

Knowing What You See

Let's Talk About Front-end Consistency

Yifan Wu, UC Berkeley

@yifanwu

advised by Prof Joe Hellerstein and Prof Eugene Wu, worked with Larry Xu

Front-end Consistency?

Front-end Consistency?

conformity** for the sake of **logic, accuracy

Usually it's fine...

Usually it's fine...

Search Facebook

Yifan Home

Yifan Wu

Edit Profile

Stop loading this page

Photo/Video Photo/Video Album

What's on your mind?

Friends Post

Usually it's fine...

The image displays two side-by-side screenshots of social media platforms.

Facebook Profile (Left):

- Header: Search Facebook
- User: Yifan Wu
- Profile picture: A person wearing sunglasses.
- Options: Photo/Video, Photo/Video, Stop loading this page.
- Text input field: What's on your mind?
- Large white area below the input field.

Twitter Feed (Right):

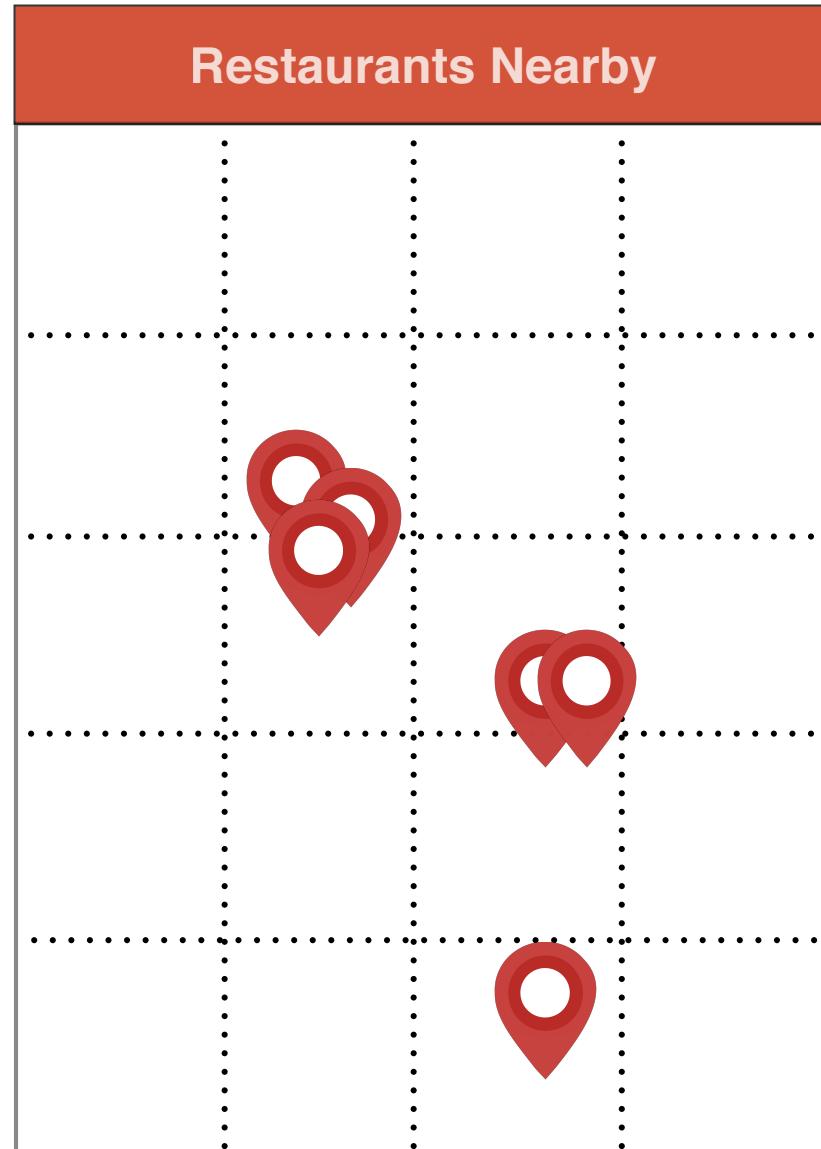
- Header: Messages, Search Twitter
- Text input field: What's happening?
- Tweet by **Bored Yann LeCun** (@boredyannlecun) 32s ago: Per latest health disclosures, Donald Trump, like most neural networks, carries too much weight #torched
- Interaction icons: Retweet, Like, More
- Text: While you were away...
- Tweet by **Angela Chen** (@chengela) 56m ago: "War on Drugs" op-ed narrated by Jay Z, illustrated by @mollycrabapple

You Don't See What You Expect

You Don't See What You Expect



You Don't See What You Expect



Time Diagram



User

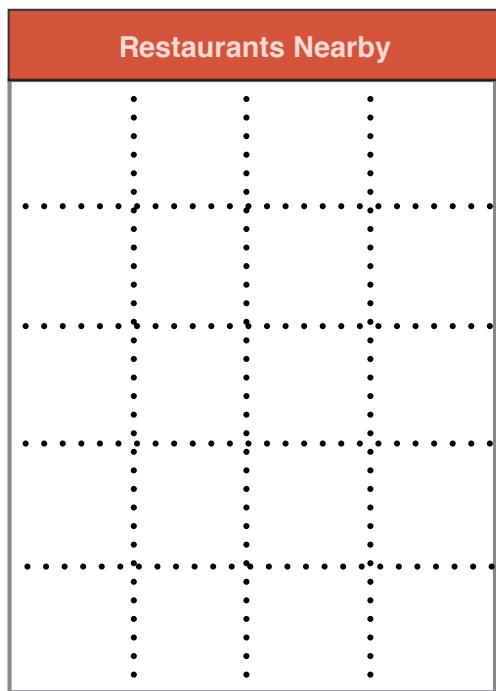


Frontend



Backend

Time Diagram



User

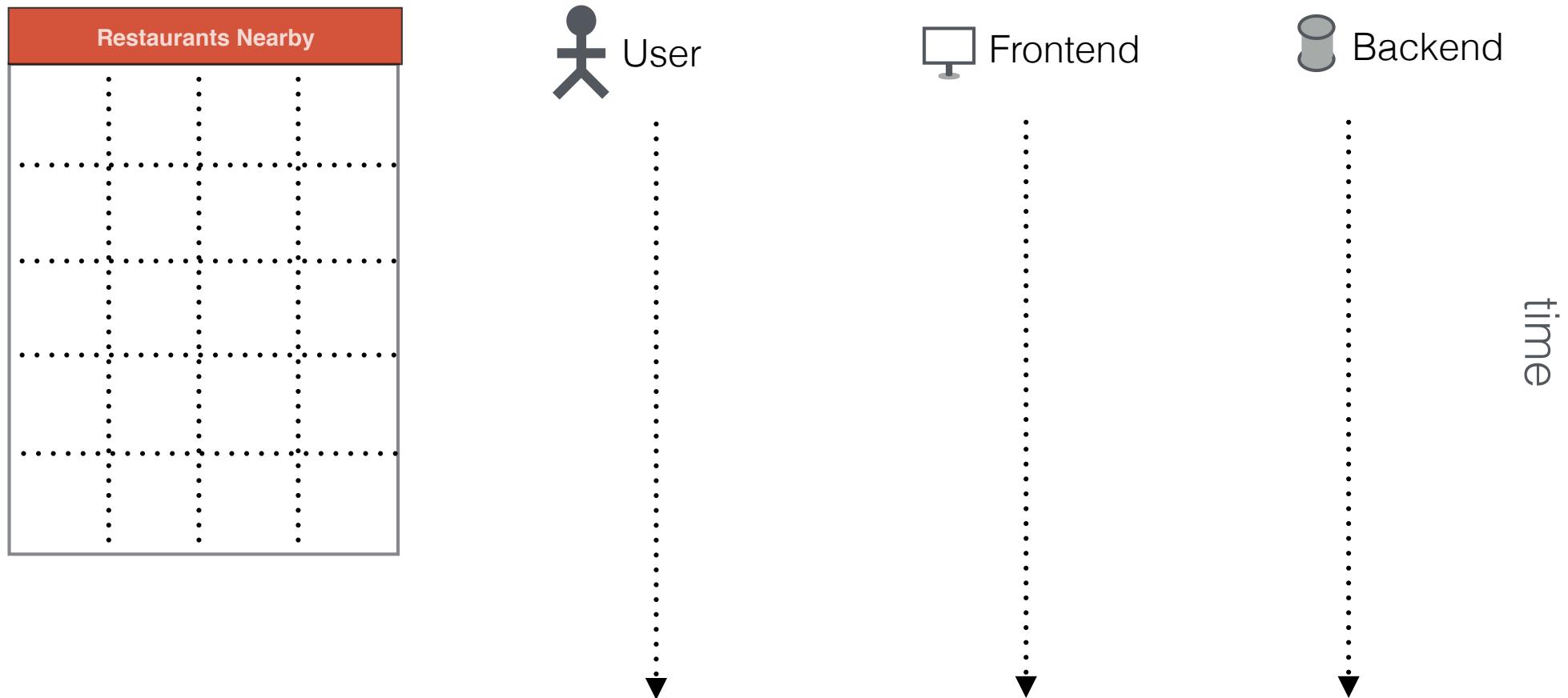


Frontend

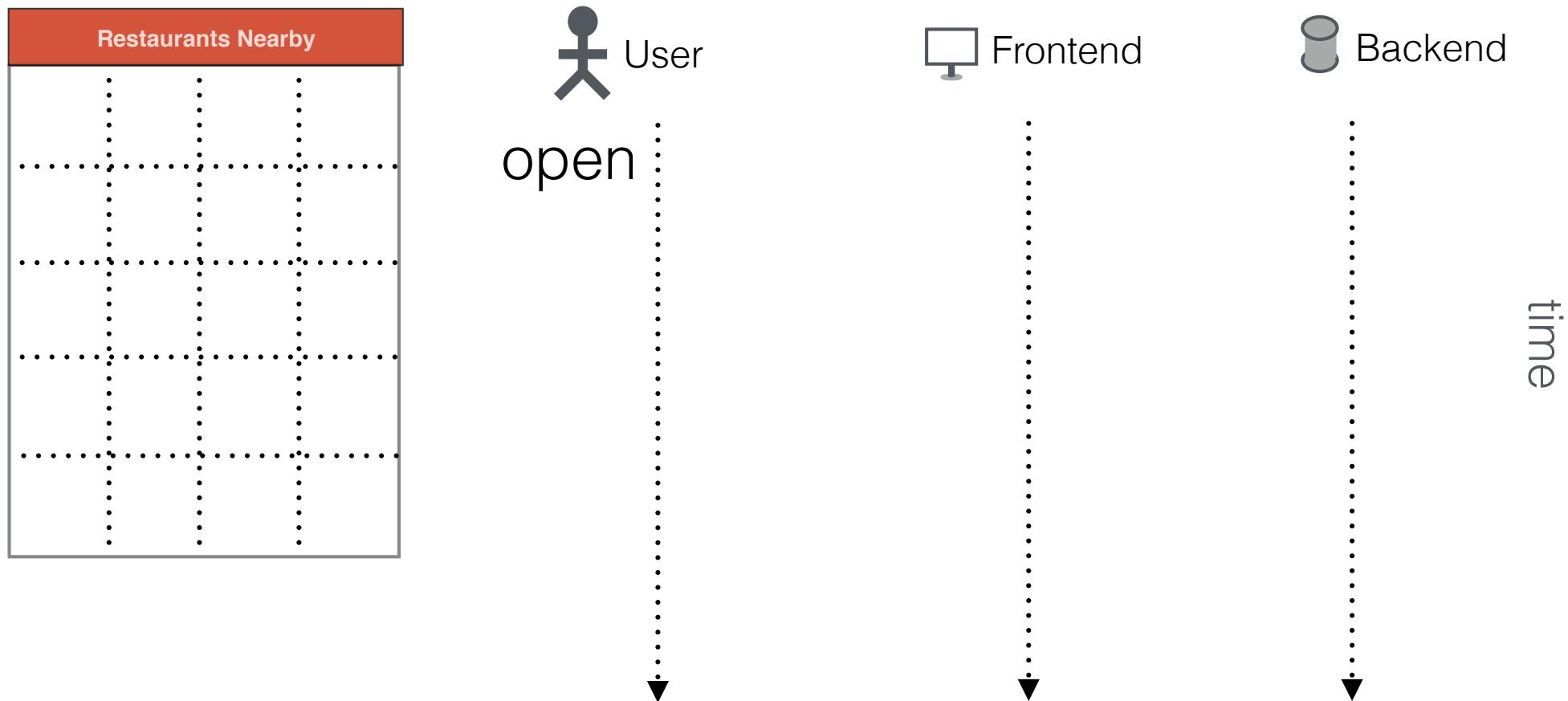


Backend

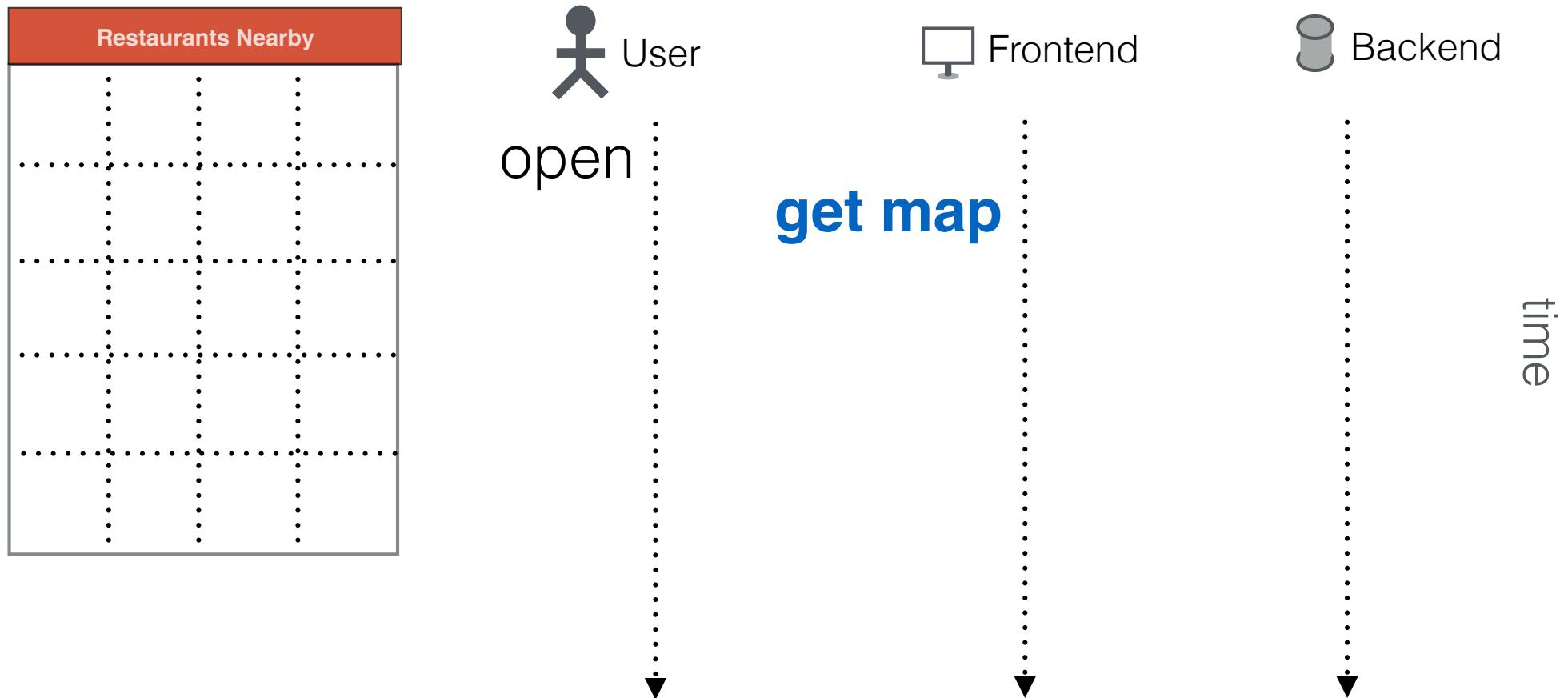
Time Diagram



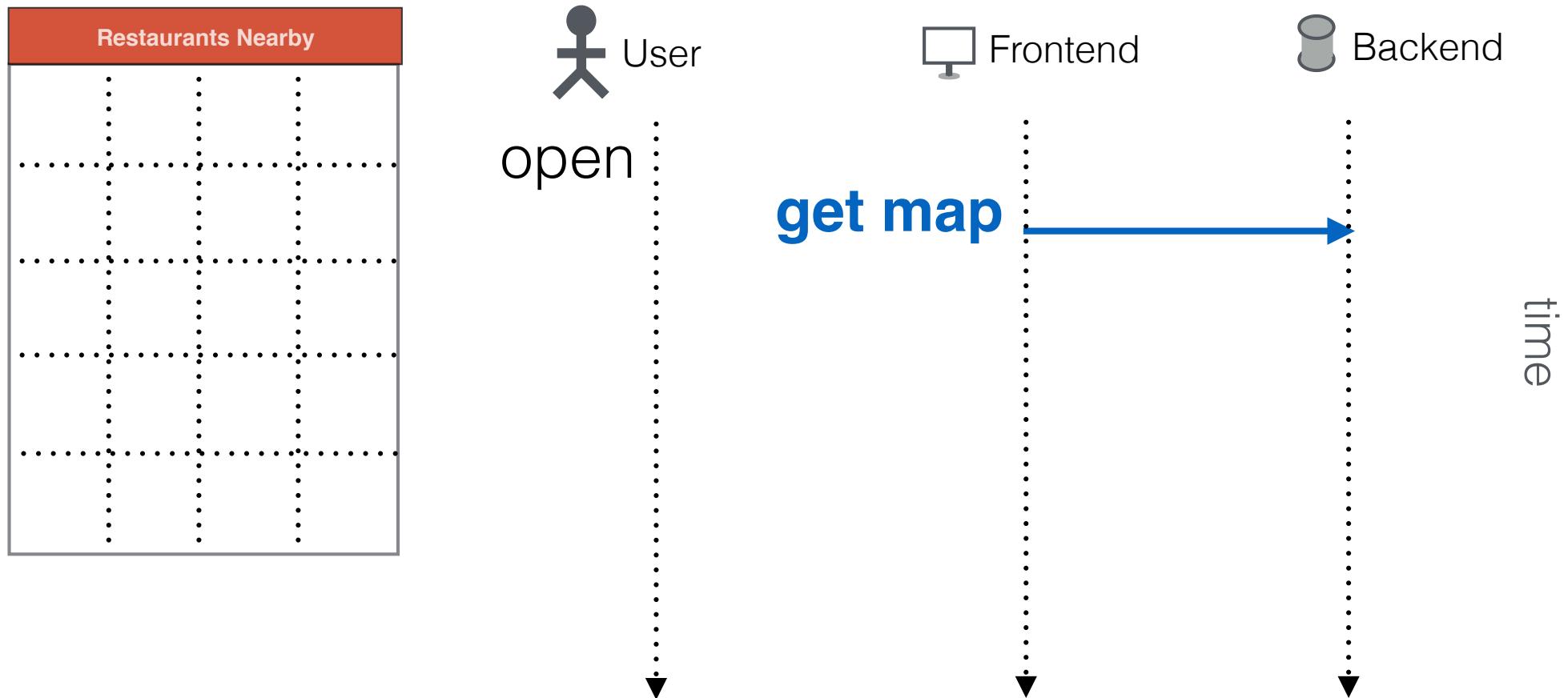
Time Diagram



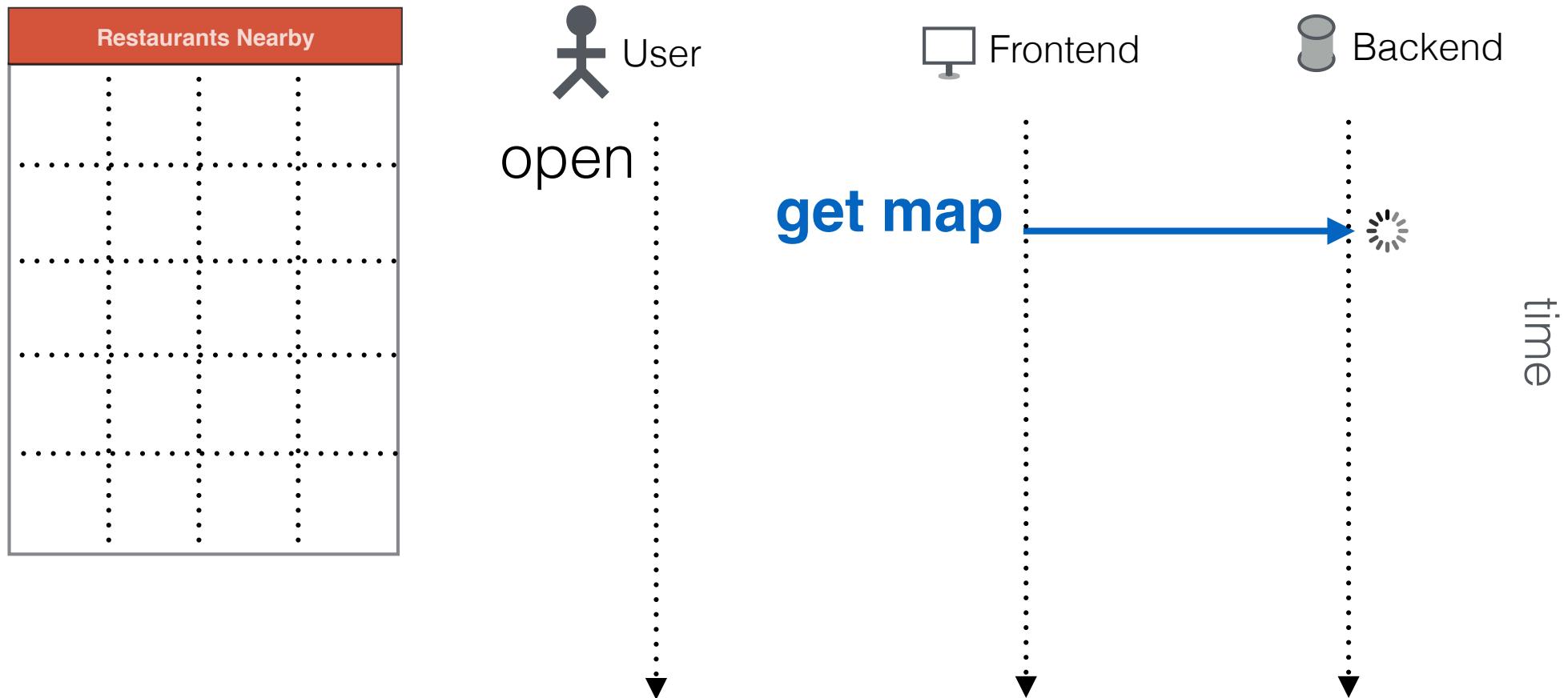
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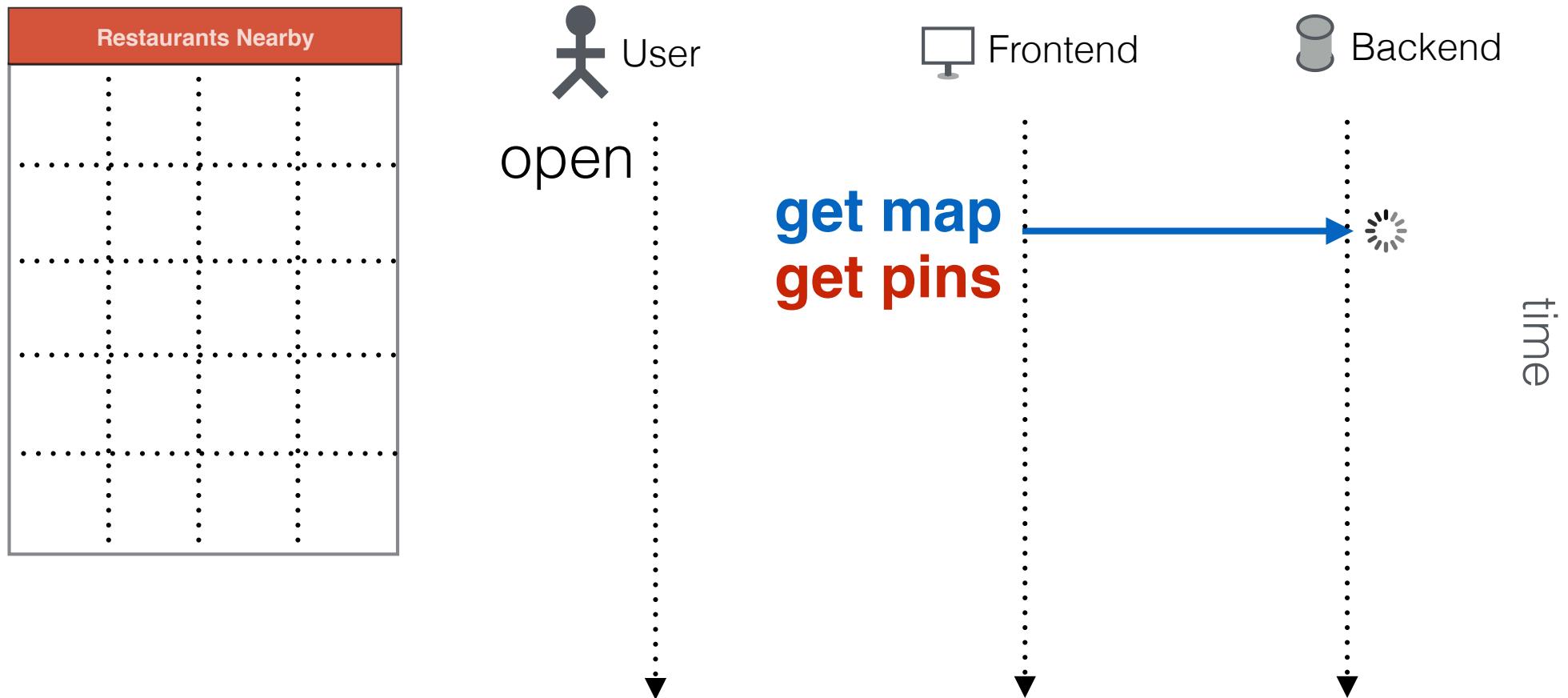
Time Diagram



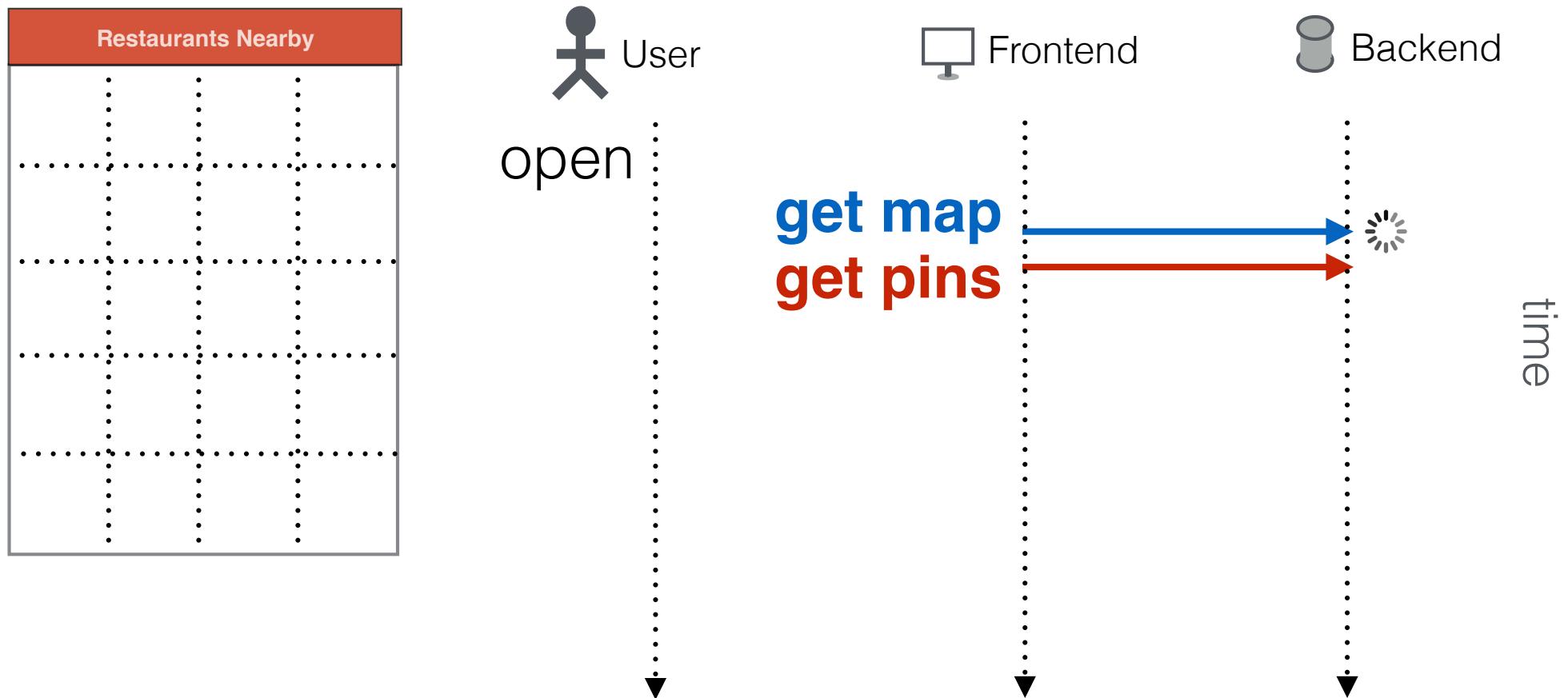
Time Diagram



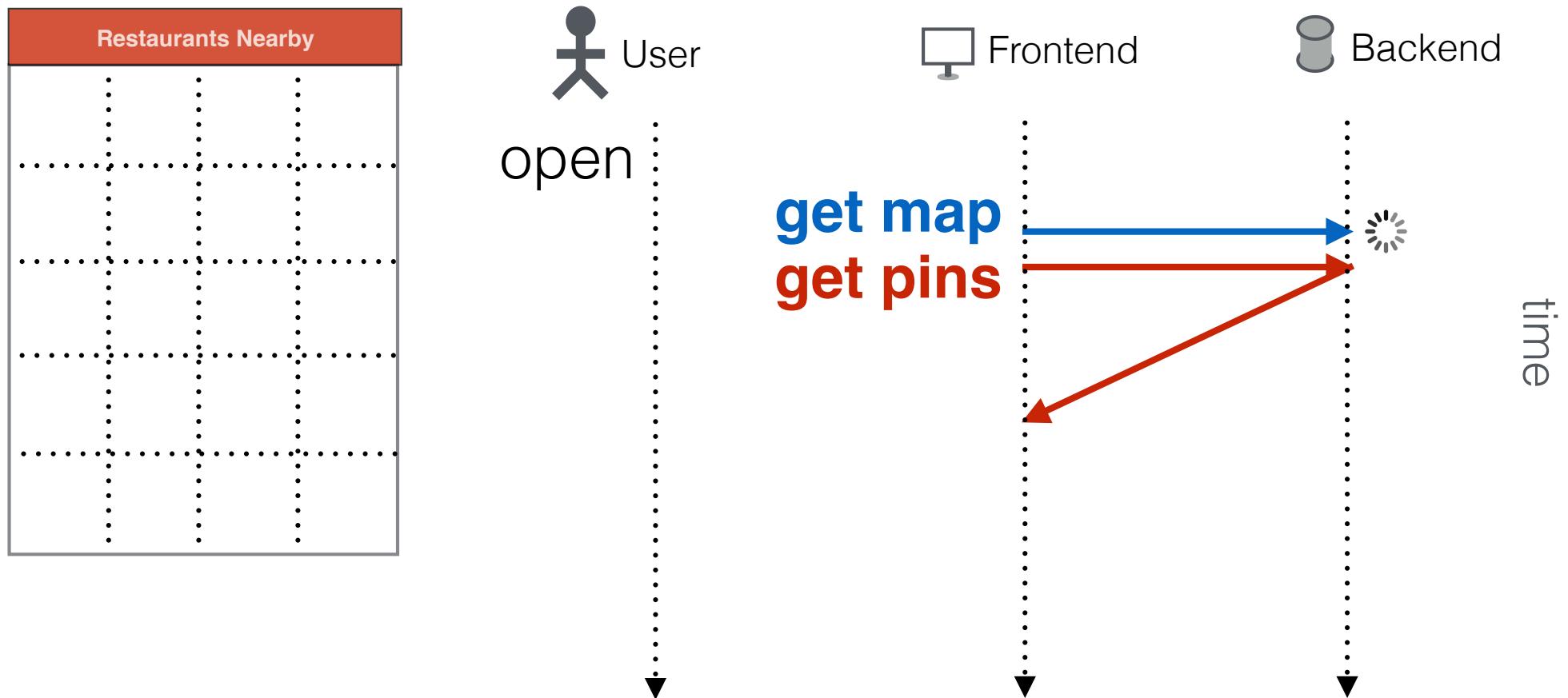
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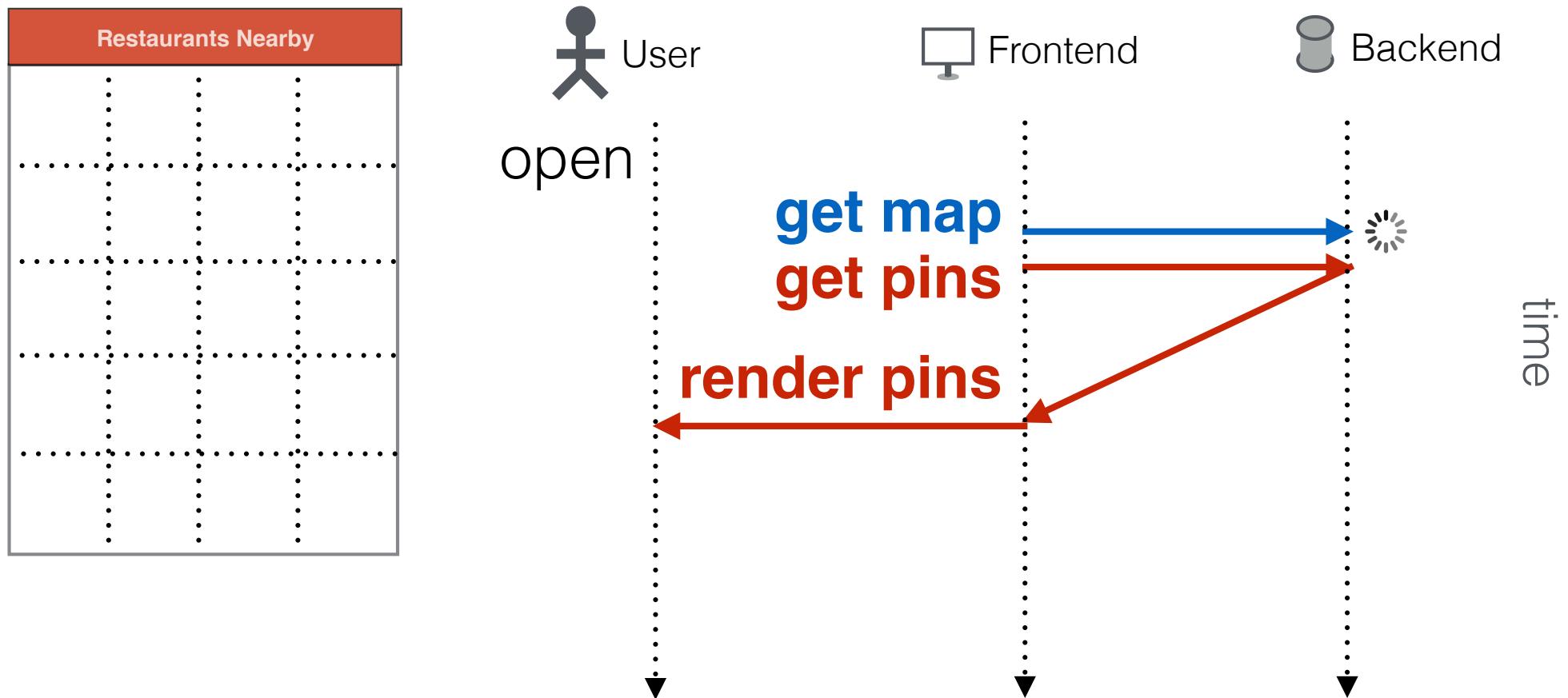
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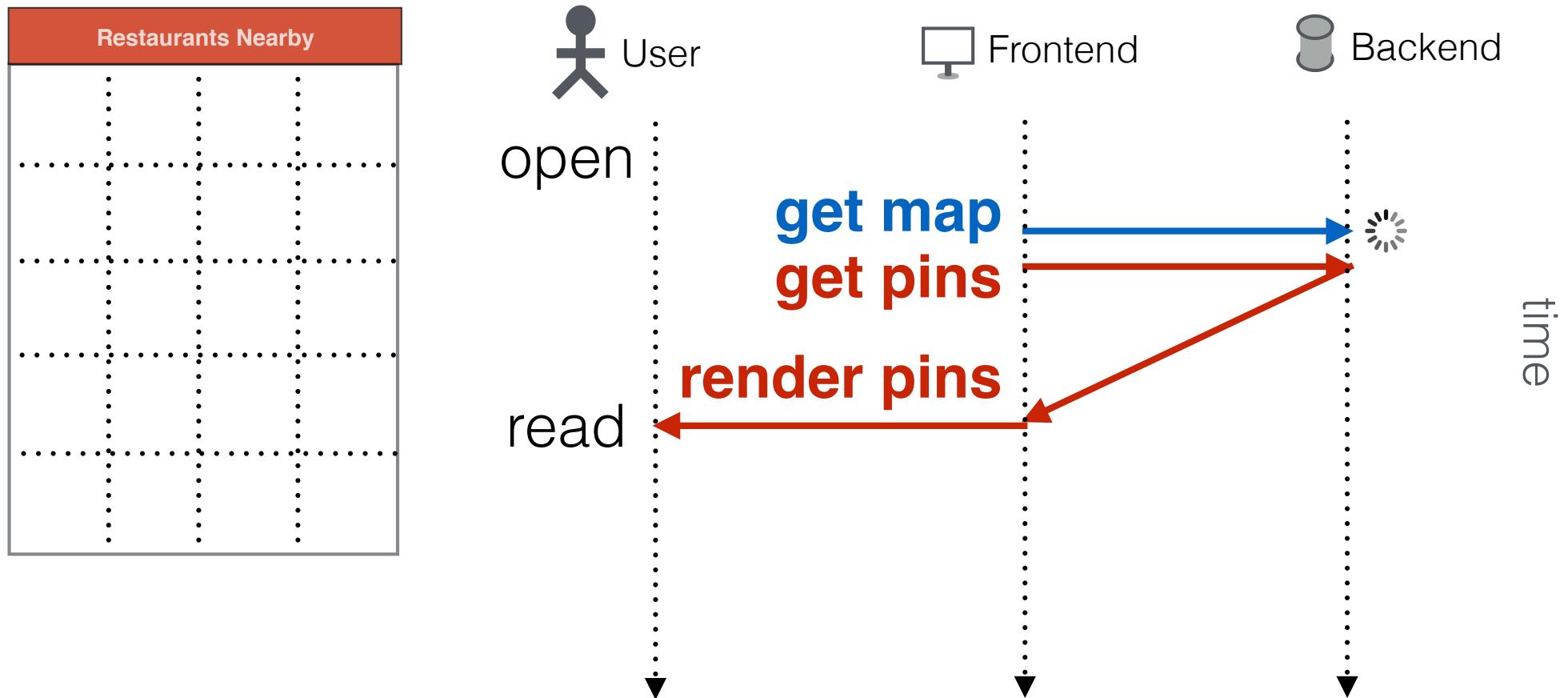
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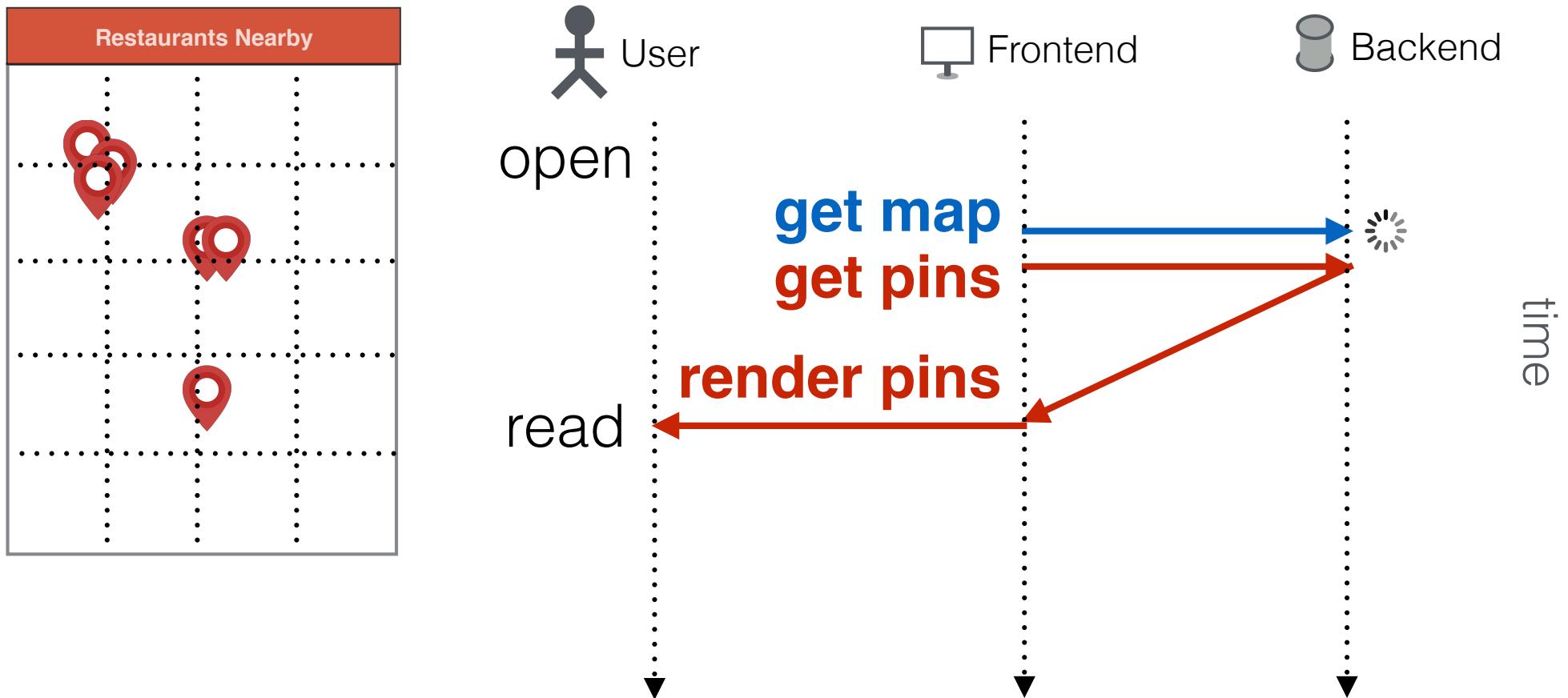
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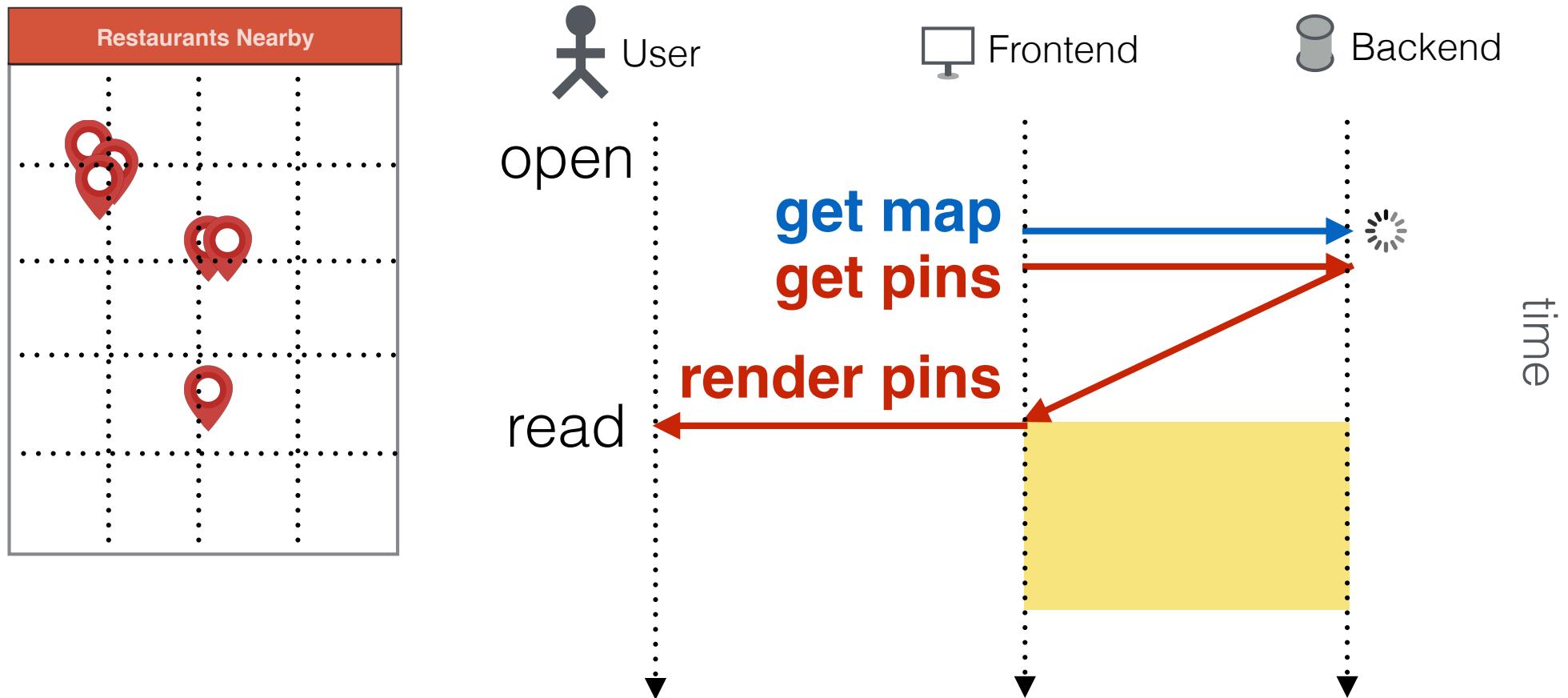
Time Diagram



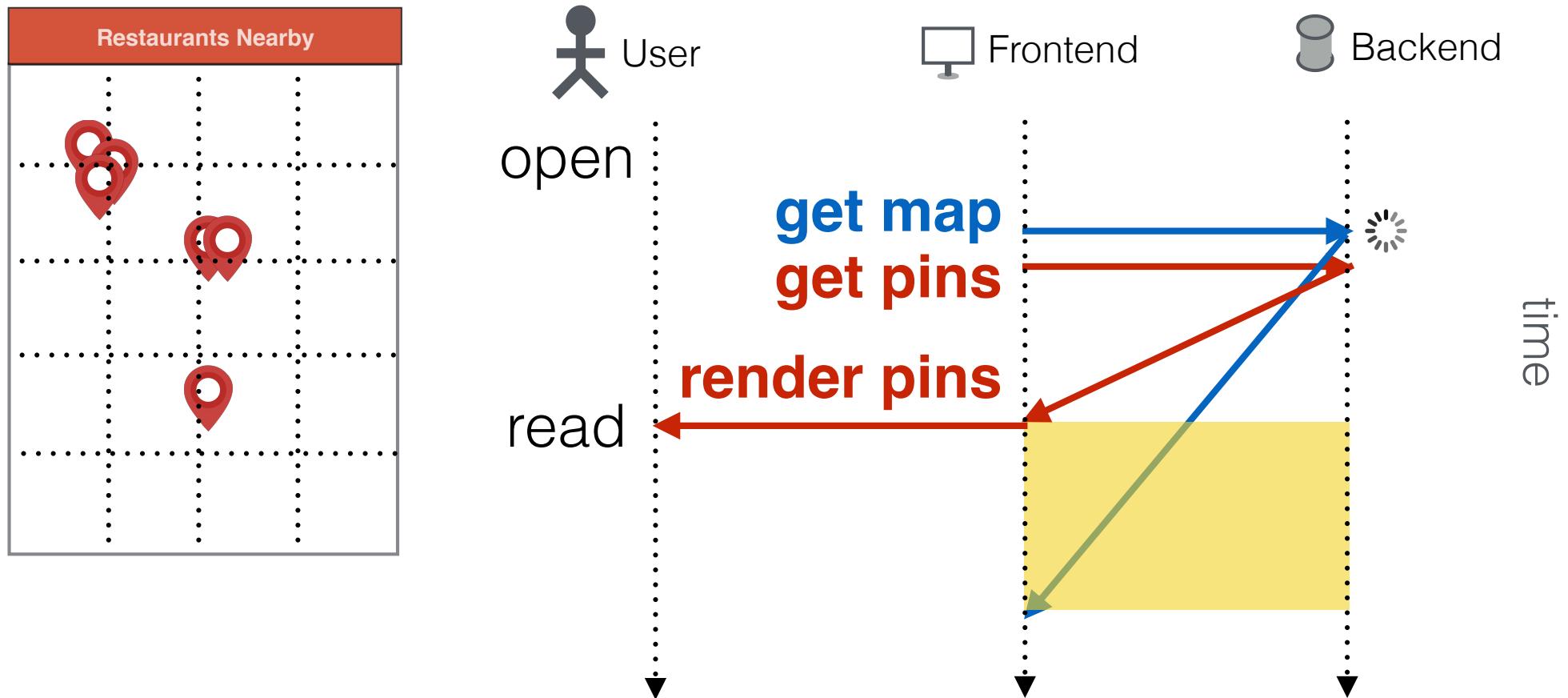
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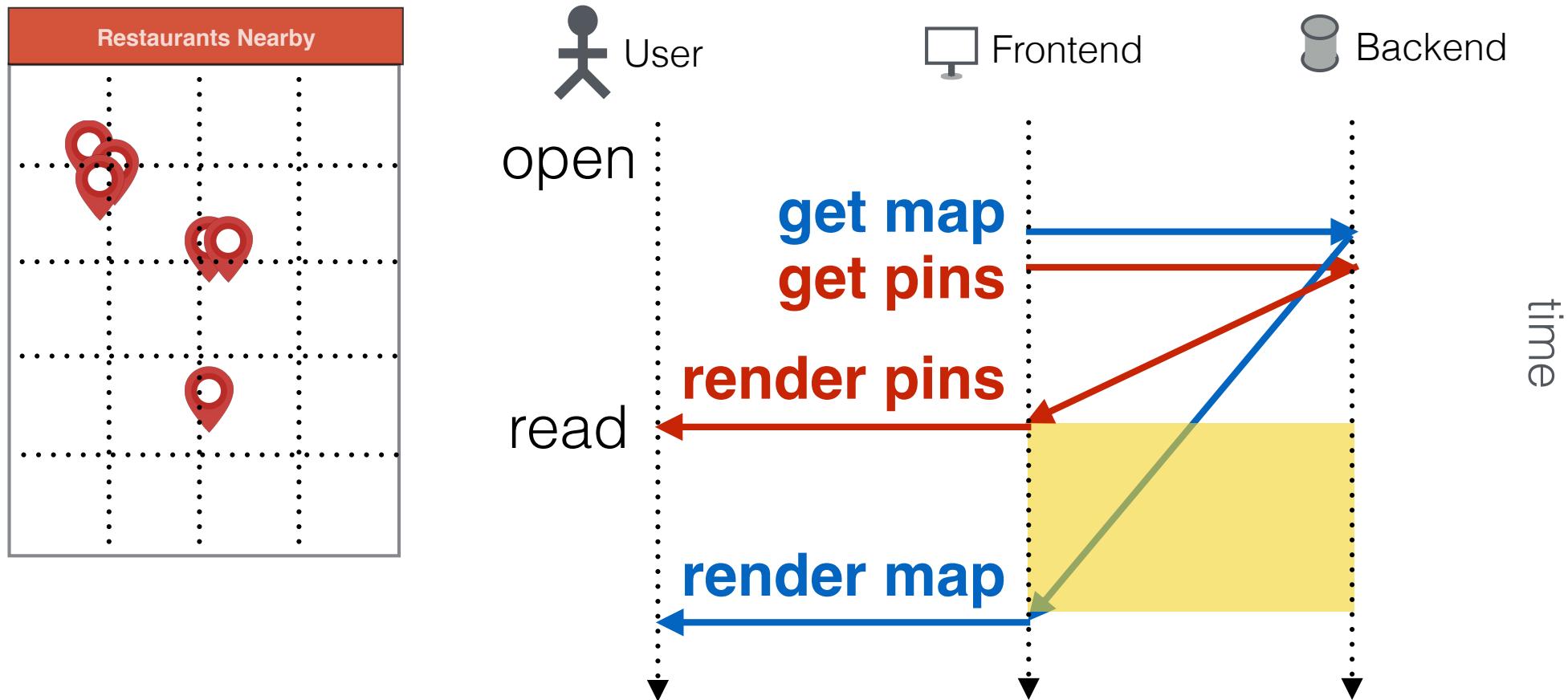
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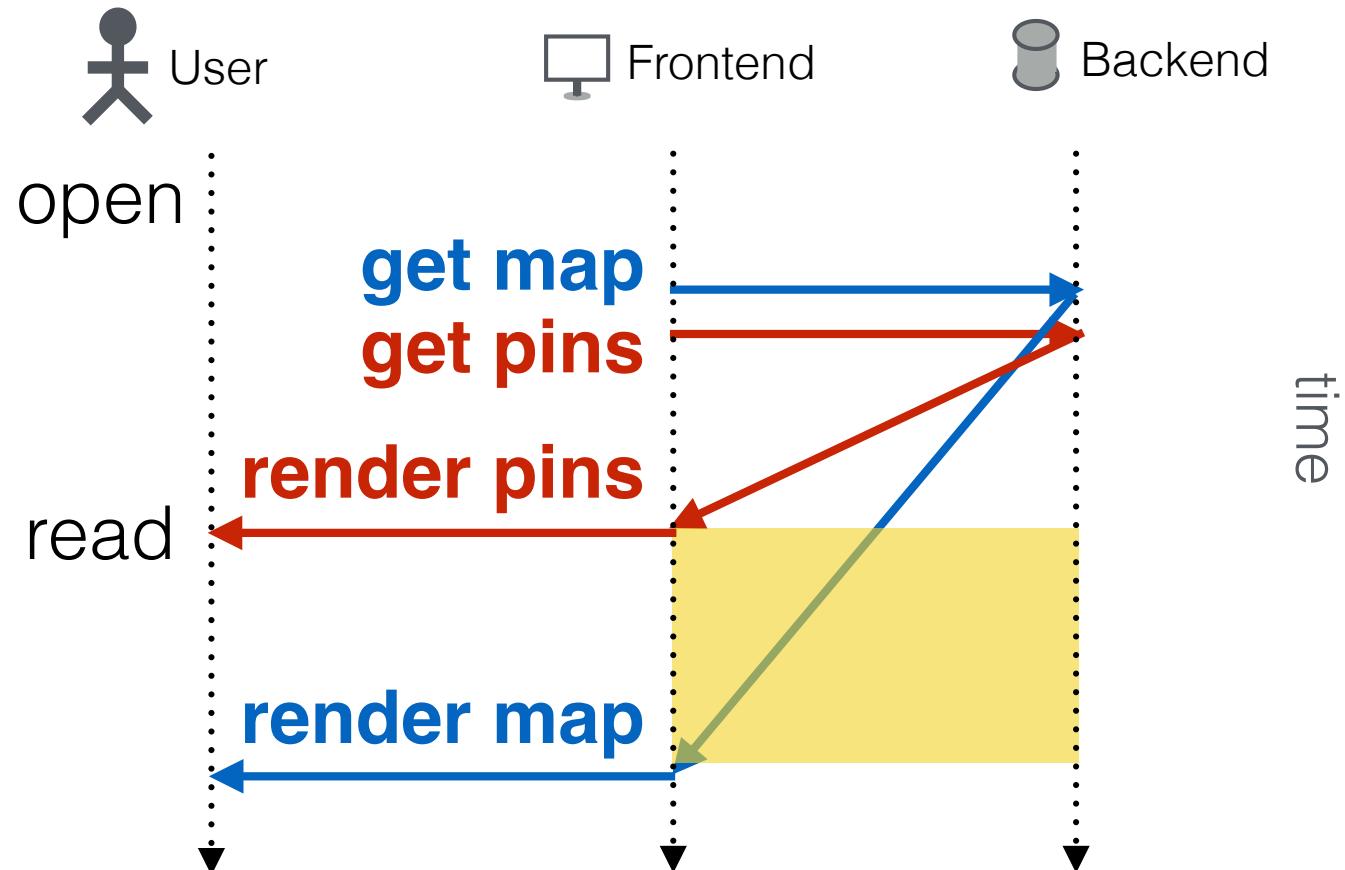
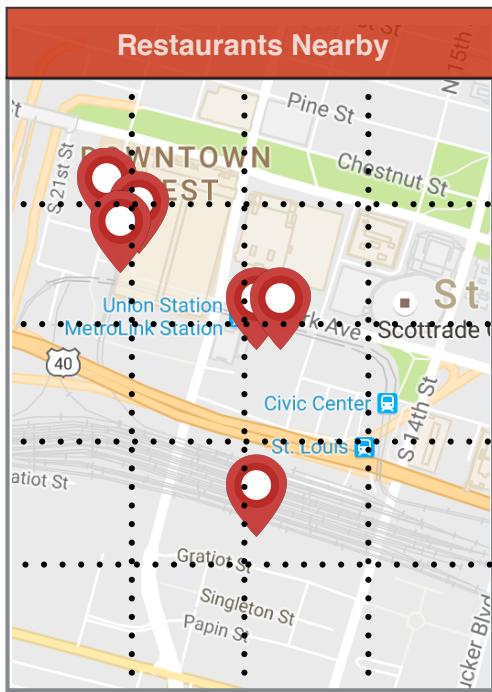
Time Diagram



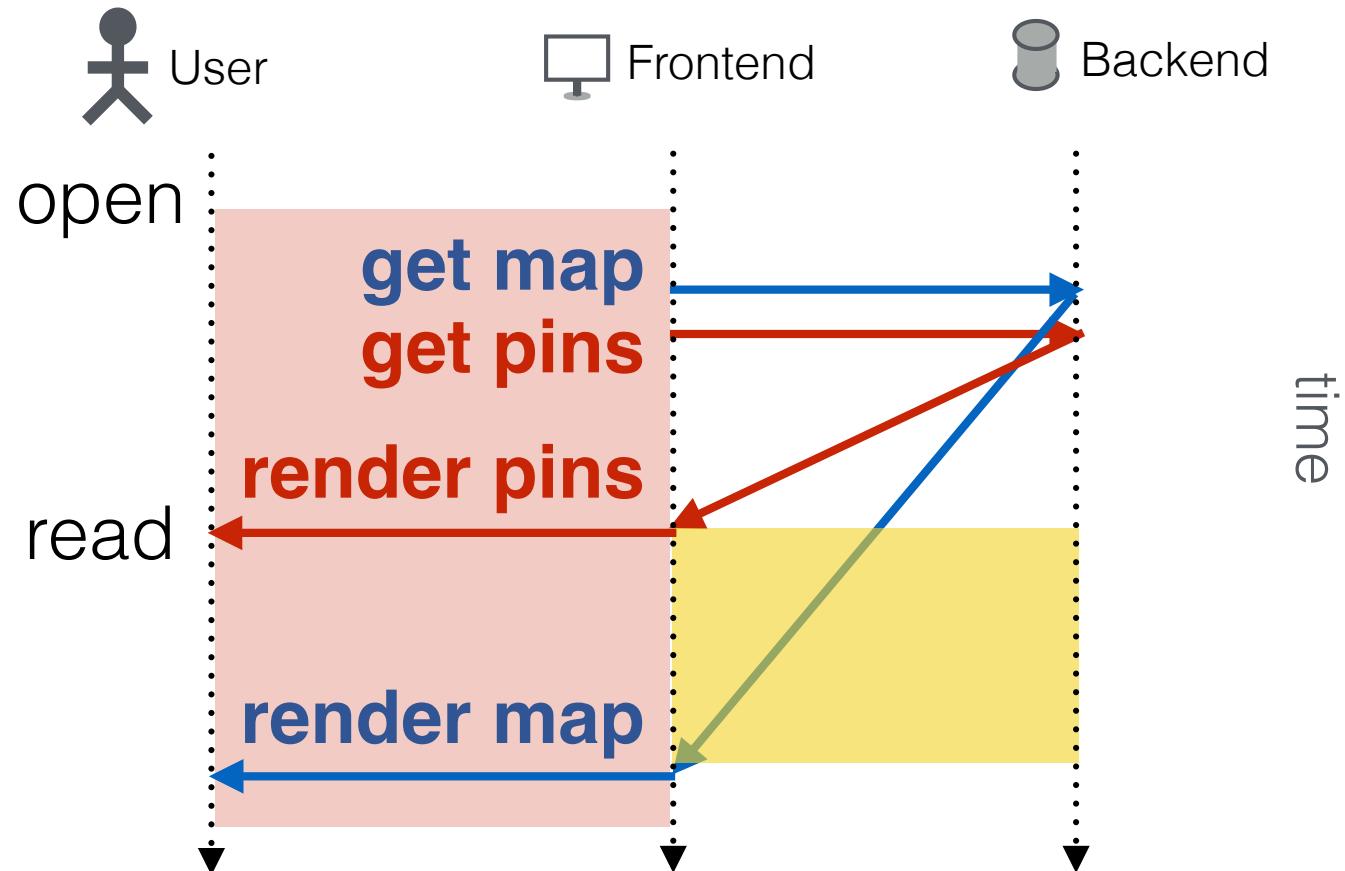
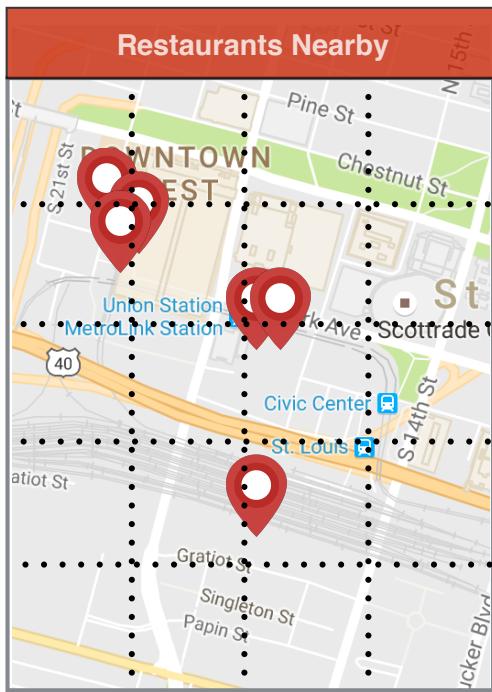
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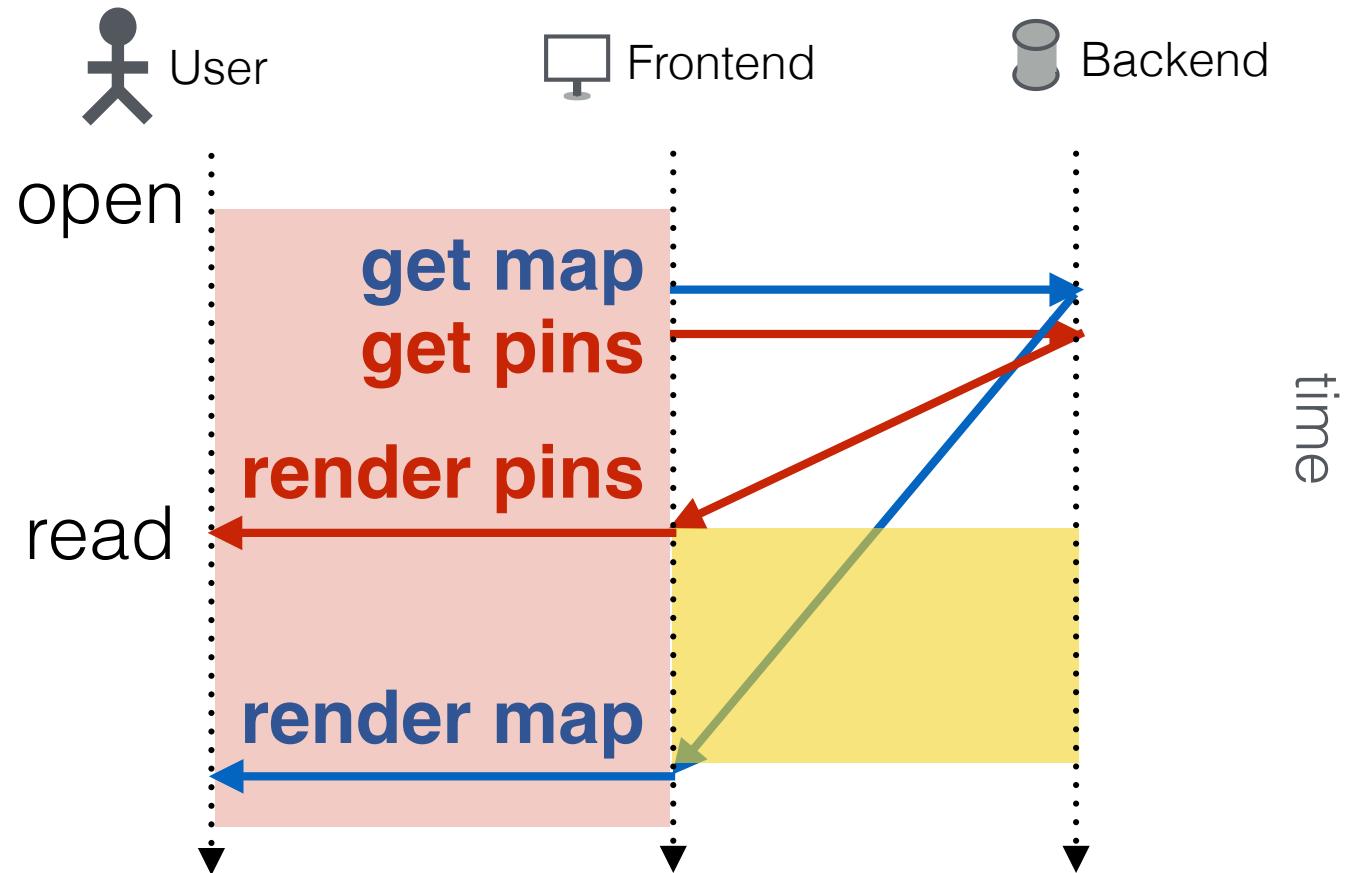
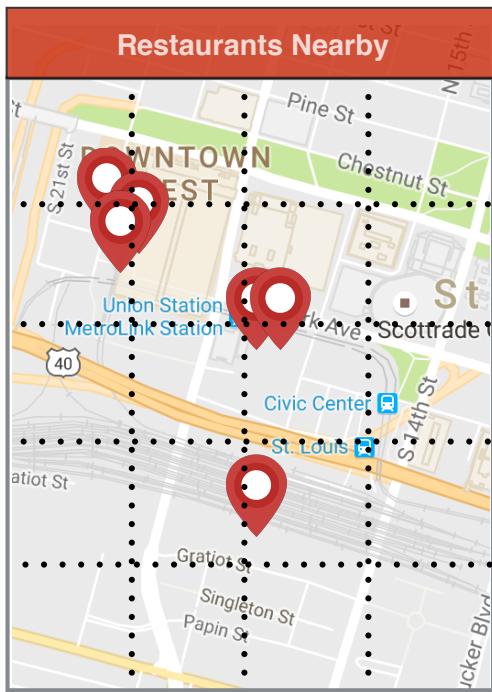
Time Diagram



Time Diagram



Time Diagram

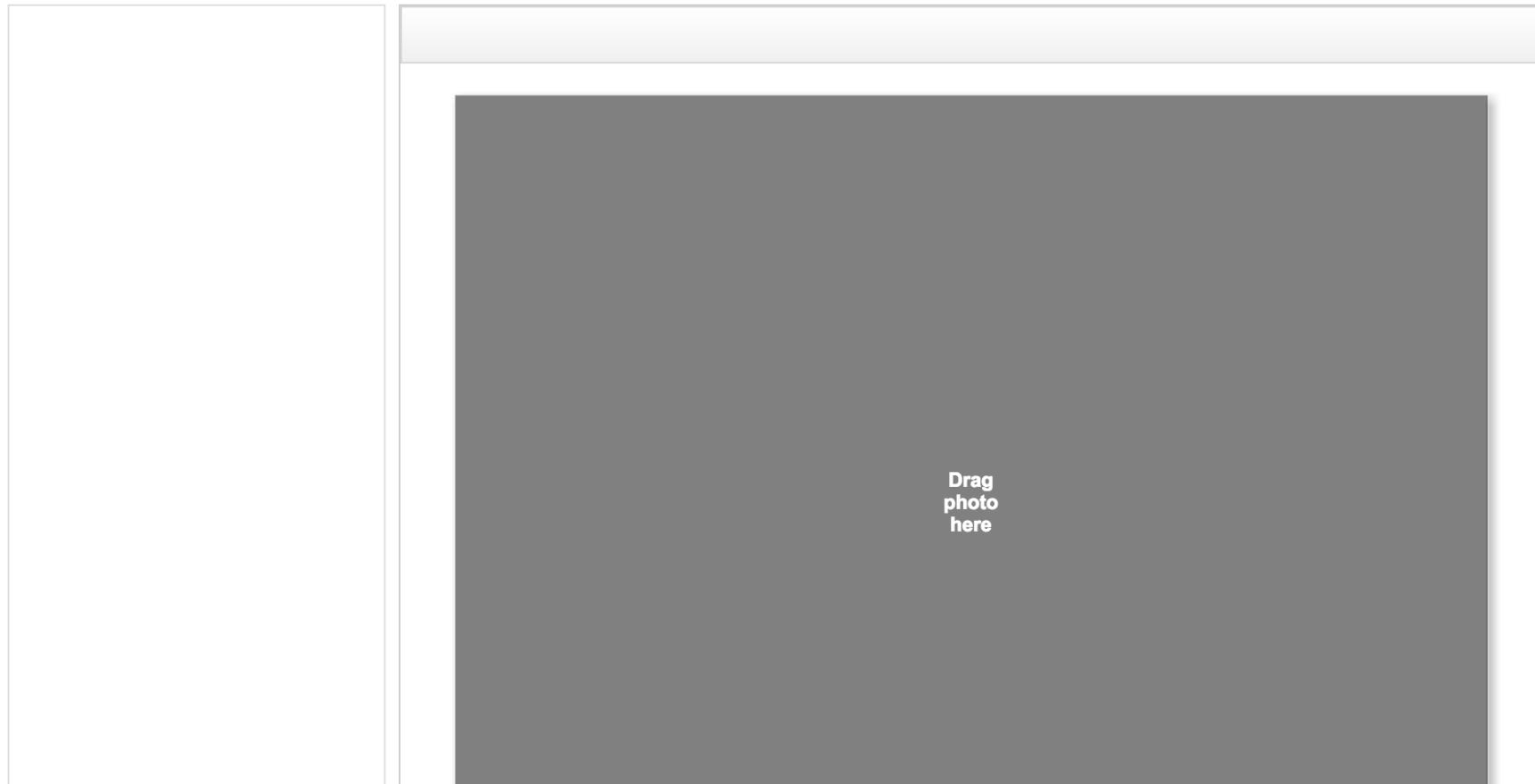


Anomaly: Reordering

Current Poster: 11x14 Poster Print, **\$10.99**

Back

Review



Drag
photo
here

Current Poster: 11x14 Poster Print, **\$10.99**

[Back](#)

[Review](#)



Drag
photo
here

Current Poster: 11x14 Poster Print, **\$10.99**

Back

Review

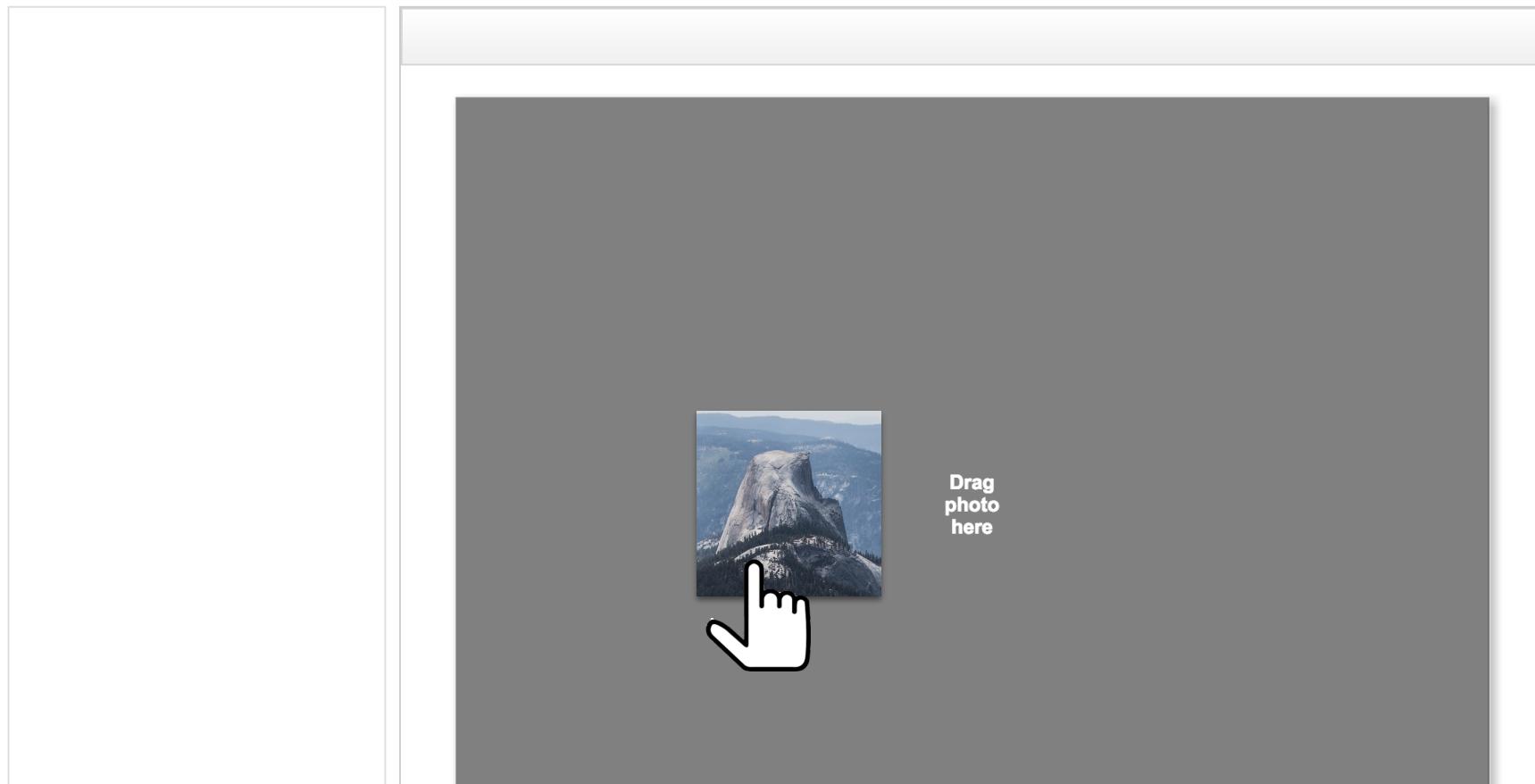


Drag
photo
here

Current Poster: 11x14 Poster Print, **\$10.99**

Back

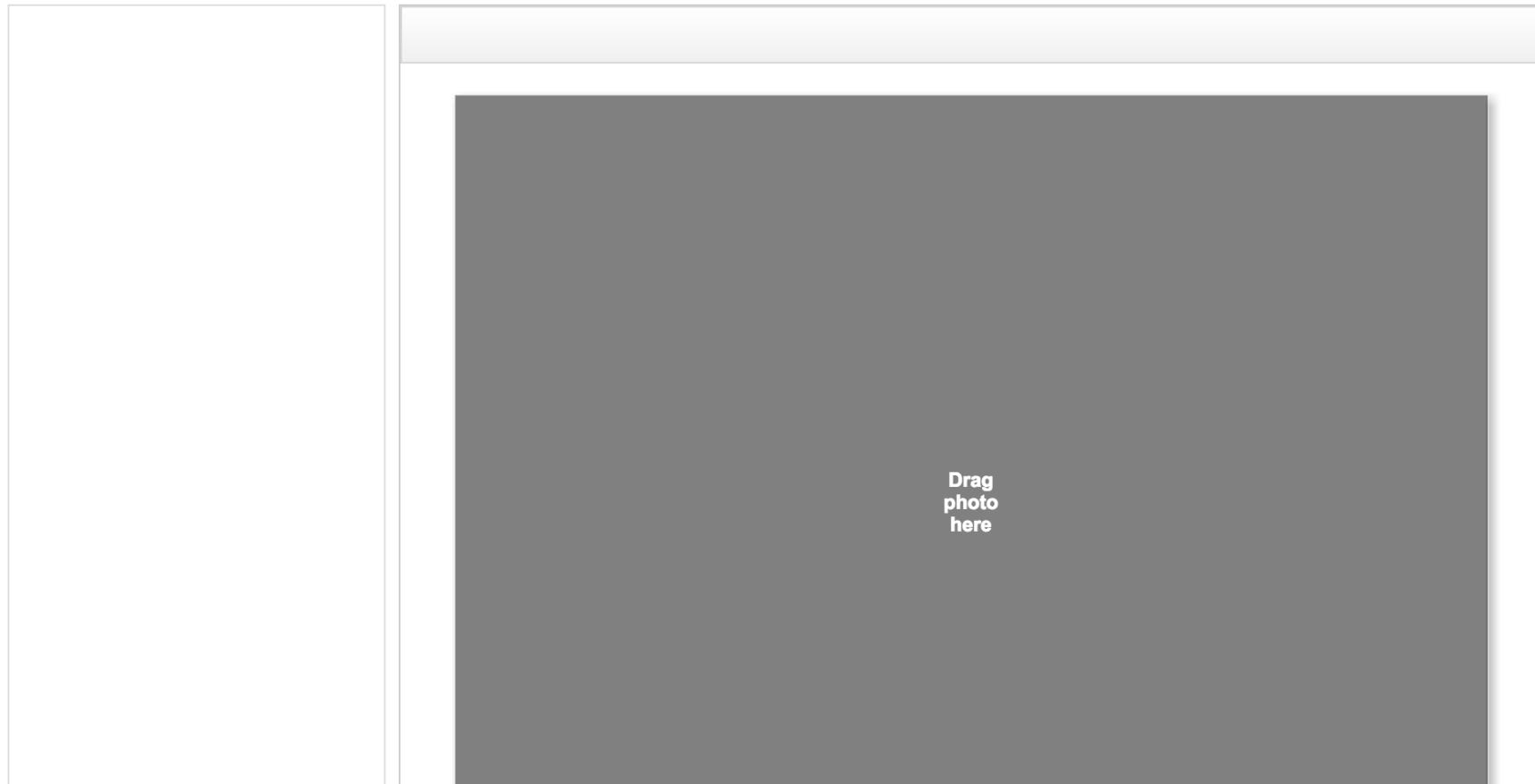
Review



Current Poster: 11x14 Poster Print, **\$10.99**

Back

Review



Drag
photo
here

Current Poster: 11x14 Poster Print, **\$10.99**

Back

Review

???

