Not Your Average App: A Large-scale Privacy Analysis of Android Browsers

Amogh Pradeep, Álvaro Feal, Julien Gamba, Ashwin Rao, Martina Lindorfer, Narseo Vallina-Rodriguez, David R. Choffnes
Mobile Browsers as Web Browsers

Popular

- Over 58% of global website visits in 2022
Mobile Browsers as Web Browsers

Popular

Handle sensitive browsing data
Mobile Browsers as Web Browsers

Popular

Handle sensitive browsing data

- Browsing history, logins, etc.
Mobile Browsers as Mobile Apps
Mobile Browsers as Mobile Apps

Can access mobile-specific sensitive user data
Mobile Browsers as Mobile Apps

Can access mobile-specific sensitive user data
Mobile Browsers - Questions

How do mobile browsers **harm users?**

- Access mobile-specific user data
- Share data with web hosts
- Fail to implement security measures

How do mobile browsers **protect users?**

- User data
- Browsing the Internet
Harms - User Data Access

What mobile-specific user data do browsers access?
Harms - User Data Access

What mobile-specific user data do browsers access?
Harms - User Data Access

What mobile-specific user data do browsers access?

What components are responsible for this access?
Harms - User Data Access

What mobile-specific user data do browsers access?

What components are responsible for this access?
Harms - User Data Access

What mobile-specific user data do browsers access?

- Permission requested

What components are responsible for this access?
Harms - User Data Access

What mobile-specific user data do browsers access?
- Permission requested

What components are responsible for this access?
- 3rd party code analysis
Do browsers share user data with unrelated parties?
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic with mitmproxy
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic with **mitmproxy**
- What traffic is legitimate?
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic with mitmproxy
- What traffic is legitimate?

Baseline browser
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic with mitmproxy
- What traffic is legitimate?

Baseline browser

- Compare traffic
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

- Inspect network traffic with mitmproxy
- What traffic is legitimate?

Baseline browser

- Compare traffic
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

Do browsers render websites accurately?
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

Do browsers render websites accurately?

- Inject with **mitmproxy**
Protections - Browsing the Internet

Do browsers share user data with unrelated parties?

Do browsers render websites accurately?

- Inject with **mitmproxy**
- Obtain rendered content
Mobile Browsers - Collection & Identification

Google Play and 4 popular Chinese stores
Mobile Browsers - Collection & Identification

Google Play and 4 popular Chinese stores

Well known browsers, app category, search for “browser”, etc.
Filtering False Positives

“Browser” ambiguous
Filtering False Positives

“Browser” ambiguous

Try launching a website
Filtering False Positives

“Browser” ambiguous

Try launching a website

- Only browsers pass
Filtering False Positives

“Browser” ambiguous

Try launching a website
- Only browsers pass

Total of 424 browsers
Putting It All Together

Multiple browsers

Multiple websites

Mitmproxy

Automate installation and tests

Baseline for ground truth
Results - Overview

Browsing history collection
Identifier collection
Other harms/protections measured
Combined multidimensional analysis
Harms - Browsing History Collection

~3% (13 of 424) browsers send browsing history along with identifier(s)

~9% (37 of 424) share browsing history
  - Was unrelated to any user-facing browser features

~14% (60 of 424) share browsing history
  - Related to known browser feature (sitecheck, suggestion, search, etc.)
  - Still poses a potential privacy risk
Harms - Observed Identifier Collection
Harms - Observed Identifier Collection

3 browsers **bridge IDs** (collect resettable and non-resettable IDs)
Harms - Observed Identifier Collection

3 browsers **bridge IDs** (collect resettable and non-resettable IDs)

- Collecting IMEI & Ad ID
Harms - Observed Identifier Collection

3 browsers **bridge IDs** (collect resettable and non-resettable IDs)

2% Play, 6% Chinese browsers collect non-resettable identifiers
Harms - Observed Identifier Collection

3 browsers **bridge IDs** (collect resettable and non-resettable IDs)

2% Play, 6% Chinese browsers collect non-resettable identifiers

32% browsers collect at least one identifier
Results - Other Harms and Protections

Harm Privacy

- 10% fail to validate TLS certificates
Results - Other Harms and Protections

Harm Privacy
- 10% fail to validate TLS certificates

Protect Privacy
- 65% block trackers and 51% block scripts (from content modification analysis)
- 2% promote connection security, default to HTTPS
Results - Multidimensional Analysis
Results - Multidimensional Analysis

![Graph showing multidimensional analysis results]

Legend:
- Script blocking
- No TLS validation
- PII Exposure
- HTTPS default
- History Leak
- Request blocking missed
Results - Multidimensional Analysis
Results - Multidimensional Analysis
Mobile Browsers - Wrap Up

Evaluated privacy and security for a large set of mobile browsers

Findings:

- Most browsers (including popular) show mixed behavior
- History leaks are prevalent (~14%)
- PII collection is prevalent (~23%)

Apps, data, and analysis code are publicly available

Google disclosure

for the DDPRP program, but the information you provided was passed to our Trust and Safety team, leading to actions being taken against some of the apps.
Not Your Average App: A Large-scale Privacy Analysis of Android Browsers

Amogh Pradeep, Álvaro Feal, Julien Gamba, Ashwin Rao, Martina Lindorfer, Narseo Vallina-Rodriguez, David R. Choffnes

Questions?

https://neu-sns.github.io/mobile-browsers/