Telescope

Fine-Tuned Discovery of Interactive Web UI Feature Implementation

Joshua Hibschman
Haoqi Zhang

Why learn from professional web UI’s?

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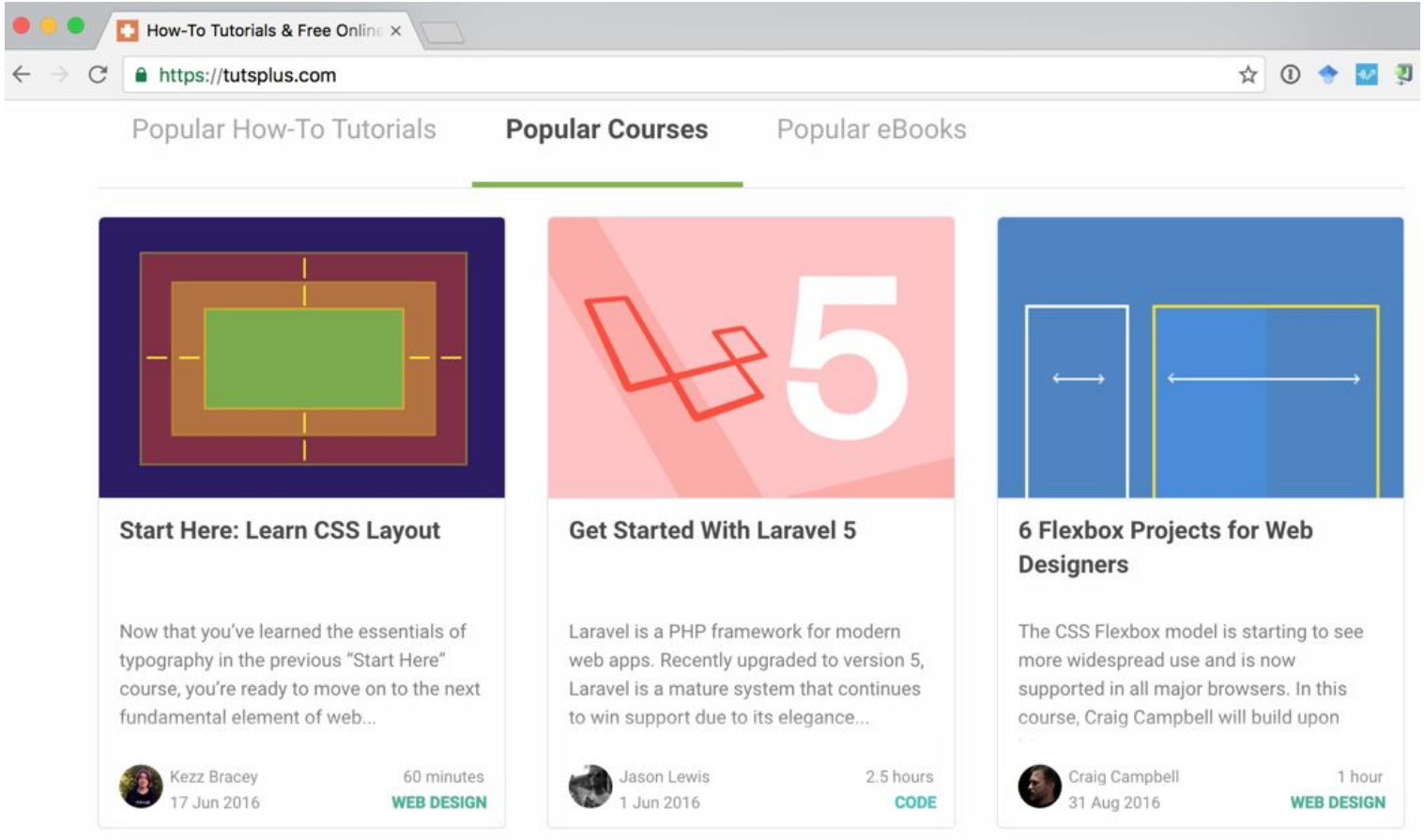
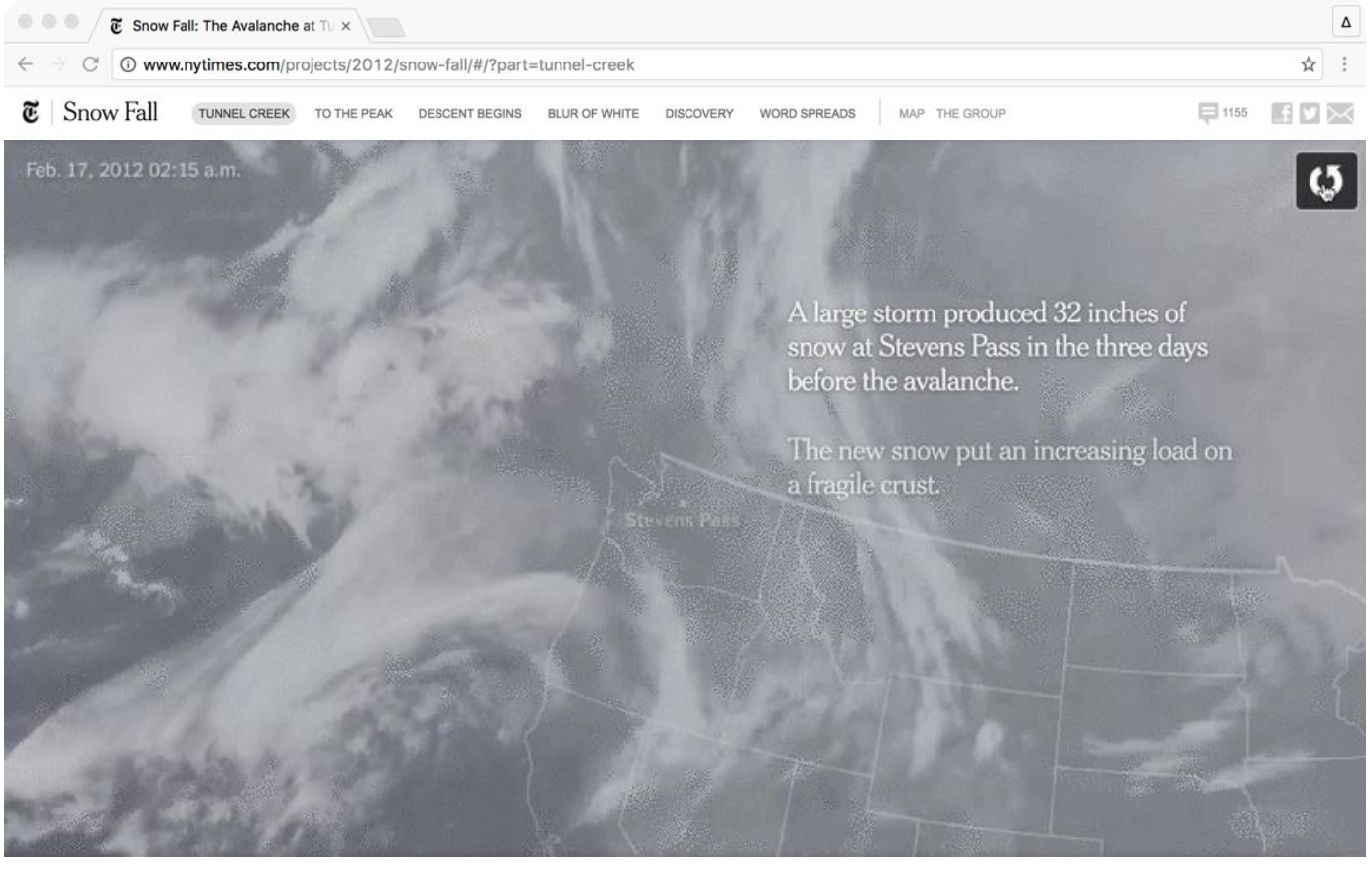
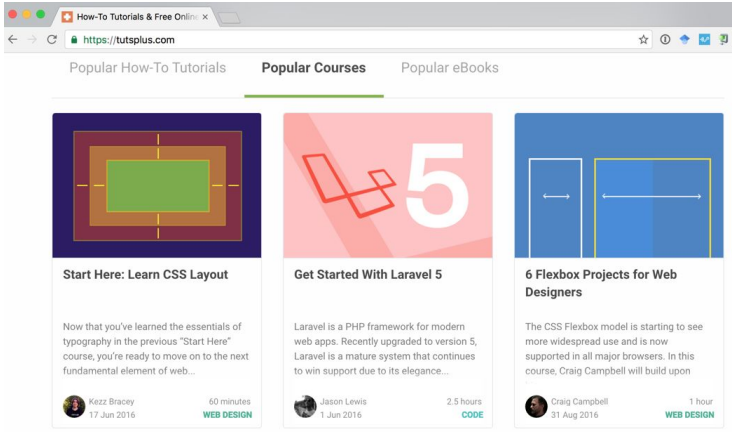
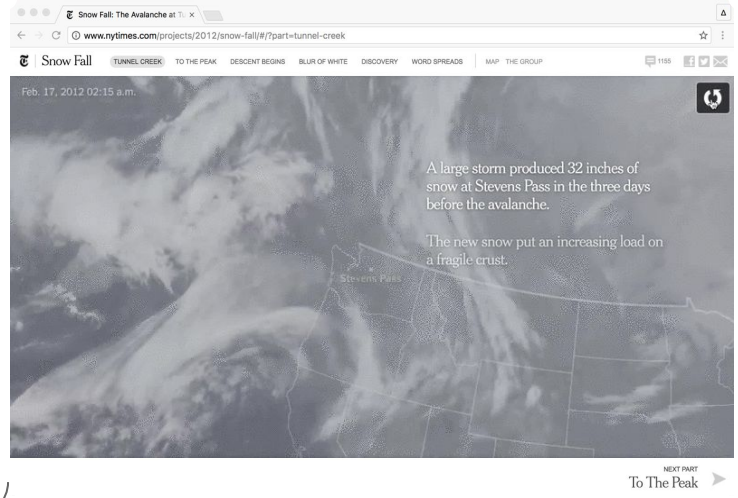


How do I do that?



