Server-side Adoption of Certificate Transparency

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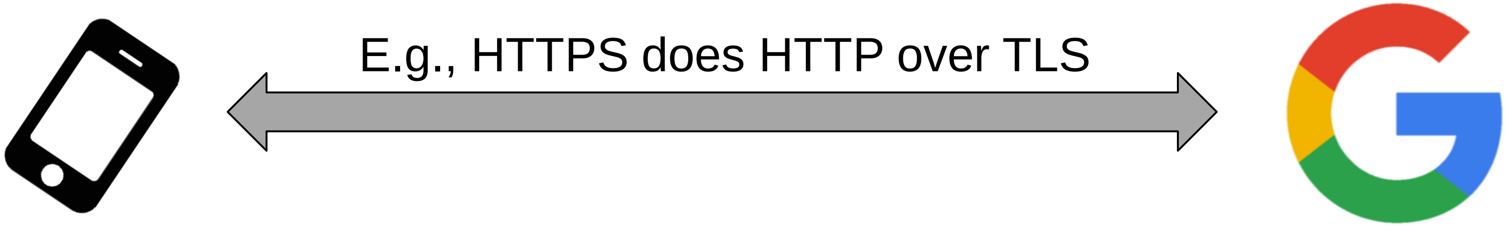
LINKÖPING UNIVERSITY

Motivation and high-level problem

- Private and confidential communication important



E.g., HTTPS does HTTP over TLS

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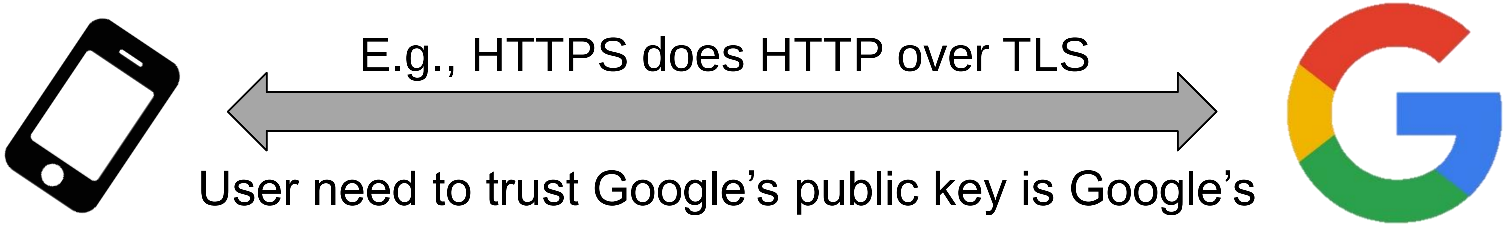

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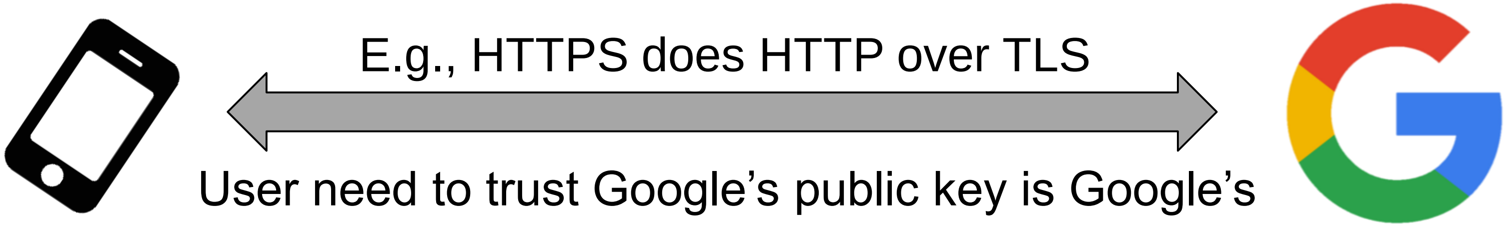
User need to trust Google’s public key is Google’s

Motivation and high-level problem

- Private and confidential communication important
  - Billions of devices
  - Millions of services



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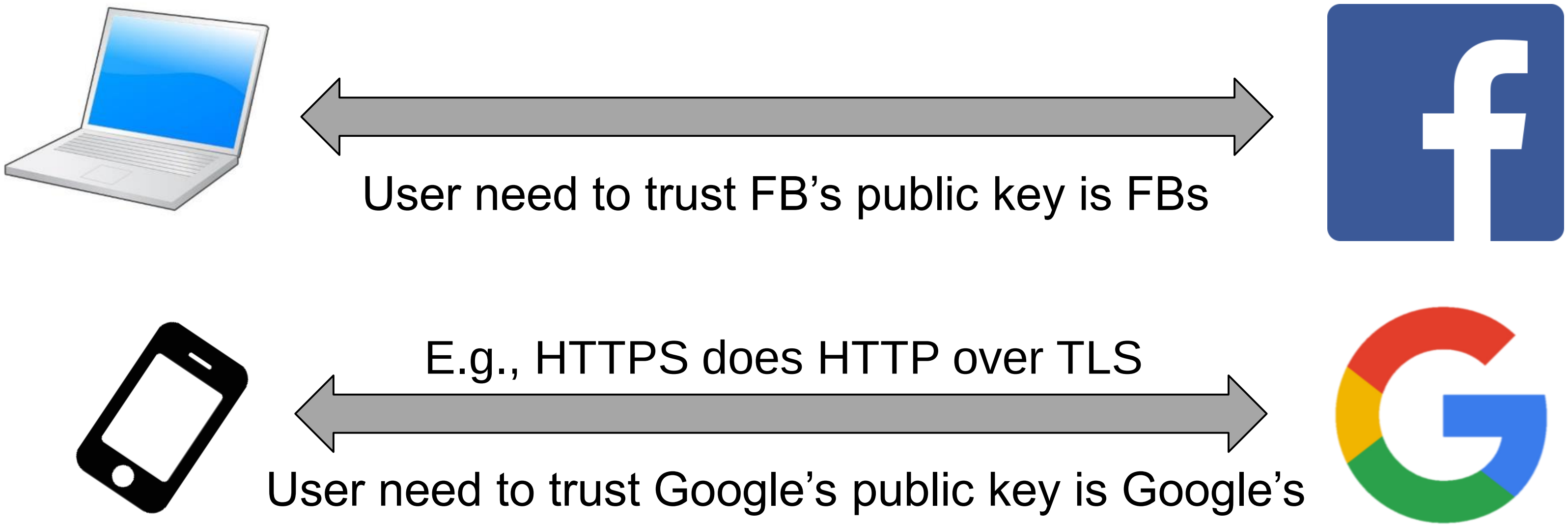

User need to trust FB's public key is FBs

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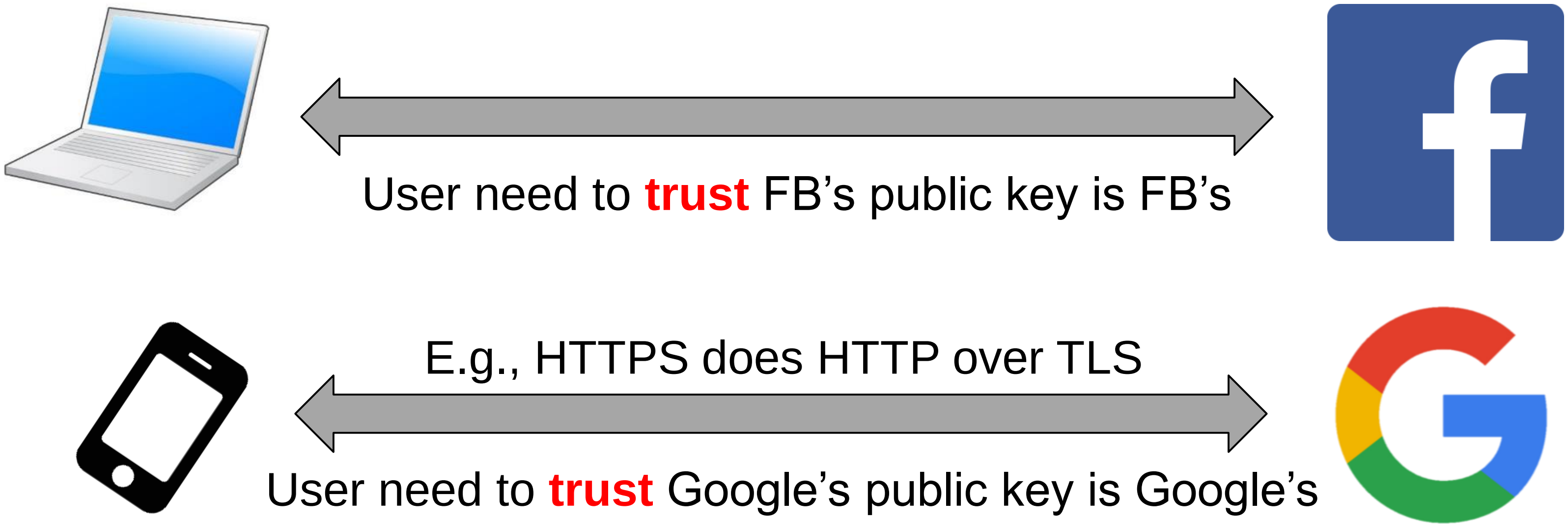

User need to **trust** FB’s public key is FB’s

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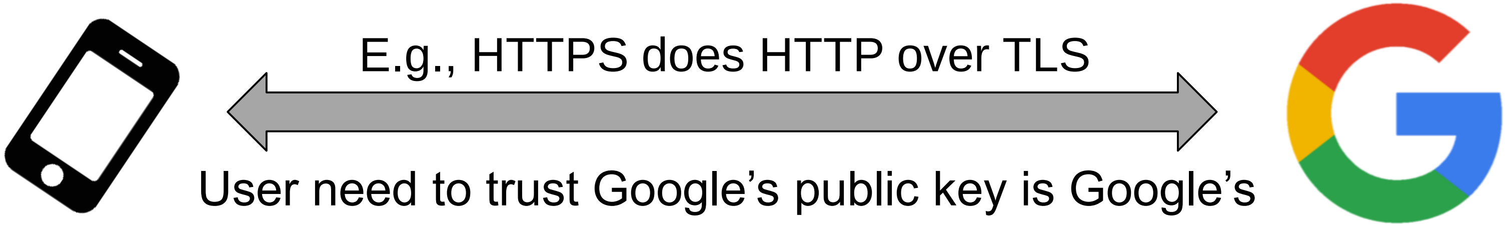
User need to **trust** Google’s public key is Google’s

Motivation and high-level problem

- Private and confidential communication important
  - Billions of devices
  - Millions of services
- Certification Authorities (CAs) issue certificates
  - Proof of identity (signed with their private key)



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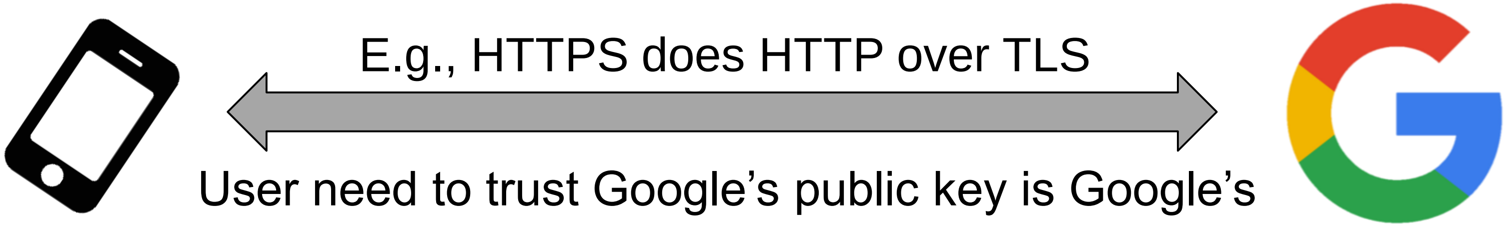
- If CAs in our trust (root) store (e.g., Symantec/ Verisign) tells us that a public key belongs to Google, our browsers (and us) trust that this is the case



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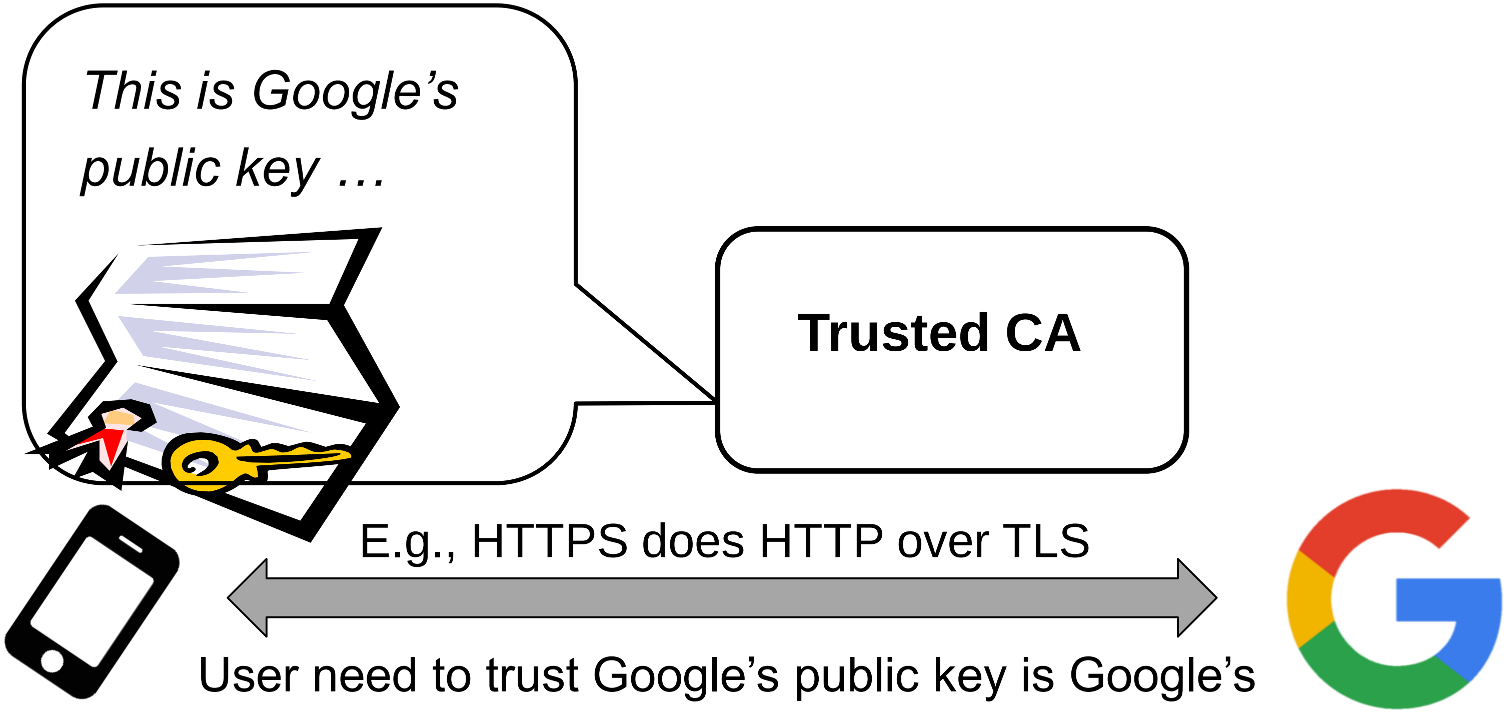

This is Google's public key …

Trusted CA

E.g., HTTPS does HTTP over TLS

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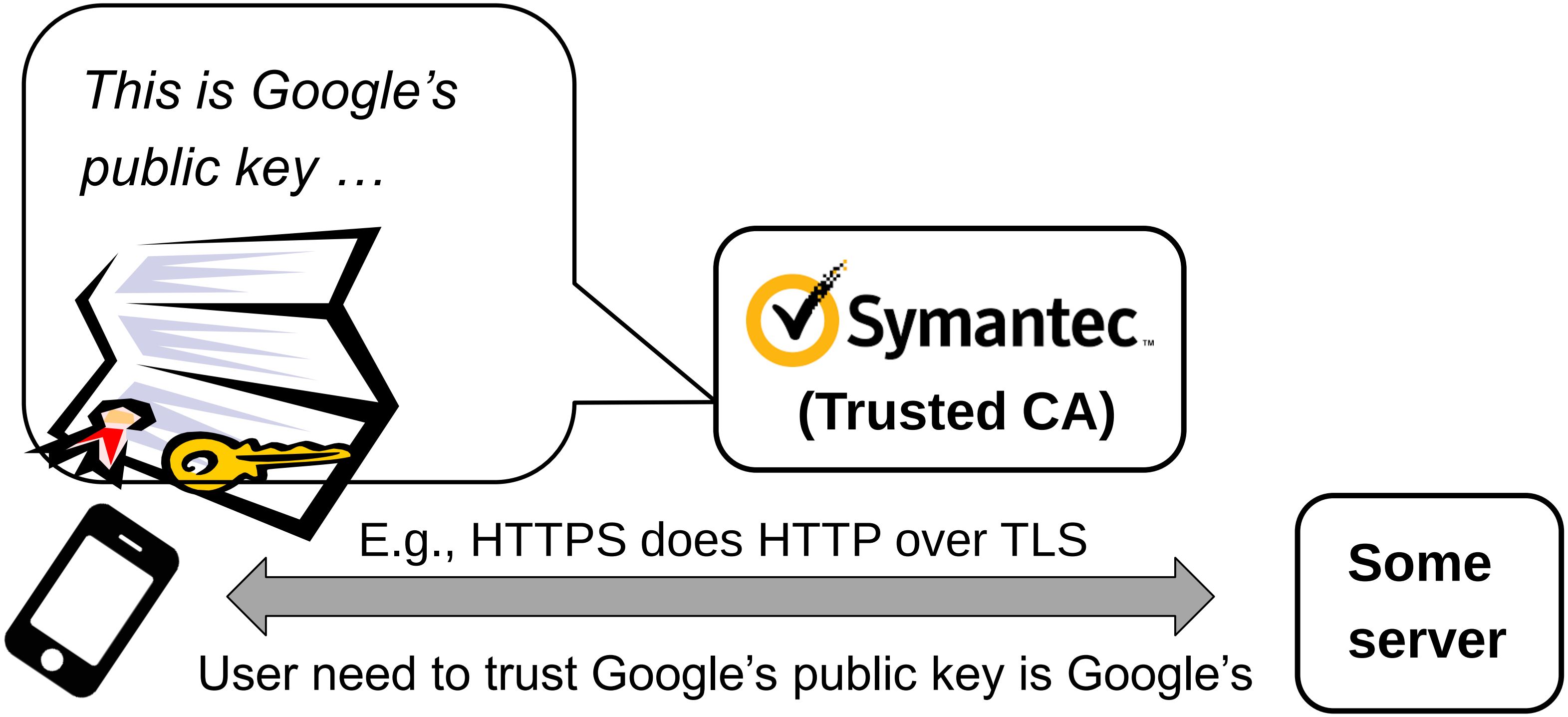
Motivation and high-level problem

- However, mistakes happen ...
  - E.g., in Oct. 2015, Google discovered (using CT) that Symantec had issued test certificates for 76 domains that they did not own (including Google domains) and another 2,458 unregistered domains …



