ConScript

Specifying and Enforcing Fine-Grained Security Policies for JavaScript in the Browser

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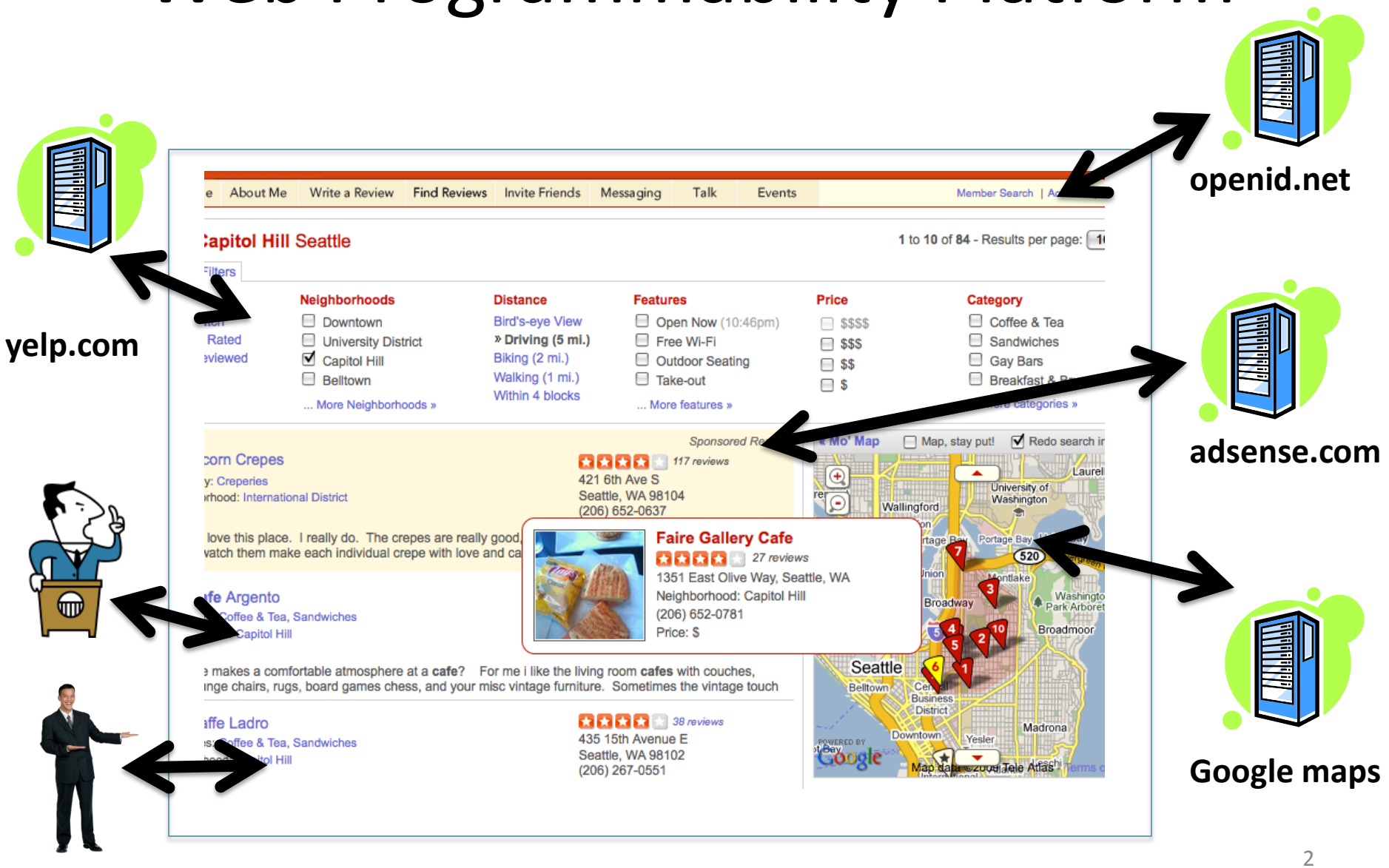
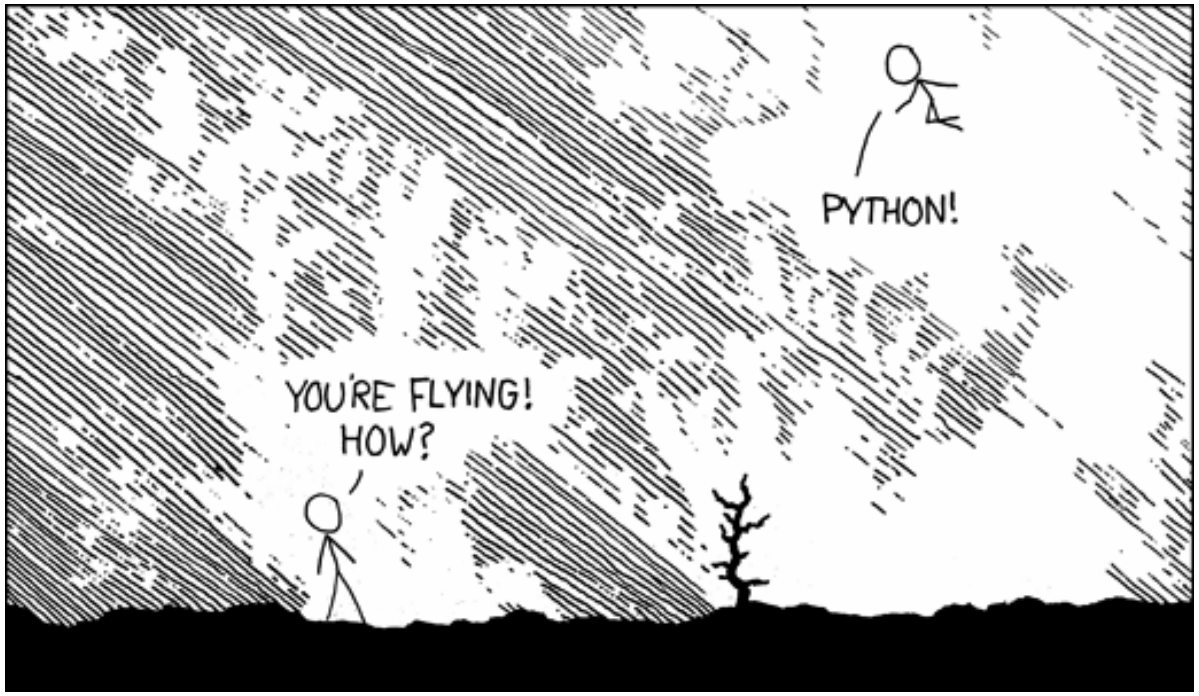
Web Programmability Platform



