



# PrivacyTests.org

*Open source tests of web browser privacy*

Arthur Edelstein, July 28, 2023

PEARG

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# In this talk

- My past work on browser privacy
- The high-level approach to PrivacyTests.org
- Overview of specific privacy tests and results
- Notable recent browser privacy progress
- What I have learned
- Future work
- Questions!

# My background

Developer for Tor Browser (2014-2018)

Product Manager for Firefox Privacy and Security (2018-2021)

PrivacyTests.org (2021-Present)

Research and Privacy Engineer at Brave (2022-Present)

# Problem: the Web is a major target of mass surveillance

- The Web is a primary means of modern reading, writing, communication and commerce
- Most web browsers are heavily exposing their users to mass surveillance by governments and corporations

## **U.S. Spy Agencies Buy Vast Quantities of Americans' Personal Data, U.S. Says**

Commercially available data from cars, phones and web browsers rivals results from wiretaps, cyber espionage and physical surveillance

# How web browsers facilitate surveillance

- Browsers allow websites you visit and the trackers embedded in them to gather your browsing history
- Browsers leak a lot of unnecessary data
- Browsers fail to encrypt your network connections

## Why are browsers (still) leaky? Opacity, bad incentives

- Web browser privacy leaks are hidden, technical, and complex
- Privacy has not been a priority for most browsers
- Some major web browsers get their revenue from top trackers (Google, Bing), not from users
- WebCompat

## PrivacyTests.org: attempting to provide visibility

Try to make web browsers more accountable for protecting all web users from mass surveillance through:

- Detecting privacy leaks
- Monitoring those leaks over time
- Informing the public
- Informing browser makers
- Facilitating competition over privacy





# Building PrivacyTests.org

Proposed it at Tor 2018, slow progress

Started working on it independently full time in August 2021

First launched in mid-October 2021; Android and iOS in December

Iterative – it remains a work in progress!

**PrivacyTests.org** News About    

No. 65 *Open-source tests of web browser privacy.* Updated 2023-07-23

**Desktop browsers** Desktop private modes iOS browsers Android browsers Nightly builds Nightly private modes

✓ = Passed privacy test ✗ = Failed privacy test — = No such feature  
(Click anywhere for more info.)

**Desktop Browsers** (default settings)

	Brave 1.56	Chrome 114.0	Edge 115.0	Firefox 115.0	Librewolf 115.0	Mulvad 12.5	Opera 100.0	Safari 16.5	Tor 12.5	Ungogged 114.0	Vivaldi 6.1
<b>State Partitioning tests</b>											
Which browsers isolate websites to prevent them from sharing data to track you?											
Alt-Svc	✓	✓	✓	✓	✓	✓	✓	—	—	✓	✓
blob	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗
BroadcastChannel	✓	✗	✗	✓	✓	—	✗	✓	✓	✗	✗
CacheStorage	✓	✗	✗	✓	✓	—	✗	✓	—	✓	✗
cookie (HTTP)	✓	✗	✗	✓	✓	—	✗	✓	✓	✓	✗
cookie (JS)	✓	✗	✗	✓	✓	—	✗	✓	✓	✓	✗
CookieStore	✓	✗	✗	—	—	—	✗	—	—	—	✗
CSS cache	✓	✗	✗	✓	✓	—	✗	—	—	✗	✗
favicon cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
fetch cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
font cache	✓	✗	✗	✓	✓	—	✗	✓	—	✗	✗
getDirectory	✓	✗	✗	✓	—	—	✗	—	—	—	✗
H1 connection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2 connection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H3 connection	✓	✓	✓	✓	✓	✓	—	—	—	✓	—
HSTS cache	✓	✗	✗	✓	✓	—	✗	✓	—	✗	✗
iframe cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
image cache	✓	✗	✗	✓	✓	—	✗	✓	—	✗	✗
indexedDB	✓	✗	✗	✓	✓	—	✗	✓	—	—	✗
localStorage	✓	✗	✗	✓	✓	—	✗	✓	✓	✓	✗
locks	✓	✗	✗	✓	✓	—	✗	✓	—	✓	✗
prefetch cache	✓	✗	✗	✓	—	—	✗	—	—	✗	✗
ServiceWorker	✓	✓	✓	✓	—	—	✓	—	—	✓	✓
SharedWorker	✓	✗	✗	✓	—	—	✗	✓	—	✓	✗
TLS Session ID	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Web SQL Database	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XMLHttpRequest cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Navigation tests</b>											
Which browsers prevent websites from sharing tracking data when you click on a link?											
document.referrer	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
sessionStorage	✓	✗	✗	✓	✓	—	✗	✓	✓	✓	✗
window.name	✓	✗	✗	✓	✓	—	✗	✓	✓	✓	✗
<b>HTTPS tests</b>											
Which browsers use encrypted network connections whenever possible?											
Insecure website	✗	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable address	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable hyperlink	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable image	✓	✓	✓	✗	✓	✓	—	✗	✓	✓	✓
Upgradable script	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

