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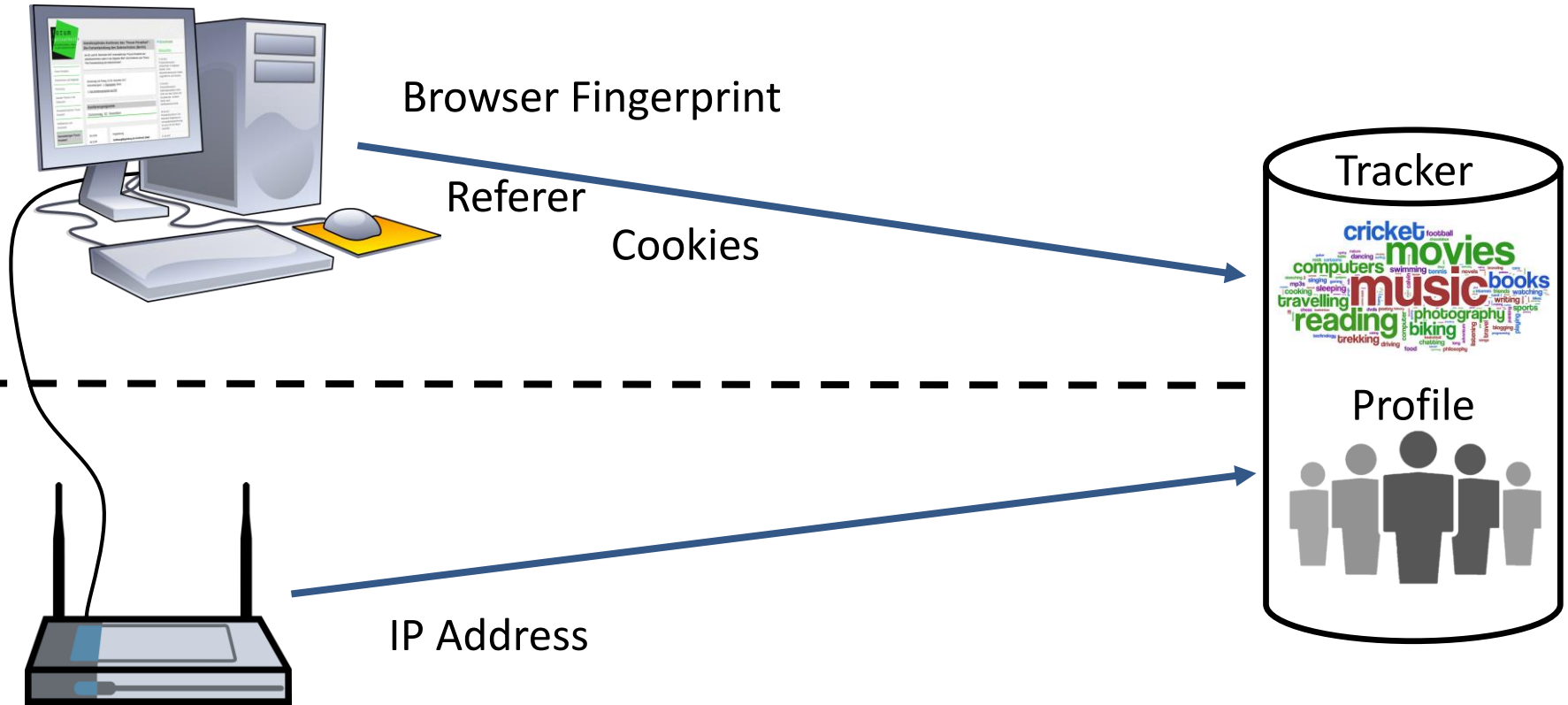DER FORSCHUNG | DER LEHRE | DER BILDUNG