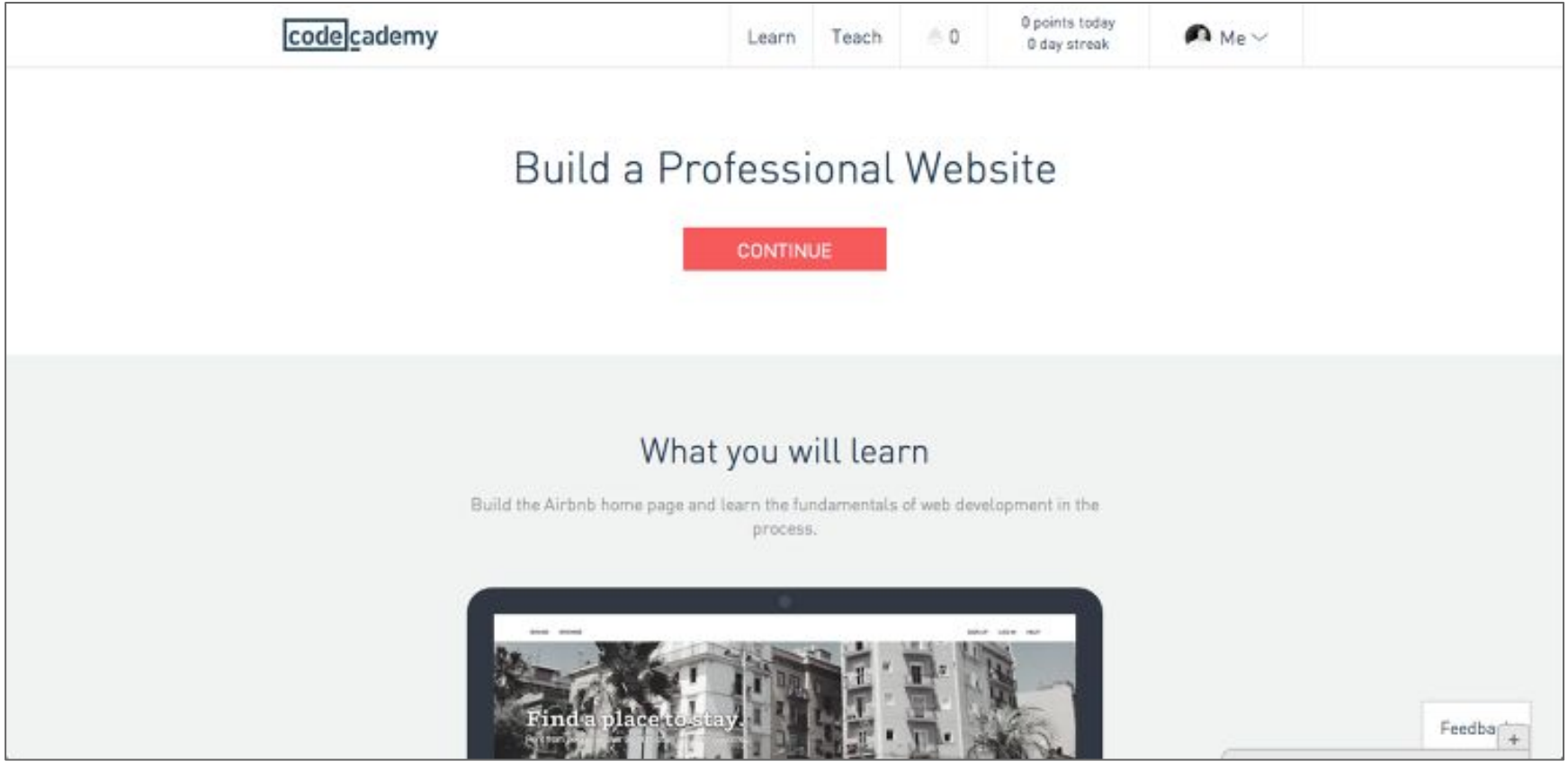
Learning Gap: Self-starter to Professional



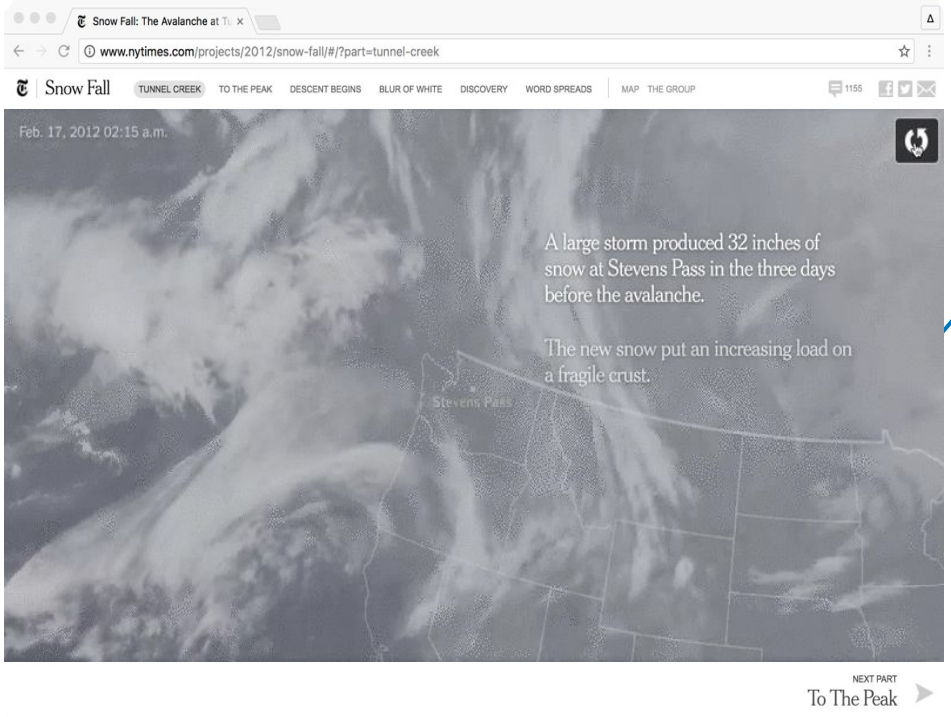


???

Self-Starter to Professional Learning Gap

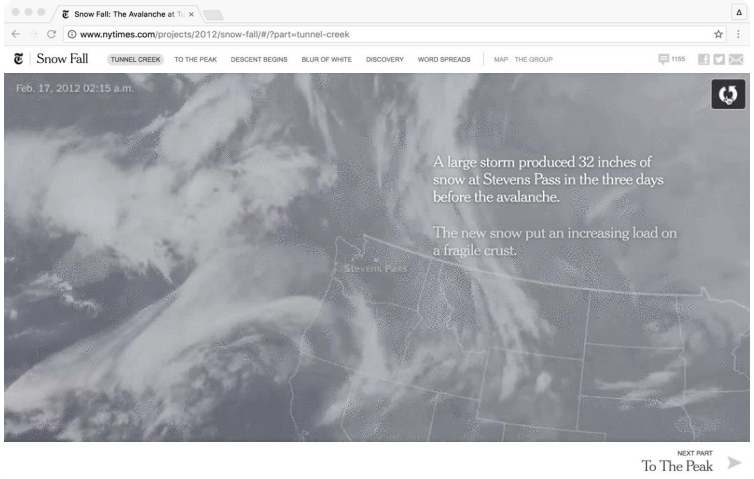


Inspection Burden



28,238 Lines of JavaScript!

Last Year: Unravel



/slide.js:9:32 (user.setInteractive)

/slide.js:15:1 (completeLoad)

/slide.js:58:2 (clickMap)

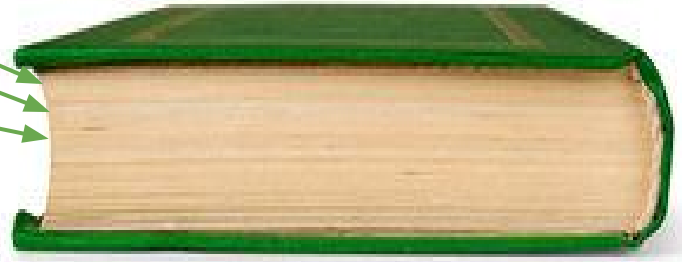
```
(r=bind(this,function(t){this.init([],function()
{return t},null,
{enabled:!0})}),r.error=bind(this,function(t)
{this.inited=!0,this.error=t,t.requireModules=
[e],eachProp(T,function(t)
{0===t.map.id.indexOf(e+"_unnormalized")&&f(t.map
.id)}),c(t)}),r.fromText=bind(this,function(n,i,t
){var
name=t.name;user=getUser(state),isInteractive=use
r.setInteractive();}use.interactive()=!1),a(u),ha
sProp(k.config,e)&& (k.config[o]=k.config[e]);try
{req.exec(n)}catch(f){return c(makeError(
"fromtexteval", "fromText eval for "+e+" failed:
"+f,f,[e]))}l&&
(useInteractive=!0),this.depMaps.push(u),w.comple
teLoad(o),m([o],r)}),void
i.load(t.name,m,r,k))})),w.enable(i,this),this.pl
uginMaps[i.id]=i},enable:function()
{C[this.map.id]=this,this.enabled=!0,this.enablin
g=!0,each(this.depMaps,bind(this,function(t,e)
{var n,i,r;if("string"==typeof t)
{if(t=s(t,this.map.isDefine?
this.map:this.map.parentMap,!1,!this.skipMap),thi
s.depMaps[e]=t,r=getOwn(x,t.id))return
void(this.depExports[e]=r(this));this.depCount+=1
,u(t,"defined",bind(this,function(t)
{this.defineDep(e,t),this.check()})),this.errback
&&u(t,"error",bind(this,this.errback))}n=t.id,i=T
[n],hasProp(x,n)||!i||i.enabled||w.enable(t,this)
})),eachProp(this.pluginMaps,bind(this,function(t
```