# Challenges and design

Browser privacy leaks have been unquantified and unknown to most people

Run objective automated tests and make results public

Browsers update ~1 month

Run and publish results every week

Results should be actionable

Show side-by-side comparison

Privacy leaks are too technical for most readers

Simplify results to pass/fail

Hard for readers to know who to trust

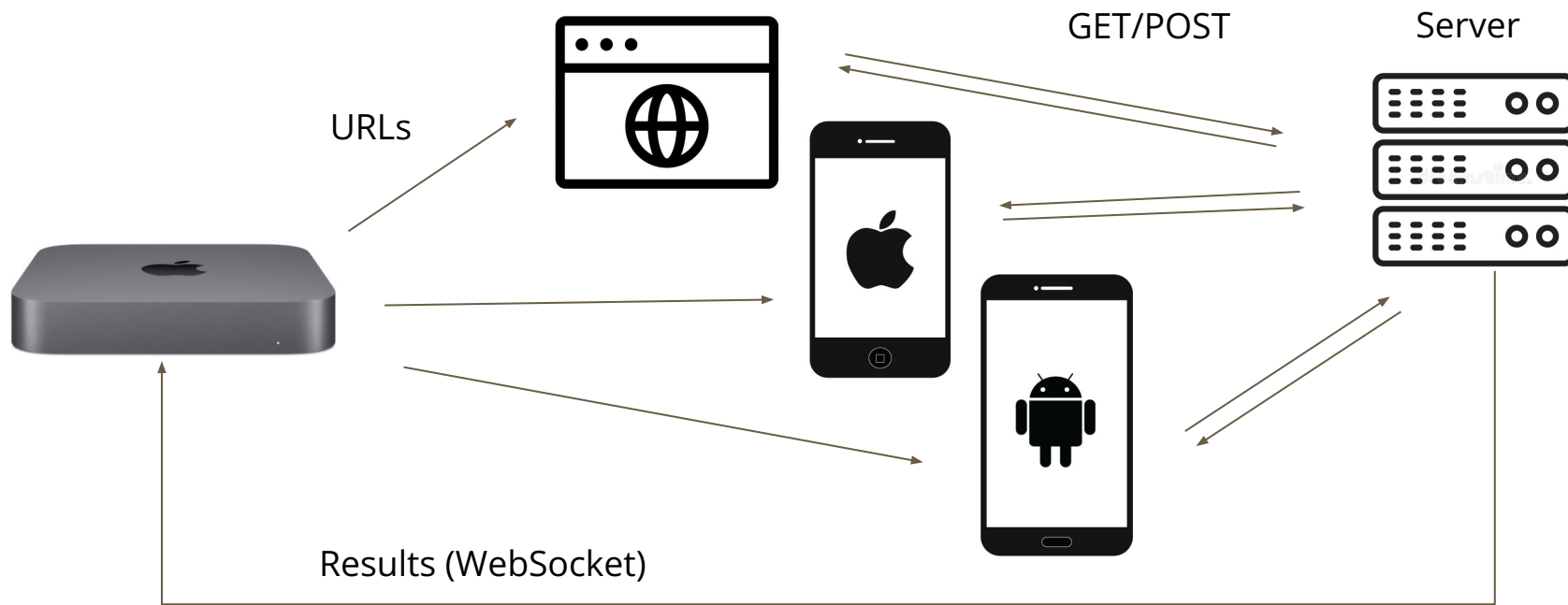
Make tests open source; stick to facts and make no recommendations