Context-aware IPv6 Address Hopping

Matthias Marx, Monina Schwarz, Maximilian Blochberger, Frederik Wille, Hannes Federrath
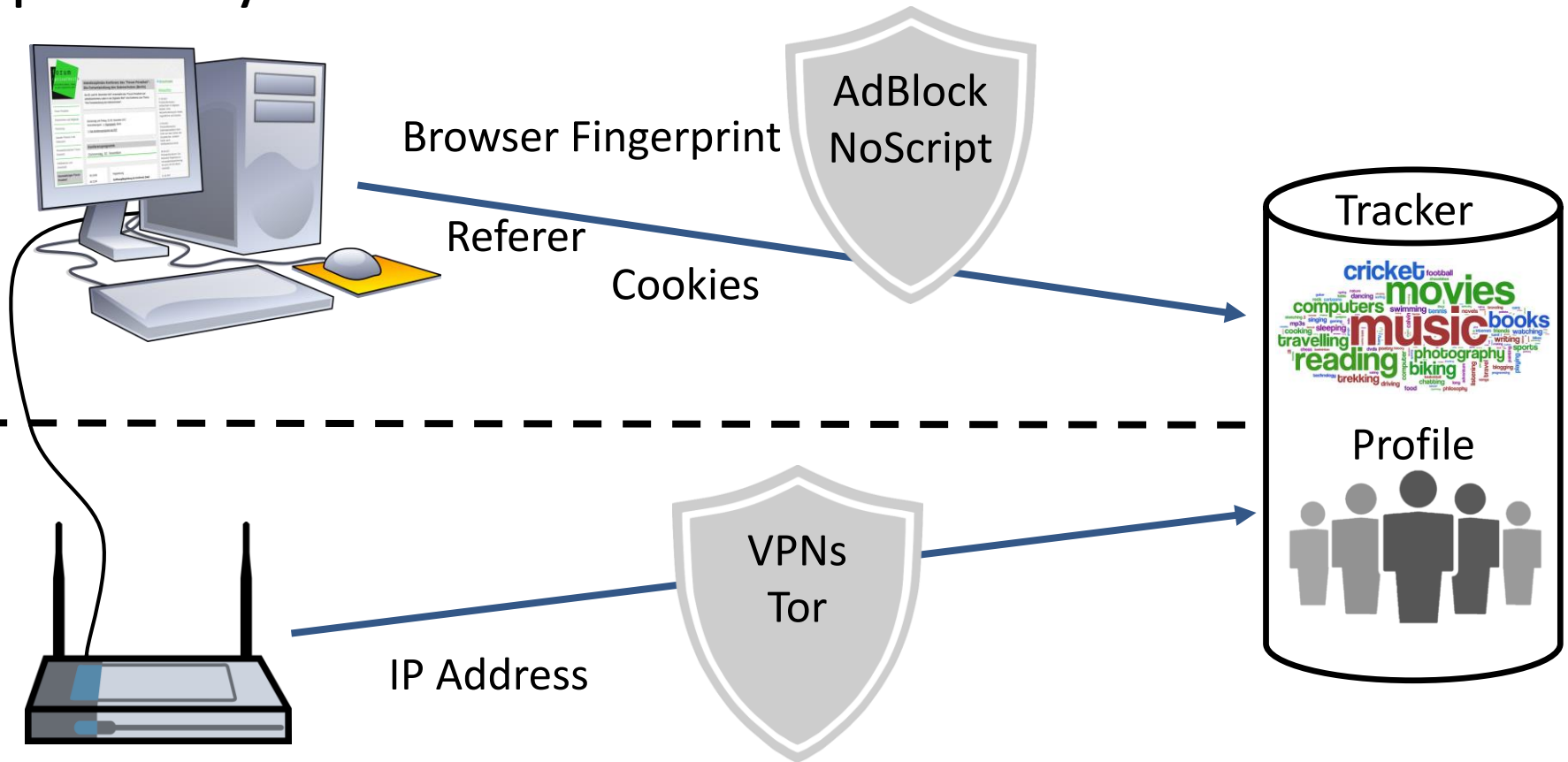
Motivation and Idea

Application Layer

Browser Fingerprint

Referer

Cookies

Tracker

Profile

IP Address

Network Layer

Application Layer

Browser Fingerprint

AdBlock
NoScript

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VPNs
Tor

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cricket football
computers movies
dancing swimming tennis
singing mp3s books
travelling music writing
reading photography
biking
trekking

