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Tracking Users across the Web via TLS Session Resumption

Erik Sy, M.Sc.

Introduction to TLS Session Resumption

- Allows a client-server pair to establish a new TLS connection with a previously exchanged symmetric key
  - Provides temporal and computational performance gains
  - The client is identified by the server (tracker) through knowledge of this secret key

- Deployment on the Internet
  - 96% of TLS-enabled Alexa Top Million Sites support session resumption
  - Google/Cloudflare report a share of approx. 50% of their connections to be established through TLS session resumption (SR)

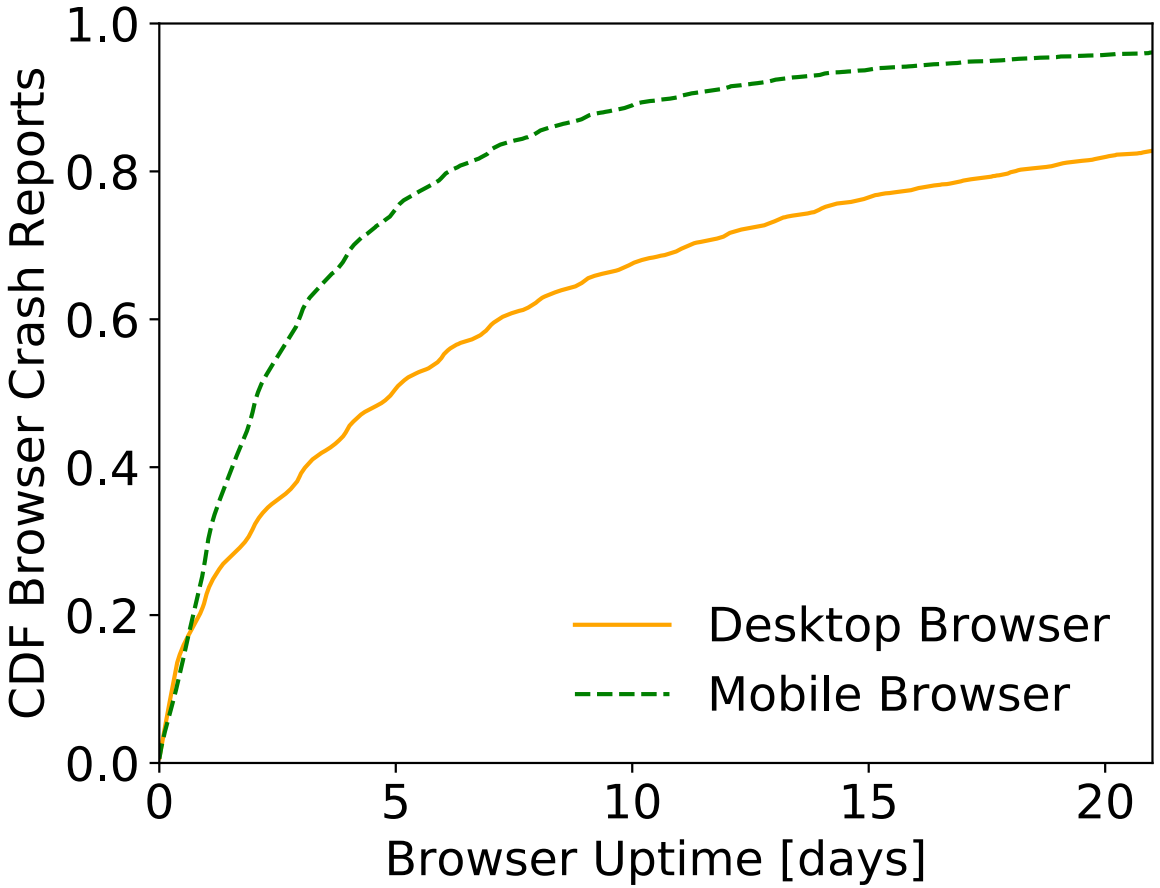
Opportunities and Limitations of Tracking via TLS SR

- Opportunities compared to HTTP cookies/ browser fingerprinting
  - Faster unique identification of a user
  - Lower consumption of bandwidth and computational resources