Many browser, and many privacy leaks

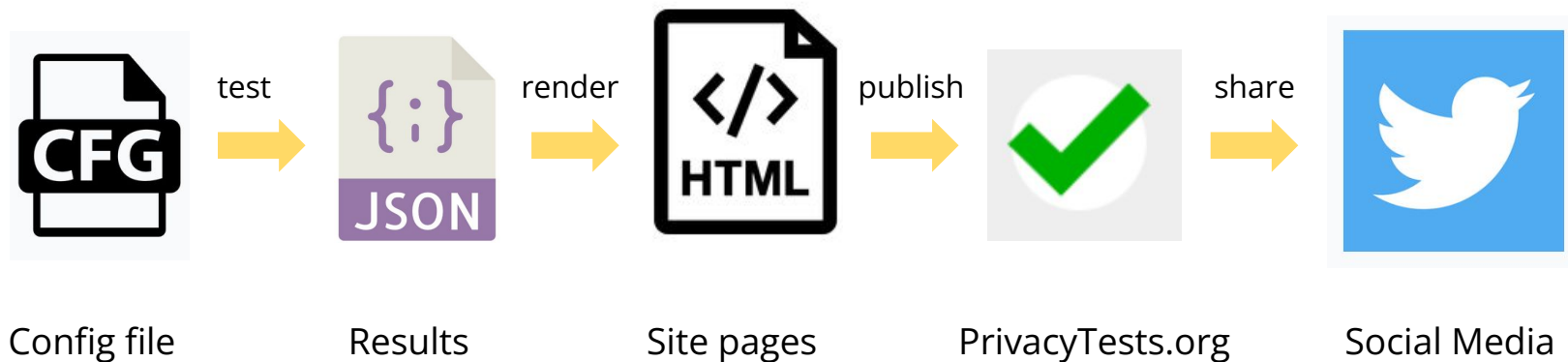
Launch early, continue to add tests and browsers

# PrivacyTests.org browser testing framework

Almost all JavaScript (NodeJS and in-browser)



# PrivacyTests.org data pipeline



# PrivacyTests.org platform coverage

<b>Platform</b>	<b>Device</b>	<b>Control</b>	<b>Browser windows</b>
Desktop (MacOS)	Mac Mini	Browser command-line arguments	Regular, Private, Nightly, Nightly Private
Android	Samsung phone	Appium	Regular, Private
iOS	iPhone	Appium	Regular, Private

