# The Web Never Forgets: Persistent Tracking Mechanisms in the Wild

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*Expanded version of CCS 2014 Talk*



# Background

# Advertising

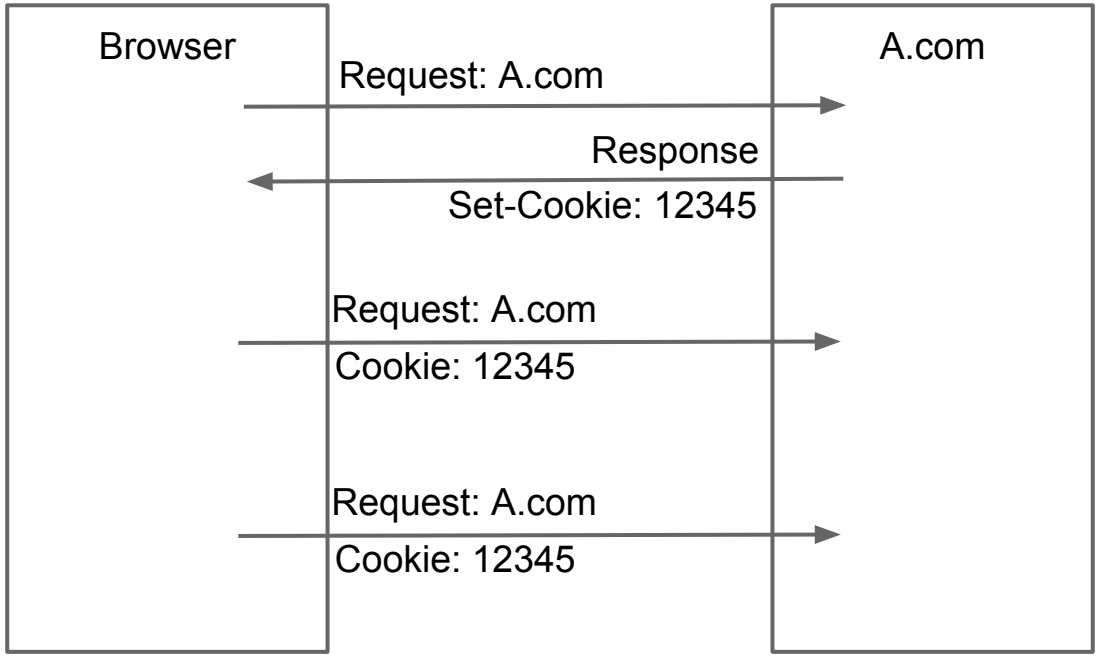
- $42.8 billion revenues in 2013 (IAB)
- Relies on tracking

Source: IEEE Spectrum, Photo: Dan Saelinger; Prop Stylist: Dominique Baynes


*Source: Mayer & Mitchell; Third-Party Web Tracking: Policy and Technology (and many COS432 lectures)*

# Tracking with Cookies

Primary tracking mechanism - built into requests



# Tracking with Cookies

Not good enough?

- can be blocked
- don’t work well on mobile
- 20-40% of the users delete cookies (ComScore, April 2010)

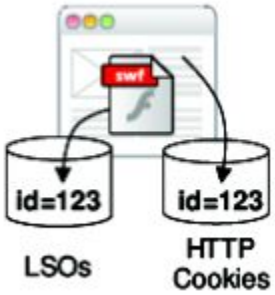
# Advanced Tracking Mechanisms

Cookie Respawning

Fingerprinting

Cookie Syncing

# Respawning (Evercookies)






Respawn cookies using obscure storage mechanisms

- e.g. Flash cookies, HTML5 localStorage, ETags

# Respawning - Data collection & Analysis

Procedure:

1. Crawl top 10,000 sites with OpenWPM
2. Clear HTTP cookies, keep other location (e.g. LSOs)
3. Recrawl top 10,000 sites (independent visits)
4. Check for regenerated cookies
    a. Check that IDs also in other location to rule out IDs regenerated by other means

