Fledging Will Continue Until Privacy Improves: Empirical Analysis of Google's Privacy-Preserving Advertising

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Presenter: Dylen Greenenwald

Presentation Overview

- Summary
- Background
- Measurement
- Attacks
- Discussion

Main Points

- **Motivation of the Google Privacy Sandbox**
  - Utility vs privacy tradeoff
  - Incentive structure of advertising ecosystem
  - Replacement of 3rd party cookies
- Measurement of FLEDGE ecosystem across experimental & production periods
- Introduction of PoC attacks against FLEDGE

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- Utility vs privacy tradeoff that motivates the Google Privacy Sandbox
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- Introduced proof of concept attacks against FLEDGE

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Background

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- *Buyers* refer to any entity who manages the purchase of ad space
- *Sellers* refer to any entity who manages the sale of ad space
- *Ad networks* refer to intermediaries in the ad ecosystem
- Protected Audience API ~ FLEDGE API

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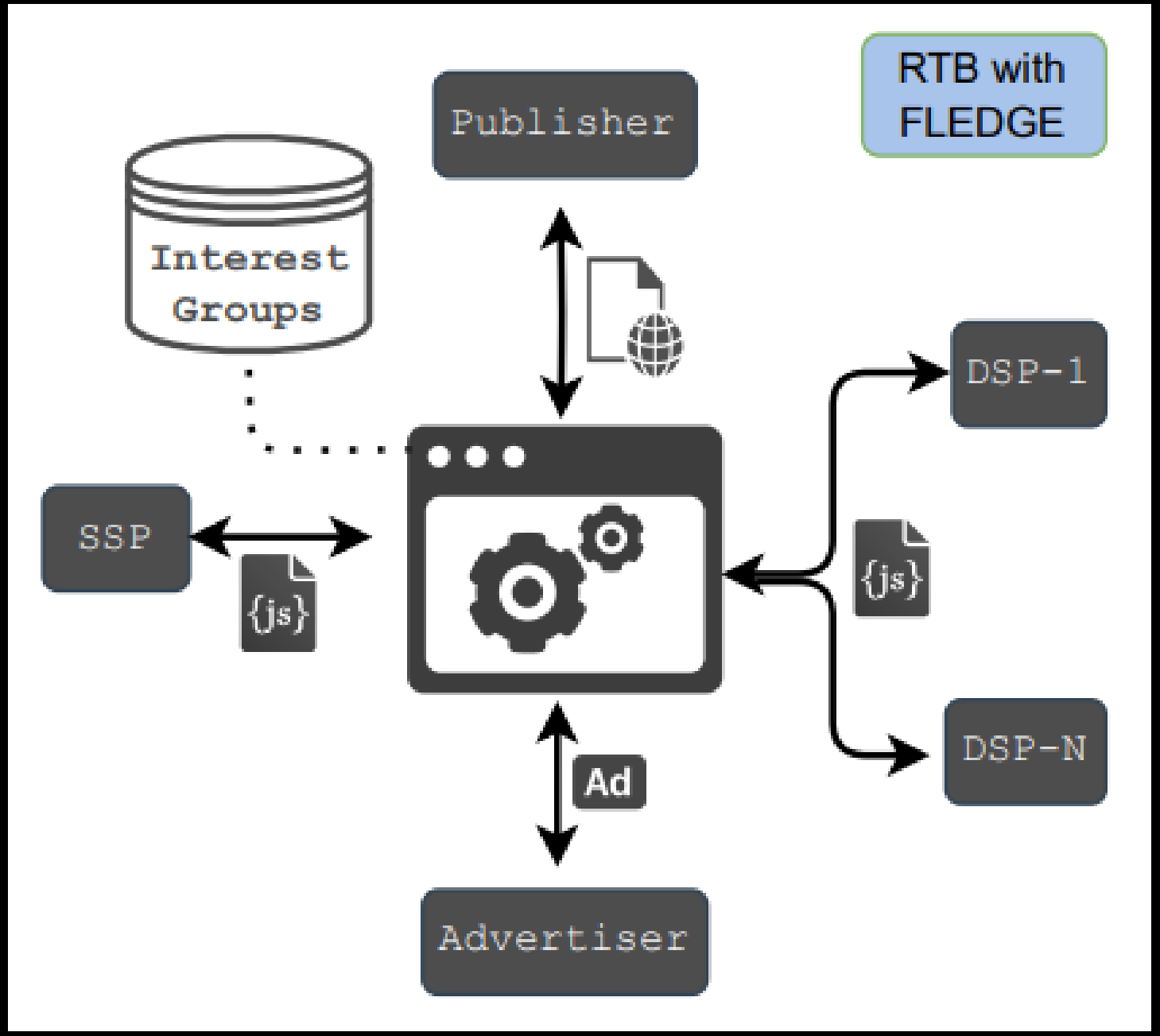
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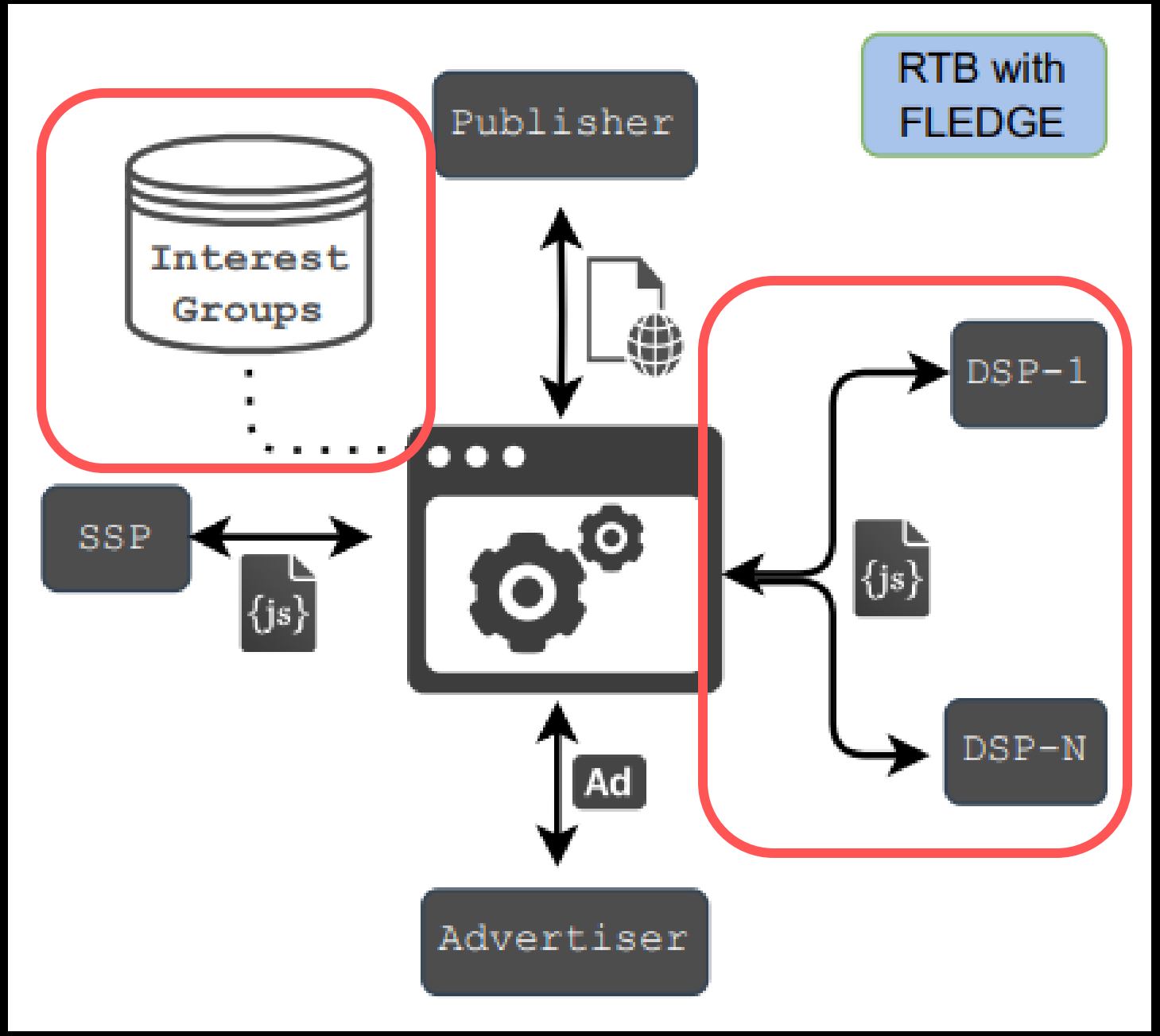
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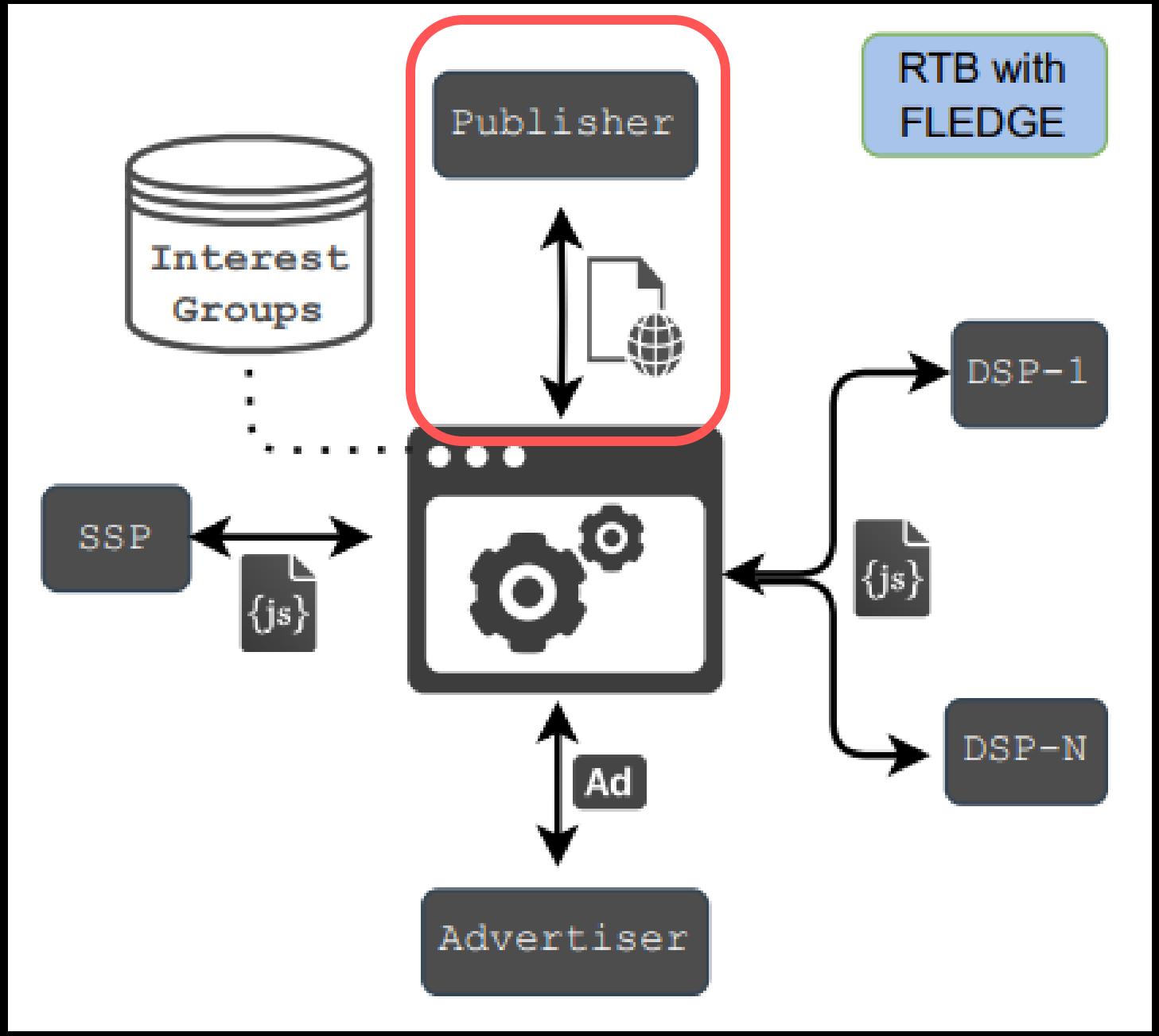
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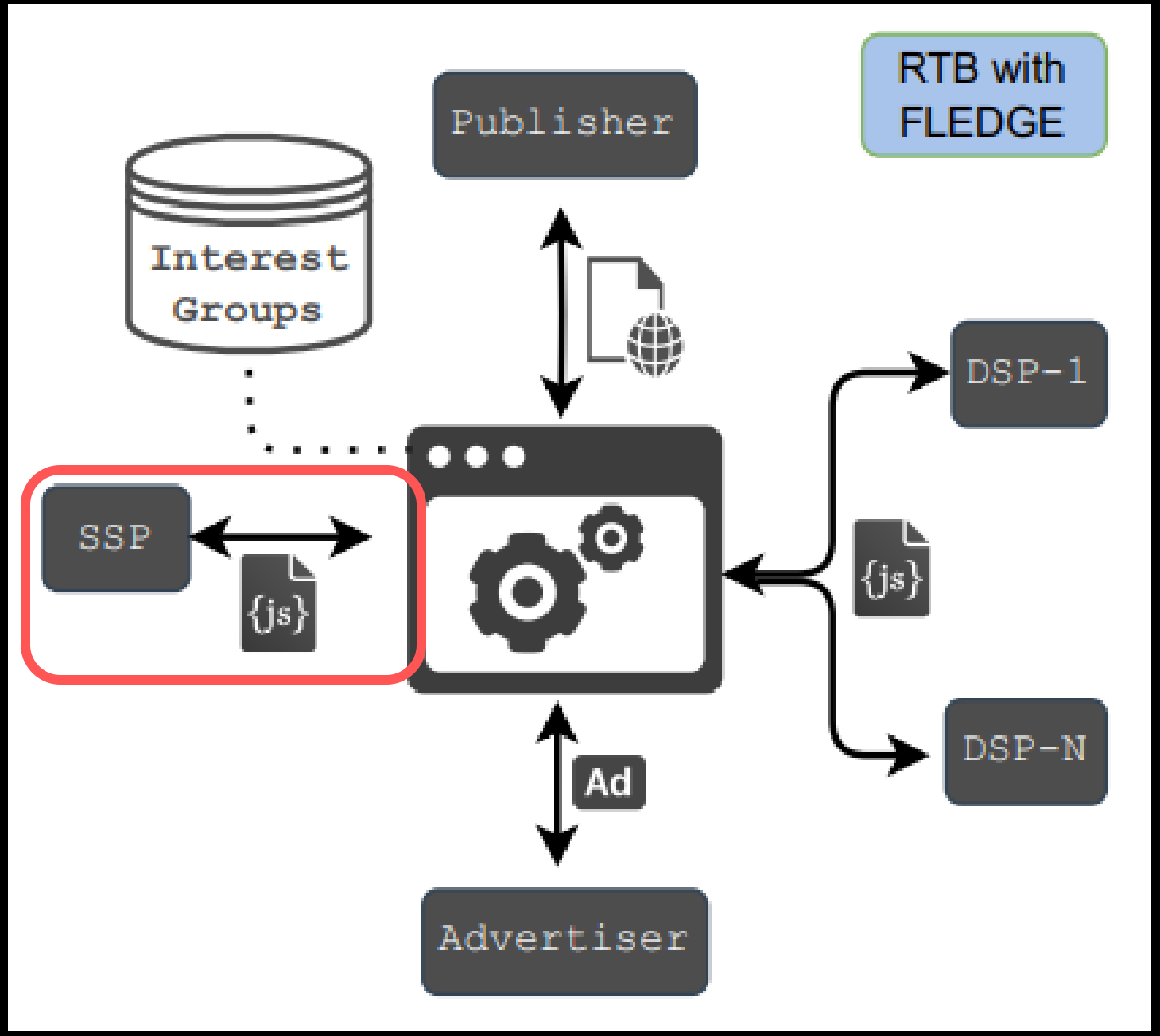
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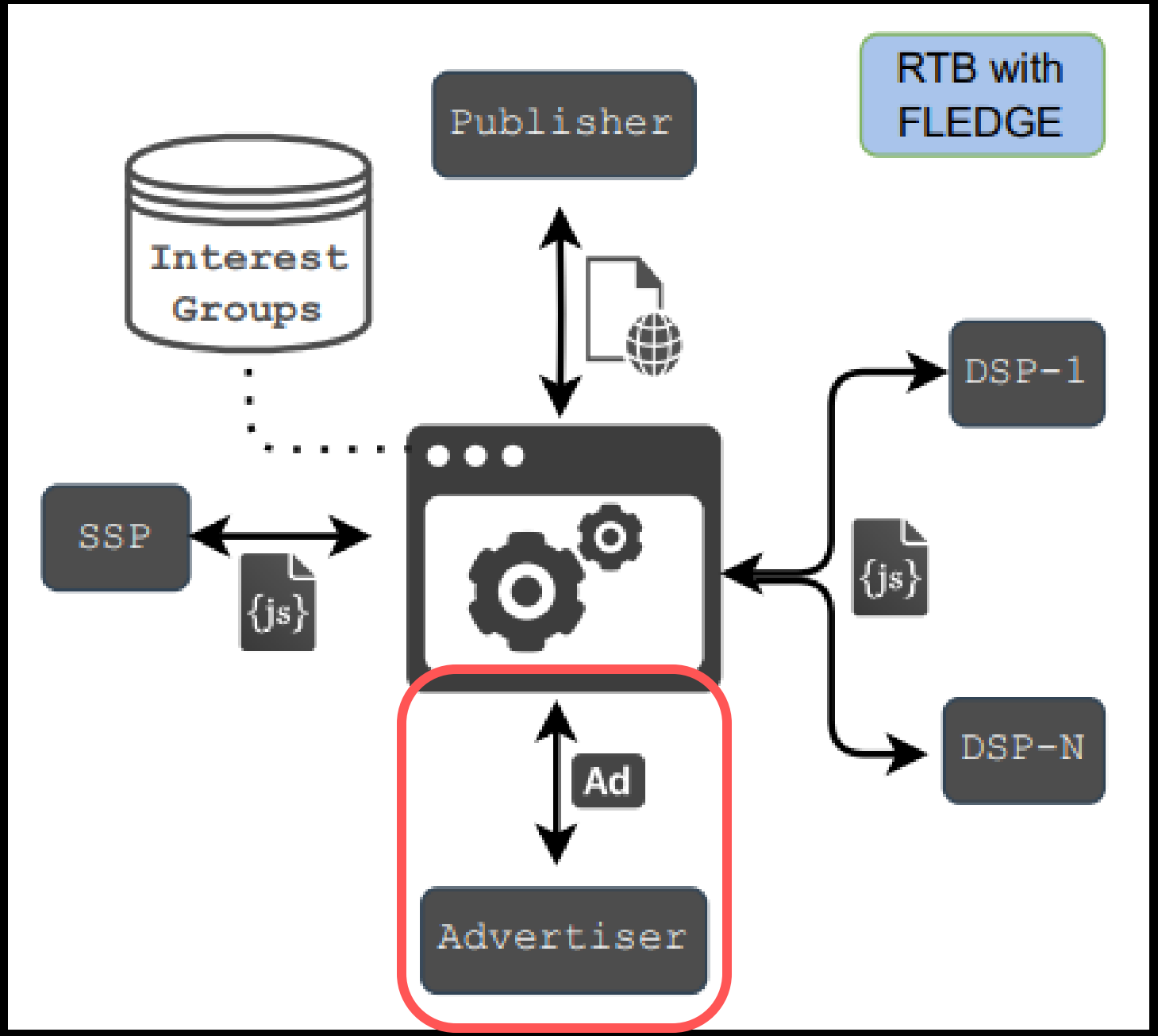
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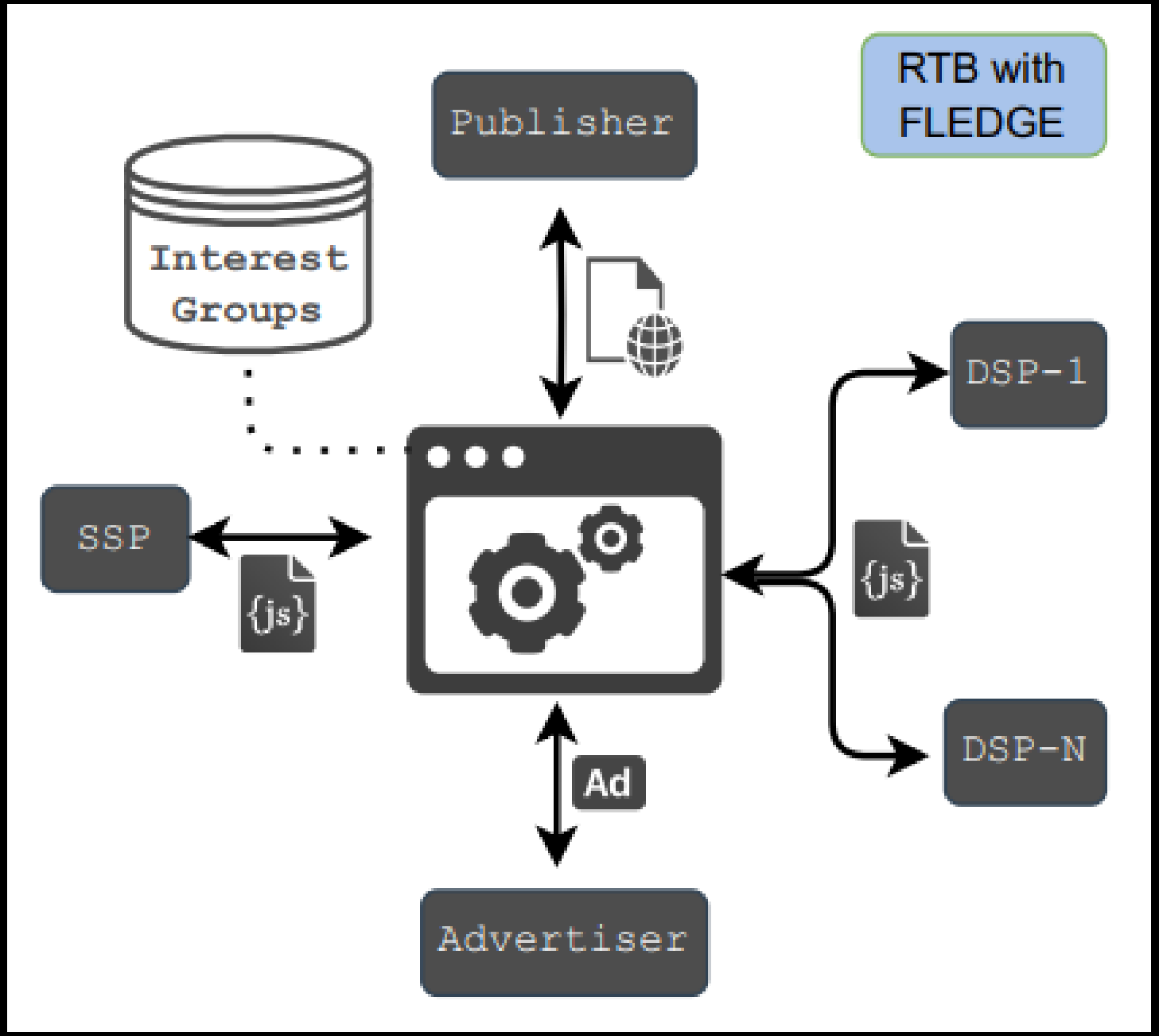
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Measurements