# Kinds of browser privacy leaks currently tested

Stateful tracking

Navigational tracking

Miscellaneous

Insecure leaks

Fingerprinting

Tracking query parameters

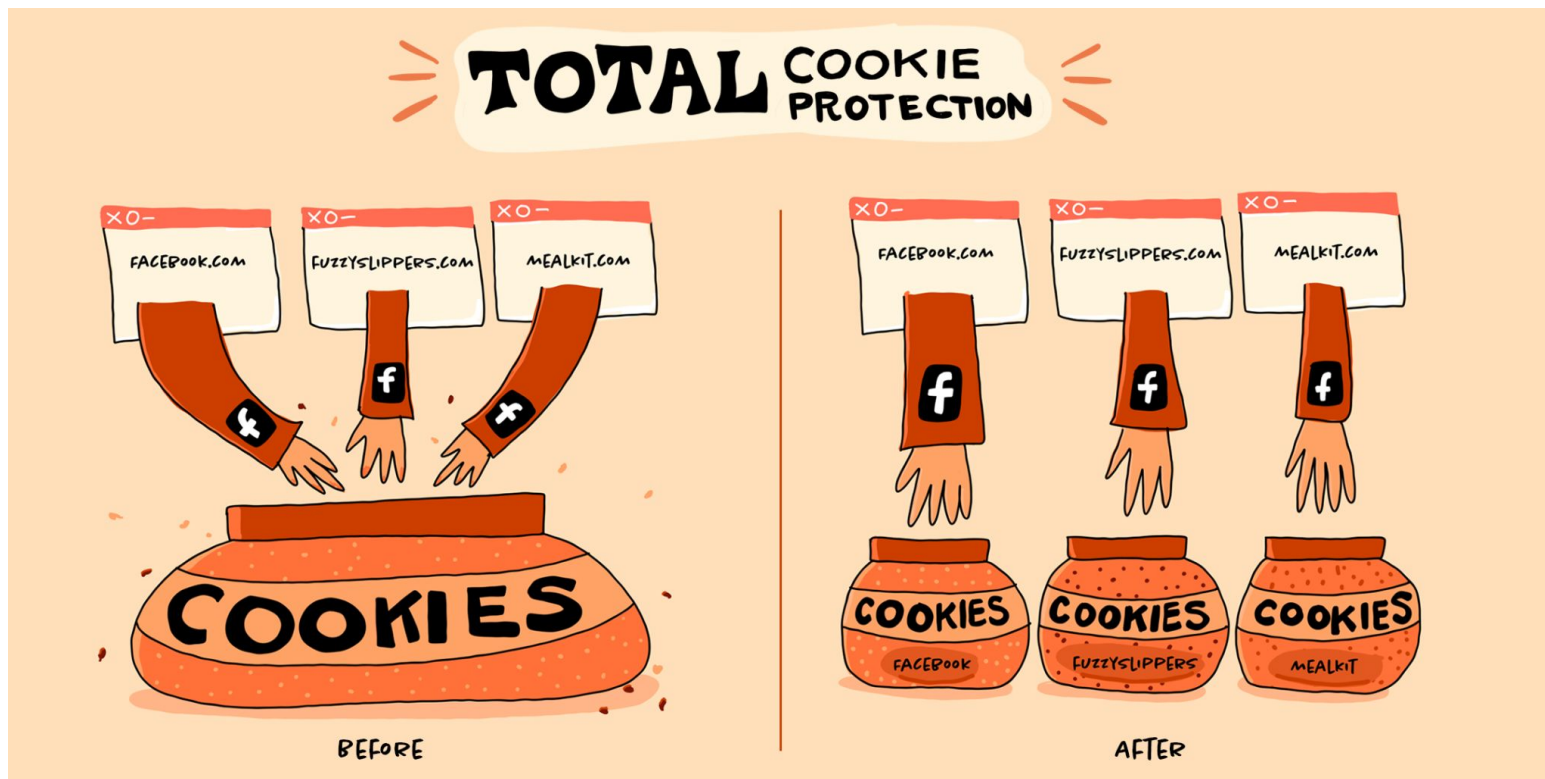
Tracking content (scripts, pixels)

Tracking cookies

Cross-session tracking (first-party, third-party)

# State partitioning

Credit: Megan Newell, Mozilla



# State partitioning

## Desktop Browsers

(default settings)



Brave  
1.56



Chrome  
114.0



Edge  
115.0



Firefox  
115.0



Librewolf  
115.0



Multivad  
12.5



Opera  
100.0



Safari  
16.5



Tor  
12.5



Ungoogled  
114.0



Vivaldi  
6.1

### State Partitioning tests

Which browsers isolate websites to prevent them from sharing data to track you?

	Brave	Chrome	Edge	Firefox	Librewolf	Multivad	Opera	Safari	Tor	Ungoogled	Vivaldi
Alt-Svc	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓
blob	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗
BroadcastChannel	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
CacheStorage	✓	✗	✗	✓	✓	–	✗	✓	–	✓	✗
cookie (HTTP)	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
cookie (JS)	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
CookieStore	✓	✗	✗	–	–	–	✗	–	–	✓	✗
CSS cache	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
favicon cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
fetch cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
font cache	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
getDirectory	✓	✗	✗	✓	✓	–	✗	–	–	✓	✗
H1 connection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2 connection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H3 connection	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓
HSTS cache	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
iframe cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
image cache	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
indexedDB	✓	✗	✗	✓	✓	–	✗	✓	–	✓	✗
localStorage	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
locks	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
prefetch cache	✓	✗	✗	✓	–	–	✗	–	–	✗	✗
ServiceWorker	✓	✓	✓	✓	✓	–	✓	✓	–	✓	✓
SharedWorker	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
TLS Session ID	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Web SQL Database	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XMLHttpRequest cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

# IP Address tracking

IP addressed tracking  
is a big problem!