Tor-
Browser

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IP Address

Context-aware IPv6 Address Hopping

Network Layer
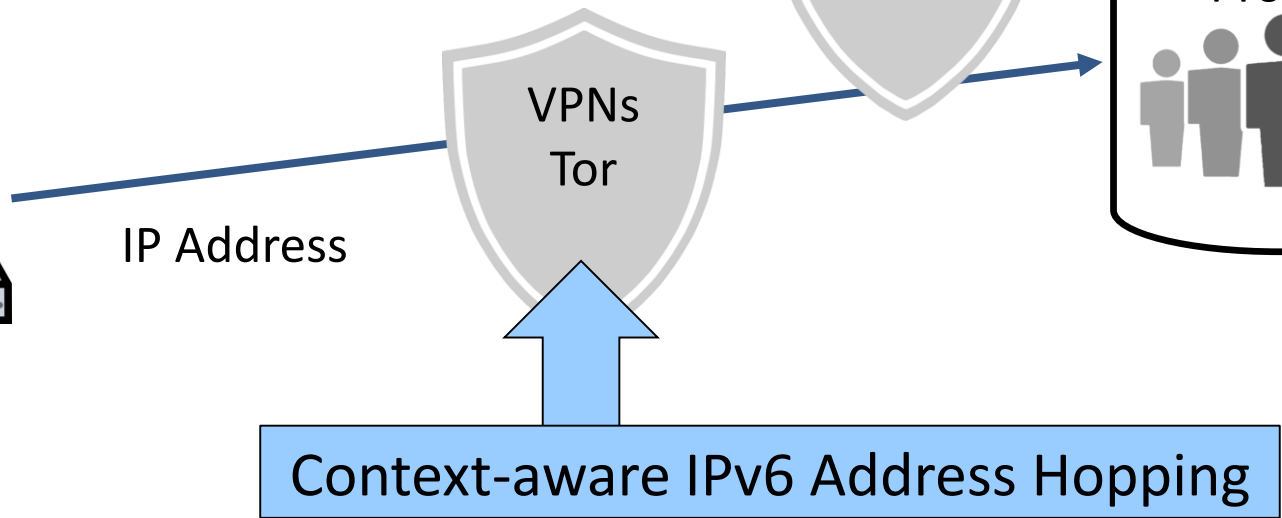
- IPv6 addresses have 128 bit $\qquad$ $2^{128} \approx 3.4 \times 10^{38}$

- ISPs assign at least one 64 bit IPv6 prefix to home users

  2001:db8:85a3:8a2e::/64 $\qquad$ $2^{64} \approx 1.8 \times 10^{19}$

- Only a fraction of these IP addresses are used today
  - One or few IP addresses per device
  - New tracking opportunities arise
  - IPv6 Privacy Extension does not protect against tracking

- We will utilize the large IPv6 address space

  A distinct outbound IPv6 address for each visited website

Address hopping for **enhanced privacy**

- **IPv6 Privacy Extension**
  - Temporary, random addresses for outbound connections
  - IP addresses are usually used for one day

- **Virtual protocol stack**
  - Alter identifiers on all layers: MAC, IPs, …

- *Address Hopping NAT*
  - ISP mixes IP addresses of packets sent by customers

Address hopping for **enhanced security**

- Rotate the addresses of both, sender and receiver
- Moving target defense

Context isolation in web browsers for

- Security
- Privacy
- Robustness and performance
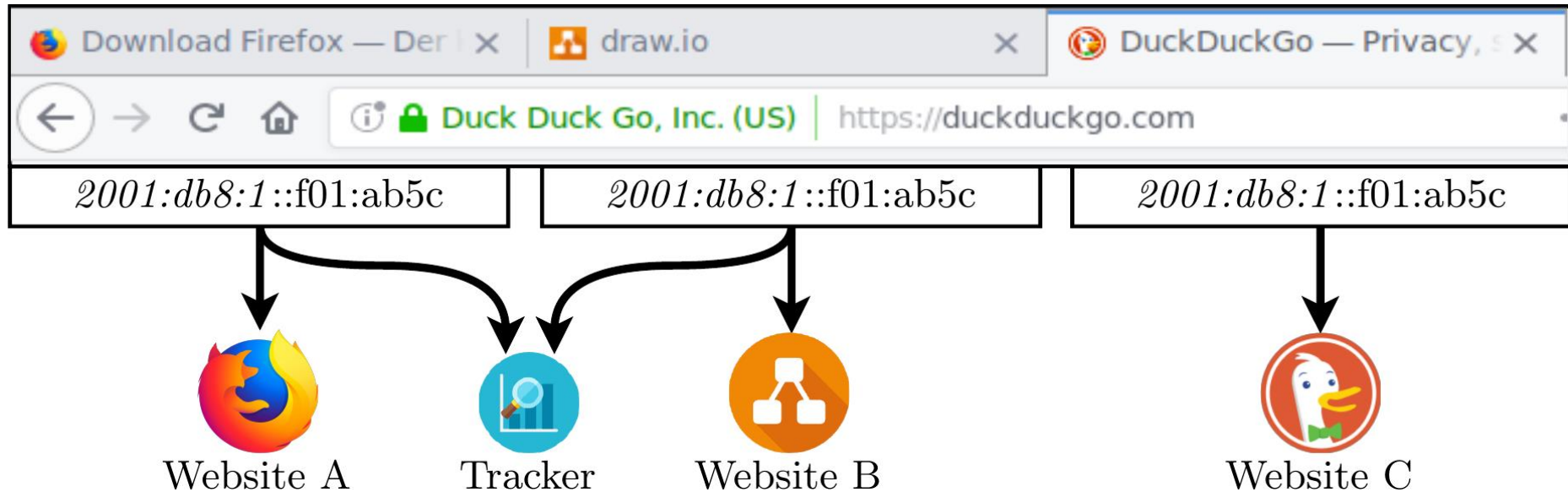
Design Goals