Results

- **Notable artifacts**
  - Publishers
  - Sellers
  - Advertisers
  - Auctions

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  - **Publishers**
    - **~10% of top 70k sites utilize FLEDGE**
    - 100% of FLEDGE API usage performed by 3rd parties
  - Sellers
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Takeaways?

Results

- Notable artifacts
  - Publishers
  - **Sellers**
    - **99.8% of auctions were ran by Google**
  - Advertisers
  - Auctions

Table 1: Overview of sellers over time.

Month	Seller	#Publishers	#Auctions
June	securepubads.g.doubleclick.net	1,761	5,738
July	securepubads.g.doubleclick.net	1,038	2,960
	cdn.mediago.io	1	1
September	securepubads.g.doubleclick.net	565	3,243
	cdn.mediago.io	9	17

Results

- Notable artifacts
  - Publishers
  - Sellers
  - **Advertisers**
    - **Only 7 advertisers adding browsers to interest groups**
  - Auctions

Wow!

Table 2: Interest groups' `join` and `leave` actions.

Owner	#Publishers	Interest Groups #Joined	#Left
td.doubleclick.net	2,924	12,190	2,533
fledge.as.criteo.com	370	880	-
fledge.teads.tv	229	1	-
fledge.eu.criteo.com	327	918	-
fledge.us.criteo.com	655	1411	-
fledge-eu.creativecdn.com	95	261	52
fledge-usa.creativecdn.com	65	133	37
fledge-asia.creativecdn.com	56	129	17
f.creativecdn.com	9	9	-
googleads.g.doubleclick.net	5	5	-
cdn.mediago.io	5	1	-
at-us-east.amazon-adsystem.com	1	1	-
adthrive.com	4	4	-

Results

- Notable artifacts
  - Publishers
  - Sellers
  - Advertisers
  - **Auctions**
    - ~21 scoring signals used on average during auctions
    - ~10 bidding signals passed to each buyer (via `perBuyerSignals`) during auctions
    - Avg (often obfuscated) signal depth of ~8

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So what?

Attacks

Threat Model

- Web attacker...
  - **Embedded as third-party resource** (e.g., via a `<script>`, `<iframe>` tag)
  - Using FLEDGE APIs (e.g., `navigator.runAdAuction()`)
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What do you see?

Table 3: Summary of our attacks, the mechanism they misuse, privacy advancements they violate, and planned mitigations.

Type	Mechanism	Field	Attacker Role	Future Mitigation	Violation
Tracking	Bidding Helpers	biddingWasmHelperUrl	Advertiser & Seller	Not Planned	PA2
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Critical attack

- Single interest group attack
- No planned mitigation

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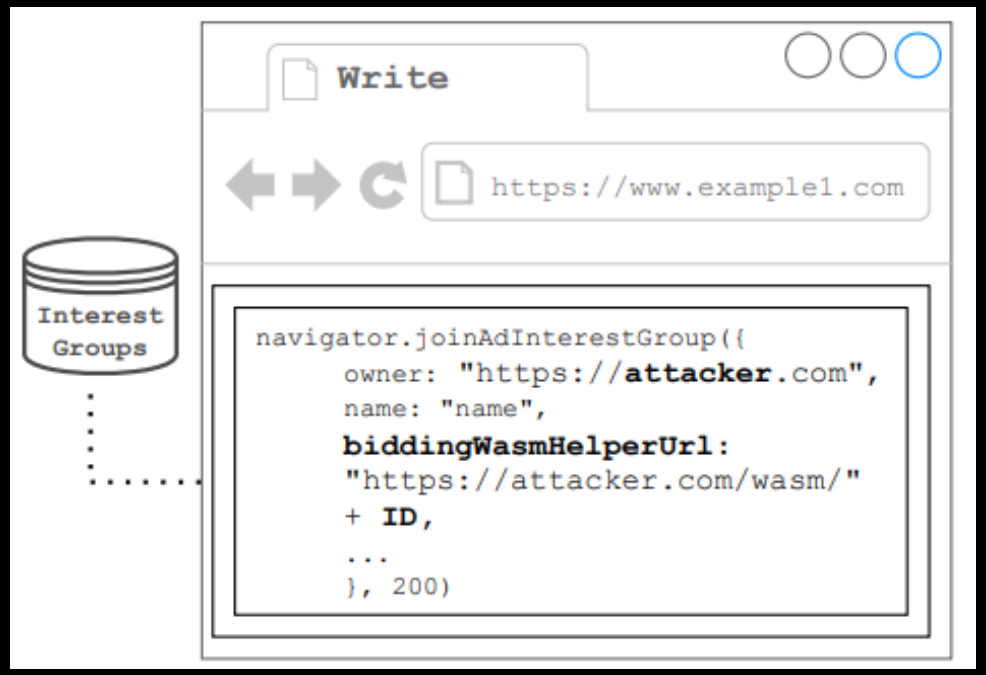

