JavaScript Errors in the Wild: An Empirical Study

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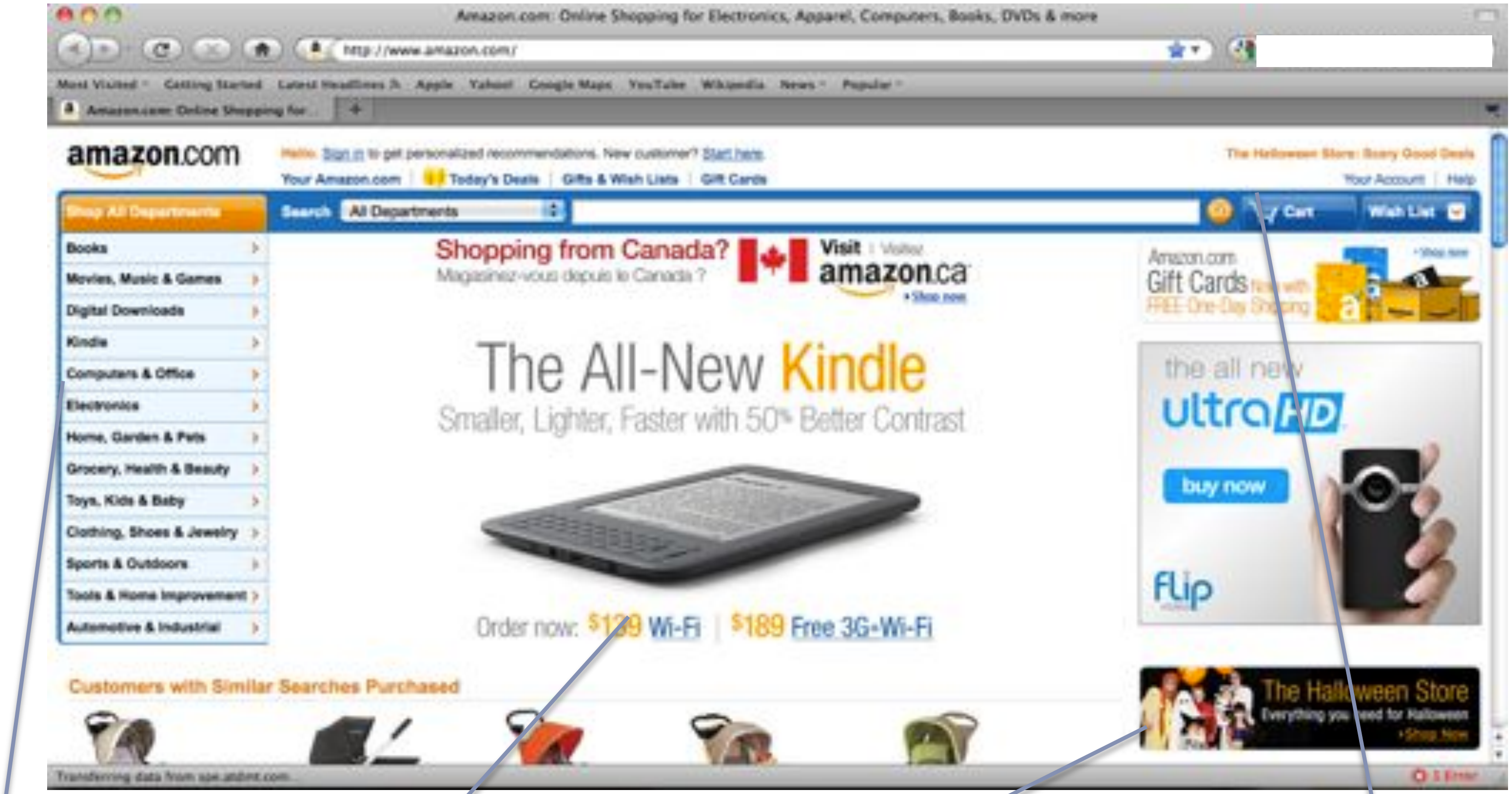
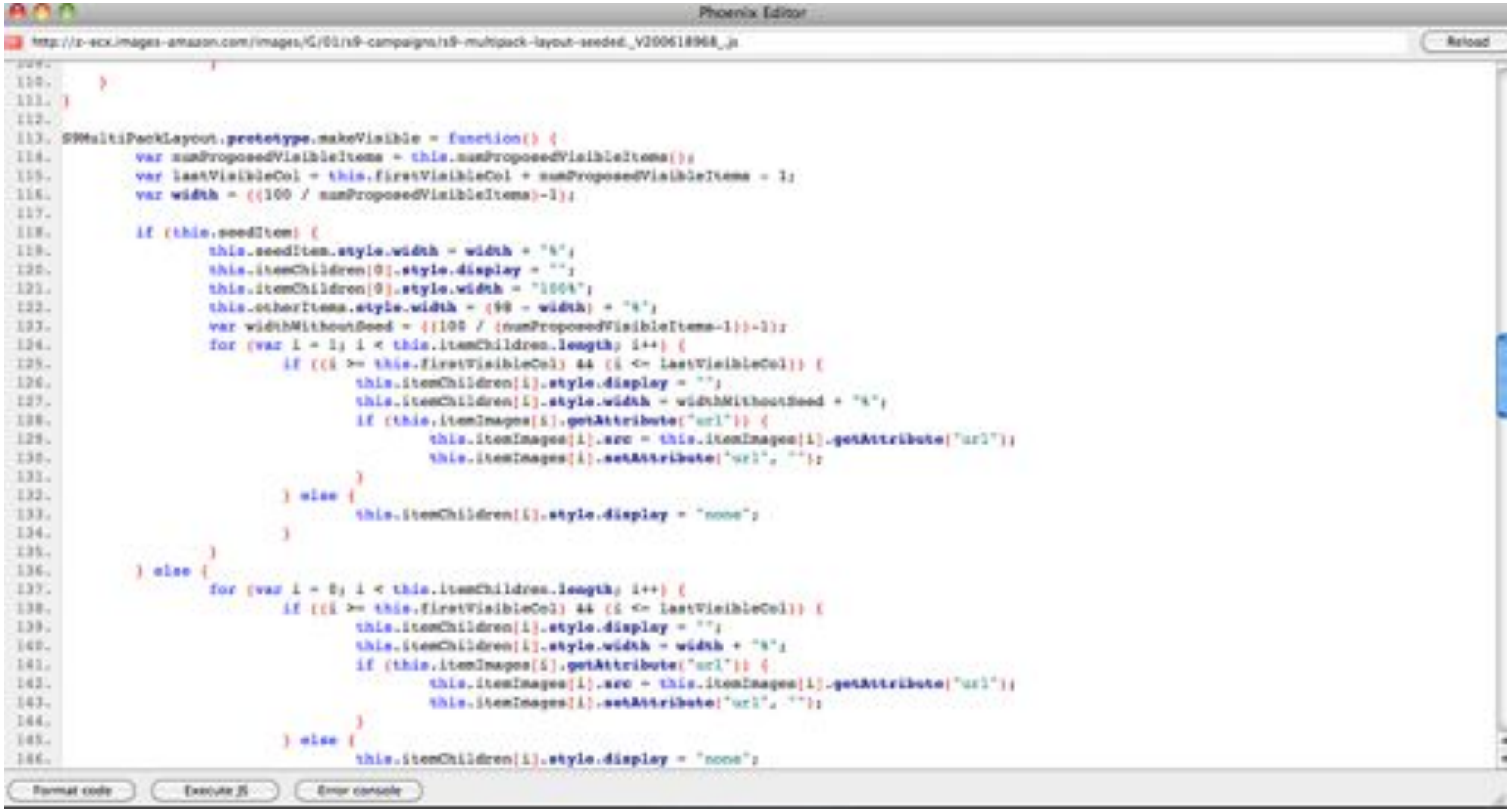
Web 2.0 Application: Amazon.com



Third

Web 2.0 applications allow rich UI functionality within a single web page

Web 2.0 Application: JavaScript


Phoenix Editor
http://z-ecx.images-amazon.com/images/G/01/s9-campaigns/s9-multipack-layout-seeded._V200618968_.js
Reload

