



Visualising **third party website trackers**

Visualising third party website trackers



I am **Princiya**

@princiya 

@princi_ya 



Lightbeam
for Firefox

moz://a

OUTREACHY



The next 45 mins...

- An overview of web tracking
- What is Lightbeam?
- The front-end
- The back-end
- Visualisations

ES6 Canvas SVG

D3.js Browser extensions

Performance

Tech cartoons

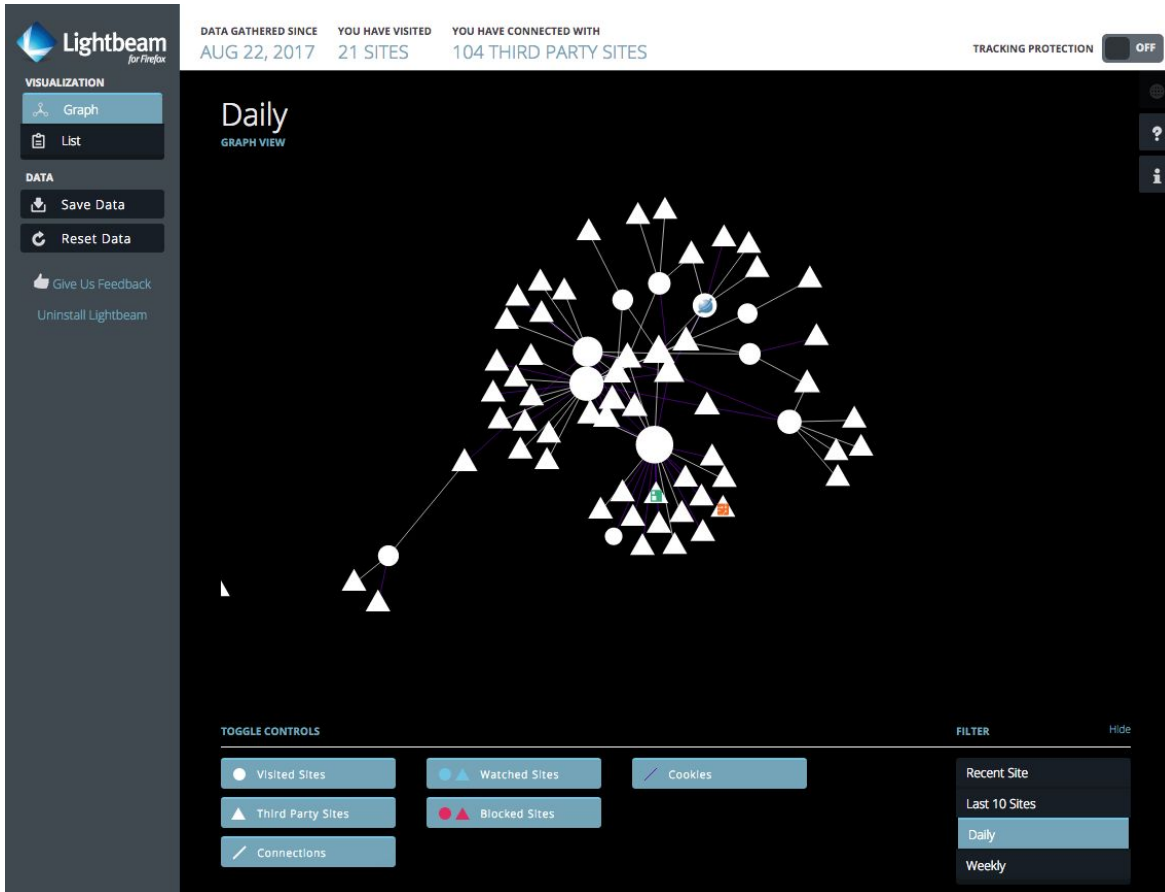


Background

The legacy Lightbeam add on



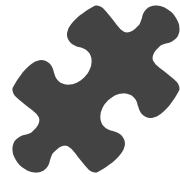
*Using interactive visualisations,
Lightbeam enables you to see
the first and third party websites
you interact with on the web.*



Web Tracking

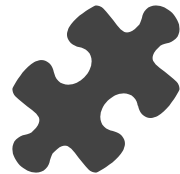
Web tracking is the practice by which websites identify and collect information about users.





An overview of web tracking

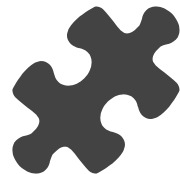
- ★ How does it work?



An overview of web tracking

★ How
does it
work?

★ Why is it
done?



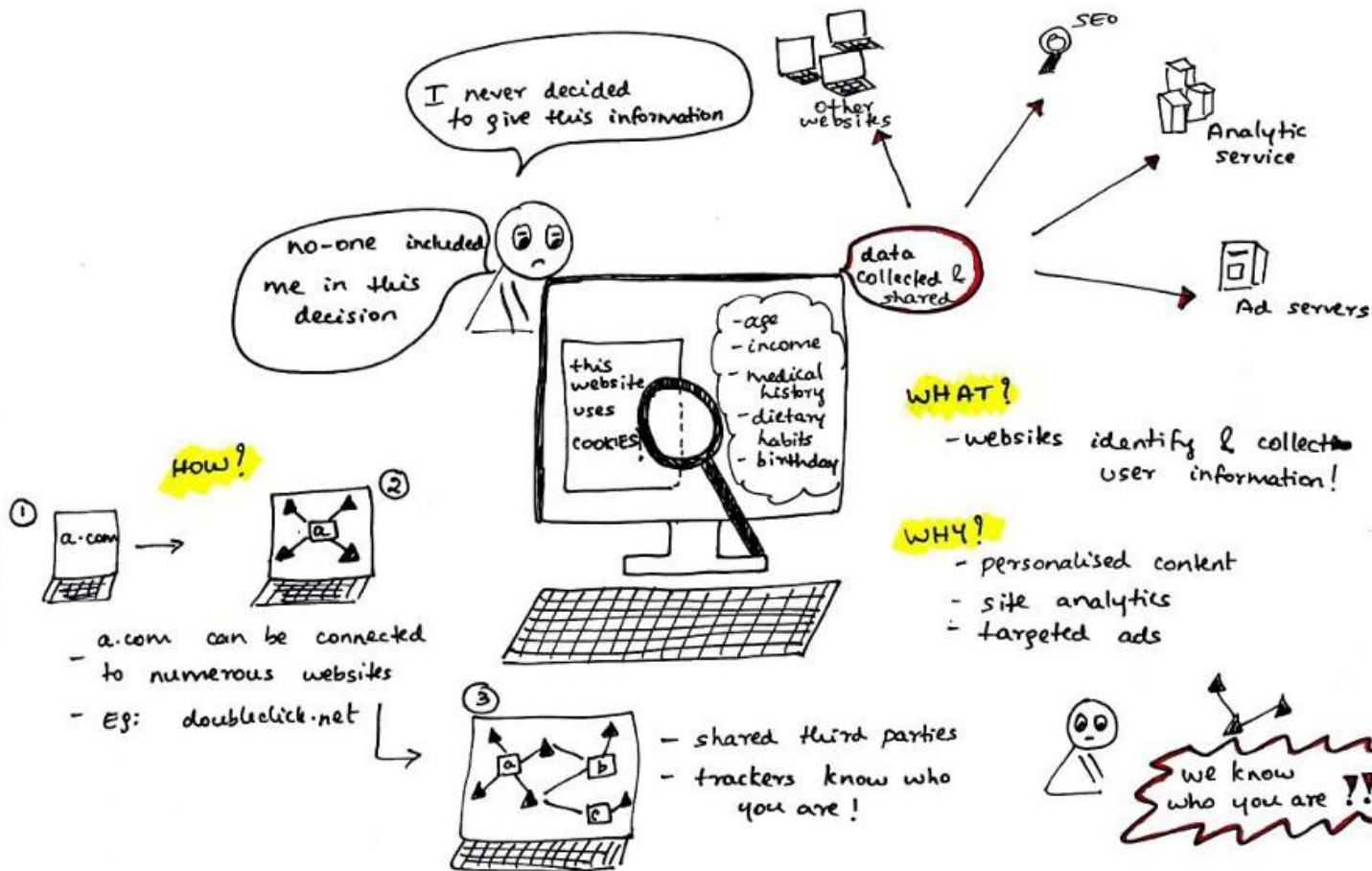
An overview of web tracking

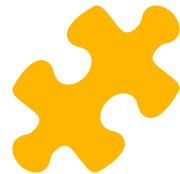
★ How
does it
work?

★ Why is it
done?

★ Is it evil?