# Respawning

## Findings - Top 10 Using Flash Cookies

| Global rank | Site | CC | Respawning (Flash) domain | 1st/3rd Party |
|---|---|---|---|---|
| 16 | sina.com.cn | CN | simg.sinajs.cn | 3rd* |
| 17 | yandex.ru | RU | kiks.yandex.ru | 1st |
| 27 | weibo.com | CN | simg.sinajs.cn | 3rd* |
| 41 | hao123.com | CN | ar.hao123.com | 1st |
| 52 | sohu.com | CN | tv.sohu.com | 1st |
| 64 | ifeng.com | HK | y3.ifengimg.com | 3rd* |
| 69 | youku.com | CN | irs01.net | 3rd |
| 178 | 56.com | CN | irs01.net | 3rd |
| 196 | letv.com | CN | irs01.net | 3rd |
| 197 | tudou.com | CN | irs01.net | 3rd |

# Advanced Tracking Mechanisms

Cookie Respawning

Fingerprinting

Cookie Syncing

A research project of the Electronic Frontier Foundation

# Panopticlick

## How Unique — and Trackable — Is Your Browser?

Is your browser configuration rare or unique? If so, web sites may be able to track you, *even if you limit or disable cookies.*

Panopticlick tests your browser to see how unique it is based on the **information** it will share with sites it visits. Click below and you will be given a uniqueness score, letting you see how easily identifiable you might be as you surf the web.

Only **anonymous data** will be collected by this site.

Your browser fingerprint **appears to be unique** among the 4,702,890 tested so far.

| Browser Characteristic | bits of identifying information | one in *x* browsers have this value | value |
|---|---|---|---|
| User Agent | 9.3 | 631.77 | Mozilla/5.0 (Windows NT 6.1; WOW64; rv:33.0) Gecko/20100101 Firefox/33.0 |
| HTTP_ACCEPT Headers | 3.96 | 15.52 | text/html, */* gzip, deflate en-US,en;q=0.5 |
| | | | Plugin 0: Adobe Acrobat; Adobe PDF Plug-In For Firefox and Netscape 10.1.12; nppdf32.dll; (Acrobat Portable Document Format; |
| | | | ▪ ▪ ▪ |
| System Fonts | 22.17+ | 4702890 | GulimChe, Gungsuh, GungsuhChe, Harlow Solid Italic, Harrington, High Tower Text, Impact, Informal Roman, IrisUPC, Iskoola Pota, JasmineUPC, Jokerman, Juice ITC, KaiTi, Kalinga, Kartika, Khmer UI, KodchiangUPC, Kokila, Kristen ITC, Kunstler Script, Lao UI, Latha, Leelawadee, Levenim MT, LilyUPC, Lucida Bright, Lucida Calligraphy, Lucida Console, Lucida Fax, Lucida Handwriting, Lucida Sans Unicode, Magneto, Malgun Gothic, Mangal, Marlett, Matura MT Script Capitals, Meiryo, Meiryo UI, Microsoft Himalaya, Microsoft JhengHei, Microsoft New Tai Lue, Microsoft PhagsPa, Microsoft Sans Serif, Microsoft Tai Le, Microsoft Uighur, Microsoft YaHei, Microsoft Yi Baiti, |
| | | | ▪ ▪ ▪ |

# Browser fingerprinting

FPDetective (Acar et al., CCS'13)

- detecting **font based fingerprinting**
- 16 previously unknown providers
- Flash based, 1.5% 10K sites
- JavaScript based, 0.04% of top 1M