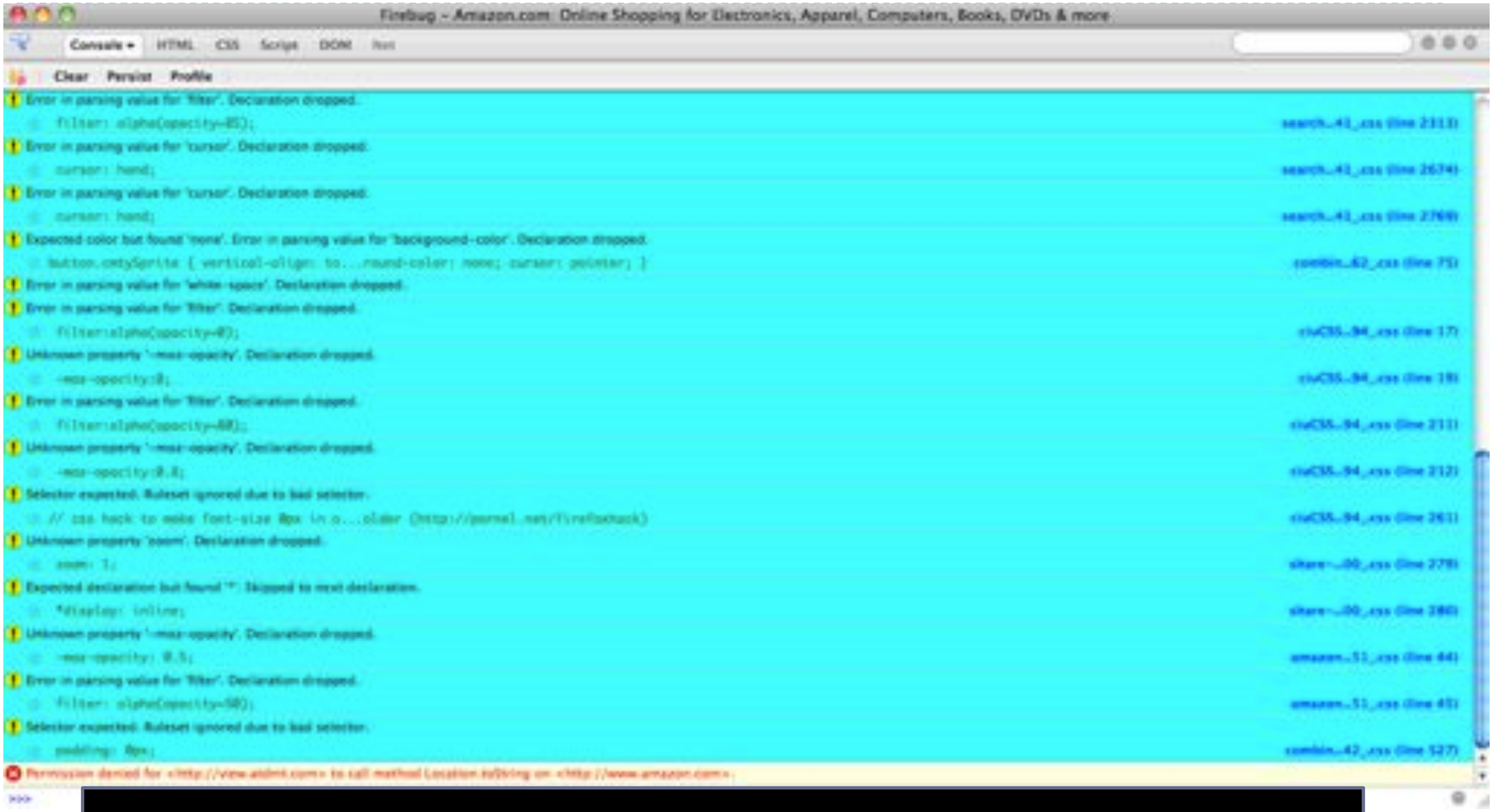
```
                }
        }
}

S9MultiPackLayout.prototype.makeVisible = function() {
        var numProposedVisibleItems = this.numProposedVisibleItems();
        var lastVisibleCol = this.firstVisibleCol + numProposedVisibleItems - 1;
        var width = ((100 / numProposedVisibleItems)-1);

        if (this.seedItem) {
                this.seedItem.style.width = width + "%";
                this.itemChildren[0].style.display = "";
                this.itemChildren[0].style.width = "100%";
                this.otherItems.style.width = (98 - width) + "%";
                var widthWithoutSeed = ((100 / (numProposedVisibleItems-1))-1);
                for (var i = 1; i < this.itemChildren.length; i++) {
                        if ((i >= this.firstVisibleCol) && (i <= lastVisibleCol)) {
                                this.itemChildren[i].style.display = "";
                                this.itemChildren[i].style.width = widthWithoutSeed + "%";
                                if (this.itemImages[i].getAttribute("url")) {
                                        this.itemImages[i].src = this.itemImages[i].getAttribute("url");
                                        this.itemImages[i].setAttribute("url", "");
                                }
                        } else {
                                this.itemChildren[i].style.display = "none";
                        }
                }
        } else {
                for (var i = 0; i < this.itemChildren.length; i++) {
                        if ((i >= this.firstVisibleCol) && (i <= lastVisibleCol)) {
                                this.itemChildren[i].style.display = "";
                                this.itemChildren[i].style.width = width + "%";
                                if (this.itemImages[i].getAttribute("url")) {
                                        this.itemImages[i].src = this.itemImages[i].getAttribute("url");
                                        this.itemImages[i].setAttribute("url", "");
                                }
                        } else {
                                this.itemChildren[i].style.display = "none";
```

Significant amount of JavaScript code executing in the browser

Web 2.0 Application: Amazon.com


Firebug - Amazon.com: Online Shopping for Electronics, Apparel, Computers, Books, DVDs & more
Console ▾
HTML
CSS
Script
DOM
Net
Clear
Persist
Profile

```
Error in parsing value for 'filter'. Declaration dropped.
    filter: alpha(opacity=85);                                                      search...41_.css (line 2313)
Error in parsing value for 'cursor'. Declaration dropped.
    cursor: hand;                                                                   search...41_.css (line 2674)
Error in parsing value for 'cursor'. Declaration dropped.
    cursor: hand;                                                                   search...41_.css (line 2769)
Expected color but found 'none'. Error in parsing value for 'background-color'. Declaration dropped.
   button.cmtySprite { vertical-align: to...round-color: none; cursor: pointer; }    combin...62_.css (line 75)
Error in parsing value for 'white-space'. Declaration dropped.
Error in parsing value for 'filter'. Declaration dropped.
    filter:alpha(opacity=0);                                                        riuCSS...94_.css (line 17)
Unknown property '-moz-opacity'. Declaration dropped.
    -moz-opacity:0;                                                                 riuCSS...94_.css (line 19)
Error in parsing value for 'filter'. Declaration dropped.
    filter:alpha(opacity=80);                                                       riuCSS...94_.css (line 211)
Unknown property '-moz-opacity'. Declaration dropped.
    -moz-opacity:0.8;                                                               riuCSS...94_.css (line 212)
Selector expected. Ruleset ignored due to bad selector.
   // css hack to make font-size 8px in o...older (http://pornel.net/firefoxhack)    riuCSS...94_.css (line 261)
Unknown property 'zoom'. Declaration dropped.
    zoom: 1;                                                                        share-...00_.css (line 279)
Expected declaration but found '*'. Skipped to next declaration.
    *display: inline;                                                               share-...00_.css (line 280)
Unknown property '-moz-opacity'. Declaration dropped.
    -moz-opacity: 0.5;                                                              amazon...51_.css (line 44)
Error in parsing value for 'filter'. Declaration dropped.
    filter: alpha(opacity=50);                                                      amazon...51_.css (line 45)
Selector expected. Ruleset ignored due to bad selector.
    padding: 0px;                                                                   combin...42_.css (line 527)
Permission denied for <http://view.atdmt.com> to call method Location.toString on <http://www.amazon.com>.
>>>
```

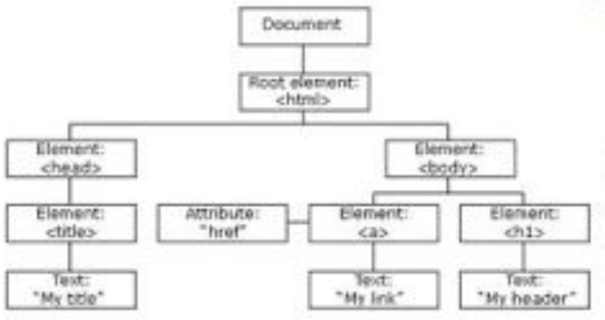
Web Apps experience errors, yet they continue to execute !