This is Google's public key …

Symantec
(Trusted CA)

E.g., HTTPS does HTTP over TLS

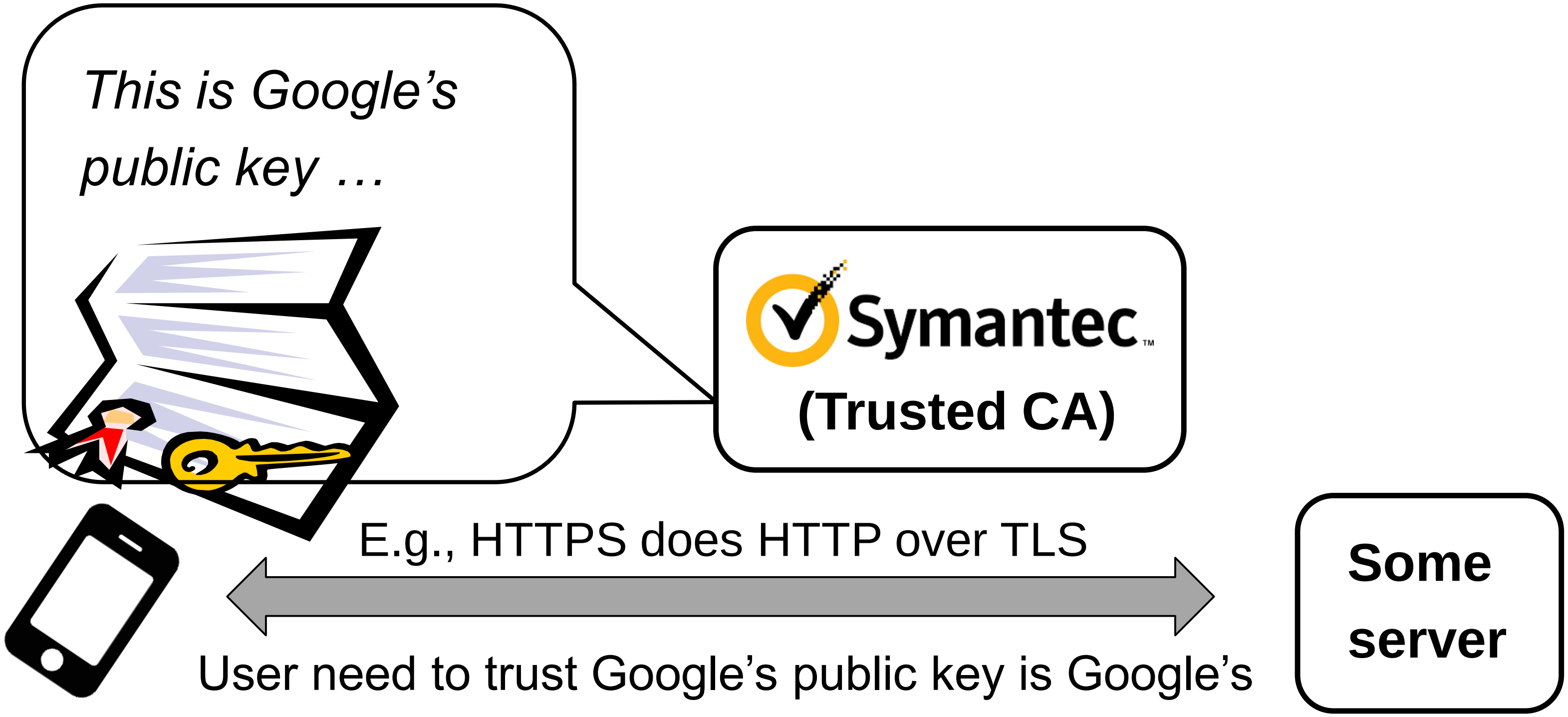
User need to trust Google's public key is Google's

Some server

CT: Emerging trust-monitoring solution

- Since then, Google has demanded that Symantec logs all their certificates in public (append-only) CT logs
- Since Jan. 2015, the Chrome browser requires all EV certificates be logged in 1 Google log and 1 other log
  - Mozilla planning to make similar demands
  - Both Chrome and Mozilla expected to implement policies for DV certificates too …

CT: Emerging trust-monitoring solution



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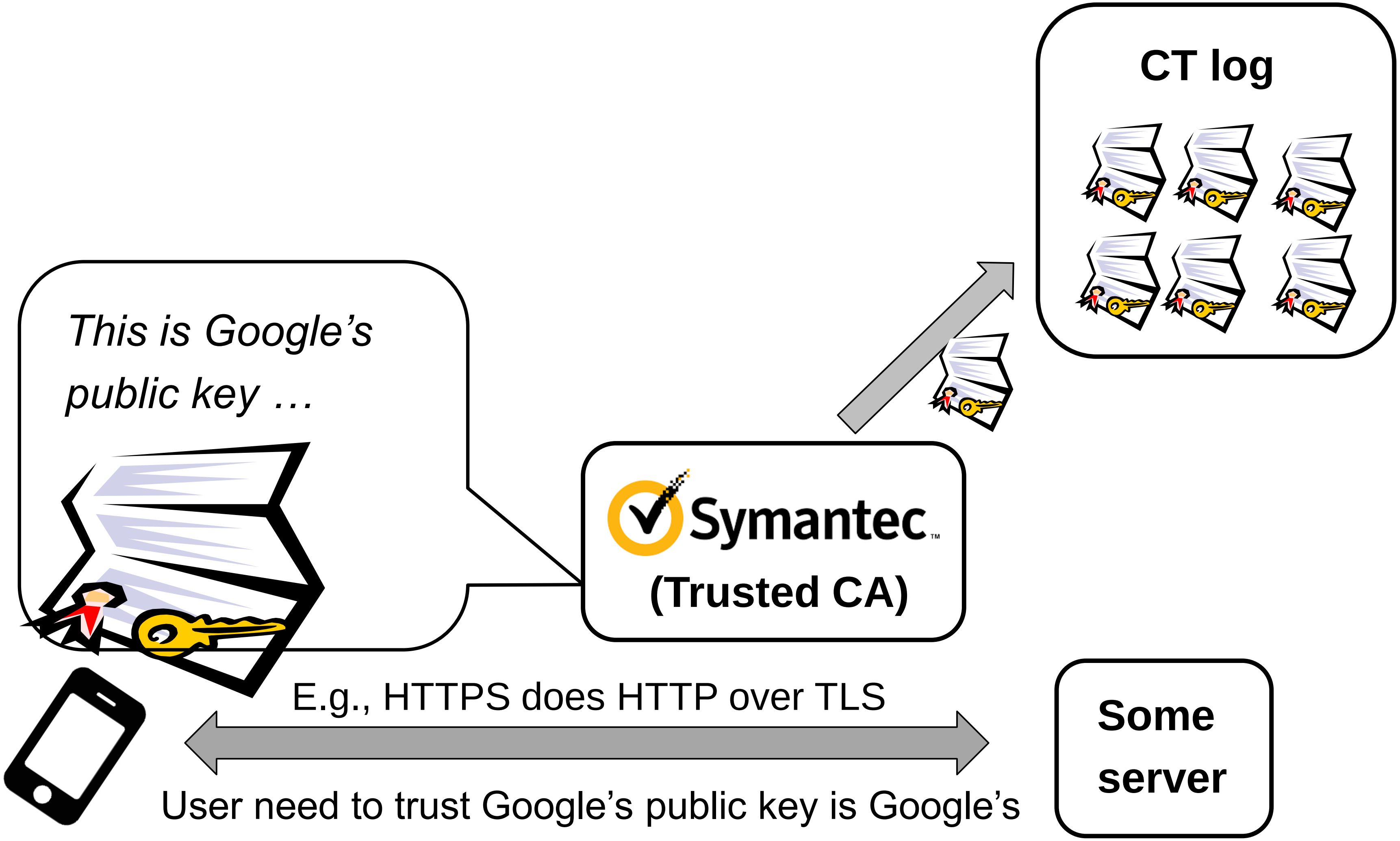
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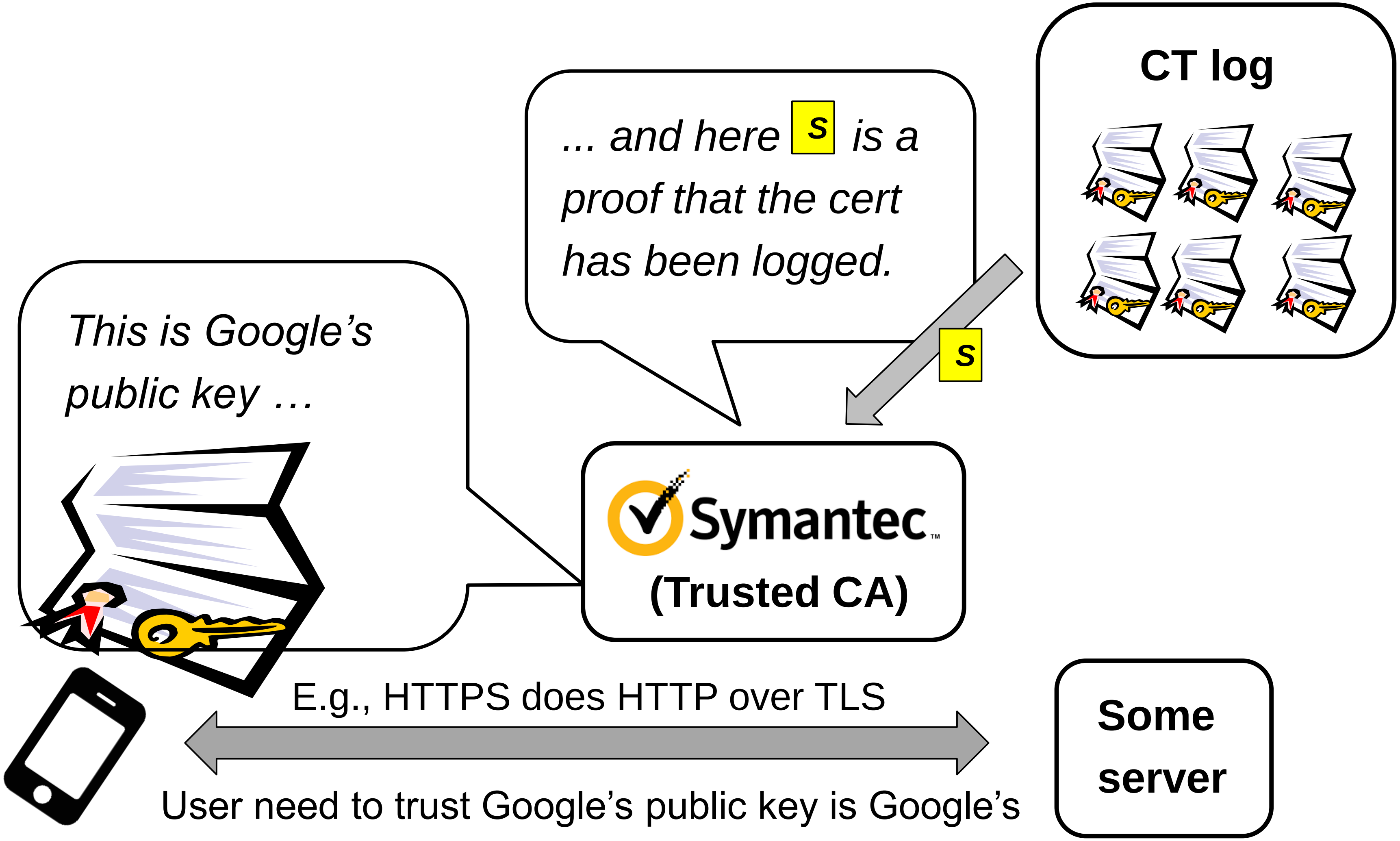

CT log

... and here **S** *is a proof that the cert has been logged.*

This is Google's public key …

S

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E.g., HTTPS does HTTP over TLS

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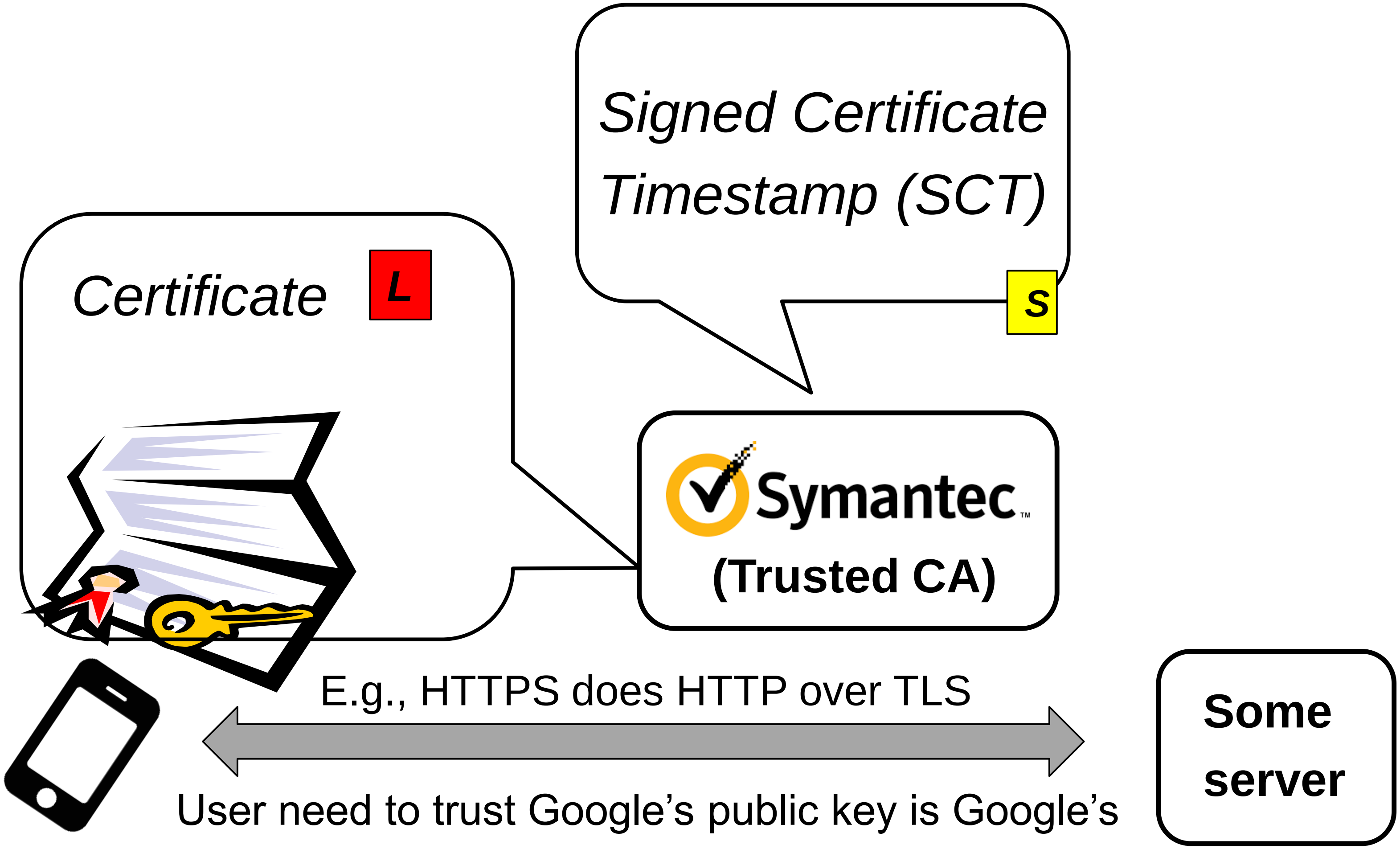
CT: Emerging trust-monitoring solution



Signed Certificate Timestamp (SCT)

S

Certificate

L

Symantec

(Trusted CA)

E.g., HTTPS does HTTP over TLS

Some server

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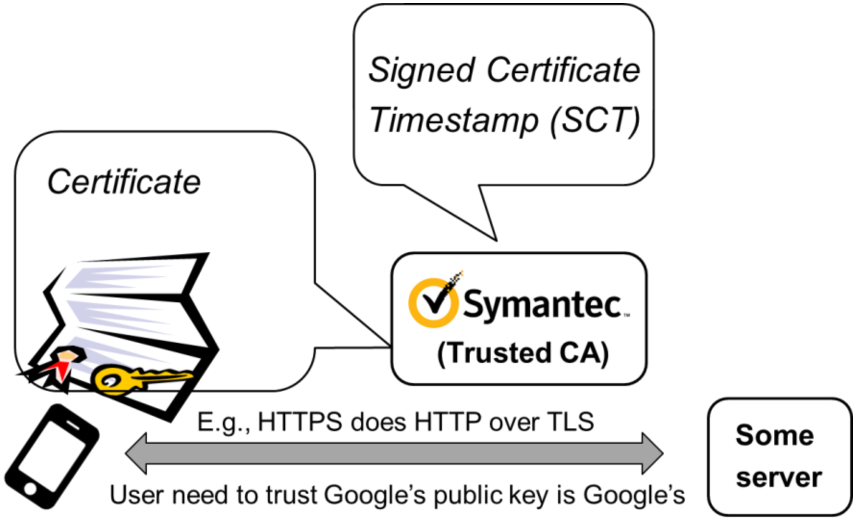
Signed Certificate Timestamps (SCTs)

- SCTs delivered three different ways
  - X.509v3 extension
  - TLS extension
  - OSCP stapling
- In this paper, we characterize and compare
  - Server-side usage of these methods
  - Client-side performance of these methods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Background

Certification of public keys

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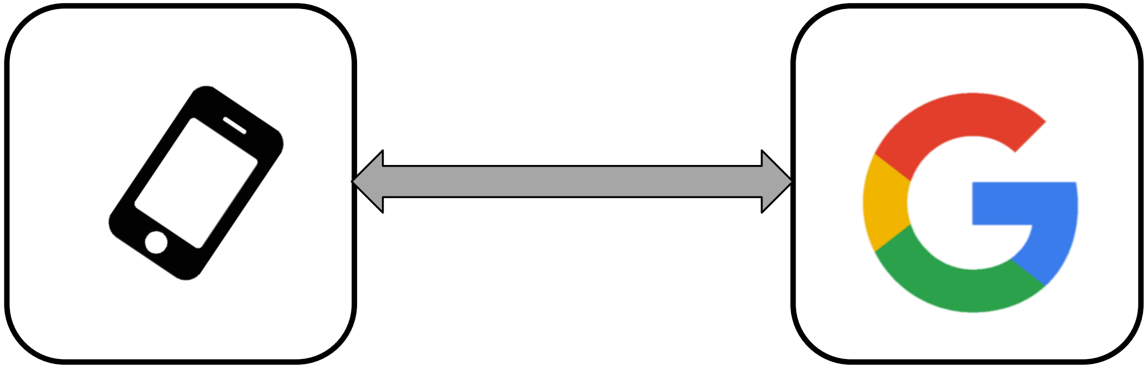