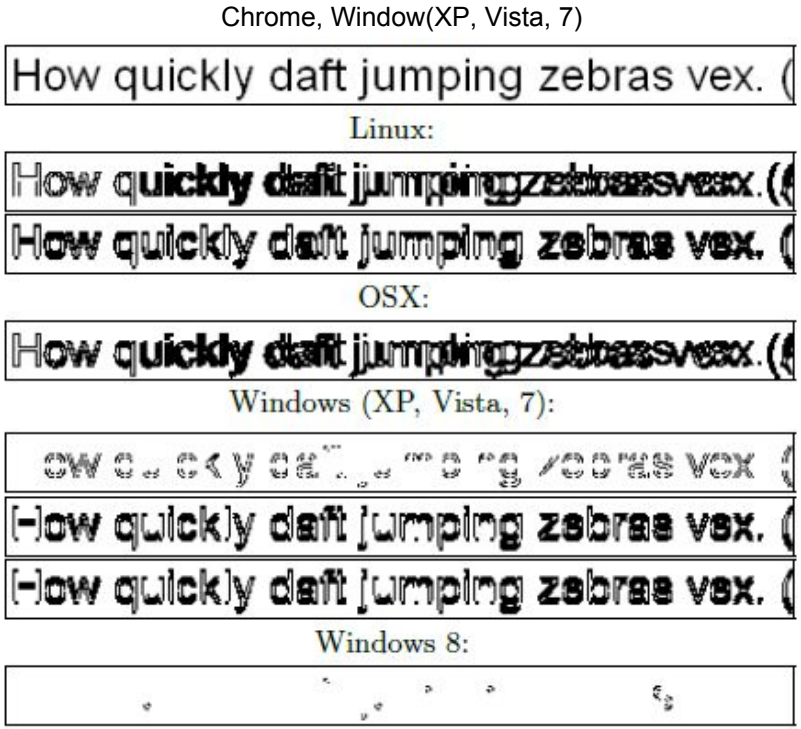

Source: lalit.org

# Canvas Fingerprinting

- Canvas and WebGL API
  - Allows sites to draw and render images from javascript
- Depends on:
  - OS
  - browser
  - fonts
  - font library
  - **graphics card & driver**
  - **font rendering (ClearType)**

Different than other fingerprinting vectors


Arial; 20px rendering

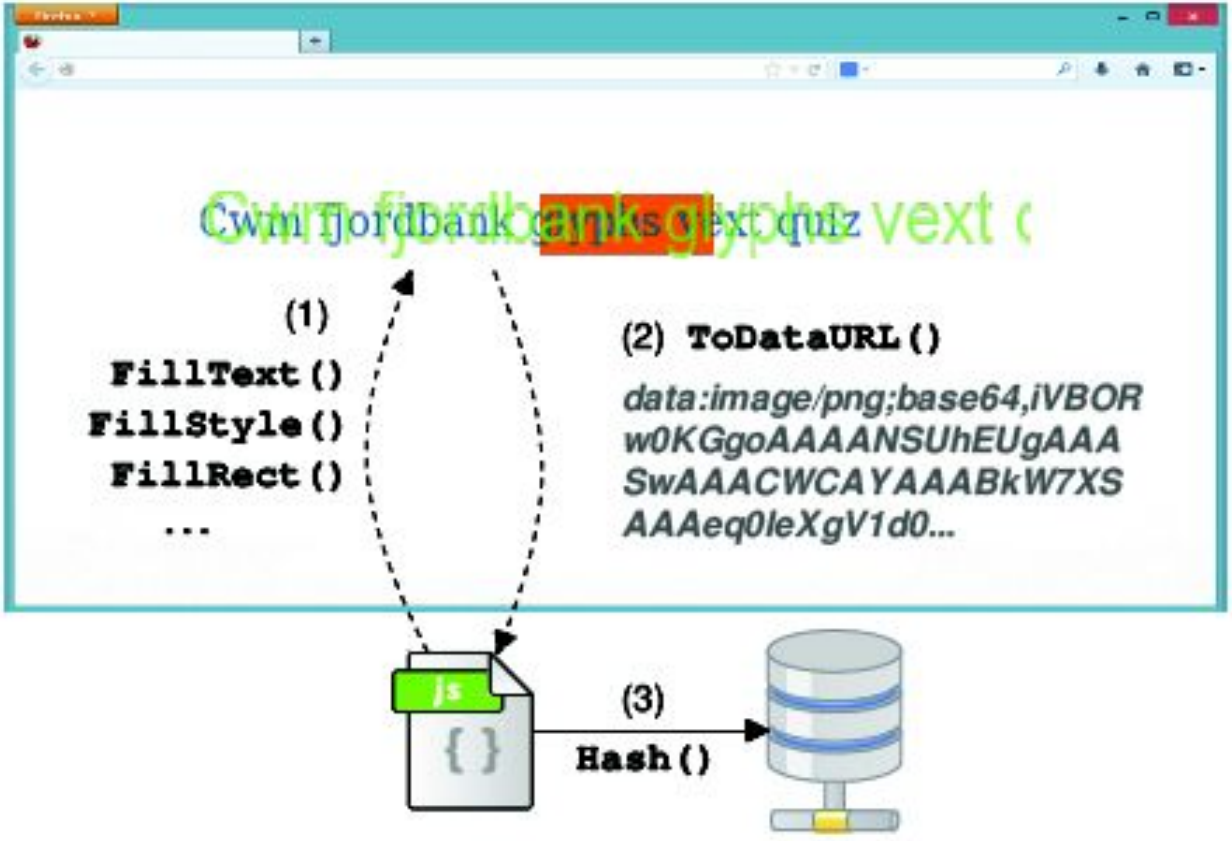



Diffs between renderings

Source: Mowery & Shacham; Pixel Perfect: Fingerprinting Canvas in HTML5 (W2SP'2012)


