

Privacy on the Web

Advanced Computer Security
CS563/ECE524

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Announcements



- Make sure you're on Slack!
 - Add your intro to #introductions
- Readings for Web Privacy posted
 - Start reading papers for next week
 - Volunteer to present
- Start thinking about projects
 - Project discussion on Feb 11
- Registration — still working on it

**Your preferred name, pronouns
Research interests, advisor (if any)
Favorite recent paper and why
An interesting non-work related fact about you**

Cookies

- HTTP was designed as a *stateless* protocol
- Cookies added to keep client state
 - Set-Cookie header asks browser to remember a string
 - Browser sends Cookie header on future requests to *same domain*
- Example:
 - Add item to cart: “Set-Cookie: cart_contents=XXX” -> saved by browser
 - Go to checkout: “Cookie: cart_contents=XXX” -> sent by browser

3rd Party Cookies & Tracking

- Websites include 3-party content
 - Images, scripts, **ads**
- 3rd party pages use Set-Cookie to do cross-site tracking
 - Visit cnn.com
 - Request ad from double-click.net
 - Set-Cookie: client_id=12345
 - Visit microsoft.com
 - Request ad from doubleclick.net
 - Browser sends: Cookie: client_id=12345

Tracking and Profiling

- Track user across websites, contexts
- Profile activities
 - Interests
 - Shopping patterns
 - Infer demographic attributes (e.g., income, gender, ...)
- Link to identities
 - Name, email address, social media
- Why?

Targeted Advertising

- Online advertising is a big market
 - \$237B in 2022, 15% annual growth rate
 - Chief source of revenue for many media sites (news, social)
- Targeted advertising is estimated to make advertising ~2x more profitable than contextual ads

Literature review: Value of a cookie estimates

Study	Data	Method	Outcome	Estimate
Goldfarb & Tucker (2011)	9,596 ad campaigns	Natural experiment (e-Privacy Directive)	User purchase intent (surveyed)	65%
Beales & Eisenach (2014)	2 ad exchanges + large, multi-site publisher	Regression adjustment	Exchange/publisher price	>66% [†]
Johnson, Shriver, & Du (2019)	Ad exchange (10K+ advertisers, publishers)	Regression adjustment	Exchange price	52%
Marotta, Abhishek, & Acquisti (2019)	large, multi-site publisher	Augmented inverse probability weighting	Publisher revenue	4%
Google (2019)	Google top 500 publishers	Experiment	Publisher revenue	52%

Notes: Value estimates measure loss in e.g. price without a cookie. Industry studies in grey. [†]Marginal effect estimates for new cookie (Figure A-1).

Studies:

Goldfarb, A. & Tucker, C. (2011). Privacy regulation and online advertising. *Management Science*.
 Beales, J. H. & Eisenach, J. A. (2014). An empirical analysis of the value of information sharing in the market for online content. Technical report, Navigant Economics.
 Johnson, G., Shriver, S., & Du, S. (2019) Consumer privacy choice in online advertising: Who opts out and at what cost to industry? *Marketing Science*, forthcoming.
 Marotta, V., Abhishek, V., & Acquisti, A. (2019). Online tracking and publishers' revenues: An empirical analysis. Working paper.
 Google (2019) <https://www.blog.google/products/ads/next-steps-transparency-choice-control/>

Web Tracking Arguments

- Pro-tracking:
 - Ads are a key enabling technology for sustainable open web
 - Targeted advertising improves user experience
- Anti-tracking:
 - Advertising industry as a whole knows too much
 - Ads suck!

DISPLAY LUMAscape



[Dashed Box] Denotes acquired company

[Solid Box] Denotes shuttered company

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Cookie Blocking

- 3rd party cookie blocking
- Countermeasures:
 - Other state tracking
 - Blocked by state segregation
 - Fingerprinting
 - 1st party cookies

Fingerprinting

- Use features of browser to identify person
 - User-agent (browser version)
 - Plugins, fonts
 - Screen size, time zone
 - ...