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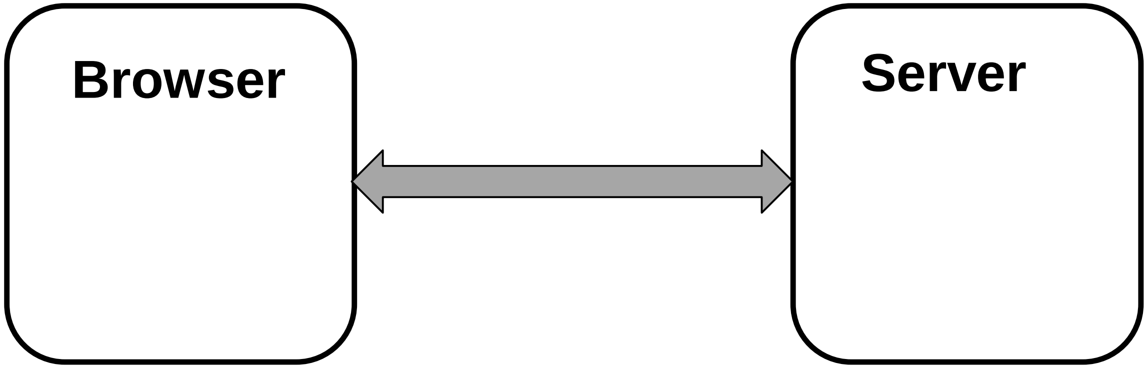

Certification of public keys

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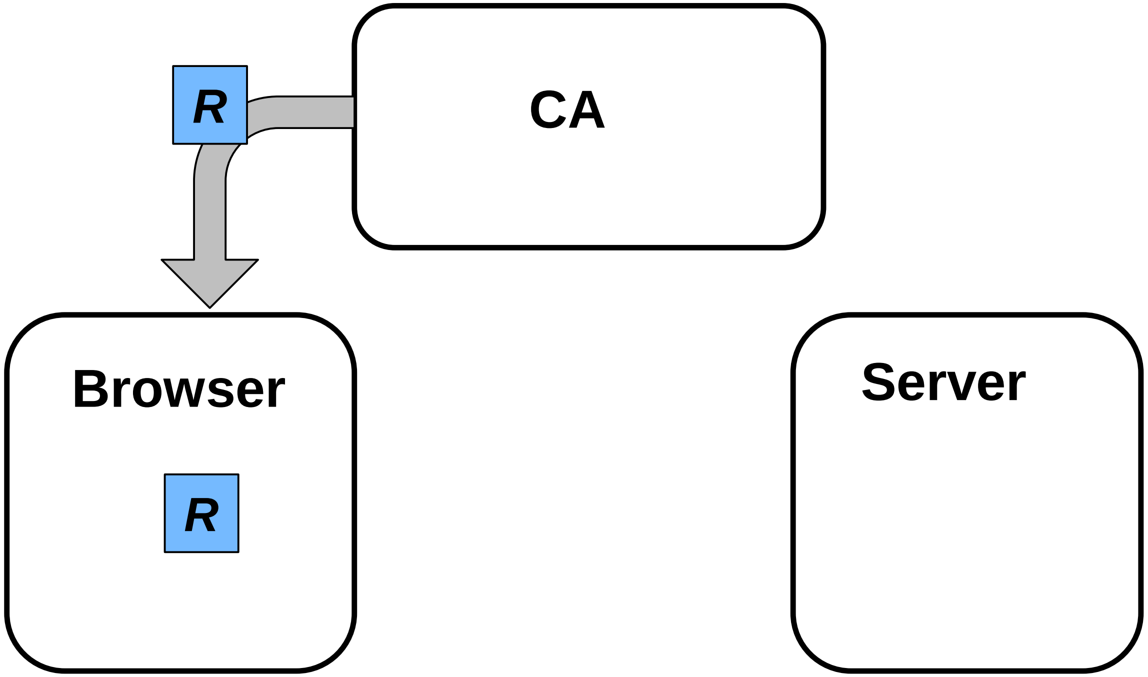

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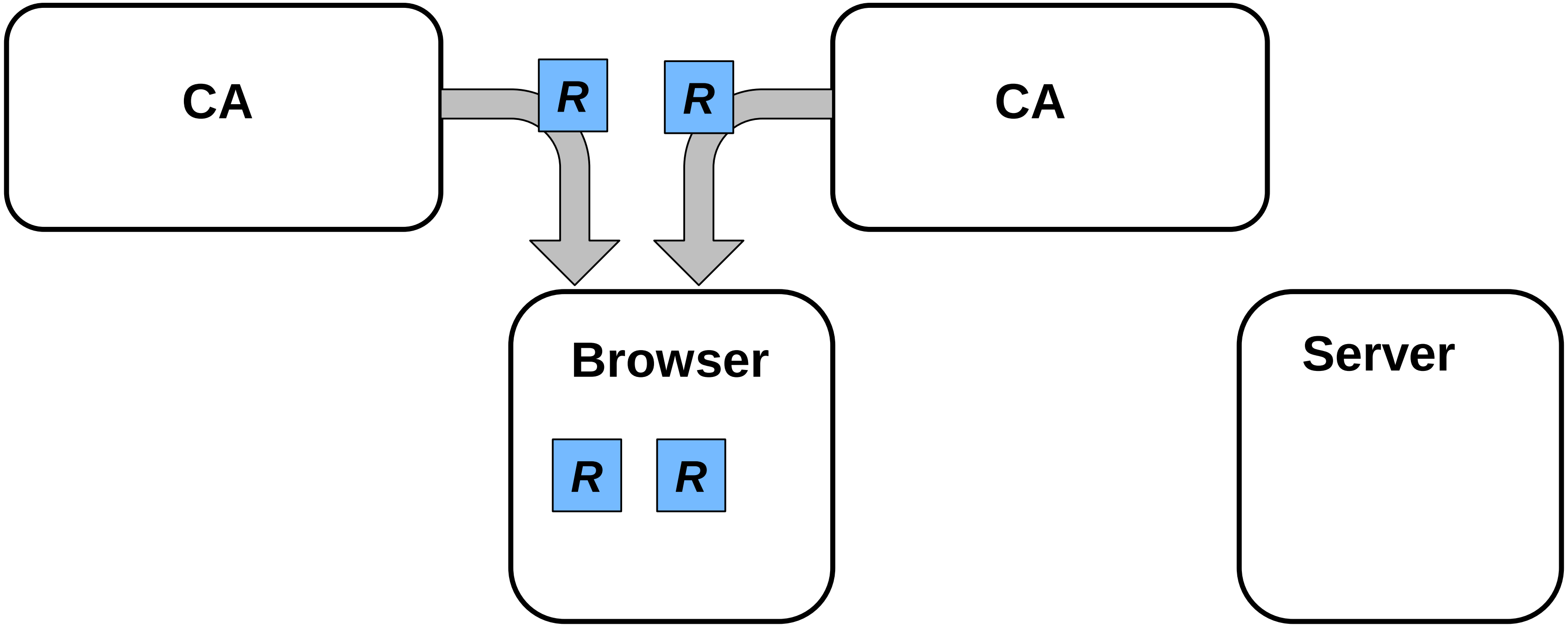

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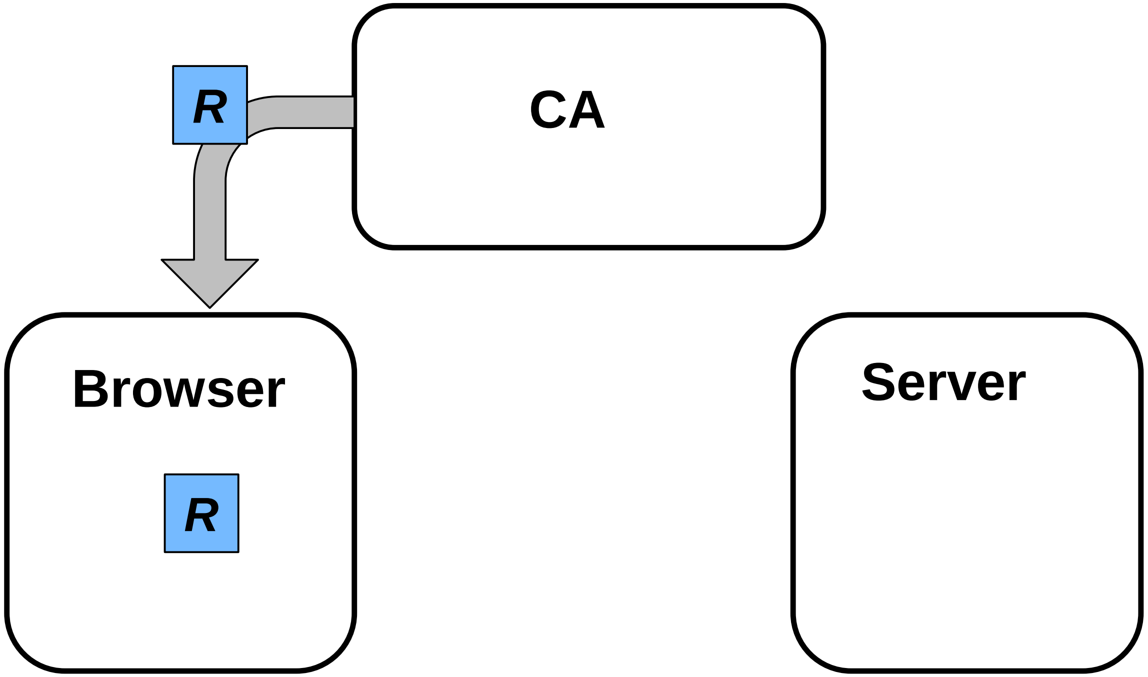

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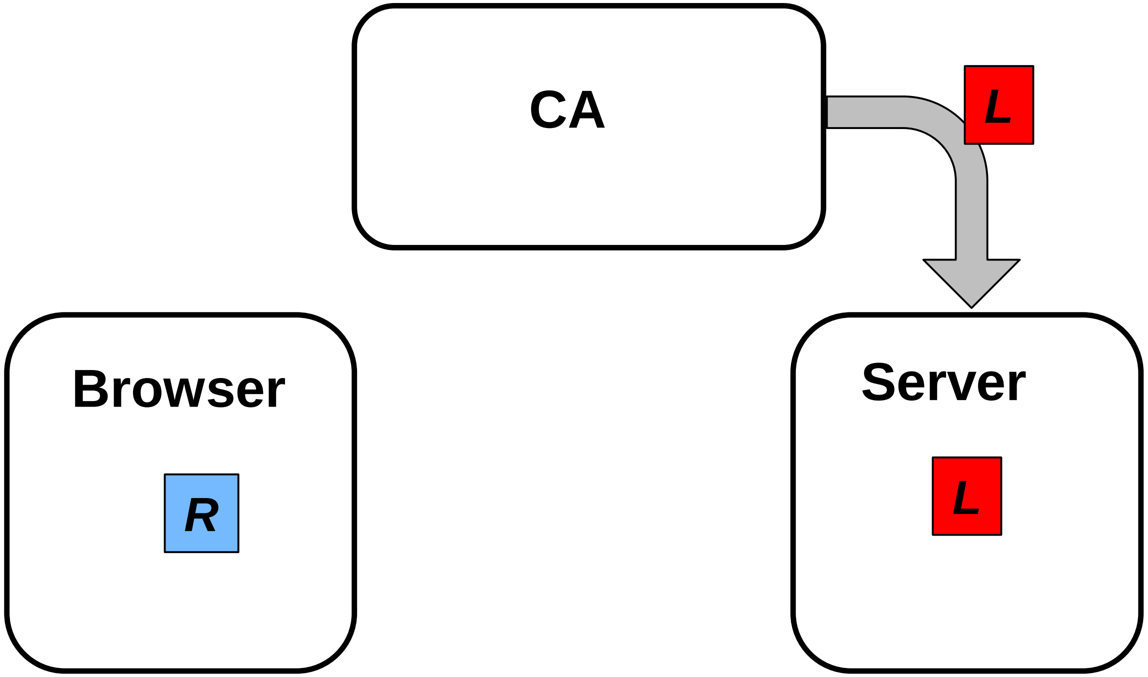
  - Certs are proof that public key belongs to server/domain



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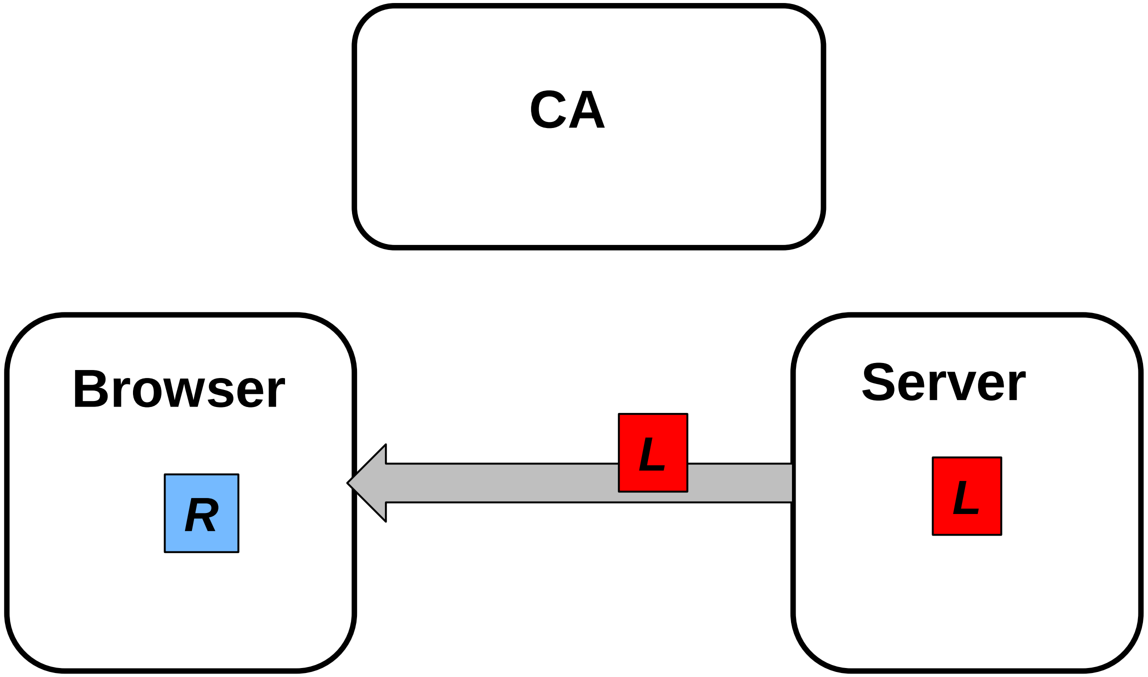

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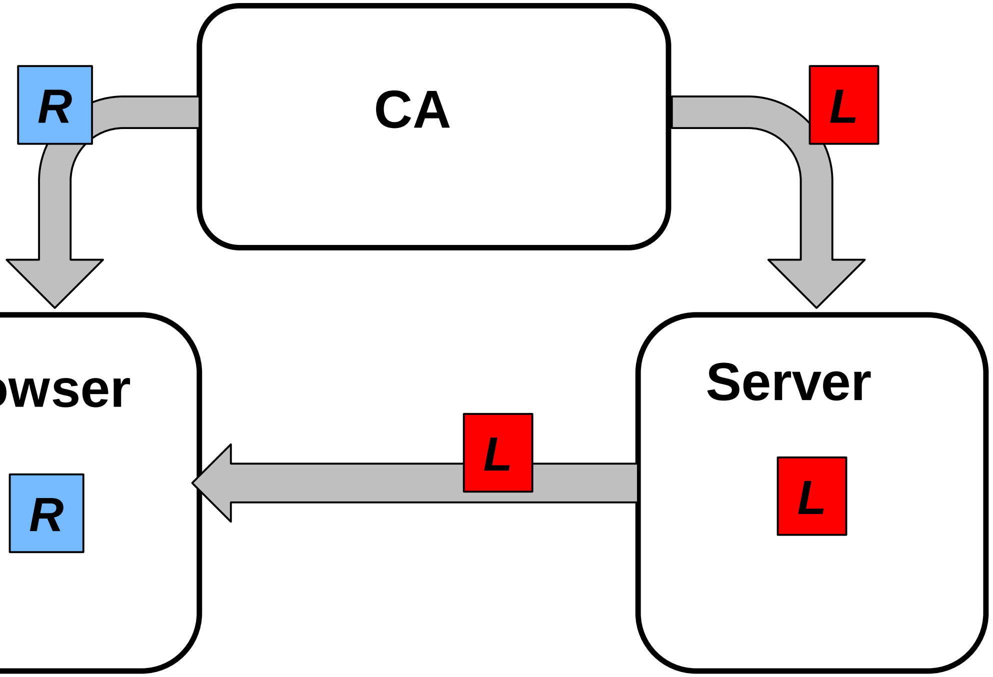

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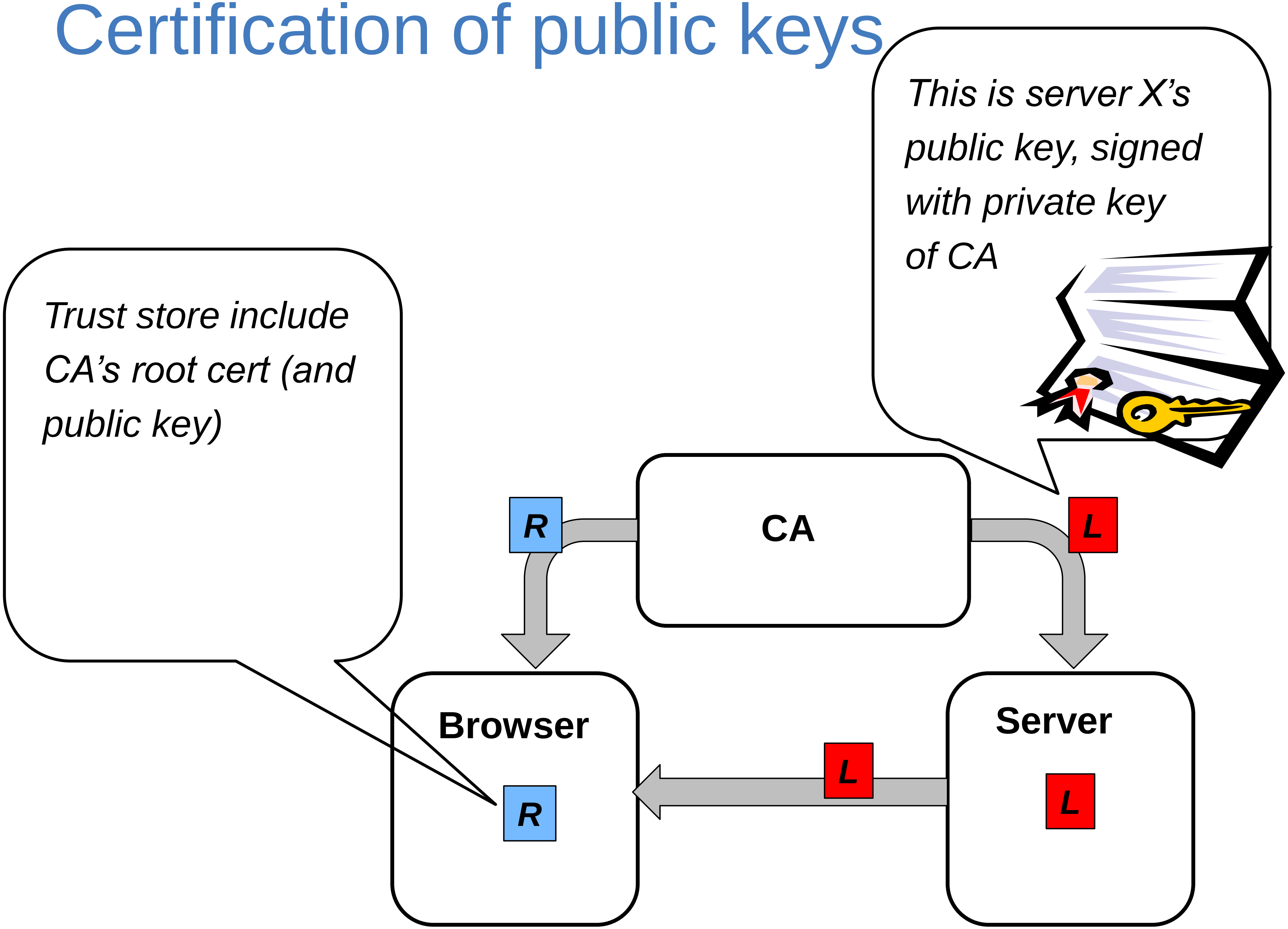

