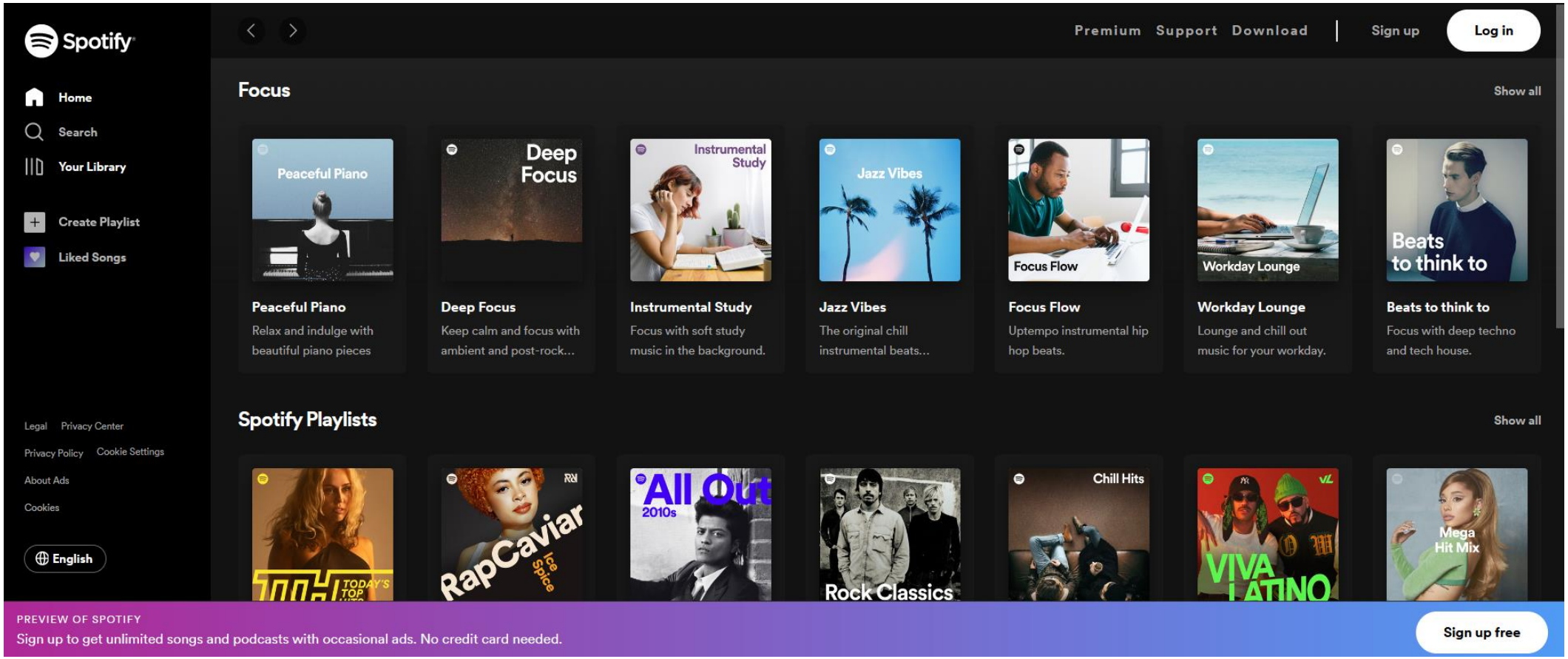
Exploring the Cookieverse:

A Multi-Perspective Analysis of Web Cookies

PASSIVE AND ACTIVE
MEASUREMENT
CONFERENCE 2023

ALI RASAII
SHIVANI SINGH
DEVASHISH GOSAIN
OLIVER GASSER


Spotify
Home
Search
Your Library
Create Playlist
Liked Songs
Legal
Privacy Center
Privacy Policy
Cookie Settings
About Ads
Cookies
English
Premium
Support
Download
Sign up
Log in
Focus
Show all
Peaceful Piano
Relax and indulge with beautiful piano pieces
Deep Focus
Keep calm and focus with ambient and post-rock...
Instrumental Study
Focus with soft study music in the background.
Jazz Vibes
The original chill instrumental beats...
Focus Flow
Uptempo instrumental hip hop beats.
Workday Lounge
Lounge and chill out music for your workday.
Beats to think to
Focus with deep techno and tech house.
Spotify Playlists
Show all
RapCaviar
Ice Spice
All Out 2010s
Rock Classics
Chill Hits
VIVA LATINO
Mega Hit Mix
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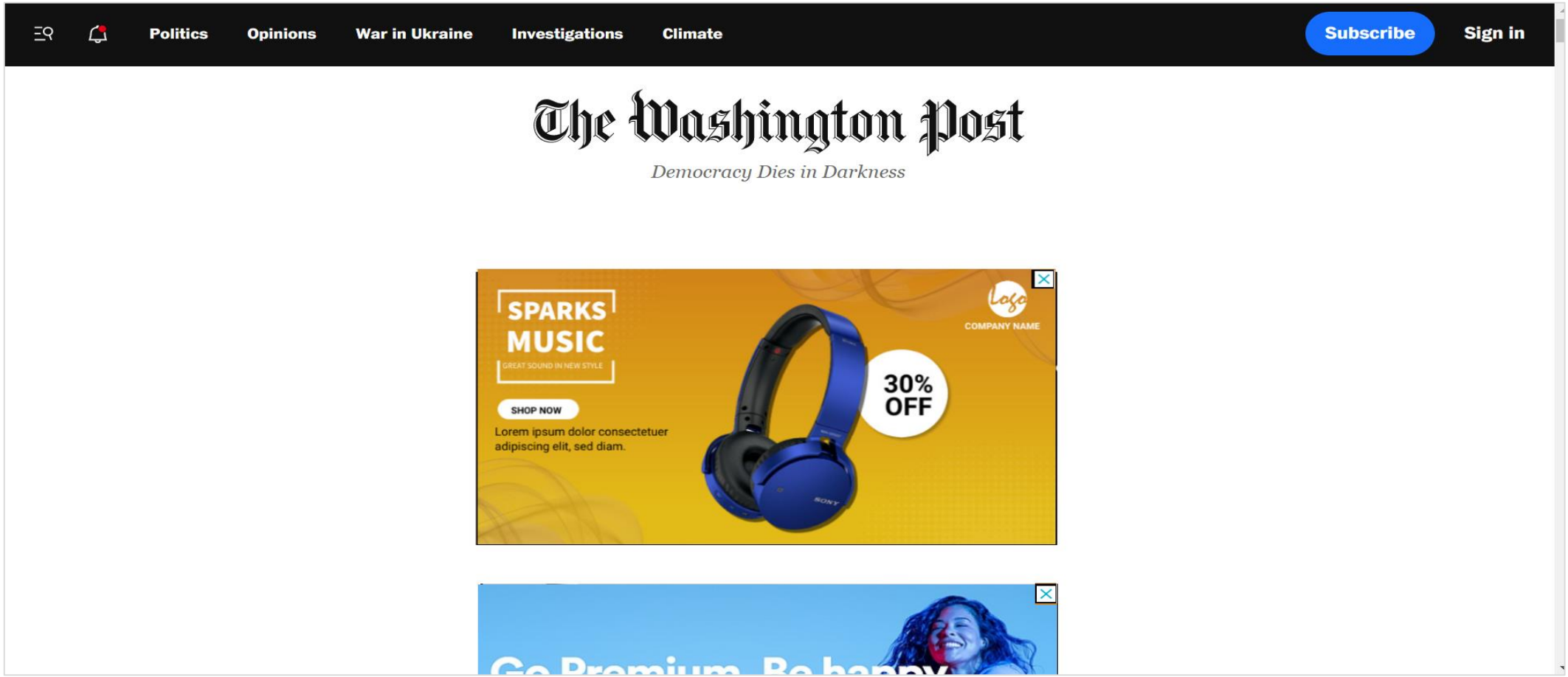
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SHOP NOW
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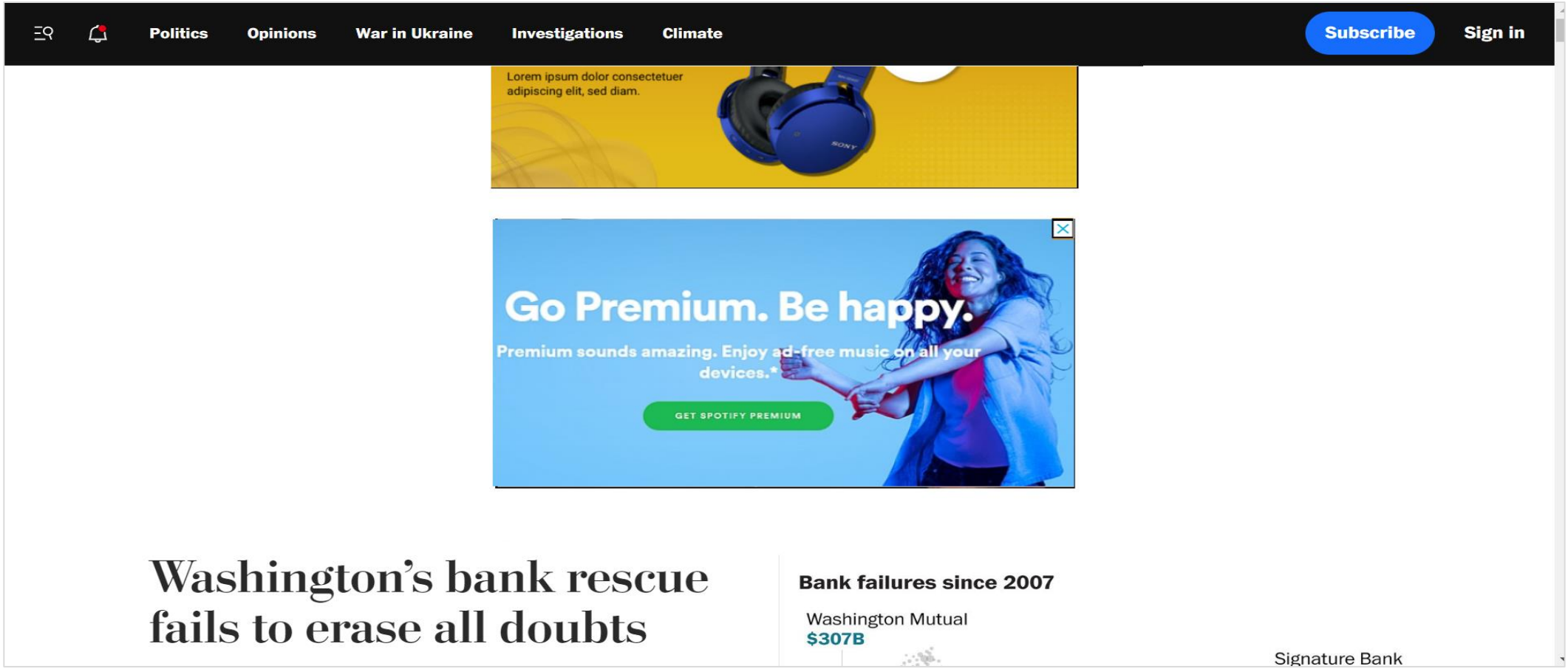
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Premium sounds amazing. Enjoy ad-free music on all your devices.*
GET SPOTIFY PREMIUM
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Bank failures since 2007
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$307B
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Background

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- General Data Protection Regulation (GDPR)
  - EU law
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  - Enhance individuals' control and rights over their personal data

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  - Enhance individuals' control and rights over their personal data
- California Consumer Privacy Act (CCPA)
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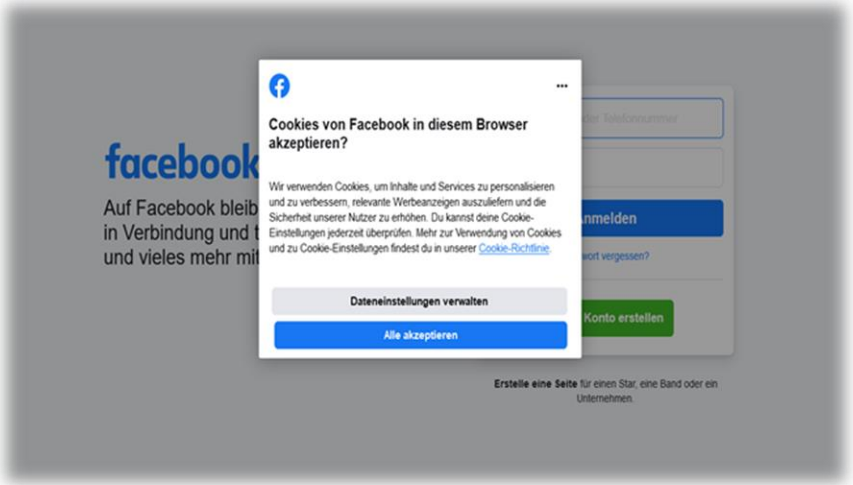
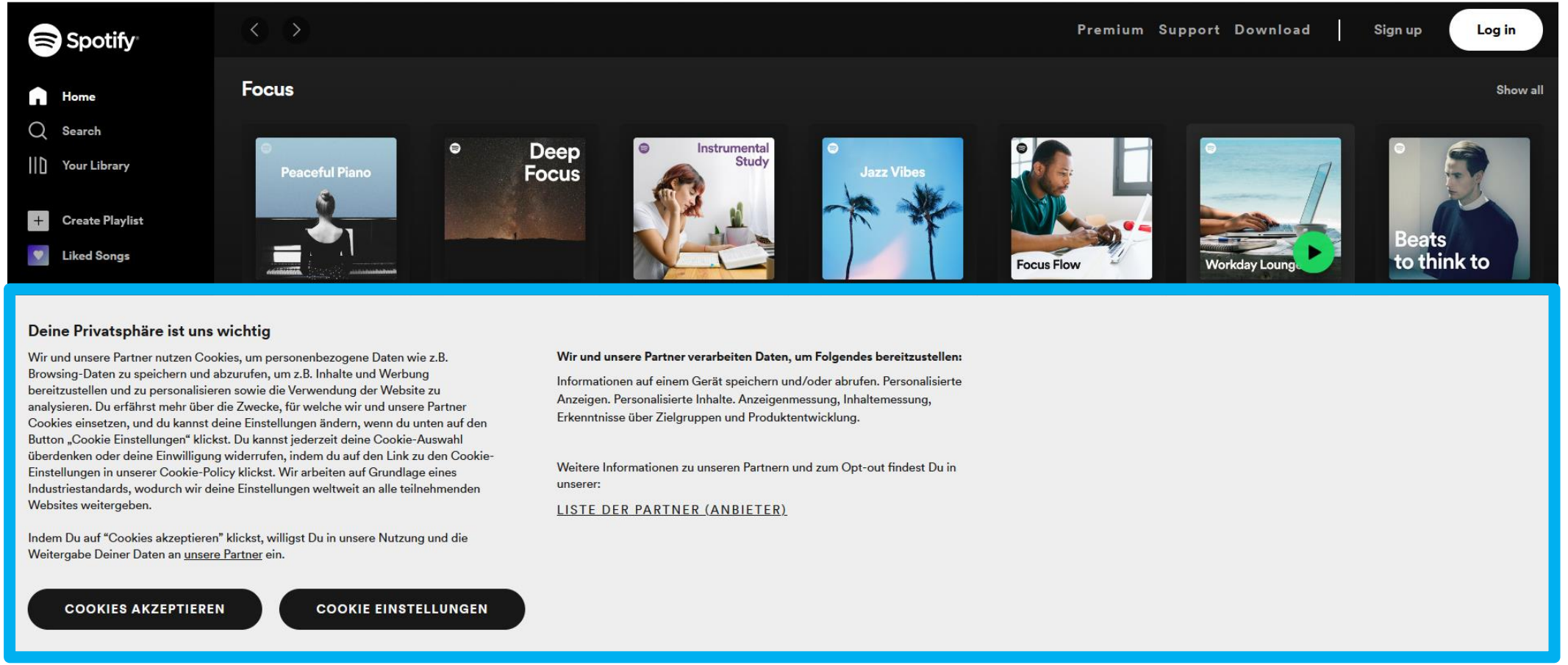
  - January 1, 2020
- Enterprises and vendors react
  - Cookies banners




Spotify
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Search
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Liked Songs
Premium
Support
Download
Sign up
Log in
Focus
Show all
Peaceful Piano
Deep Focus
Instrumental Study
Jazz Vibes
Focus Flow
Workday Lounge
Beats to think to
Deine Privatsphäre ist uns wichtig
Wir und unsere Partner nutzen Cookies, um personenbezogene Daten wie z.B. Browsing-Daten zu speichern und abzurufen, um z.B. Inhalte und Werbung bereitzustellen und zu personalisieren sowie die Verwendung der Website zu analysieren. Du erfährst mehr über die Zwecke, für welche wir und unsere Partner Cookies einsetzen, und du kannst deine Einstellungen ändern, wenn du unten auf den Button „Cookie Einstellungen“ klickst. Du kannst jederzeit deine Cookie-Auswahl überdenken oder deine Einwilligung widerrufen, indem du auf den Link zu den Cookie-Einstellungen in unserer Cookie-Policy klickst. Wir arbeiten auf Grundlage eines Industriestandards, wodurch wir deine Einstellungen weltweit an alle teilnehmenden Websites weitergeben.
Indem Du auf “Cookies akzeptieren” klickst, willigst Du in unsere Nutzung und die Weitergabe Deiner Daten an unsere Partner ein.
COOKIES AKZEPTIEREN
COOKIE EINSTELLUNGEN
Wir und unsere Partner verarbeiten Daten, um Folgendes bereitzustellen:
Informationen auf einem Gerät speichern und/oder abrufen. Personalisierte Anzeigen. Personalisierte Inhalte. Anzeigenmessung, Inhaltemessung, Erkenntnisse über Zielgruppen und Produktentwicklung.
Weitere Informationen zu unseren Partnern und zum Opt-out findest Du in unserer:
LISTE DER PARTNER (ANBIETER)

Research Questions

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  - Geographic location (EU vs. non-EU)

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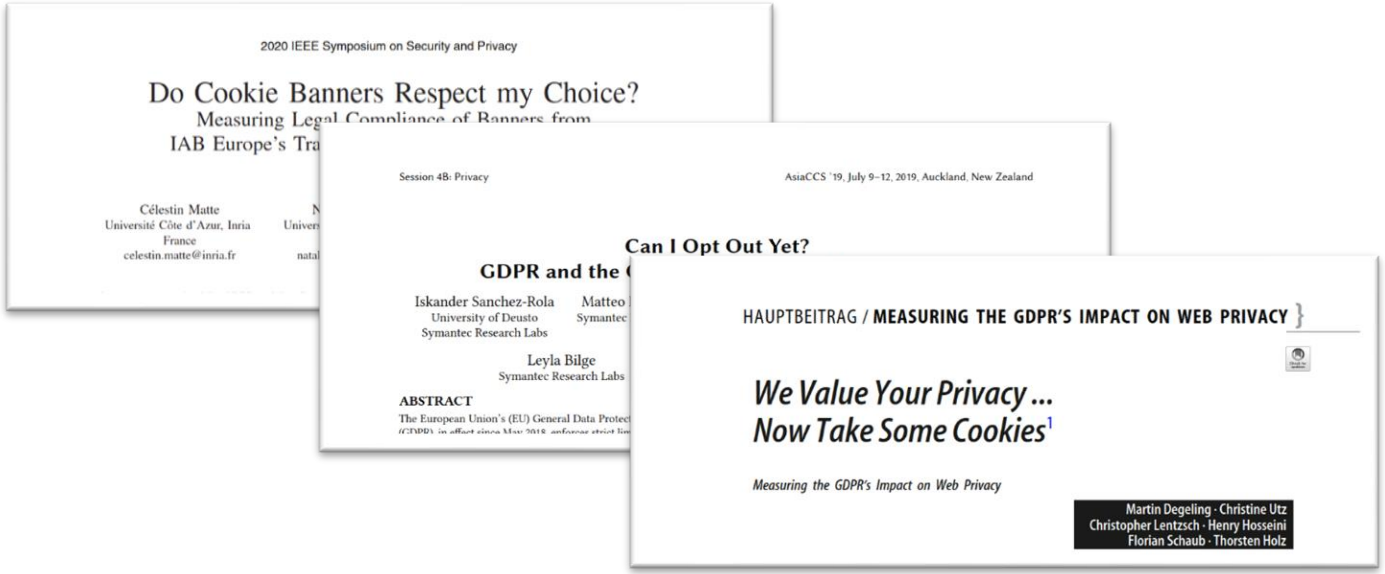
- Do websites exhibit different behavior?
  - Geographic location (EU vs. non-EU)
  - User agent (mobile vs. desktop)

Related works

Related works

- Not considering users' characteristics
- Manual or semi-automated inspection



Related works

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- Hard-to-scale automated tool
- Just "accept" option

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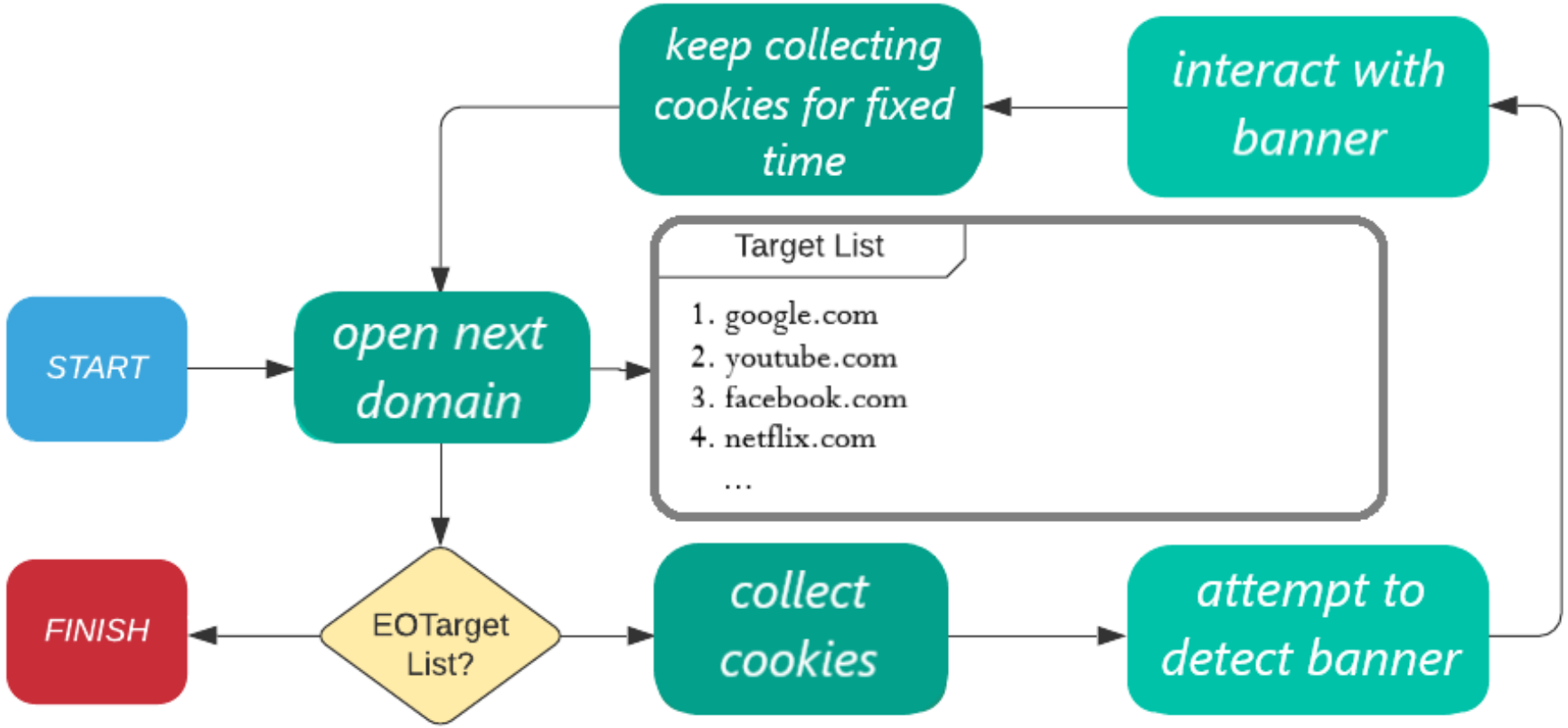
Goal: analysis of cookie landscape from different perspectives in a automated way