- **Unlinkability**

  A third party must not be able to link visitors on different websites to the same user based on the IP address

- **No perceptible influence** on the browsing performance
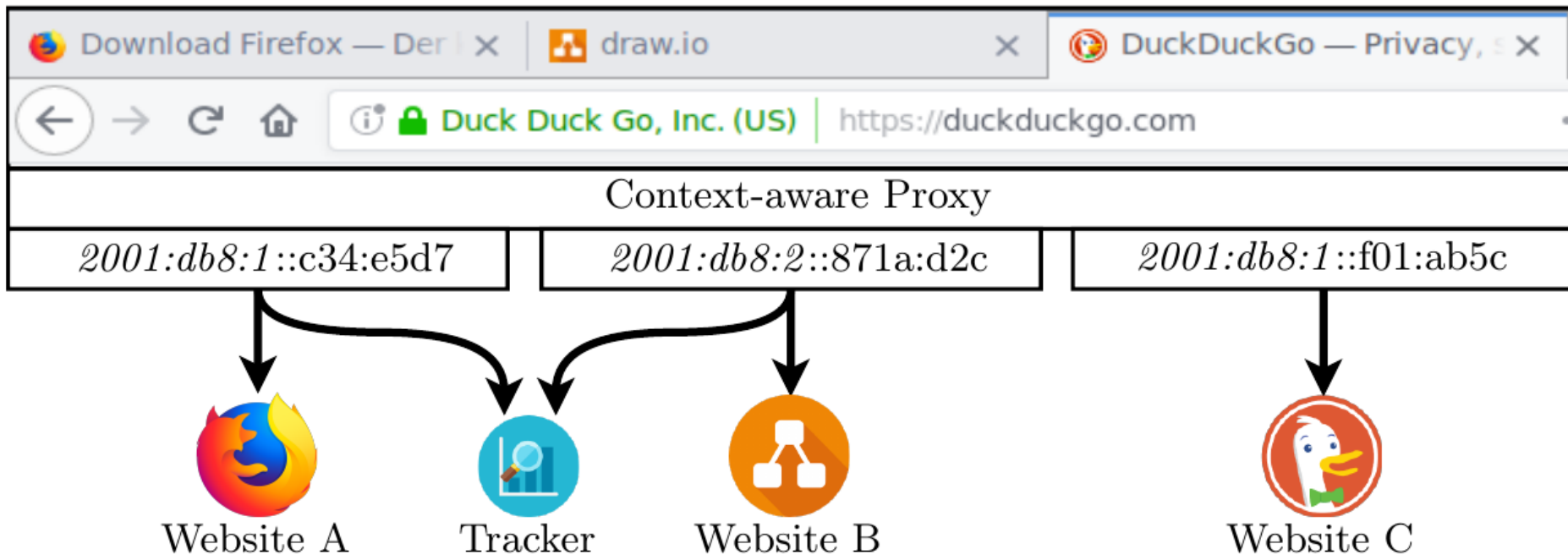
- **Transparent** to the user

- **Backwards compatible** to existing web applications and Internet infrastructure

Browsing with plain Firefox Browser

- All tabs use the same IP address
- The tracker can link activities based on the IP address

