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Tracking Users across the Web via TLS Session Resumption

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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)
- Privacy leakage by TLS version 1.2 and below allow a network-based attacker to track users via this mechanism

Opportunities and Limitations of Tracking via TLS SR

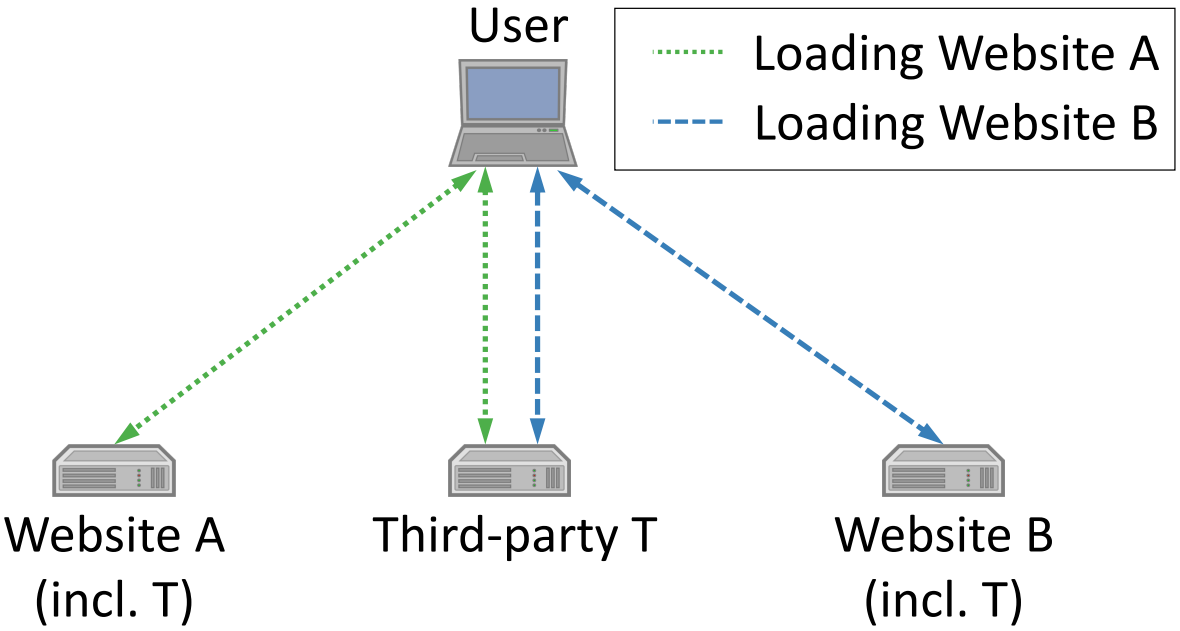
- Opportunities compared to HTTP cookies/ browser fingerprinting
  - Faster unique identification of a user
  - Tracking via TLS SR cannot be directly detected
  - Lower consumption of bandwidth and computational resources compared to browser fingerprinting