Rich Internet Applications are Dynamic



Yelp.com:

main.js

… jQuery.js

… adSense.js

… GoogleMaps.js

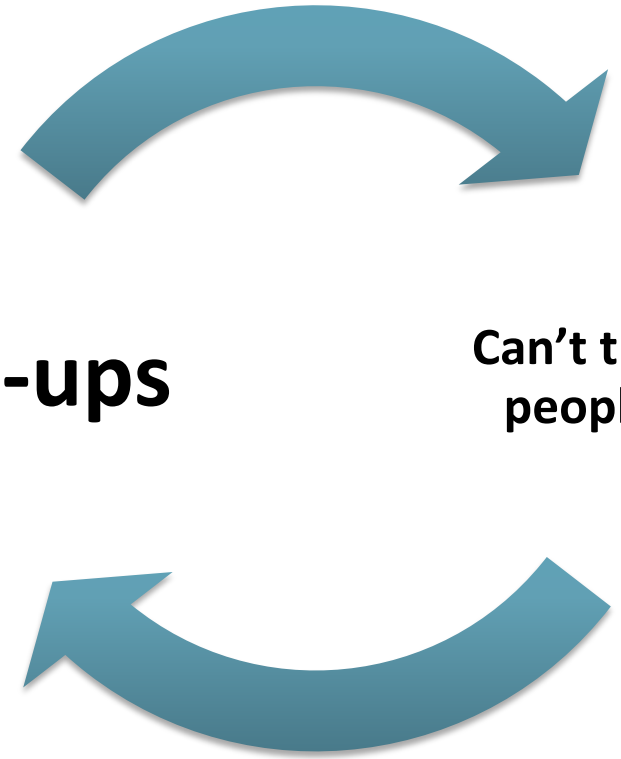
… OpenID_API.js

flexible runtime composition

… but little control.

Towards Safe Programmability for the Web

Mash-ups



Can't trust other people's code

Goals and Contributions

control loading and use of scripts	• protect benign users • by giving control to hosting site • ConScript approach: aspects for security
express many policies *safely*	• 17 hand-written policies • correct policies are hard to write • proposed type system to catch common attacks • implemented 2 policy generators
browser support	• built into IE 8 JavaScript interpreter • runtime and space overheads under 1% (vs. 30-550%) • smaller trusted computing base (TCB)

approach
protect benign users by giving control
to the hosting site
: aspects for security

ConScript

- Approach
  - protect benign Web users
  - give control to the hosting site
- How
  - Browser-supported aspects for security

Contributions of ConScript

A case for aspects in browser

- protect benign users by giving control to hosting site
- ConScript approach: aspects for security
- built into IE 8 JavaScript interpreter

Correctness checking

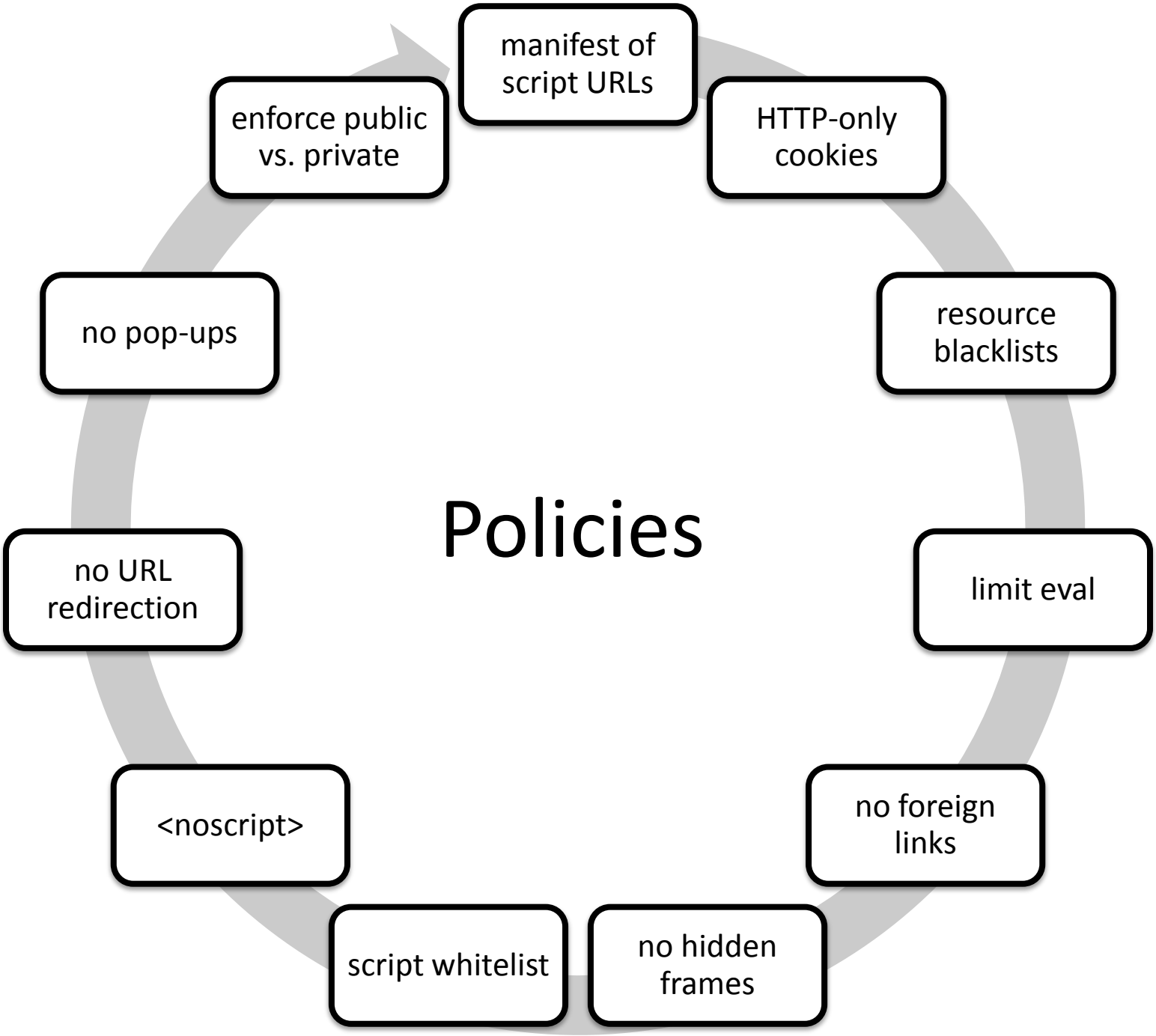
- Policies are easy to get wrong
- Type system to ensure policy correctness

Expressiveness

- 17 hand-written policies
- Comprehensive catalog of policies from literature and practice
- implemented 2 policy generators

Evaluation

- Tested on real apps: Google Maps, Live Desktop, etc.
- runtime and space overheads under 1% (vs. 30-550%)
- smaller trusted computing base (TCB)


Policies
manifest of script URLs
HTTP-only cookies
resource blacklists
limit eval
no foreign links
no hidden frames
script whitelist
<noscript>
no URL redirection
no pop-ups
enforce public vs. private

ConScript aspects

implementing aspects in IE8

checking ConScript policies

generating ConScript policies

performance

No **postMessage**: A Simple Policy?