Drag
photo
here

should i wait or refresh?

Store > Posters > Create Poster

Current Poster: 11x14 Poster Print, \$10.99

Back

Review

???

Drag
photo
here

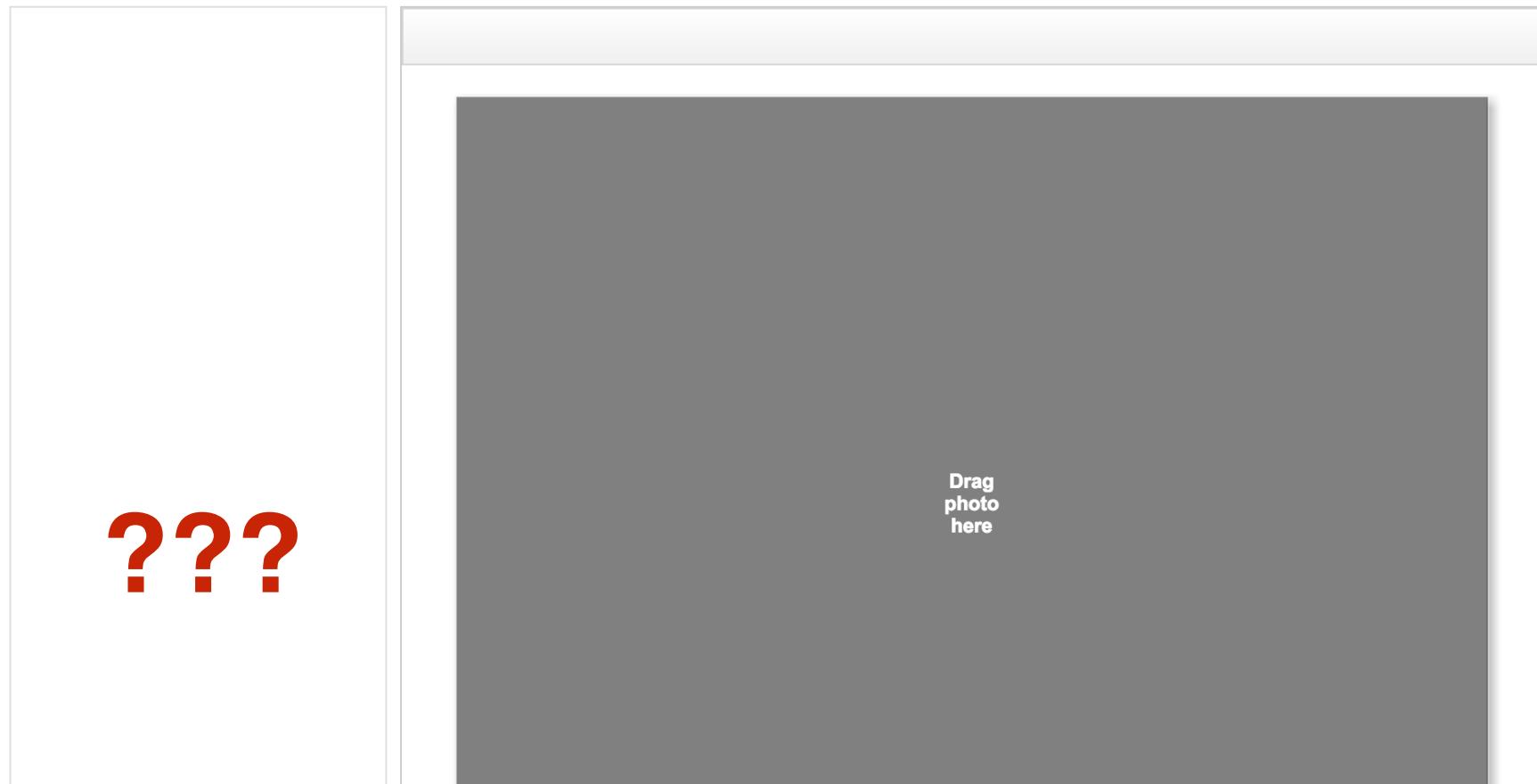
should i wait or refresh?

Store > Posters > Create Poster

Current Poster: 11x14 Poster Print, \$10.99

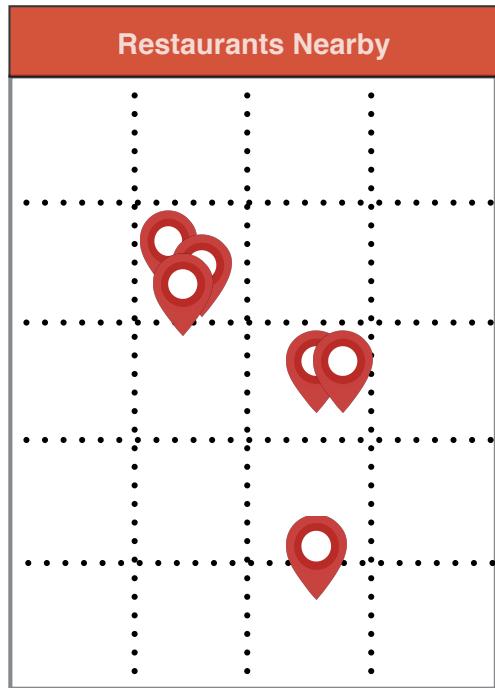
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Review



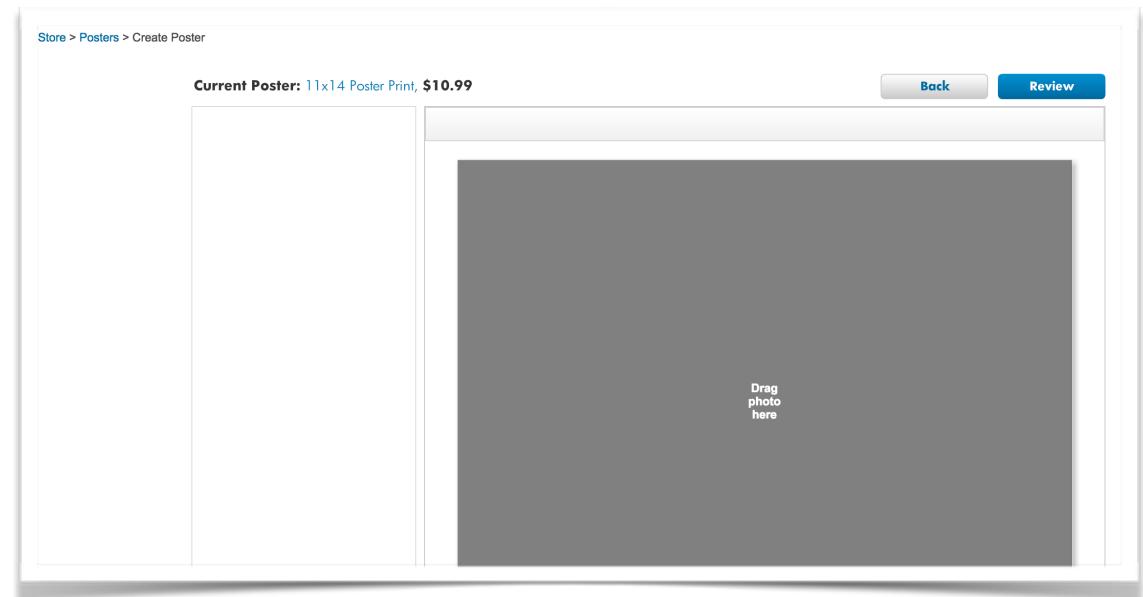
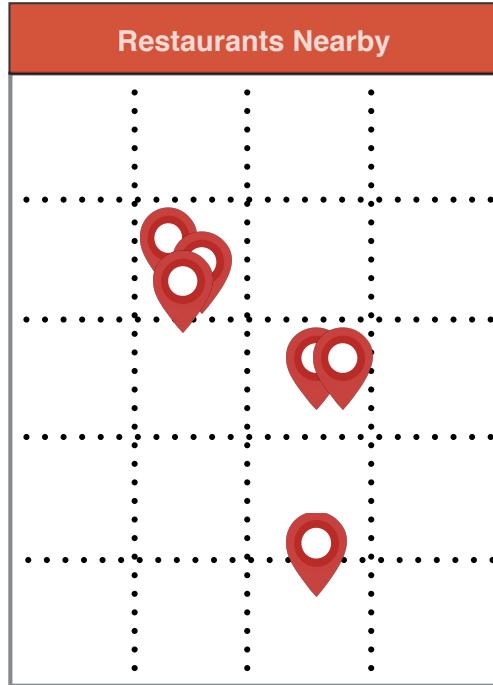
Anomaly: Varying Delays

Anomalies So Far



reordering

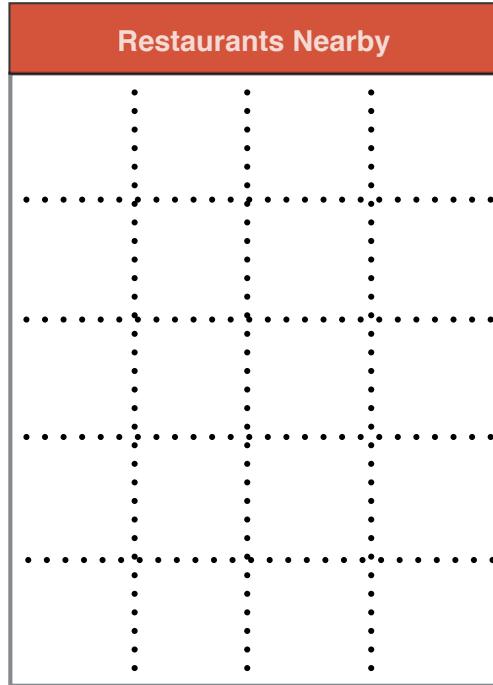
Anomalies So Far



reordering

varying delays

Anomalies So Far

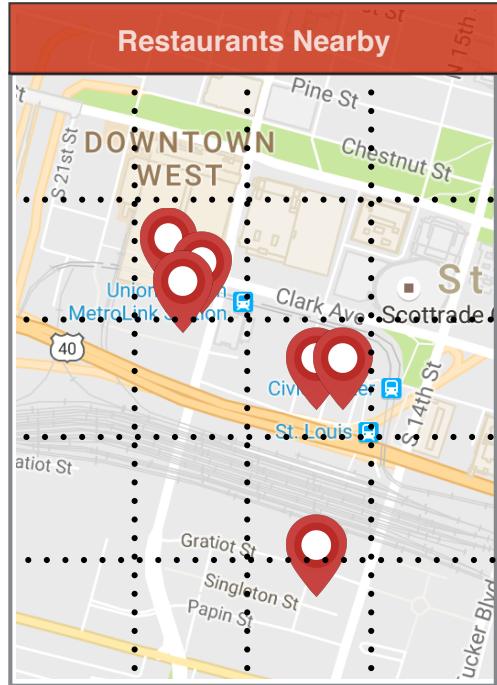


reordering

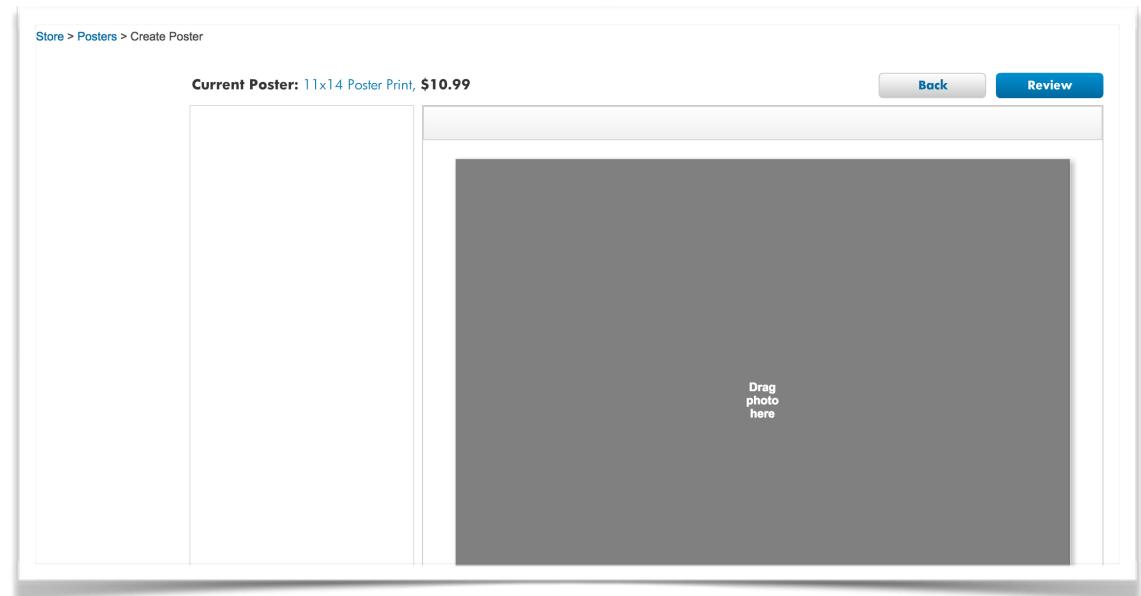


varying delays

Anomalies So Far

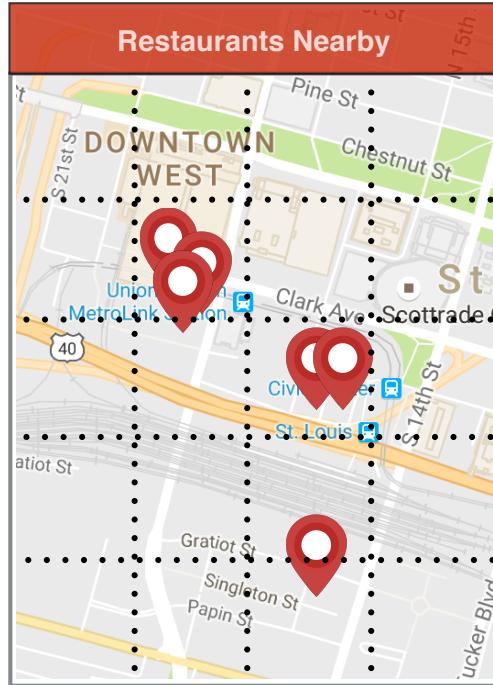


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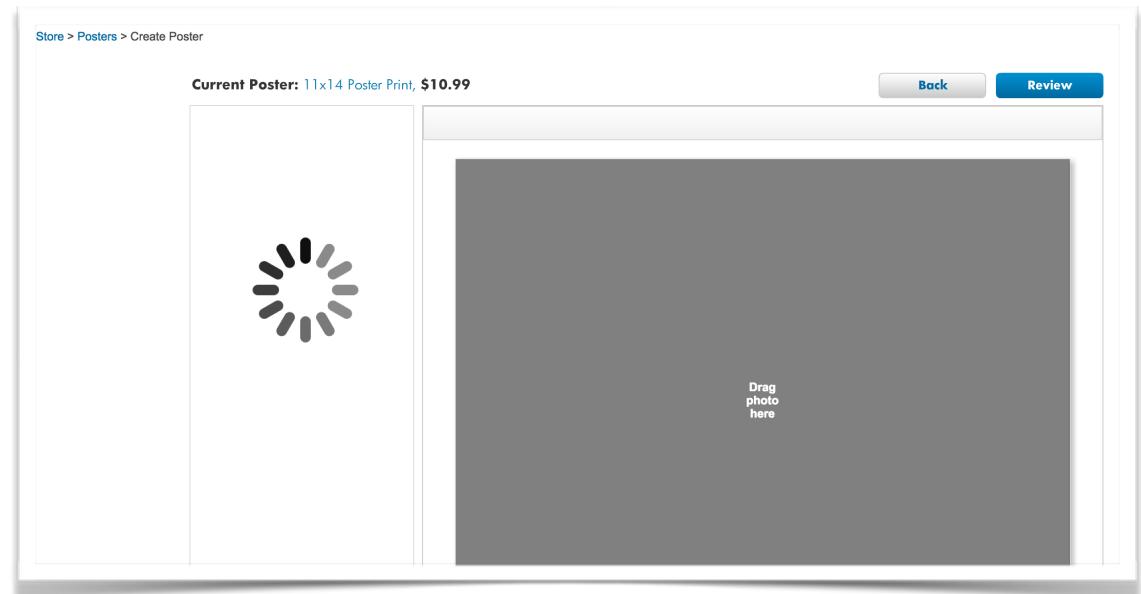


varying delays

Anomalies So Far



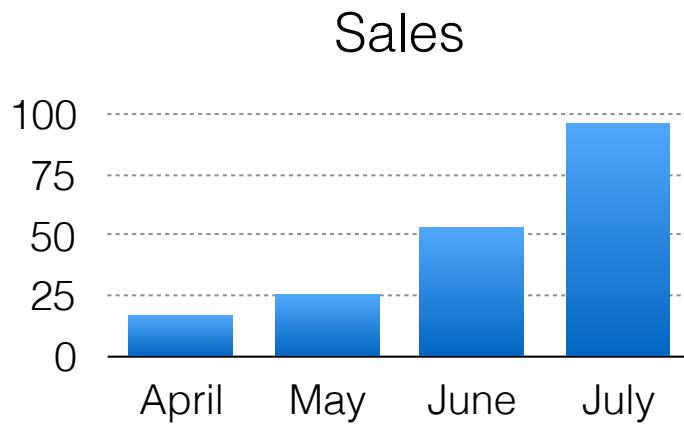
reordering



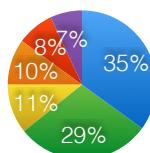
varying delays



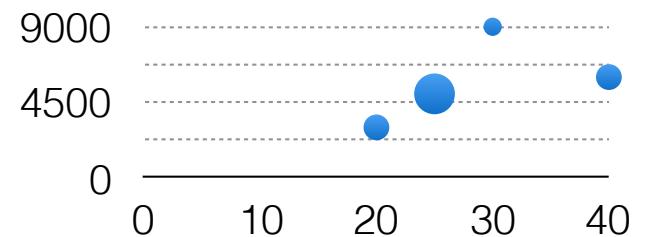
zoom

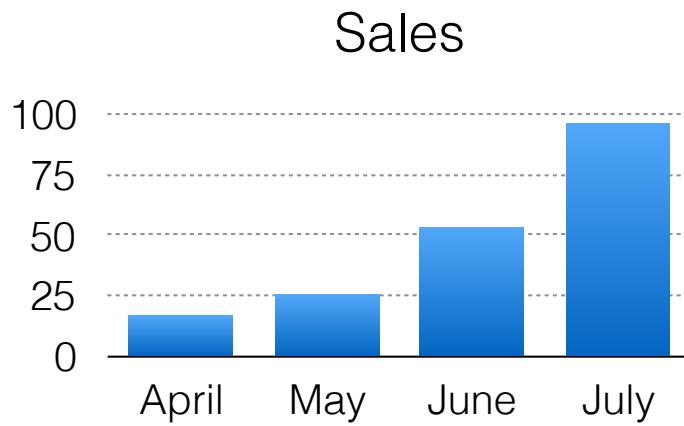


Share by Region



Customer Distribution by Age Group and Income

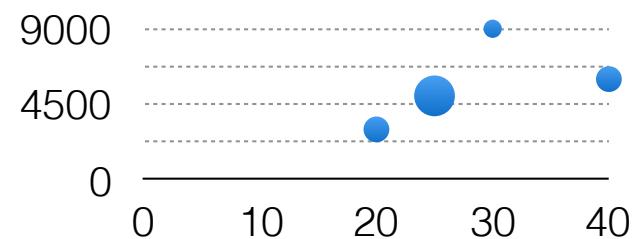




Share by Region

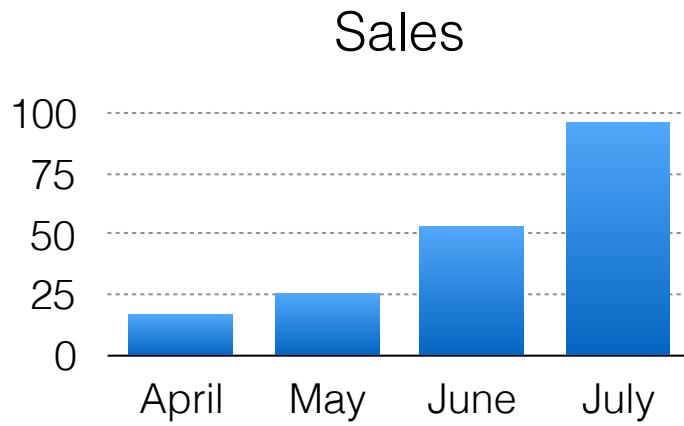


Customer Distribution by Age Group and Income

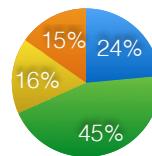




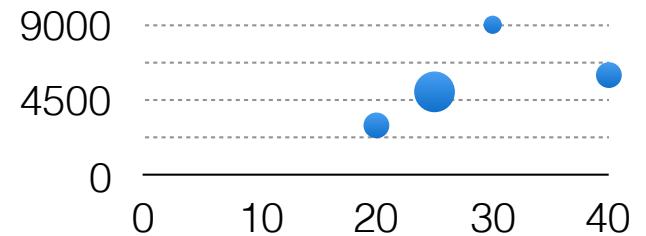
zoom



Share by Region

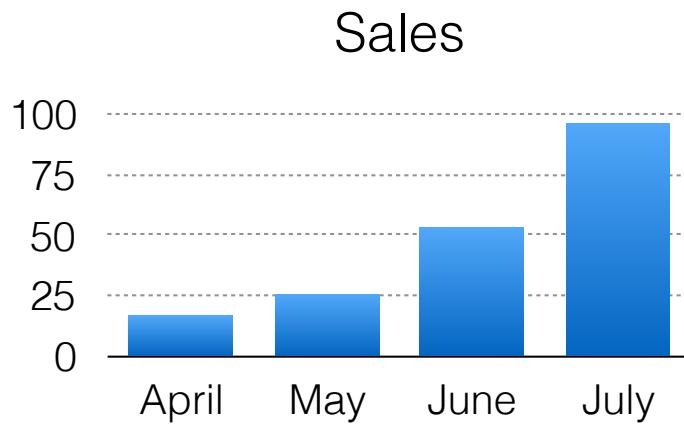


Customer
Distribution by Age
Group and Income

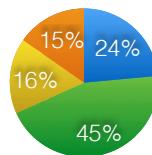




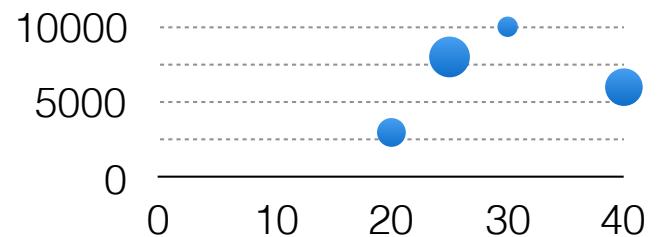
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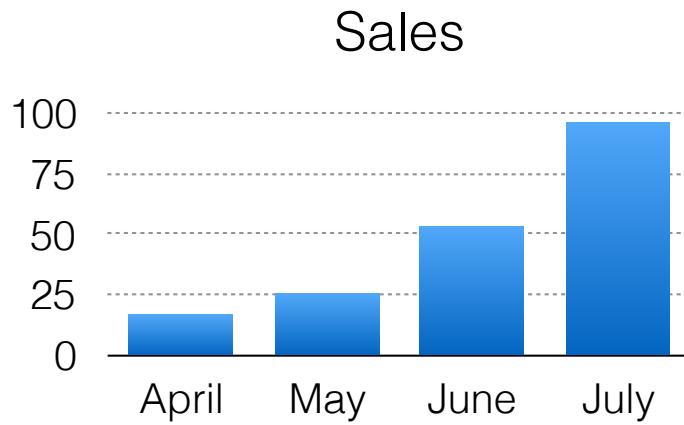
Share by Region



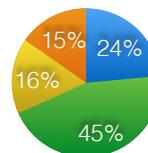
Customer
Distribution by Age
Group and Income



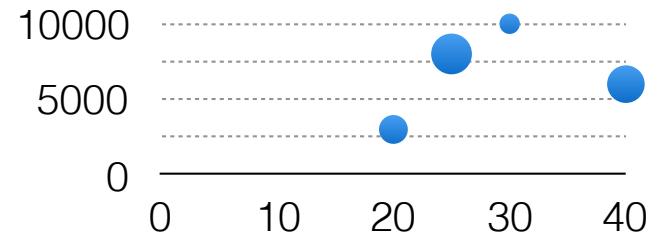
what region does the data correspond to?



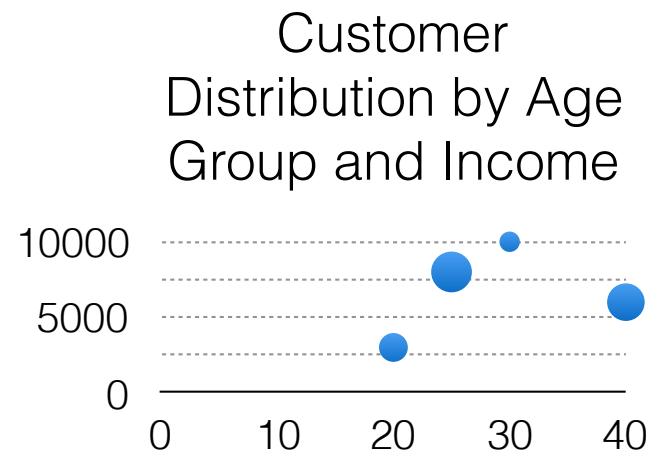
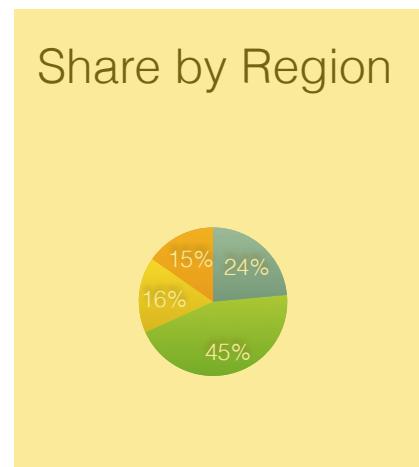
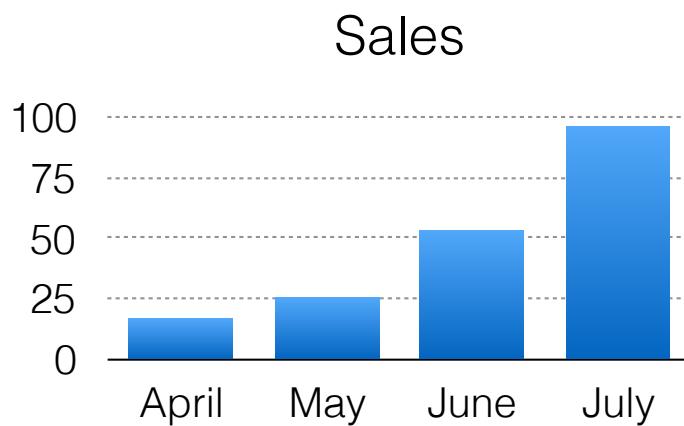
Share by Region



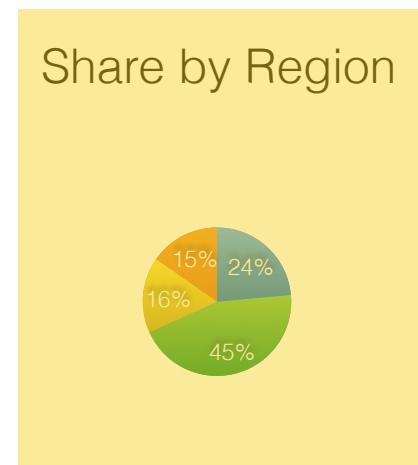
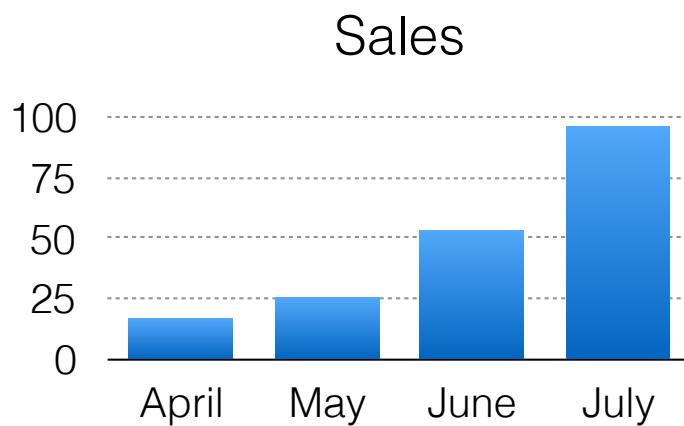
Customer Distribution by Age Group and Income



what region does the data correspond to?



what region does the data correspond to?

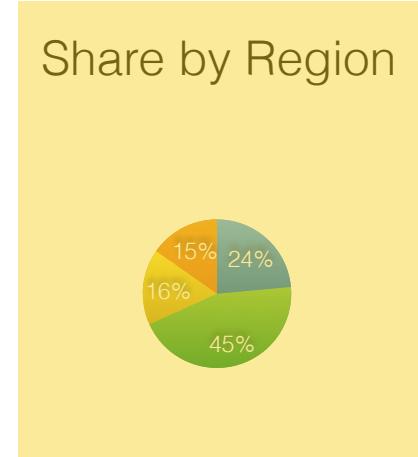
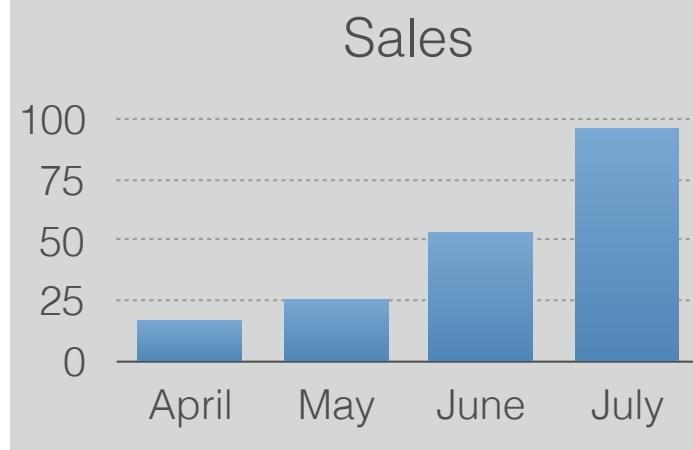


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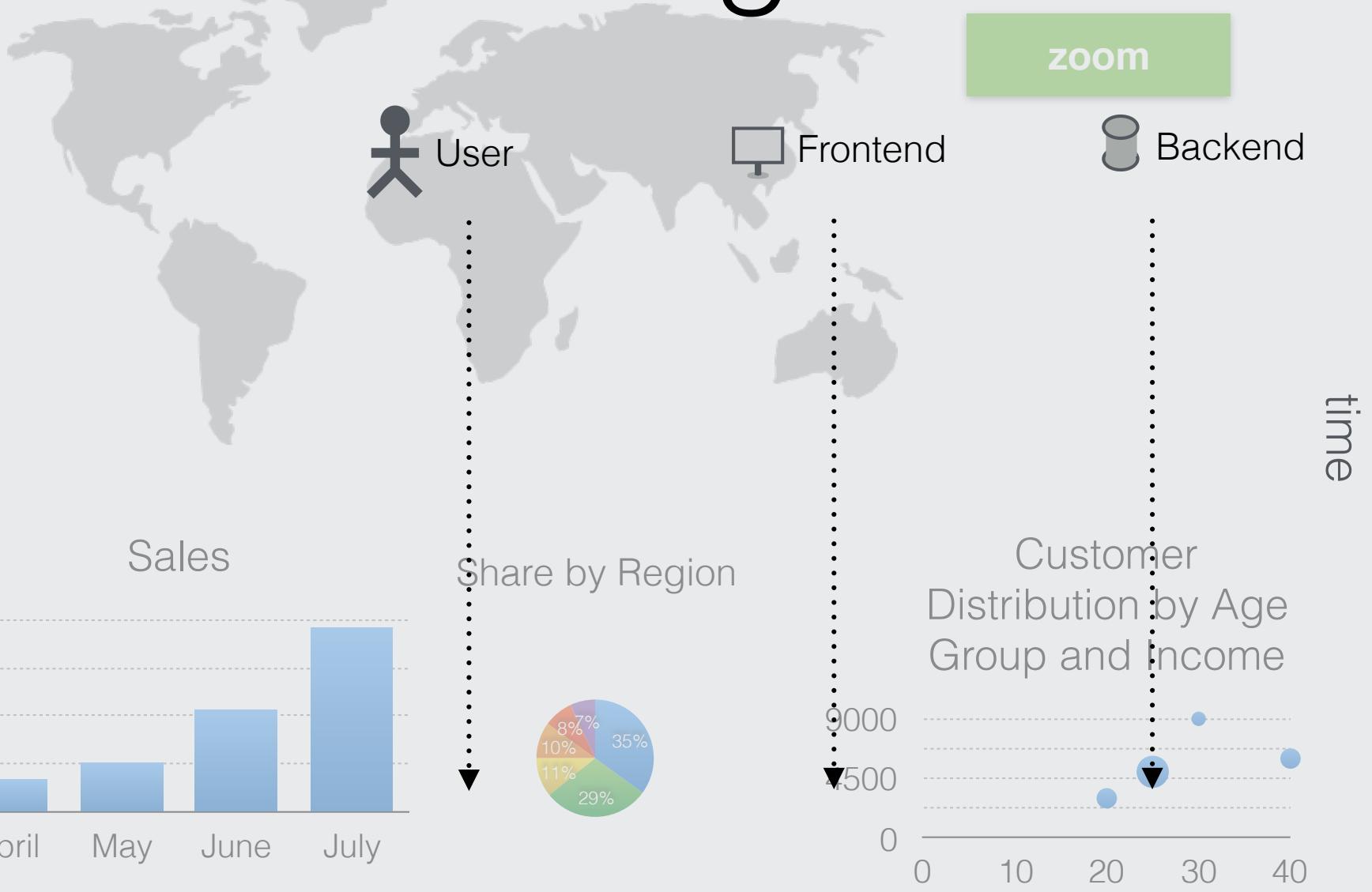
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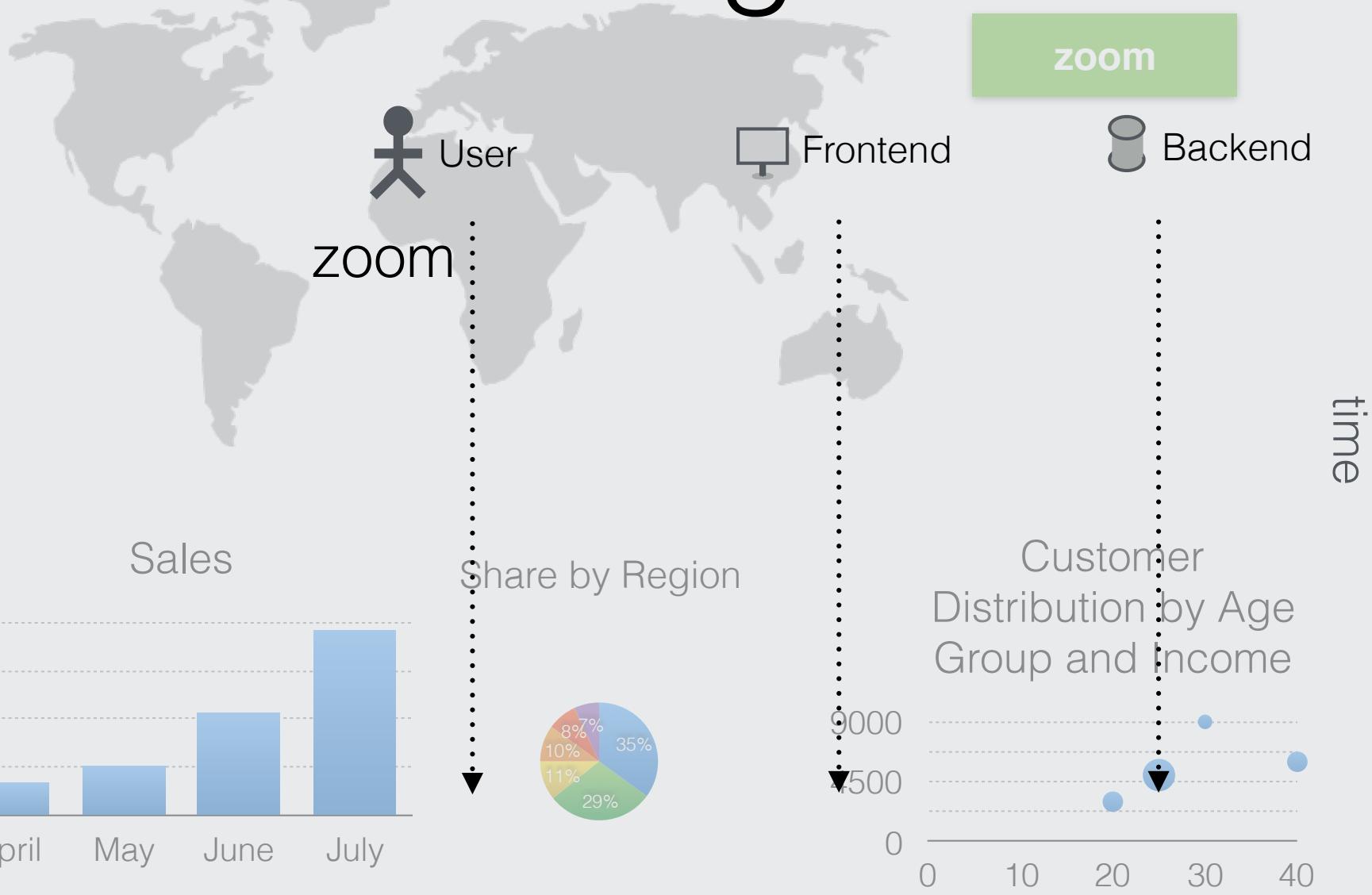
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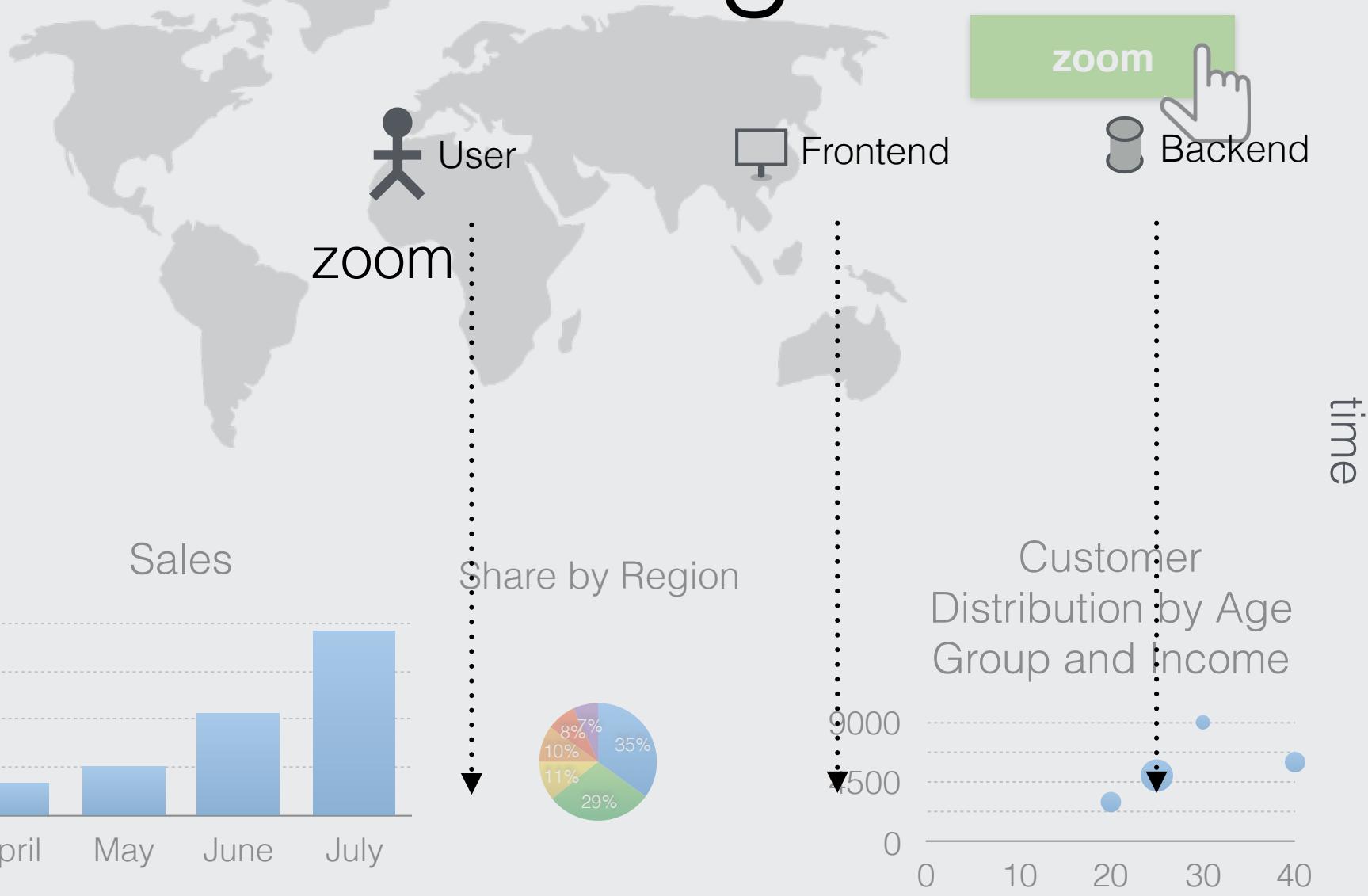
Time Diagram



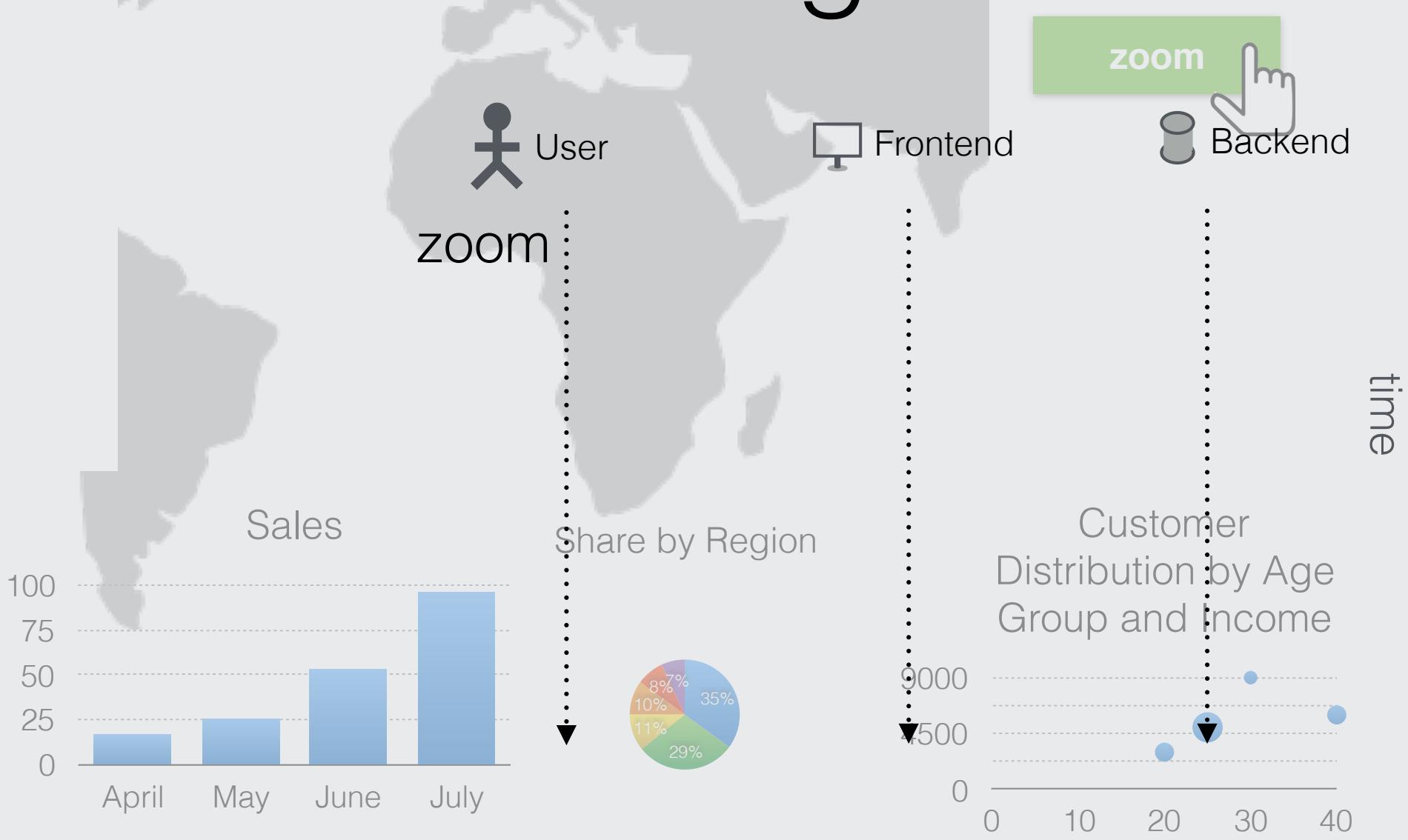
Time Diagram



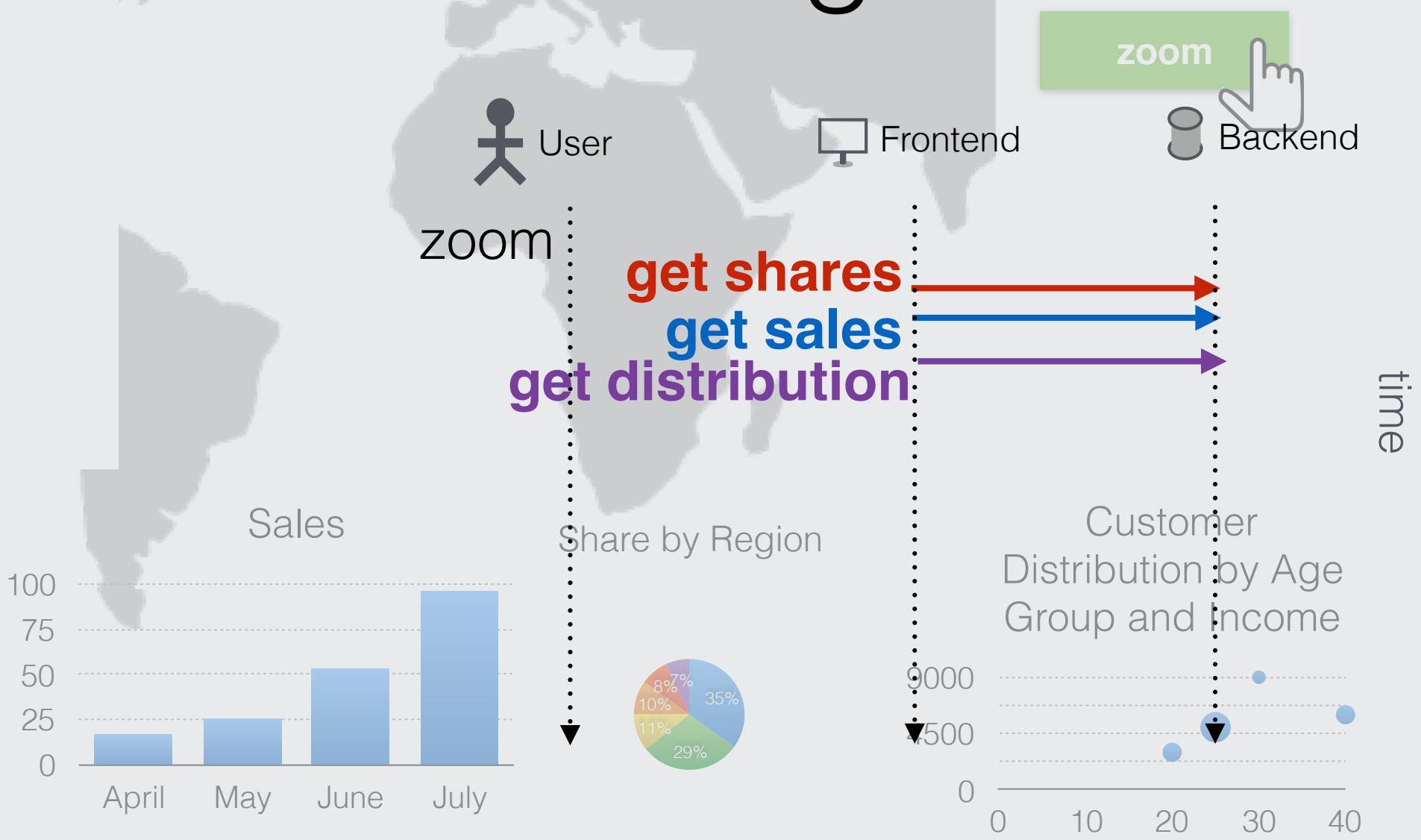
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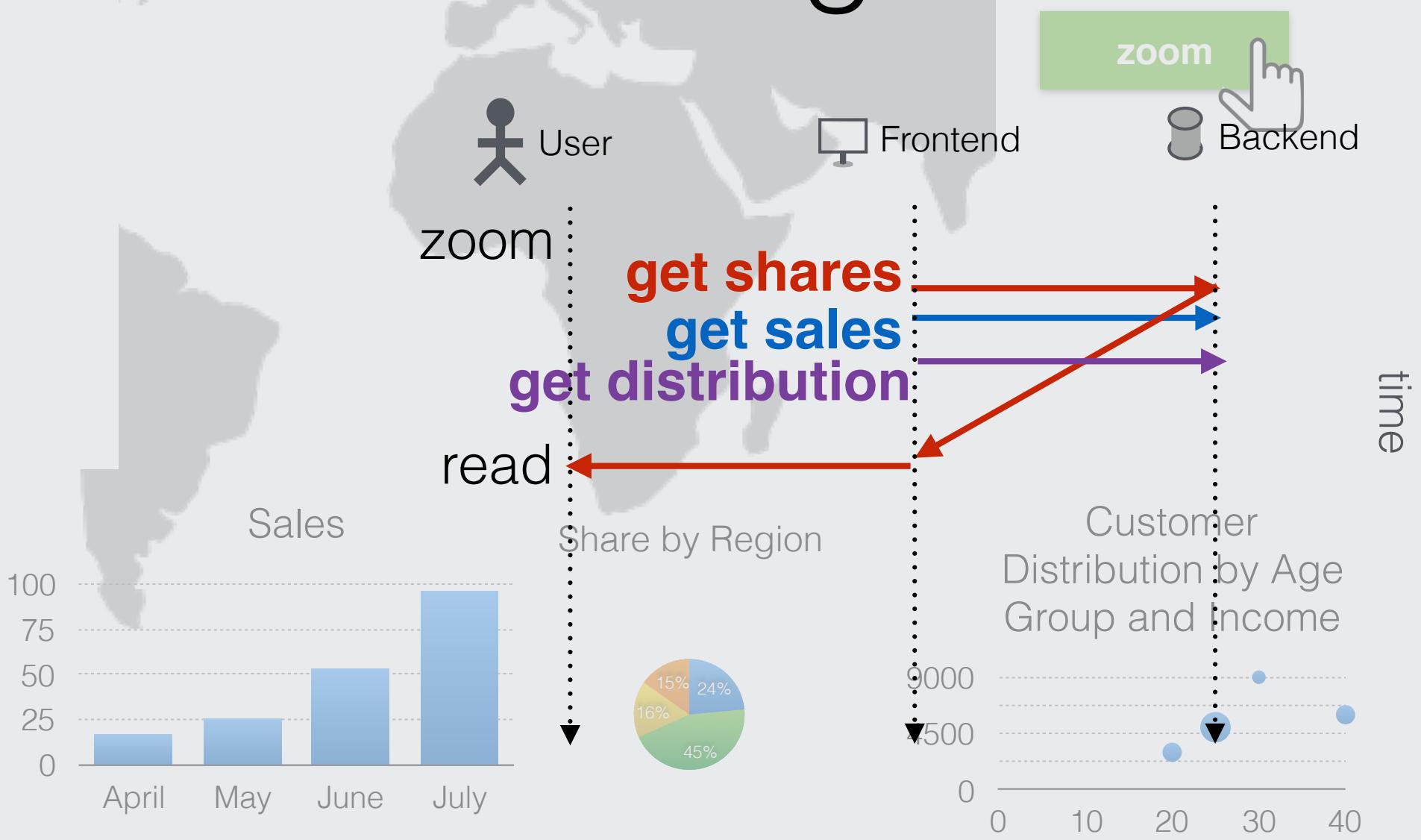
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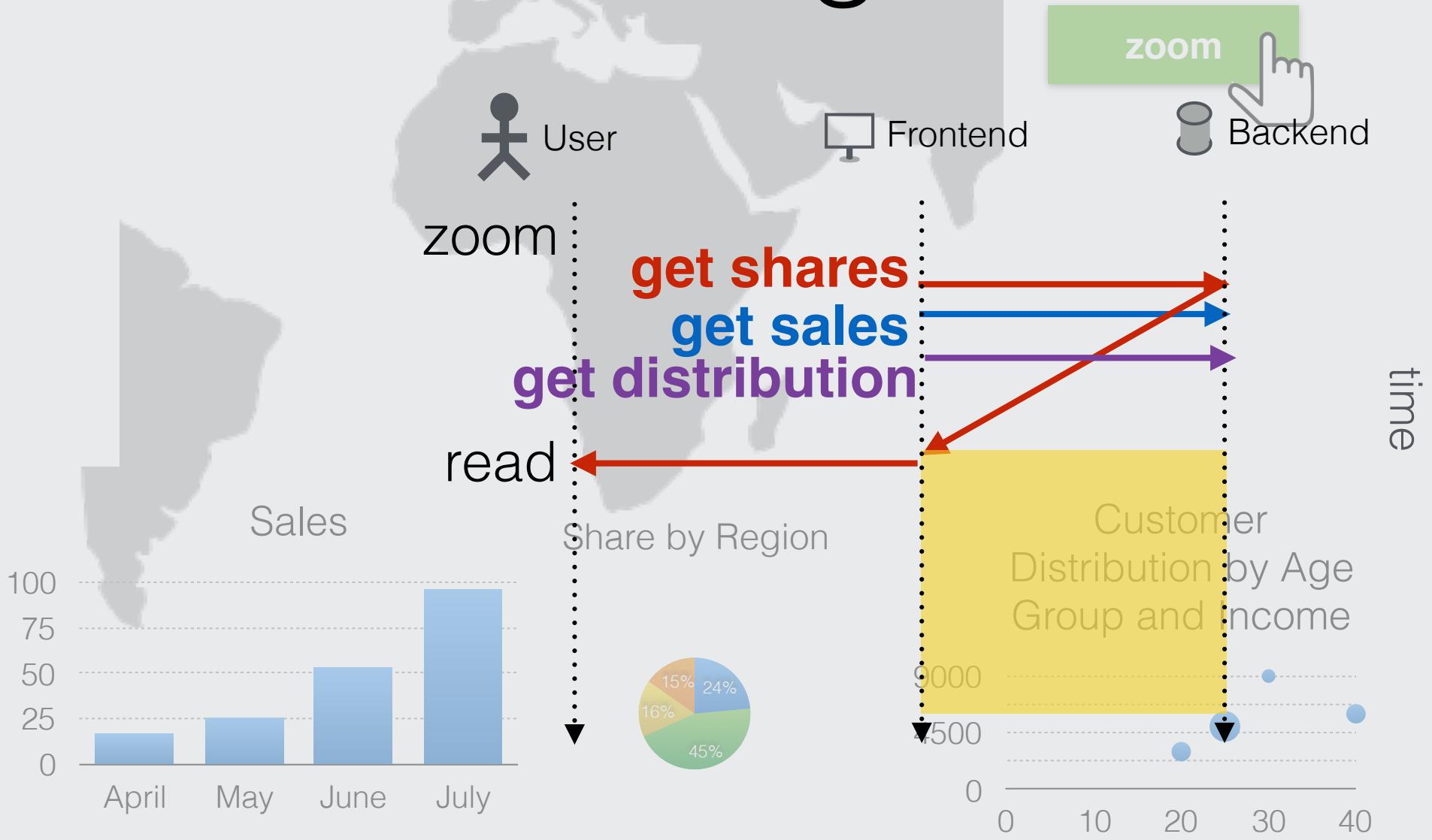
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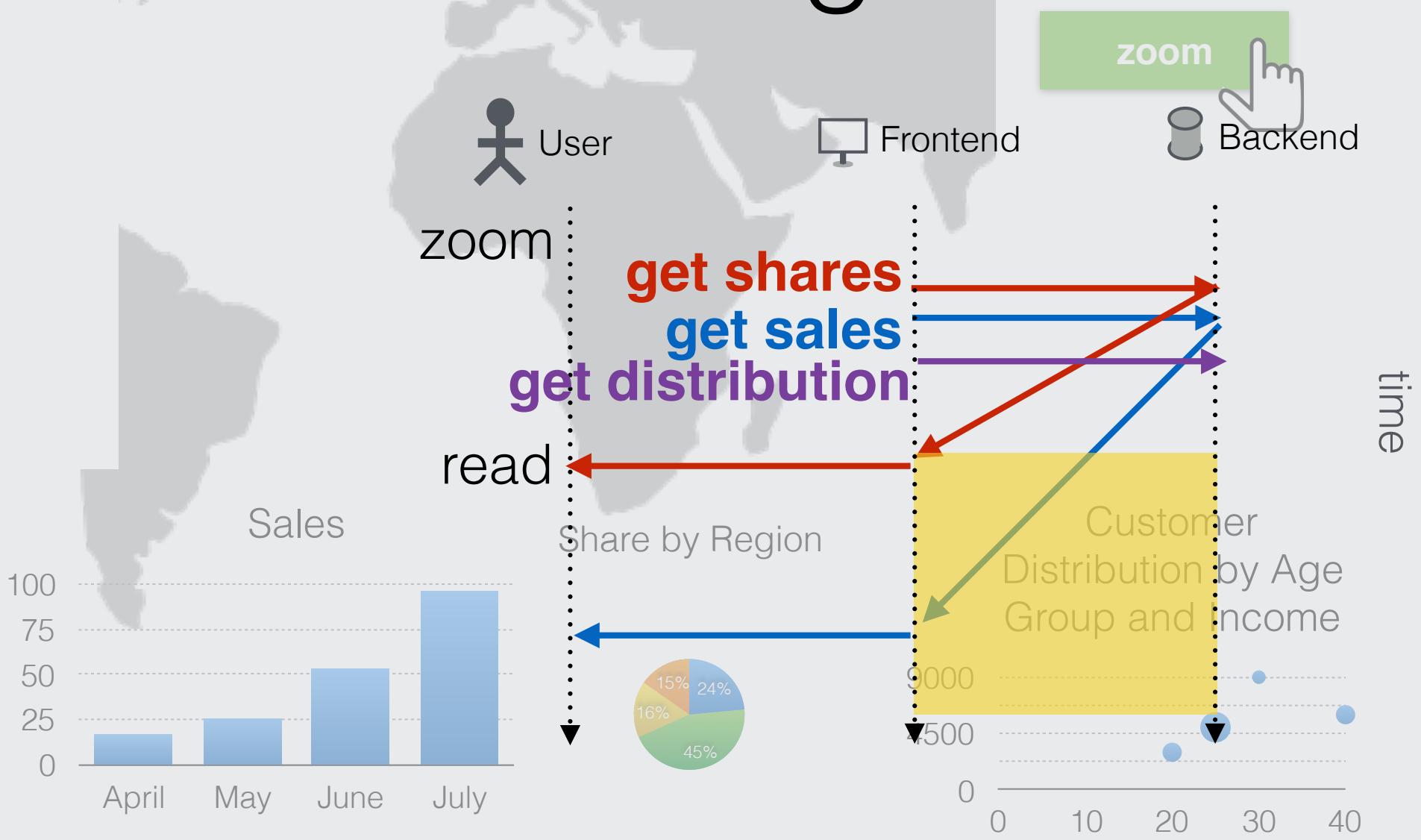
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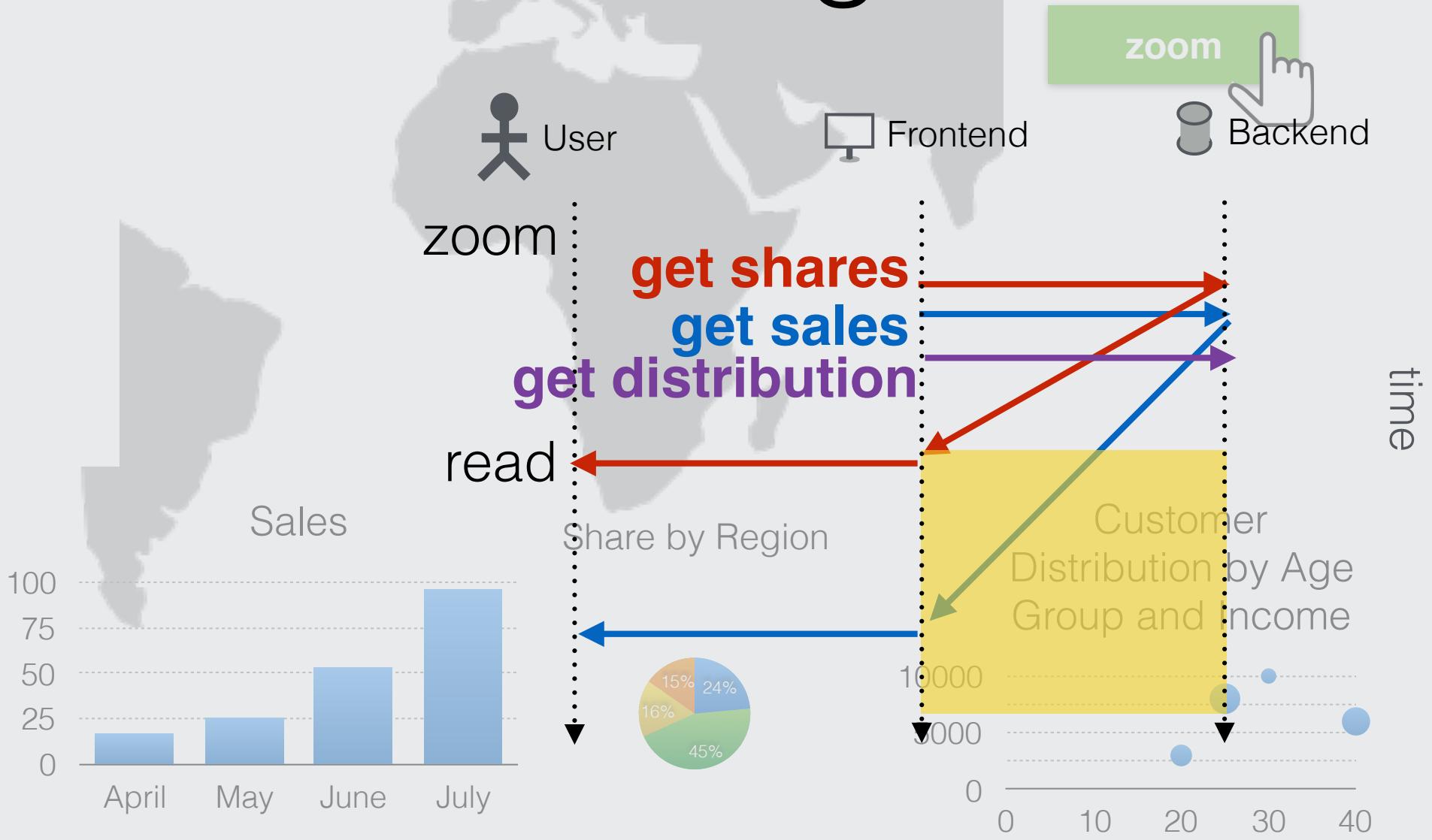
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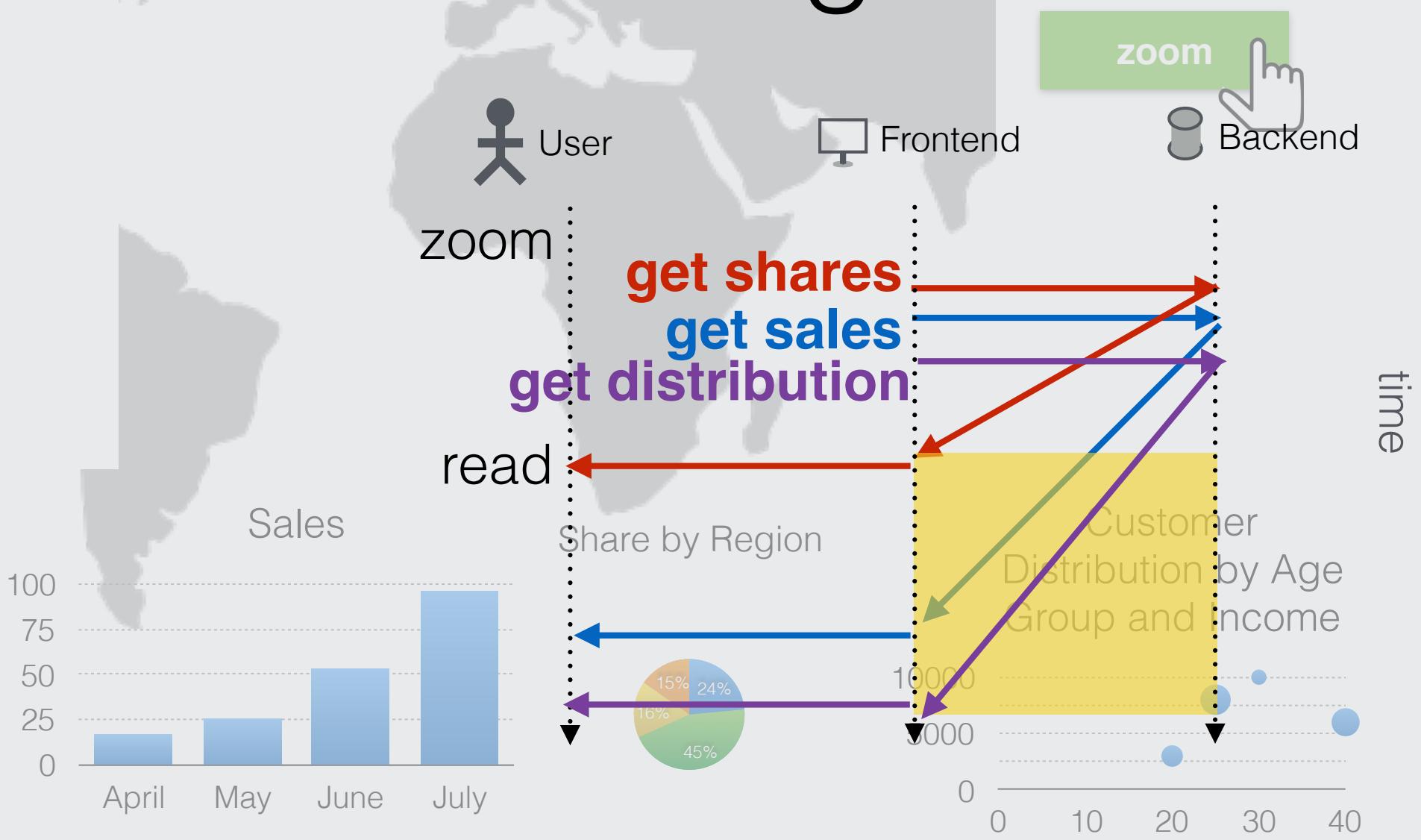
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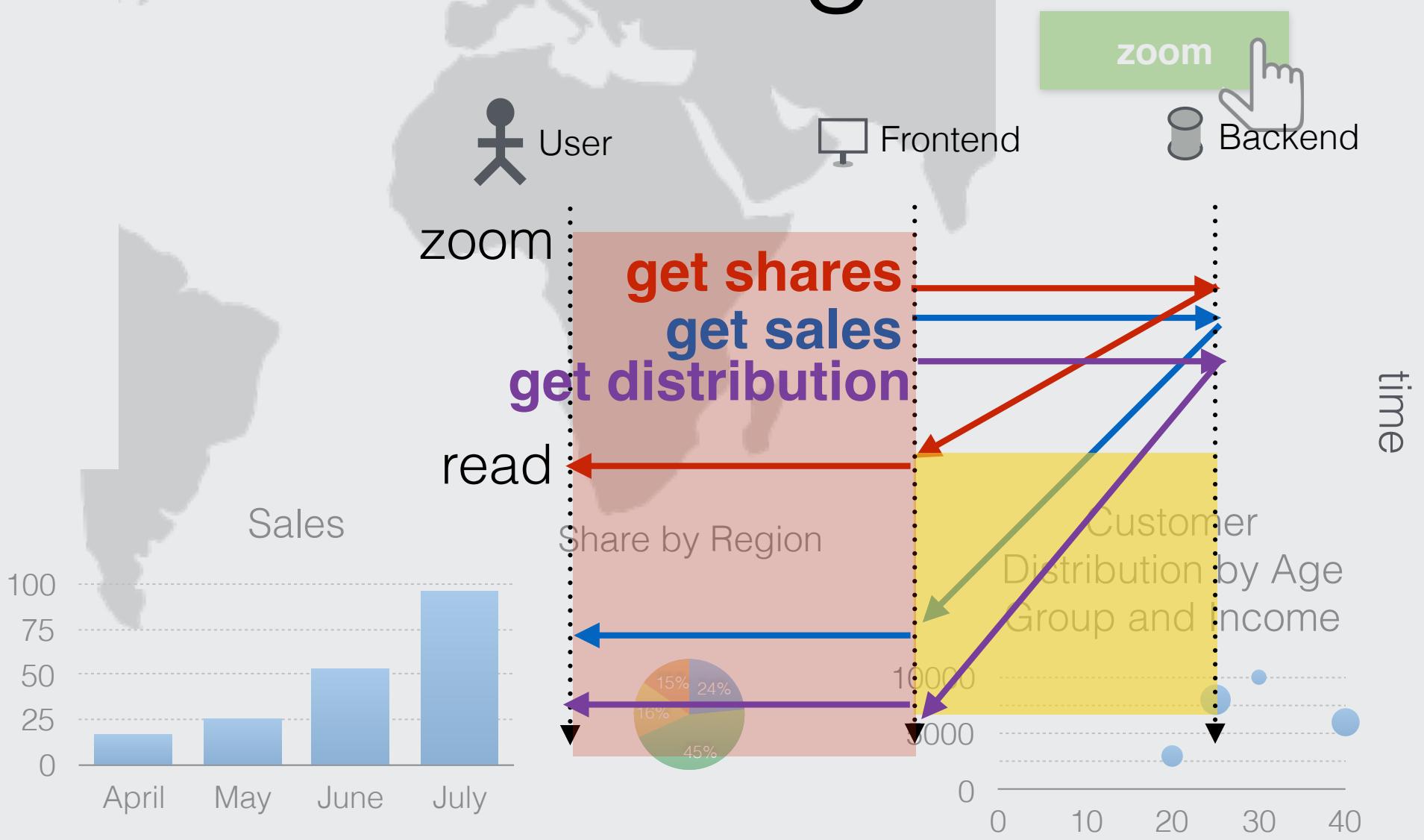
Time Diagram



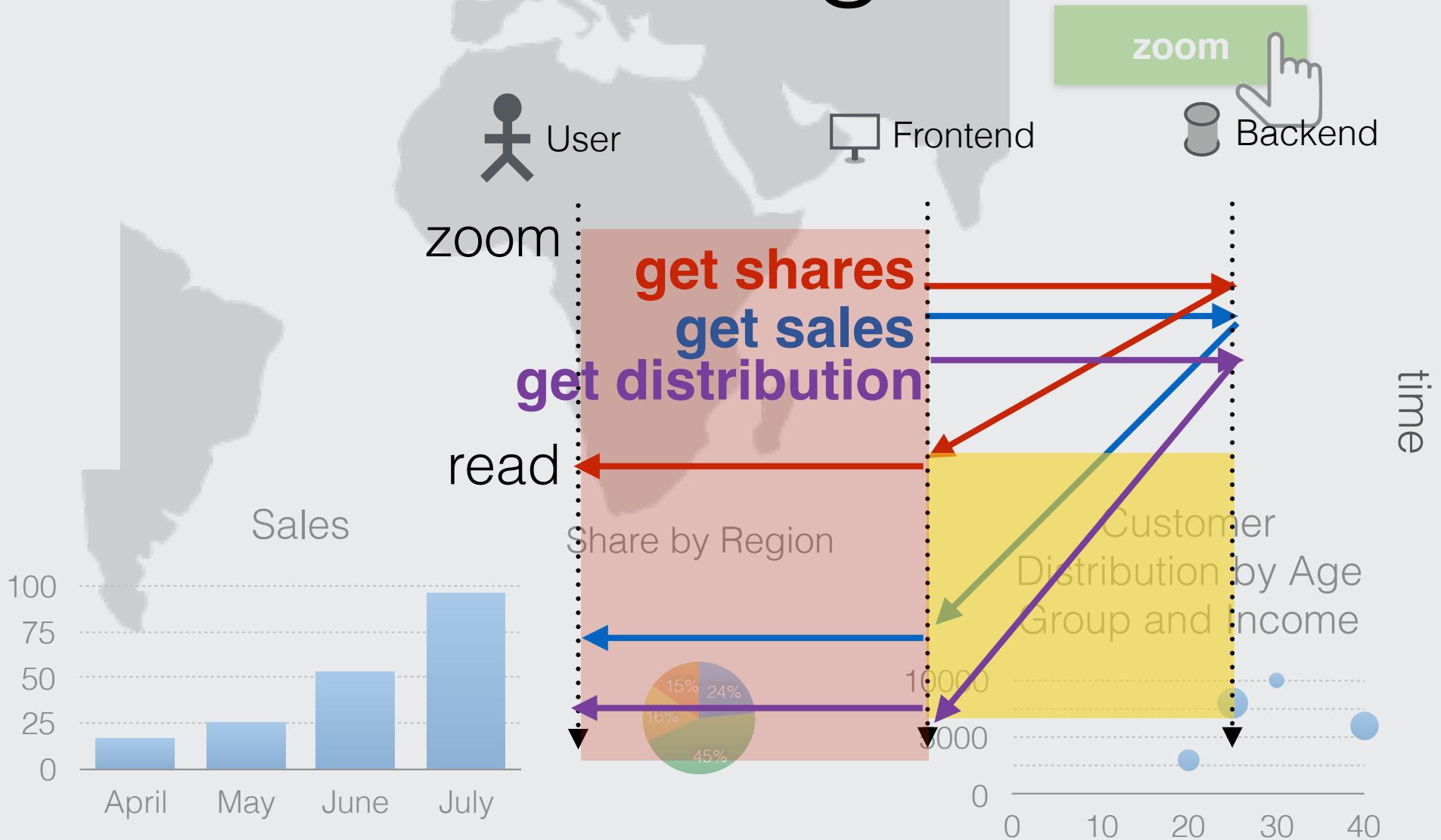
Time Diagram



Time Diagram



Time Diagram



Anomaly: Mistaken Correspondence

Wait, but it's simple!