Methodology



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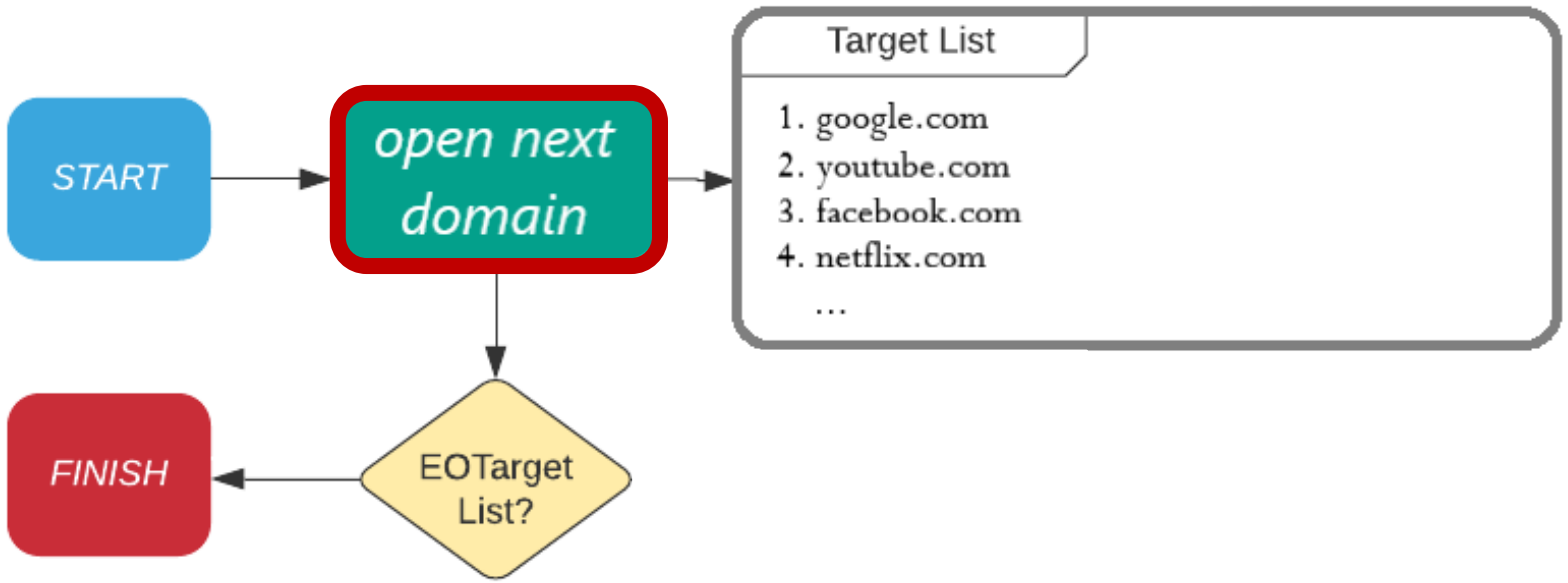

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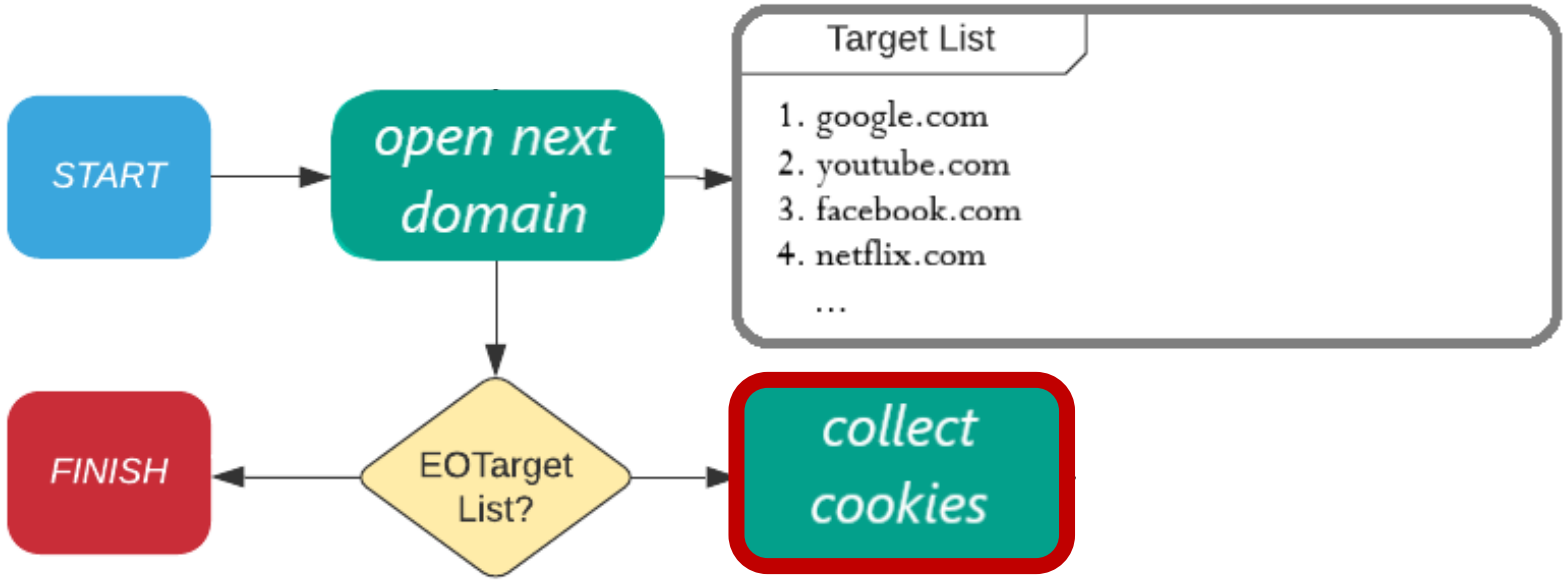

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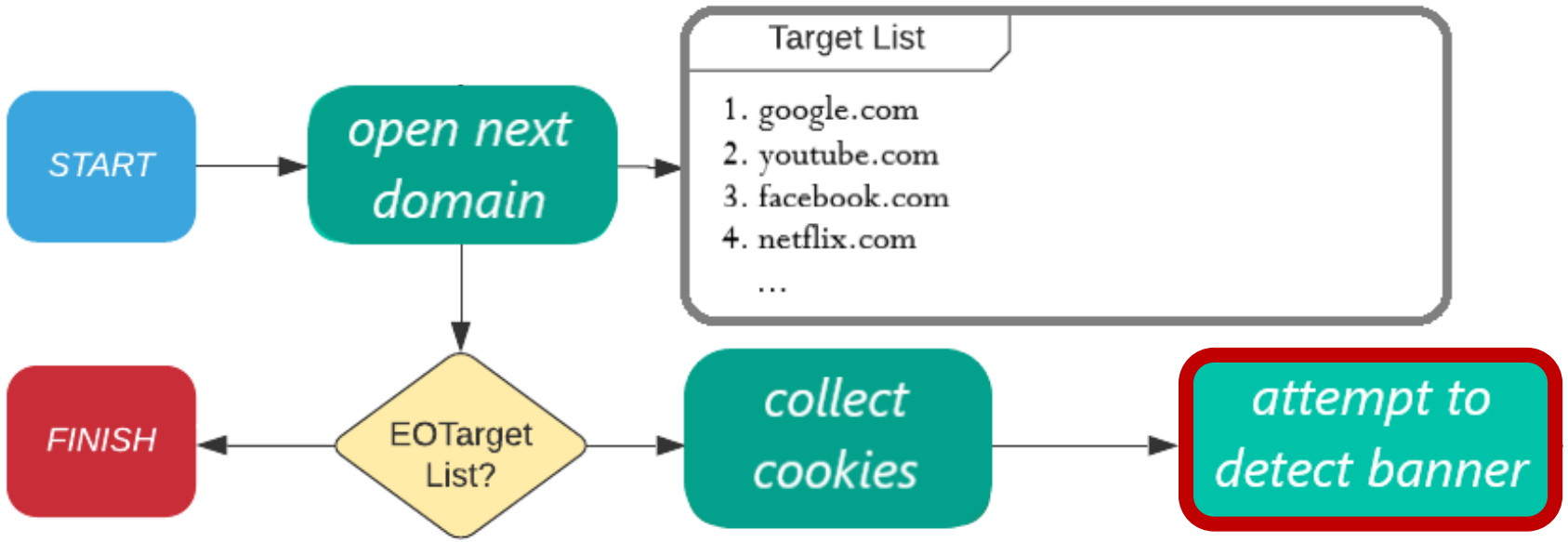
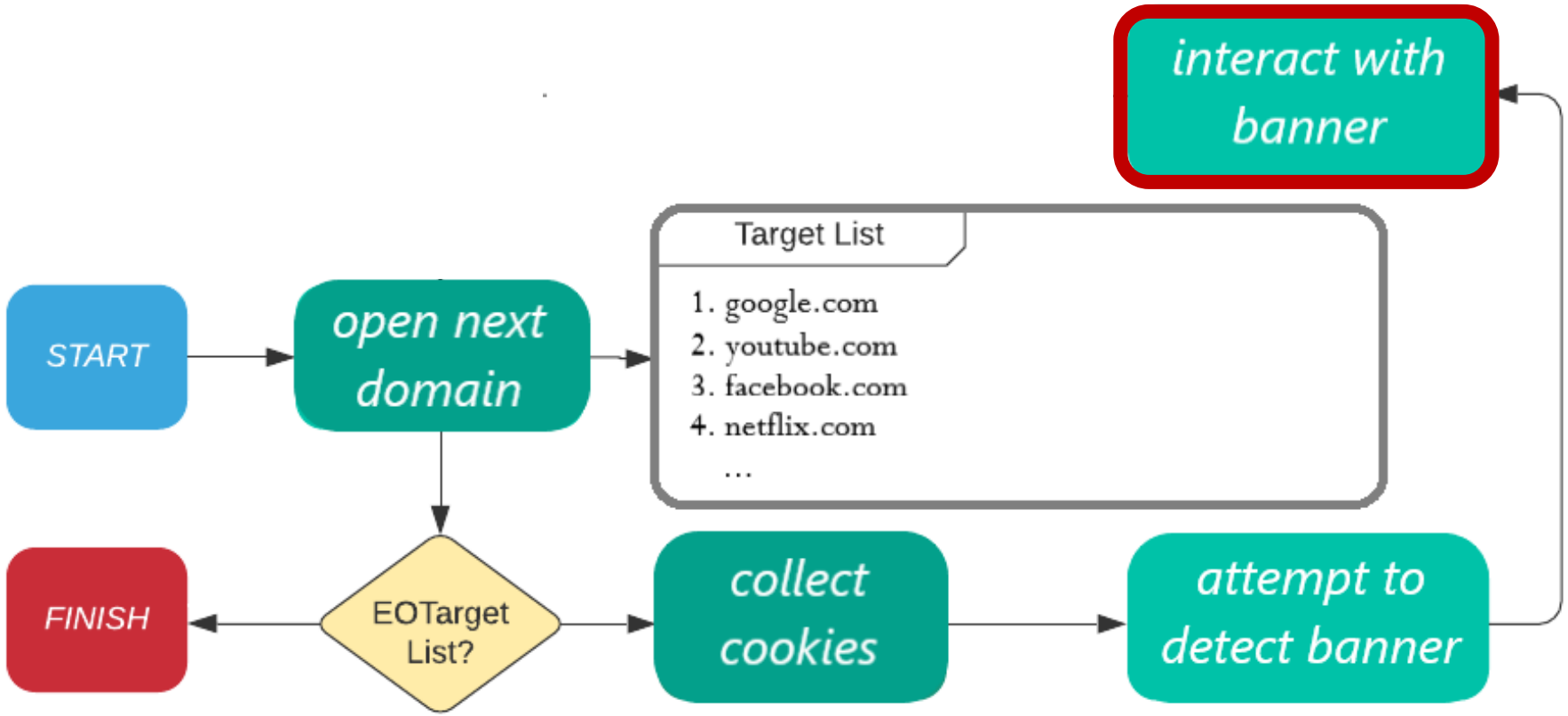
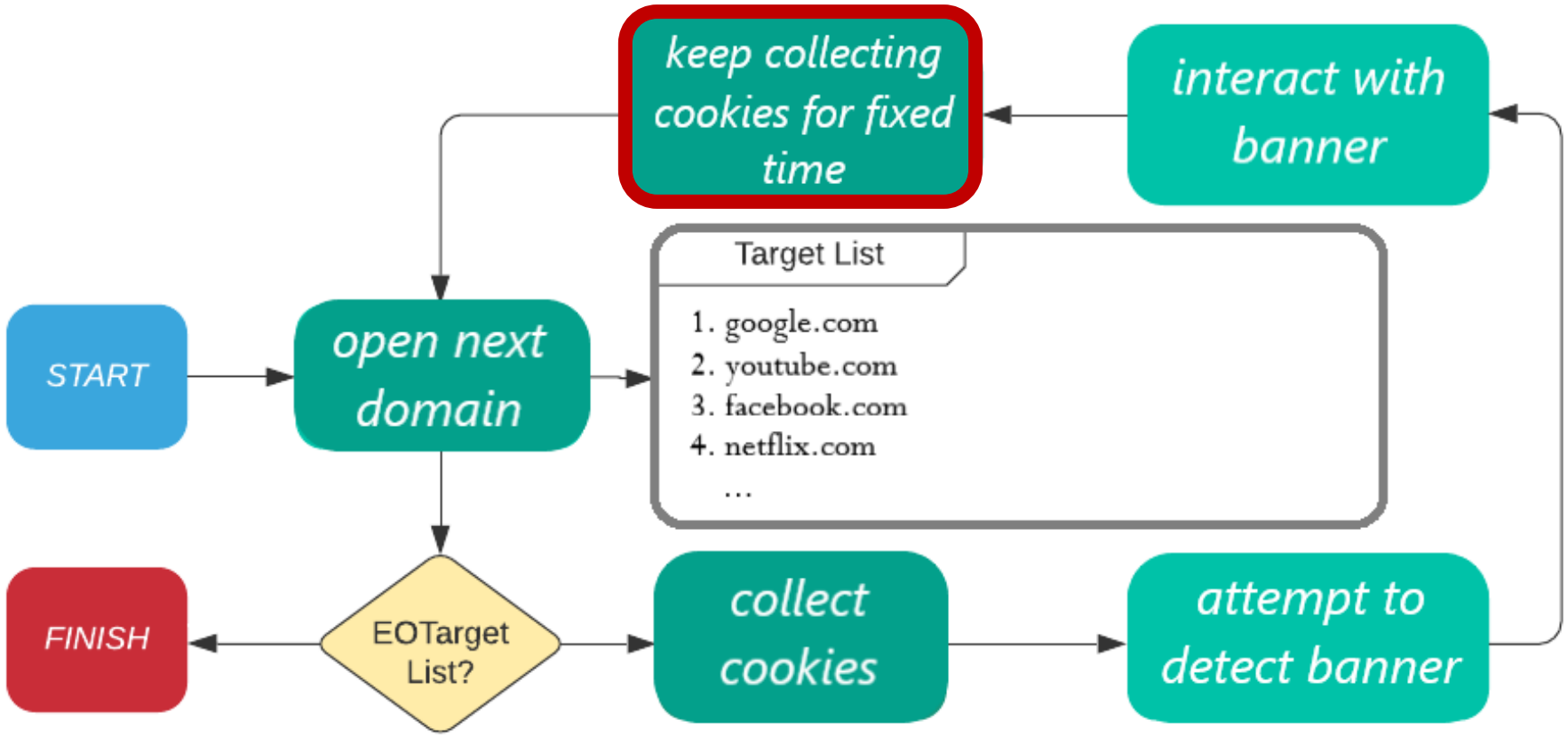


Methodology



Methodology



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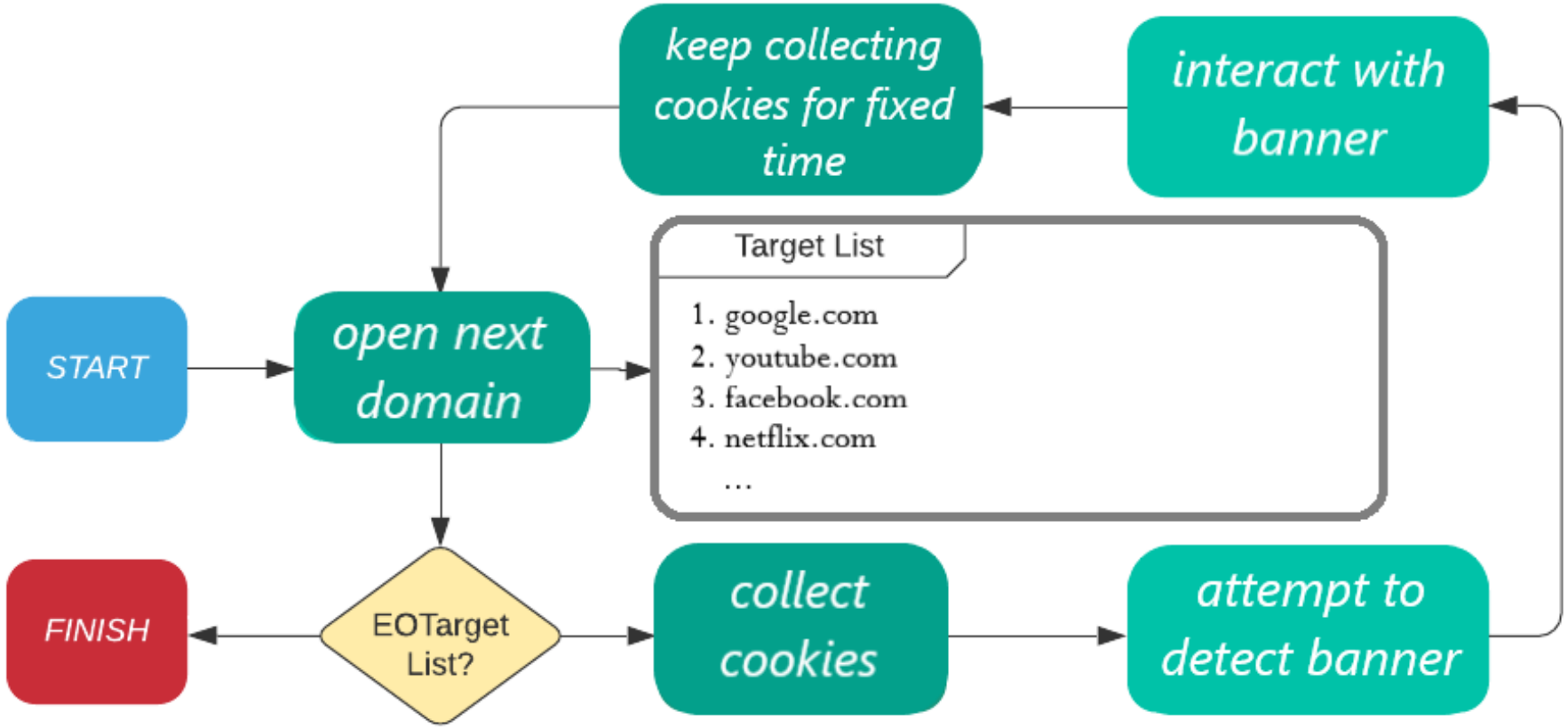

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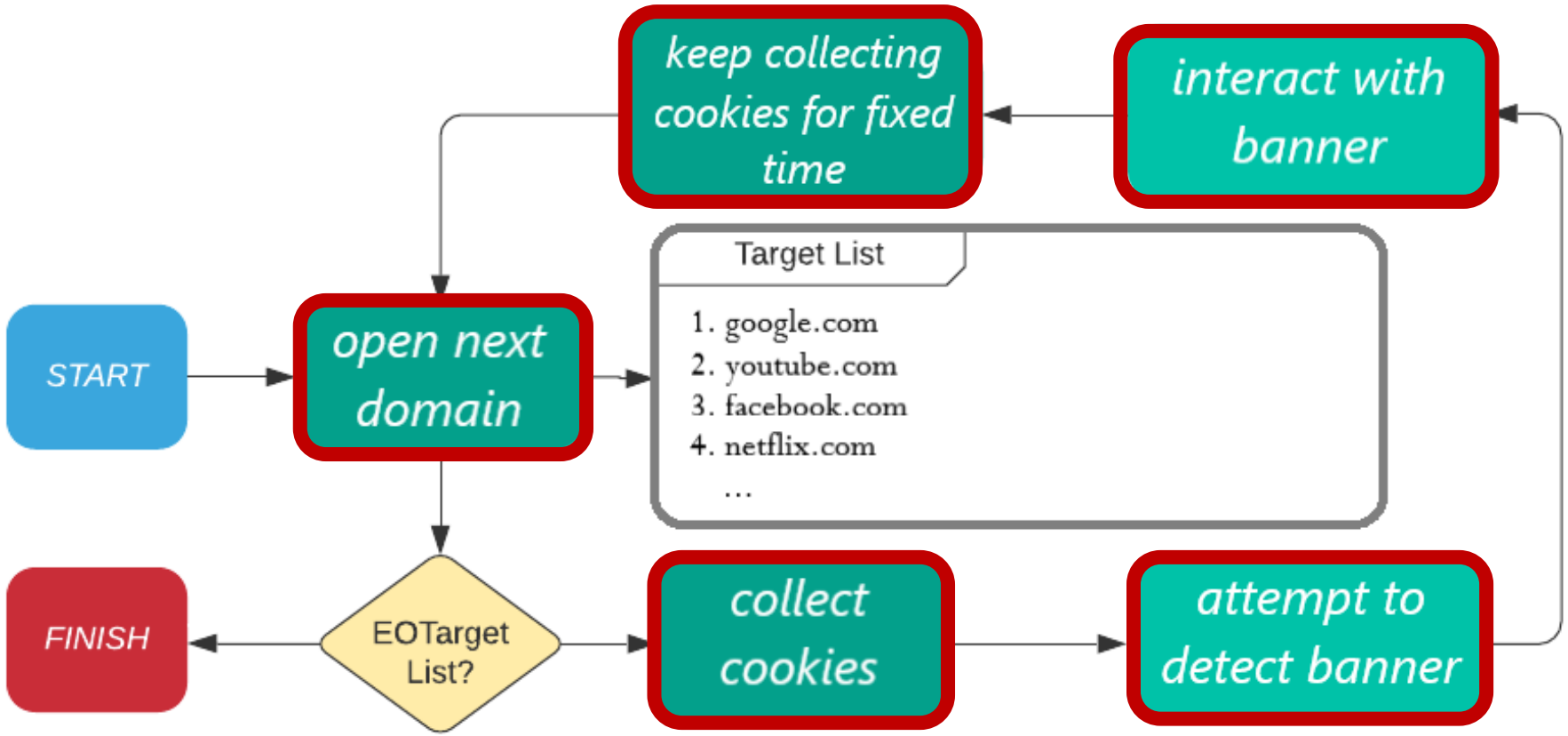