Cwm fjordbank glyphs vext quiz
http://valve.github.io
http://admicro.vn/
http://www.plentyoffish.com
ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/

# Canvas Fingerprinting



# Canvas Fingerprinting - Experimental Setup

- Crawler based on Selenium, mitmproxy and modified Firefox
  - Alexa top 100K (May 1-5, 2014)
  - Ran in parallel
  - Log canvas access functions (R/W)
  - Insert into a SQLite database
- Analysis & false positive removal

# Canvas Fingerprinting
## Findings - Alexa Top 100K

| Fingerprinting script | Number of including sites | Text drawn into the canvas |
|---|---|---|
| ct1.addthis.com/static/r07/core130.js | 5282 | Cwm fjordbank glyphs vext quiz,😃 |
| i.ligatus.com/script/fingerprint.min.js | 115 | http://valve.github.io |
| src.kitcode.net/fp2.js | 68 | http://valve.github.io |
| admicro1.vcmedia.vn/fingerprint/figp.js | 31 | http://admicro.vn/ |
| amazonaws.com/af-bdaz/bquery.js | 26 | Centillion |
| *.shorte.st/js/packed/smeadvert-intermediate-ad.js | 14 | http://valve.github.io |
| stat.ringier.cz/js/fingerprint.min.js | 4 | http://valve.github.io |
| cya2.net/js/STAT/89946.js | 3 | ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz0123456789+/ |
| images.revtrax.com/RevTrax/js/fp/fp.min.jsp | 3 | http://valve.github.io |
| pof.com | 2 | http://www.plentyoffish.com |
| *.rackcdn.com/mongoose.fp.js | 2 | http://api.gonorthleads.com |
| 9 others* | 9 | *(Various)* |
| TOTAL | 5559 *(5542 unique[1])* | - |