Why can't we pre-fetch everything?



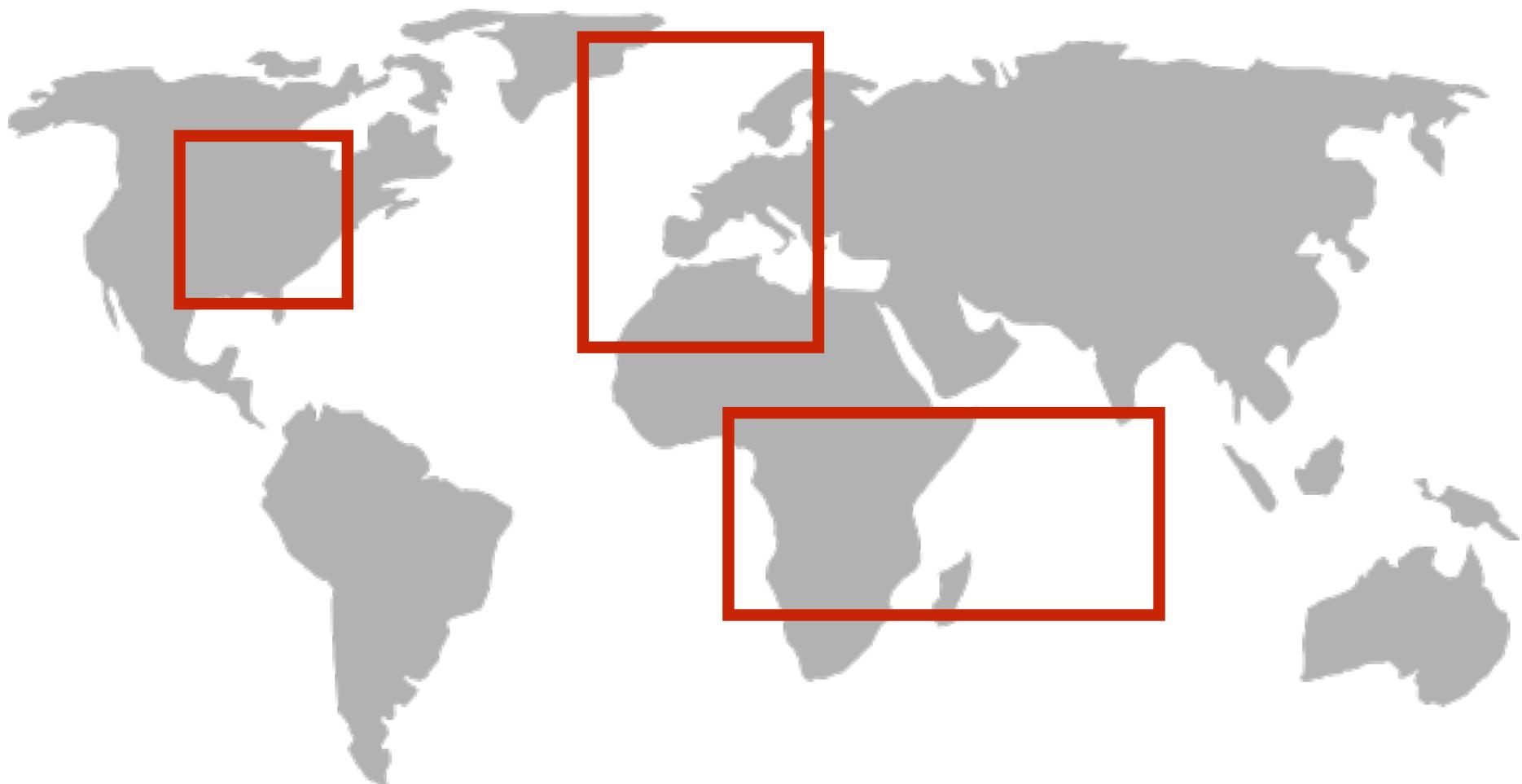
Why can't we pre-fetch everything?



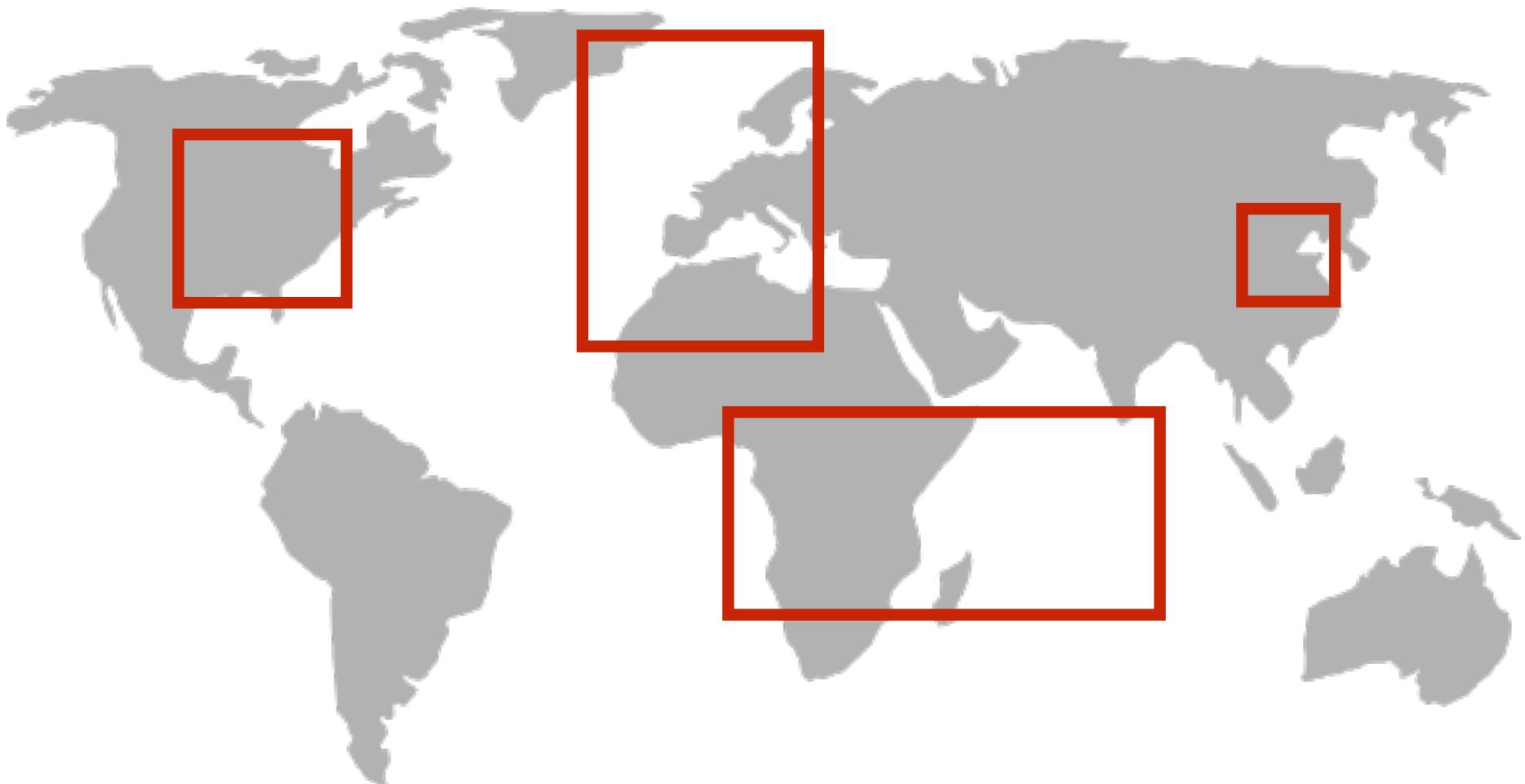
Why can't we pre-fetch everything?



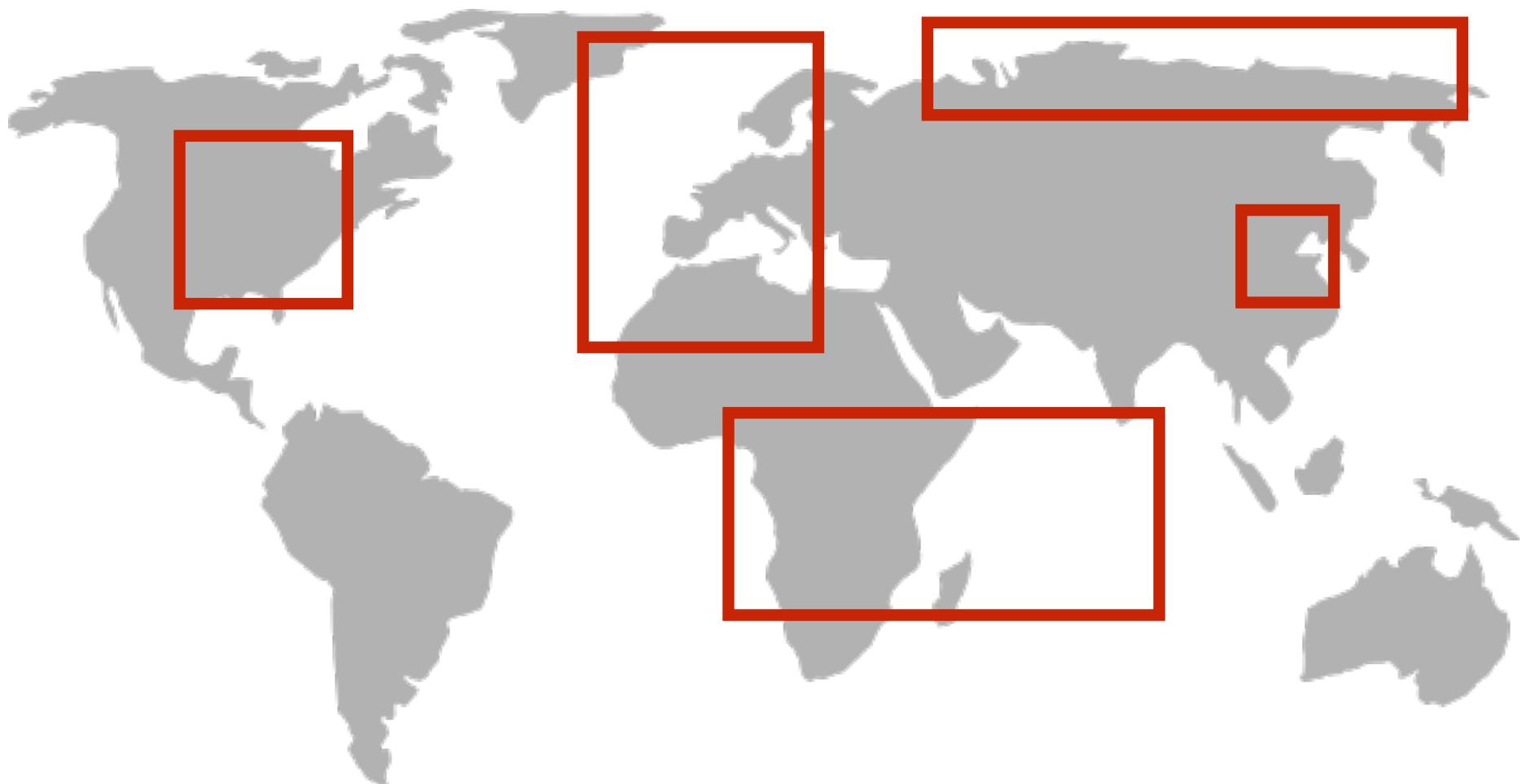
Why can't we pre-fetch everything?



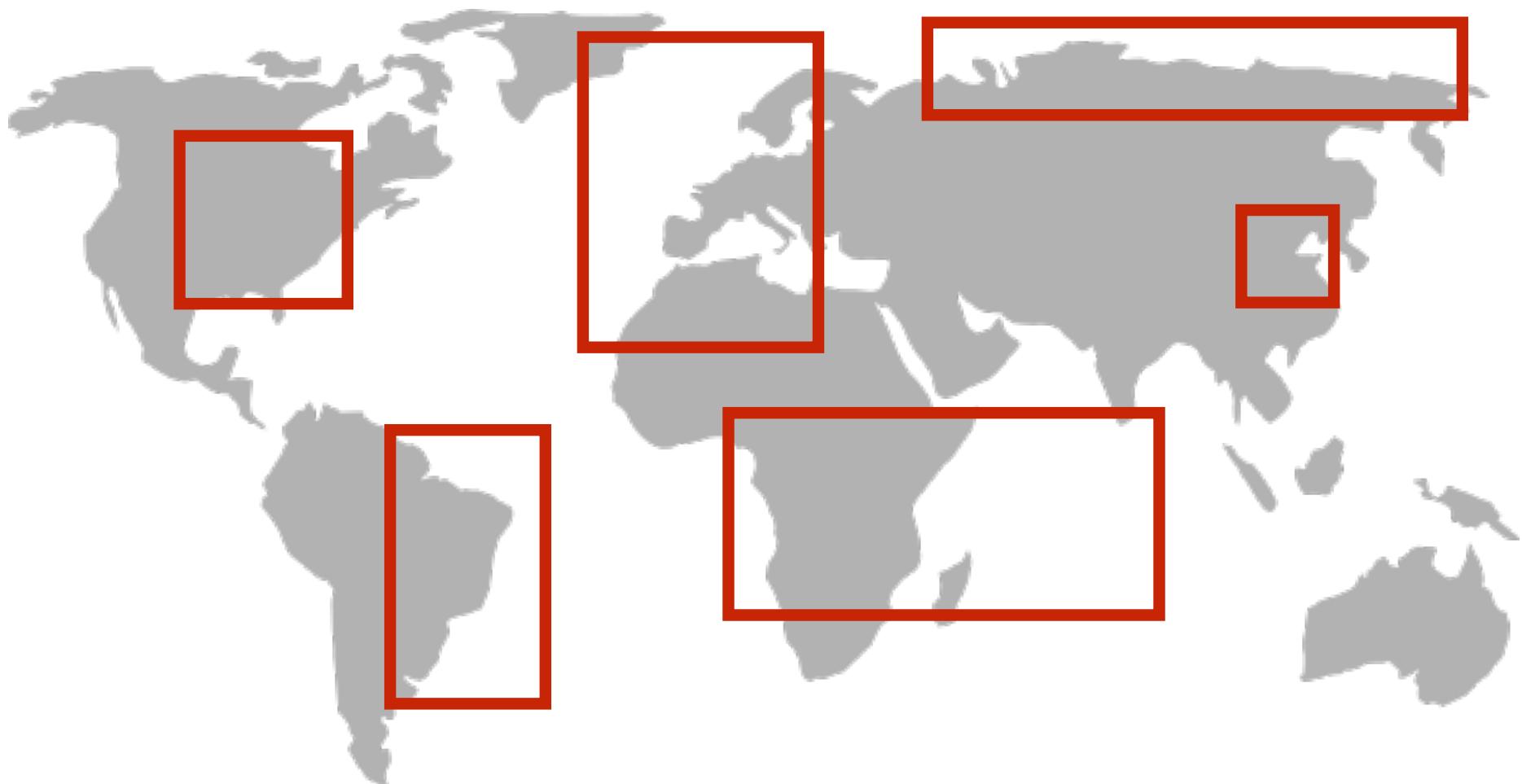
Why can't we pre-fetch everything?



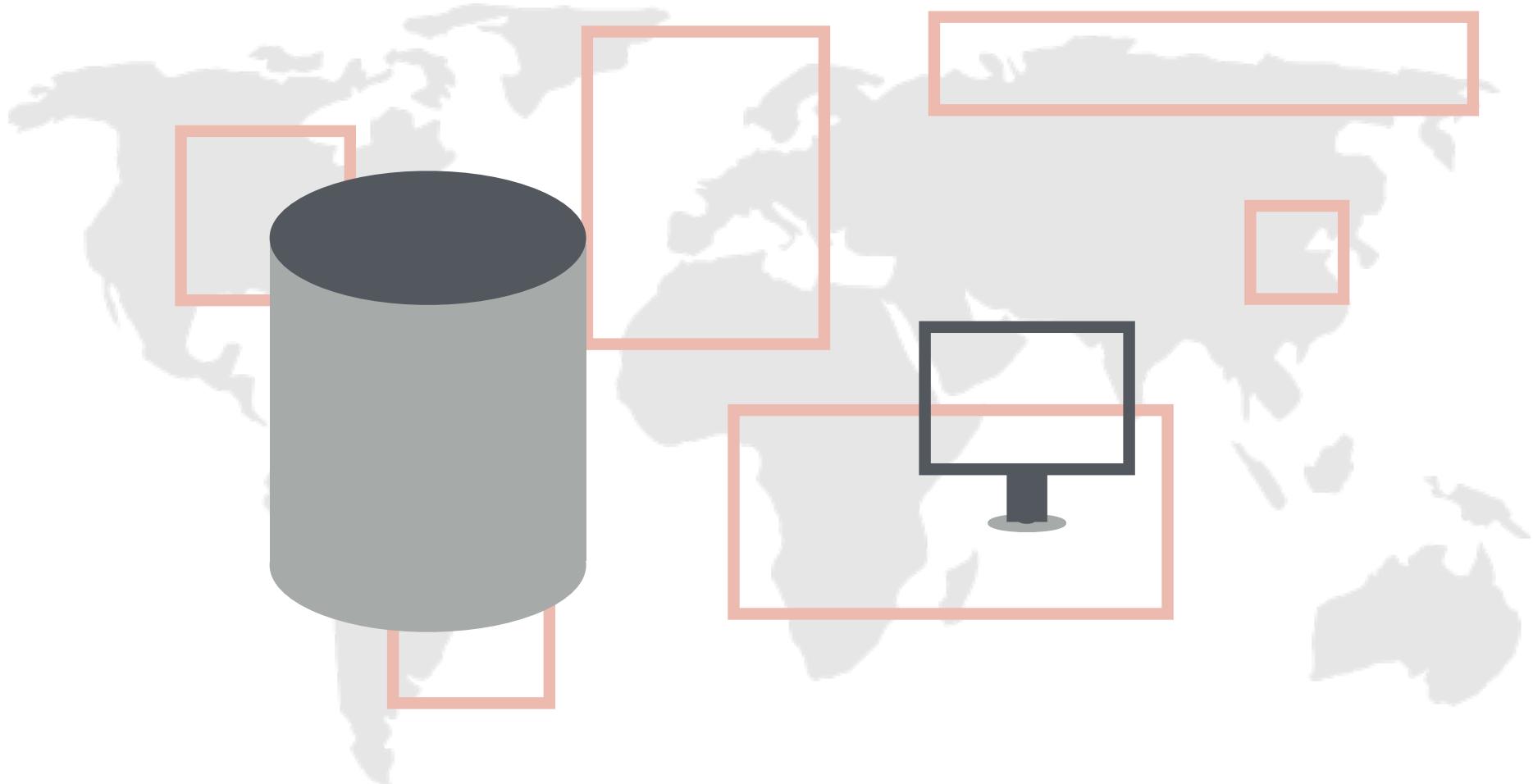
Why can't we pre-fetch everything?



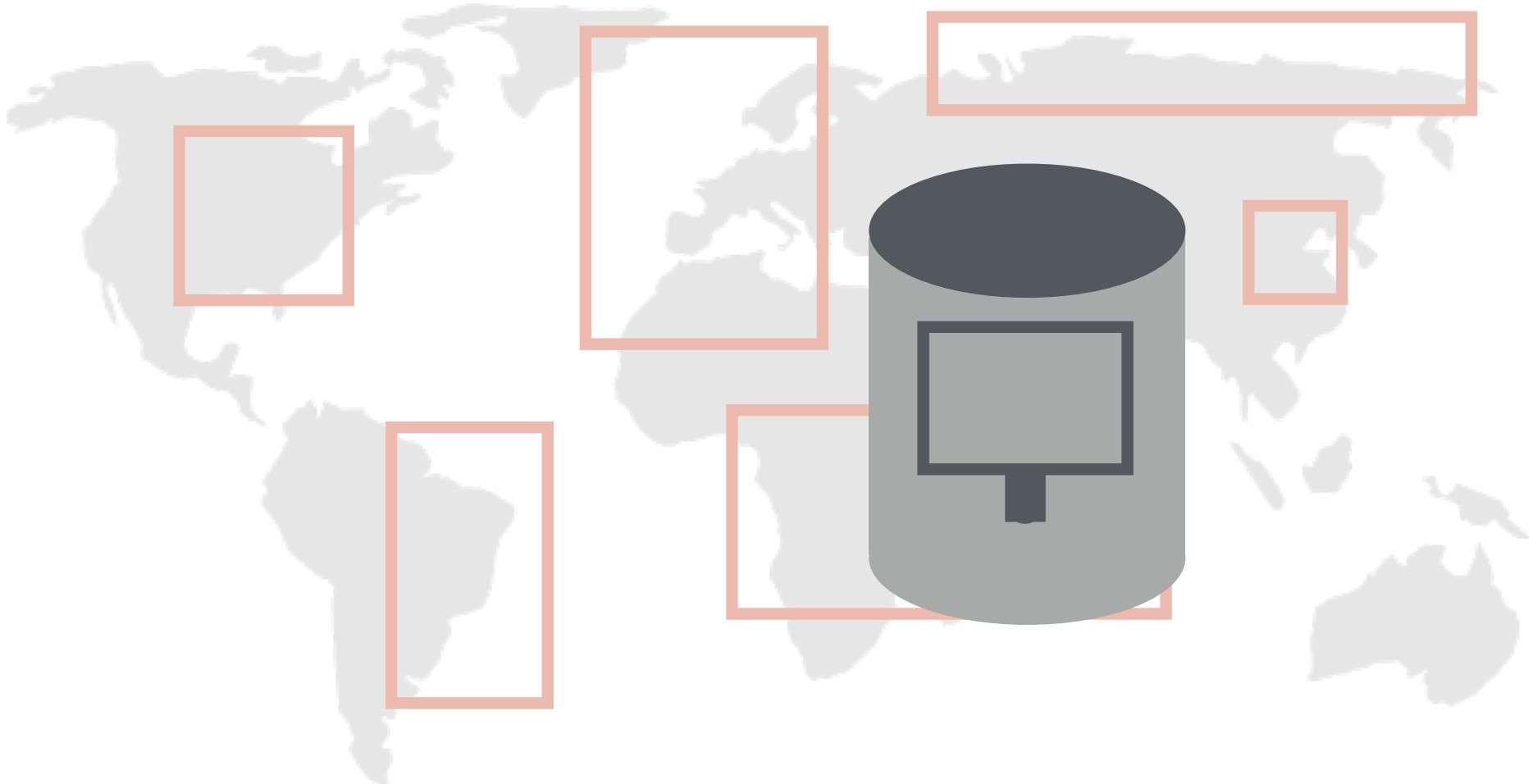
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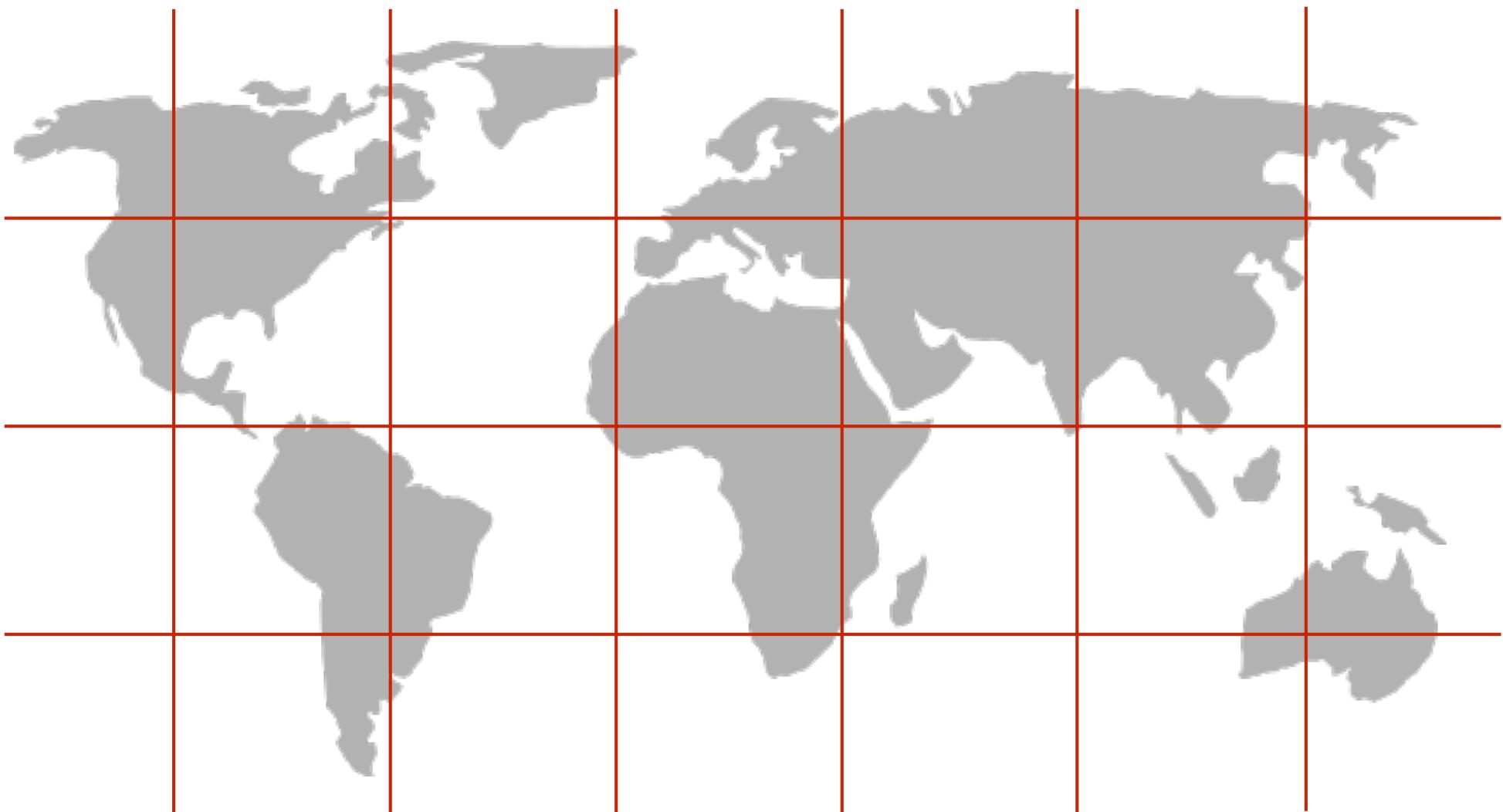


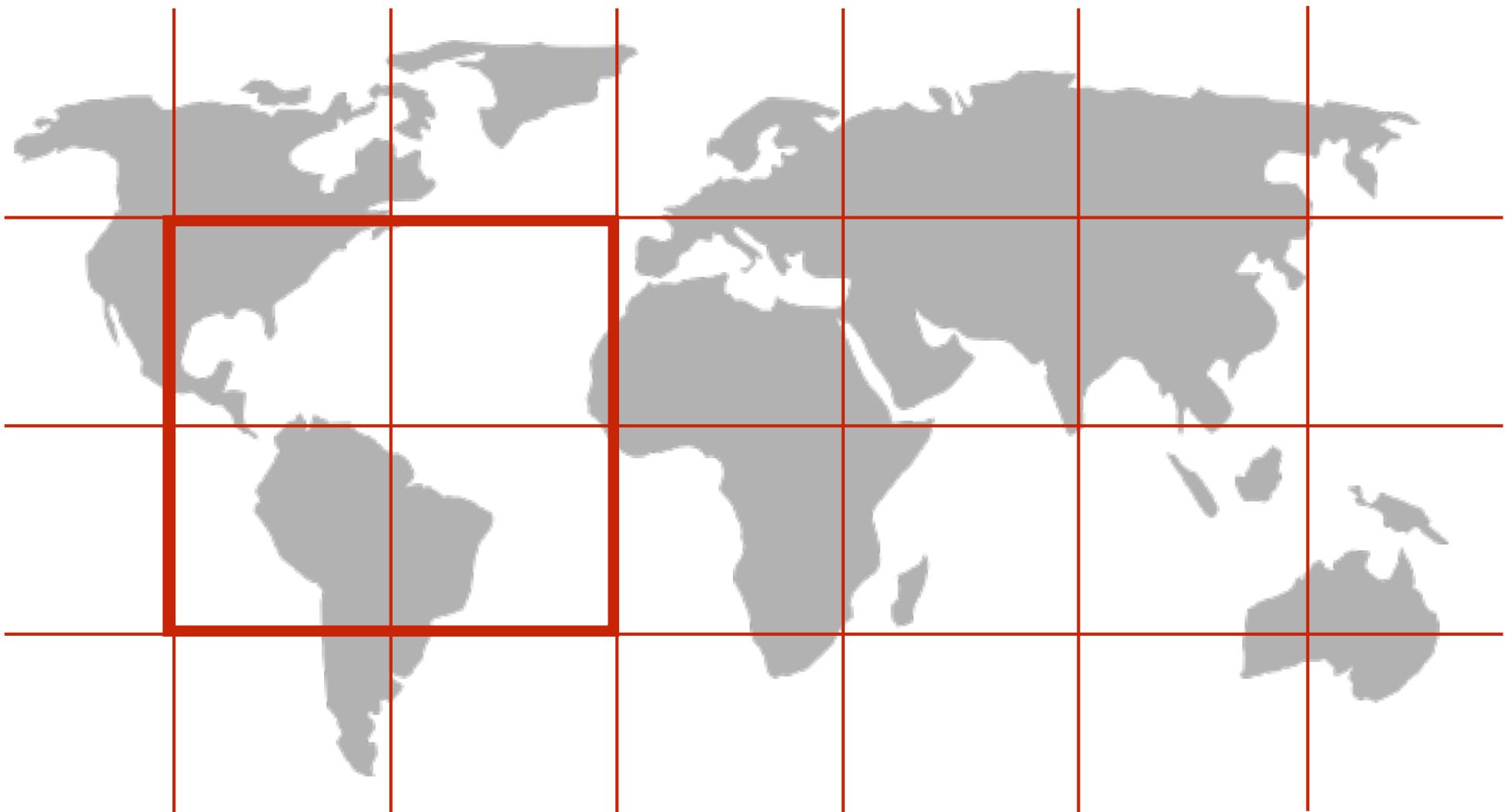
Why can't we pre-fetch everything?



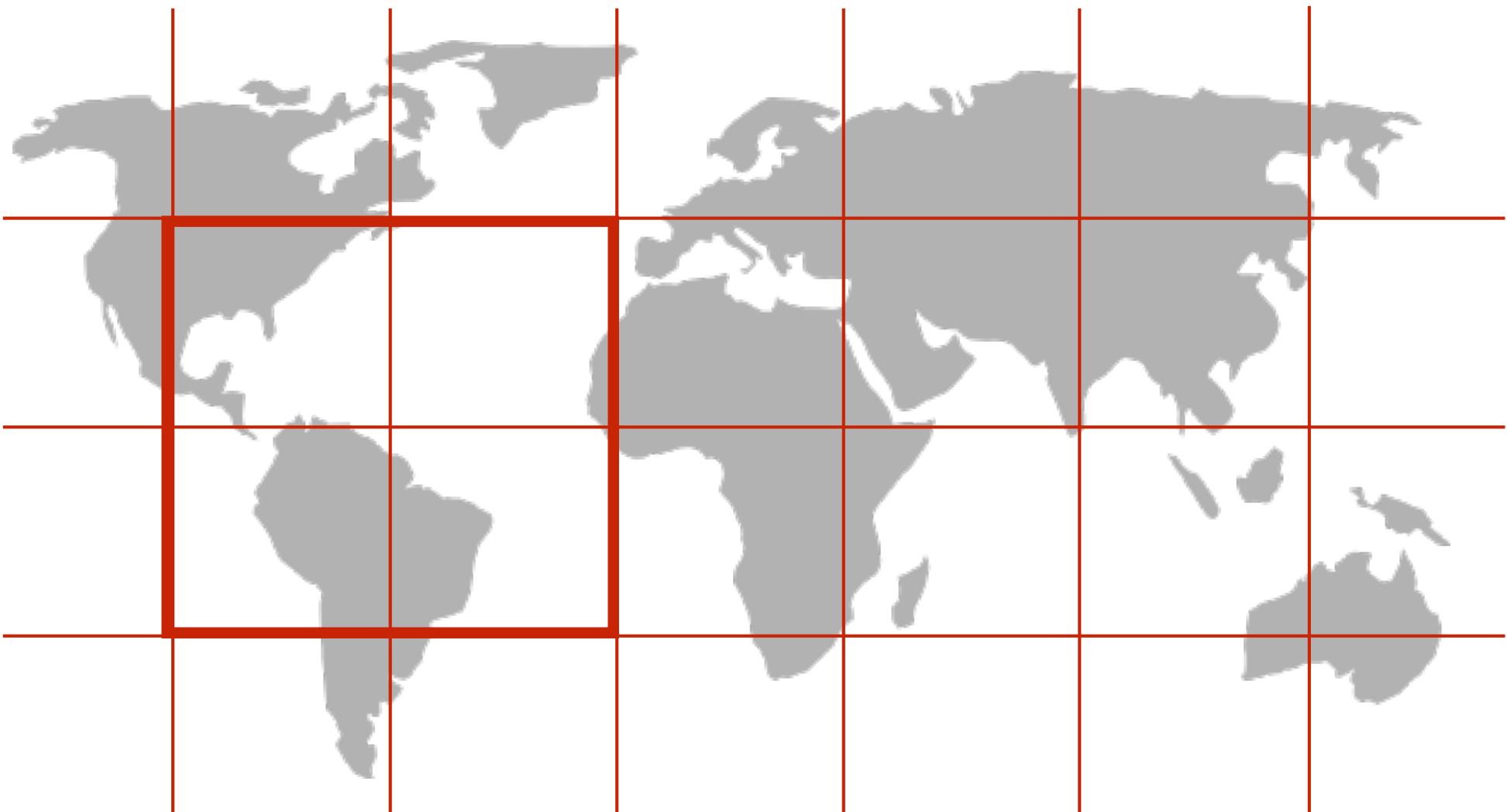
Why can't we pre-fetch everything?

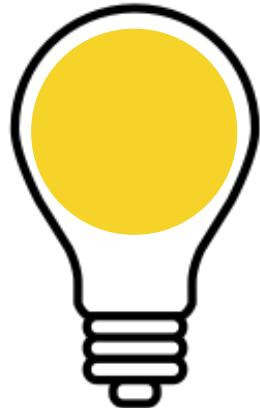




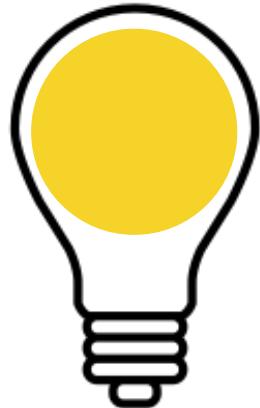


Functionality vs Performance

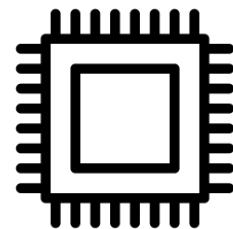




Why not just ask the backend
engineers to make things fast?



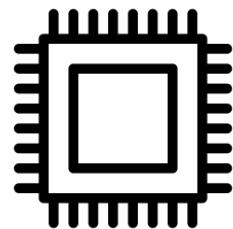
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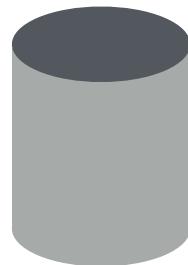
server compute time



Why not just ask the backend
engineers to make things fast?



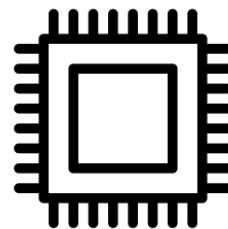
server compute time



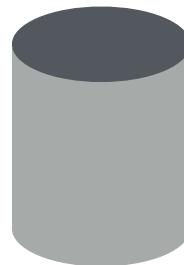
cache miss



Why not just ask the backend
engineers to make things fast?



server compute time



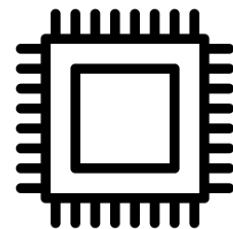
cache miss



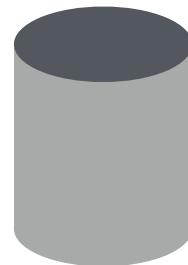
slow connection



Why not just ask the backend
engineers to make things fast?



server compute time



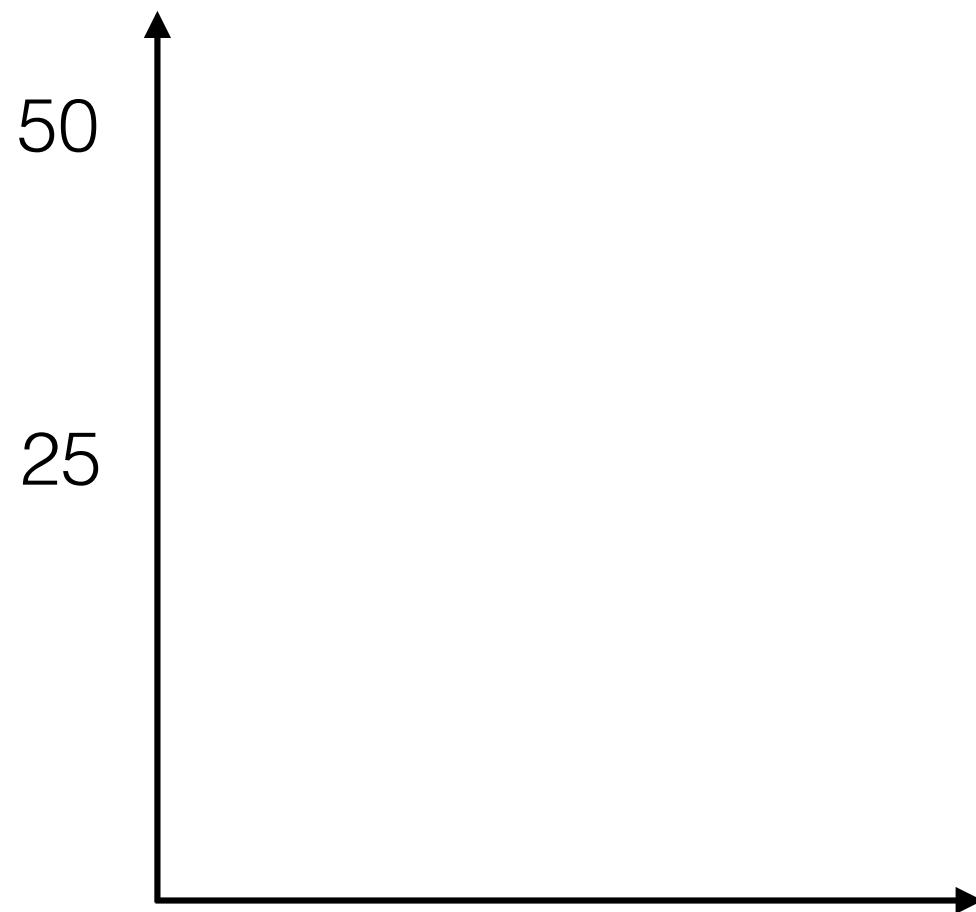
cache miss



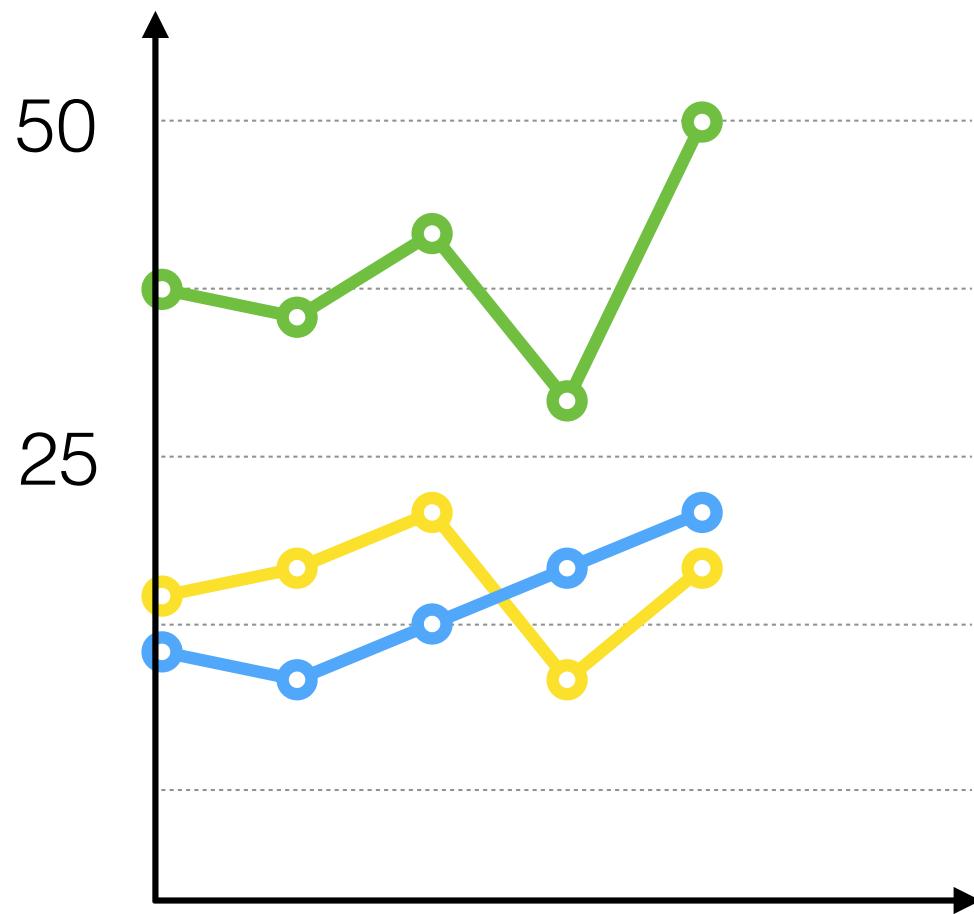
slow connection

There are more anomalies
:(

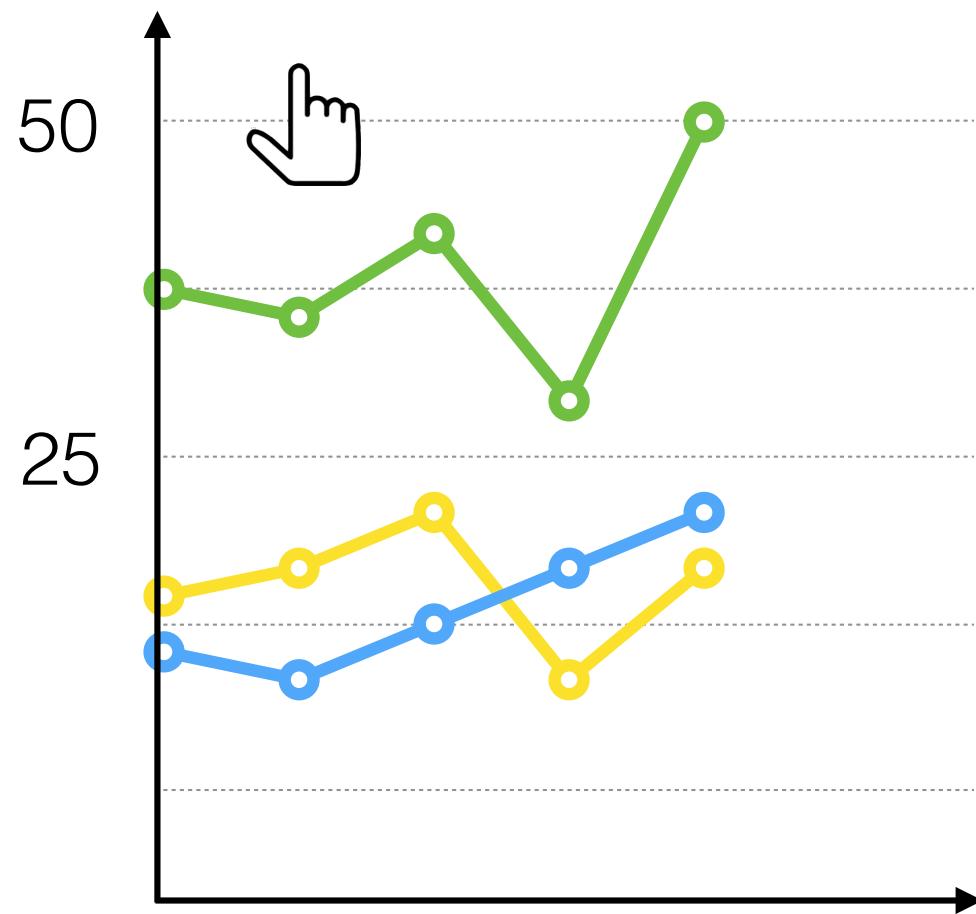
Real Time Interaction



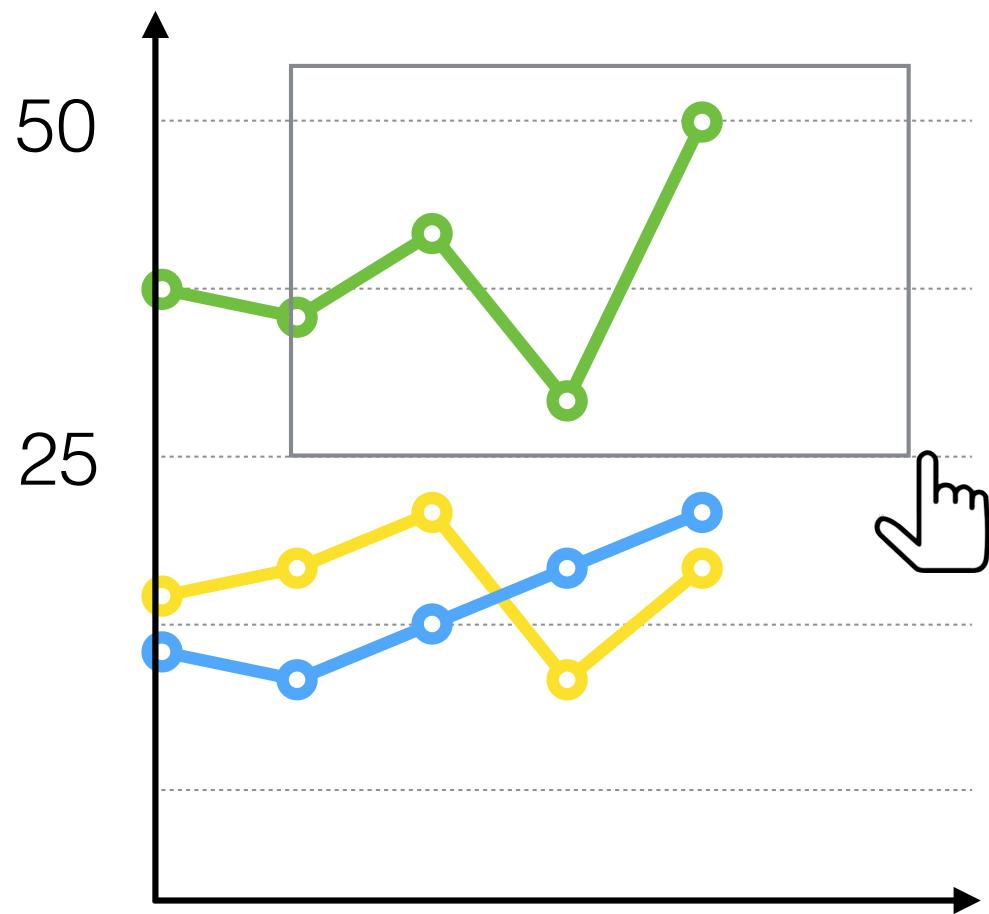
Real Time Interaction



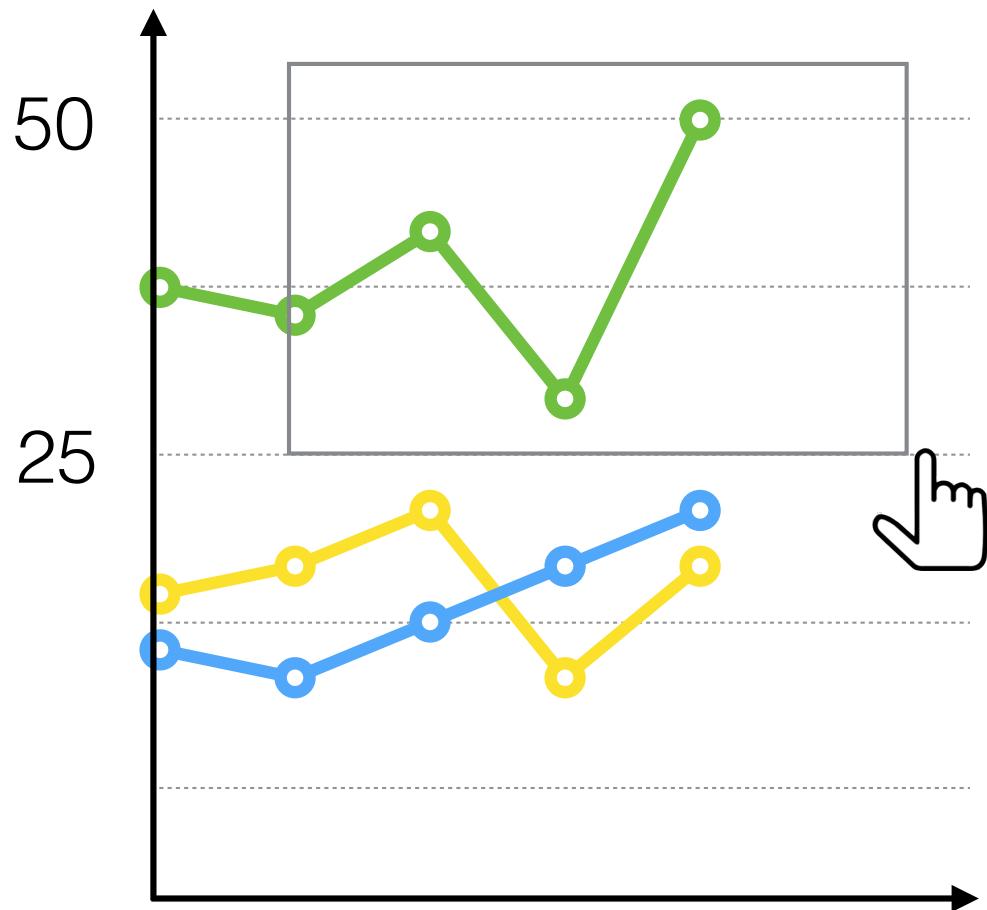
Real Time Interaction



Real Time Interaction

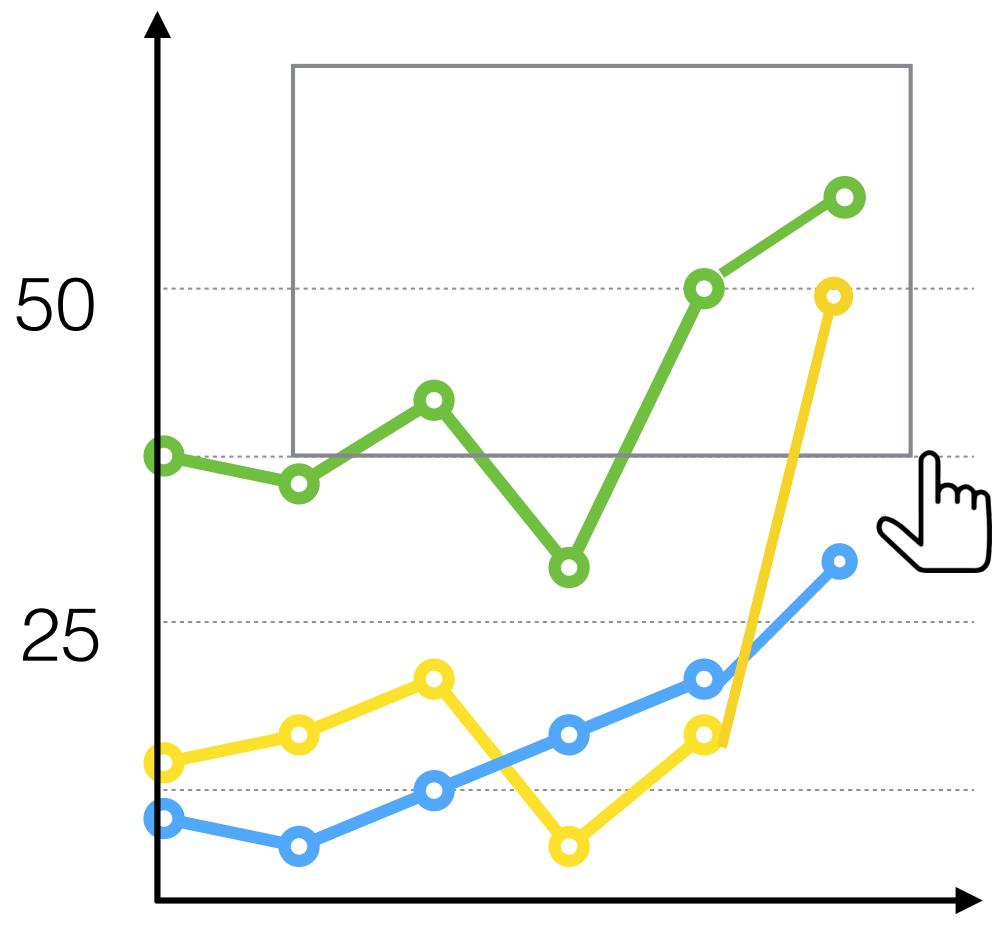


Real Time Interaction



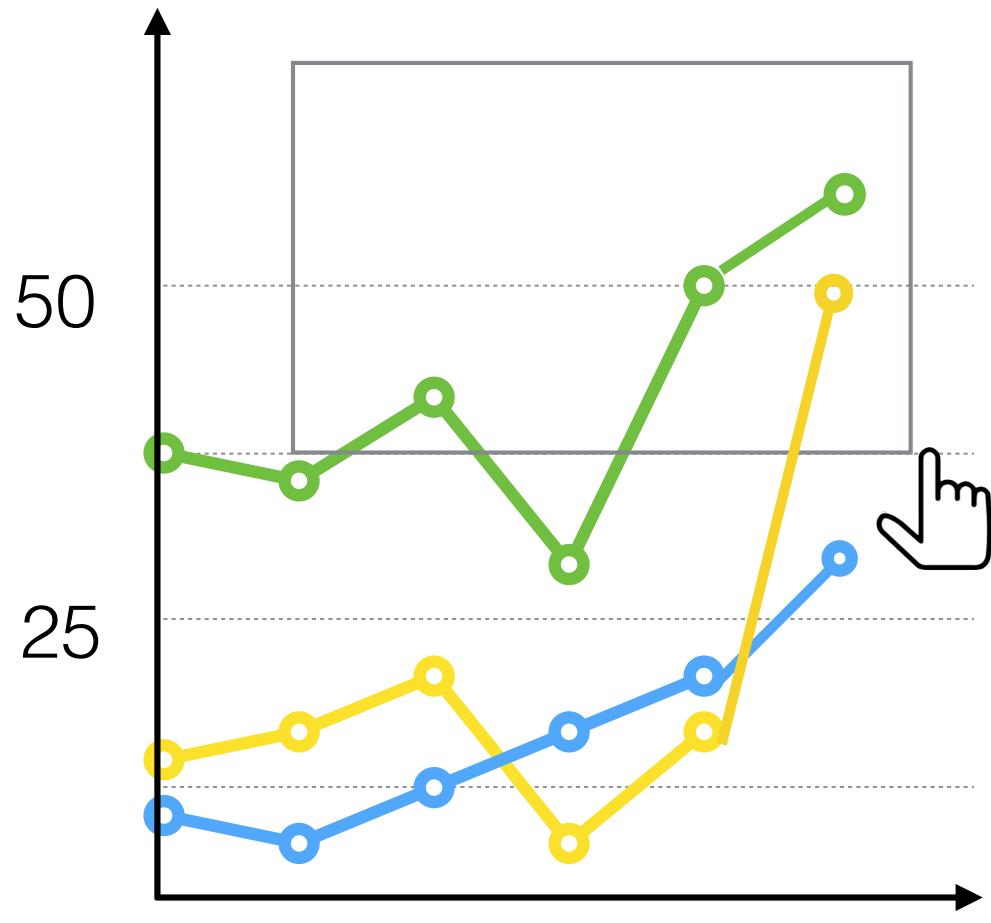
average dividend: 2.37%

Real Time Interaction



average dividend: 2.37%

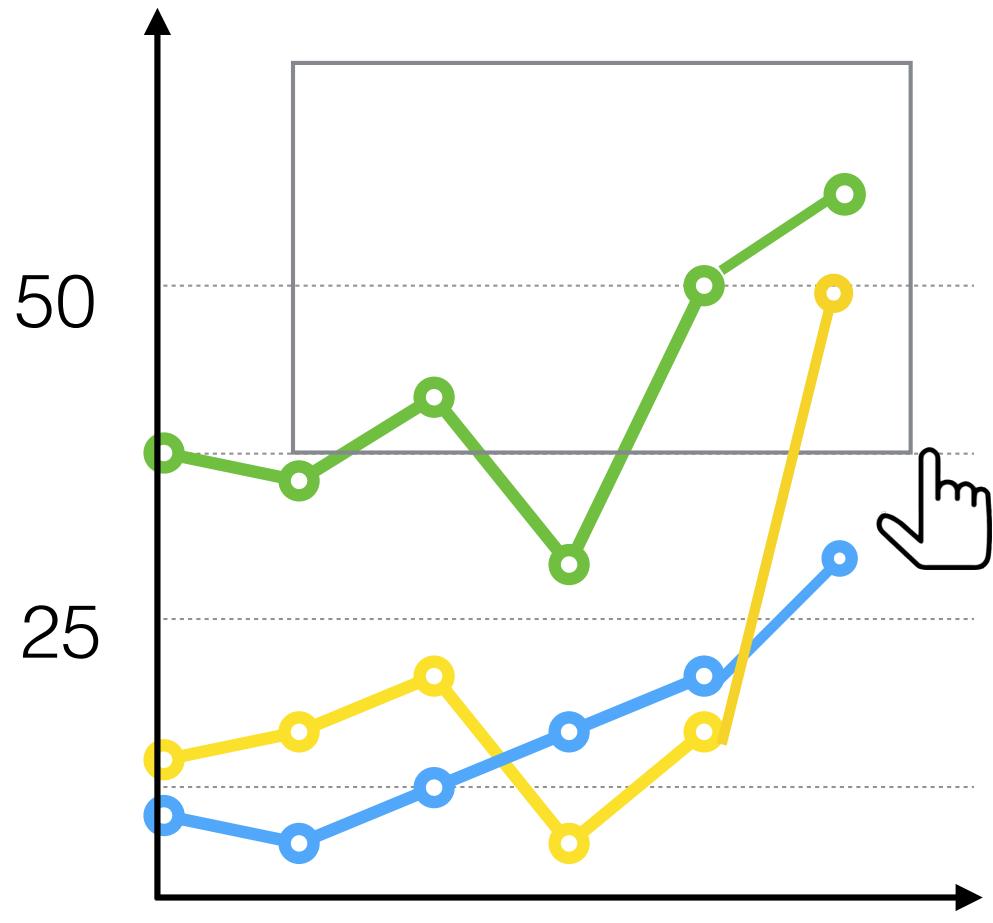
Real Time Interaction



average dividend: 2.37%



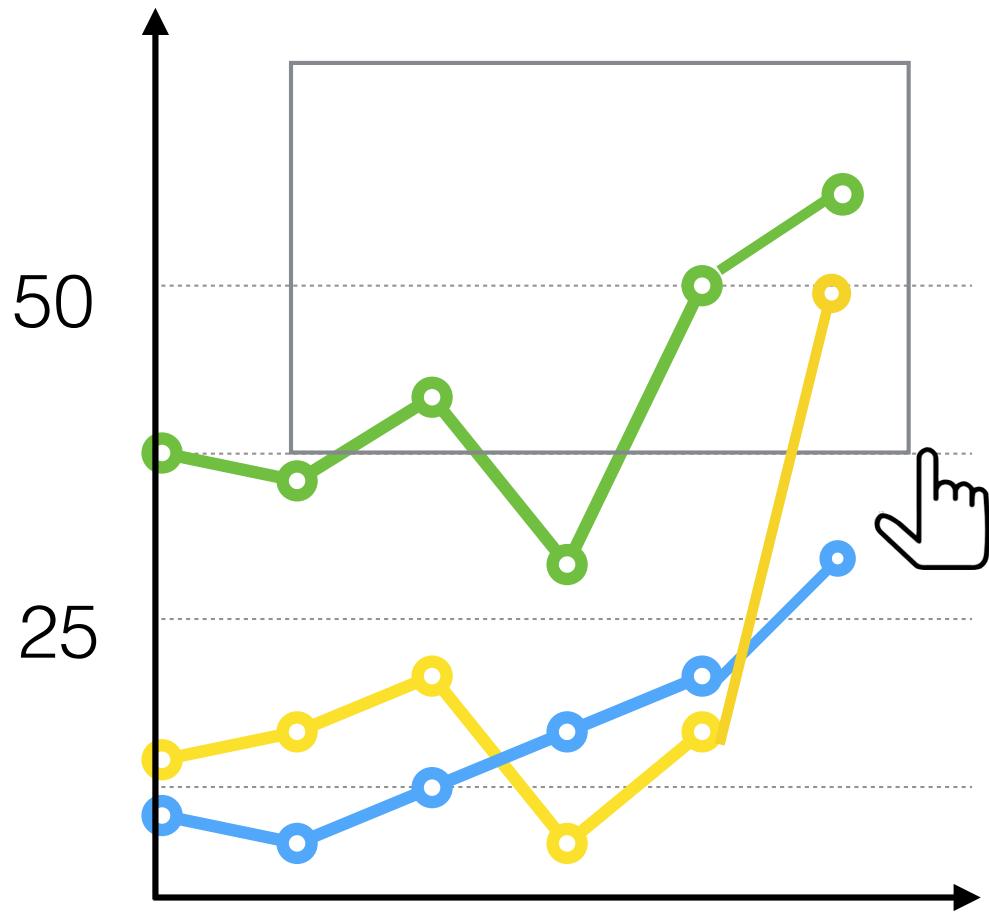
Real Time Interaction



average dividend: 2.37%



Real Time Interaction



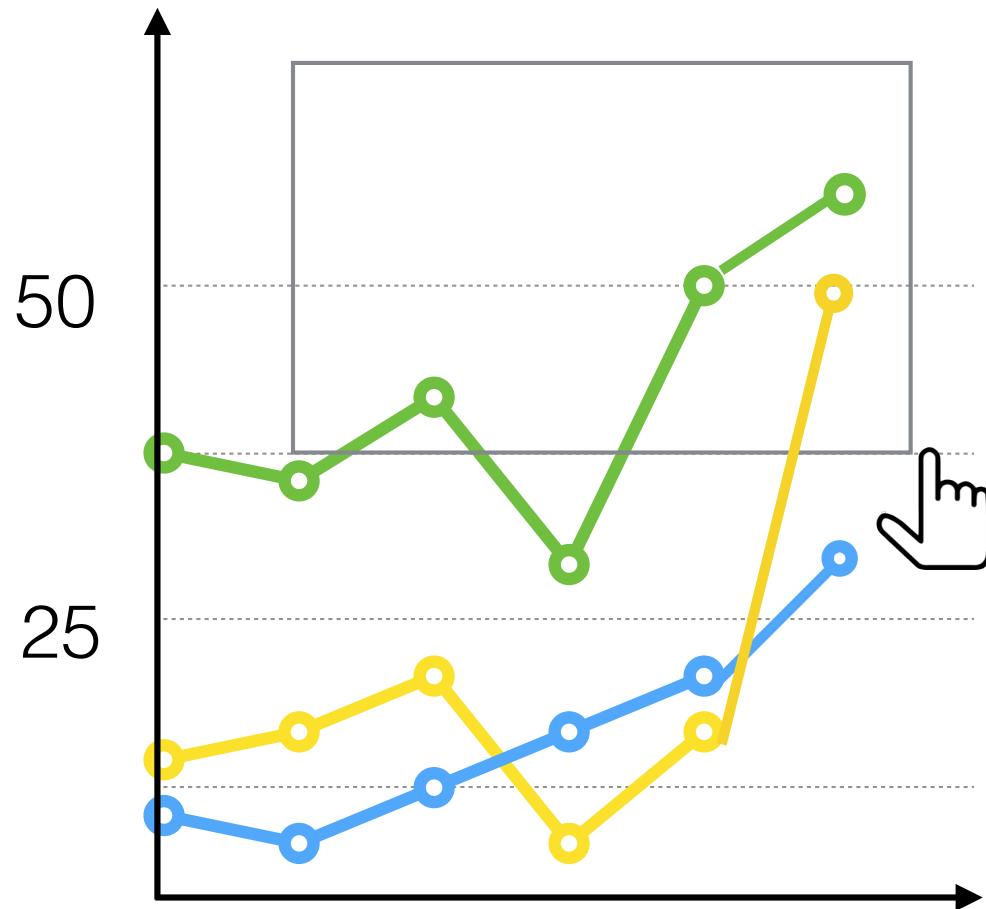
average dividend: 2.37%



is yellow selected?



Real Time Interaction



average dividend: 2.37%

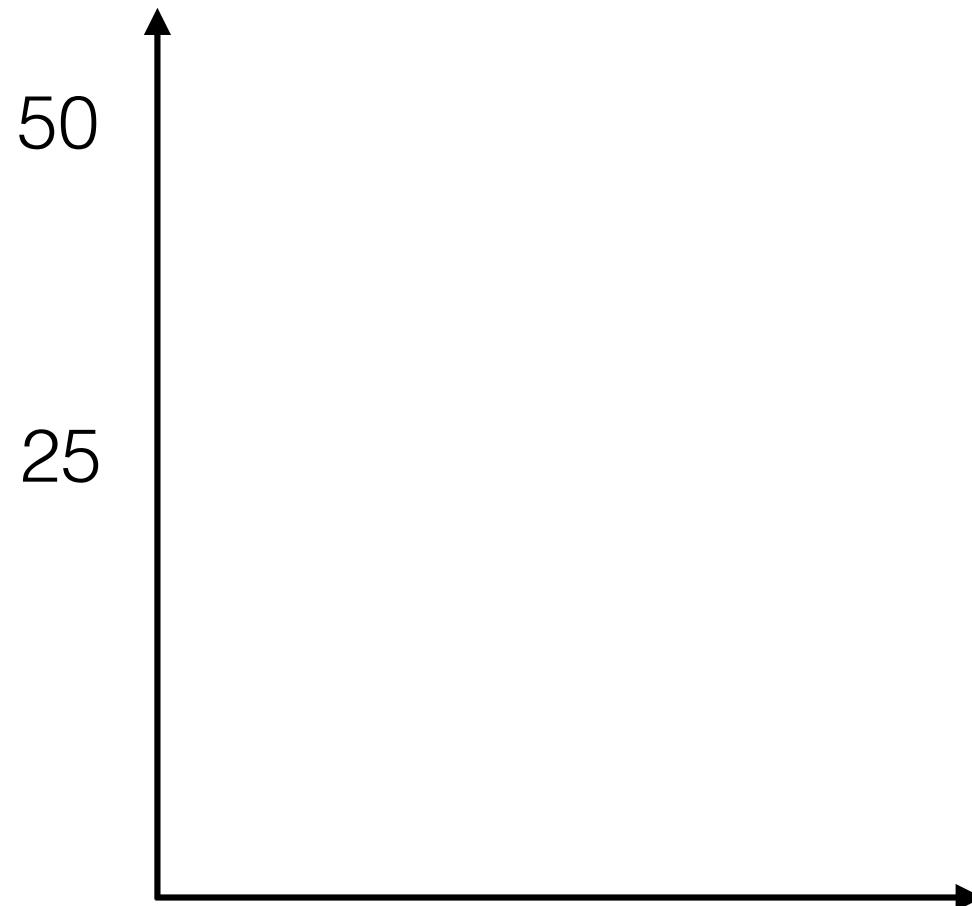


is yellow selected?