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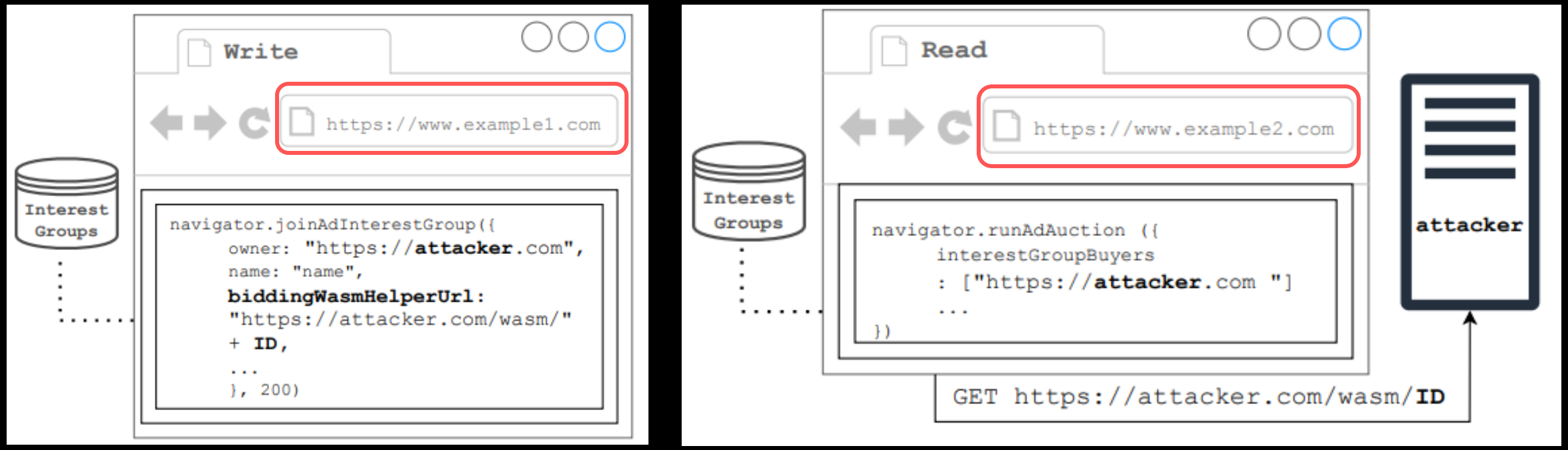

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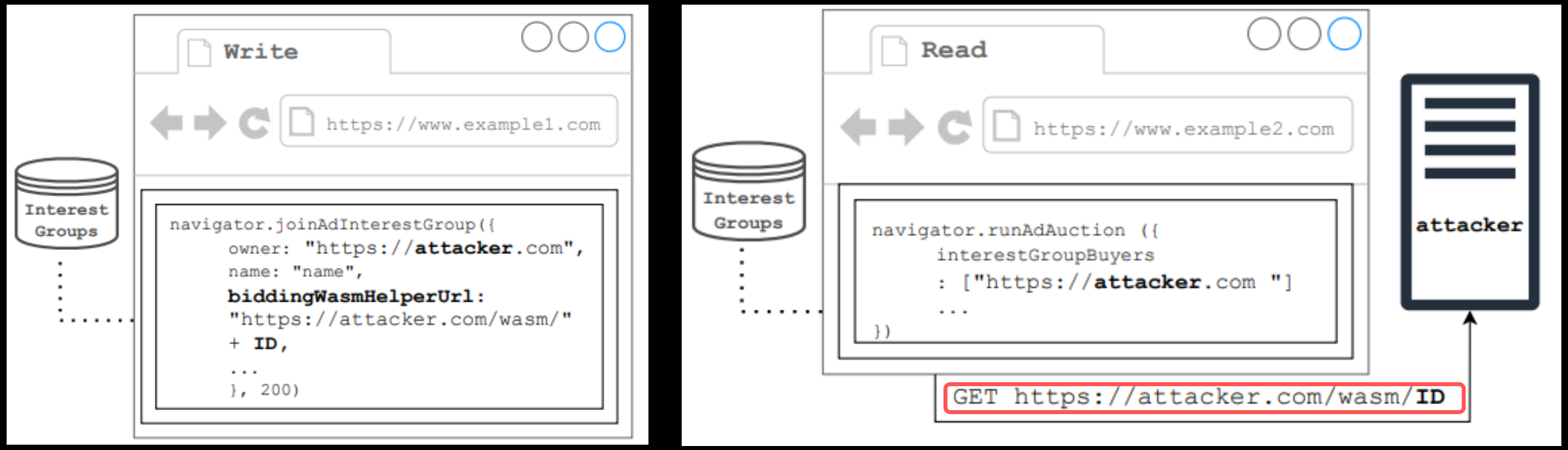

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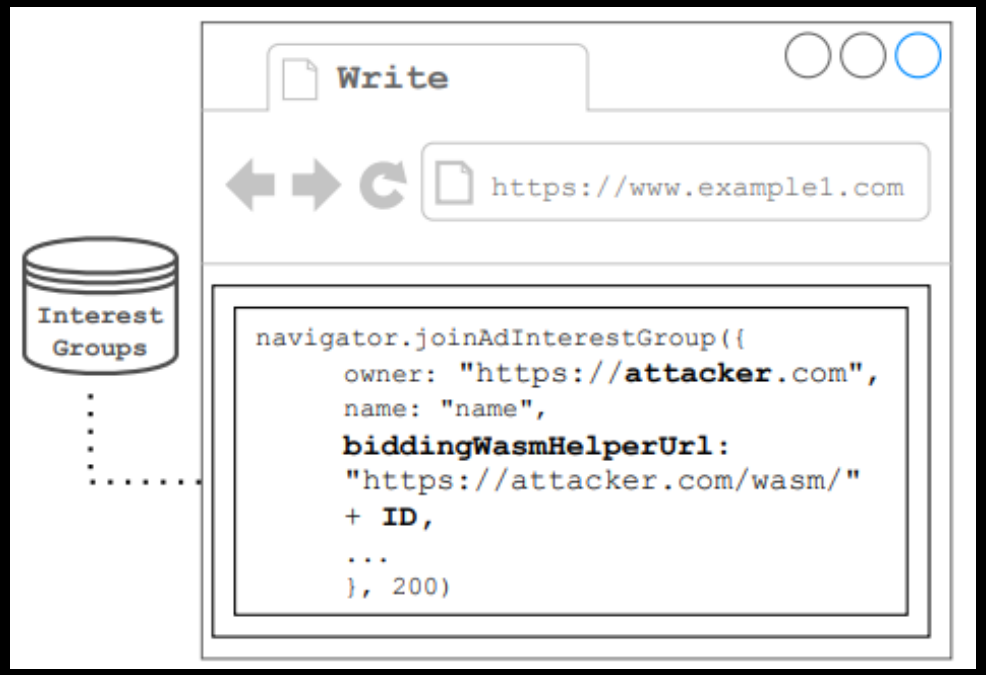

Questions?

What I see

Critical attack

- Multiple interest group attack
- k-anonymity: k=10
- Fenced Frames required "no sooner than 2026"

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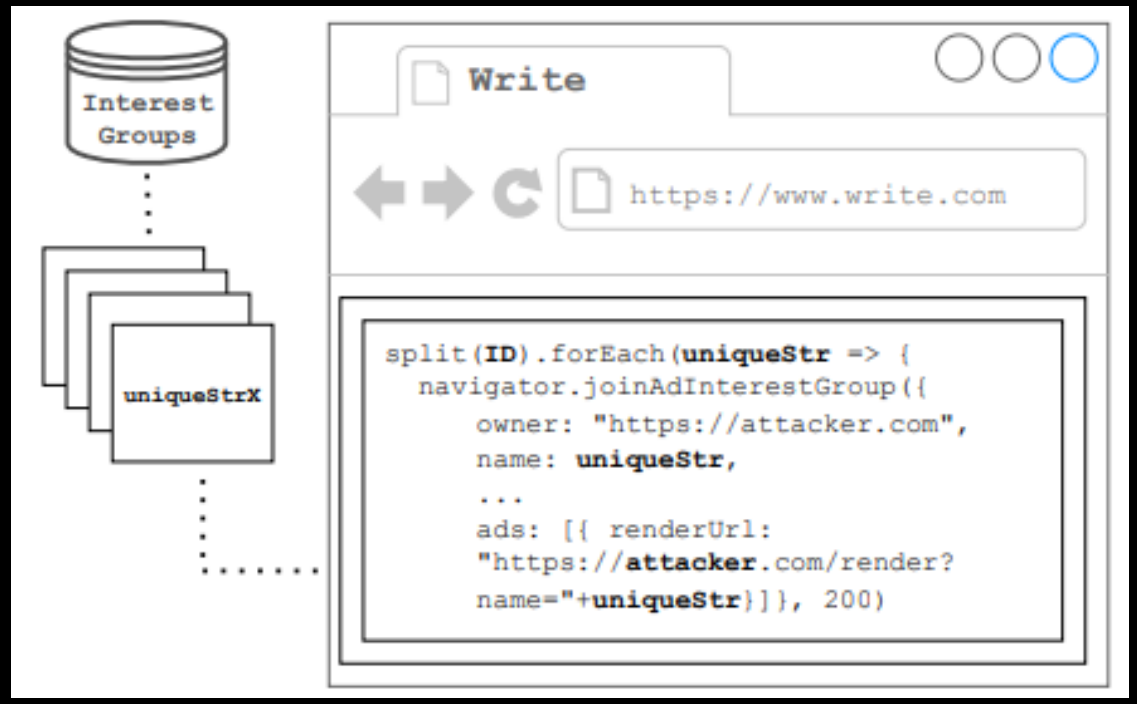