Last Year: Unravel

THE FELLOWSHIP OF THE RING

BOOK ONE

I A Long-expected Party
II The Shadow of the Past
III Three is Company
IV A Short Cut to Mushrooms
V A Conspiracy Unmasked
VI The Old Forest
VII In the House of Tom Bombadil
VIII Fog on the Barrow-downs
IX At the Sign of The Prancing Pony
X Strider
XI A Knife in the Dark
XII Flight to the Ford

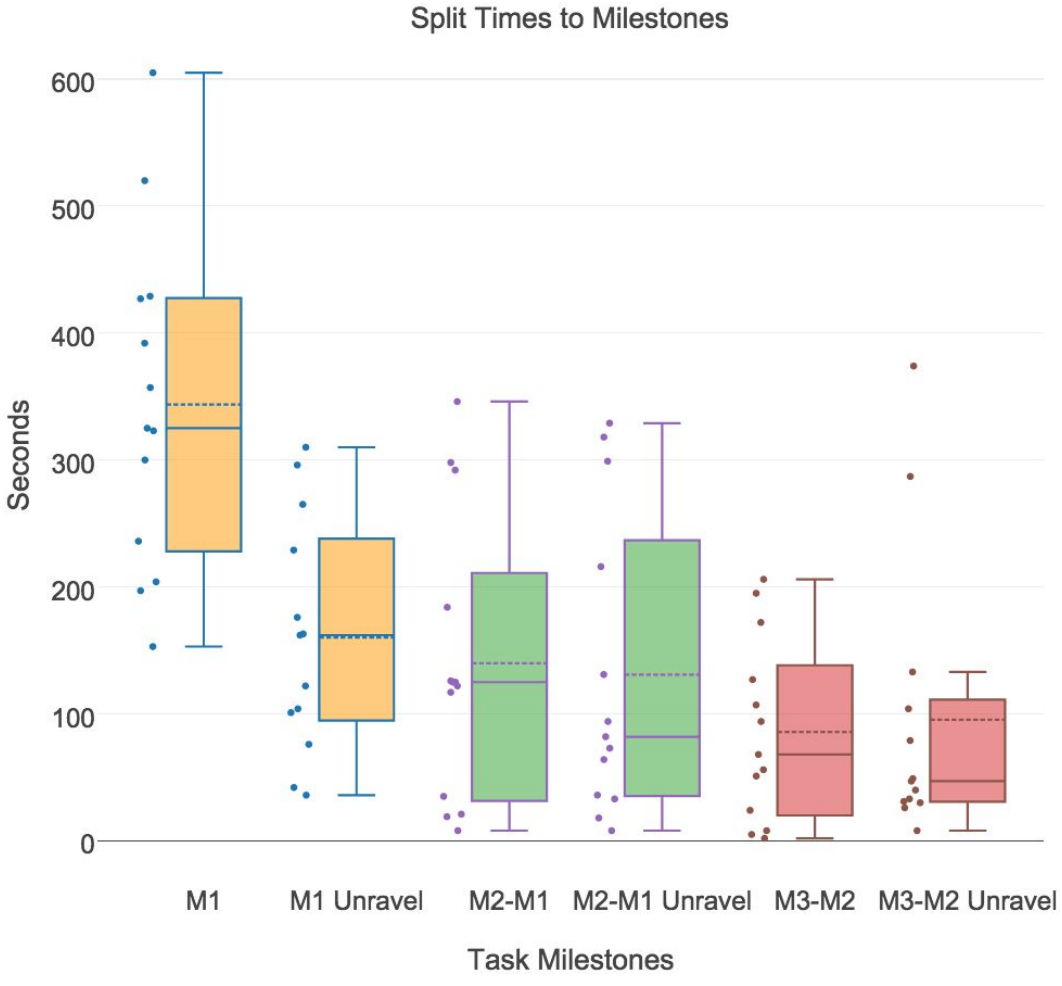


Last Year: Unravel

M1: Key Source 1

M2: Key Source 2

M3: “Ah-ha” moment



Human-Centered Prototyping

Prototype 1: Extract Feature Code

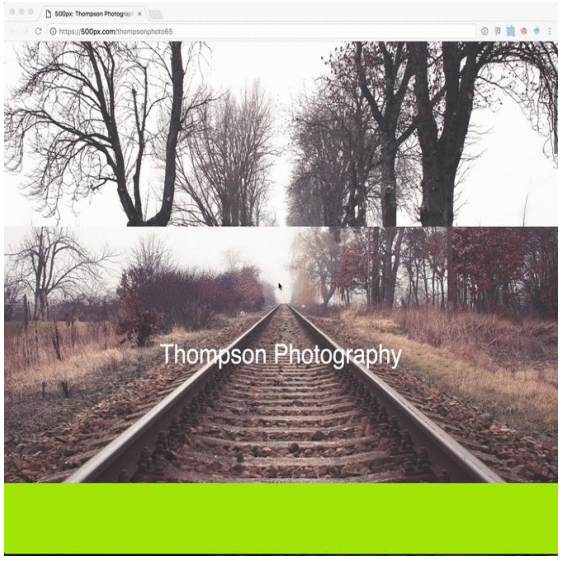
Feedback: Show us relevant code

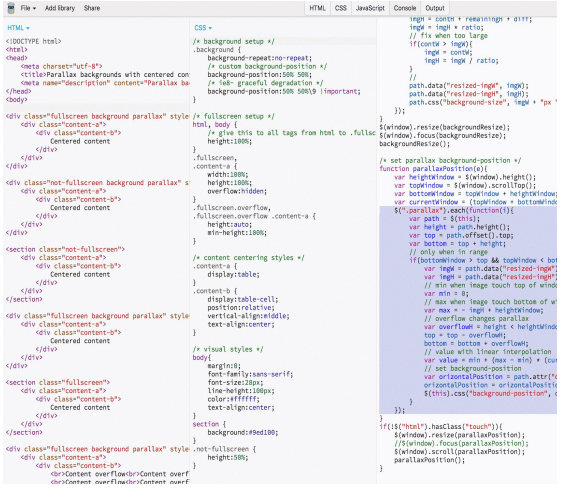
Prototype 2: Activity Highlighting

Feedback: Show us live activity

Prototype 3: Live Traces

Feedback: Slow it down, play

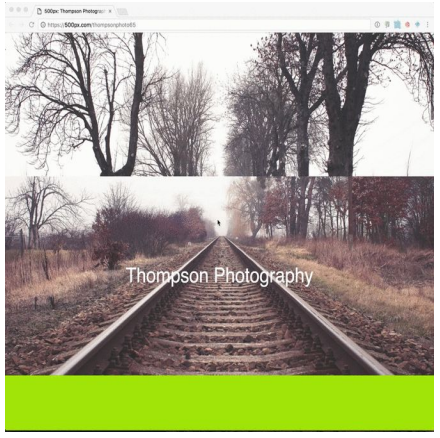


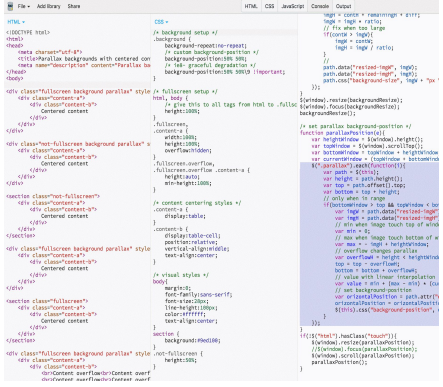


Human-Centered Design Findings

User Needs

- Variable amounts of JavaScript
- Personalized views (play, inspect)
- Visual connections
- *Feature reduction





Telescope Approach

Fellowship of the Ring

Bilbo Baggins has a ring (more…)

The wizard Gandalf arrives (more…)

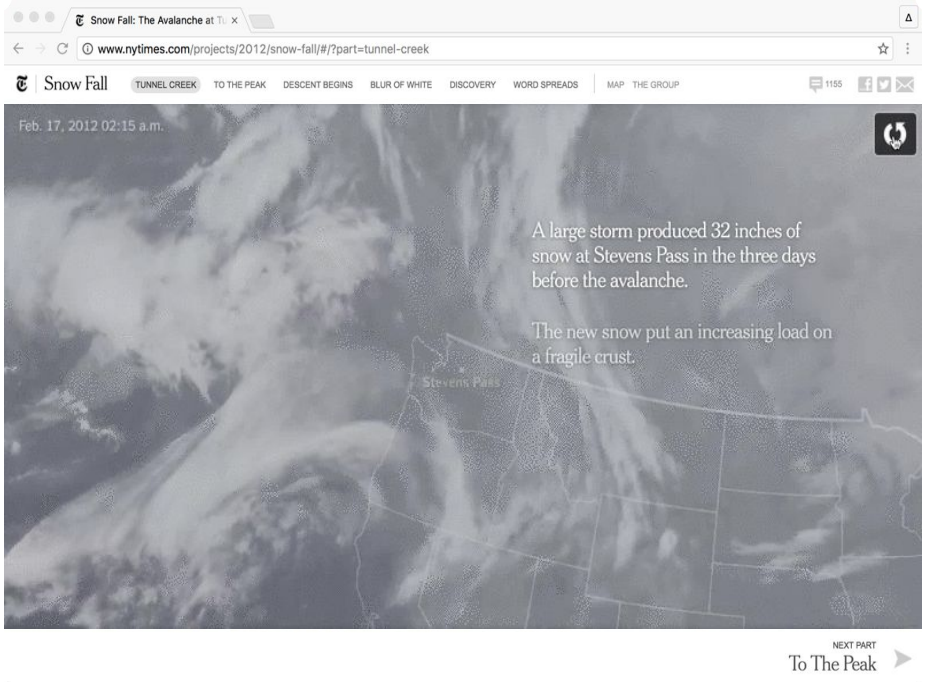
Bilbo leaves (more…)

In addition, ever since Bilbo came back to the Shire with the ring—which he has kept secret from nearly everyone—he has not seemed to age at all. In fact, he reaches his 111th birthday virtually unchanged.
When Bilbo announces that he is throwing a grand party for his "eleventy-first" birthday, everyone in the Shire takes interest. After extensive and elaborate preparation, the day of Bilbo's birthday finally arrives. All of Hobbiton has a fine time eating, drinking, and watching the spectacular fireworks provided by Gandalf.

