Web Tracking

Vitaly Shmatikov

Slides courtesy of Arvind Narayanan and Hovav Shacham

Reading Material

Mayer and Mitchell

Third Party Web Tracking: Policy and Technology

Oakland 2012

Mowery and Shacham

Pixel Perfect: Fingerprinting Canvas in HTML 5

W2SP 2012

Acar et al.

The Web Never Forgets: Persistent Tracking Mechanisms in the Wild

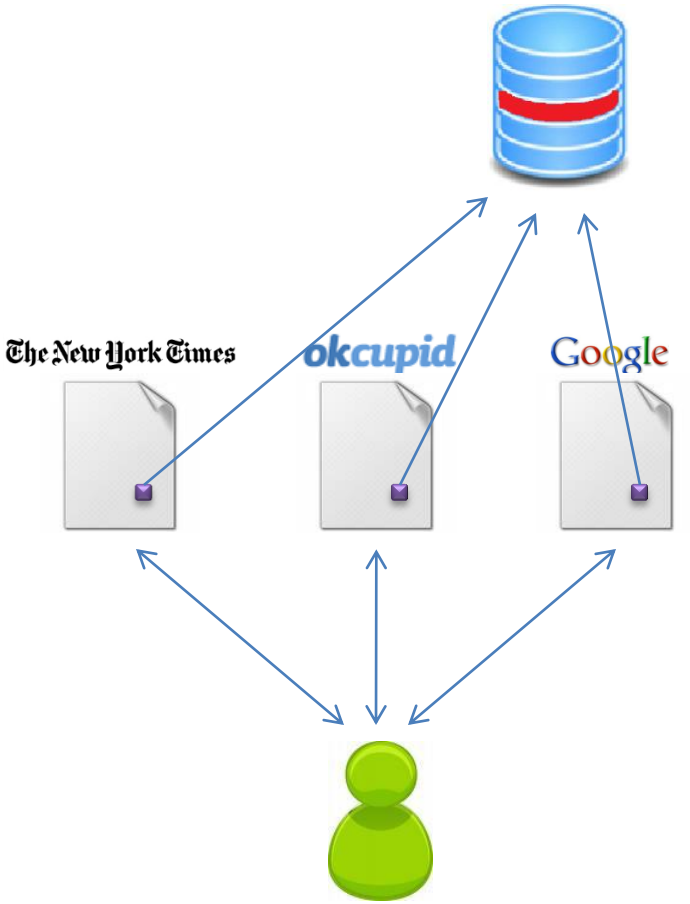
CCS 2014

It's the Internet! Of course they know you're a dog. They also know your favorite brand of pet food and the name of the cute poodle at the park that you have a crush on!

Tracking via Cookies

- Cookie: value set by Web server, automatically sent by the browser on subsequent requests to same(ish) origin
- Link two sessions at same site
- Link sessions between different sites (third-party cookies)
- Can be combined with user-identifying information