Our tests indicate that you have **some protection against Web tracking, but it has **some gaps**.**

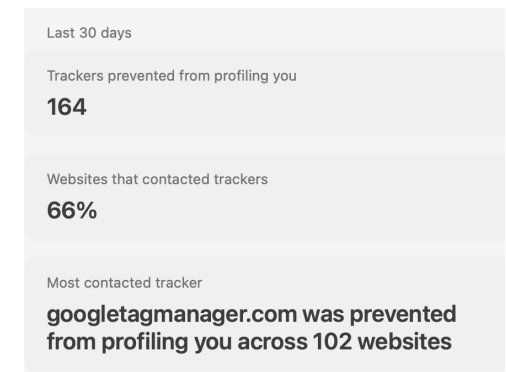
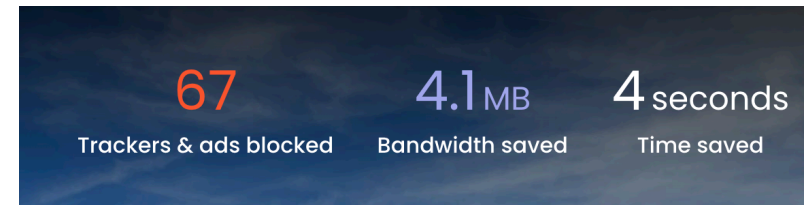
IS YOUR BROWSER:

Blocking tracking ads?	<u>Partial protection</u>
Blocking invisible trackers?	<u>Partial protection</u>
Protecting you from fingerprinting?	<u>Your browser has a nearly-unique fingerprint</u>

coveryourtracks.eff.org

Ad & Tracker Blocking

- Block ads and trackers
 - By domain
 - By script
 - By functionality
- Implemented in plugins (uBlock), Safari (ATP), Brave
- Challenges:
 - Arms race to identify tracking
 - Breakage (accidental and intentional)



Tensions in Web Privacy

- Multiple actors with split loyalties
 - Users
 - Browser vendors
 - Publishers
 - Advertisers
- Pressure points
 - Economic (revenue, user demand)
 - Regulatory

Regulation

- General Data Protection Regulation (EU): how user data are stored, used
- ePrivacy directive: specifically governs cookies
- California Consumer Privacy Act (CCPA)

Privacy Sandbox

- Planks:
 - Improve privacy protection in browser
 - Use privacy-preserving ad targeting
 - Use MPC for privacy-reserving conversion, analytics

Privacy-Preserving Targeting

- Federated Learning of Cohorts (FLoC)
 - Large (1K+ user) cohorts with similar behavior
 - Target advertising to those
- Topics API
 - In-browser learning of topics from an ontology
 - Transparency and cover topics
- FLEDGE
 - In-browser bidding based on behavior



Challenges

Maintain privacy while achieving desirable functionality
Have publishers and advertising ecosystem adapt to new functionality

Papers

- Cookies and Tracking (Feb 4)
 - CookieGraph: Understanding and Detecting First-Party Tracking Cookies
 - FP-Fed: Privacy-Preserving Federated Detection of Browser Fingerprinting
- Ad Targeting (Feb 11)
 - Collaborative Ad Transparency: Promises and Limitations
 - When and Why Do People Want Ad Targeting Explanations? Evidence from a Four-Week, Mixed-Methods Field Study

Papers

- Project Discussion (Feb 11)
- Tracker Blocking
 - Defining 'Broken': User Experiences and Remediation Tactics When Ad-Blocking or Tracking-Protection Tools Break a Website's User Experience
 - Blocking Tracking JavaScript at the Function Granularity

Papers

- Privacy-Preserving Advertising
 - Privacy Limitations of Interest-based Advertising on The Web: A Post-mortem Empirical Analysis of Google's FLoC
 - Fledging Will Continue Until Privacy Improves: Empirical Analysis of Google's Privacy-Preserving Targeted Advertising
- Regulation
 - RuleKeeper: GDPR-Aware Personal Data Compliance for Web Frameworks
 - The Effect of Design Patterns on (Present and Future) Cookie Consent Decisions

Wrap Up

Your preferred name, pronouns
Research interests, advisor (if any)
Favorite recent paper and why
An interesting non-work related fact about you

- Introductions
- Start reading papers
 - Read paper reading advice on web page
- Volunteer to present and/or scribe
- Think of projects
- Thursday: paper reviewing advice + project milestones