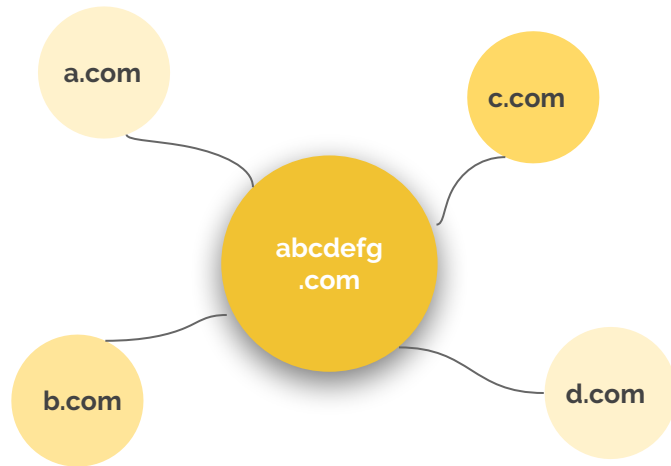
WEB TRACKING





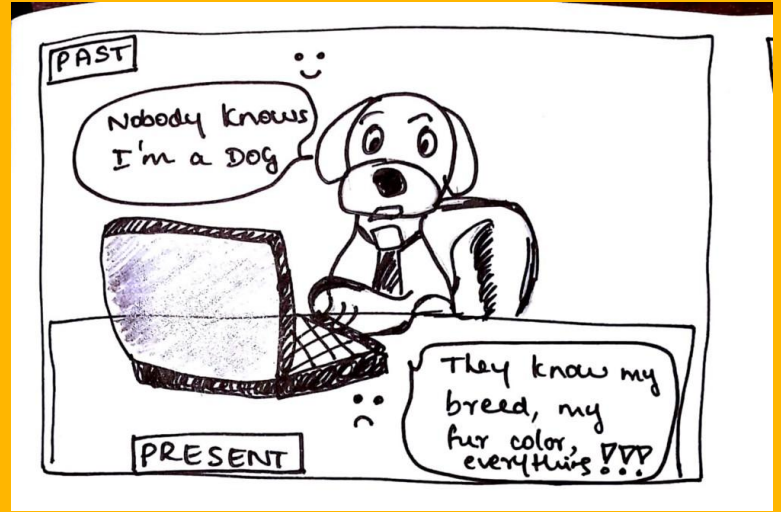
First party **vs** third party

party

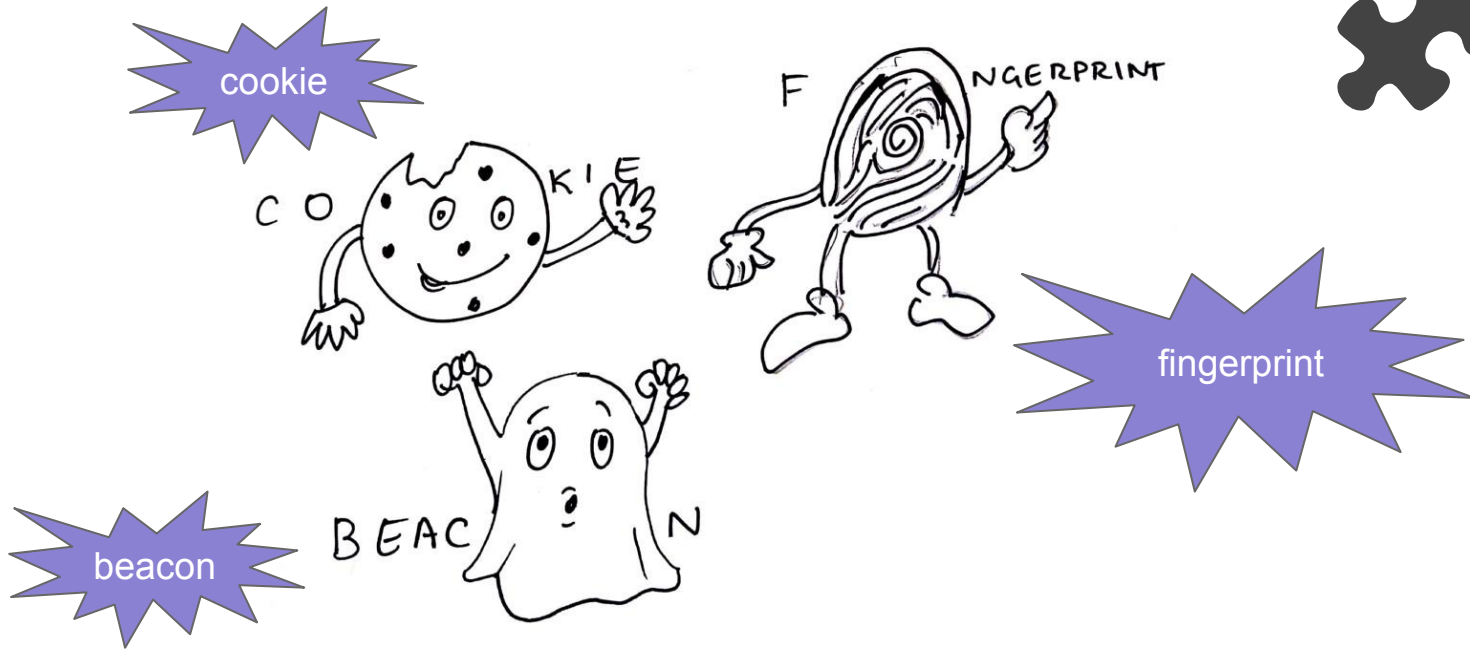




Third party trackers are creepy!



Tracking is not anonymous



Tracking mechanisms



How to **track** the **trackers**?

- Lightbeam
- Discover who is tracking you online



182,515 users

Whoa! That's a big number!

5,816,940 Downloads
12,637 in last 30 days

182,515 Average Daily Users
180,951 average in last 30 days

Browser extension

A new frontier



manifest_version
name
version

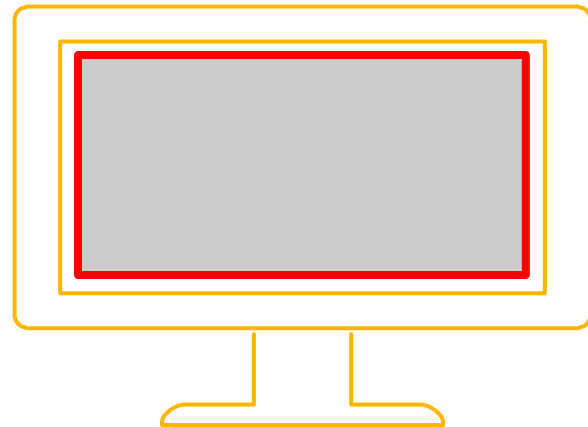
description

icons

permissions

scripts

```
document.body.style.border =  
"5px solid red";
```



manifest.json

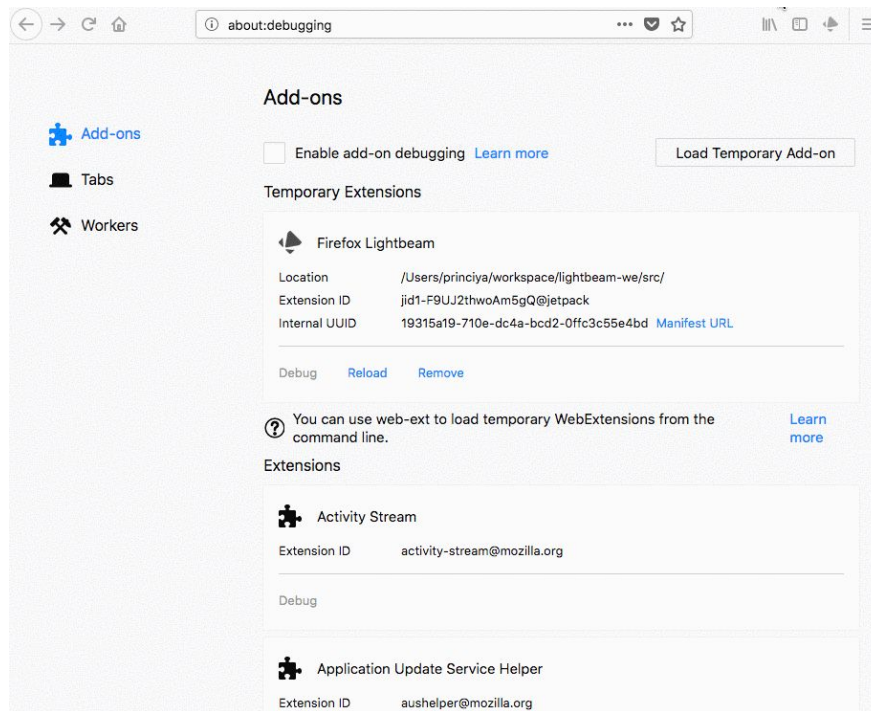
script

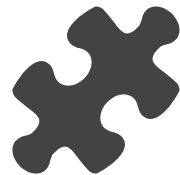
about:debugging

```
{
  "permissions": [
    "webRequest",
    "<all_urls>",
    "tabs"
  ],
  "browser_action": {
    "default_icon": "lb.png",
    "default_title": "Lightbeam"
  },
  "background": {
    "scripts": ["background.js"]
  }
}
```

```
browser.browserAction.onClicked.addListener(runLightbeam);
```

```
browser.tabs.create({url: 'index.html'});
```



