

Telescope

Fine-Tuned Discovery of Interactive Web UI Feature
Implementation

NORTHWESTERN
UNIVERSITY



Joshua Hibsichman
Haoqi Zhang

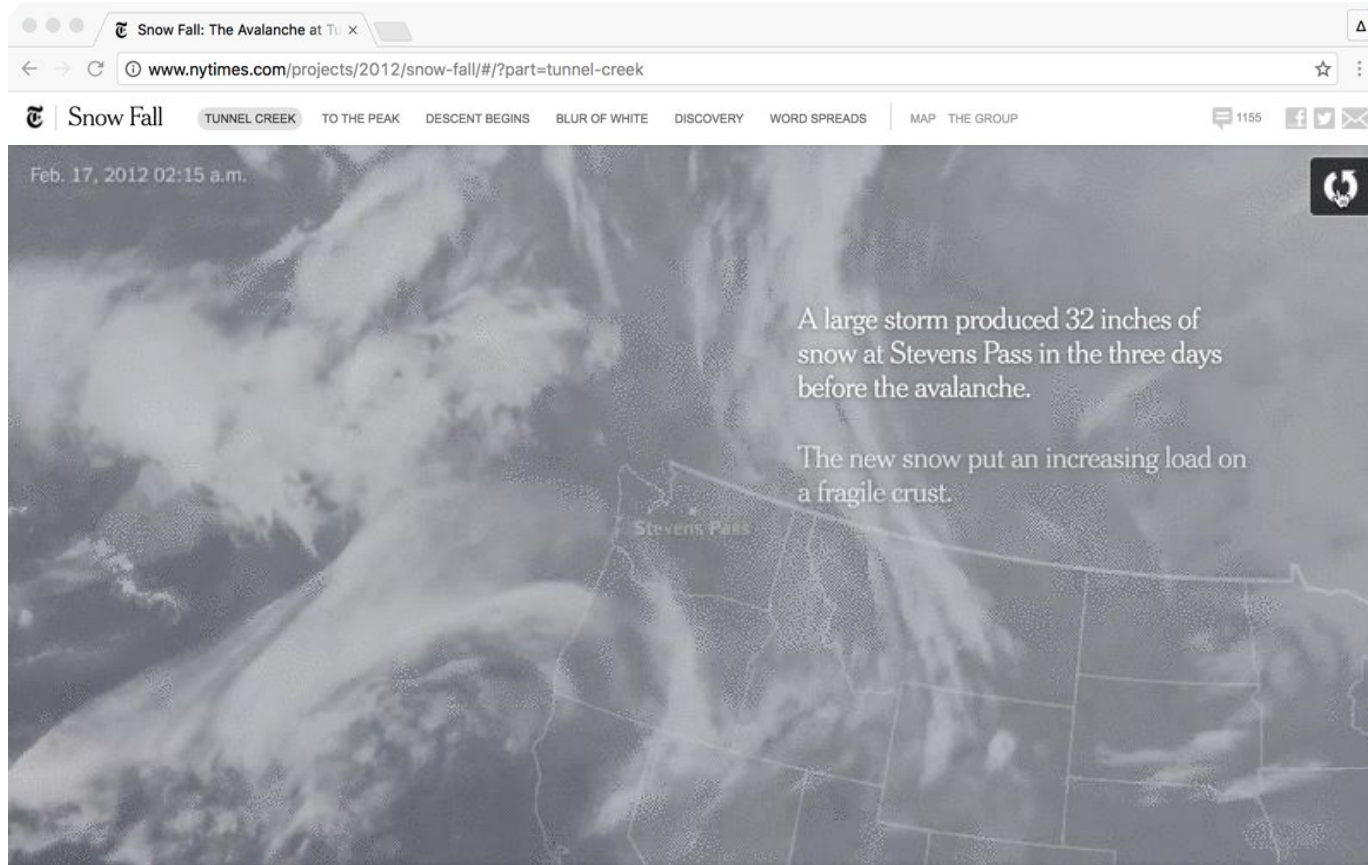
Why learn from professional web UI's?

Why learn from professional web UI's?

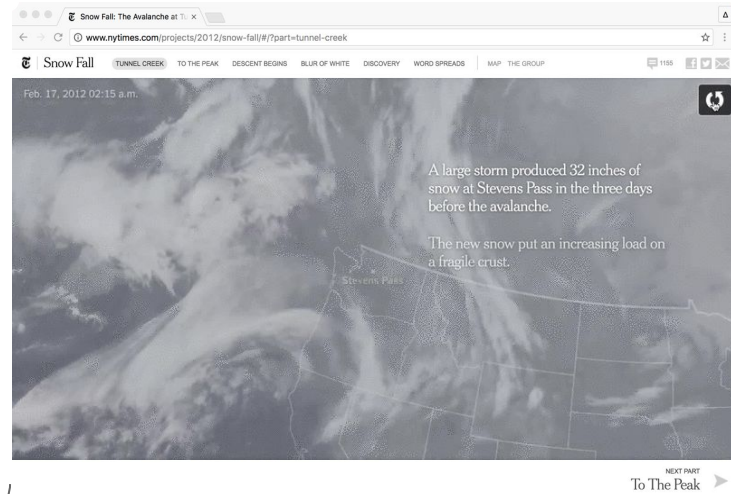
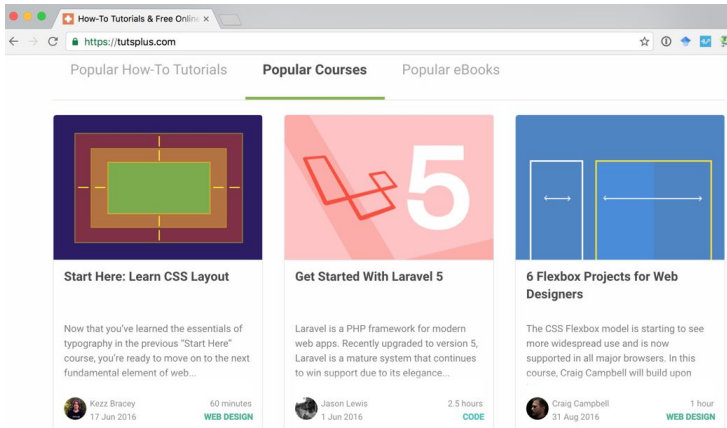
The screenshot shows a web browser window with the URL <https://tutsplus.com>. The page has three navigation tabs: "Popular How-To Tutorials", "Popular Courses" (which is selected and underlined), and "Popular eBooks". Below the tabs are three course cards:

- Start Here: Learn CSS Layout**
Now that you've learned the essentials of typography in the previous "Start Here" course, you're ready to move on to the next fundamental element of web...
Kezz Bracey, 17 Jun 2016, 60 minutes, WEB DESIGN
- Get Started With Laravel 5**
Laravel is a PHP framework for modern web apps. Recently upgraded to version 5, Laravel is a mature system that continues to win support due to its elegance...
Jason Lewis, 1 Jun 2016, 2.5 hours, CODE
- 6 Flexbox Projects for Web Designers**
The CSS Flexbox model is starting to see more widespread use and is now supported in all major browsers. In this course, Craig Campbell will build upon...
Craig Campbell, 31 Aug 2016, 1 hour, WEB DESIGN

How do I do that?