- Limitations
  - Browser restarts terminate a tracking period
  - TLS configuration of a browser
    - Session resumption lifetime
    - Feasibility of third-party tracking

Browser Restarts as a Limitation

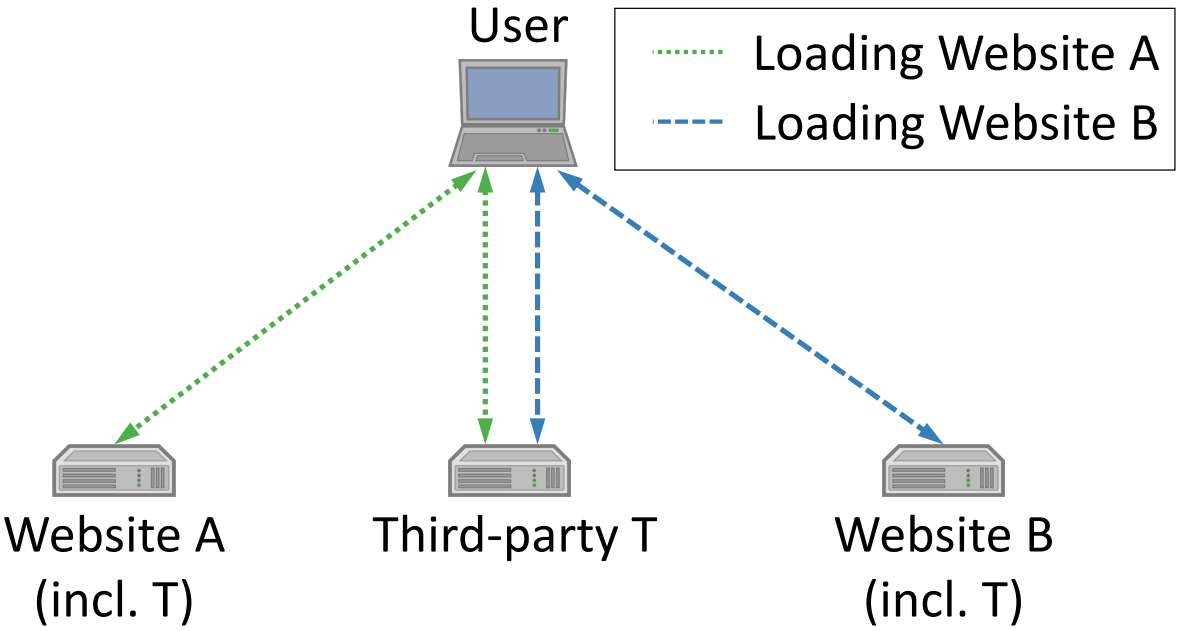
- Analysis of reported browser uptime within crash reports (normalized over total browser uptime)



Experiments to test Browsers' default TLS Configuration

- Measurement of the session resumption lifetime of 48 browsers
  - Maximum delay between two website visits for which the browser still attempts to establish the new connection through TLS SR

