Brave, Fingerprinting and Privacy on the Web

Me (the early years)

- **Grew up in Chicago**
  …actual Chicago

- **Law school, then freelance web design**
  Started: Anchorage, AK
  Ended: Judge Judy Show invitation

- **PhD in Computer Science**
  University of Illinois at Chicago

Me, now

- **Privacy Researcher at Brave**
  Research to improve privacy in the browser

- **Co-Chair of PING**
  Privacy reviews of new web standards

- **Academic Collaborator**
  “Pure” research

Brave in a Slide

- Privacy focused
- Alternative funding model for the web
- Research and engineering focused
- Browsers and infrastructure now, more to come…

Overview

1. Why websites track (and how much)
2. “Classic” tracking
3. Fingerprinting / “passive tracking”
4. Fingerprinting counter measures
5. Anti-finger printing exercise
6. Privacy protections in Brave
7. Wrapping up

Overview

1. **Why websites track (and how much)**
2. “Classic” tracking
3. Fingerprinting / “passive tracking”
4. Fingerprinting counter measures
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6. Privacy protections in Brave
7. Wrapping up

Why Does Tracking Exist?

TAYLOR . . . big audition

Taylor's one-day mission

From JOHN ETHERIDGE

JAMES TAYLOR can prove he is up to being England's permanent one-day captain after getting chosen to lead the new generation.

The pint-sized batsman, 25, takes charge against Ireland on May 8 — the first 50-over match since the World Cup disaster.

Regular skipper Eoin Morgan misses the game to play in the IPL.

He had a nightmare World Cup and, if Taylor impresses, the selectors might switch. The most likely long-term prospect, though, is Joe Root.

Notts star Taylor said: "We must put the World Cup behind us — not ignore it but learn from it. This is a fresh start."

England's 11-man squad has five uncapped players: Kent keeper/batsman Sam Billings, Surrey all-rounder Zafar Ansari, Somerset seamer Lewis Gregory, Northants all-rounder David Willey and Hampshire batsman James Vince.

More players will be added after England pick their Third Test XI to face West Indies on Friday.

(ENGLAND (v Sri Lanka): Hales, Roy, Taylor (capt), Vince, Ansari, Bairstow (wk), Billings (wk), Brennan, Gregory, Willey, Finn.

Kid Dan's ton of fun

TEENAGER Dan Lawrence upstaged Kevin Pietersen by becoming one of county cricket's youngest century-makers.

The 17-year-old hit 161 in only his second first-class fixture as Essex racked up 610-8 against Surrey at The Oval.

Kent's Godfrey Bryan in 1920 and Dipak Patel for Worcestershire in 1976 are believed to have hit tons when younger than Lawrence, whose previous highest score was ten.

KP was eight not out as Surrey trailed by 175 runs in their second innings.

Lee: Oui will return

By JONNY FORDHAM

LEE DICKSON believes English rugby can wrestle back control from teams across the Chanel.

A French invasion takes place at Twickenham on Saturday as Clermont face Toulon in the European Champions Cup final.

Dickson's Premiership leaders Northampton were KO'd by Clermont. But the England scrum-half, 30, said: "We will be back.

"In the past we have beaten the big French teams — and Wasps nearly turned Toulon over."

Captaincy is wrong Root

IT WOULD BE A ROAD TO RUIN

SMOKIN' JOE . . . Root is red-hot

Graeme Swann

OUR COLUMNISTS ARE THE TALK OF SPORT

JOE ROOT has become a world-class batsman, averaging more than 100 in Test cricket in the past year.

But to make him England captain any time in the next five years would be a disaster. I think it would ruin him as a batsman.

Like a few players before him, Joe has been handed the mantle of FEC – Future England Captain.

Everyone expects it to happen and I've little doubt he will lead England at some point. But I hope and pray it doesn't happen for at least five years, by which time he will be only 29.

In fact, I'm not sure Joe will ever be a good captain because it just doesn't suit his character.

Joe has a natural cheeky chappy personality – he's a joker, a jester, a wind-up merchant and a general breath of fresh air around the dressing room.

To be captain, he would need to change and become more mature and perhaps even feign gravitas. That simply is not Joe.

Of course, there is no vacancy at the moment anyway because Alastair Cook is doing a fine job now he is back concentrating on Test cricket. Cooky won't still be captain in five years' time but please don't give the job to Joe.

Just let Joe Root bat at No3 and score hundred after hundred. He can be England's Steve Waugh. So don't think about moving him up the order, either.

I love the way Joe handles himself on the field. He has this angelic face and looks as though butter wouldn't melt in his mouth. He's at his best when chatting away, taking the mickey and behaving like your annoying little brother.

He doesn't really sledge. It would be like being sledged by a baby because of the way he looks. Nobody could take him seriously.

Joe is great at smiling to take the heat out of situations. There's nothing more annoying for a steaming, sweating Neanderthal fast bowler than having some kid smiling and winking back at him.

But don't be fooled – Joe has a streak of steel, too. You don't score eight international centuries in the past 14 months without being a tough cookie.

The key to Rooty's success is he discovered the secret of Test cricket very early.

The ball is the same size, the pitch the same length, the bowlers the same as you've played against in county cricket. Joe realised the only big difference is how you think about the game with the pressure, the spotlight and TV coverage.

It is a mental thing, what goes on inside your head. And Joe's head is full of calmness, confidence and positive thoughts right now.

It was obvious right from the start that Joe had great talent and temperament.

He went on the tour to India in late 2012 as a back-up batsman and forced his way into the final Test in Nagpur.

He scored 73 and looked certain to make a debut century.

I was batting with him when he was out and accept some of the blame.

I kept trying to hit the spinners over the top, then Joe tried something similar and was caught and bowled.

Joe has certainly cashed in since and his last five Test centuries have been 180, 200 not out, 154 not out, 149 not out and 182 not out. Daddy hundreds, as Graham Gooch calls them. The best thing about Joe's batting is the energy he brings to the crease.

He walks in like an excited puppy, playing 100 shots before he's ten yards on to the outfield.

He has positive intent and urgency from the start and it normally perks up the rest of the team.

Every other batsman in the Second Test in Grenada struggled to score at a strike-rate of 50 runs per 100 balls but Joe rattled off 182 not out from 229 balls.

I tend to watch the way batsmen play spin bowling and Joe always looks to attack against spin.

A lot of batsmen wait for a rank bad ball before attacking.

So Joe forces spinners to bowl more loose stuff, especially a wrist-spinner like Devendra Bishoo. He played Bishoo magnificently.

I'm calling Joe the new Geoffrey Boycott – the Yorkshireman who scores all the runs and runs everyone out. I even think some of the lads have started calling him Geoffrey.

He was involved in three run outs in Grenada but only one was his fault – the one when he barbecued Chris Jordan.

The Jimmy Anderson run out was hilarious because nobody has the right to pluck a ball from the air that's about 15 feet from the ground.

But Jason Holder did and dozy old Jimmy was way short of his ground.

Apparently, Holder's brother plays basketball in the States!

After the game, Rooty handed over a stump to Jimmy, pretending it was a white stick.

That's the sort of cheeky fun we like from Joe Root.

MAY THE SAUCE BE WITH YOU

ALL ROOTS lead to the cricket! England batsman Joe Root met up with super sauce maker Lewi Roots ahead of the Third Test against West Indies in Barbados on Friday. Let's hope it's a spicy affair.

BRIGHTON'S summer transfer policy may have to take a hit after chairman Tony Bloom's bet of misfortune. The Seagulls supremo placed £13,000 on himself to finish the Brighton Marathon in no more than 3hr 45 min — only to cross the line four minutes and 38 seconds later.

VIEW TO A DILL

ANDREW DILLON

Cough not that Good

EVERTON is known as the school of science but they have been turning their hands to amateur dramatics too.

Reporters were gathered to interview Gareth Barry when the subject of team-mate Ross Barkley inevitably surfaced seeing as he is the **ONLY** interesting topic of conversation at Goodison Park.

As soon as Barkley's name was mentioned, the club's subtle press officer came out with an outrageously staged cough – as in 'be careful here mate, tricky subject coming up'.

But the carefully-managed plan to thwart the nasty hacks backfired when the entire group fell silent and he was presented with a packet of throat lozenges at the next press conference.

Ooh, suits you Shaun

SHAUN MURPHY'S garish suits have been dazzling fans, TV crews and players at snooker's world championship.

But spokesman for tournament sponsors Betfred, Mark 'Stuart' Pearson, told VTAD: "Every time we sponsor a horserace we give a prize for the best-dressed nag, taking into account coat, condition and colours. It's similar with Shaun. Murphy will thus be given a cheque for the Royal Manchester Children's Hospital.

A 'Parker' can cut it

SOMETHING for the weekend, sir?

Traditional barber's shops would always offer extras to gentleman patrons to keep them safe while enjoying the company of others on a Saturday night.

The latest marketing trend is the 'pop-up' shop and this one in South West London offered customers the chance to have their hair cut in the style of Fulham captain Scott Parker.

Well, let's be honest. Those Fulham supporters have more chance of getting a s**g than seeing their team win on Saturday.

WORLD SNOOKER

BAD TABLE MANNERS . . . Ronnie puts his chalk down

CHALK OF SHAME

O'Sullivan in dust-up

RONNIE O'SULLIVAN is caught in a World Snooker probe after breaking the rules in his quarter-final clash with Stuart Bingham.

By HARRY TALBOT

The five-time world champ placed his chalk on the table to line up a shot but was **NOT** reprimanded by referee Terry Camilleri.

The official should have called a foul and awarded Bingham seven points, but the Rocket was allowed to continue his break and won the fifth frame to lead 3-2.

Rule 3 (d) ii states a seven-point penalty will be awarded if a player "uses any object to measure gaps or distance".

Former world champion Ken Doherty said: "You are not allowed to put chalk on the table because you are using it as a tool to measure the ball.

"That is exactly what Ronnie has done. Stuart Bingham was looking at him and should really be aware.

"If he had more knowledge of rules, he would have jumped out of his chair.

"The referee is unaware, Ronnie is too but for me, that is a foul. You are not allowed to do that."

Former referee Michaela Tabb tweeted: "Chalkgate . . . Foul seven. I don't have Terry's opinion though, he may have seen it differently. Also the Crucible is the hardest venue to ref in."

It is the latest controversy surrounding 29-year-old O'Sullivan in this year's tournament.

He escaped a fine after briefly playing in his socks during his first round win over Craig Steadman and came close to snapping his cue in fit of rage against Matthew Stevens in round two.

More recently O'Sullivan, 39, has taken a shine to boxing and even begun sparring.

And snooker's box-office star is well aware of the riches earned by those in the ring. He said: "Boxing is pay-per-view and if snooker was like that, I would be able to command and dictate more."

JUDD HEA-DING THROUGH

TRUMP . . . on a roll

JUDD TRUMP put China's No1 Ding Junhui to the sword as he moved to within a frame of the Crucible semi-finals.

The Juddernaut leads world No3 Ding 12-4 to take another massive stride towards his first world title.

After his best season that has seen titles in Australia and at the World Grand Prix in Llandudno, 25-year-old Trump rattled in breaks of 54, 82, 94, 108, 76, 100, 55, 127 and 111 to leave Ding in a daze.

NEIL ROBERTSON faces a fight to make the last four as he lost four frames on the spin to trail Barry Hawkins 5-3.

In the final quarter-final, SHAUN MURPHY leads Anthony McGill 9-7 after winning the final three frames of last night's session.

£30m CUP DEAL

From Back Page

144-year history that full naming rights have been granted.

US drinks giant Budweiser – who paid £8m a year merely to be "in association with" the trophy FA Cup – ended their three-year partnership last year.

But the Emirates deal is a complete rebranding that will upset the purists.

Lawrie McMenemy, who guided Second Division Southampton to [illegible] Cup triumph over Manchester United in 1976, quipped: "It's the one and only, it's **THE** FA Cup and it would be a pity to see it lose that tradition, not just in our game but in the game worldwide. It was the biggest and the best. But football today is solely about money, money, money."

McMenemy *(above)* added: "I would have thought there was enough money circulating in football in TV rights to avoid this. Football is about history and tradition. Our Cup was different. No other country had anything to compare with it."

Football fans also took to Twitter last night, calling the deal "awful", "horrible" and "bull-dozing over football".

With this year's competition not having a sponsor, FA commercial director Stuart Turner and his team have had to offer full naming rights to secure a new £30m-a-year deal.

During [illegible] Emirates – sponsors of current Cup holders Arsenal's shirts and kit – made their move about doubling a £30m-a-year relationship with the FA.

An FA spokesman admitted: "We continue to have discussions with a number of parties about FA Cup partner opportunities."


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THE WEEKND
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HELL ON WHEELS
BUST IT EVERY TIME
AMERICA'S 100 GREATEST COURSES+
GLAMOUR
WOMEN
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SUBSCRIPTIONS!

Welcome the The "First" Banner Ad

Yes, this site is supposed to look this way. After all, this is what most web pages looked like back on October 27, 1994 -- the day that Wired Magazine flipped the switch on its first website, hotwired.com, starting a revolution in web content and advertising that still reverberates today.

This site is dedicated to showing off one of the ads that ran on that site. No, it wasn't the "first" as there were a handful of other ads that ran on various sections of hotwired.com. This site is also here to tell the story of how that ad came to be, how it succeeded beyond anything we had imagined, and how we tried to set an example for how corporations could communicate with their audiences.

This site launched on October 27, 2014. It is being constantly updated, so please check back again soon for more. In the meantime, get started by clicking your mouse in the banner ad above explore these other options:


Disney Lover's
Web Ring
Previous | Next | Random | List Sites

Chicago Tribune: Chicago news,

chicagotribune.com

SECTIONS SEARCH ENEWSPAPER WEATHER NEWSLETTERS BEST REVIEWS $2 FOR 20 WEEKS SALE ENDS 11/4 LOG IN

CPS STRIKE IS OFFICIALLY ON AS CHICAGO TEACHERS UNION SAYS THERE IS NO LAST-MINUTE DEAL

TOP LOCAL NEWS SOURCE

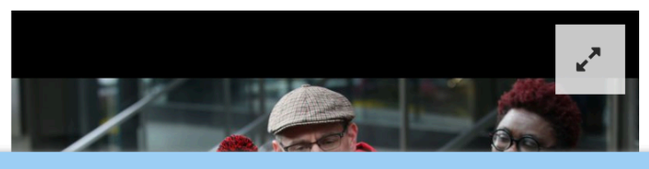
Chicago Tribune

OCTOBER 16, 2019

51°F

BREAKING NEWS SPORTS BUSINESS POLITICS OPINION ENTERTAINMENT

CPS STRIKE IS ON



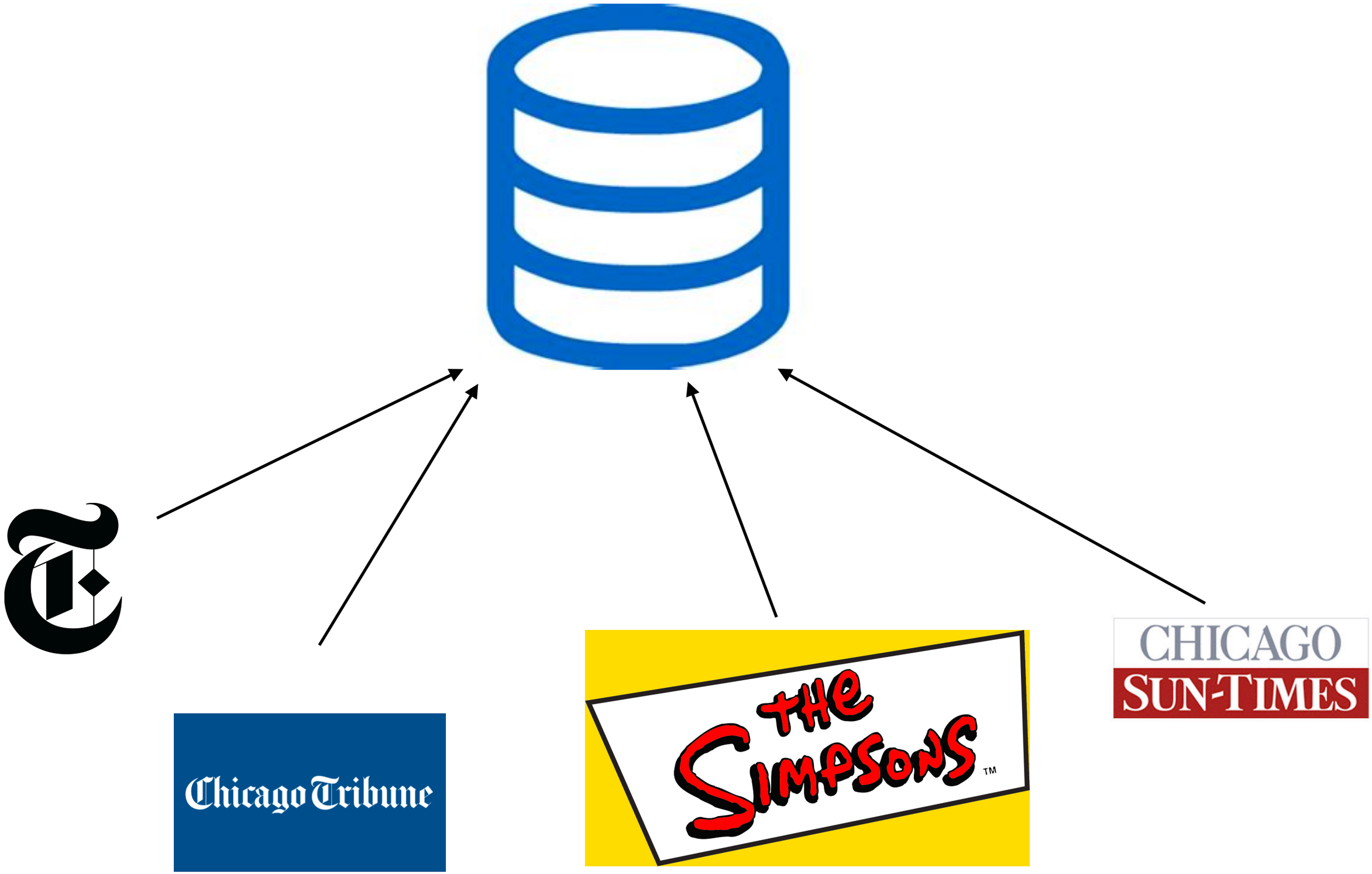
CPS strike is officially on as teachers union, Chicago

MORE CPS STRIKE COVERAGE

CPS strike live updates: Chicago teachers reject city offer, will walk off job Thursday

Chicago Park District workers reach contract

Waiting for securepubads.g.doubleclick.net...