Anomaly: Unclear Selection

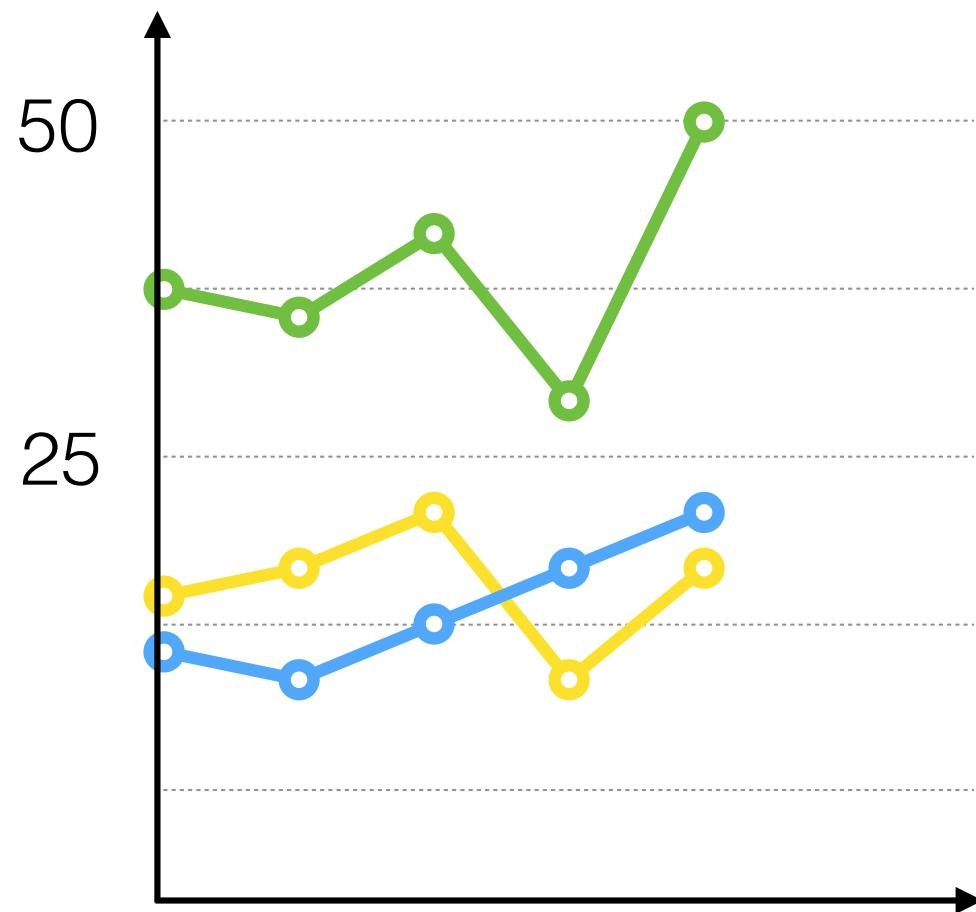
Real Time Interaction

Updates **Before** Interaction



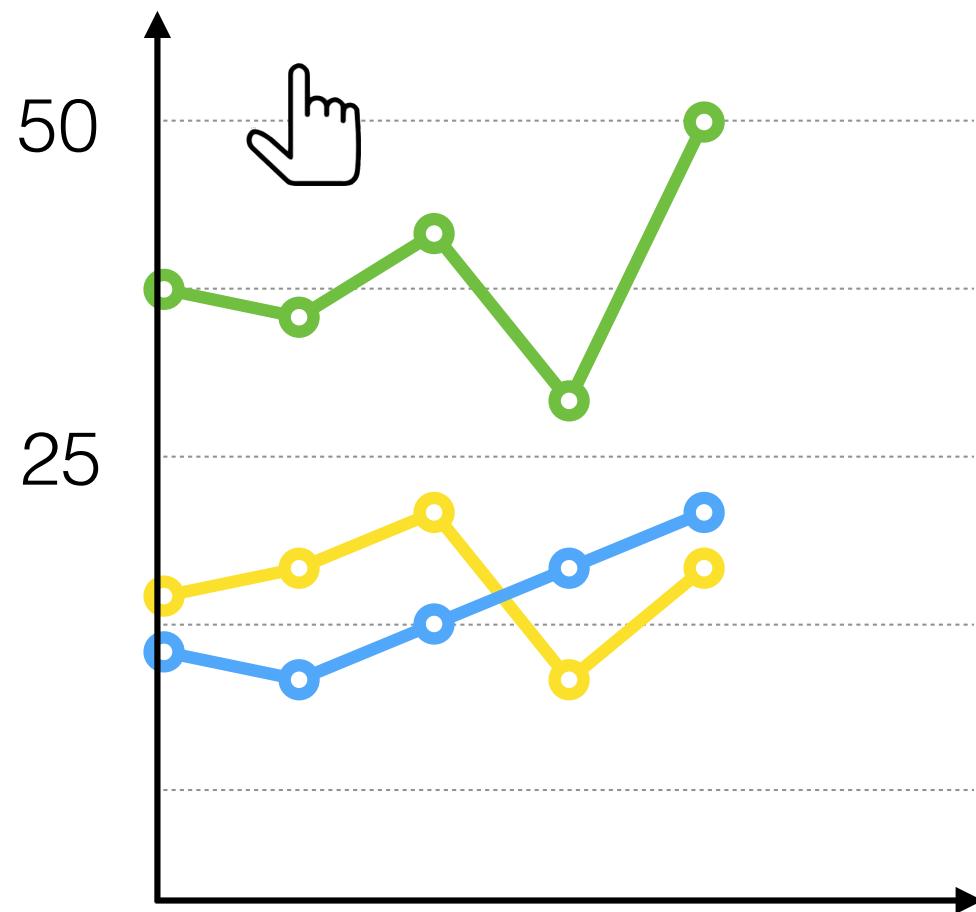
Real Time Interaction

Updates **Before** Interaction



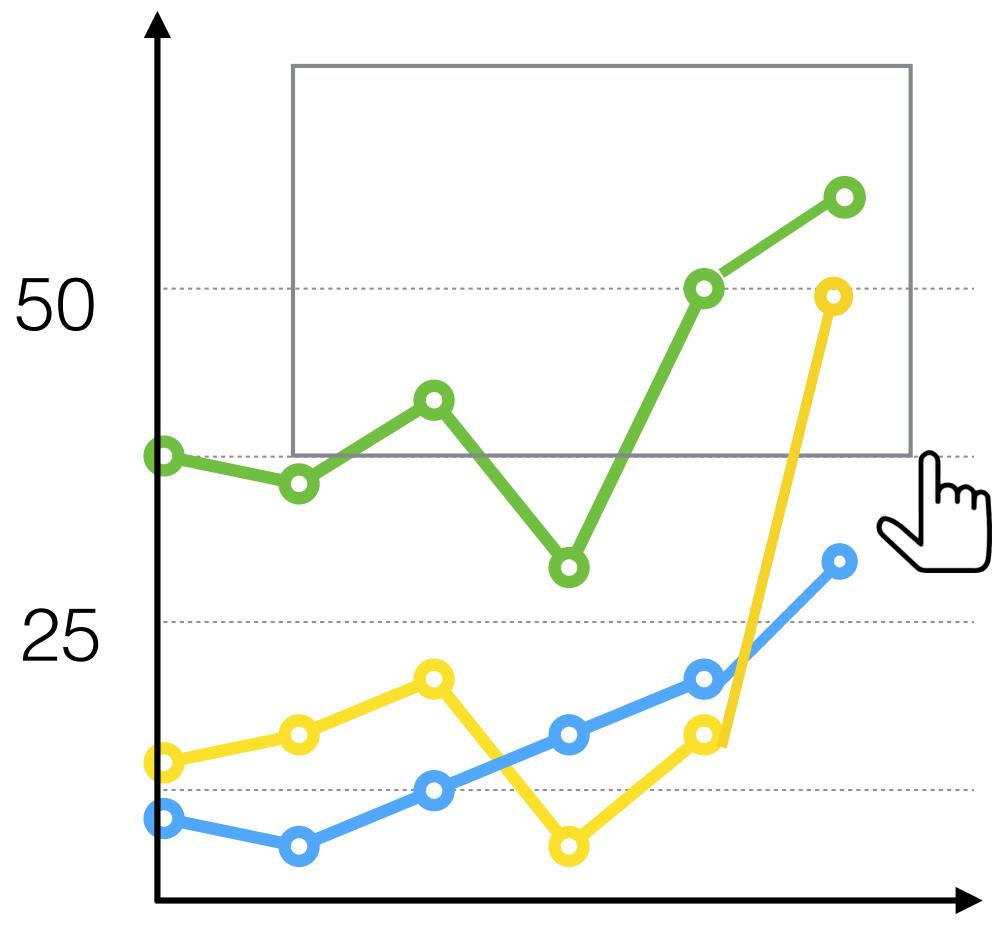
Real Time Interaction

Updates **Before** Interaction



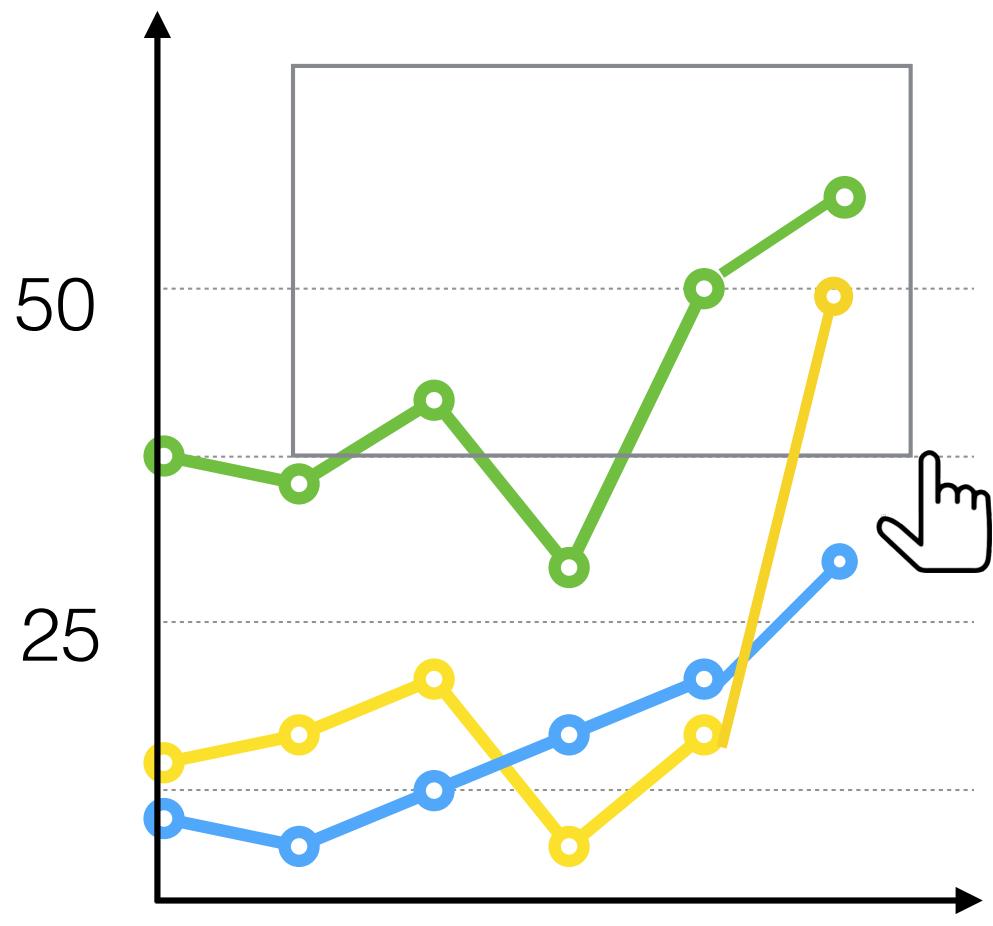
Real Time Interaction

Updates **Before** Interaction



Real Time Interaction

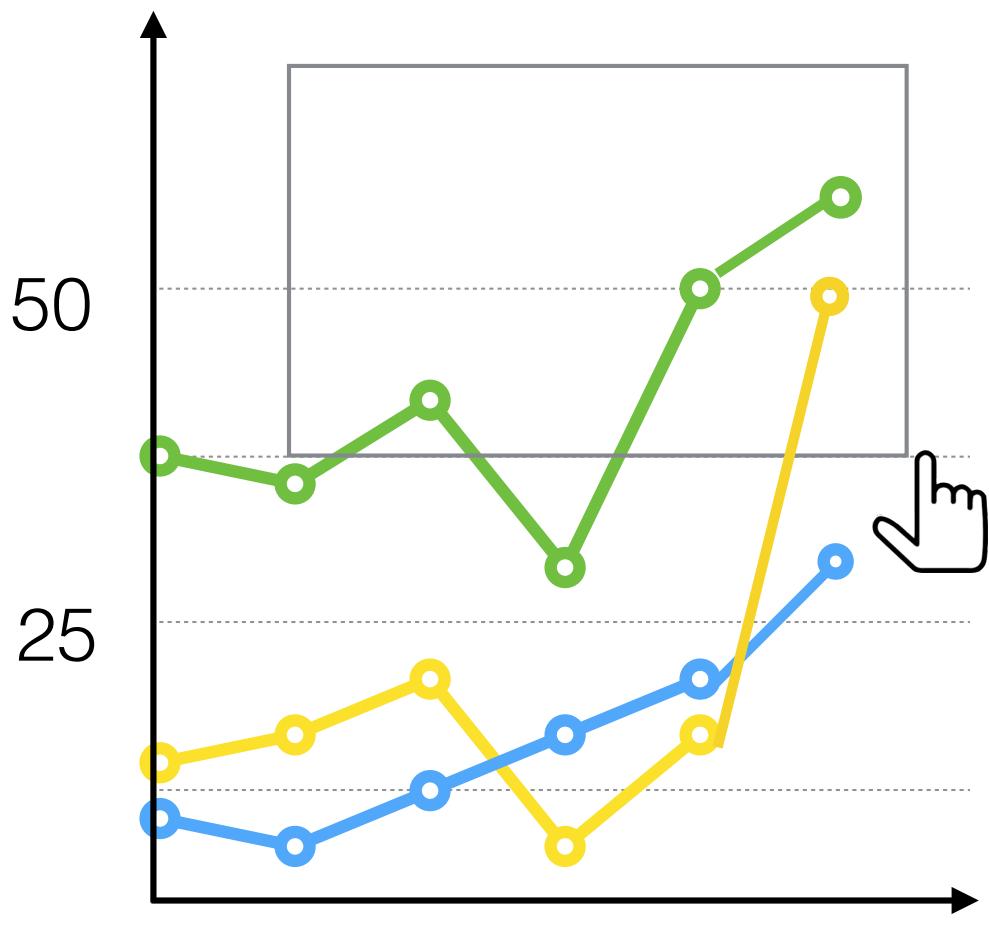
Updates **Before** Interaction



intended to select
between 25 and 55

Real Time Interaction

Updates **Before** Interaction



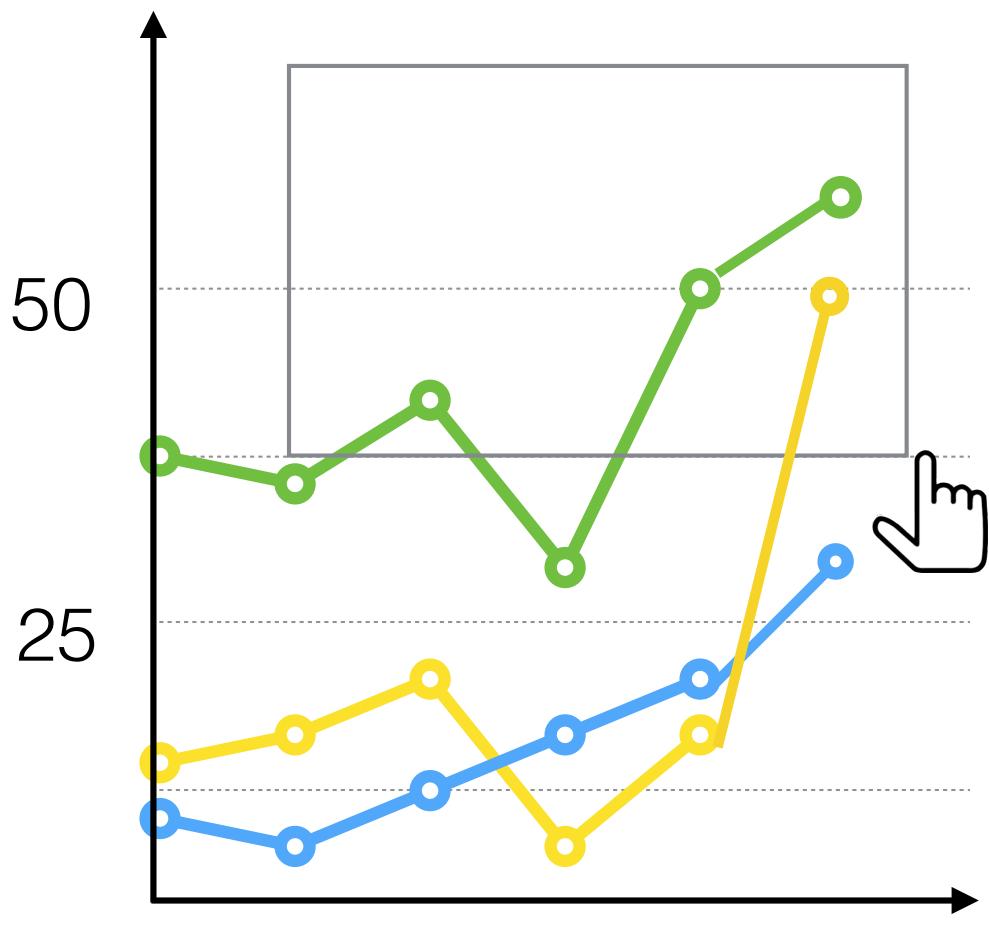
average dividend: 2.37%



intended to select
between 25 and 55

Real Time Interaction

Updates **Before** Interaction

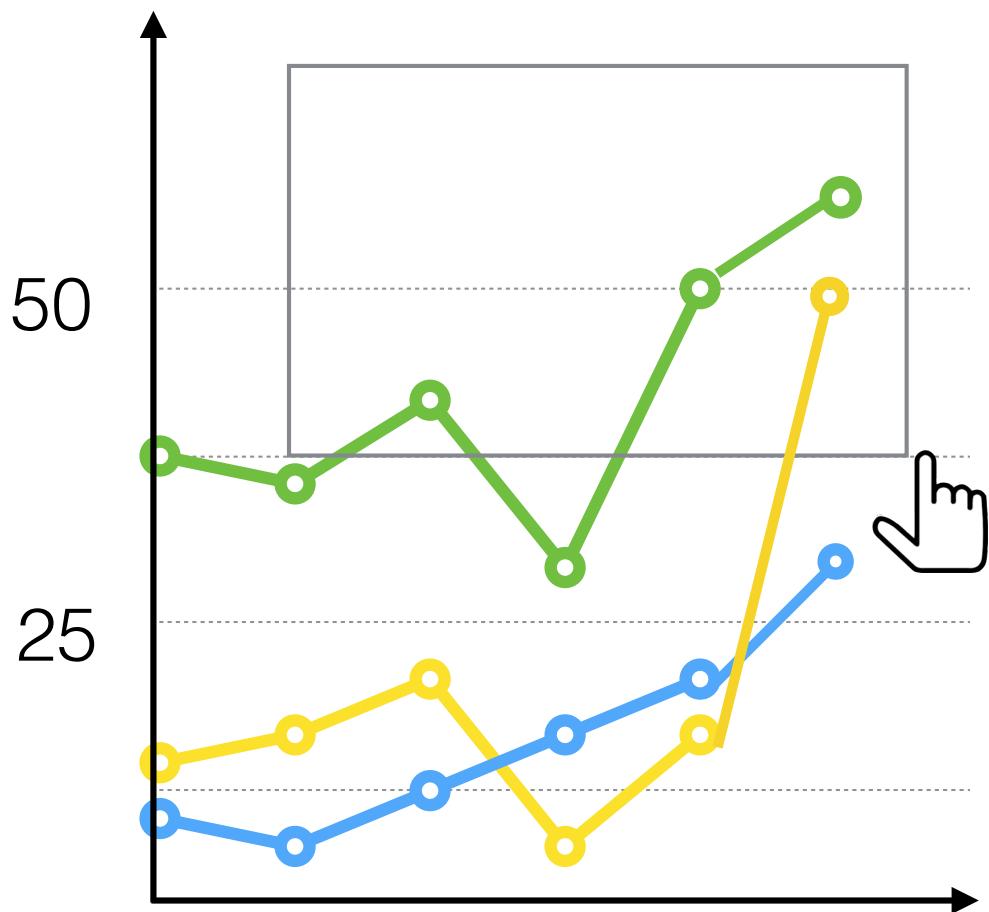


average dividend: 2.37%



intended to select
between 25 and 55

Real Time Interaction Updates **Before** Interaction



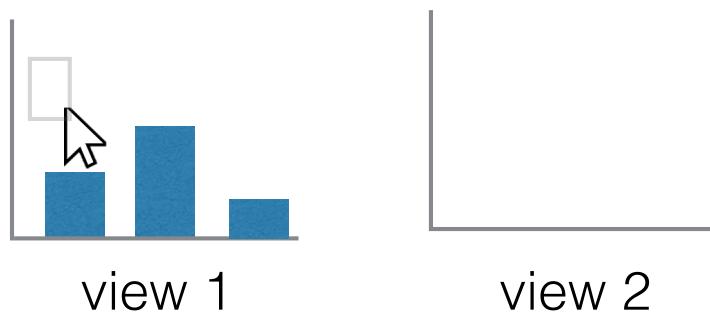
average dividend: 2.37%



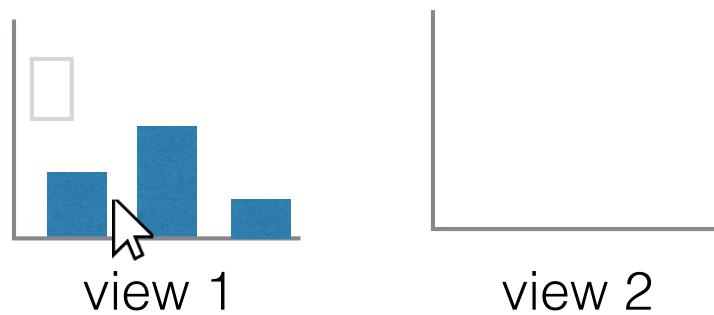
intended to select
between 25 and 55

Anomaly: Wrong Selection

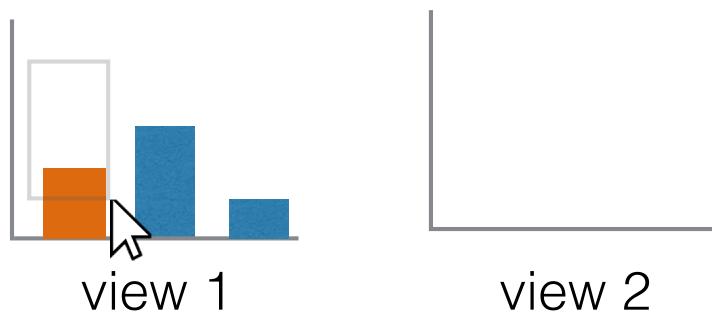
Incremental Visualization



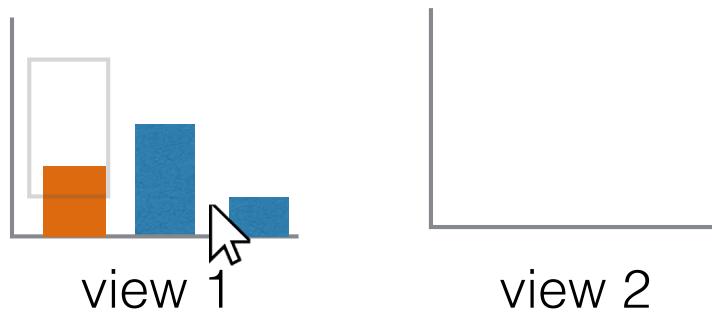
Incremental Visualization



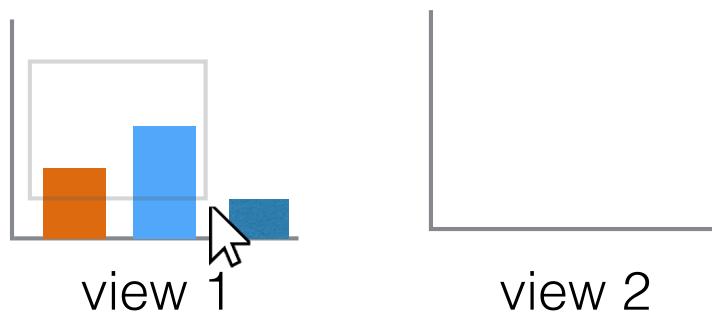
Incremental Visualization



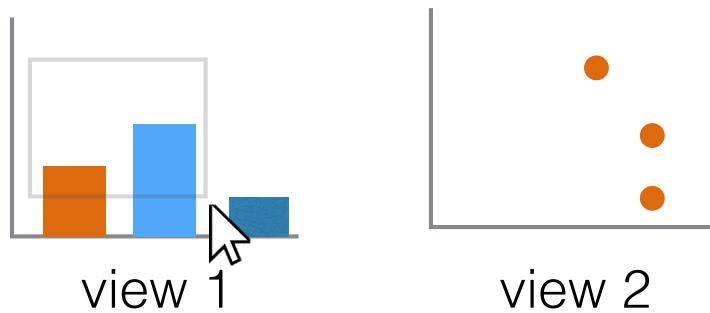
Incremental Visualization



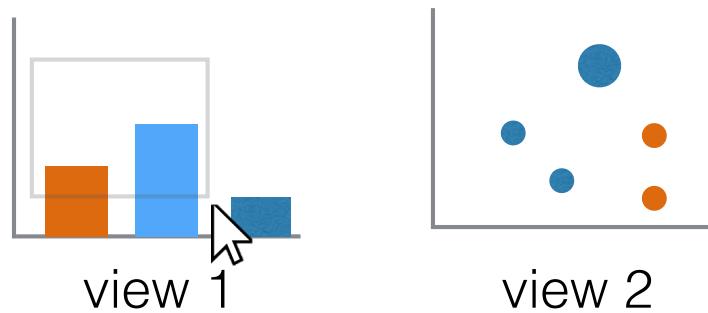
Incremental Visualization



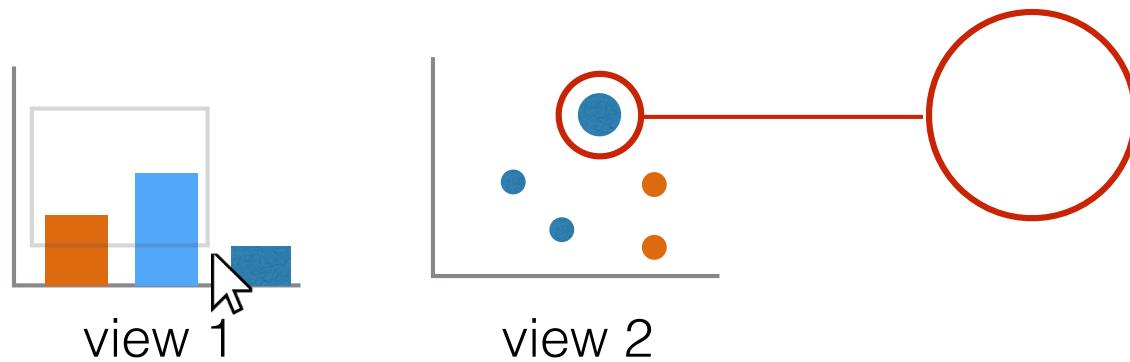
Incremental Visualization



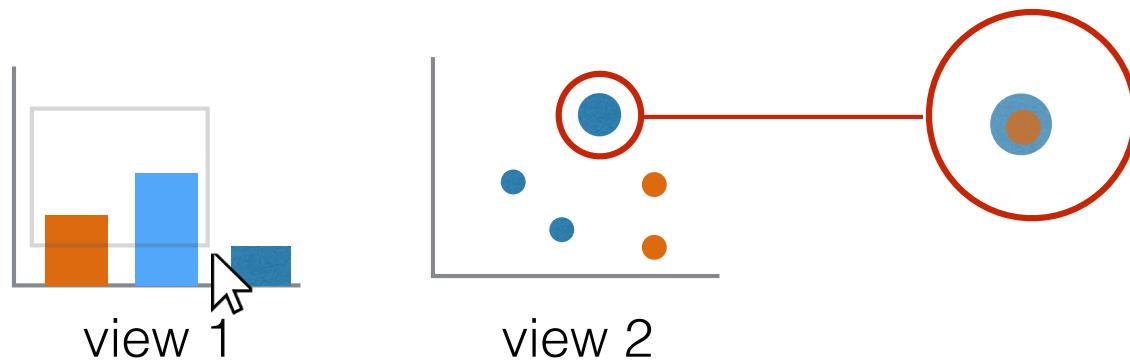
Incremental Visualization



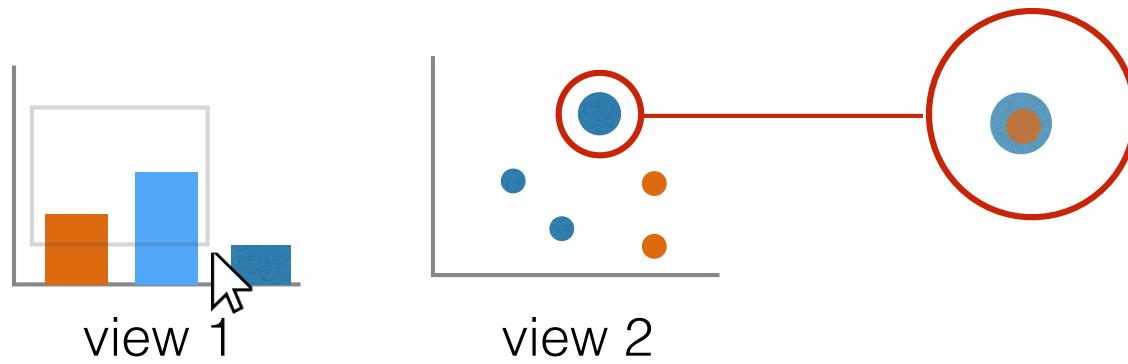
Incremental Visualization



Incremental Visualization



Incremental Visualization

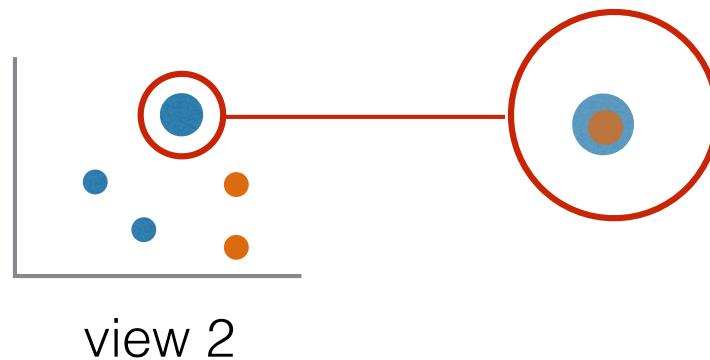
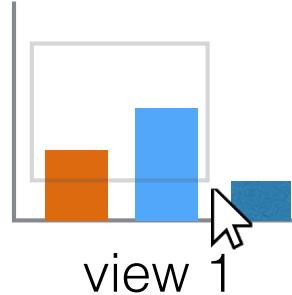


Anomaly: Overwritten Marks

Incremental Visualization



Isn't this a layout issue?



Anomaly: Overwritten Marks

A cartoon illustration of a white bear with a pink shirt and a yellow crown. The bear is shouting with its mouth wide open, showing many sharp, white, triangular teeth. It is holding a torch with a brown handle and a yellow flame. The background consists of several large, yellow, radiating shapes resembling sunbeams or flames.

Find all the bugs!

- **Reordering**



- **Reordering**
- **Varying Delays**
 - Mistaken Correspondence



- **Reordering**
- **Varying Delays**
 - Mistaken Correspondence
- **Concurrent Updates**
 - Unclear Selection
 - Wrong Selection
 - Overwritten Marks



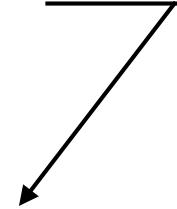
Consistency Definition?

Consistency Definition?

Consistency is in the **eyes of the beholder**.

Consistency Definition?

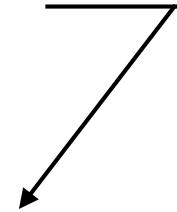
Consistency is in the **eyes of the beholder**.



Application Semantics

Consistency Definition?

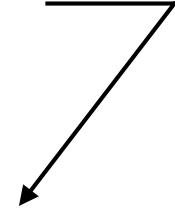
Consistency is in the **eyes of the beholder**.



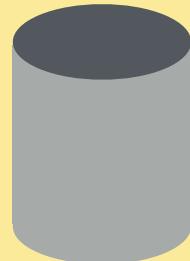
Application Semantics

Consistency Definition?

Consistency is in the **eyes of the beholder**.

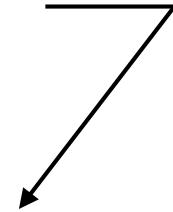


Application Semantics



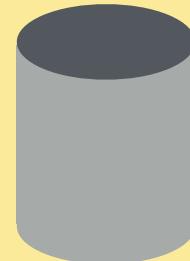
Consistency Definition?

Consistency is in the **eyes of the beholder**.



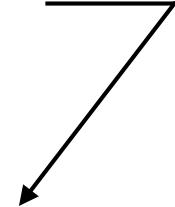
Application Semantics

checking



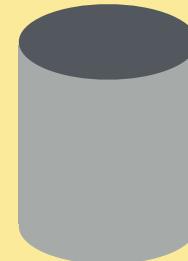
Consistency Definition?

Consistency is in the **eyes of the beholder**.



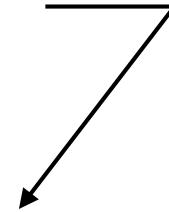
Application Semantics

checking
balance > 0



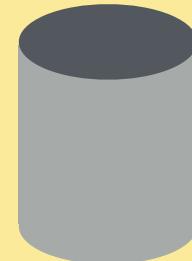
Consistency Definition?

Consistency is in the **eyes of the beholder**.



Application Semantics

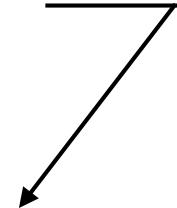
checking
balance > 0



credit card

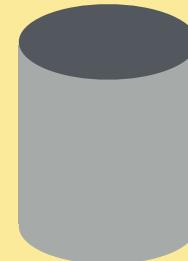
Consistency Definition?

Consistency is in the **eyes of the beholder**.



Application Semantics

checking
balance > 0



credit card
balance > - \$8000

What Gives?

What Gives?

- ✖ Data analysts frustration

What Gives?

- ✖ Data analysts frustration
- ✖ Engineering frustration

What Gives?

- ✖ Data analysts frustration
- ✖ Engineering frustration
- ✖ **Wrong conclusions**

What Gives?

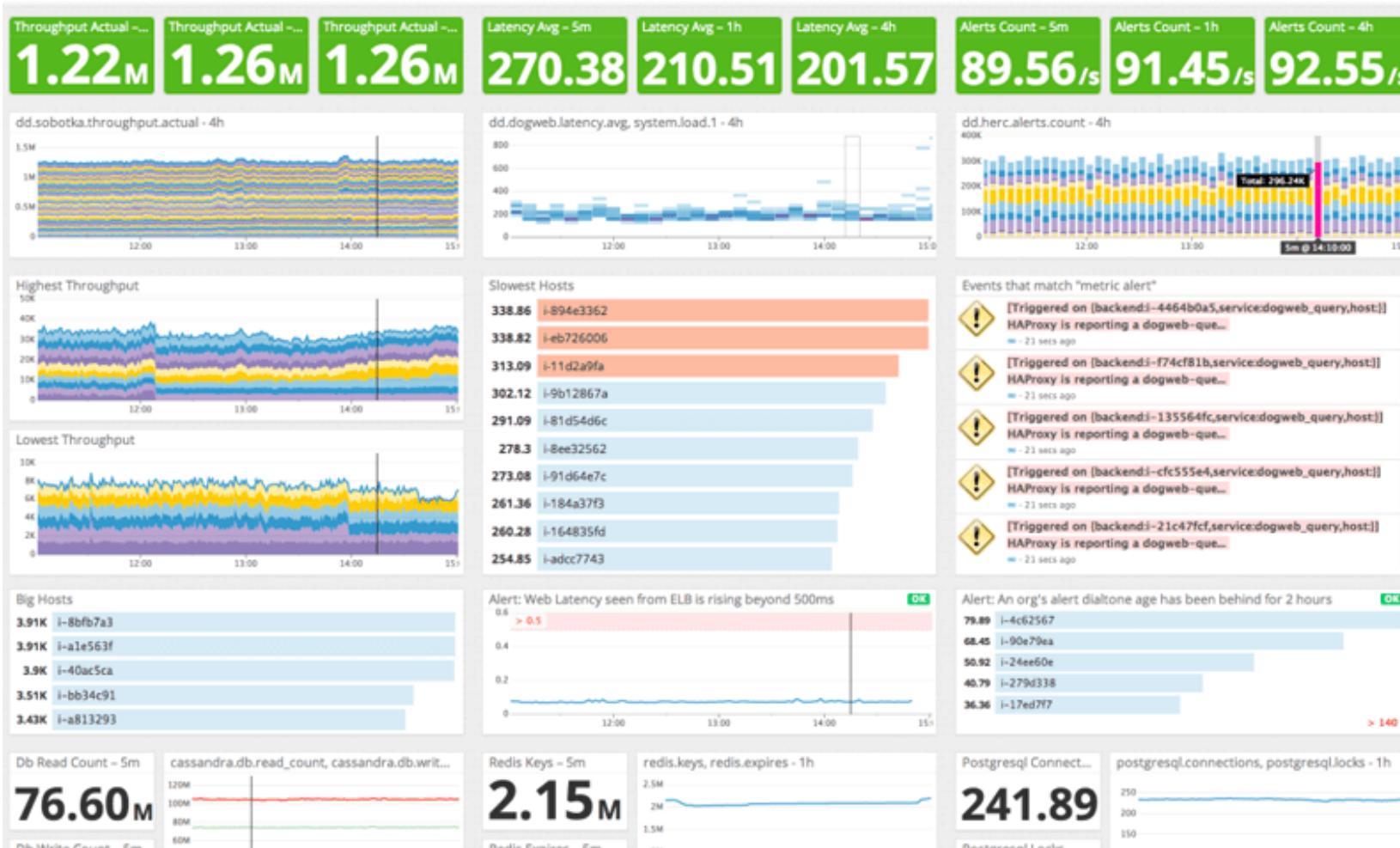
- ✖ Data analysts frustration
- ✖ Engineering frustration
- ✖ **Wrong conclusions**





★ Screen Overview

[Edit Board](#)



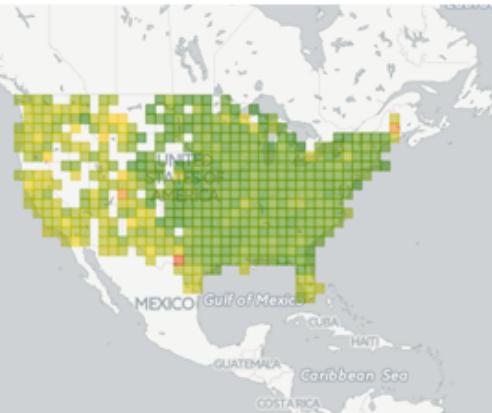
★ Screen Overview Edit Board



DATA APP: KEEP OPERATIONS MOVING

Operations Overview

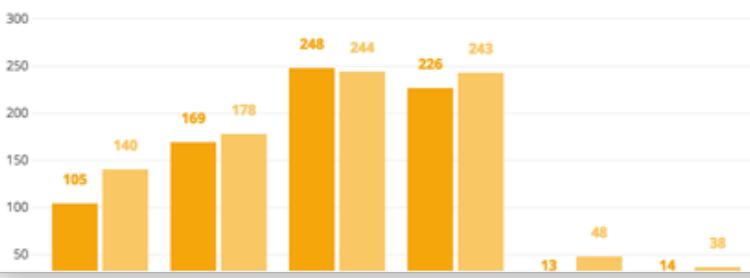
Average Shipping Time to Users



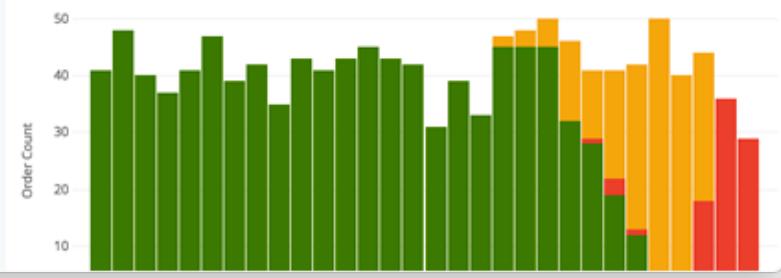
Most Common Shipping Locations



Inventory Aging Report



30 day Shipment Status



Highest Throughput

50K
40K
30K
20K
10K
0

Lowest Throughput

10K
8K
6K
4K
2K
0

Big Hosts

3.91K i-8bf87

3.91K i-a1e56

3.9K i-40ac5

3.51K i-bb34c

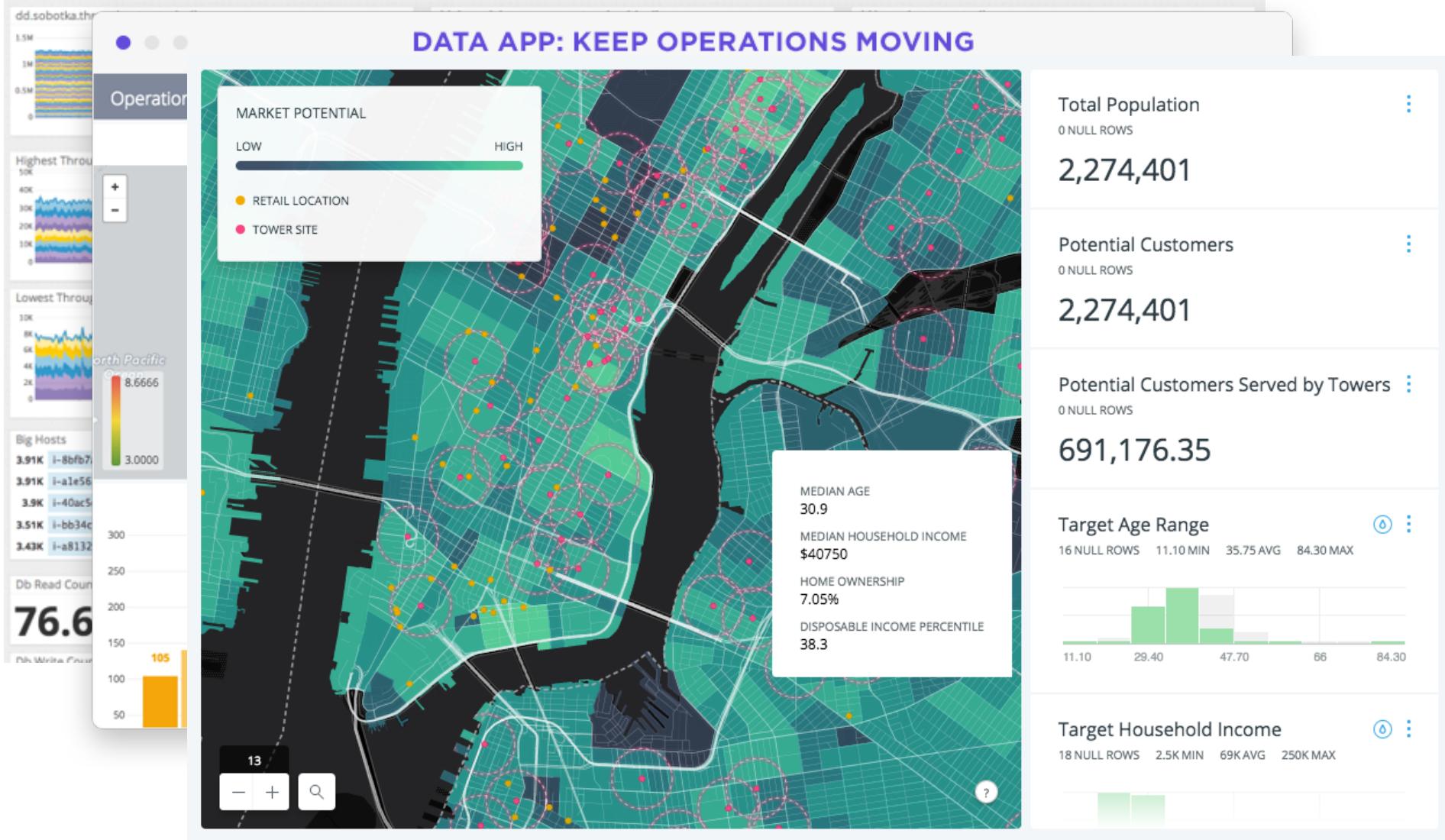
3.43K i-a8132

Db Read Count

76.6

This Metric is Custom

★ Screen Overview Edit Board



★ Screen Overview Edit Board

Throughput Actual ~...

Throughput Actual ~...

Throughput Actual ~...

Latency Avg - 5m

Latency Avg - 1h

Latency Avg - 4h

Alerts Count - 5m

Alerts Count - 1h

Alerts Count - 4h

1.22M

1.26M

1.26M

270.38

210.51

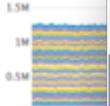
201.57

89.56/s

91.45/s

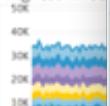
92.55/s

dd.sobotka.th...



Operation

Highest Throu...



Lowest Throu...



Big Hosts

3.91K i-8bf...

3.91K i-ale...

3.9K i-40ac...

3.51K i-bb34...

3.43K i-a813...

Db Read Count

76.6

105

DATA APP: KEEP OPERATIONS MOVING

MARKET POTENTIAL

LOW

HIGH

RETAILTOWER...

+-

Operation

...

Highest Throu...

Lowest Throu...

Big Hosts

Db Read Count

76.6

105

13

...

Layer Mapbox

Total Population0 NULL ROWS

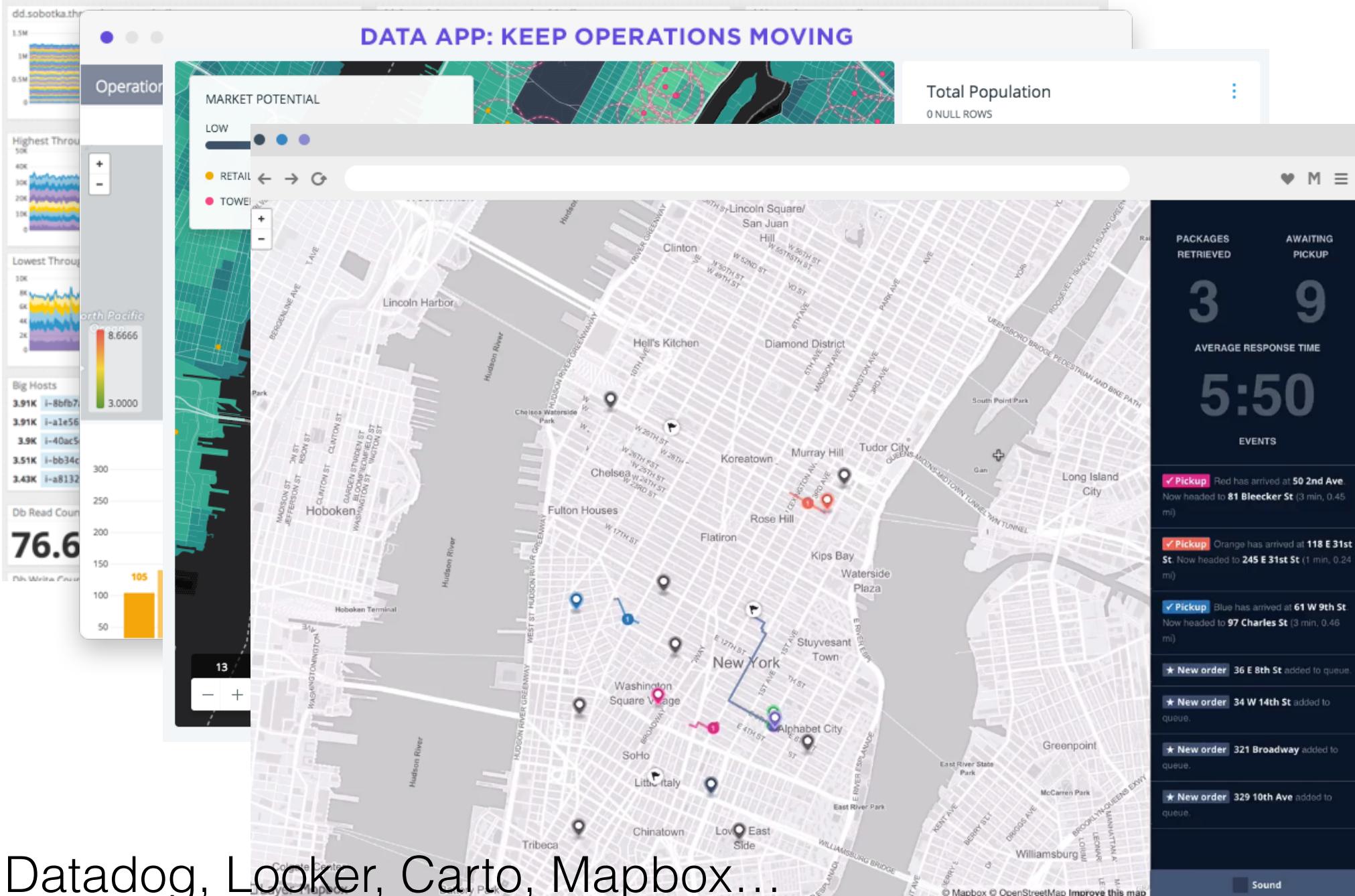
PACKAGES RETRIEVED3AWAITING PICKUP9

AVERAGE RESPONSE TIME5:50

EVENTS

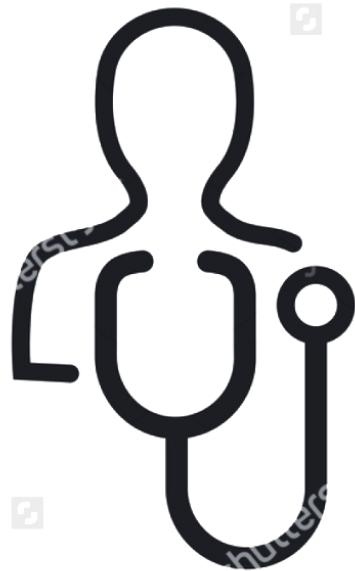
- ✓ Pickup Red has arrived at **50 2nd Ave**. Now headed to **81 Bleeker St** (3 min, 0.45 mi)
- ✓ Pickup Orange has arrived at **118 E 31st St**. Now headed to **245 E 31st St** (1 min, 0.24 mi)
- ✓ Pickup Blue has arrived at **61 W 9th St**. Now headed to **97 Charles St** (3 min, 0.46 mi)
- ★ New order **36 E 8th St** added to queue.
- ★ New order **34 W 14th St** added to queue.
- ★ New order **321 Broadway** added to queue.
- ★ New order **329 10th Ave** added to queue.

★ Screen Overview Edit Board



Mission Critical

Mission Critical



Mission Critical



Mission Critical



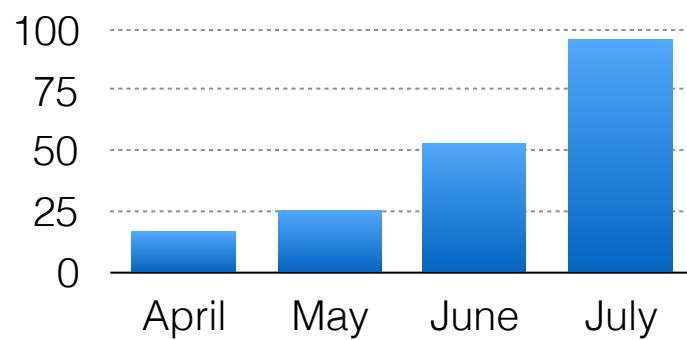
Existing Approaches

Blocking



zoom

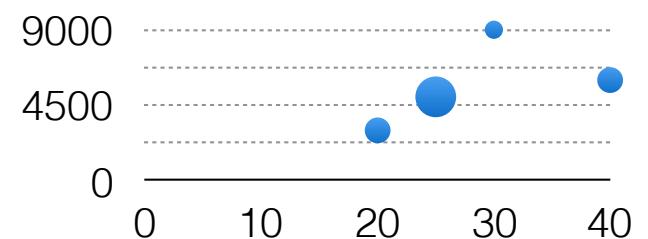
Sales by Month



Share by Region



Customer Distribution
by Age Group and
Income

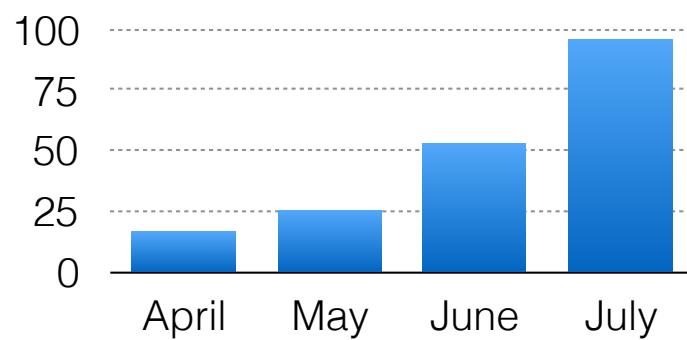


Blocking

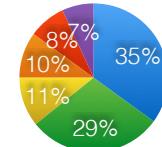


zoom 

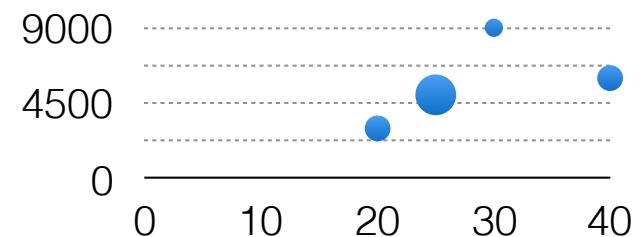
Sales by Month



Share by Region



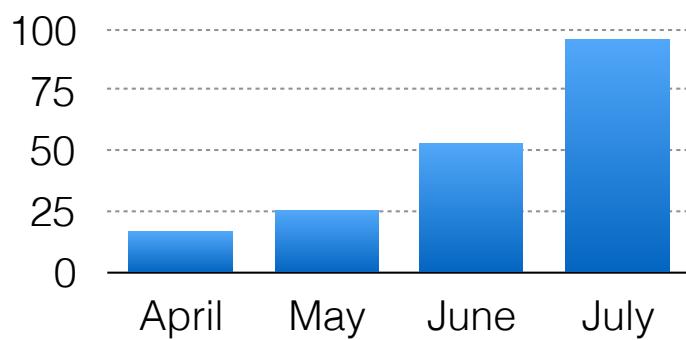
Customer Distribution
by Age Group and
Income



Blocking



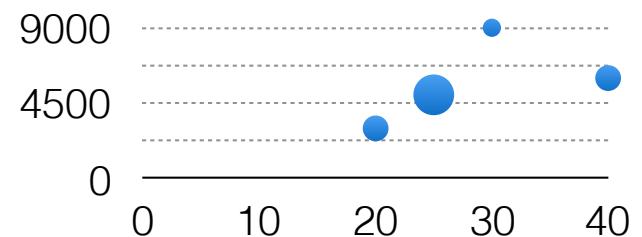
Sales by Month



Share by Region



Customer Distribution
by Age Group and
Income



Blocking



Sales by Month

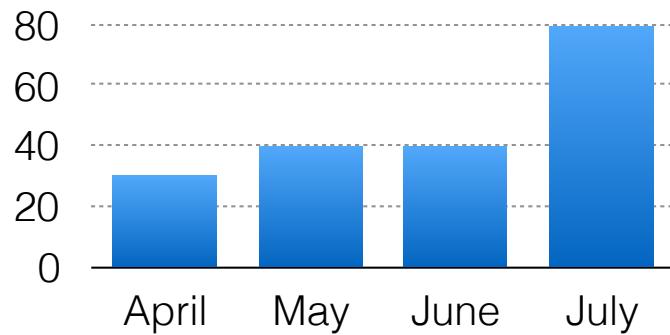
Share by Region

Customer Distribution
by Age Group and
Income

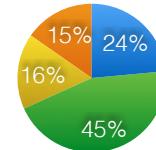
Blocking



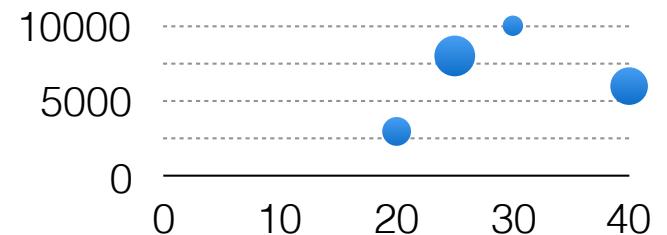
Sales by Month



Share by Region



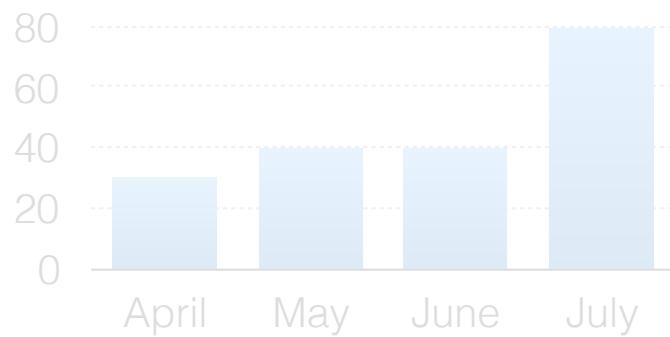
Customer Distribution
by Age Group and
Income



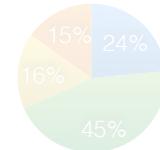
Blocking



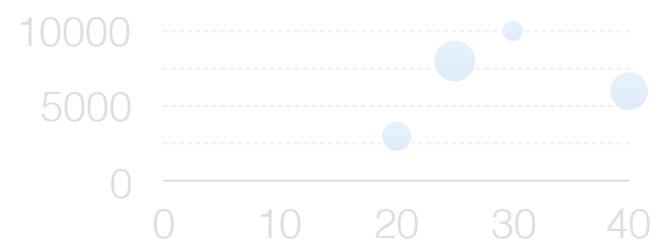
Sales by Month



Share by Region

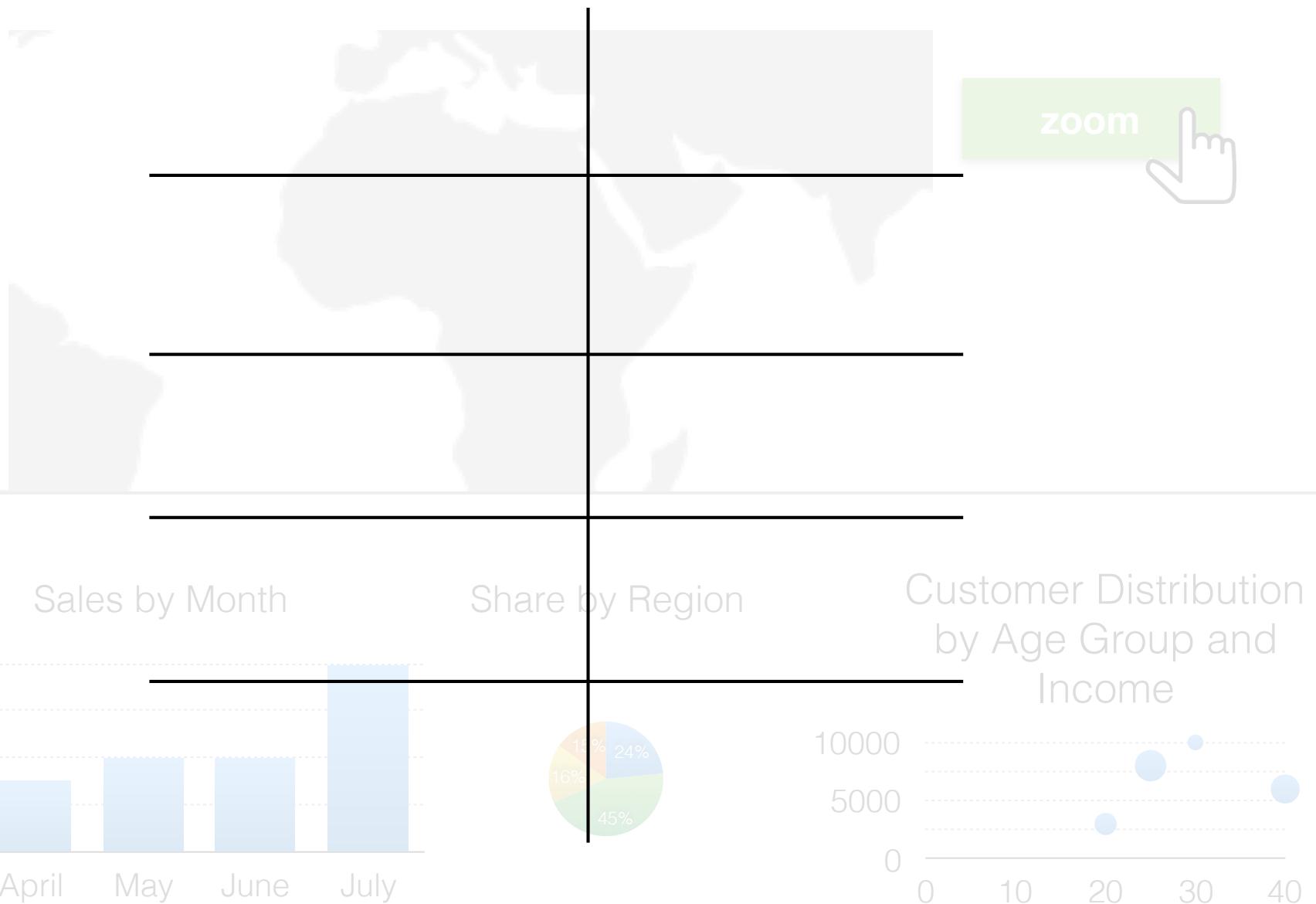


Customer Distribution
by Age Group and
Income

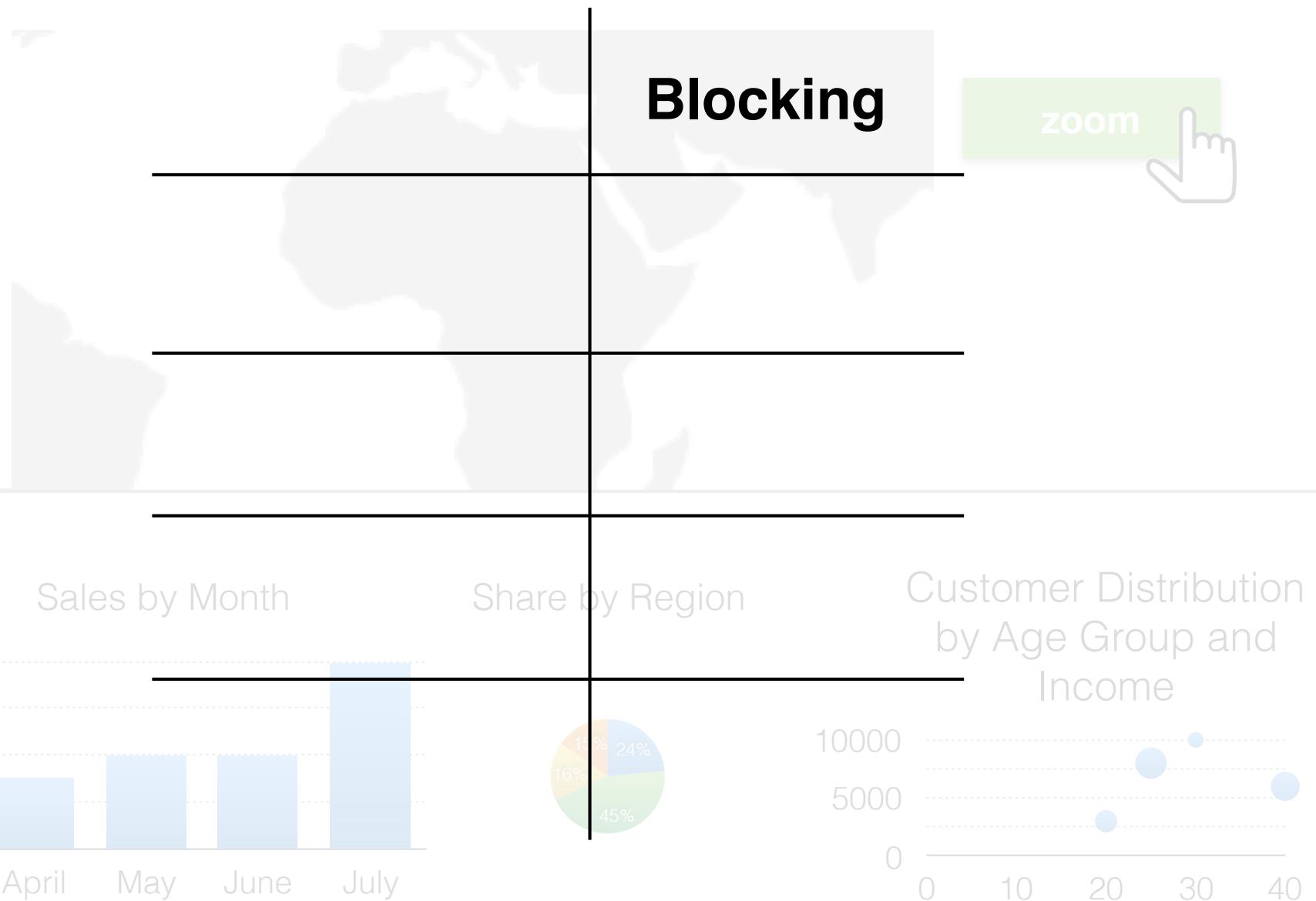


Blocking

zoom



Blocking



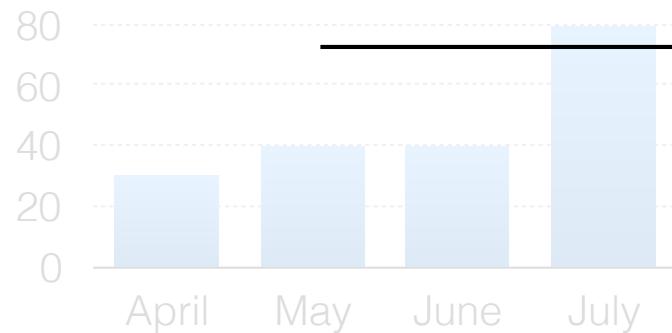
Blocking

Blocking

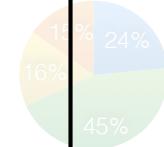
zoom

consistency

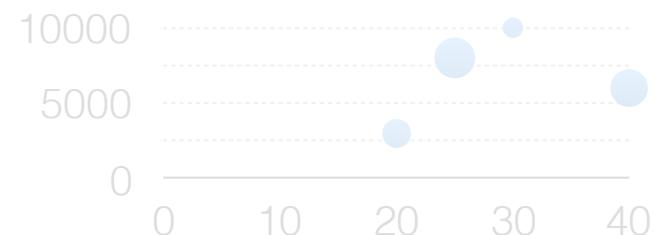
Sales by Month



Share by Region



Customer Distribution
by Age Group and
Income



Blocking

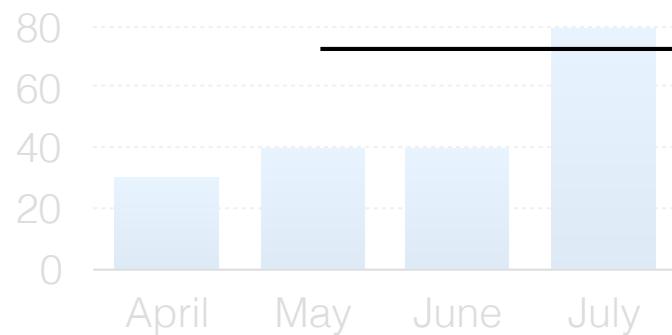
Blocking

zoom

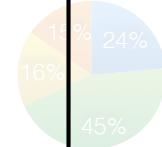


consistency

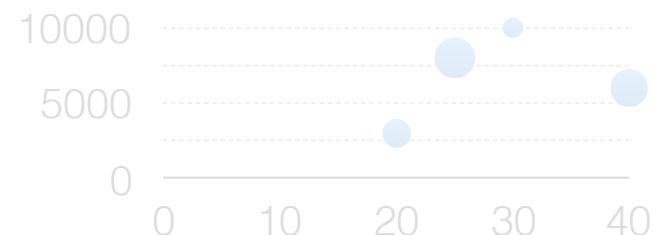
Sales by Month



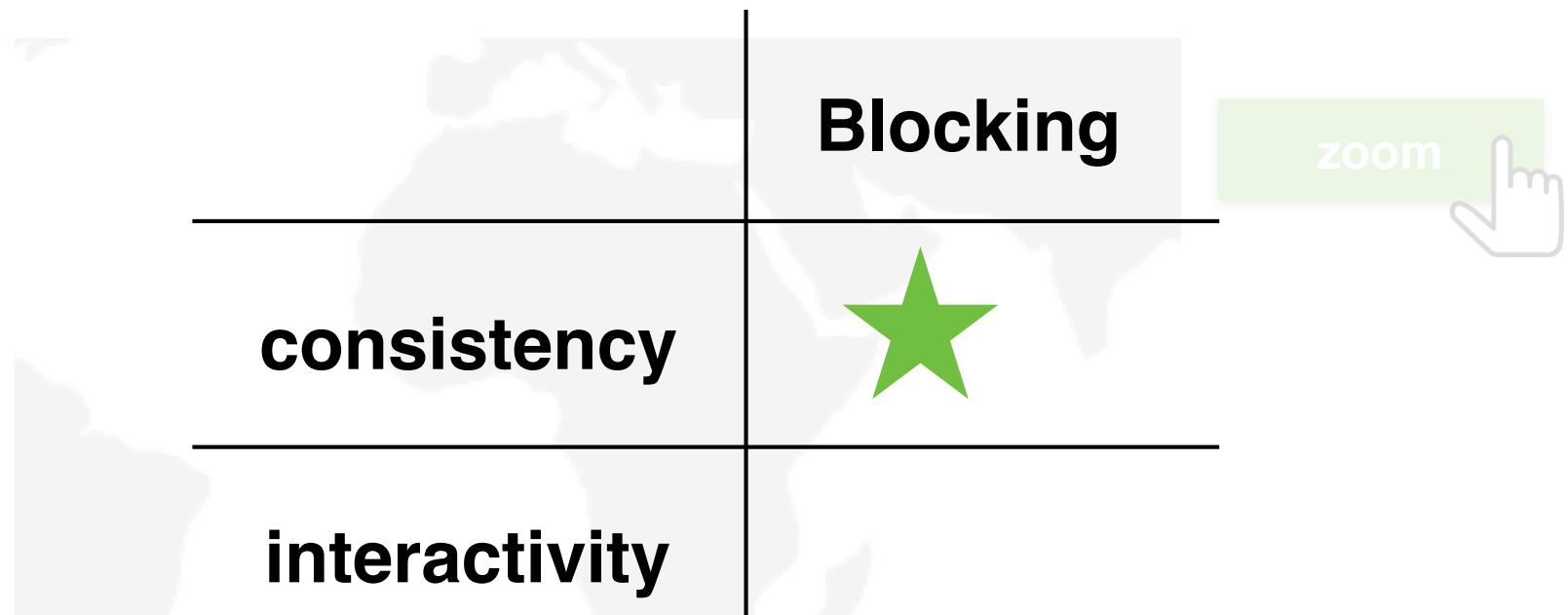
Share by Region



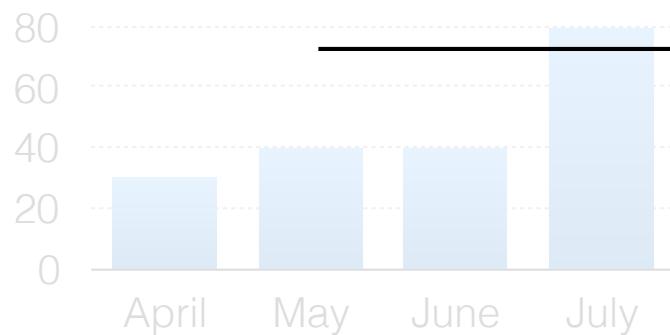
Customer Distribution
by Age Group and
Income



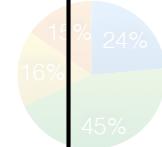
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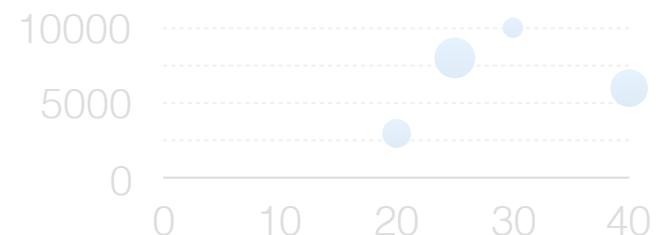
Sales by Month



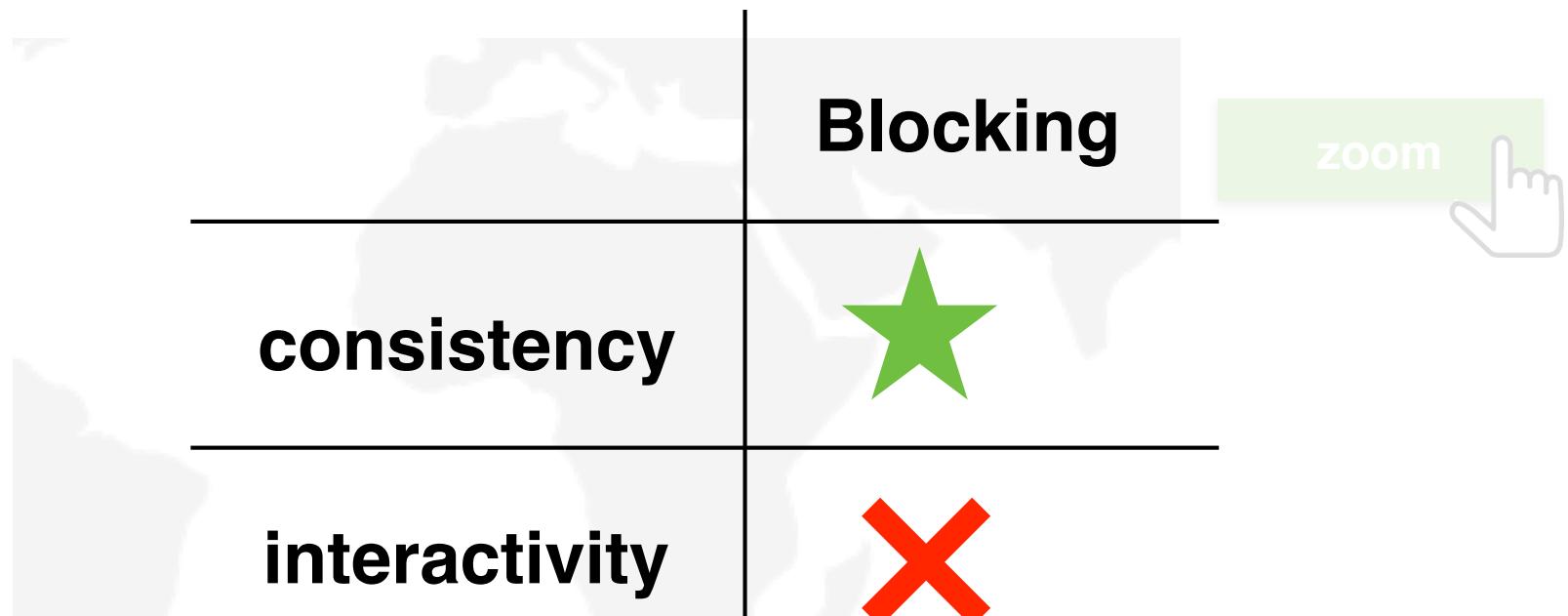
Share by Region



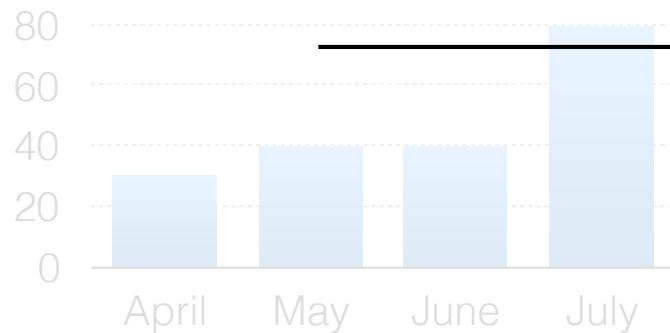
Customer Distribution
by Age Group and
Income