- Investigating the feasibility of third-party tracking via TLS SR



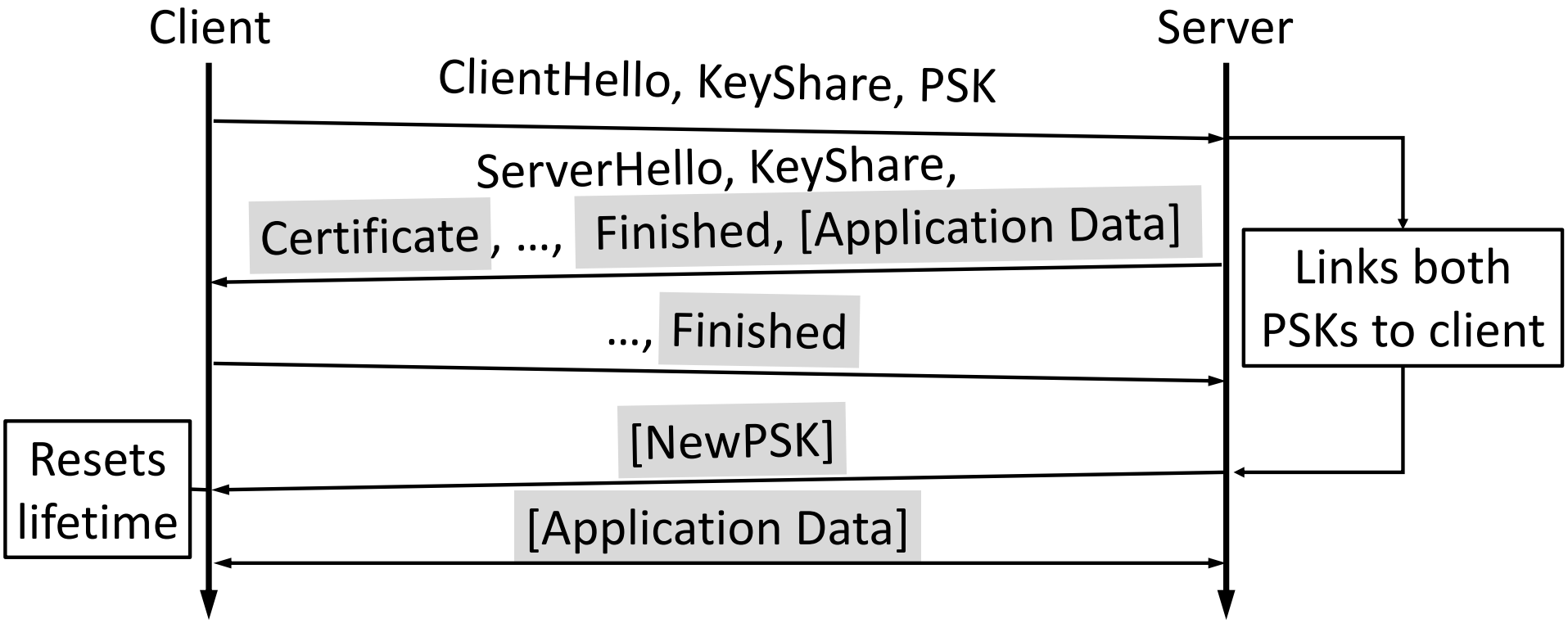
Summary on the Browser's default TLS Configuration

Browser	Session Resumption Lifetime	Third-party Tracking
Chrome	1 hour	viable
Firefox	24 hours	viable
Microsoft Edge	10 hours	blocked
Safari	24 hours	viable

Can a tracker extend these tracking periods?