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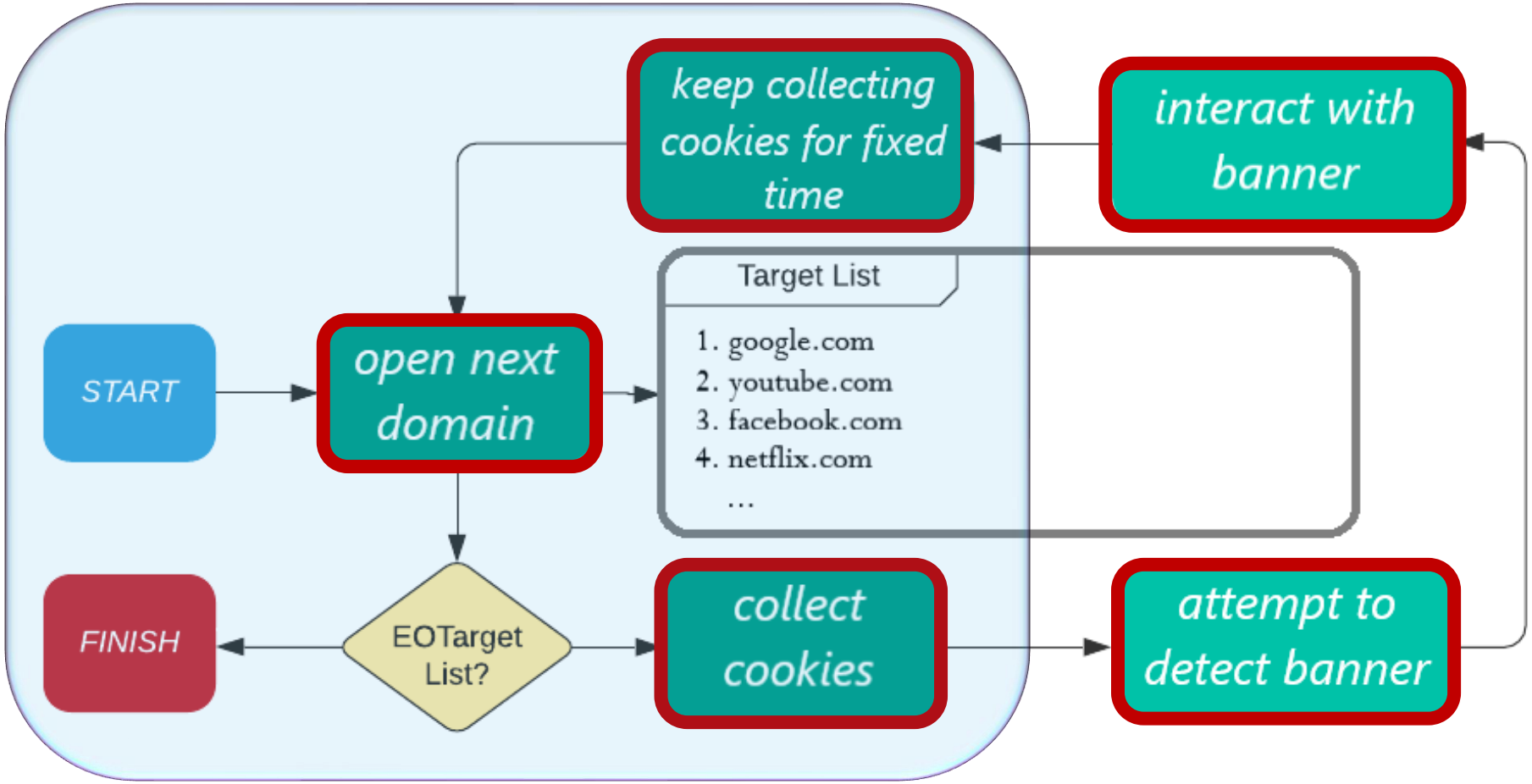

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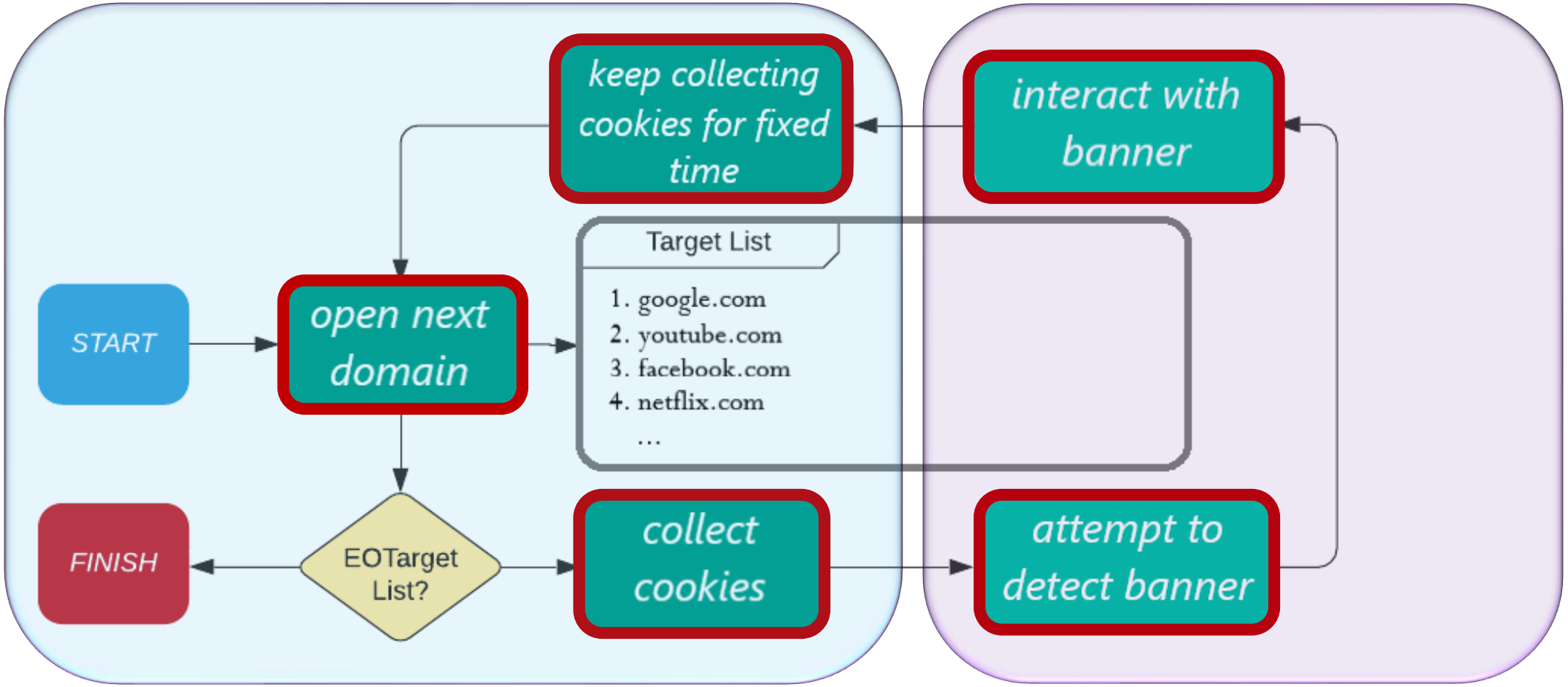

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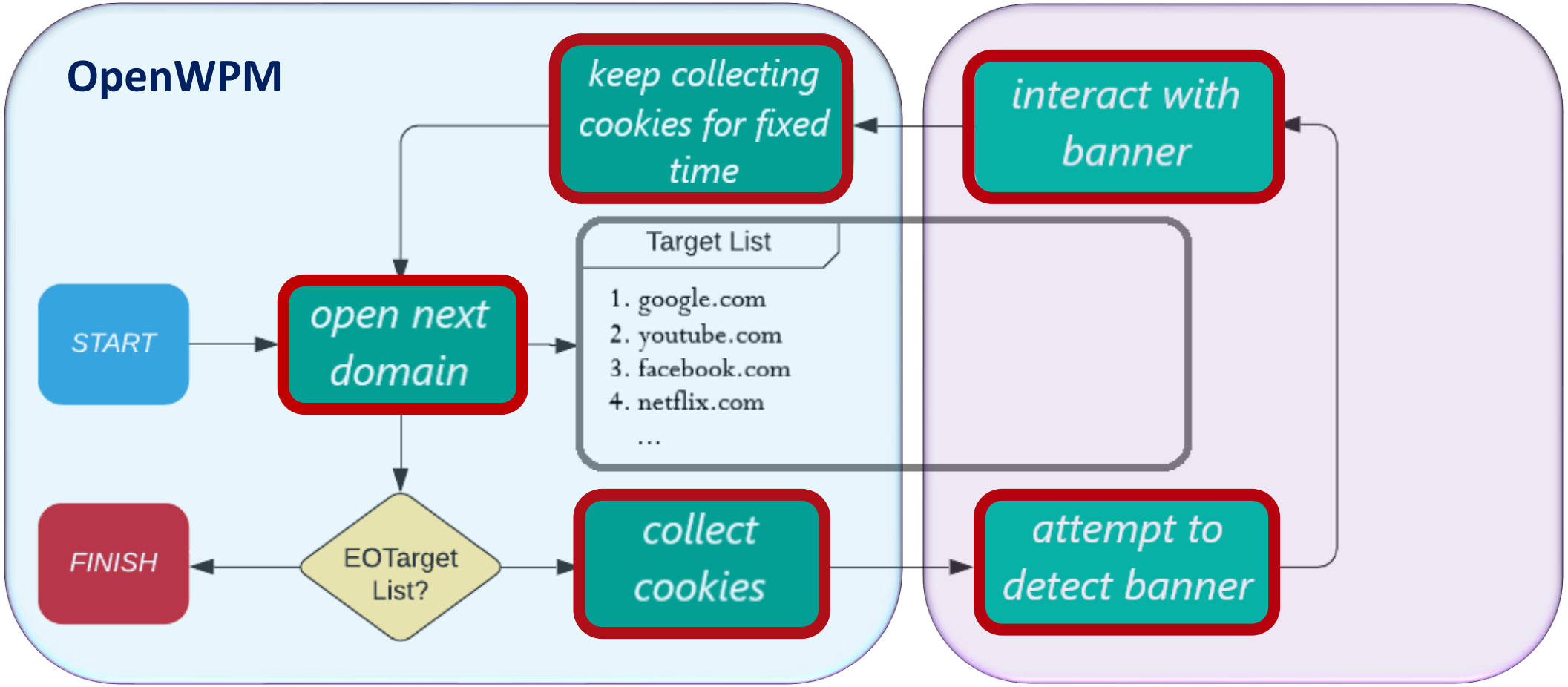

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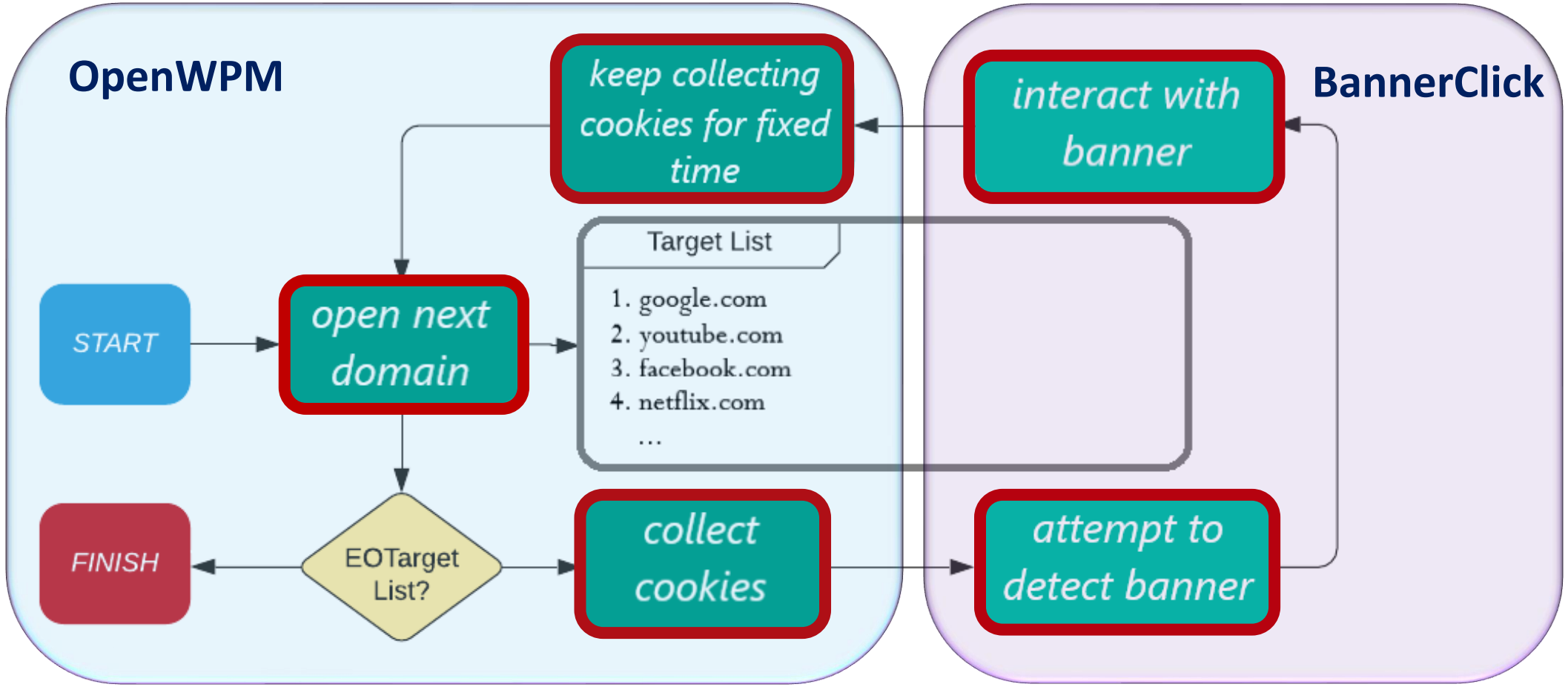
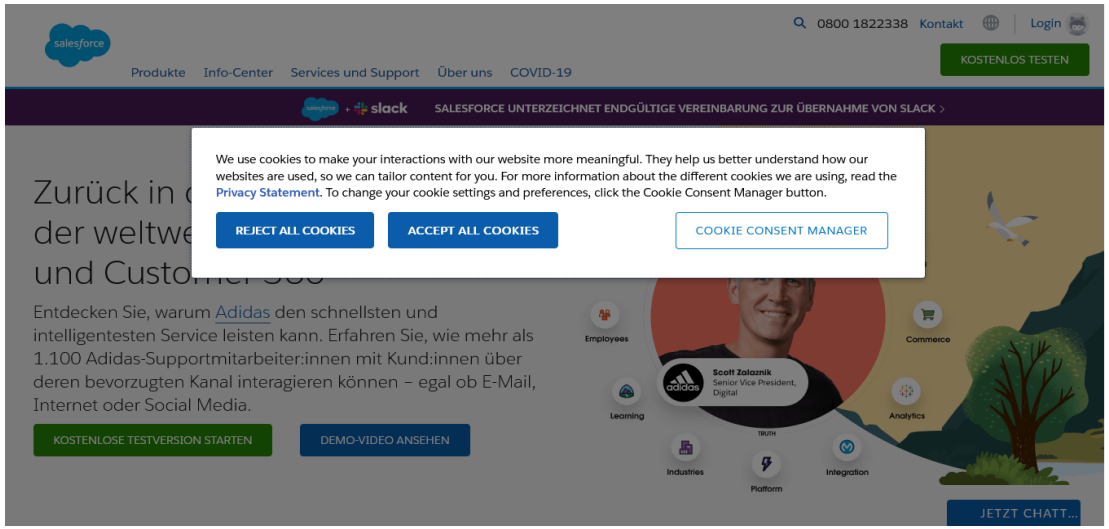


BannerClick



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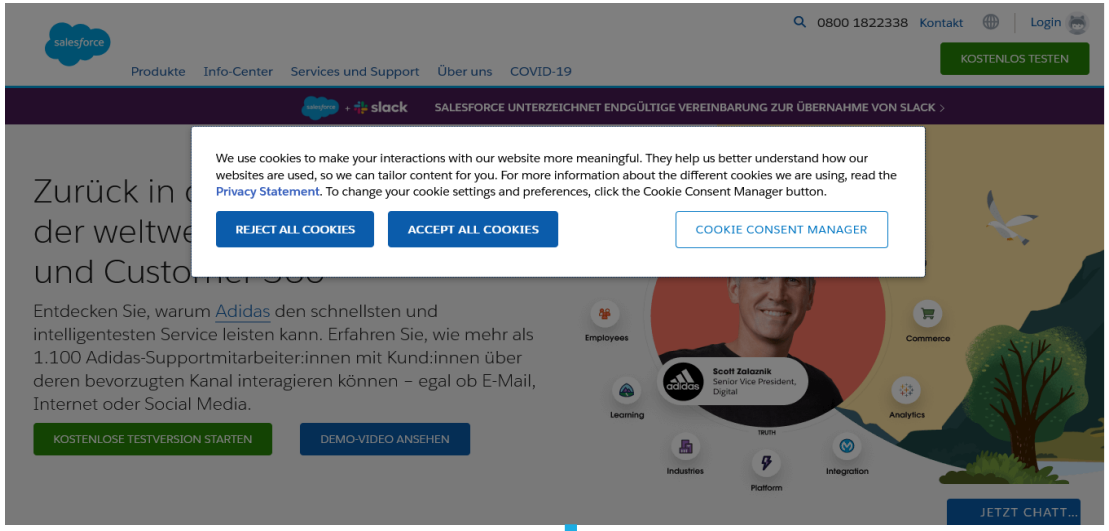

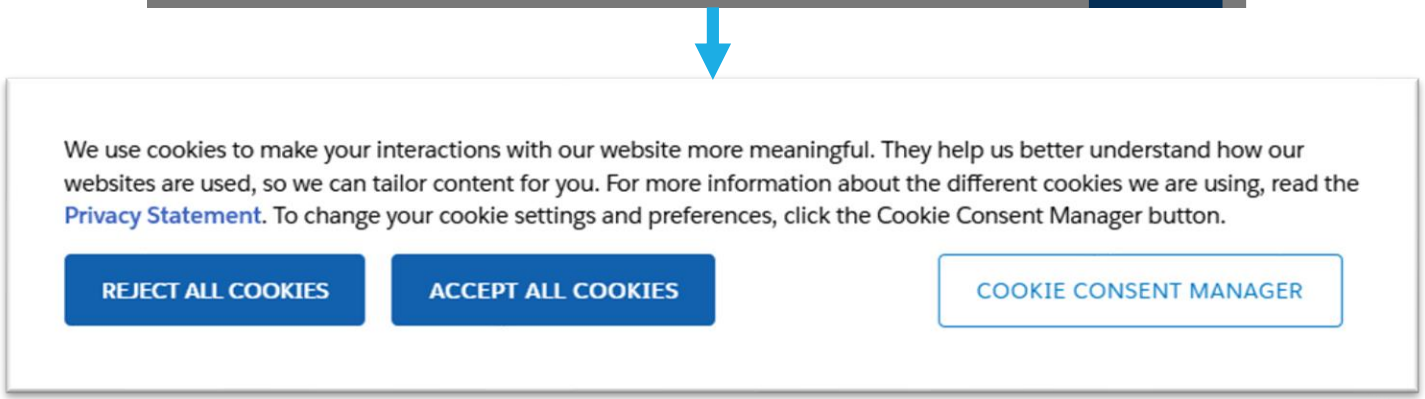

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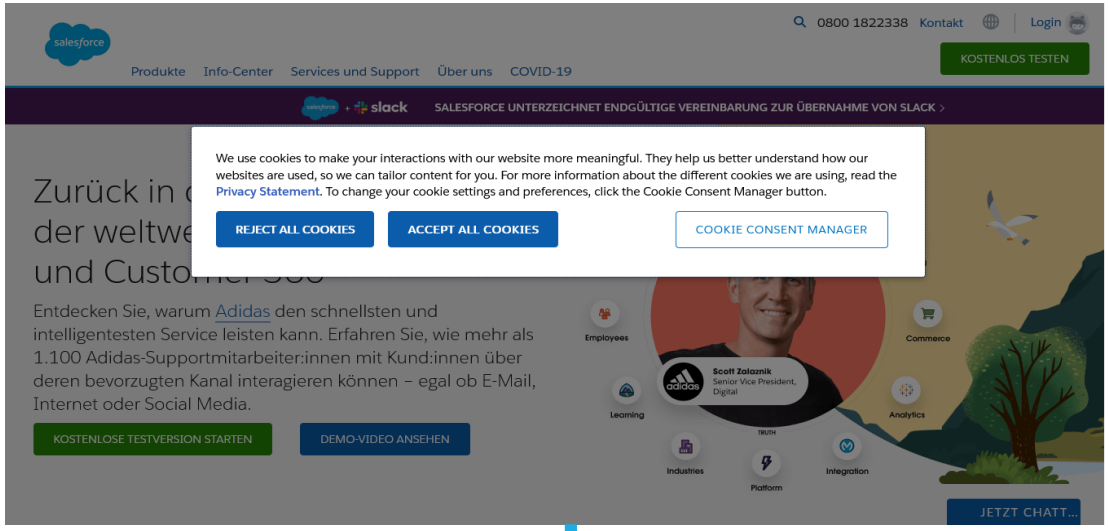
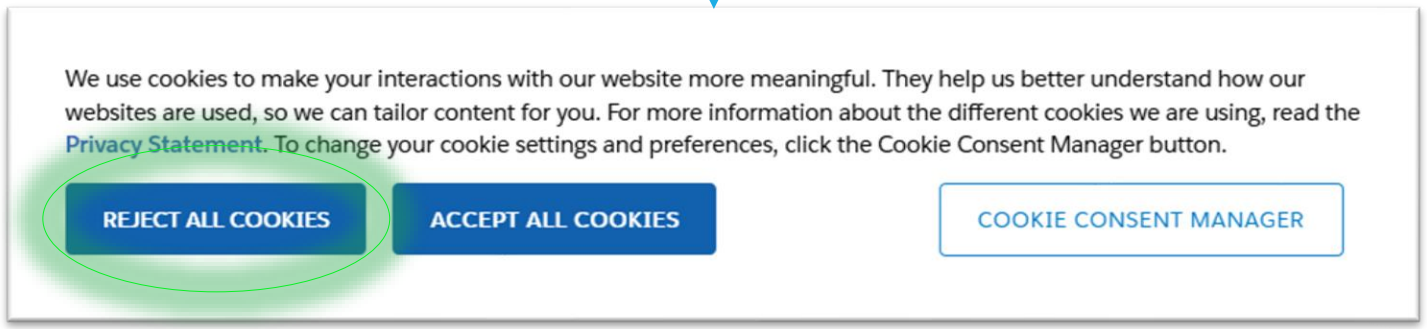
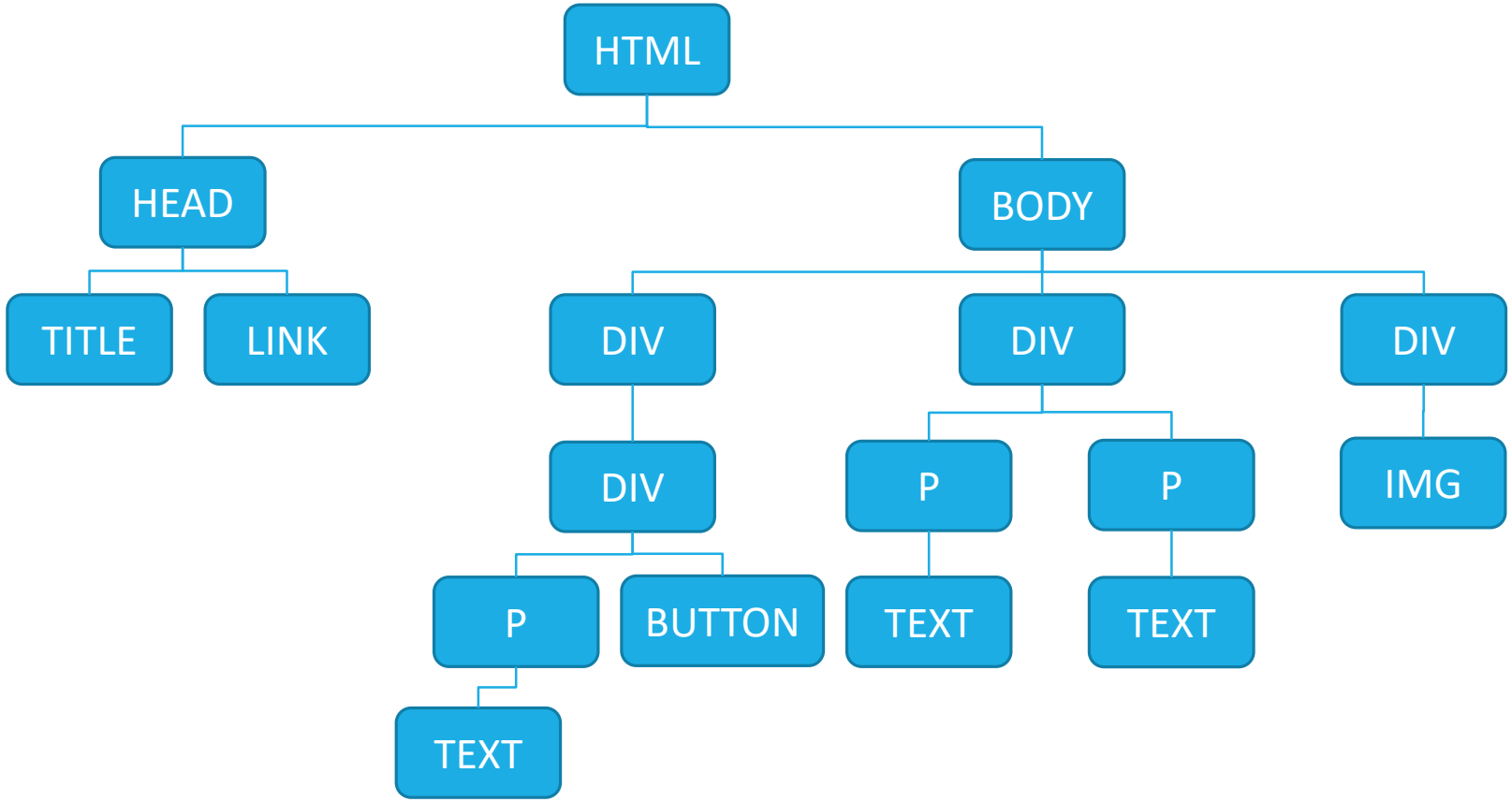




