

Doloto:

Code Splitting for AJAX Applications

Ben Livshits and Emre Kiciman
Microsoft Research
Redmond, WA

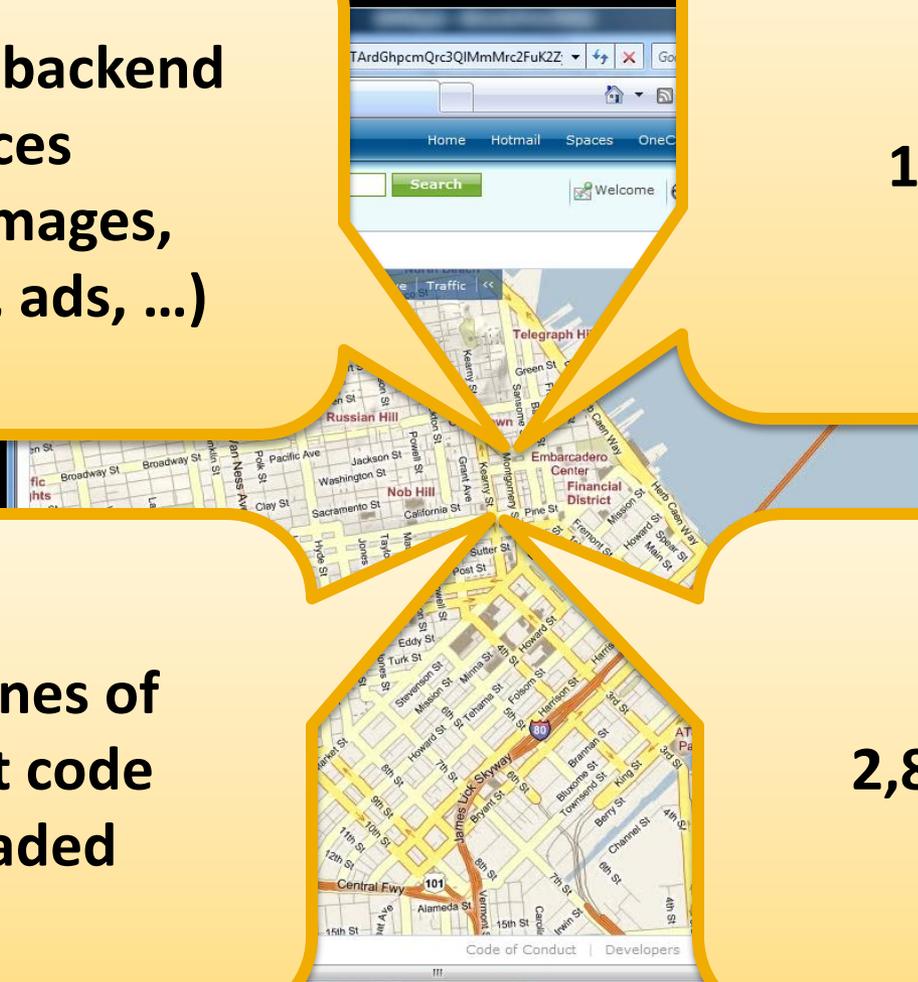
A Web 2.0 Application Disected

Talks to 14 backend services
(traffic, images, directions, ads, ...)