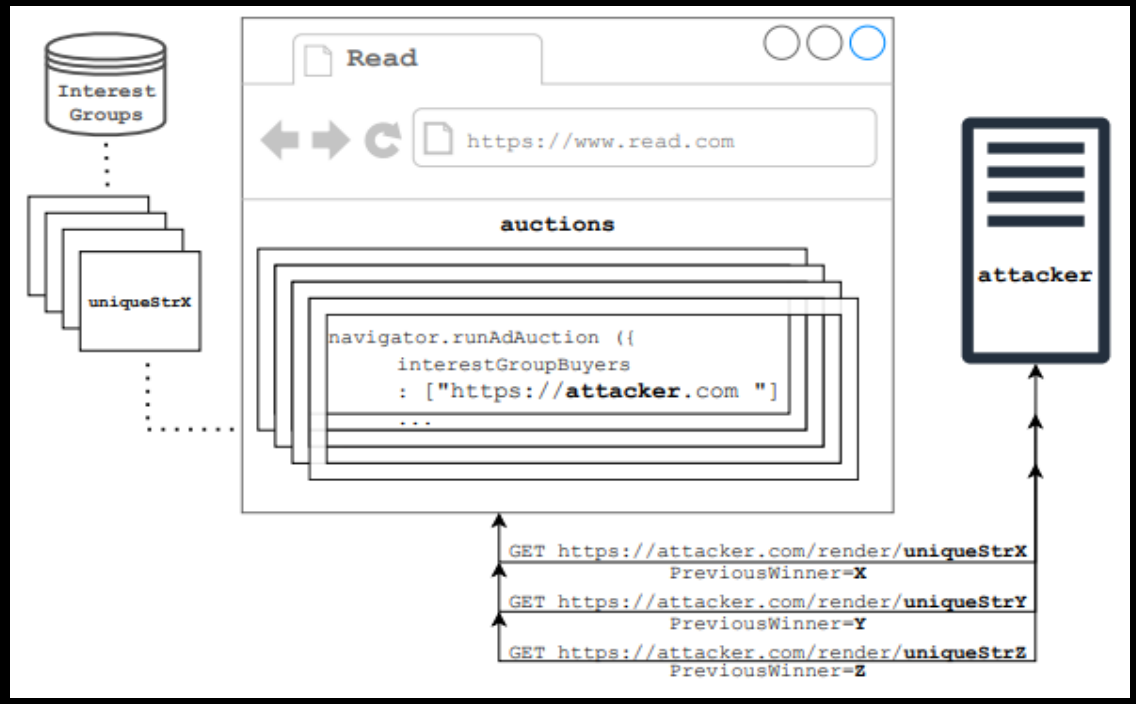

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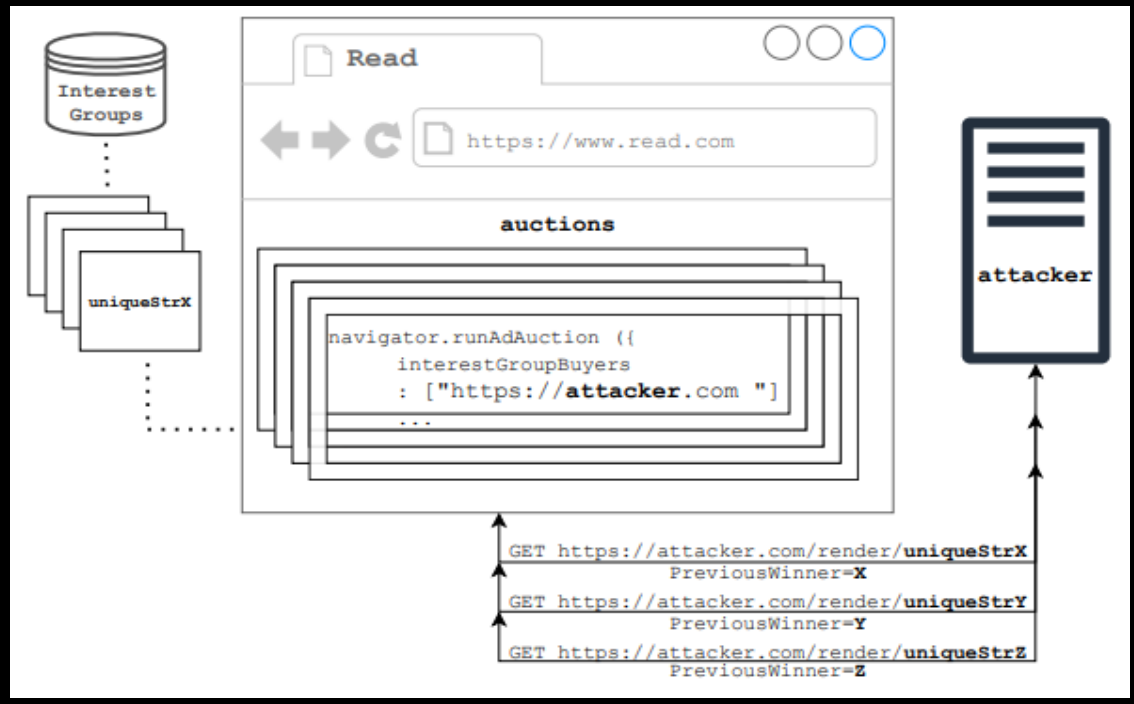