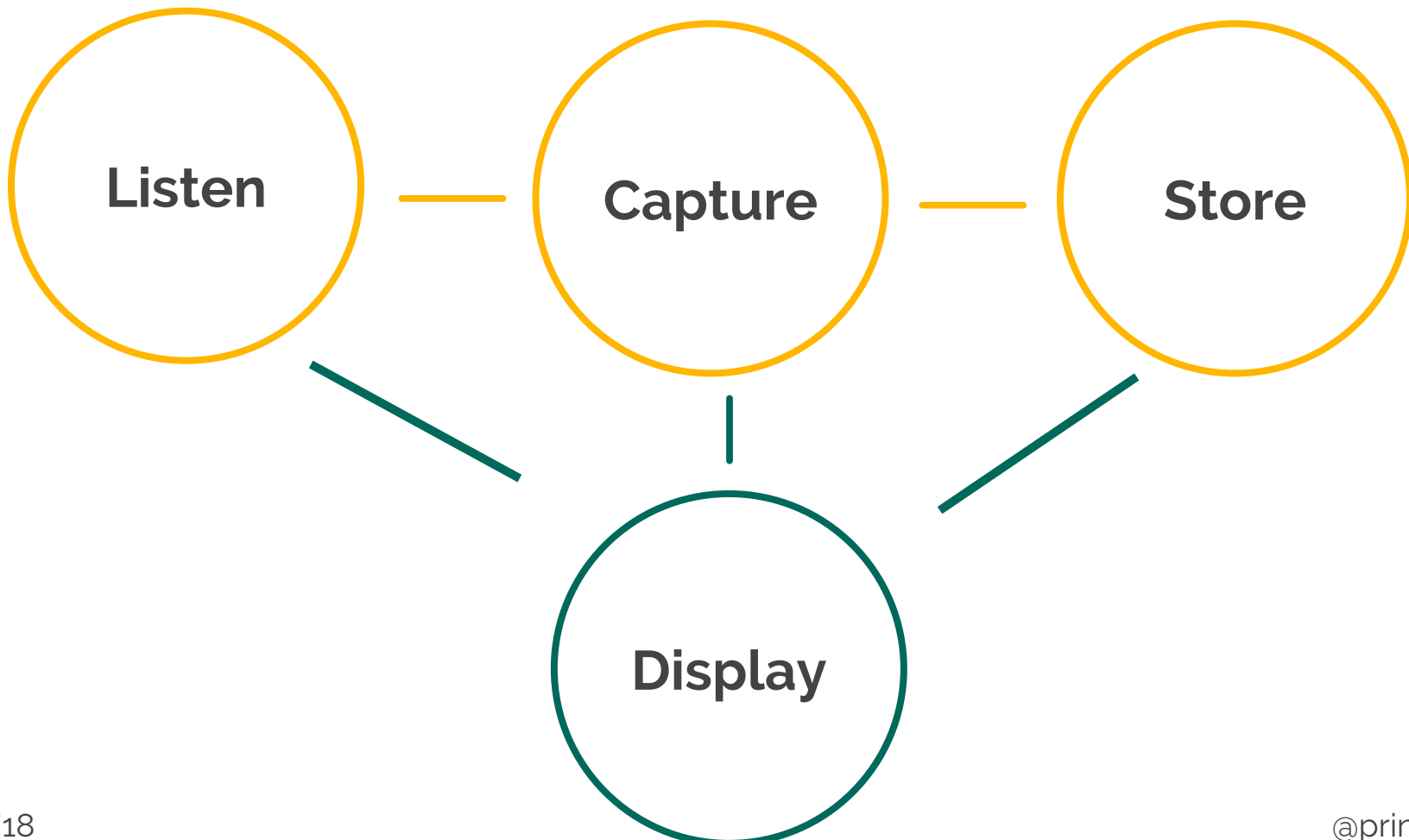


The different scripts

★ Content

★ Background

★ Page

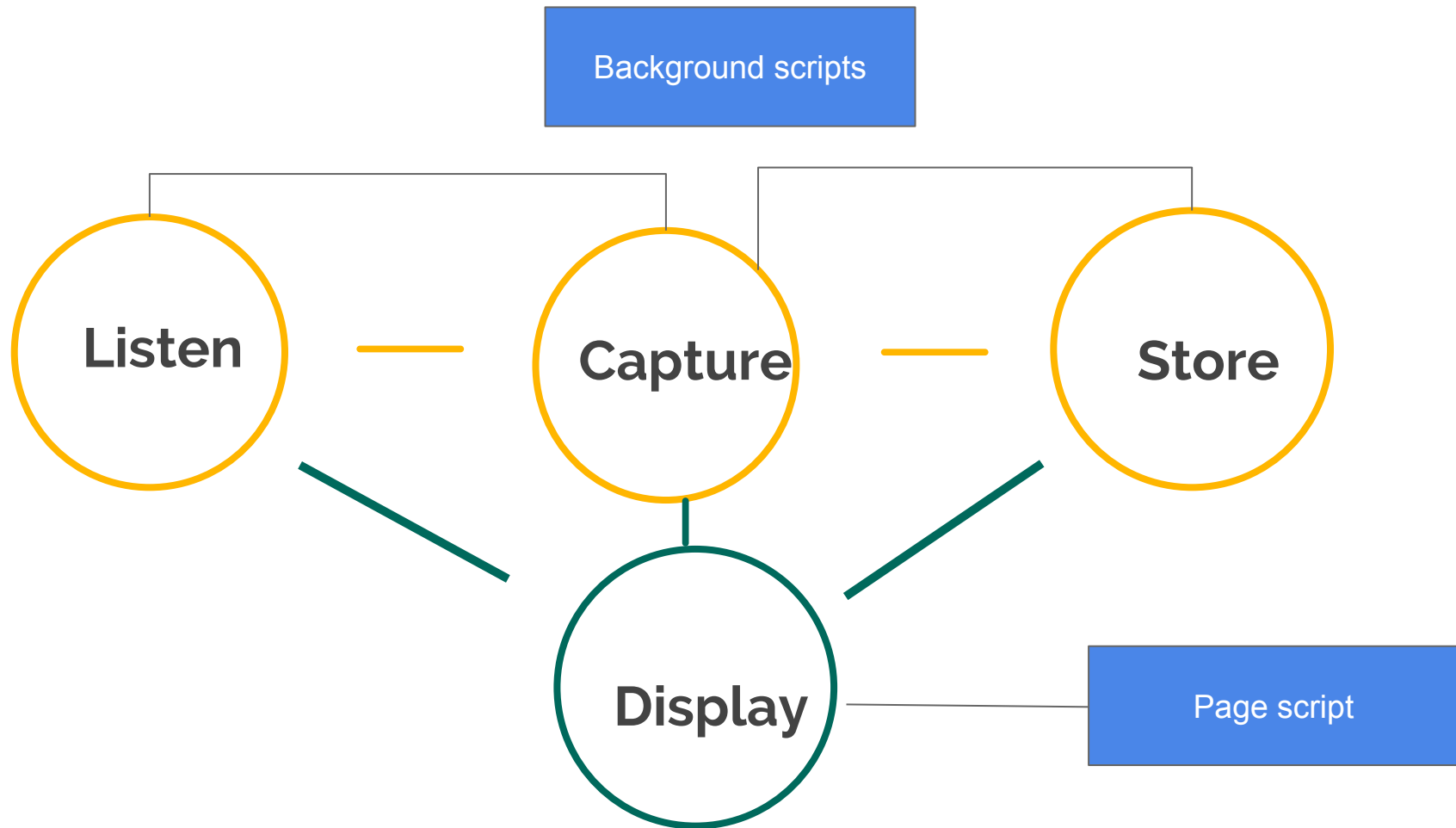


Listen

Capture

Store

Display



Background scripts


Listen

Capture


Store

Display

Page script

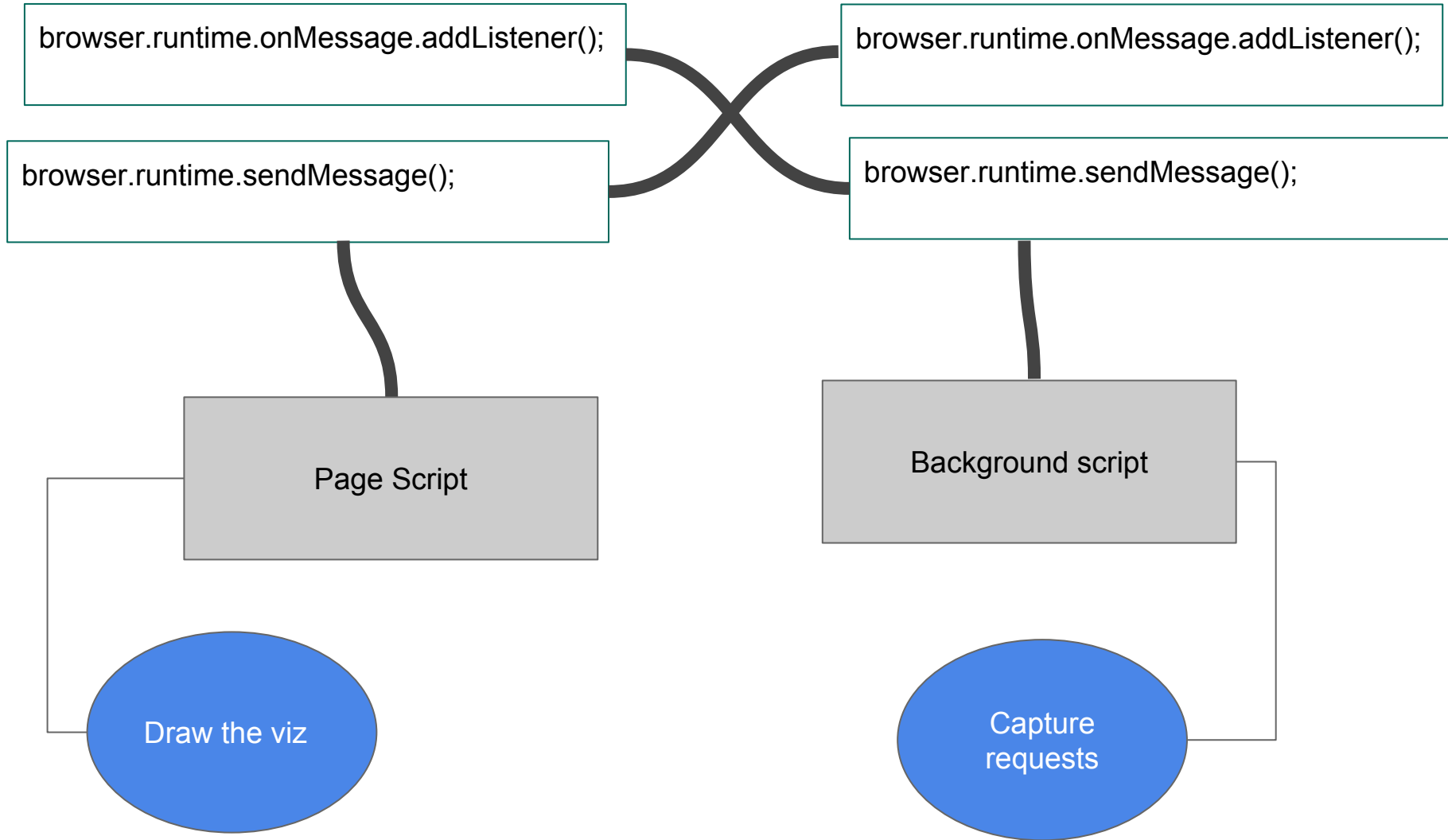


Asynchronous
message
passing



runtime web
extensions
API

The communication



```
browser.runtime.onMessage.addListener();
```

```
browser.runtime.onMessage.addListener();
```

```
browser.runtime.sendMessage();
```

```
browser.runtime.sendMessage();
```

The screenshot shows the Lightbeam browser extension interface. The top bar displays "New Tab" and "Lightbeam". The address bar shows a resource URL: `resource://jid1-f9uj2thwoam5gq-at-jetpack/data/in`. The main content area is titled "Daily GRAPH VIEW" and includes statistics: "DATA GATHERED SINCE JUNE 14, 2018", "YOU HAVE VISITED 1 SITE", and "YOU HAVE CONNECTED WITH 1 THIRD PARTY SITE". A "TRACKING PROTECTION" toggle is set to "OFF". The left sidebar contains navigation options: "Graph", "List", "Save Data", "Reset Data", "Give Us Feedback", and "Uninstall Lightbeam".

The screenshot shows the Google homepage in a browser window. The address bar displays `https://www.google.com/?gws_rd=ssl`. The page includes "About" and "Store" links at the top. The large, multi-colored "Google" logo is centered on the page, with a search input field below it.

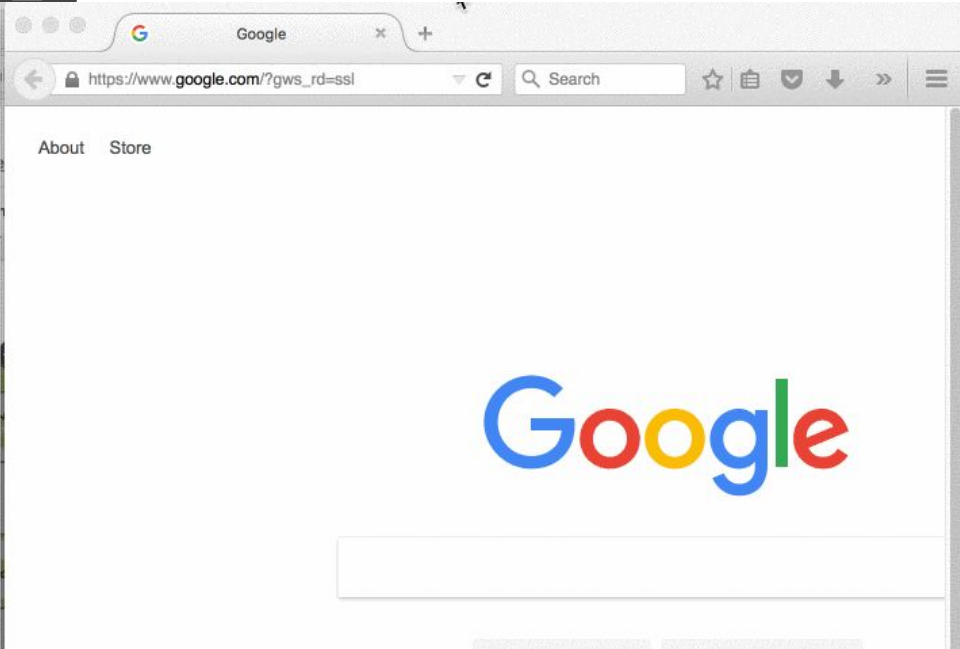
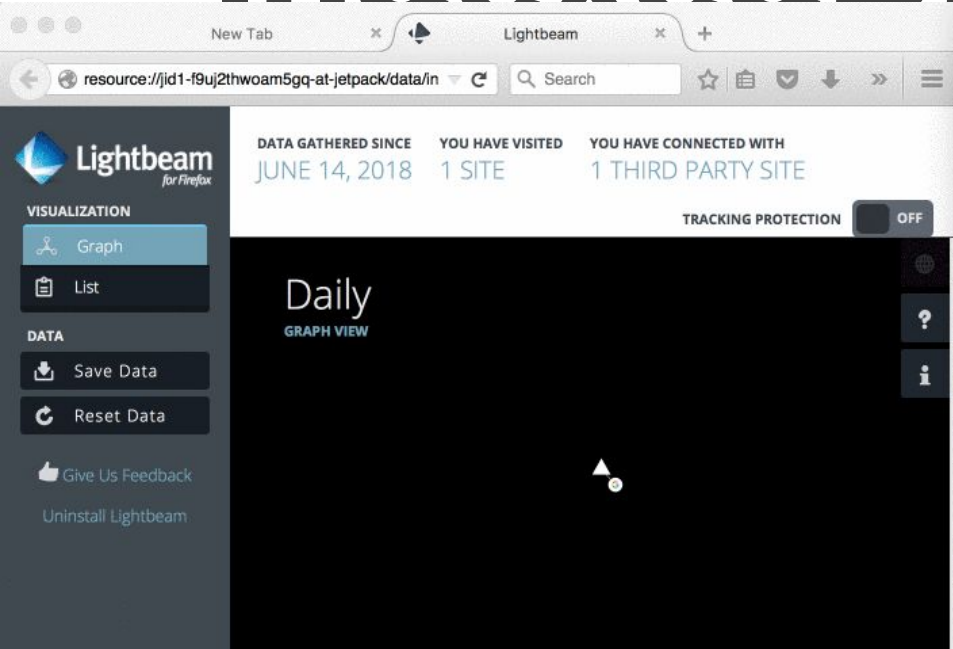