Chicago Tribune
THE SIMPSONS
CHICAGO
SUN-TIMES

The World's Worst Website

Gratuitous use of frames is a common mistake of web designers.

Many older browsers do not support frames. They disrupt the flow of the website and can be difficult to anticipate where a page may appear when a link is clicked. Click here for an example of a frames page which is opening in the wrong window. Use your browser's 'Back' button to escape.

Check out these links to websites whose opinions about frames is self evident:

The "I Hate Frames" Frames Page

Another I Hate Frames Page

The International I Hate Frames Club

Why Frames Suck (Most of the Time)

site!

Welcome to the World's Worst Website!

This web was designed to graphically demonstrate the most common mistakes made by new Web Page designers.

Where am I and where are the links to other pages?

An easy to use navigation structure is essential to any well designed website! Important information should never be more than 2 clicks away.

As you can see, this text is difficult to read. There needs to more contrast between the background color and the text color. **Here's another example** of a poor choice of a background/ text color and size.

Keep your backgrounds simple. White or light colors usually work best. Your background should not compete with the content of the page for the users attention. If you would like to use a background picture, select a picture that uses muted colors or format your picture as a watermark. Select text colors which will contrast well with the background picture.

Constantly running animations can be distracting when used excessively.

Chicago Tribune

CHICAGO SUN-TIMES

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Chicago Tribune

CHICAGO SUN-TIMES

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Chicago Tribune

CHICAGO SUN-TIMES

The New York Times

BREITBART

Identify “expensive” people here

Pay a little to advertise to them here

How Target Figured Out A Te

www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/

Kashmir Hill, Forbes Staff
Welcome to The Not-So Private Parts where technology & privacy collide
+ Follow (1,089) Follow 174k

TECH | 2/16/2012 @ 11:02AM | 1,913,626 views

How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did

307 comments, 167 called-out + Comment Now + Follow Comments

Every time you go shopping, you share intimate details about your consumption patterns with retailers. And many of those retailers are studying those details to figure out what you like, what you need, and which coupons are most likely to make you happy. Target, for example, has figured out how to data-mine its way into your womb, to figure out whether you have a baby on the way long before you need to start buying diapers.

DISPLAY LUMAscape

MARKETER

Agencies
- OmnicomGroup
- WPP
- PUBLICIS
- IPG Interpublic Group
- HAVAS
- AEGIS
- MDC PARTNERS
- AKQA
- LBi
- ROSETTA
- epsilon
- iCrossing
- InnovationINTERACTIVE
- MERKLE
- camelot
- Mediasmith
- at&t Interactive
- yodle
- ReachLocal
- WebVisible

Agency Trading Desks
- Accuen The Trading Desk
- XAXIS
- m!g
- ViVAKi
- CADREON
- RUN adnetik
- accordantmedia
- VARICKMEDIA

DSPs
- MediaMath
- invitemedia
- TURN
- DataXu
- EfficientFrontier
- TRIGGIT
- thetradedesk
- AdBuyer.com
- BRANDSCREEN
- adz

appnexus

Exchanges
- doubleclick by Google
- rightmedia a YAHOO! company
- ADECN
- OpenX
- adjug
- casalex
- adBrite
- OPERA software
- mobclix

Ad Networks Horizontal
- YAHOO!
- Google
- Tribal FUSION
- 5:1
- Microsoft Media Network
- Aol.
- cpx interactive
- 247 REALMEDIA
- audience network
- ValueClick
- ADTEGRITY.COM
- Undertone
- Brand.net
- BurstMedia
- UNDERDOG Media
- Casale MEDIA
- SOLVE media
- xertive media
- AdDynamix
- traffic marketplace

Video / Rich Media
- SAY:
- TREMOR VIDEO
- videology
- YuMe
- BBE
- TubeMogul
- BrightRoll
- spotXchange
- adQtube
- meebo
- BREAK MEDIA
- adconion MEDIA GROUP
- ScanScout
- OGGIFINOGI
- Jambo Media

Vertical / Custom
- ravora
- Sportgenic
- LONGBOARD MEDIA
- ADiFY
- GORILLA NATION
- NetShelter Technology Media
- RGM ALLIANCE
- GourmetAds
- jumpSTART
- martini media
- Glam
- Q1Media
- InflectionPointMedia
- IDGTechNetwork
- SOJERN
- Ideas People
- TonsFuse
- intergi ENTERTAINMENT
- Technorati
- FEDERATED MEDIA

Targeted Networks / AMPs
- NetSeer
- peer39
- CONTEXTWEB
- pulse360
- media6degrees
- specificmedia
- lucidmedia
- 33across
- radium one
- XTEND
- resonate networks
- XGRAPH
- Adblade
- OwnerIQ
- svnetwork
- rocketfuel
- Audience Science
- collective
- interclick

Performance
- epic ADVERTISING
- MATOMY MEDIA GROUP
- VANTAGE MEDIA PERFORMANCE SEARCH TECHNOLOGY
- VIBRANT
- adknowledge
- commission junction
- Kontera
- moxy media
- MARCHEX
- neverblue
- LinkShare
- ADTERACTIVE TRUSTED INTERNET LEAD GENERATION
- Datran Media
- hydra
- Tatto Media
- TheUseful
- MediaTrust

Mobile
- admob
- pontiflex
- mojiva
- Jumptap
- transpera
- millennialmedia Mobile. Delivered.
- GREYSTRIPE
- InMobi
- Quattro WIRELESS
- rhythm

Media Mgmt Systems
- DDS
- mediaXL
- telmar
- centro
- MEDIABANK
- facilitate DIGITAL
- TRAFFIQ

Ad Operations
- operative.
- theorem
- Solbright
- SHINY ADS
- AdPro

Sharing Data / Social Tools
- facebook
- ShareThis
- clearspring
- tynt
- gigya

SSPs
- Admeld
- rubicon PROJECT
- PubMatic
- ReviNet
- LIFTDNA

Publisher Tools
- Yieldex
- fatTail
- ShortTail
- Lijit
- DailyMe
- YieldBuild
- yieldbot
- BuzzFeed
- scout analytics
- isocket
- Mochila THE MEDIA MARKETPLACE
- daylife
- PerfectMarket Content Matters
- METAMARKETS
- MAXIFIER
- outbrain
- Jump Time

Ad Servers
- doubleclick by Google
- 247 REALMEDIA
- apt from YAHOO!
- LiveIntent
- BLOOM DIGITAL PLATFORMS
- ADTECH
- ZEDO
- OpenX
- AdJuggler
- Adzerk
- aiMatch ad intelligence

PUBLISHER

CONSUMER

Retargeting
- dotomi
- criteo
- TellApart
- Simplifi STEELHOUSE
- Chango
- FetchBack
- buysight
- crosspixelmedia
- ReTargeter
- AdRoll
- myThings
- MAGNETIC
- mediaFORGE

Creative Optimization
- iteracent
- TUMRI
- adroit
- dapper
- struq
- choiceStream
- MIXPO
- flashtalking
- snapads
- adacado
- STEELHOUSE
- ipromote
- DYNAMIC VIDEO
- spongecell
- CERTONA
- AdReady
- richrelevance
- ADISN

Media Planning and Attribution
- MarketShare
- COGNITIVE MATCH
- NETWORKED INSIGHTS
- M FACTOR
- pulsepoint
- visualIQ
- C3 Metrics
- convertro
- Encore
- ThinkVine
- COVARIO
- ADCHEMY
- Korrelate

Tag Mgmt
- TagMan
- ENSIGHTEN
- TEALIUM
- BRIGHT TAG

Measurement and Analytics
- OMNITURE
- unica
- Core metrics
- tracksimple
- webtrends
- vizu
- nielsen
- FLURRY
- comScore
- biscience
- aprimo

DMPs and Data Aggregators
- bluekai
- x+1
- akamai
- Demdex
- exelate
- quantcast
- brilig
- bizo
- LOTAME
- JovianDATA
- krux DIGITAL
- Red Aril
- AlmondNet
- RapLeaf
- LeGOlas
- proximic
- PEER39
- acerno

Data Suppliers
- Experian
- ACXIOM
- datalogix
- QUOVA
- TARGUSinfo
- eBureau
- NETEZZA
- where
- IXI
- bluecava
- V12 group
- infogroup
- SymphonyIRIGroup

Ad Servers
- doubleclick by Google
- atlas
- Mediaplex
- mediamind
- pictela
- DG
- adform
- BLOOM DIGITAL PLATFORMS
- pointroll
- eyeWONDER
- FLITE

Verification / Privacy
- DoubleVerify
- adsafe
- ANCHOR intelligence
- ADXPOSE
- Ad-Juster
- adometry
- The Media Trust
- TRUSTe
- privacychoice
- EVIDON

LUMA partners

Denotes acquired company

But how much…

Online Tracking:
A 1-million-site Measurement and Analysis

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ABSTRACT

We present the largest and most detailed measurement of online tracking conducted to date, based on a crawl of the top 1 million websites. We make 15 types of measurements on each site, including stateful (cookie-based) and stateless (fingerprinting-based) tracking, the effect of browser privacy tools, and the exchange of tracking data between different sites ("cookie syncing"). Our findings include multiple sophisticated fingerprinting techniques never before measured in the wild.

This measurement is made possible by our open-source web privacy measurement tool, OpenWPM[1], which uses an automated version of a full-fledged consumer browser. It supports parallelism for speed and scale, automatic recovery from failures of the underlying browser, and comprehensive browser instrumentation. We demonstrate our platform's strength in enabling researchers to rapidly detect, quantify, and characterize emerging online tracking behaviors.

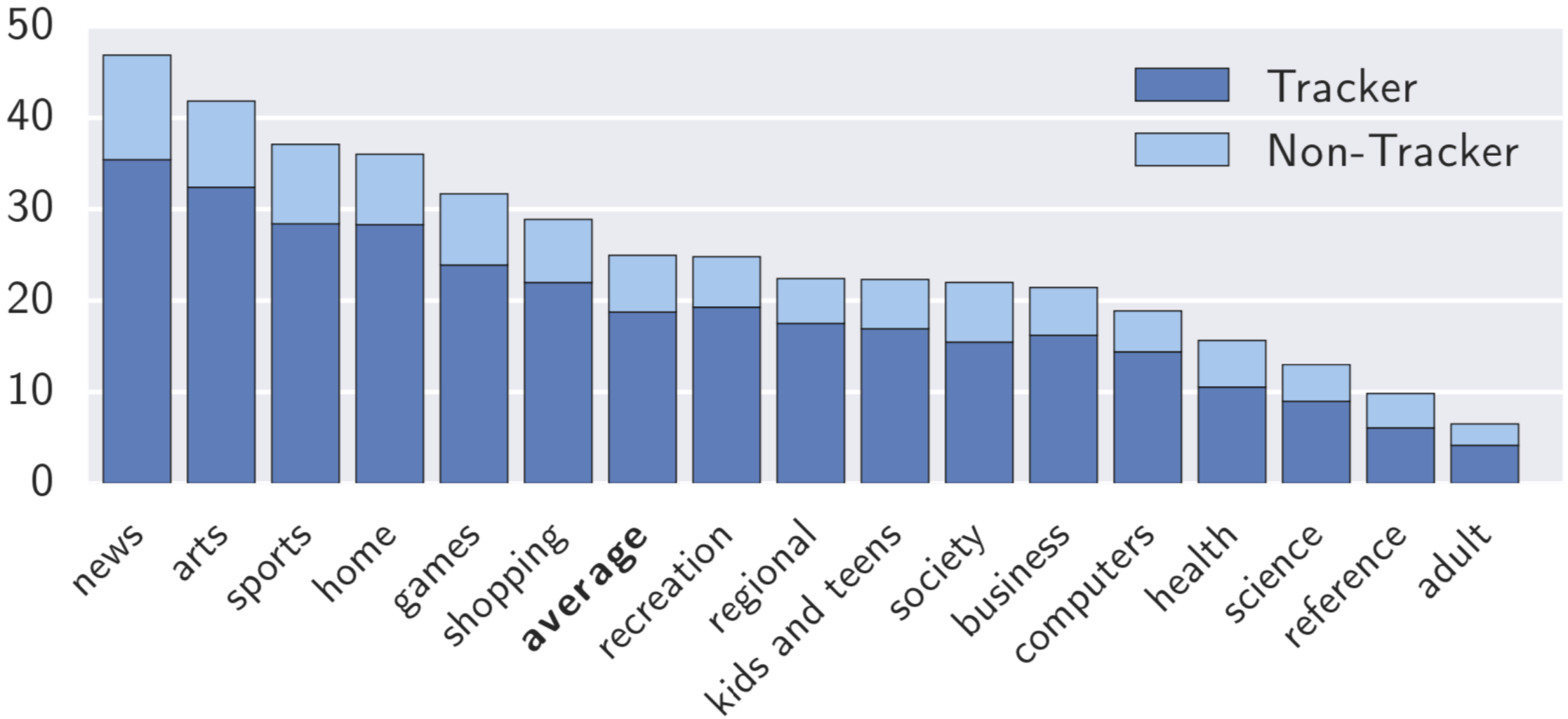
1. INTRODUCTION

Web privacy measurement — observing websites and services to detect, characterize and quantify privacy-impacting behaviors — has repeatedly forced companies to improve

to resort to a stripped-down browser [31] (a limitation we explore in detail in Section 3.3). (2) We provide comprehensive instrumentation by expanding on the rich browser extension instrumentation of FourthParty [33], without requiring the researcher to write their own automation code. (3) We reduce duplication of work by providing a modular architecture to enable code re-use between studies.

Solving these problems is hard because the web is not designed for automation or instrumentation. Selenium,[2] the main tool for automated browsing through a full-fledged browser, is intended for developers to test their *own* websites. As a result it performs poorly on websites not controlled by the user and breaks frequently if used for large-scale measurements. Browsers themselves tend to suffer memory leaks over long sessions. In addition, *instrumenting* the browser to collect a variety of data for later analysis presents formidable challenges. For full coverage, we've found it necessary to have three separate measurement points: a network proxy, a browser extension, and a disk state monitor. Further, we must link data collected from these disparate points into a uniform schema, duplicating much of the browser's own internal logic in parsing traffic.