BannerClick – Detection



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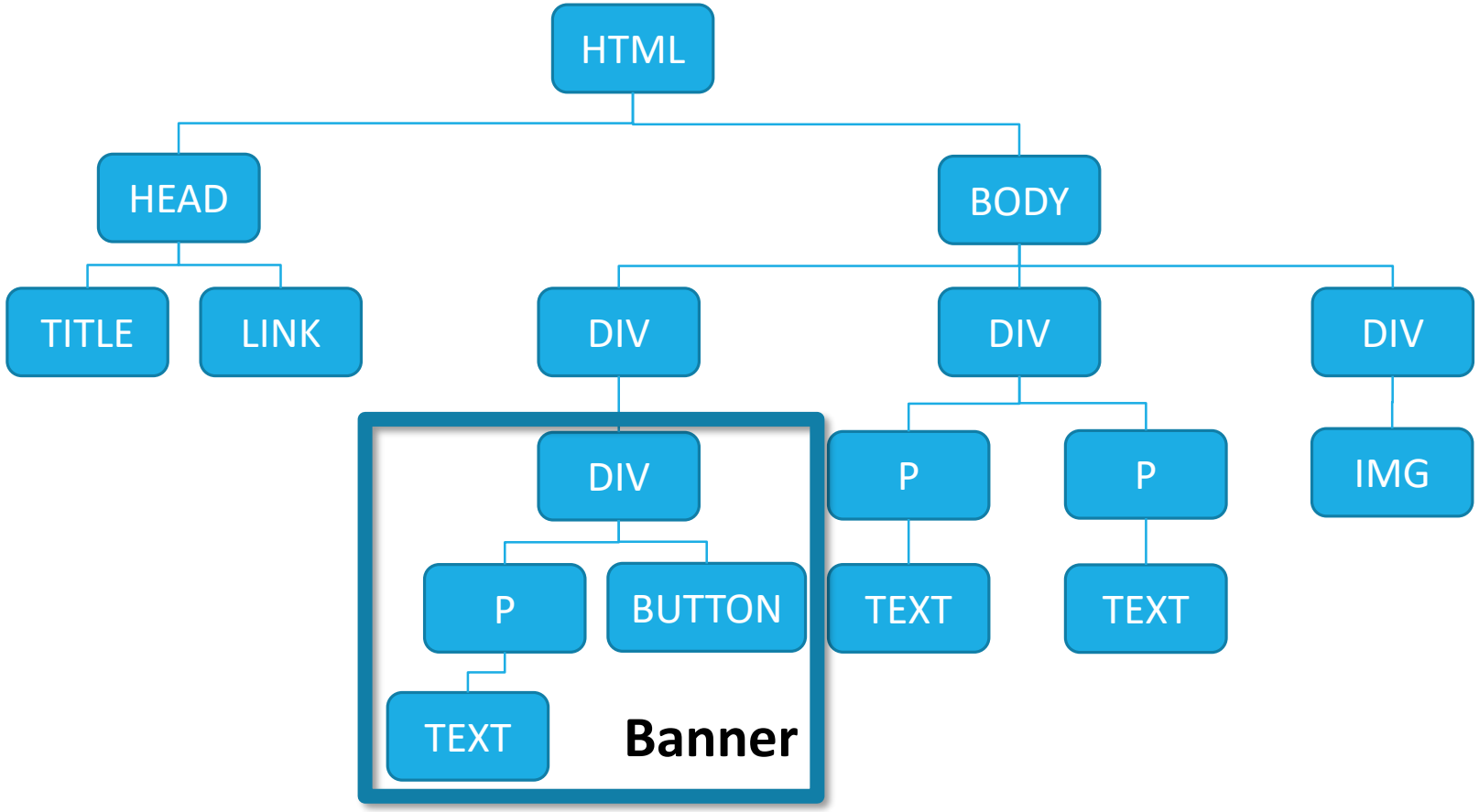

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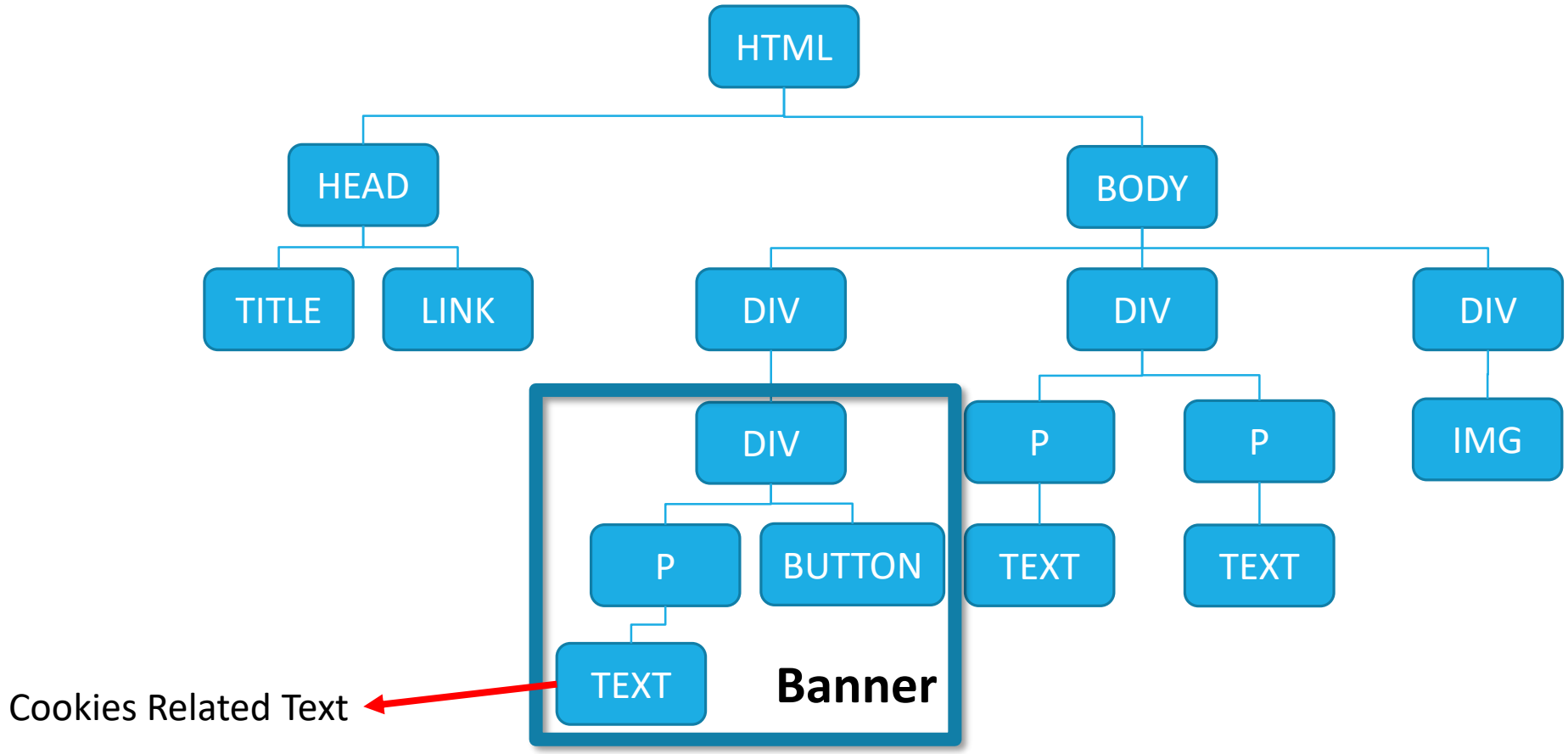

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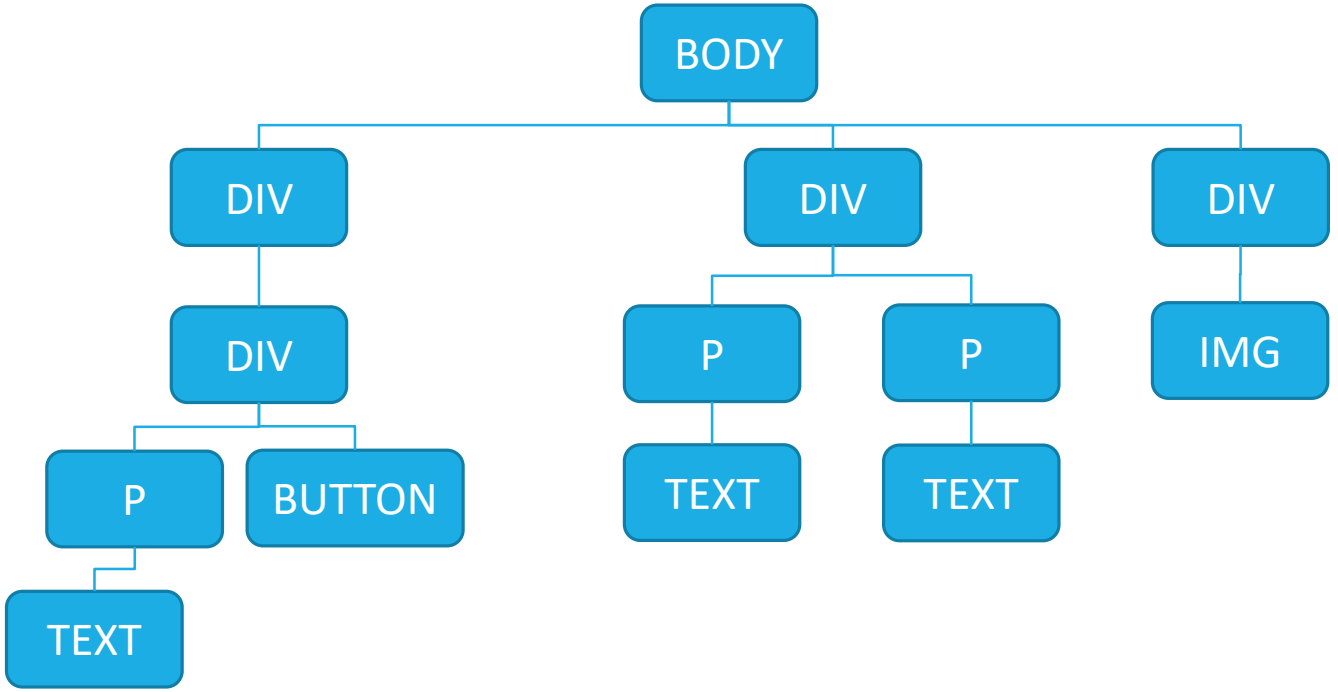

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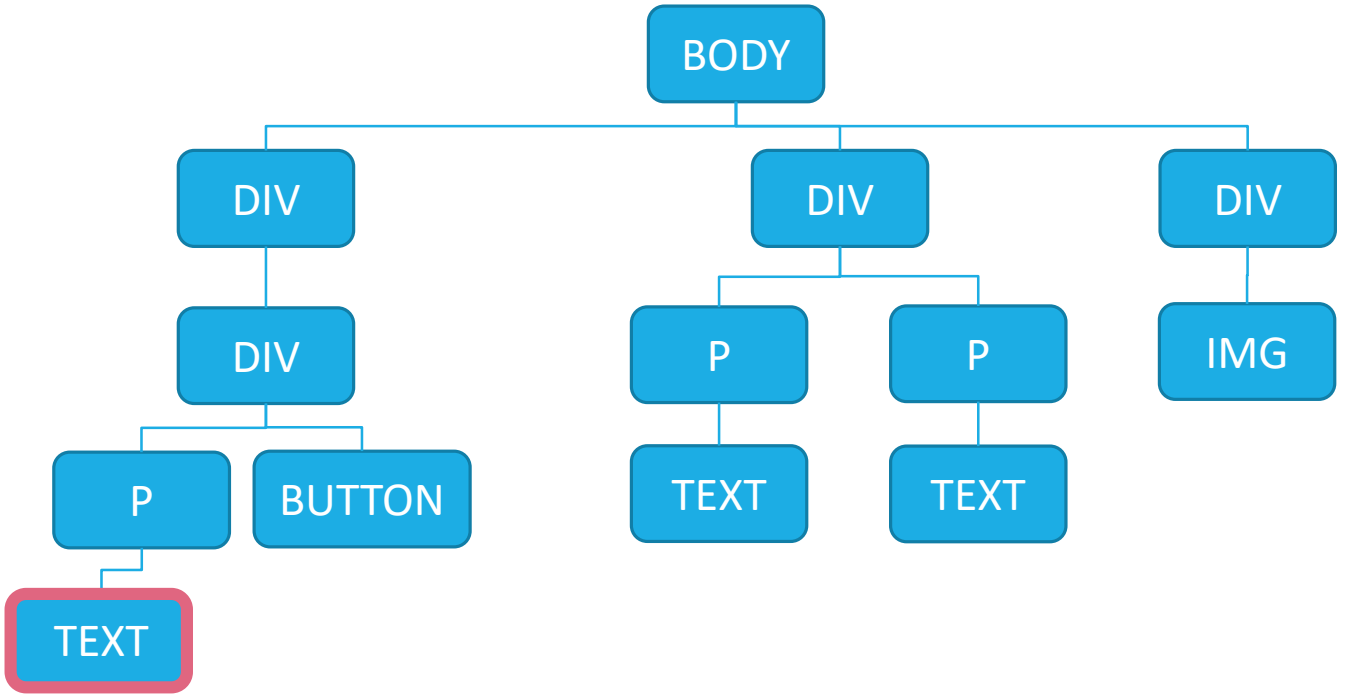
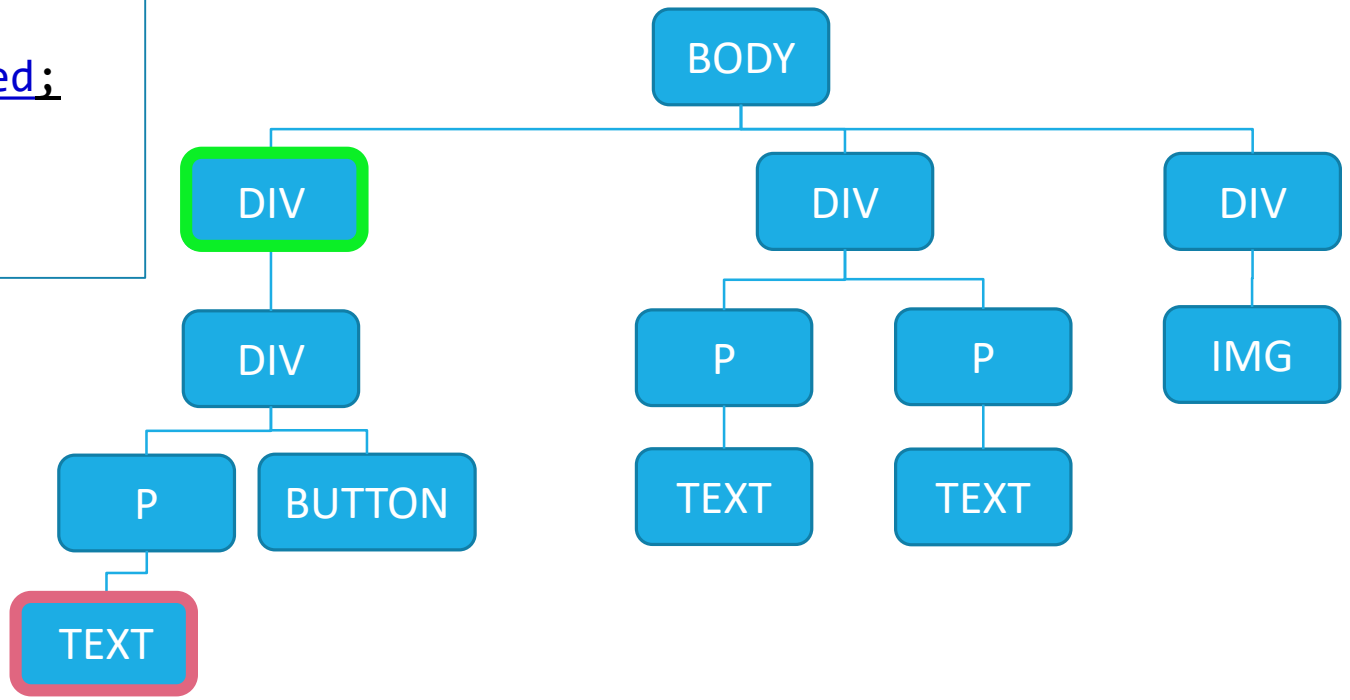


End Node

"Cookies"
"Accept" + "Legitimate Interest"
"Accept" + "Privacy Policy"
….

BannerClick – Detection

```
div.firstnode {
  position: fixed;
  width: 300px;
  border: 3px
}
```



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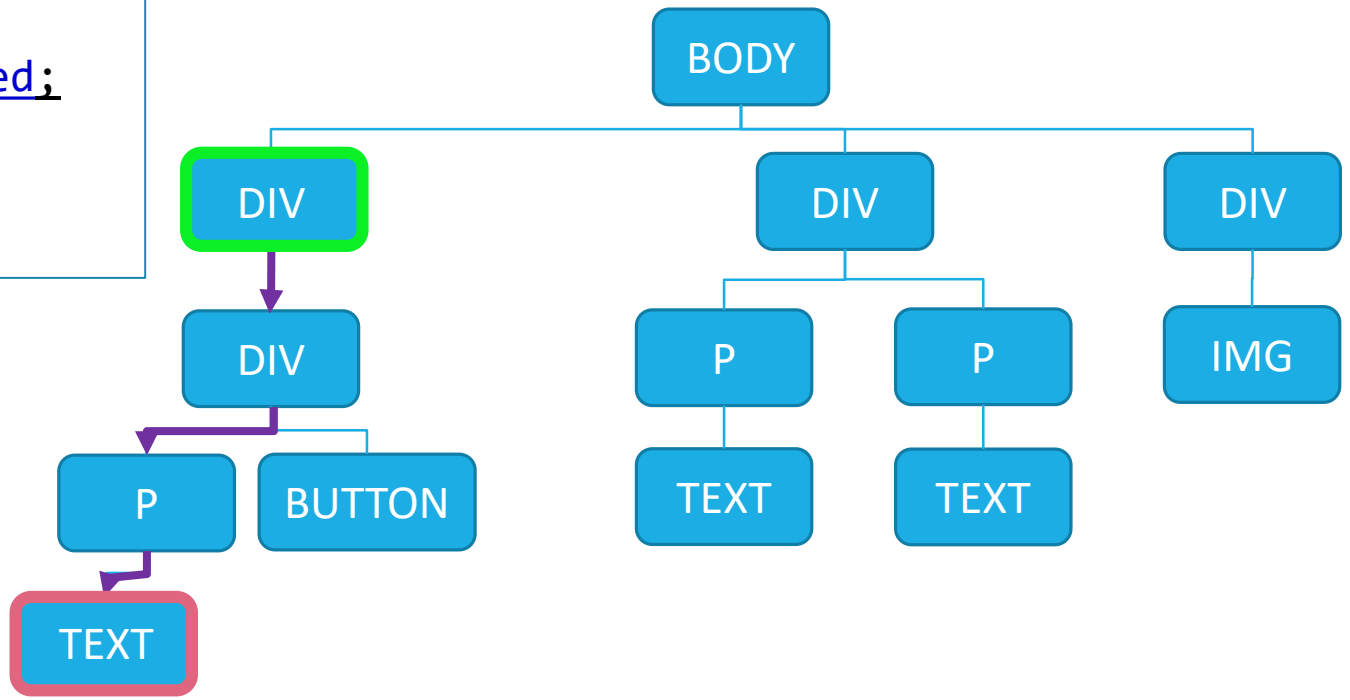

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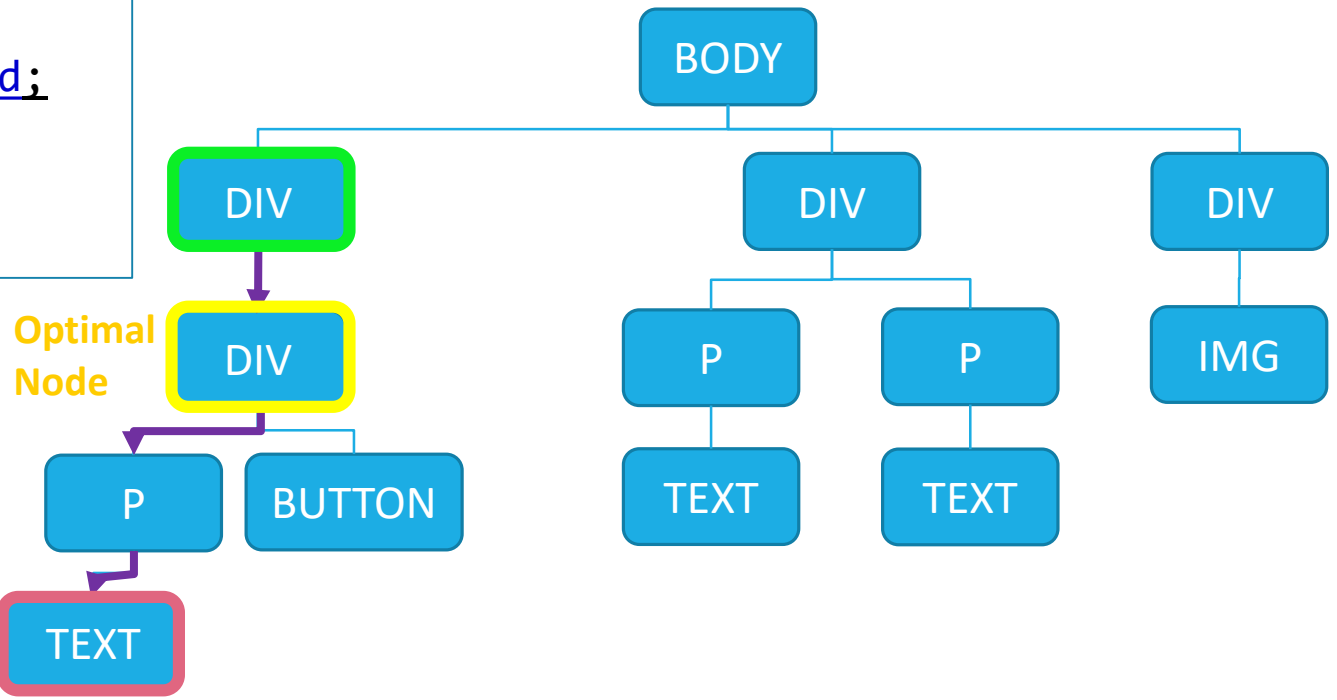