Web 2.0 Applications: Problems

Multiple Clients

Copyright © Ron Leishman * http://ToonClips.com/4944

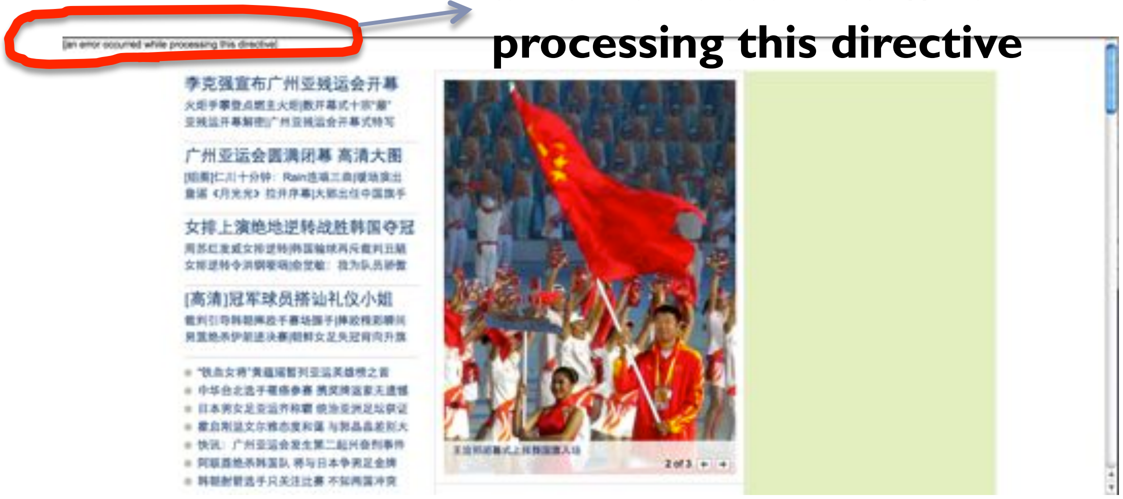
Loose semantics



DOM

an error occurred when processing this directive

- Snapshot of iFeng.com: Leading media website in China



[an error occurred while processing this directive]

李克强宣布广州亚残运会开幕
火炬手攀登点燃主火炬|数开幕式十宗"最"
亚残运开幕解密|广州亚残运会开幕式特写

广州亚运会圆满闭幕 高清大图
[组图]仁川十分钟：Rain连唱三曲|哑剧演出
童谣《月光光》拉开序幕|大郅出任中国旗手

女排上演绝地逆转战胜韩国夺冠
周苏红泪洒女排逆转|韩国输球再斥裁判丑陋
女排逆转令洪钢哑哨|俞觉敏：我为队员骄傲

[高清]冠军球员搭讪礼仪小姐
裁判引导韩朝换手套场握手|棒球韩国卫冕
朝鲜绝杀伊朗进决赛|朝鲜女足夺冠背向升旗

- "铁血女将"黄蕴瑶暂列亚运英雄榜之首
- 中华台北选手罹癌参赛 携奖牌返家天遗憾
- 日本男女足亚运齐称霸 彼治亚洲足坛获证
- 霍启刚谈文尔雅恋爱和谐 与郭晶晶差别大
- 快讯：广州亚运会发生第二起兴奋剂事件
- 阿联酋绝杀韩国队 将与日本争男足金牌
- 韩朝射箭选手只关注比赛 不知两国冲突

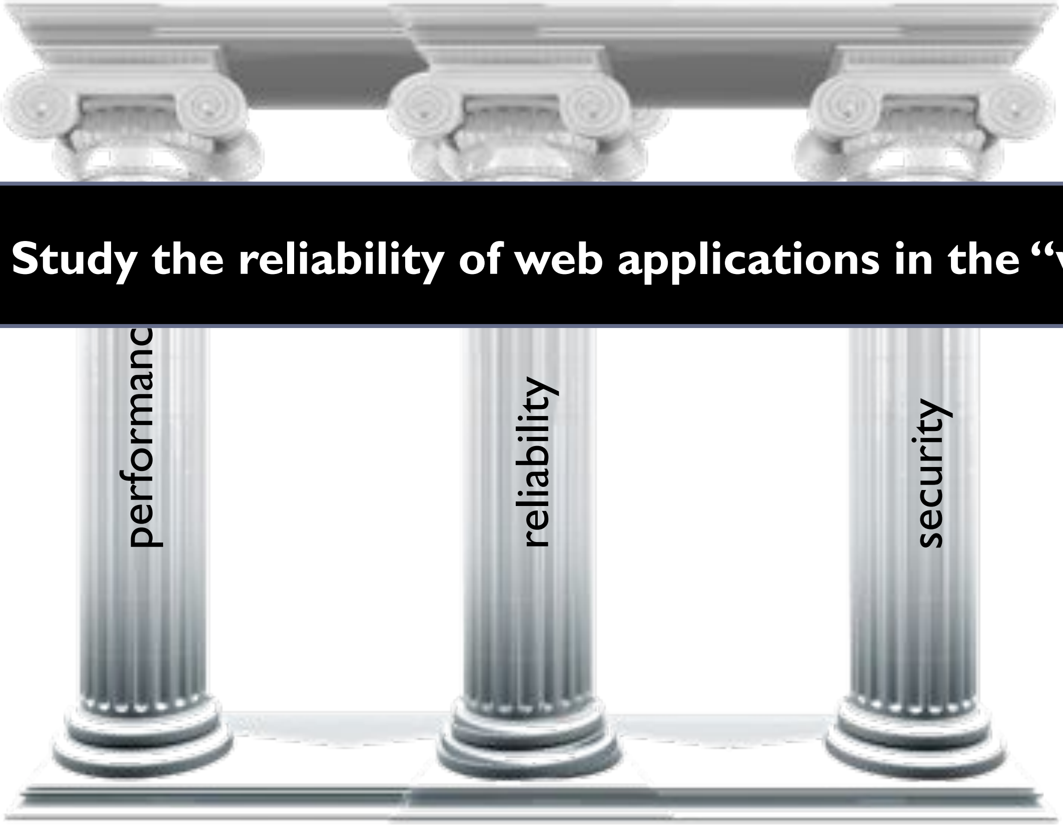
Studies of JavaScript Web Applications

Performance and parallelism:
JSMeter [Ratanaworabhan-2010], [Richards-2009], [Fortuna-2011]

Reliability

?

Security and Privacy:
[Yue-2009], Gatekeeper [Guarnieri-2009], [Jang-2010]



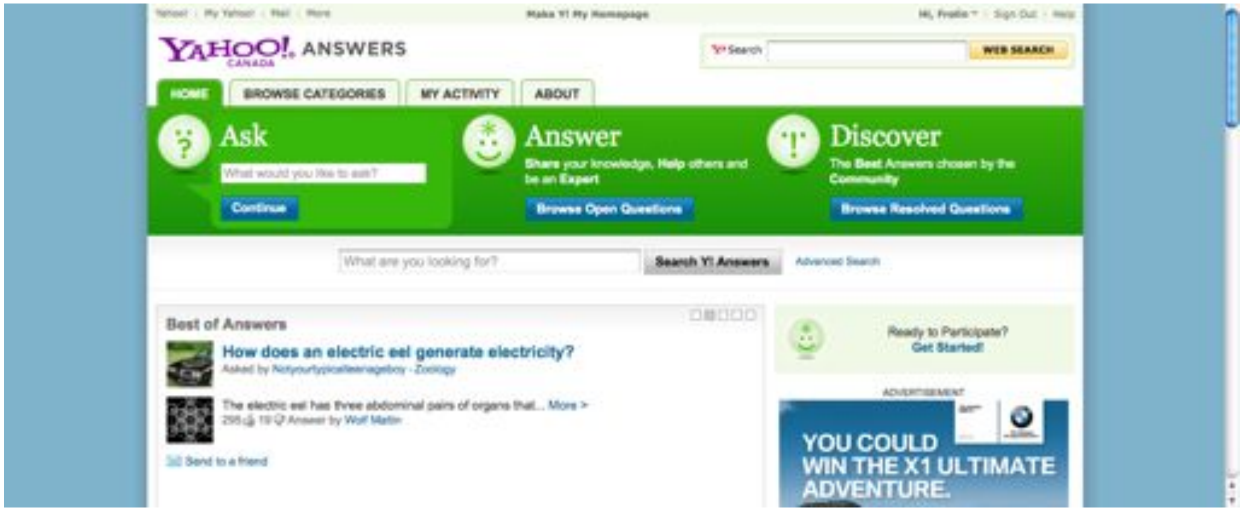
Goal: Study the reliability of web applications in the "wild"

Contributions

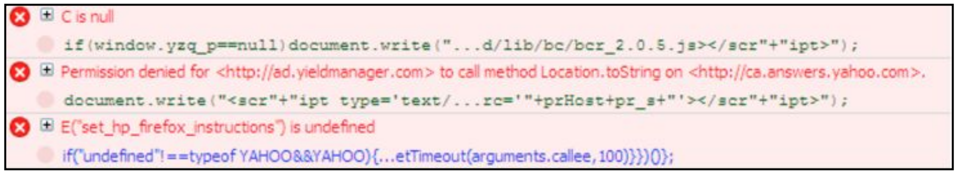
- Devised methodology to collect and categorize JS error messages from web applications
- Characterized JS error messages that appeared in 50 top websites
- Analysis of the implications of results
  - Find possible ways to write more reliable JS code
  - Improve the quality of JS testing
  - Highlight JS characteristics that should be captured by static analysis tools