- We use many IP addresses on a per-destination basis
- The tracker can not link activities based on the IP address

$$2001:db8:85a3::8a2e:370:7334$$

subnet prefix   interface identifier

- Interface identifiers can be varied easily
- Prefix needs to be varied, too. Otherwise: prefix-based tracking
- The prefix can not be varied easily without changing the infrastructure

  - **Prefix Bouquets**
    ISPs could delegate multiple prefixes to one user

  - **Prefix Sharing**
    ISPs could delegate the same prefix to multiple users

Prefix Sharing: uniqueness of IP addresses is not guaranteed
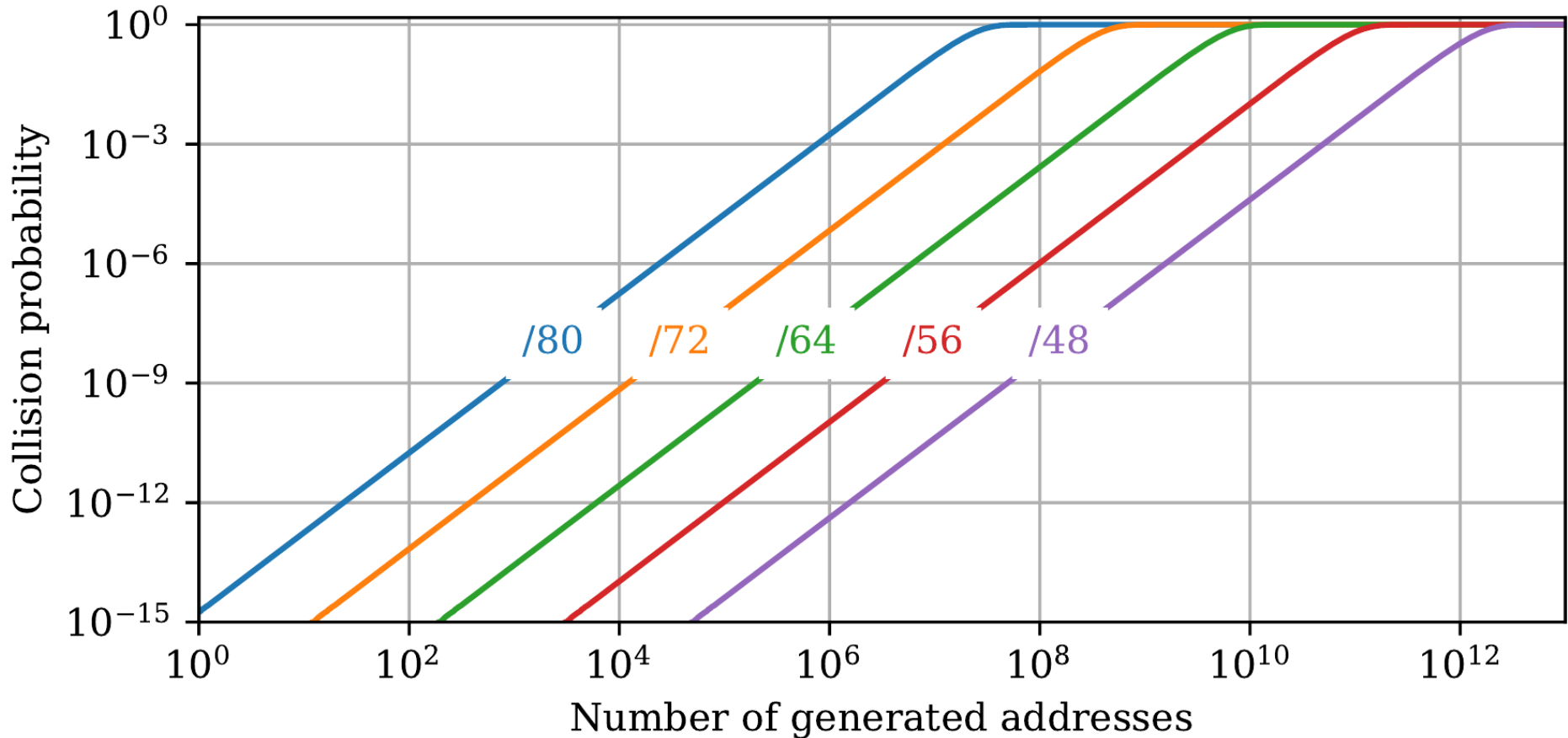
1. Prevent collicions: ensure IP address uniqueness
2. Detect collisions