Trust store include CA's root cert (and public key)

This is server X's public key, signed with private key of CA

Certification of public keys

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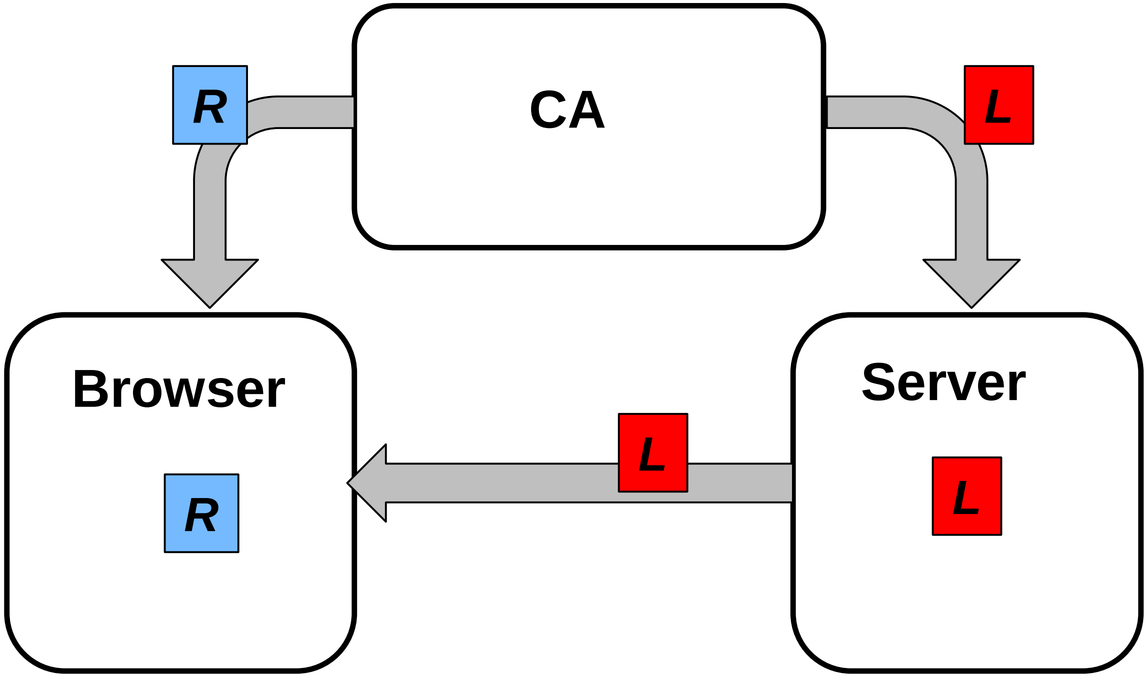

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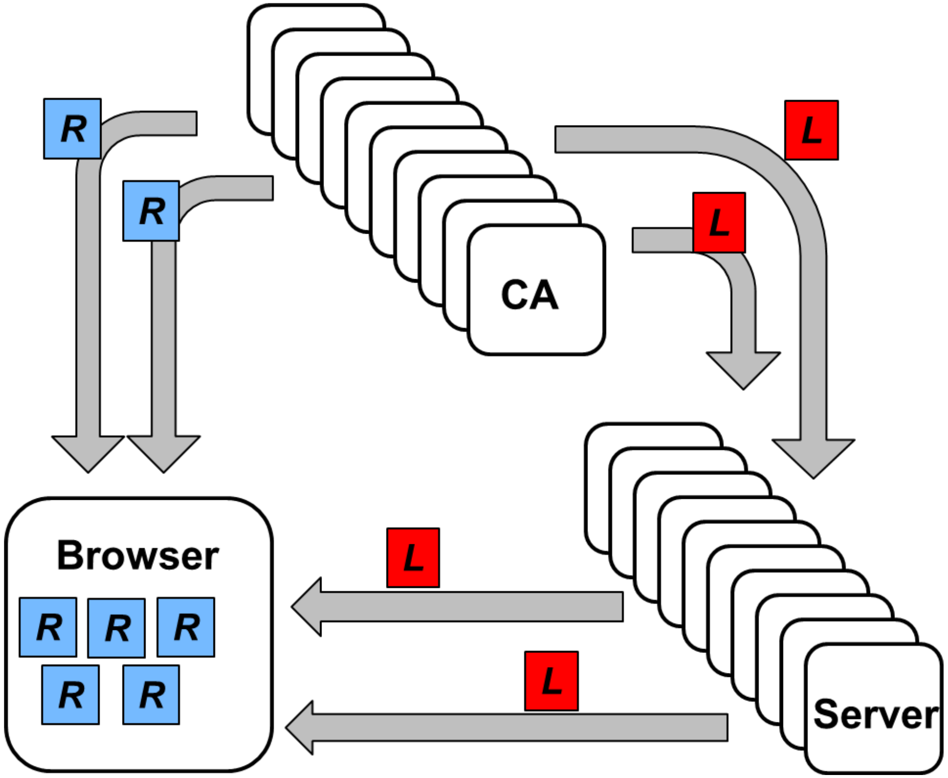
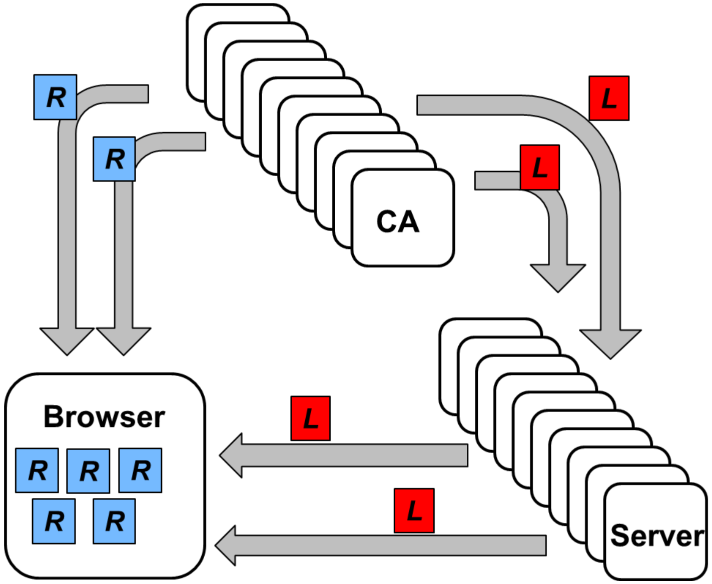
- In practice, many
  - Many CAs, servers
  - Varying trust+security



Certification Transparency (CT)



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- Logs
  - Public record of certs
  - Append only (Merkle trees)
  - Create SCTs
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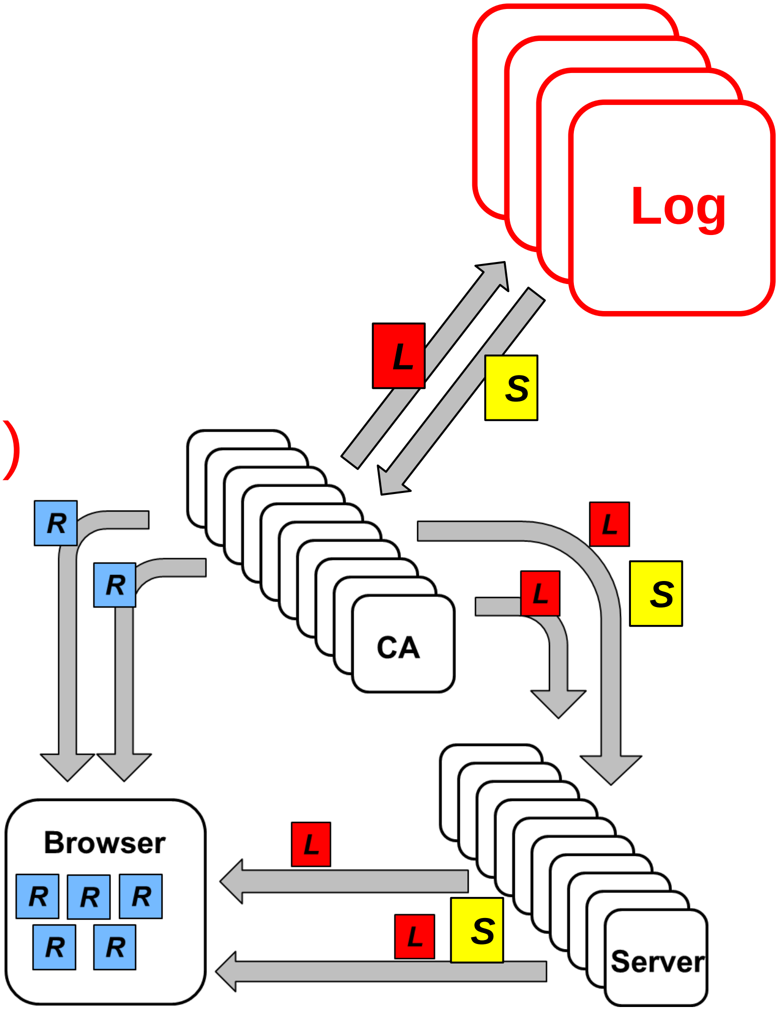

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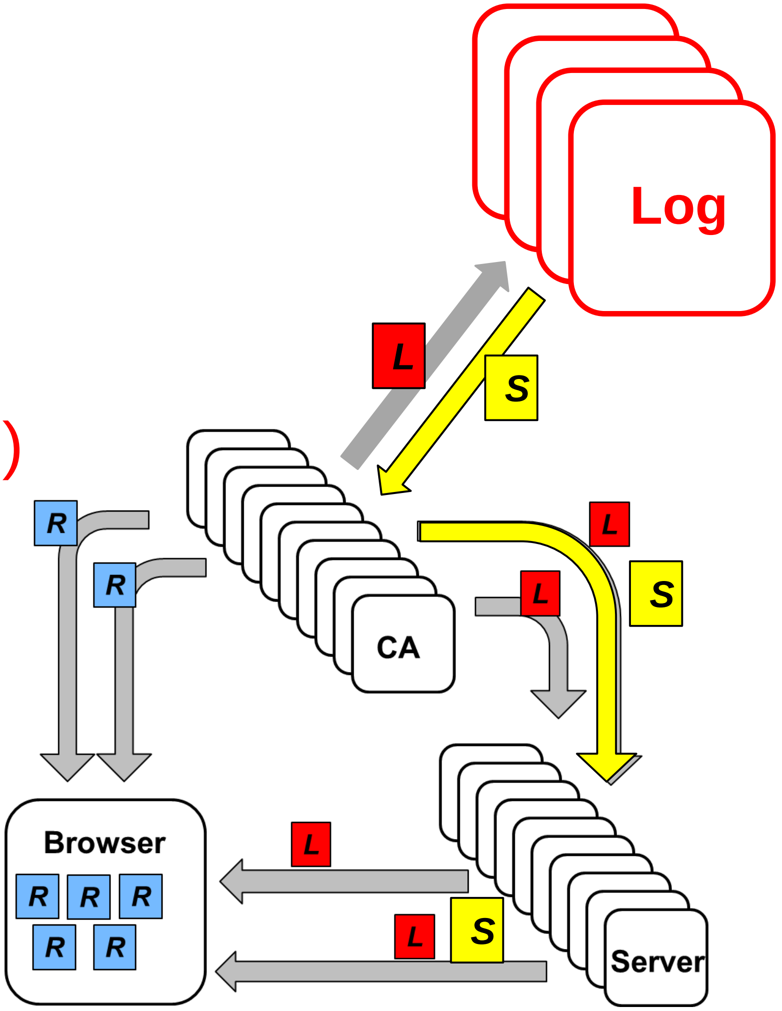

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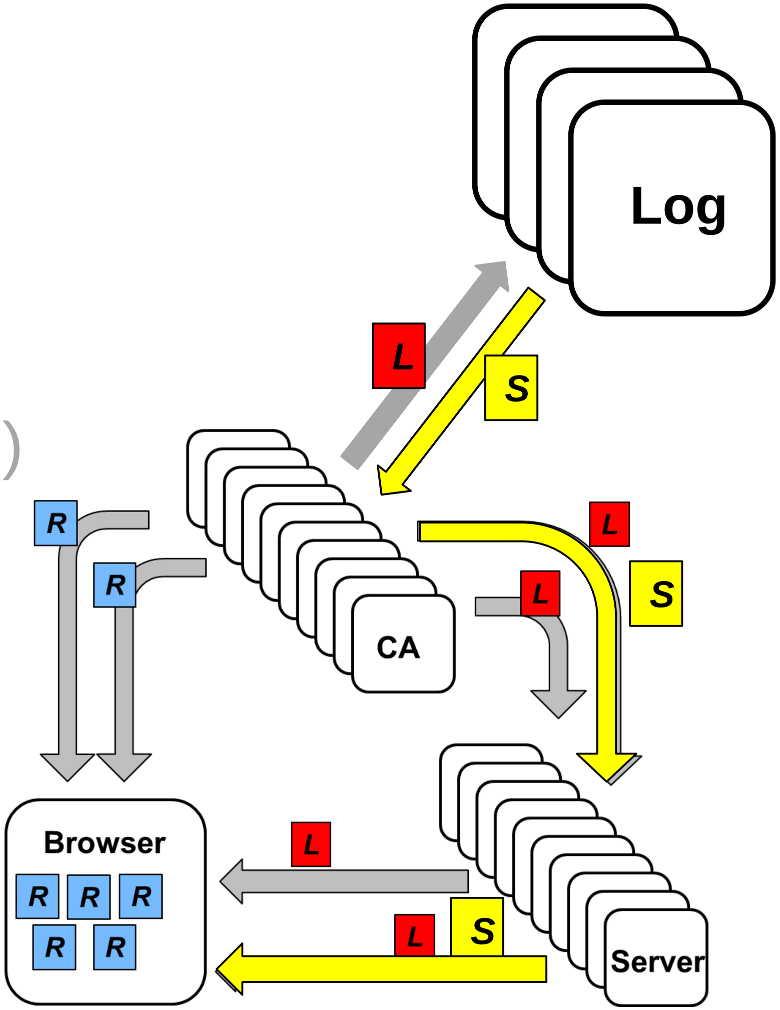

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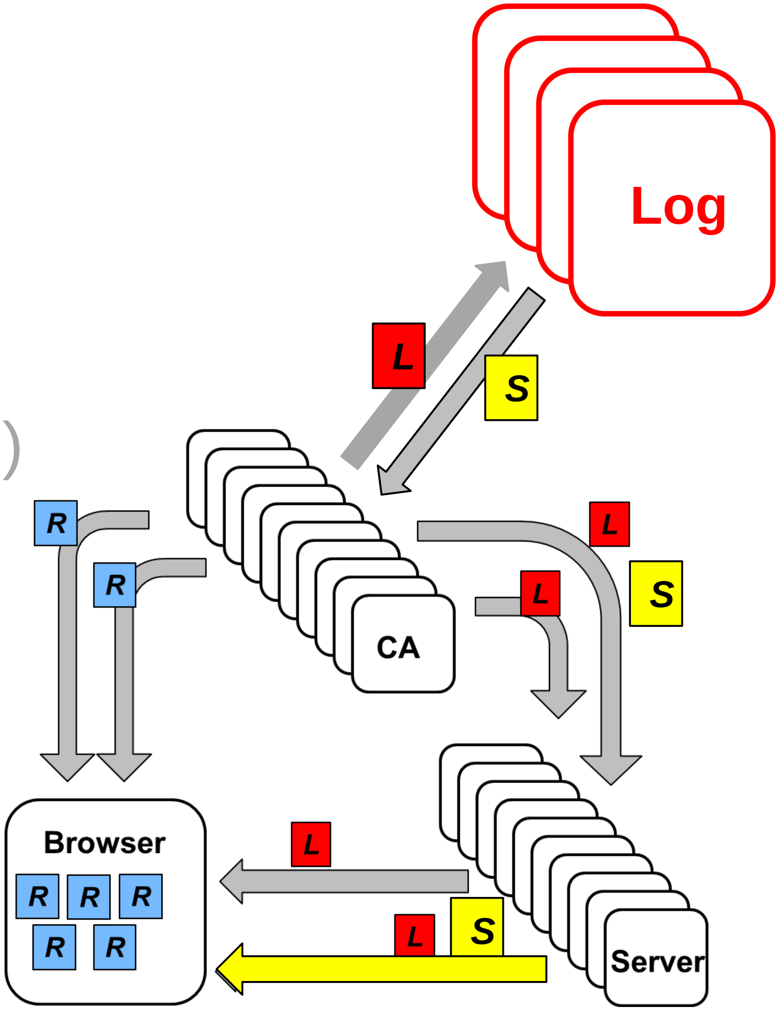
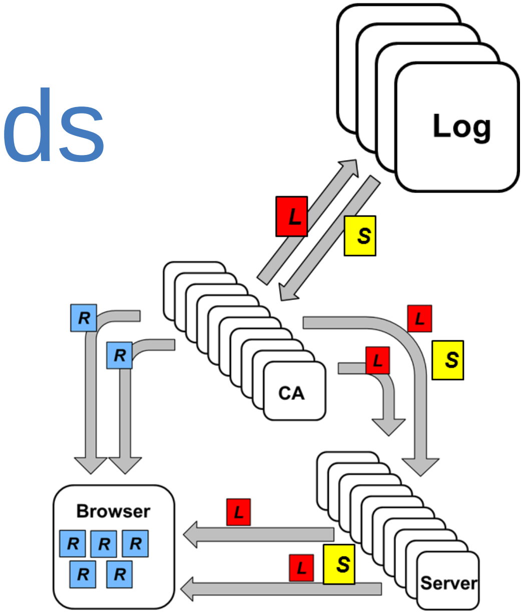
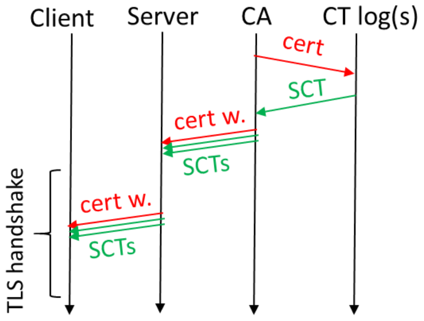
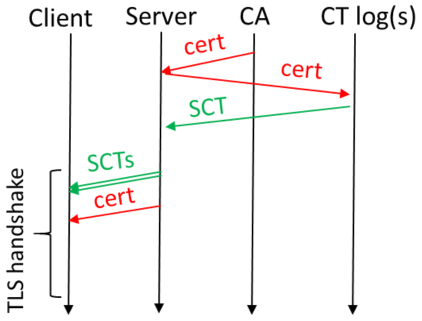