Data capture & storage

IndexedDB



asynchronous

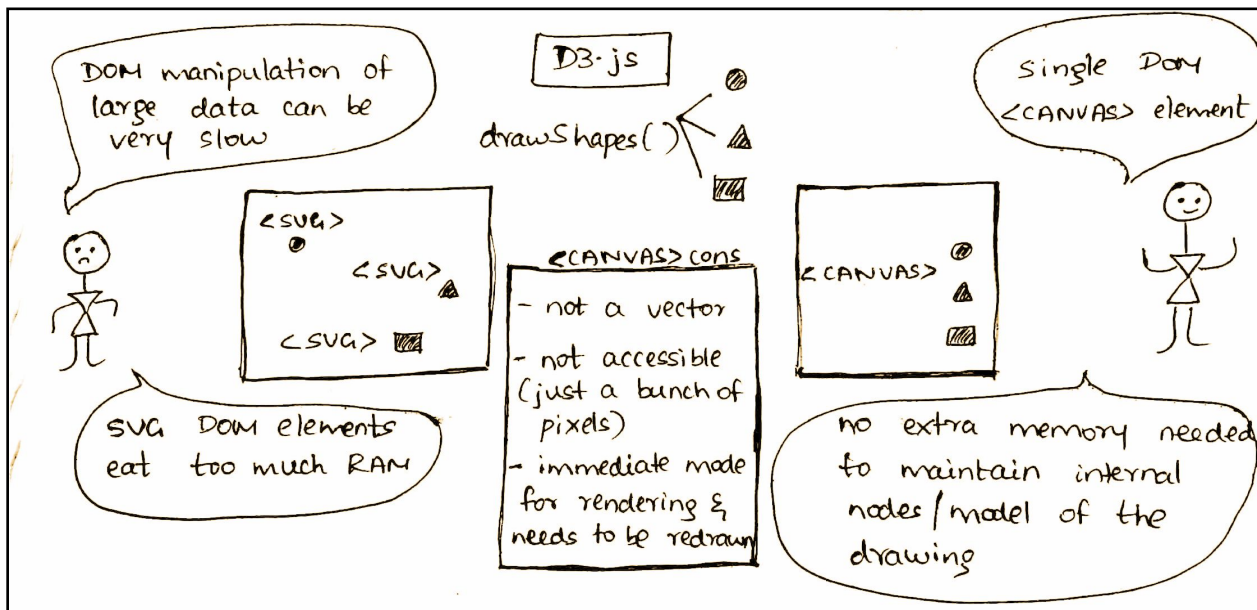




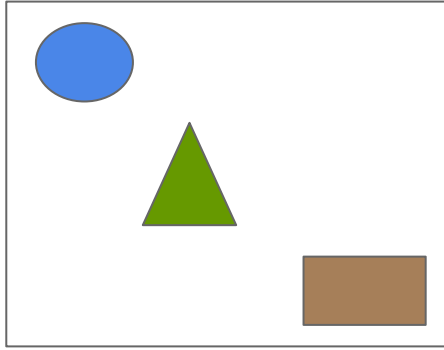
The graph



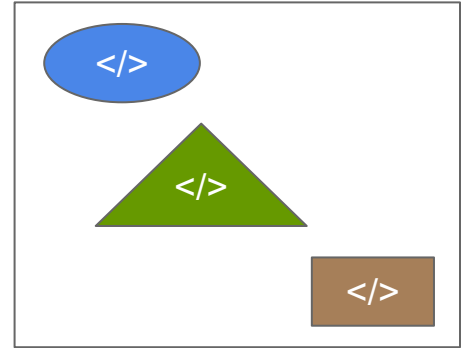
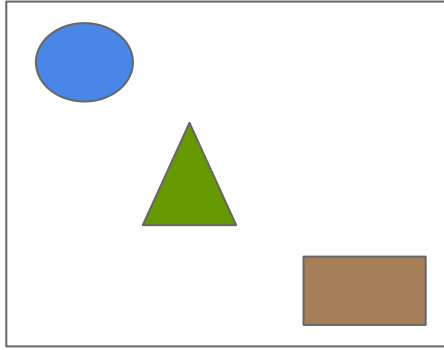
*We decided to continue using
D3.js and the force directed
graph layout...*



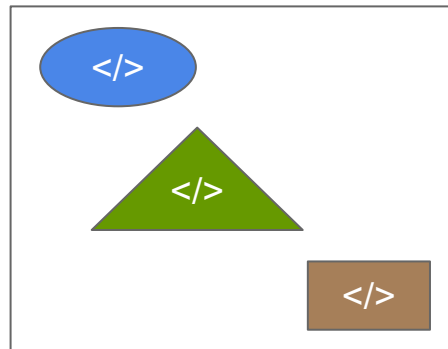
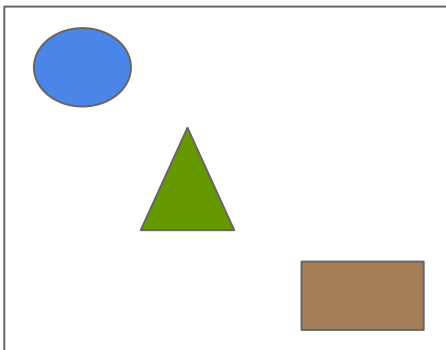
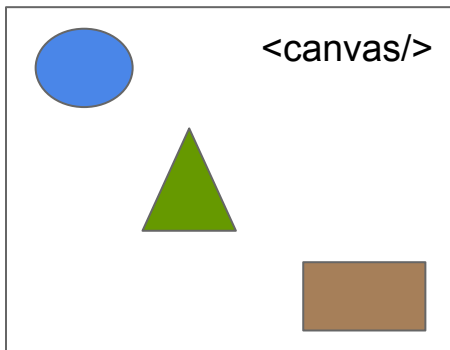
Canvas vs SVG



Canvas **vs** SVG



Canvas vs SVG

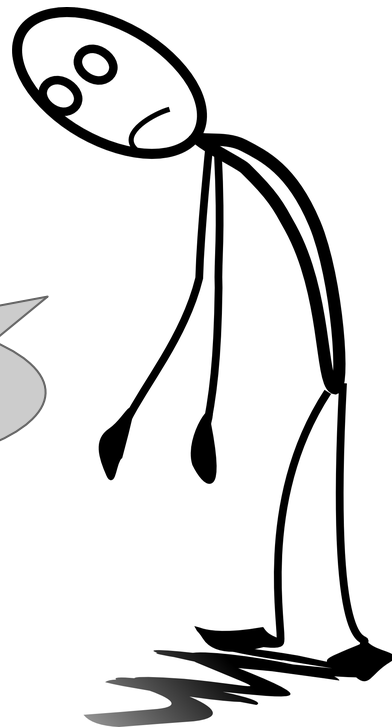


Canvas vs SVG

SVG

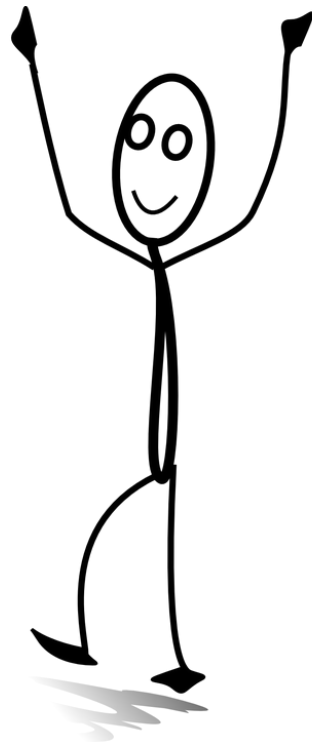
Slow DOM for
large data

Eat too much RAM



Single DOM
element

No extra memory
required



Canvas



Not a vector

Not accessible

Needs to be redrawn

Canvas

Single DOM element

No extra memory required





VISUALIZATION

Graph

List

DATA

Save Data

Reset Data

Give Us Feedback

Uninstall Lightbeam

DATA GATHERED SINCE
JUNE 4, 2018

YOU HAVE VISITED
5 SITES

YOU HAVE CONNECTED WITH
50 THIRD PARTY SITES

TRACKING PROTECTION OFF

Daily
GRAPH VIEW



TOGGLE CONTROLS

FILTER

Hide

Visited Sites

Watched Sites

Third Party Sites

Blocked Sites

Connections

Cookies

```

Inspector Console Debugger Style Editor Performance
div#content > div.stage-stack > div.stage > svg.vizcanvas >
<!-- Used by d3 for drawing the graph -->
<svg class="vizcanvas" viewBox="0 0 750 750" height="100%
width="100%" style="cursor: default;">
  <line class="edge cookieYes highlighted coloured"
x1="352.32766623003727" y1="360.85287045575785"
x2="268.8719222903143" y2="283.34432800036495"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="288.9548000949117"
y2="389.85210184661963"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="312.0671743730296"
y2="298.22751027740526"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="261.3782029872227"
y2="316.52872489167606"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="297.69284094303987"
y2="334.96320333102744"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="293.7558963739089"
y2="466.97105926625363"></line>
  <line class="edge cookieYes highlighted coloured"
x1="352.32766623003727" y1="360.85287045575785"
x2="328.93640265790964" y2="453.92239495770696"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="341.4864414675192"
y2="248.140566752309"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="235.21473758652502"
y2="346.6262495496004"></line>
  <line class="edge highlighted" x1="352.32766623003727"
y1="360.85287045575785" x2="446.7775815748134"

```

Lightbeam
for Firefox

DATA GATHERED SINCE **JUN 08 2018** YOU HAVE VISITED **7 SITES** YOU HAVE CONNECTED WITH **12 THIRD PARTY SITES** TRACKING PROTECTION **OFF**

Recent Site
GRAPH VIEW

VISUALIZATION
Graph

DATA
Save Data
Reset Data
Give Us Feedback

Inspector Console Debugger Style Editor Performance

Search HTML

```

<!DOCTYPE html>
<html lang="en">
<head>
<body>
  <aside class="max-graph">
  <main role="main">
    <section class="top-bar max-graph">
      <section class="vis">
        <div class="vis-header max-graph">
        <div class="vis-controls info-panel-controls unimplemented">
        <div id="visualization" class="vis-content">
          <div id="tooltip" style="display: none;">
            <canvas width="1884" height="1746" style="width: 942px; height: 873px;">
              event
            </div>
          </section>
        <footer class="unimplemented">
        </main>
        <dialog id="reset-data-dialog" aria-labelledby="reset-data-dialog-title" role="dialog">
          </dialog>
        </body>
      </html>
    
```