Third-Party Tracking

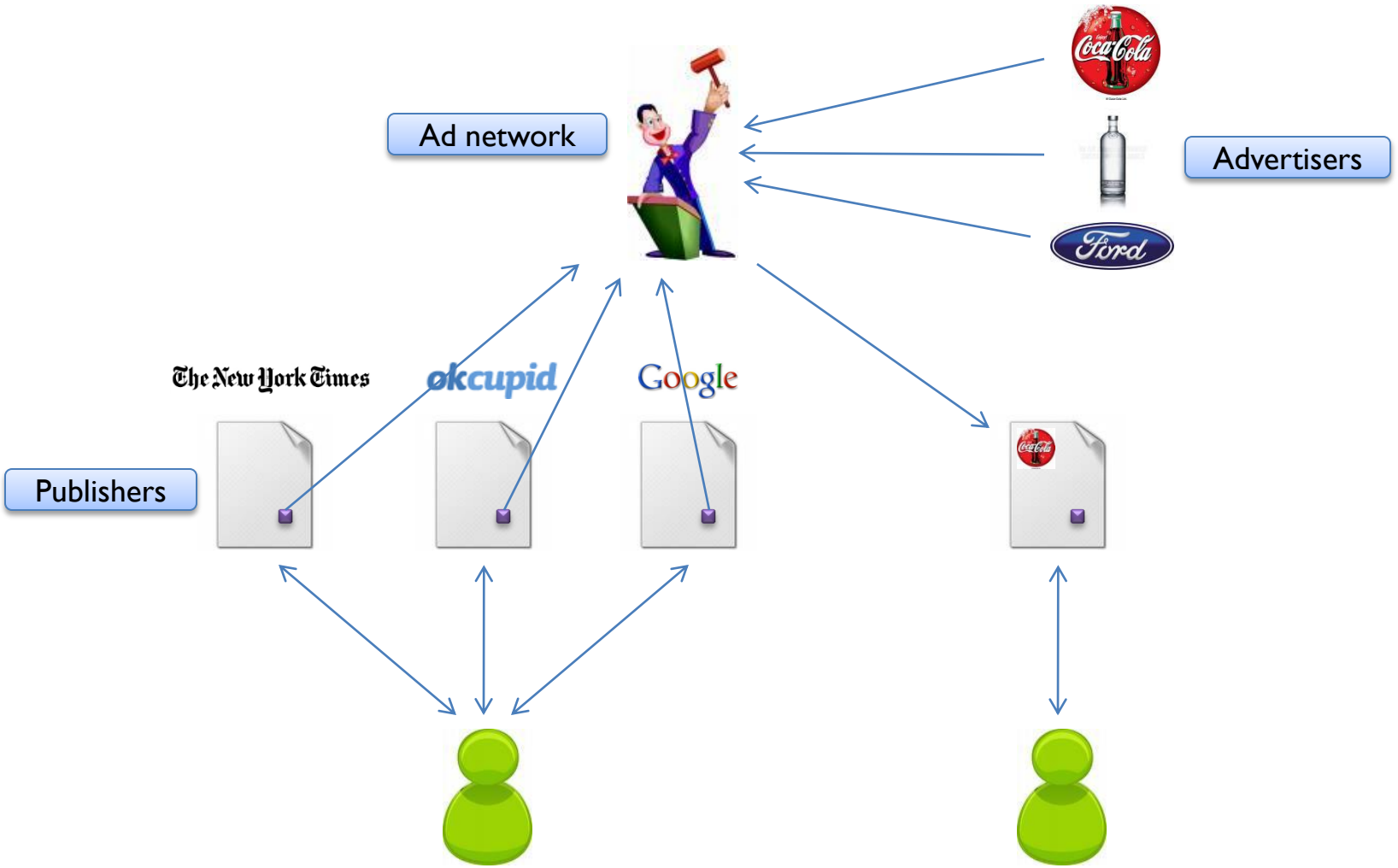


Third-party cookies:

- Disabled by default (Safari)
- Can be disabled by user (many browsers)
- Cannot be disabled (Android)

… but there are many other tracking technologies

Behavioral Targeting



Partial List of Ad Networks

24/7 Real Media	33Across	Acerno	Acxiom Relevence-X	AdAdvisor	AdBrite
Adify	AdInterax (Yahoo!)	AdJuggler	AdShuffle	ADTECH (AOL)	Advertising.com (AOL)
Aggregate Knowledge	Akamai	AlmondNet	Atlas (Microsoft)	AudienceScience	Bizo
Blue Kai	BlueLithium (Yahoo!)	Bluestreak	BrightRoll	BTBuckets	Burst Media
Casale Media	Chitika	ChoiceStream	ClickTale	Collective Media	comScore VoiceFive
Coremetrics	Cossette	Criteo	Effective Measure	Eloqua	Eyeblaster
eXelate	EyeWonder	e-planning	Facilitate Digital	FetchBack	Flashtalking
Fox Audience Network	FreeWheel	Google	Hurra	interCLICK	Lotame
Navegg	NextAction	NexTag	Mediaplex (ValueClick Media)	Media 6 Degrees	Media Math
Microsoft	MindSet Media	Nielsen Online	nugg.ad	Omniture	OpenX
Outbrain	PointRoll	PrecisionClick	Pulse 360	Quantcast	Quigo (AOL)
richrelevance	Right Media (Yahoo!)	Rocket Fuel	Safecount *	ScanScout	Smart Adserver
Snoobi	Specific Media	TACODA (AOL)	Tatto Media	Tealium	TradeDoubler
Traffic Marketplace	Tribal Fusion / Exponential	TruEffect	Tumri	Turn	Undertone Networks / Zedo
ValueClick Media	Vizu	Weborama	WebTrends	Yahoo!	[x+1]

Display Advertising Technology Landscape

tkawaja@lumapartners.com


2012 DISPLAY ADVERTISING ECOSYSTEM EUROPE
PUBLISHERS
ADVERTISERS
Data Suppliers
Data Management Platforms
Data Exchanges
Sales Houses
SSP & Private Ad Exchanges
Delivery Systems, Tools & Analytics
Verification & Privacy
Ad Networks
Audience Targeting / Re-Targeting
Ad Exchanges
Demand Side Platforms
Agency Trading Desks
Trading Desks
Agencies
Delivery Systems, Tools & Analytics
Verification & Privacy
Published by
IMPROVE DIGITAL