A large-scale view of web tracking and privacy.
In this paper we report results from a January 2016 mea-


50
40
30
20
10
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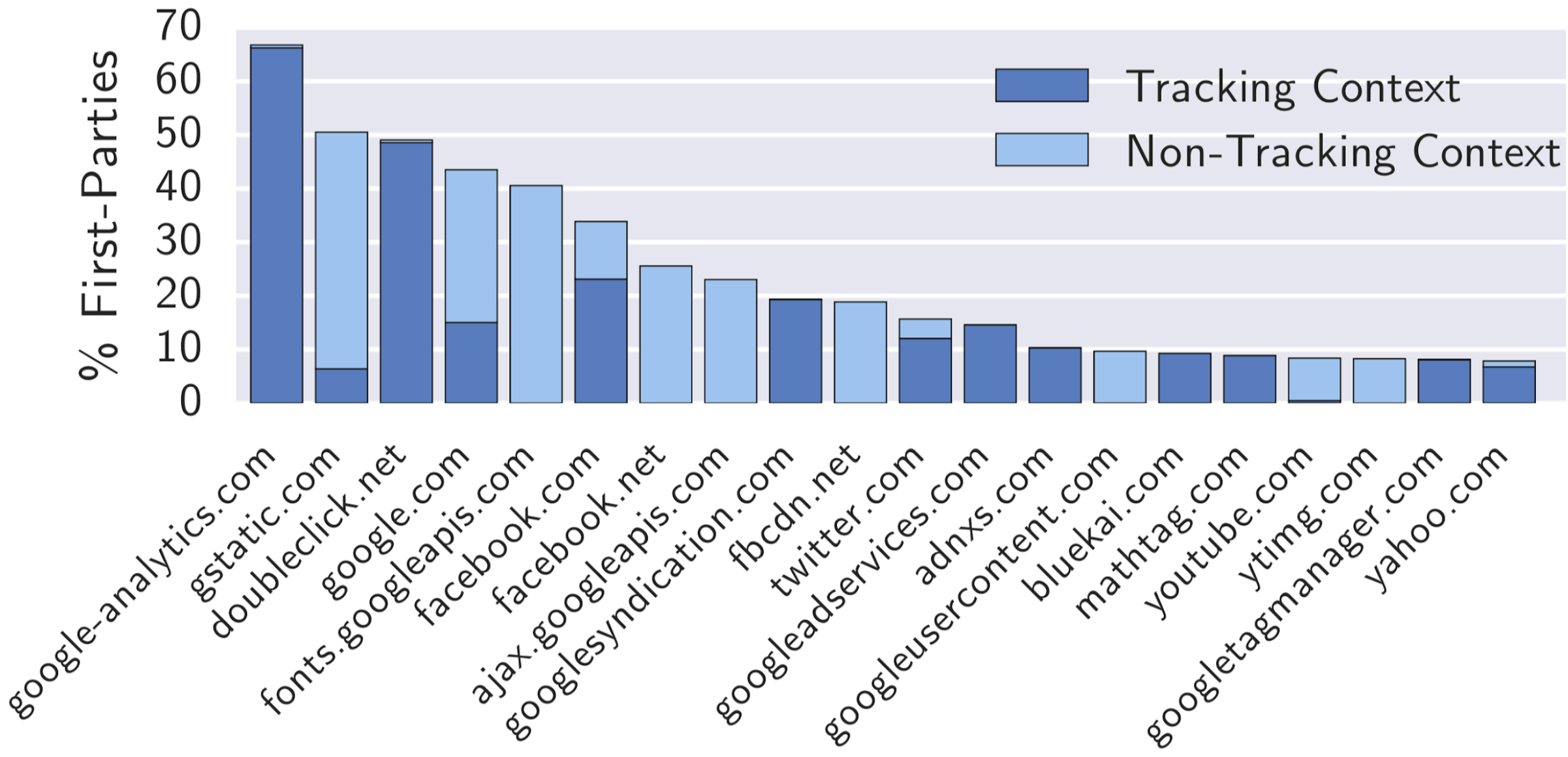
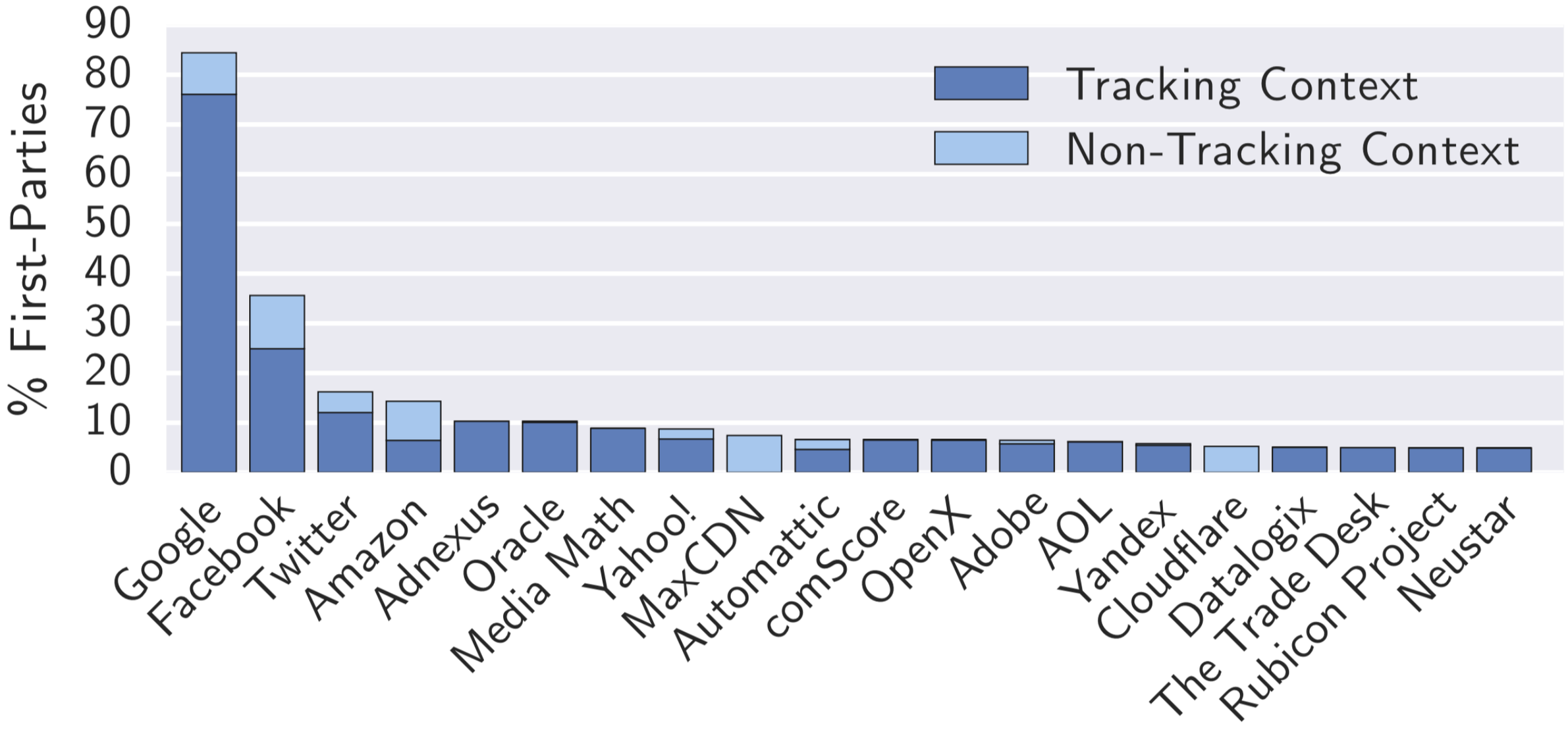
Tracker
Non-Tracker
news
arts
sports
home
games
shopping
average
recreation
regional
kids and teens
society
business
computers
health
science
reference
adult


% First-Parties
70
60
50
40
30
20
10
0
Tracking Context
Non-Tracking Context
google-analytics.com
gstatic.com
doubleclick.net
google.com
fonts.googleapis.com
facebook.com
facebook.net
ajax.googleapis.com
googlesyndication.com
fbcdn.net
twitter.com
googleadservices.com
adnxs.com
googleusercontent.com
bluekai.com
mathtag.com
youtube.com
ytimg.com
googletagmanager.com
yahoo.com


% First-Parties
90
80
70
60
50
40
30
20
10
0
Tracking Context
Non-Tracking Context
Google
Facebook
Twitter
Amazon
Adnexus
Oracle
Media Math
Yahoo!
MaxCDN
Automattic
comScore
OpenX
Adobe
AOL
Yandex
Cloudflare
Datalogix
The Trade Desk
Rubicon Project
Neustar

But how much…

a lot / too much

Overview

1. Why websites track
2. **“Classic” tracking**
3. Fingerprinting / “passive tracking”
4. Fingerprinting counter measures
5. Anti-finger printing exercise
6. Privacy protections in Brave
7. Wrapping up

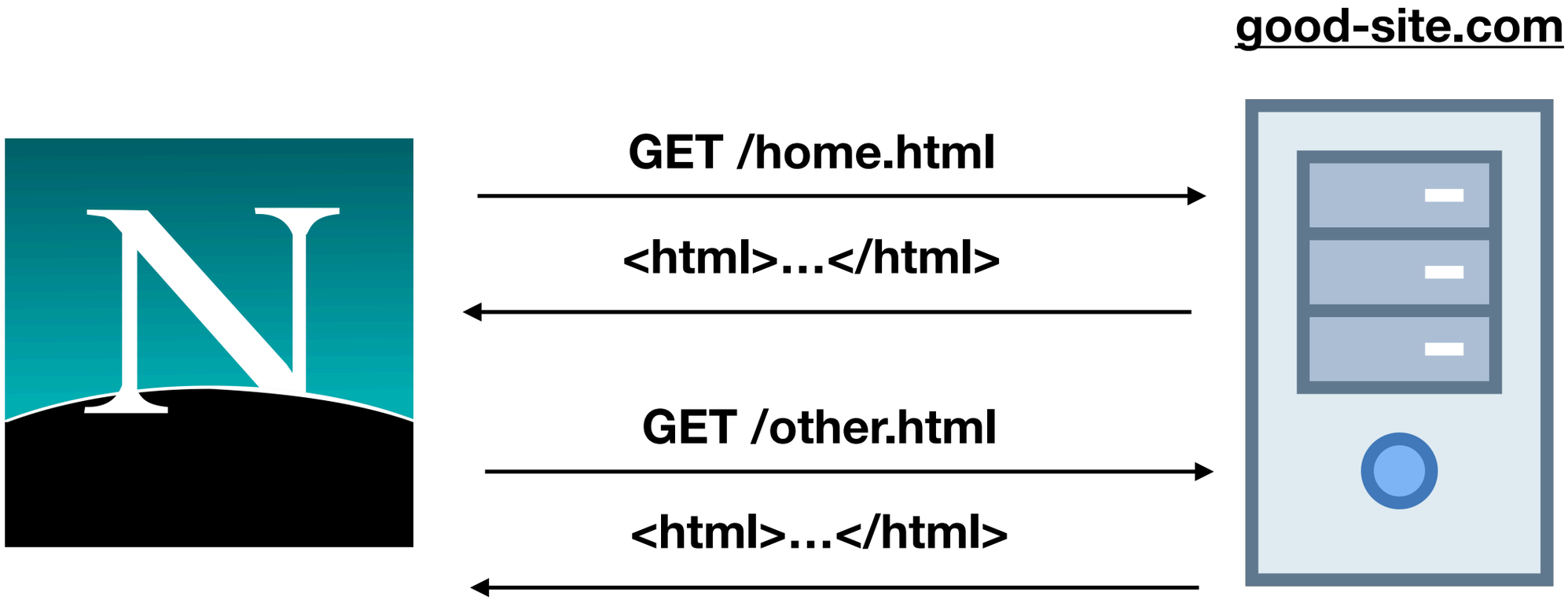
- Javascript
- DOM / Initial Web API
- Netscape
- Firefox
- Brave + BAT

Web 0.0

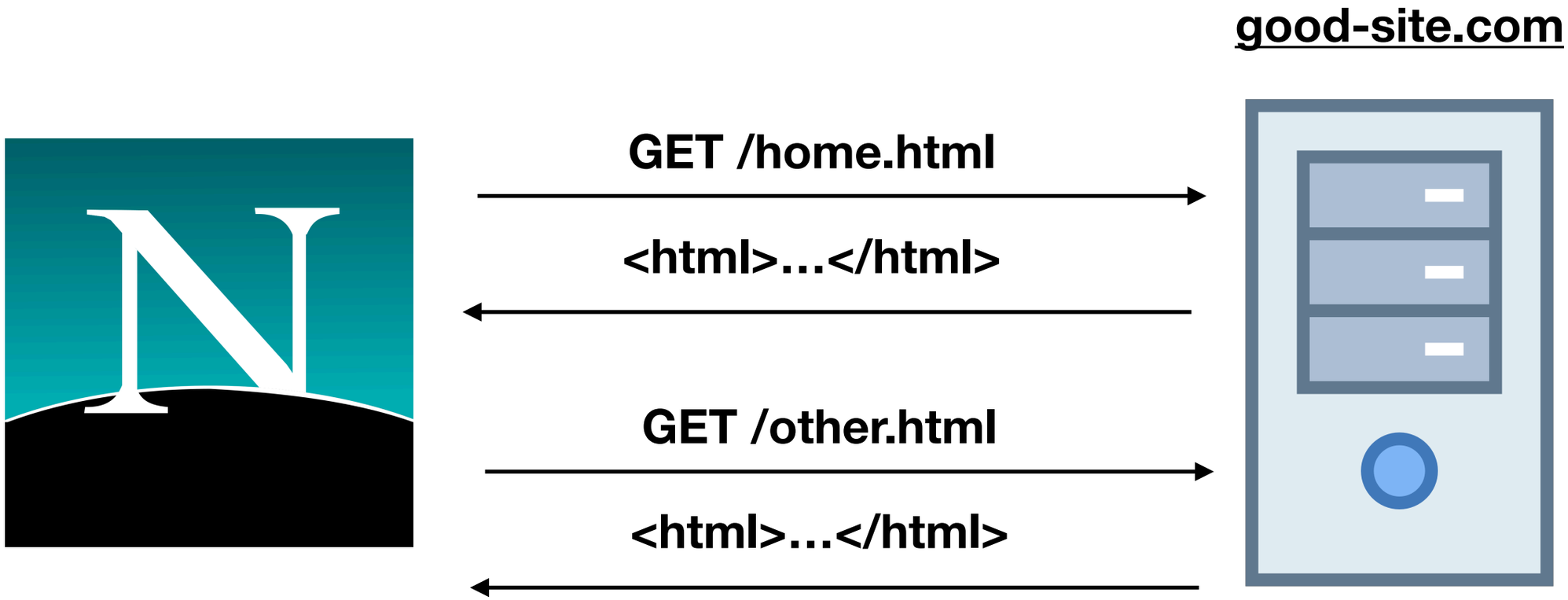
good-site.com

Web 0.0

Web 0.0


good-site.com
GET /home.html
<html>…</html>
GET /other.html
<html>…</html>

Web 0.0


good-site.com
GET /home.html
<html>…</html>
GET /other.html
<html>…</html>

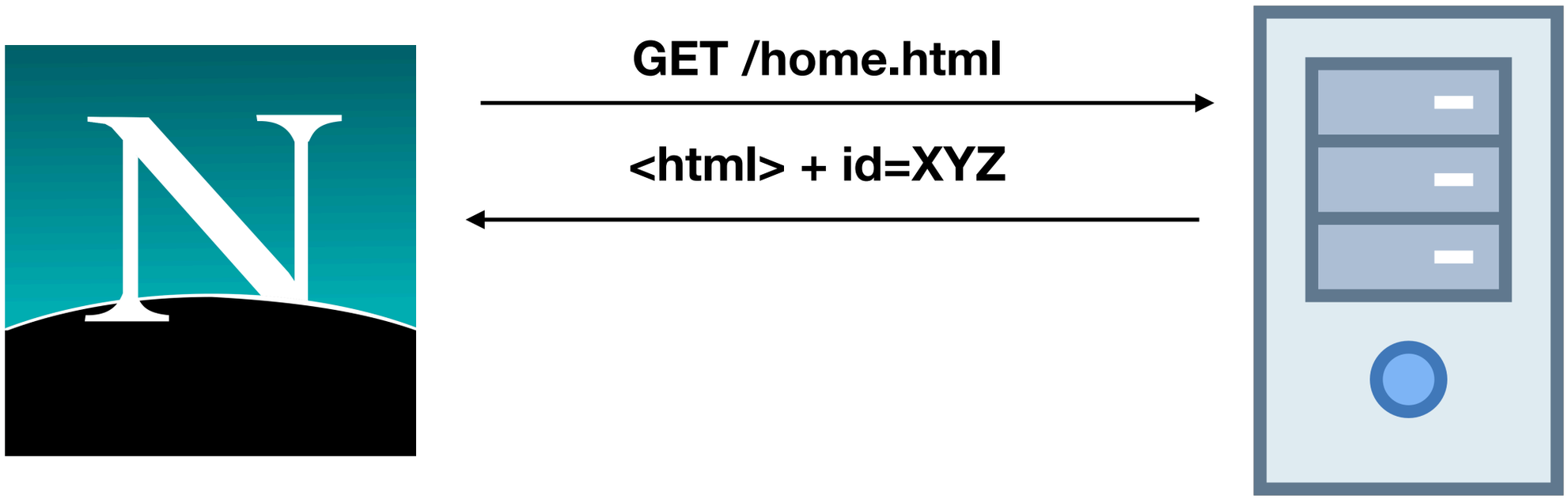
Birth of the Tracking

- **Problem**
  - Authentication?
  - Can’t log in every time
    - HTTP auth is terrible and limited
- **Solution**
  - Server gives token to user
  - User returns it on requests
  - Aka “cookies”