As dinner winds down, Bilbo rises and asks to speak to the assembled guests. The speech is short. Just as Bilbo is starting to lose his audience's attention, he announces that he is leaving, and he suddenly disappears in a flash of light. The party guests are not amused, and they return, muttering, to their eating and drinking.

Bilbo, having used his ring to become invisible, walks back to Bag End, takes off the ring and begins packing for a

Telescope Approach




```
$("#map").click(function(e){
  scrollTop();
  animateWeather();
});
```

```
var requirejs,require,define;if(function(global)
}function f(){}function h(t,n){var i,r,o,s,a,u,c
filter:function(t,e){return null==t.which&&(t.wh
},contents:{script:/(?:java|ecma)script/},conver
for(var e in t){var i=t[e];if(n.isFunction(i)||(
t.fn.scrollspy.noConflict=function(){return t.fn
this.i&&(3<=this.a[gt]?(this.X=this.a[1],this.W=
```

play-dot-to-dot-com

play-dot-to.com

Telescope - UI Discovery

telescope/bod/edit?html,js

Paused | Reset Traces | JS Order ↑ | JS Detail: 1 | JS Call Time: 17s ↔ 45s

HTML

```
1  <html class="js no-touch fontface svg
   inlinesvg" lang="en">
2  <body>
3   <div class="content">
4    <div id="countdown" style="display: none">
Query
5     <h1>0</h1> </div>
6    <div id="svg"></div>
7    <div id="start" style="display: none">
8     <div class="logo"></div>
9     <h4>click and drag to start</h4> </div>
10   <div id="game" style="display: block">
11    <div class="logo"></div>
12    <h3 id="progress">
13           <span class="1
   active">1</span>/<span
   class="2">2</span>/<span
   class="3">3</span>/<span
   class="4">4</span>/<span class="5">5</span>
14        </h3>
Query
15    <h2 id="timer" style="">00:07</h2>
16    <h2 id="nice">well done!</h2> <img
   id="retry" src="http://play-dot-
   to.com/img/img_retry.png" style="display:
   none">
17    <div class="bg1 bg active"><img
   src="http://play-dot-to.com/img/bg_1.png">
   </div>
18    <div class="bg2 bg"><img src="http://play-
   dot-to.com/img/bg_2.png"></div>
19    <div class="bg3 bg"><img src="http://play-
   dot-to.com/img/bg_3.png"></div>
20    <div class="bg4 bg"><img src="http://play-
   dot-to.com/img/bg_4.png"></div>
21    <div class="bg5 bg"><img src="http://play-
   dot-to.com/img/bg_5.png"></div>
22   </div>
23   <div id="finish"> <img id="medal"
   src="http://play-dot-to.com/img/img_end.png">
24    <p>You scored: <span
   class="score">0000</span></p>
25    <p>Total play time: <span class="play-
   time">00:00:00</span></p>
```

JavaScript

```
3 Calls
1   var n = window.setInterval(function () {
2    e--;
3    t.find("h1").html(e);
4    if (0 === e) {
5     clearInterval(n);
6     u = null;
7     t.css({
8      display: "none"
9     });
10    y(100 * r + 900);
11    return;
12   }
13  }, 1e3);
55 Calls
14  u = window.setInterval(function () {
15   var n = Date.now();
16   var i = Math.round(.1 * (n - t));
17   e -= i;
18   t = n;
19   $("#timer").html(m(e));
20   if (e <= 0) {
21    clearInterval(u);
22    u = null;
23    $("#retry").css({
24     display: "block"
25    }).off().on("click", function () {
26     c(r, a, p, false);
27    });
28    $("#timer").css({
29     display: "none"
30    });
31    return;
32   }
33  }, 1e3 / 100);
3 Calls
34  function bc(a, b, c, d) {
35   c = c || [], b = b || r;
36   var e, f, i, j, k = b.nodeType;
37   if (!a || "string" != typeof a) {
38    return c;
39   }
40   if (1 !== k && 9 !== k) {
41    return [];
42   }
```

Live Demo!