JavaScript Error Messages

- Any exception thrown by JS code is logged to JS console



YAHOO! ANSWERS
HOME
BROWSE CATEGORIES
MY ACTIVITY
ABOUT
Ask
Continue
Answer
Share your knowledge. Help others and be an Expert
Browse Open Questions
Discover
The Best Answers chosen by the Community
Browse Resolved Questions
Search Y! Answers
Best of Answers
How does an electric eel generate electricity?
Ready to Participate?
Get Started!
YOU COULD WIN THE X1 ULTIMATE ADVENTURE.



```
C is null
if(window.yzq_p==null)document.write("...d/lib/bc/bcr_2.0.5.js></scr"+"ipt>");
Permission denied for <http://ad.yieldmanager.com> to call method Location.toString on <http://ca.answers.yahoo.com>.
document.write("<scr"+"ipt type='text/...rc='"+prHost+pr_s+"'></scr"+"ipt>");
E("set_hp_firefox_instructions") is undefined
if("undefined"!==typeof YAHOO&&YAHOO){...etTimeout(arguments.callee,100)}})();
```

Multiple exceptions

Error Messages: Pros and Cons

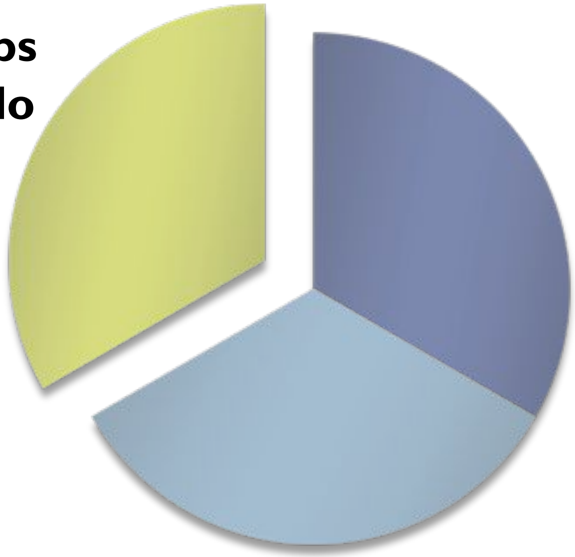
- Pros
  - No false positives unlike static analysis
  - Challenging to analyze JavaScript statically
  - Capture interactions with the DOM
- Cons
  - Error message may be benign
    - Still an indication of potential problem
  - May be incomplete
    - Publicly available JS bug reports very limited

Steps to Collect Error Messages

- Chose 50 web applications from the Alexa top 100
- Created test suites for normal interactions in Selenium
- Capture JavaScript Errors printed to Firebug console

Research Questions

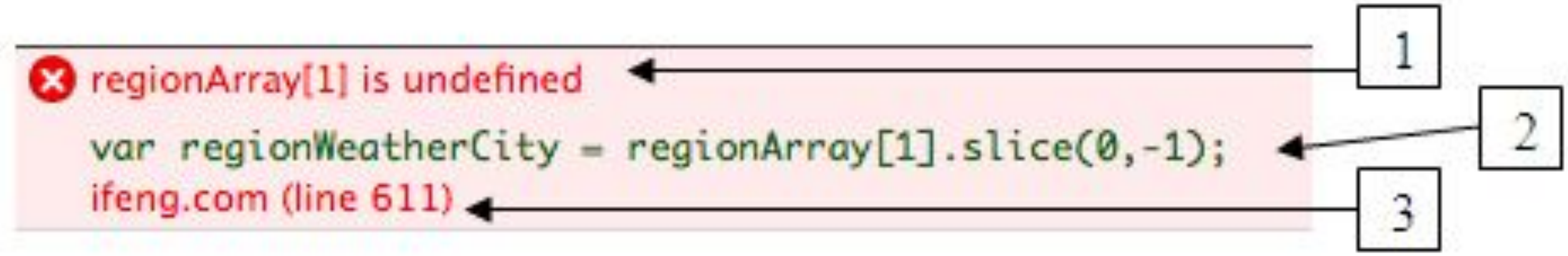
Do errors occur in web apps and if so, what categories do they fall in ?



How do errors correlate with static and dynamic characteristics of the app?

How do errors vary by speed of testing ? Are they all deterministic ?

Firebug Error Messages



regionArray[1] is undefined

```
var regionWeatherCity = regionArray[1].slice(0,-1);
```

ifeng.com (line 611)