Learning Gap: Self-starter to Professional

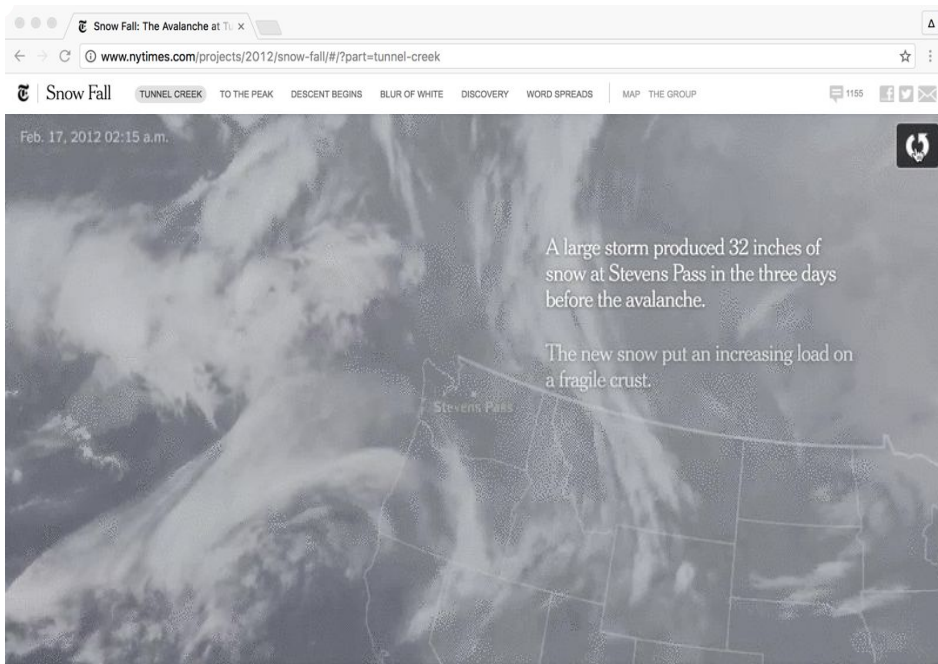


???

Self-Starter to Professional Learning Gap

The screenshot shows the Codecademy interface for a course titled "Build a Professional Website". At the top, the Codecademy logo is on the left, and navigation links for "Learn" and "Teach" are in the center. On the right, there is a user profile icon labeled "Me" and a progress indicator showing "0 points today" and "0 day streak". The main heading "Build a Professional Website" is centered, with a red "CONTINUE" button below it. A section titled "What you will learn" follows, with a sub-heading "Build the Airbnb home page and learn the fundamentals of web development in the process." Below this is a preview of the Airbnb website on a tablet, showing the text "Find a place to stay." and a "Feedback" button with a plus sign.

Inspection Burden

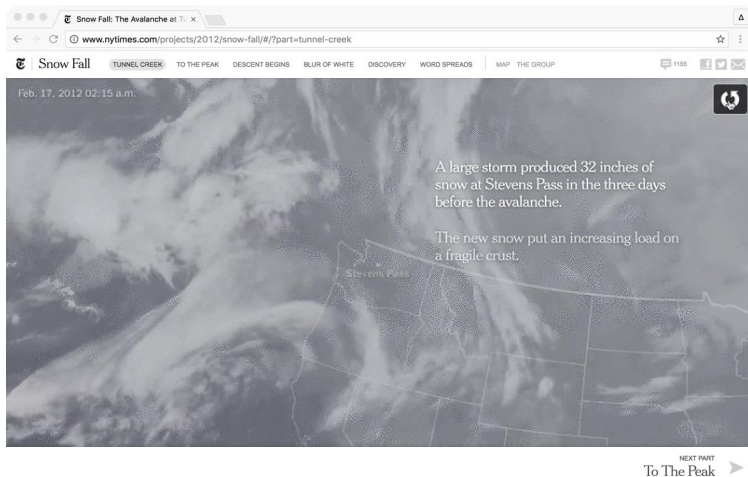


```
Developer Tools - http://www.nytimes.com/projects/2012/snow-fall/
Elements Console Sources Network Timeline >> 1 2
AvalancheDeploy.js AvalancheDeploy.js:formatted x
28215 setEnv: function() {
28216   if (this.opts.presentationType === "ios" || this.opts.presentationType
28217     this.$html.addClass("nytm_avalanche_touch");
28218     if (this.opts.presentationType === "touch") {
28219       this.$html.addClass("nytm_avalanche_touch_low")
28220     }
28221   } else {
28222     this.$html.addClass("nytm_avalanche_desktop")
28223   }
28224   this.$html.addClass("nytm_avalanche_" + this.opts.presentationType +
28225   if (this.opts.presentationType === "ios" || this.opts.presentationType
28226     if (NYTD.NYTMM.iOS) {
28227       this.$head.append('<meta name="viewport" content="width=device
28228     } else {
28229       this.$head.append('<meta name="viewport" content="width=device
28230     }
28231   }
28232   if (NYTD.NYTMM.Device.features.isRetina()) {
28233     this.$html.addClass("nytm_avalanche_retina")
28234   }
28235   if (b.address.parameter("source") && b.address.parameter("source") ==
28236     this.$html.addClass("nytm_avalanche_inapp")
28237   }
28238 }
```

28,238 Lines of JavaScript!

