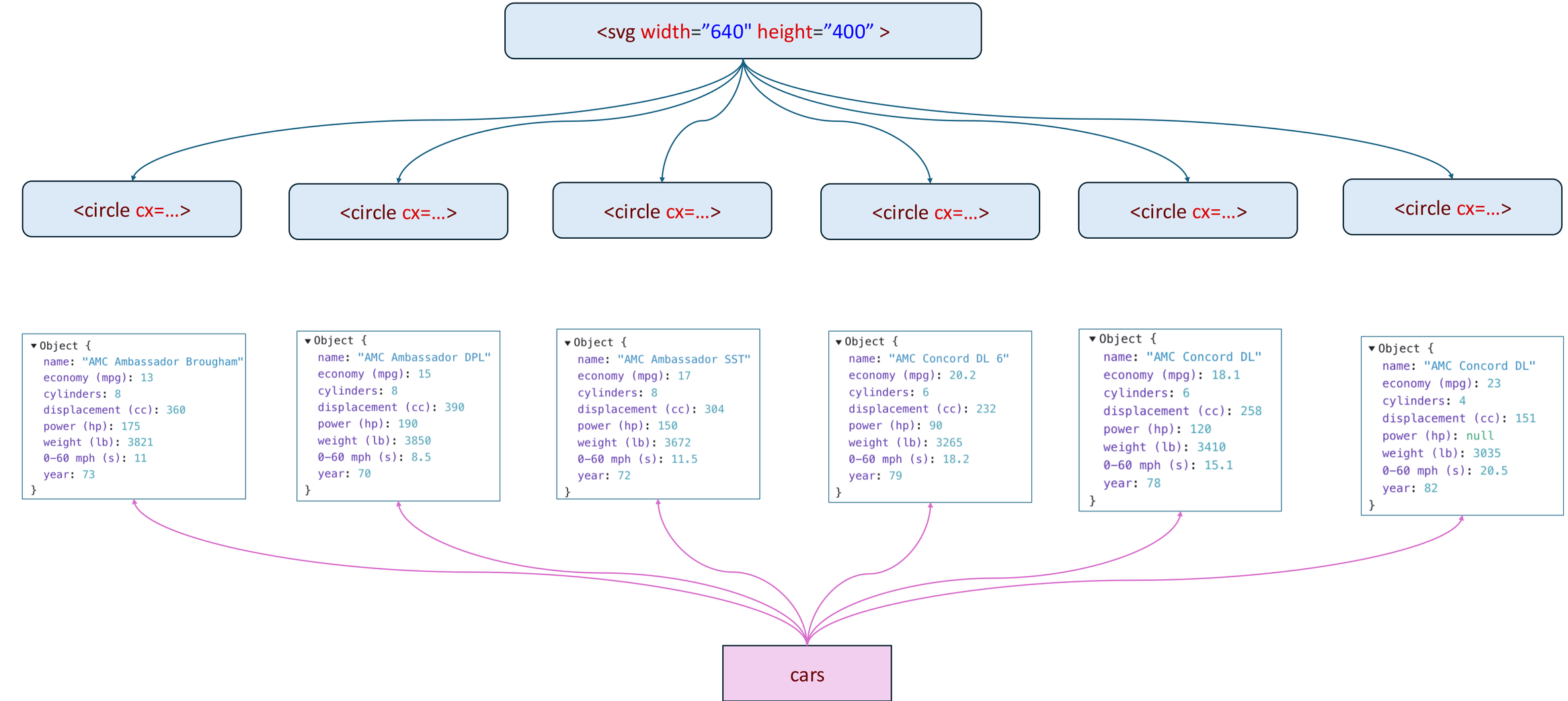
```
function onclick(event, datum) {
  svg.selectAll('circle')
    .transition().duration(500)
    .attr('opacity', 0.5)
    .attr('fill', 'lightgrey')
    .attr('r', 3)
    .filter((d) => d.year == datum.year)
    .attr('fill', 'red')
    .attr('opacity', 1.)
    .attr('r', 4);
}
```

```
svg.append("g")
    .attr("transform", `translate(0,${height - margin.bottom})`
    .call(d3.axisBottom(x));

svg.append("g")
    .attr("transform", `translate(${margin.left},0)`)
    .call(d3.axisLeft(y));
```

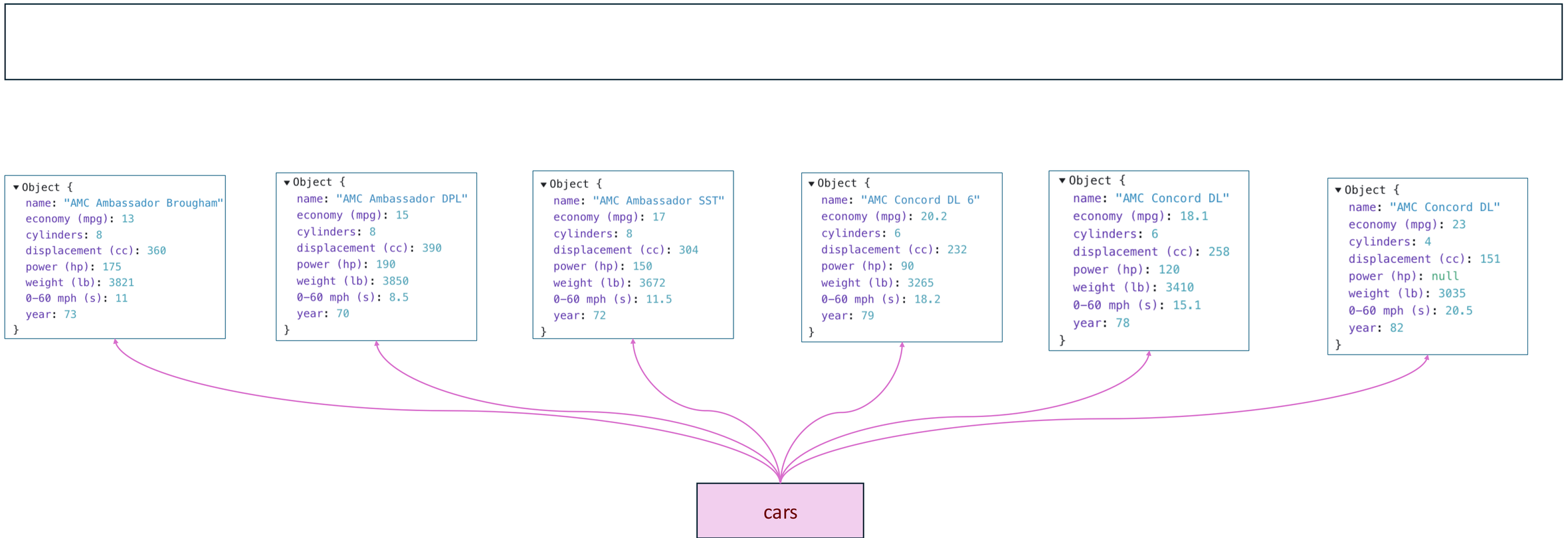


```
svg.selectAll('circle')
    .data(cars)
    .enter().append('circle')
    .filter((d) => d["power (hp)"] > 0 && d["economy (mpg)"] > 0)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

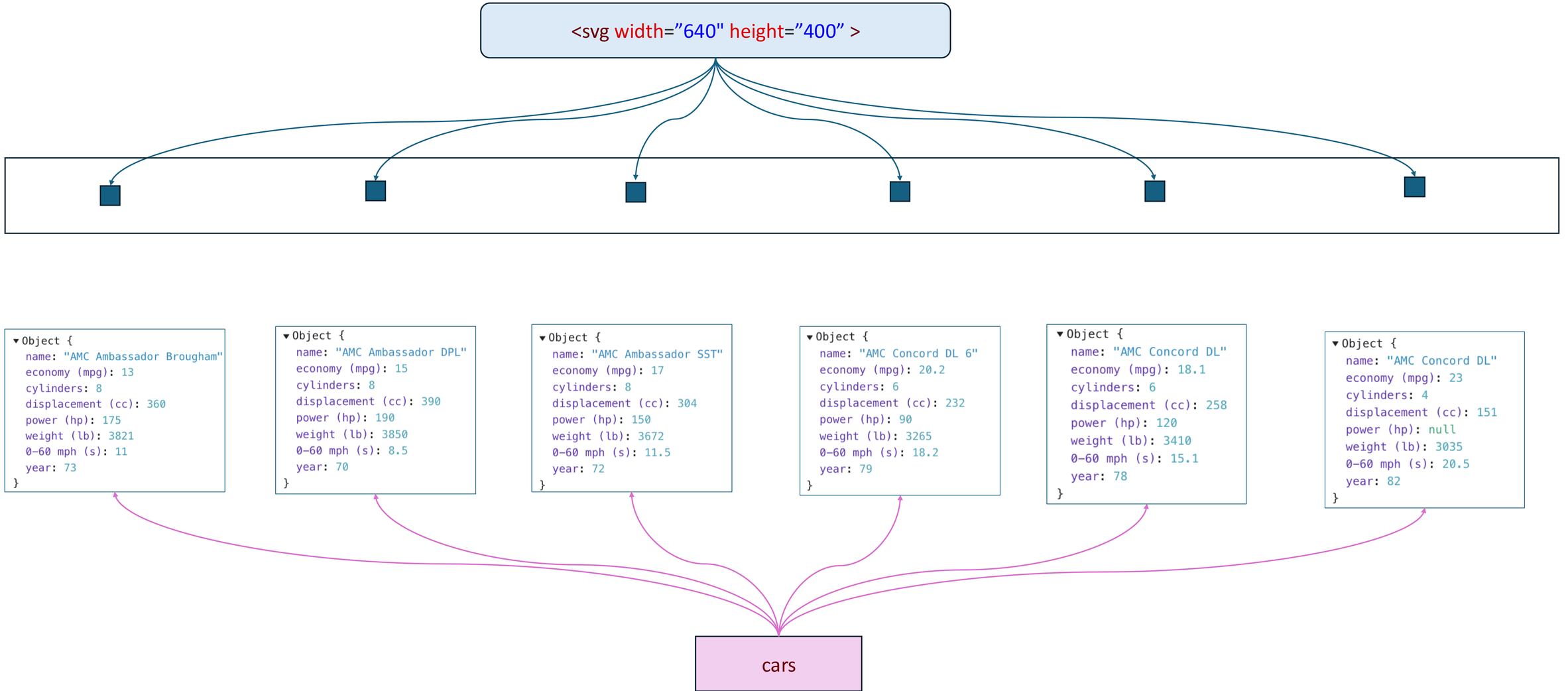