Three SCT delivery methods

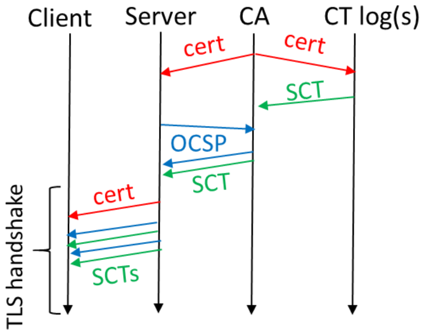




(a) X.509v3 extension



(b) TLS extension



(c) OCSP stapling

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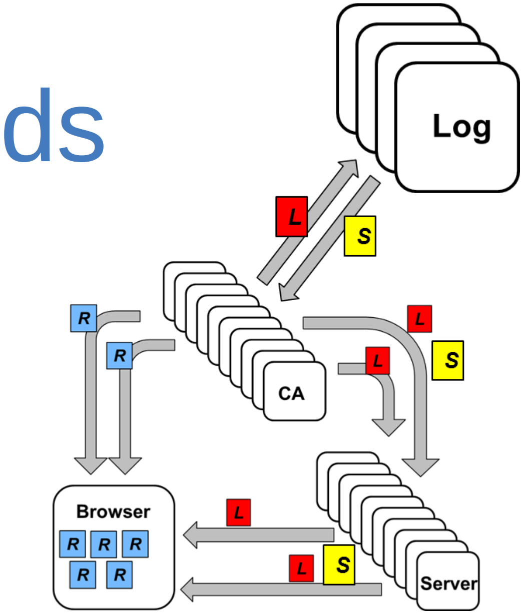

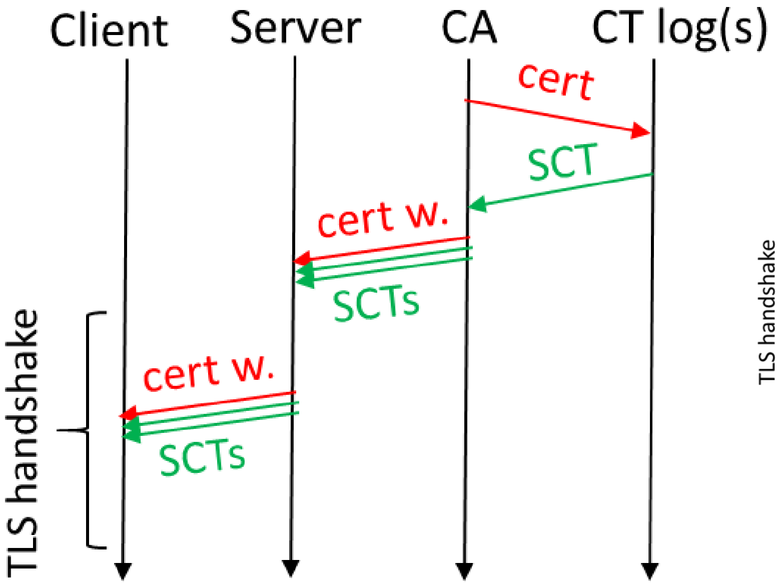

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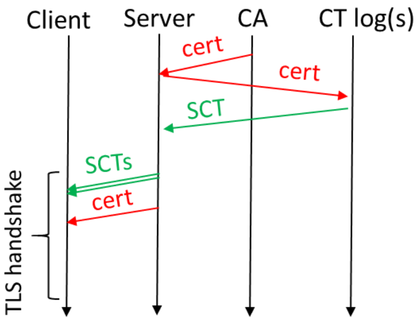

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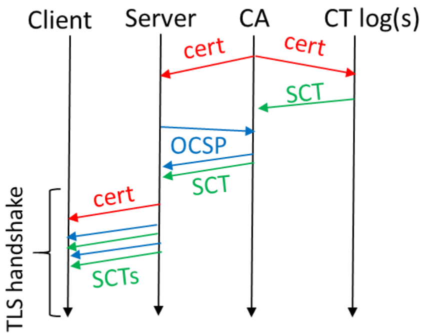

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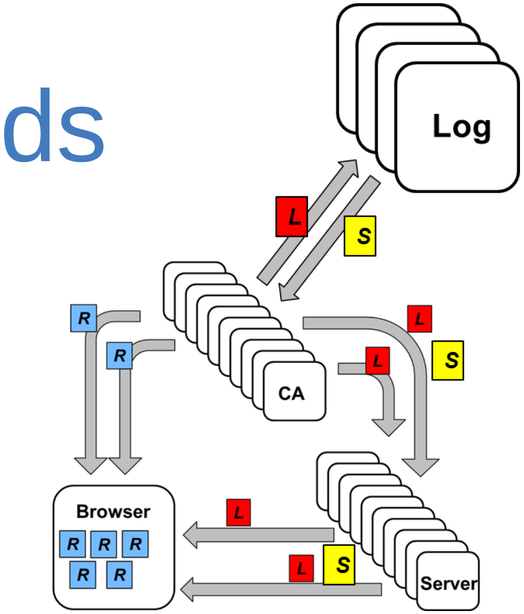

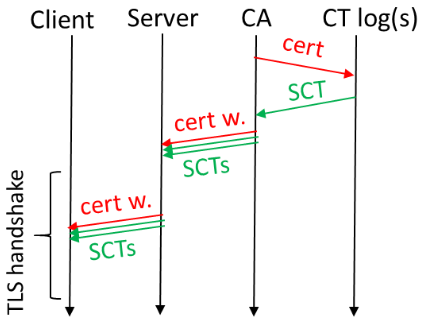

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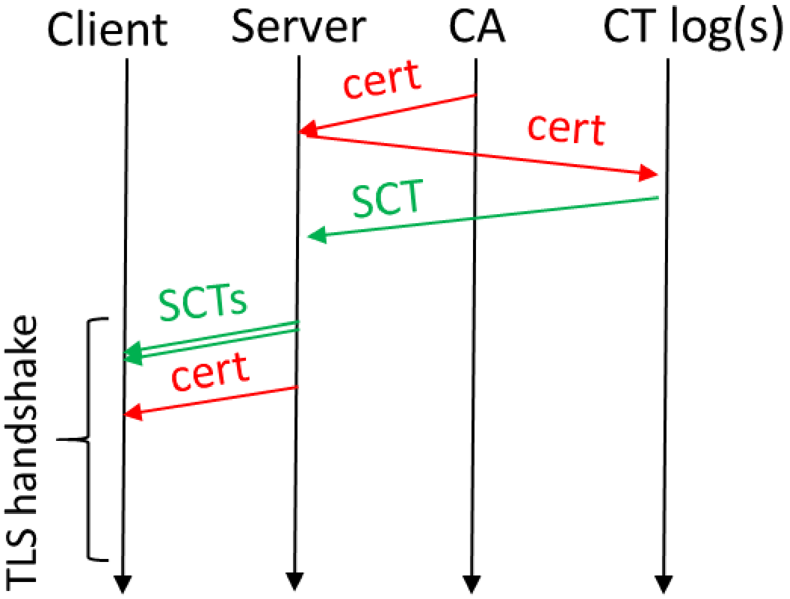

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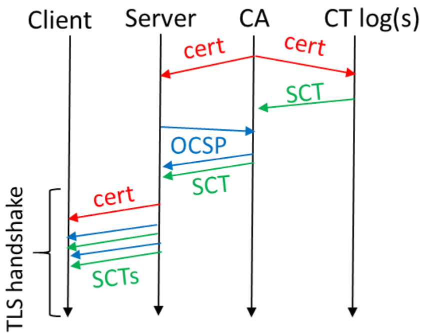

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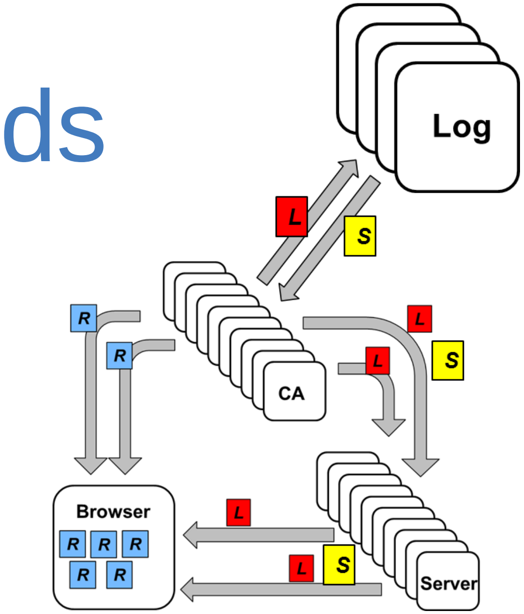

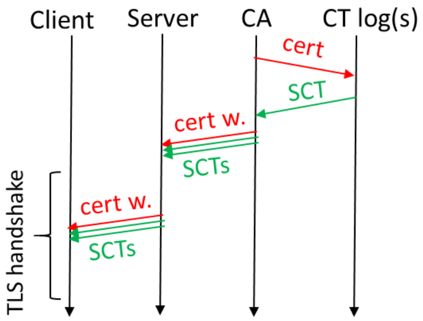

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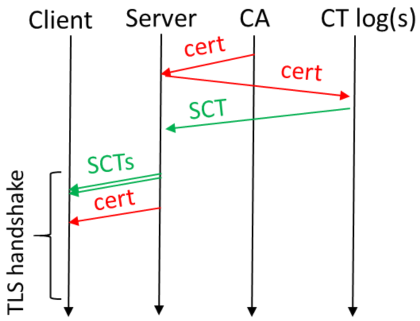

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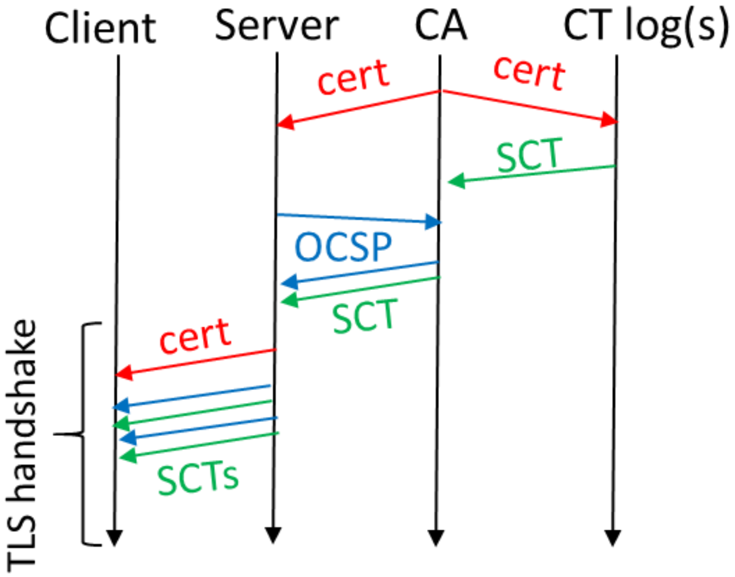

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Bigger picture

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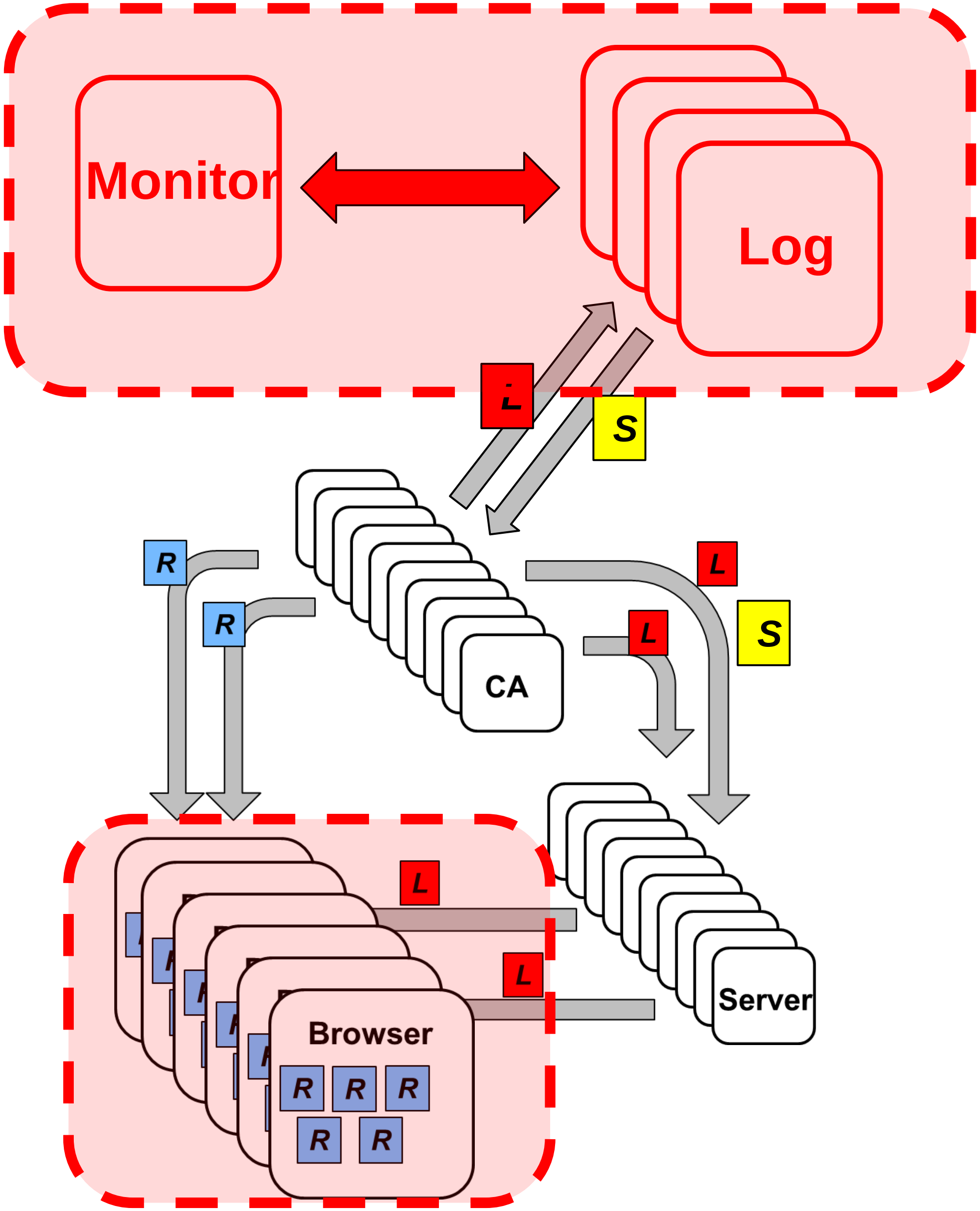
- Last year's (PAM '17)
  - Monitor: All public logs
  - Campus measurements: All HTTPS sessions for a week
- This paper (PAM '18)
  - Server-side SCT usage
  - Client-side performance
- Other related work
  - Gasser et al. (PAM '18), Amann et al. (IMC '17), VanderSloot et al.(IMC '16)



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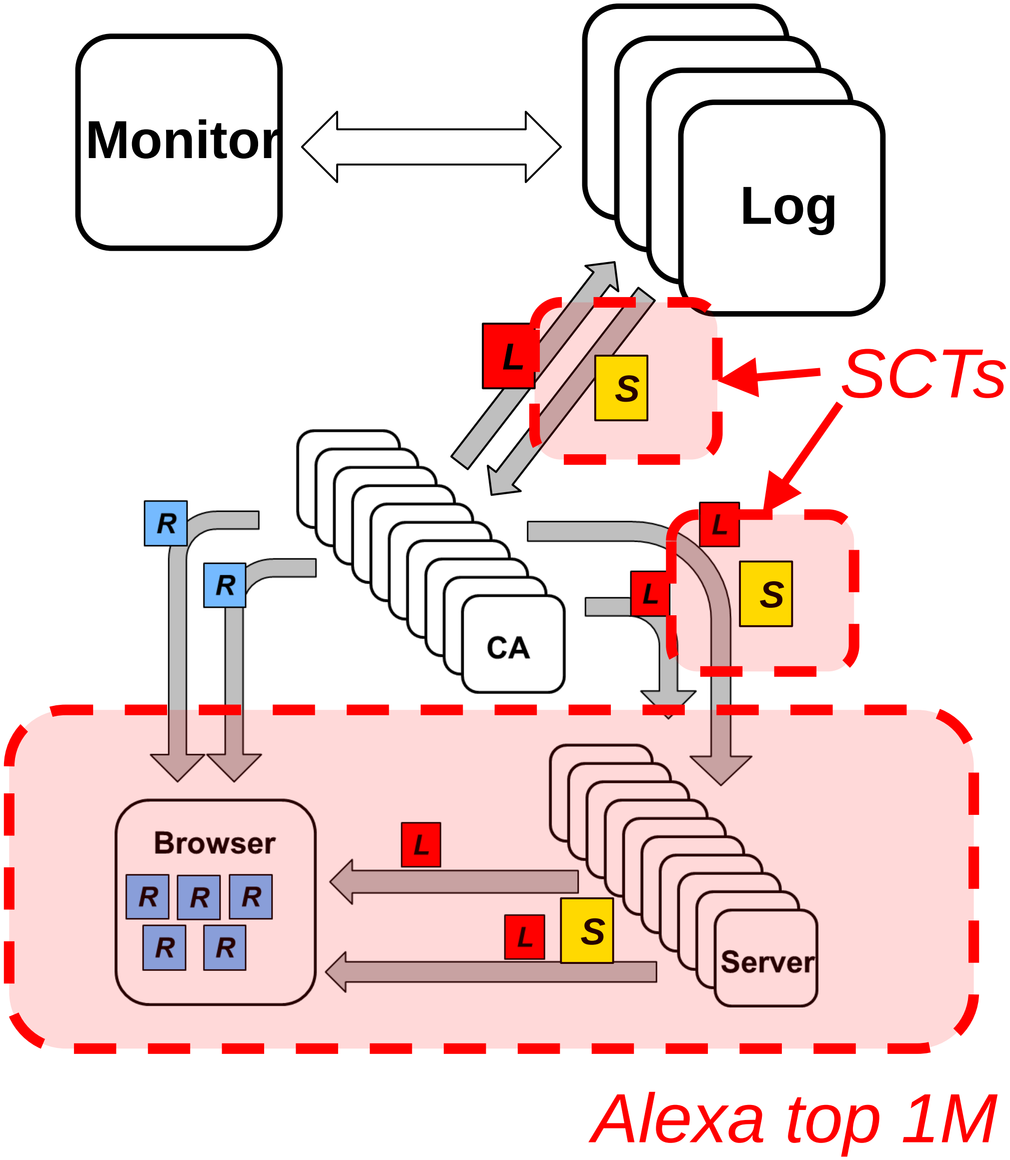
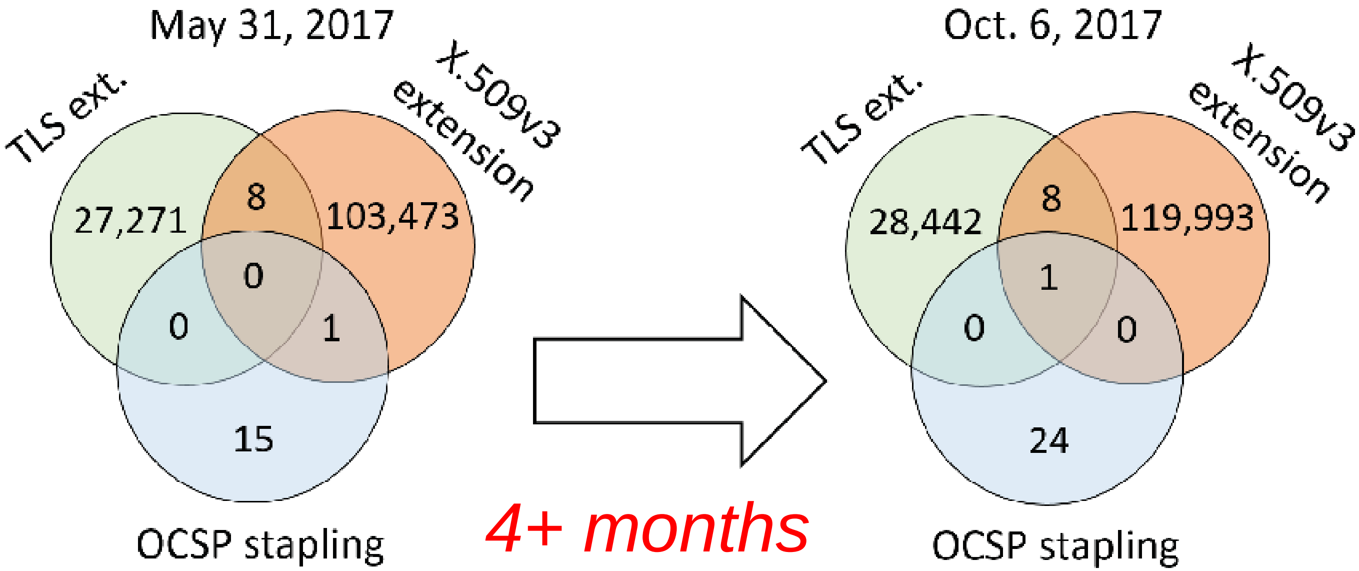