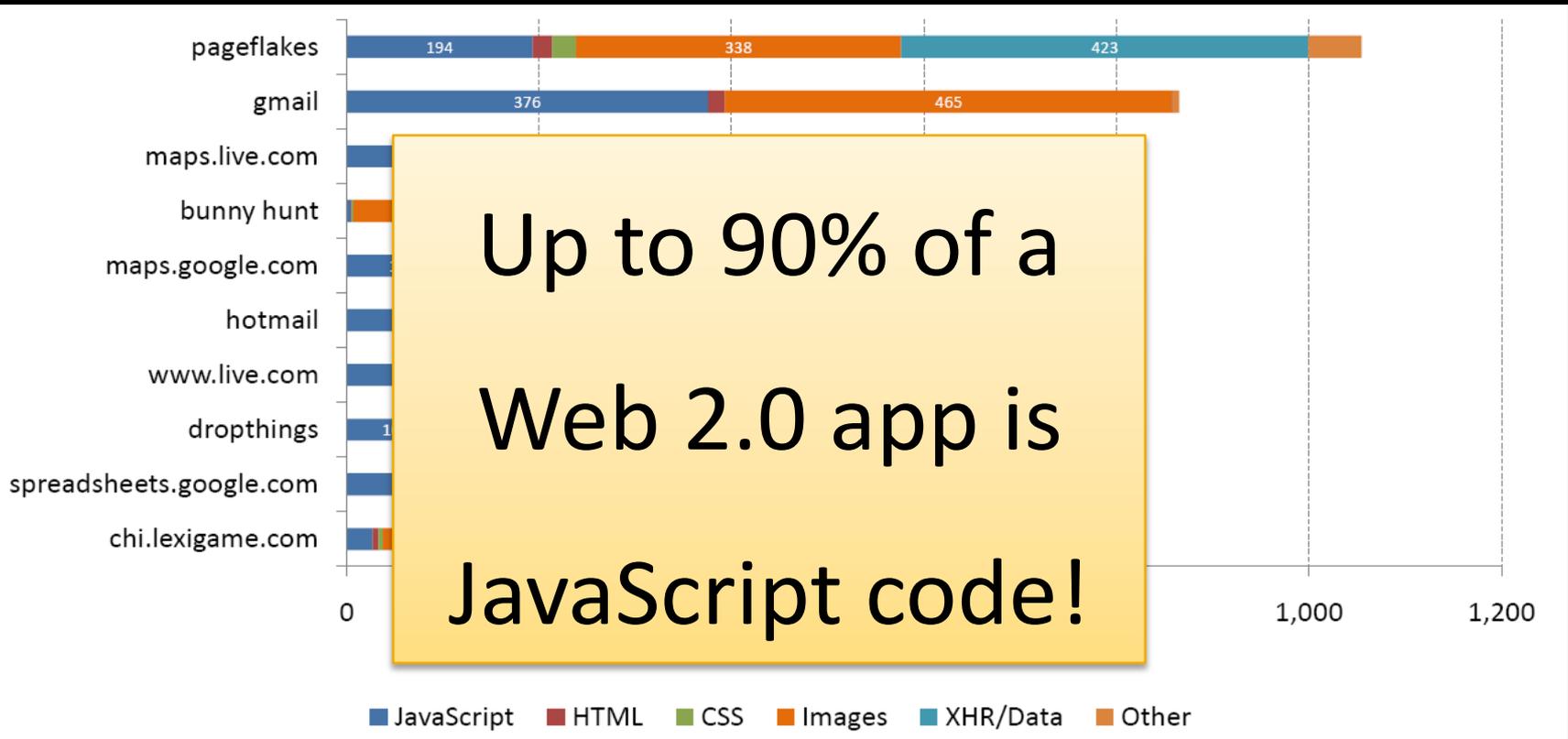
1+ MB code

70,000+ lines of JavaScript code downloaded

2,855 Functions



AJAX Apps Have Lots of Code



Why AJAX?

- Client-side JavaScript code
 - Reduces latency and improves user experience
 - Avoids constant network round trips
- Catch-22
 - Takes a while to transfer code to the client
 - Code can be MBs in size
 - Application execution is blocked until code arrives

Motivation for Doloto

- Idea behind Doloto
 - Start with a small piece of code on the client
 - Download required code on demand (pull)
 - Send code when bandwidth available (push)
- Leads to better application responsiveness
 - Interleave code download & execution
 - Faster startup times
 - Rarely executed code is rarely downloaded

Doloto Training Tool

Doloto: Clustering Information Summary

Training summary

There are 6 clusters for <http://maps.live.com/> (window ID 11395600)

- Cluster c1 containing 96 functions with a total size of 26,300 bytes
- Cluster c2 containing 652 functions with a total size of 309,615 bytes
- Cluster c3 containing 188 functions with a total size of 49,569 bytes
- Cluster c4 containing 113 functions with a total size of 25,589 bytes

Training summary Cluster details

Cluster	Function name	URL	First use time	Size	Line	Cha
cluster c1 of size 96						
c1 for winid 11395600	_Anonymous	http://maps.live.com/	1204742171525	69	00	
c1 for winid 11395600	SetLiveDomain	http://maps.live.com/	1204742172509	546	126	
c1 for winid 11395600	IsParentAccessible	http://maps.live.com/	1204742172509	172	113	
c1 for winid 11395600	LaunchSurveyWindow	http://maps.live.com/	1204742172509	1,043	70	
c1 for winid 11395600	Web.Browser._Private.MozillaFilterSub	http://sc1.maps.live.com/js/atlascompat.js	1204742172712	405	99	
c1 for winid 11395600	EstablishMode	http://sc1.maps.live.com/js/atlascompat.js	1204742172712	254	125	
c1 for winid 11395600	Web.Browser.AttachMozillaCompatibility	http://sc1.maps.live.com/js/atlascompat.js	1204742172712	4,501	119	
c1 for winid 11395600	_VERegisterNamespaces	http://sc1.maps.live.com/js/atlascompat.js	1204742172712	317	10	
c1 for winid 11395600	Web.Browser.isMozilla	http://sc1.maps.live.com/js/atlascompat.js	1204742172712	48	43	
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	161	00	
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	68	00	29
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	40	00	29
c1 for winid 11395600	j	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	191	00	
c1 for winid 11395600	c	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	141	00	
c1 for winid 11395600	b	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	166	00	
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	89	00	39
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	82	00	40
c1 for winid 11395600	GetManifestUrl	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	67	00	40
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	57	00	29
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	70	00	29
c1 for winid 11395600	_Anonymous	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	67	00	39
c1 for winid 11395600	Men.VF.BrowserInfo	http://sc1.maps.live.com/mapcontrol.ashx?mkt=en-us&v=1.3.20071113130328.94	1204742188681	454	00	