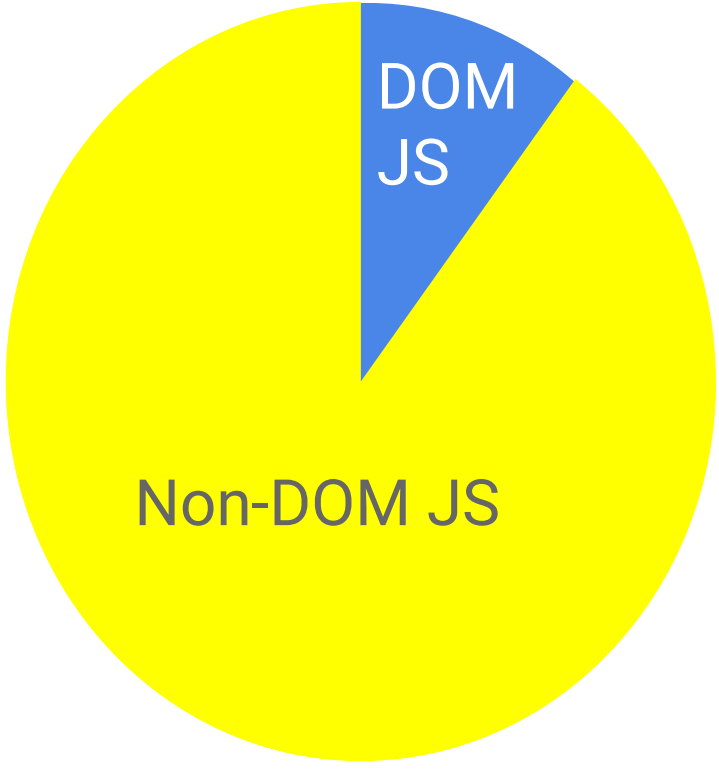
Technical Challenges

Fully trace all front end JavaScript

On any public website

Regardless of state or HTTPS

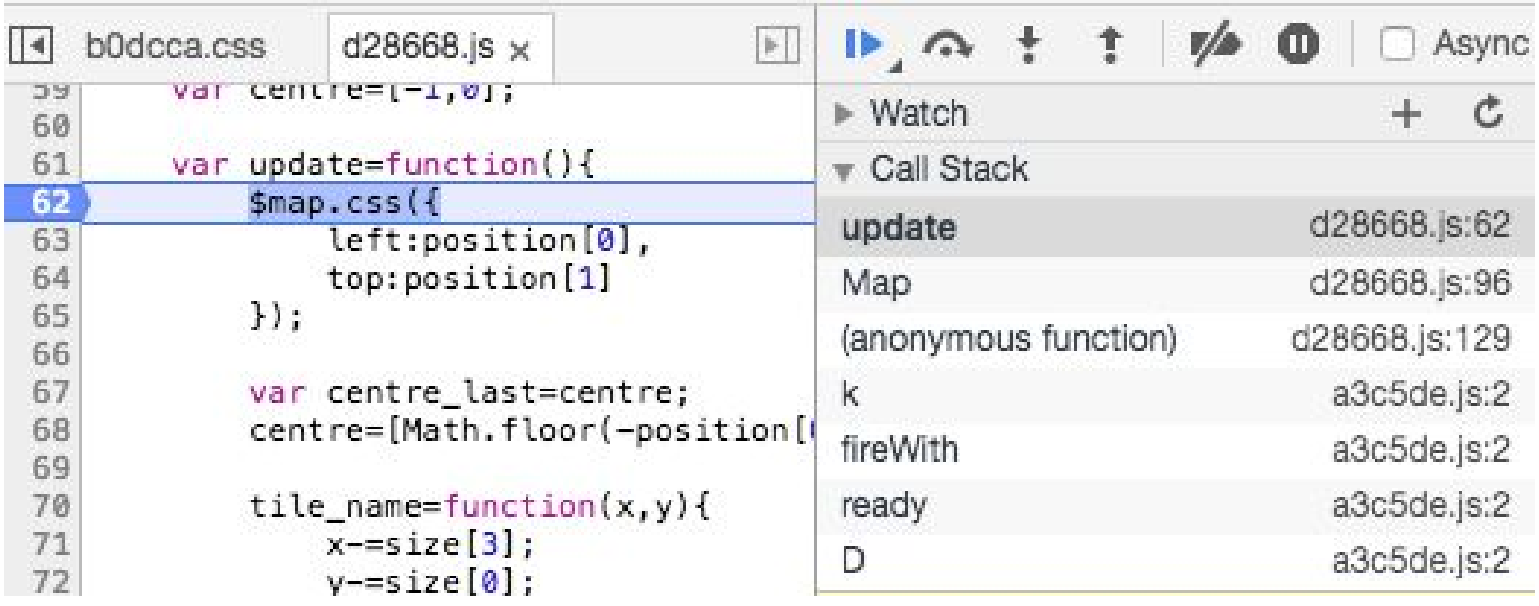
- Unravel
- Scry
- Theseus
- Telescope



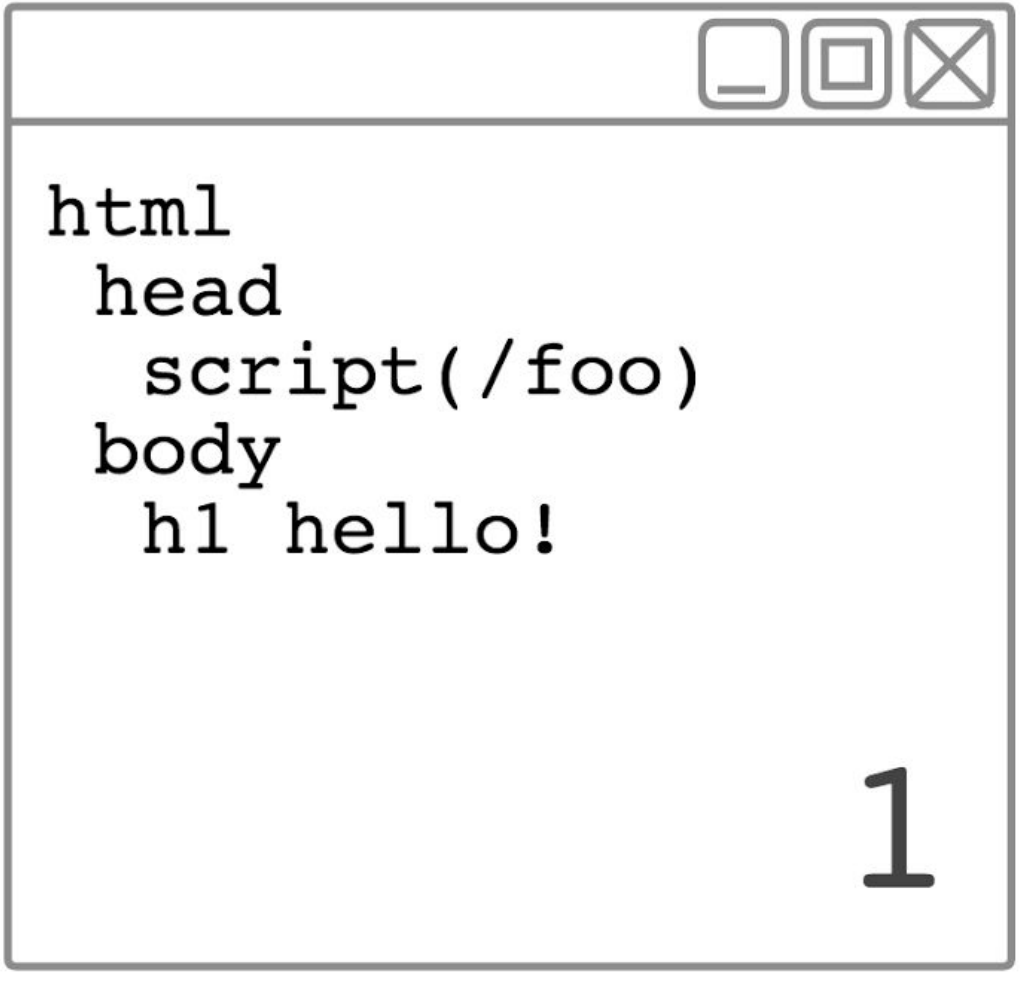
Technical Blockers

JavaScript debug API’s are not cumulative.

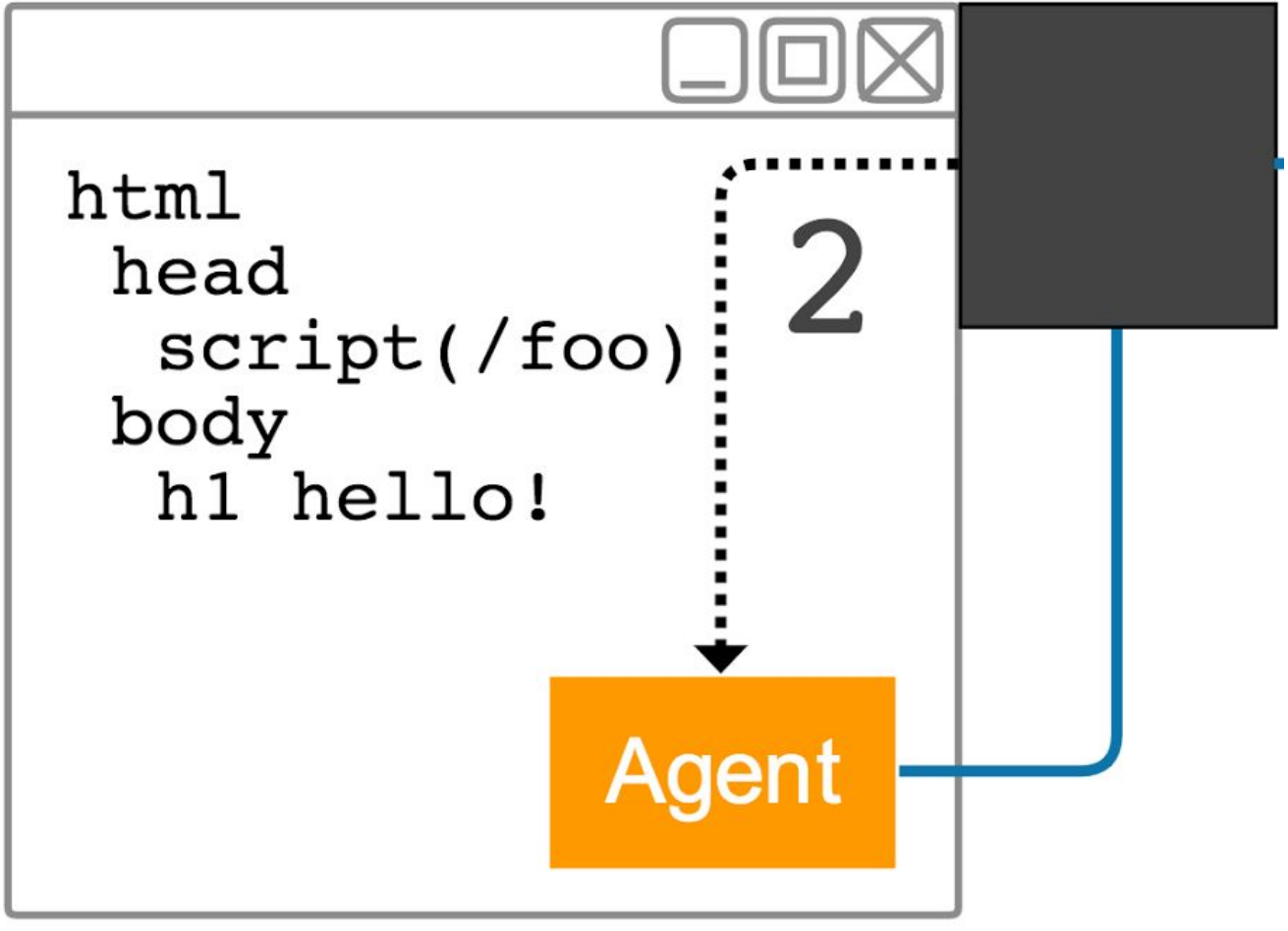
Browser policies block script alteration/instrumentation.