## Don't Count Me Out: On the Relevance of IP Address in the Tracking Ecosystem

Vikas Mishra  
Inria / Univ. Lille  
vikas.mishra@inria.fr

Pierre Laperdrix  
CNRS / Univ. Lille / Inria  
pierre.laperdrix@univ-lille.fr

Antoine Vastel  
Univ. Lille / Inria  
antoine.vastel@inria.fr

Walter Rudametkin  
Univ. Lille / Inria  
walter.rudametkin@univ-lille.fr

Romain Rouvoy  
Univ. Lille / Inria / IUF  
romain.rouvoy@univ-lille.fr

Martin Lopatka  
Mozilla  
mlopatka@mozilla.com

We present an analysis of 34,488 unique public IP addresses collected from 2,230 users over a period of 111 days and we show that IP addresses remain a prime vector for online tracking. 87 % of participants retain at least one IP address for more than a month and 45 % of ISPs in our dataset allow keeping the same IP address for more than 30 days. Furthermore, we also detect the presence of cycles of IP addresses in a user's history and highlight their potential to be abused to infer traits of the user behaviour, as well as mobility traces. Our findings paint a bleak picture of the current state of online tracking at a time where IP addresses are overlooked compared to other techniques like cookies or fingerprinting.

# IP Address tracking

## Desktop Browsers

(default settings)



Brave  
1.56



Chrome  
114.0



Edge  
115.0



Firefox  
115.0



Librewolf  
115.0



Mullvad  
12.5



Opera  
100.0



Safari  
16.5



Tor  
12.5



Ungoogled  
114.0



Vivaldi  
6.1

## Misc tests

Which browsers provide additional assorted privacy protections?

GPC enabled first-party	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
GPC enabled third-party	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
IP address leak	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗
Stream isolation	-	-	-	-	-	-	-	-	✓	-	-
Tor enabled	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗

# HTTPS usage

## Desktop Browsers

(default settings)



Brave  
1.56



Chrome  
114.0



Edge  
115.0



Firefox  
115.0



Librewolf  
115.0



Mullvad  
12.5



Opera  
100.0



Safari  
16.5



Tor  
12.5



Ungoogled  
114.0



Vivaldi  
6.1

## HTTPS tests

Which browsers use encrypted network connections whenever possible?

Insecure website	✗	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable address	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable hyperlink	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Upgradable image	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓
Upgradable script	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

# Fingerprinting

## Desktop Browsers

(default settings)



Brave  
1.56



Chrome  
114.0



Edge  
115.0



Firefox  
115.0



Librewolf  
115.0



Mullvad  
12.5



Opera  
100.0



Safari  
16.5



Tor  
12.5



Ungoogled  
114.0



Vivaldi  
6.1

## Fingerprinting resistance tests

Which browsers hide what's unique about your device?

Media query screen height	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
Media query screen width	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
outerHeight	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
screen.height	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
screen.width	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
screenX	✓	✗	✗	✓	✓	✓	✗	✗	✓	✗	✗
screenY	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗
System font detection	✓	✗	✗	✗	✓	✓	✗	✓	✓	✗	✗

# Tracker query parameters (1)

[https://www.vrbo.com/travel/staycation?utm\\_campaign=vrbo:prog:usa-en:t:g:xxx:iroas&utm\\_medium=display&utm\\_source=dbm&utm\\_content=a:ban:dbm:xxx:pro:xxx:lake:xxx&utm\\_term=20193083|252013460|133520644|448385033&dclid=CNrN5PDpm\\_YCFRQTfQodiRAJuA](https://www.vrbo.com/travel/staycation?utm_campaign=vrbo:prog:usa-en:t:g:xxx:iroas&utm_medium=display&utm_source=dbm&utm_content=a:ban:dbm:xxx:pro:xxx:lake:xxx&utm_term=20193083|252013460|133520644|448385033&dclid=CNrN5PDpm_YCFRQTfQodiRAJuA)



Google "DoubleClick" ID

# Tracker query parameters (2)

## Desktop Browsers

(default settings)



Brave  
1.56



Chrome  
114.0



Edge  
115.0



Firefox  
115.0



Librewolf  
115.0



Mullvad  
12.5



Opera  
100.0



Safari  
16.5



Tor  
12.5



Ungoogled  
114.0



Vivaldi  
6.1

## Tracking query parameter tests

Which browsers remove URL parameters that can track you?

__hsfp	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
__hssc	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
__hstc	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
__s	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗
_hsenc	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
_openstat	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
dclid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
fbclid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
gclid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
hsCtaTracking	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
mc_eid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
mkt_tok	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
ml_subscriber	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
ml_subscriber_hash	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
msclkid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
oly_anon_id	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
oly_enc_id	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
rb_clickid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
s_cid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
vero_conv	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
vero_id	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
wickedid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
yclid	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗

# Tracking cookies and tracking content

## Desktop Browsers

(default settings)



### Tracking cookie protection tests

Which browsers block important known tracking cookies?