```
svg.selectAll('circle')
```

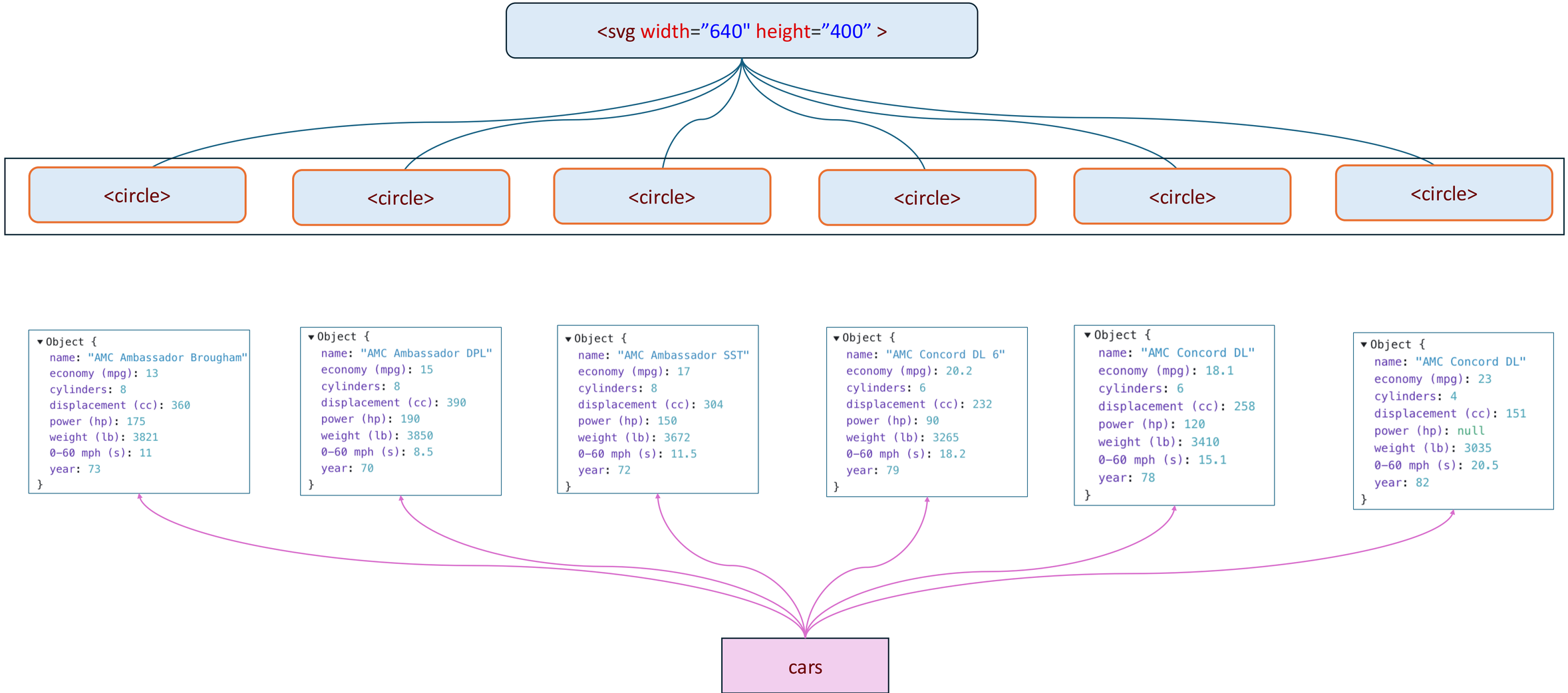
<svg width=”640" height=”400” >



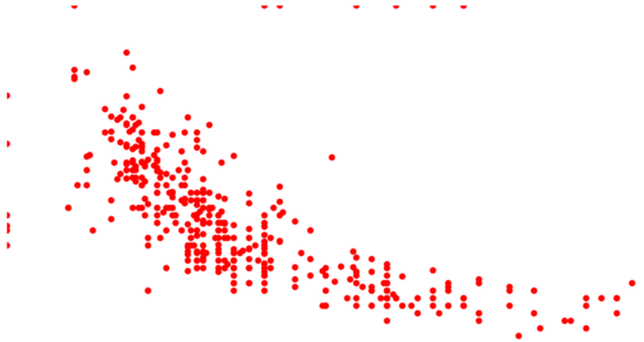
```
svg.selectAll('circle')
    .data(cars).enter()
```

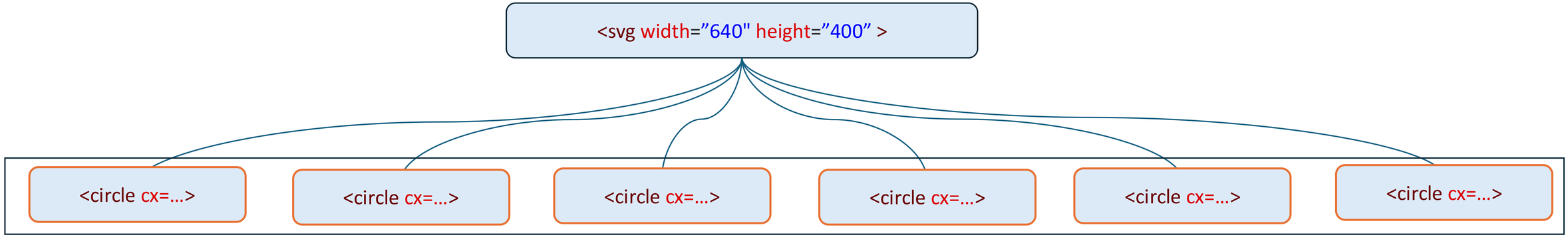


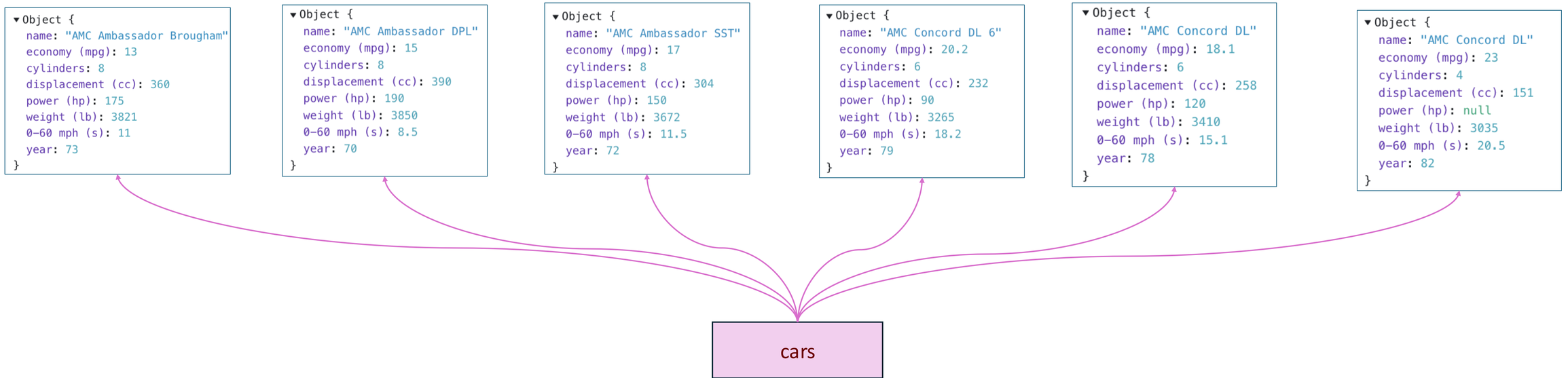
```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
```