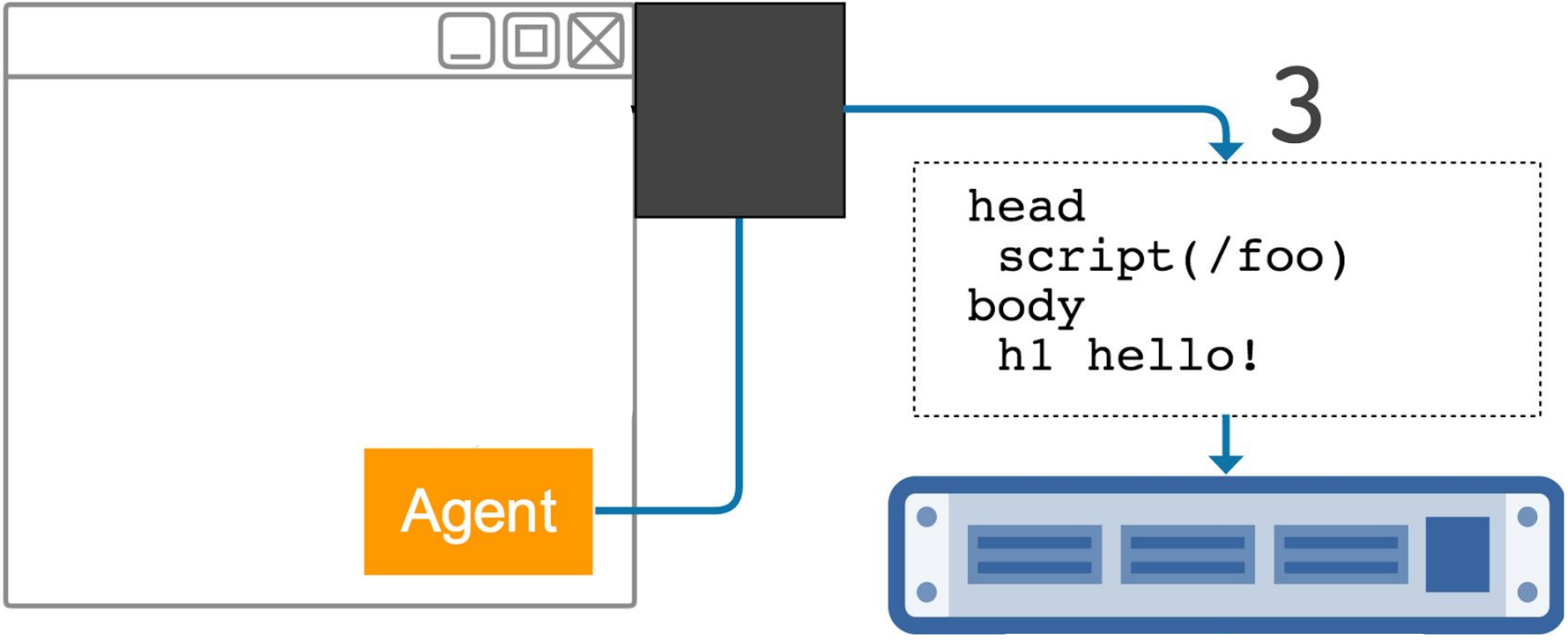
Technique: Sleight of Hand



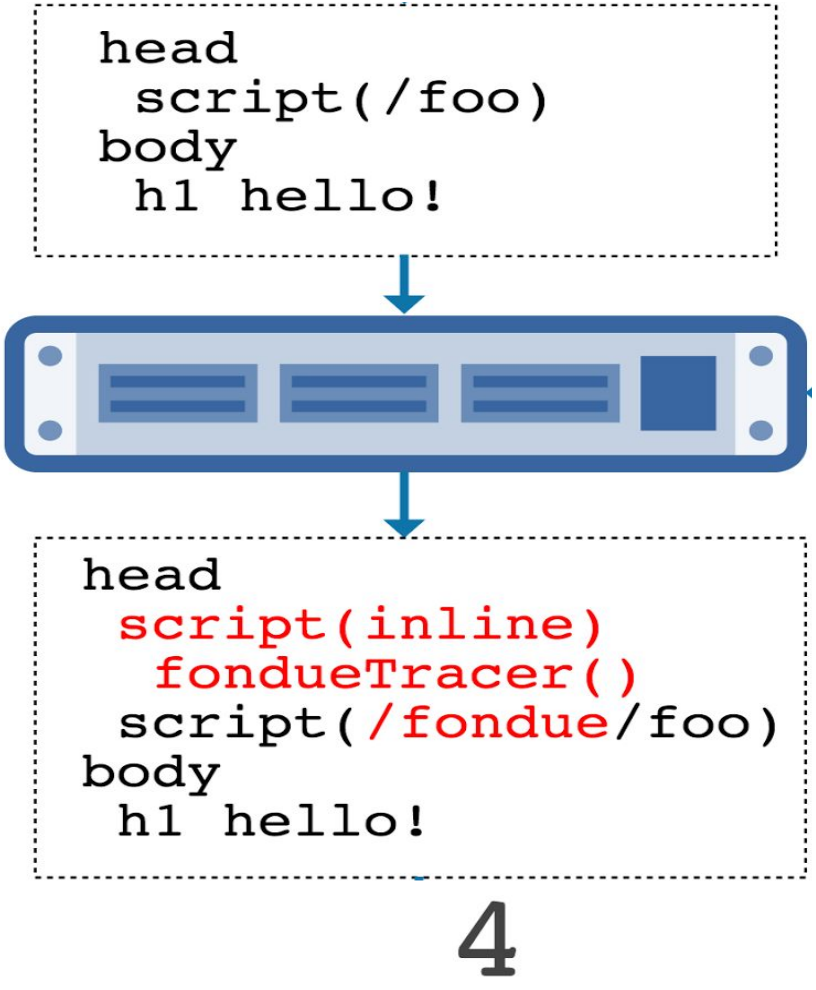
Technique: Sleight of Hand



Technique: Sleight of Hand



Technique: Sleight of Hand



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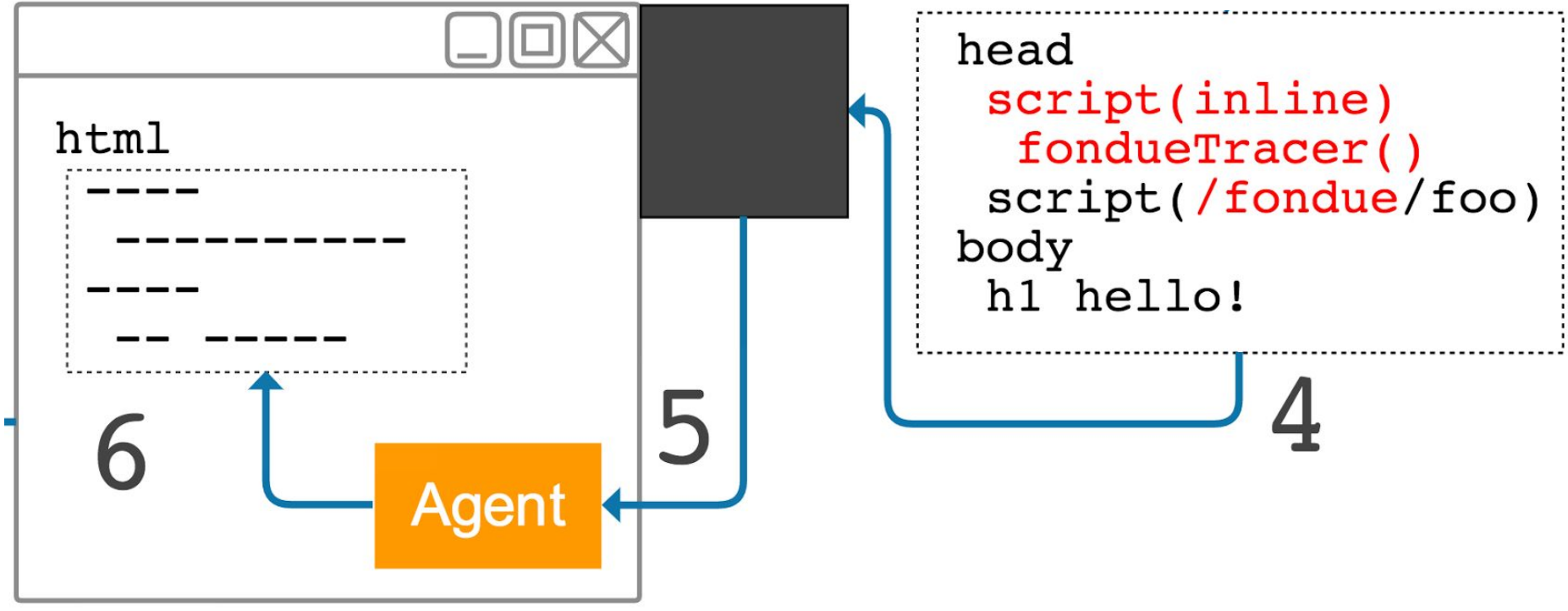
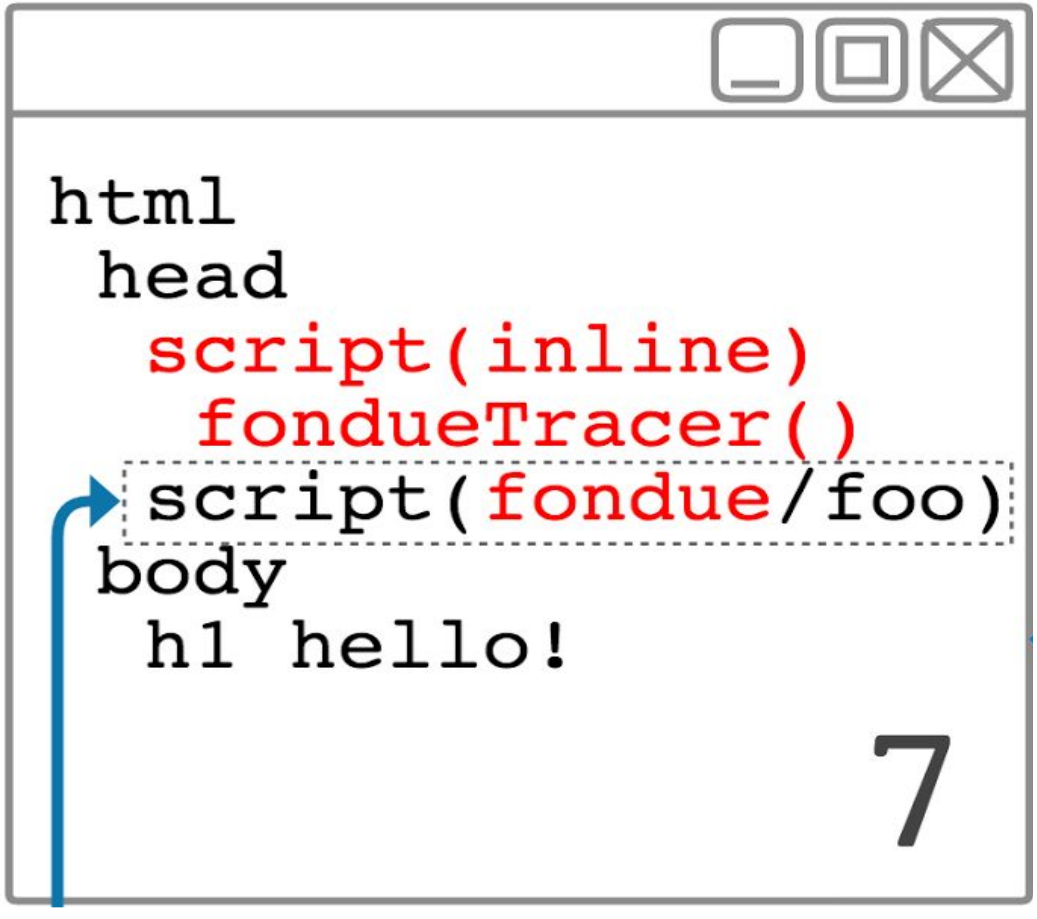
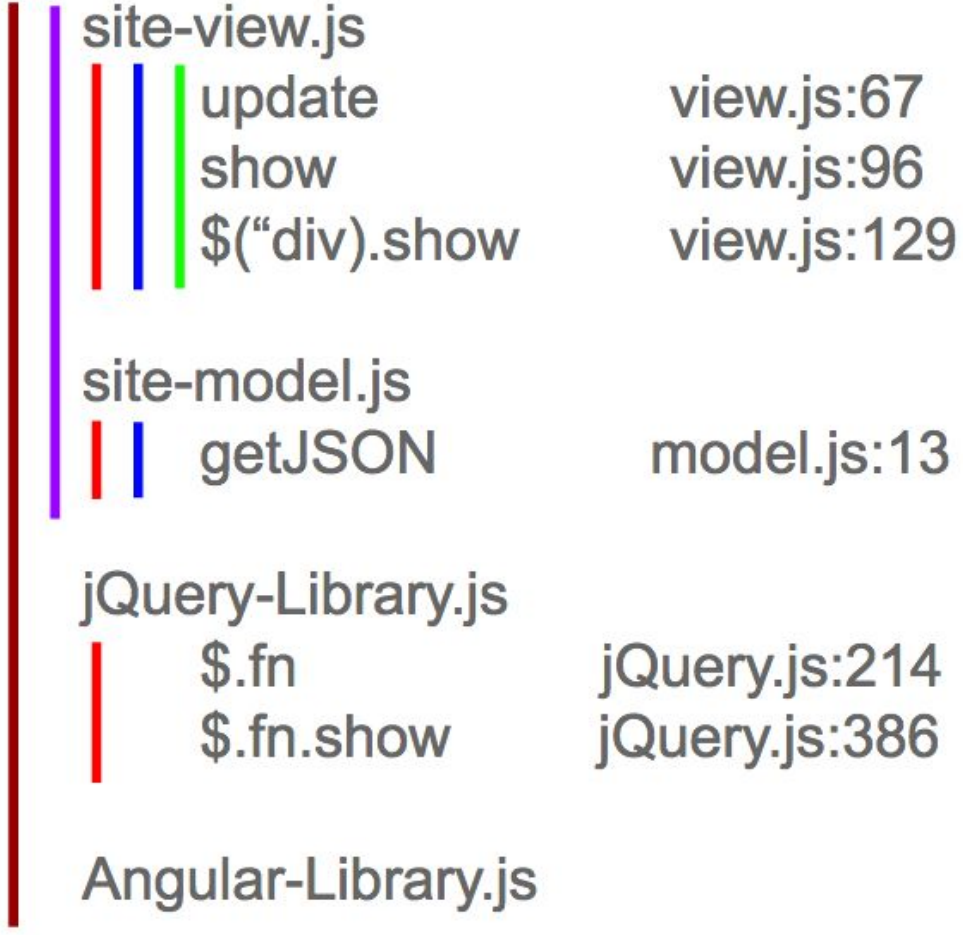