	Brave 1.56	Chrome 114.0	Edge 115.0	Firefox 115.0	LibreWolf 115.0	Mullvad 12.5	Opera 100.0	Safari 16.5	Tor 12.5	Ungoogled 114.0	Vivaldi 6.1
Adobe	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Adobe Audience Manager	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Amazon adsystem	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
AppNexus	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Bing Ads	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Chartbeat	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Criteo	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
DoubleClick (Google)	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Facebook tracking	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Google (third-party ad pixel)	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Google Analytics	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Google Tag Manager	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Index Exchange	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
New Relic	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Quantcast	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Scorecard Research Beacon	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Taboola	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗
Twitter pixel	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗
Yandex Ads	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗

## Desktop Browsers

(default settings)



### Tracker content blocking tests

Which browsers block important known tracking scripts and pixels?

	Brave 1.56	Chrome 114.0	Edge 115.0	Firefox 115.0	LibreWolf 115.0	Mullvad 12.5	Opera 100.0	Safari 16.5	Tor 12.5	Ungoogled 114.0	Vivaldi 6.1
Adobe	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Adobe Audience Manager	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Amazon adsystem	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
AppNexus	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Bing Ads	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Chartbeat	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Criteo	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
DoubleClick (Google)	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Facebook tracking	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Google (third-party ad pixel)	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Google Analytics	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Google Tag Manager	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Index Exchange	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
New Relic	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Quantcast	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Scorecard Research Beacon	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Taboola	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Twitter pixel	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Yandex Ads	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗

# Cross-session tracking

## Desktop Browsers

(default settings)



### Cross-session first-party tracking tests

Which browsers prevent websites from tracking you across browser sessions?

	Brave 1.56	Chrome 114.0	Edge 115.0	Firefox 115.0	LibreWolf 115.0	Mullvad 12.5	Opera 100.0	Safari 16.5	Tor 12.5	Unguarded 114.0	Vivaldi 6.1
Alt-Svc	x	x	x	x	✓	✓	x	-	-	x	x
CacheStorage	x	x	x	x	✓	-	✓	-	-	✓	x
cookie (HTTP)	✓	✓	✓	x	✓	✓	✓	x	✓	✓	✓
cookie (JS)	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓
CookieStore	✓	✓	✓	-	-	-	✓	-	-	✓	✓
CSS cache	x	x	x	x	✓	✓	x	x	✓	x	x
favicon cache	x	x	x	x	✓	✓	x	x	✓	x	x
fetch cache	x	x	x	x	✓	✓	x	x	✓	x	x
font cache	x	x	x	x	✓	✓	x	x	✓	x	x
iframe cache	x	x	x	x	✓	✓	x	x	✓	x	x
image cache	x	x	x	x	✓	✓	x	x	✓	x	x
indexedDB	x	x	x	x	✓	-	x	-	-	✓	x
localStorage	x	x	x	x	✓	✓	x	✓	✓	✓	x
prefetch cache	x	x	x	x	-	-	x	-	-	x	x
Web SQL Database	x	x	x	-	-	-	x	-	-	✓	x
XMLHttpRequest cache	x	x	x	x	✓	✓	x	x	✓	x	x

### Cross-session third-party tracking tests

Which browsers prevent third-party trackers from tracking you across browser sessions?