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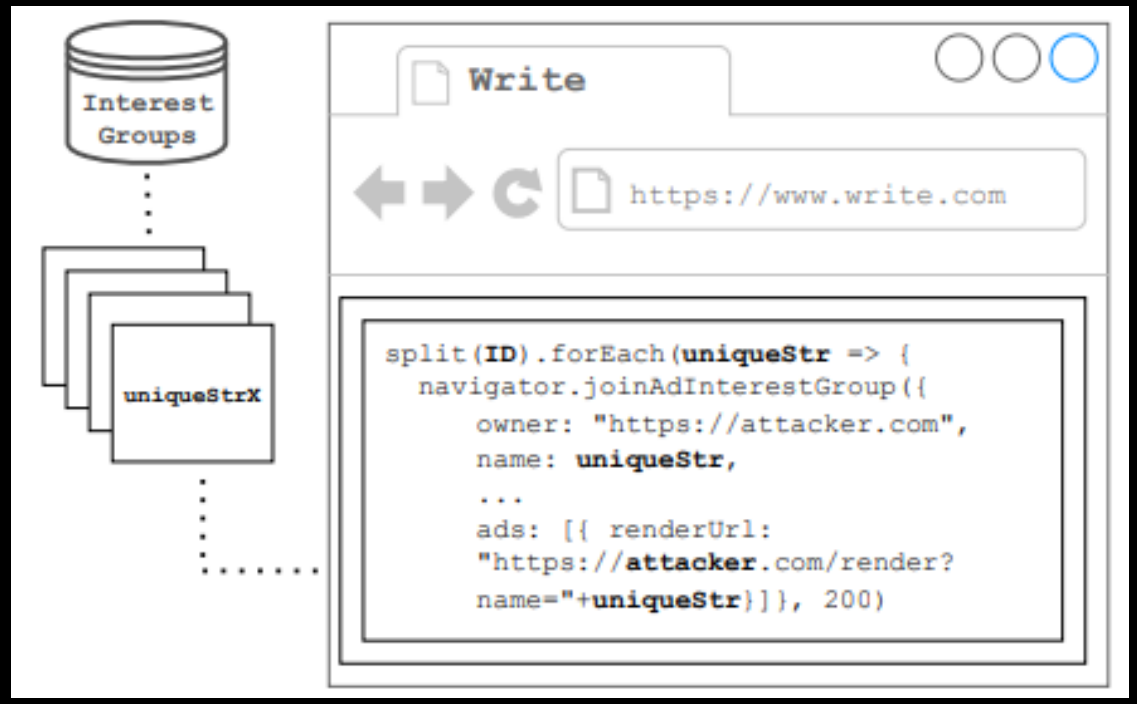

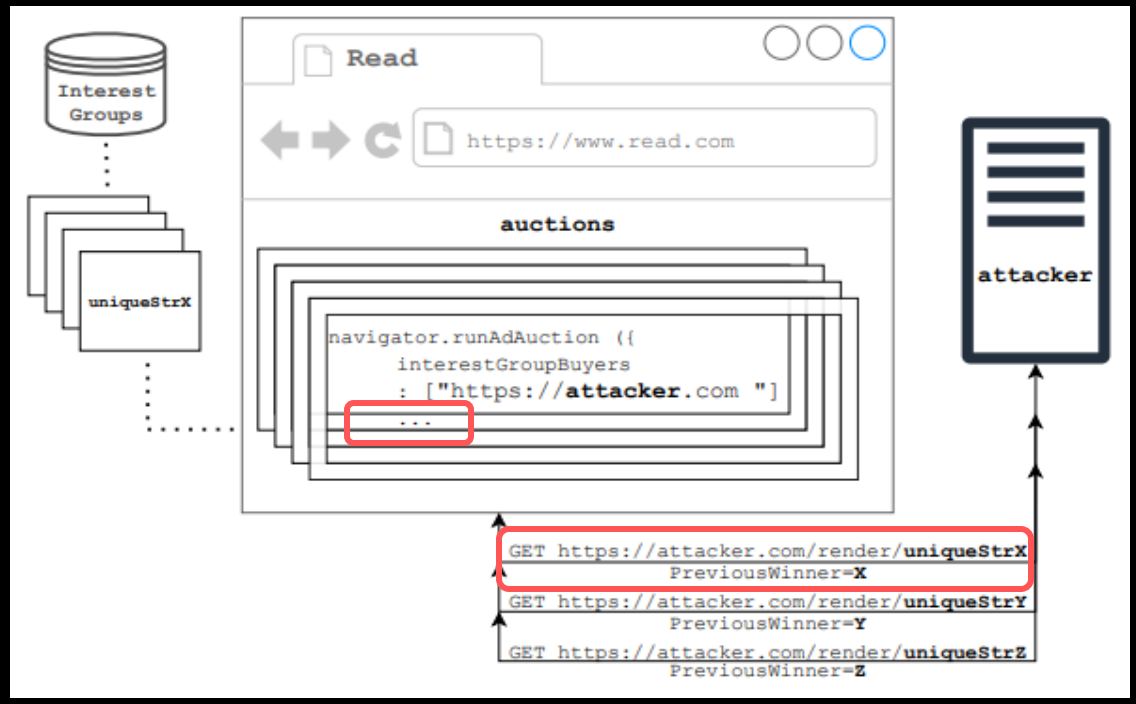

What I see

Severe attacks

- Stronger threat model
- TEEs "required no sooner than Q3 2025"
- All fundamental privacy violations

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XS Leak Attacks Overview

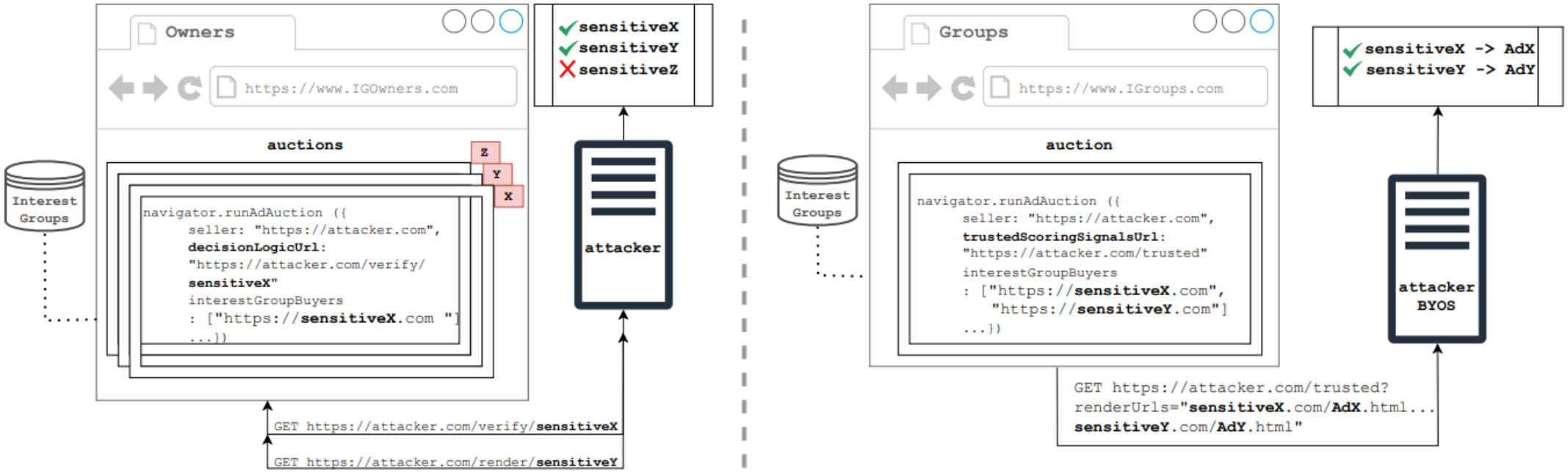

Figure 6: Cross-site leaks of owners (left) and interest group contents (right).