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

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



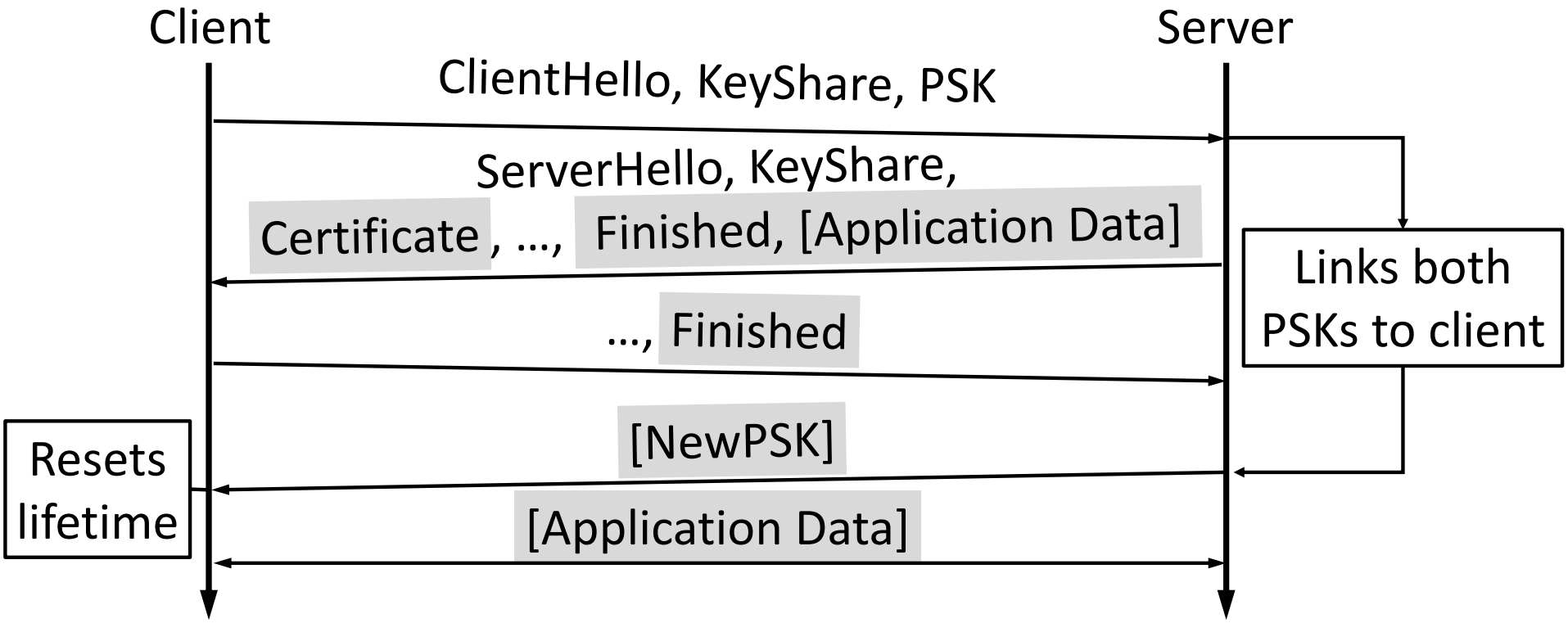
Summary on the Browser's default TLS Configuration

Browser	Session Resumption Lifetime	Third-party Tracking
Chrome	1 hour	viable
Firefox	24 hours	viable
Internet Explorer	10 hours	viable
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