NEXT PART
To The Peak ▶

Last Year: Unravel



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

/slide.js:15:1 (completeLoad)

/slide.js:58:2 (clickMap)

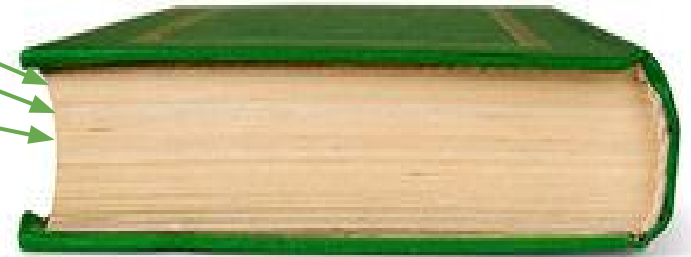
```
(r=bind(this,function(t){this.init([],function()  
{return t},null,  
{enabled:!0})),r.error=bind(this,function(t)  
{this.inited=!0,this.error=t,t.requireModules=  
[e],eachProp(T,function(t)  
{0===t.map.id.indexOf("+"_unnormalized")&&f(t.map  
.id)}),c(t)),r.fromText=bind(this,function(n,i,t  
)  
{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

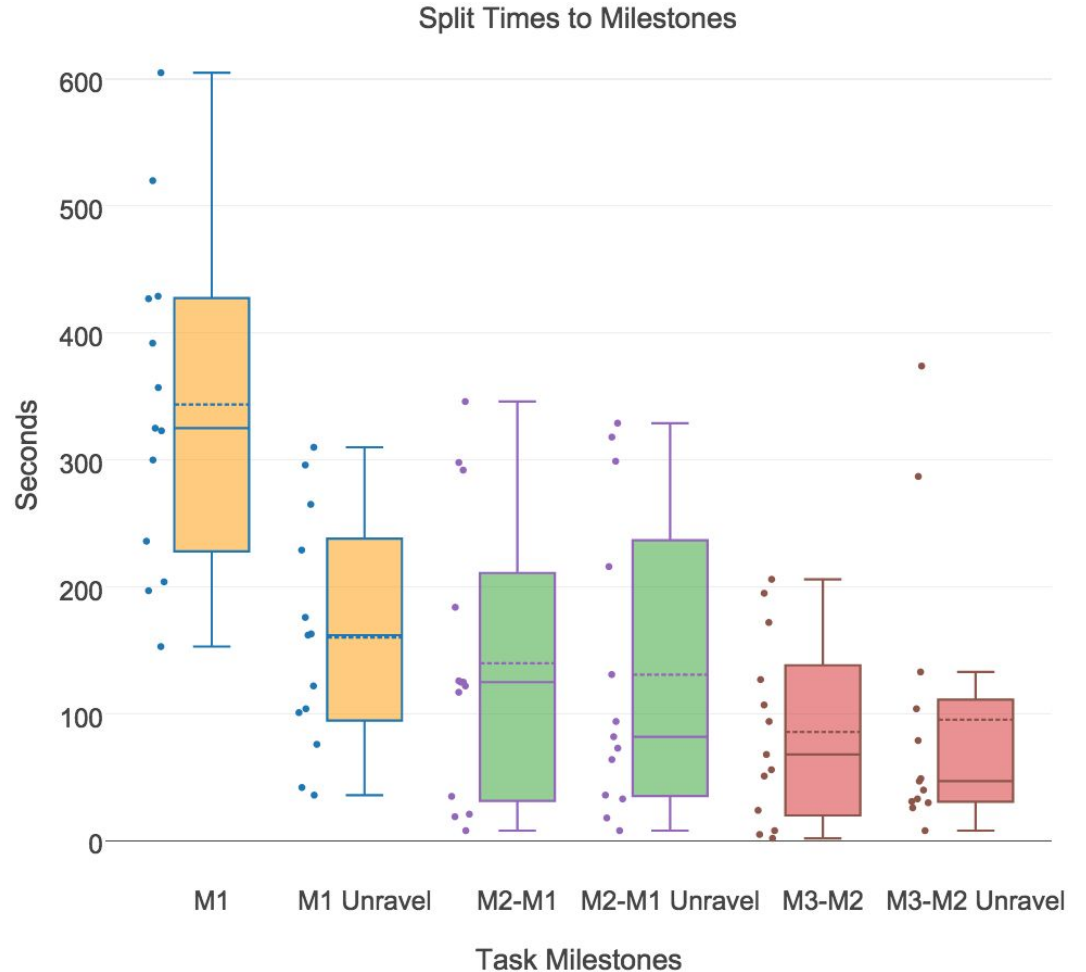


Last Year: Unravel

M1: Key Source 1

M2: Key Source 2

M3: "Ah-ha" moment



Telescope Approach

Fellowship of the Ring



Bilbo Baggins has a ring (more...)

The wizard Gandalf arrives (more...)

Bilbo leaves (more...)

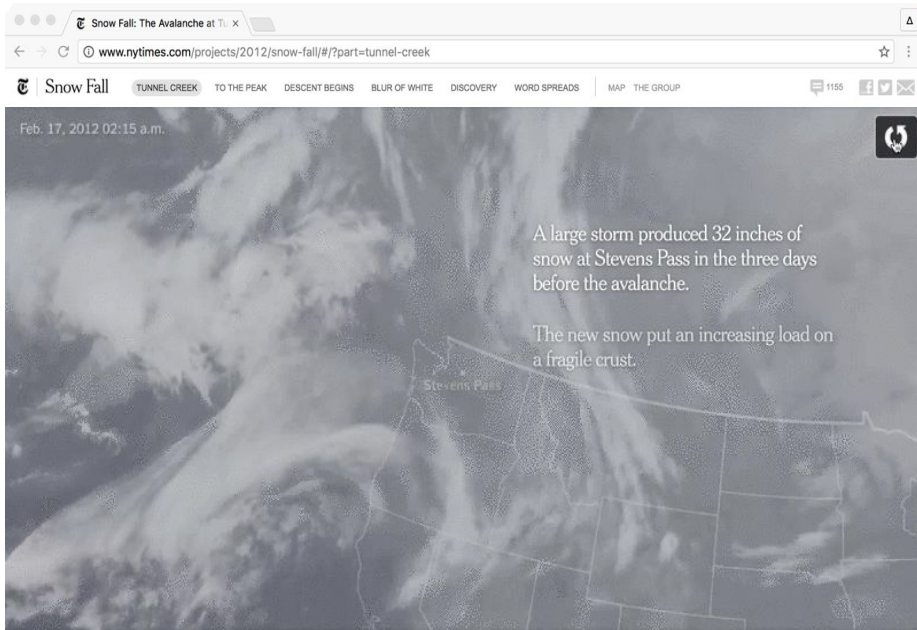
In addition, ever since Bilbo came back to the Shire with the ring—which he has kept secret from nearly everyone—he has not seemed to age at all. In fact, he reaches his 111th birthday virtually unchanged.

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



NEXT PART
To The Peak ▶