Implementation
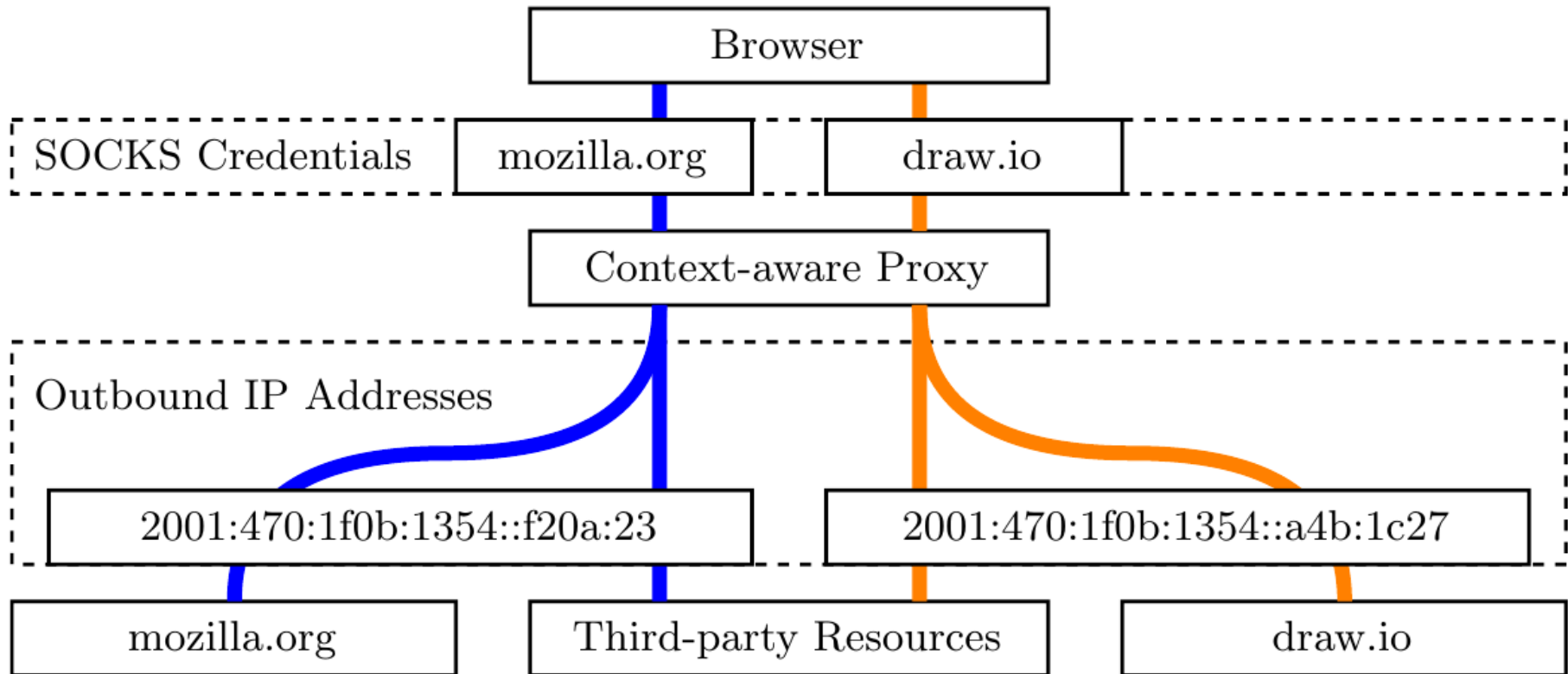
- Alternative proxy for the Tor Browser
- Makes use of the Tor browser's website isolation feature but the traffic is not routed through Tor

- **Unlinkability**
  - Different outbound IP addresses for different websites
  - Prefix is changed to a certain degree only
- **No perceptible influence** on the browsing performance
- **Transparent** to the user
  - Not interfering with applications
  - Nothing to configure
- **Backwards compatible** to existing web applications and Internet infrastructure
  - HTTP & WebSocket protocol
  - Third-party authentication services