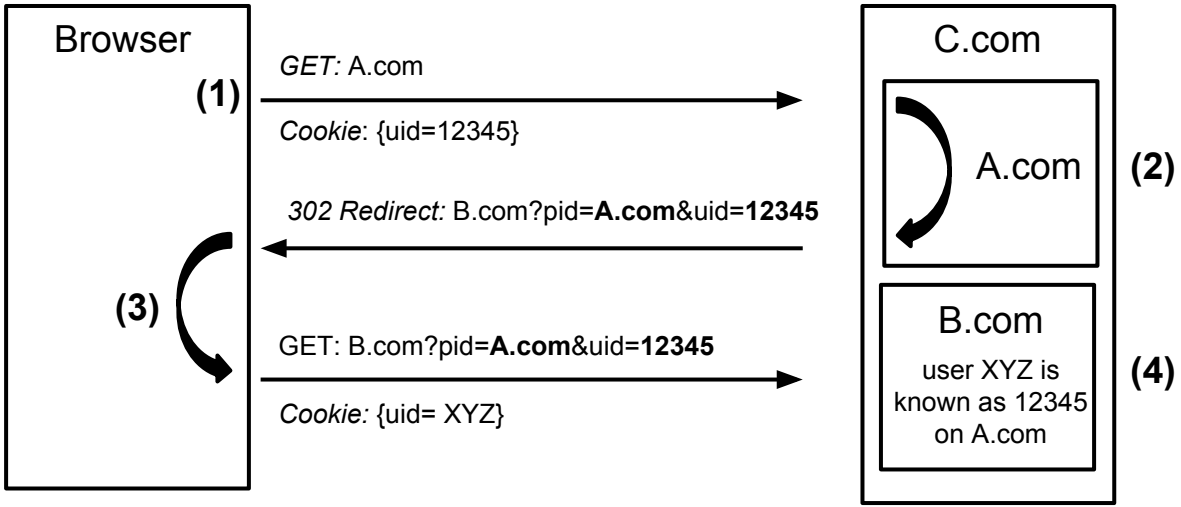
# Advanced Tracking Mechanisms

Cookie Respawning

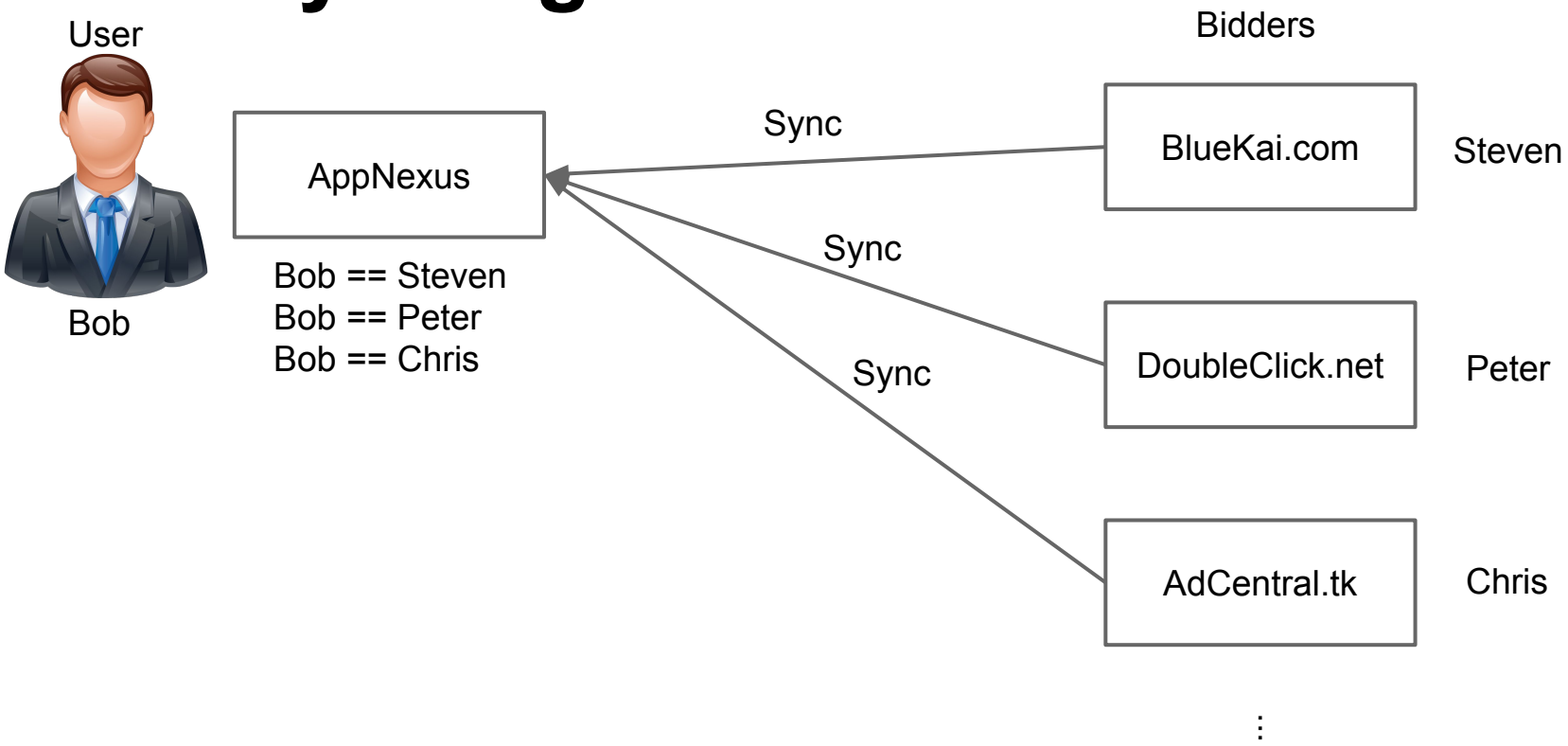
Fingerprinting

Cookie Syncing

# Cookie Syncing



# Cookie Syncing



# Cookie Syncing - Experiments

- Top 3000 sites crawled while accumulating the state using OpenWPM
- Procedure:
  1. Detect identifying cookies and extract identifiers
  2. Search for identifiers in request / redirect URLs
  3. Mark all pairs of third-parties which share IDs

# Cookie Syncing - Results

- Olejnik et al. finds **125 companies** syncing cookies (NDSS'14)
- We find **40%** of all tracking IDs are synced
- On average, **3.4 domains** see each ID
  - Turn.com's ID cookie is seen by **43 domains**

# Why do we care?

This can make it much more difficult to start with a fresh profile.