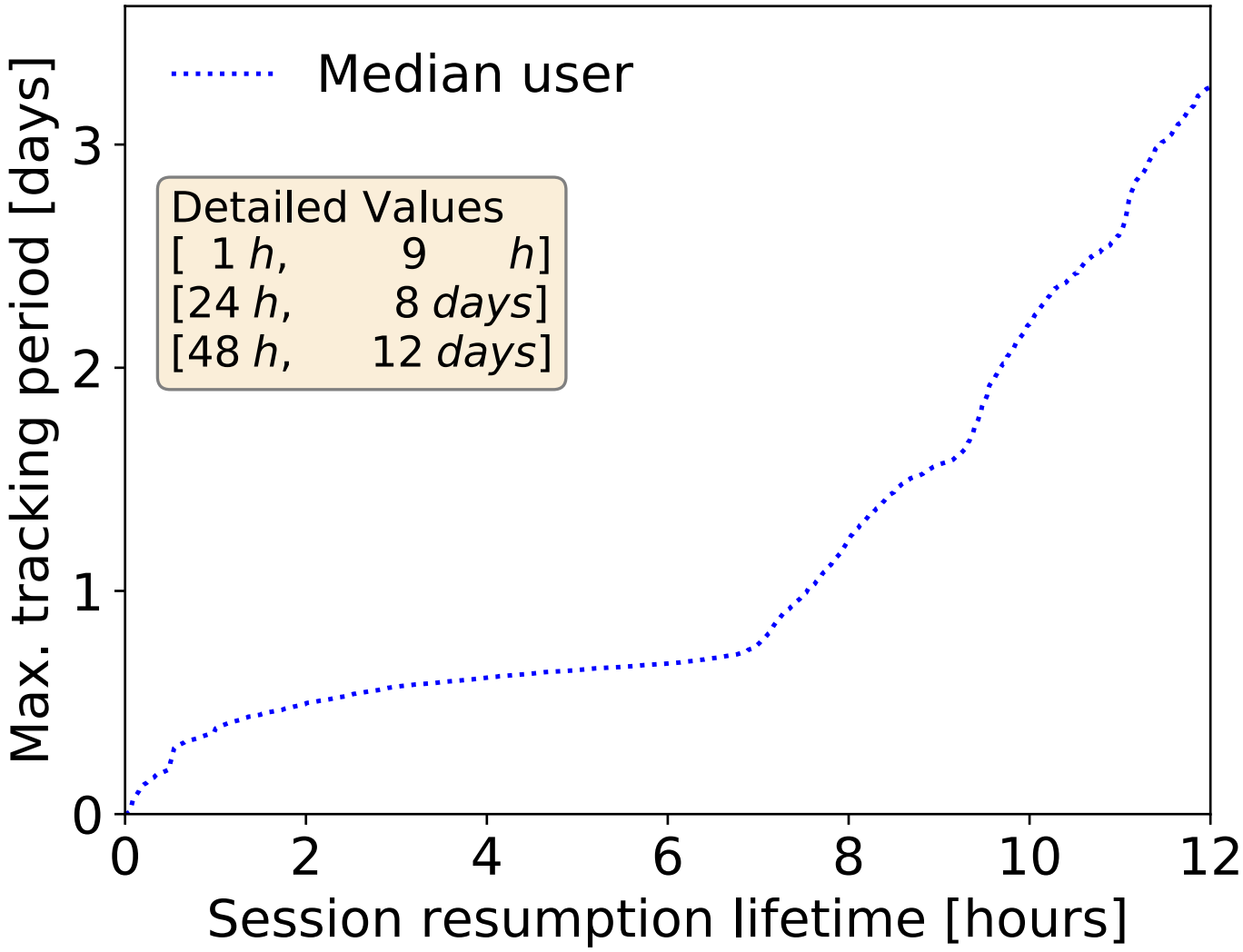
Successful TLS 1.3 resumption handshake with issuance of a new pre-shared key (PSK)