Wrapping: [[Caja, DoCoMo, AOJS, lightweightjs, Web Sandbox, …]]

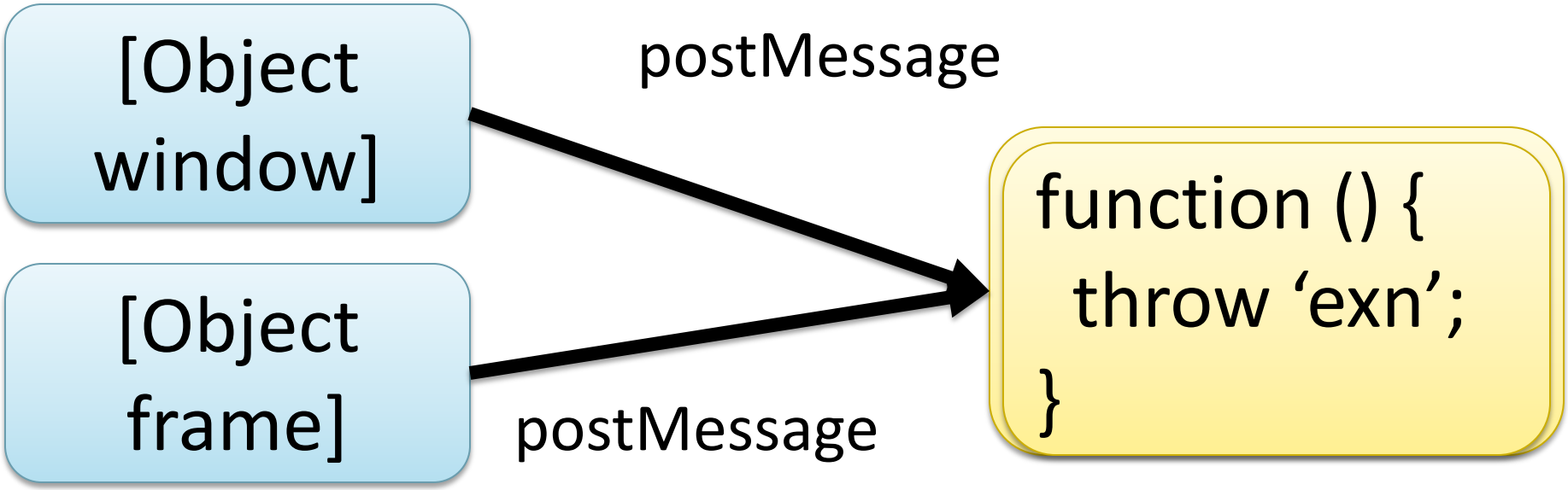
```
window.postMessage = function () {};
frame1.postMessage("msg", "evil.com")
```

Aspects: [[AspectJ]]

```
void around(String msg, String uri) :
call DOM.postMessage(String m, String u)
{   /* do nothing instead of call */   }
```

… no classes in JavaScript / DOM …

Specifying Calls using References




```
around(window.postMessage,
       function () { throw 'exn'; });
```

ConScript Interface

1. Functions

   DOM: `aroundExt(postMessage, function (pm2, m, uri) { … });`

   JS: `aroundNat(eval, function (eval, str) { … });`

   User-defined: `aroundFnc(foo, function (foo2, arg1) { … });`

2. Script introduction

   <script>: `aroundScr(function (src) { return src + ';' + pol;});`

   inline: `aroundInl(function (src) { return src + ';' + pol;});`

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Problem: Implementation?

Source Rewriting [[aojs, docomo, caja, sandbox, fbjs]]

```
function f () { … }
```

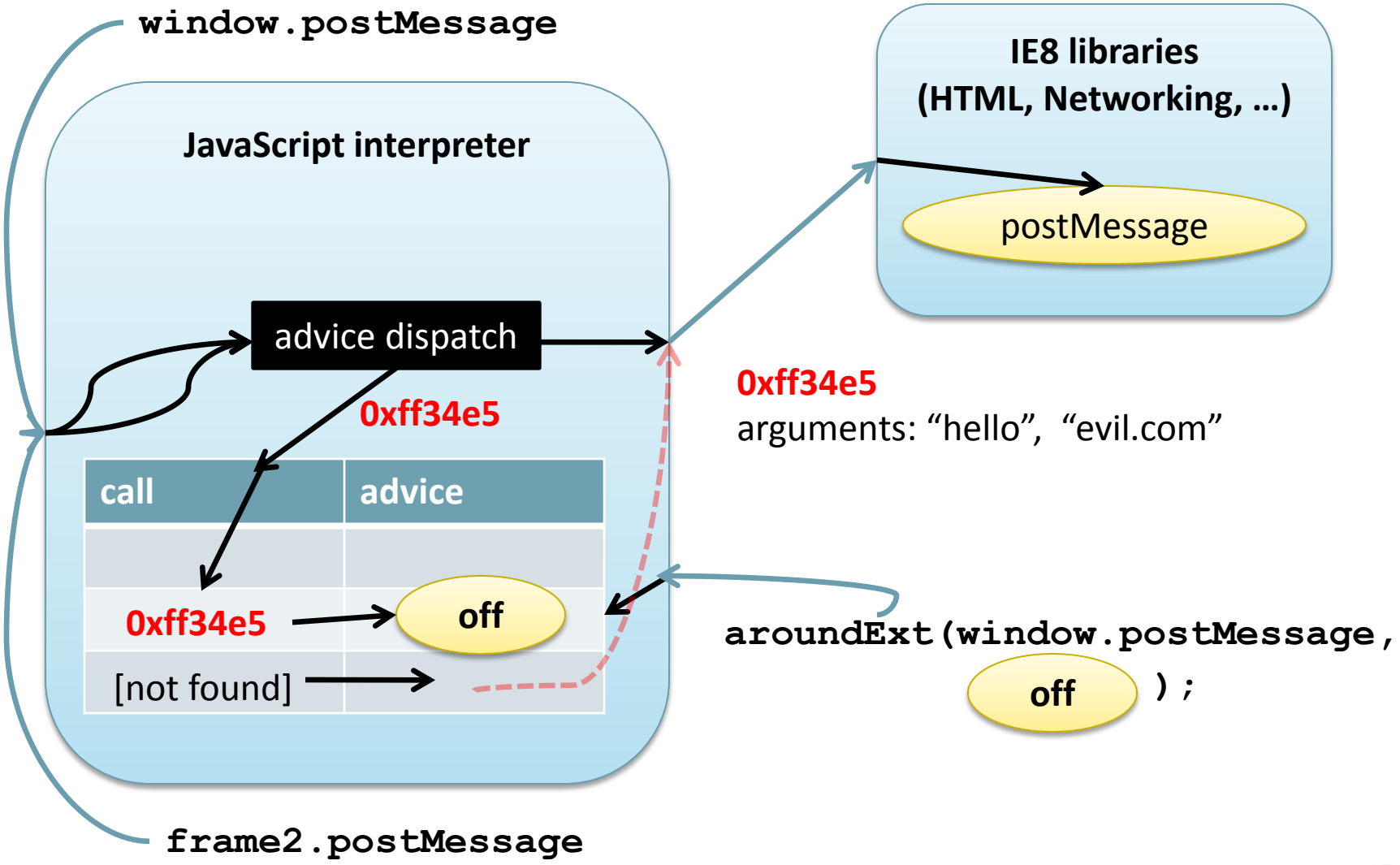
```
function f () {<before> … <after>}
```