```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```







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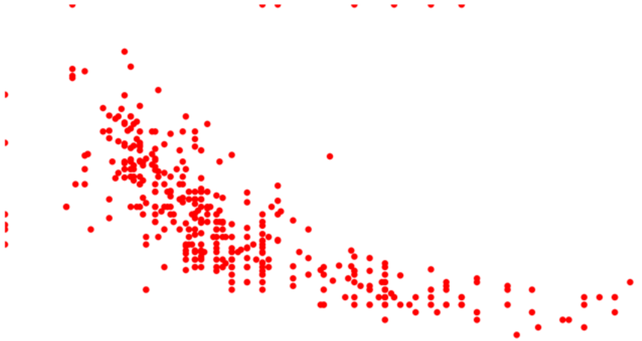
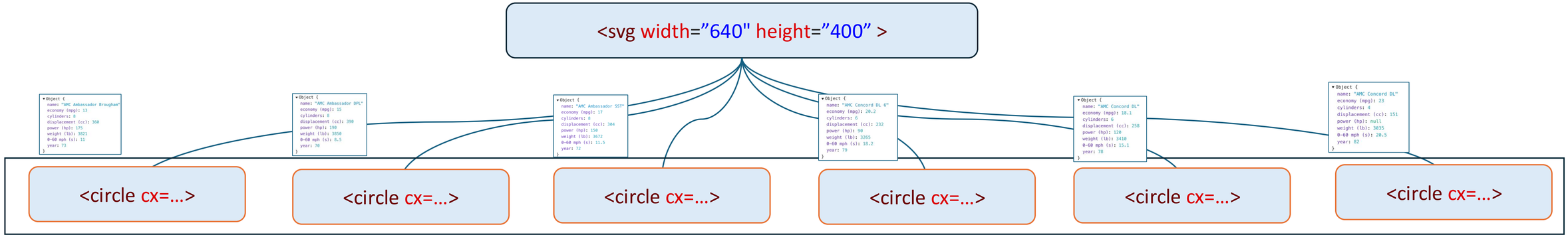
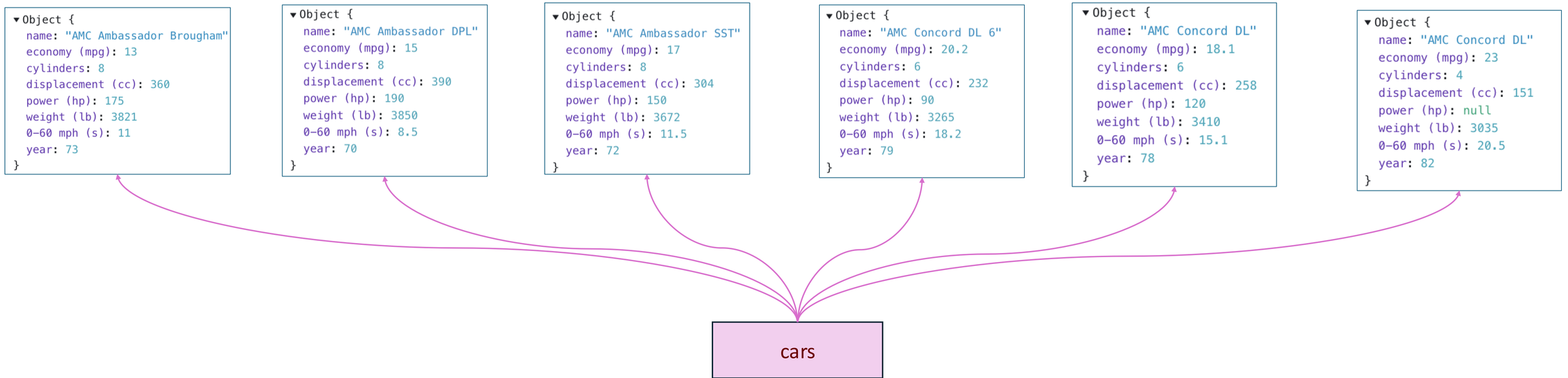
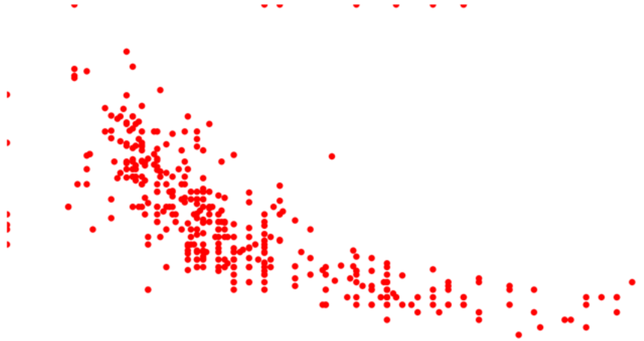
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