Challenges with Canvas

1. ~~D3 joins~~
2. Interactivity

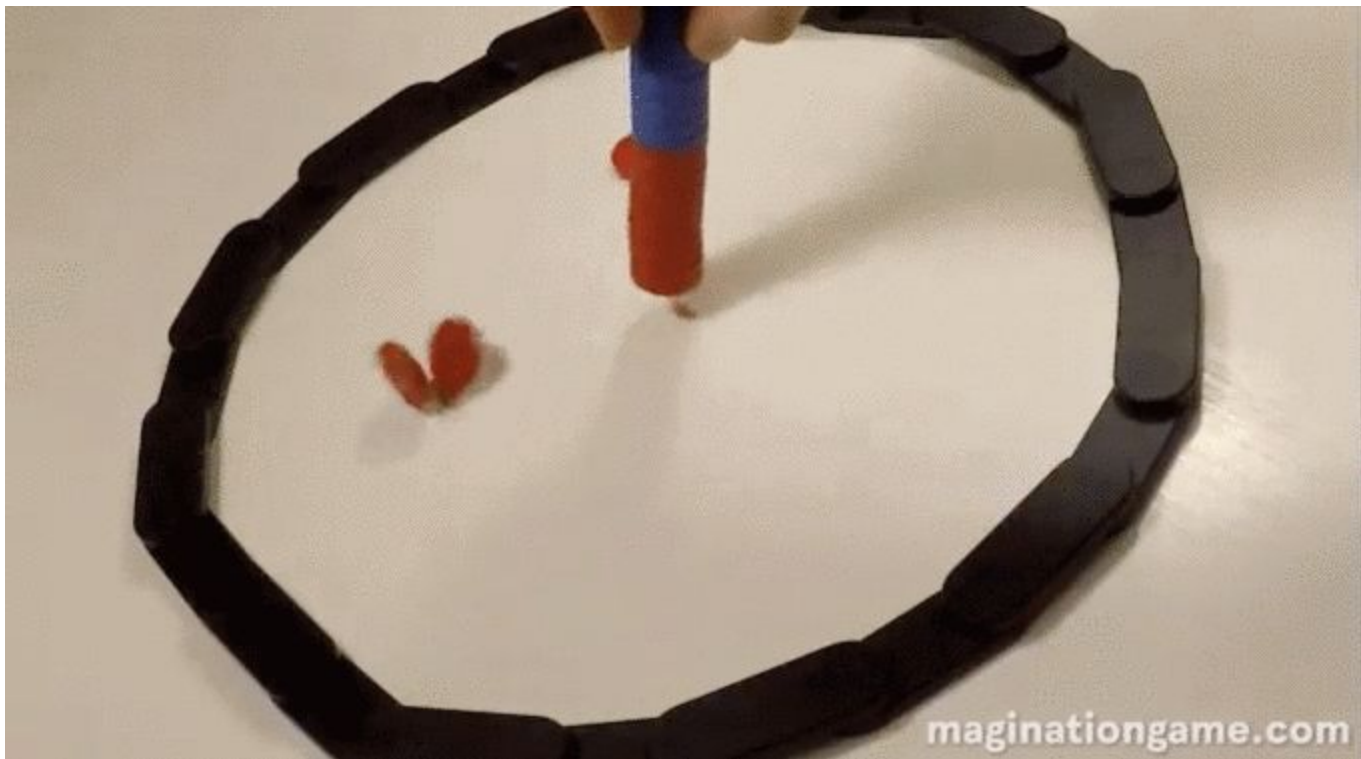


```
draw(nodes, links) {  
  simulateForce();  
  drawOnCanvas();  
}
```

Data **to** Graph

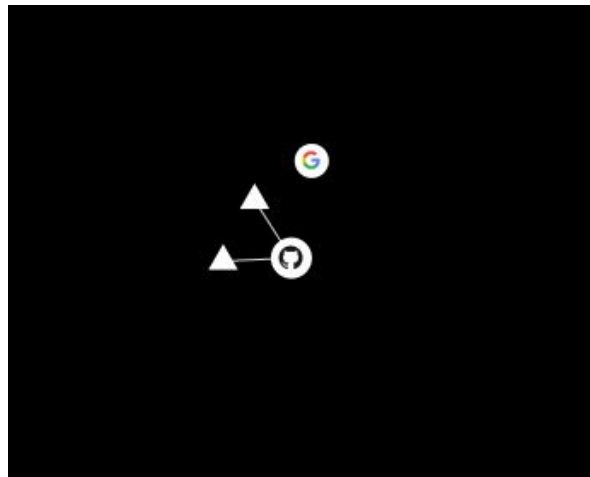


The force directed graph layout



D3.js force layout

Creates a simulation for an array of nodes and links and composes the desired forces that modify nodes positions or velocities.

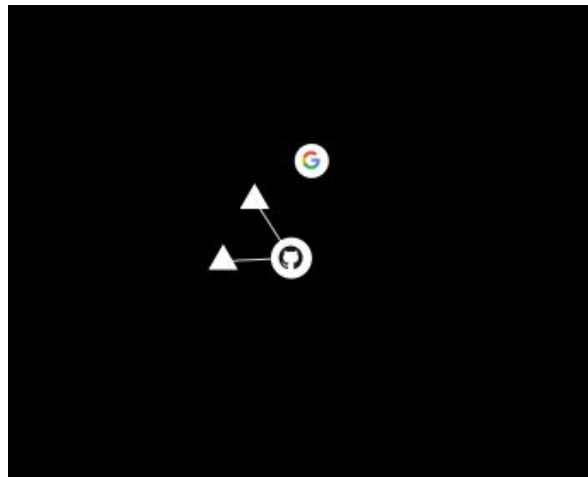




Debugging the force layout

```
draw(nodes, links) {  
  simulateForce();  
  drawOnCanvas();  
}
```

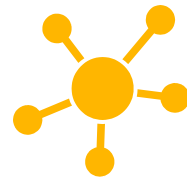
```
draw(nodes, links) {  
  simulateForce();  
  drawOnCanvas();  
}
```



Initialise simulation during page load

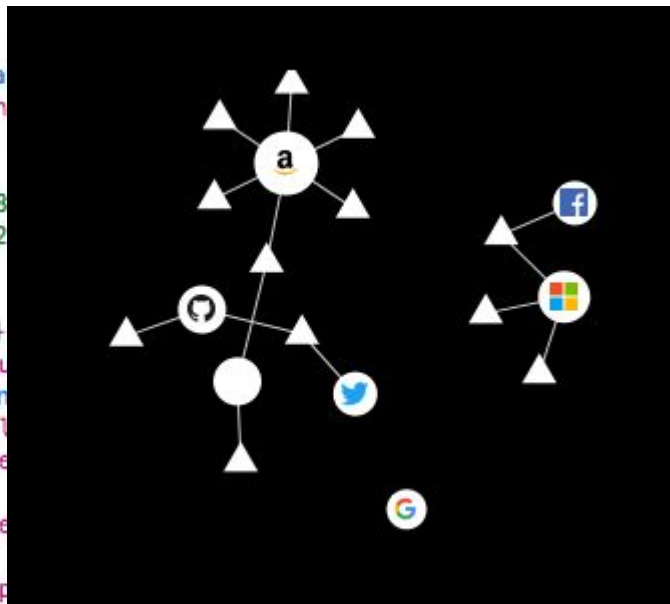
```
simulateForce(nodes) {  
  simulation = d3.forceSimulation(nodes);  
}
```

d3.forceSimulation



1. index
2. x -
3. y -
4. vx
5. vy

```
0: {...}
  favicon: ""
  firstParty: false
  firstPartyHostnames: Array
  hostname: "collector.github
  index: 0
  thirdParties: Array []
  vx: -0.001234397157965168
  vy: 0.0007850245729739332
  x: 436.12697309688787
  y: 525.942030377843
  <prototype>: Object { ... }
1: Object { hostname: "github
  /favicon.ico", firstPartyHostr
2: Object { hostname: "google
3: Object { hostname: "image
}
4: Object { hostname: "image
}
5: Object { hostname: "img-p
index: 5, ... }
```

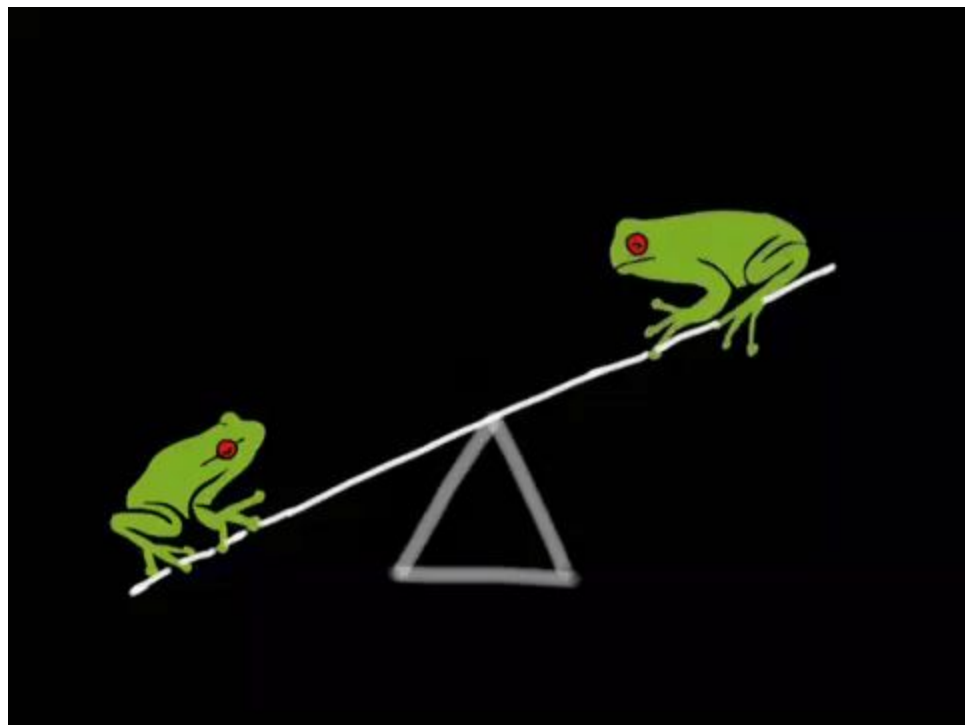


```
com
index: 2, ... }
se, index: 3, ...
se, index: 4, ...
stParty: false,
```



```
simulateForce(nodes) {  
  simulation = d3.forceSimulation(nodes);  
  
  simulation.on('tick', () =>  
    drawOnCanvas();  
  );  
}
```

Register the simulation's internal timer





```
simulateForce(nodes) {  
  simulation = d3.forceSimulation(nodes);  
  simulation.on('tick', () =>  
    drawOnCanvas());  
};  
registerSimulationForces();  
}
```

Subsequent dynamic node additions
to the graph

VISUALIZATION

Graph

DATA

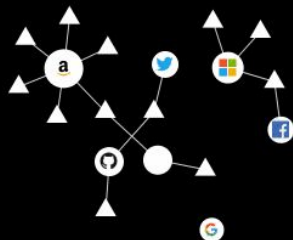
Save Data

Reset Data

[Give Us Feedback](#)

Recent Site

GRAPH VIEW



H
TES

e) ;

```
reg  
c  
W  
)  
s  
}
```

VISUALIZATION

Graph

DATA

Save Data

Reset Data

Give Us Feedback

Recent Site

GRAPH VIEW



VISUALIZATION

Graph

DATA

Save Data

Reset Data

Give Us Feedback

Recent Site

GRAPH VIEW



```
simulation) {  
  X(width / 2);  
}
```

```
simulation.for
```

```
}
```

Lightbeam
for Firefox

DATA GATHERED SINCE JUN 08 2018 YOU HAVE VISITED 8 SITES YOU HAVE CONNECTED WITH 14 THIRD PARTY SITES TRACKING PROTECTION OFF

VISUALIZATION

[Graph](#)

DATA


[Save Data](#)

[Reset Data](#)