1. Description of error message

2. Line of code corresponding to error

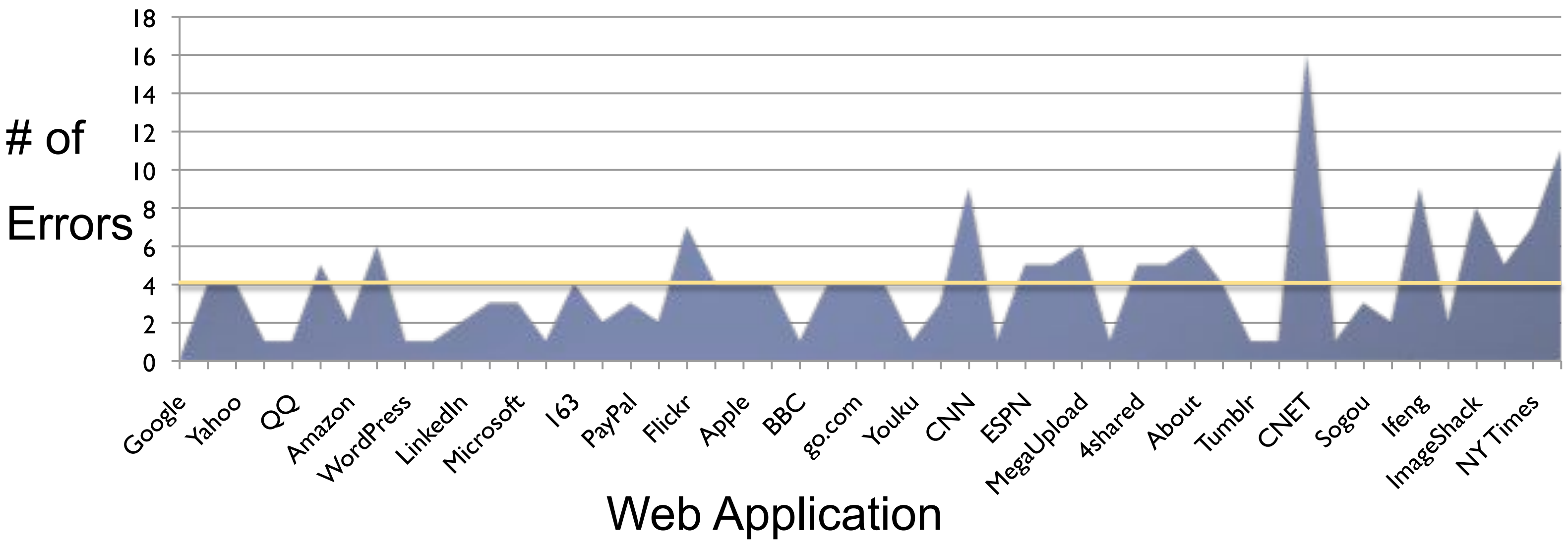
3. File name and line number

Two errors are different if any attribute is different

Errors and their classification: Results

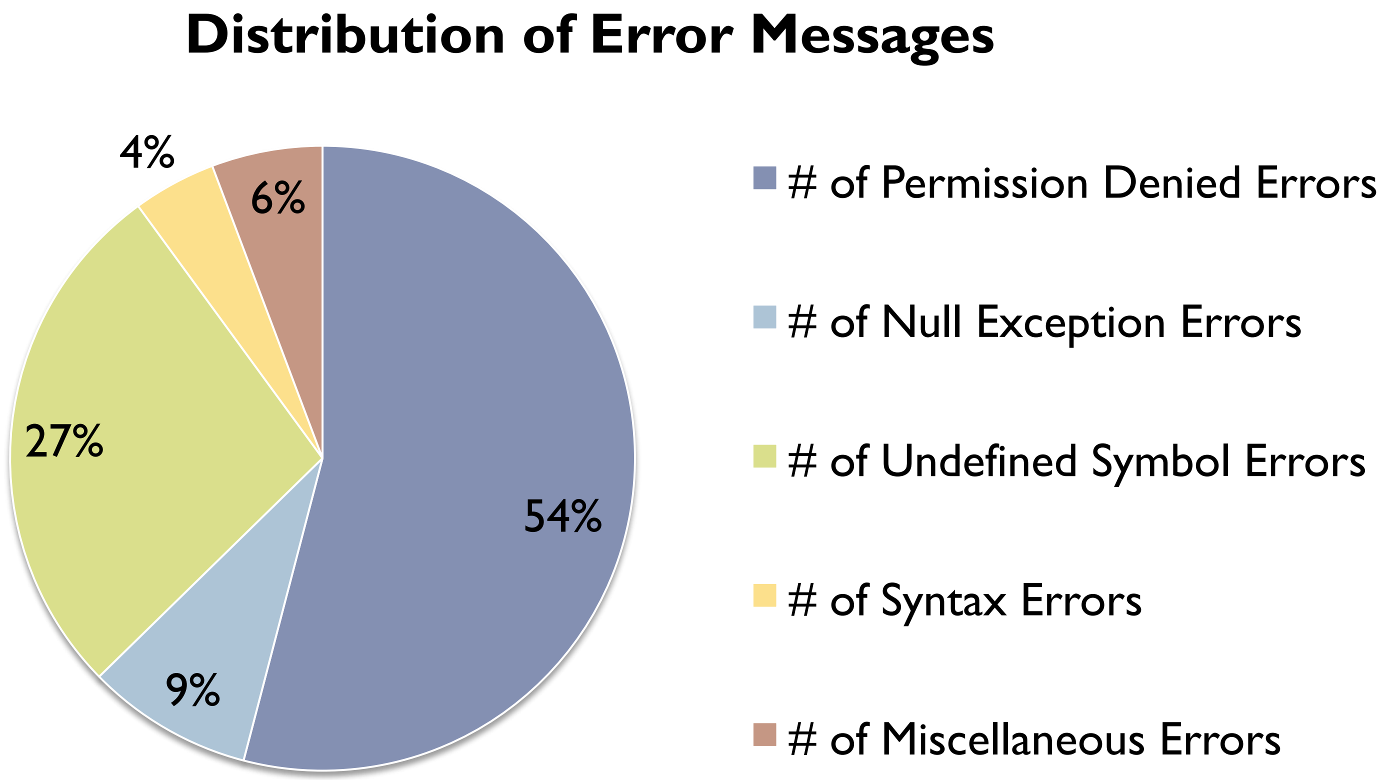
- **Average of 4 distinct error messages for each app**
  - **Standard dev**: 3
  - **Max:** 16 (Cnet)
  - **Min:** 0 (Google)

Total Distinct Errors

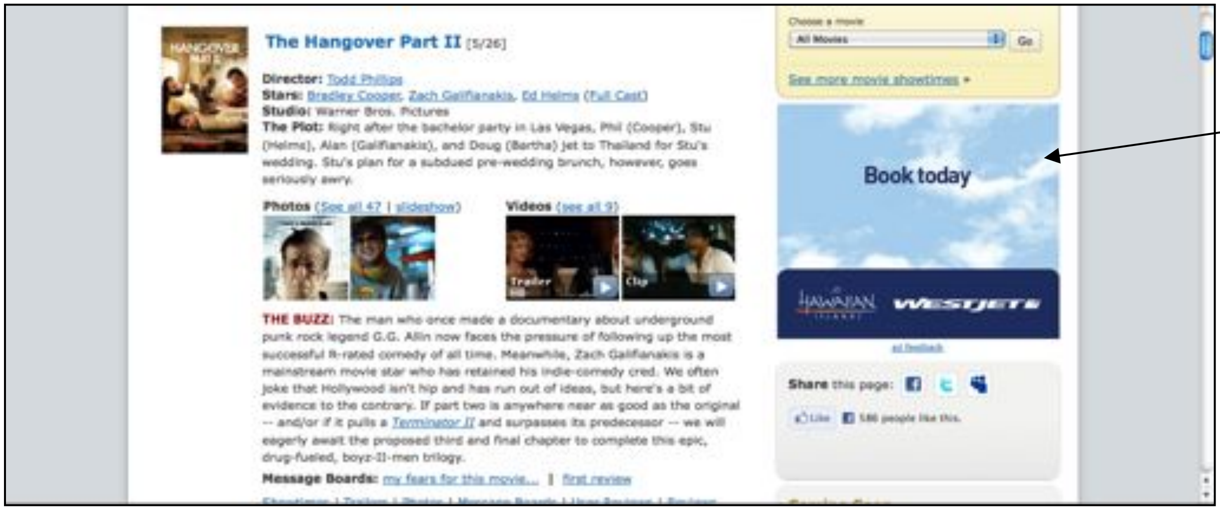


Errors and their classification: Results (2)

- 94 % of errors fall into four predominant categories



Permission Denied Example



The Hangover Part II [5/26]

Director: Todd Phillips
Stars: Bradley Cooper, Zach Galifianakis, Ed Helms (Full Cast)
Studio: Warner Bros. Pictures
The Plot: Right after the bachelor party in Las Vegas, Phil (Cooper), Stu (Helms), Alan (Galifianakis), and Doug (Bartha) jet to Thailand for Stu's wedding. Stu's plan for a subdued pre-wedding brunch, however, goes seriously awry.

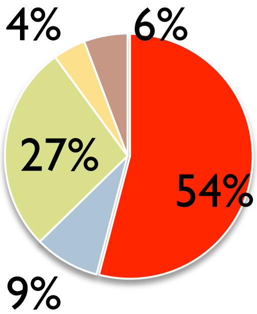
Photos (See all 47 | slideshow) **Videos** (see all 9)

THE BUZZ: The man who once made a documentary about underground punk rock legend G.G. Allin now faces the pressure of following up the most successful R-rated comedy of all time. Meanwhile, Zach Galifianakis is a mainstream movie star who has retained his indie-comedy cred. We often joke that Hollywood isn't hip and has run out of ideas, but here's a bit of evidence to the contrary. If part two is anywhere near as good as the original -- and/or if it pulls a Terminator II and surpasses its predecessor -- we will eagerly await the proposed third and final chapter to complete this epic, drug-fueled, boyz-II-men trilogy.

Message Boards: my fears for this movie... | first review

Taken from imdb.com

advertisement



•**Error Message**: Permission denied for http://view.atdmt.com to call method Location.toString on http://www.imdb.com

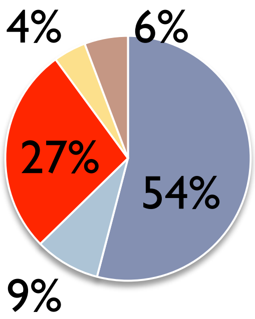
•**Explanation:** Triggered by appearance of advertisement. Leads to SOP violation.

Bottom Line: JS errors may appear as a result of code written by others

Undefined Symbol Example

EDITION: U.S. | INTERNATIONAL | MÉXICO
CNN Entertainment
SEARCH
Home Video NewsPulse U.S. World Politics Justice Entertainment Tech Health Living Travel Opinion iReport Money Sports
THE MARQUEE BLOG
main Charlie Sheen Celebrities TV recaps Music Movies
DETAILS
Ryan Reynolds talks ScarJo split
Cheryl Cole dropped from 'X Factor' already?
Nice guy takes the win again on 'Idol'
Throwback: 'Wonka' star on anniversary
Oprah Winfrey says farewell
Sprint
Nexus S 4G
The first phone

Taken from cnn.com



- **Error Message**: cnn_onMemFBInit() is undefined

  // this probably isn't needed anymore

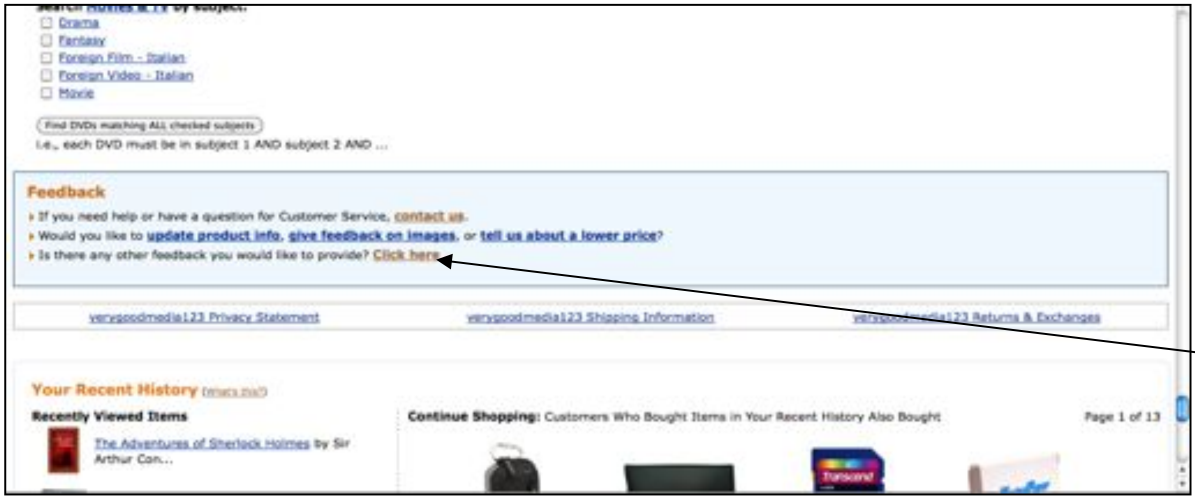
  ```
  if (CNN_ISMemInit && CNN_IsFBInit) cnn_onMemFBInit();
  ```

- **Explanation**: Both CNN_IsMemInit and CNN_IsFBInit set to true

- **Bottom Line: JS code is difficult to maintain**

Null Exception Example

Taken from amazon.com



Search Movies & TV by subject:

- ☐ Drama
- ☐ Fantasy
- ☐ Foreign Film - Italian
- ☐ Foreign Video - Italian
- ☐ Movie

Find DVDs matching ALL checked subjects

i.e., each DVD must be in subject 1 AND subject 2 AND ...