Tracking Is Pervasive

64

independent tracking mechanisms in an average top-50 website

Sticky Tracking

Subverting same origin policy

(publisher also runs an ad network)

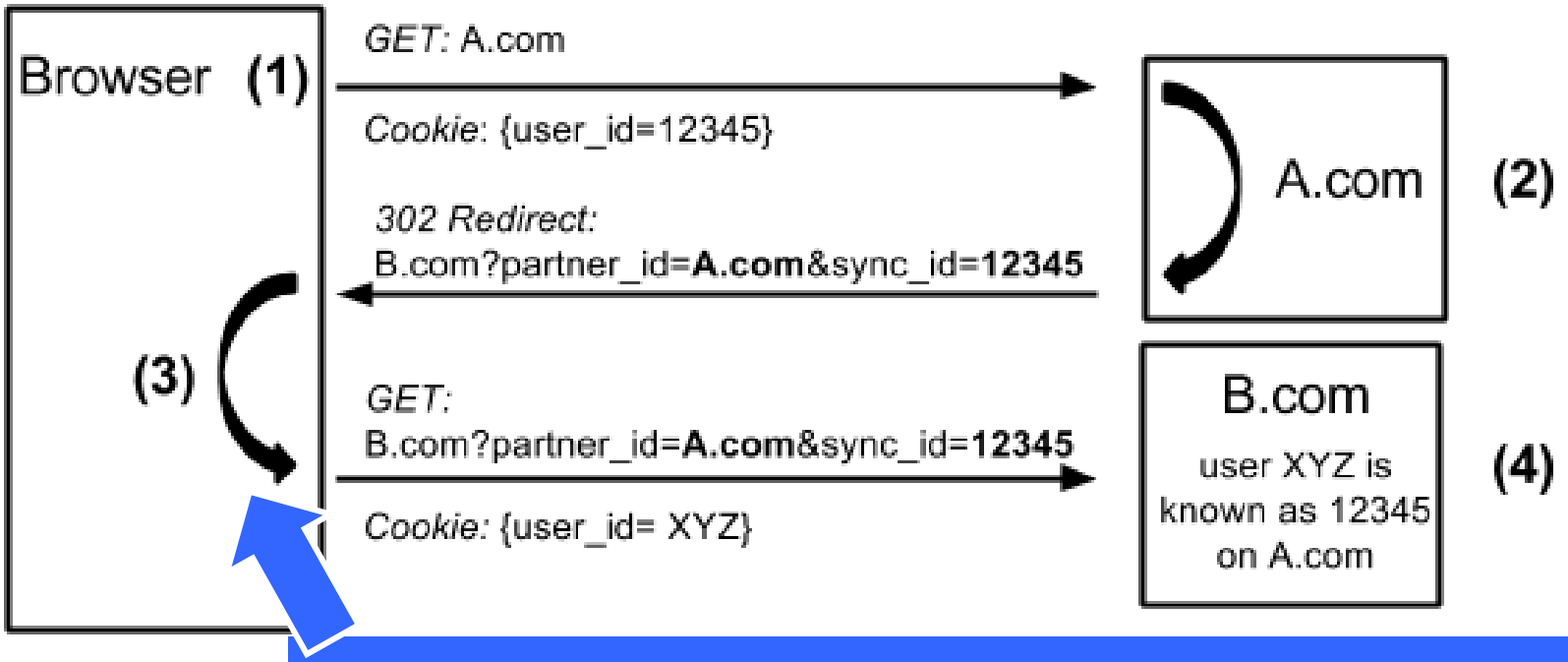
`ad.hi5.com = ad.yieldmanager.com`

Flash cookies 

Browser fingerprinting 

History sniffing

Cookie Syncing



Site A informing site B about user's identity (via user's browser)

Allows aggregation across multiple trackers

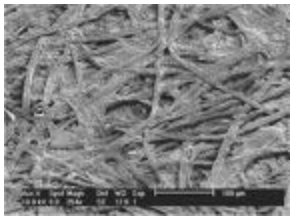
Tracking Technologies

- HTTP Cookies
- HTTP Auth
- HTTP Etags
- Content cache
- IE userData
- HTML5 protocol and content handlers
- HTML5 storage
- Flash cookies
- Silverlight storage
- TLS session ID & resume
- Browsing history
- window.name
- HTTP STS
- DNS cache

Everything Has a Fingerprint







Fingerprinting Web Browsers

- User agent
- HTTP ACCEPT headers
- Browser plug-ins
- MIME support
- Clock skew
- Installed fonts
- Cookies enabled?
- Browser add-ons
- Screen resolution


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
Your browser fingerprint appears to be unique among the 3,435,834 tested so far
web.
Only anonymous data will be collected by this site.
TEST ME
A paper reporting the statistical results of this experiment is now available: How Unique Is Your Browser?, Proceedings of the Privacy Enhancing Technologies Symposium (PETS 2010), Springer Lecture Notes in Computer Science.
Learn about Panopticlick and web tracking.
The Panopticlick Privacy Policy.
Learn about the Electronic Frontier Foundation.