Extending Tracking Periods beyond the TLS SR Lifetime

- Prolongation attack allows a Server to track the user across a chain of PSK's



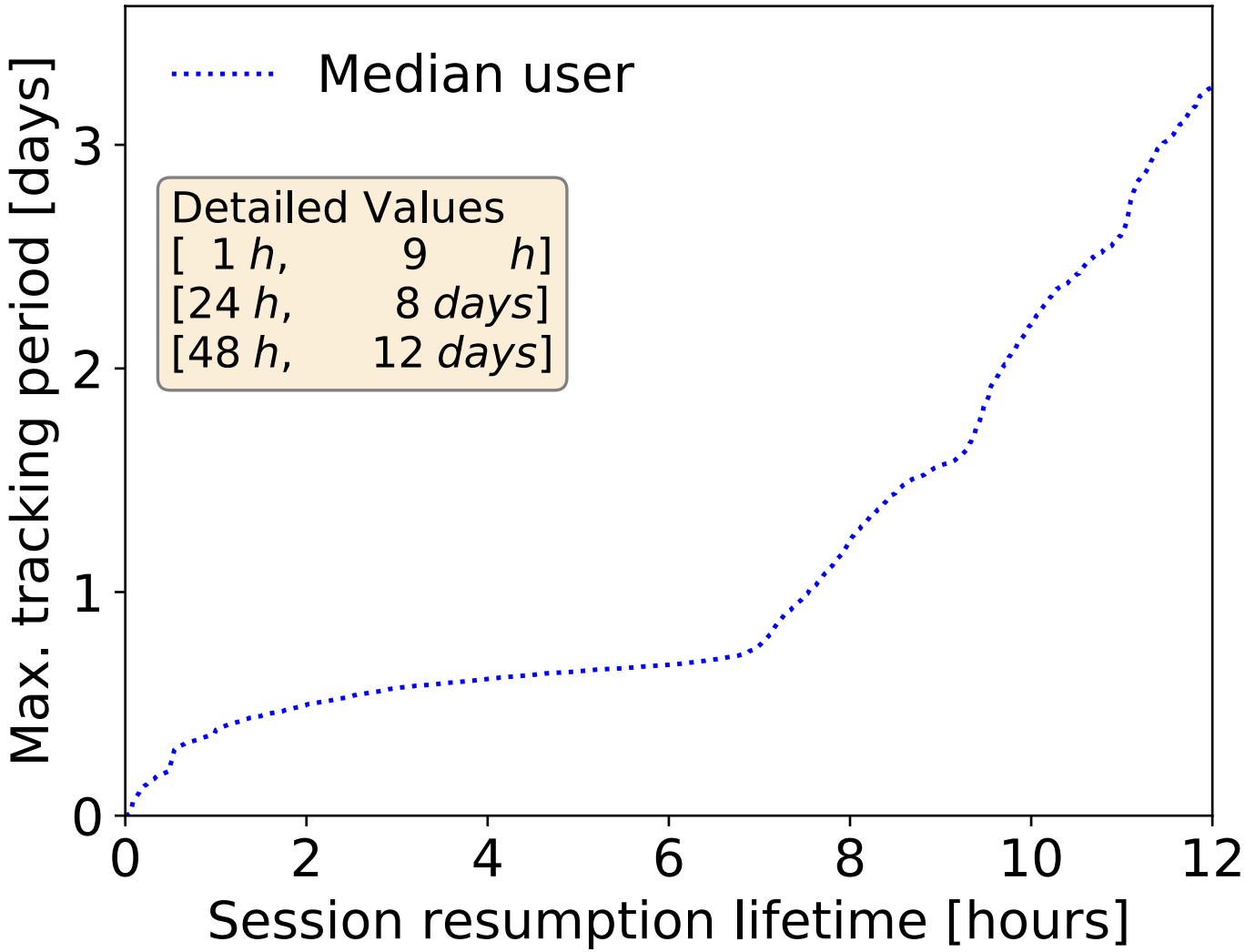
Successful TLS 1.3 resumption handshake with issuance of a new pre-shared key (PSK)