Feedback

- If you need help or have a question for Customer Service, contact us.
- Would you like to update product info, give feedback on images, or tell us about a lower price?
- Is there any other feedback you would like to provide? Click here

verygoodmedia123 Privacy Statement | verygoodmedia123 Shipping Information | verygoodmedia123 Returns & Exchanges

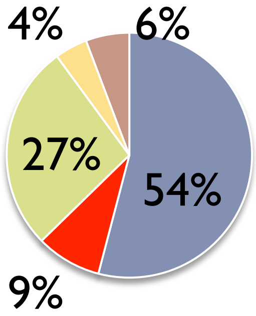
Your Recent History (what's this?)

Recently Viewed Items

The Adventures of Sherlock Holmes by Sir Arthur Con...

Continue Shopping: Customers Who Bought Items in Your Recent History Also Bought

Page 1 of 13



Causes error on click

•**Error Message**: document.getElementById("inappDiv") is null

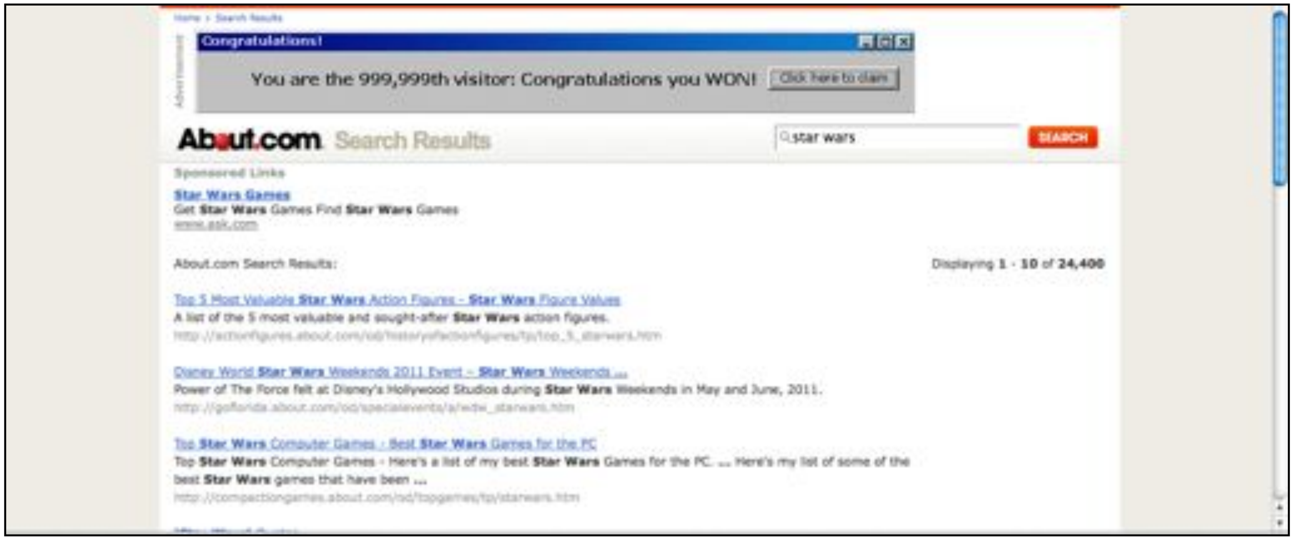
```
    document.getElementById("inappDiv").style.display = 'none';
```

•**Explanation:** inappDiv was only defined for users who are logged in

•**Bottom Line: JS code may depend on the DOM**

Syntax Error Example

Taken from about.com



You are the 999,999th visitor: Congratulations you WON!

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About.com Search Results:

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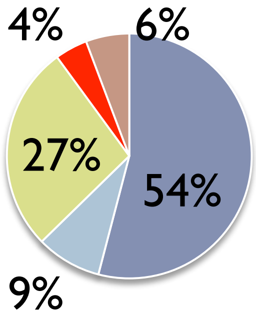
Top 5 Most Valuable **Star Wars** Action Figures - **Star Wars** Figure Values
A list of the 5 most valuable and sought-after **Star Wars** action figures.
http://actionfigures.about.com/od/historyofactionfigures/tp/top_5_starwars.htm

Disney World **Star Wars** Weekends 2011 Event - **Star Wars** Weekends ...
Power of The Force felt at Disney's Hollywood Studios during **Star Wars** Weekends in May and June, 2011.
http://goflorida.about.com/od/specialevents/a/wdw_starwars.htm

Top **Star Wars** Computer Games - Best **Star Wars** Games for the PC
Top **Star Wars** Computer Games - Here's a list of my best **Star Wars** Games for the PC. ... Here's my list of some of the best **Star Wars** games that have been ...
http://compactiongames.about.com/od/topgames/tp/starwars.htm



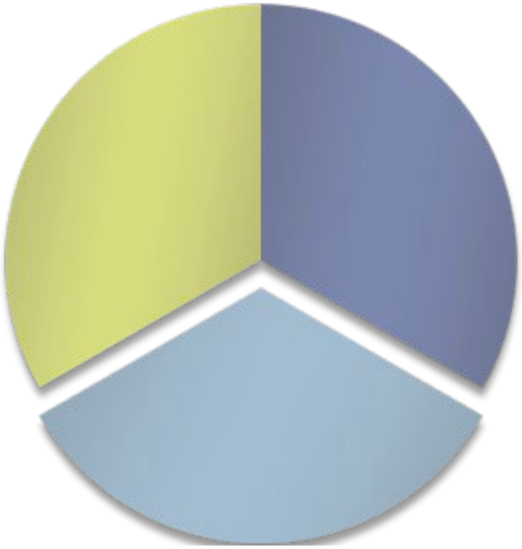
- **Error Message**: unterminated string literal

```
zGPU = ‘http://movies.about.com/od/onlinemovies
Movies_Available_on_the_Internet.html’”
```

- **Bottom Line: JS code is sometimes not well-tested**

Research Questions

Do errors occur in web apps and if so, what categories do they fall in ?

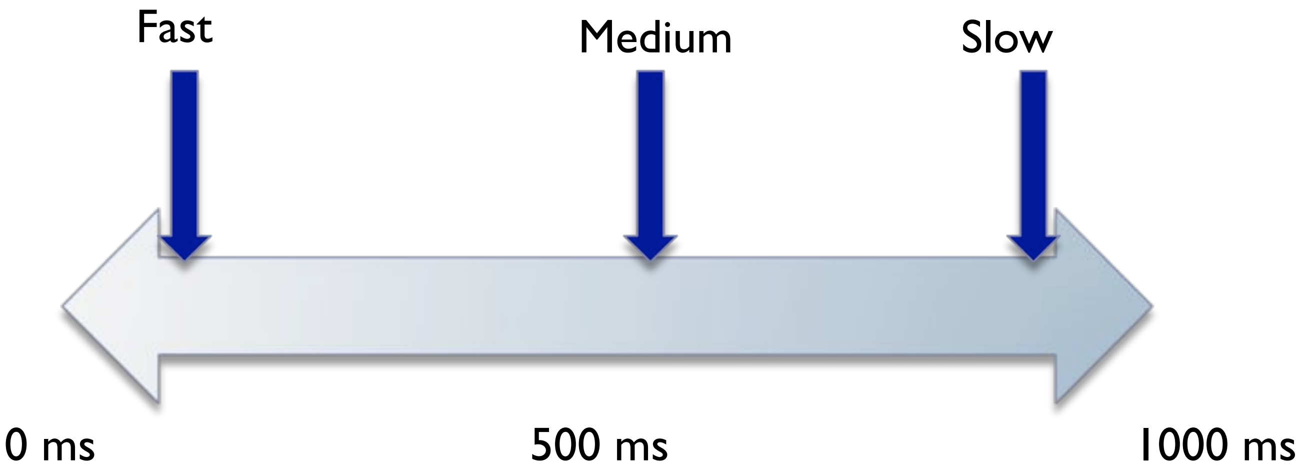


How do errors correlate with static and dynamic characteristics of the app?