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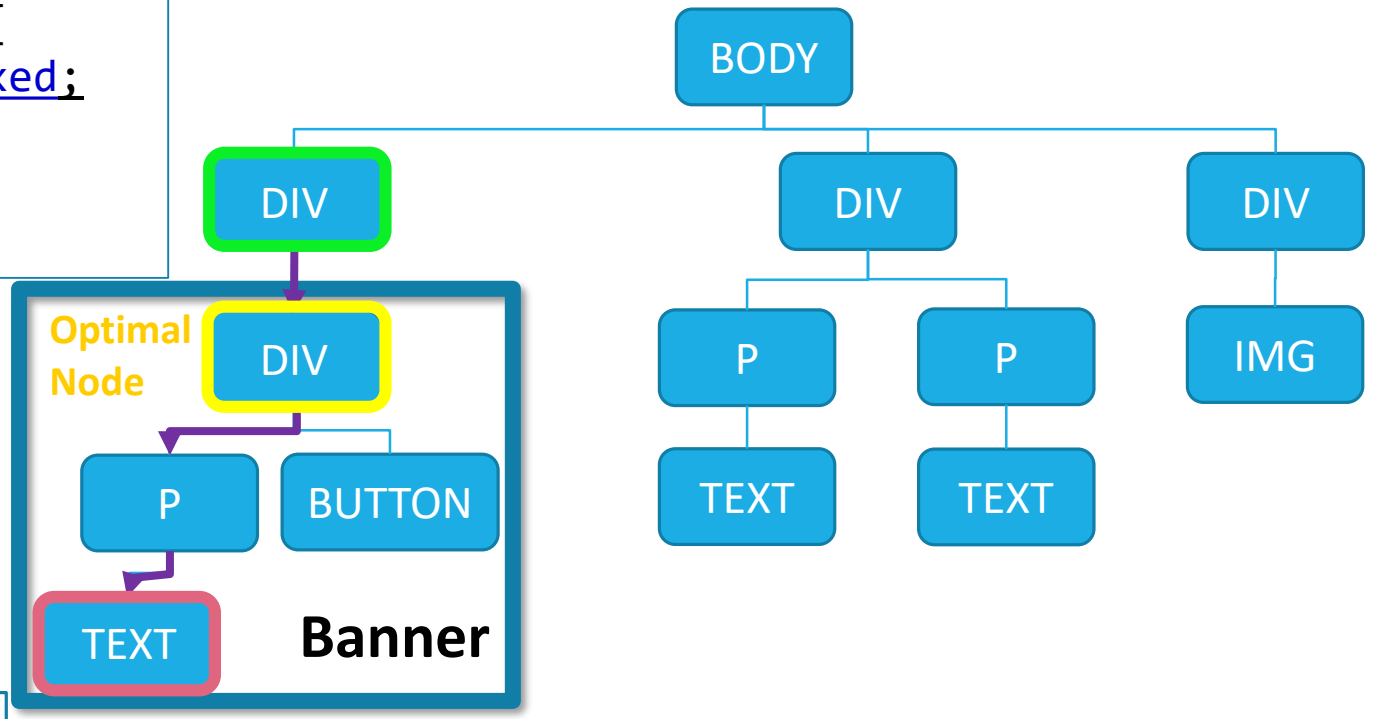

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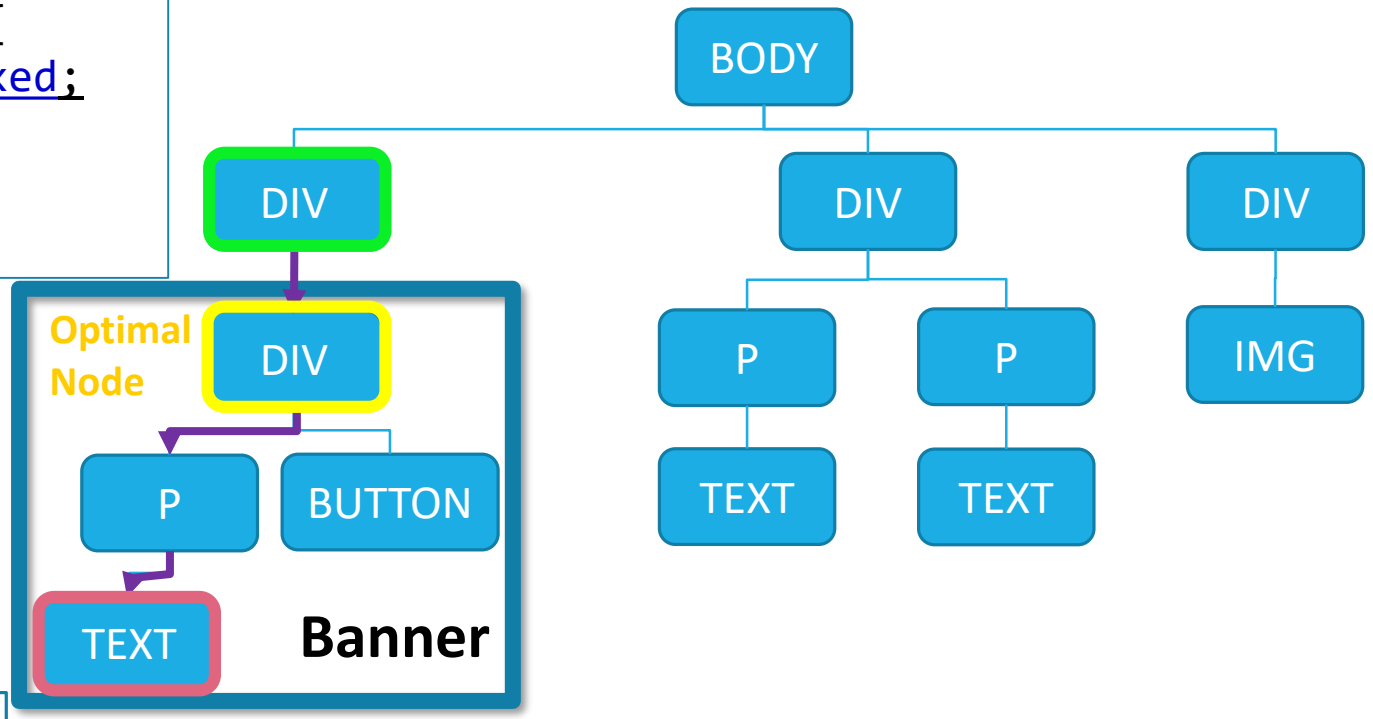

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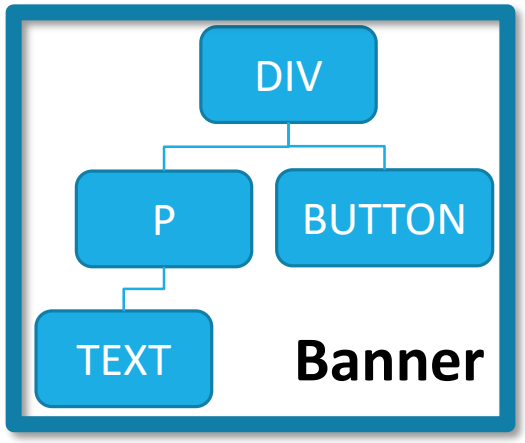
99% Accuracy

BannerClick – Interaction



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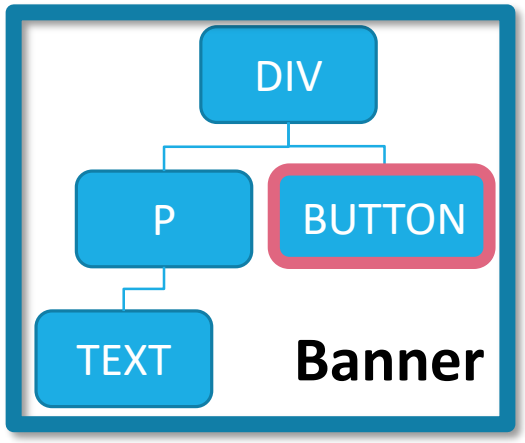
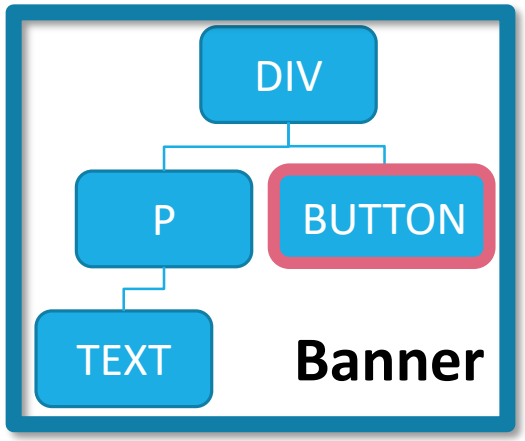


Word sets:

acc: ["accept","agree","confirm"]

BannerClick – Interaction

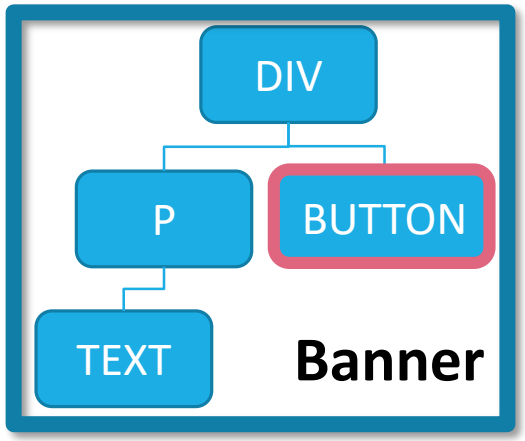


Word sets:

acc: ["accept","agree","confirm"]

rej: ["reject","refuse",” decline"]

BannerClick – Interaction



Word sets:

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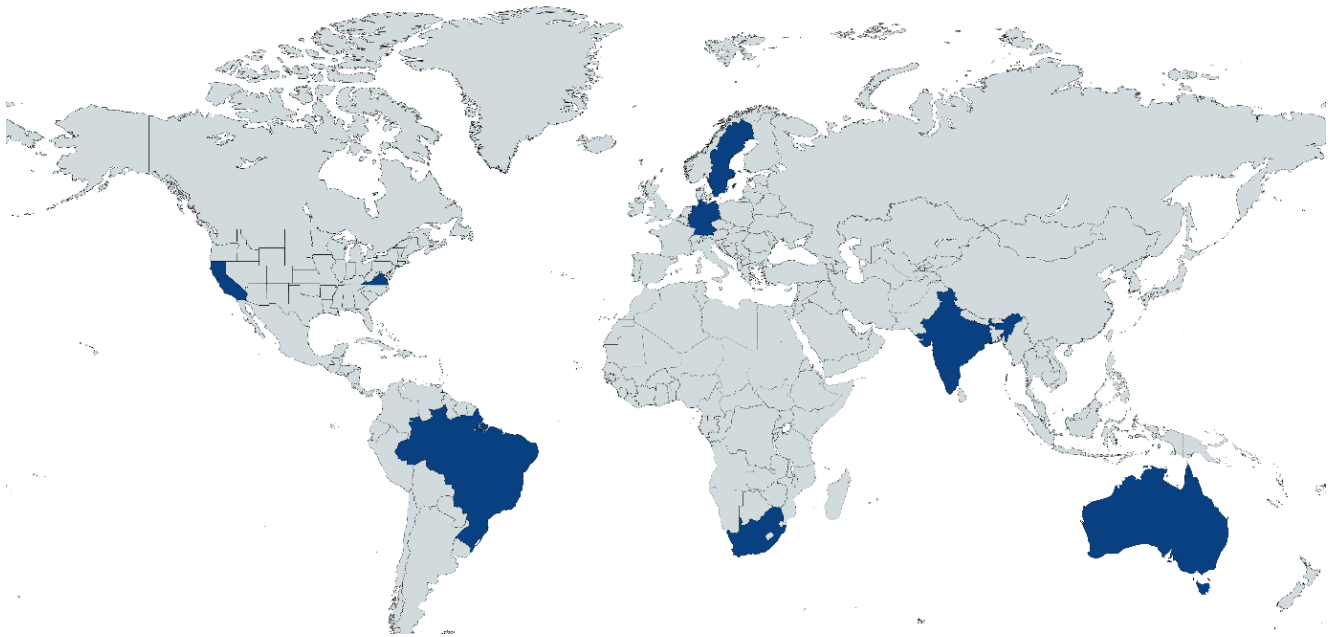
rej: ["reject","refuse",” decline"]

set: ["setting","option","choice"]

Measurement Setup



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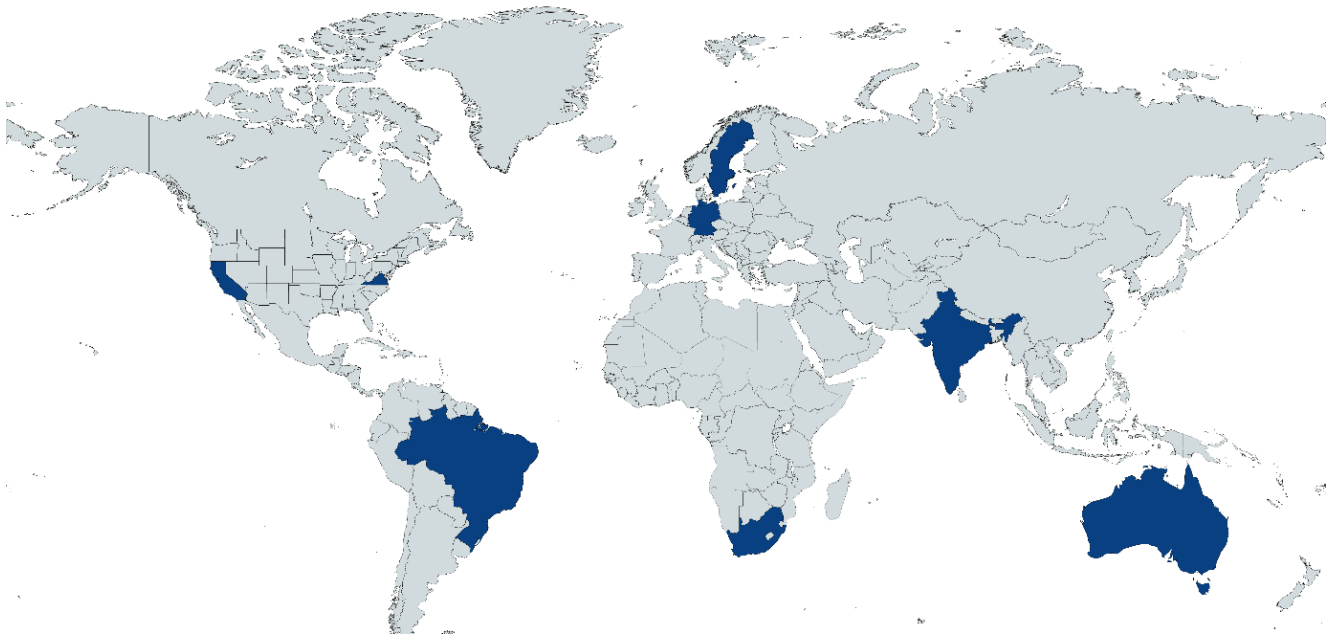

- **8 vantage points:** Germany, Sweden, US West, US East, India, Brazil, South Africa, Australia

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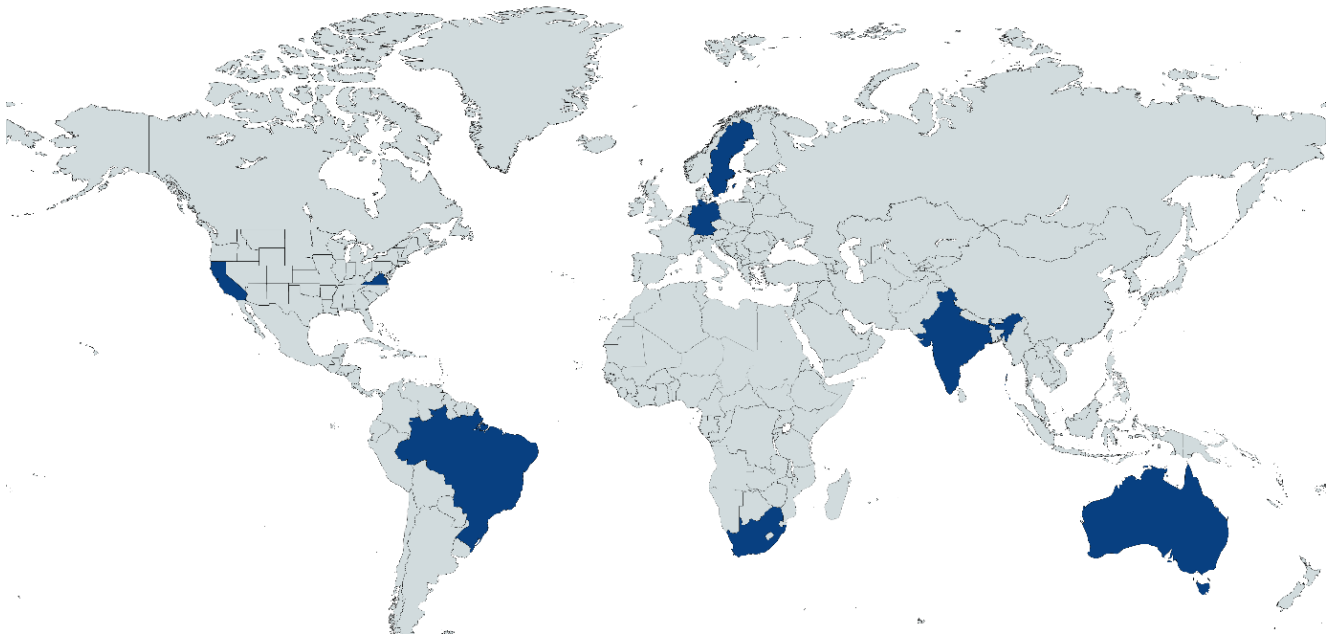
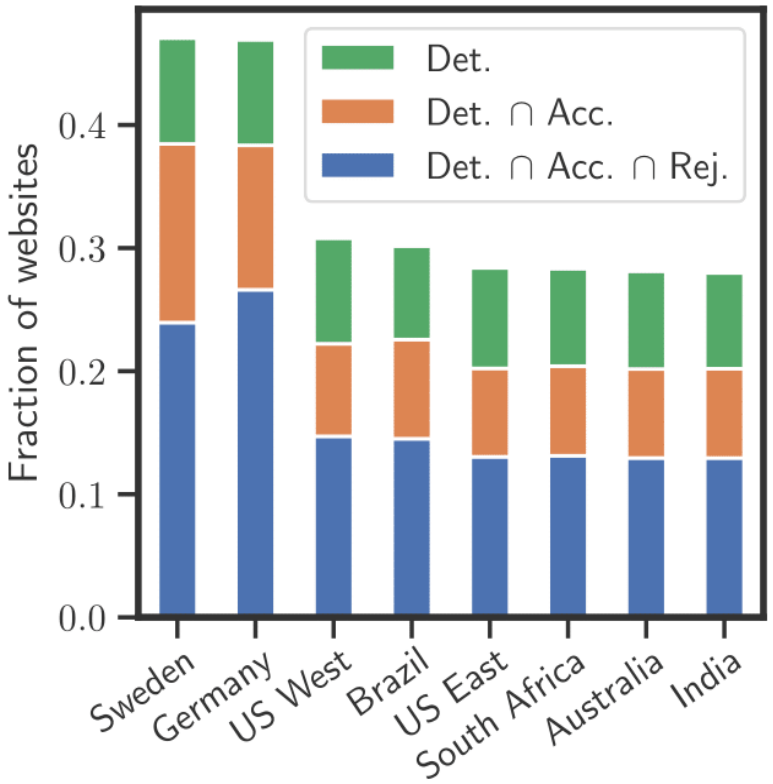
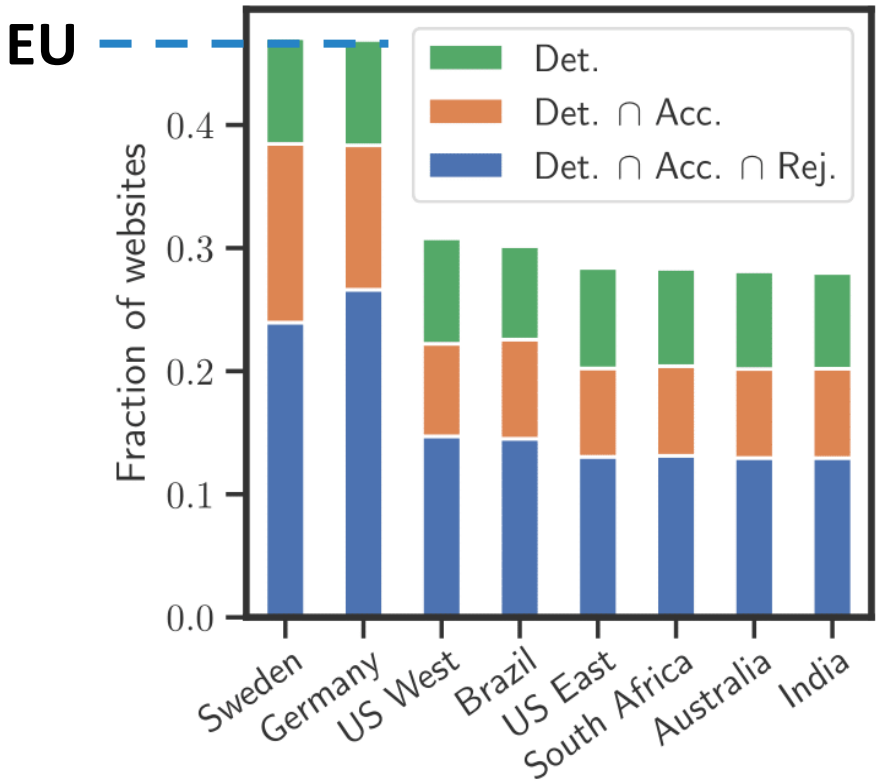


- **8 vantage points:** Germany, Sweden, US West, US East, India, Brazil, South Africa, Australia
- **Target list:** Tranco Top 10k domains