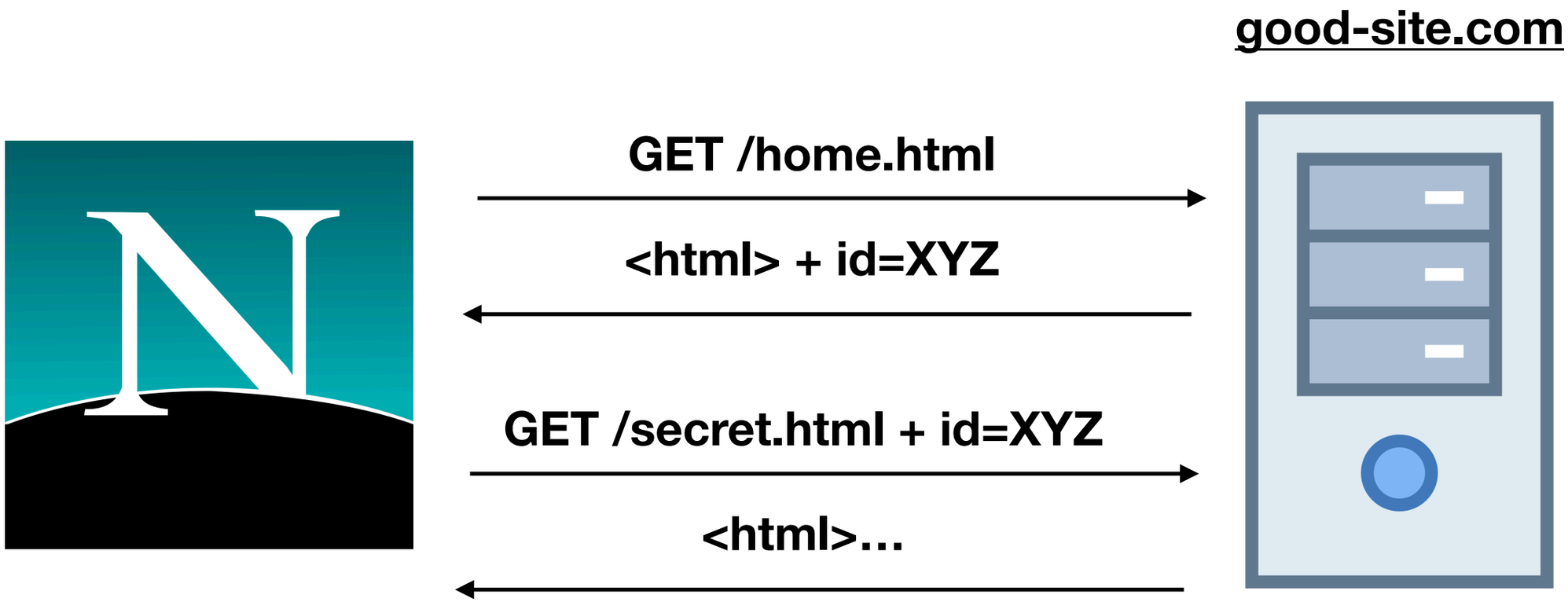
Web 0.0

good-site.com

Web 0.0



Web 0.0


good-site.com
GET /home.html
<html> + id=XYZ
GET /secret.html + id=XYZ
<html>…

Web 0.0

good-site.com

GET /home.html

<html> + id=XYZ

GET /secret.html + id=XYZ

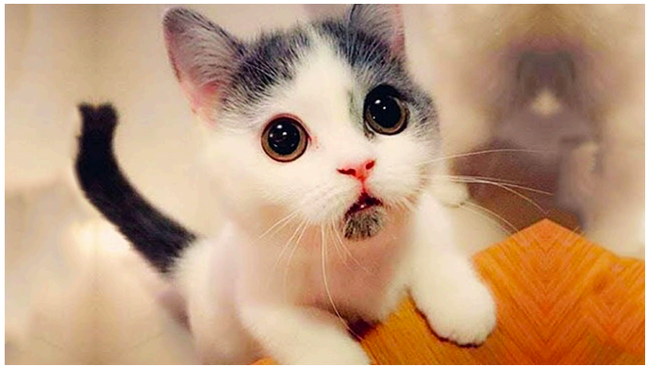
<html>…

GET /secret.html

🙅‍♀️🙅‍♂️

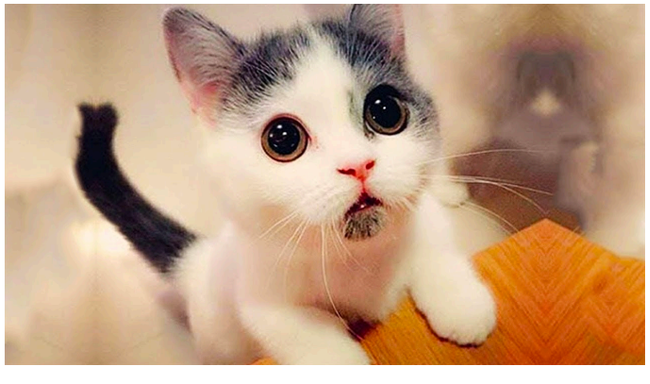
But in the meantime...

cat-cuties.com

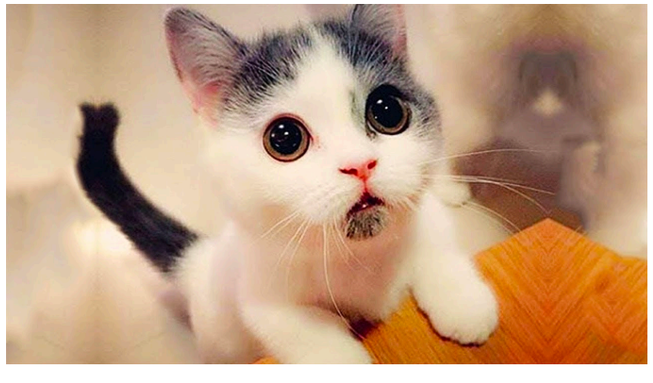


kozy-kittens.com

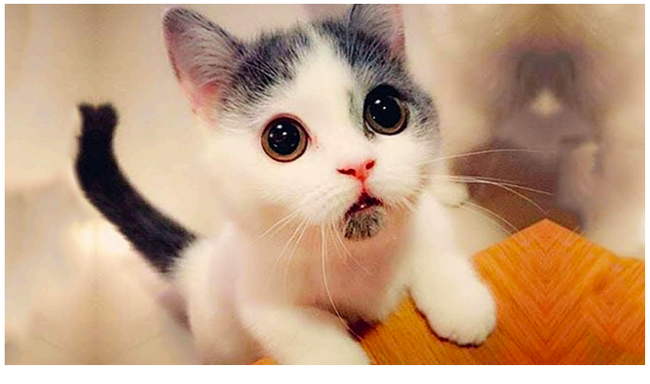
cat-cuties.com



kozy-kittens.com

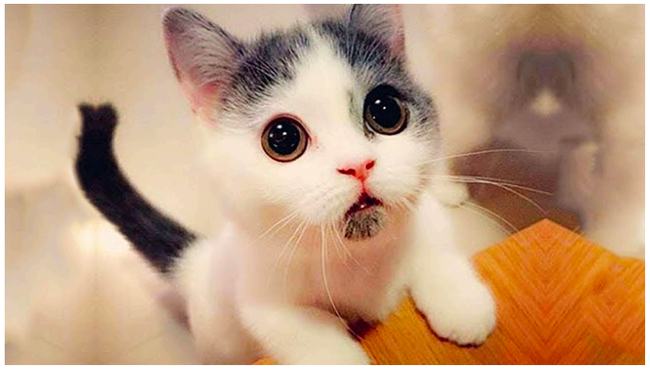


cat-cuties.com



kozy-kittens.com

cat-cuties.com



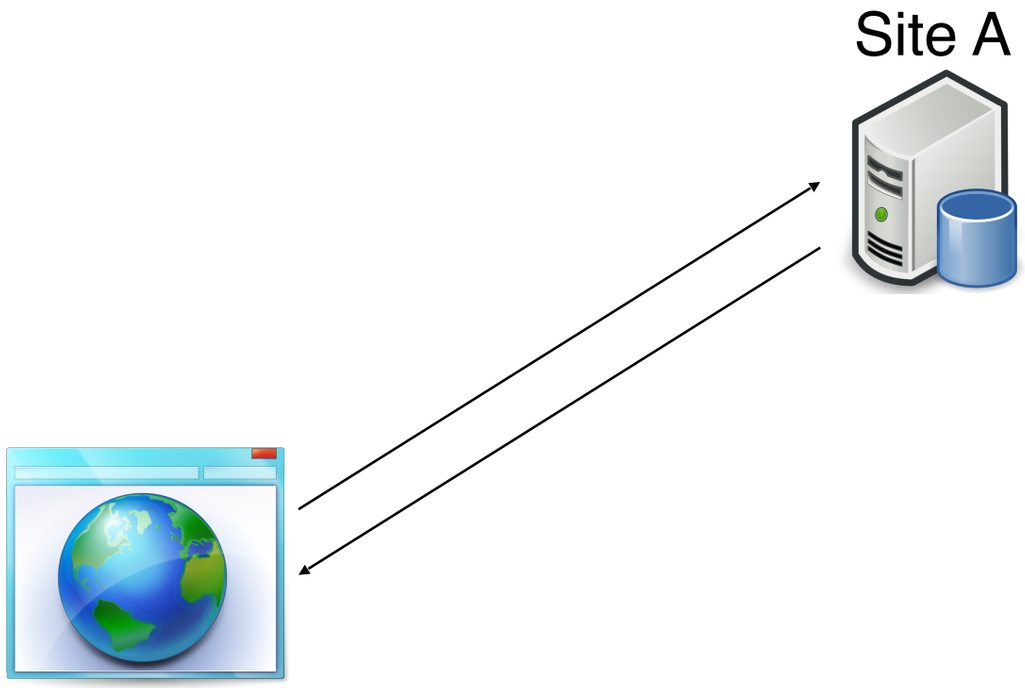
kozy-kittens.com

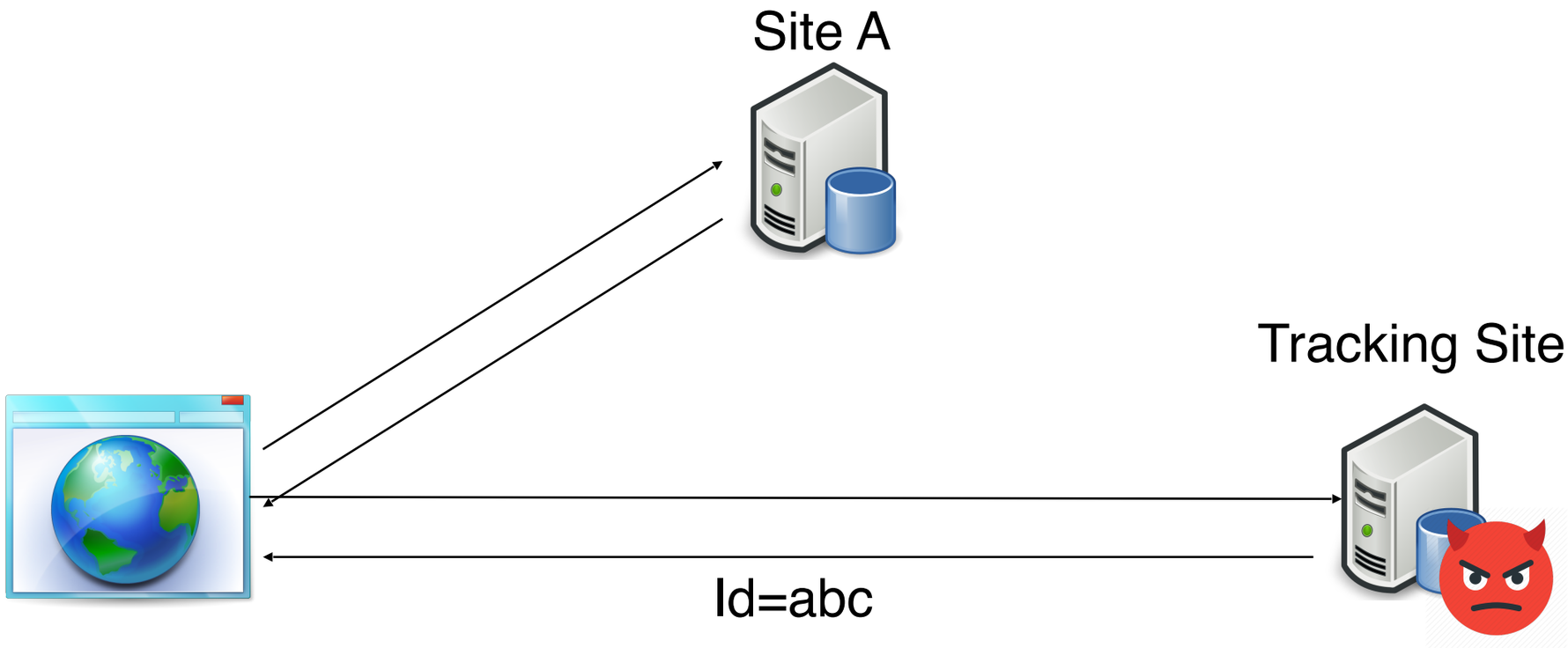
cookies, cookies everywhere…

Cookies

+ 3p Resources

Tracking


Site A


Site A
Tracking Site
Id=abc

Site A

Tracking Site

Site B

Site A

Tracking Site

Id=abc

Site B

Site A

Tracking Site

Tracker knows the same person visited A + B

Site B

Tracking Patient Zero

- The internets “original sin”
  - cross origin resources
  - 3p cookies
  - or both…

- “I invitent Javascript and 3p script, and I’ve been making up for it ever sense…” (paraphrase)

“Ever-Cookies”

- **Some browsers started fighting back**
  Brave, Safari, Firefox, extensions…

- **Trackers fought back**
  Moving IDs information out of cookies, to other location

- **Long list of locations**
  - Local and Session Storage
  - HSTS
  - Cache (etags, Cache API, etc)
  - Plugins
  - many many many more…

Overview

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4. Fingerprinting in web standards
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Fingerprinting, what's diff?

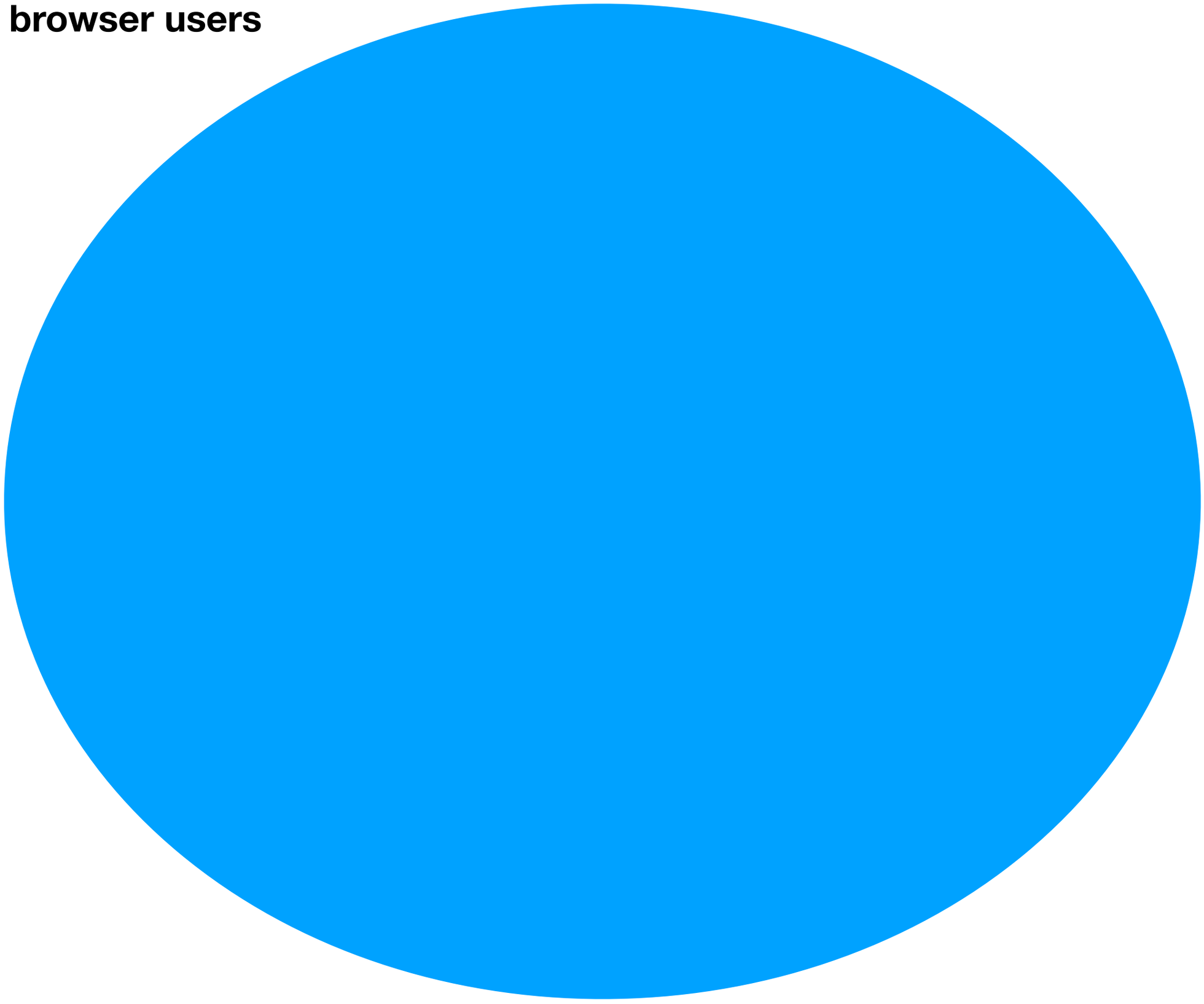
- **Classic tracking**
  - Website stores an id on the client
  - The client returns the id to the server (cookie or JS)
  - The id is what allows re-identification