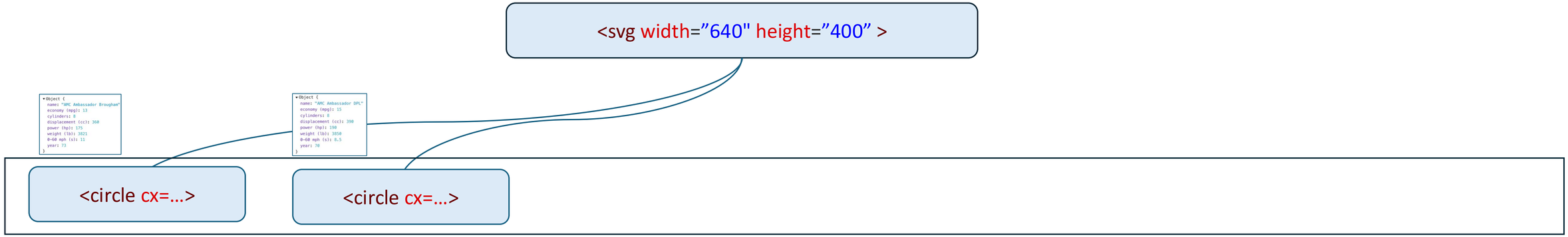


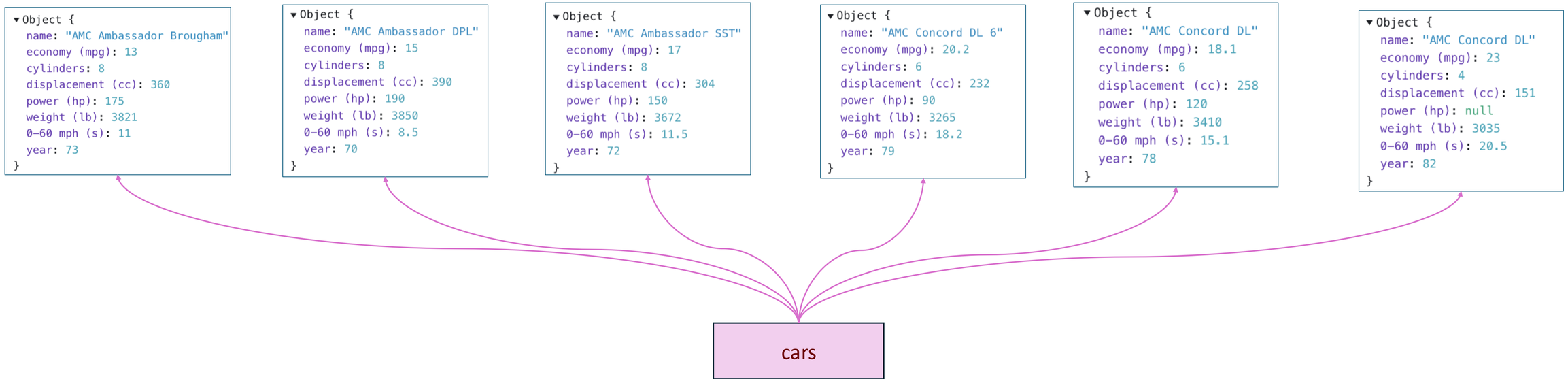




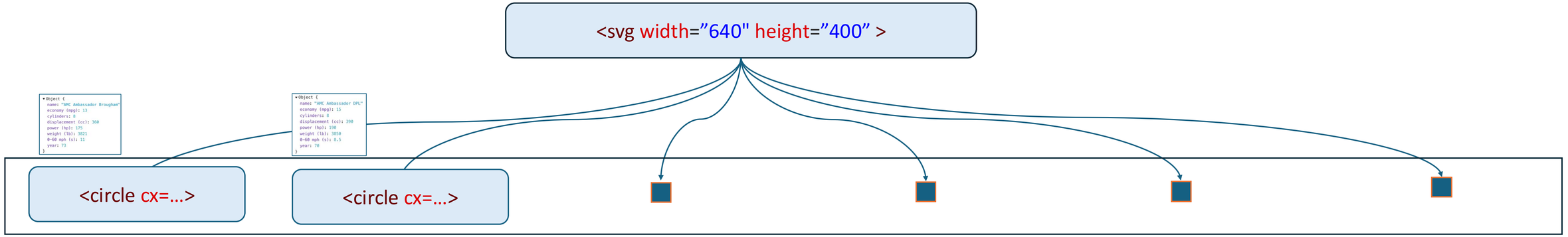
```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

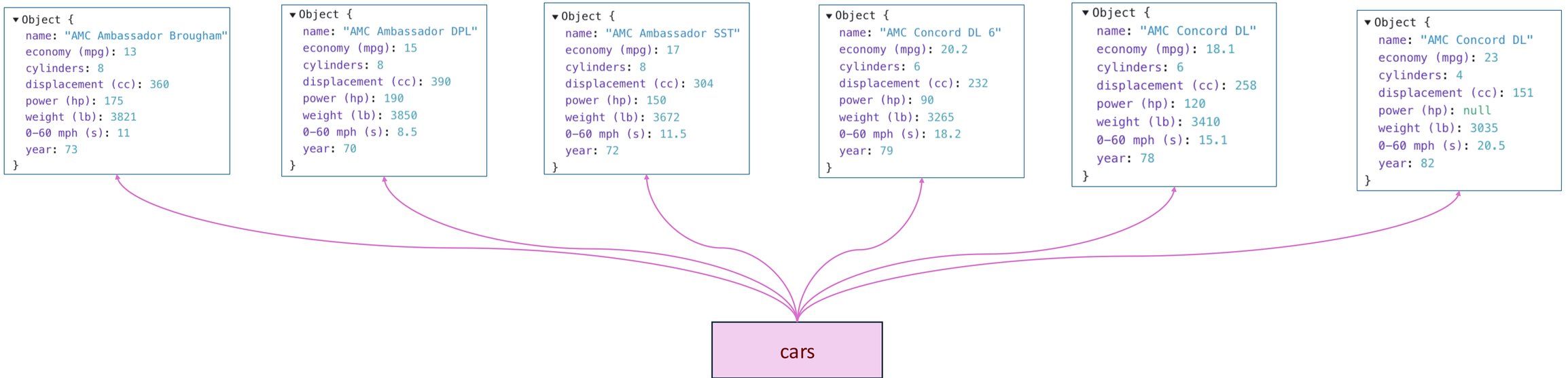






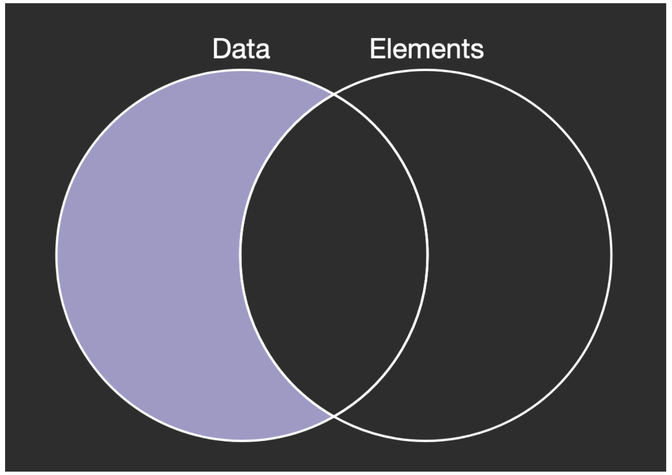
```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

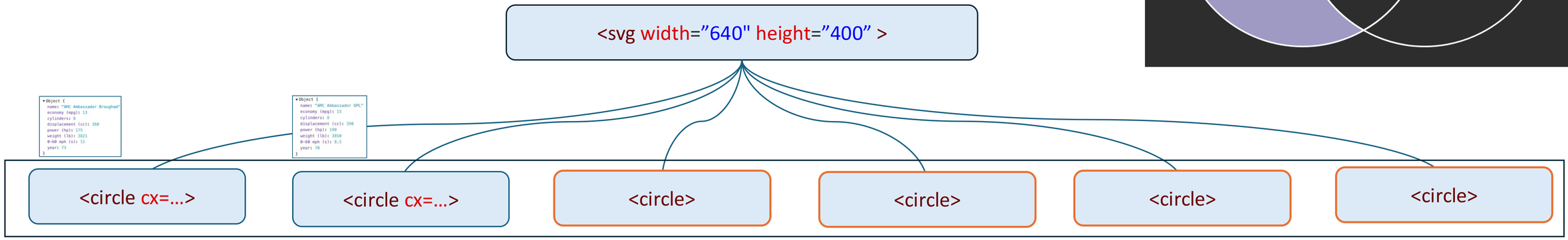


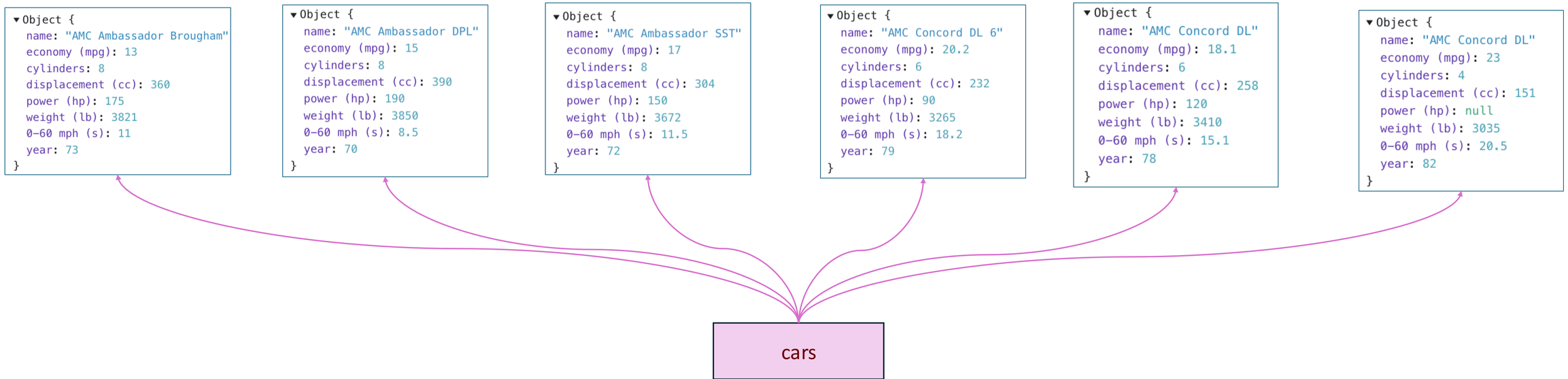


```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

Enter:

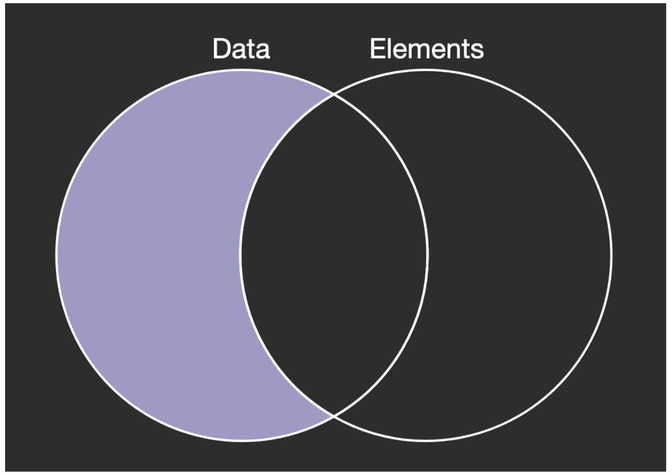


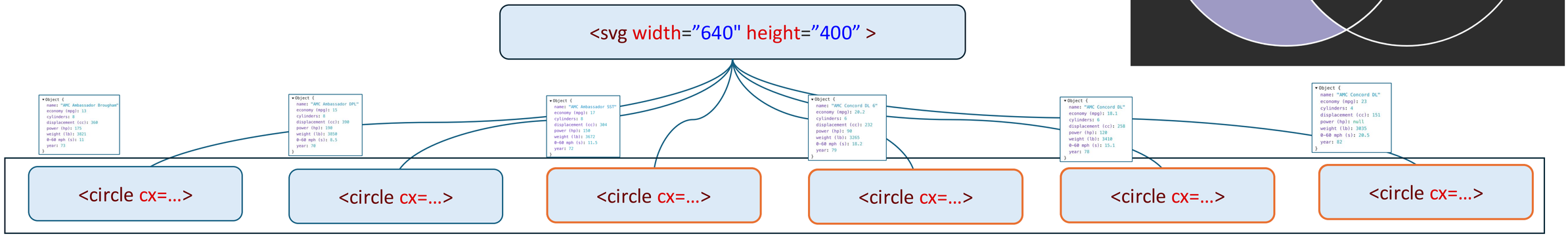


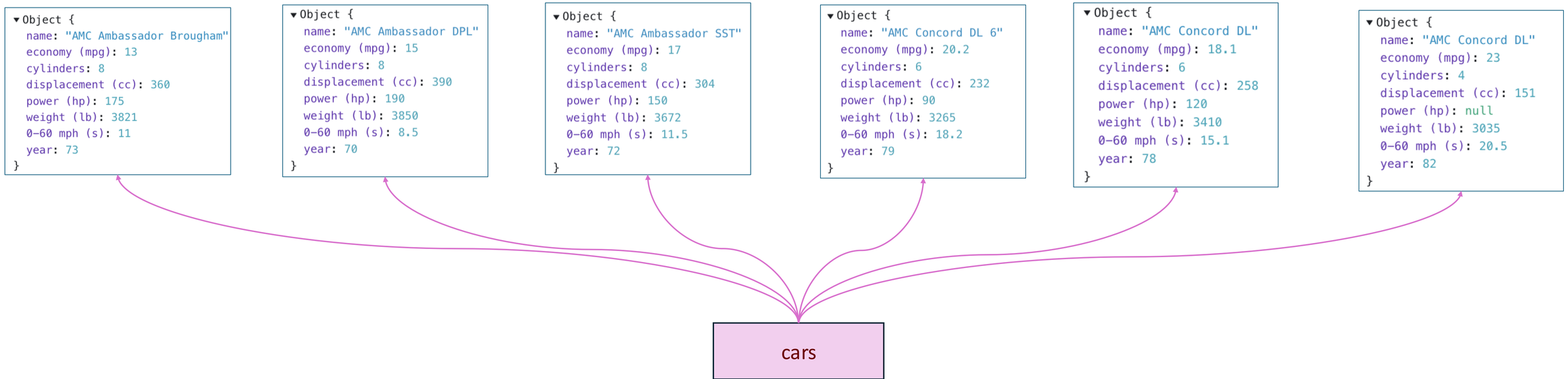