Evaluation of the Prolongation Attack

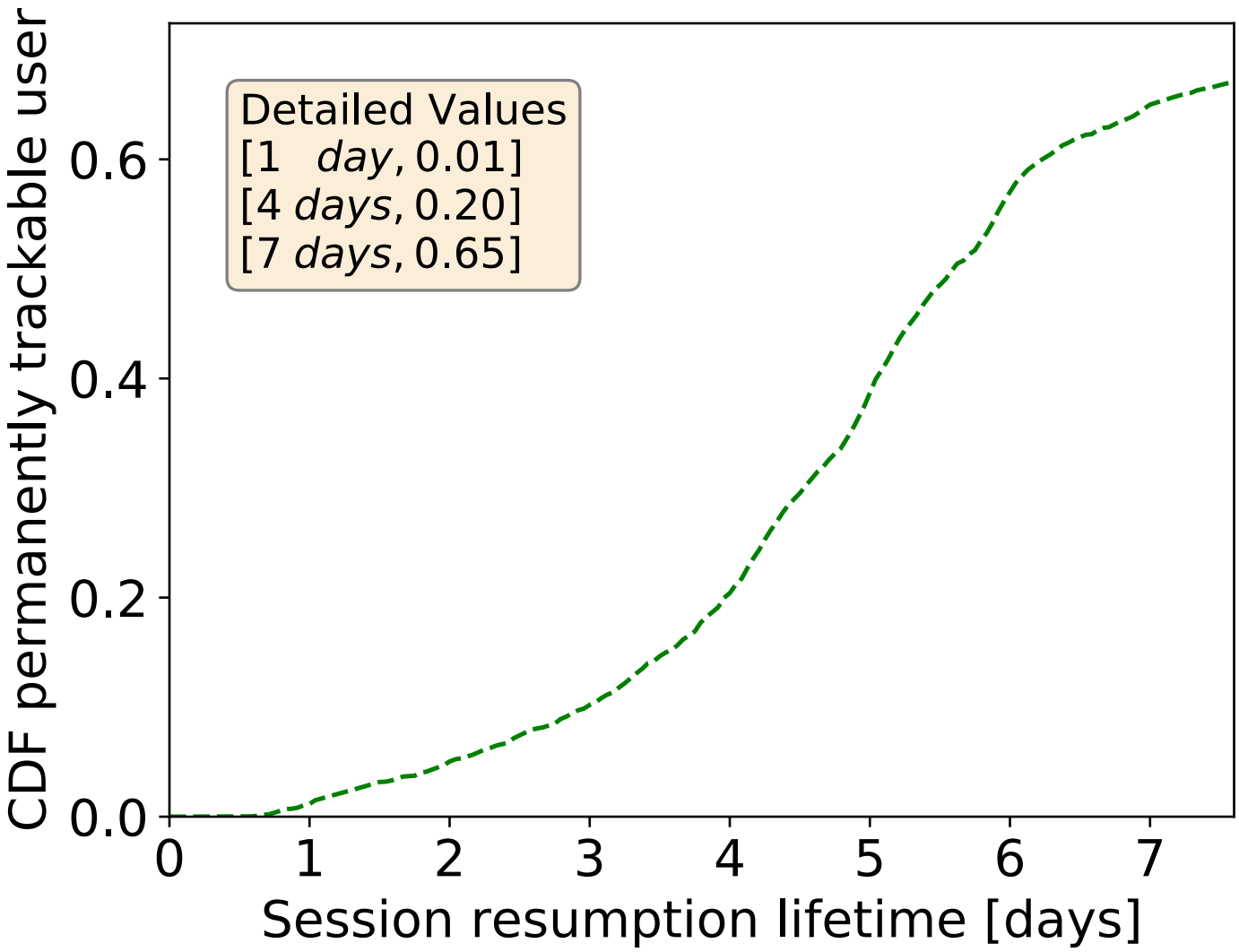
- Simulating users' browsing behaviour based on a DNS data set
  - Pseudonymized DNS traffic logs of 3862 users over a 60-day period[1]
- Approximating feasible tracking periods from a server perspective
  - Tracking period is extendible if the duration between to website visits is smaller than a given 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