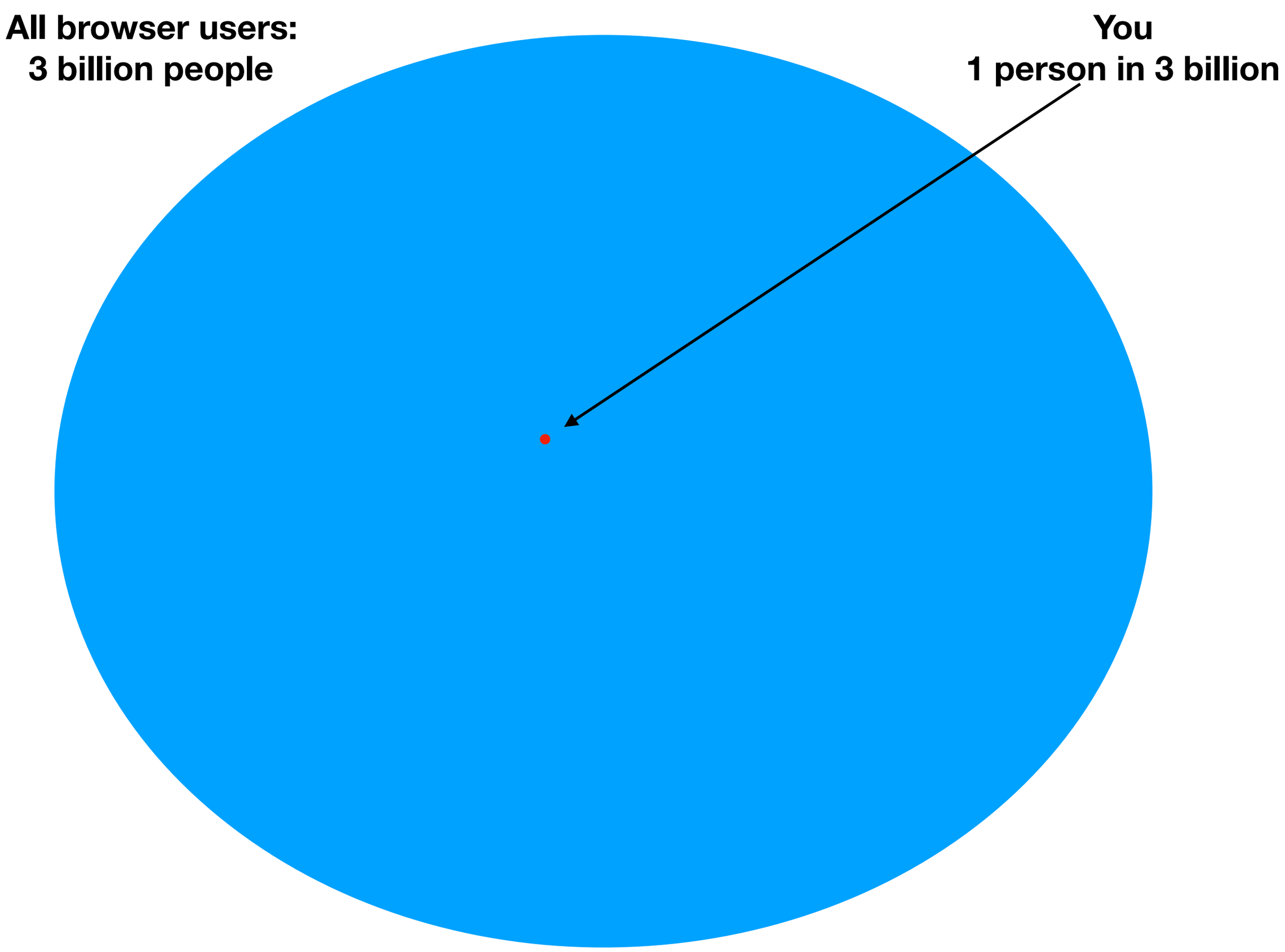
- **Fingerprinting / passive tracking**
  - Website finds things different about each visitor
  - That difference allows re-identification

Fingerprinting, how

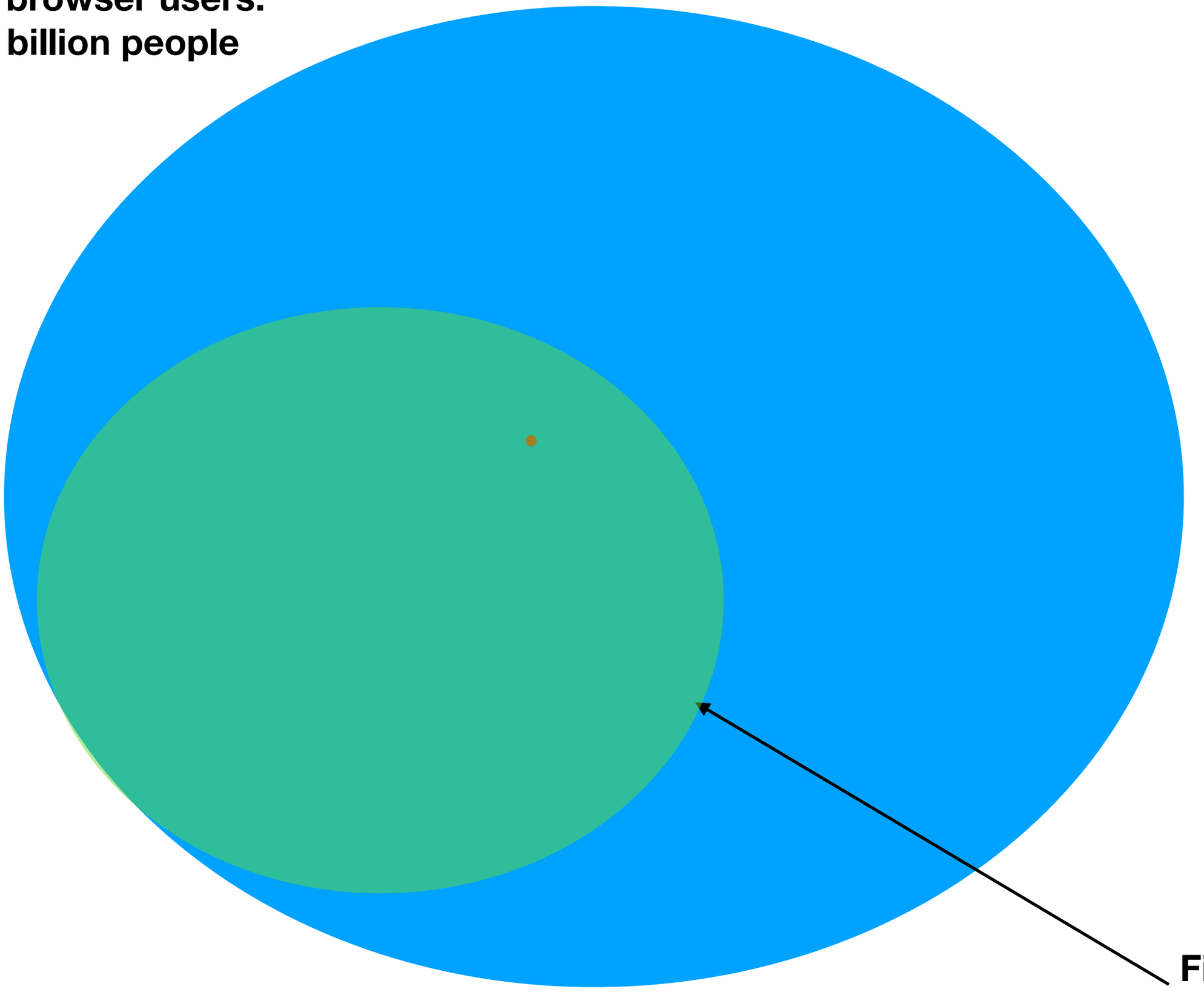
- Large number of semi-identifiers
  - Browser size
  - Extra fonts
  - Audio hardware
  - Video hardware
  - Installed plugins
  - Color depth
  - etc etc etc…