```
svg.selectAll('circle')
    .data(cars).enter()
    .append('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

Enter:

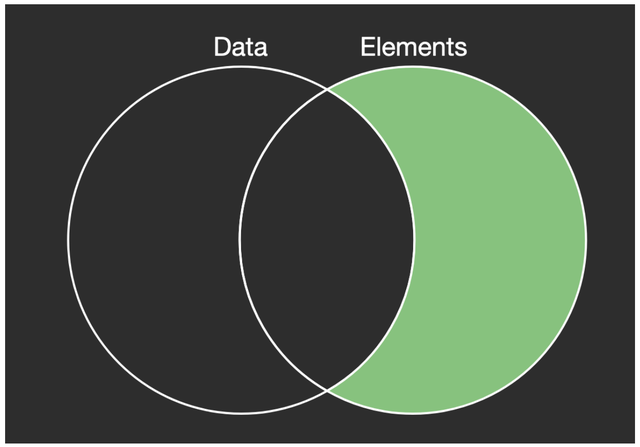


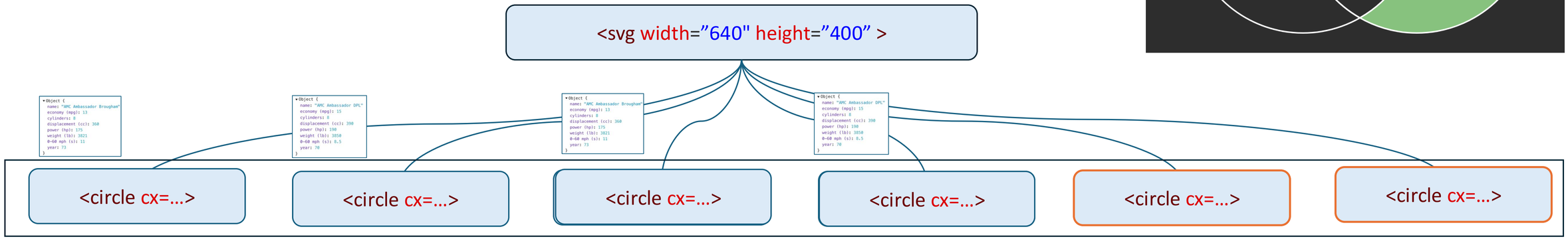


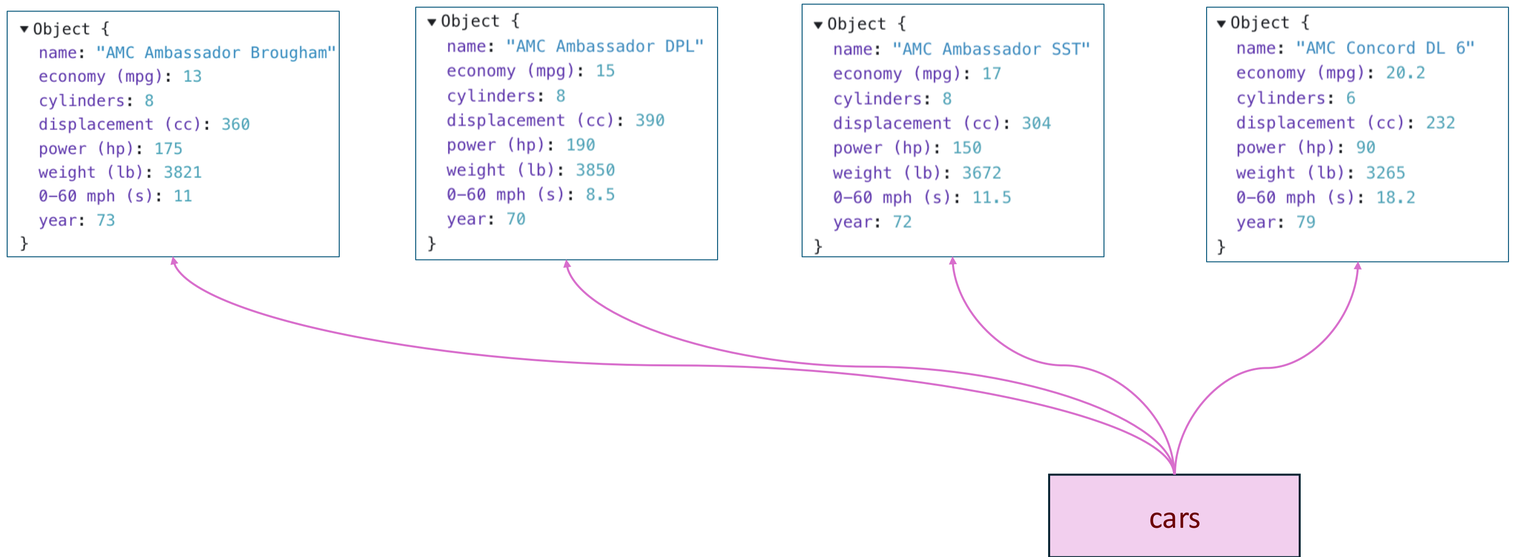


```
svg.selectAll('circle')
    .data(cars).exit()
    .remove()
```

Exit:

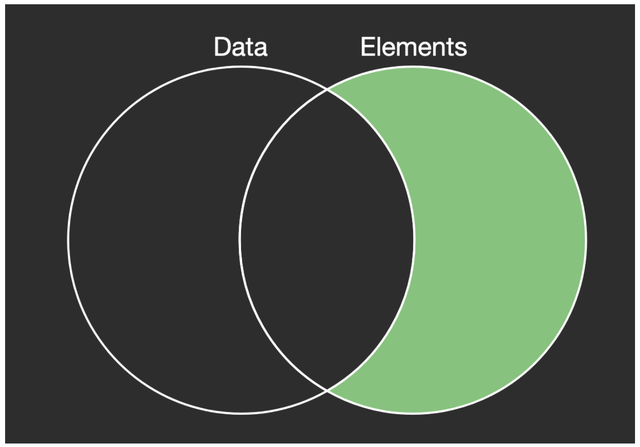


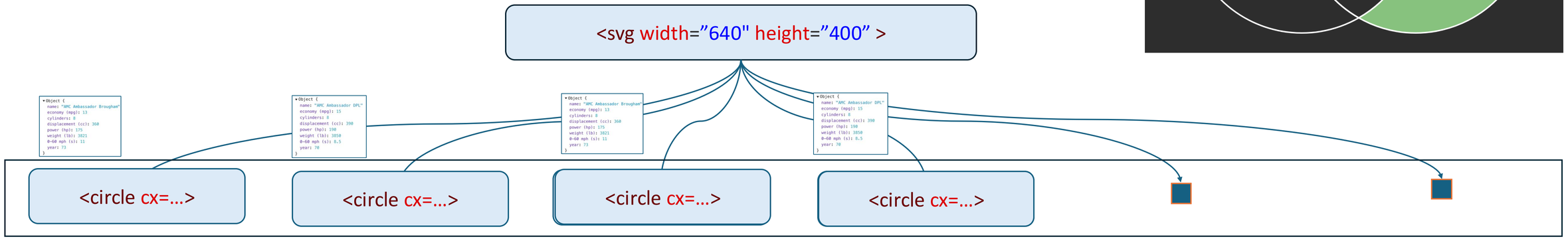


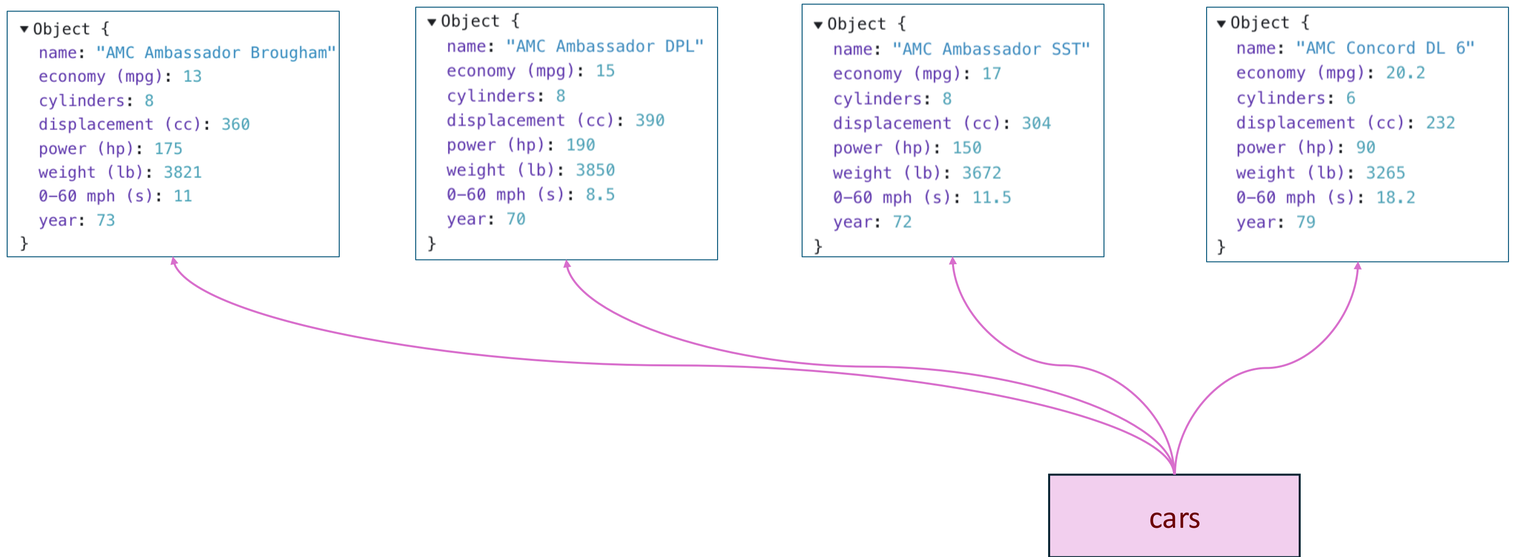


```
svg.selectAll('circle')
    .data(cars).exit()
    .remove()
```

Exit:

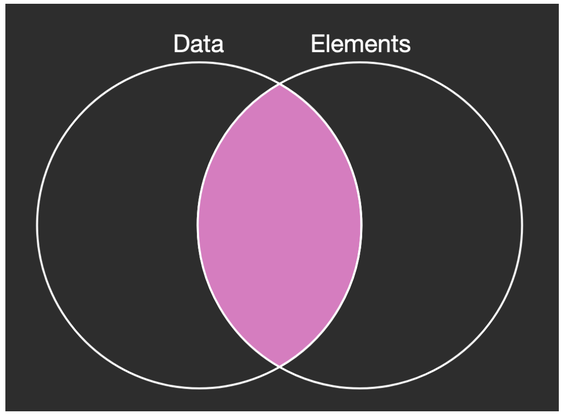


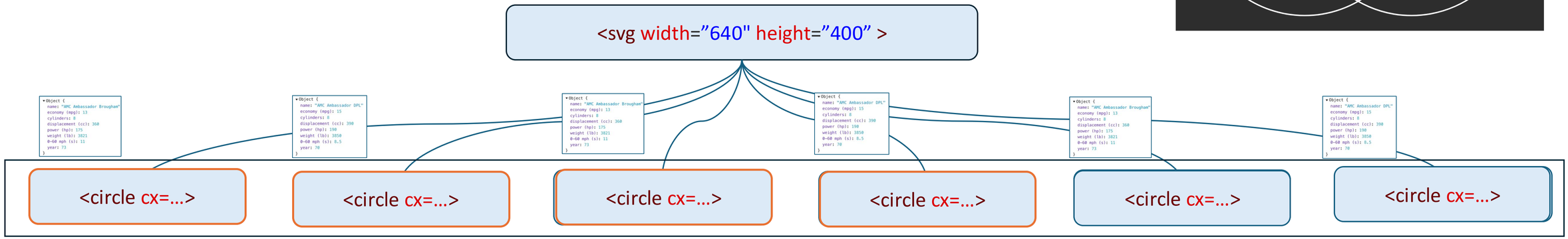


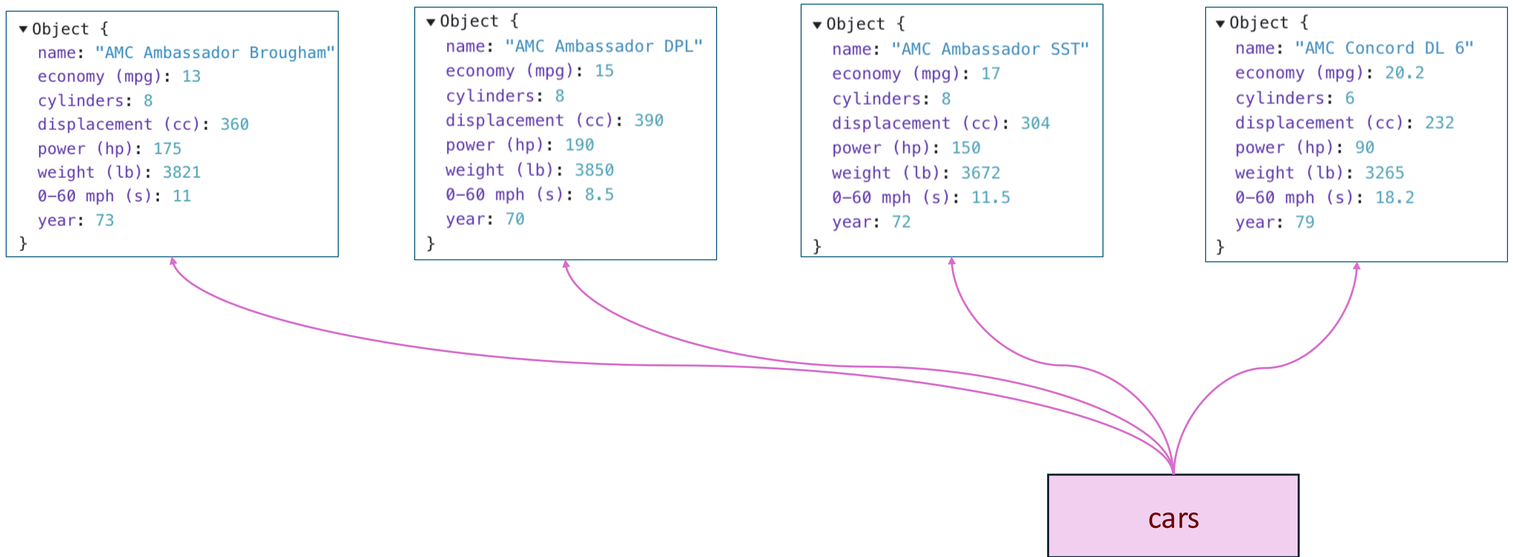


```
svg.selectAll('circle')
    .data(cars)
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```

Update:

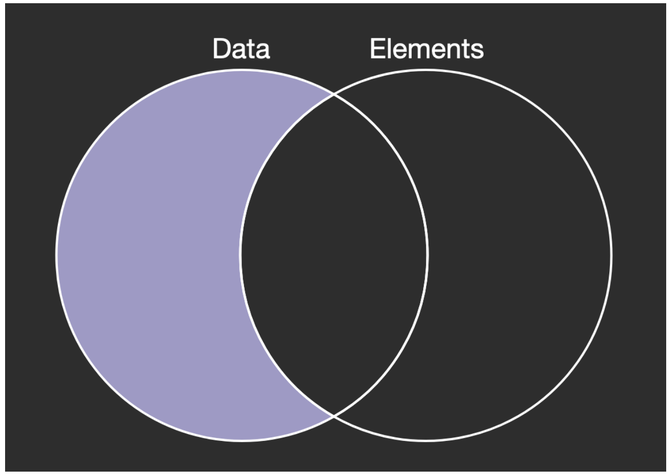


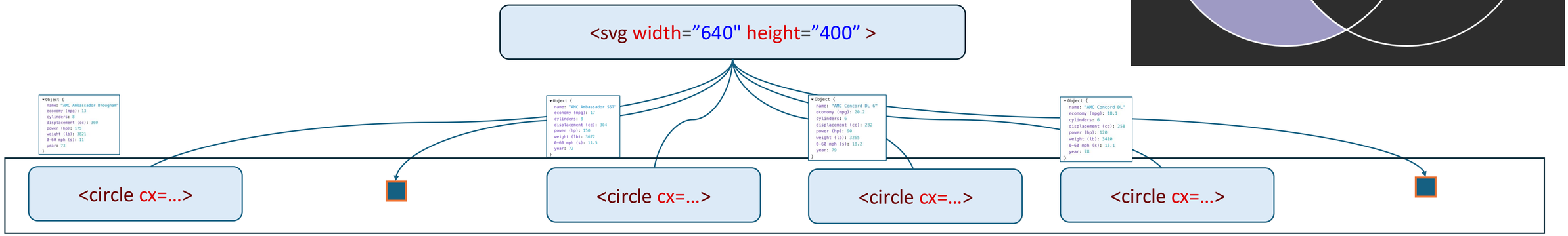


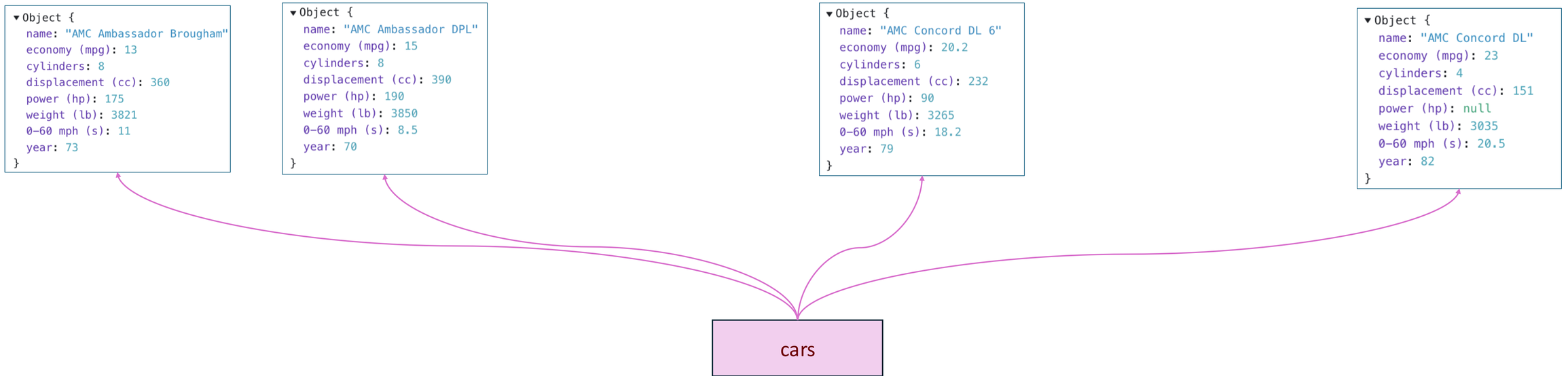