Evaluation of the Prolongation Attack

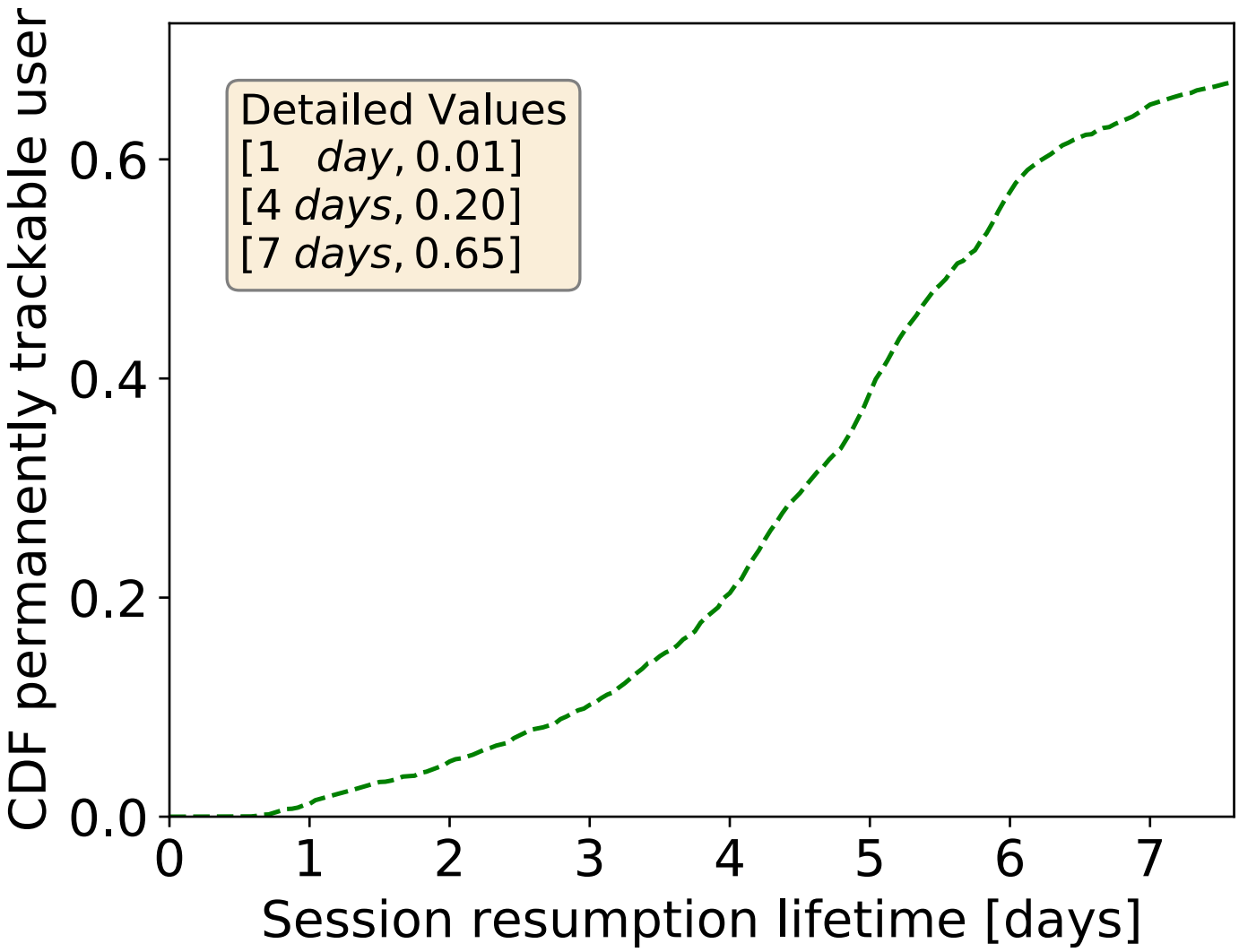
- Simulating users' browsing behaviour based on a DNS data set
  - Pseudonymized DNS traffic logs of 3862 users over a 60-day period[1]
- Approximating feasible tracking periods from a server perspective
  - Tracking period is extendible if the duration between to website visits is smaller than a given session resumption lifetime
- Estimating the share of permanently trackable user
  - The ratio of users in our data set that can be identified by the server beyond the boundaries of the DNS data set

[1]: D. Herrmann et al., Behavior-based tracking: Exploiting characteristic patterns in DNS traffic. (2013)

Feasible Tracking Periods based on the Prolongation Attack



The Share of Permanently Trackable Users



Countermeasures

- Browser vendors
  - Disable third-party tracking via session resumption through sandboxing
  - Reduce TLS SR lifetime to a single page visit or at most six hours
  - Prevent a reset of the resumption lifetime
- TLS Working Group
  - Reduce the recommended upper lifetime limit in the draft of TLS 1.3
  - Recommend measures to prevent a reset of the TLS SR lifetime
- Research Community
  - Investigate handshake designs based on semi-static Diffie-Hellman key establishment such as OPTLS 1.3 and draft-rescorla-tls13-semistatic-dh
    - Public key is shared within an anonymity group

Conclusion

- TLS SR is a widely-supported mechanism, which allows unique user identification with a low bandwidth, computational and temporal overhead
- Browser vendors and the TLS working group need to further restrict this privacy problem
- Countermeasures heal the privacy problem but lead to a performance reduction

Thank you

Questions and Answers

Slides available: www.erik-sy.de/hotpets

E-mail: hotpets@erik-sy.de

Preprint: Please request pre-print article per email.

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Backup: When do Users revisit a Website?