Clustering granularity presets

- Coarse
- Medium
- Fine-grained

Clustering parameters

Gap between clusters: 5.000 seconds

Cluster size threshold: 25 KB

0 seconds 15 seconds

0 ms 1000 ms

0 KB 100 KB

Automated Function Splitting

```
var g = 10;
function f1() {
  var x=g+1;
  ...
  ...
  ...
  ...
  ...
  return ...;
}
```

```
var g = 10;
var real_f1;
function f1() {
  if(!real_f1) {
    var code = load("f1");
    real_f1 = eval(code);
    f1 = real_f1;
  }
  return real_f1.apply(this,
                        arguments);
}
```

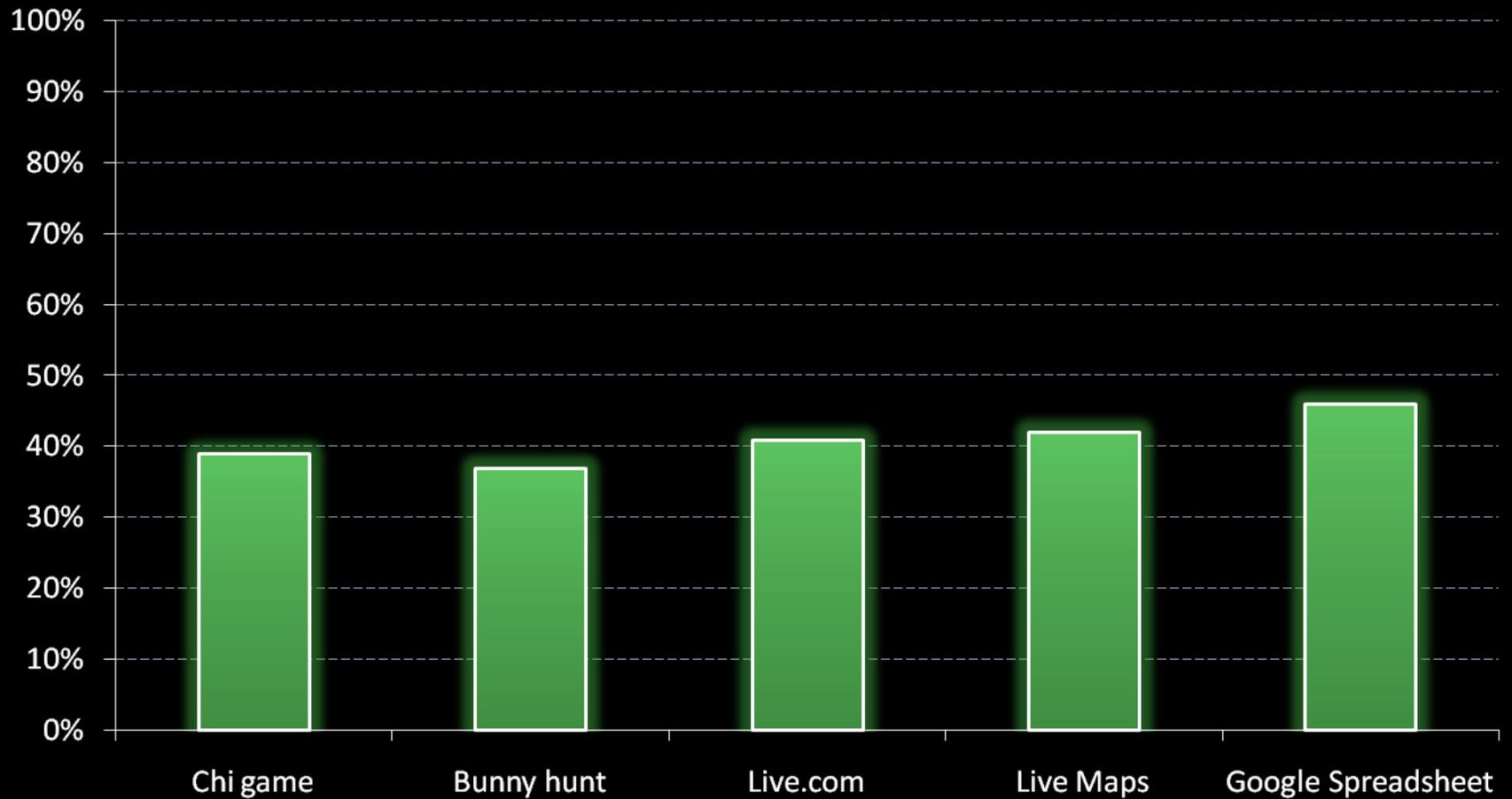


```
eval($exp("f1"), ""); // 21 chars
```