Panopticlick Example

Plugin 0: Adobe Acrobat; Adobe Acrobat Plug-In Version 7.00 for Netscape; nppdf32.dll; (Acrobat Portable Document Format; application/pdf; pdf) (Acrobat Forms Data Format; application/vnd.fdf; fdf) (XML Version of Acrobat Forms Data Format; application/vnd.adobe.xfdf; xfdf) (Acrobat XML Data Package; application/vnd.adobe.xdp+xml; xdp) (Adobe FormFlow99 Data File; application/vnd.adobe.xfd+xml; xfd). Plugin 1: Adobe Acrobat; Adobe PDF Plug-In For Firefox and Netscape; nppdf32.dll; (Acrobat Portable Document Format; application/pdf; pdf) (Adobe PDF in XML Format; applicati Forms Data Fo f) (Acrobat XML Da d+xml; xfd). Plugin 2: in 3: MicrosoftA® Windows Media Player Firefox Plugin; np-mswmp; np-mswmp.dll; (np-mswmp; application/x-ms-wmp; *) (; application/asx; *) (; video/x-ms-asf-plugin; *) (; application/x-mplayer2; *) (; video/x-ms-asf; asf,asx,*) (; video/x-ms-wm; wm,*) (; audio/x-ms-wma; wma,*) (; audio/x-ms-wax; wax,*) (; video/x-ms-wmv; wmv,*) (; video/x-ms-wvx; wvx,*). Plugin 4: Move Media Player; npmnqmp 07103010; npmnqmp07103010.dll; (npmnqmp; application/x-vnd.moveplayer.qm; qmx,qpl) (npmnqmp; application/x-vnd.moveplay2.qm;) (npmnqmp; application/x-vnd.movenetworks.qm;). Plugin 5: Mozilla Default Plug-in; Default Plug-in; npnul32.dll; (Mozilla Default Plug-in; *; *). Plugin 6: Shockwave Flash; Shockwave Flash 10.0 r32; NPSWF32.dll; (Adobe Flash movie; application/x-shockwave-flash; swf) (FutureSplash movie; application/futuresplash; spl). Plugin 7: Windows Genuine Advantage; 1.7.0059.0; npLegitCheckPlugin.dll; (npLegitCheckPlugin; application/WGA-plugin; *).

84% of browser fingerprints are unique
With Flash or Java, 94% are unique

<CANVAS>

- Programmatic drawing in the browser
  - Draw shapes, add text, 3D (via WebGL)
- Access to drawn pixels
  - Array of RGBA values
  - PNG-encoded data URL

Text Rendering …

```
<script type="text/javascript">
  var canvas =
    document.getElementById("drawing");
  var context = canvas.getContext("2d");
  context.font = "18pt Arial";
  context.textBaseline = "top";
  context.fillText("Some letters", 2, 2);
</script>
```

… Text Inspection

```
<script type="text/javascript">
  var canvas =
    document.getElementById("drawing");
  var context = canvas.getContext("2d");
  context.font = "18pt Arial";
  context.textBaseline = "top";
  context.fillText("Some letters", 2, 2);

  var pixels =
    canvas.toDataURL("image/png");
</script>
```