☹ 50%-450% more to transfer, 30-70% slowdown

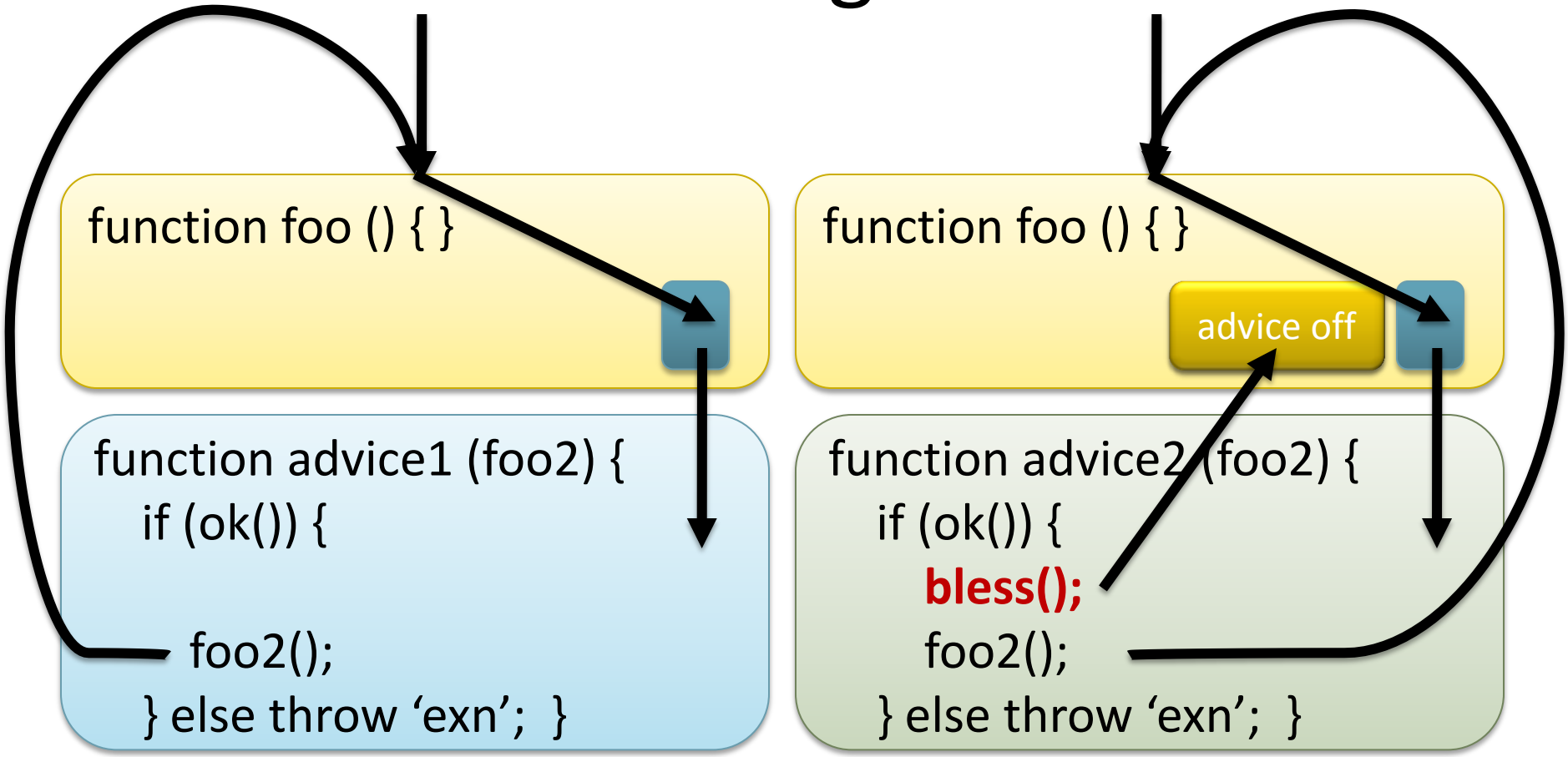
☹ limited: native (DOM) functions, dynamic code?

☹ big assumptions: adds parser to TCB, …

Mediating DOM Functions

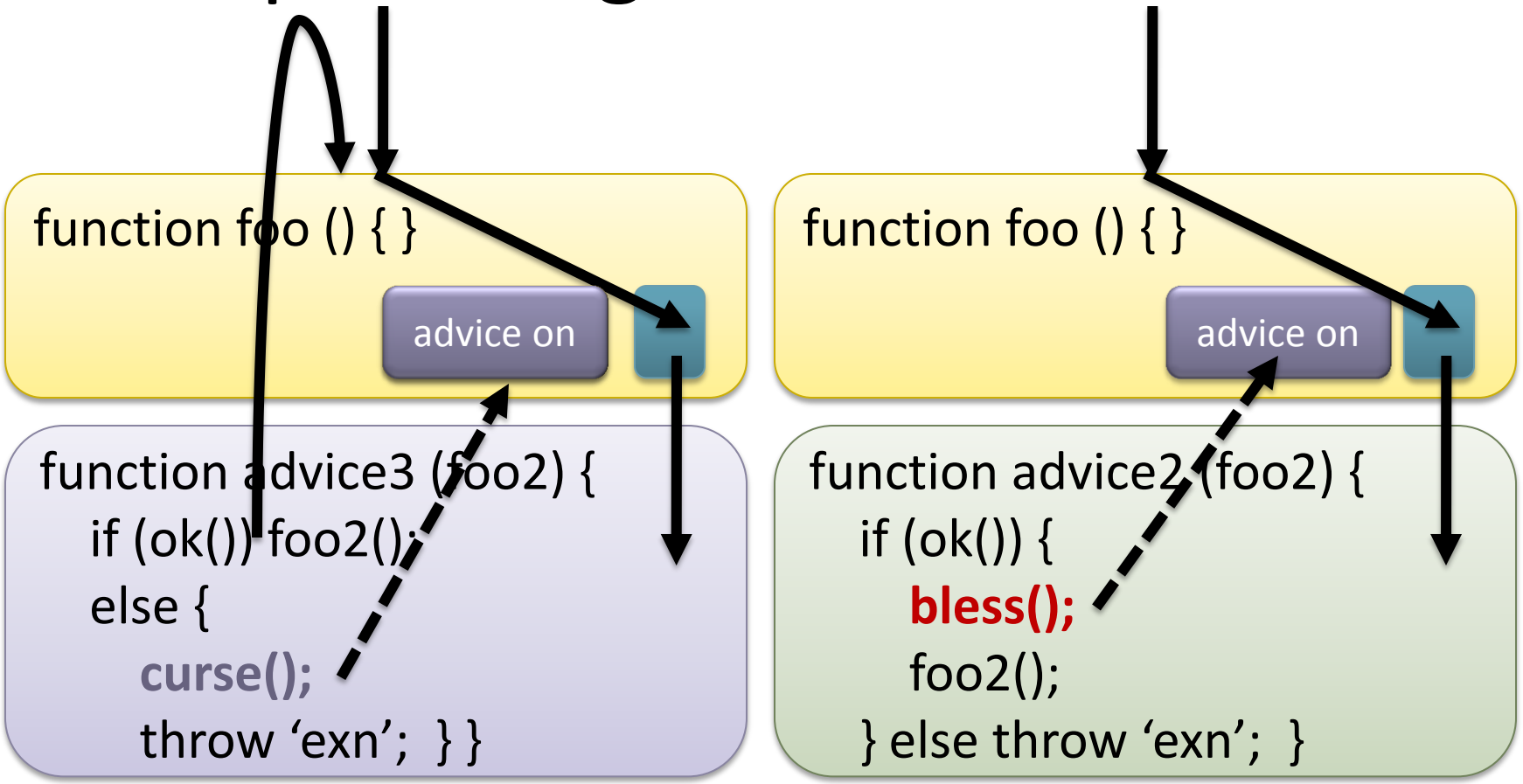


Resuming Calls



bless() temporarily disables advice for next call

Optimizing the Critical Path



- calling advice turns advice off for next call
- **curse()** enables advice for next call

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Basic Usage

script whitelist

Yel

..