Technique: Sleight of Hand



JavaScript Detail Levels

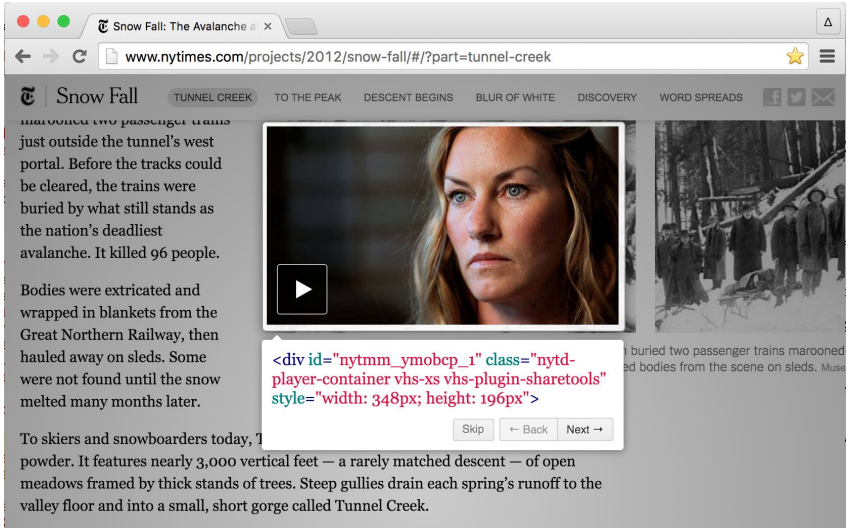
- L1: DOM JS, Non-Library
- L2: Active JS, Non-Library
- L3: Active JS
- L4: All JS, Non-Library
- L5: All JS

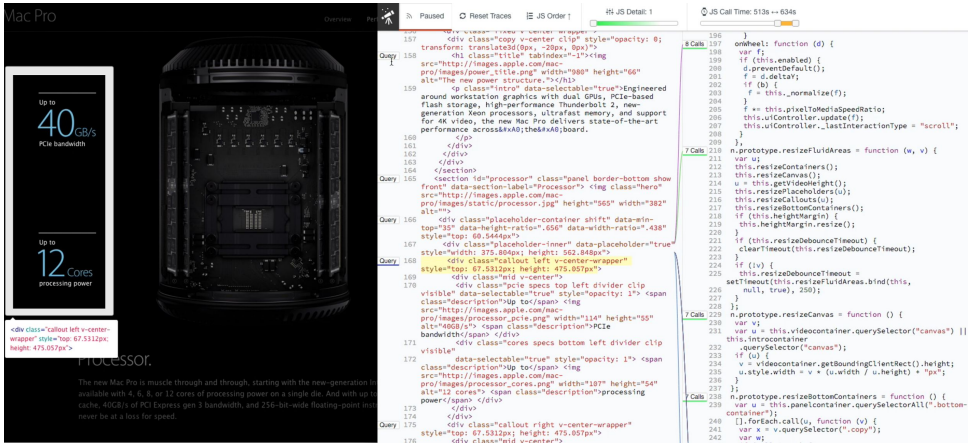


Case Study

Telescope Reduction

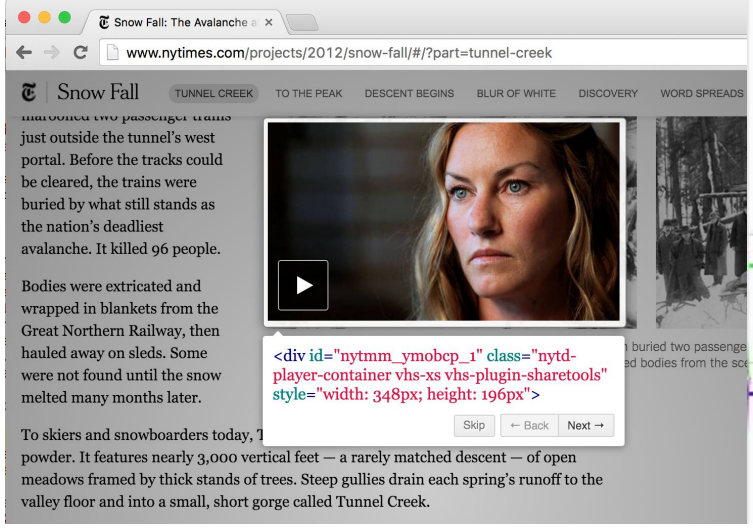
- 7 Popular Websites
- 10,000+ LOC each
- 6 Sites
  - <150 LOC Features
- 7th Site
  - <1K LOC of 30K





Snapshot

NYT Snowfall: 41K LOC



Snapshot

Dot Game: 12K LOC

JS Call Time: 21s ↔ 36s

JavaScript

1 Call

```
1   c = function (e, t, n, r) {
2    if (e > 0) {
3     $("#game").find(".active").removeClass("active");
4     $("#progress").find("." + e).addClass("active");
5     $("#game").find(".bg" + e).addClass("active");
6     $(".dot").remove();
7     $(".number").remove();
8     for (var i = 0; i < n.length; i++) {
9      n[i].controls.remove();
10     n[i].curve.remove();
11    }
12    if (!r) {
13     $("#retry").css({
14      display: "none"
15     });
16    }
17   }
```

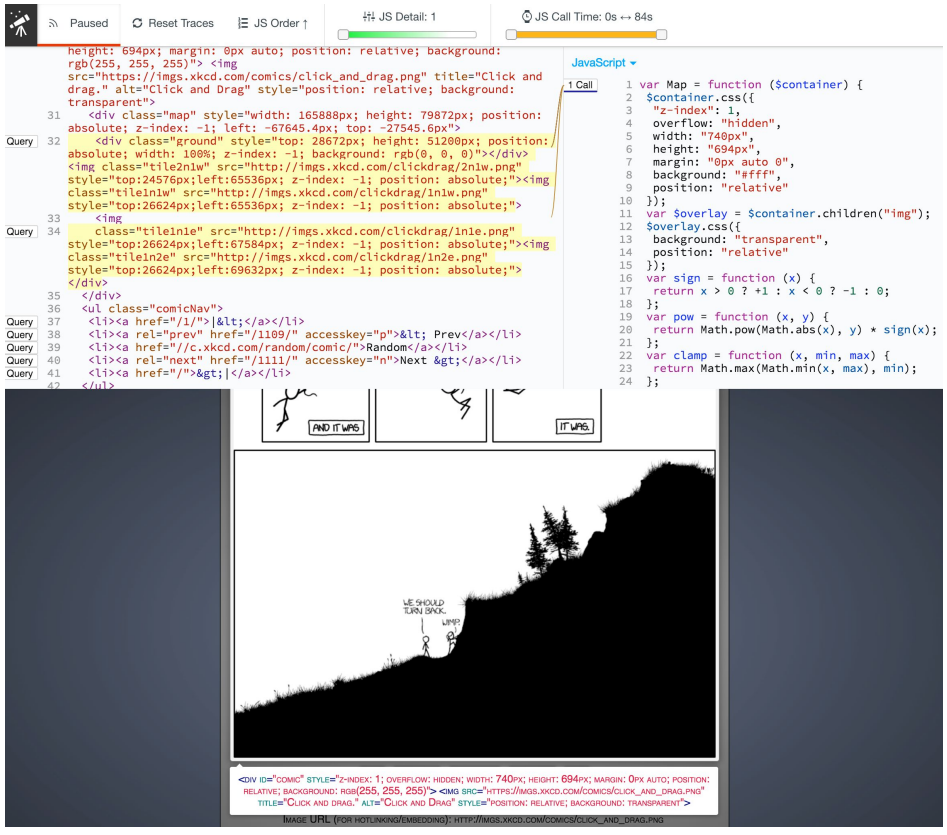
Exploratory User Study

Self-Starter Discovery

- Class-based toggling
- Simple animation

Student Web Dev Discovery

- Event-driven design
- MVC Patterns

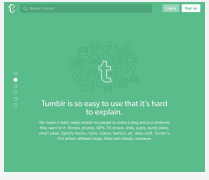


Limitations

- Preventative Web Architecture Techniques
  - HTML/CSS Minification
  - Content Security Policies
- Performance
  - Non-cached instrumentation Delay (5-180 seconds)
  - Memory limits for large runtimes
- User Class
  - Novices without sufficient HTML and JS knowledge

Future Work: Social Snapshot Learning

```
$("#map").click(function(e){
  scrollTop();
  animateWeather();
});
```

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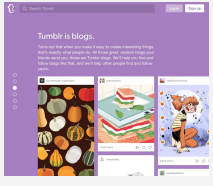



```
$("#map").click(function(e){
  scrollTop();
  animateWeather();
});
```

```
$("#map").click(function(e){
  scrollTop();
  animateWeather();
```

HTML & CSS

- Lesson 1 - Introducing HTML
- Lesson 2 - Introducing CSS
- Lesson 3 - Beyond the basics
- Lesson 4 - CSS, layouts and formatting
- Lesson 5 - Dive into HTML5 & CSS3
- Lesson 6 - Advanced HTML5

This is really similar to the Amazon product carousel and Flickr picture viewer.