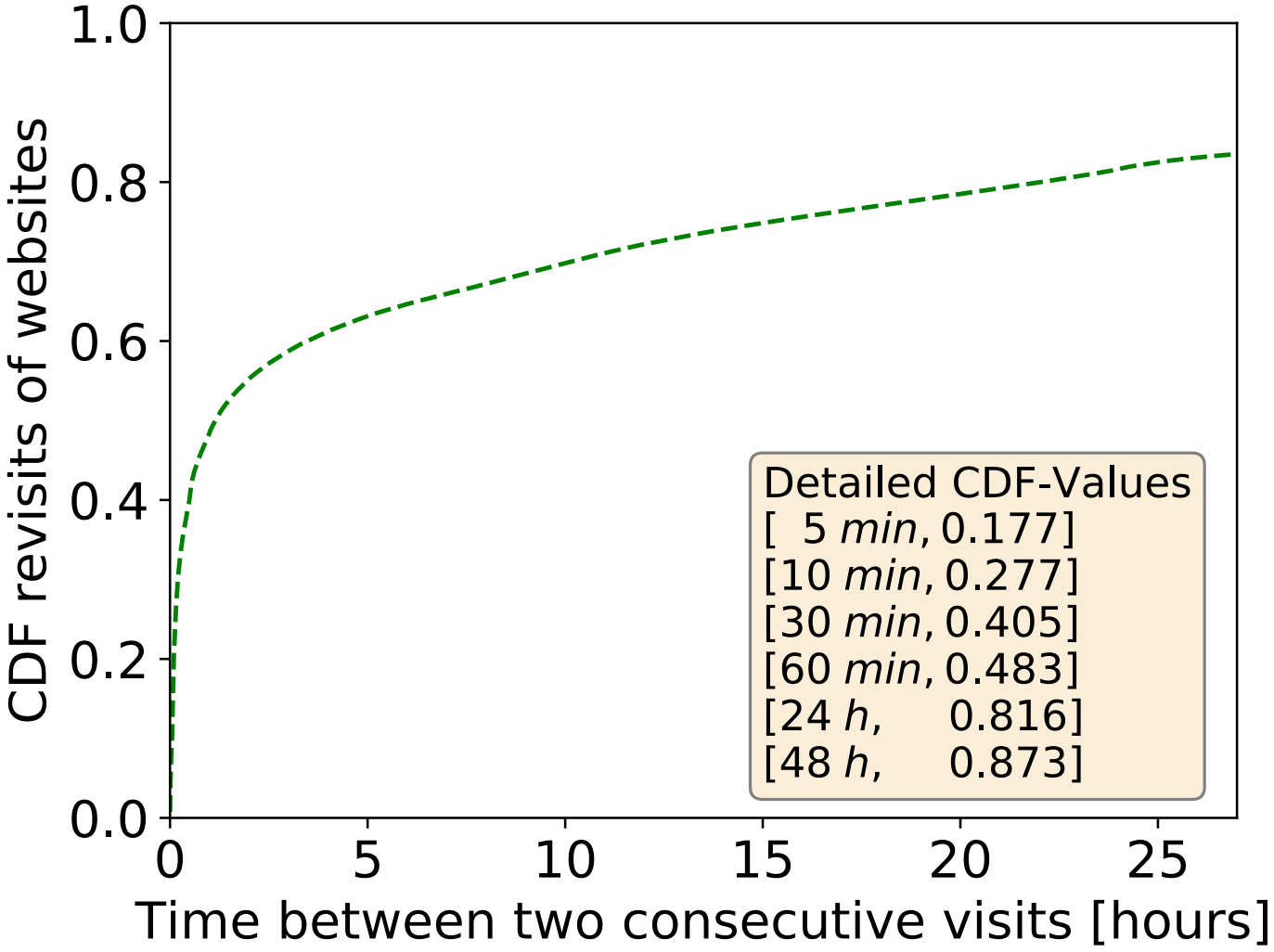
The Share of Permanently Trackable Users



Countermeasures

- Disable TLS SR if a host must not track a user
  - Potentially impacts temporal and computational performance
- Restrict TLS SR to balance privacy and performance needs of the user
  - Limit lifetime of TLS SR and prevent the prolongation of this lifetime
  - Define the context of a connection (e.g. via browser tabs & visited website) and allow TLS SR only within the same context
  - Use a full handshake instead of the 1-RTT TLS 1.3 SR mode because the number of required round trips is identical

Evaluation of a limited TLS SR lifetime



Conclusion

- Do not depend on user behaviour (e.g. Browser restart) to prevent tracking via TLS SR
- TLS SR should be aligned with legitimate browser-based tracking mechanisms to achieve a better performance versus privacy tradeoff
  - For hosts that legitimately track a user, a longer TLS SR lifetime can be applied to realise more performance gains
- The recommended upper lifetime of TLS 1.3 SR of seven days enables in combination with the prolongation attack to permanently track 65% of users

Thank you

Questions and Answers

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

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