```
$("#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=
```




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">
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></span>
14 <span class="2">2</span></span></span>
15 <span class="3">3</span></span></span>
16 <span class="4">4</span></span></span>
17 <span class="5">5</span></span></span>
18 </h3>
19 <h2 id="timer" style="''>00:07</h2>
20 <h2 id="nice">well done!</h2> 
21 <div class="bg1 bg active">
22 </div>
23 <div class="bg2 bg">
24 <div class="bg3 bg">
25 <div class="bg4 bg">
26 <div class="bg5 bg">
27 </div>
28 <div id="finish"> 
29 <p>You scored: <span class="score">0000</span></p>
30 <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);
14 55 Calls
15 u = window.setInterval(function () {
16 var n = Date.now();
17 var i = Math.round(.1 * (n - t));
18 e -= i;
19 t = n;
20 $("#timer").html(m(e));
21 if (e <= 0) {
22 clearInterval(u);
23 u = null;
24 $("#retry").css({
25 display: "block"
26 }).off().on("click", function () {
27 c(r, a, p, false);
28 });
29 $("#timer").css({
30 display: "none"
31 });
32 return;
33 }
34 }, 1e3 / 100);
35 3 Calls
36 function bc(a, b, c, d) {
37 c = c || [], b = b || r;
38 var e, f, i, j, k = b.nodeType;
39 if (!a || "string" !== typeof a) {
40 return c;
41 }
42 if (1 !== k && 9 !== k) {
43 return [];
```


Live Demo!

Technical Challenges

Fully trace all front end JavaScript

On any public website

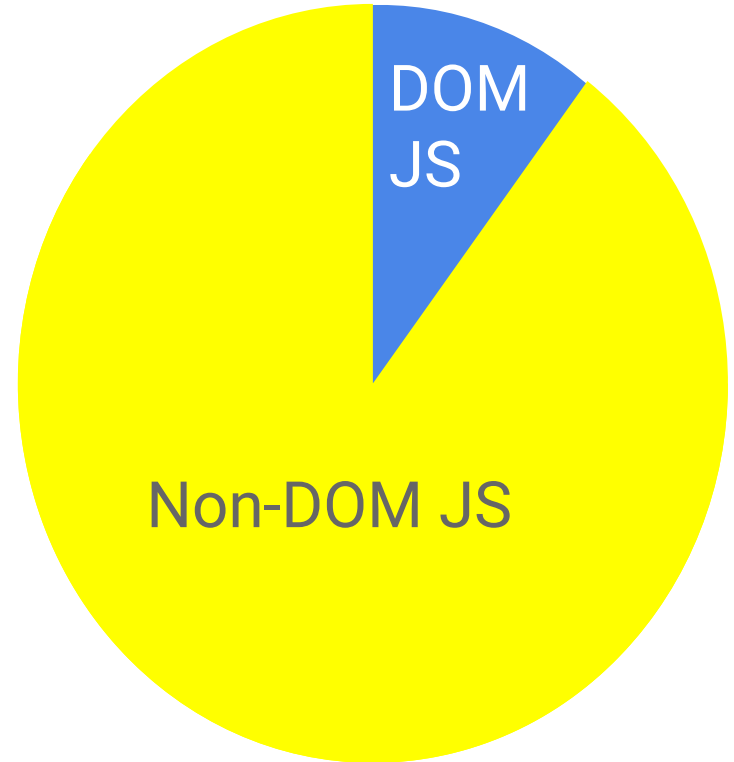
Regardless of state or HTTPS

■ Unravel

■ Scry

▲ Theseus

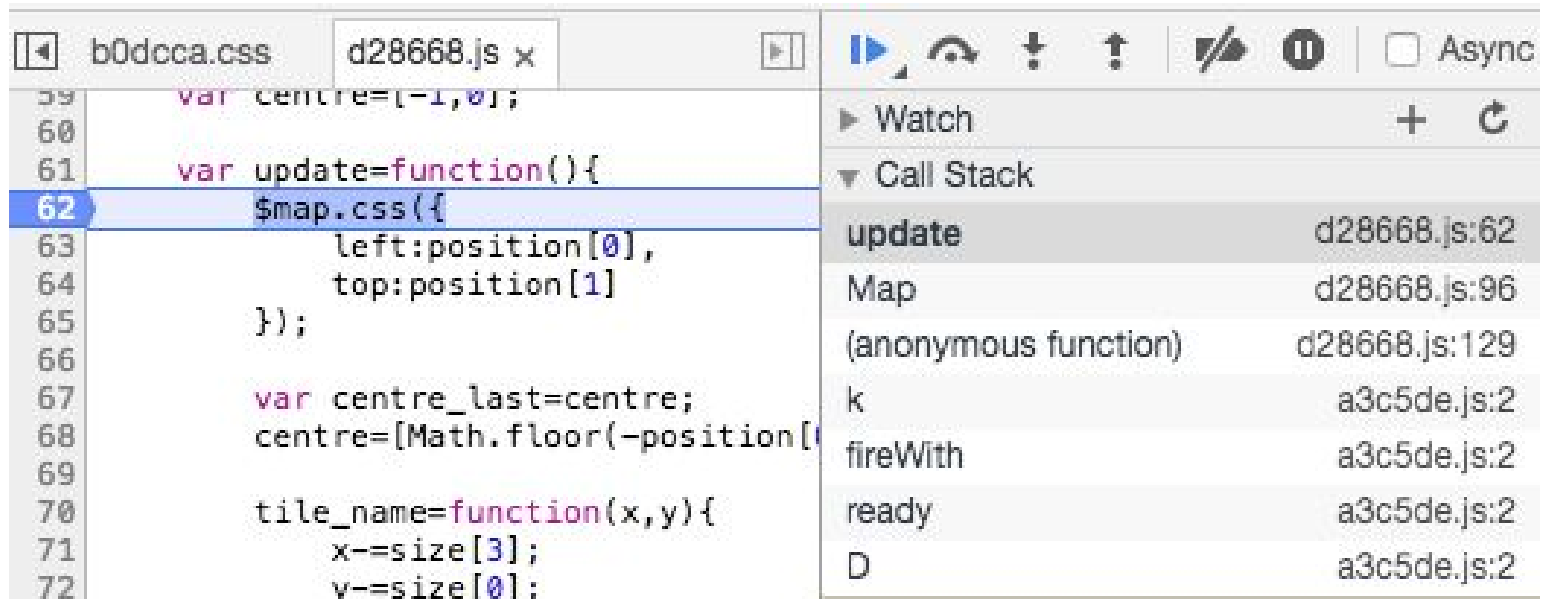
■ Telescope



Technical Blockers

JavaScript debug API's are not cumulative.