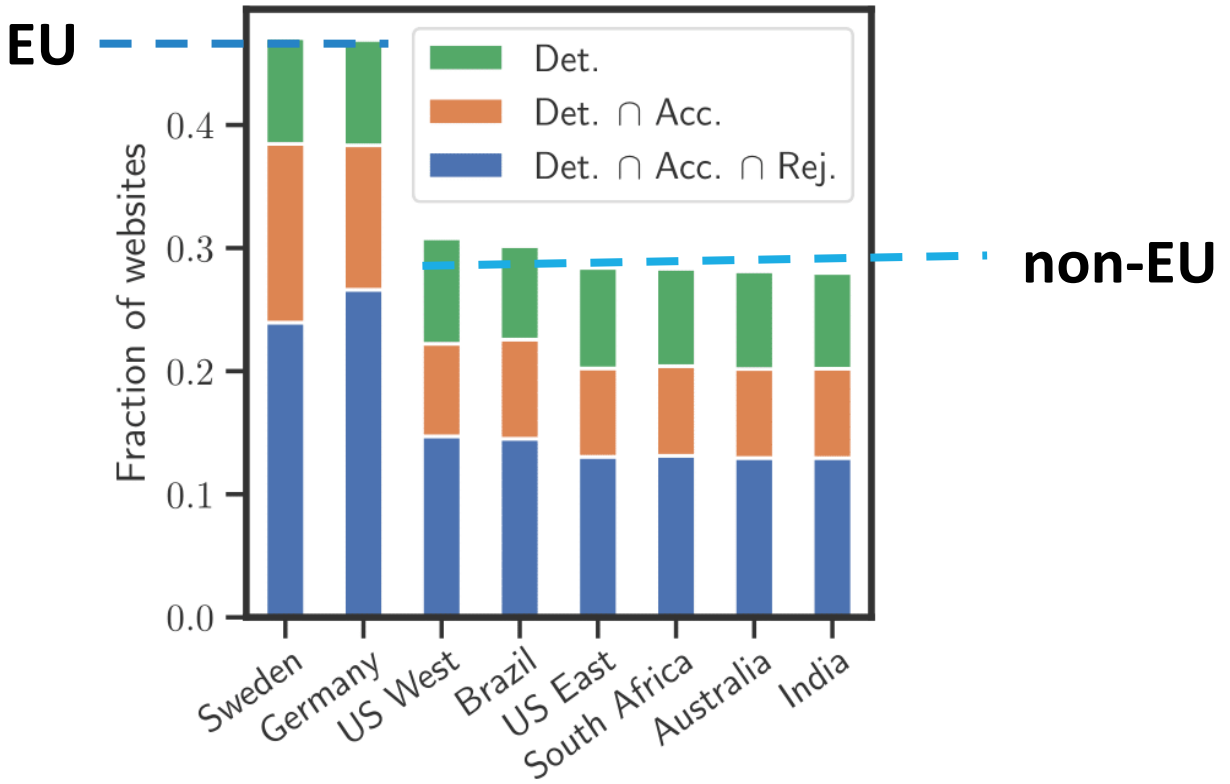
Banners detected, accepted, rejected



Banners detected, accepted, rejected

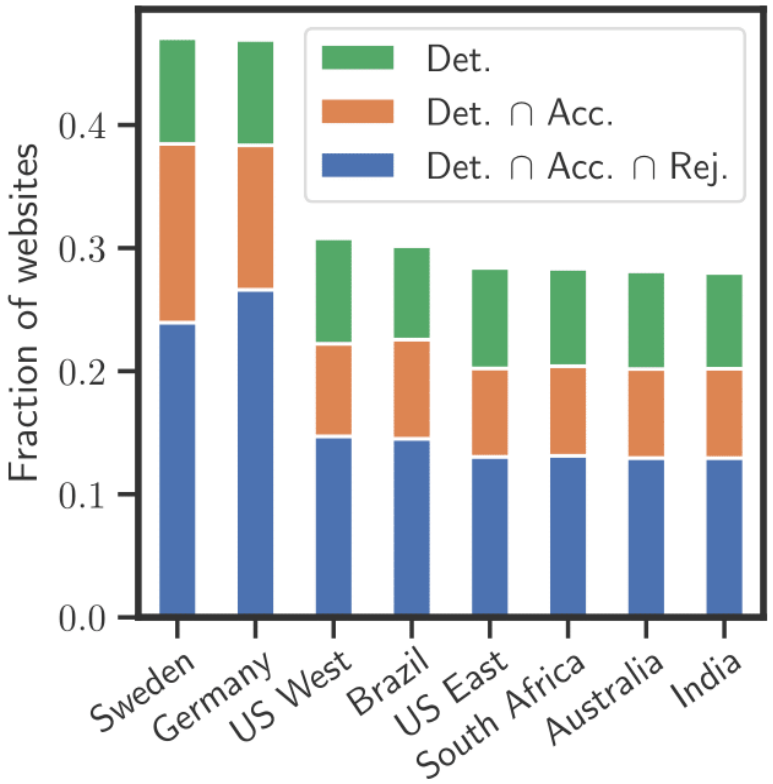


Banners detected, accepted, rejected

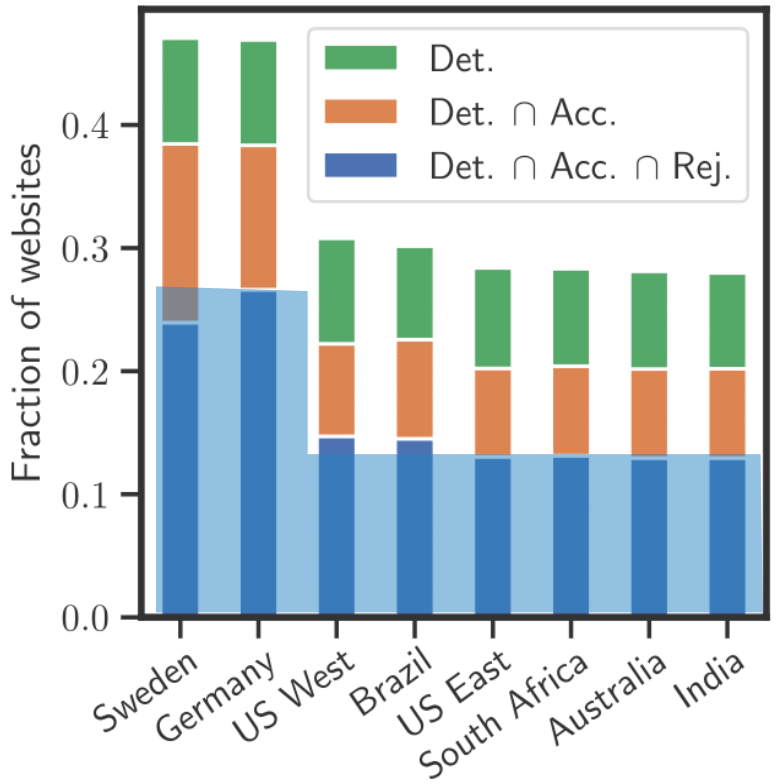


More banners in EU compared to non-EU countries

Banners detected, accepted, rejected

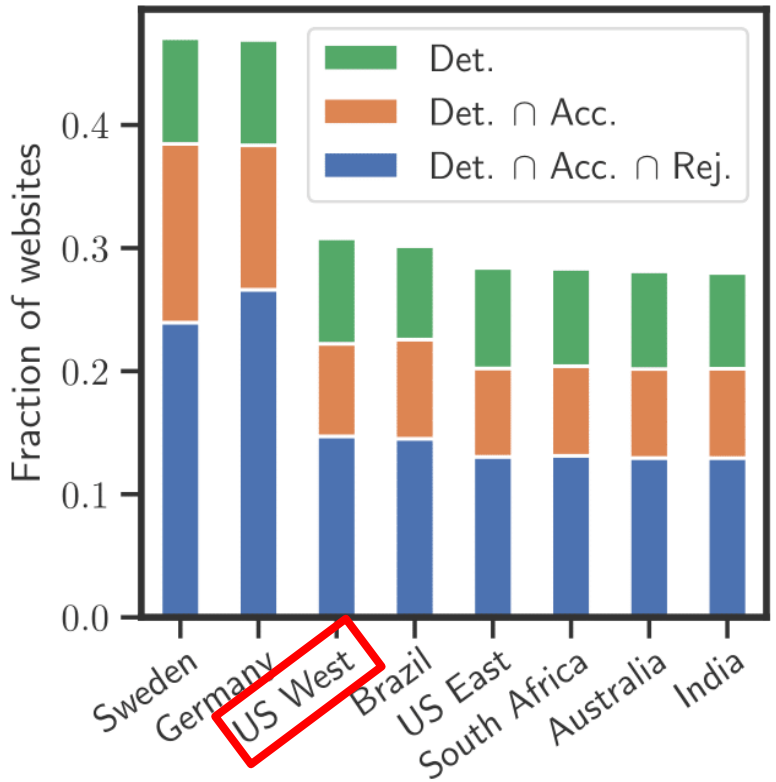


Banners detected, accepted, rejected

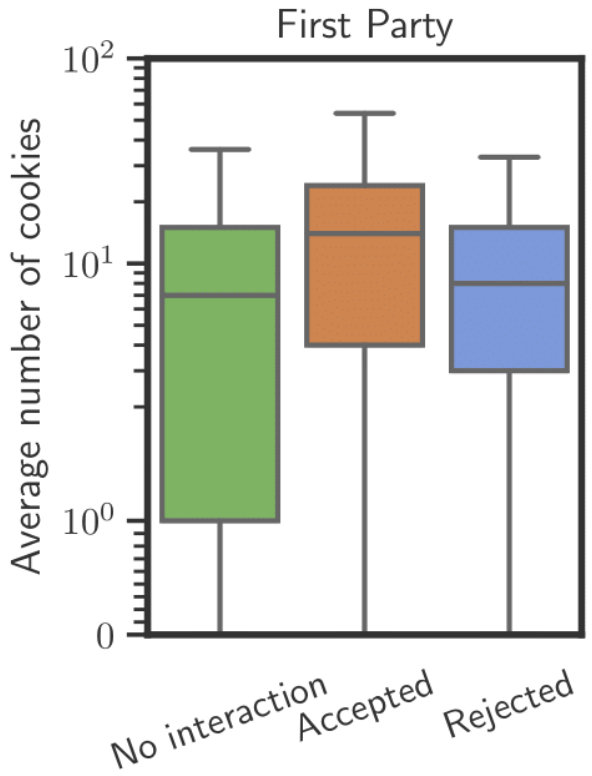


Half of the websites do not show any reject option

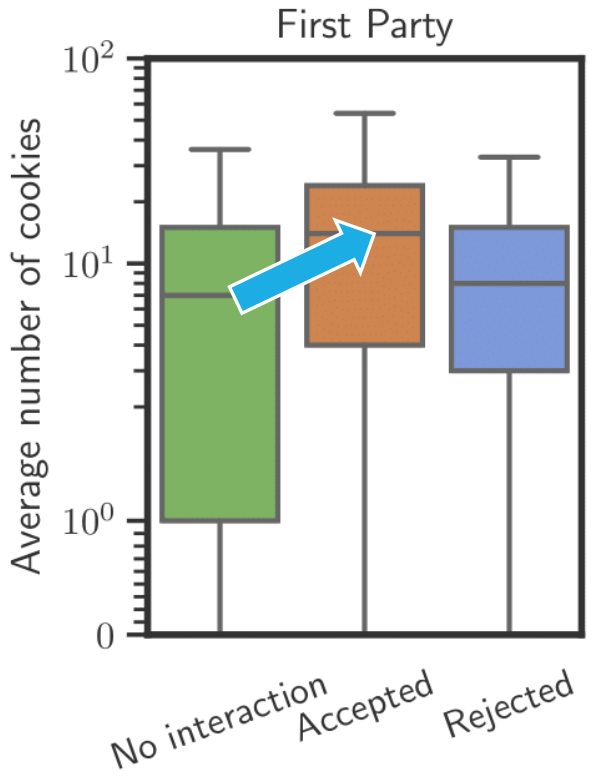
Banners detected, accepted, rejected



Cookies differences after interaction

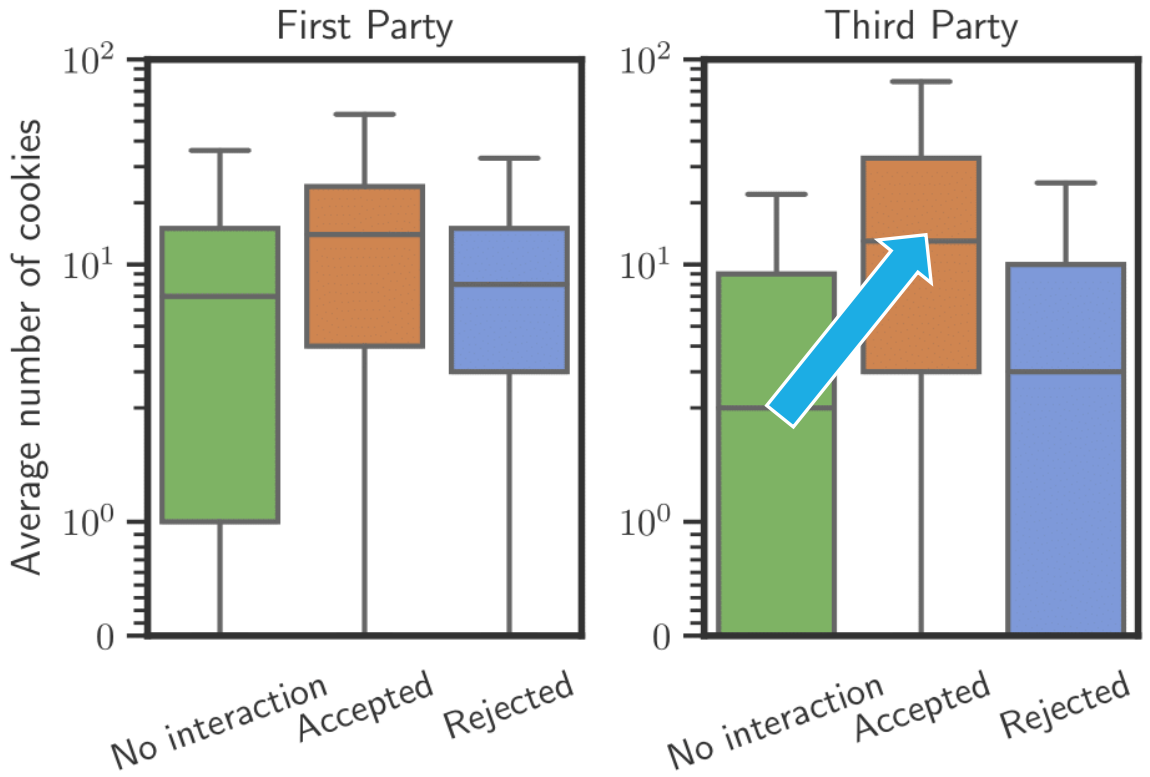


Cookies differences after interaction



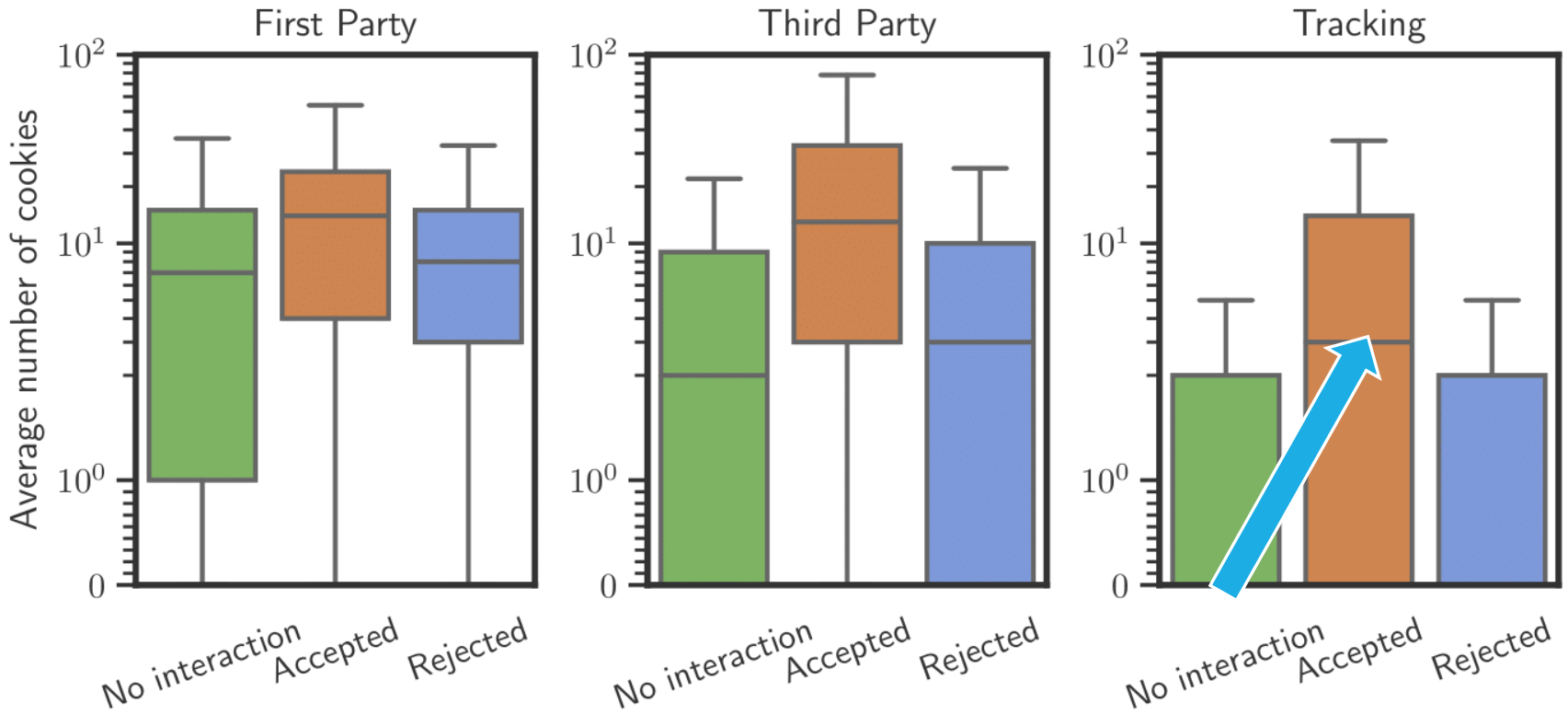
Interacting with banners impacts cookie distribution

Cookies differences after interaction



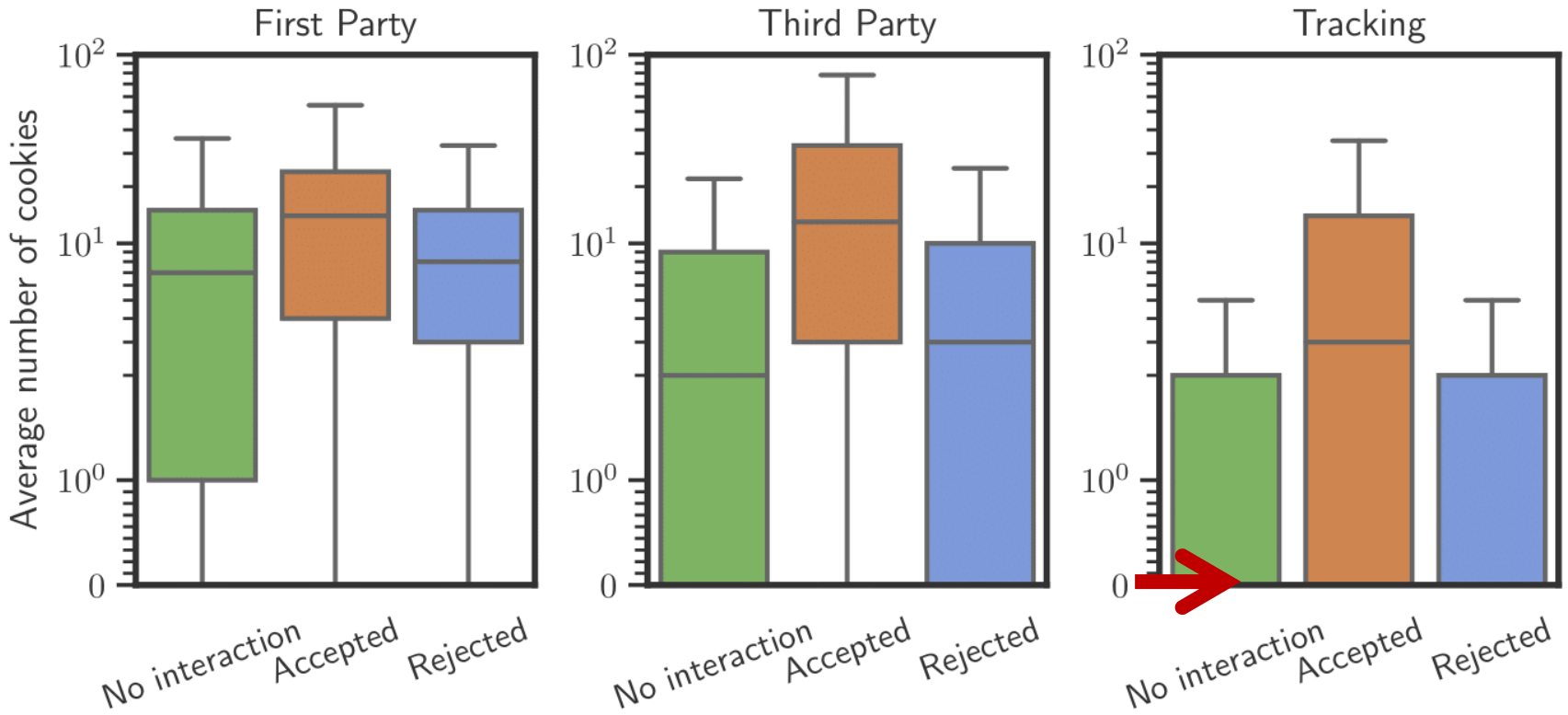
Interacting with banners impacts cookie distribution

Cookies differences after interaction



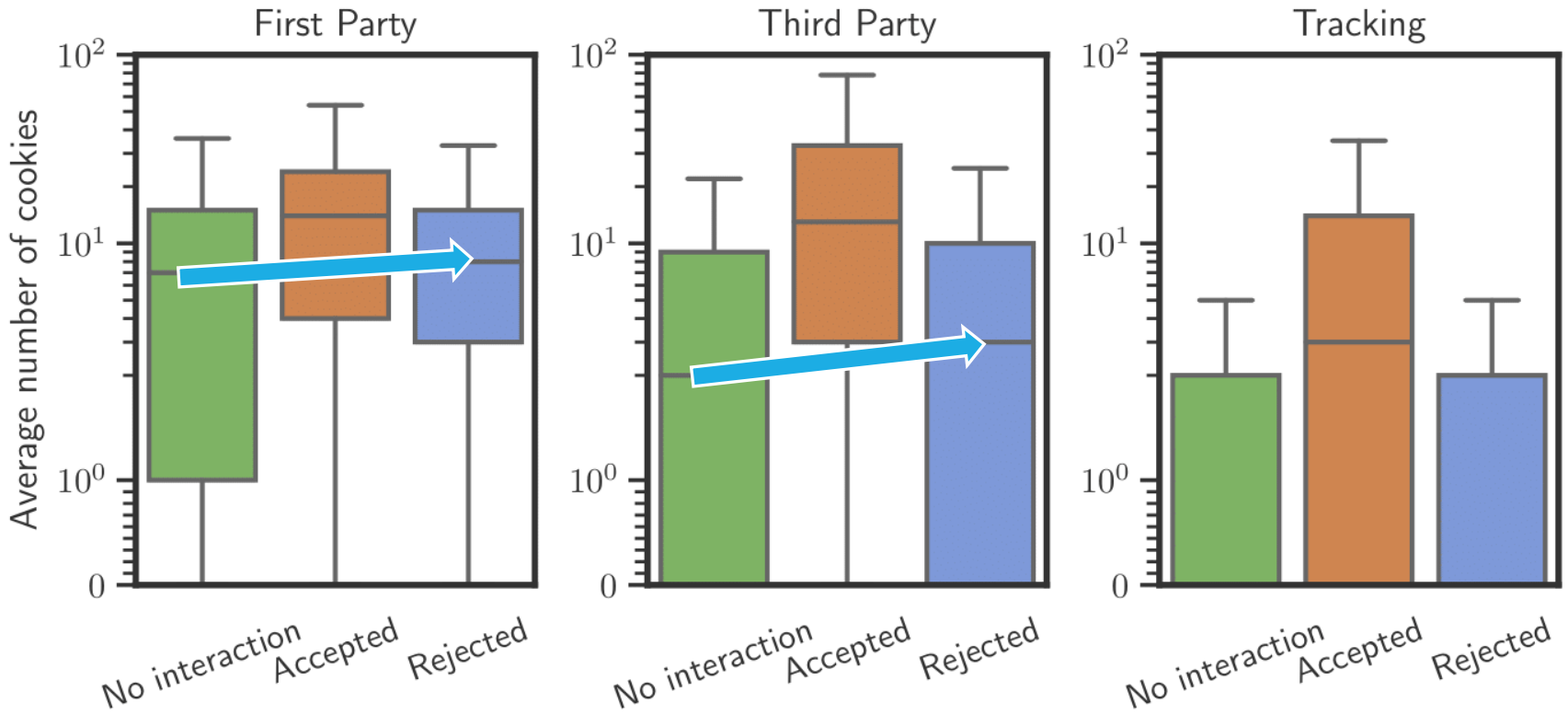
Interacting with banners impacts cookie distribution