..

..

..

SURGEON GENERAL'S WARNING

Policies are written in a small JavaScript subset.

Applications only lose a few dangerous features.

```
<script src="main.js" policy="noEval()"/>
```

Policy Integrity

Objects defined with policy constructors do not flow out

Old Policy

```
around(postMessage, function (m, url) {
  w = {"msn.com": true};
  …
```

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policy object: must protect

unknown: do not pass privileged objects!

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Old Policy

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around(postMessage, function (m, url) {
  w = {"msn.com": true};
  …
```

User Exploit

```
postMessage("", "msn.com");
w["evil.com"] = 1;
postMessage("", "evil.com");
```

Policy Integrity

Objects defined with policy constructors do not flow out

New Policy

```
around(postMessage, function (m, url) {
  var w = {"msn.com": true};
  …
```

User Exploit

```
postMessage("", "msn.com");
w["evil.com"] = 1;
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Policy Integrity

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New Policy

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    var w = {"msn.com": true};
    …
```

policy object: must protect

unknown: do not pass privileged objects!

Maintaining Integrity

1. **Policy objects do not leak out of policies**
2. **Access path integrity of calls** (no prototype hijacking)

- ML-style type inference
  - ☹ basic
  - ☺ program unmodified
  - 😐 only manually tested on policies
- JavaScript interpreter support
  - call(ctx, fnc, arg1, …), hasOwnProperty(obj, “fld”)
  - caller

Transparency

- If running with policies throws no errors
  - … for same input, running without should be safe
  - **empty advice should not be functionally detectable**
- Difficult with wrapping or rewriting
  - `Function.prototype.apply, exn.stacktrace, myFunction.callee, arguments.caller, myFunction.toString, Function.prototype.call`
  - correctness vs. compatibility vs. performance …
- Simpler at interpreter level
  - rest up to developer
  - no proof

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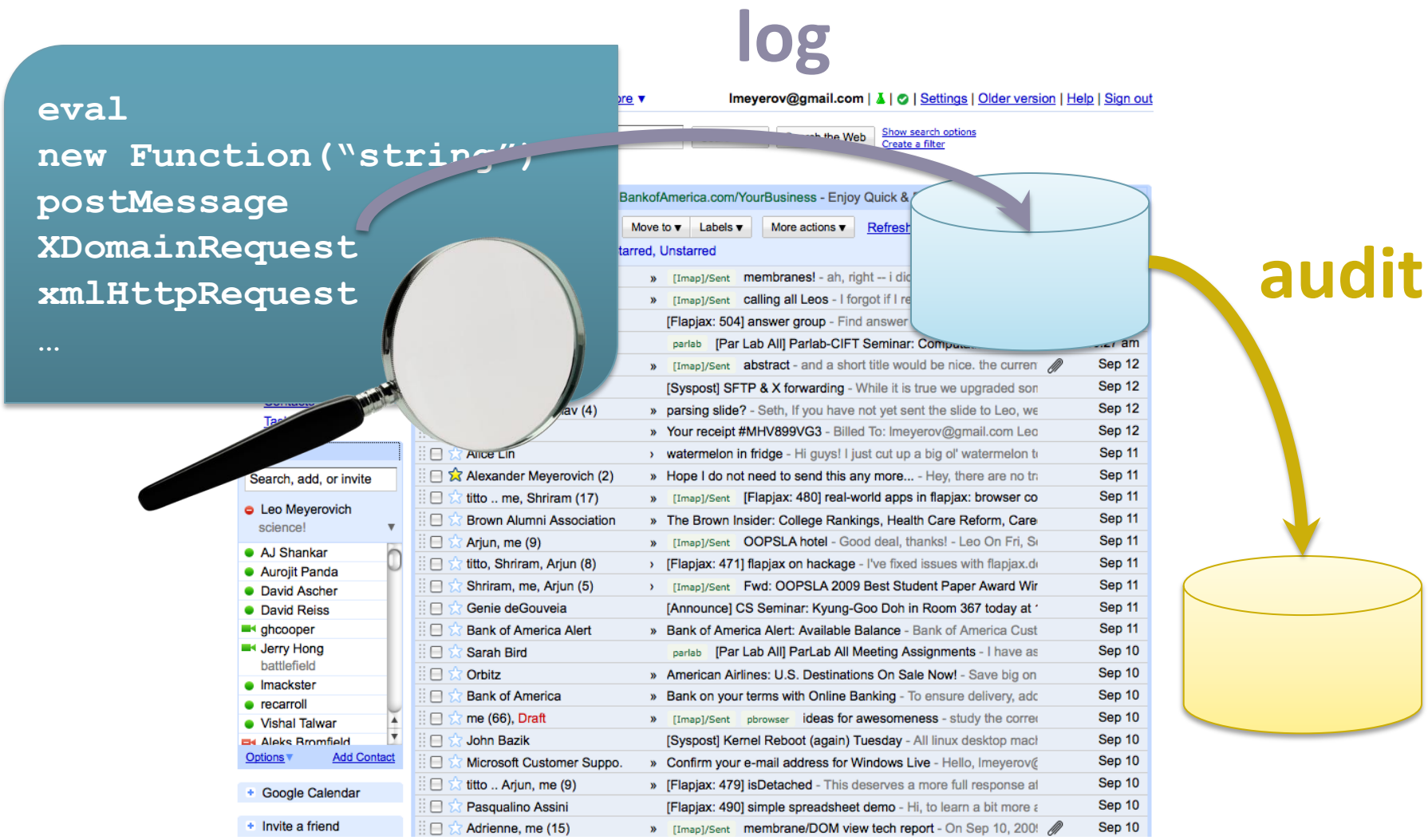
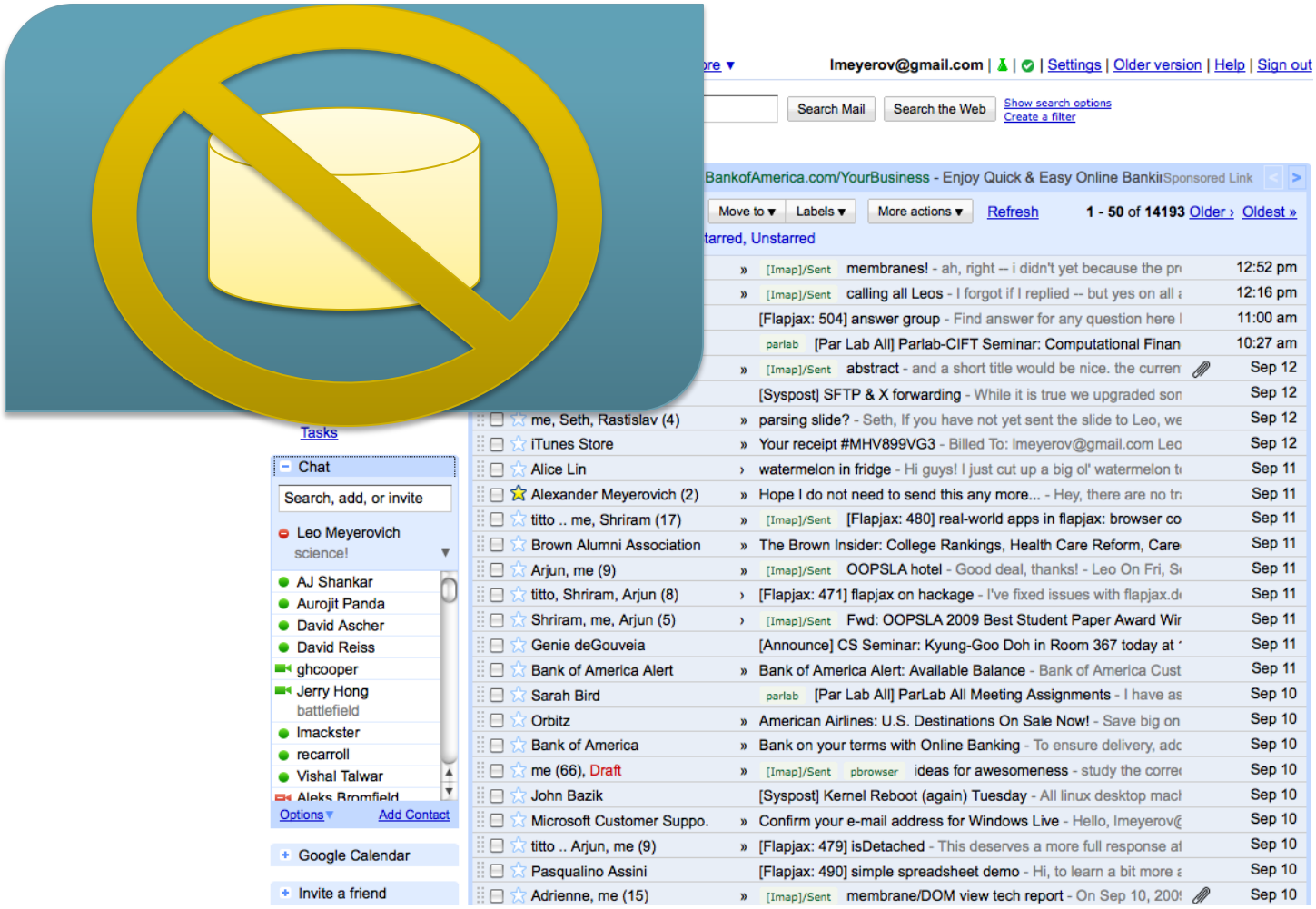
Automatically Generating Policies

- Intrusion detection
  - can we infer and disable unneeded DOM functions?
- C# access modifiers
  - can we enforce access modifiers like *private*?
- ASP policies
  - can we guarantee no scripts get run in <% echo %>?

Intrusion Detection 1: Learn Blacklist

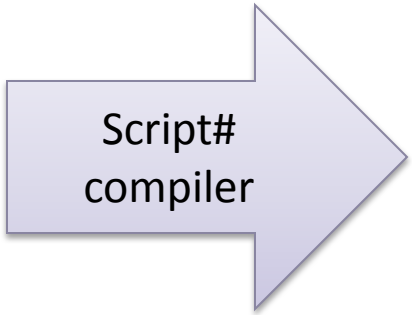


Intrusion Detection 2: Enforce Blacklist



Enforcing C# Access Modifiers