```
svg.selectAll('circle')
    .data(cars, d => d.name).enter()
    .append('circle')
    .attr("fill", "red")
```

Enter:

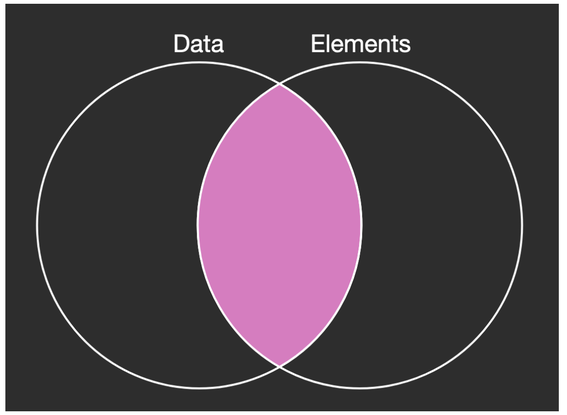


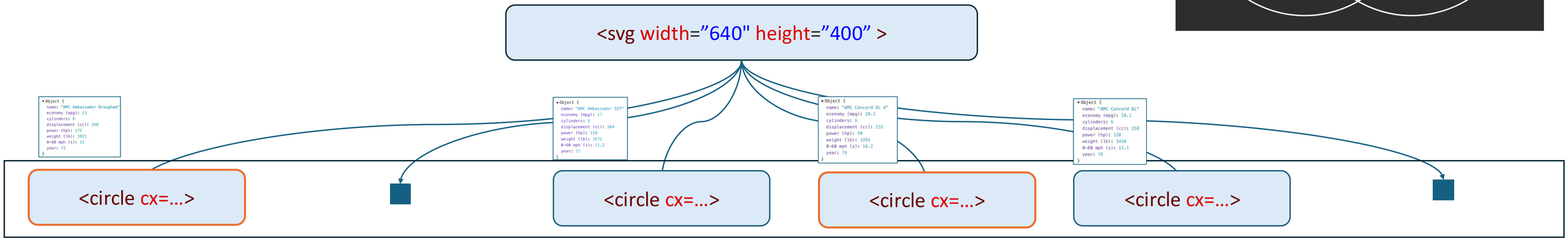


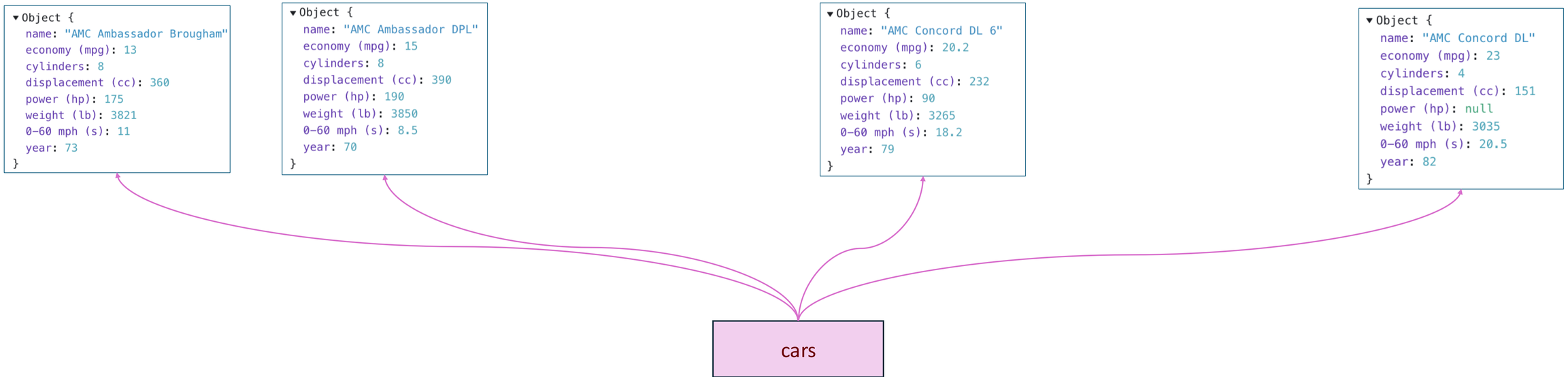


```
svg.selectAll('circle')
    .data(cars, d => d.name)
    .attr("fill", "red")
```

Update:

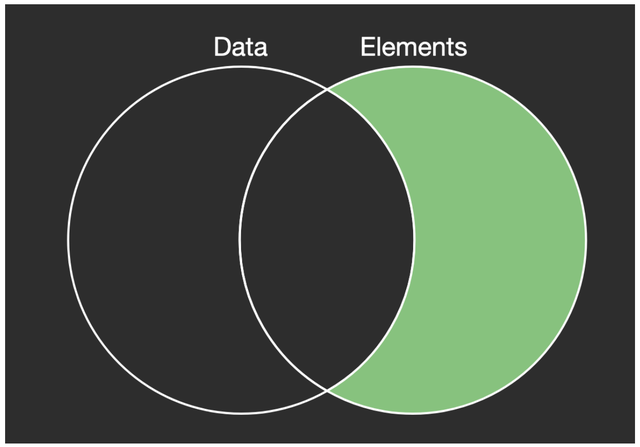


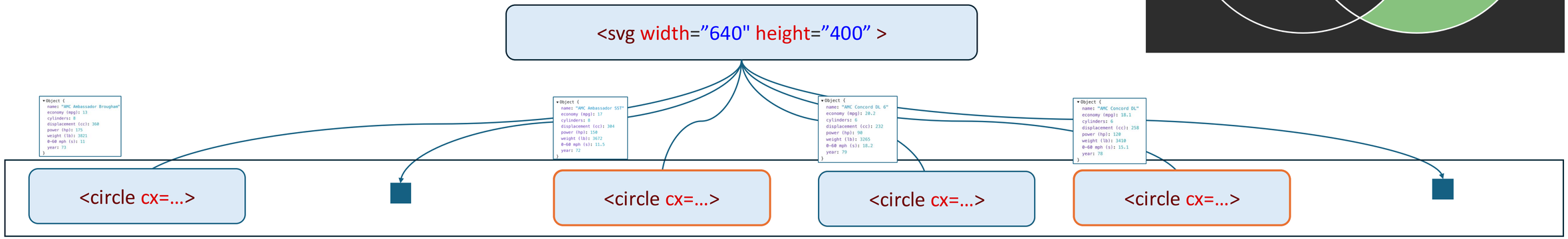


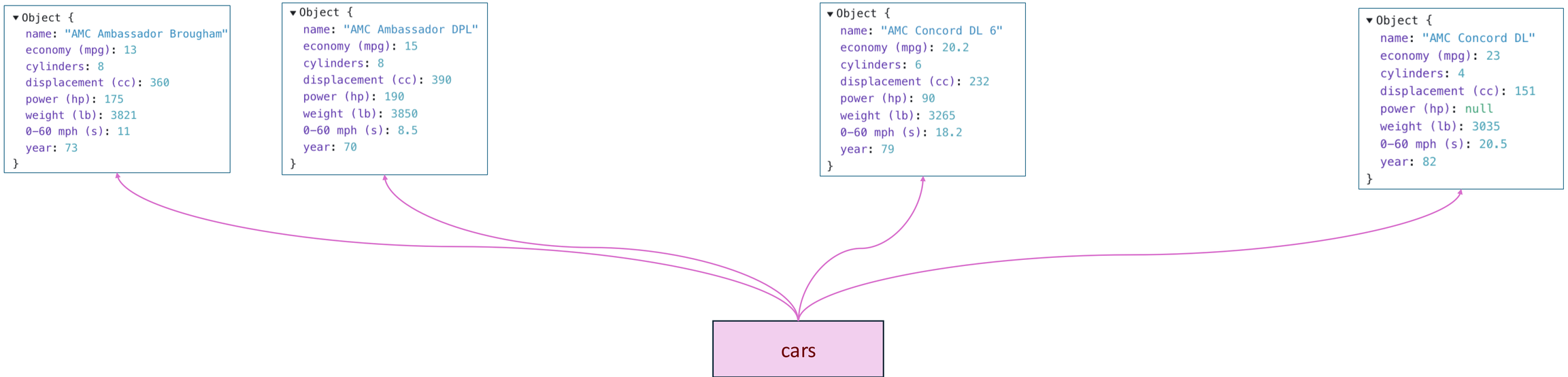