How do errors vary by speed of testing ? Are they all deterministic ?

Effect of Testing Speed: Method

- Varied testing speed for replaying events
- Performed three executions in each testing speed



Effect of Testing Speed: Results

Error Message (shortened)	F1	F2	F3	M1	M2	M3	S1	S2	S3
Permission Denied for view.atdmt.com to call <fname> on marquee.blogs.cnn.com	4	4	4	1	3	3	2	2	3
targetWindow.cnnad showAd is not a function	0	2	5	0	0	0	0	0	0
window.parent.CSIManager is un-defined	0	0	0	0	0	0	1	1	0

Non-Deterministic Error: Example

- Tumblr page

change_promo(promo) → expects *promo* to be within range 1-4

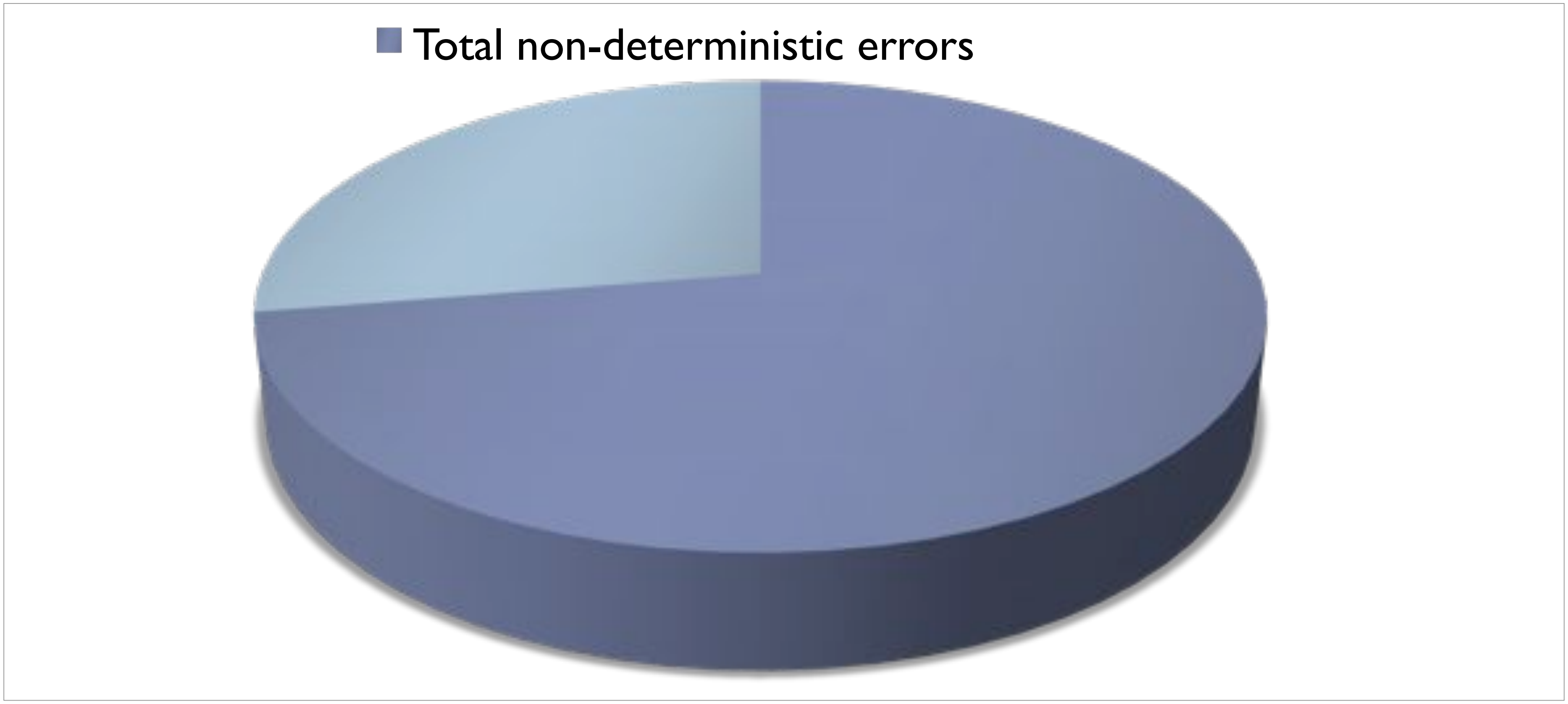
setTimeout(change_promo, 5000) → no parameter specified, so random value for *promo*

No exception if *promo* within range

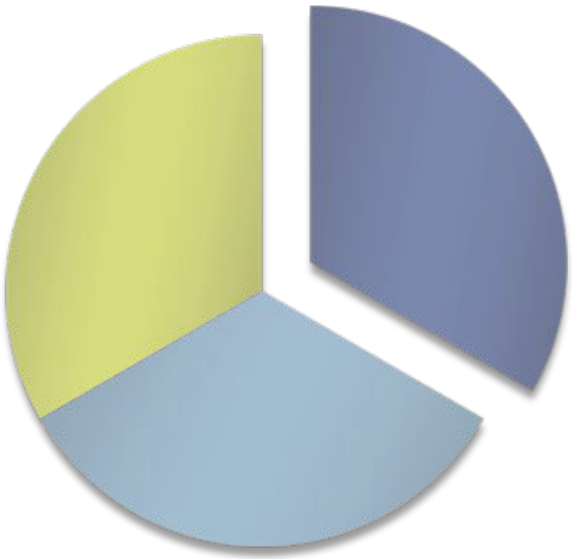
Exception if *promo* out of range

Effect of Testing Speed: Non-Determinism

- More than 70% of distinct errors are non-deterministic



Research Questions



Do errors occur in web apps and if so, what categories do they fall in ?

How do errors correlate with static and dynamic characteristics of the app?

How do errors vary by speed of testing ? Are they all deterministic ?

Static/Dynamic Correlations: Summary

Static Characteristics

Measured using Phoenix & Firebug plugins

- Alexa Rank
- Bytes of JavaScript code
- Number of domains
- Domains containing JS

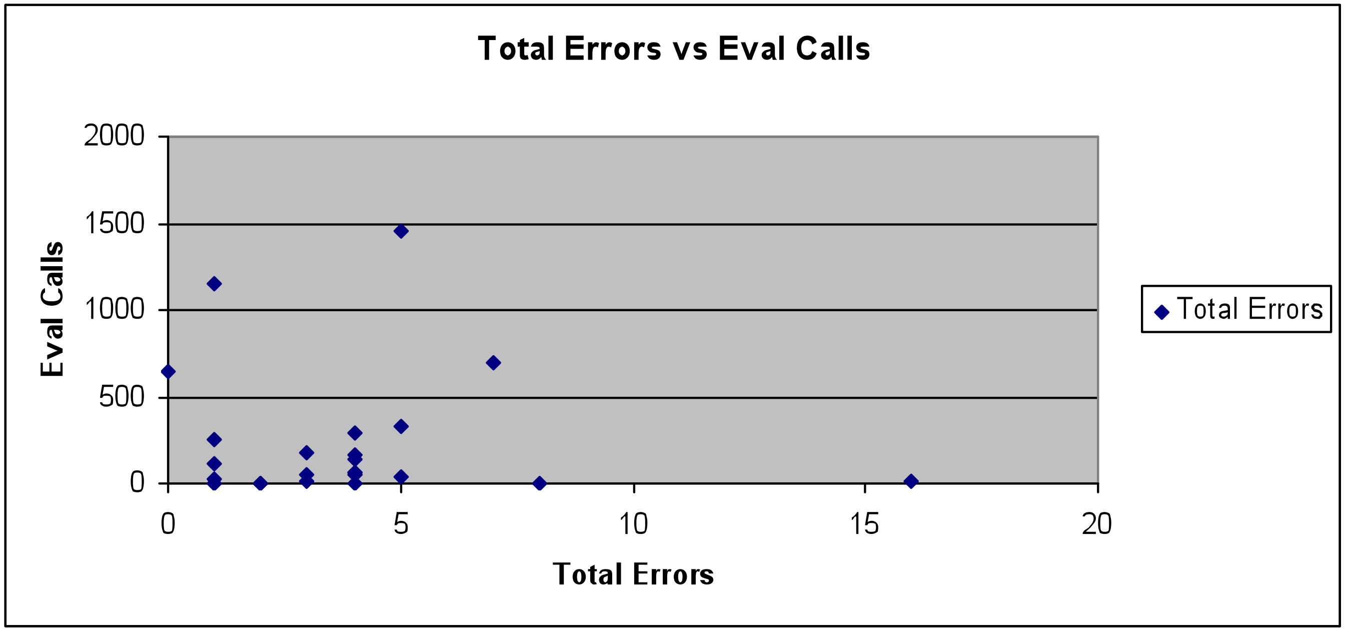
Dynamic Characteristics

From Richards et al. [PLDI – 2010]