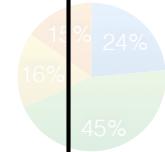
Blocking



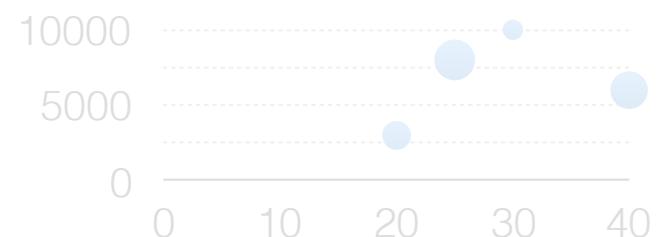
Sales by Month



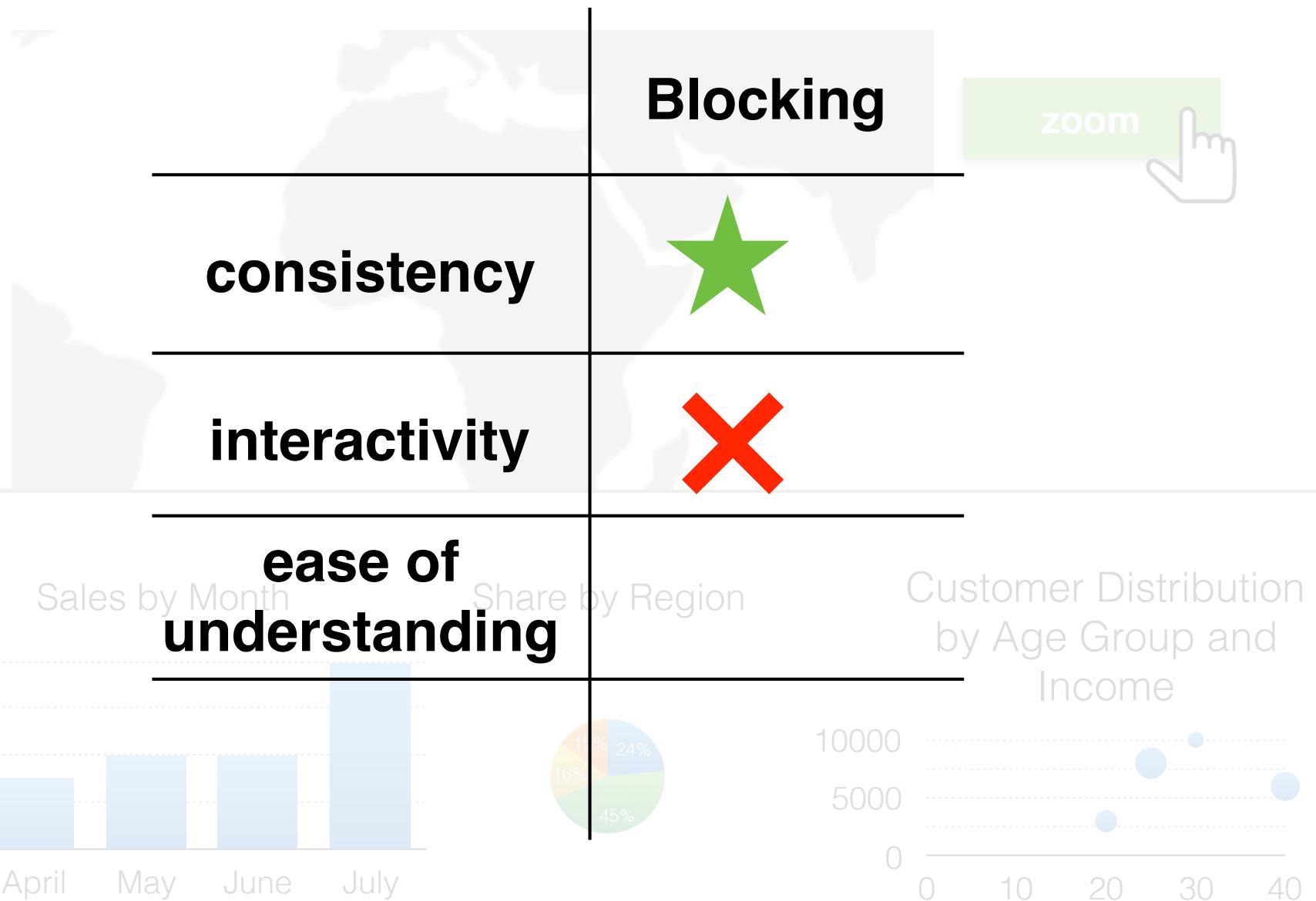
Share by Region



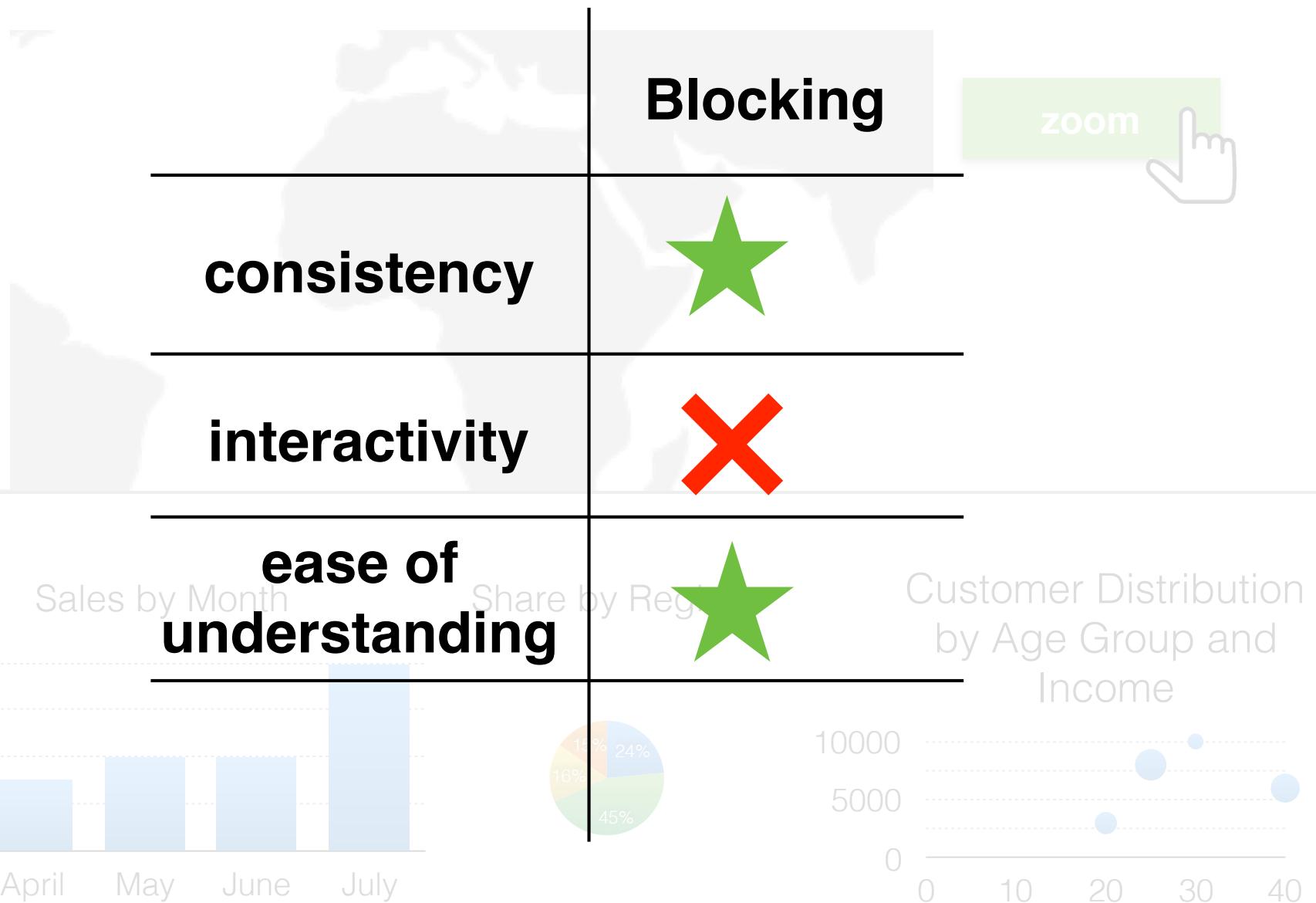
Customer Distribution
by Age Group and
Income



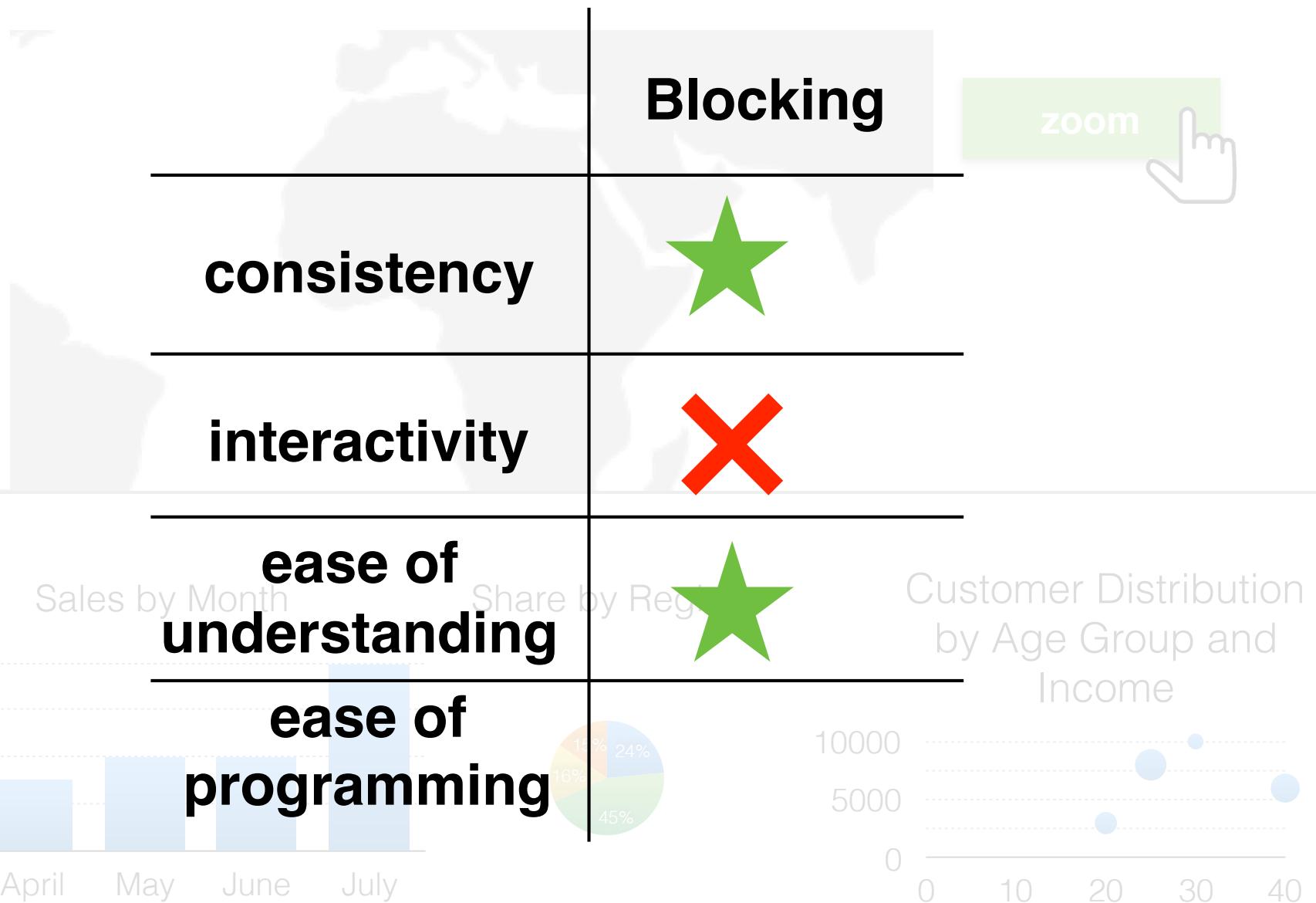
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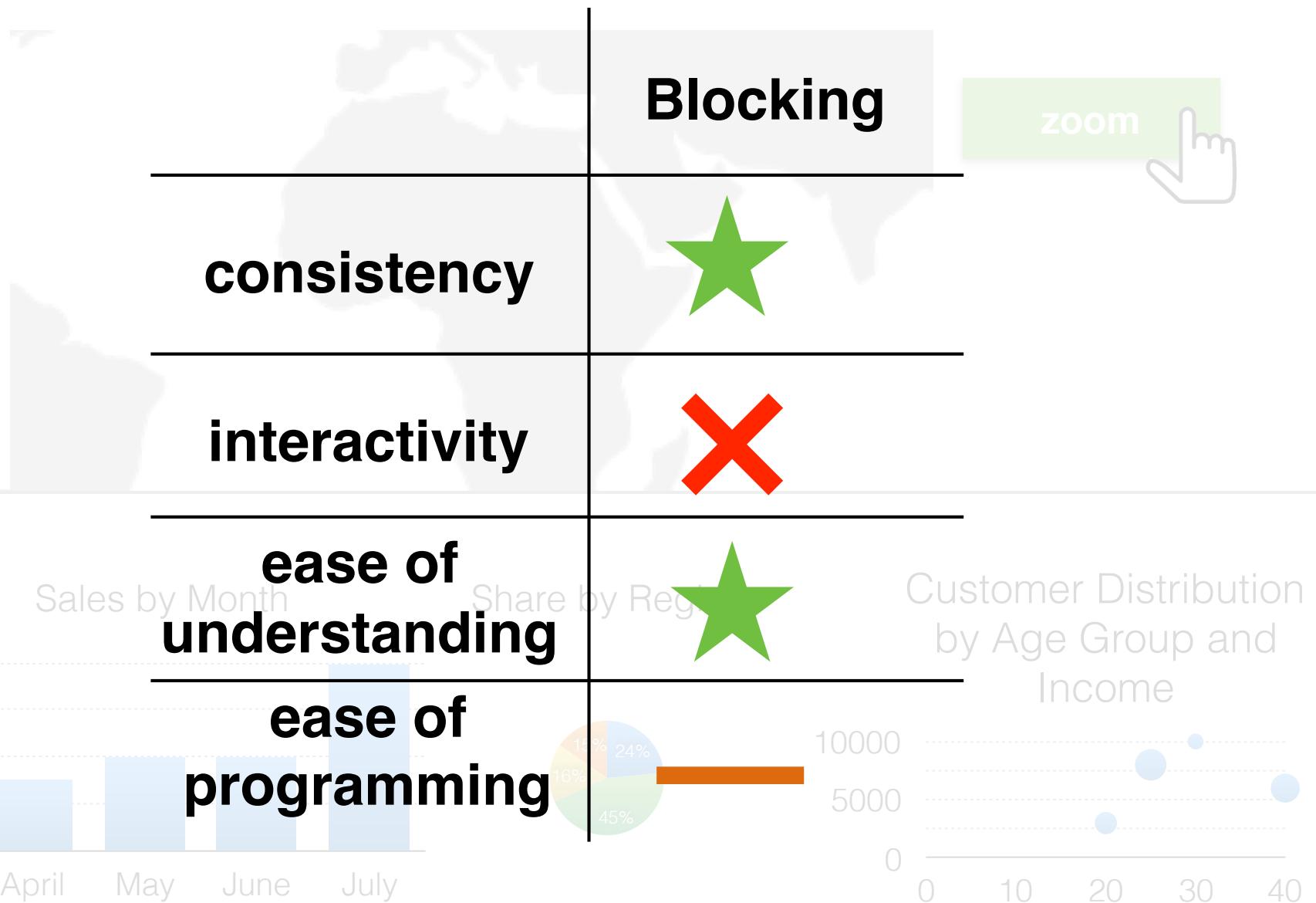
Blocking



Blocking



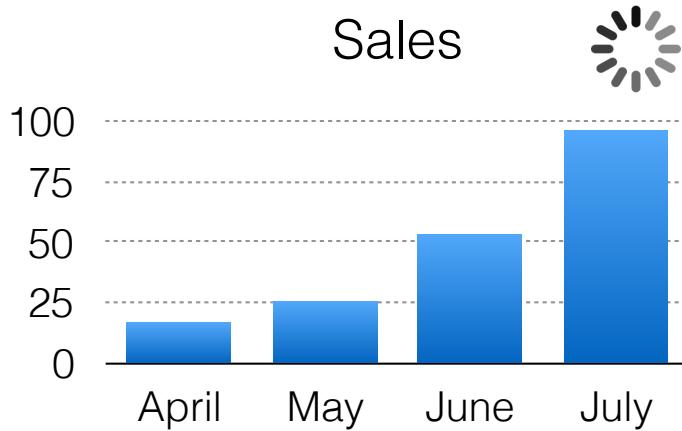
Blocking



Spinners



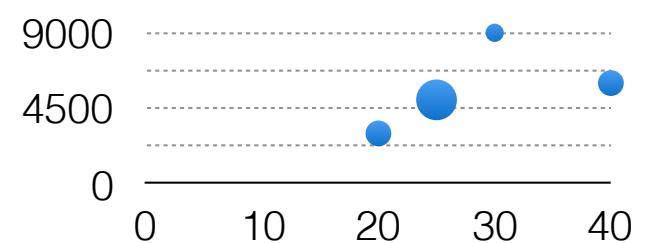
zoom



Share by Region



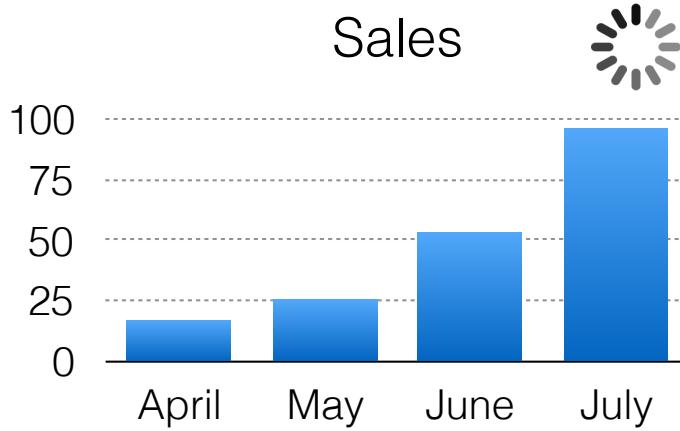
Customer
Distribution by Age
Group and Income



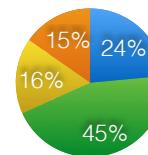
Spinners



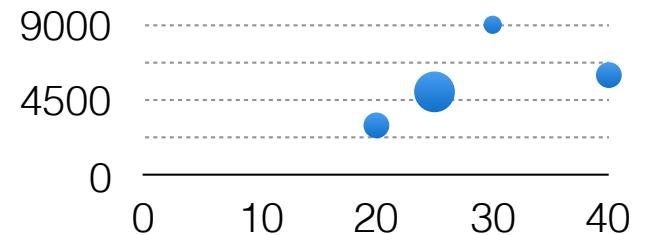
zoom



Share by Region



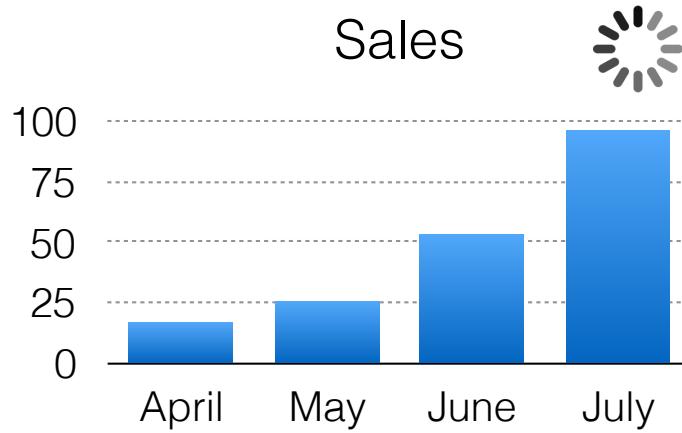
Customer
Distribution by Age
Group and Income



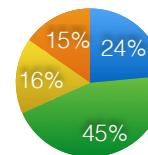
Spinners



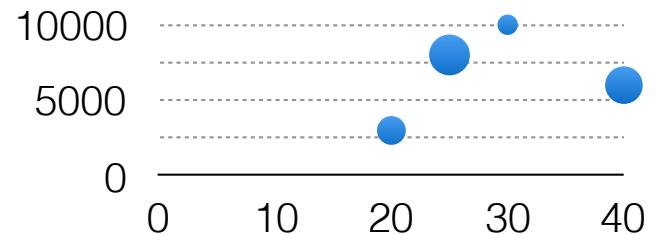
zoom



Share by Region



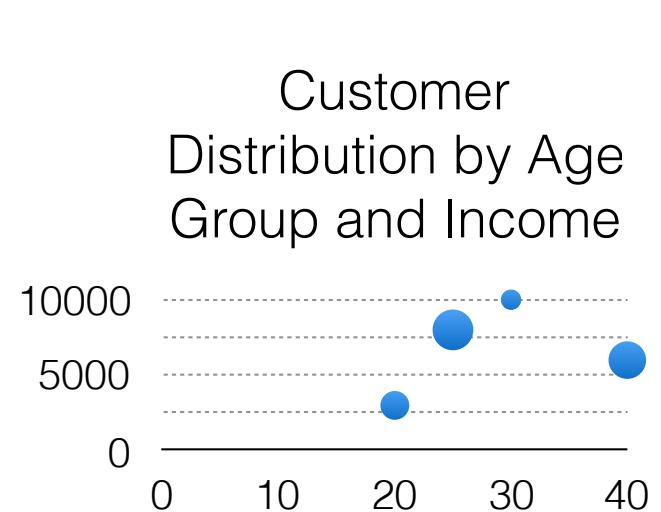
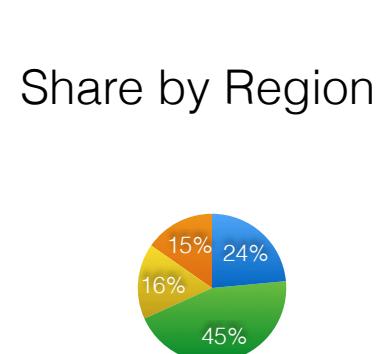
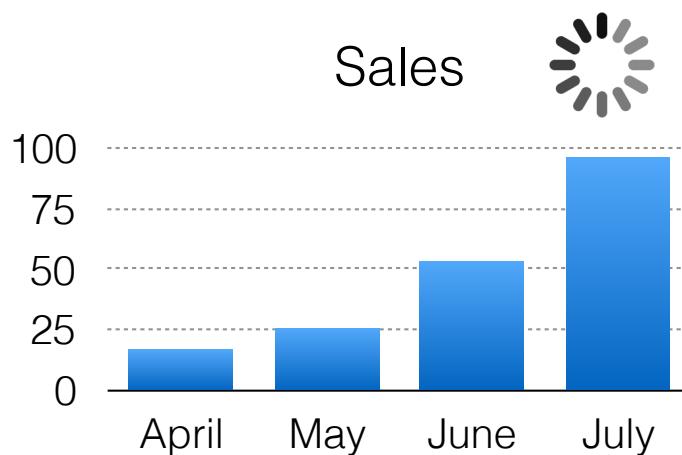
Customer Distribution by Age Group and Income



Spinners, Multiple Zoom Levels



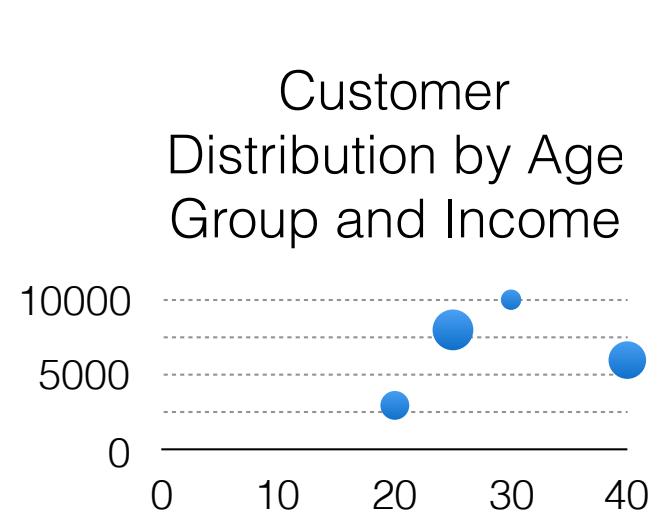
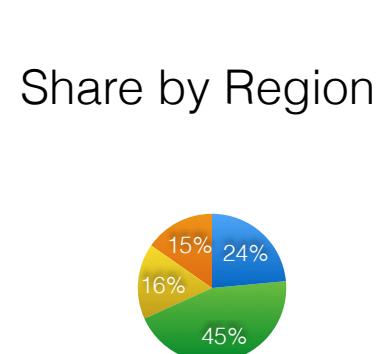
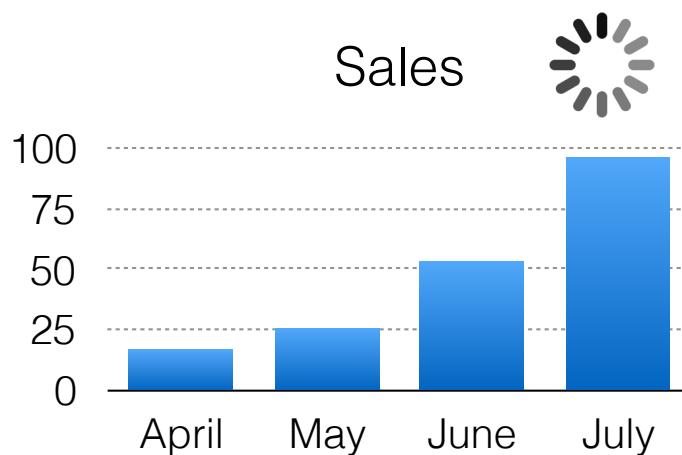
zoom



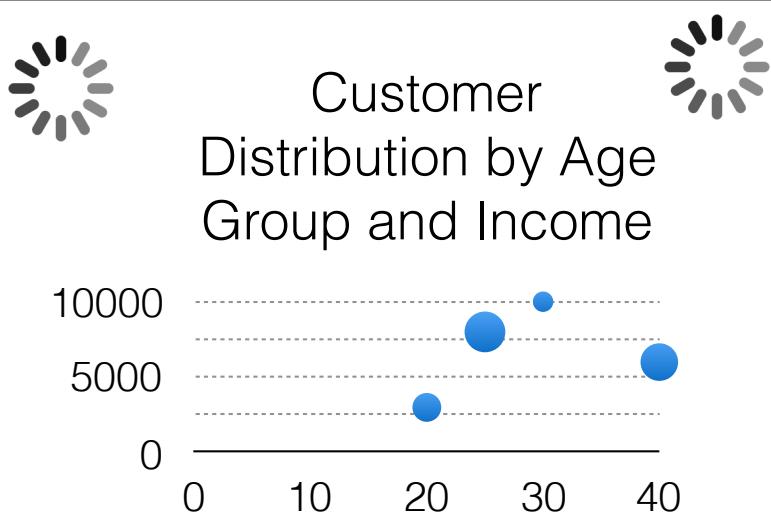
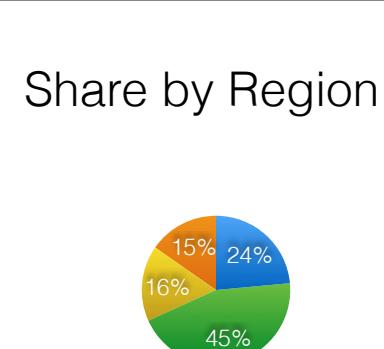
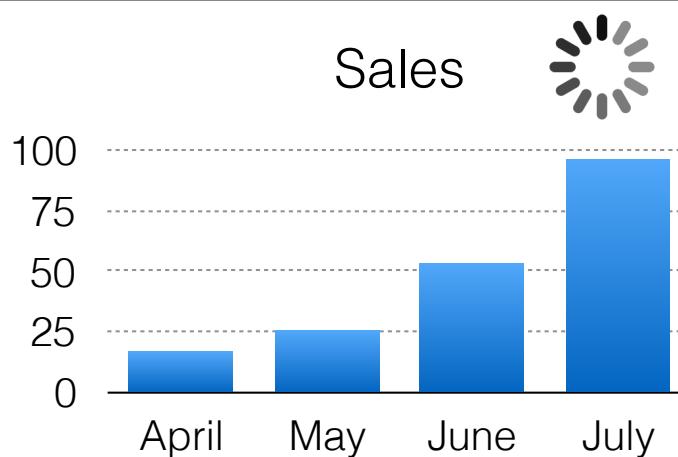
Spinners, Multiple Zoom Levels



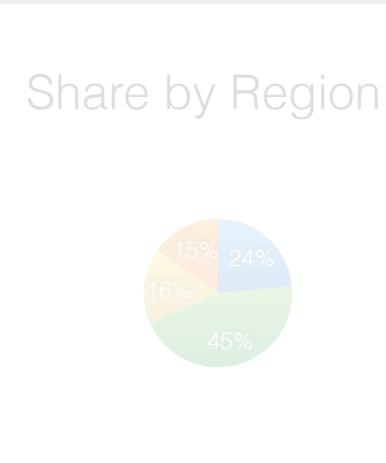
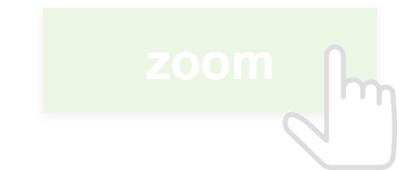
zoom



Spinners, Multiple Zoom Levels

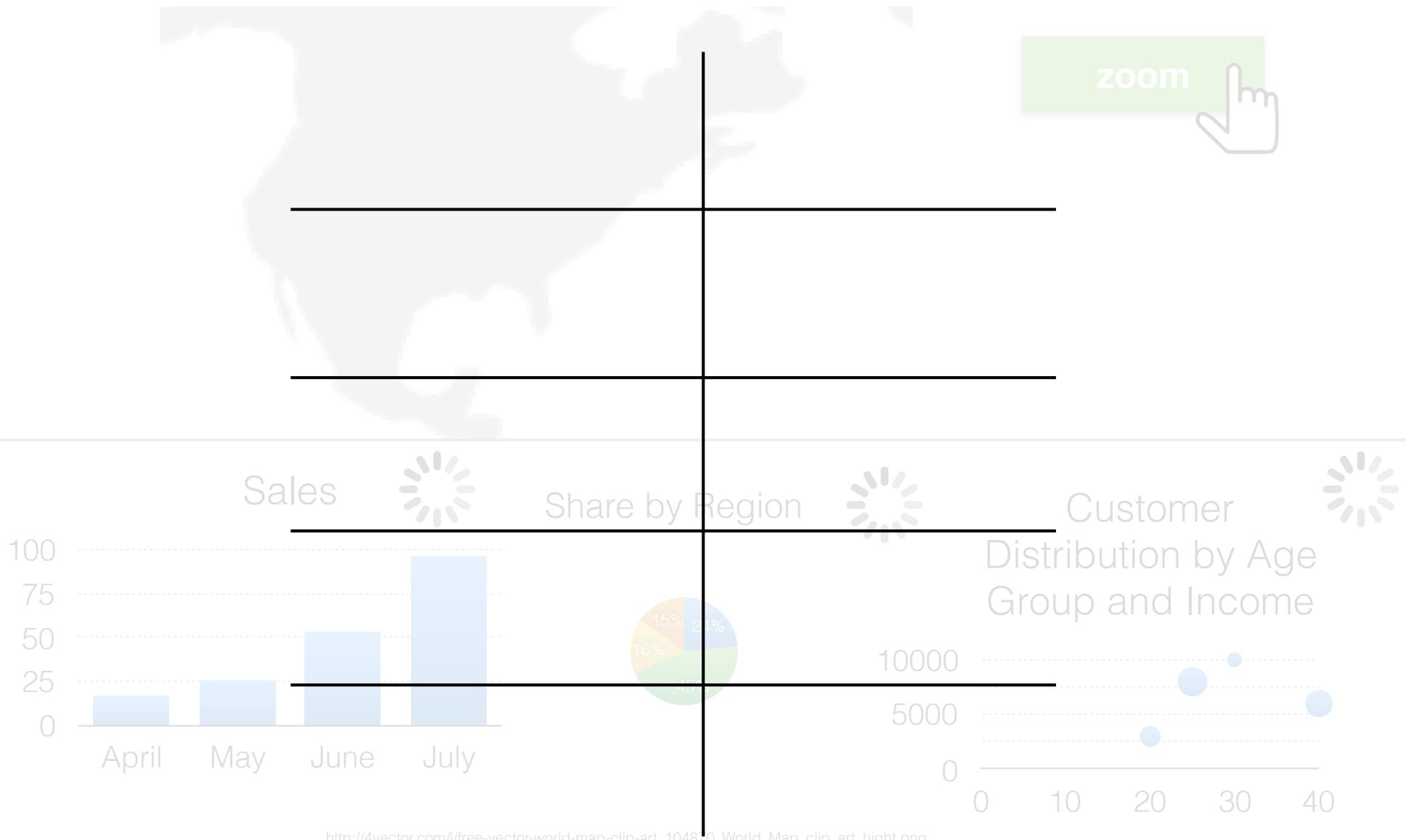


Spinners, Multiple Zoom Levels

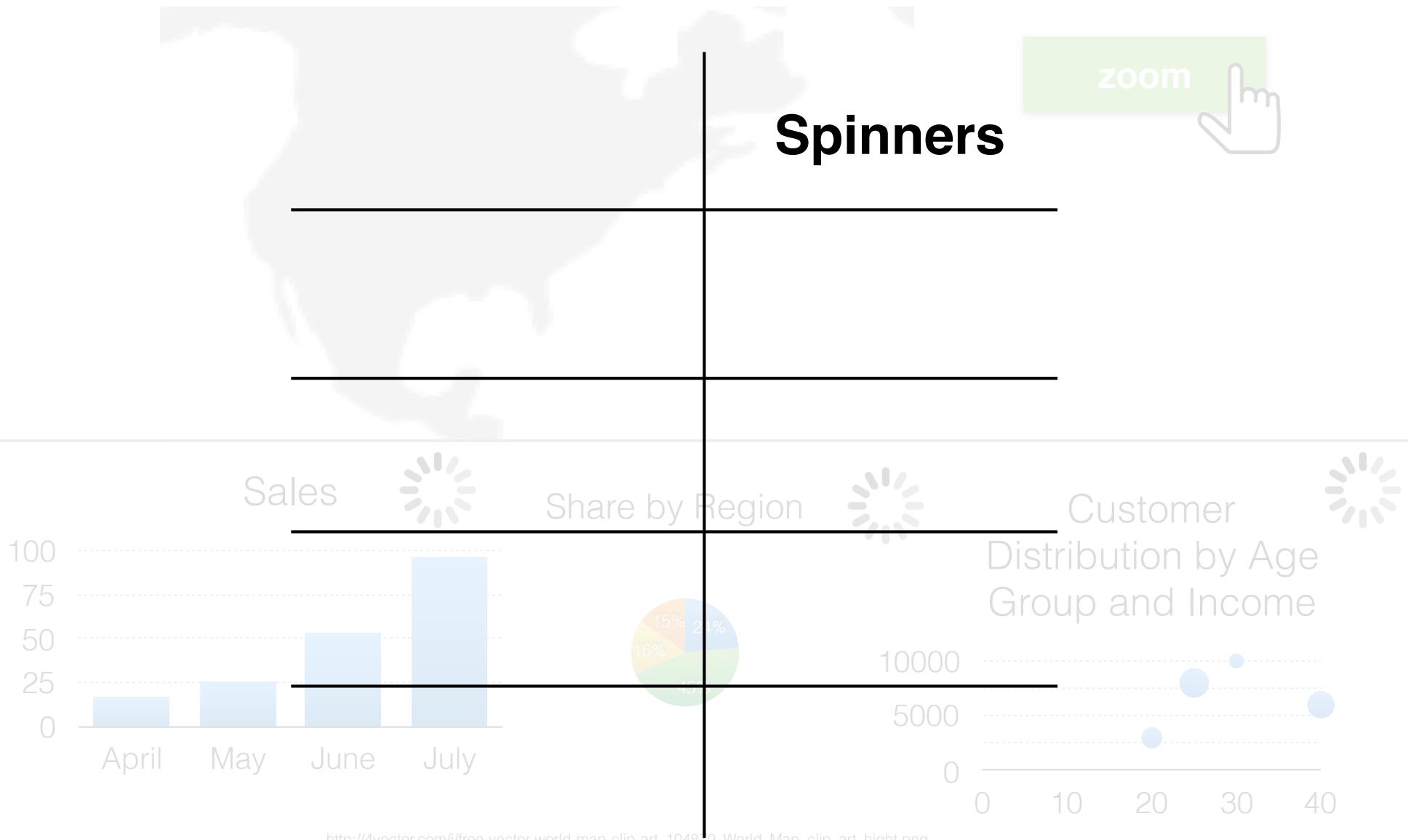


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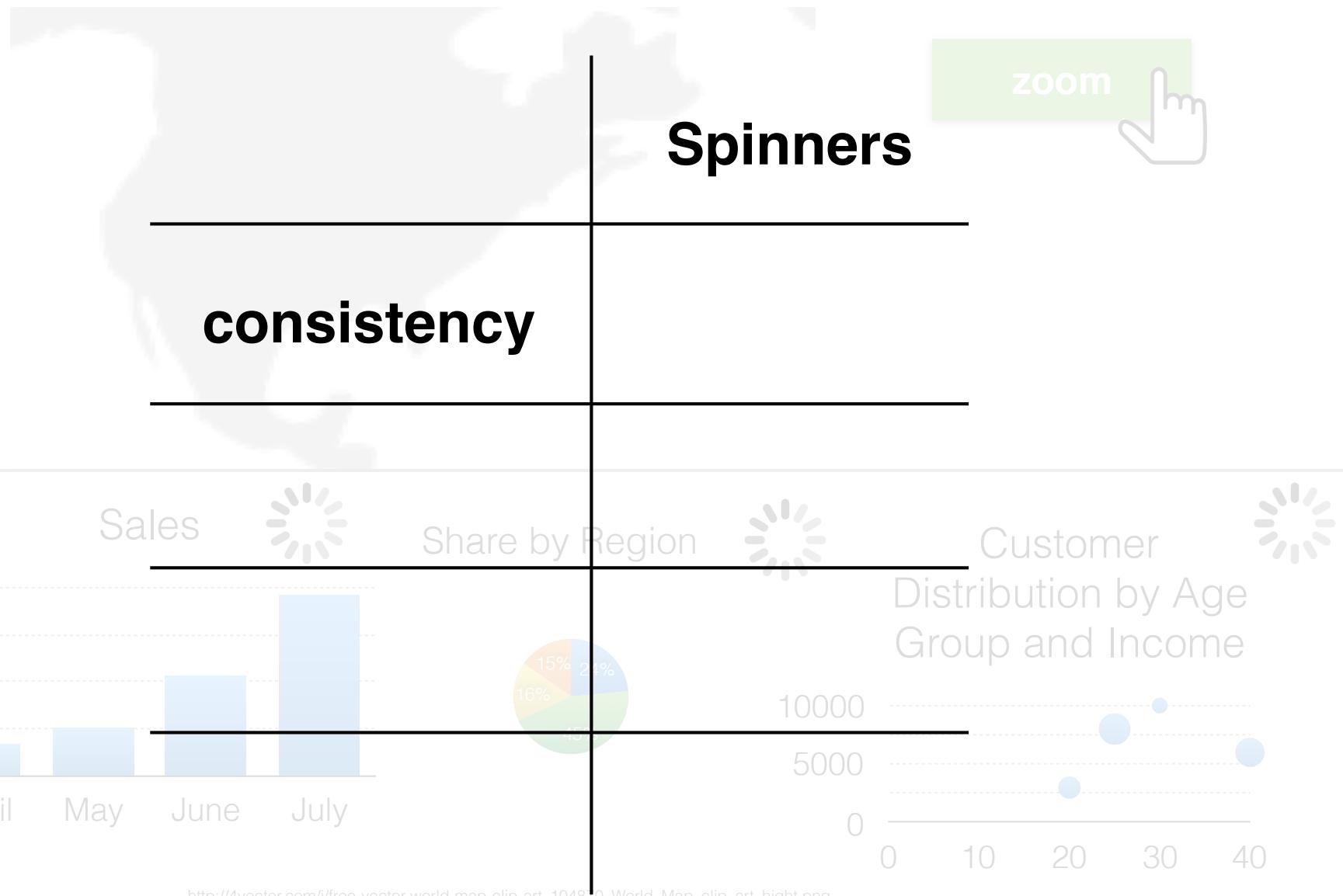
Spinners, Multiple Zoom Levels



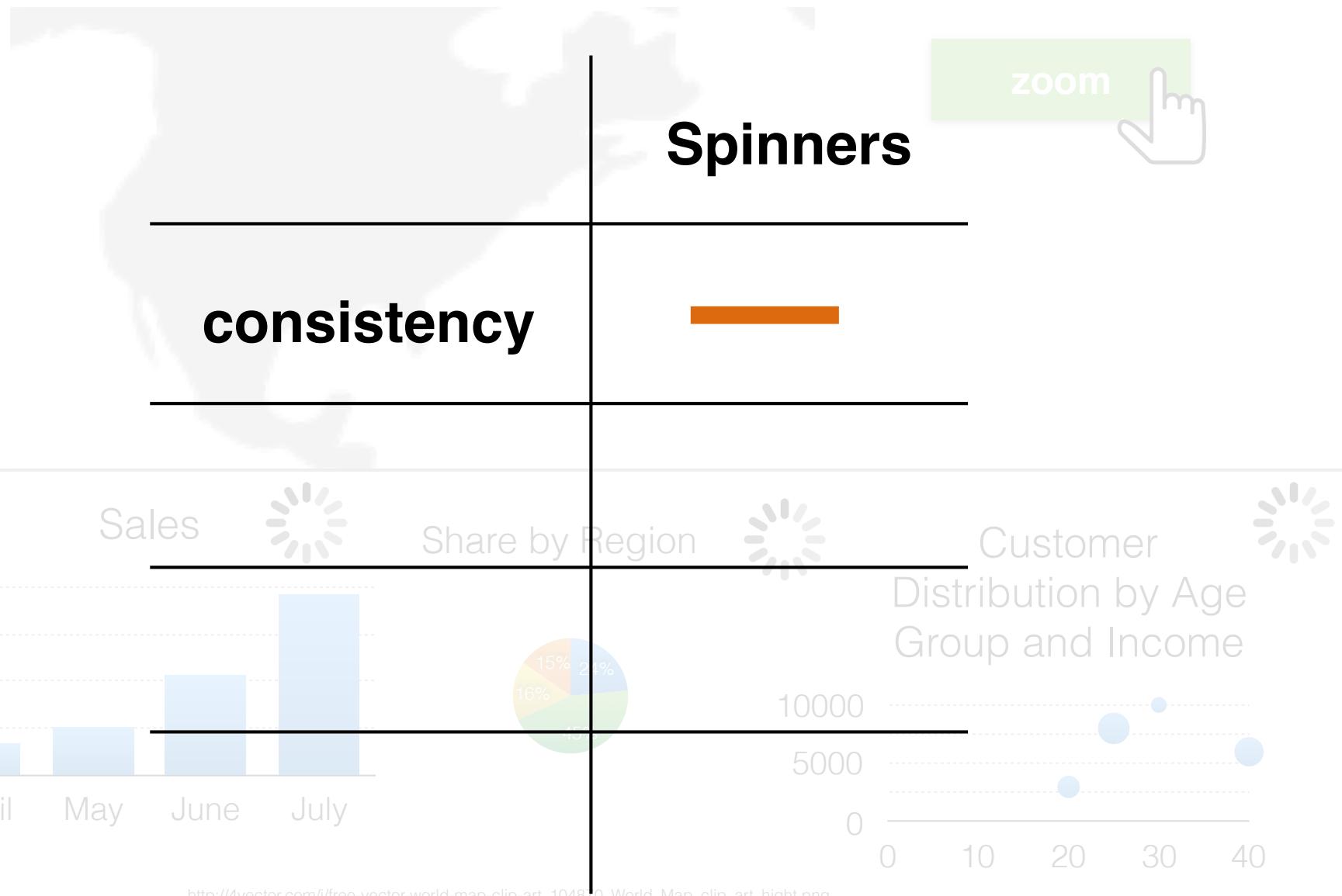
Spinners, Multiple Zoom Levels



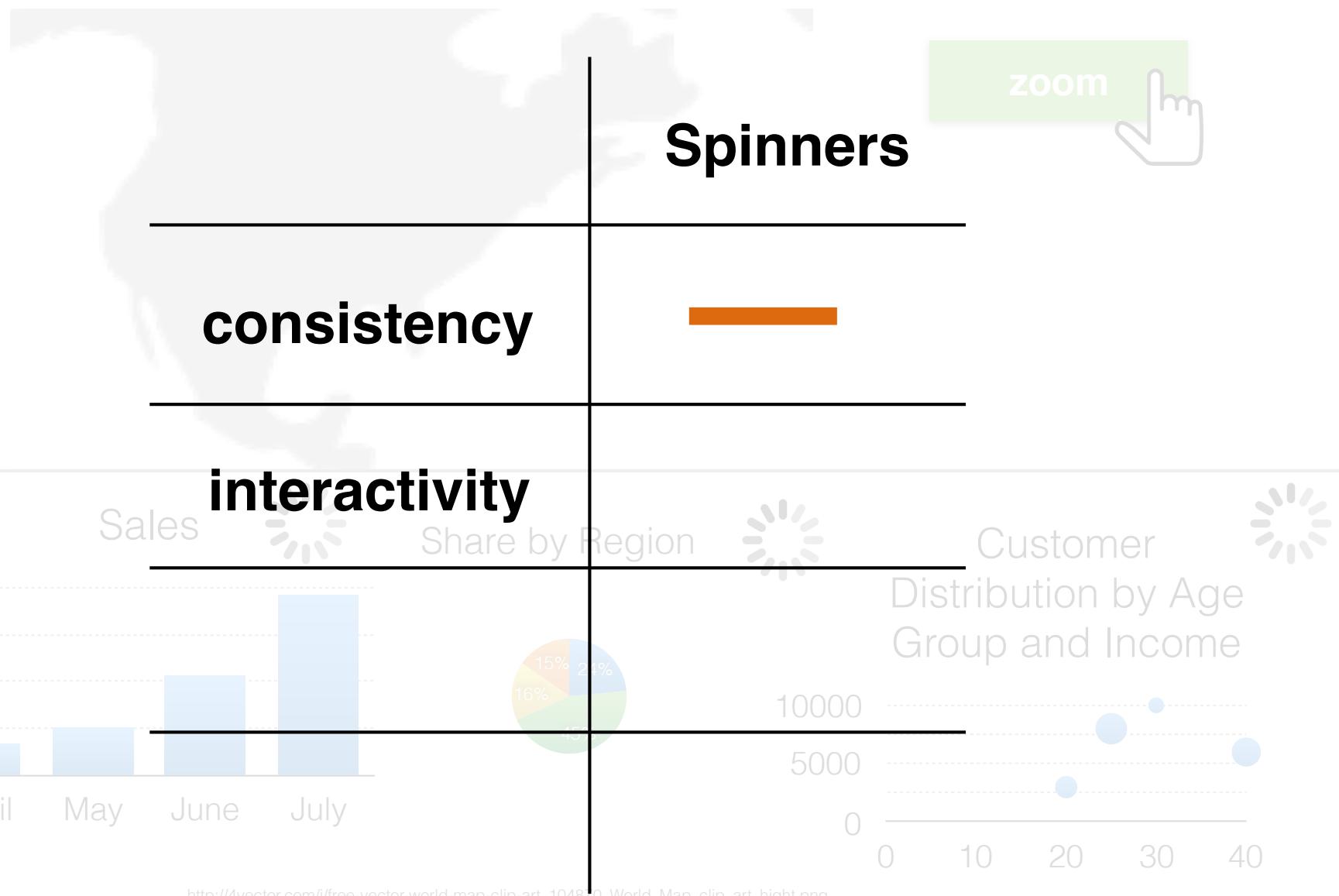
Spinners, Multiple Zoom Levels



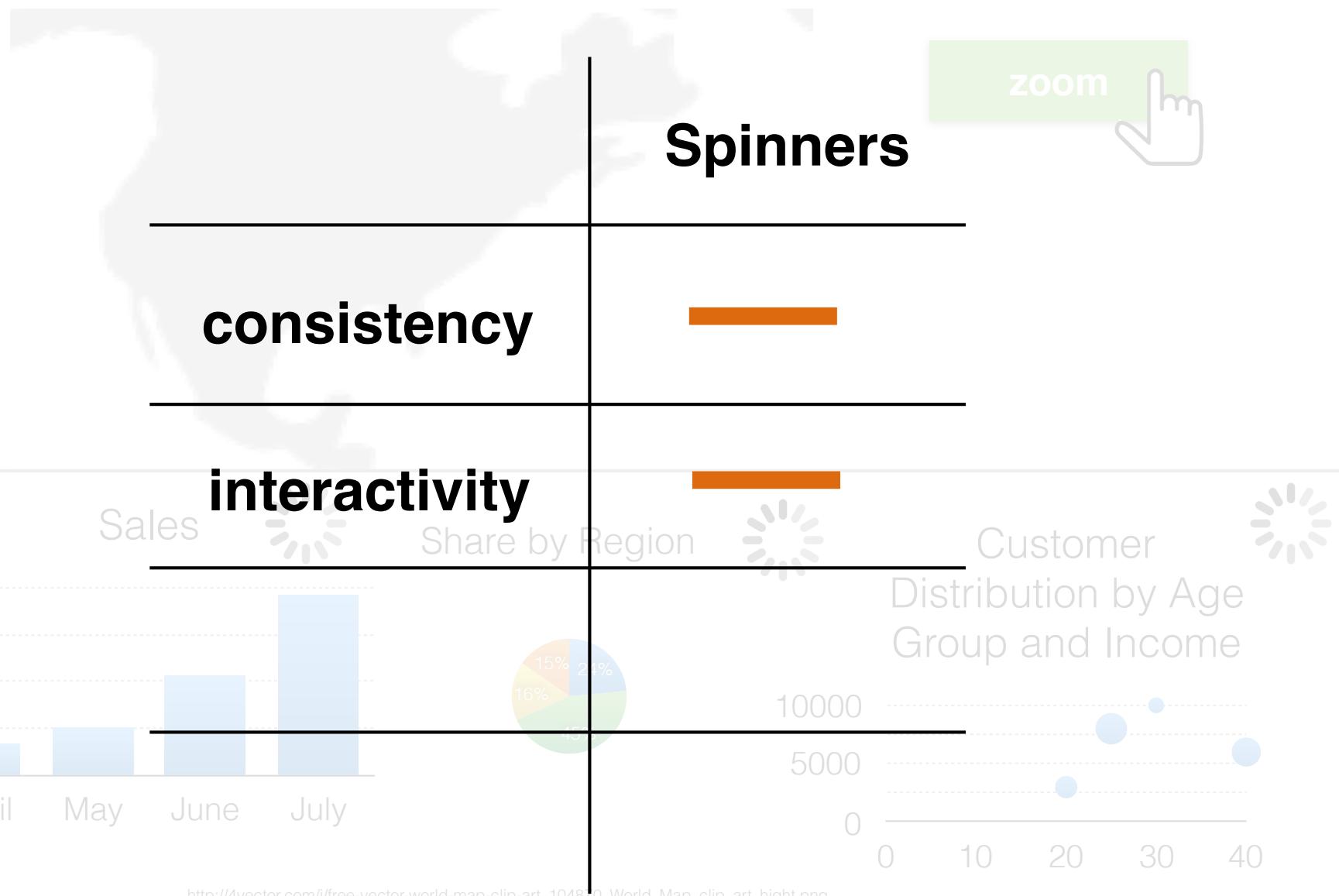
Spinners, Multiple Zoom Levels



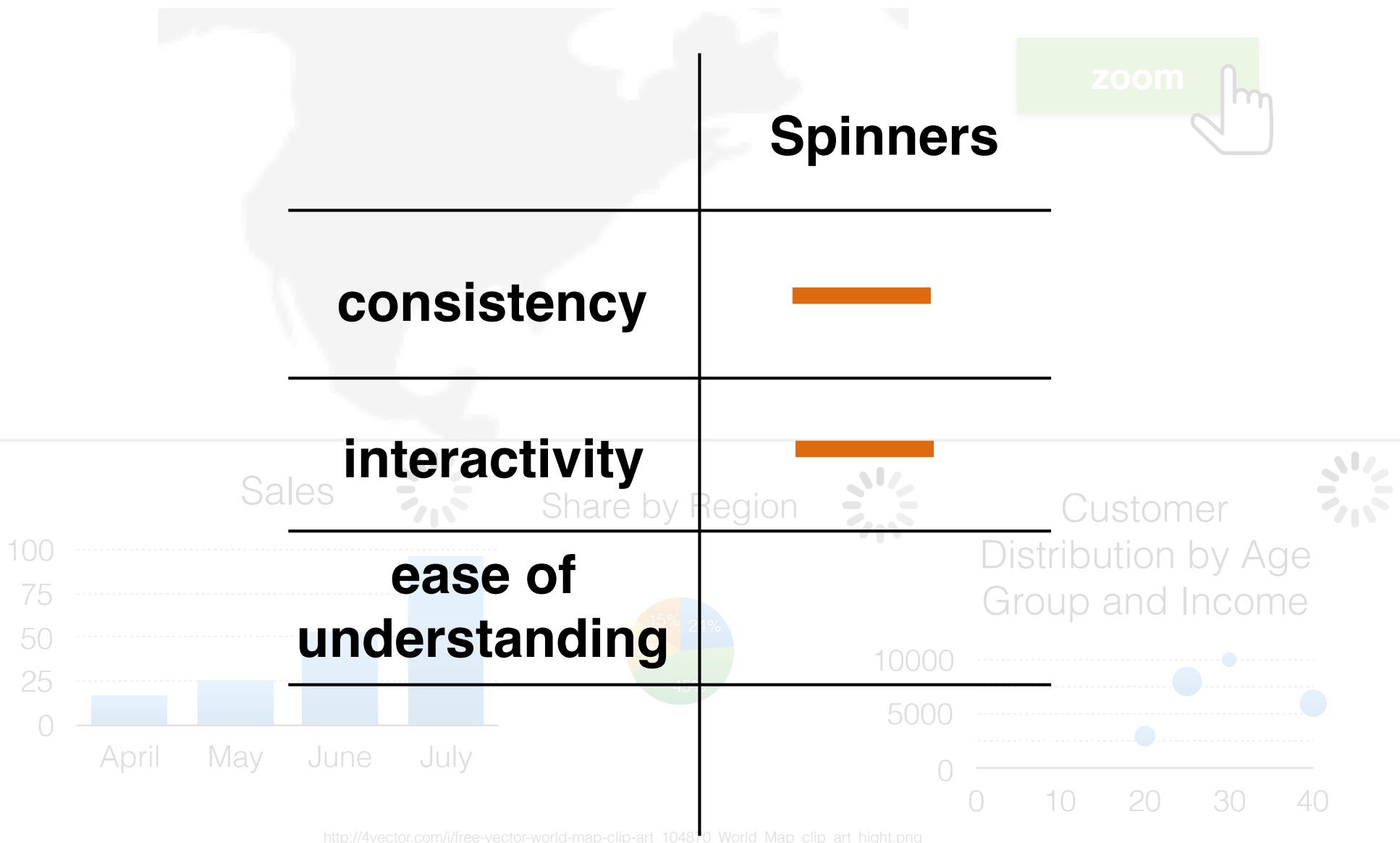
Spinners, Multiple Zoom Levels



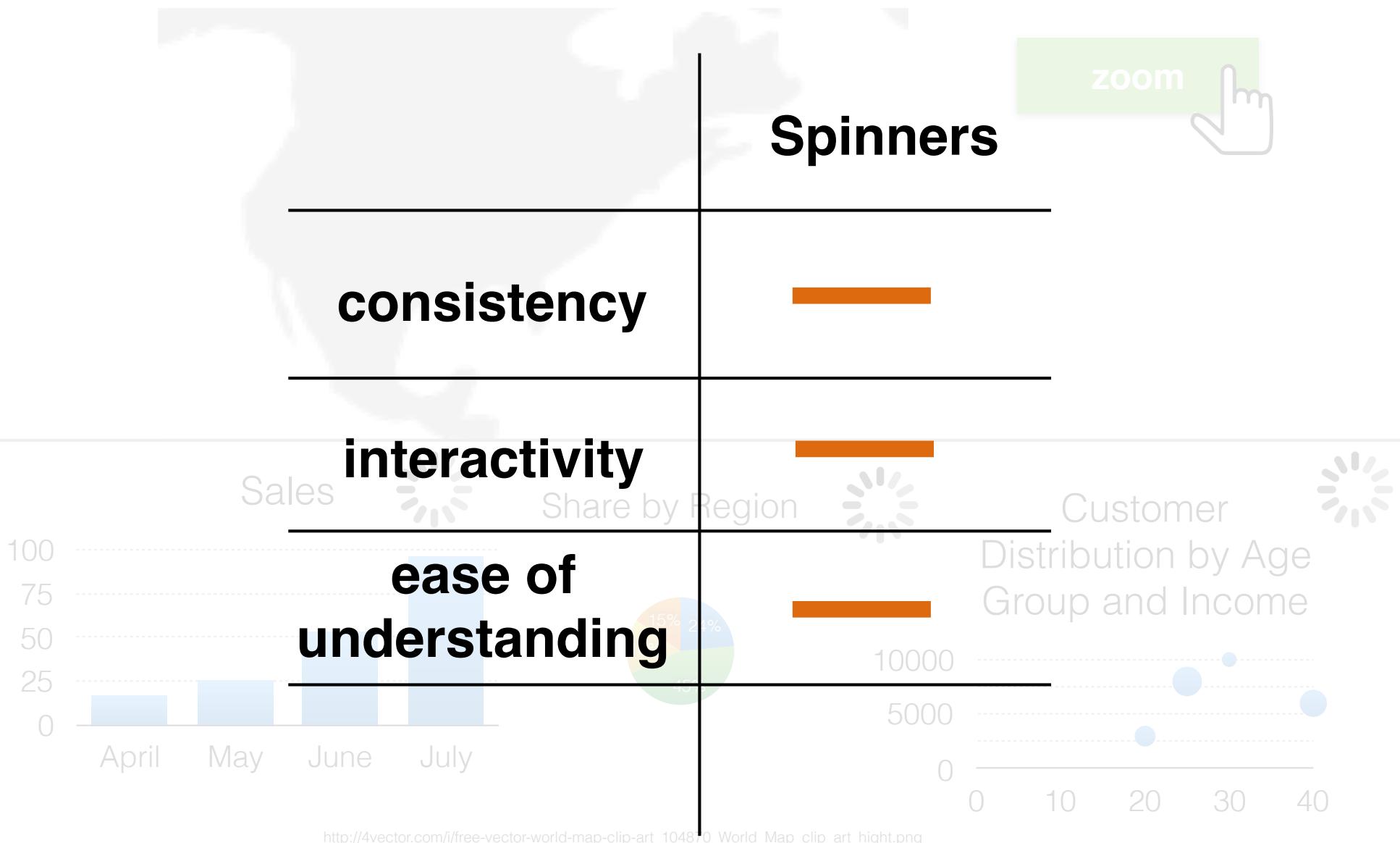
Spinners, Multiple Zoom Levels



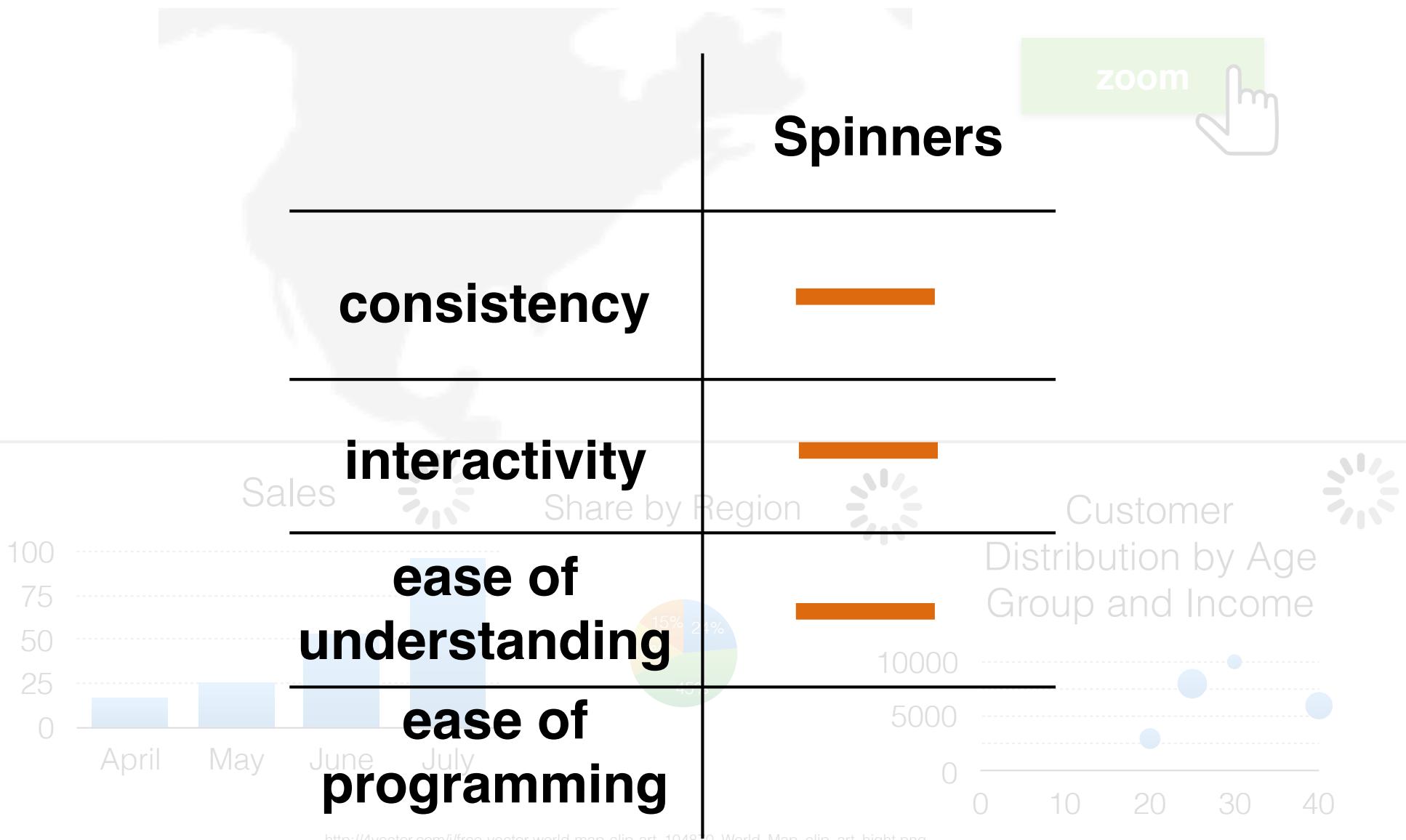
Spinners, Multiple Zoom Levels



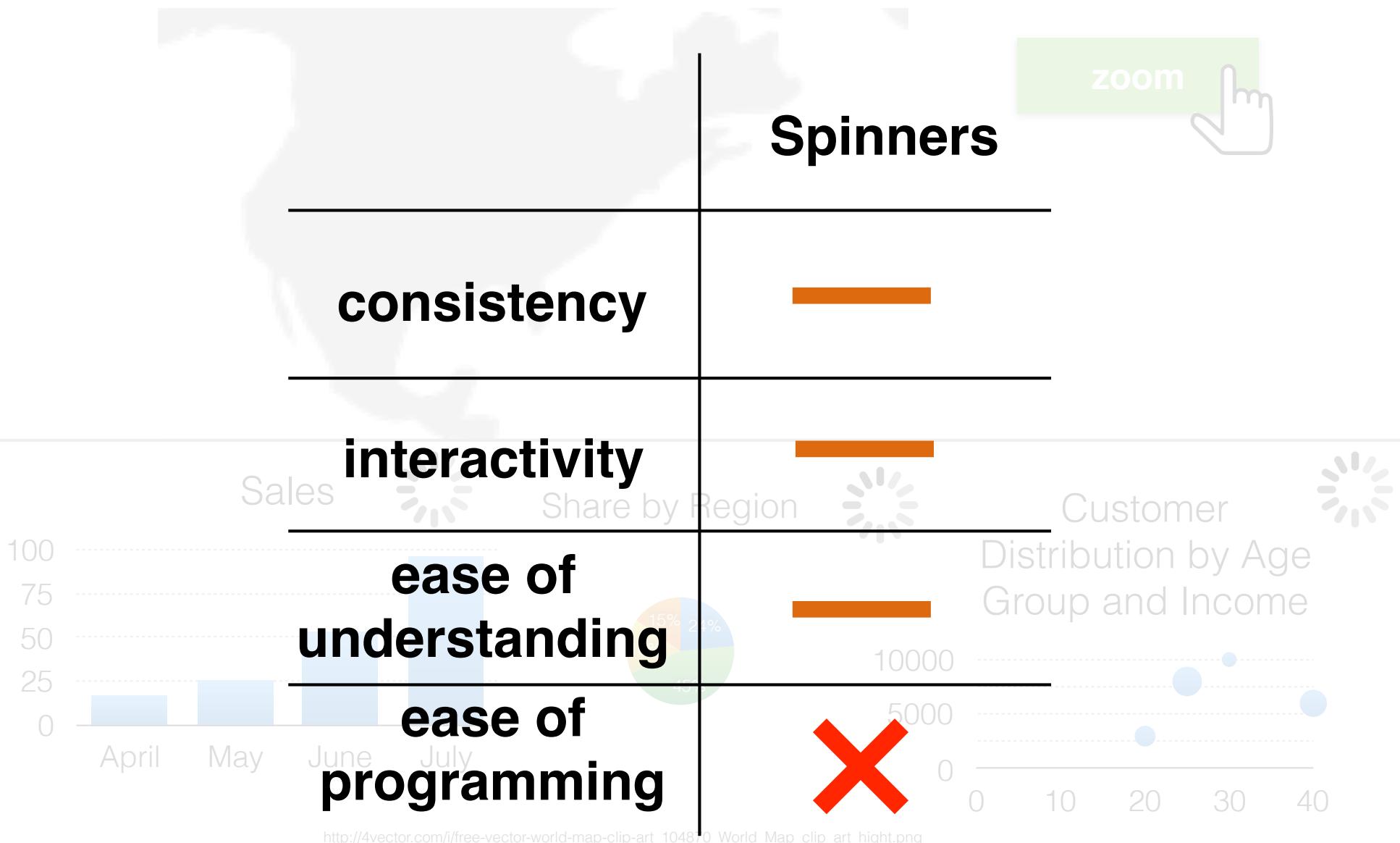
Spinners, Multiple Zoom Levels



Spinners, Multiple Zoom Levels



Spinners, Multiple Zoom Levels

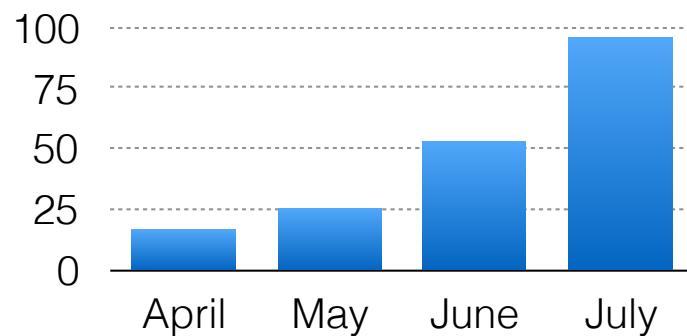


Labeling



zoom

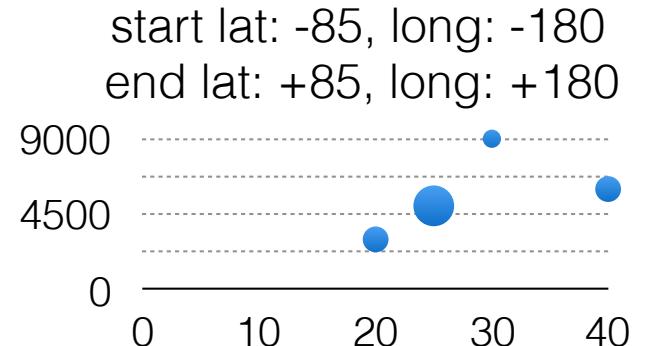
Sales by Month
start lat: -85 long: -180
end lat: +85, long: +180



Share by Region
start lat: -85, long: -180
end lat: +85, long: +180



Customer Distribution
by Age Group and
Income

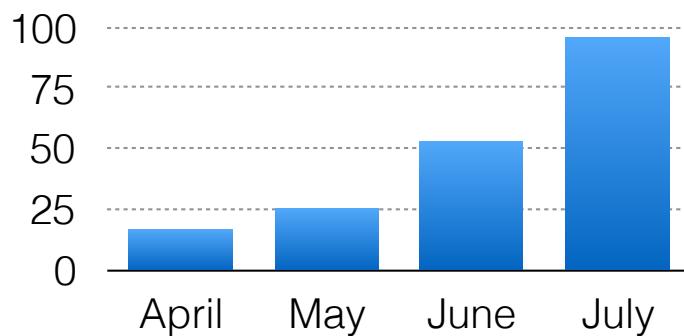


Labeling



Sales by Month

start lat: -85 long: -180
end lat: +85, long: +180



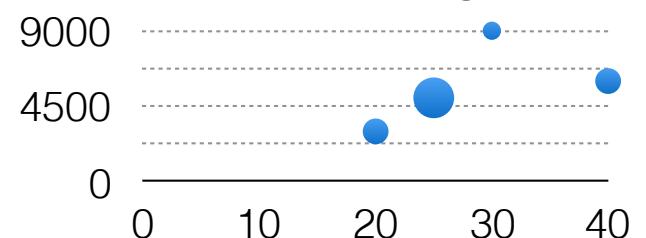
Share by Region

start lat: -85, long: -180
end lat: +85, long: +180



Customer Distribution
by Age Group and
Income

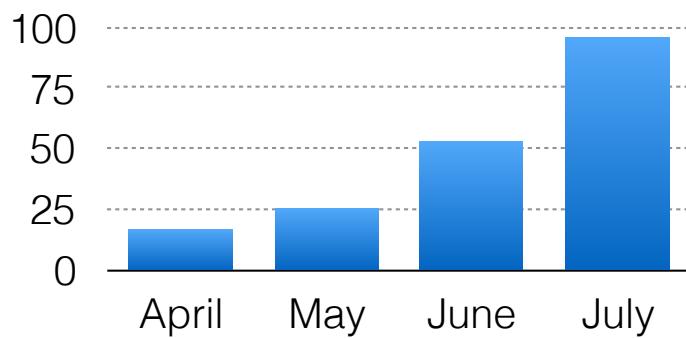
start lat: -85, long: -180
end lat: +85, long: +180



Labeling



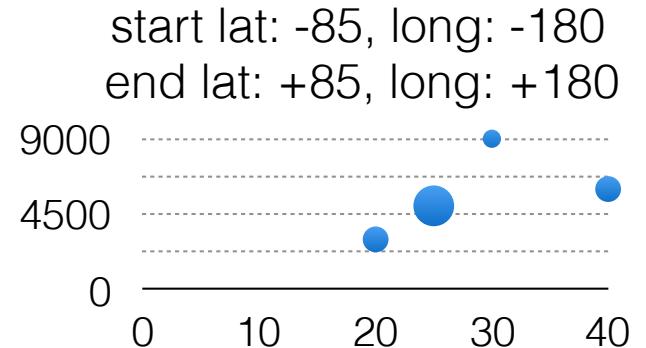
Sales by Month
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end lat: +85, long: +180



Share by Region
start lat: -85, long: -180
end lat: +85, long: +180



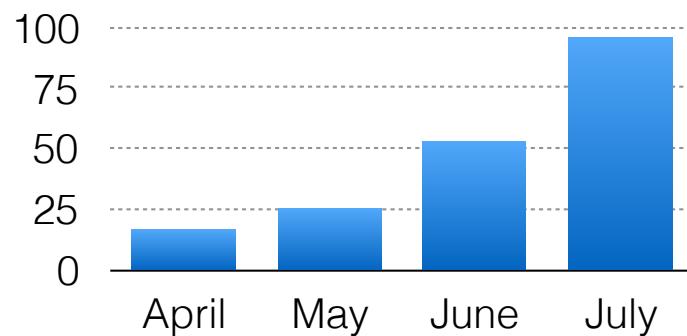
Customer Distribution
by Age Group and
Income



Labeling



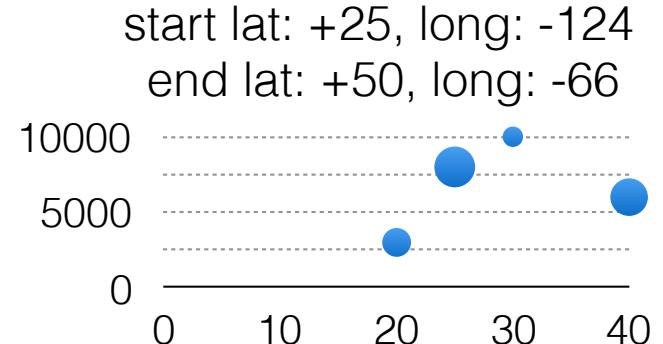
Sales by Month
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end lat: +85, long: +180



Share by Region
start lat: -85, long: -180
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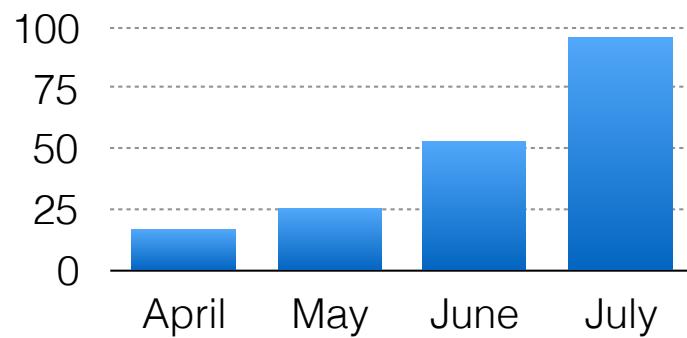
Customer Distribution
by Age Group and
Income