All browser users



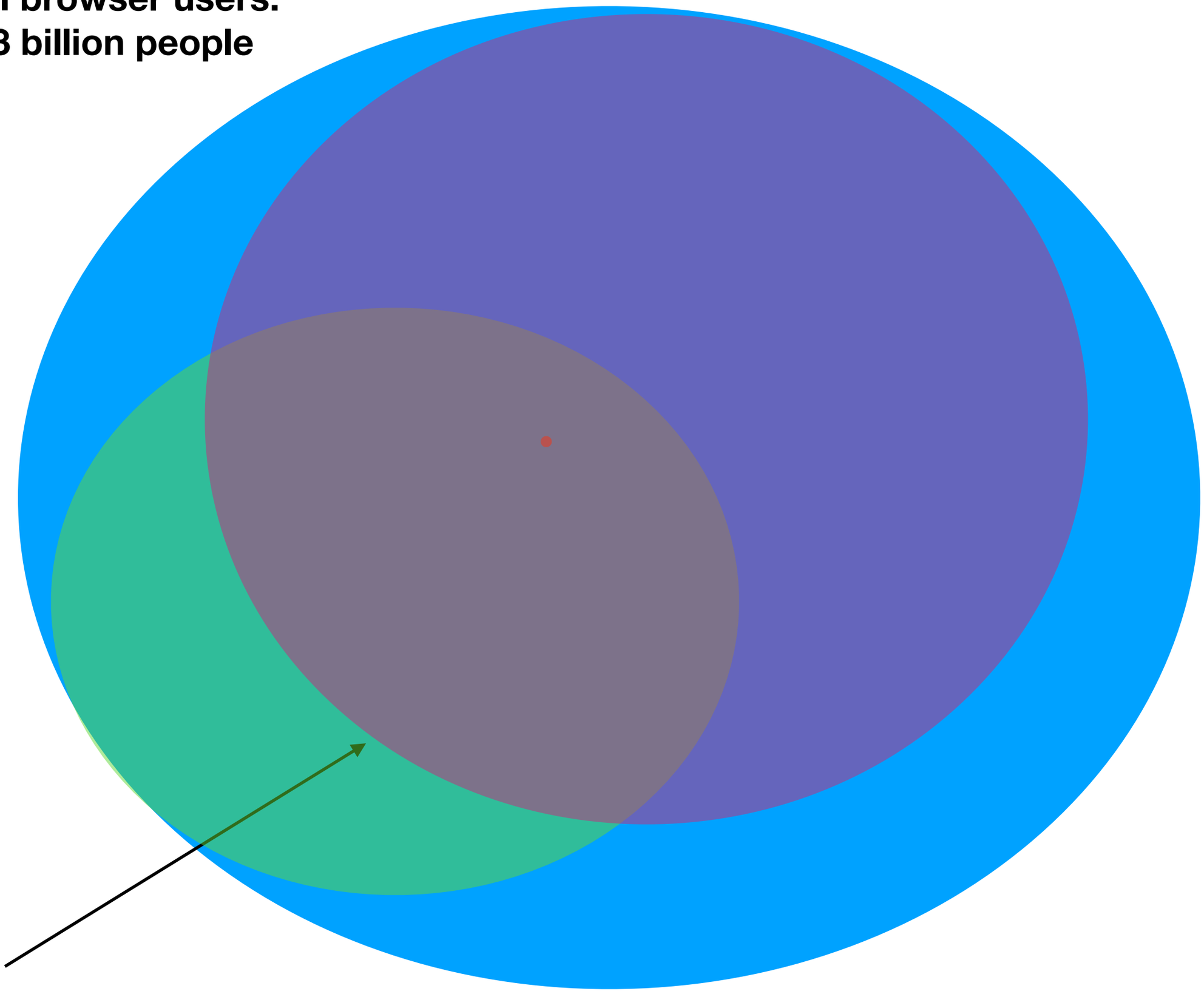

All browser users:
3 billion people
You
1 person in 3 billion

All browser users:
3 billion people



Firefox Users

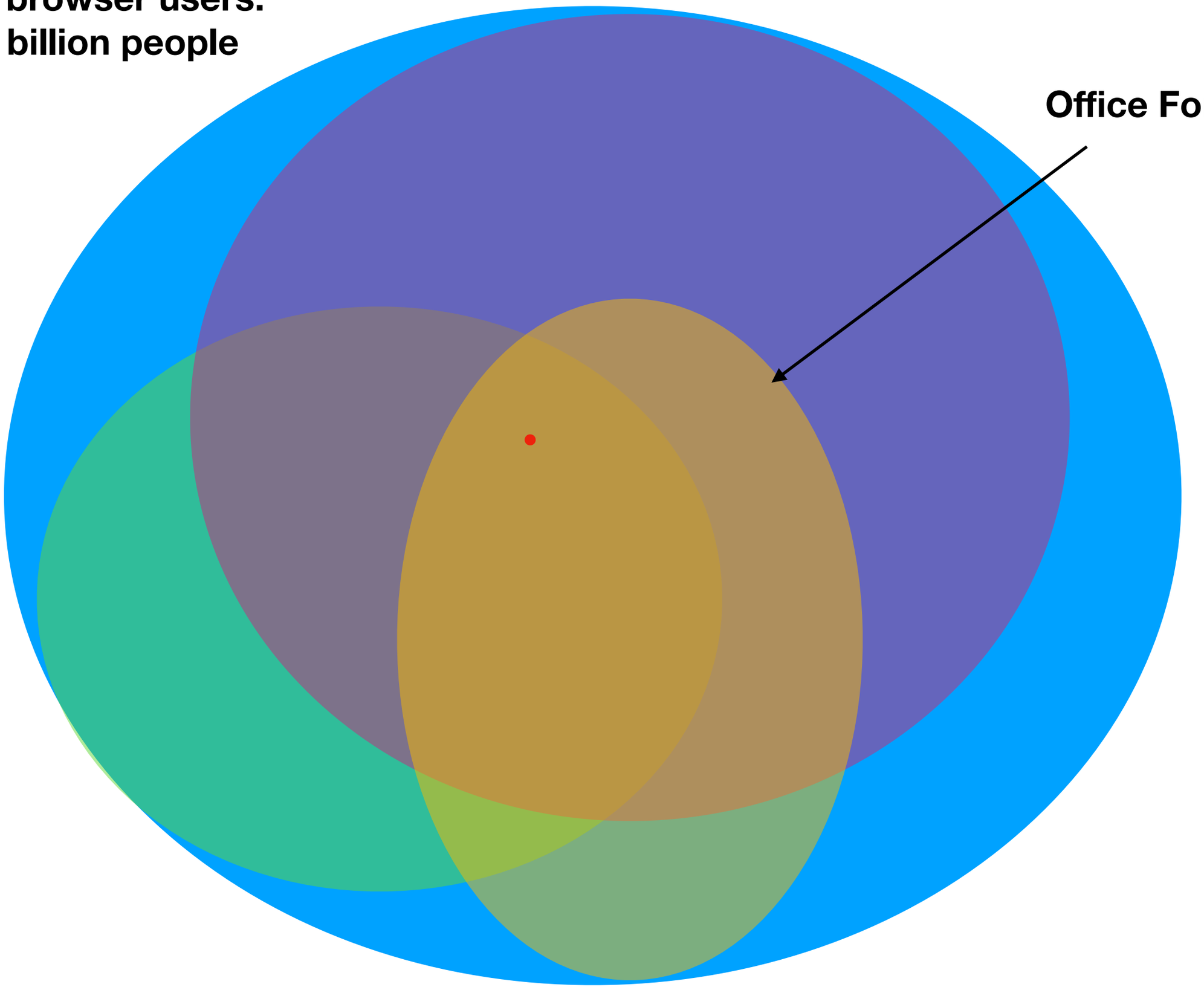
All browser users:
3 billion people



Windows users

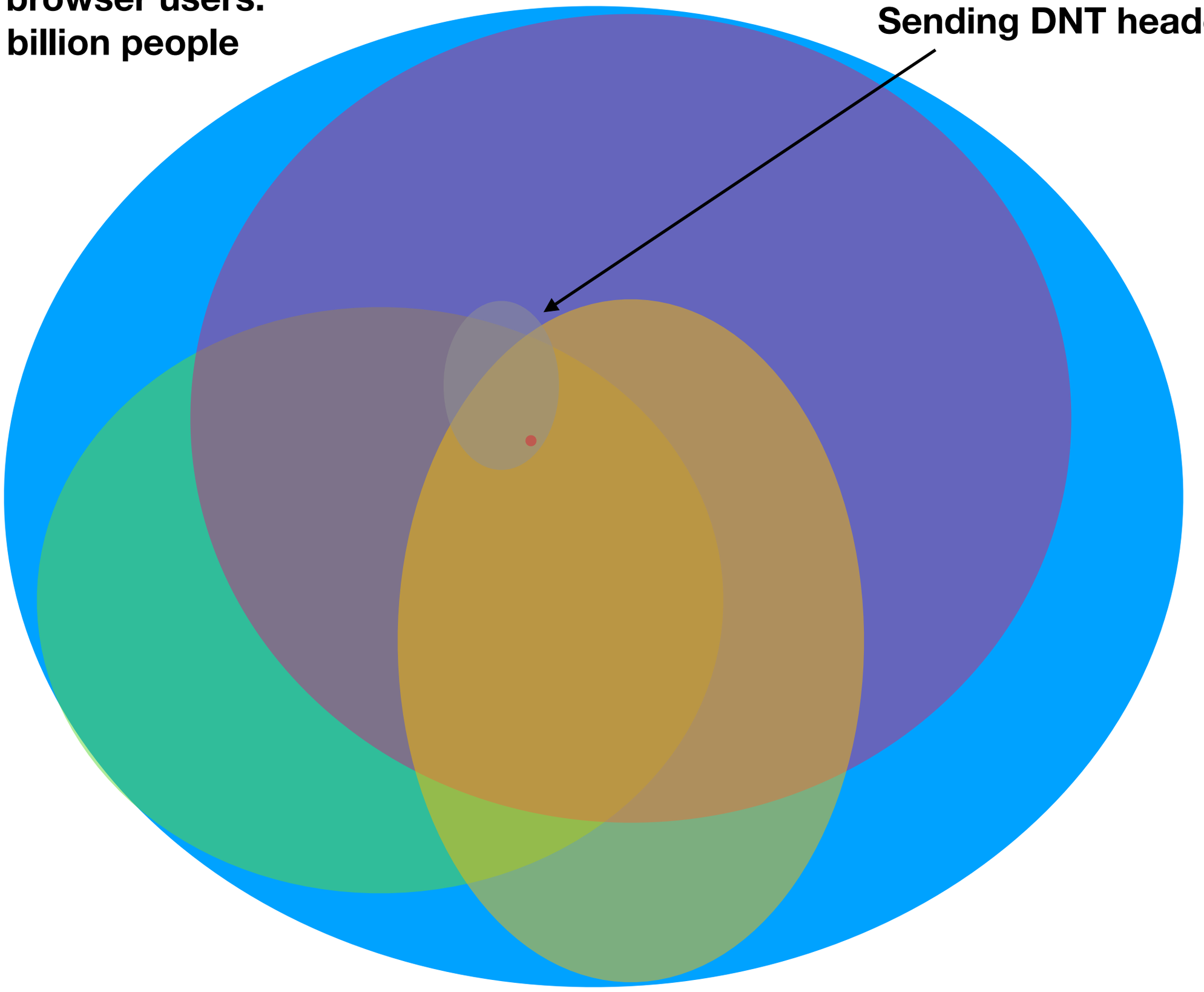
All browser users:
3 billion people

Office Fonts



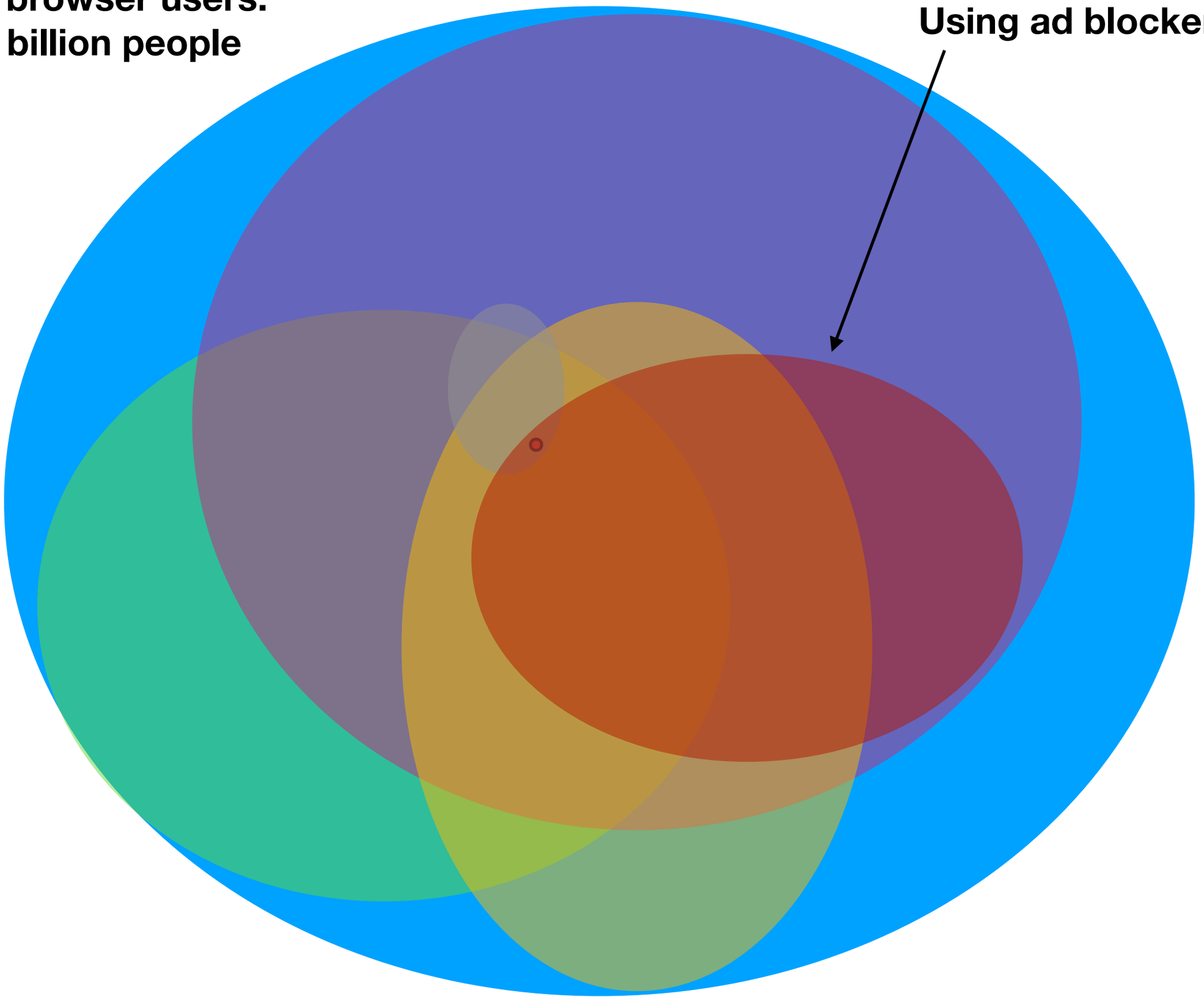
All browser users:
3 billion people

Sending DNT header



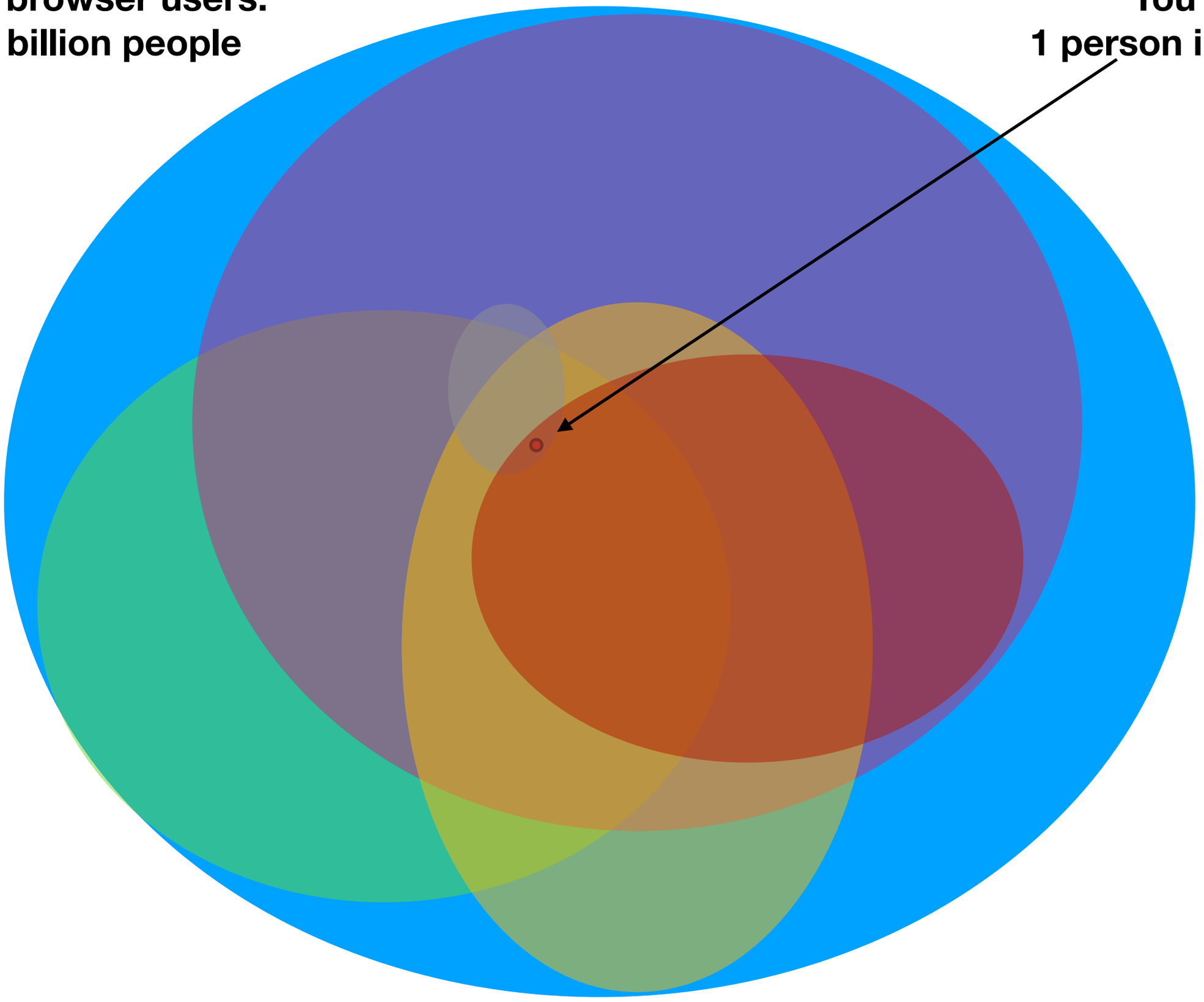
All browser users:
3 billion people

Using ad blocker



All browser users:
3 billion people

You
1 person in 100



Succeeding at Fingerprinting

1. **Breath of fingerprints**
   Large number of semi-identifiers

2. **Depth of fingerprints**
   How uniquely each identifier can… identify

Breath (examples)

- User agent string
- Installed fonts
- Canvas / WebGL
- Hardware (many)
- Height / width

User Agent String

- **History of the Browser user-agent string**
  https://webaim.org/blog/user-agent-string-history/

- **Katamari-Damacy of identifiers**

- **Brave / Chrome**
  `Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_0) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/78.0.3904.50 Safari/537.36`

- **Easy to extract**
  - navigator.userAgent
  - User-Agent:

Installed Fonts

- **Three categories of fonts**
  - System
  - Local
  - Web

- **“Local” is the tricky part**
  - Office
  - Photoshop
  - Goofery

- **Easy to extract**
  - plugins
  - css + span + width

[‘Andale Mono', 'Arial', 'Arial Black', 'Arial Hebrew', 'Arial MT', 'Arial Narrow', 'Arial Rounded MT Bold’…]

[‘Andale Mono', 'Arial', 'Arial Black', 'Arial Hebrew', 'Arial MT', 'Arial Narrow', 'Arial Rounded MT Bold’…]

```
<span>Example</span>
```

['Andale Mono', 'Arial', 'Arial Black', 'Arial Hebrew', 'Arial MT', 'Arial Narrow', 'Arial Rounded MT Bold'...]

For each font...


```
<span>Example</span>
```

[‘Andale Mono', 'Arial', 'Arial Black', 'Arial Hebrew', 'Arial MT', 'Arial Narrow', 'Arial Rounded MT Bold’…]

For each font…

Fingerprinter

```
for (const fontName of fonts) {
  // 1. Apply font to span
  // 2. Measure width of span
  // 3. If it changes, user has font…
}
```

```
<span>Example</span>
```

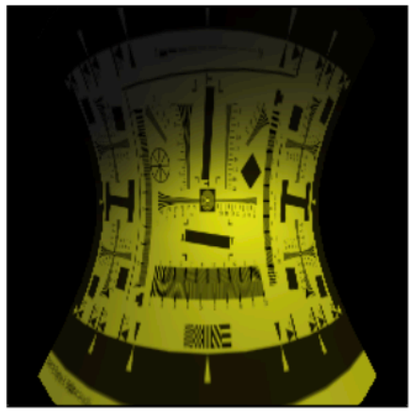
Canvas / WebGL

- **Pixel Perfect: Fingerprinting Canvas in HTML5**
  Keaton Mowery and Hovav Shacham

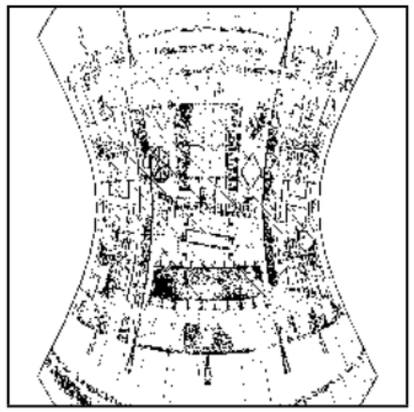
- **Drawling APIs**
  e.g. Drawing lines / shapes

- **Standardized, but subtle differences**

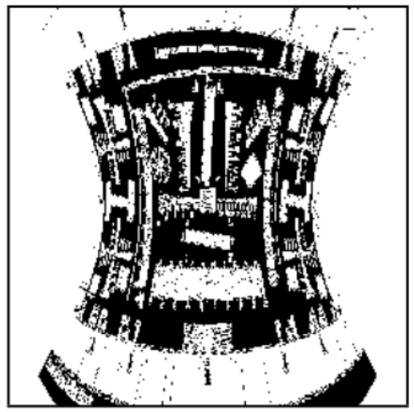
- **Easy to extract**
  - Create canvas
  - Do some drawing
  - toDataURL()



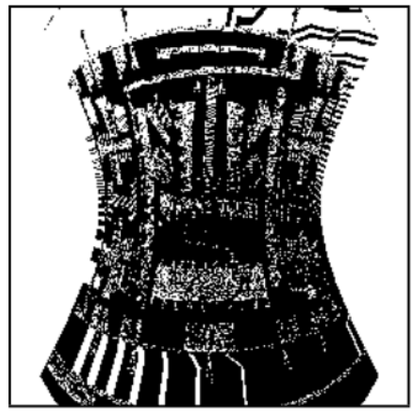
(a) Original
(Intel G41)



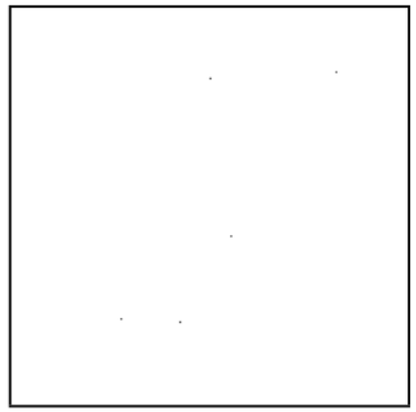
(b) Group 1
(Radeon HD 2400)



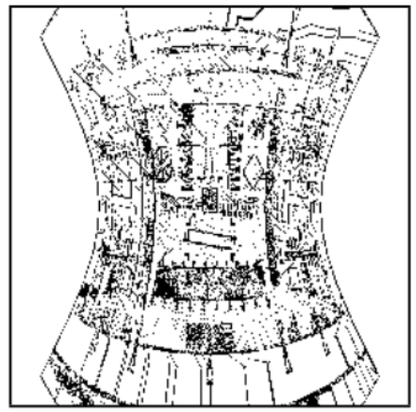
(c) Group 20
(Intel 82945G)



(d) Group 23
(Intel G33/G31)



(e) Group 25
(Intel HD Graphics)



(f) Group 36
(GeForce 6200)

Hovav Shacham

The Geometry of Innocent Flesh on the Bone: Return-into-libc without Function Calls

Hardware Identifiers

- **Many Web APIs leak capabilities**
  - number of cores (HTML)
  - number of audio channels (Web Audio API)
  - num shaders and similar (WebGL API)
  - device memory (Device Memory API)
  - network (WebRTC, Network status API)

- **Semi identifying**

- **Easy to extract**
  - All browsers have subset of the above
  - Most platforms have no permissions

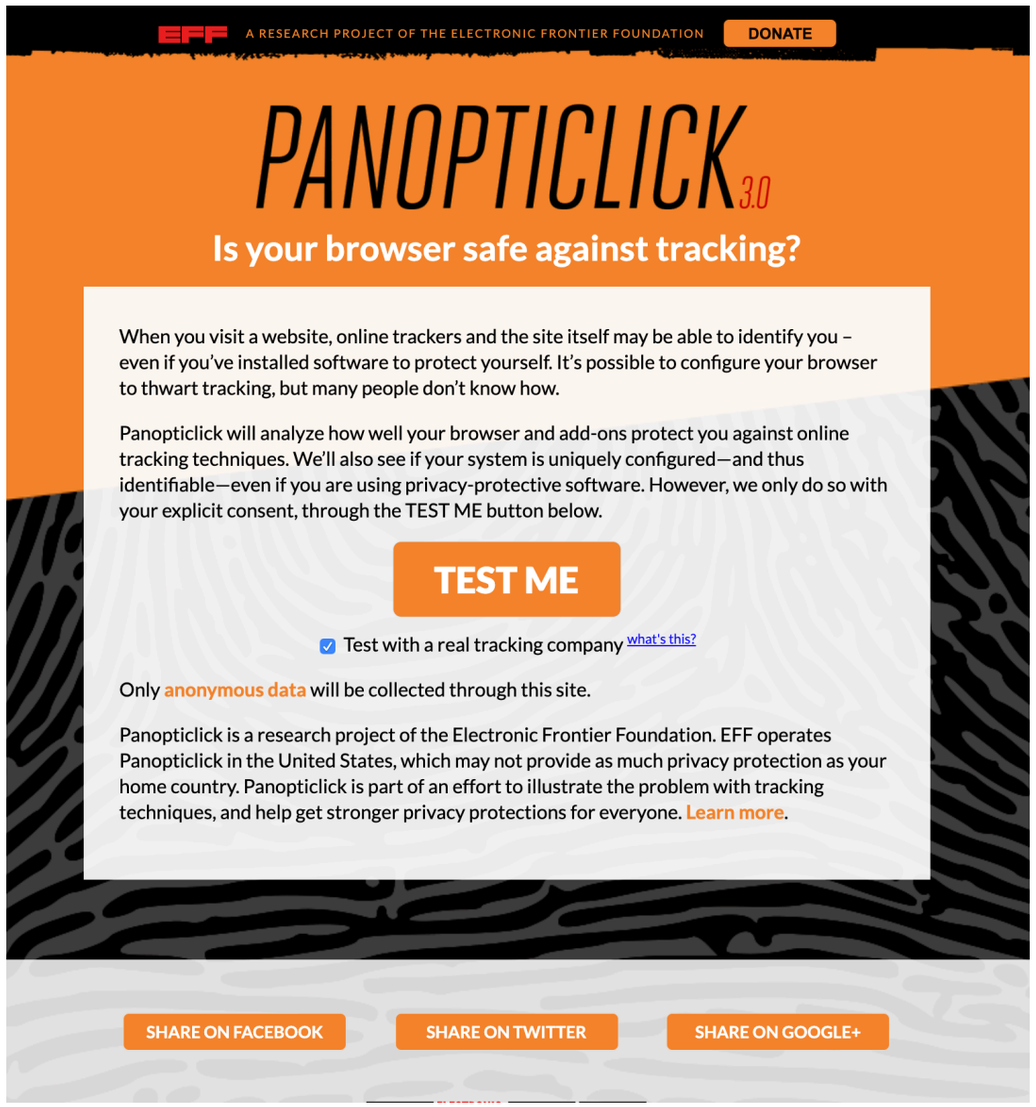
Height / Width

?