[Give Us Feedback](#)

Recent Site

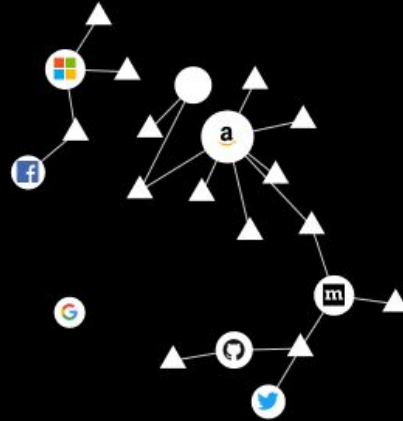
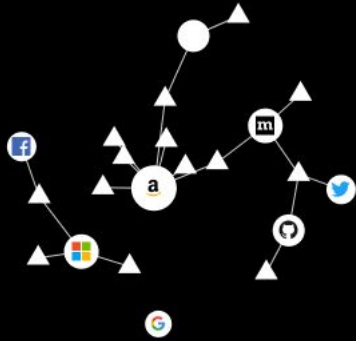
GRAPH VIEW



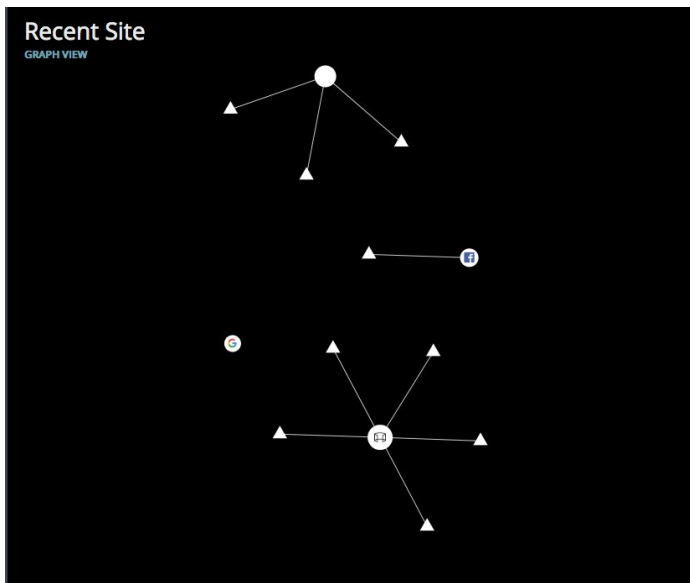
```
regi  
co  
ch  
si  
}
```

```
{  
  y ();  
  rce);
```

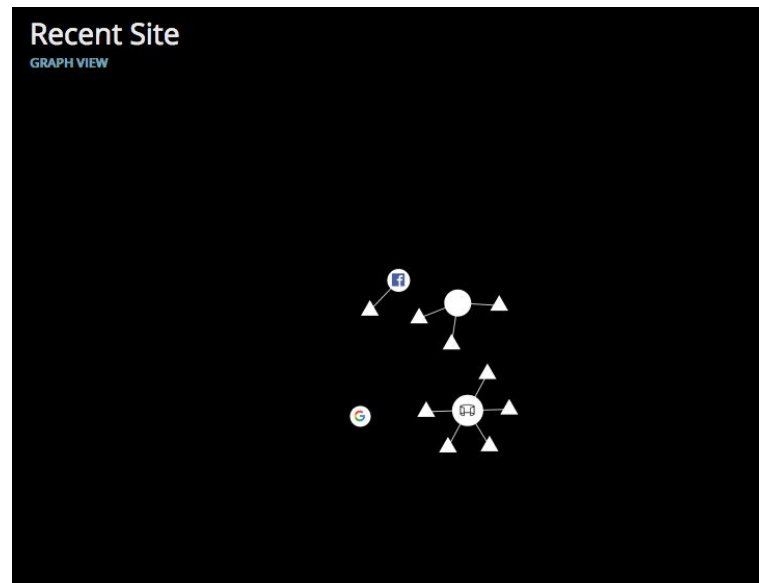
by detection
S.



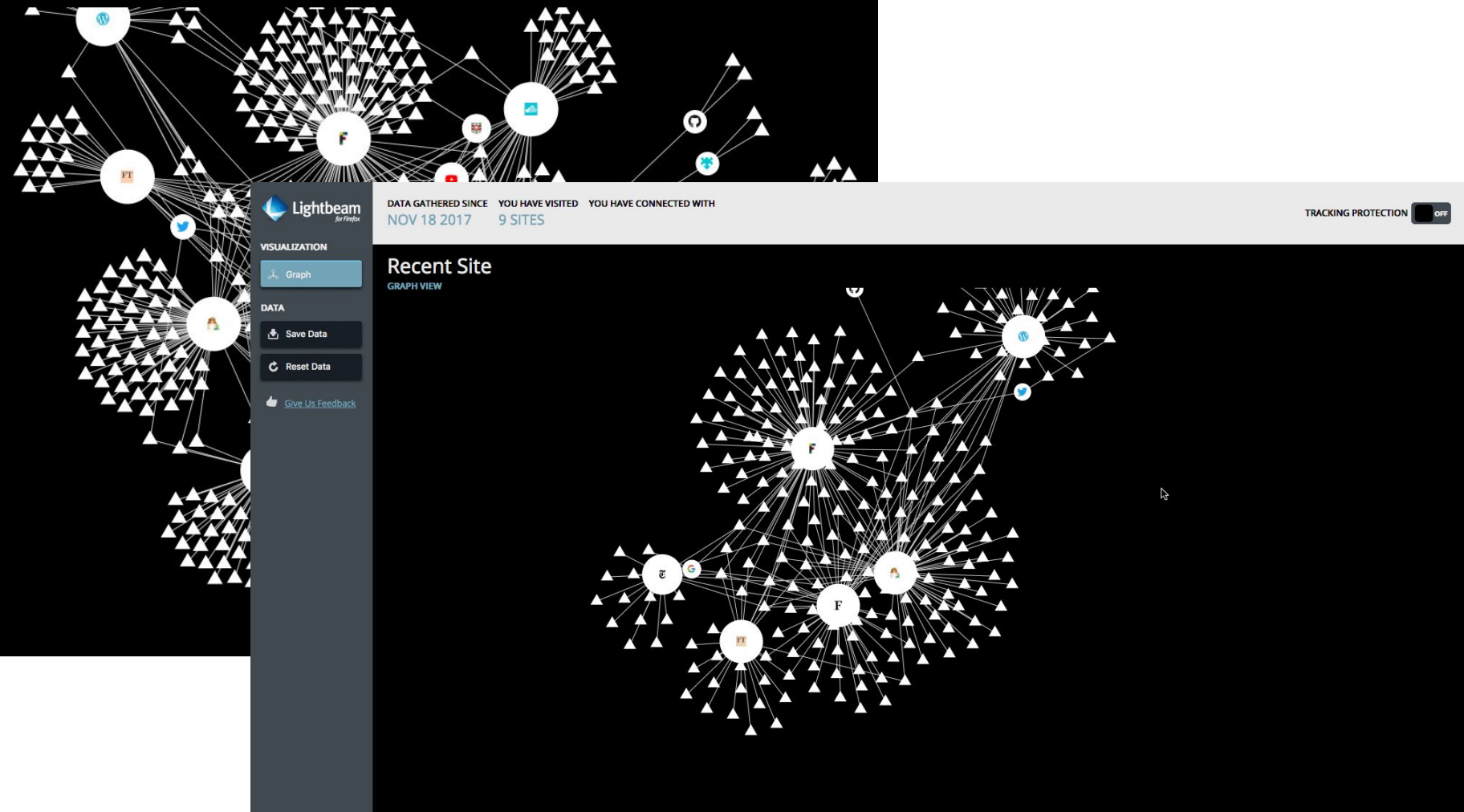
}

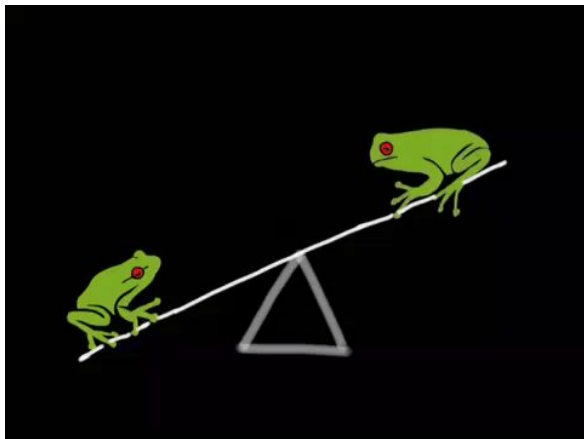
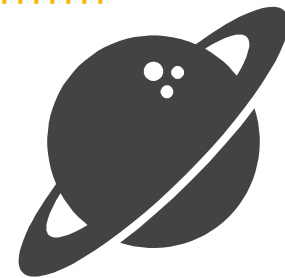


collision radius = 30



collision radius = 10





simulation.tick()

alpha = 1 to alpha = 0

The **algorithm**

- increments the current **alpha** by **(alphaTarget - alpha) * alphaDecay**
- decrements each node's velocity by **velocity * velocityDecay**
- increments each node's position by **velocity**
- invokes the registered forces ensuring the newly calculated values fit in to match the requirements.



Baron Byrd's



Default values

alpha	1
alphaMin	0.001
alphaDecay	0.0228
alphaTarget	0
velocityDecay	0.4

VISUALIZATION

Graph

Recent Site

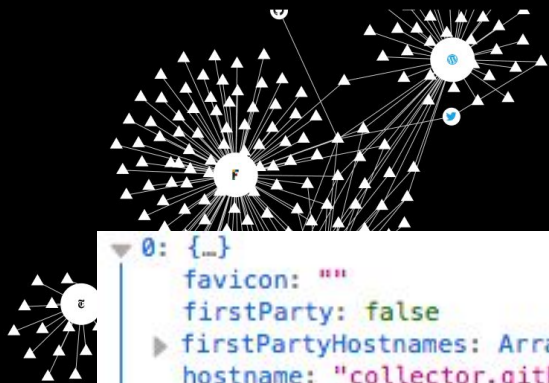
GRAPH VIEW

DATA

Save Data

Reset Data

Give Us Feedback



```
0: {  
  favicon: ""  
  firstParty: false  
  firstPartyHostnames: Array [ "github.com" ]  
  hostname: "collector.githubapp.com"  
  index: 0  
  thirdParties: Array []  
  vx: -0.0012343971579651684  
  vy: 0.0007850245729739332  
  x: 436.12697309688787  
  y: 525.942030377843  
  <prototype>: Object { ... }  
1: Object { hostname: "github.com", favicon: "https://assets-cdn.github.com/favicons/favicon.ico", firstPartyHostnames: false, ... }  
2: Object { hostname: "googleads.g.doubleclick.net", firstParty: false, index: 2, ... }  
3: Object { hostname: "images-eu.ssl-images-amazon.com", firstParty: false, index: 3, ... }  
4: Object { hostname: "images-na.ssl-images-amazon.com", firstParty: false, index: 4, ... }  
5: Object { hostname: "img-prod-cms-rt-microsoft-com.akamaized.net", firstParty: false, index: 5, ... }
```