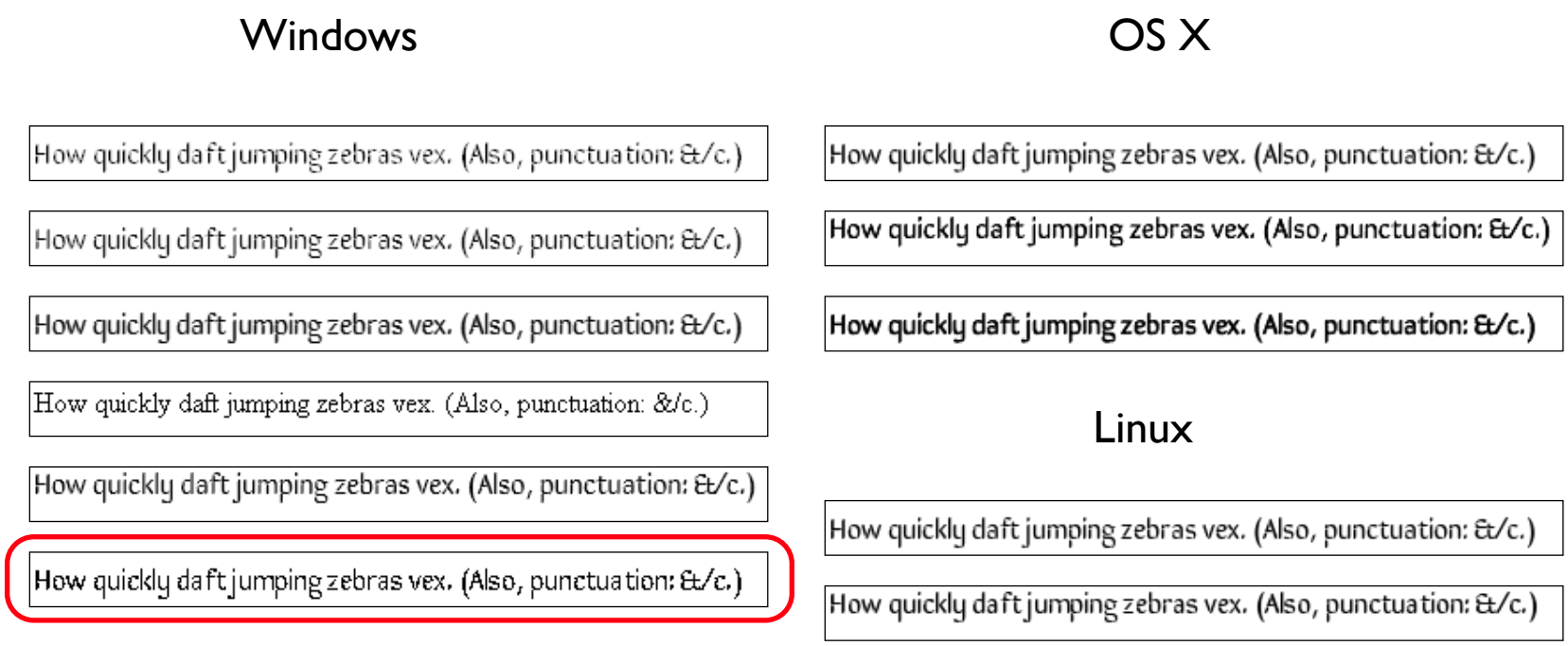
WebFonts

- Problem: Clients ship with ugly fonts
- Solution: Browsers should download fonts from the Internet on demand!

```
@font-face {  font-family: 'Sirin Stencil';
font-style: normal;  font-weight: 400;  src:
url(http://themes.googleusercontent.com/stat
ic/fonts/sirinstencil/v1/[...].woff)
format('woff');}
```