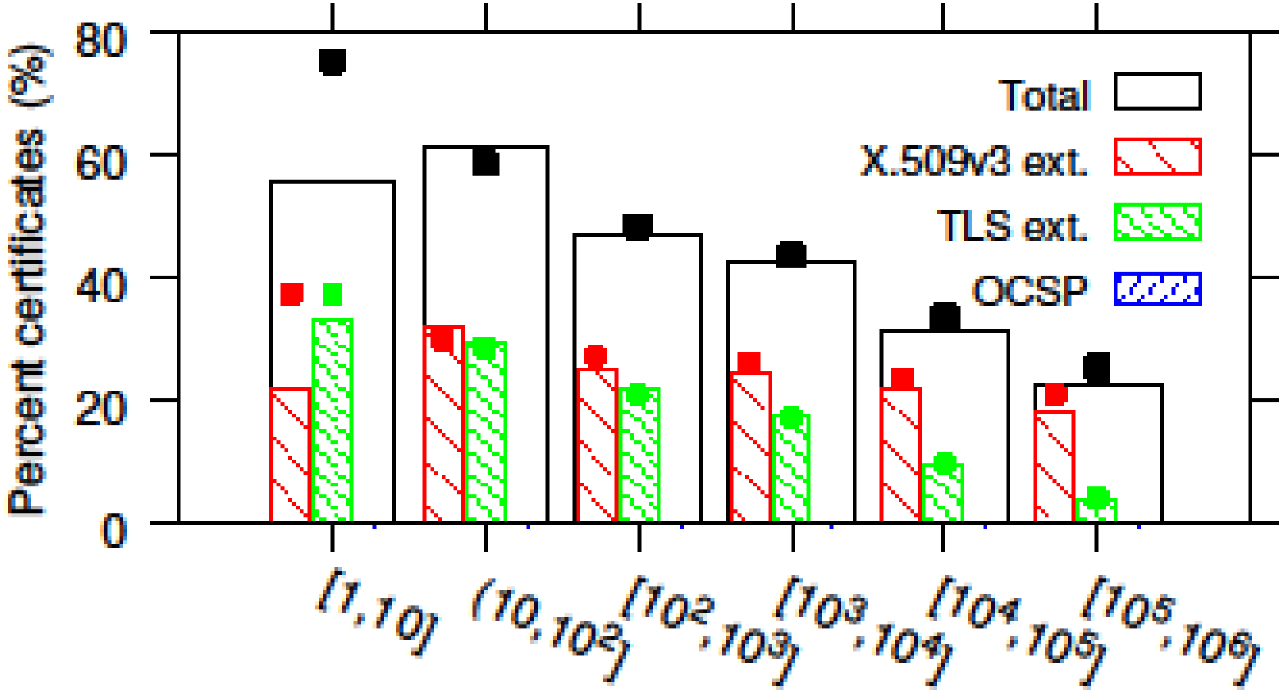
Results

Dataset overview



- Method
    - Alexa top-1M
    - Two snapshots: May 31 (2017) and Oct. 6 (2017)
    - Single machine, 600 parallel threads (approx. 4 hours)
- SCT usage increase across all methods
- X.509v3 dominates (easiest method for server domains)

Popularity-based breakdown



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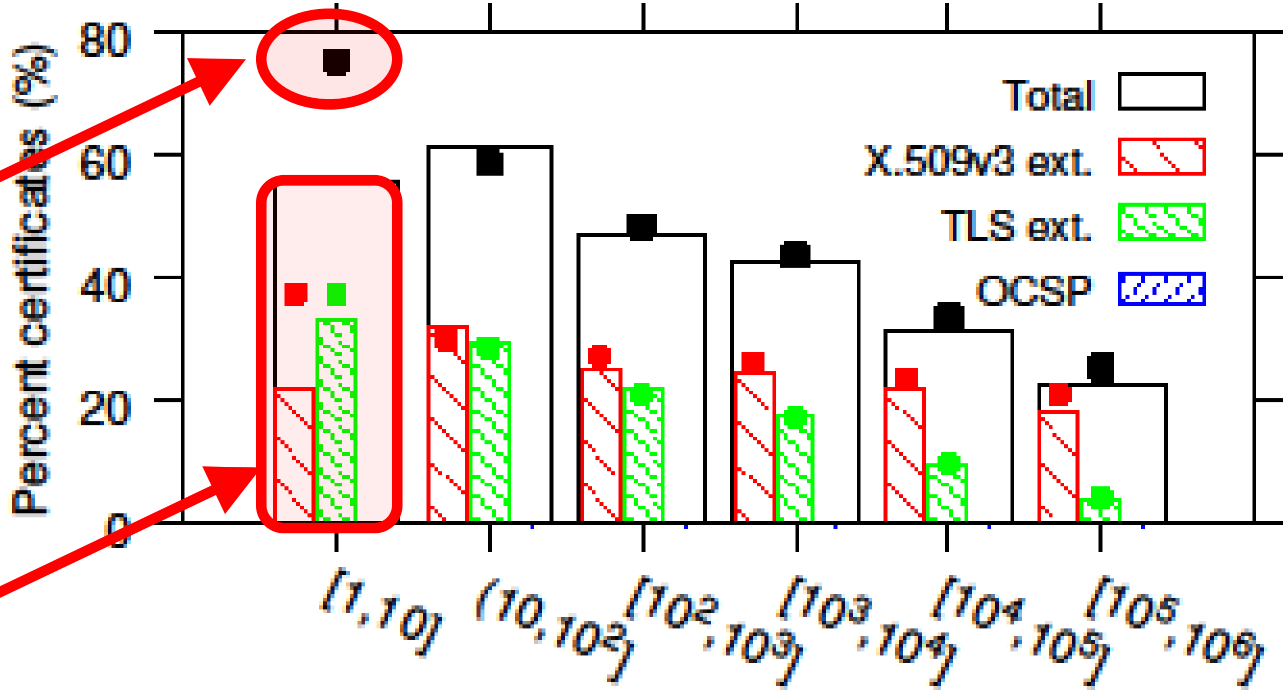

Oct 2017

May 2017

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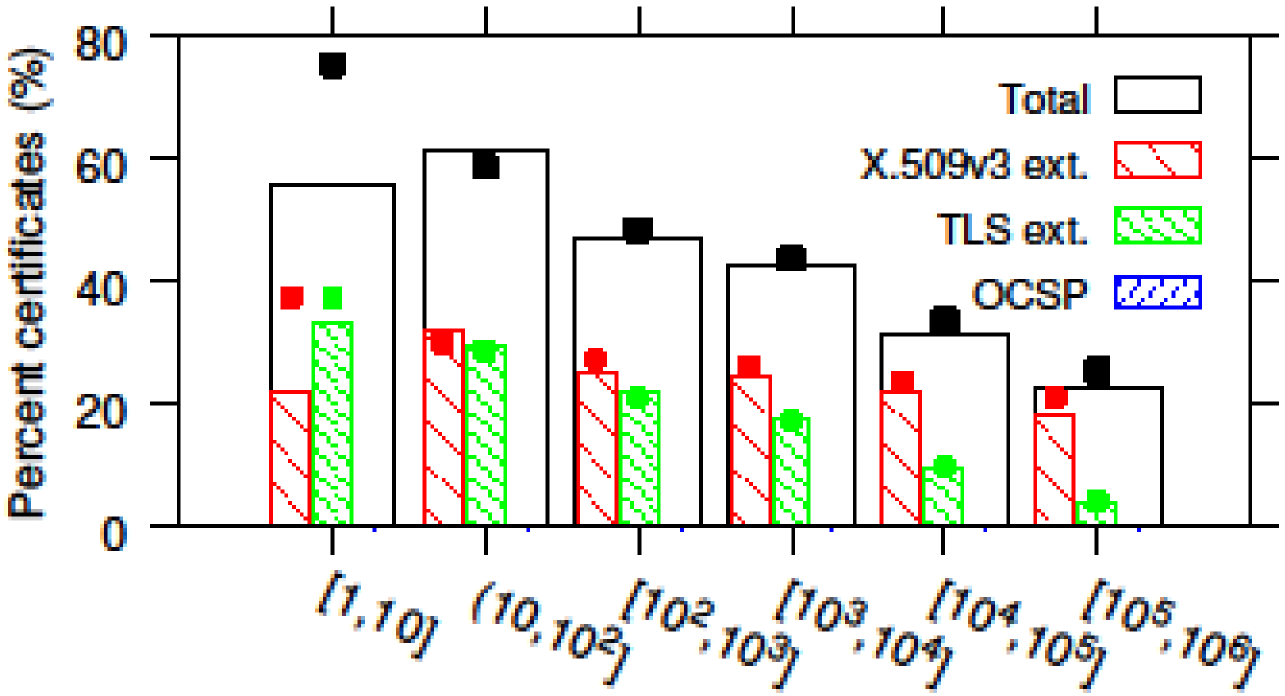

- SCT usage highest among most popular domains
- TLS usage highest among most popular domains

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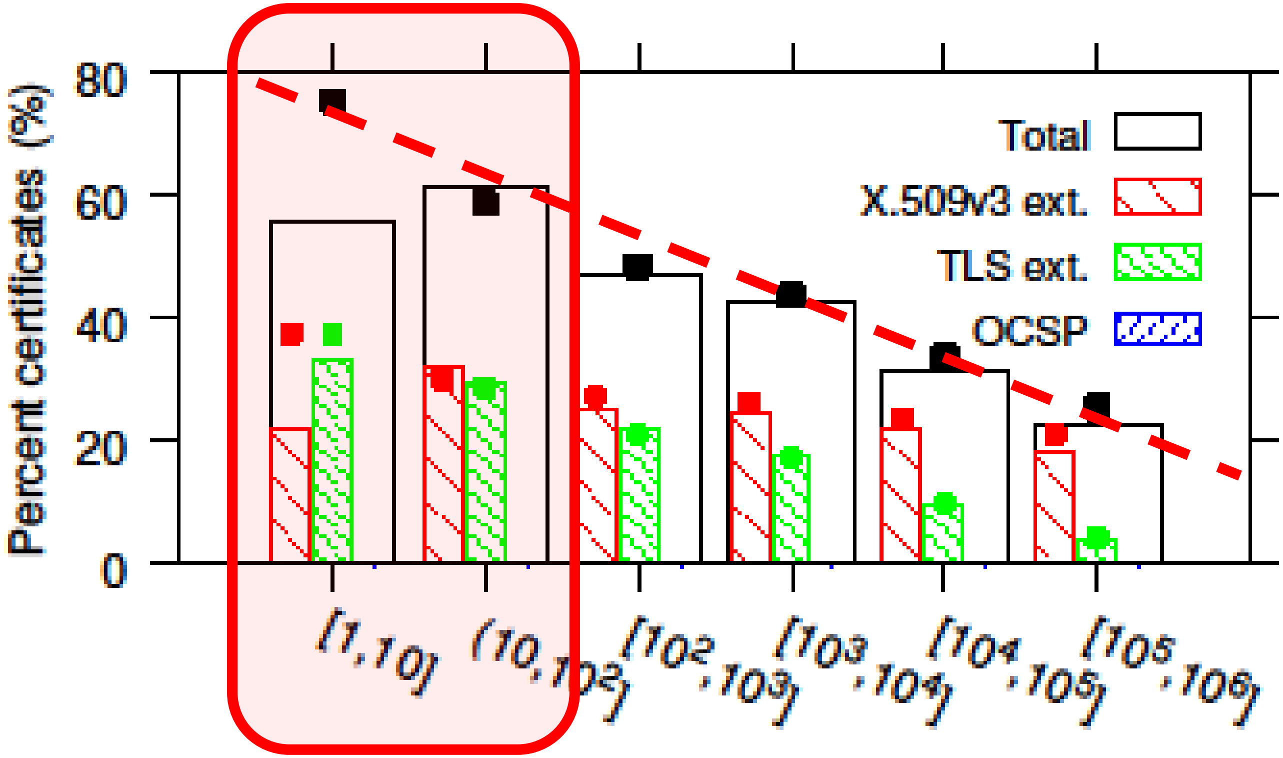

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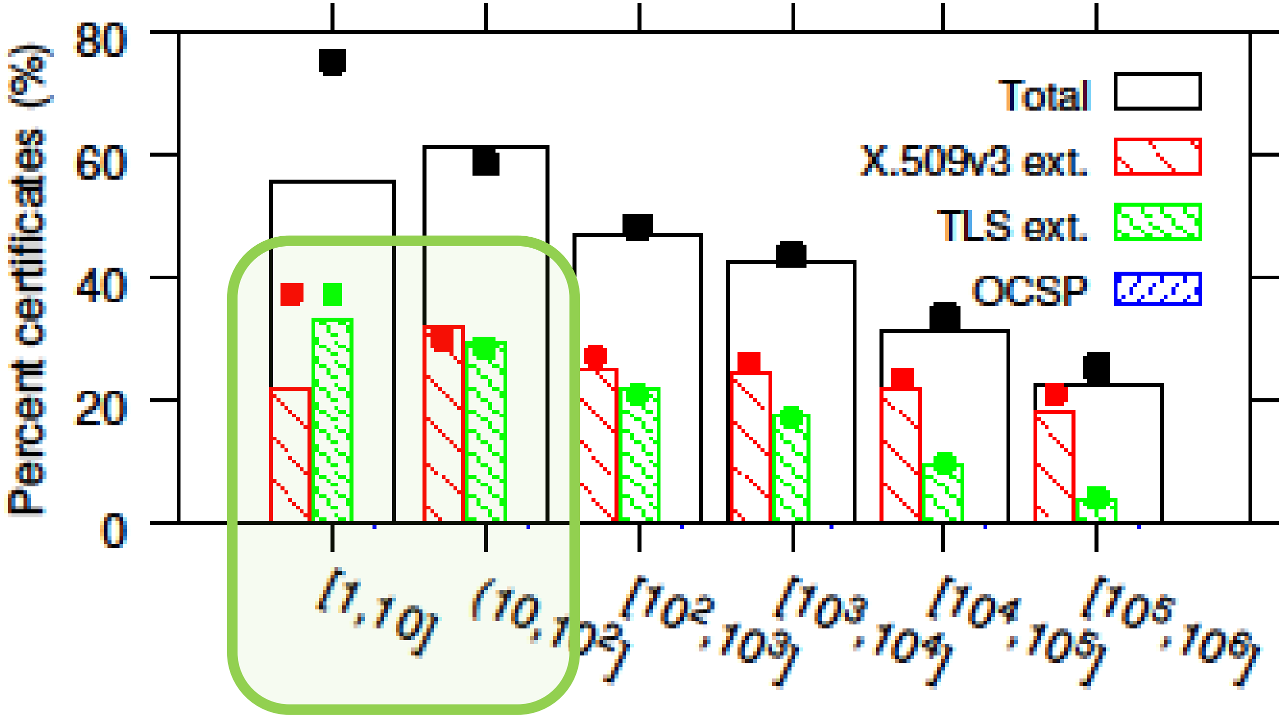

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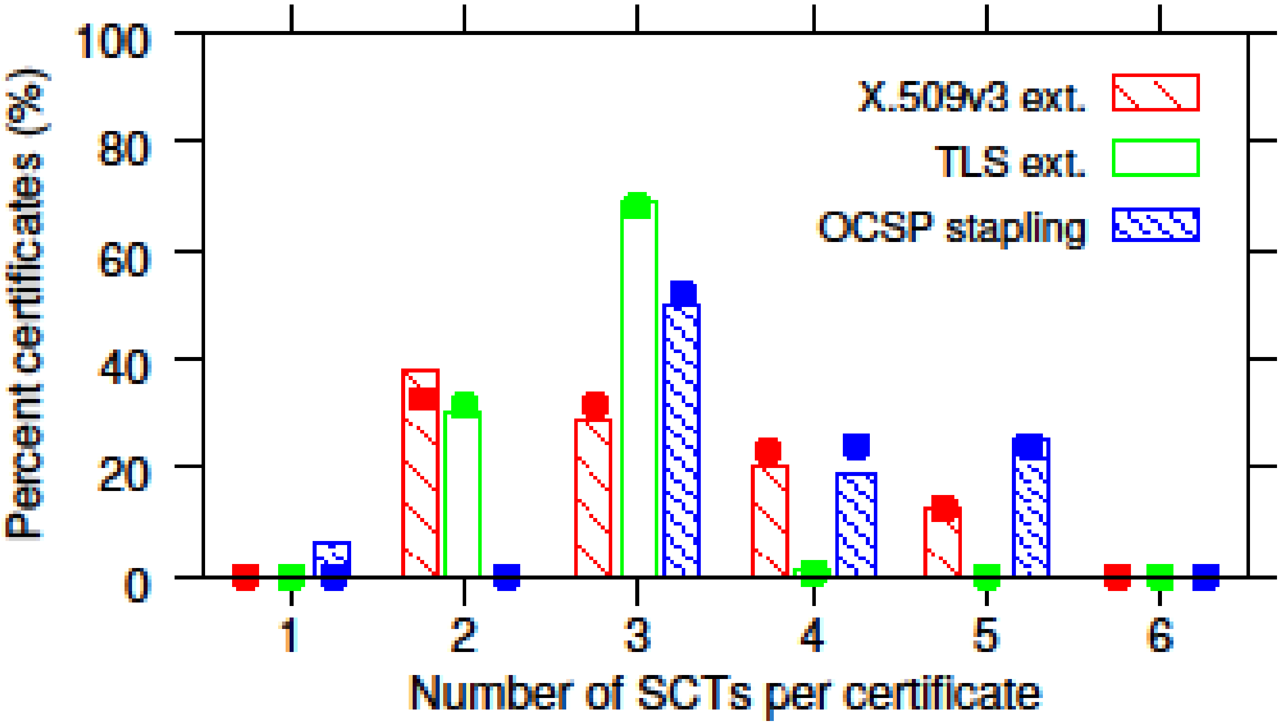
Number of SCTs per certificate