Evaluation: Performance
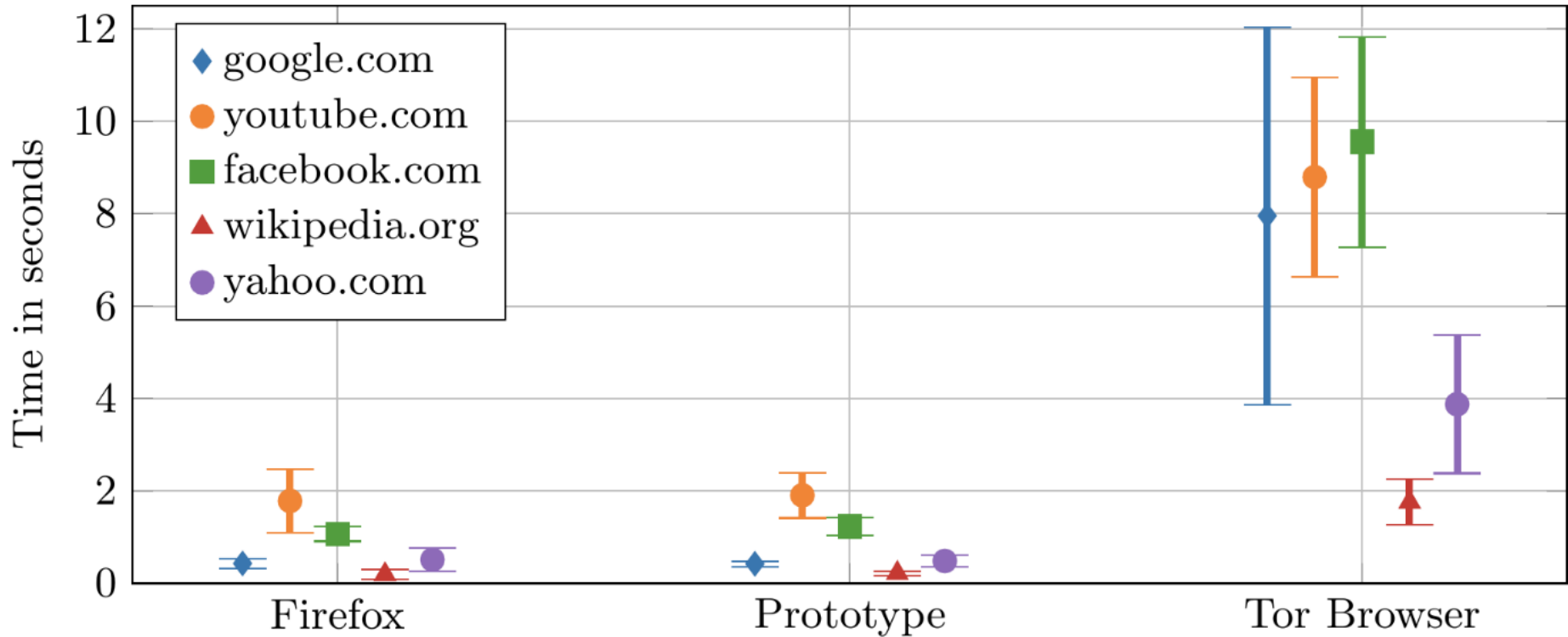
Time that is needed to retrieve and render a website

Future Work

- How can ISPs provide users with multiple and frequently changing IPv6 prefixes?

- Extend the context-aware approach to other applications and the operating system

- How can existing anonymous communication networks such as Tor be made more context-aware?

Conclusion

- We introduced context-aware IPv6 address hopping to prevent IP address-based tracking

  A distinct outbound IPv6 address for each visited website

- A prototype has been implemented

- Impact on browsing performance is negligible

- In combination with application-level measures, effective protection against tracking can be achieved

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Context-aware IPv6 Address Hopping

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Slides:
https://marx.wtf/2019-12-ICICS.pdf

Evaluation: Performance

Website	Firefox Mean	SD	Prototype Mean	SD	Tor Browser Mean	SD	3rd-party Resources
google.com	0.43	0.11	0.42	0.06	7.96	4.09	3
youtube.com	1.78	0.68	1.91	0.49	8.79	2.16	10
facebook.com	1.07	0.16	1.23	0.20	9.55	2.27	1
wikipedia.org	0.19	0.10	0.22	0.05	1.76	0.50	0
yahoo.com	0.51	0.25	0.48	0.13	3.88	1.49	1
Alexa Top 10	0.27	0.49	0.28	0.51	2.13	3.32	3
Alexa Top 100	0.30	0.72	0.64	0.39	2.28	4.74	12.26