Browser policies block script alteration/instrumentation.




The screenshot shows a browser's developer console with a JavaScript error. The error message is "Uncaught ReferenceError: \$map is not defined" on line 62 of the file d28668.js. The call stack shows the following frames:

Function Name	File Name	Line Number
update	d28668.js	62
Map	d28668.js	96
(anonymous function)	d28668.js	129
k	a3c5de.js	2
fireWith	a3c5de.js	2
ready	a3c5de.js	2
D	a3c5de.js	2

The code editor shows the following JavaScript code:

```
59     var centre=[-1,0];
60
61     var update=function(){
62         $map.css({
63             left:position[0],
64             top:position[1]
65         });
66
67         var centre_last=centre;
68         centre=[Math.floor(-position[0]),Math.floor(-position[1])];
69
70         tile_name=function(x,y){
71             x-=size[3];
72             y-=size[0];
```

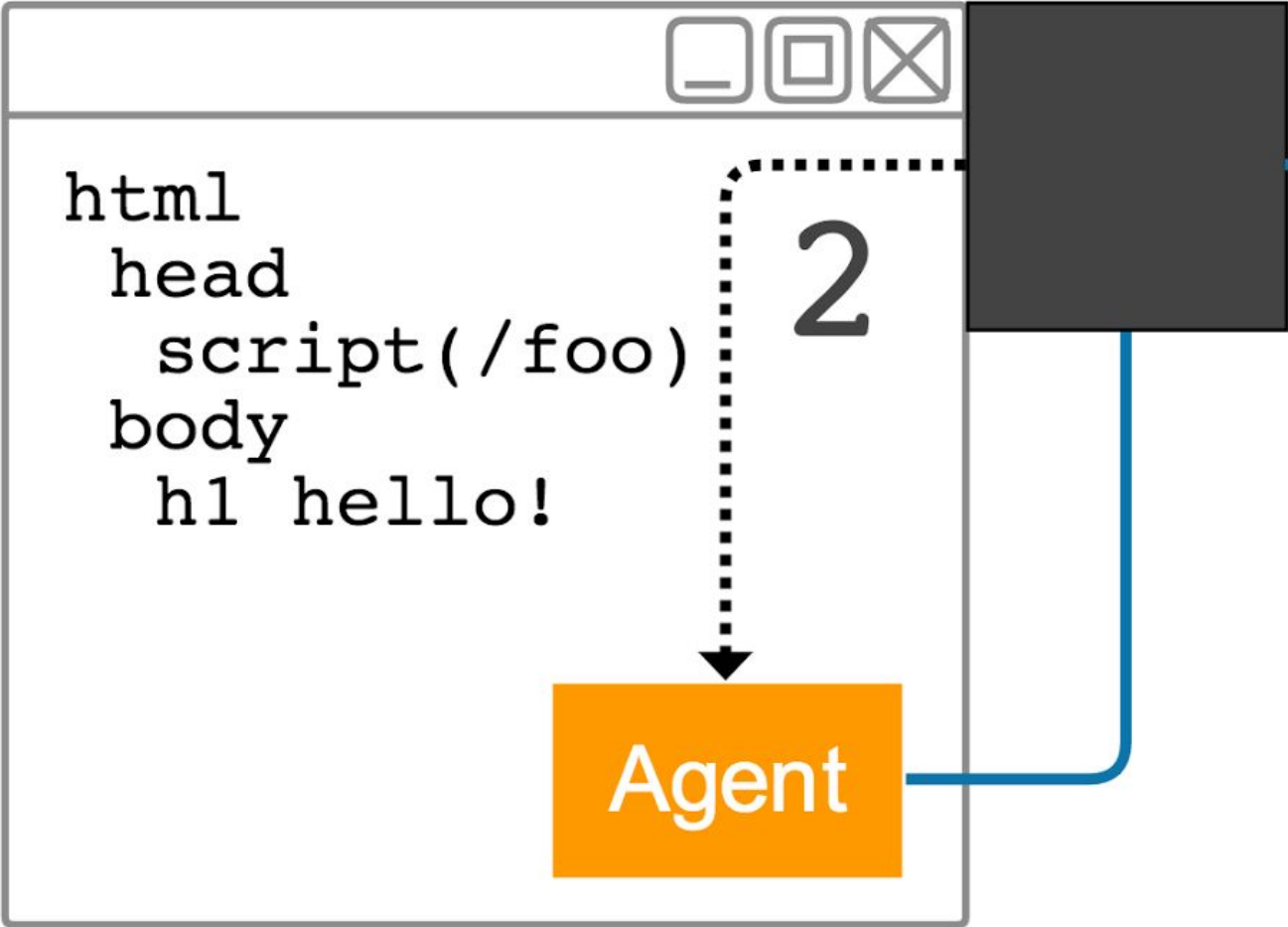
Technique: Sleight of Hand



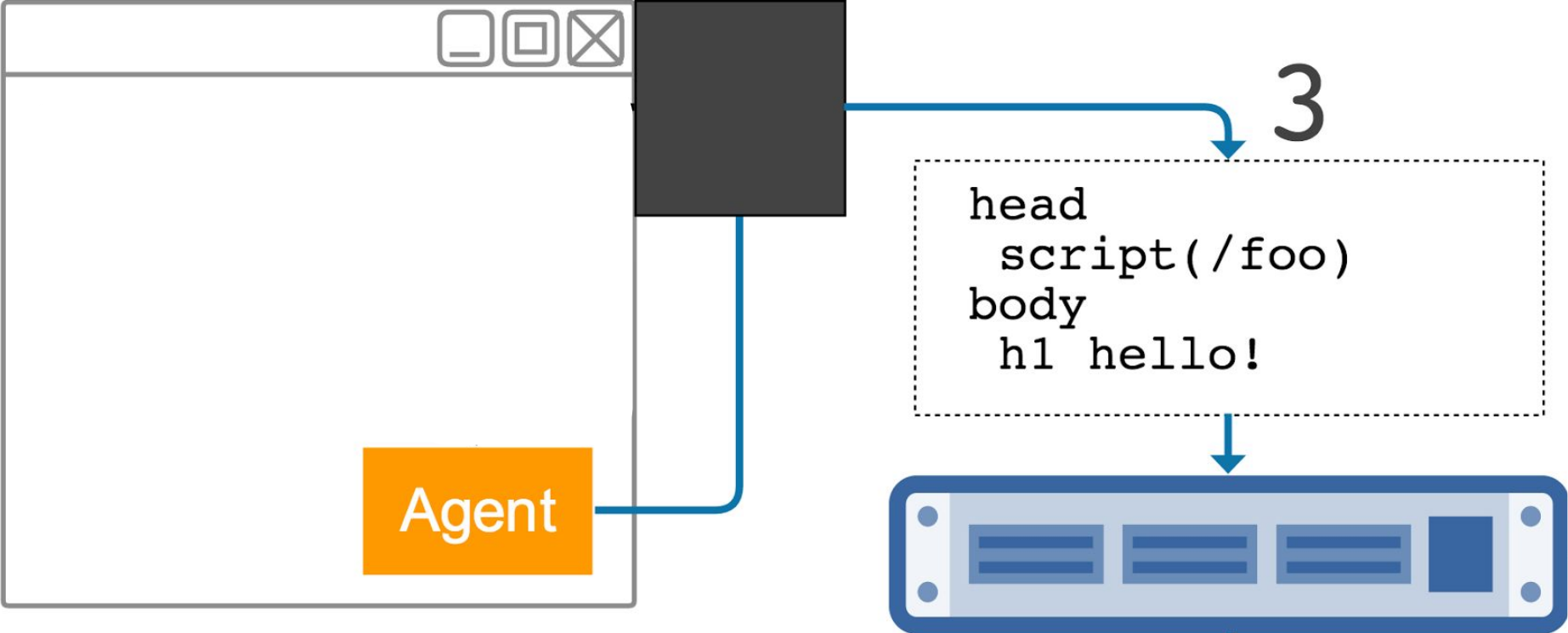
```
html
  head
    script(/foo)
  body
    h1 hello!
```

1

Technique: Sleight of Hand



Technique: Sleight of Hand



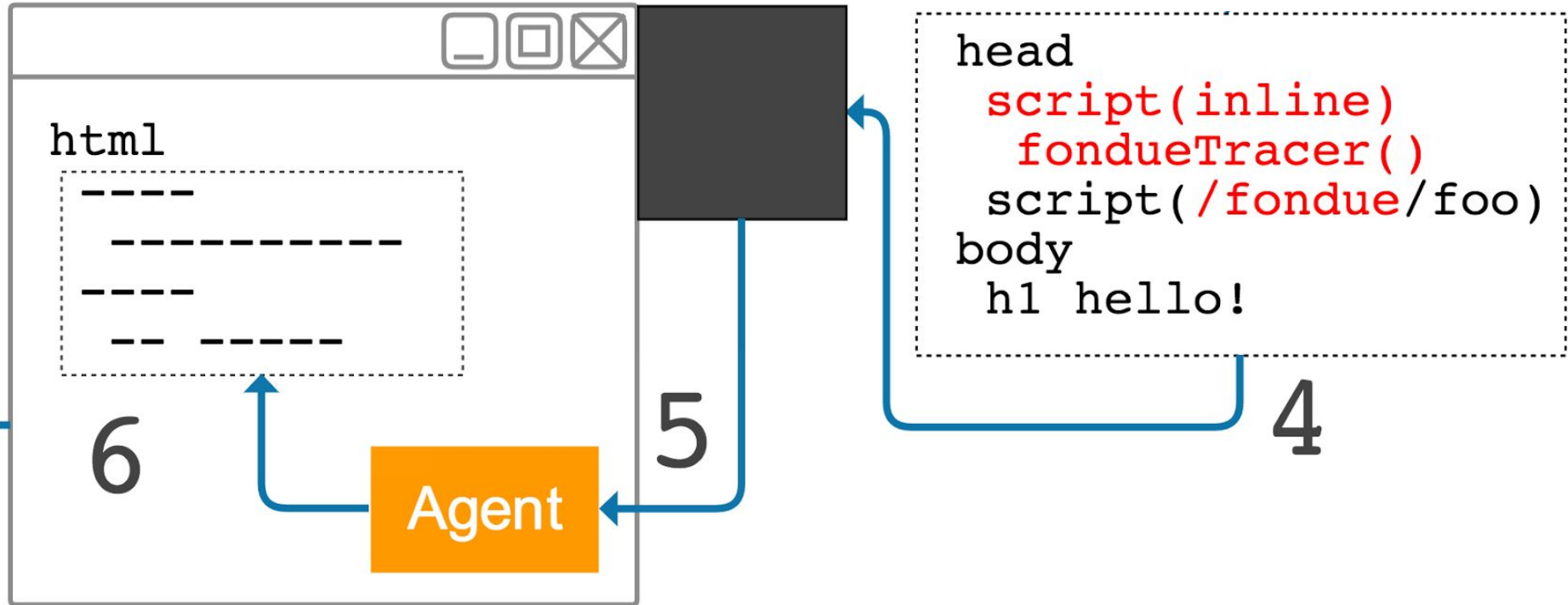
Technique: Sleight of Hand

```
head
  script(/foo)
body
  h1 hello!
```




```
head
  script(inline)
  fondueTracer()
  script(/fondue/foo)
body
  h1 hello!
```