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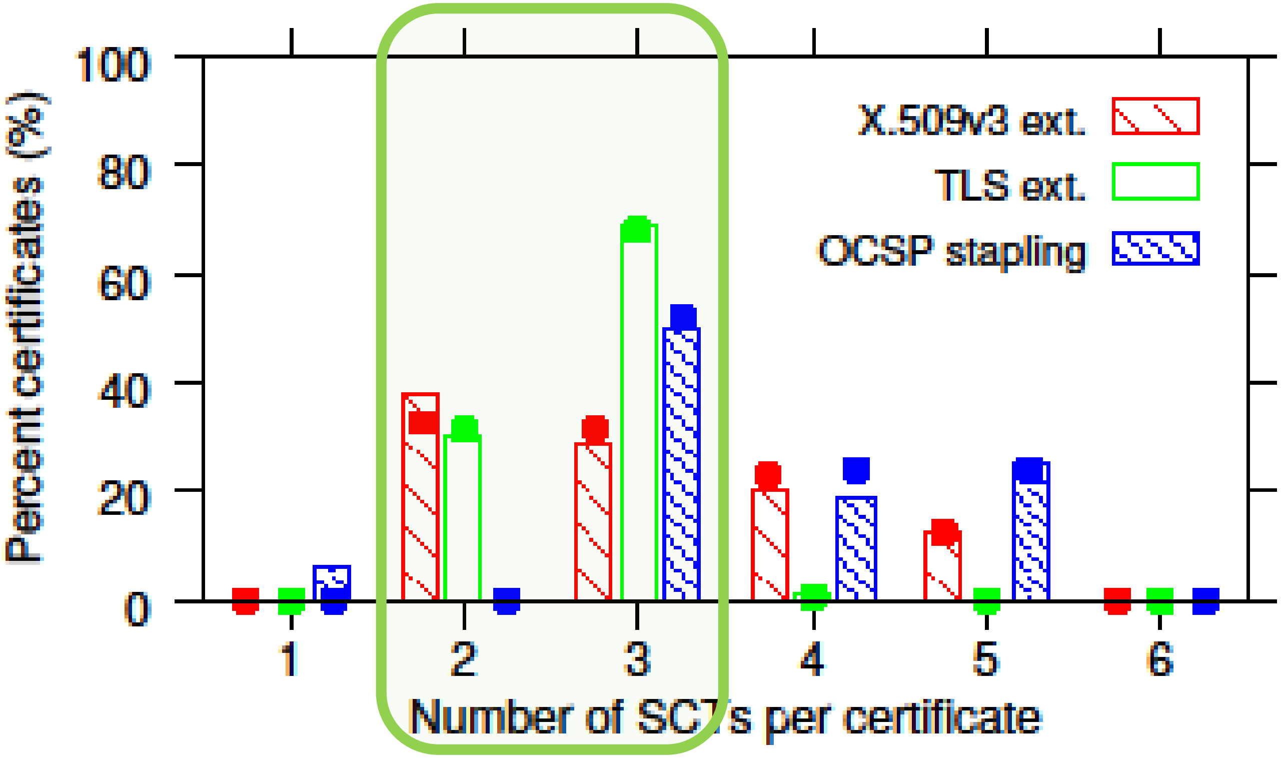

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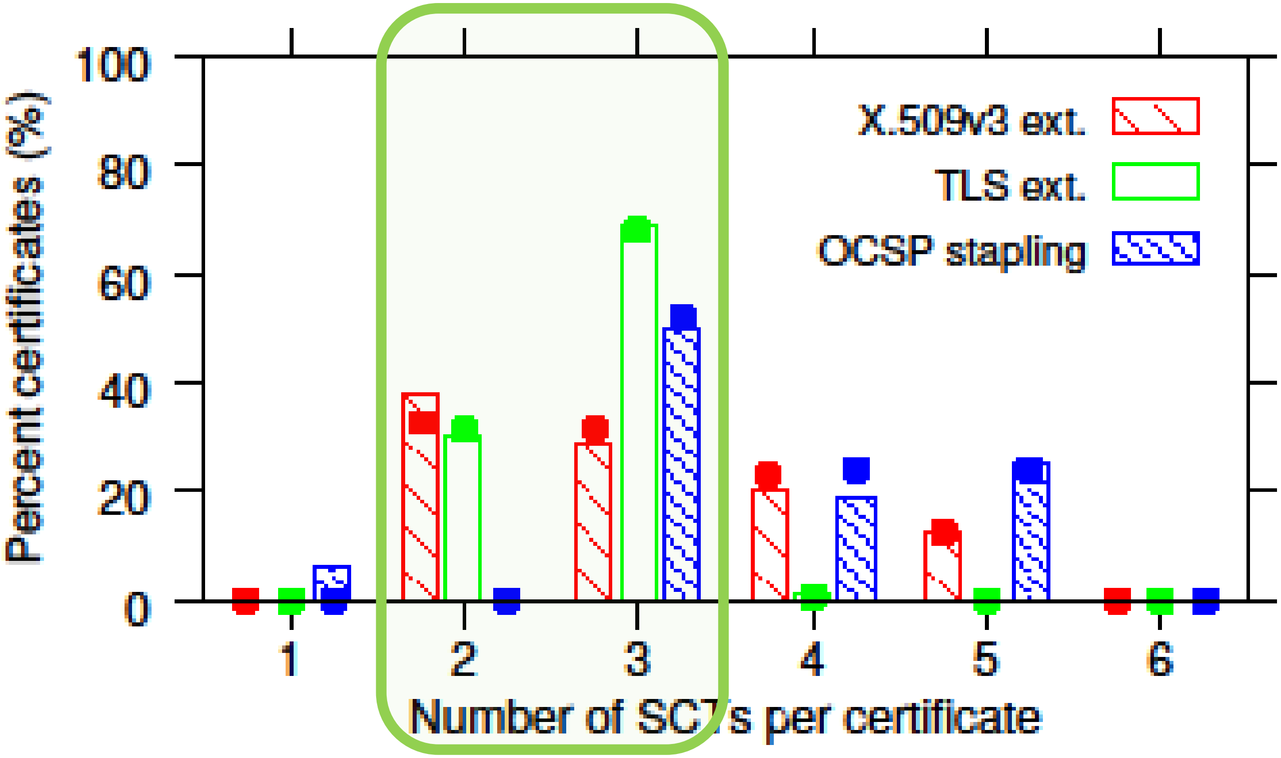

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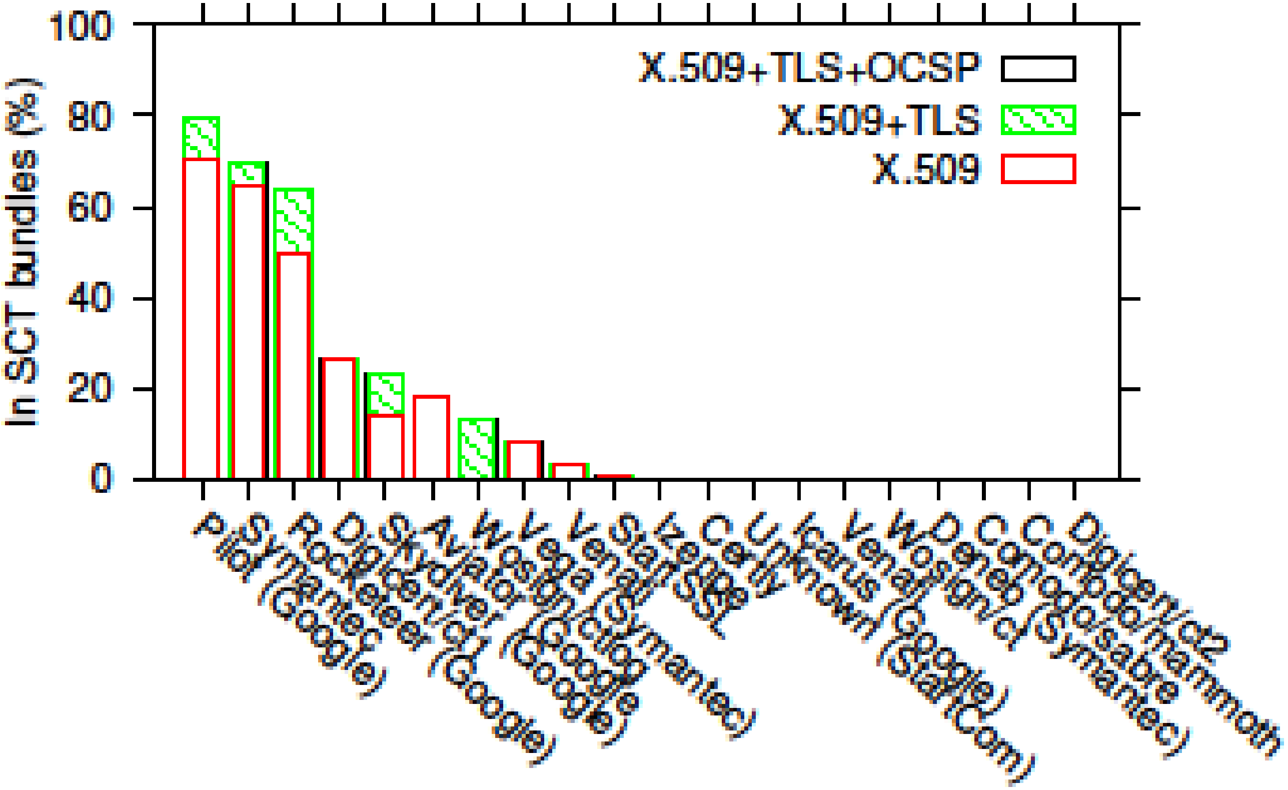

- A few dominating logs
- Big differences in TLS frequency among CA logs
  - Wosign almost only TLS
- Aviator (frozen on Nov 29, 2016) almost only X.509v3
  - Again, TLS is increasing (but way behind)

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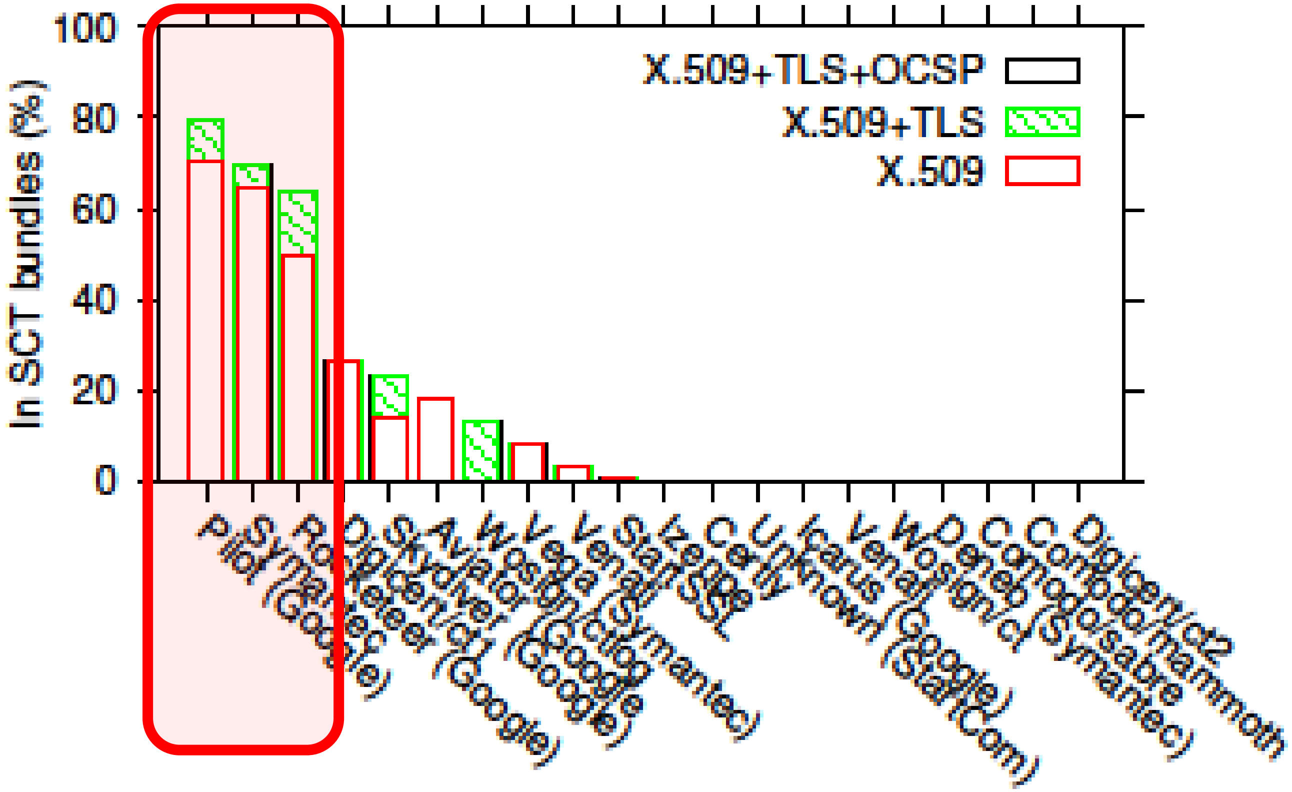

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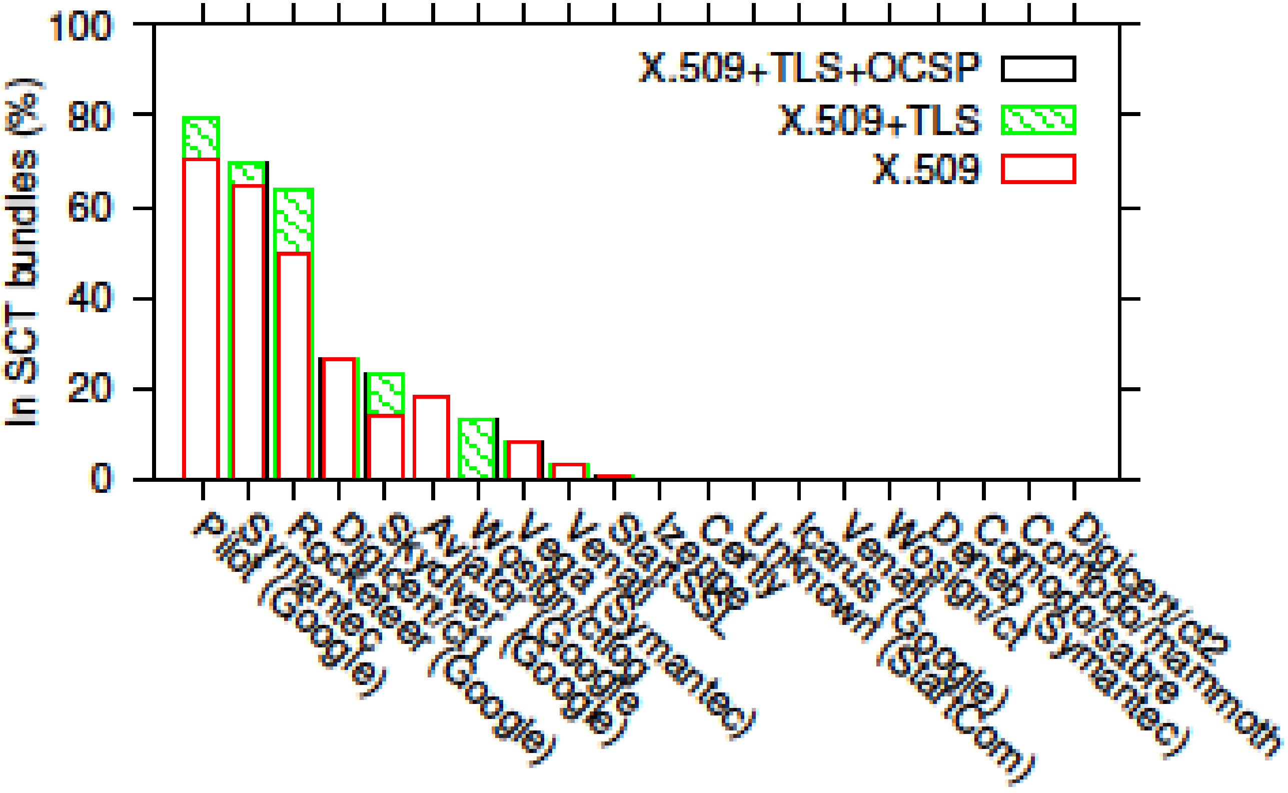