VISUALIZATION

Graph

DATA

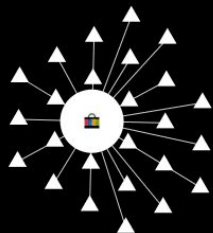
Save Data

Reset Data

Give Us Feedback

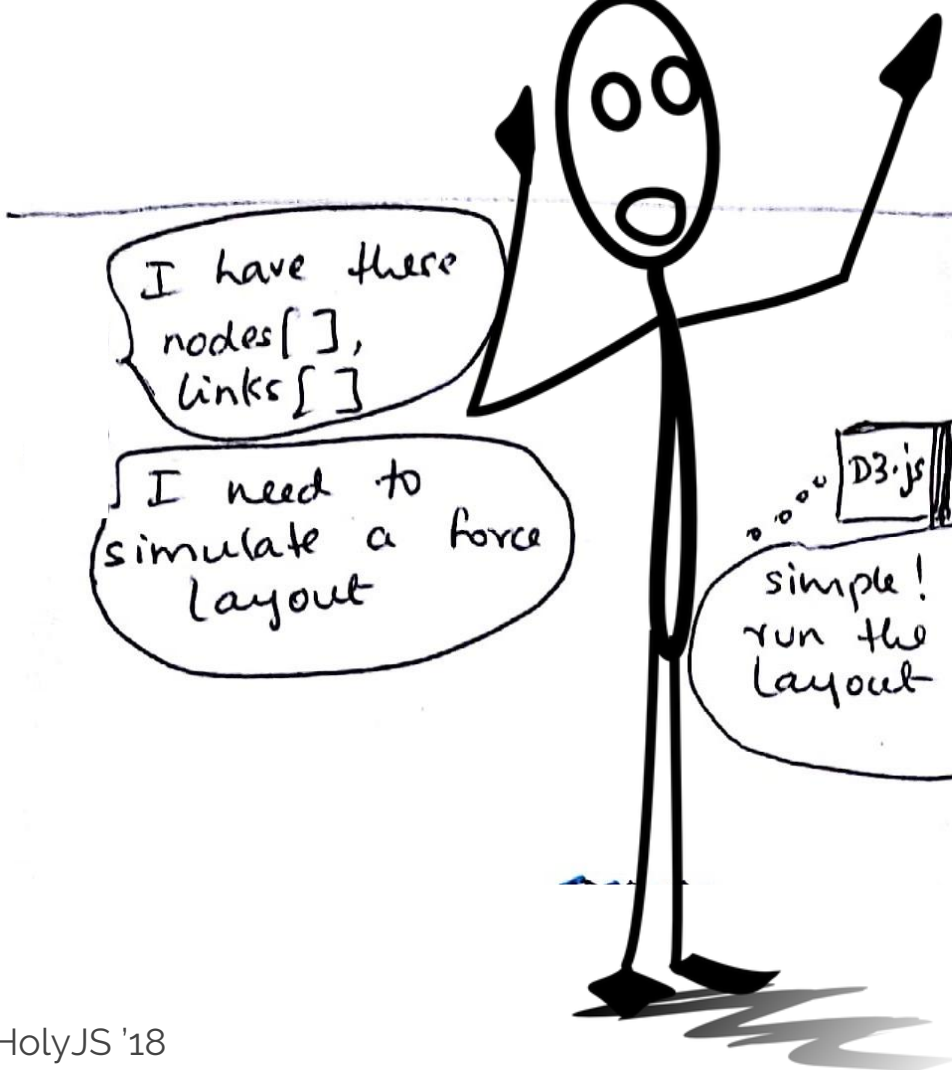
Recent Site

GRAPH VIEW



updates

```
resetAlpha() {  
  const alpha = this.simulation.alpha();  
  const alphaRounded = Math.round((1 - alpha) * 100);  
  if (alphaRounded === 100) {  
    this.simulation.alpha(this.alphaStart);  
    this.restartSimulation();  
  }  
}
```



I have these
nodes[],
links[]

I need to
simulate a force
layout


simple! I shall
run the force
layout algorithm
😊

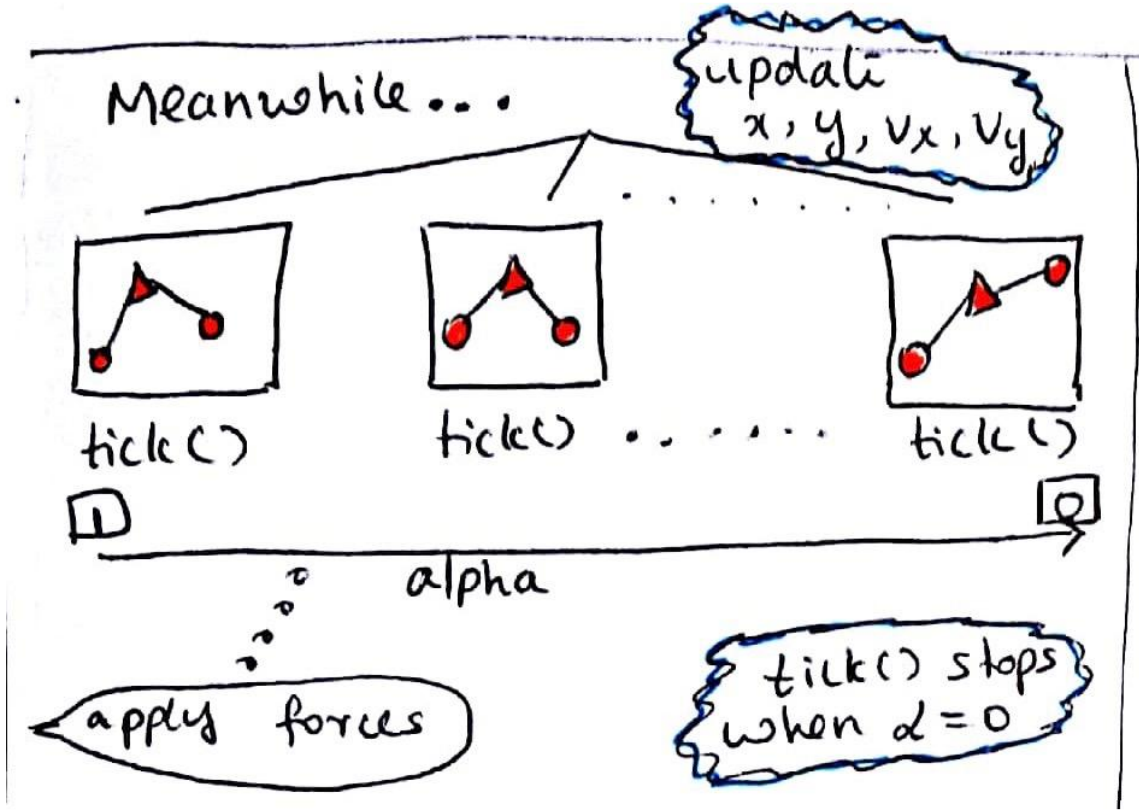
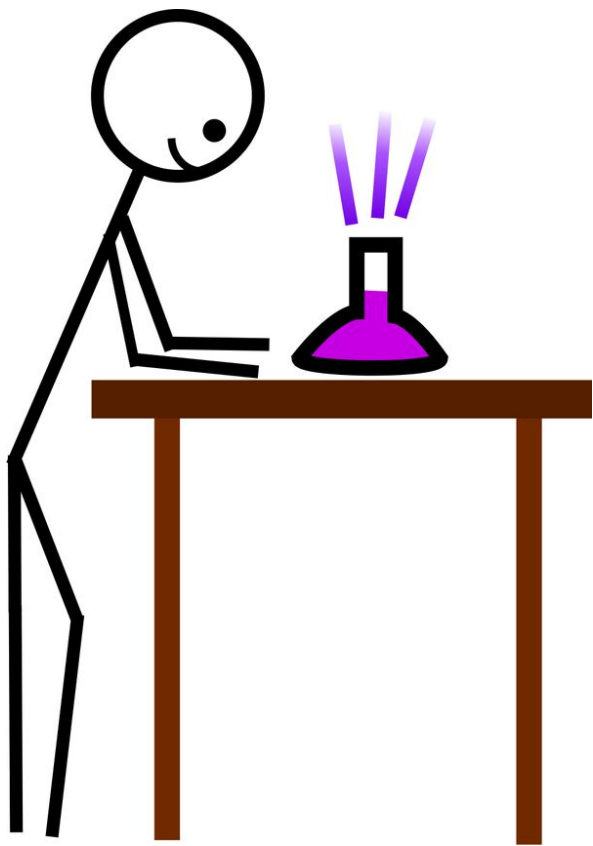
① initialise

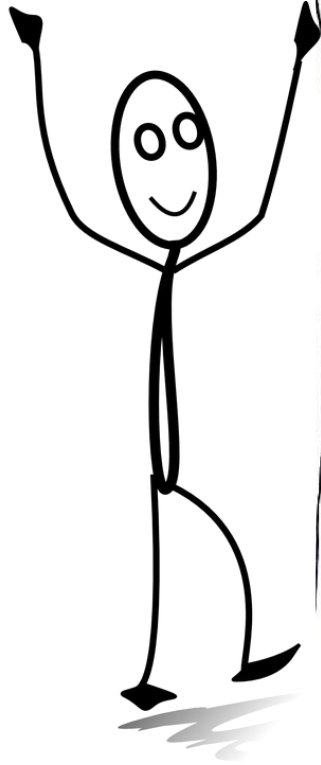
```
d3.forceSimulation  
(nodes);
```

②

```
simulation.on(  
'tick', draw);
```

internal timer



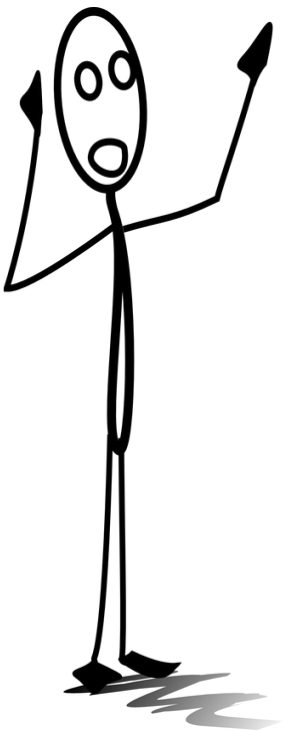


D3

I have computed
 x, y, v_x, v_y for each
node

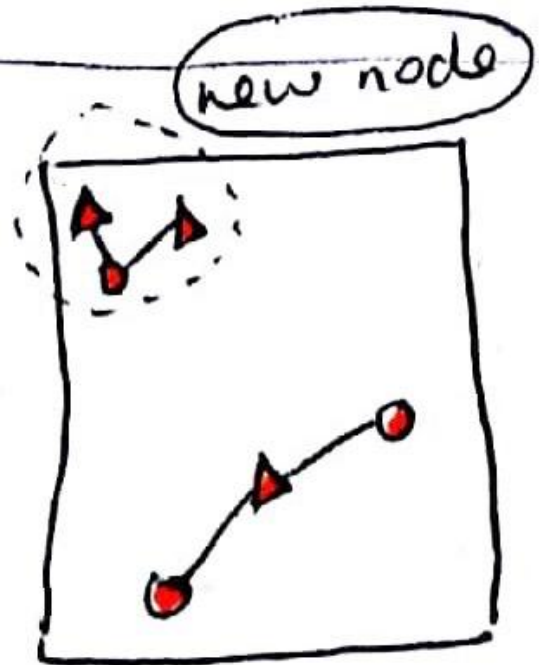
$$a_t = (a_T - a) \times a_D$$
$$v_t = v * v_D$$

thanks! I like
this layout



I have a new node

I need to update my graph





oh! the newly added
node isn't positioned
right

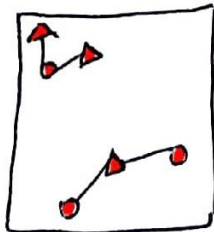
It starts from top left,
but it should be in the
center

HELP!!!