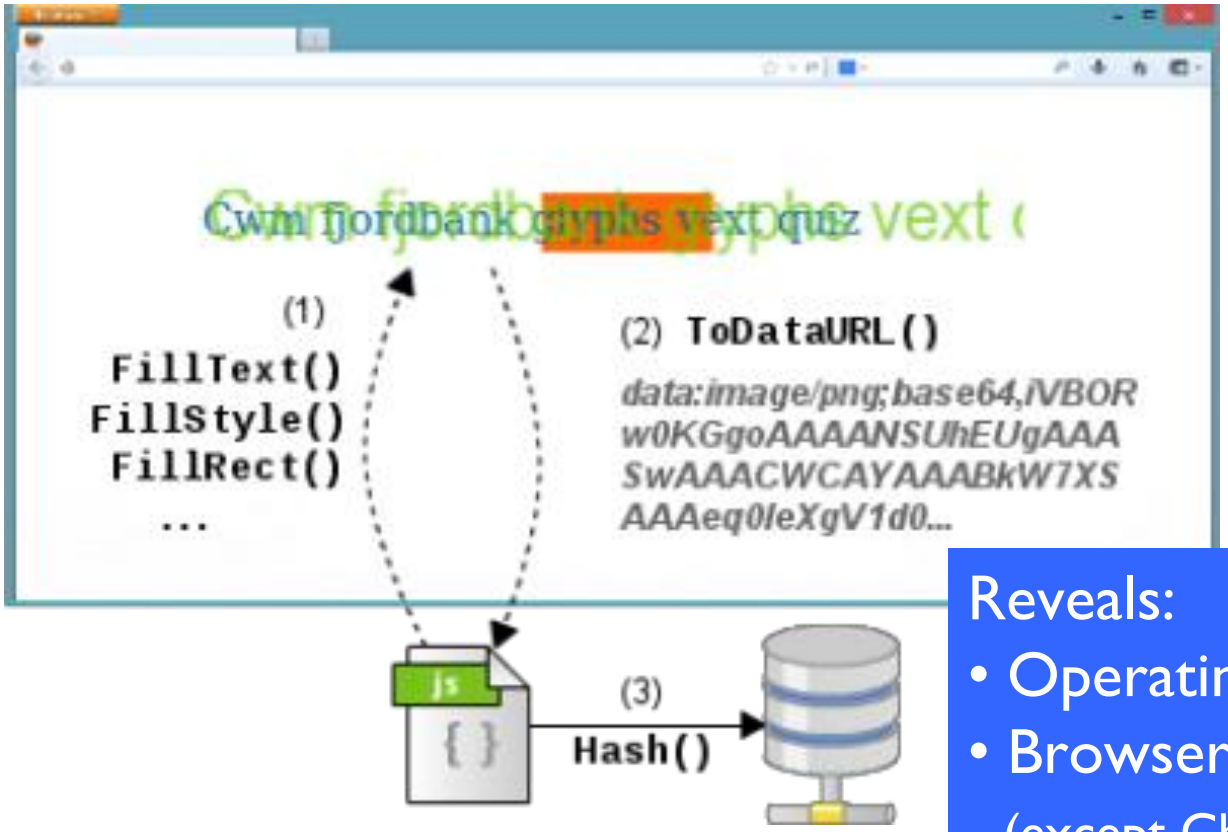
45 Ways To Sirin Stencil

```
context.font = "12pt 'Sirin Stencil'";
```



Canvas Fingerprinting Power

[Mowery and Shacham]



Reveals:

- Operating system family
- Browser family
  (except Chrome, Safari on OS X)
- Installed fonts
- Font smoothing parameters

How Pervasive?

[Acar et al. CCS 2014]

- Present in 5.5% of top 100,000 websites
- Fingerprinting code comes from 20 different domains
  - addthis.com by far the most popular (95%)

Draws
Cwm fjordbank glyphs vext quiz
into the canvas

Why this text?

"Don't Worry, It's All Anonymous"

- Is it?
- What's the difference between

  "anonymous"

  "pseudonymous"

  "identified"
- Which technology changed data collection from anonymous to pseudonymous?

How Websites Get Your Identity

Third party is sometimes the site itself

Leakage of identifiers

```
GET http://ad.doubleclick.net/adj/...
Referer: http://submit.SPORTS.com/...?email=jdoe@email.com
Cookie: id=35c192bcfe0000b1...
```

Security bugs

XSUH: cross-site URL hijacking

Third party buys your identity

Syphilis - NHS Choices

Syphilis - NHS Choices

http://www.nhs.uk/conditions/syphilis/pages/introduction.aspx

Google

Feedback

Home | About | Contact | Communities | Tools | Video | Choose and Book

Log in or create an account

NHS choices Your health, your choices

Enter a search term

Search

Health A-Z | Live Well | Carers Direct | Health news | Find and choose services

Syphilis

Share Save Easy print Like 5

Overview | Map of Medicine | Medicines Info | Clinical trials

Syphilis | Symptoms | Causes | Diagnosis | Treatment | Complications | Prevention

Introduction

Syphilis is a bacterial infection that is usually passed on through having sex with someone who is infected. It can also be passed from an infected mother to her unborn child and, in rare cases, can be caught through injecting drugs.

It is extremely rare to catch syphilis through a blood transfusion in the UK as blood donors are carefully screened.

Three stages of disease

Stage 1 (primary syphilis). Symptoms of syphilis begin with a painless but highly infectious sore on the genitals or sometimes around the mouth. If somebody else comes into close contact with the sore, typically during sexual contact, they can also become infected. The sore lasts two to six weeks before disappearing.

Stage 2 (secondary syphilis). Secondary symptoms, such as a skin rash and sore throat, then develop. These symptoms may disappear within a few weeks, after which you experience a latent (hidden) phase with no symptoms, which can last for years. After this, syphilis can progress to its third, most dangerous stage.

Stage 3 (tertiary syphilis). At this stage, it can cause serious damage to the body.