Jake Archibald has a great tutorial on how to build an app cache like the one here.

Telescope

Fine-Tuned Discovery of Interactive Web UI Feature Implementation

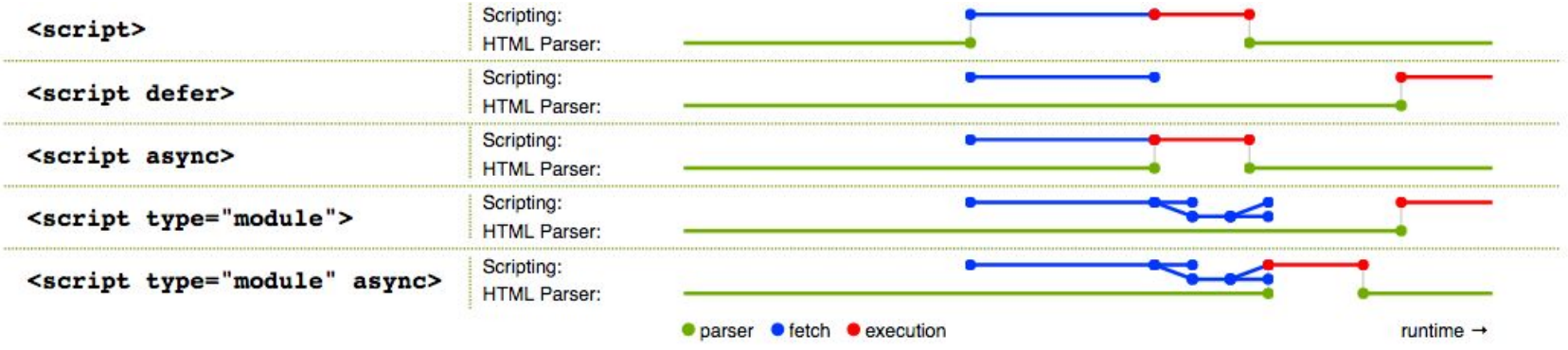
Joshua Hibschman
Haoqi Zhang

Architecture: Sleight of Hand

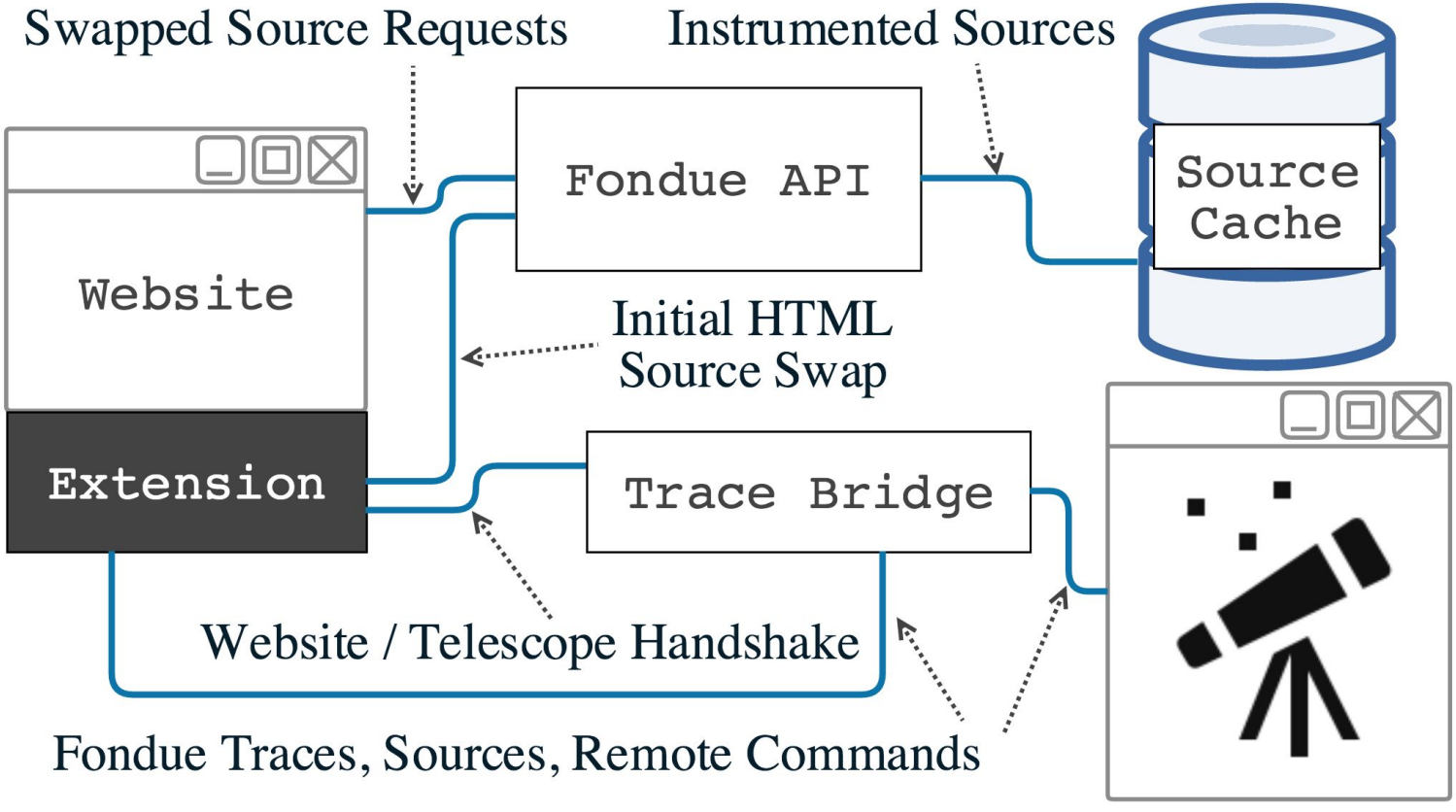
Artificial State Restoration

Artificial Script Loading

```
Window
▼ Properties
    applicationCache
    caches
    closed
    console
    controllers
    crypto
```



Architecture: Website Instrument Swap and Trace



Approach

1. Connect code to observable output
2. Help users reconstruct execution flow
3. Provide interactions to fully navigate code
4. Help users use poorly constructed code

Unravel

|

Prototype 1

|

Prototype 2

|

Prototype 3

|

Telescope

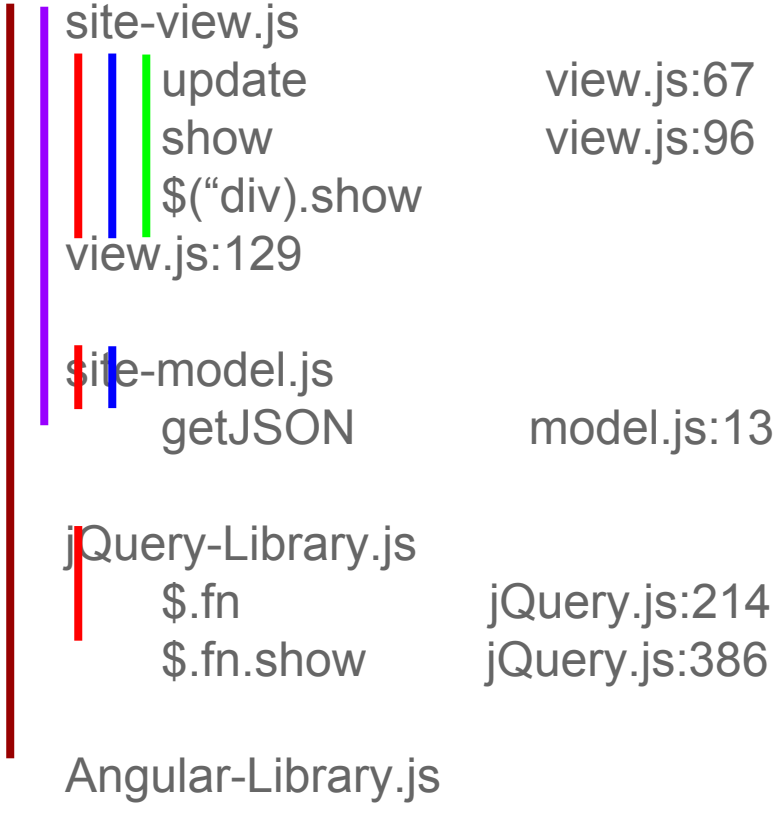
Gross, P., and Kelleher, C. Non-programmers identifying functionality in unfamiliar code: strategies and barriers. *Journal of Visual Languages & Computing 21, 5* (2010), 263–276.

JavaScript Detail Levels

L1: DOM JS, Non-Library

L2: Active JS, Non-Library

L3: Active JS

L4: All JS, Non-Library

L5: All JS