```
class File {
    public File () { … }
    private open ()  { … }
    …
```




```
function File () { … }
File.construct = …
File.open = …
…
```

C#

JavaScript


```
around(File, pubEntryPoint);
around(File.construct, pubEntryPoint);
around(File.open, privCall);
```

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Performance

Microbenchmarks: 1.2x (vs. 3.4x)

Initialization time: 0-1%

Runtime: 0-7% (vs. 30+%)

File size blowup: < 1% (vs. 50+%)

Microbenchmark: Mediation Overhead

```
var raw = obj.f;
obj.f = function () { raw();}
```

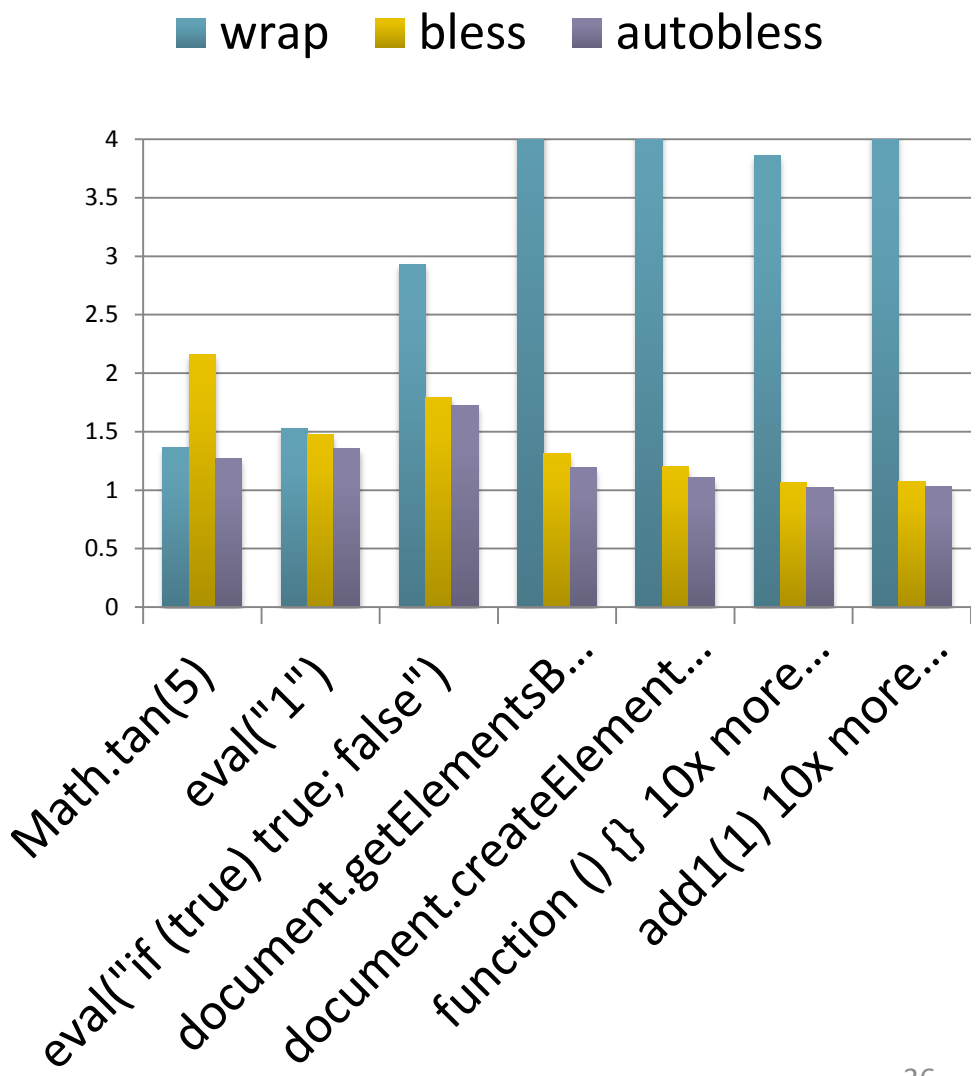
3.42x