What I see

Serious attack

- No planned mitigations
- Usability violation

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Auction Blocking Attack Overview

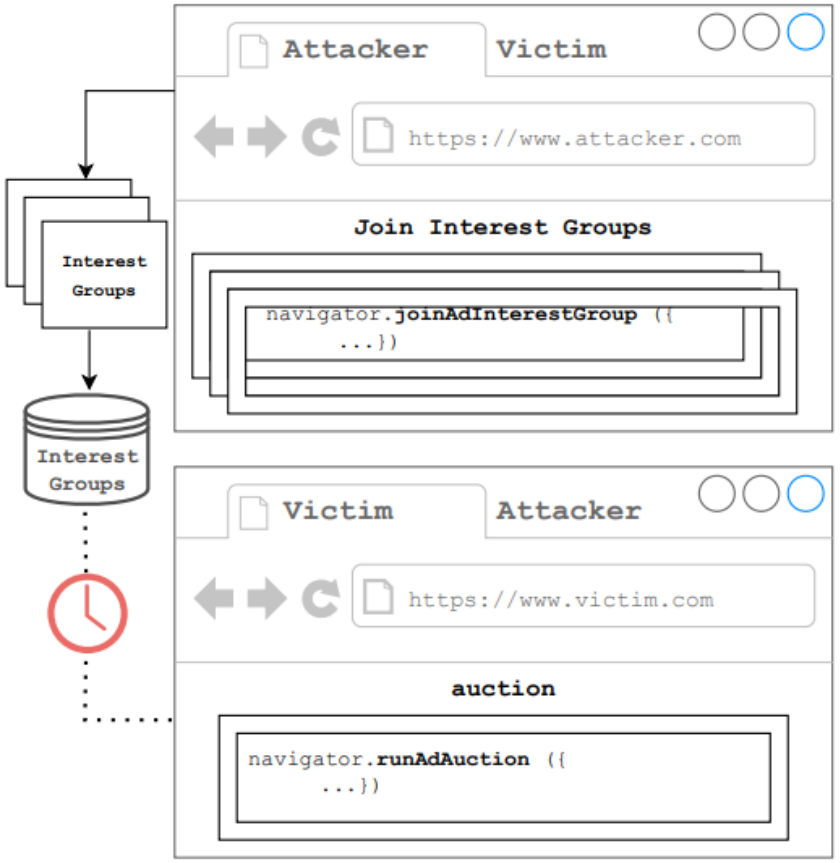
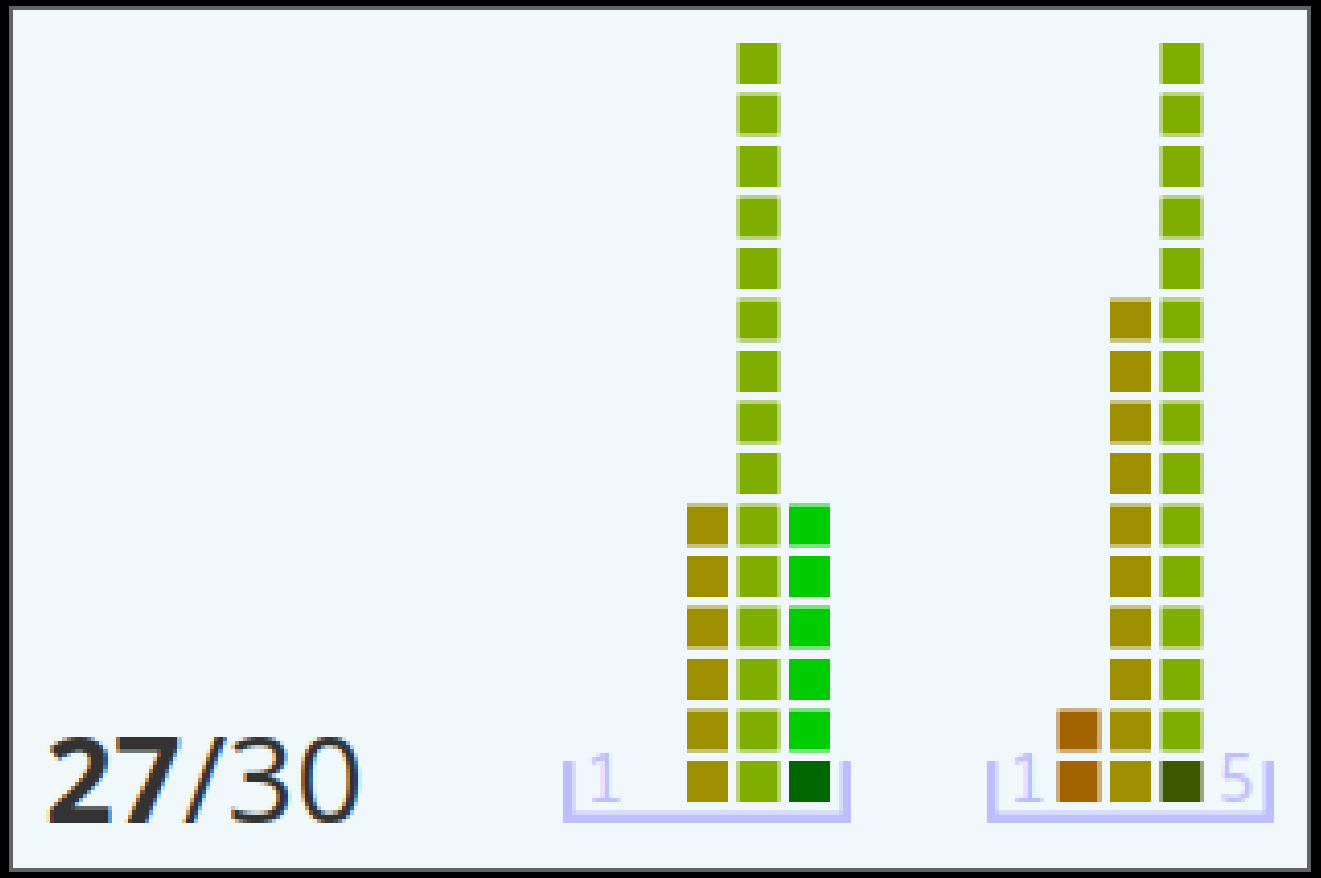


Figure 8: Blocking Ad Auctions.

Denial of Service

Discussion


27/30
1
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Personal Points

OPINIONS

- Authors...
  - Performed non-comprehensive measurement
  - Found creative attacks with serious implications
  - Produced an award-quality paper
- Attack surface of FLEDGE likely still vulnerable

QUESTIONS

- What was your "favorite" attack?
- What is more privacy-invasive: 3rd party cookies or FLEDGE?
- Can 3rd party cookies and the Google Privacy Sandbox coexist?
  - *Google walked back its announcement to deprecate 3rd party cookies.*

Class Points

OPINIONS

- Attacks...
  - Should have been tested on real users (?!)
  - Have a strong/narrow threat model
  - Are too limited in scope
    - "test other APIs"
  - Are already achievable with 1st party cookies
  - Are hard to understand
  - Are clever
  - Are alarming
    - "So many attacks, why haven't we moved to other browsers?"

    => *we have* ***;)***

QUESTIONS

- Is private advertising possible?
- How does the privacy level of FLEDGE compare to traditional RTB?
- Should Google disable FLEDGE? Should users turn it off?
- How would FLEDGE do in other browsers?
- How does FLEDGE affect Google's business model? What about small advertisers?

Class Points

OPINIONS

- The Google Privacy Sandbox...
  - is good for user privacy
  - requires further investigation
- We should investigate...
  - new Sandbox proposals
  - browser side-channels
  - further measurements on FLEDGE adoption
  - economic implications

QUESTIONS

- What is the right balance of utility and privacy?
  - Ad revenue vs privacy?
  - Rapid development vs security/privacy?
- To what extent does Google care about user privacy? Can we trust them?
  - Google *still* hasn't responded to 10/12 disclosures
- How can we nerf Google's role in the ad ecosystem?

Class Points

OPINIONS

- Proposed mitigations...
  - Lack specificity
  - Are not well-enough thought out
- There should be a FLEDGE usability study

QUESTIONS

- Should the researchers have published with the flaws still present?
- How can we regulate the advertising industry?
  - Remove targeted ads (i.e., contextual ads only)?

Thank you! :)