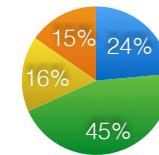
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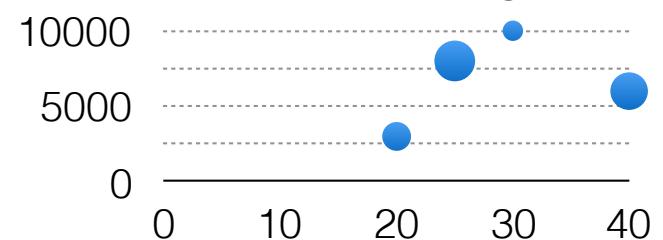
Sales by Month
start lat: -85 long: -180
end lat: +85, long: +180



Share by Region
start lat: +25, long: -124
end lat: +50, long: -66



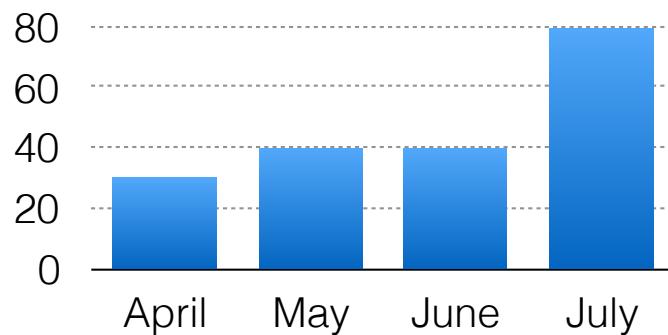
Customer Distribution
by Age Group and
Income



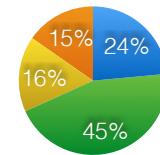
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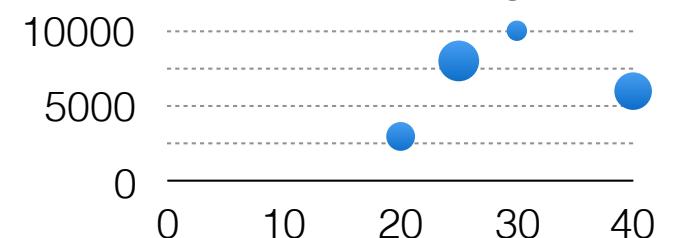
Sales by Month
start lat: +25, long: -124
end lat: +50, long: -66



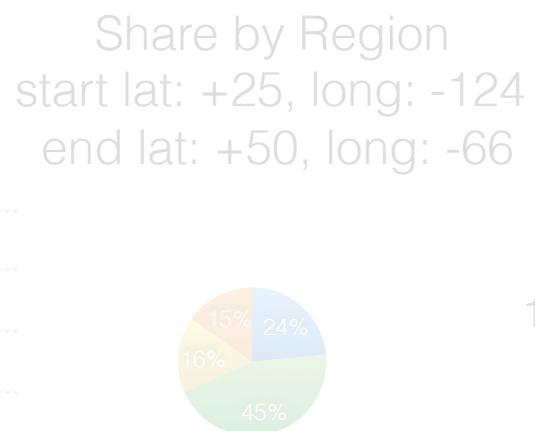
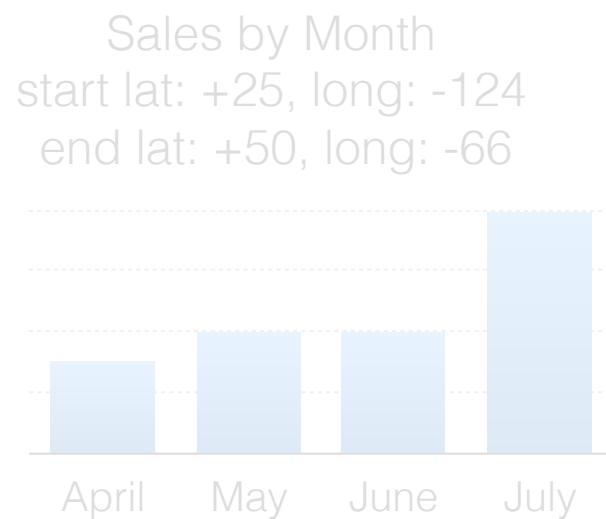
Share by Region
start lat: +25, long: -124
end lat: +50, long: -66



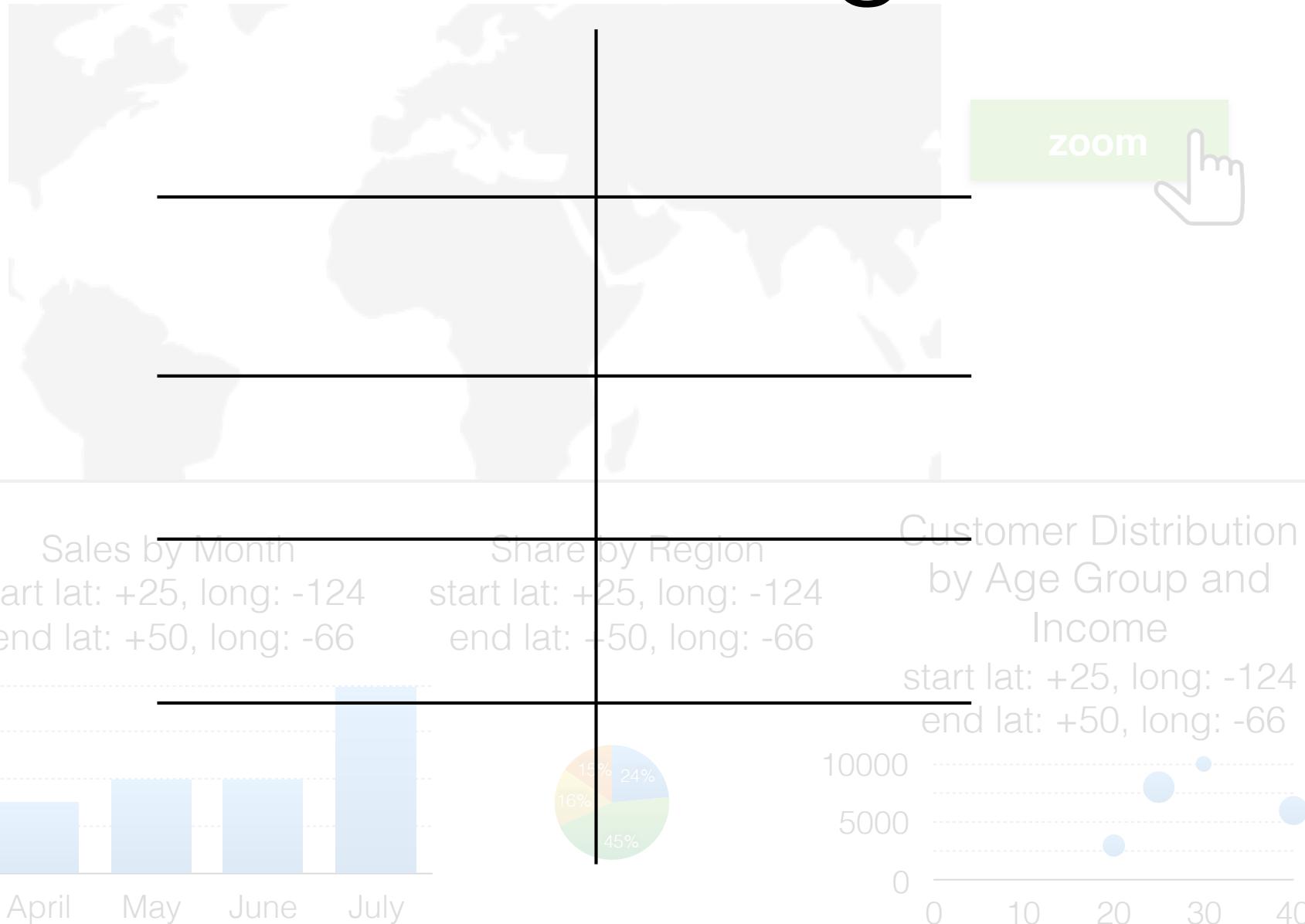
Customer Distribution
by Age Group and
Income



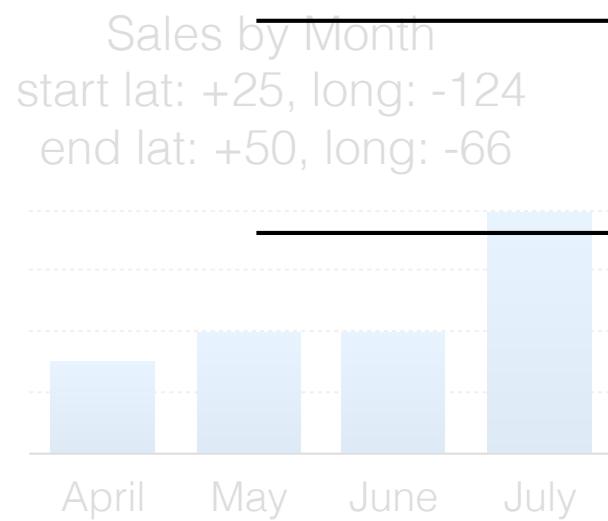
Labeling



Labeling



Labeling



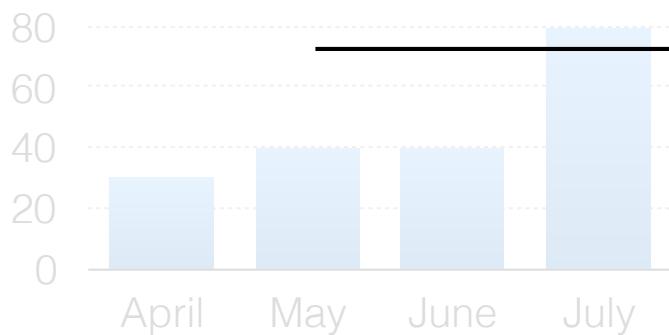
Labeling

Labeling

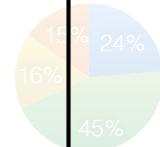
zoom

consistency

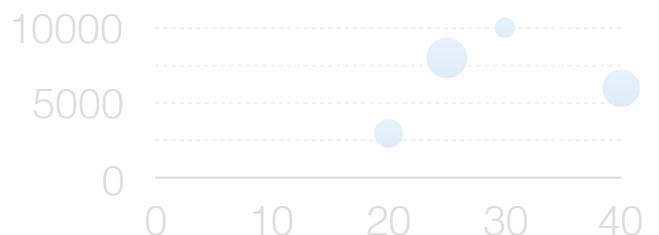
Sales by Month
start lat: +25, long: -124
end lat: +50, long: -66



Share by Region
start lat: +25, long: -124
end lat: +50, long: -66



Customer Distribution
by Age Group and
Income
start lat: +25, long: -124
end lat: +50, long: -66



Labeling

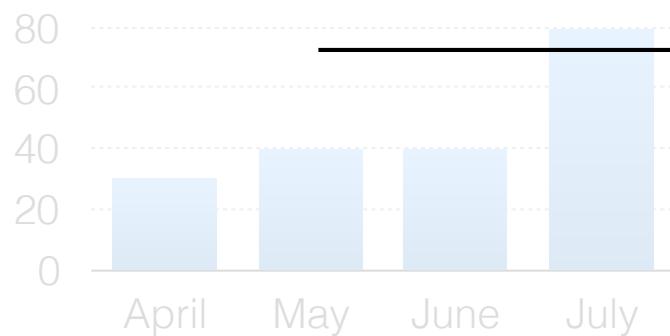
Labeling

zoom

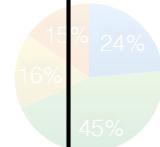


consistency

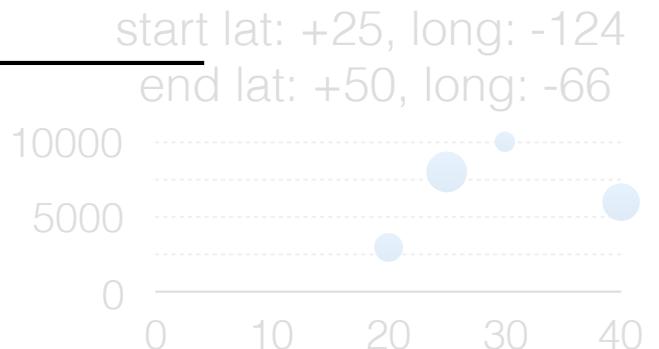
Sales by Month
start lat: +25, long: -124
end lat: +50, long: -66



Share by Region
start lat: +25, long: -124
end lat: +50, long: -66



Customer Distribution
by Age Group and
Income



Labeling

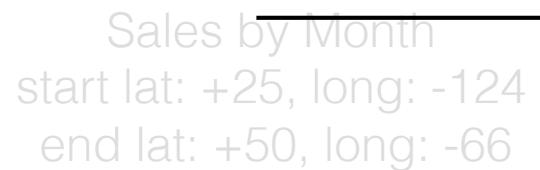
Labeling

zoom

consistency



interactivity



Labeling

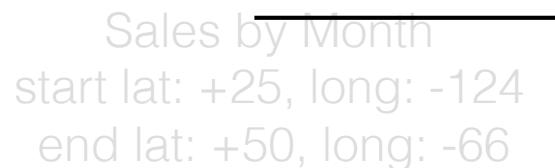
Labeling

zoom

consistency



interactivity



Labeling

Labeling



consistency



interactivity

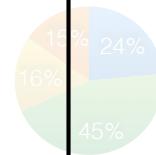


Sales by Month

start lat: +25, long: eas
end lat: +50, long: -66
under



Share by Region
lat: +25, long: -124
lat: -50, long: -66



Customer Distribution by Age Group and Income

Labeling

Labeling



consistency



interactivity

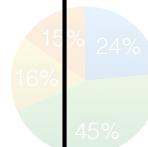
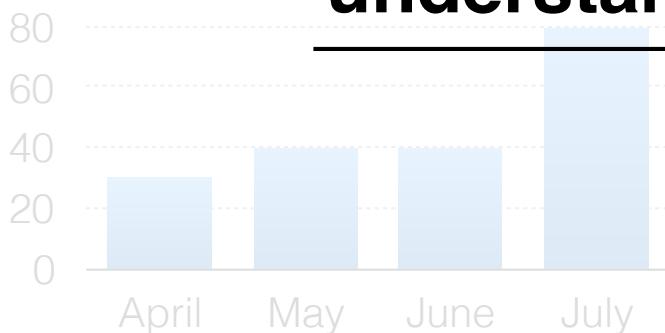


Sales by Month

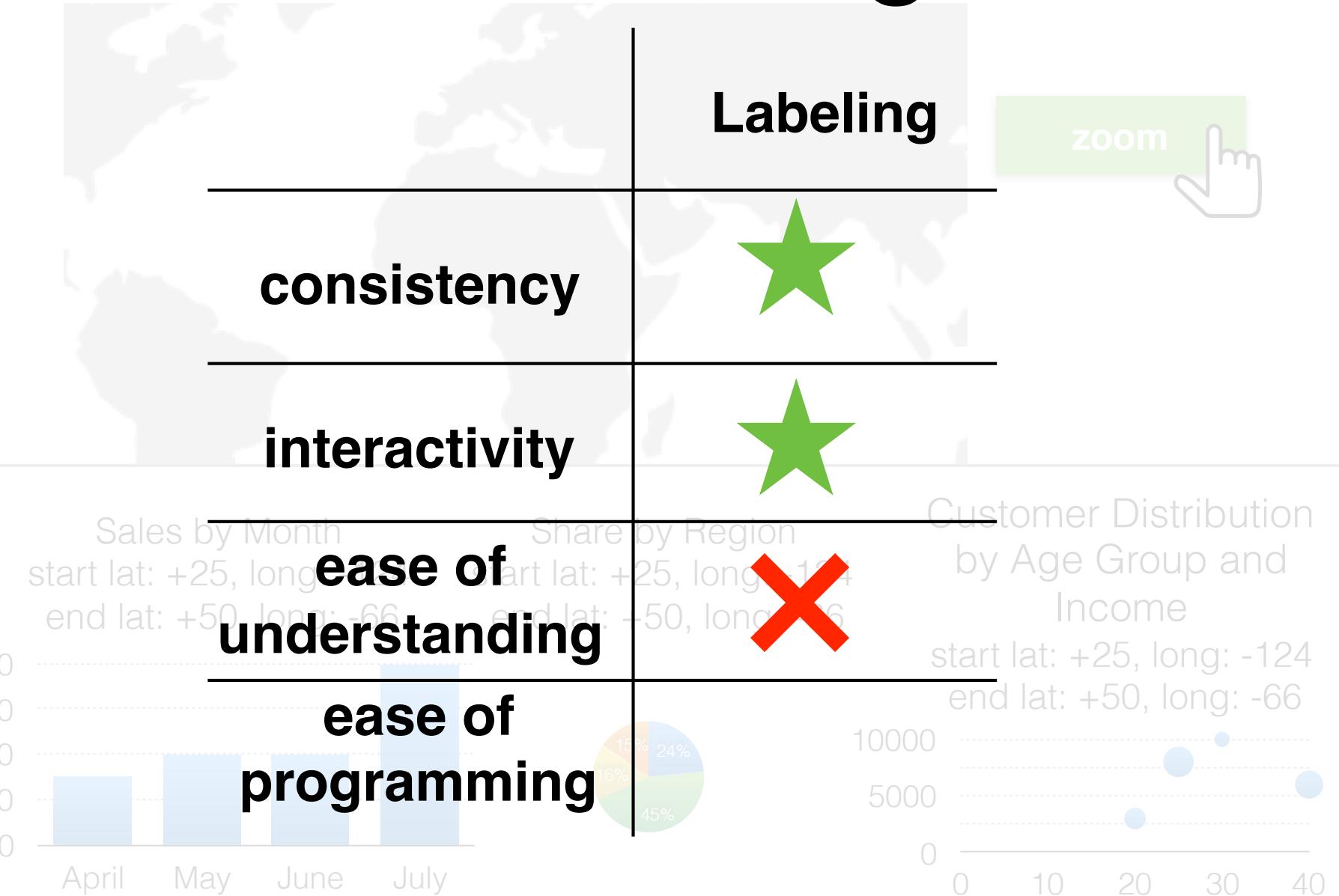
start lat: +25, long: -100 end lat: +50, long: -66

Share start lat: end lat:

ease of understanding



Labeling



Labeling

Labeling



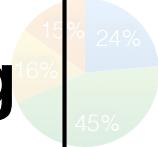
consistency



interactivity

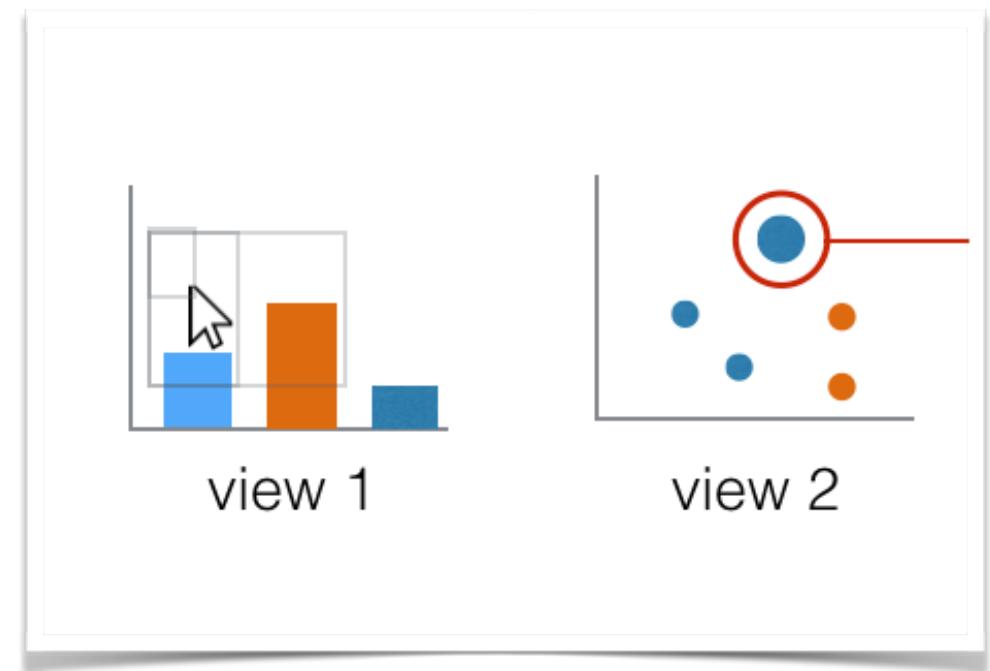


ease of understanding

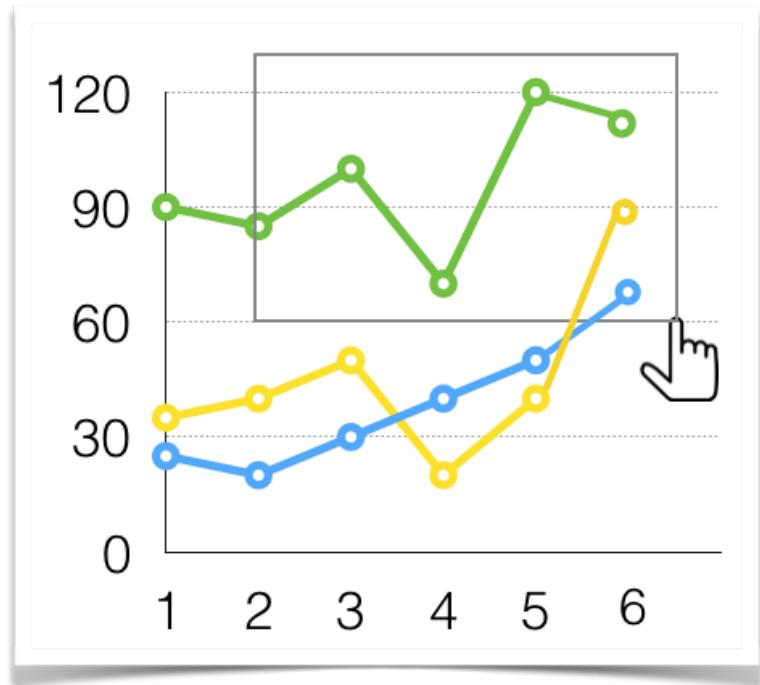


ease of programming

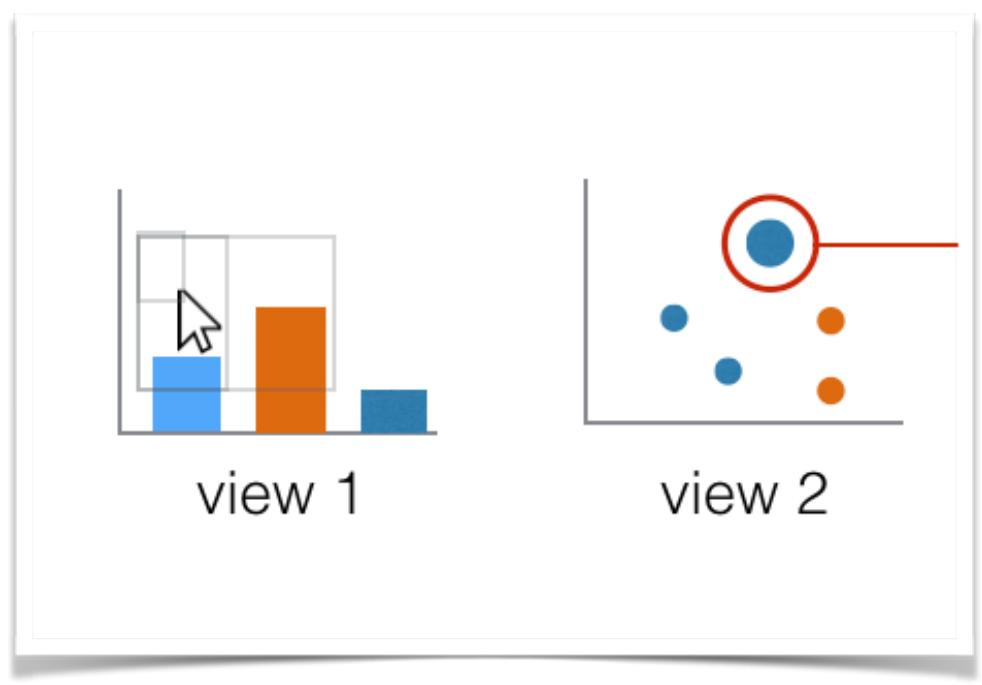
Unaccounted for Anomalies



Unaccounted for Anomalies



Unclear Selection



Overwritten Marks

Design Space

consistency			
interactivity			
ease of understanding			
ease of programming			

Design Space

	Anything Goes			
consistency				
interactivity				
ease of understanding				
ease of programming				

Design Space

	Anything Goes			
consistency	X			
interactivity				
ease of understanding				
ease of programming				

Design Space

	Anything Goes			
consistency				
interactivity				
ease of understanding				
ease of programming				

Design Space

	Anything Goes			
consistency				
interactivity				
ease of understanding				
ease of programming				

Design Space

	Anything Goes			
consistency				
interactivity				
ease of understanding				
ease of programming				

Design Space

	Anything Goes	Blocking	Spinners	Labeling
consistency	✗	★	—	★
interactivity	★	✗	—	★
ease of understanding	✗	★	—	✗
ease of programming	★	—	✗	✗

front end engineering?

front end engineering?
or distributed systems?

front end engineering?
or distributed systems?

It's all data centric programming.

front end engineering?
or distributed systems?

It's all data centric programming.

The front-end is a database!



front end engineering?



or distributed systems?

It's all data centric programming.

The front-end is a database!

database_techniques(**reordering**)

=

consistency & declarativity



Data-Driven Documents

Select Project Join



Streams and Iterators



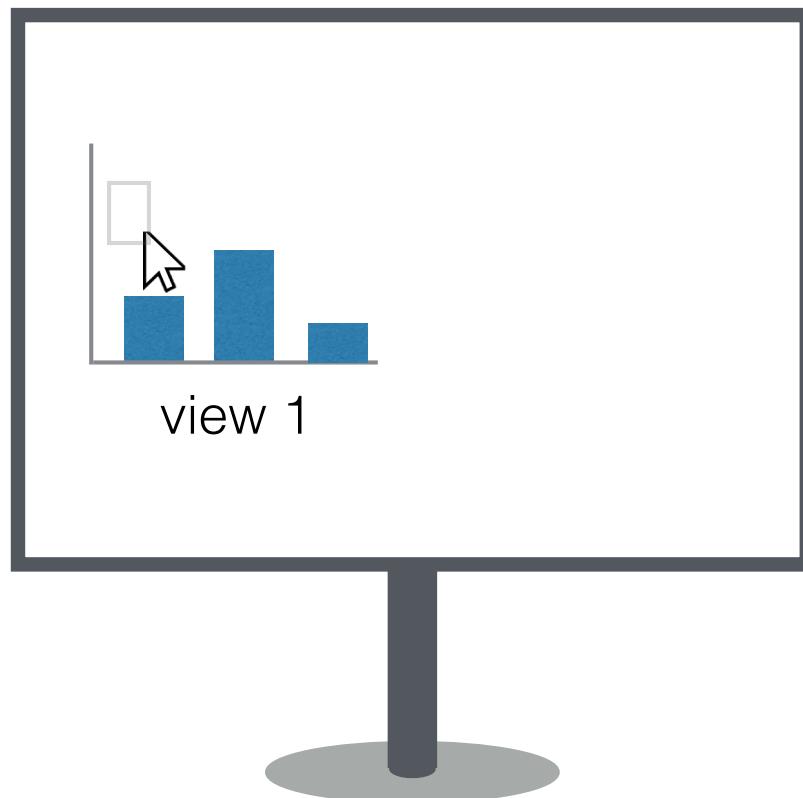
Query Optimization

Dealing with Inconsistency

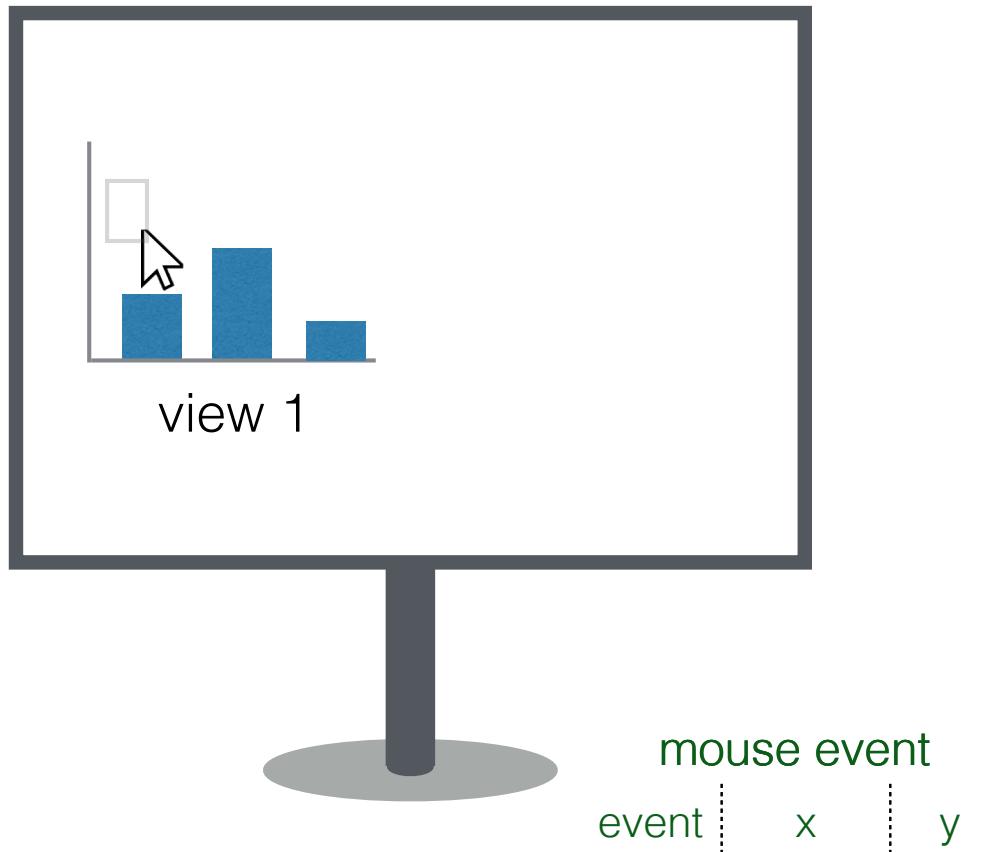
- **Detection: formal framework**
- **Prevention:**
 - **Ensure consistency**
 - **Communicate inconsistency**



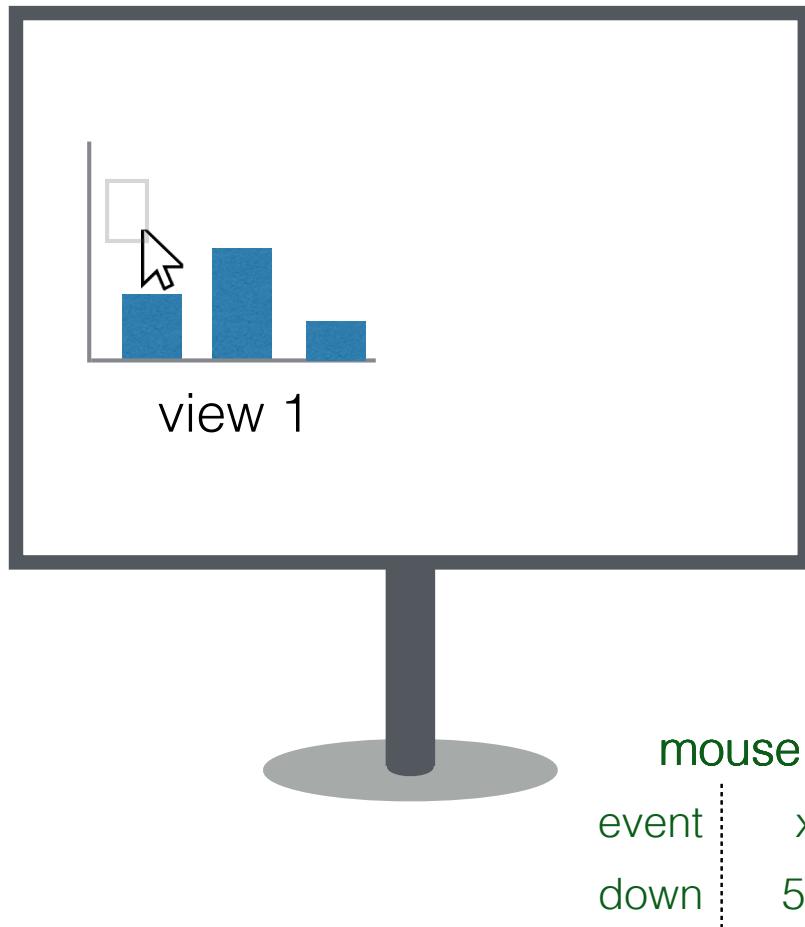
A Relational Model



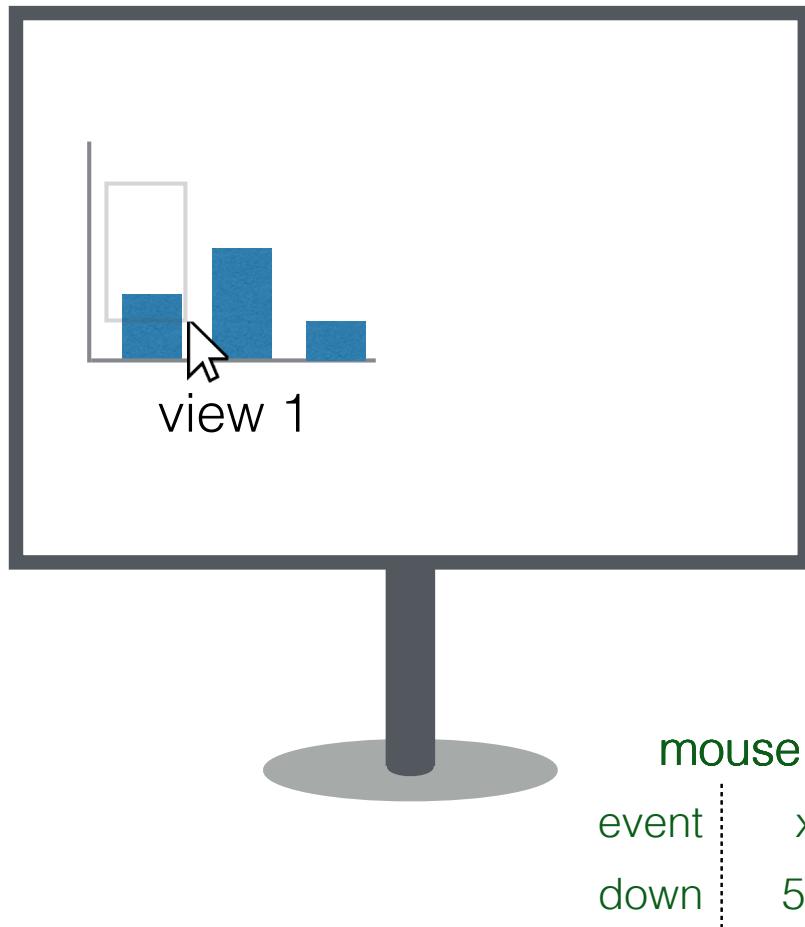
A Relational Model



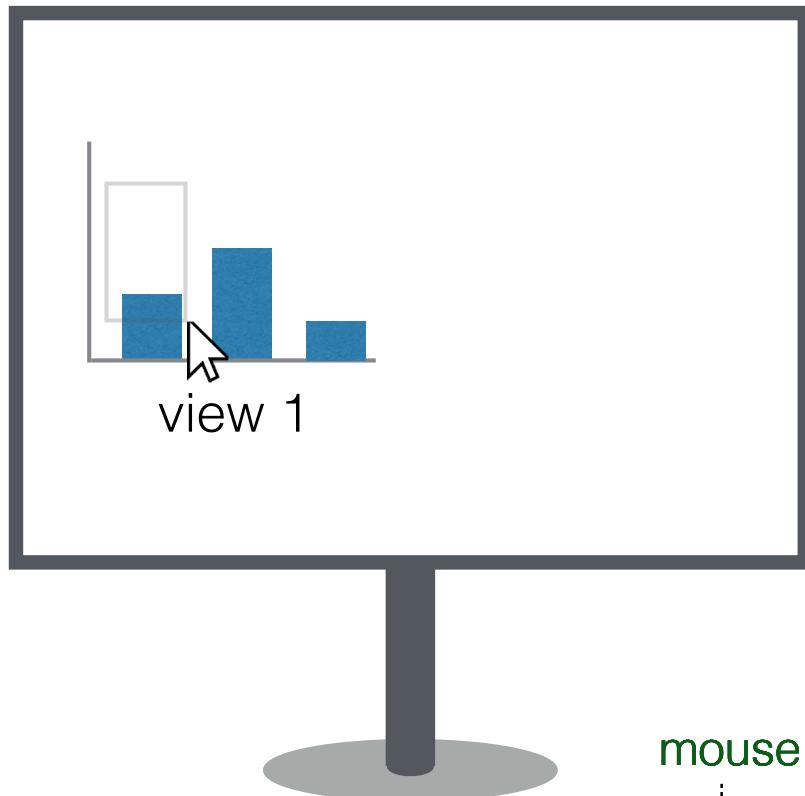
A Relational Model



A Relational Model



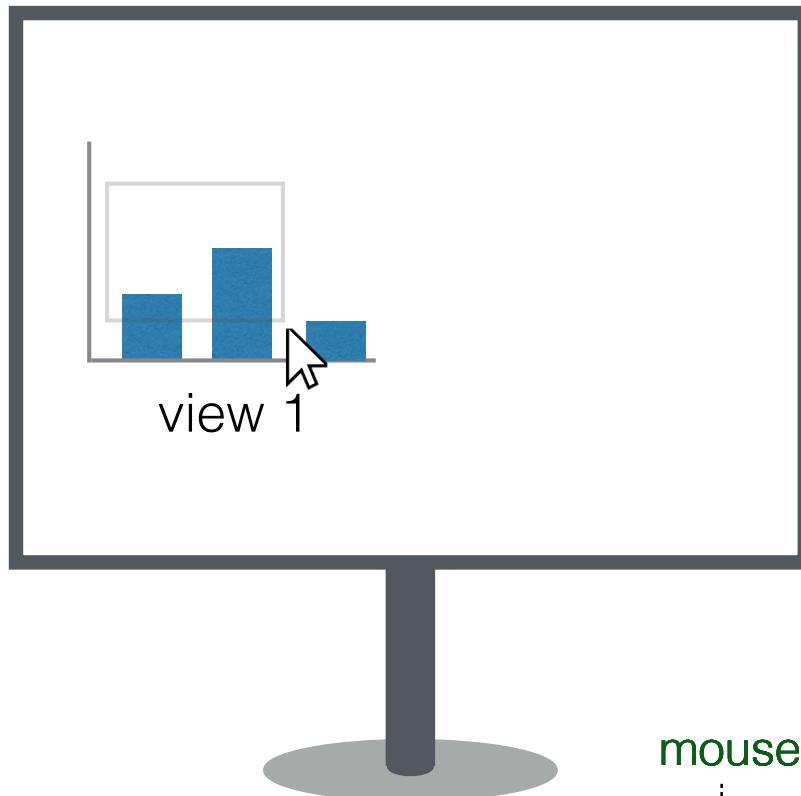
A Relational Model



mouse event

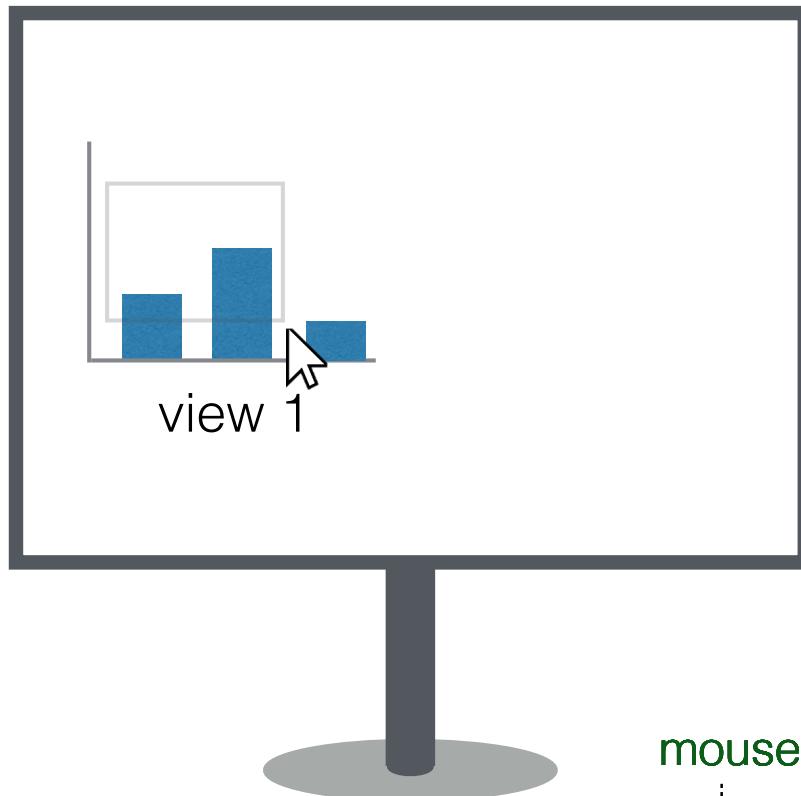
event	x	y
down	50	95
move	55	150

A Relational Model



mouse event		
event	x	y
down	50	95
move	55	150

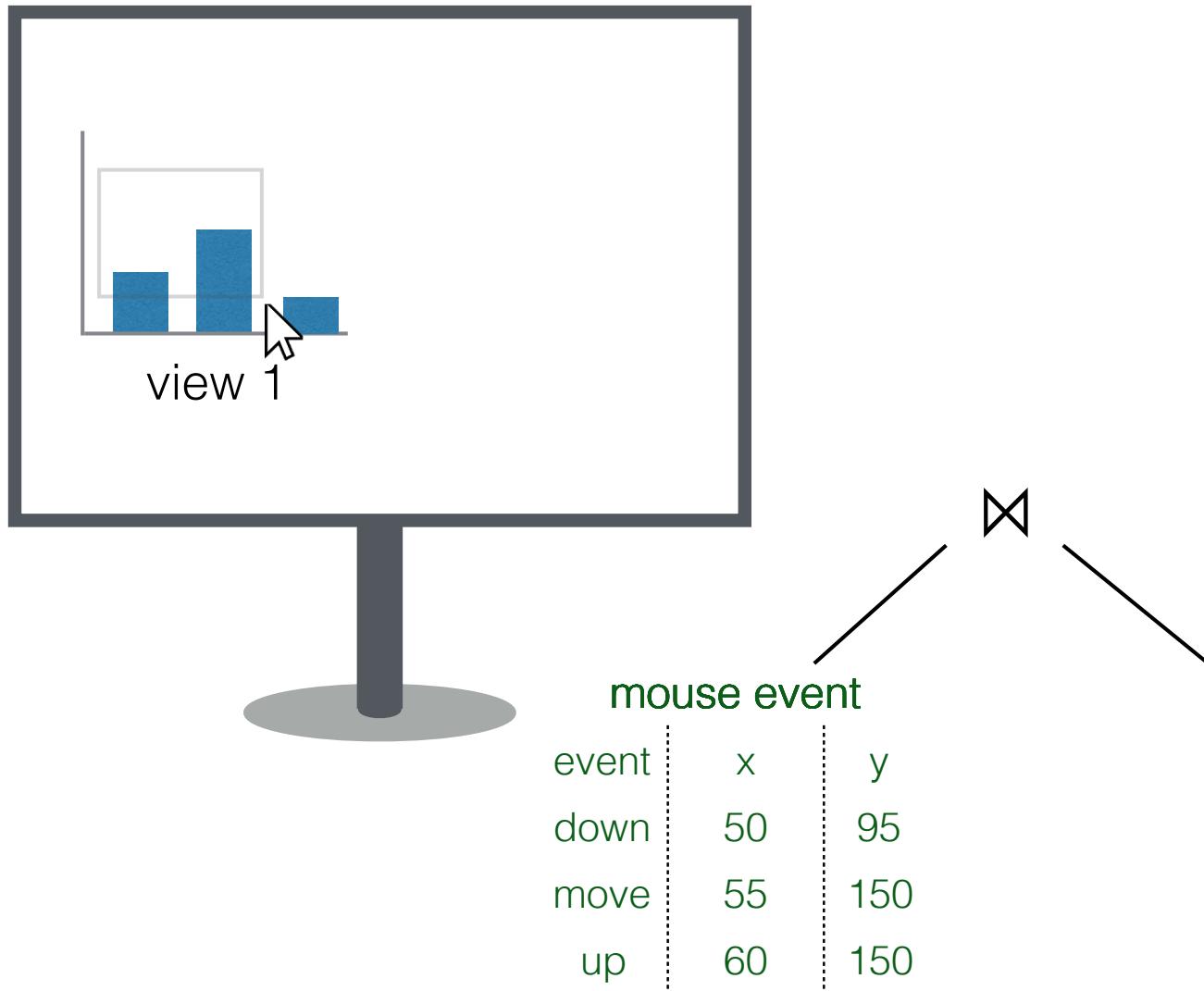
A Relational Model



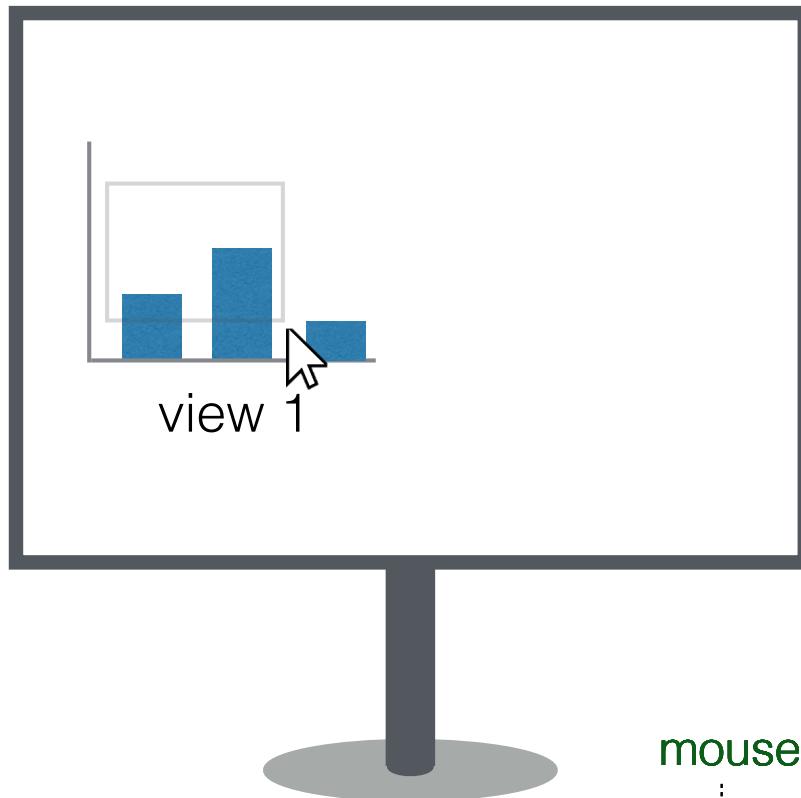
mouse event

event	x	y
down	50	95
move	55	150
up	60	150

A Relational Model



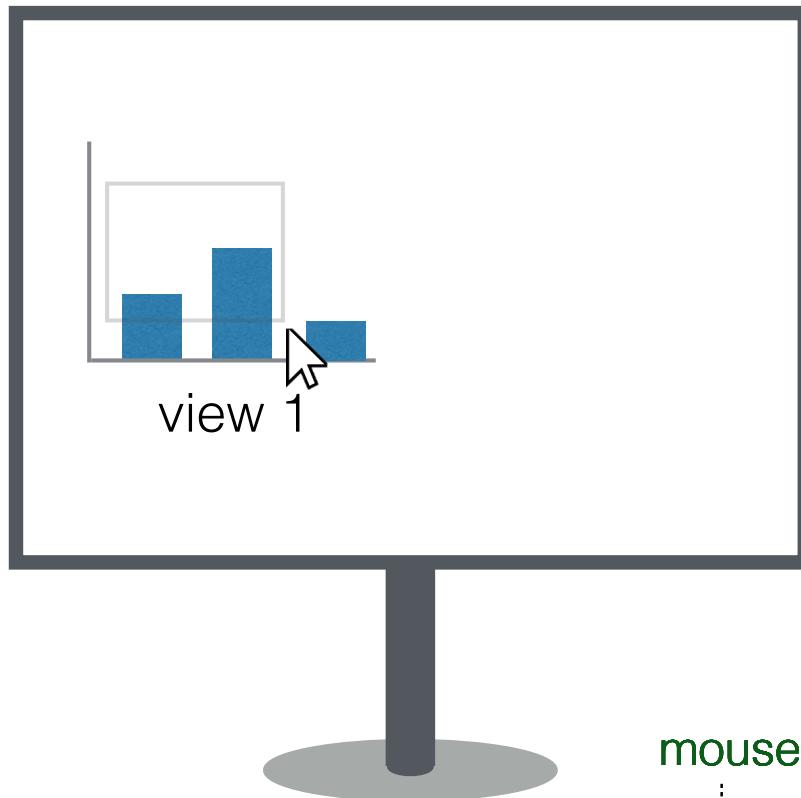
A Relational Model



⋈

mouse event		view1_rects @ t1					
event	x	y	x	y	width	height	color
down	50	95	50	150	5	20	blue
move	55	150	60	150	5	30	blue
up	60	150	90	150	5	60	blue

A Relational Model



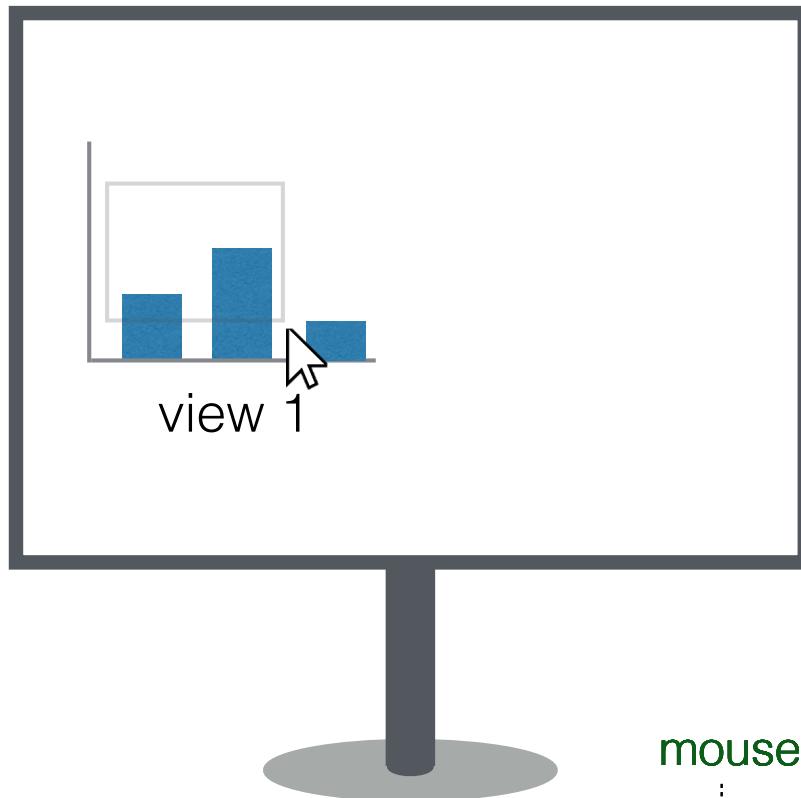
mouse event

event	x	y
down	50	95
move	55	150
up	60	150

view1_rects @ t1

x	y	width	height	color
50	150	5	20	blue
60	150	5	30	blue
90	150	5	60	blue

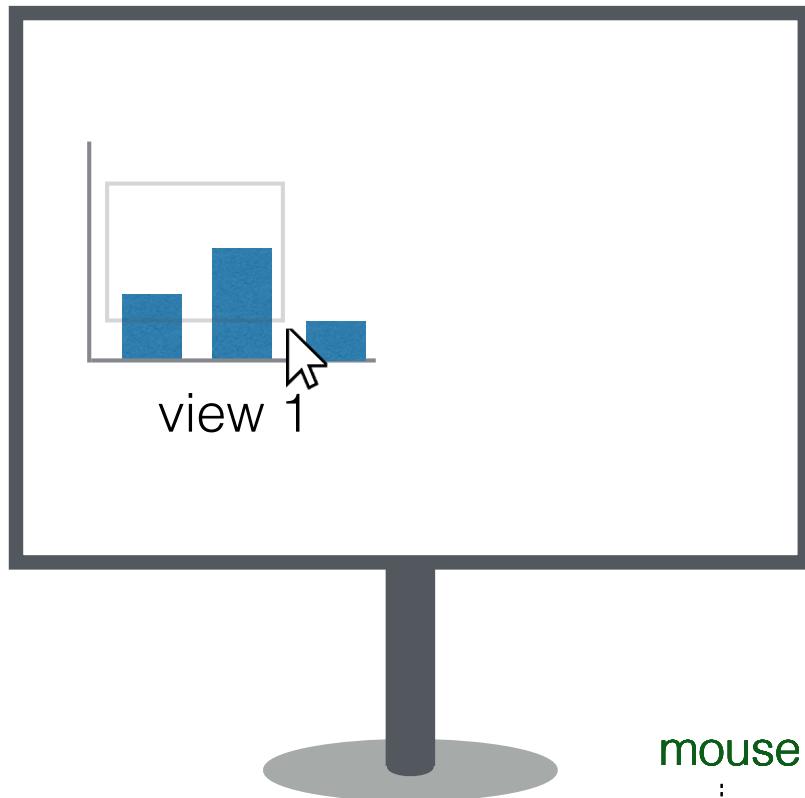
A Relational Model



event	x	y	x	y	width	height	color
down	50	95	50	150	5	20	blue
move	55	150	60	150	5	30	blue
up	60	150	90	150	5	60	blue

city	stores	sales	reps
SF	50	800	5
NYC	30	300	2
LA	5	100	1
BOS	1	50	1

A Relational Model



event	x	y	x	y	width	height	color
down	50	95	50	150	5	20	blue
move	55	150	60	150	5	30	blue
up	60	150	90	150	5	60	blue

mouse event

view2_rects @ t2

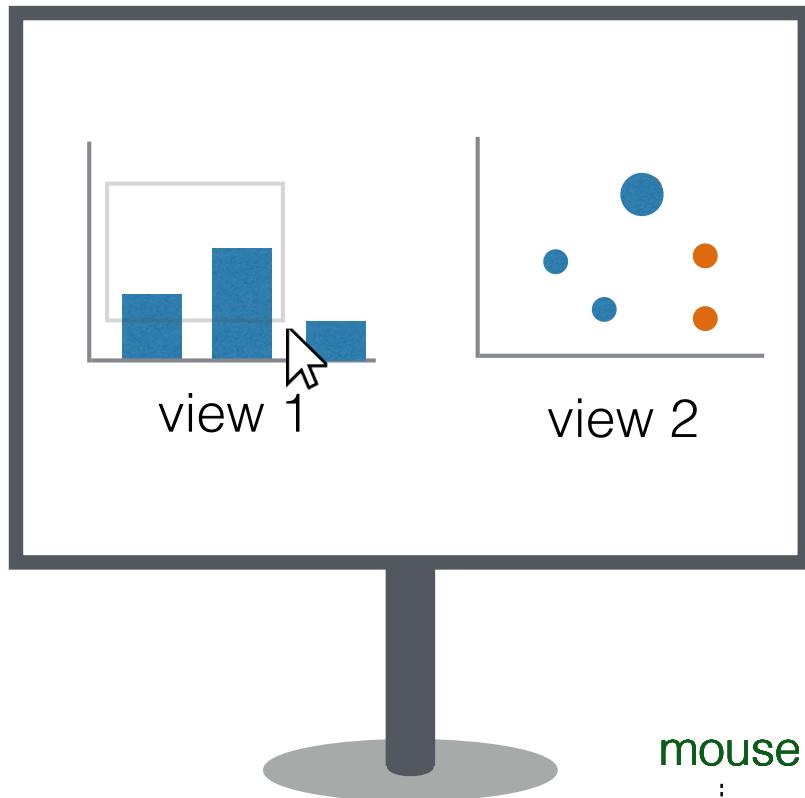
cx	cy	r	color
160	90	5	orange
130	140	2	blue

base data

city	stores	sales	reps
SF	50	800	5
NYC	30	300	2
LA	5	100	1
BOS	1	50	1

view1_rects @ t1

A Relational Model



event	x	y	x	y	width	height	color
down	50	95	50	150	5	20	blue
move	55	150	60	150	5	30	blue
up	60	150	90	150	5	60	blue

mouse event

view2_rects @ t2

cx	cy	r	color
160	90	5	orange
130	140	2	blue

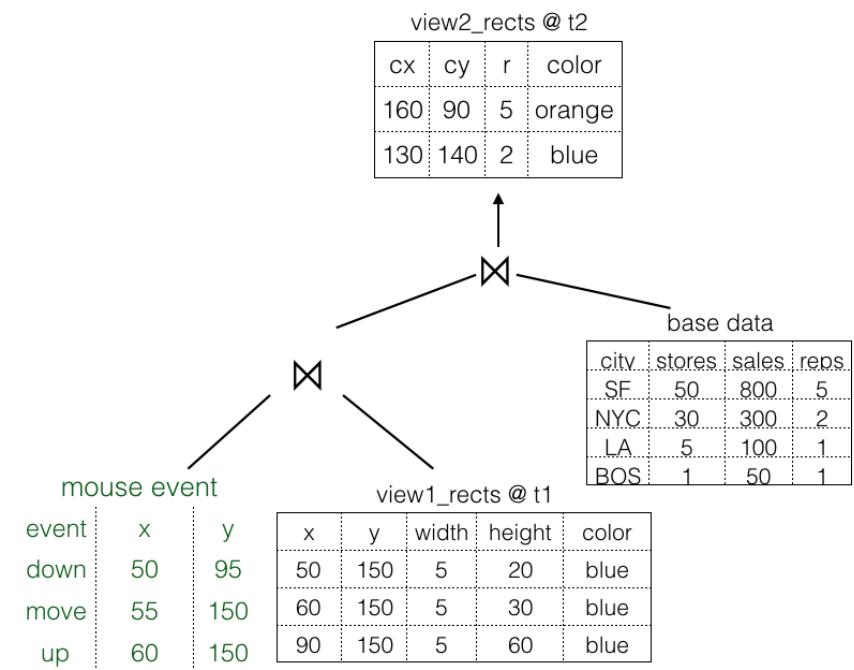
city	stores	sales	reps
SF	50	800	5
NYC	30	300	2
LA	5	100	1
BOS	1	50	1

base data



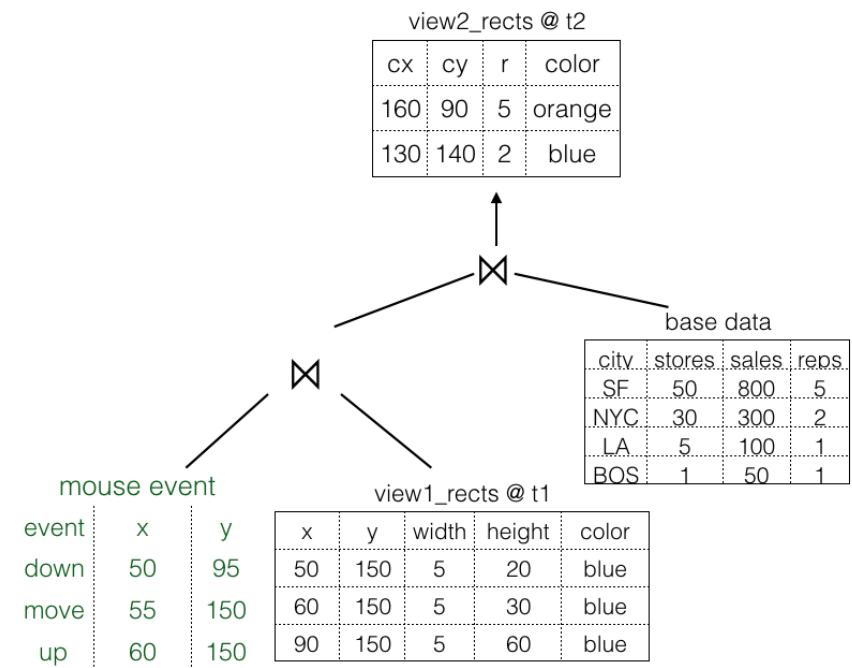
view1_rects @ t1

Interaction as a Transaction



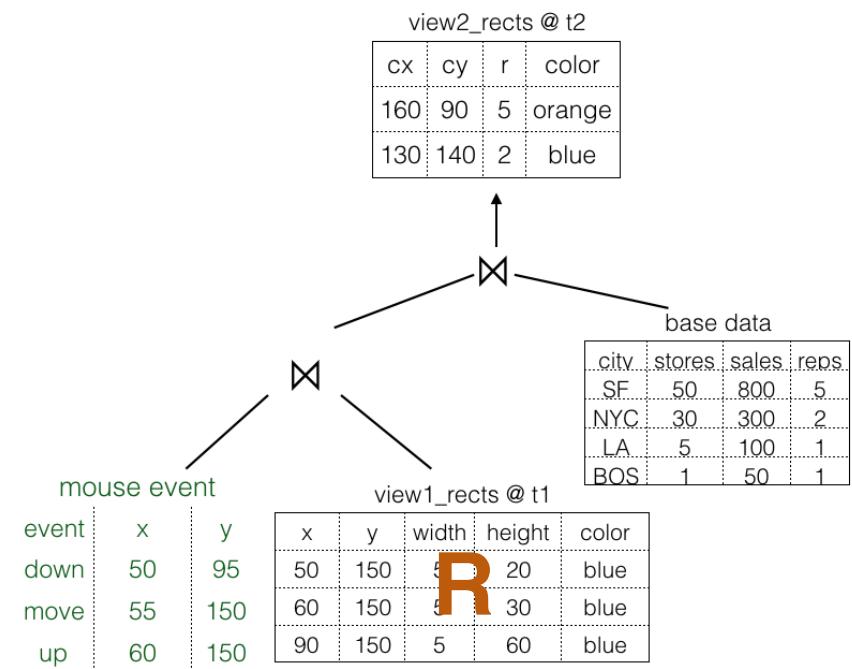
Interaction as a Transaction

- Interpreting interaction is a **read**.



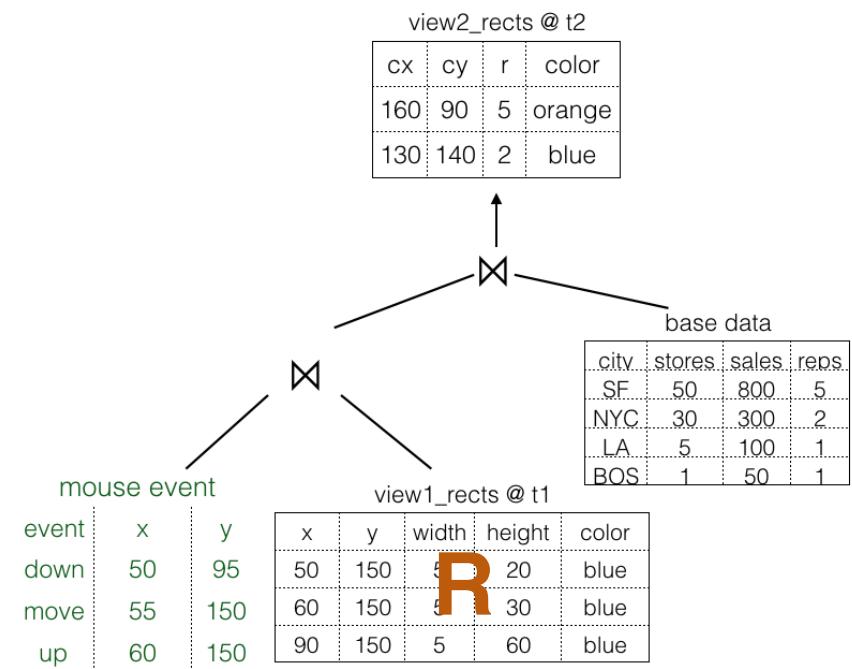
Interaction as a Transaction

- Interpreting interaction is a **read**.



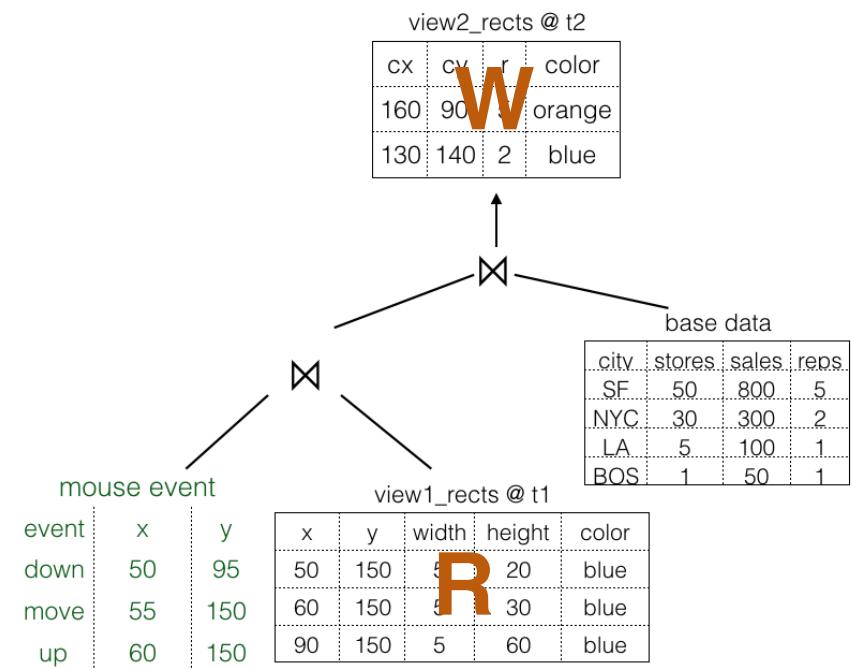
Interaction as a Transaction

- Interpreting interaction is a **read**.
- Rendering the data is a **write**.

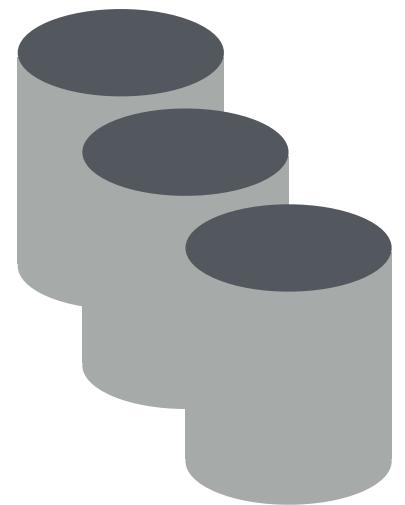
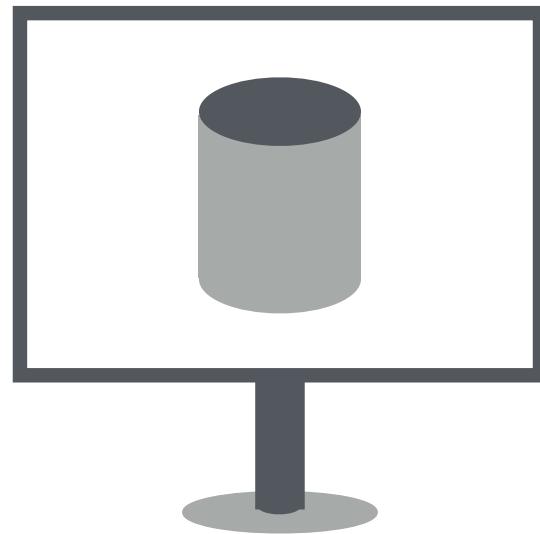
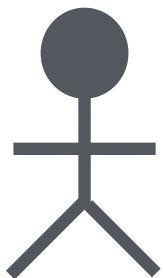


Interaction as a Transaction

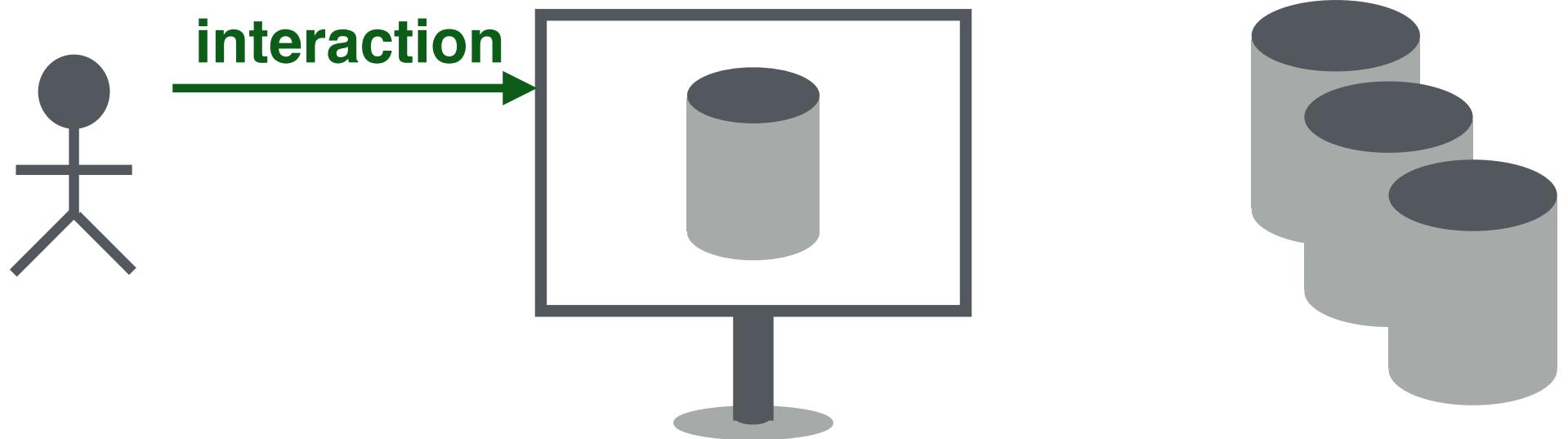
- Interpreting interaction is a **read**.
- Rendering the data is a **write**.