```
function advice2() {
  bless();
  foo2();
}
```

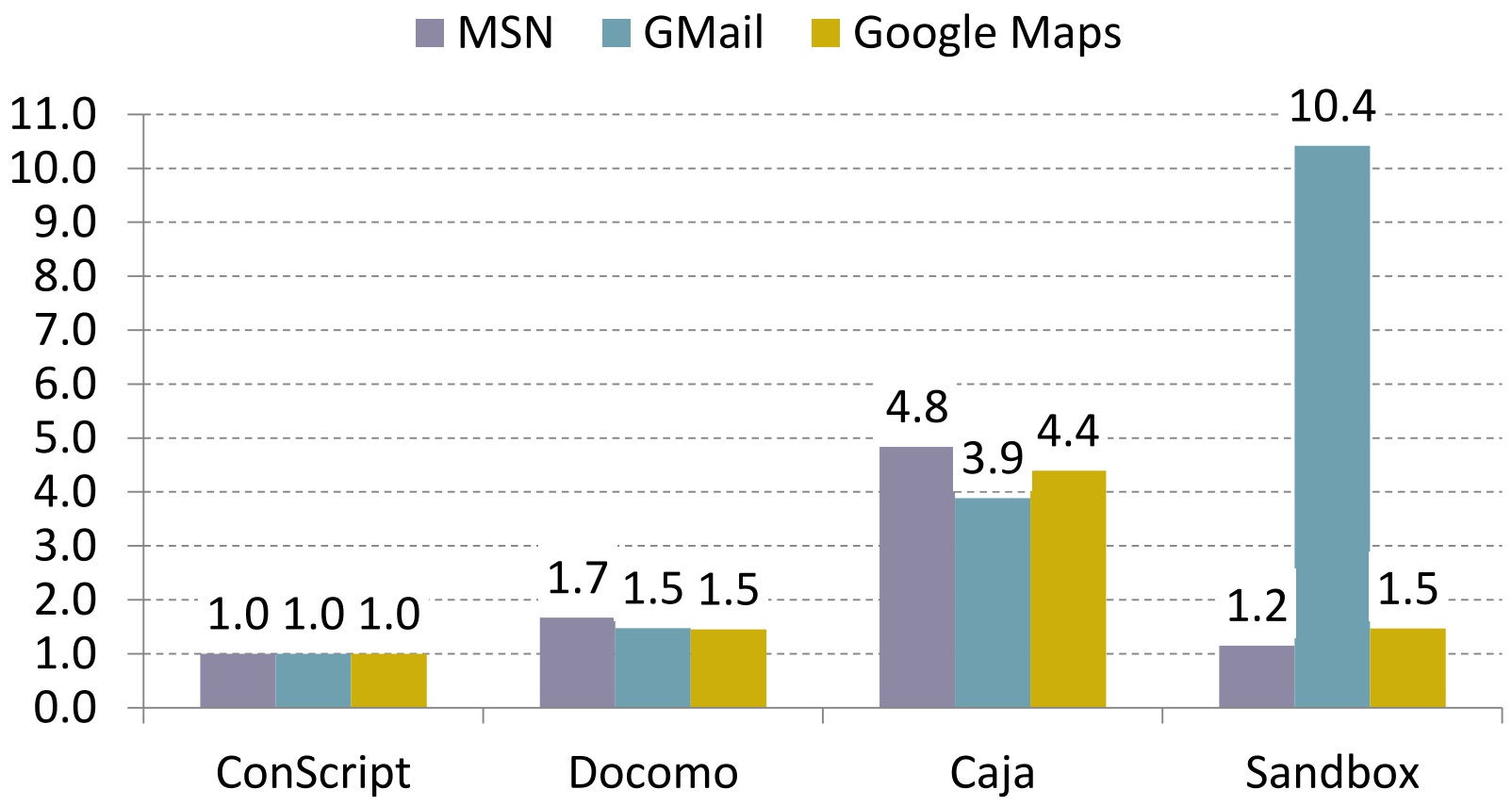
1.44x