	Brave 1.56	Chrome 114.0	Edge 115.0	Firefox 115.0	LibreWolf 115.0	Mullvad 12.5	Opera 100.0	Safari 16.5	Tor 12.5	Unguarded 114.0	Vivaldi 6.1
Alt-Svc	x	x	x	x	✓	✓	x	-	-	x	x
CacheStorage	-	x	x	x	✓	-	x	-	-	-	x
cookie (HTTP)	✓	✓	✓	x	✓	-	✓	-	-	✓	✓
cookie (JS)	✓	✓	✓	x	✓	-	✓	-	-	✓	✓
CookieStore	✓	✓	✓	-	-	-	✓	-	-	✓	✓
CSS cache	x	x	x	x	✓	✓	x	x	✓	x	x
favicon cache	x	x	x	x	✓	✓	x	x	✓	x	x
fetch cache	x	x	x	x	✓	✓	x	x	✓	x	x
font cache	x	x	x	x	✓	✓	x	x	✓	x	x
iframe cache	x	x	x	x	✓	✓	x	x	✓	x	x
image cache	x	x	x	x	✓	✓	x	x	✓	x	x
indexedDB	-	x	x	x	✓	-	x	✓	-	-	x
localStorage	✓	x	x	x	✓	-	x	✓	-	-	x
prefetch cache	x	x	x	-	-	-	x	-	-	x	x
Web SQL Database	-	-	-	-	-	-	x	-	-	✓	x
XMLHttpRequest cache	x	x	x	x	✓	✓	x	x	✓	x	x

## Desktop private modes

(default settings)



### Cross-session first-party tracking tests

Which browsers prevent websites from tracking you across browser sessions?

	Brave 1.56 Private	Chrome 114.0 Private	Edge 115.0 Private	Firefox 115.0 Private	LibreWolf 115.0 Private	Mullvad 12.5 Private	Opera 100.0 Private	Safari 16.5 Private	Tor 12.5 Private	Unguarded 114.0 Private	Vivaldi 6.1 Private
Alt-Svc	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓
CacheStorage	✓	✓	-	-	-	✓	✓	✓	✓	✓	✓
cookie (HTTP)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cookie (JS)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CookieStore	✓	✓	-	-	-	✓	-	-	✓	✓	✓
CSS cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
favicon cache	✓	✓	✓	✓	✓	✓	✓	x	✓	✓	✓
fetch cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
font cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
iframe cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
image cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
indexedDB	✓	✓	✓	✓	✓	-	✓	-	-	✓	✓
localStorage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
prefetch cache	✓	✓	✓	✓	✓	-	✓	-	-	✓	✓
Web SQL Database	✓	✓	✓	✓	✓	-	✓	-	-	✓	✓
XMLHttpRequest cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

### Cross-session third-party tracking tests

Which browsers prevent third-party trackers from tracking you across browser sessions?

	Brave 1.56 Private	Chrome 114.0 Private	Edge 115.0 Private	Firefox 115.0 Private	LibreWolf 115.0 Private	Mullvad 12.5 Private	Opera 100.0 Private	Safari 16.5 Private	Tor 12.5 Private	Unguarded 114.0 Private	Vivaldi 6.1 Private
Alt-Svc	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓
CacheStorage	-	-	✓	-	-	-	-	✓	-	-	-
cookie (HTTP)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cookie (JS)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CookieStore	✓	-	✓	✓	✓	✓	✓	-	-	✓	✓
CSS cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
favicon cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
fetch cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
font cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
iframe cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
image cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
indexedDB	-	-	✓	✓	✓	-	✓	-	-	✓	✓
localStorage	✓	-	✓	✓	✓	-	✓	-	-	✓	✓
prefetch cache	✓	✓	✓	x	✓	✓	✓	-	-	✓	✓
Web SQL Database	-	-	-	-	-	-	✓	-	-	✓	✓
XMLHttpRequest cache	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

# Notable browser updates since October 2021

December 2021	Brave <a href="#">partitions network state</a>
June 2022	DuckDuckGo mobile blocks Bing trackers
July 2022	Tor Browser introduces <a href="#">HTTPS-Only Mode by default</a>
Fall of 2022	Firefox ships Total Cookie Protection (full partitioning) by default
Spring 2023	Chrome rolls out network state partitioning <a href="#">by default</a> and other Chromium-based browsers follow
June 2023	Brave <a href="#">ships</a> HTTPS by Default
June 2023	Safari 17 <a href="#">blocks</a> tracking query parameter links in Private Browsing



# Future work ideas

- More network leak tests (e.g. DoH, SNI, OCSP)
- More fingerprinting tests
- Telemetry tests
- Disk forensic tests
- “Privacy Sandbox” and other attribution APIs
- More browsers
- Browser Extensions
- Mobile apps (based on browsers)

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# Thank you!

Reach me at:

[contact@privacytests.org](mailto:contact@privacytests.org)

[@privacytests](https://twitter.com/privacytests) (Twitter)

<https://github.com/arthuredelstein/privacytests.org>