Technique: Sleight of Hand








Technique: Sleight of Hand

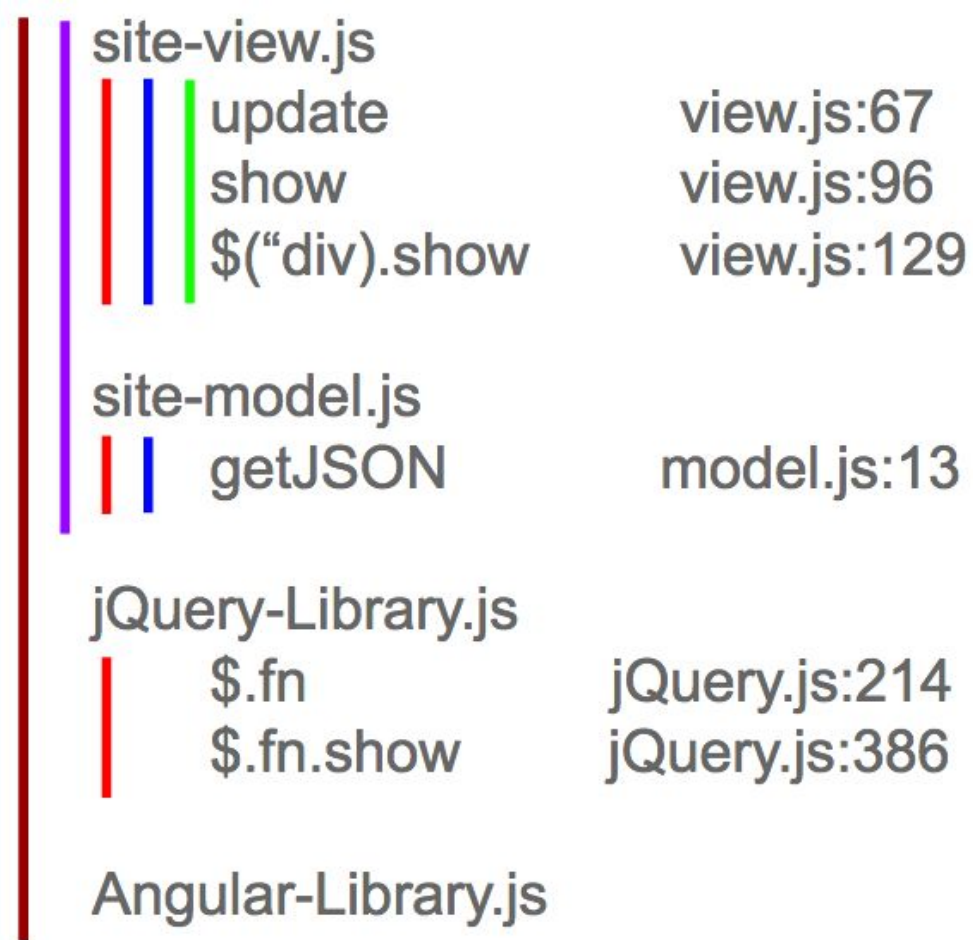


```
html
  head
    script(inline)
      fondueTracer()
    script(fondue/foo)
  body
    h1 hello!
```

7

JavaScript Detail Levels

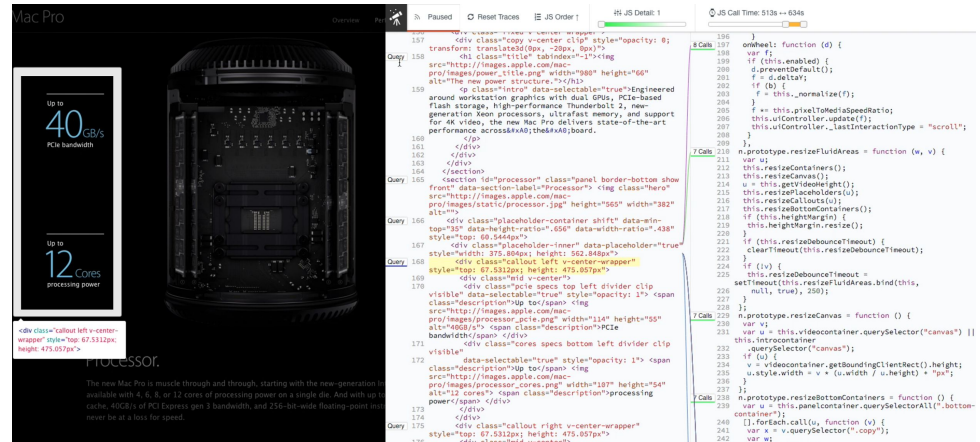
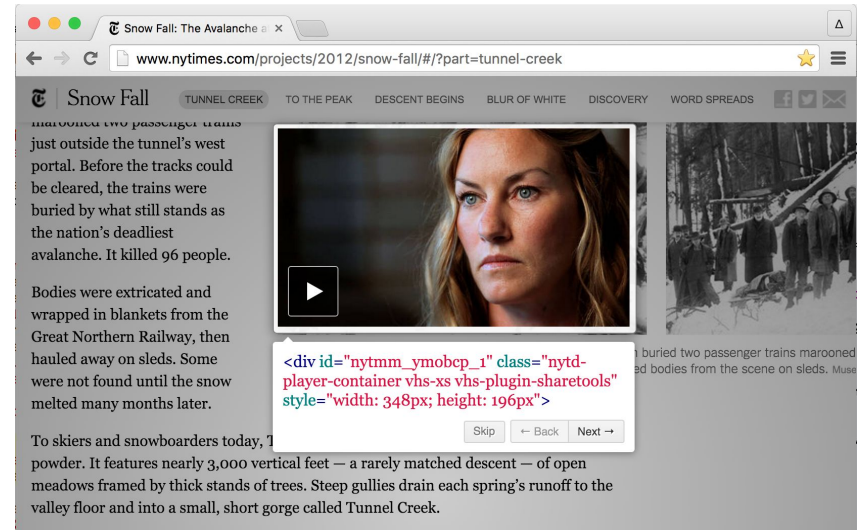
-  L1: DOM JS, Non-Library
-  L2: Active JS, Non-Library
-  L3: Active JS
-  L4: All JS, Non-Library
-  L5: All JS



Case Study

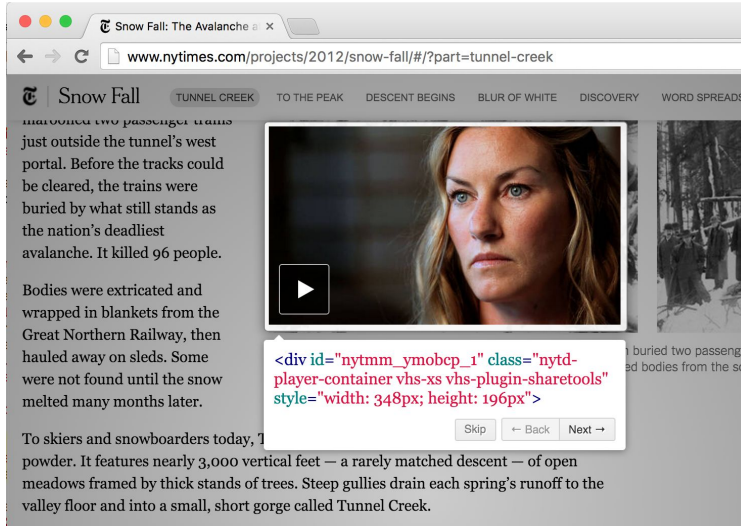
Telescope Reduction

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



Snapshot

NYT Snowfall: 41K LOC



JS Call Time: 7s ↔ 31s

```
2 Calls 113  _initialize: function () {
114    var t = this;
115    this.utils = i.util;
116    this.body = e("body").first();
117    this.uptContainer = e(document.createElement("div"));
118    this.hideElement(this.uptContainer);
119    this.body.append(this.uptContainer);
120    this.uptURL = [document.location.protocol,
121    "//up.nytimes.com/"].join("");
122    var n = window["dcsvid"] ||
123    e("meta[name='WT.dcsvid']").attr("content") ||
124    "";
125    this.uid = encodeURIComponent(n);
126    this.tracked = false;
127    this.trackedUptProgress = false;
128  },
129  this.getData(t, "video", function (t) {
130    e._data = t;
131    e.renderPlayer();
132  });
133  renderPlayer: function () {
134    var t = this;
135    var n = this.options.render && false ===
136    this.options.cover || true ===
137    this.options.autoplay;
```

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

The screenshot shows a web browser's developer tools interface. The top bar indicates the page is paused, with options for 'Reset Traces', 'JS Order', and 'JS Call Time: 0s -- 84s'. The main area is split into two panes: HTML and JavaScript.