# I want to start a new profile

Clear cookies (from the beginning of time)?

→ Oops, forgot to check “Cache”

→ Forced cached PNGs respawns cookies

# I want to start a new profile

Clear all local browser state?

→ Your browser fingerprint didn’t change.

→ You visit site again

→ Site links your old history to new cookie using fingerprint

# I want to start a new profile

Okay, so a few parties fingerprinted me or respawned cookies -- no big deal, most of my tracking history is gone?

→ respawned ID is cookie-synced to a large ad exchange

→ fingerprint linkage may still be shared through business relationships

# I want to start a new profile

Well maybe I'll clear all state and simultaneously change some fonts and browser plugins?

→ You *might* be okay.

→ We observed one instance of ID respawning through (what we assume is) passive, server-side fingerprinting.

# Defenses

# Opt-out

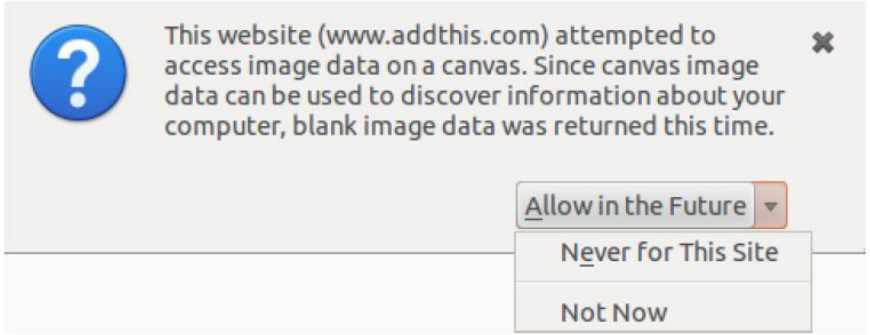
- opted-out on...
  - Network Advertising Initiative (NAI)
  - European Interactive Digital Advertising Alliance (EDAA)
  - AddThis' own Data Collection Opt-Out website
- no change for canvas fingerprinting and evercookies
- # of IDs involved in cookie sync: reduced by 30%
- # of parties involved in cookie sync: reduced by 5%

# Cookie Blocking and DNT

- DNT reduces # of parties and # of IDs in cookie syncing by 3%
- Blocking all third-party cookies reduces by a factor of two
- Ad-blockers?
  - Ghostery cuts HTTP request traffic in half

# Defenses - Canvas Fingerprinting

- no option to disable canvas
- Tor Browser returns an empty image
- no significant steps from browser manufacturers
  - pessimistic, “lost cause”




MAXMIND
Account
Language Selection
My Order
CanvasFingerprintBlock
Blocked 1 potential HTML canvas fingerprinting attempt on this page
Prevented a script on https://www.maxmind.com from capturing the following 300px × 150px canvas:
No骗
Donate
PRODUCTS
SUPPORT
DEVELOPER
GeoIP® Databases and Services
Industry leading IP intelligence
Use GeoIP intelligence for content personalization, ad targeting, traffic analysis, digital rights management, and more.
LEARN MORE
LEARN MORE
Try our GeoIP2 Precision service demo:
Enter an IP address
GO

# Conclusions

# Move along, nothing to see here

- Significant media & public attention
- Top two providers (AddThis, Ligatus) stopped using canvas fingerprinting
  - calling it an “experiment”
- community made anti-canvas fingerprinting extensions

# Takeaways

- third-party tracking isn't getting any better
- defense is hard, opt-out is not effective
- fingerprinting is becoming more common
- can automation help?

# Thanks for listening :)

More info, code and the data:

- https://securehomes.esat.kuleuven.be/~gacar/persistent/
- https://webtap.princeton.edu/