Height / Width

- **What does it mean?**
- **How to extract w/ JavaScript?**
- **How to extract w/o JavaScript?**
- **Brb 5 min (Go go go go go!)**

Fingerprinting Depth



https://panopticlick.eff.org/

Fingerprinting in Practice

- Needs to be in a database…
- Hash each endpoint
- Hash each value into a single identifier…
- Nice implication: “poisionability”…

Exercise

- Read fingerprint2.js
- List as many finger-printing approaches as possible
- Understand how they’re carried out
- Predict which are most identifying

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Fingerprinting Countermeasures

- Remove the functionality
- Make the functionality consistent
- Restrict access (permissions, 1p vs 3p, user gesture, etc)
- Noise
- “Privacy budget”

Remove the functionality

- Delete JS end point
- Remove the HTTP header
- Remove the runtime capability

Consistency

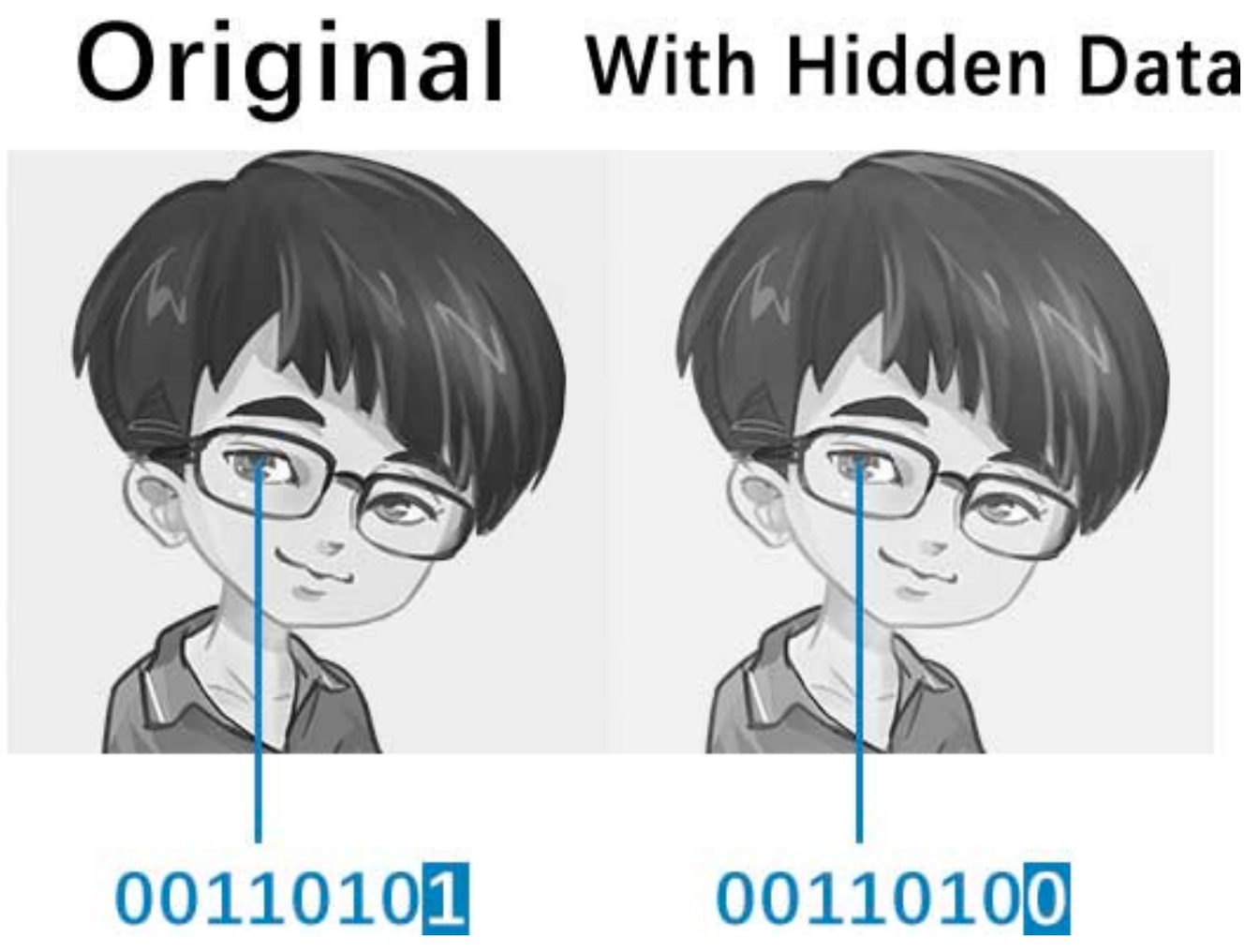
- Make every browser return the same value
- … or, most?
- Not that diff in practice from “removing”

Restrict access

- Permission prompt
- User gesture
- 1p vs. 3p
- “Site engagement”

Noise

- Stenography
- Make different every time



Privacy Budget

- Allow some identifiability
- After “identifiability budget” is exhausted do… something
- Google folks love it
- Everyone else is… skeptical

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Fingerprint2 Again…

- Choose two fingerprinting vectors to combat
  - Propose counter measures
- Choose two fingerprinting vectors that are hard
  - Why are counter measures hard?

Fingerprint2 pt 3…

- Pretend your the attacker

- How would you respond to those defenses…

Fingerprint2 pt 4…

- Pretend your the defender again

- How would you modify your defenses given the previous round…

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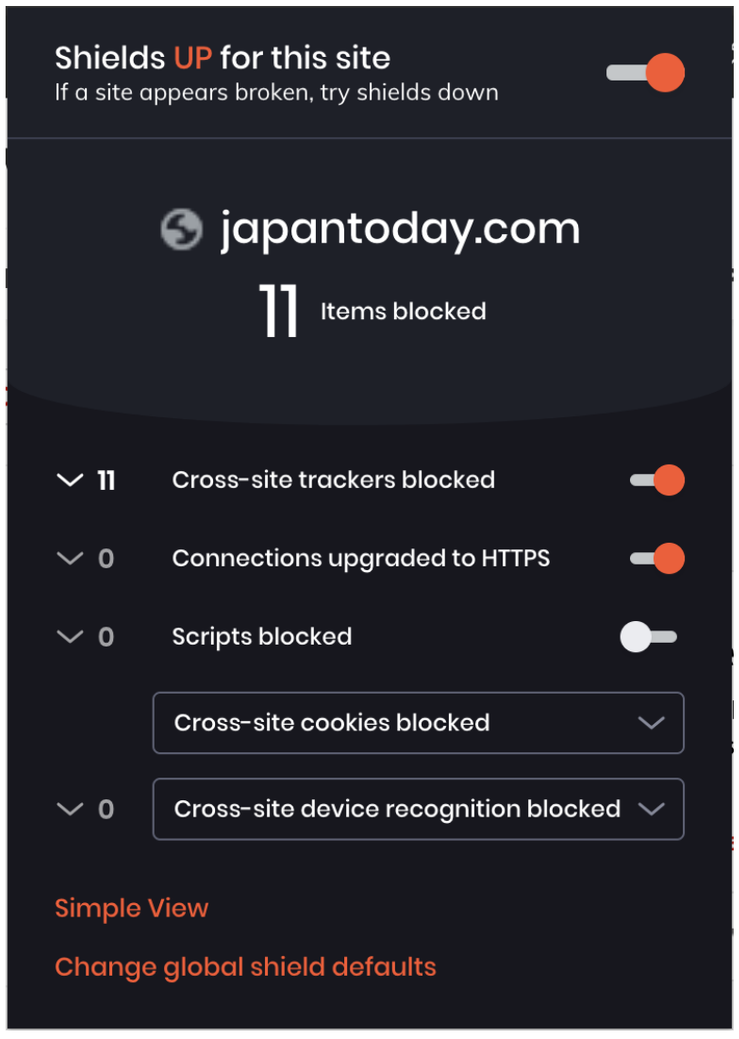
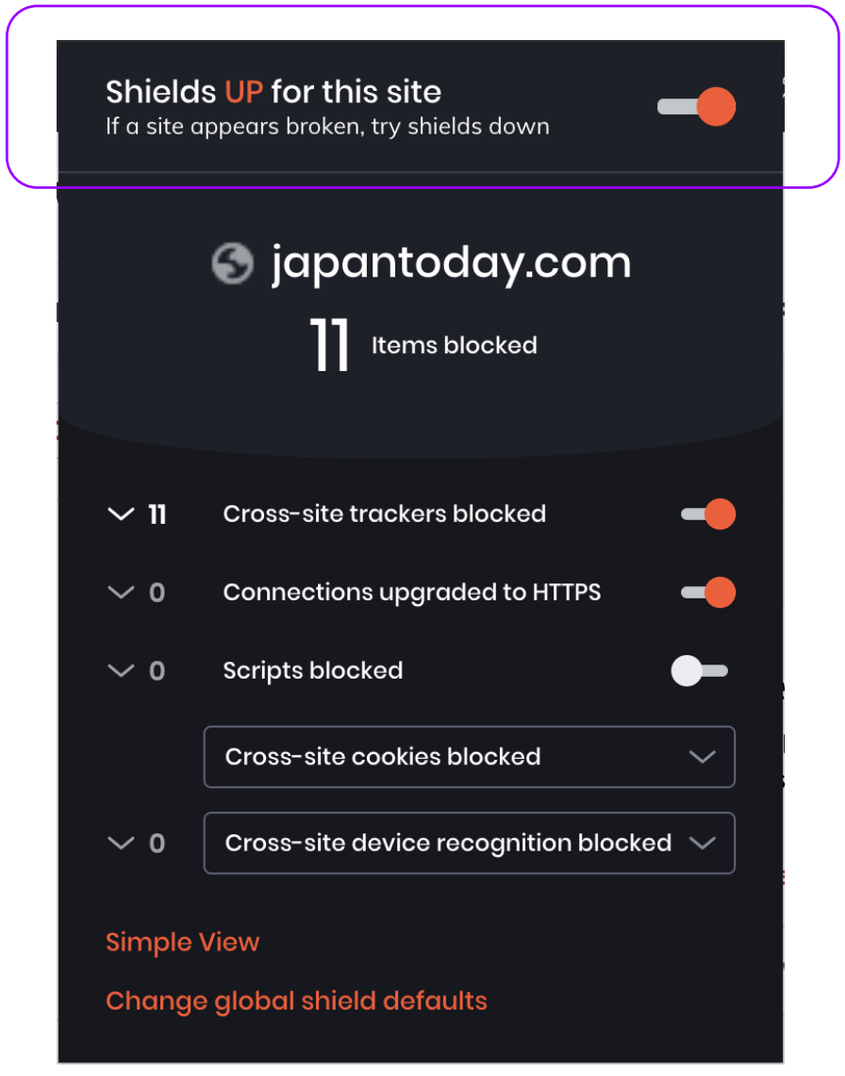
Brave Privacy Protections

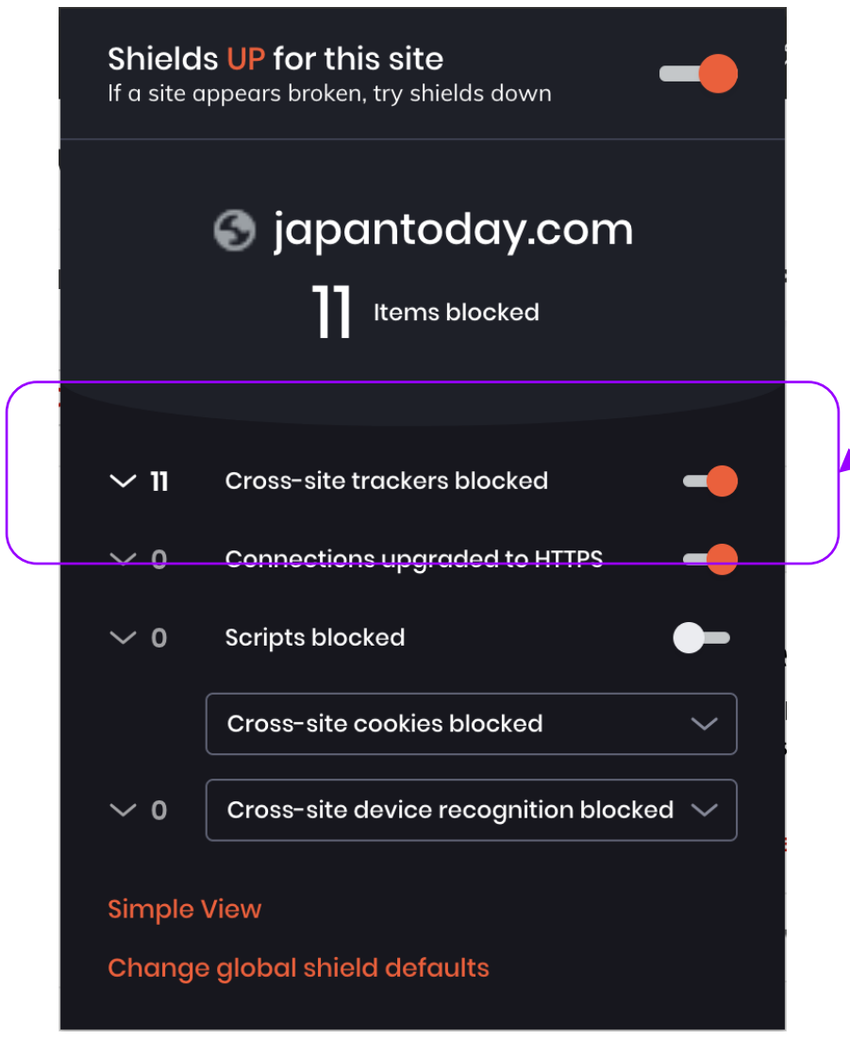


Brave Privacy Protections



- Shields
- Global protection from tracking
- On by default
- Can be disabled if needed

Brave Privacy Protections



- Block cross site trackers
- Lists of known tracking websites
- Refuse to load
- Both community and Brave generated

Blocking Cross-Site Trackers in Brave

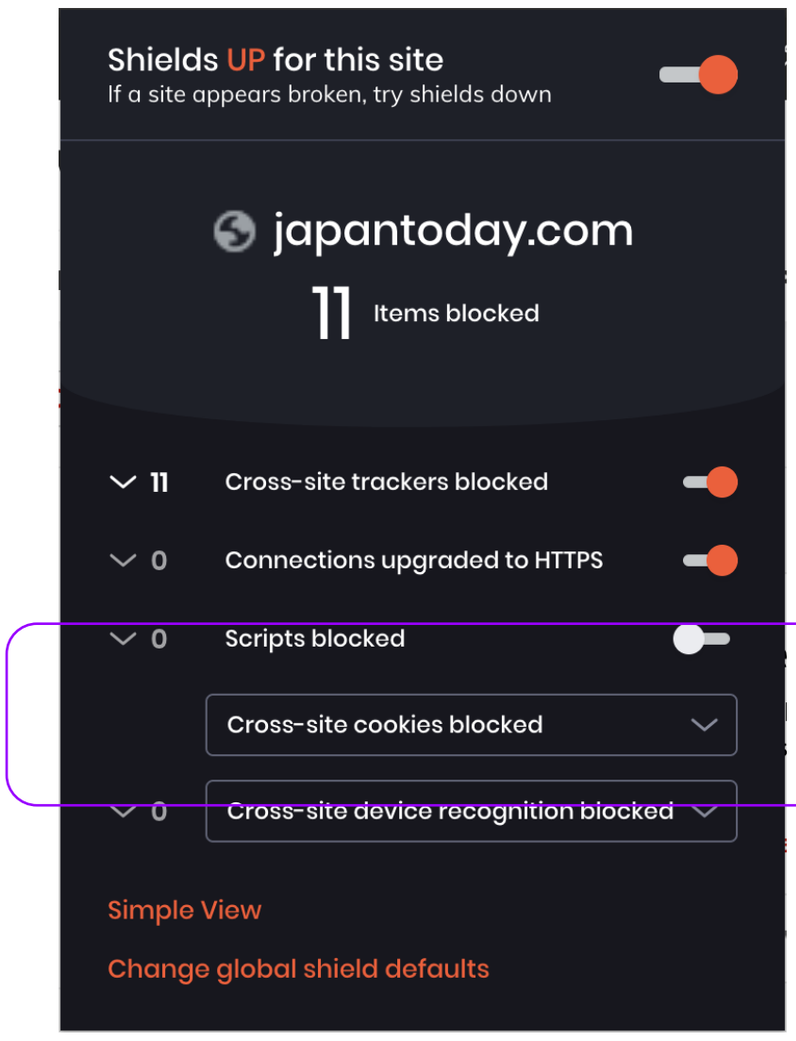
- **EasyList and EasyPrivacy**
  Used by AdBlock Plus, etc.