Cookies differences after interaction



Interacting with banners impacts cookie distribution

Cookies differences after interaction



Interacting with banners impacts cookie distribution

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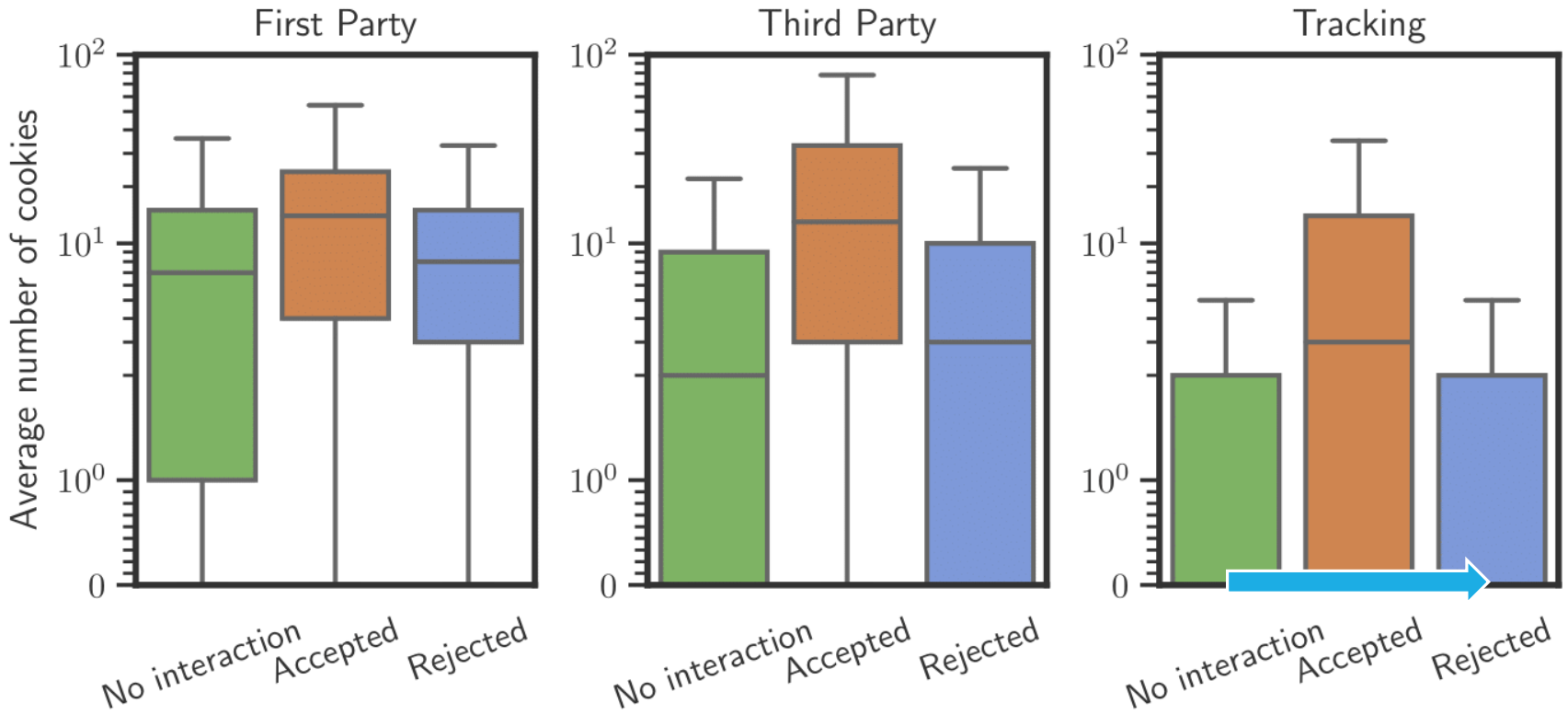
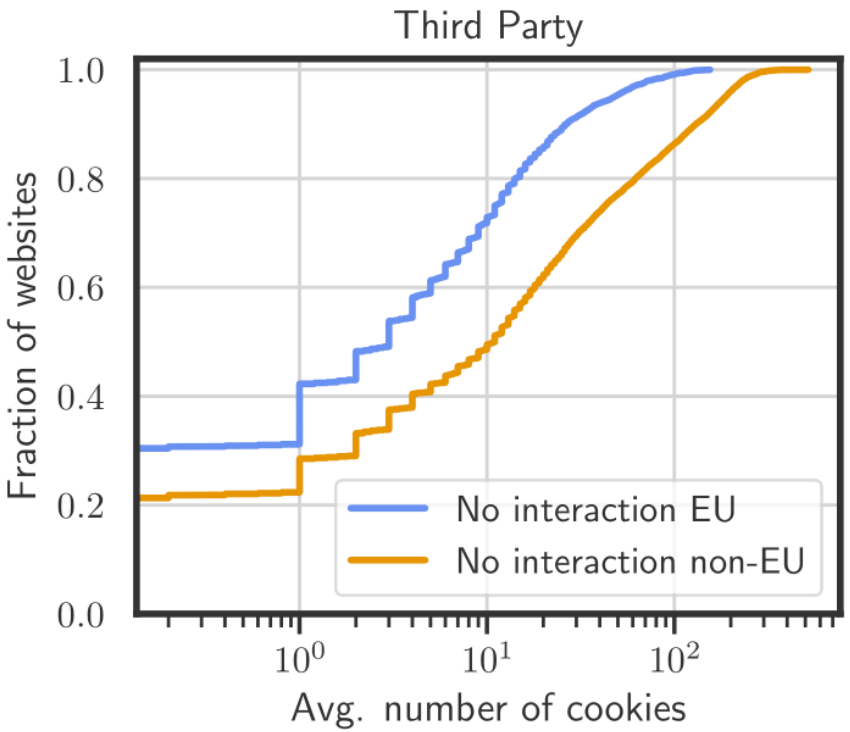
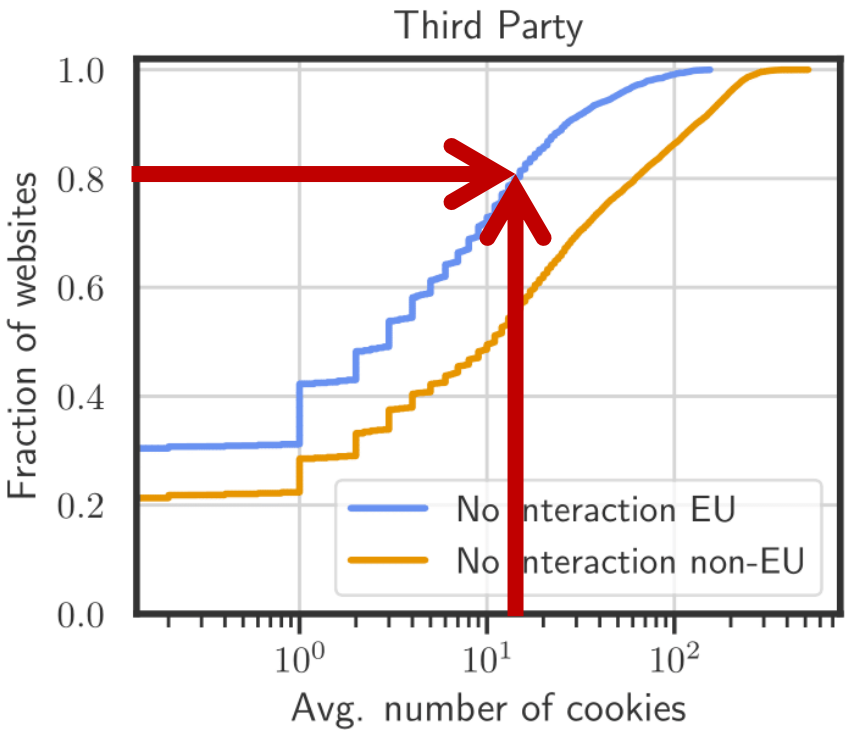


Interacting with banners impacts cookie distribution

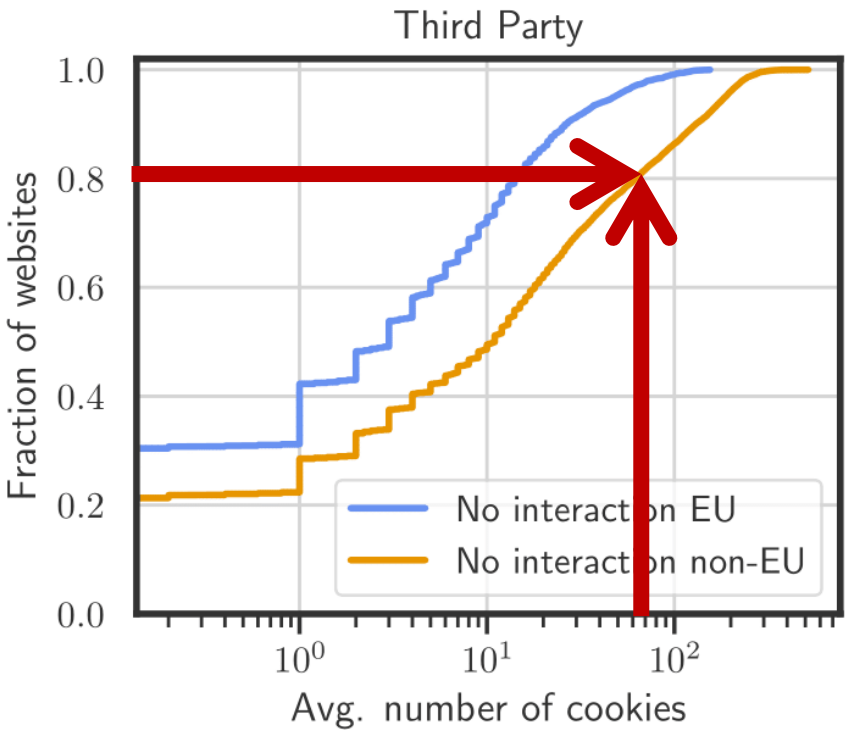
Cookies – EU vs. non-EU



Cookies – EU vs. non-EU

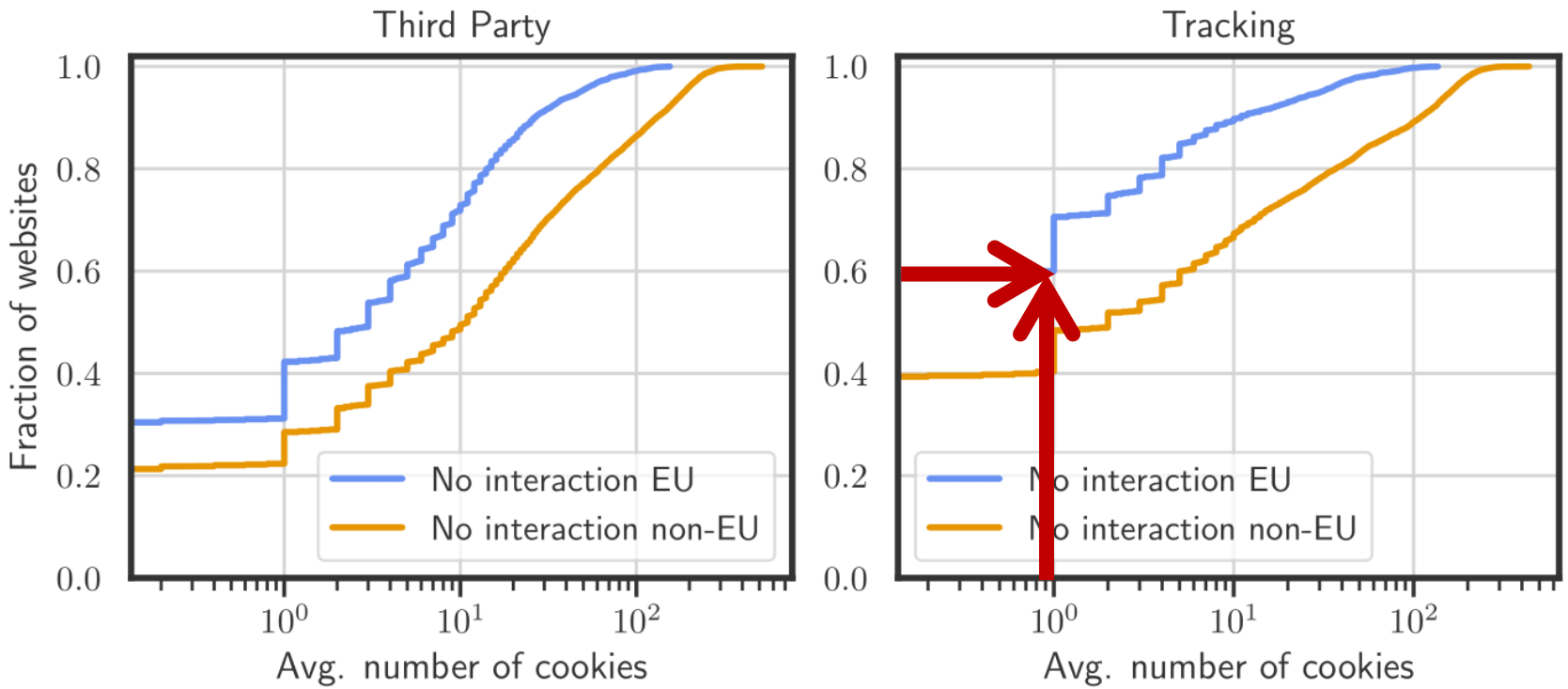


Cookies – EU vs. non-EU



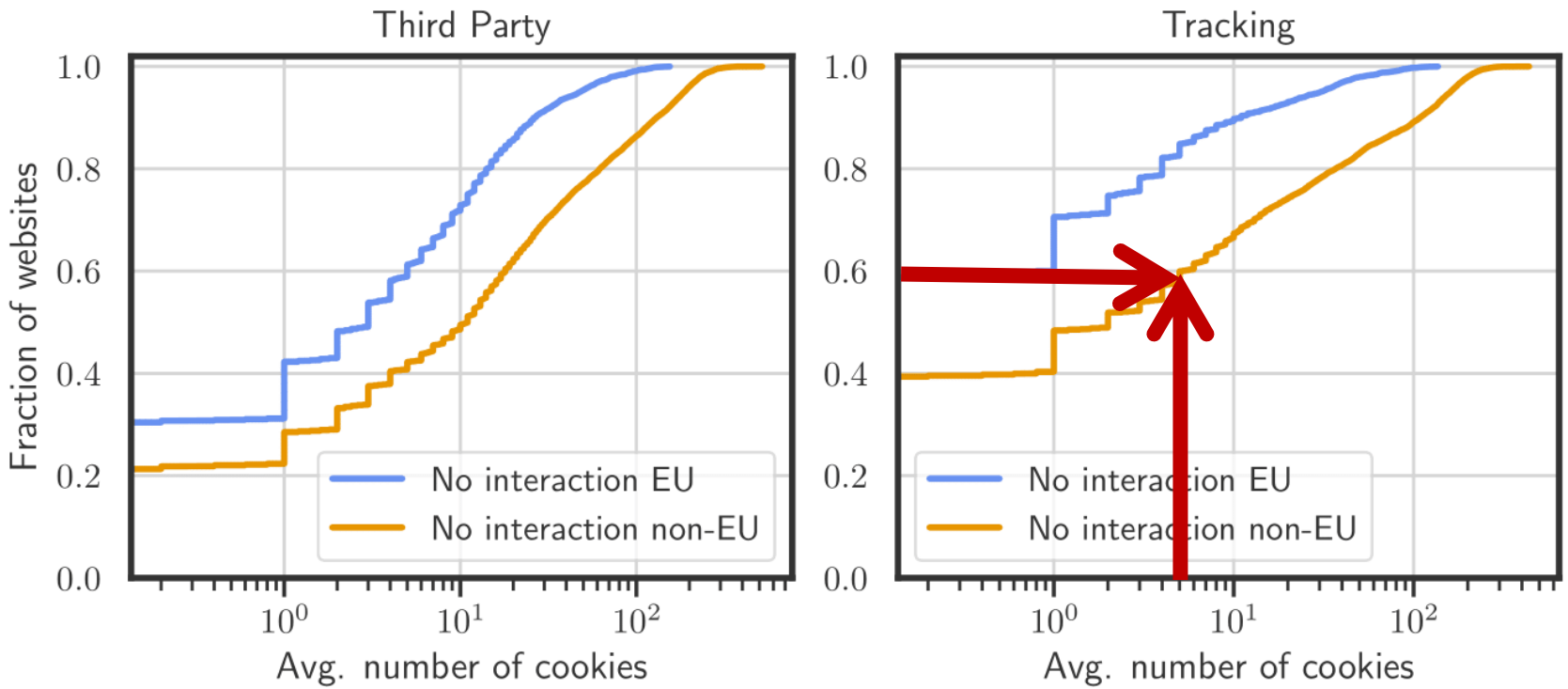
Fewer cookies in EU compared to non-EU

Cookies – EU vs. non-EU



Fewer cookies in EU compared to non-EU

Cookies – EU vs. non-EU

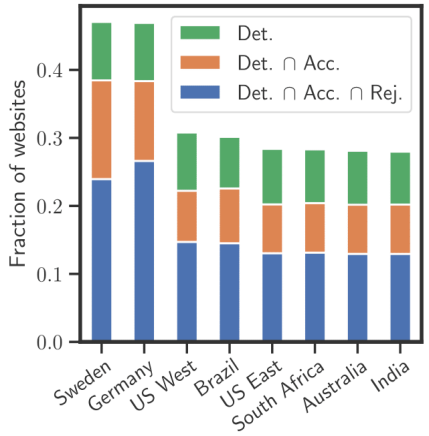


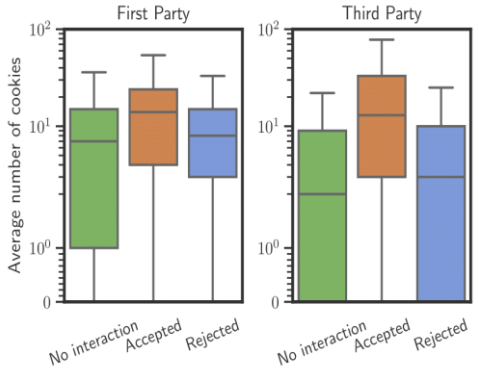
Fewer cookies in EU compared to non-EU

Conclusion

Conclusion

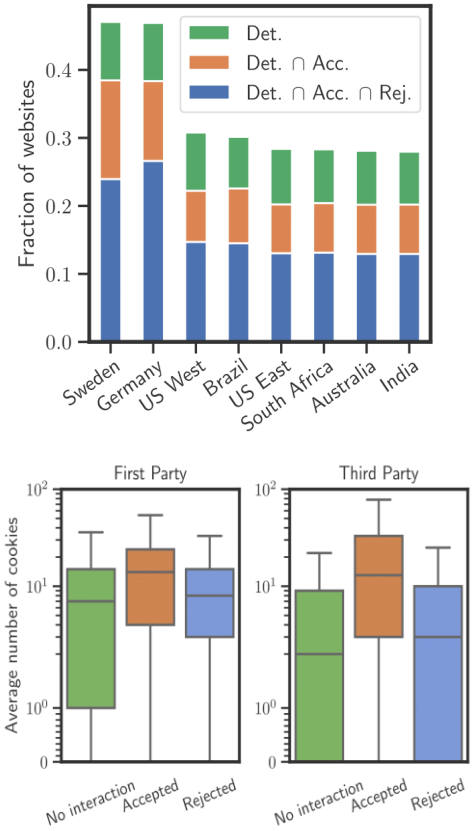
- Impact of
  - Geographical location of users
  - Interaction with banner





Conclusion

- Impact of
  - Geographical location of users
  - Interaction with banner
- Check out the paper
  - CCPA impact
  - Landing vs. Inner pages
  - Mobile vs. Desktop
  - Consistency analysis



Exploring the Cookieverse:
A Multi-Perspective Analysis of Web Cookies

Ali Rasaii[1], Shivani Singh[2], Devashish Gosain[1,3], and Oliver Gasser[1]

[1] Max Planck Institute for Informatics
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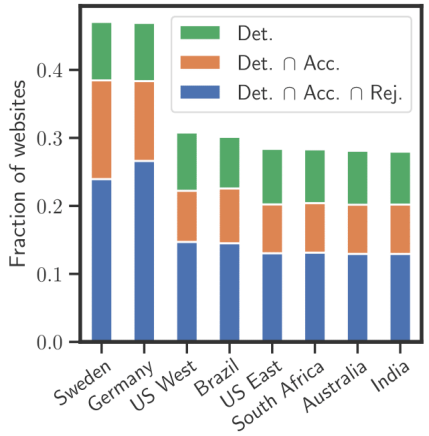
Abstract. Web cookies have been the subject of many research studies over the last few years. However, most existing research does not consider multiple crucial perspectives that can influence the cookie landscape, such as the client's location, the impact of cookie banner interaction, and from which operating system a website is being visited. In this paper, we conduct a comprehensive measurement study to analyze the cookie landscape for Tranco top-10k websites from different geographic locations and analyze multiple different perspectives. One important factor which influences cookies is the use of cookie banners. We develop a tool, *BannerClick*, to automatically detect, accept, and reject cookie banners with an accuracy of 99%, 97%, and 87%, respectively. We find banners to be 56% more prevalent when visiting websites from within the EU region. Moreover, we analyze the effect of banner interaction on different types of cookies (*i.e.*, first-party, third-party, and tracking). For instance, we observe that websites send, on average, 5.5× more third-party cookies after clicking "accept", underlining that it is critical to interact with banners when performing Web measurements. Additionally, we analyze statistical consistency, evaluate the widespread deployment of consent management platforms, compare landing to inner pages, and assess the impact of visiting a website on a desktop compared to a mobile phone. Our study highlights that all of these factors substantially impact the cookie landscape, and thus a multi-perspective approach should be taken when performing Web measurement studies.

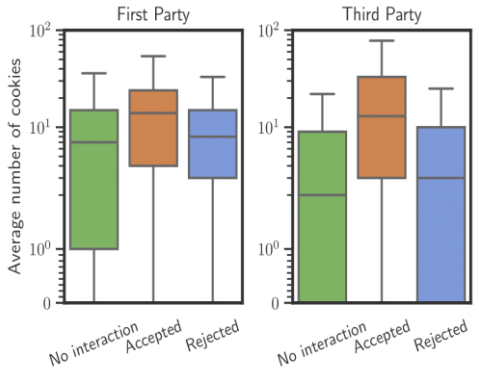
1 Introduction

Web cookies serve various purposes, like keeping the user logged in or storing a user's website settings. However, other than their originally intended use, cookies have been exploited for commercial activities like user tracking and advertisement targeting [1, 4, 17, 18, 59]. As a consequence, various data protection laws have been enacted in the past few years, *e.g.*, the General Data Protection Regulation (GDPR) [19] in the EU and the California Consumer Privacy Act (CCPA) [8] to regulate the use of cookies.