DBJS

Let me explain

It is simple!



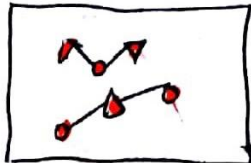
- Graph is in equilibrium
- i.e. $\alpha = 0$ from the above tick()
- When this new node came in, tick() did not run
- Because tick() runs only for $1 > \alpha > 0$

DBJS

Restart the simulation
Reset α to 1

tick()
tick()

tick()



Yayy! this is what I wanted!

Canvas based interactions

Tooltips

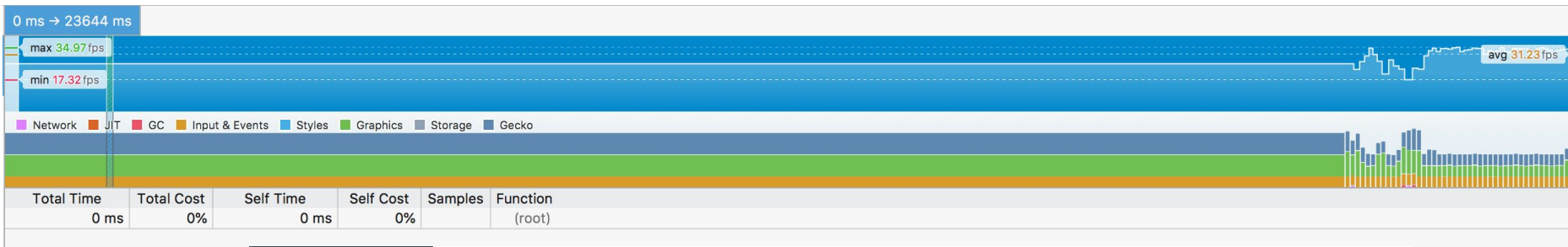
The screenshot displays the Lightbeam for Firefox interface. At the top, it shows statistics: "DATA GATHERED SINCE NOV 19 2017", "YOU HAVE VISITED 3 SITES", and "YOU HAVE CONNECTED WITH 3 THIRD PARTY SITES". The main area is titled "Recent Site" and "GRAPH VIEW". A sidebar on the left contains navigation options: "VISUALIZATION" with a "Graph" button, "DATA" with "Save Data" and "Reset Data" buttons, and a "Give Us Feedback" link. The main content area shows a graph with three nodes: a Twitter bird icon, a circular icon with a question mark, and a circular icon with a dollar sign, connected by arrows.

Drag, zoom and pan

The screenshot displays the Lightbeam for Firefox interface. At the top, it shows summary statistics: "DATA GATHERED SINCE NOV 19 2017", "YOU HAVE VISITED 3 SITES", and "YOU HAVE CONNECTED WITH 3 THIRD PARTY SITES". The main area is titled "Recent Site" and "GRAPH VIEW". A sidebar on the left contains a "VISUALIZATION" section with a "Graph" button, and a "DATA" section with "Save Data", "Reset Data", and "Give Us Feedback" options. The graph itself shows a network of nodes and edges, with a mouse cursor hovering over one of the nodes.



Performance



Lightbeam
for Firefox

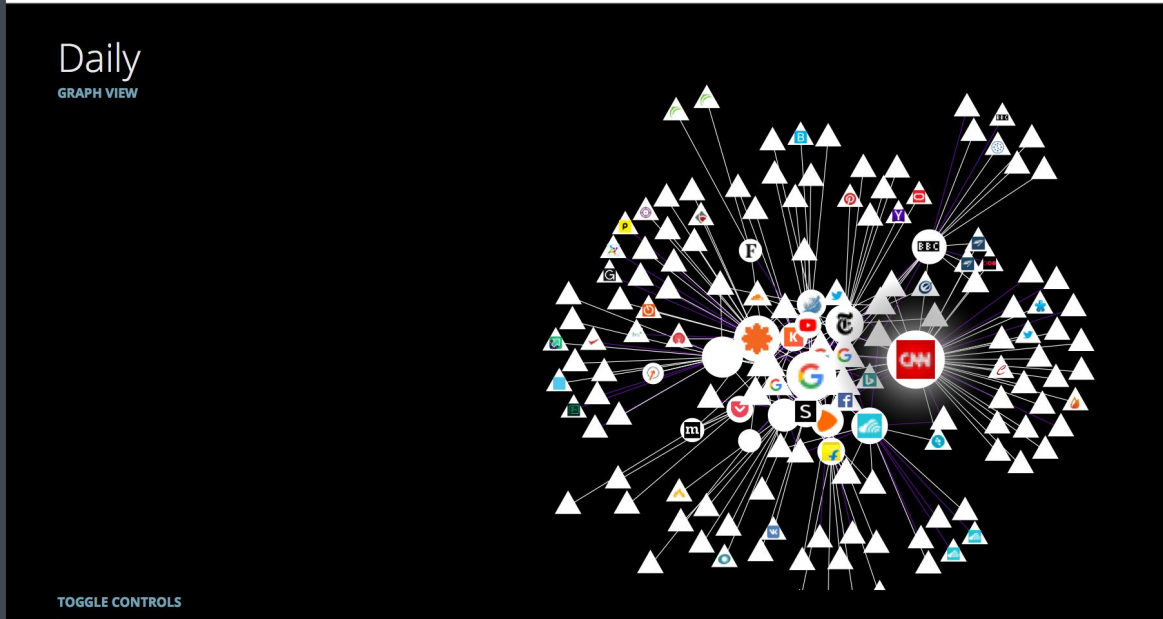
VISUALIZATION

- Graph
- List

DATA

- Save Data
- Reset Data
- Give Us Feedback
- Uninstall Lightbeam

DATA GATHERED SINCE **JUNE 9, 2018**
 YOU HAVE VISITED **19 SITES**
 YOU HAVE CONNECTED WITH **156 THIRD PARTY SITES**





Lightbeam for Firefox

DATA GATHERED SINCE JUN 10 2018 YOU HAVE VISITED 17 SITES YOU HAVE CONNECTED WITH 268 THIRD PARTY SITES TRACKING PROTECT

Recent Site
GRAPH VIEW

VISUALIZATION
Graph

DATA
Save Data
Reset Data
[Give Us Feedback](#)



Web workers

- Runs a script operation in background thread separate from the main execution thread of a web application.

Extension (Firefox Lightbeam) moz-extension://dd1e07f4-7724-154c-80da-f501acf9262c/index.html

Lightbeam for Firefox

DATA GATHERED SINCE NOV 18 2017 YOU HAVE VISITED 9 SITES YOU HAVE CONNECTED WITH 247 THIRD PARTY SITES TRACKING PROTECTION OFF

Visualization: Graph

DATA: Save Data, Reset Data, Give Us Feedback

Recent Site

GRAPH VIEW

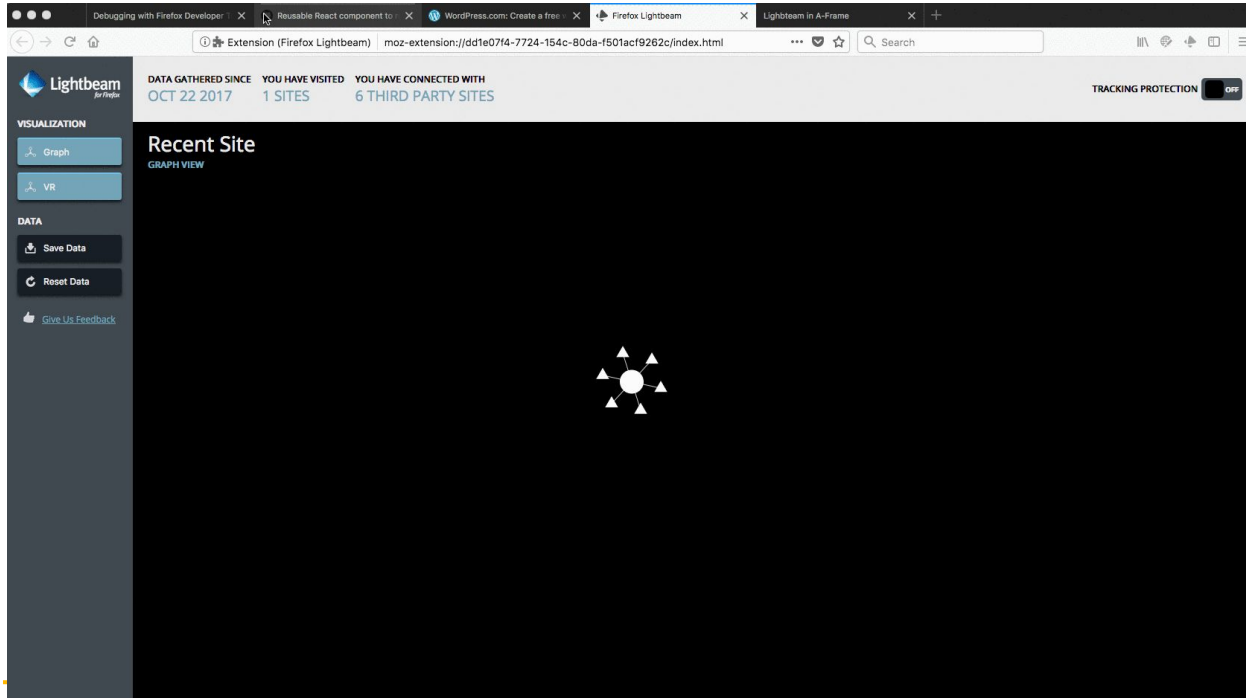


Inspect Console Debugg Style Edit Performer Memo Netwo Storag Redu

Filter output Persist Logs

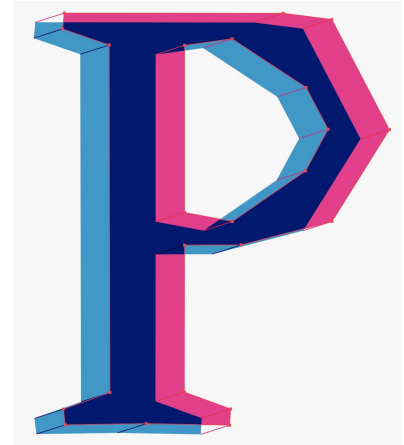
```
tick 67 vizWorker.js:46:5
tick 68 vizWorker.js:46:5
tick 69 vizWorker.js:46:5
tick 70 vizWorker.js:46:5
tick 71 vizWorker.js:46:5
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tick 98 vizWorker.js:46:5
tick 99 vizWorker.js:46:5
tick 100 vizWorker.js:46:5
```

Lightbeam in A-Frame



The next steps

- [PrototypeFund.de](https://www.prototypefund.de)
 - Civic tech, Data literacy, Data security, Software infrastructure
 - Federal Ministry of Education and Research (BMBWF)
- [Data justice project](#)



Resources

- [github/lightbeam](#)
- [addons/lightbeam/](#)

- [medium/web-tracking](#)
- [princiya/blog/lightbeam](#)

- [openleaders/lightbeam](#)



Credits

Special thanks to all the people who made and released these awesome resources for free:

- Presentation template by [SlidesCarnival](#)
- Photographs by [Unsplash](#)



Thank you!

Questions?

@princiya 

@princi_ya 



Lightbeam
for Firefox

moz://a

OUTREACHY