The primary and secondary stages are when you are most infectious to other people. In the latent phase (and usually around two years after becoming infected), syphilis cannot be passed onto others but can still cause symptoms.
See Symptoms of syphilis for more information on the

Useful links

NHS Choices links

Video: gay healthcare
Video: condom negotiation
Live Well: condoms
Live Well: drugs
Health A-Z: HIV and AIDS
Health A-Z: STIs
Find sexual health services
Infections you can catch through oral sex

External links

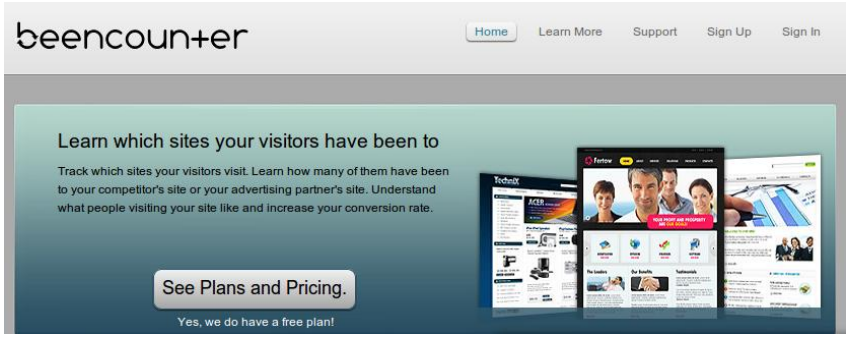
British Association for Sexual Health and HIV
Brook: for under-25s
FPA: sexual health
Health Protection Agency: syphilis
Lab Tests Online: syphilis test
Men's Health Forum

Screening and testing for gays and lesbians

Research shows that gay men and lesbians are less likely to have NHS screening and testing than heterosexuals. But it's important.

History Sniffing

How can a webpage figure out which sites you visited previously?



- Color of links
  - CSS :visited property
  - getComputedStyle()
- Cached Web content timing
- DNS timing

Identity Sniffing

[Wondracek et al. Oakland 2010]

- All social networking sites allow users to join groups
- Users typically join multiple groups
  - Some of these groups are public
- Group-specific URLs are predictable

```
http://www.facebook.com/group.php?gid=[groupID]&v=info&ref=nf+
https://www.xing.com/net/[groupID]/forums+
```

- Intersection of group affiliations acts as a fingerprint
  - Can sometimes infer identity by computing the intersection of group membership lists

One-Click Fraud

[Cristin et al. CCS 2010]

Thank you for your patronage! You successfully registered for our premium online services, at an incredible price of 50,000 JPY. Please promptly send your payment by bank transfer to ABC Ltd at Ginko Bank, Account 1234567. Questions? Please contact us at 080-1234-1234.

Your IP address is 10.1.2.3, you run Firefox 3.5 over Windows XP, and you are connecting from Tokyo.

Failure to send your payment promptly will force us to mail you a postcard reminder to your home address. Customers refusing to pay will be prosecuted to the fullest extent of the law. Once again, thank you for your patronage!