HTML Pane: Shows the DOM tree with several elements highlighted. Line 31 is a `<div class="map">` element. Line 32 is a `<div class="ground">` element containing a `<div class="tile2n1w">` and a ``. Line 33 is another `` element. Line 34 is a `<div class="tile1n2e">` element containing a ``. Line 35 is a `</div>` closing tag. Line 36 is a `<ul class="comicNav">` element containing three `` elements with `href` attributes.

JavaScript Pane: Shows a function `var Map = function ($container) {` which defines a `$container.css` object with properties like `z-index`, `overflow`, `width`, `height`, `margin`, `background`, and `position`. It also defines a `$overlay` object and a `toggle` function that uses `Math.pow` and `Math.max` to calculate a value.

Image Pane: Shows a comic strip with three panels. The first panel shows a character with a speech bubble saying "AND IT WPS". The second panel shows a character with a speech bubble saying "IT WPS". The third panel shows a character with a speech bubble saying "WE SHOULD TURN BACK".

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

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



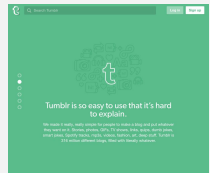
This is really similar to the [Amazon product carousel](#) and [Flickr picture viewer](#).



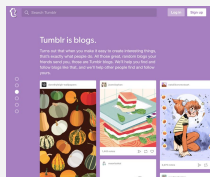
Jake Archibald has a [great tutorial](#) on how to build an app cache like the one here.



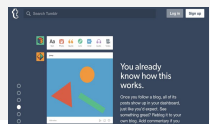
```
$("#map").click(function(e){  
  scrollTop();  
  animateWeather();  
});
```



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



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

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Fine-Tuned Discovery of Interactive Web UI Feature
Implementation

NORTHWESTERN
UNIVERSITY



Joshua Hibsichman
Haoqi Zhang

Architecture: Sleight of Hand

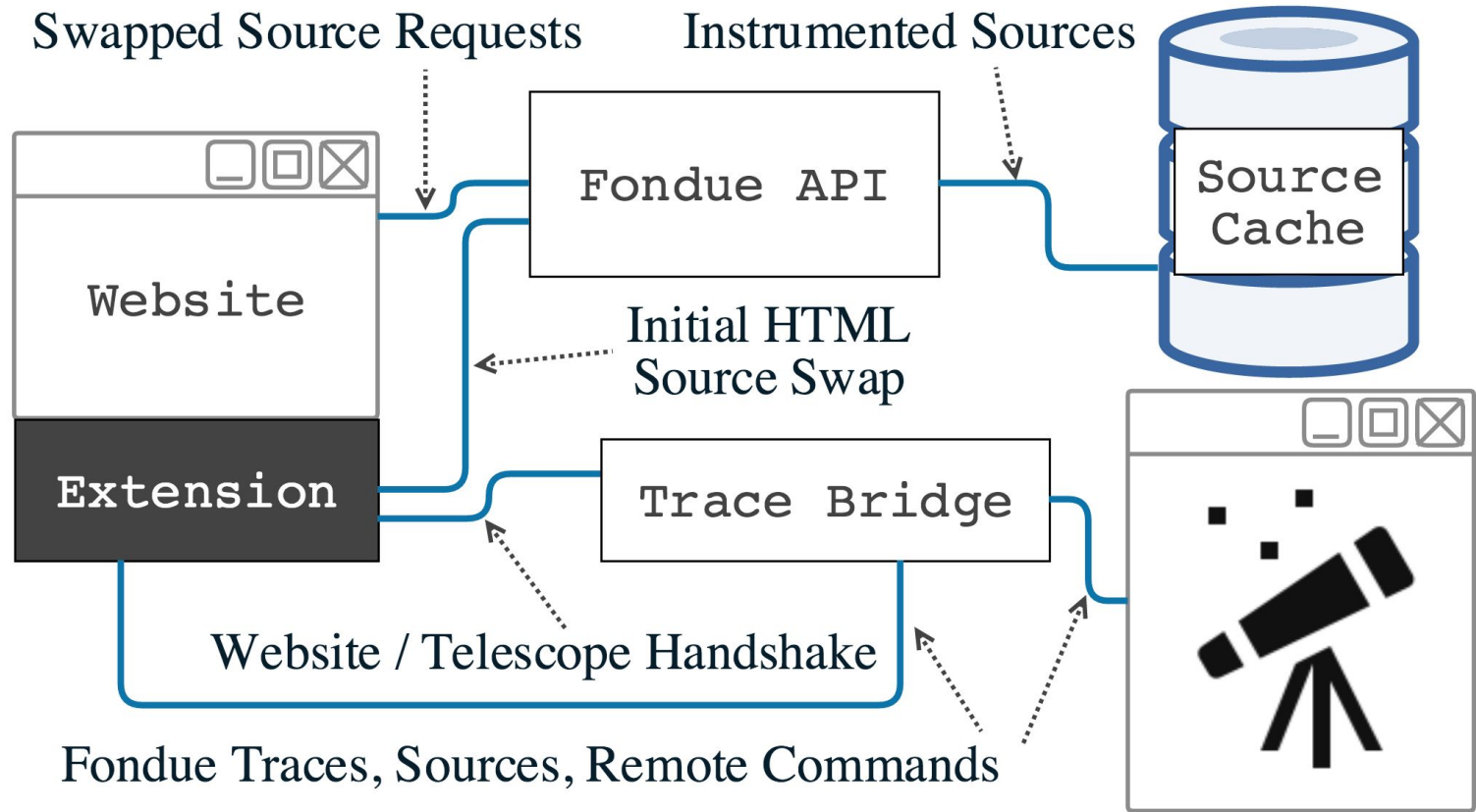
Artificial State Restoration

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



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 