```
function advice3() {
    foo2();
}
```

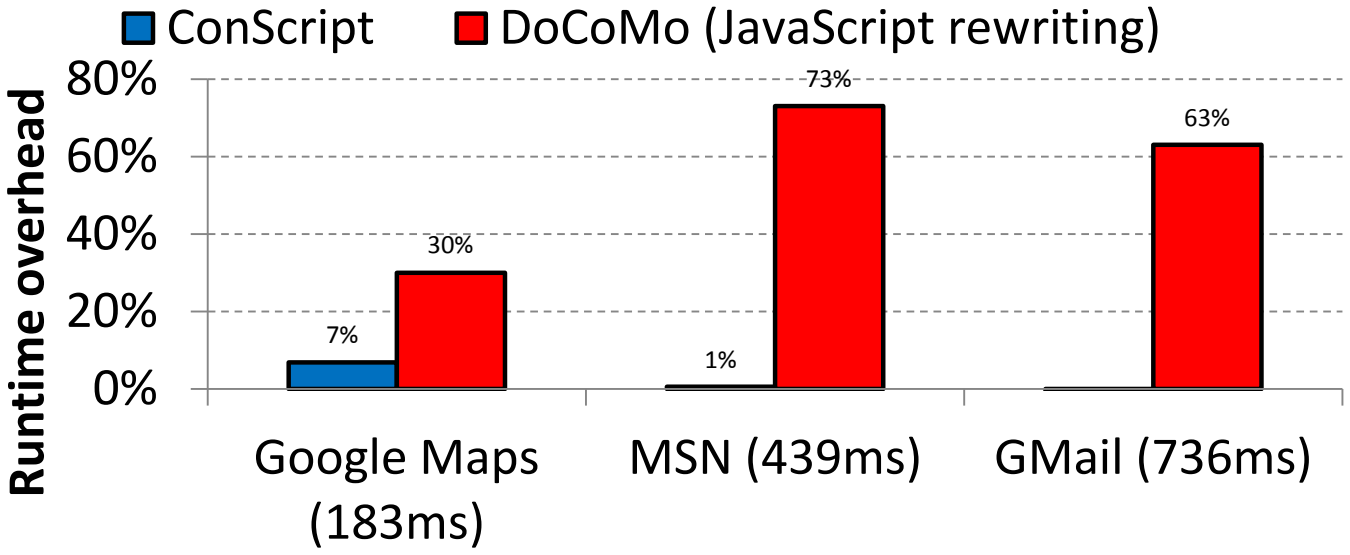
1.24x



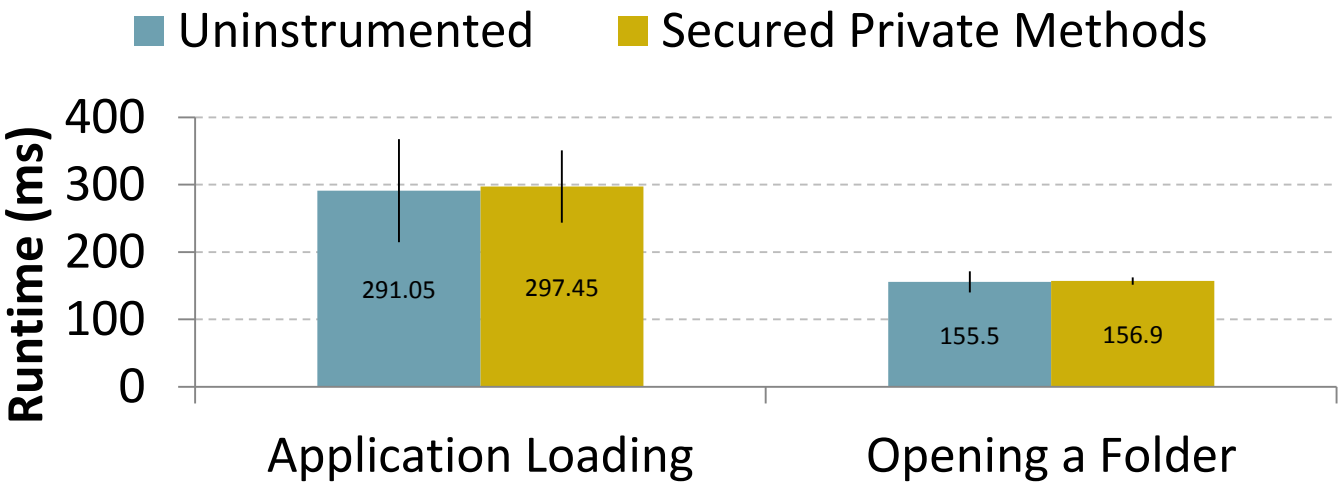
File Size Increase (IDS)



Runtime Overhead



Intrusion Detection System



Access Modifier Enforcement

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control loading and use of scripts

- protect benign users
- by giving control to hosting site
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express many policies *safely*

- 16 hand-written policies
- correct policies are hard to write
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browser support

- built into IE 8 JavaScript interpreter
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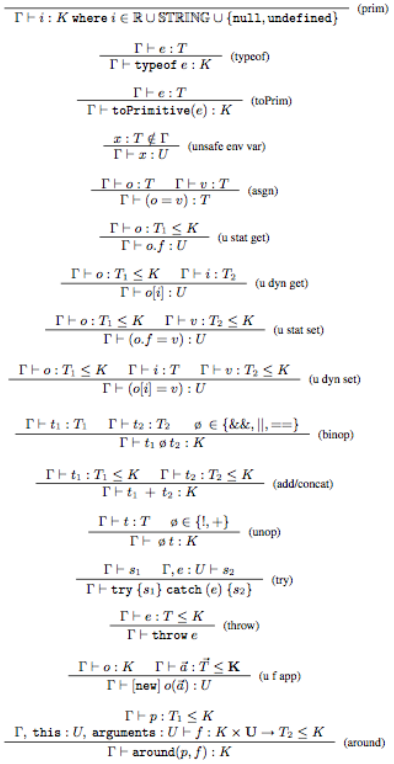
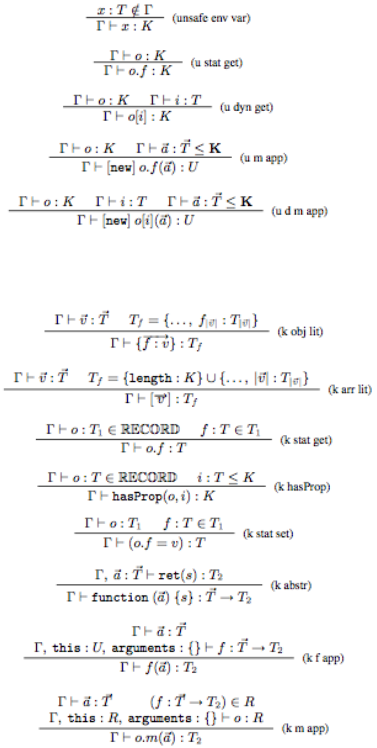
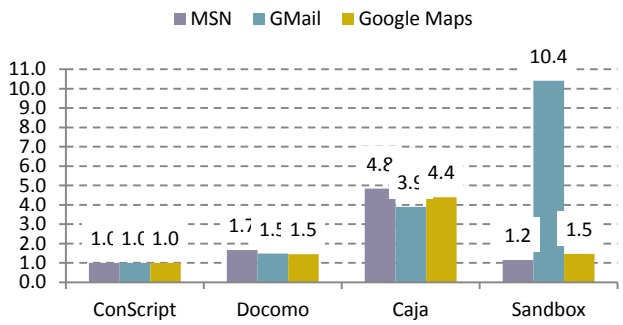
Questions?


manifest of URLs
limit eval
no foreign links
resource blacklists
no hidden frames
script whitelist
<noscript>
no URL redirection
HTTP-only cookies
no pop-ups
enforce public vs. private






MSN
GMail
Google Maps
11.0
10.0
9.0
8.0
7.0
6.0
5.0
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3.0
2.0
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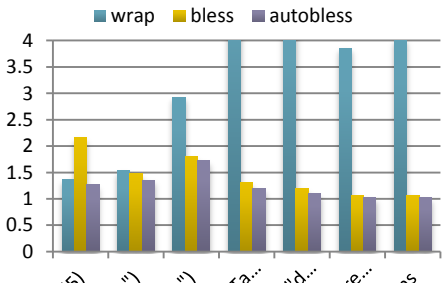
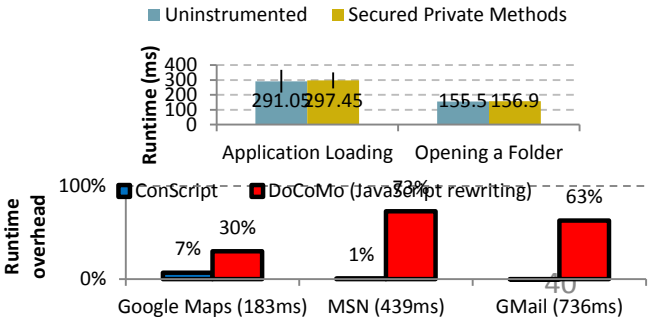
4.8
3.9
4.4
1.2
10.4
1.5
ConScript
Docomo
Caja
Sandbox


wrap
bless
autobless
4
3.5
3
2.5
2
1.5
1
0.5
0


Uninstrumented
Secured Private Methods
Runtime (ms)
400
300
200
100
0
291.05
297.45
155.5
156.9
Application Loading
Opening a Folder
Runtime overhead
100%
0%
ConScript
DoCoMo (Javascript rewriting)
7%
30%
1%
73%
63%
Google Maps (183ms)
MSN (439ms)
GMail (736ms)

END.