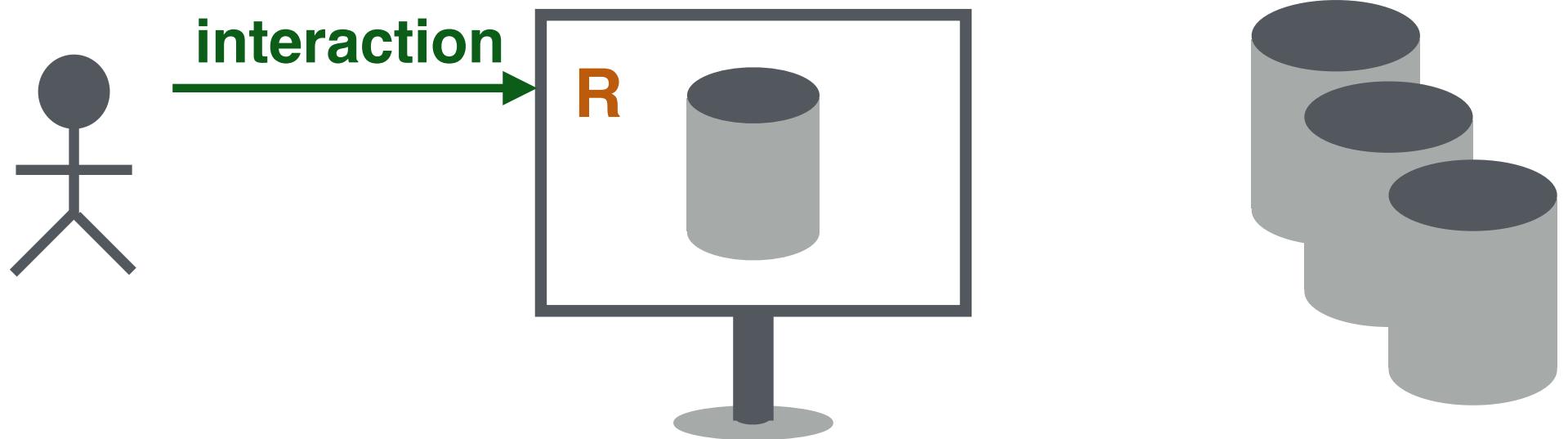
Data Flow



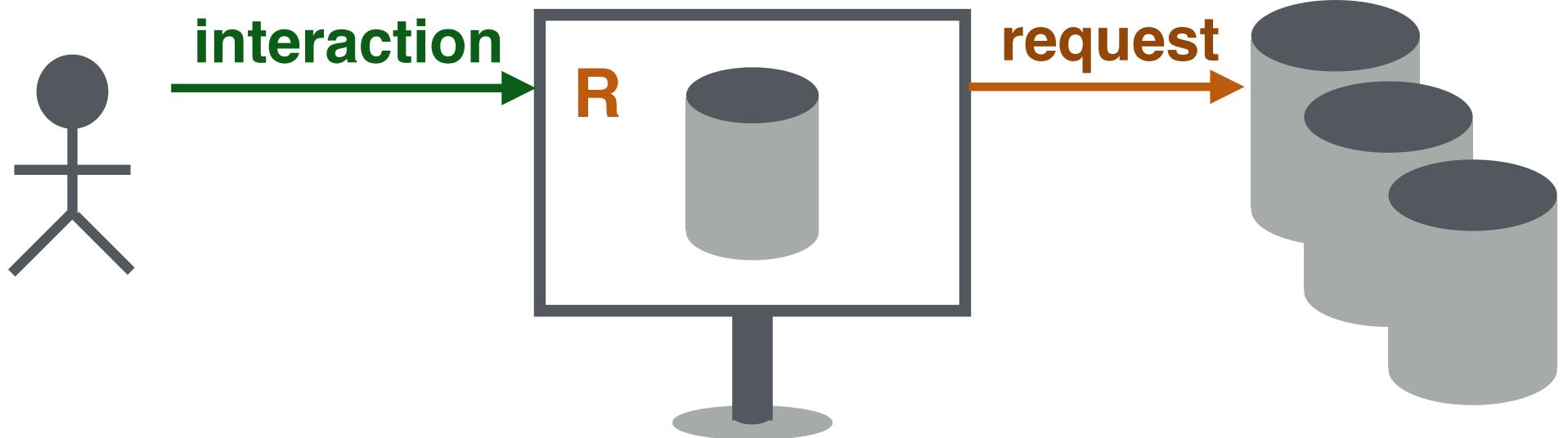
Data Flow



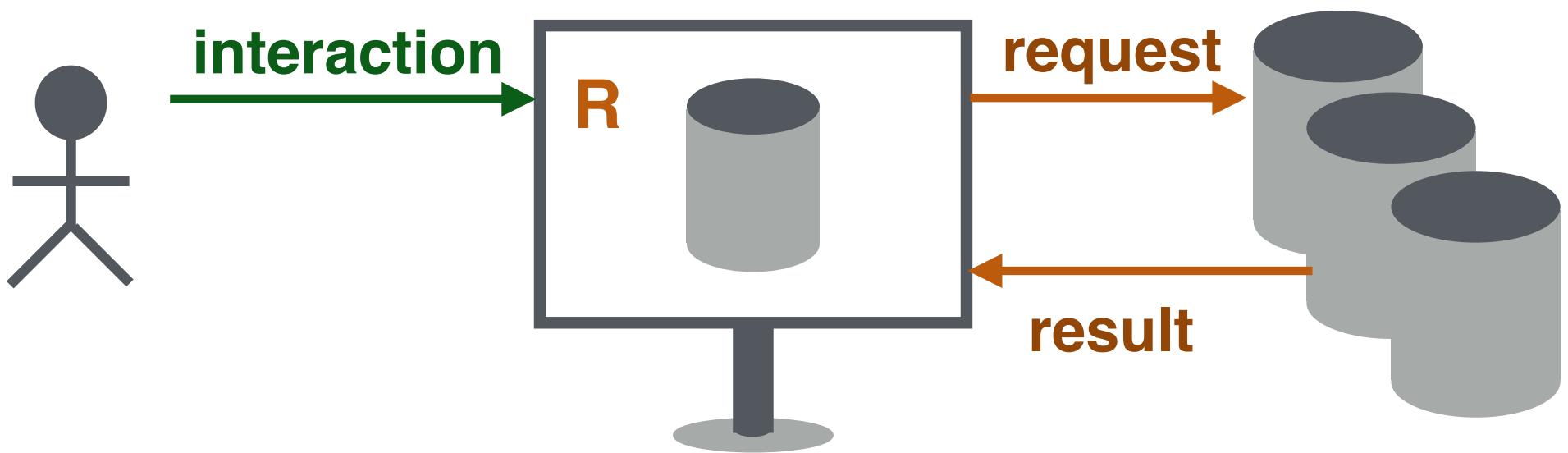
Data Flow



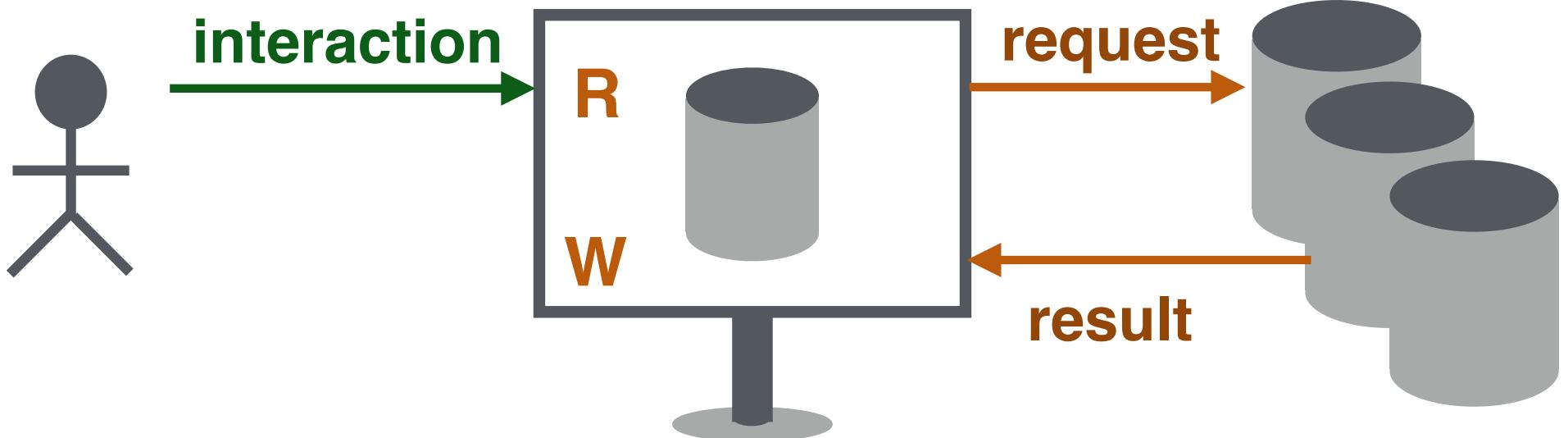
Data Flow



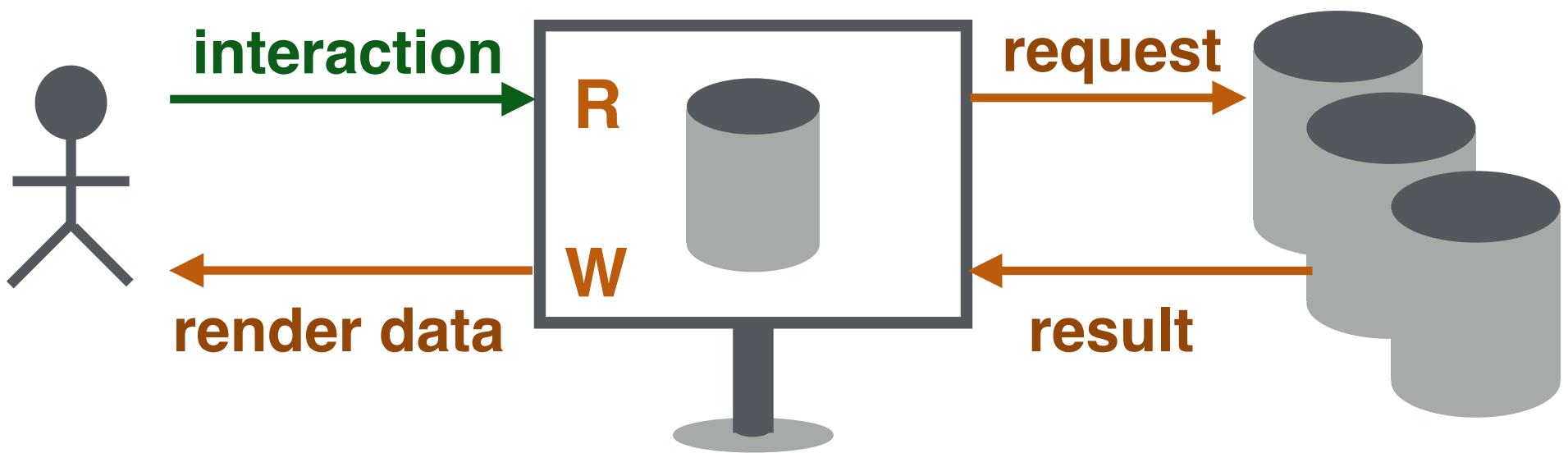
Data Flow



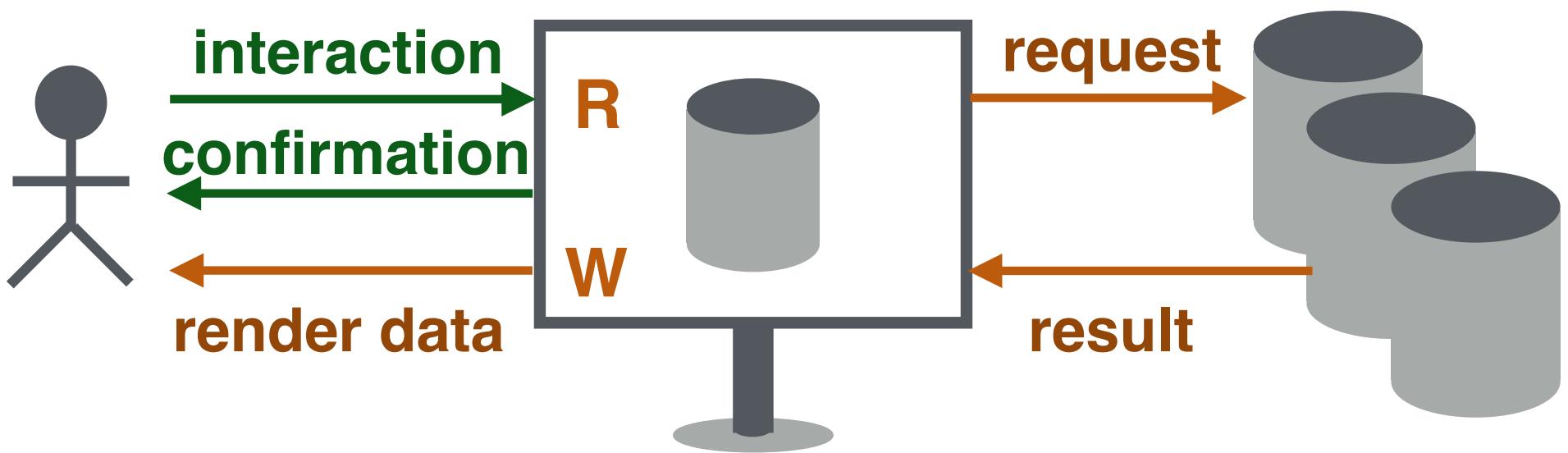
Data Flow



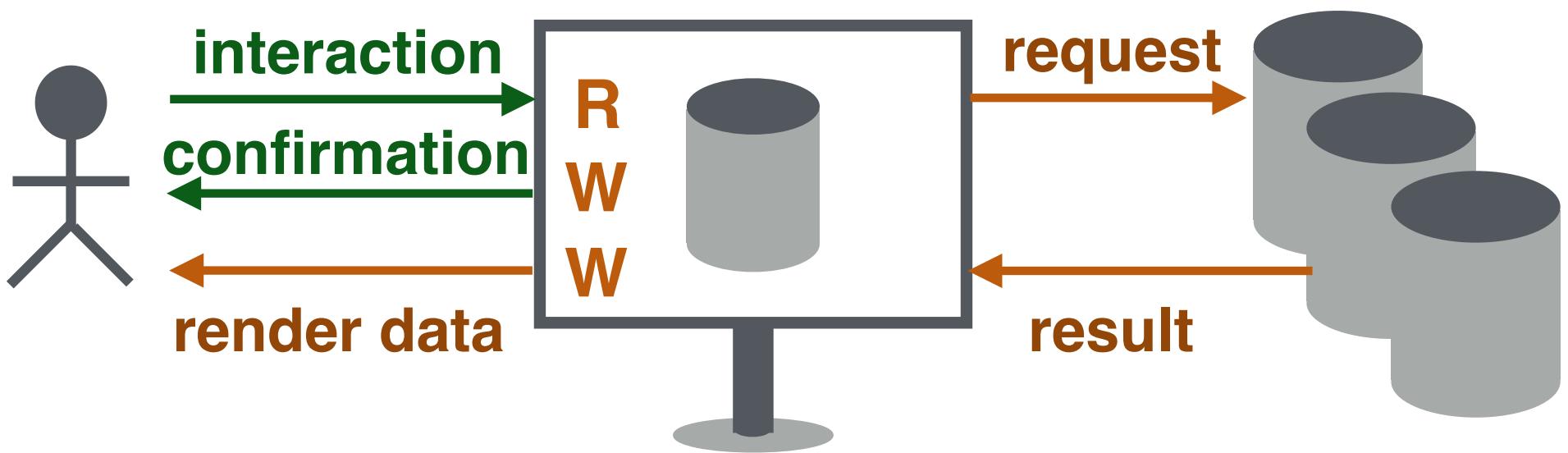
Data Flow



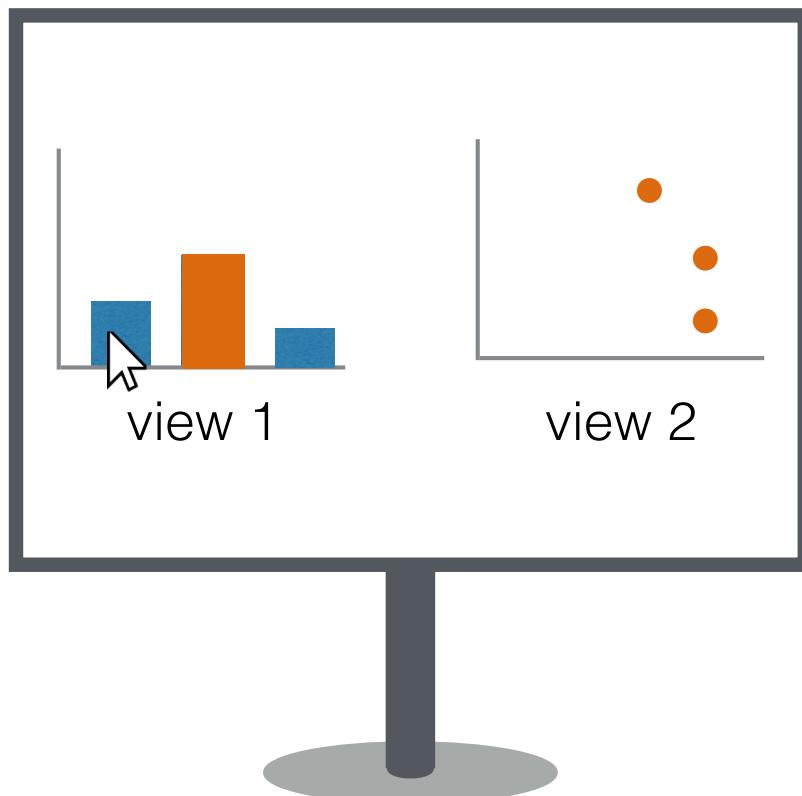
Data Flow



Data Flow



Conflict Example



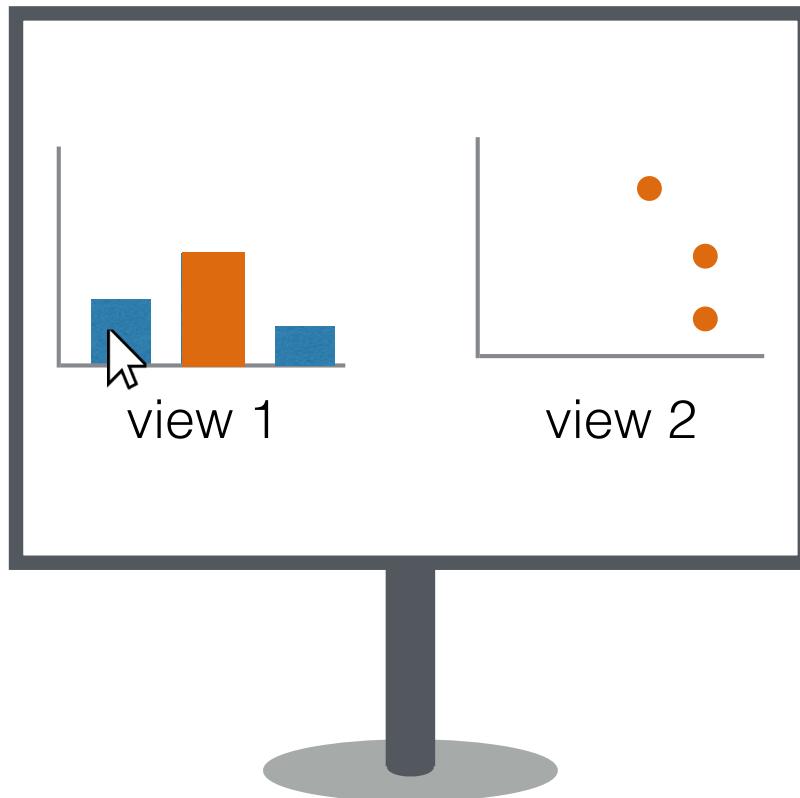
pixel data

x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A black padlock icon is positioned to the right of the table.

Conflict Example

current_interaction: I1



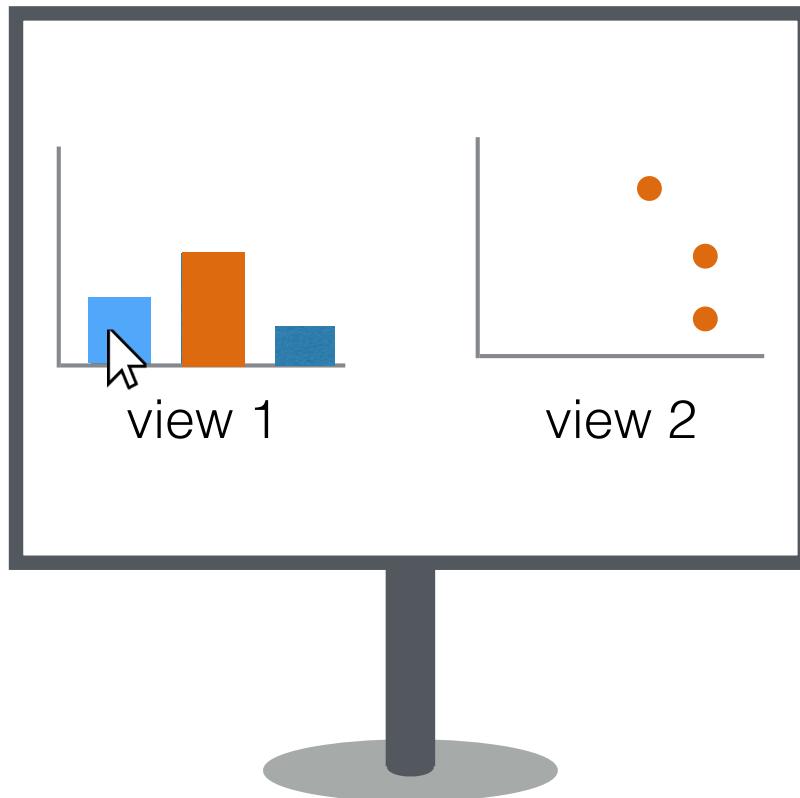
pixel data

x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A black padlock icon is located to the right of the table.

Conflict Example

current_interaction: I1



pixel data

x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A black padlock icon is positioned to the right of the table.

Conflict Example

current_interaction: I1 I2

The diagram illustrates a conflict between two interactions, I1 and I2, across two views, View 1 and View 2.

View 1: Shows a horizontal bar composed of three segments: blue, orange, and blue. A cursor icon is positioned over the orange segment. The label "view 1" is below the bar.

View 2: Shows three orange dots arranged vertically. The label "view 2" is below the dots.

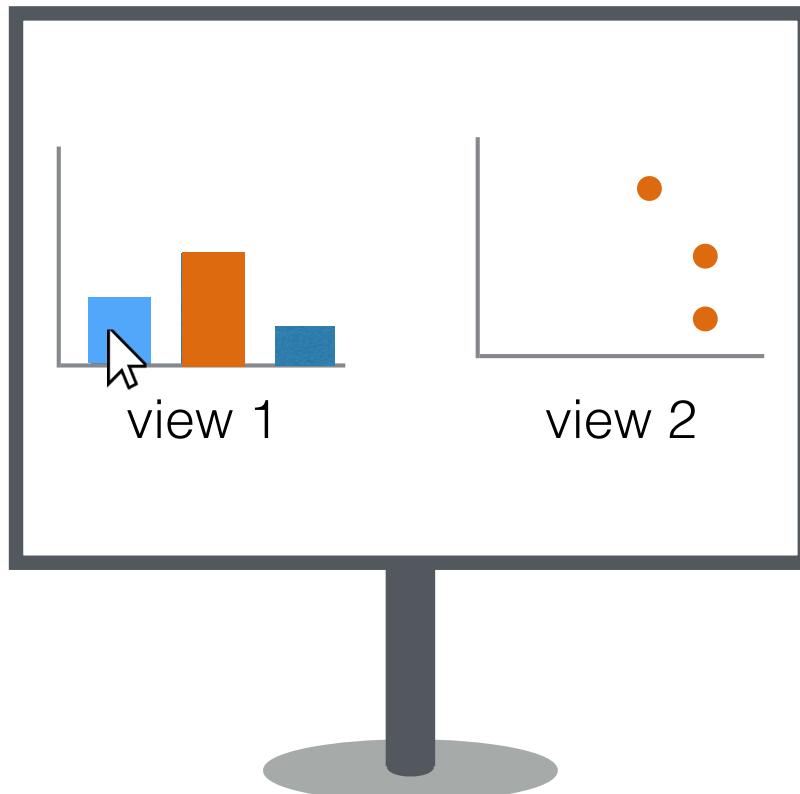
Pixel Data Table:

x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A red circle highlights the value "I2" in the "lineage" column of the first row of the table. A padlock icon is located to the right of the table.

Conflict Example

current_interaction: I1 I2



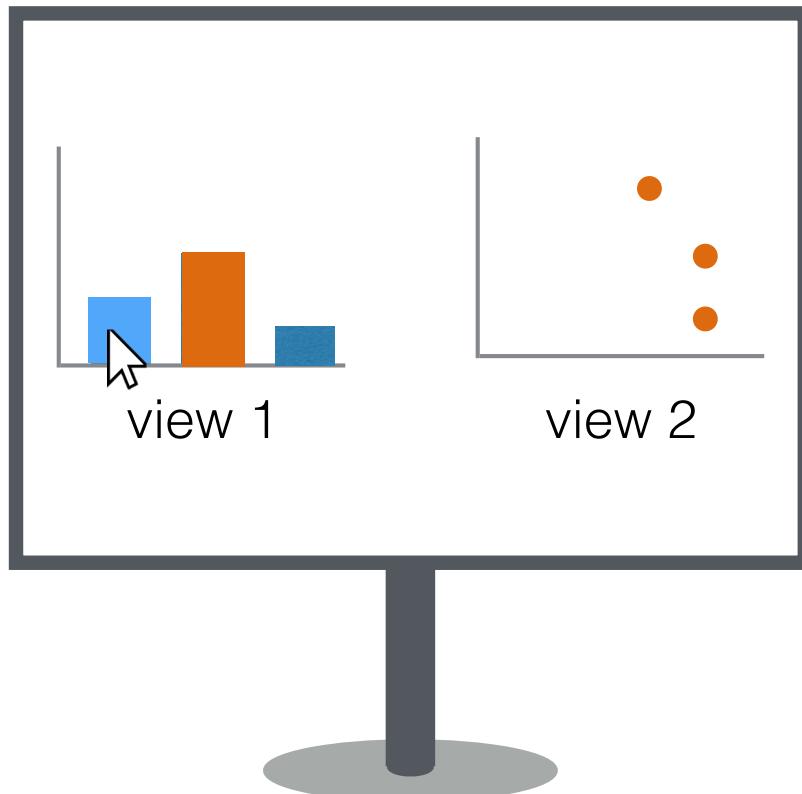
pixel data

x	y	color	lineage
...	...	blue	I2, V1, T1
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A black padlock icon is positioned to the right of the table.

Conflict Example

current_interaction: I1 I2



pixel data

x	y	color	lineage
...	...	blue	I2, V1, T1
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

A black padlock icon is positioned to the right of the table.

Conflict Example

current_interaction: I1 I2

view 1

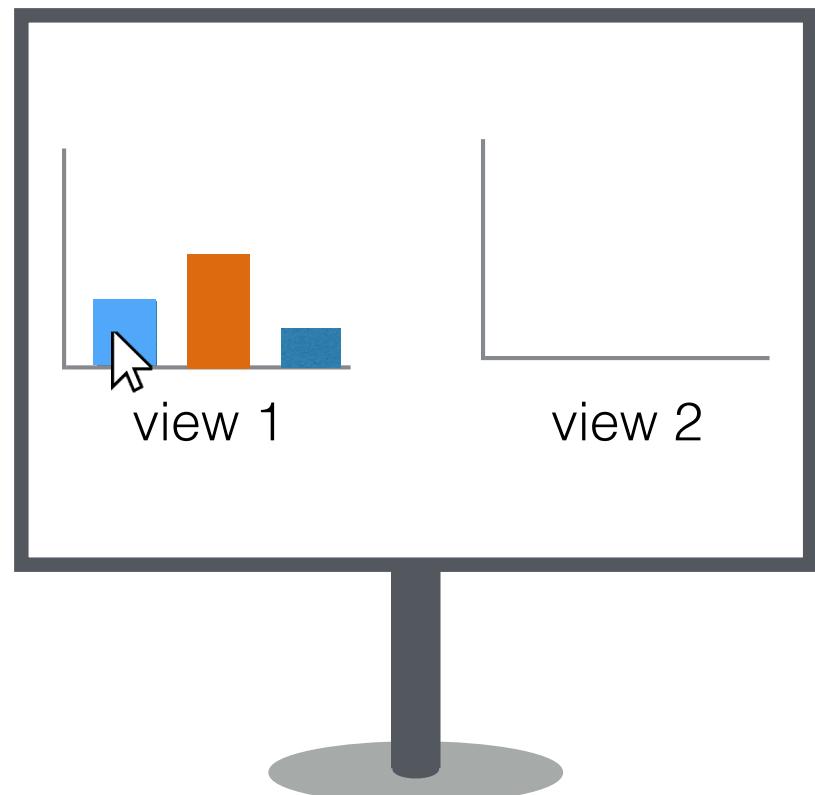
view 2

pixel data

x	y	color	lineage
...
70	140	blue	I2, V1, T1
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

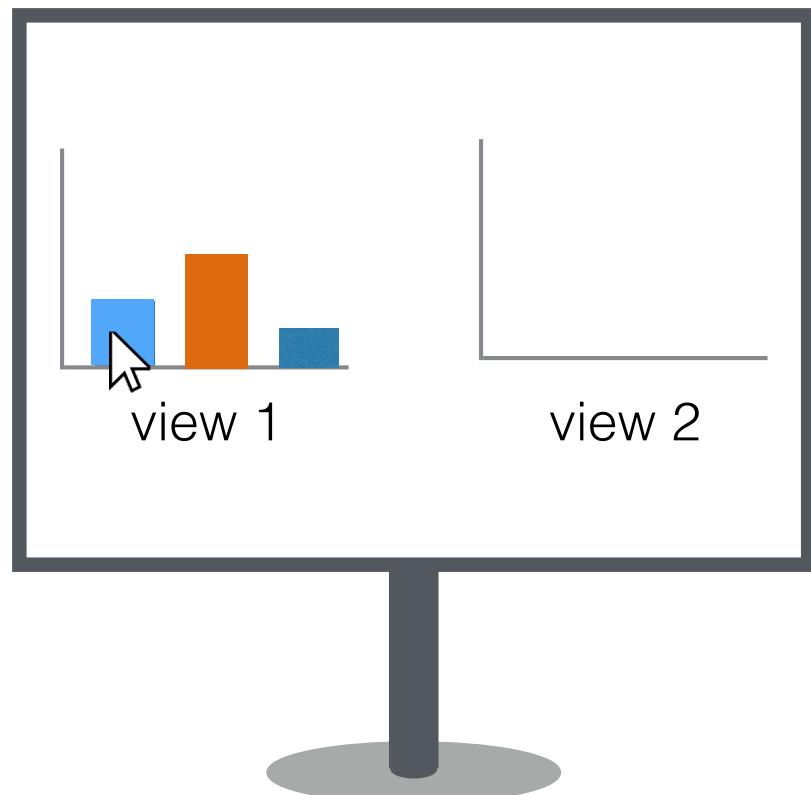
A black padlock icon is located to the right of the table.

Defining Conflict: Write-Write



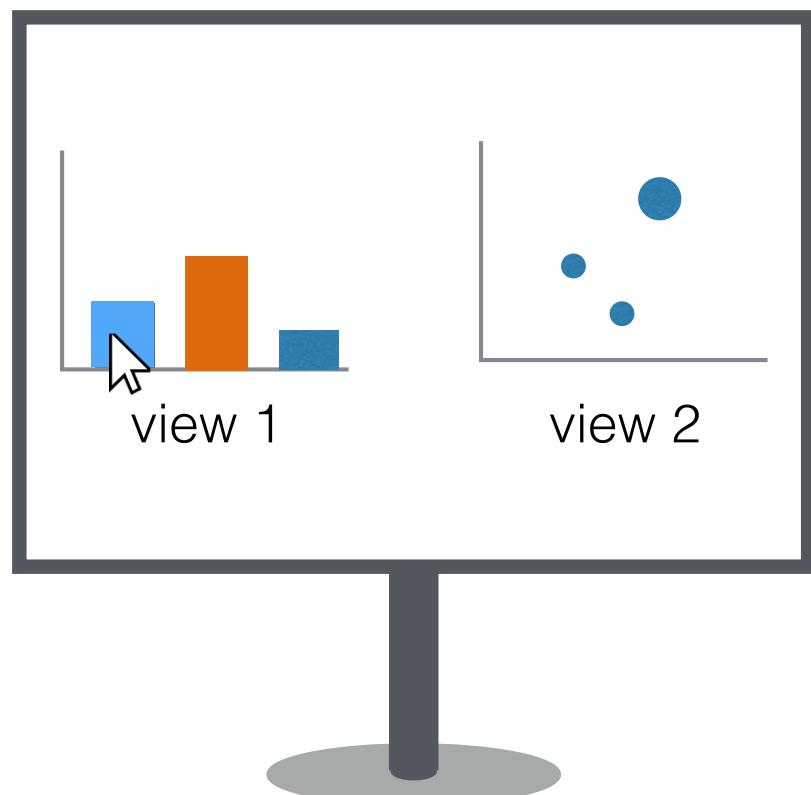
Defining Conflict: Write-Write

Two interaction attempting to **write to the same** pixel during their executions.



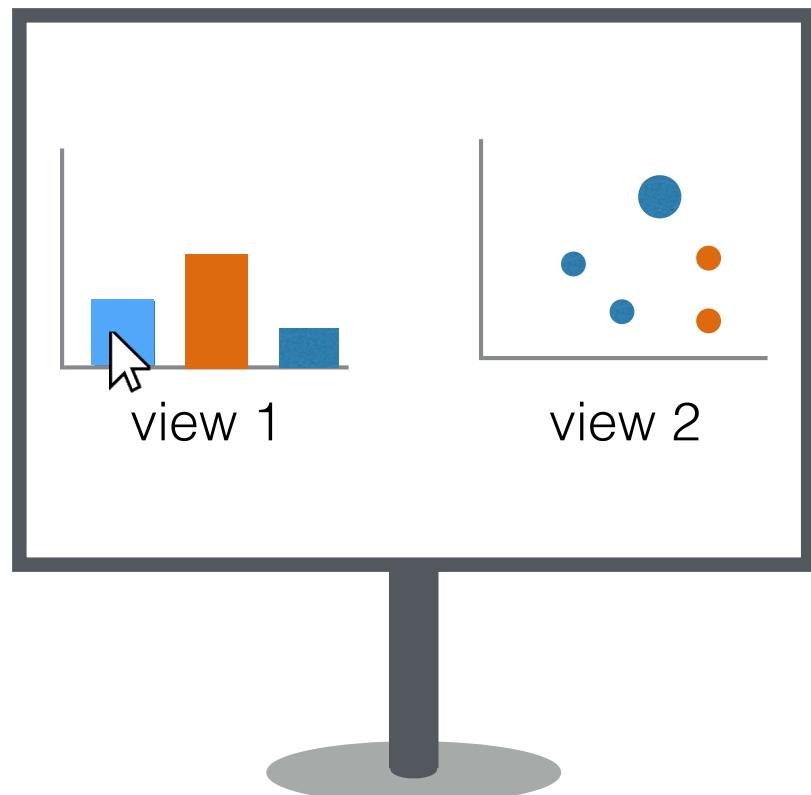
Defining Conflict: Write-Write

Two interaction attempting to **write to the same** pixel during their executions.

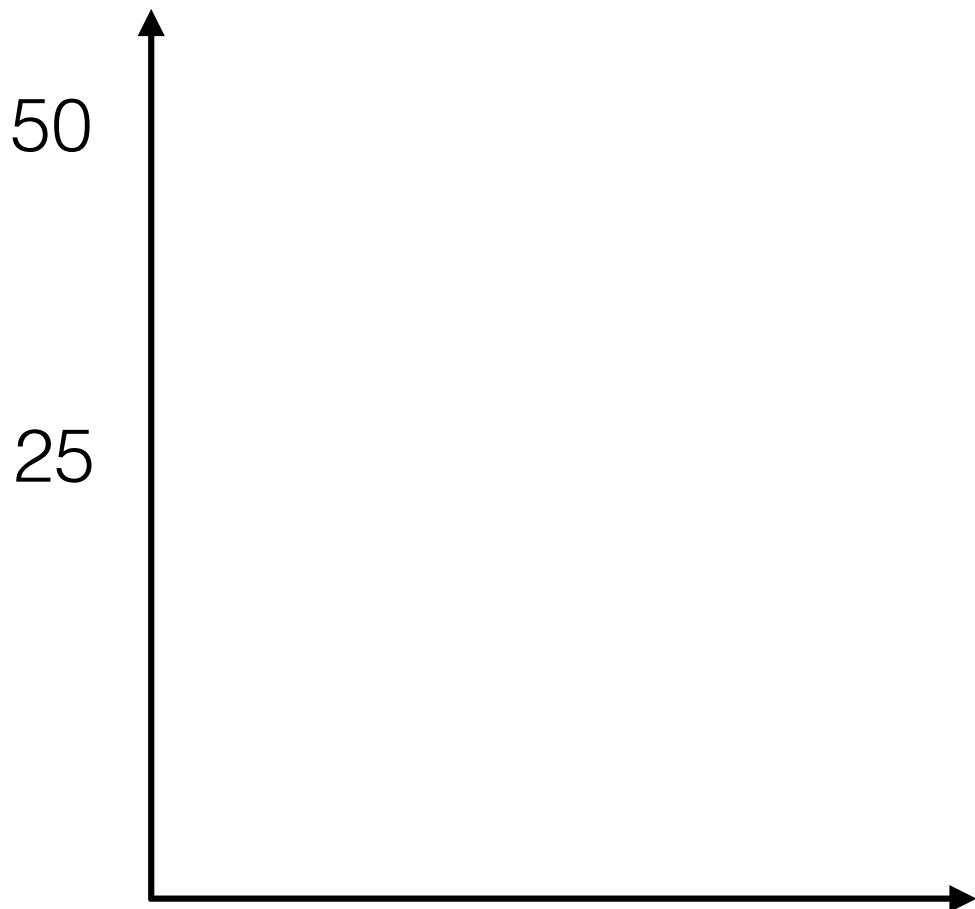


Defining Conflict: Write-Write

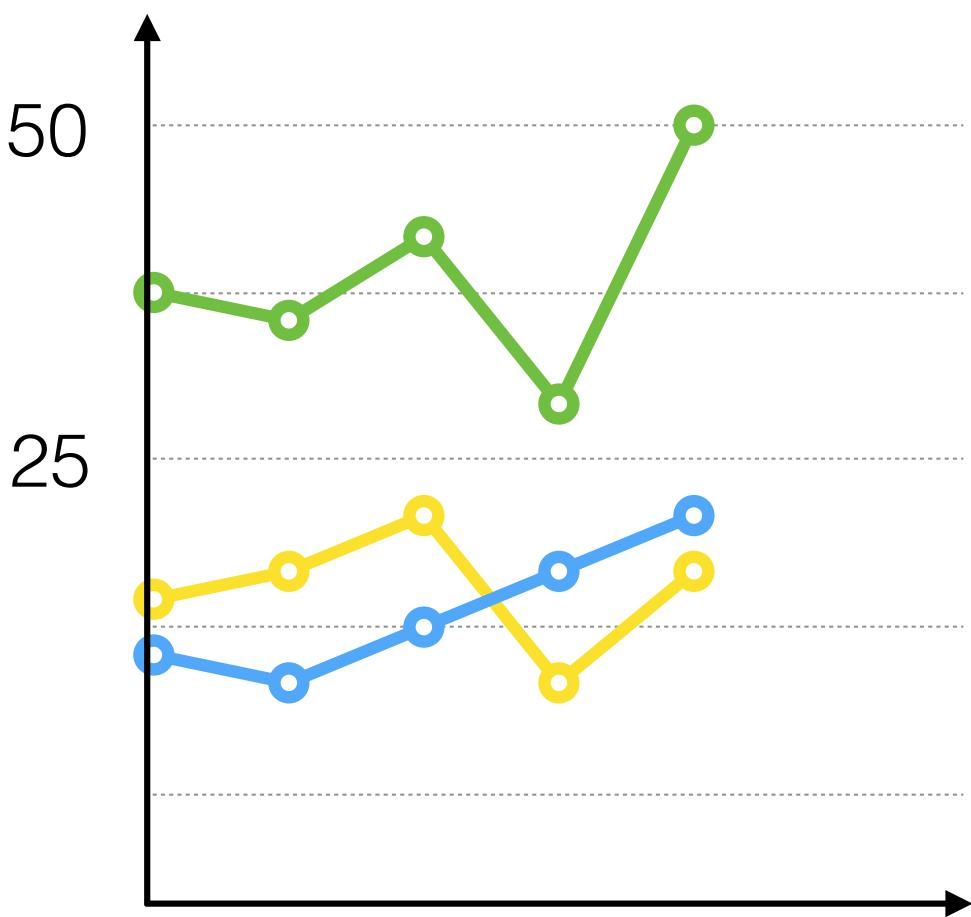
Two interaction attempting to **write to the same** pixel during their executions.



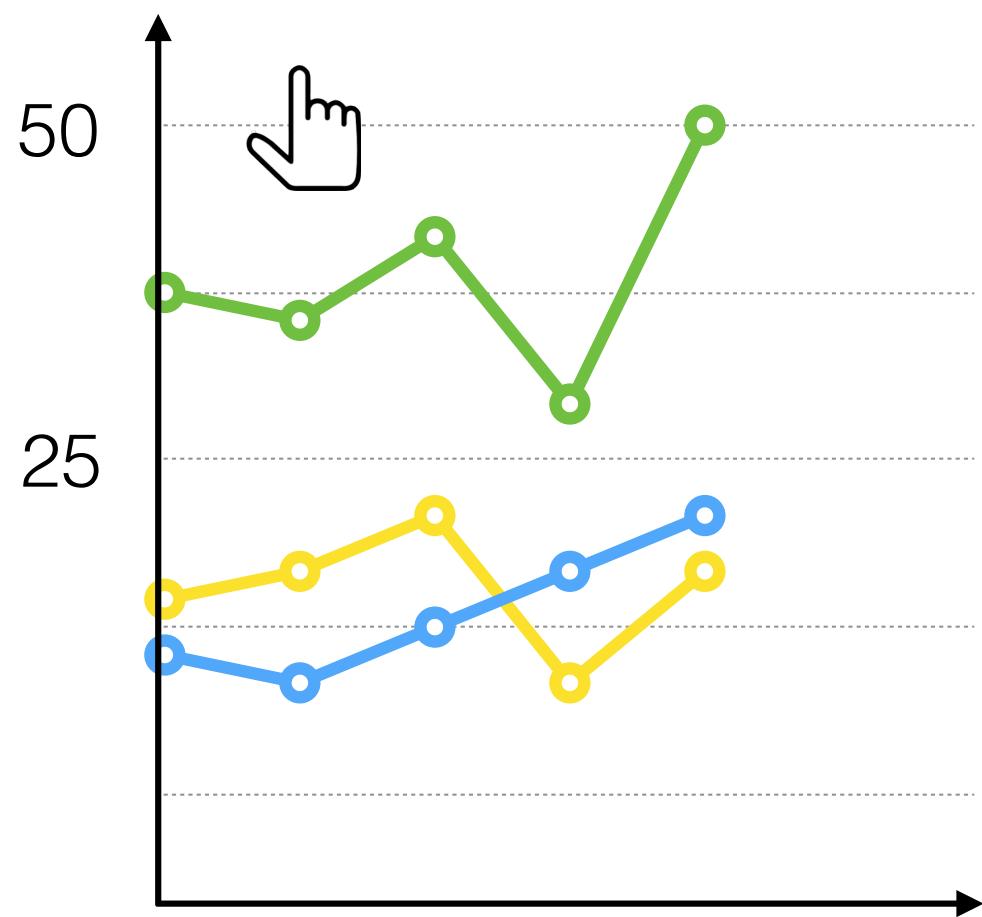
Defining Conflict: Read-Write



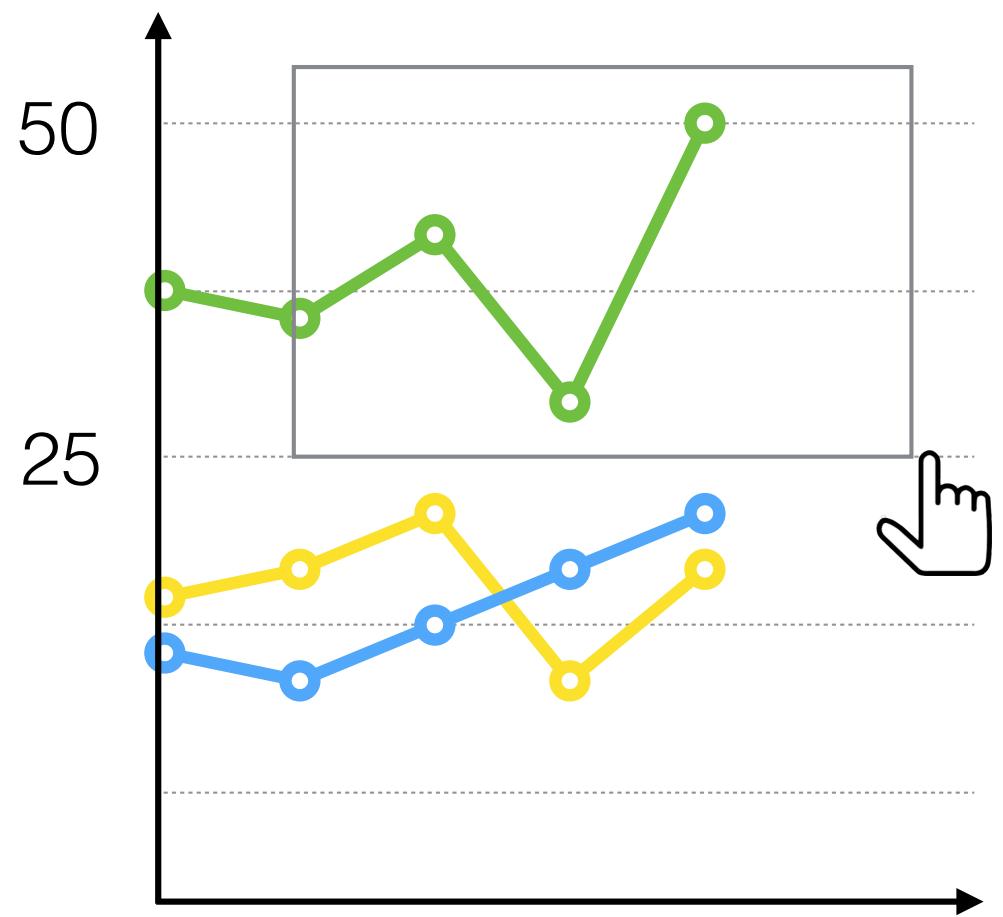
Defining Conflict: Read-Write



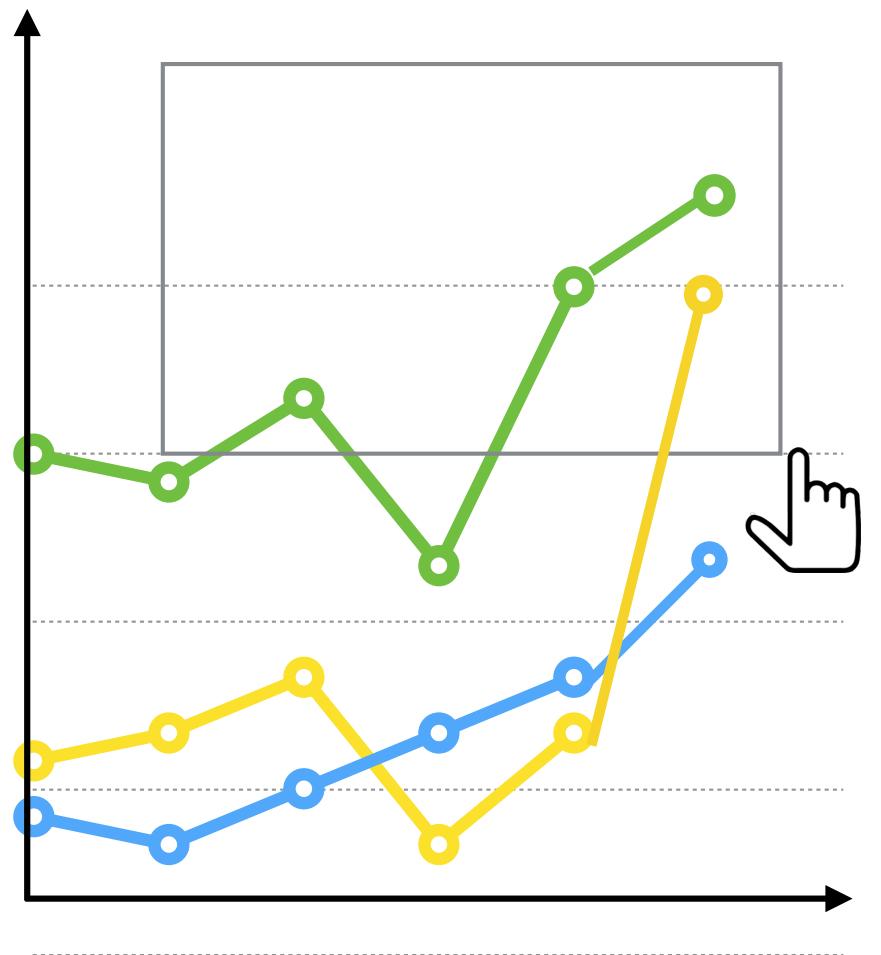
Defining Conflict: Read-Write



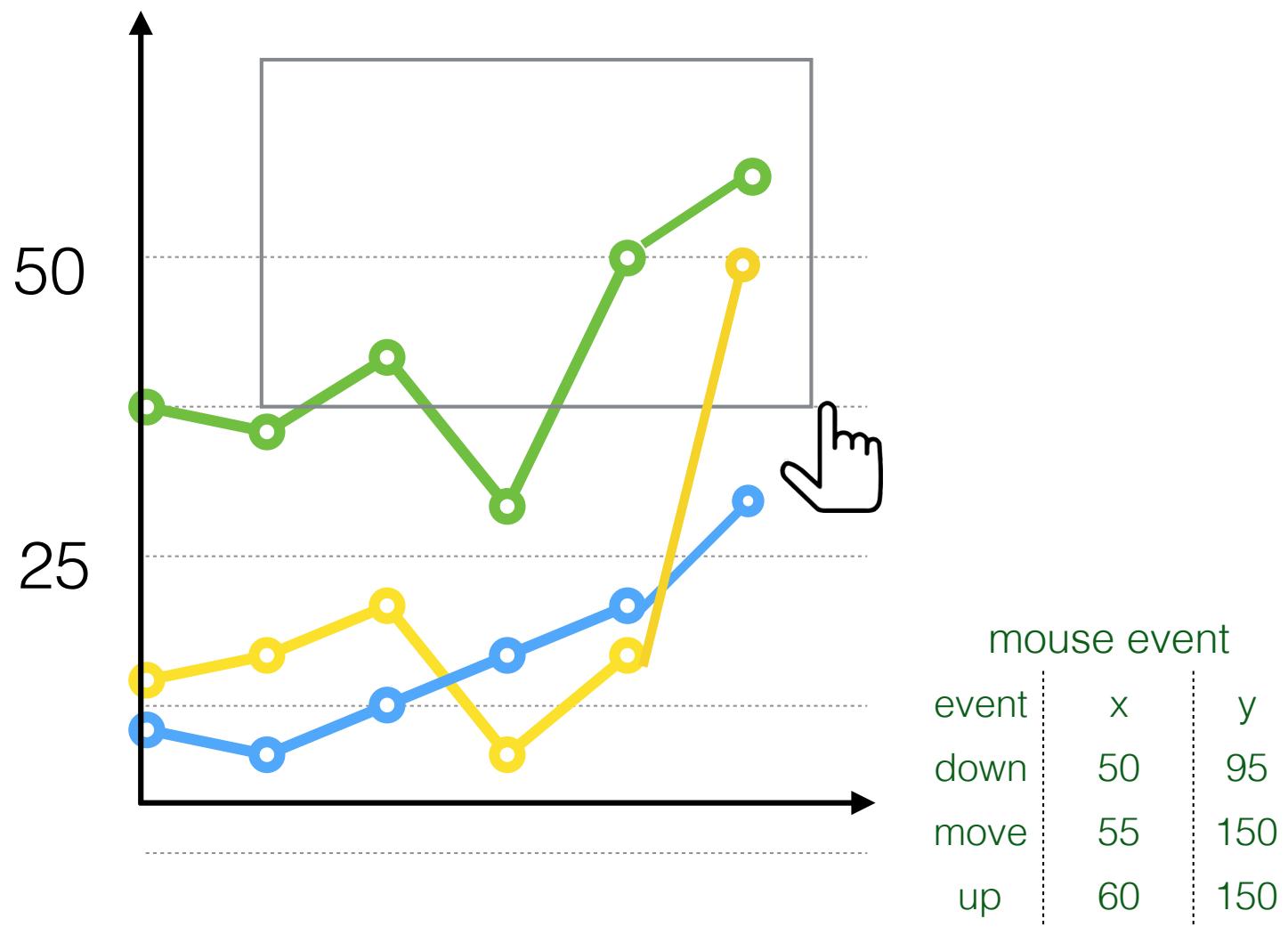
Defining Conflict: Read-Write



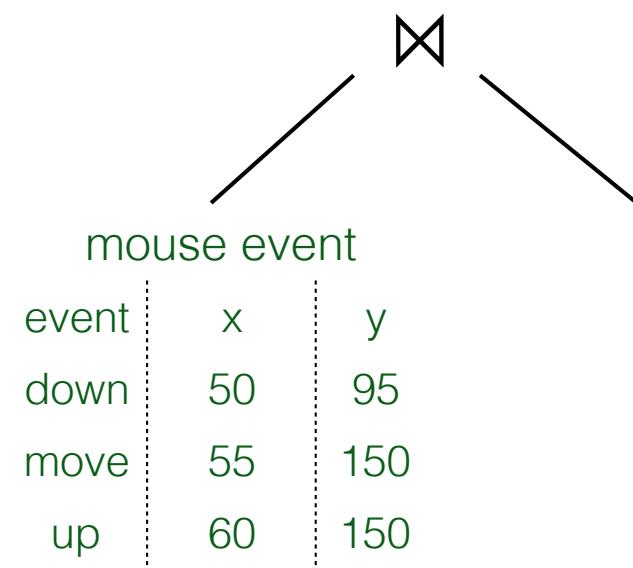
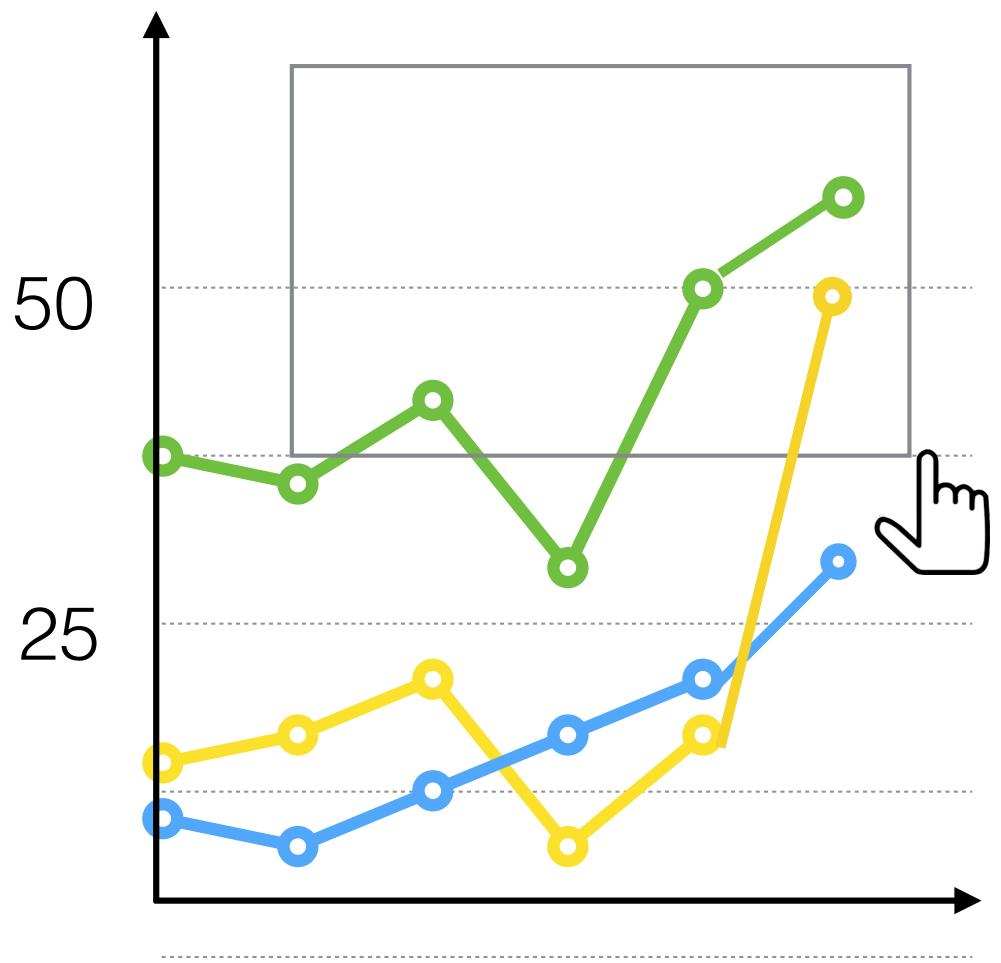
Defining Conflict: Read-Write



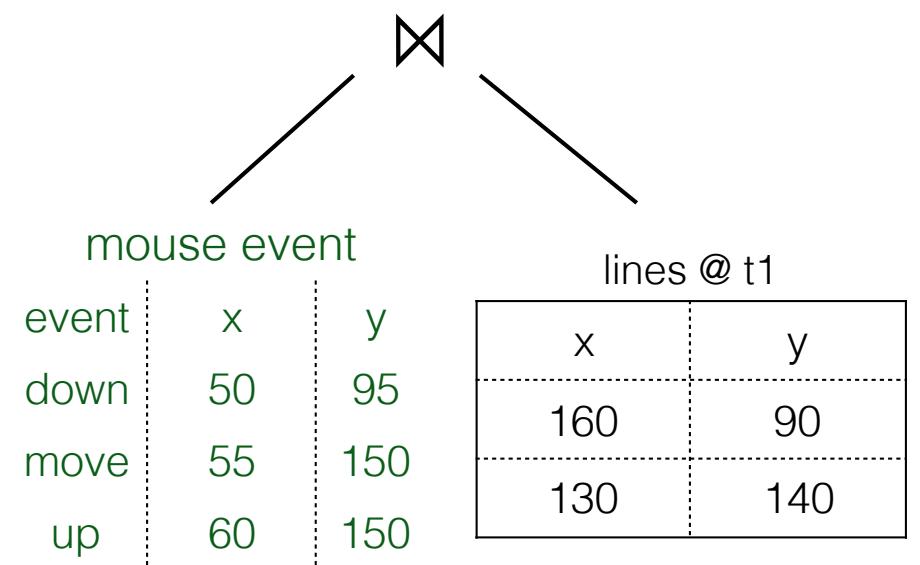
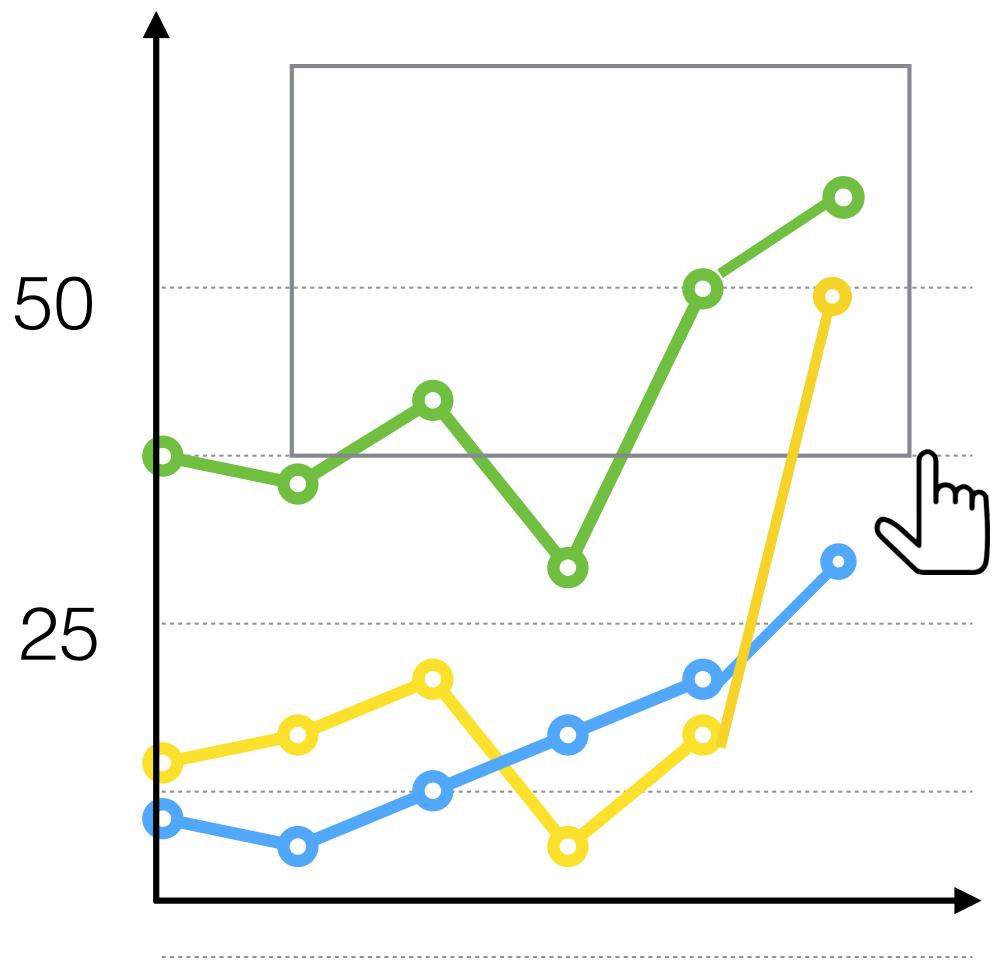
Defining Conflict: Read-Write



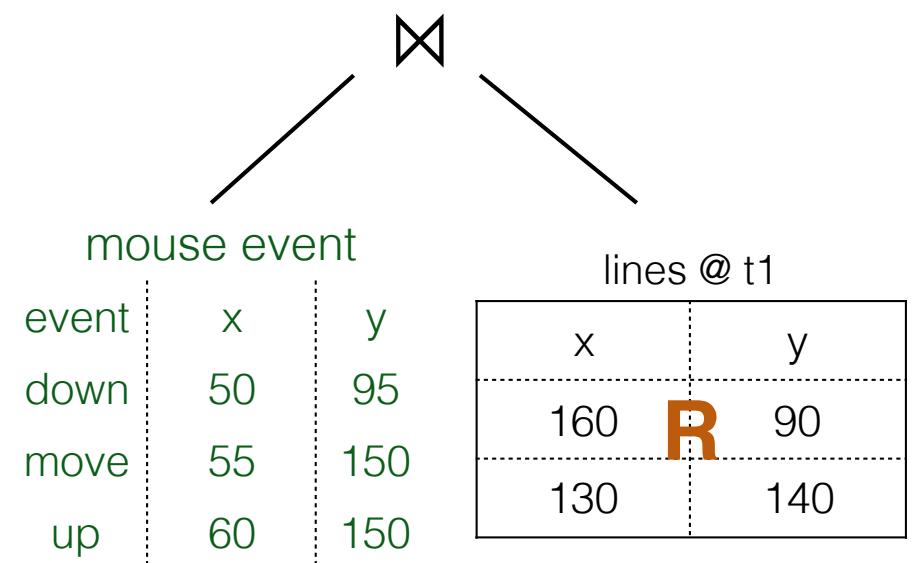
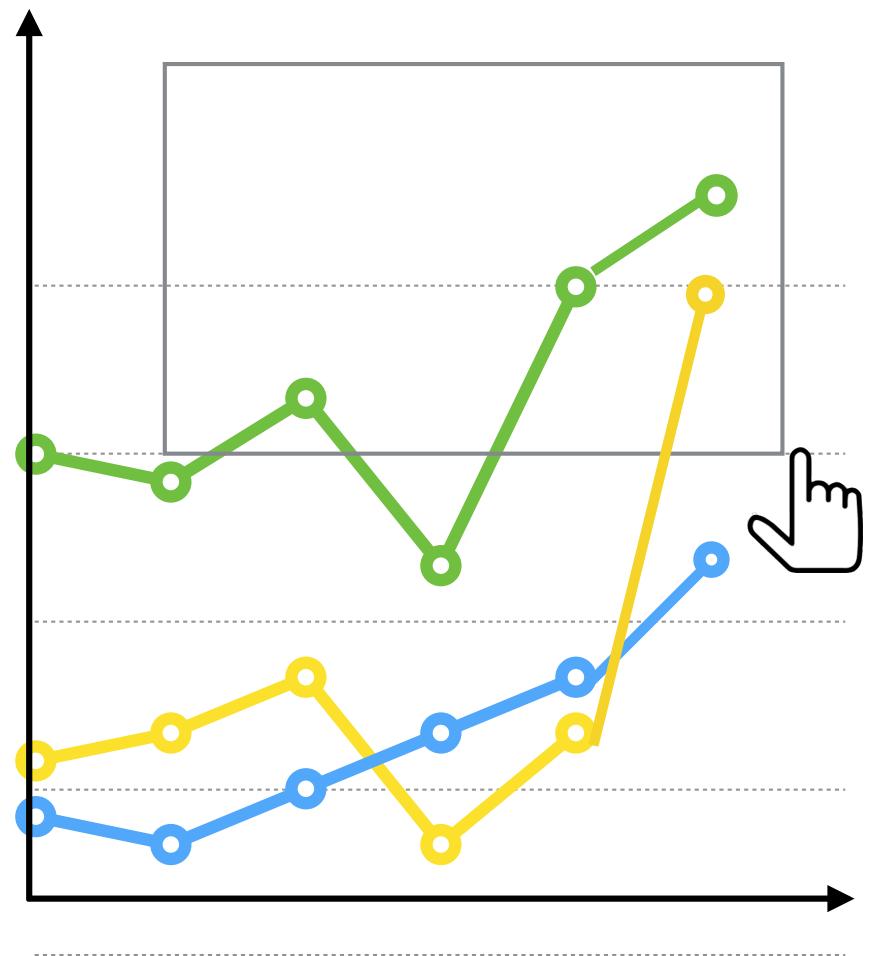
Defining Conflict: Read-Write



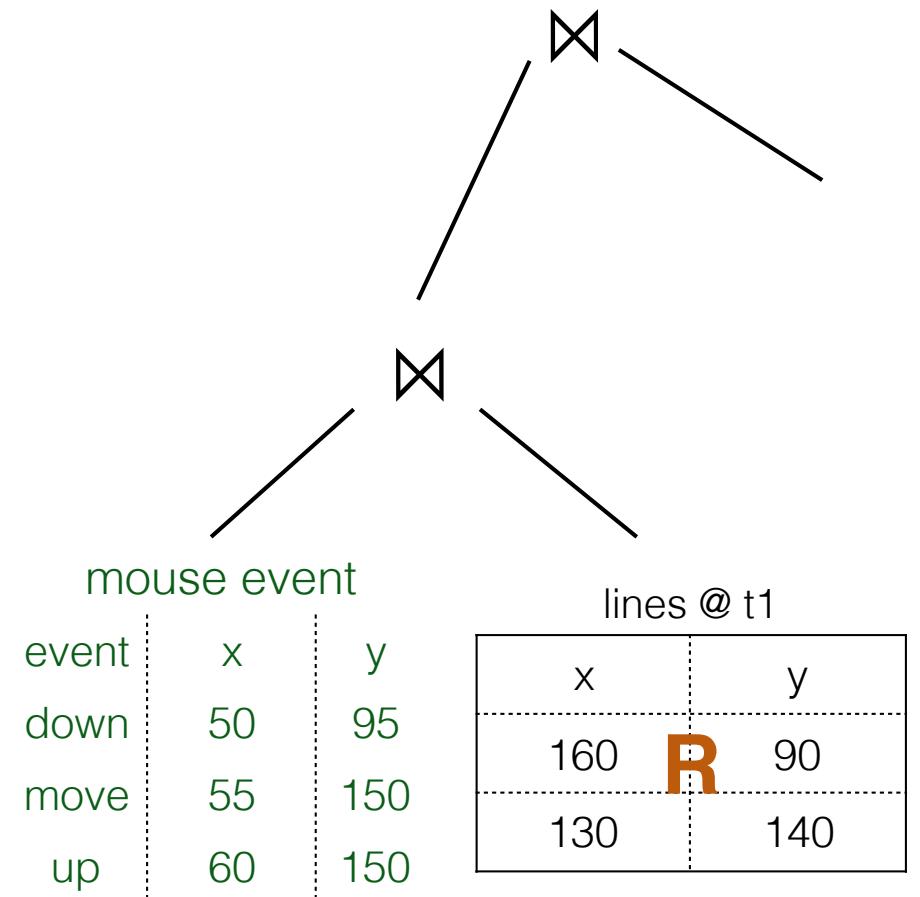
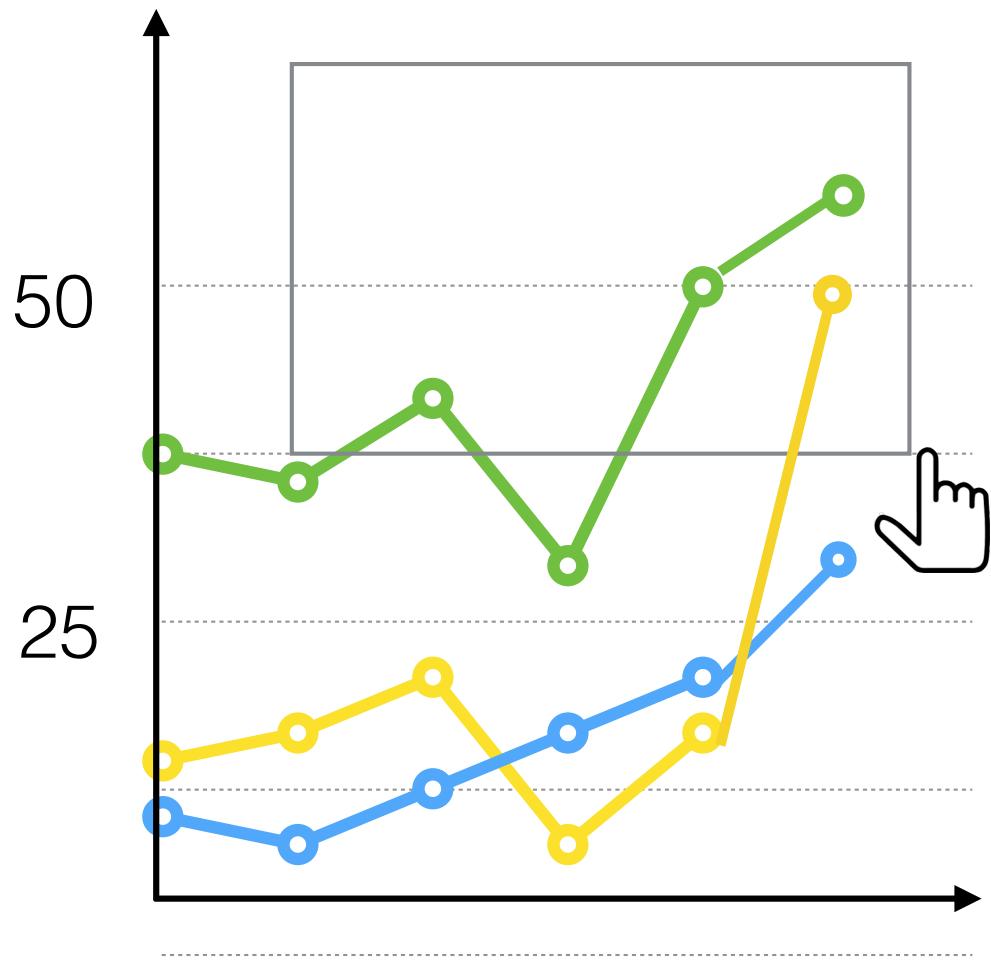
Defining Conflict: Read-Write



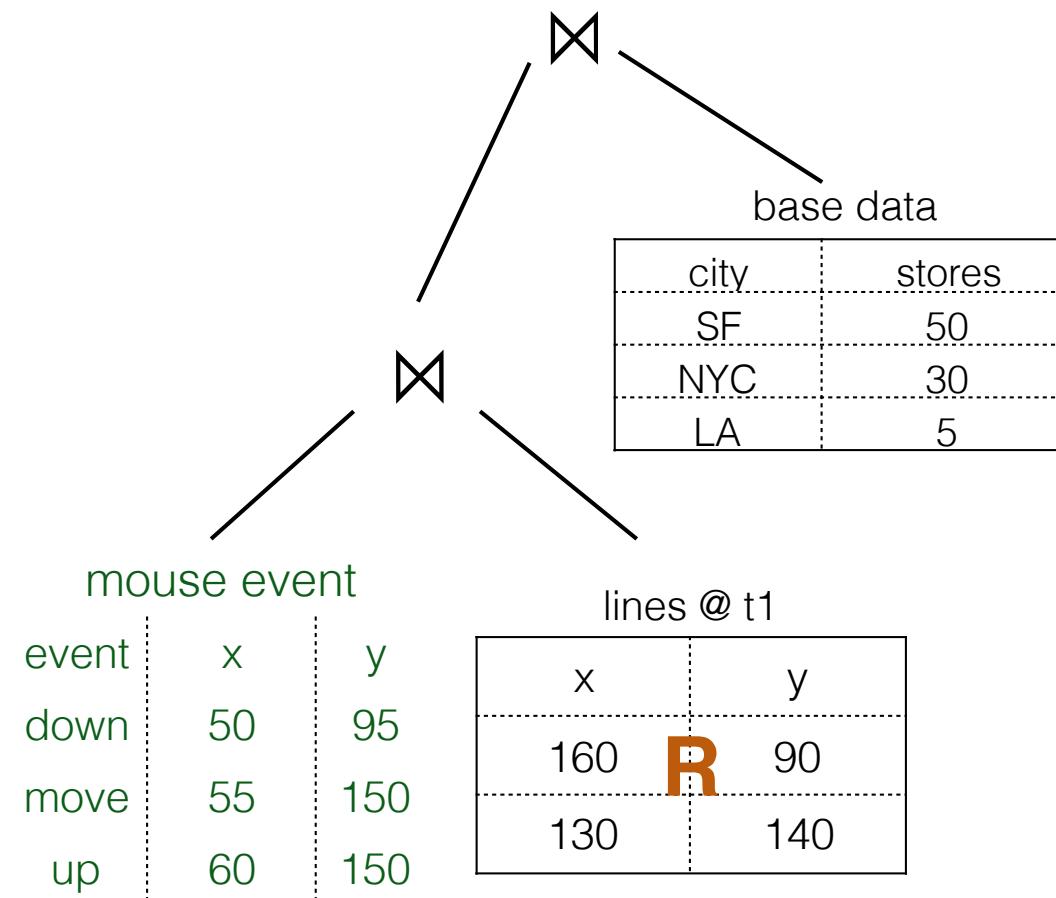
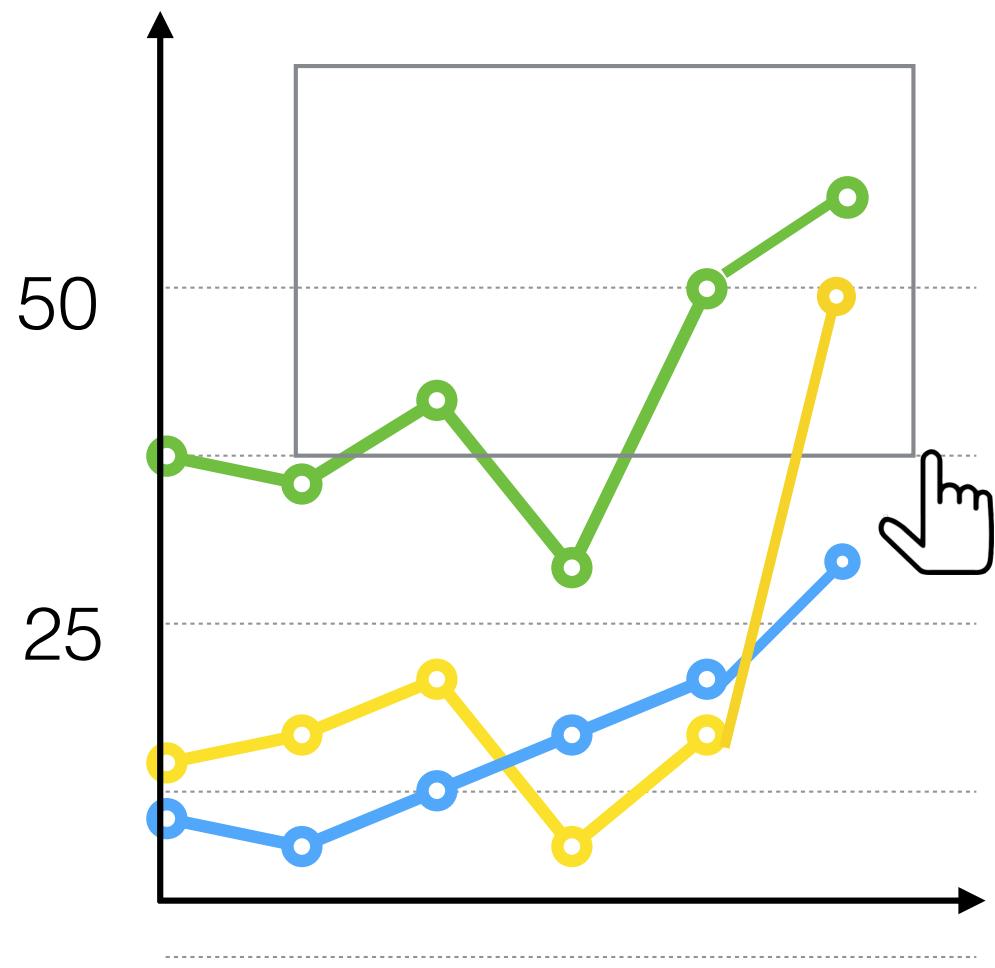
Defining Conflict: Read-Write