- **Disconnect**
  Used by Firefox, extensions

- **uBlock Origin**
  Excellent blocking extension

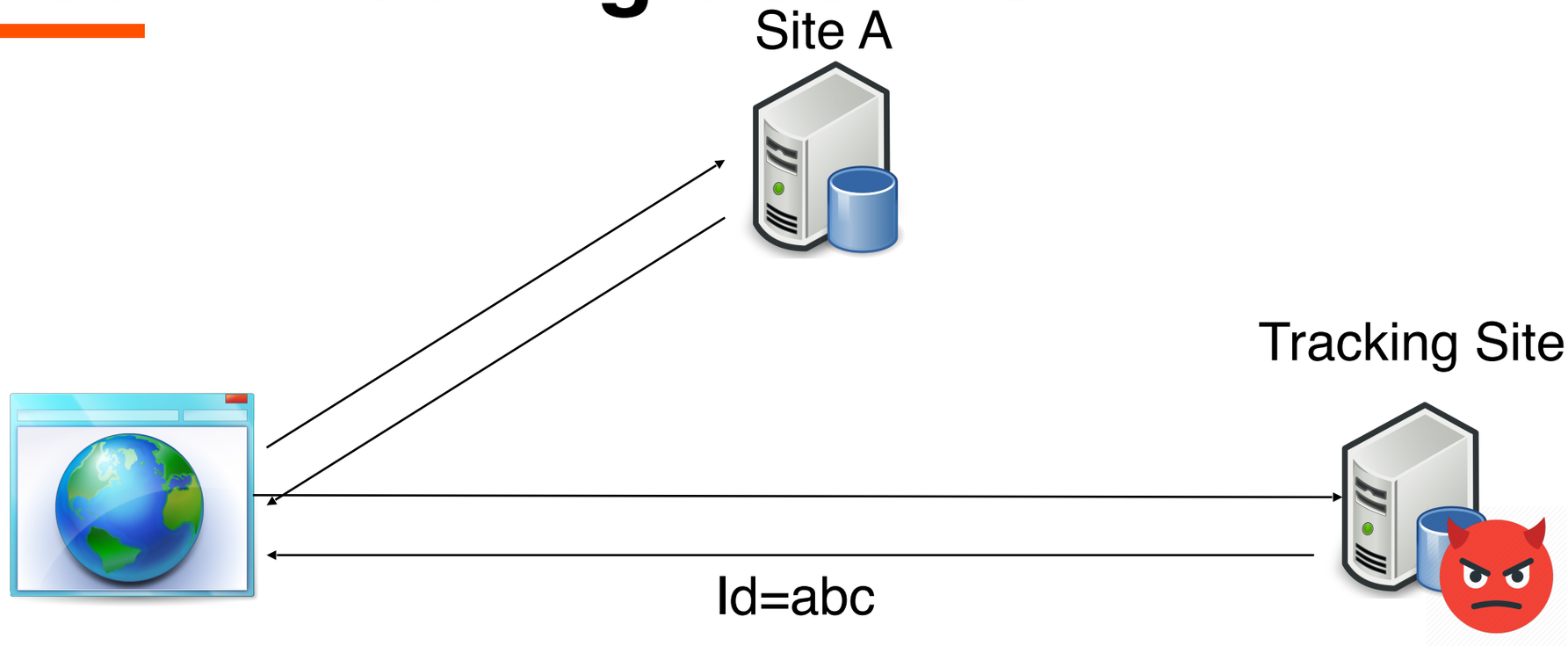
- **Brave generated**
  Open source, shared with community

Brave Privacy Protections

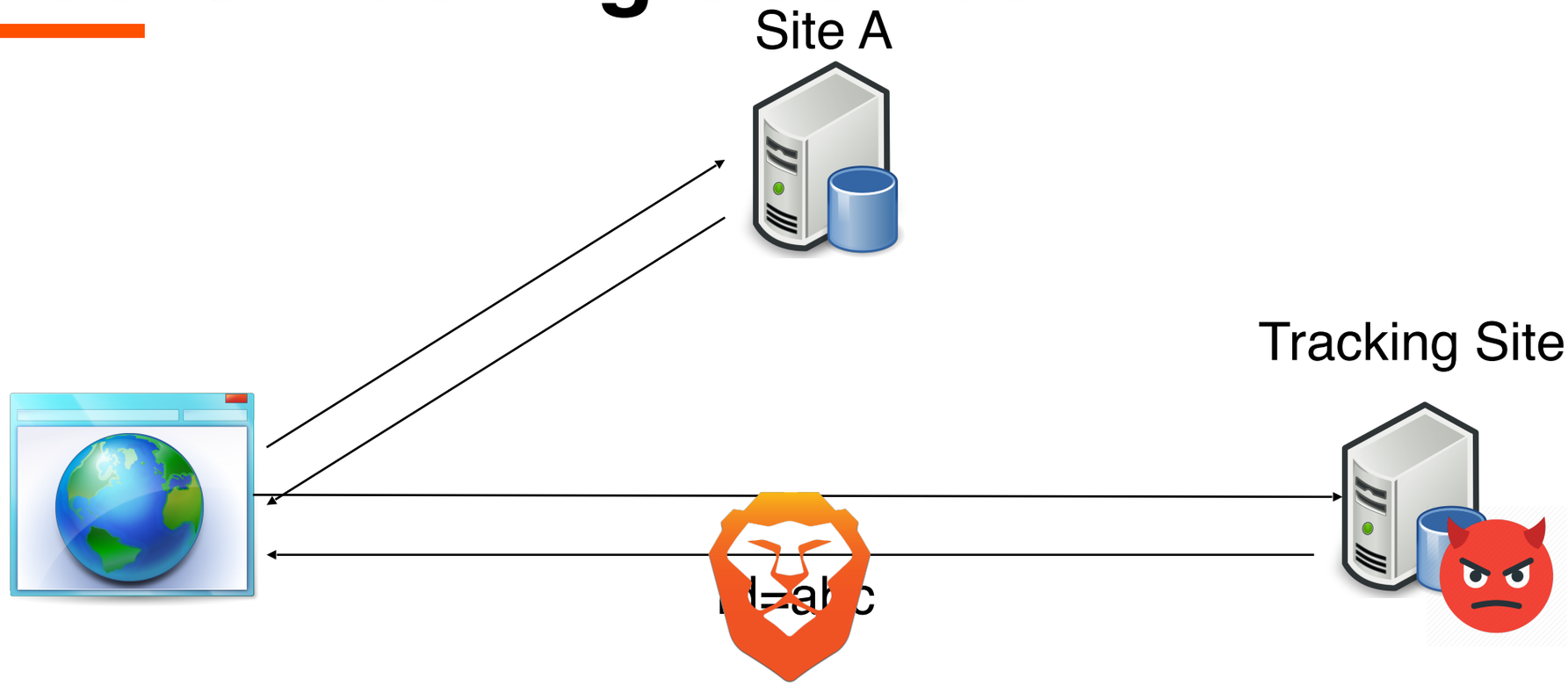


- Don’t send identifiers to third party sites
- Send to “main” site
- Same with other storage methods

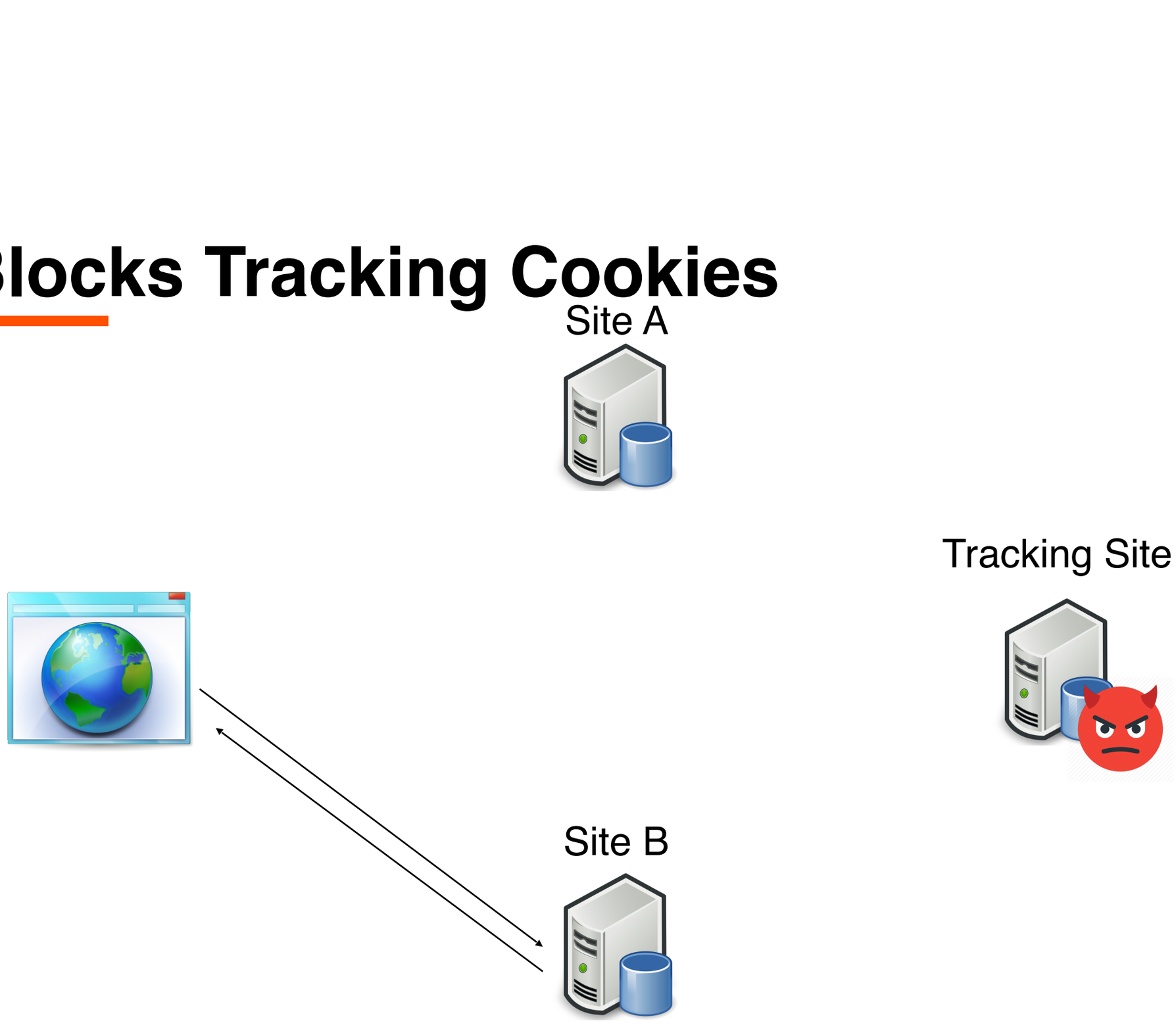
Brave Blocks Tracking Cookies



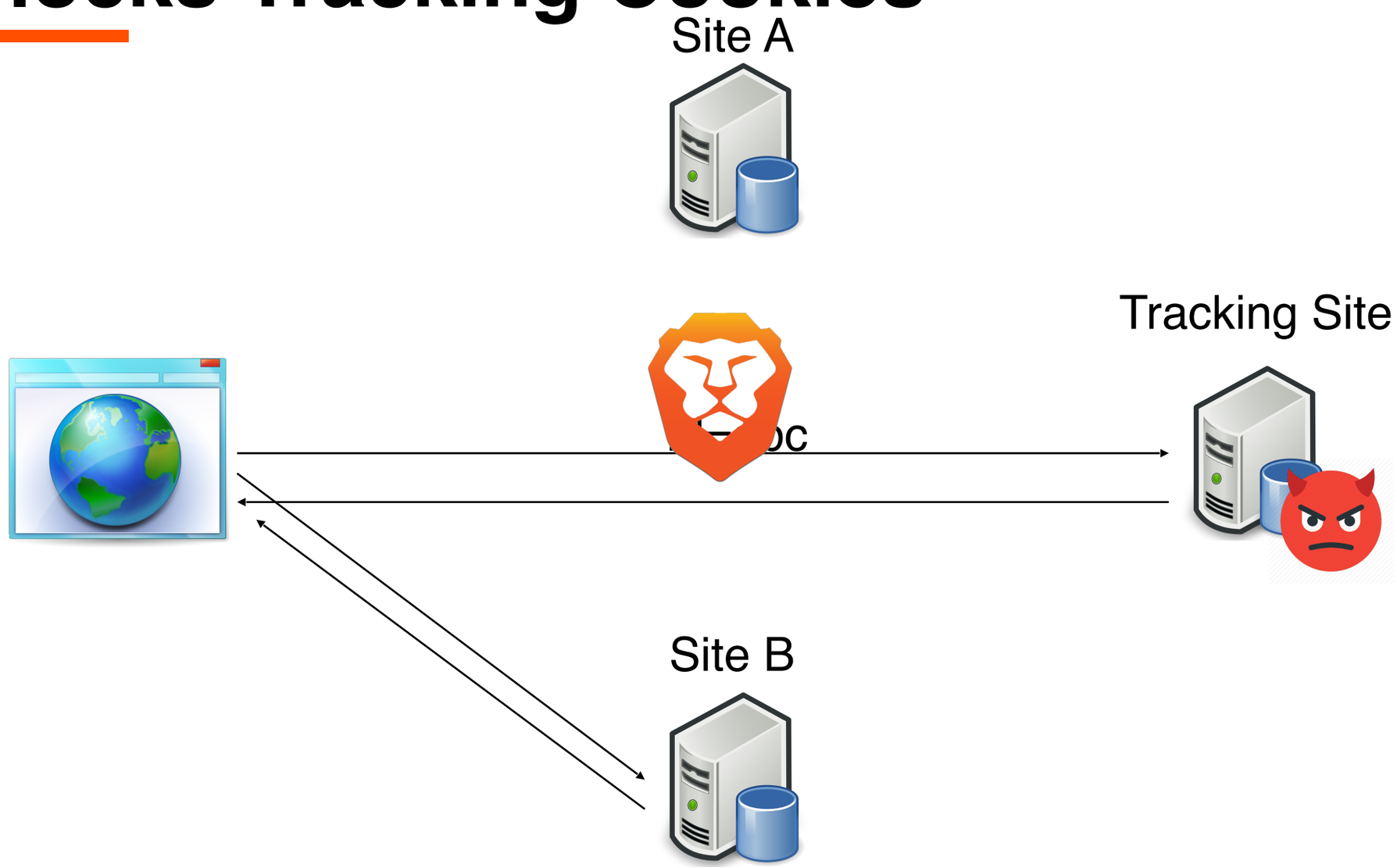
Brave Blocks Tracking Cookies



Brave Blocks Tracking Cookies



Brave Blocks Tracking Cookies



Brave Blocks Tracking Cookies

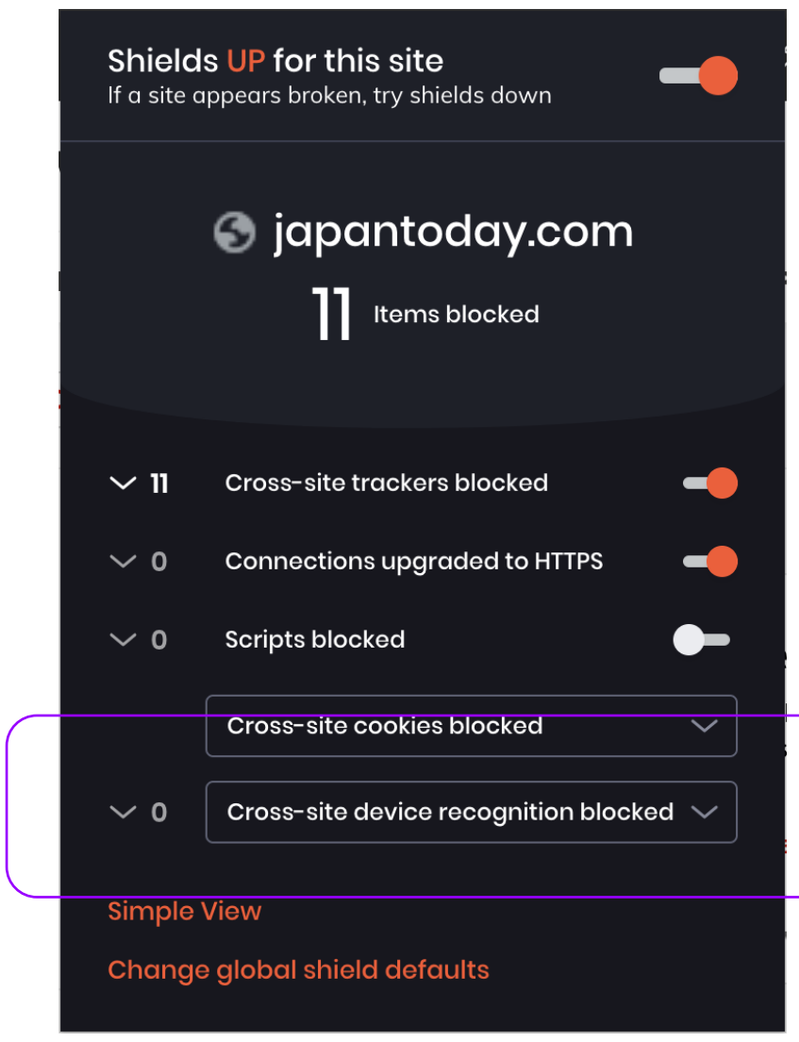
Site A

Tracking Site

Tracker can’t link A and B

Site B

Brave Privacy Protections



- Reduce finger printing vectors
- Currently:
  - Hardware identifiers
  - Canvas
  - WebGL
  - Audio
- Planned:
  - Fonts
  - User agent
  - Screen size

Under Exploration Possible Privacy Protections

- Restrictions on third-party scripts
- Identifying tracking behaviors, not just scripts / URLs
- Query parameters filtering
- Bounce tracking
- Much more…

Overview

1. Why websites track (and how much)
2. “Classic” tracking
3. Fingerprinting / “passive tracking”
4. Fingerprinting counter measures
5. Anti-finger printing exercise
6. Privacy protections in Brave
7. **Wrapping up**

Unasked for Advice

- Brave is hiring, keep us in mind
- Privacy is more than just web, there’s lots to do
- Don’t accept privacy as a feature…
- Choose your employer with values in mind

Thanks!

- **Pete Snyder**
  Privacy Researcher
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  @pes10k

- Questions?
  - Standards work?
  - Privacy jobs?
  - Brave business model
  - BAT / Block chain
  - Anything else?