```
svg.selectAll('circle')
    .data(cars, d => d.name)
    .exit().remove()
```

Exit:







```
chart = {
  const width = 1152;
  const height = 400;
  const margin = {top: 20, right: 30, bottom: 30, left: 40};

  const x = d3.scaleBand()
      .domain(d3.reverse([...Array(110).keys()]))
      .range([margin.left, width - margin.right]);

  const y = d3.scaleLinear()
      .domain([0, 3500])
      .range([height - margin.bottom, margin.top]);

  const svg = d3.create("svg")
      .attr("width", width)
      .attr("height", height);

  svg.append("g")
      .attr("transform", `translate(0,${height - margin.bottom})`)
      .call(d3.axisBottom(x).tickValues([...Array(22).keys()].map((d) => d * 5)));

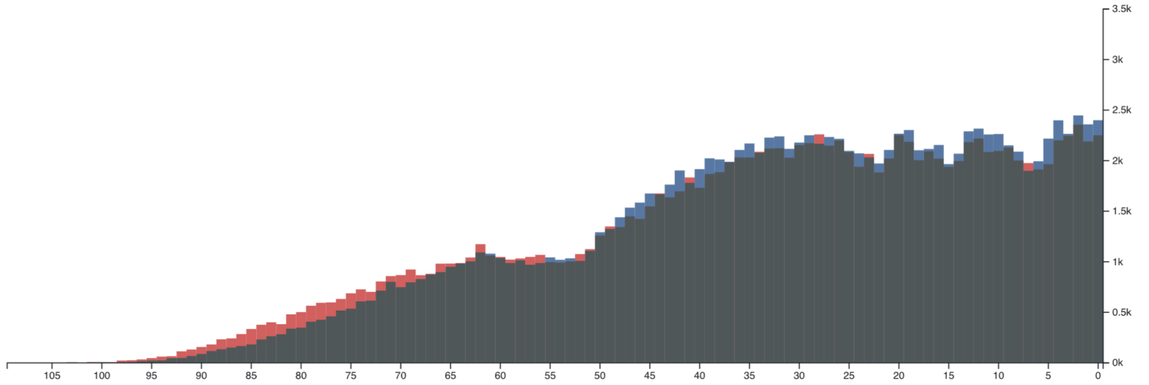
  svg.append("g")
      .attr("transform", `translate(${width - margin.right},0)`)
      .call(d3.axisRight(y).tickFormat(d => Math.round(d / 500) / 2 + 'k'));

  const colors = ["#4e79a7", "#e15759"];
  const data = population.filter((d) => d.year === icelandYear);
  svg.selectAll("rect")
      .data(data)
      .join("rect")
      .style("mix-blend-mode", "darken")
      .attr("fill", d => d.sex == 'M' ? colors[0] : colors[1])
      .attr("x", d => x(d.age))
      .attr("y", d => y(d.value))
      .attr("width", x.bandwidth())
      .attr("height", d => y(0) - y(d.value))

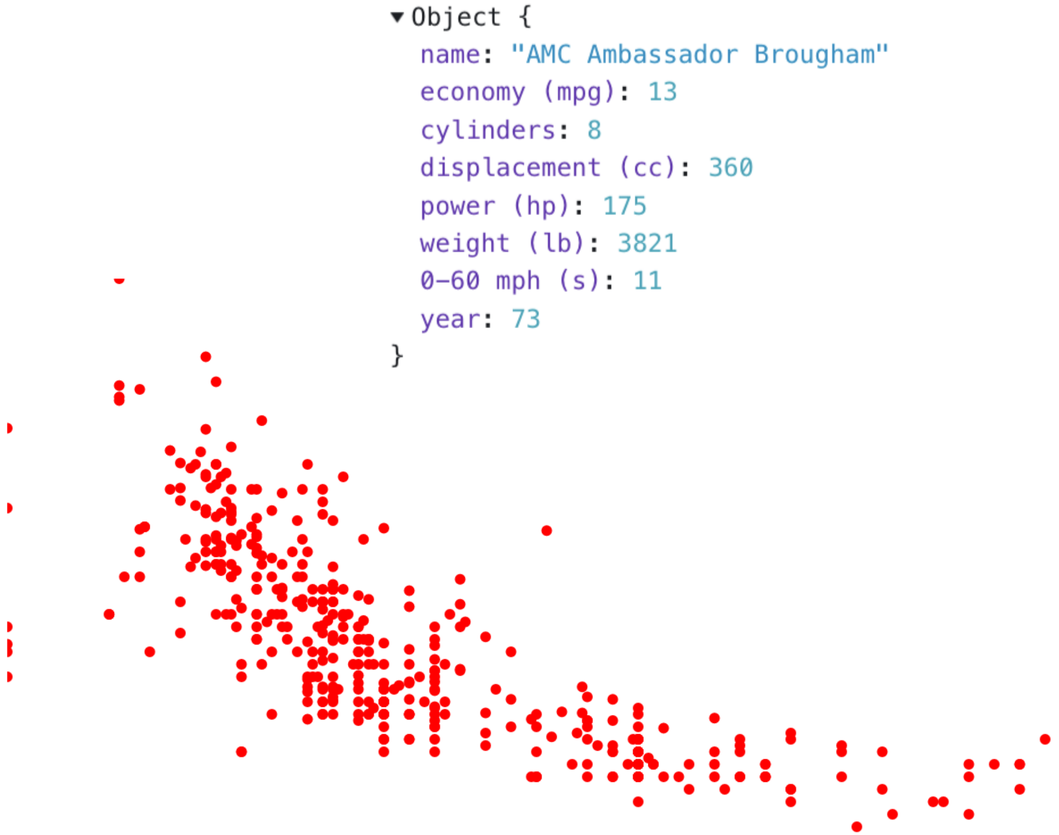
  return svg.node();
}
```

Year 1993

```
viewof icelandYear = Inputs.range([1841, 2019], {label: 'Year', step: 1})
```



```
svg.selectAll('circle')
    .data(cars)
    .join('circle')
    .attr("fill", "red")
    .attr("cx", (d) => x(d["power (hp)"]))
    .attr("cy", (d) => y(d["economy (mpg)"]))
    .attr("r", 3)
```




```
marks: [
  Plot.dot(cars, {x: "power (hp)",
                  y: "economy (mpg)",
                  r: 3,
                  fill: 'red'
                 }),
]
```

Each *top-level* variable is a reactive value

- Can be computed with a *chunk* of code

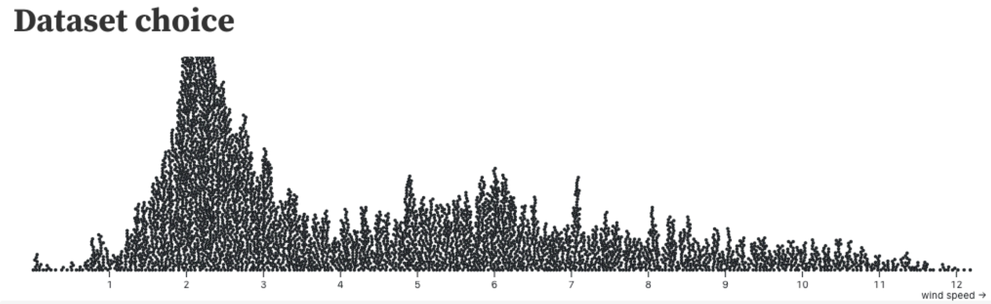
Reactive value

Dependencies

Code chunk

```
resampled = {
  resampleToggle2
  step2
  let x = resample(weights);
  let est = computeStat(x);
  estimates.push([est]);
  let output = x.arraySync();
  x.dispose()
  return output;
}
```

Reactive




```
Plot.plot({
  height: 250,
  width: 1000,
  x: {label: dataset, domain: [Math.min(...populations[dataset]),
                               Math.max(...populations[dataset])]},
  marks: [
    Plot.dot(populations[dataset], Plot.dodgeY({x: "0", r:1}))
  ]
})
```

wind speed

```
viewof dataset = Inputs.select(["wind speed", "IMDB rating"])
```

```
populations = ▸ Object {wind speed: Array(4800), IMDB rating: Array(3201)}
```

```
 populations = ({
      "wind speed": winddata.map(d => [d['speed']]),
      "IMDB rating": imdb.map(d => [d['IMDB Rating']]),
    })
```

```
▸ Array(3201) [6.1, 6.9, 6.8, null, 3.4, null, 7.7, 3.8, 5.8, 7, 7, 7.5, 8.4, null, 6.8, null, 7, 6.1, 2.5, 8.9, …]
```

```
imdb.map(d => d['IMDB Rating'])
```

```
import {windpopulation, imdbpopulation, imdb, wind, winddata, tf, windspeedDistributionPlot, imdbDistributionPlot} from
"3523e4b3244dbb93"
```