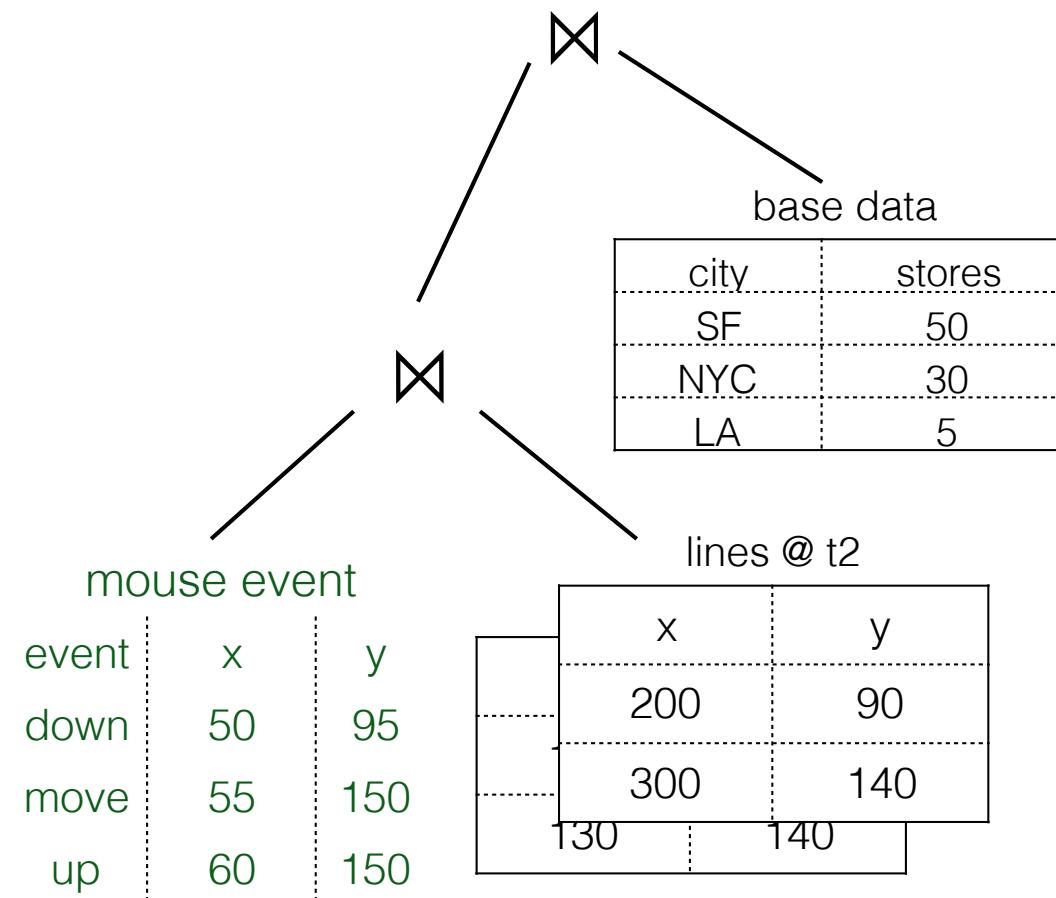
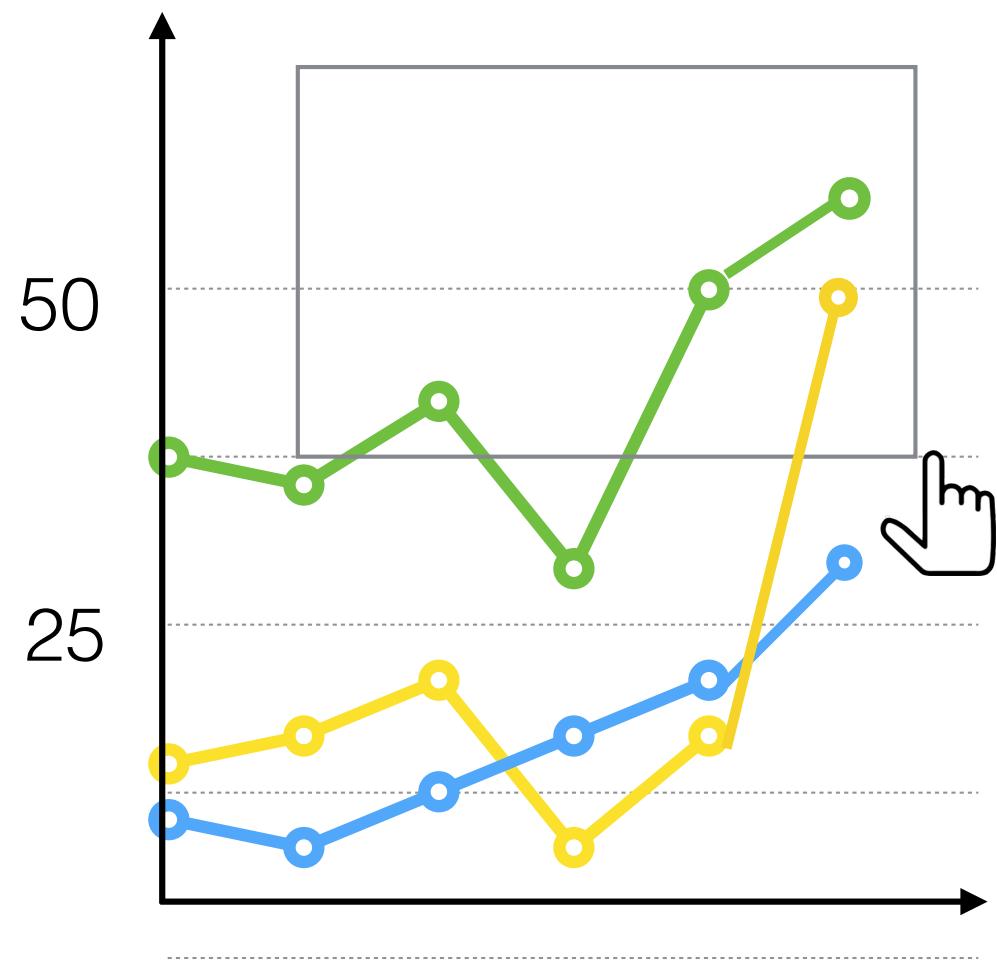
Defining Conflict: Read-Write



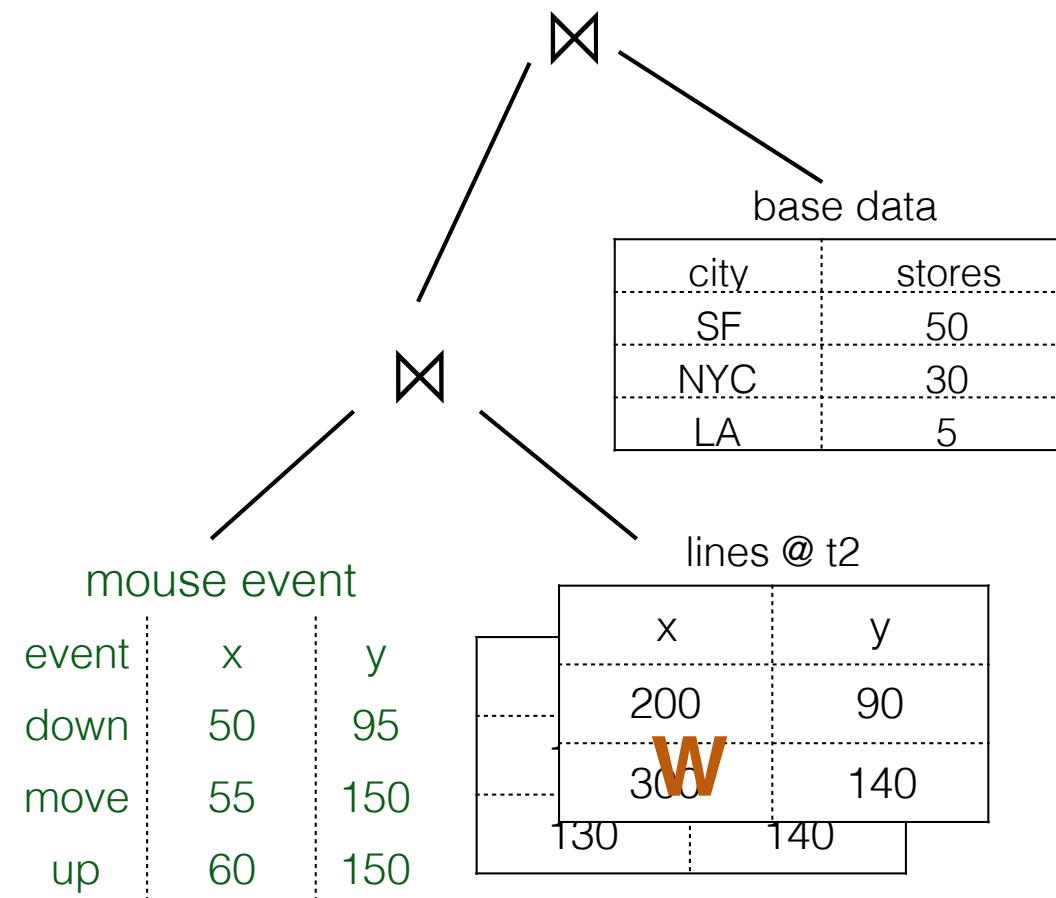
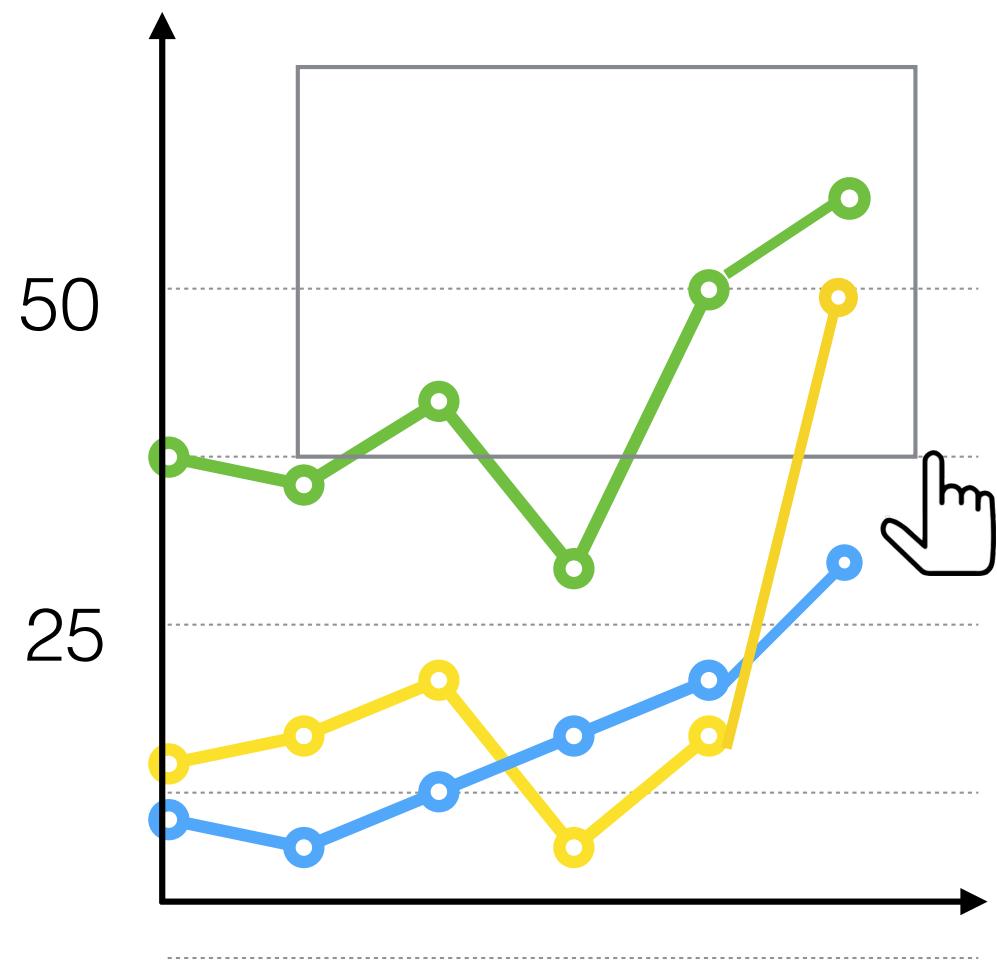
Defining Conflict: Read-Write



Defining Conflict: Read-Write



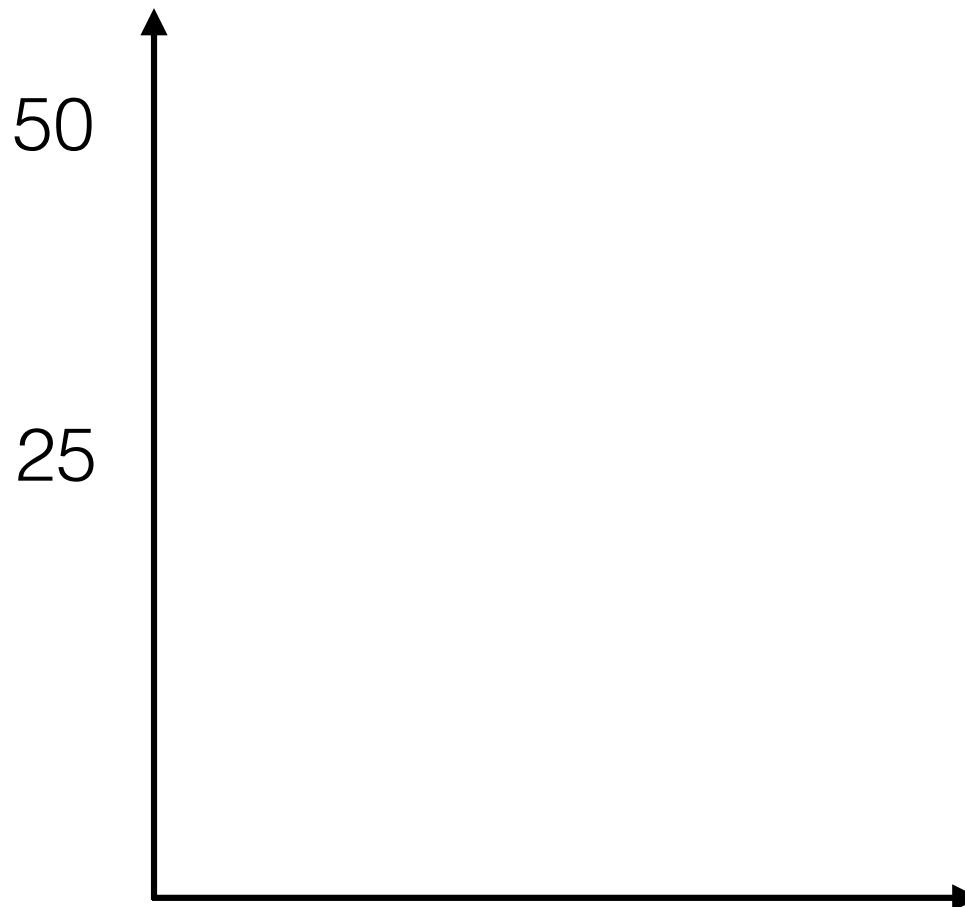
Defining Conflict: Read-Write



Defining Conflict: *Write-Read
***human latency: ~250ms**

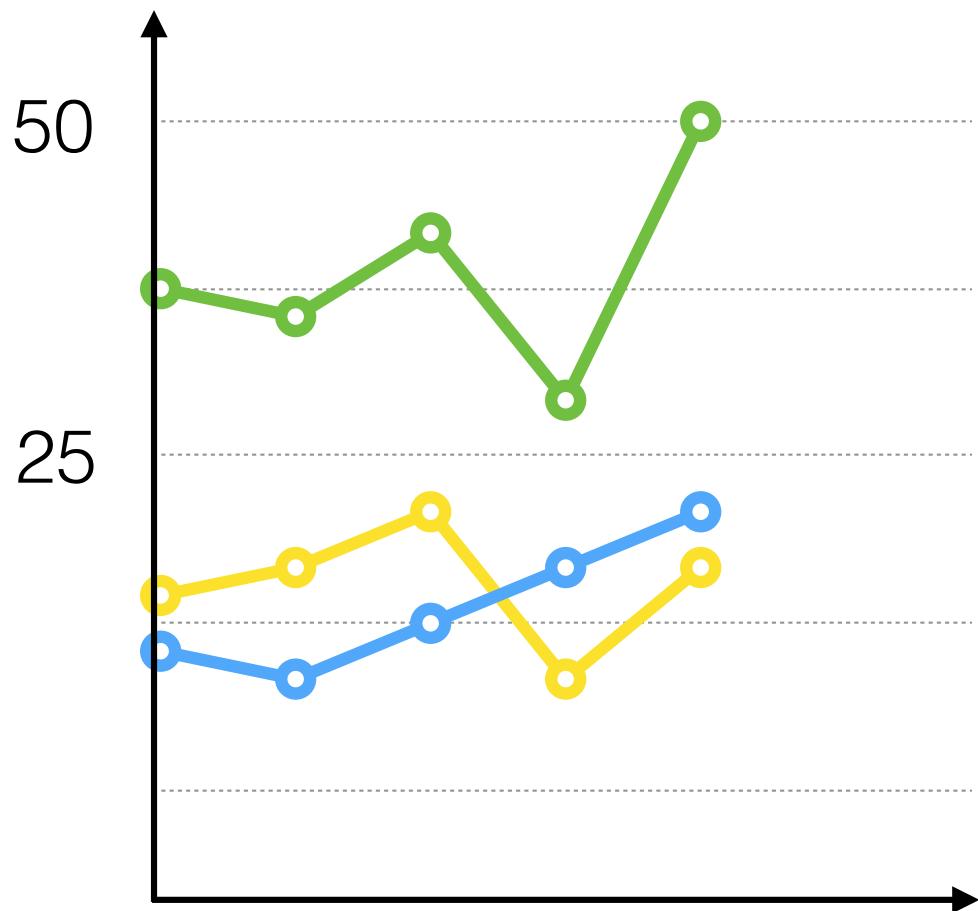
Defining Conflict: *Write-Read

***human latency: ~250ms**



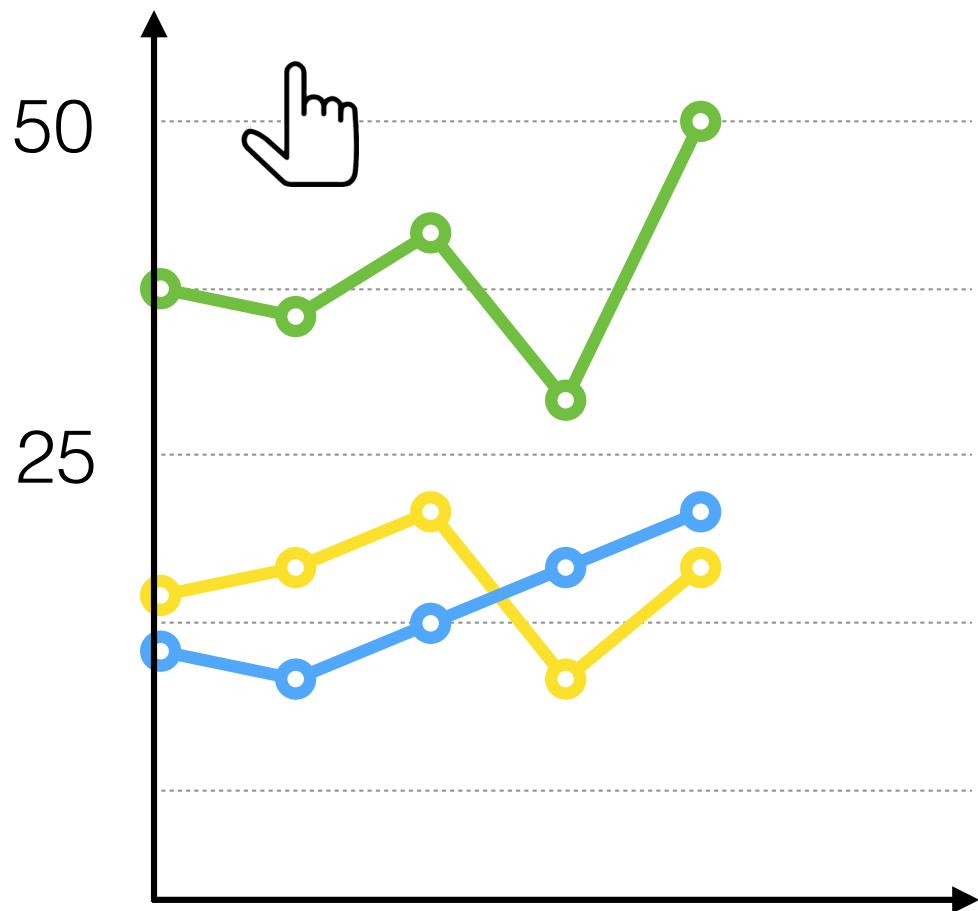
Defining Conflict: *Write-Read

***human latency: ~250ms**



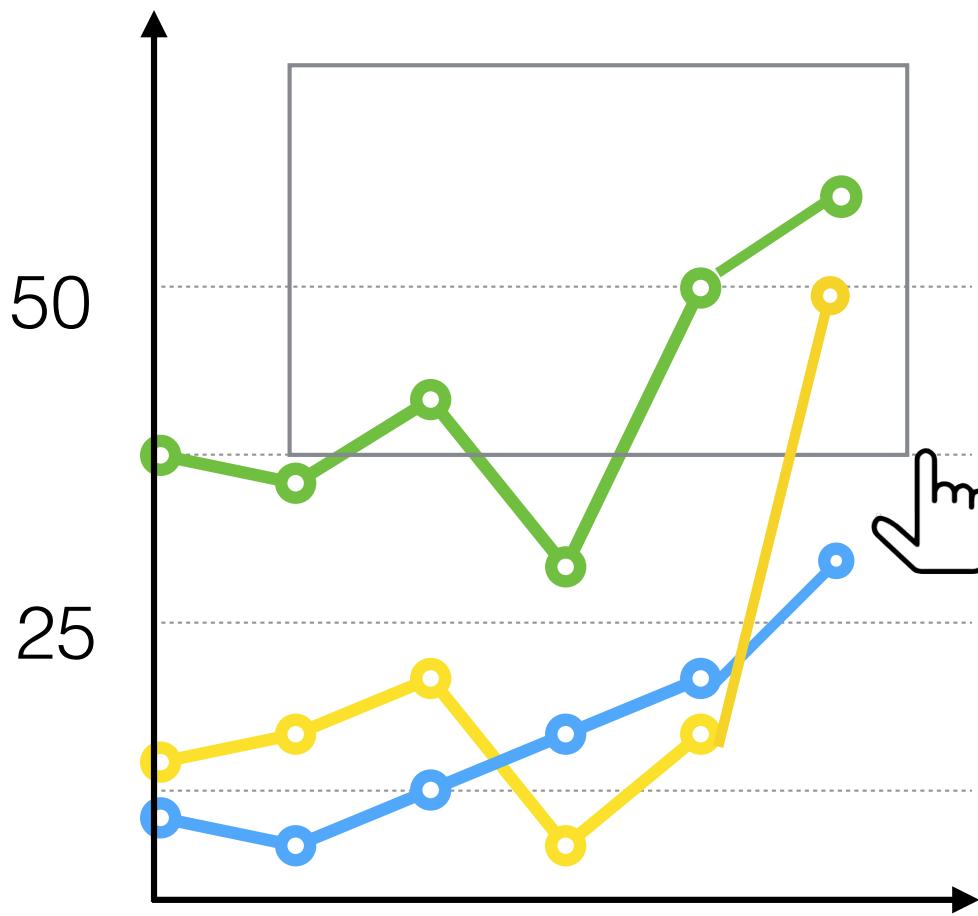
Defining Conflict: *Write-Read

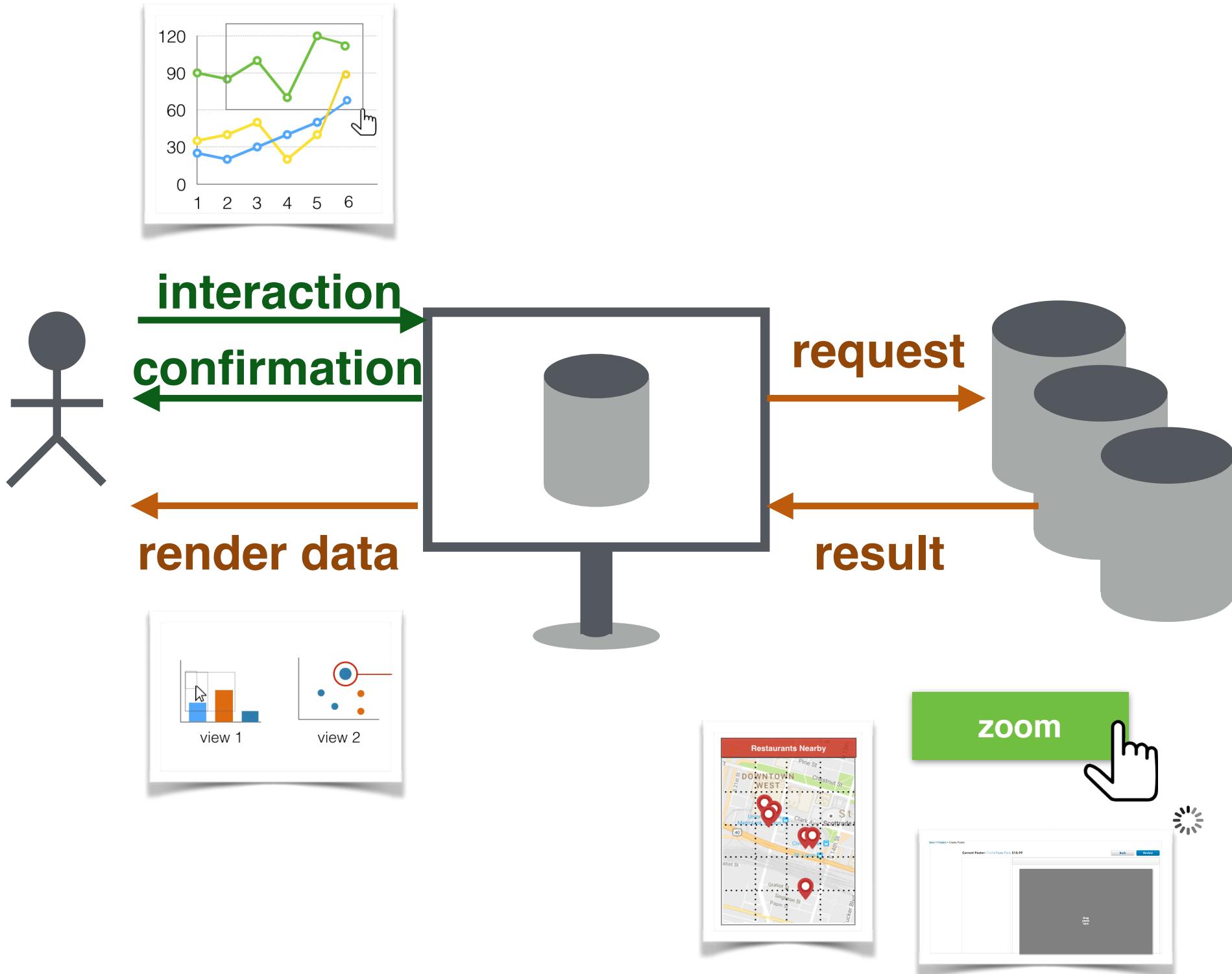
***human latency: ~250ms**



Defining Conflict: *Write-Read

***human latency: ~250ms**





Dealing with Inconsistency

- **Detection: formal framework**
- **Prevention:**
 - **Ensure consistency**
 - **Communicate inconsistency**

Seen Technique: Blocking

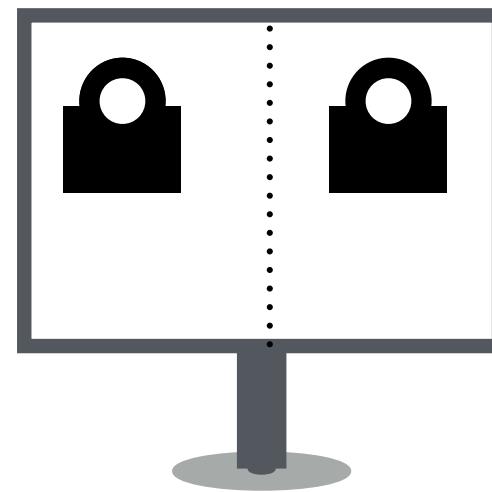


Seen Technique: Blocking



Inspiration from systems algorithms!

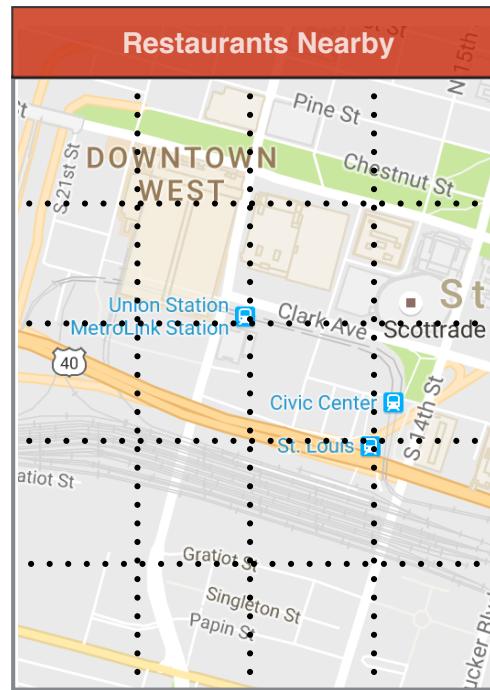
Seen Technique: Blocking



Inspiration from systems algorithms!

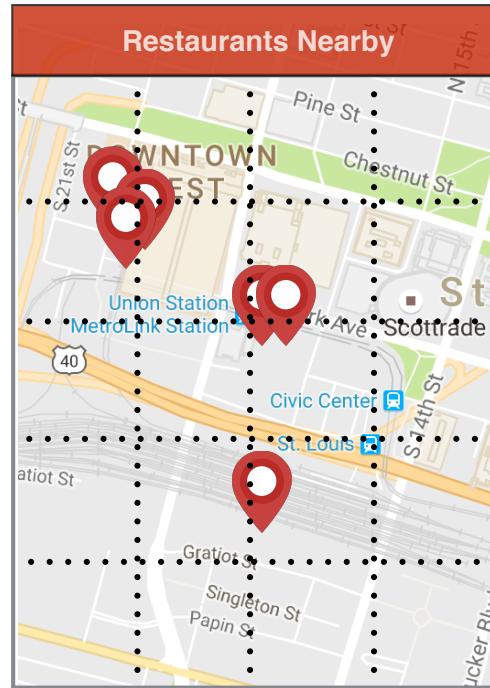
Can we draw more
insights from algorithms
for systems concurrency?

Interaction Constraints



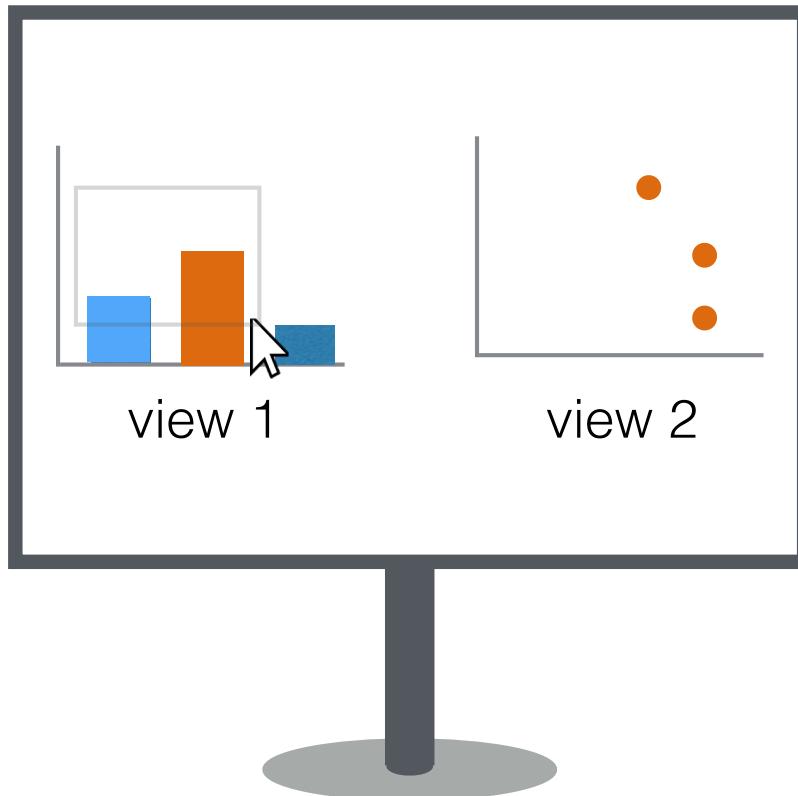
```
I.pins.render IF I.maps.render == TRUE
```

Interaction Constraints



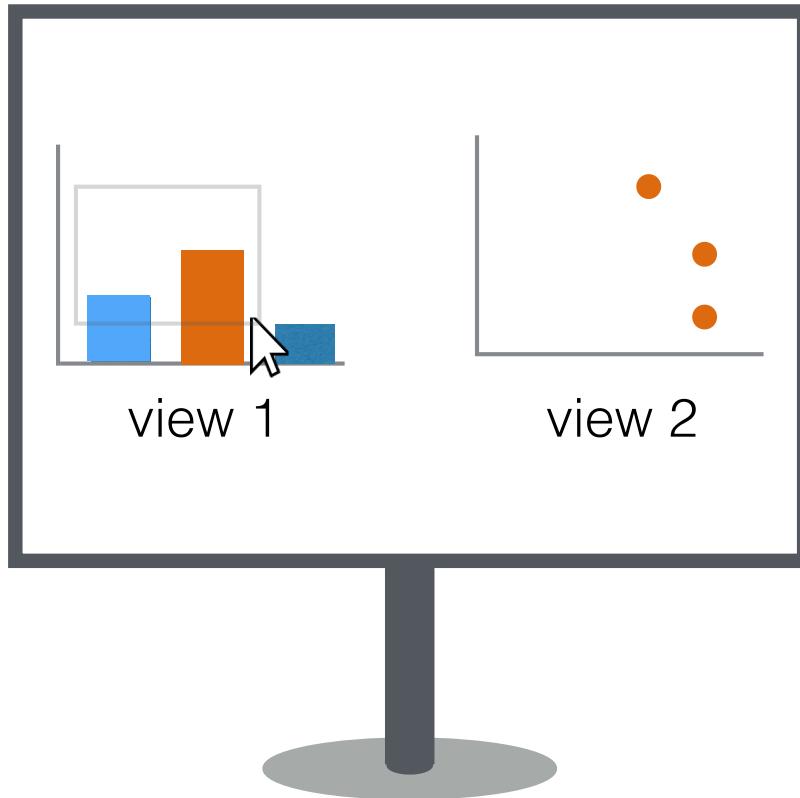
```
I.pins.render IF I.maps.render == TRUE
```

Merge Functions



pixel data			
x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

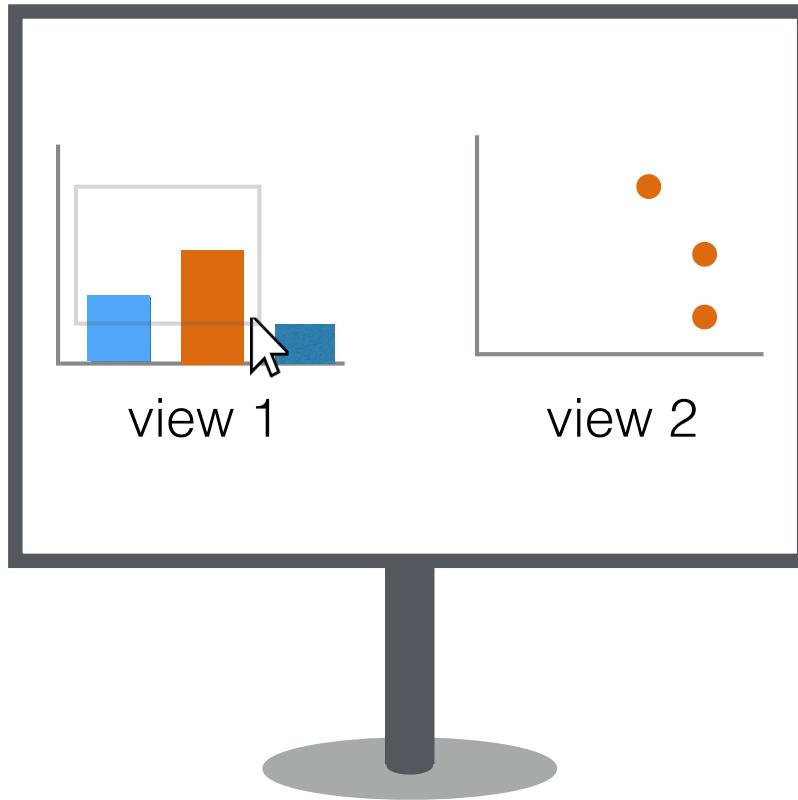
Merge Functions



pixel data			
x	y	color	lineage
...
70	140	orange	I1, V2, T2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

```
merge_func(p1,p2): [p1,p2].map(  
  p -> p.lineage.mark.transparency = 0.5)
```

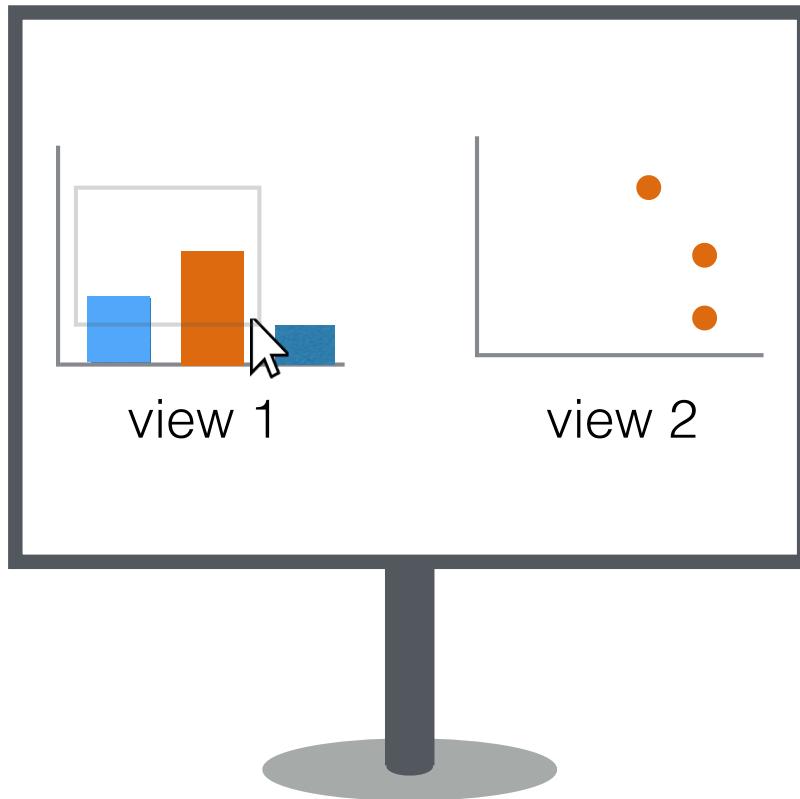
Merge Functions



pixel data			
x	y	color	lineage
...
70	140	blue orange	I1, V1, T1 I1, V2, I2
...
80	140	orange	I1, V2, T2
...
90	140	white	init
...

```
merge_func(p1,p2): [p1,p2].map(  
  p -> p.lineage.mark.transparency = 0.5)
```

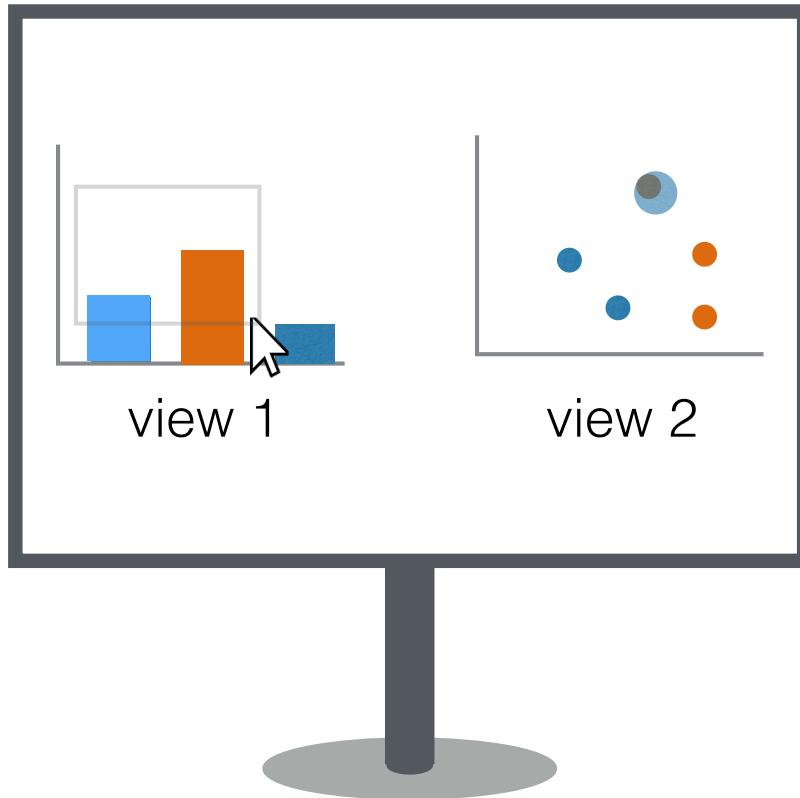
Merge Functions



pixel data			
x	y	color	lineage
...
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...
90	140	white	init
...

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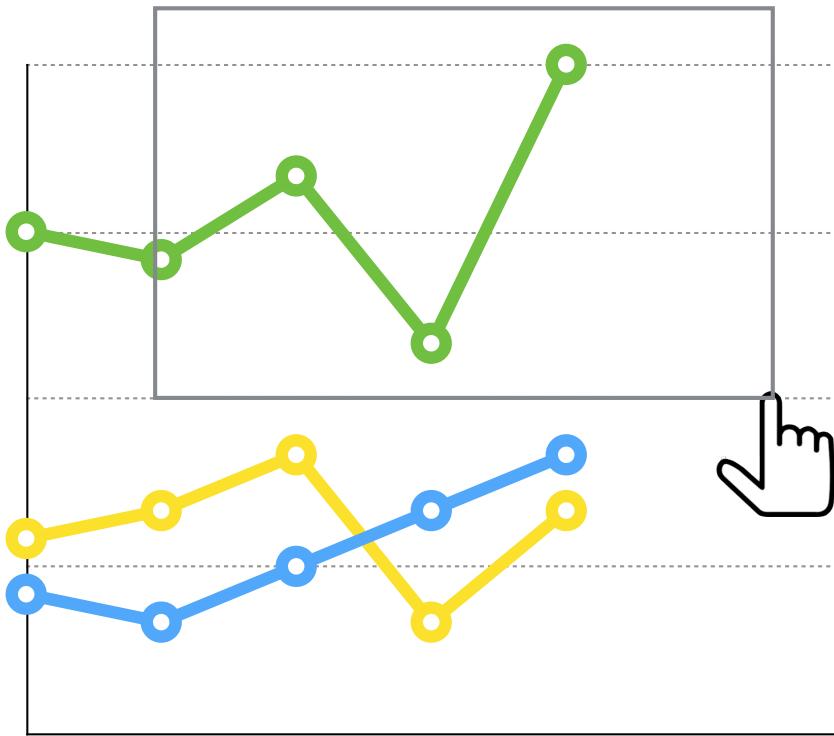
Merge Functions



pixel data			
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80	140	orange	I1,V2, T2
...
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...

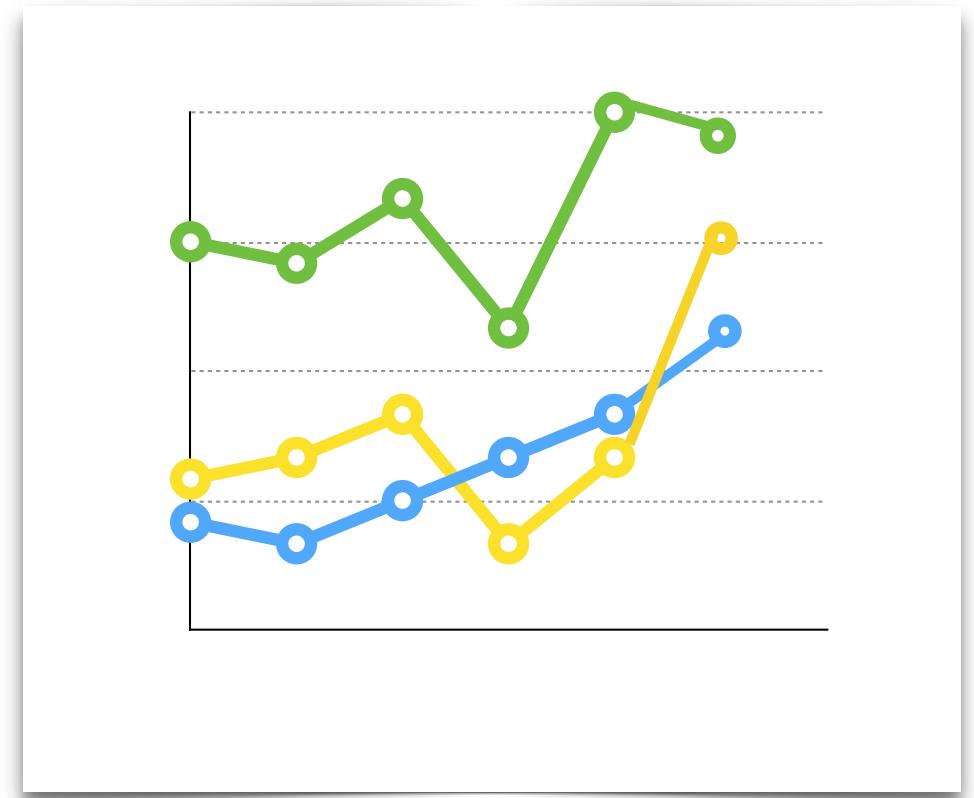
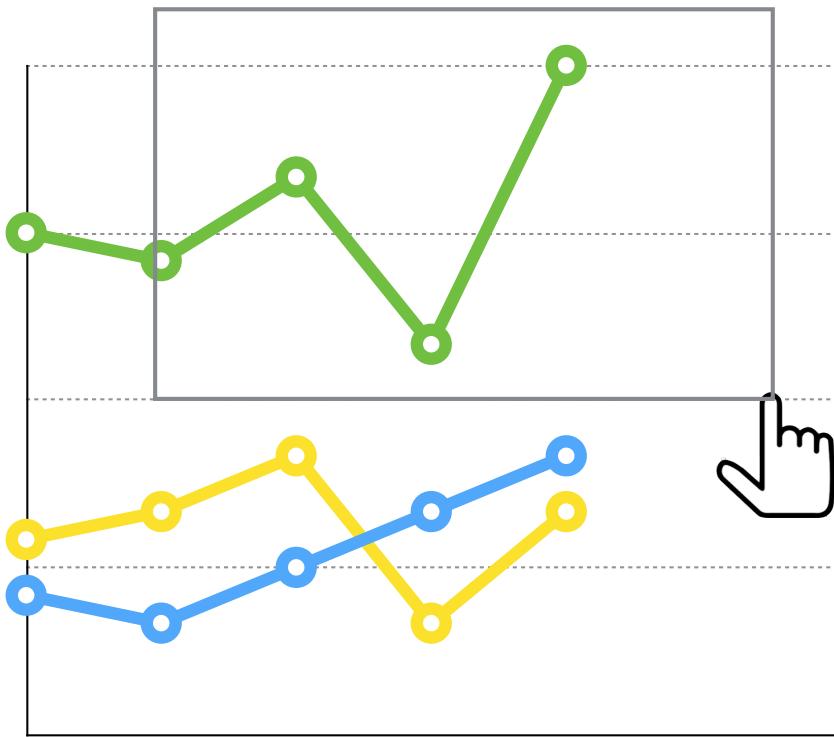
```
merge_func(p1,p2): [p1,p2].map(  
  p -> p.lineage.mark.transparency = 0.5)
```

Visualization Snapshots



Multi Version Concurrency Control

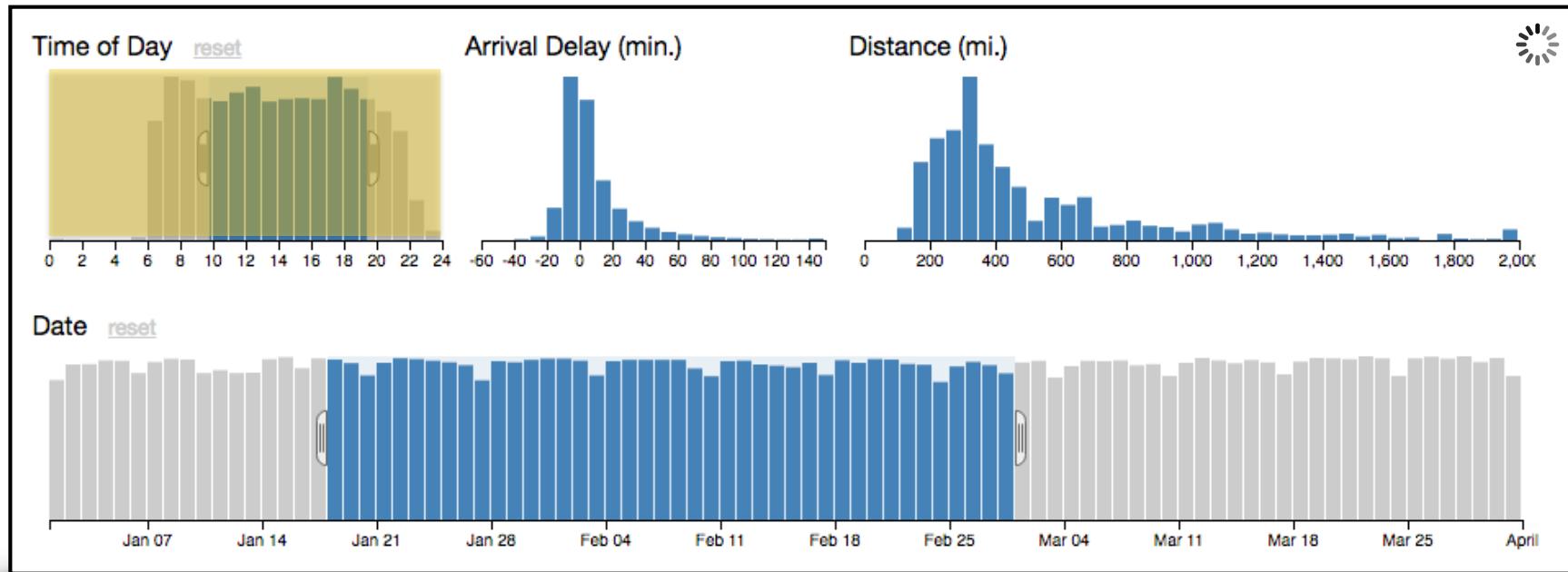
Visualization Snapshots



Multi Version Concurrency Control

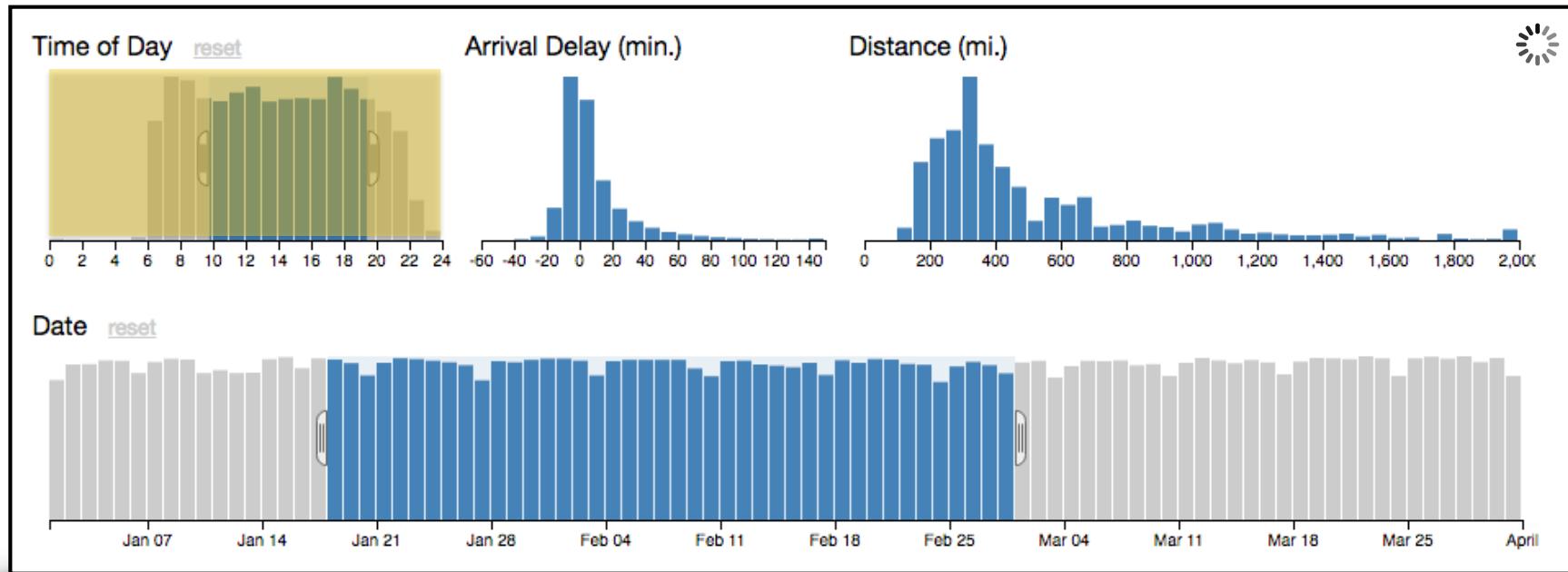
Visualization Snapshots

Example: Cross Filter



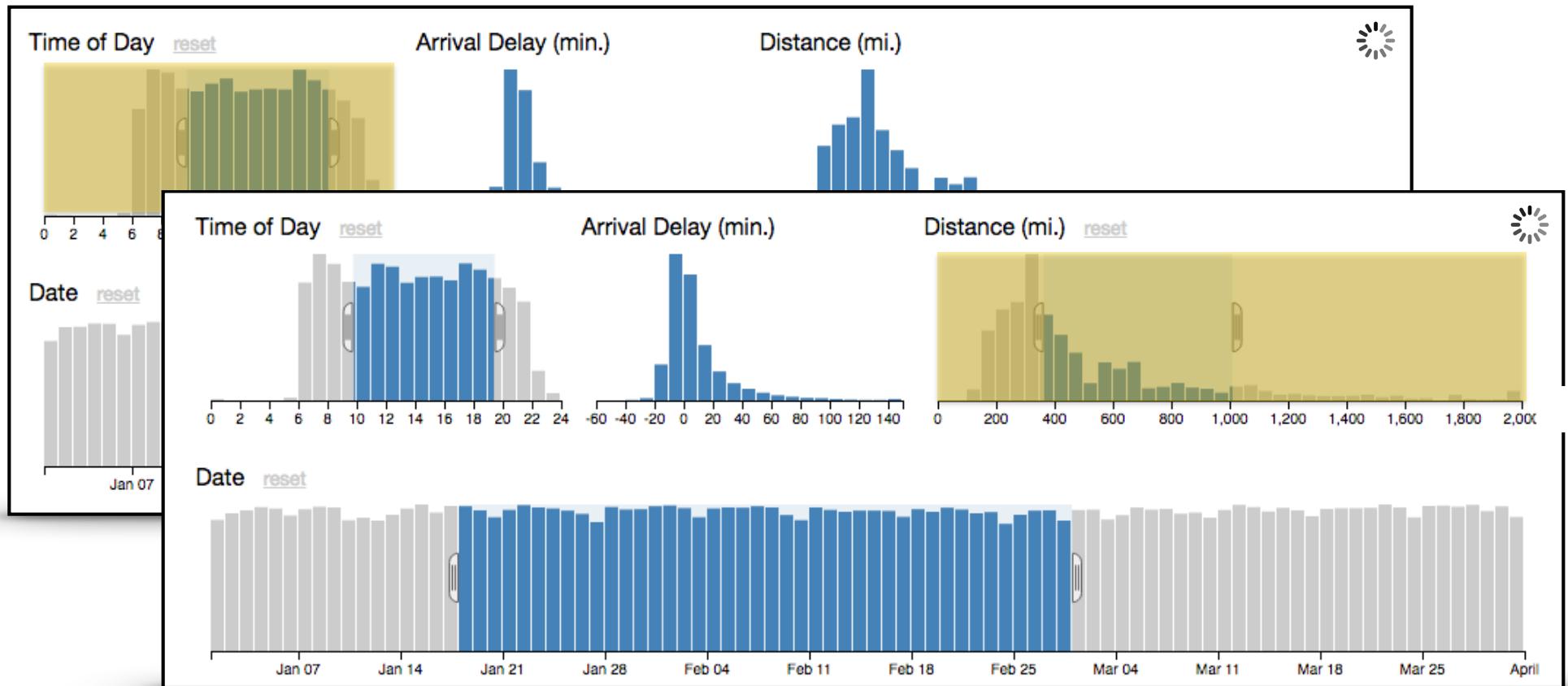
Visualization Snapshots

Example: Cross Filter



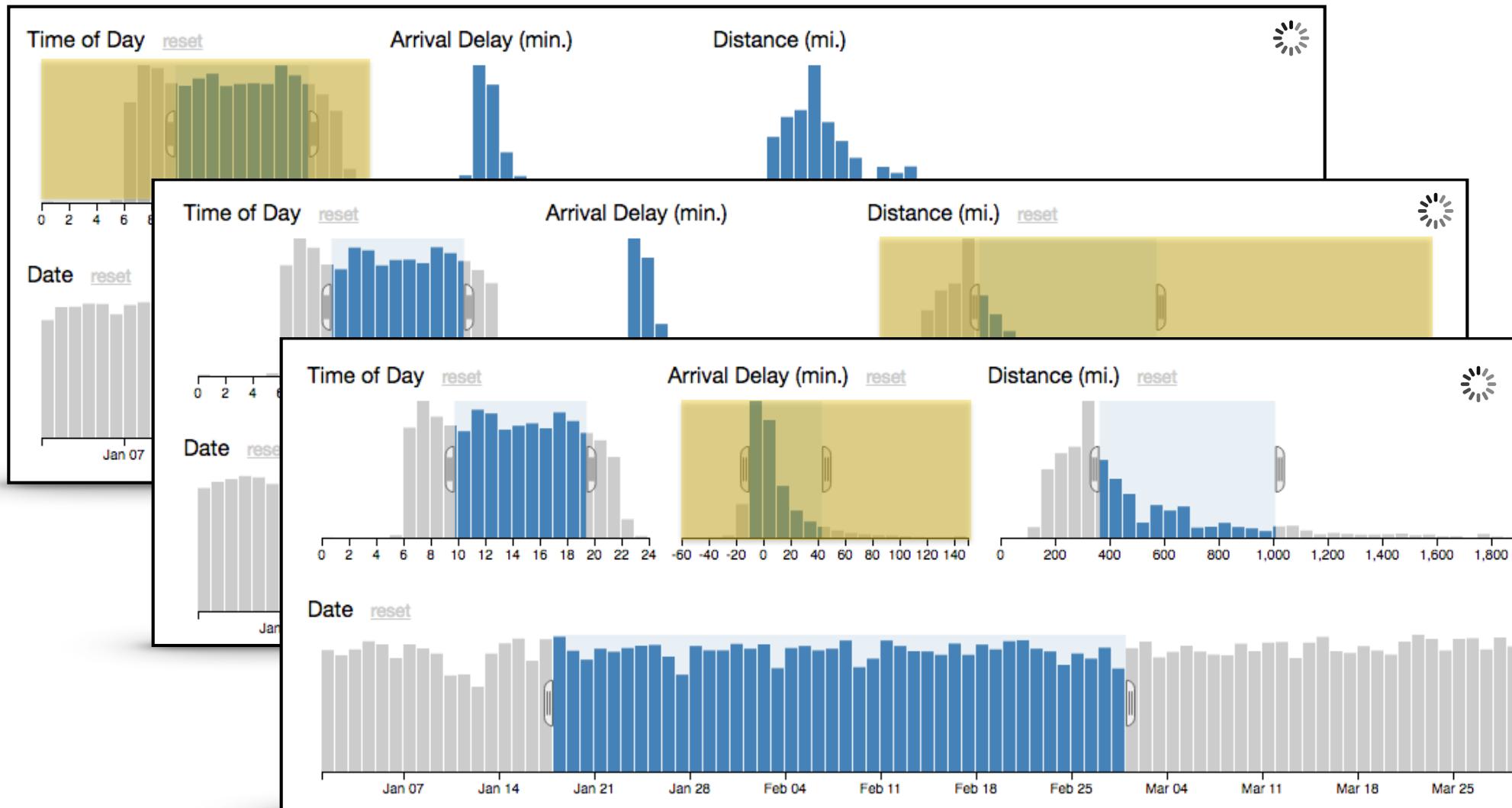
Visualization Snapshots

Example: Cross Filter



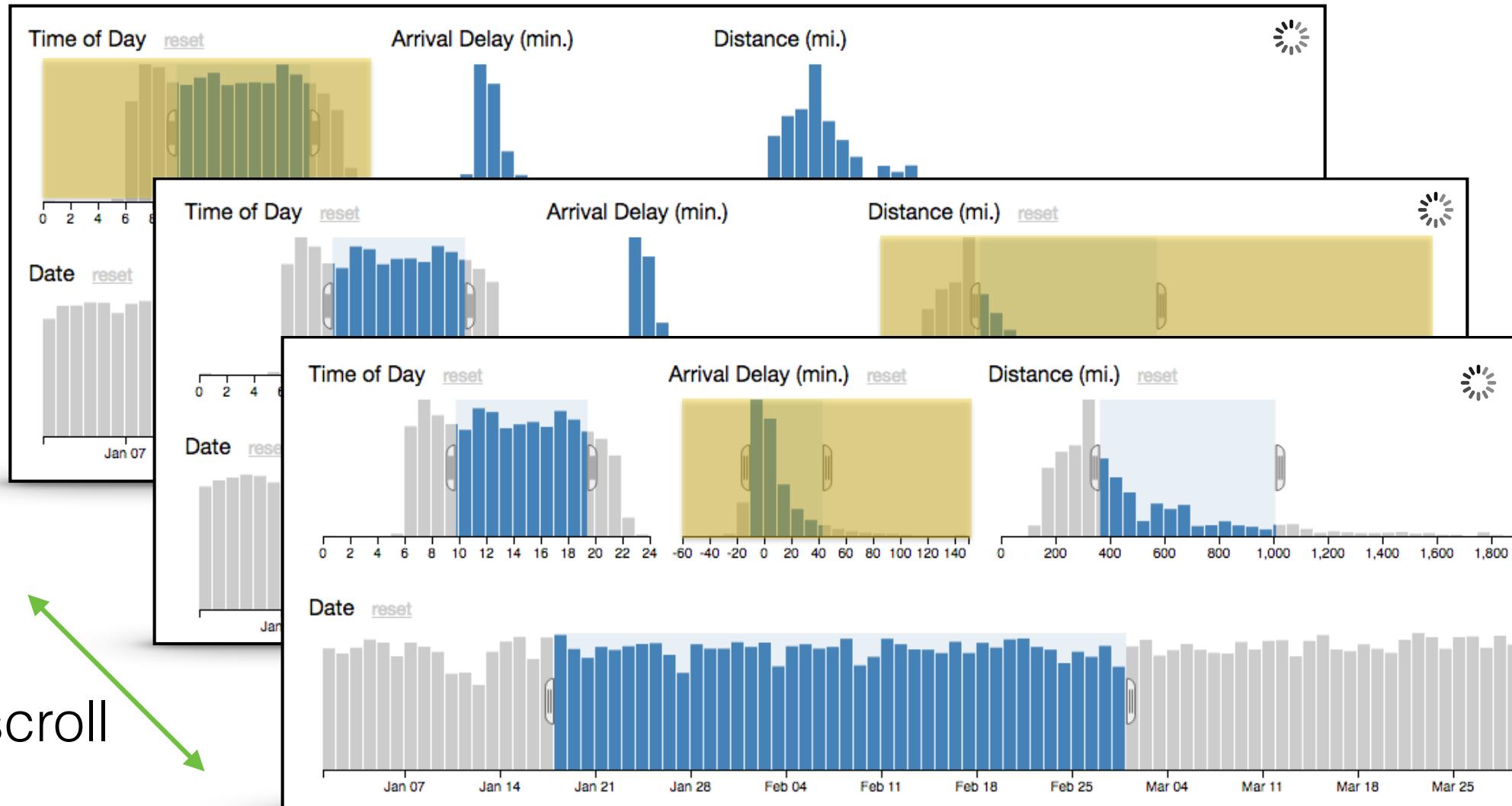
Visualization Snapshots

Example: Cross Filter



Visualization Snapshots

Example: Cross Filter

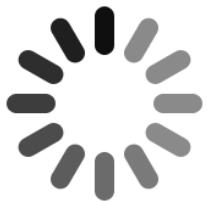


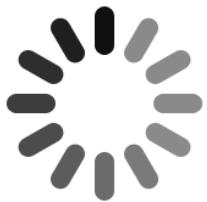
Dealing with Inconsistency

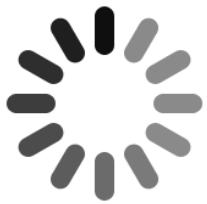
- **Detection: formal framework**
- **Prevention:**
 - **Ensure consistency**
 - **Communicate inconsistency**

Dealing with Inconsistency

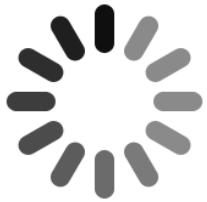
- **Detection: formal framework**
- **Prevention:**
 - **Ensure consistency**
 - **Communicate inconsistency**







labels: data from <selection description>



labels: data from <selection description>

No Callback Hell Please!



labels: data from <selection description>

No Callback Hell Please!

know the global state!

Dealing with Inconsistency

Declaratively

API for Front-End State

Shim Layer for Consistency

API for Front-End State

Shim Layer for Consistency

API for Front-End State



interaction & request handlers

conflict detector

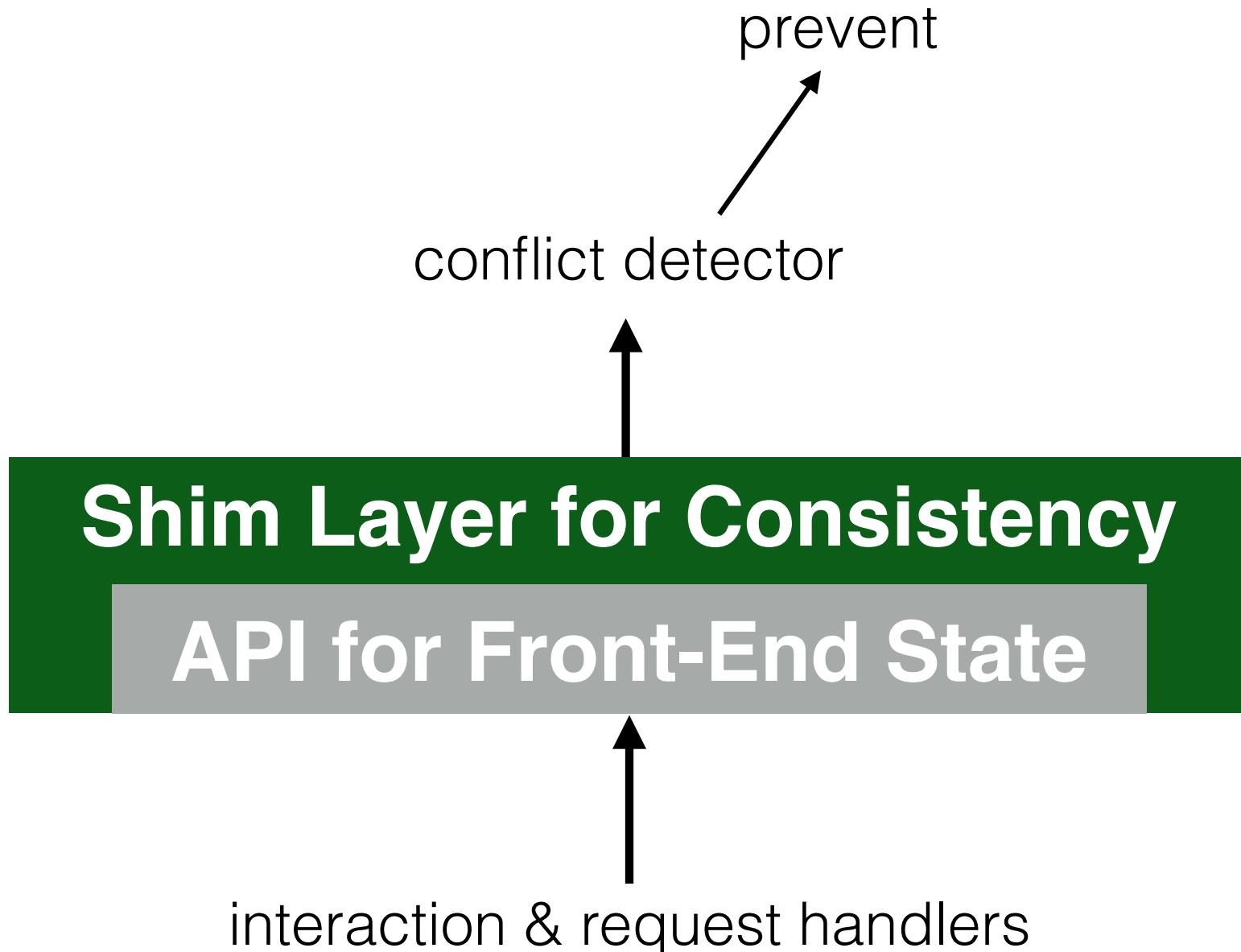


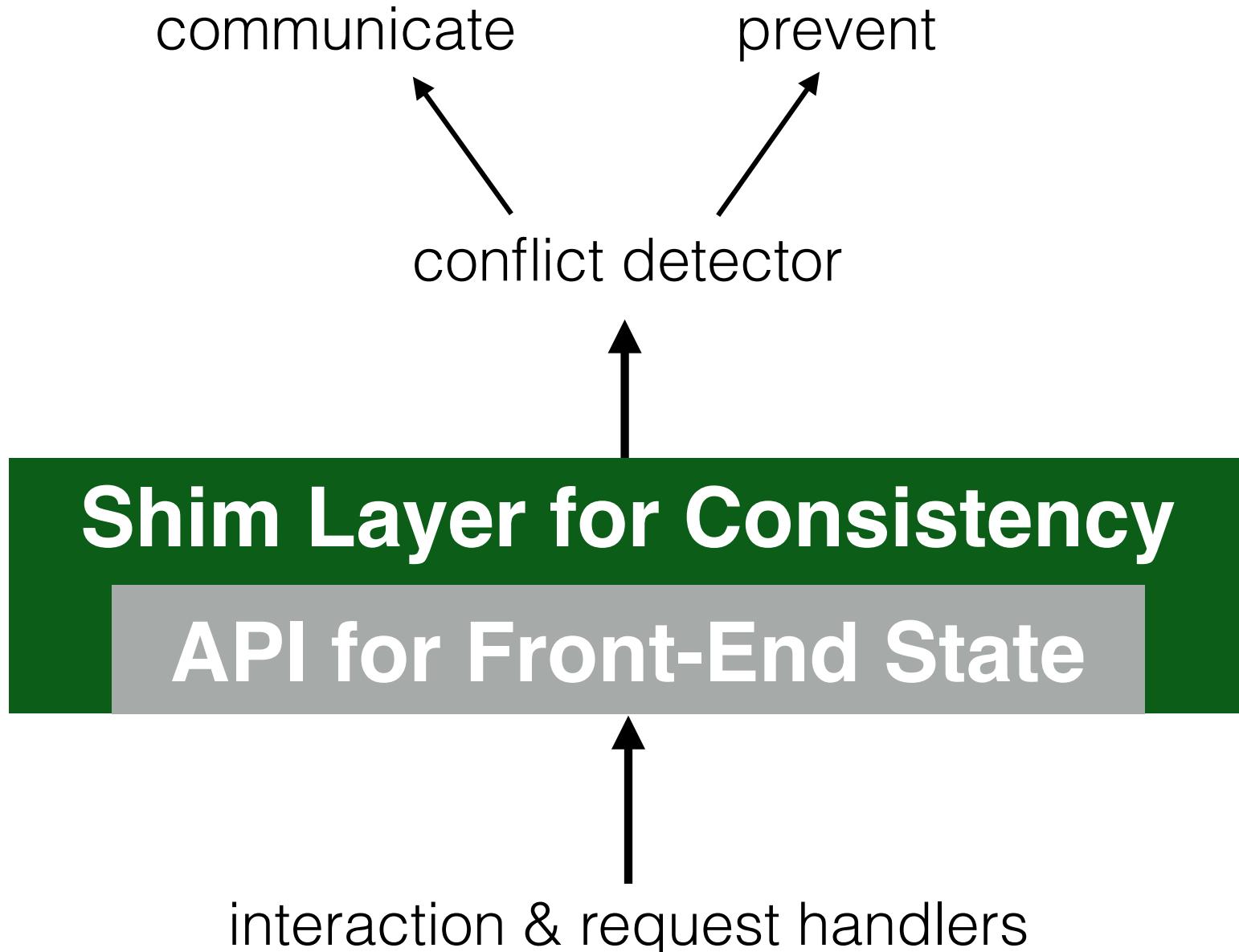
Shim Layer for Consistency

API for Front-End State



interaction & request handlers







communicate

prevent

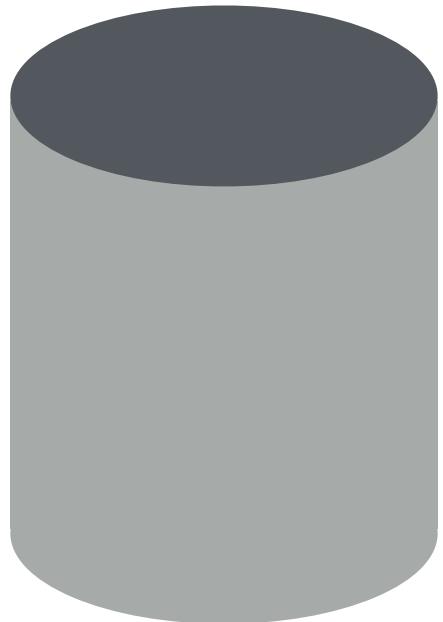
conflict detector

Shim Layer for Consistency

API for Front-End State

interaction & request handlers

the front-end is a database



Related Work

- Paper: *A DeVIL-ish approach to inconsistency in interactive visualizations.*
- Prof Eugene Wu's Data Visualization Management Systems.
- Prof. Joe Hellerstein and Peter Alvaro's work on Bloom.

Thanks!

@yifanwu

to share your comments!

or get slides, references, and project updates!