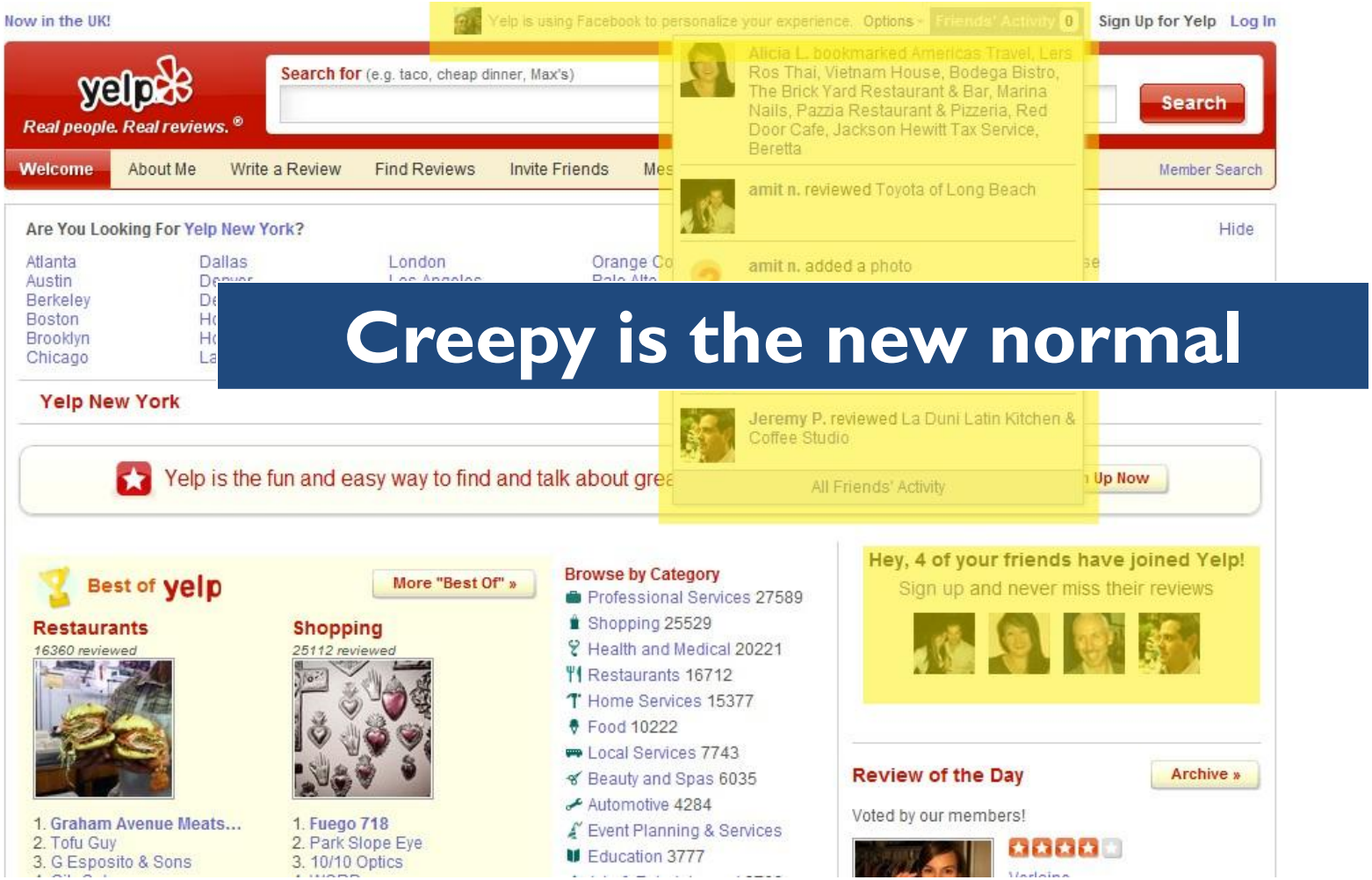
One-Click Fraud

- Estimated costs to victims:
  USD 260 million / year

- What's going on here?
- Why only Japan?
  - Cultural factors:
    susceptibility to authoritative language
    threat of public shaming

Credible because the website does have your real identity!

Instant Personalization



Creepy is the new normal

Do Not Track

Basics

HTTP header

- DNT: 1

Standardization

Browser support in FF4, IE9

Beginning to see adoption (AP, NAI)… or not

Privacy protections

No tracking across sites

- Who is the "third" party?

Can't be based on domain
Example: amazonaws.com, ad.hi5.com …

No intrusive tracking

Limits on regular log data

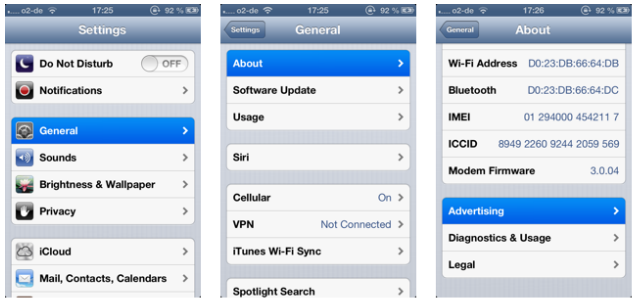
Exceptions for fraud prevention, etc.

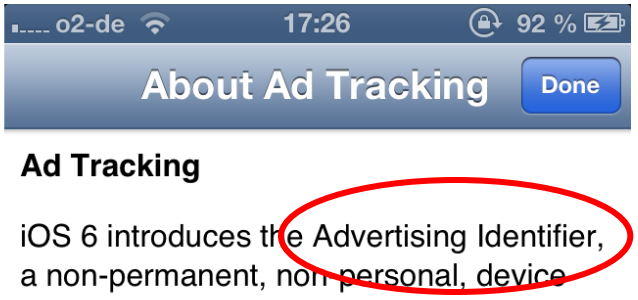
DNT Adoption Issues

"But the NAI code also recognizes that companies sometimes need to continue to collect data for operational reasons that are separate from ad targeting based on a user's online behavior. For example, online advertising companies may need to gather data to prove to advertisers that an ad has been delivered and should be paid for; to limit the number of times a user sees the same ad; or to prevent fraud."

Translation: we're going to keep tracking you, but we'll simply call it "operational reasons."

Brave New World?





How are these identifiers different from third-party cookies?