Conclusion

- Impact of
  - Geographical location of users
  - Interaction with banner
- Check out the paper
  - CCPA impact
  - Landing vs. Inner pages
  - Mobile vs. Desktop
  - Consistency analysis
- Source code available
  - BannerClick
  - Analysis data for reproducibility





bannerclick.github.io

Backup: Measurement Setup

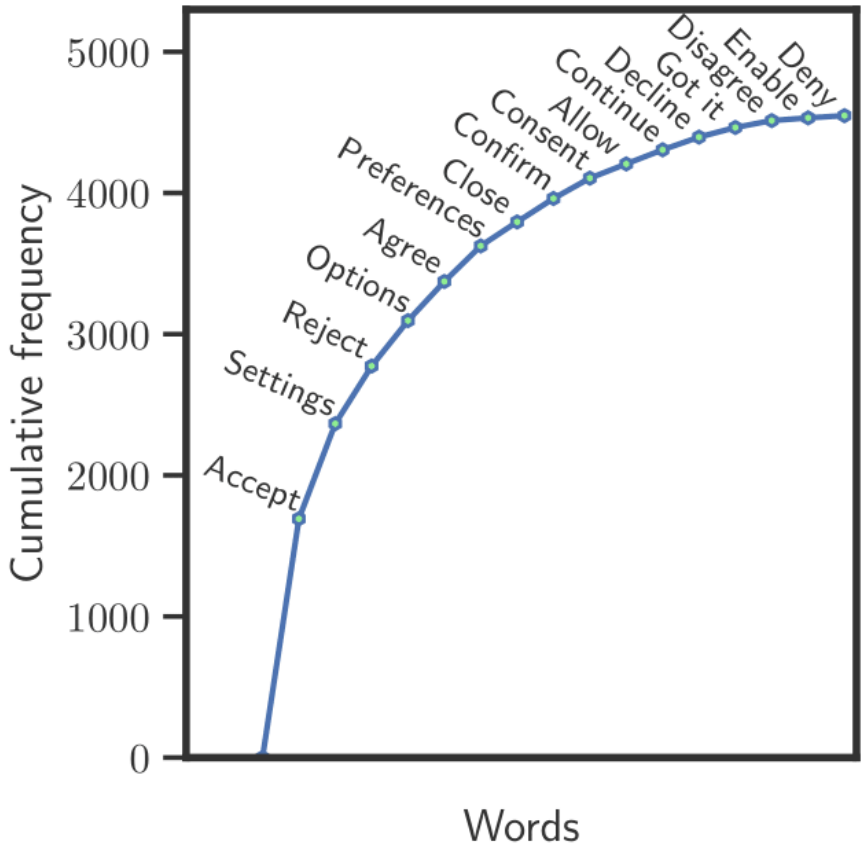
- Main run
  - TrancoTop10kList domains ➔ 9020 totally reachable
  - 5 iteration for each mode of interaction
- Desktop vs. mobile (and others)
  - Tranco tiered 300 ➔ top-100, 1001–1100, and 9901–10k
  - User Agent
    - Mobile: “Mozilla/5.0 (Android 12; Mobile; rv:68.0) Gecko/68.0 Firefox/93.0”
    - Desktop: “Mozilla/5.0 (X11; Linux x86_64; rv:95.0) Gecko/20100101 Firefox/95.0”
  - Screen size
    - Mobile: 340x695
    - Desktop: 1366x768

Backup: Measurements

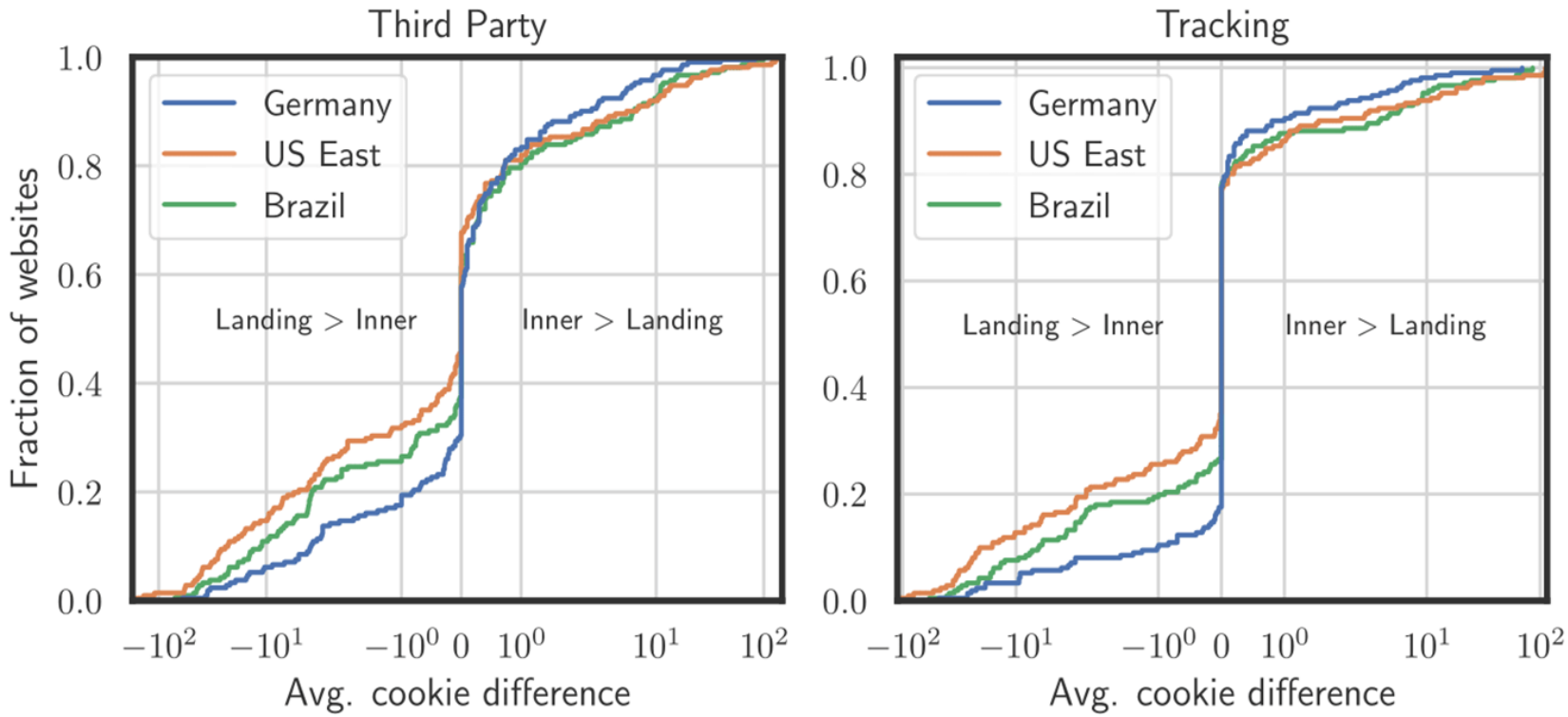
Table 1. Overview of different measurement types.

Measurement Type	Start Date	Duration	Target Websites
Banner Interaction	Jan 20, 2022	20 days	Tranco Top 10k
Consistency Tests	Feb 9, 2022	10 days	Tranco tiered 300
Landing vs. Inner	Mar 8, 2022	4 days	Tranco tiered 300
Desktop vs. Mobile	Feb 27, 2022	10 hours	Tranco tiered 300
Impact of CCPA	Mar 13, 2022	10 hours	Tranco tiered 300

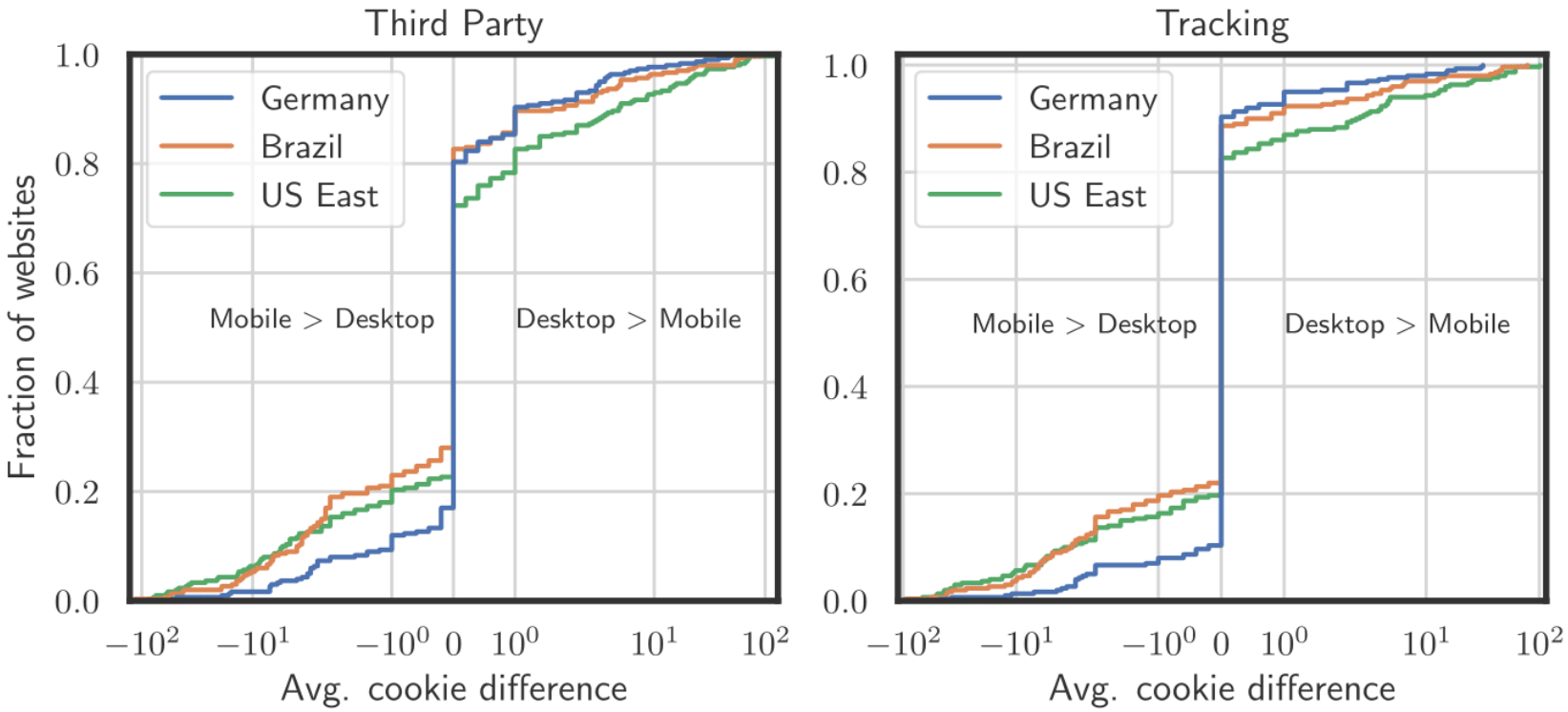
Backup: Words Frequency



Backup: Inner vs Landing

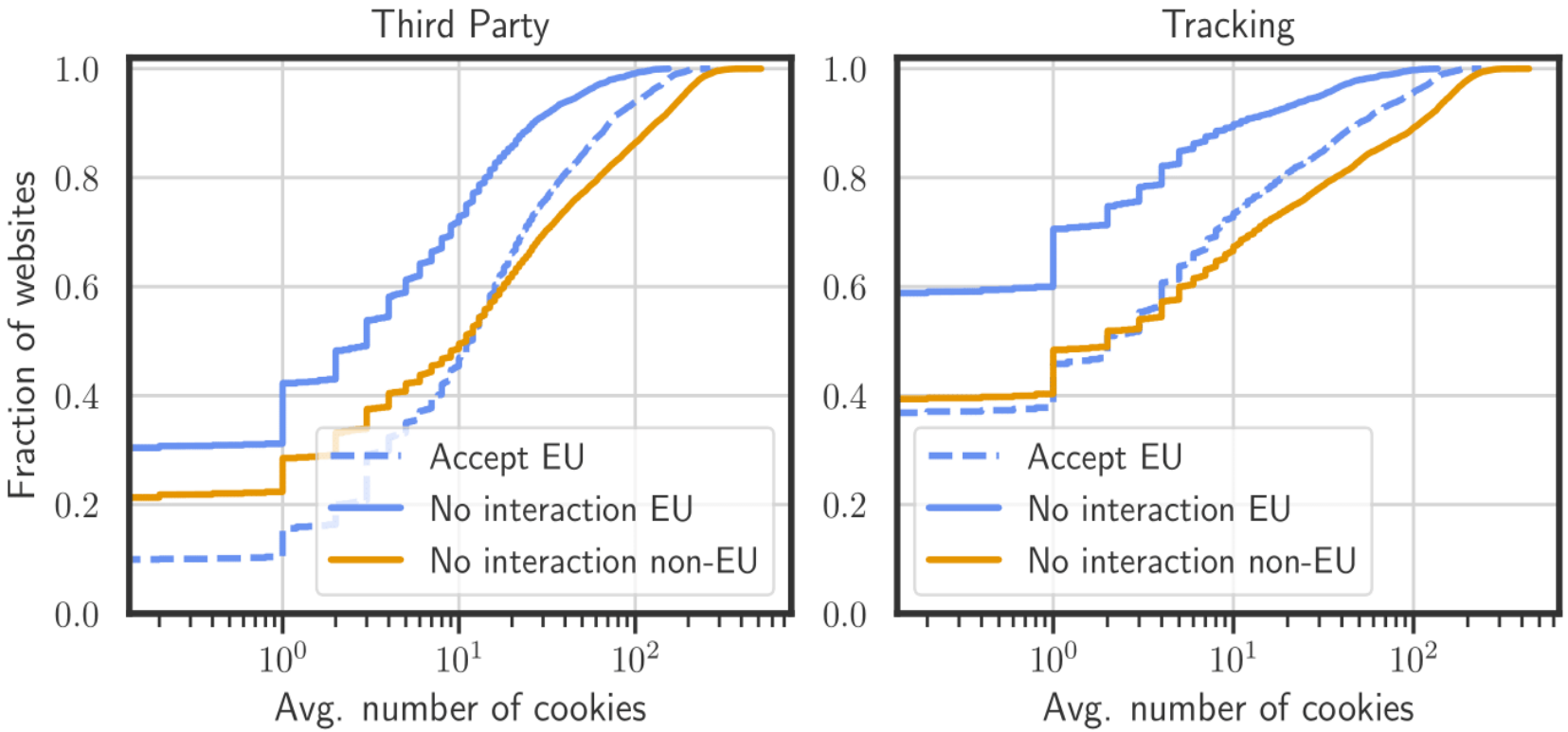


Backup: Mobile vs Desktop



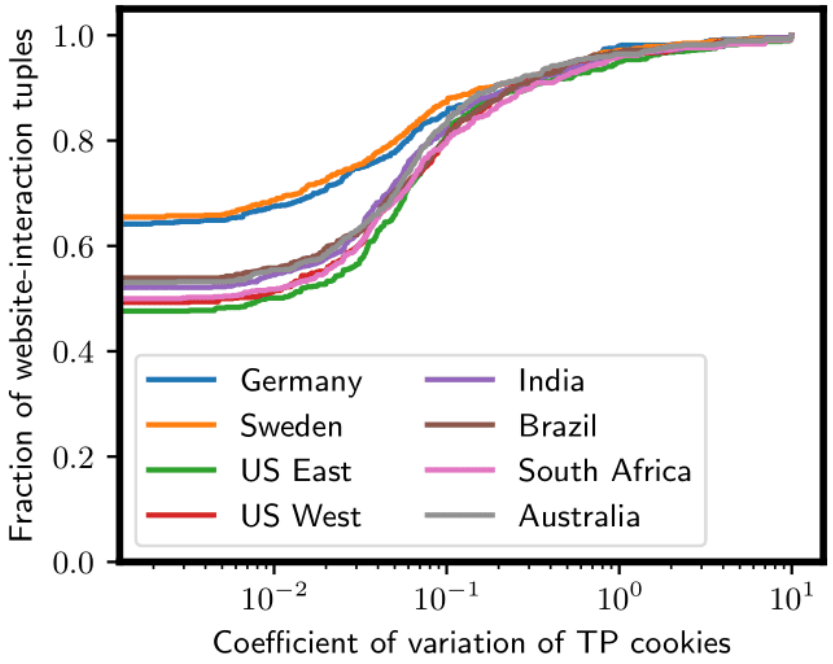
User agent would impact the number of cookies.

Backup: Cookies – EU vs non-EU

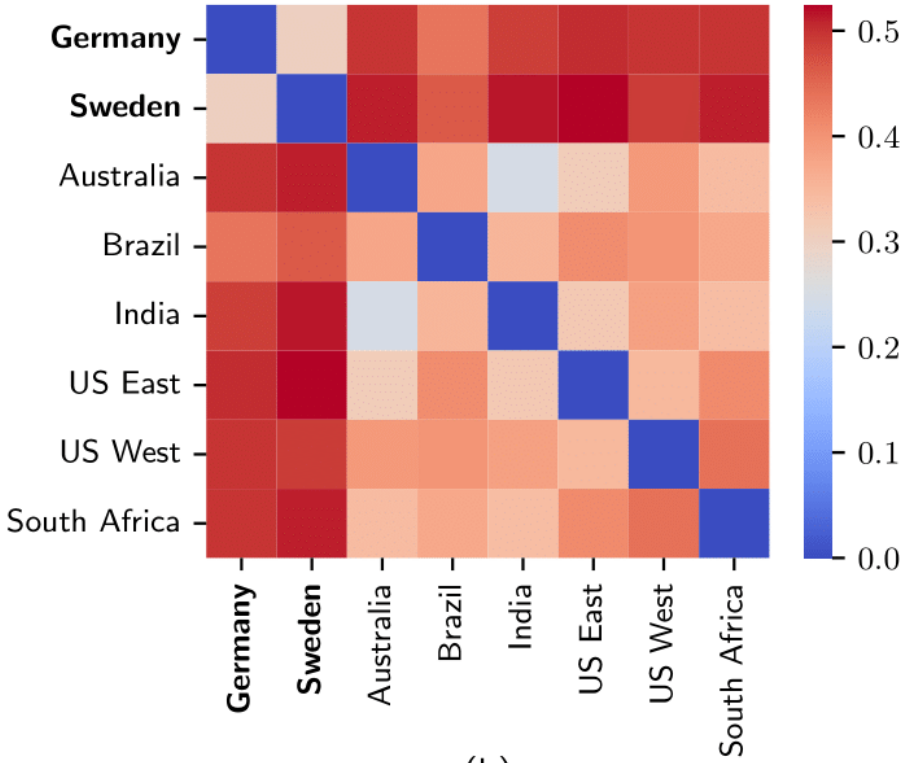


Less cookies in EU compared to non-EU

Backup: Consistency

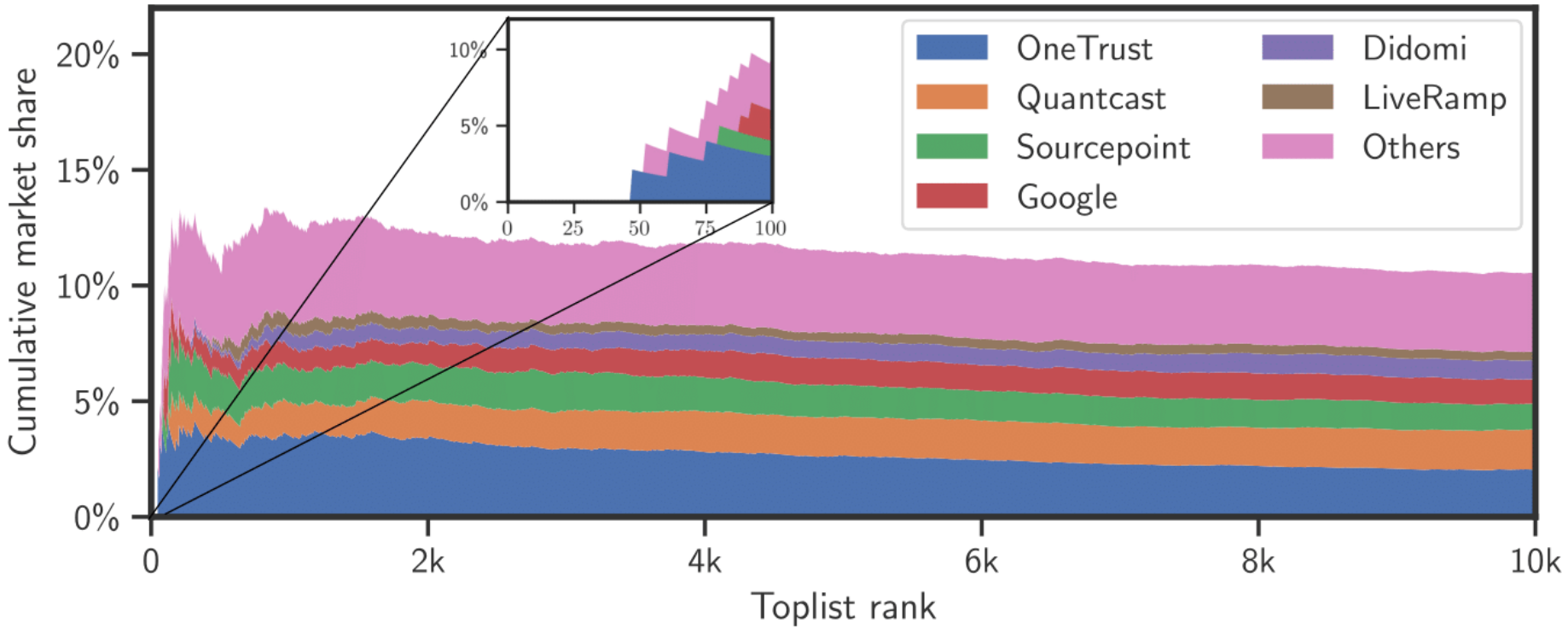
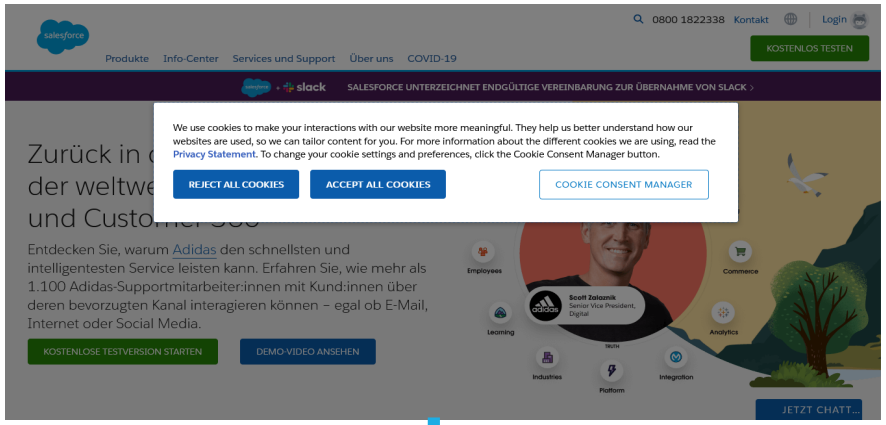
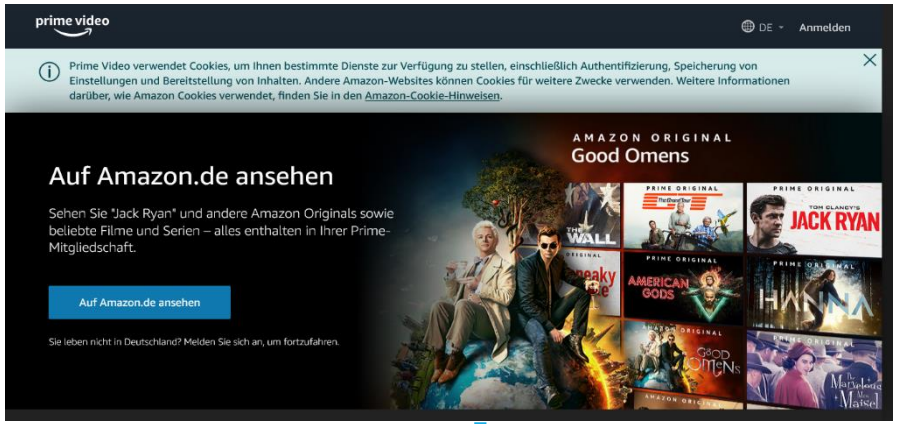
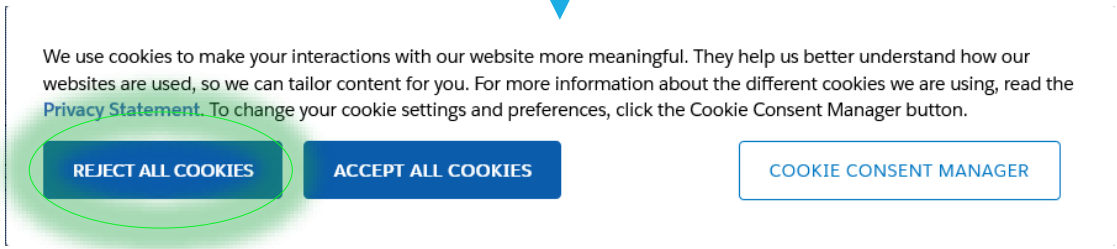
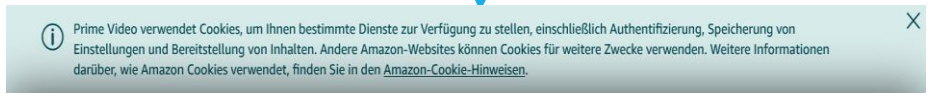


(a)



(b)

Backup: Consent Management Platform



Backup: Explicit vs. Implicit