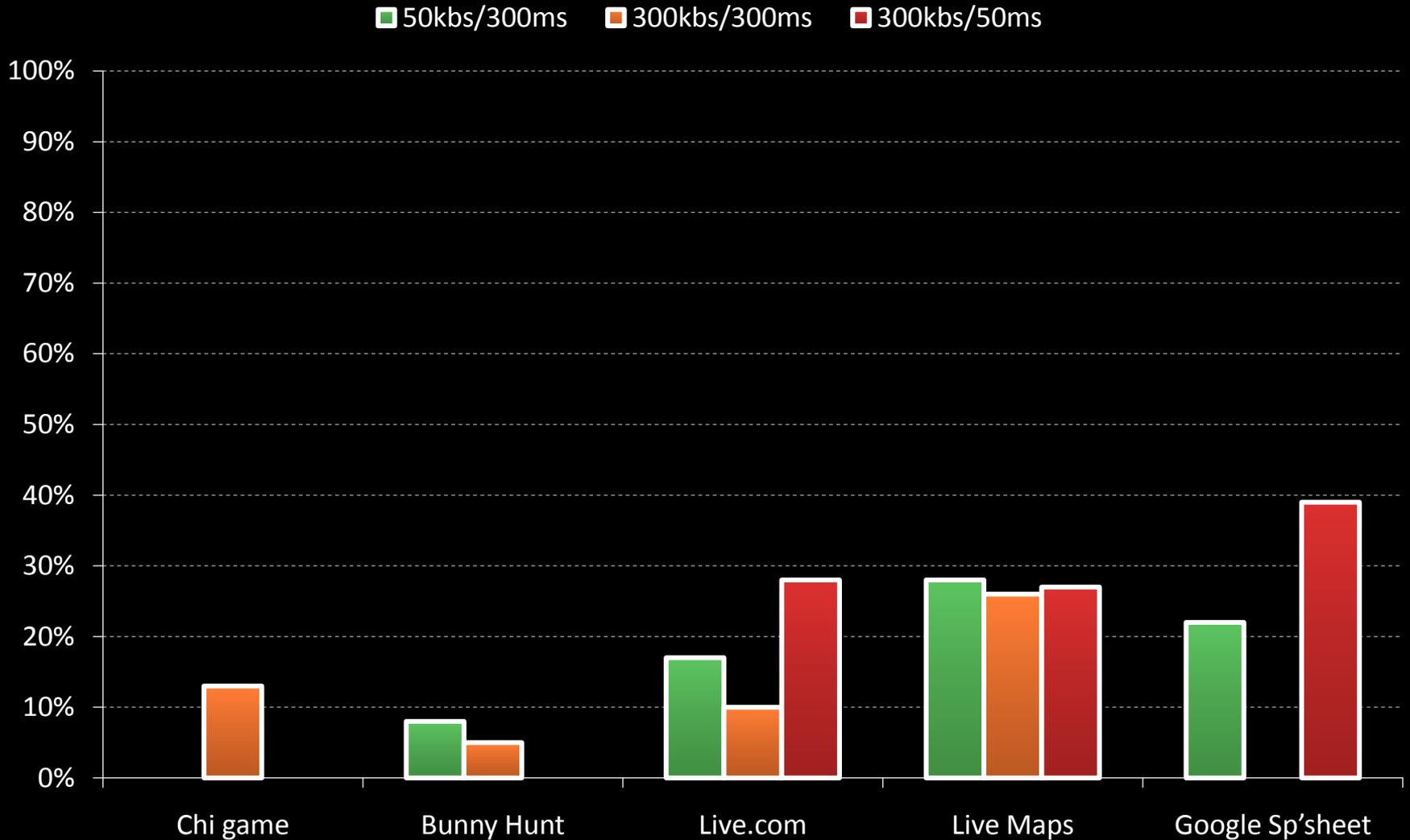
Architecture of Doloto

1. [**training**] Runtime training to collect access profiles
2. [**rewriting**] Function rewriting or “stubbing” for on-demand code loading
3. [**prefetch**] Background prefetch of clusters as the application is running

Size Savings with Doloto



Runtime Savings with Doloto



Contact us

Ben Livshits (livshits@microsoft.com)

Doloto MSR _



**Doloto: Code
Network-Bound**
Benjamin Livshits
Microsoft Research

ABSTRACT

Modern Web 2.0 applications
look and many others. We
to use AJAX to push a
This improves the
tions, but the sh
to the client
that must
turning
top