- Number of called functions
- Number of eval calls
- Properties deleted
- Object inheritance overridings

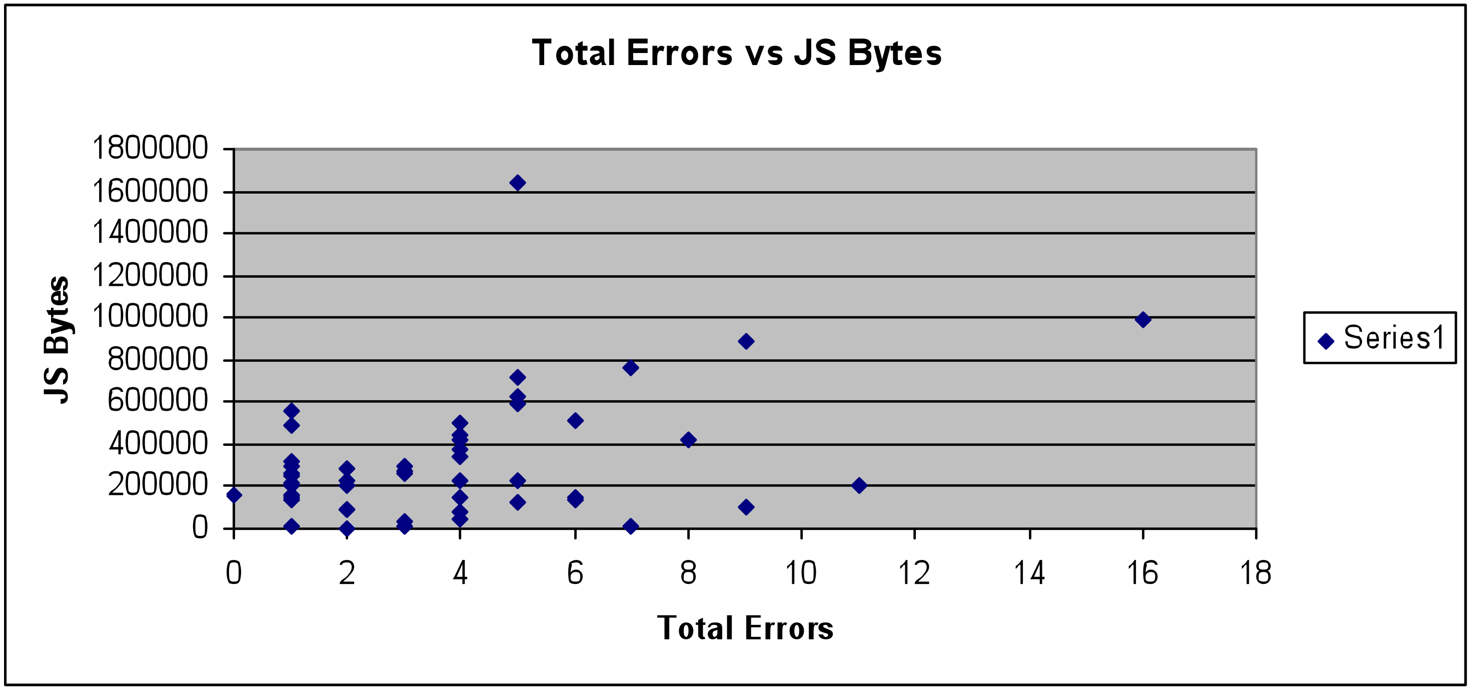
Dynamic Correlations: Eval Calls

- Low correlation
  - Compare: eval calls
    - correlate well with security



Static Correlations: JS Code Size

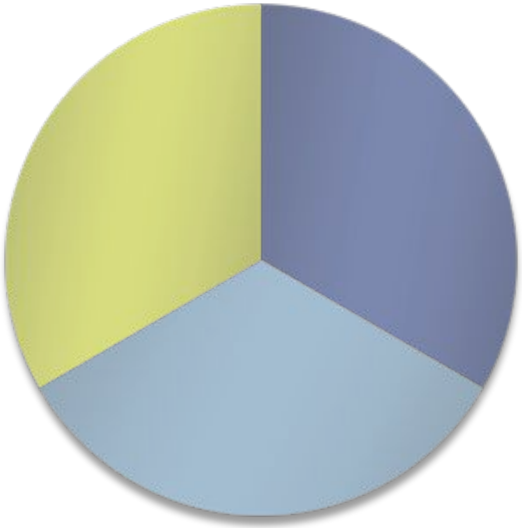
- Low correlation
  - JS reliability not tied very closely to code size



Research Questions: Answers

Do errors occur in web apps and what categories do they fall in ?

Average of four errors in each app. Errors fall into four well-defined categories



Do errors correlate with static and dynamic characteristics of the app ?

Correlated with no. of domains, # of domains with JS, Alexa rank, but not with eval calls and code size

How do errors vary by speed of testing ? Are they nondeterministic?

Errors vary by speed of testing. Majority of errors are non-deterministic

Implications of Results

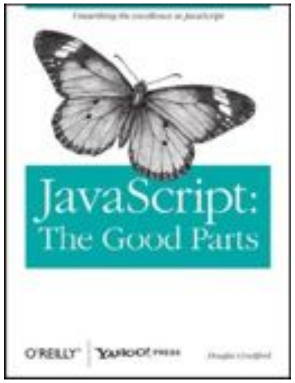
- **Programmers**
  - Need to make code robust against other code/scripts
  - Make sure interactions with DOM are checked
- **Testers**
  - Perform integration testing to see effects of ads
  - Need to test at multiple testing speeds, multiple times
- **Static analysis tool developers**
  - Target most common classes of errors
  - Need to model the DOM in the analysis

Conclusion and Future Work

- JavaScript code in production web apps → buggy!
- Study exposes JS reliability problems and analyzes errors
  - Data publicly available
    - http://ece.ubc.ca/~frolino/project/jser
- Future work
  - Better understanding of causes (root causes and correlations)
  - Currently: Fault localization

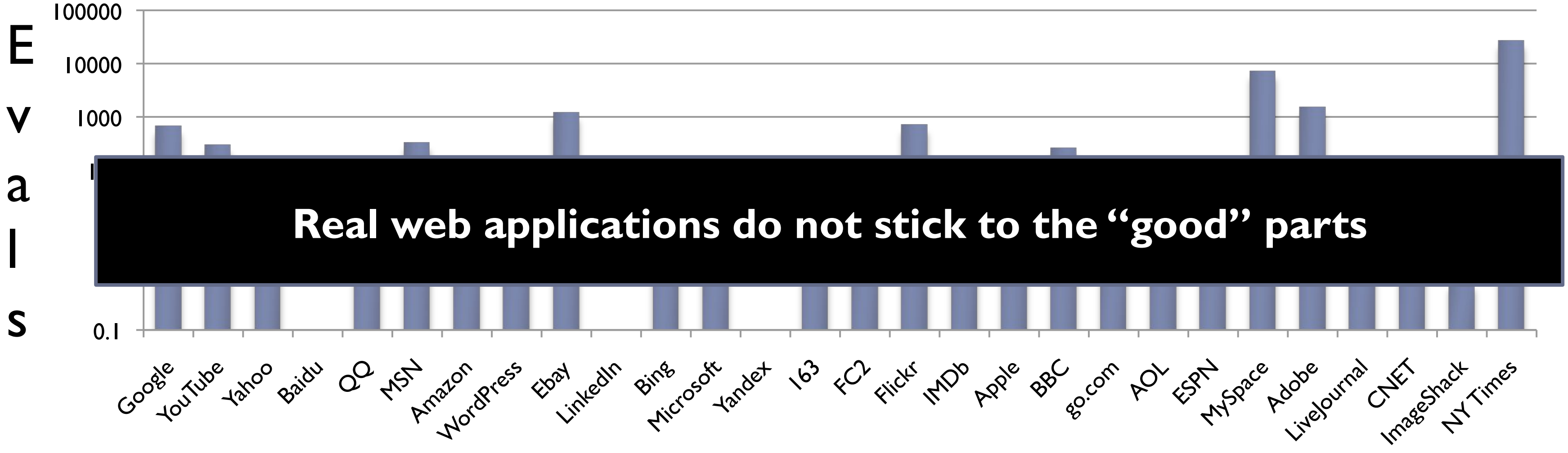
Backup Slides

JavaScript: “Good” or “Evil” ?



Versus

Eval Calls (from Richards et al. [PLDI-2010])



Real web applications do not stick to the “good” parts