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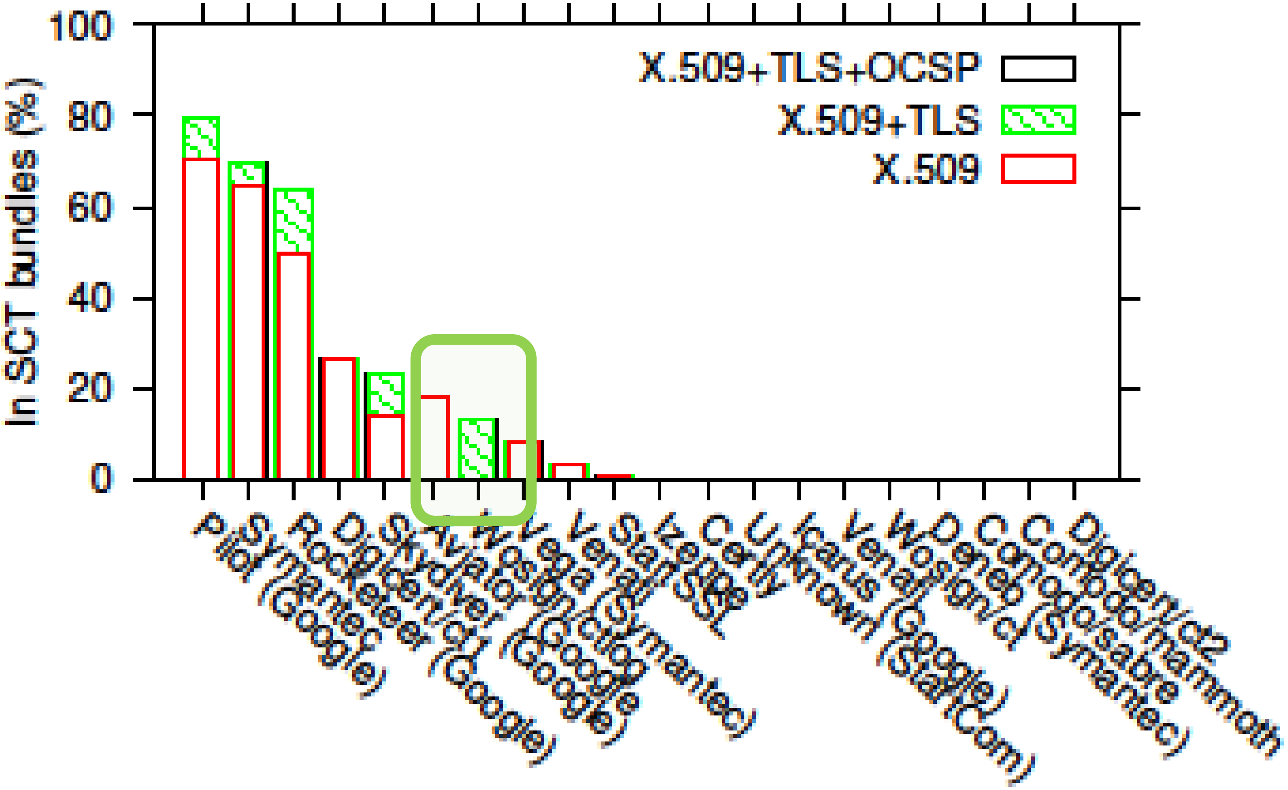

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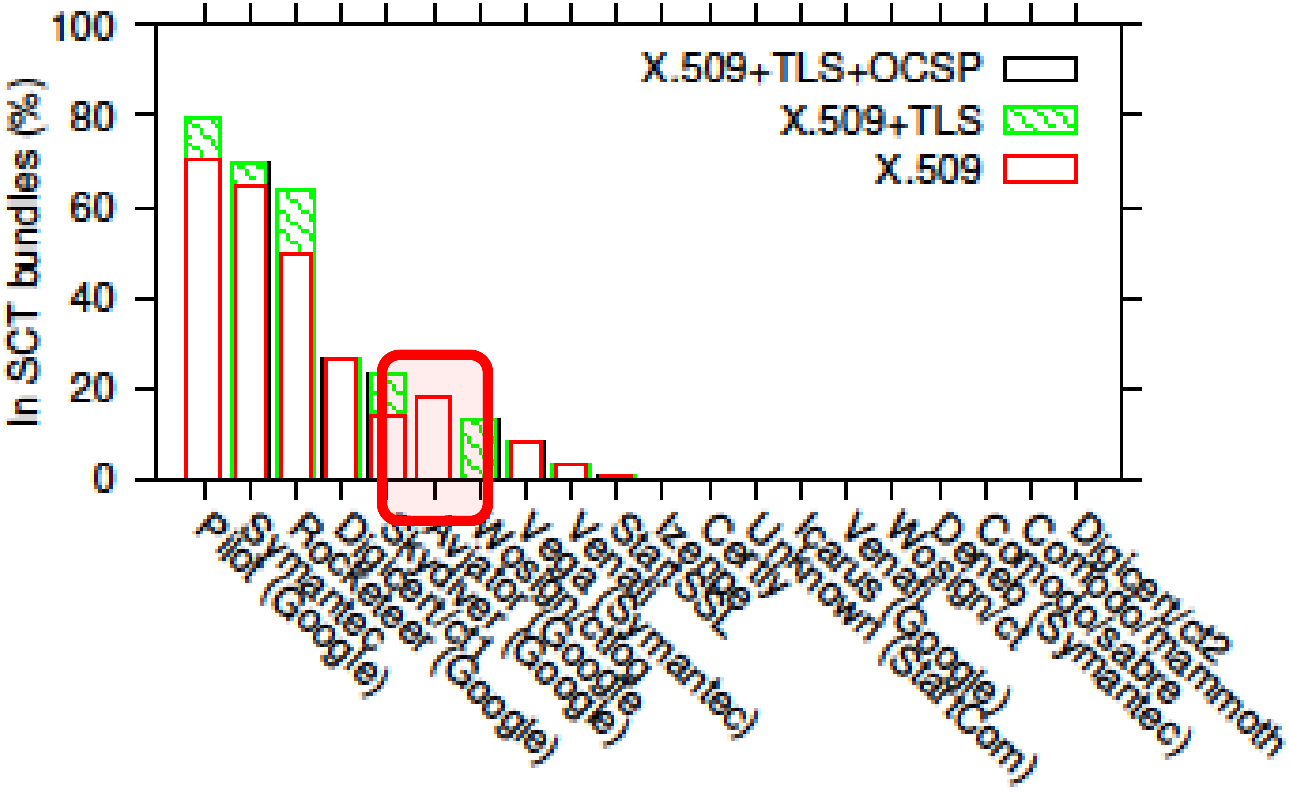

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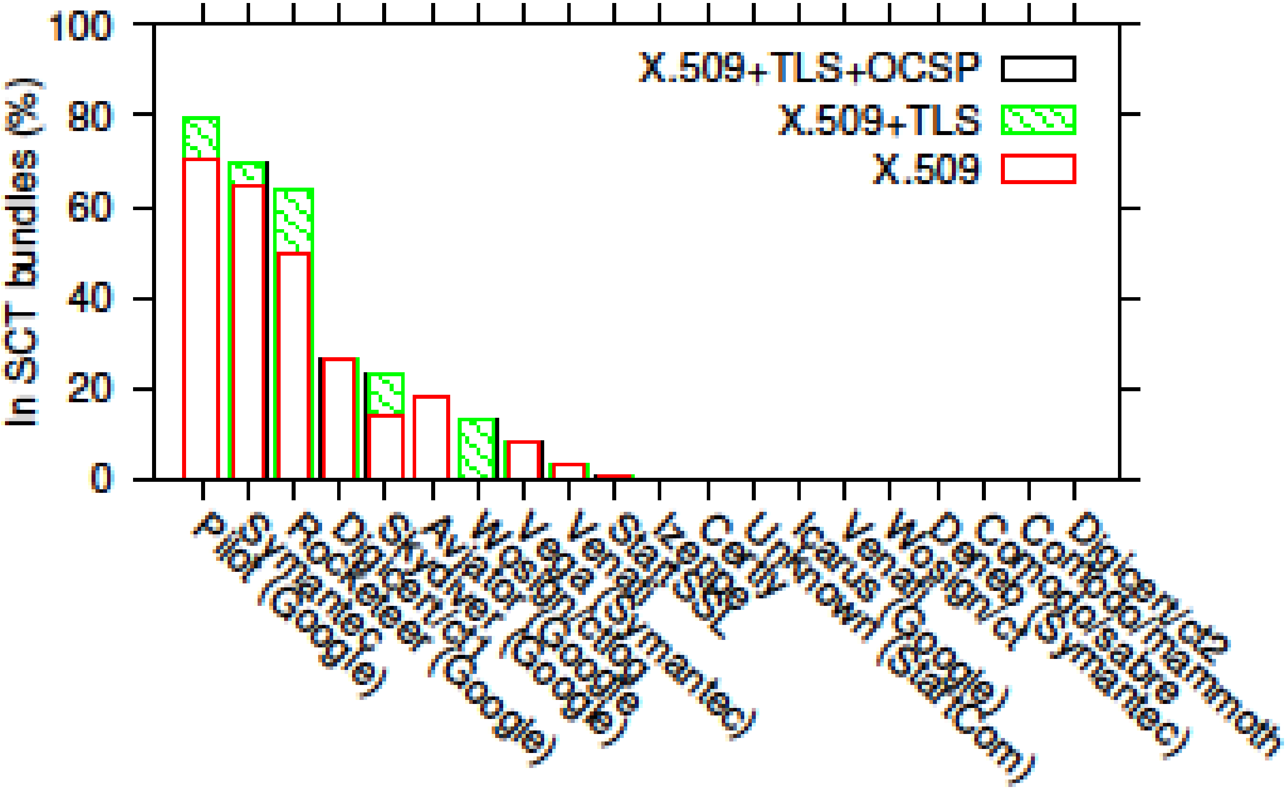

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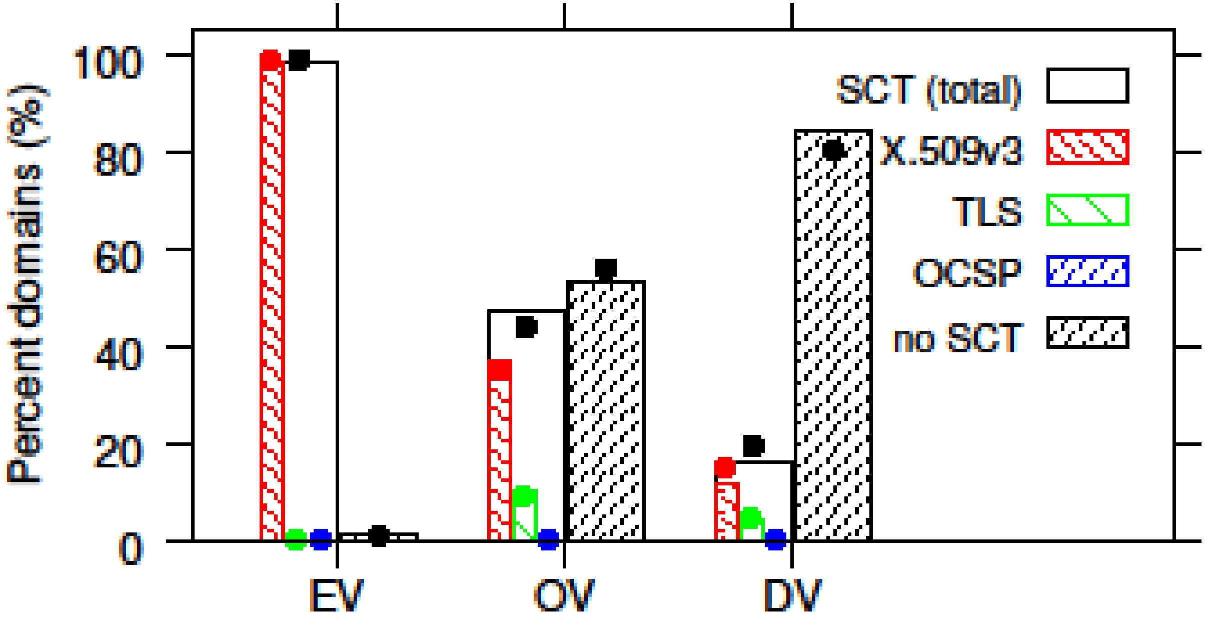

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  - Rush to get a solution ...
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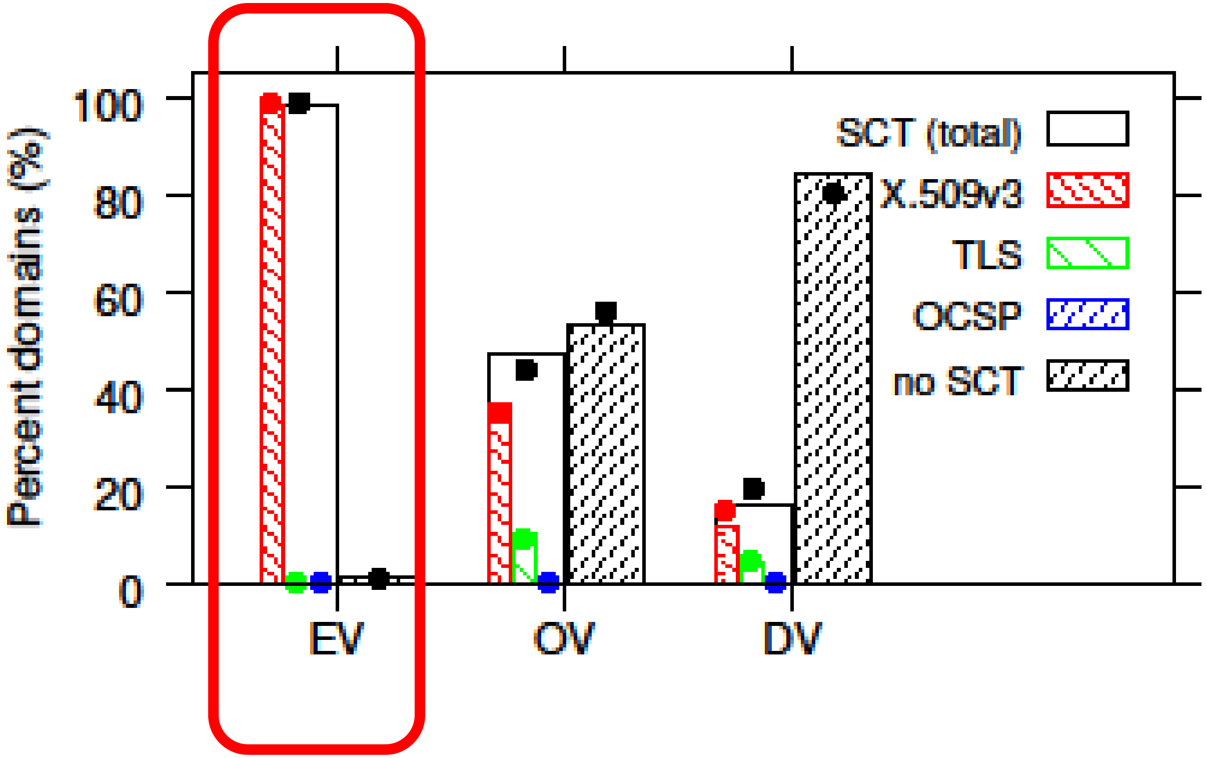

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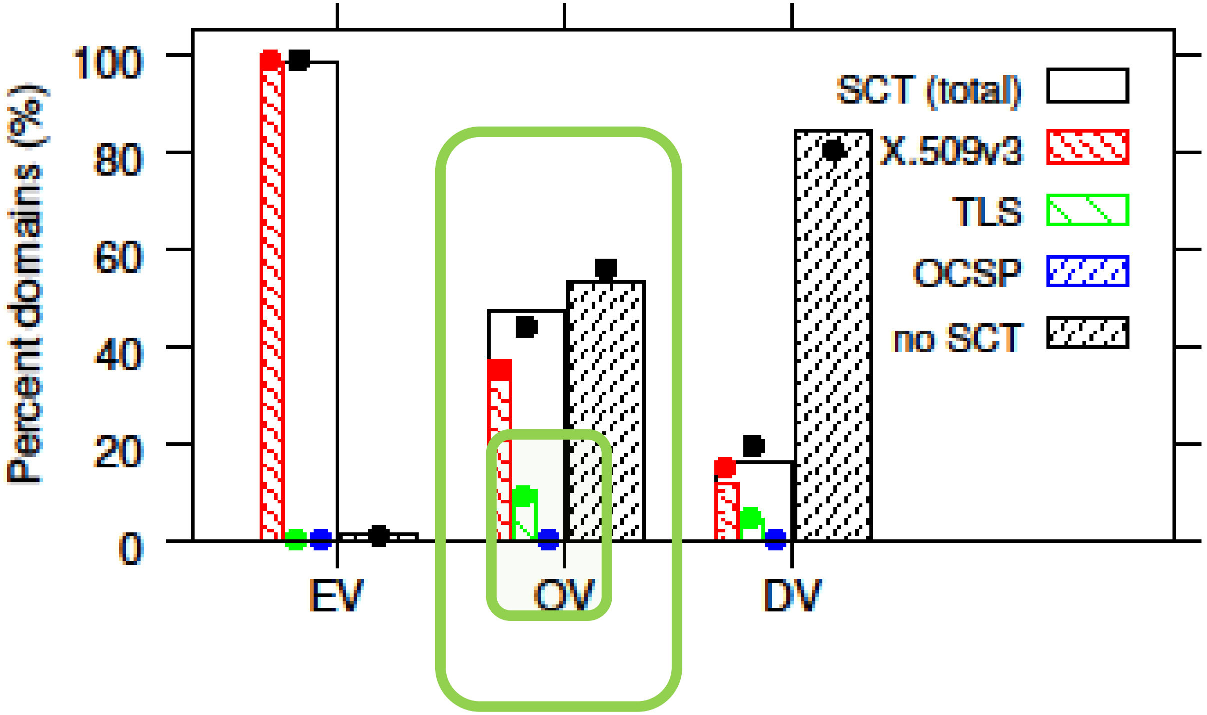

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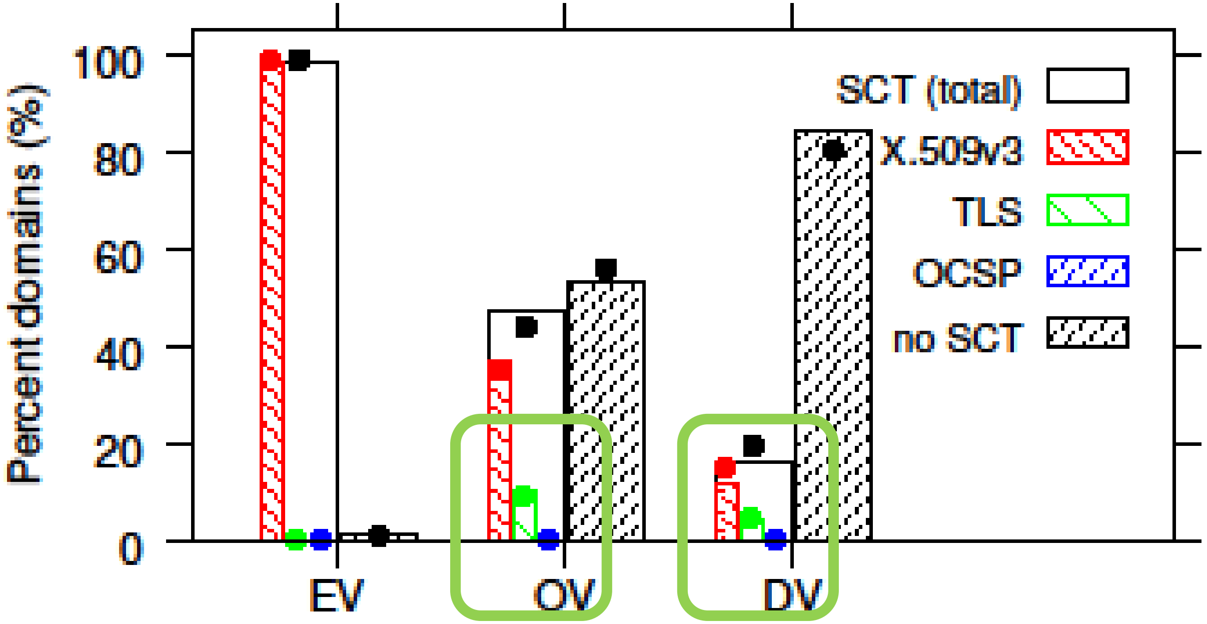

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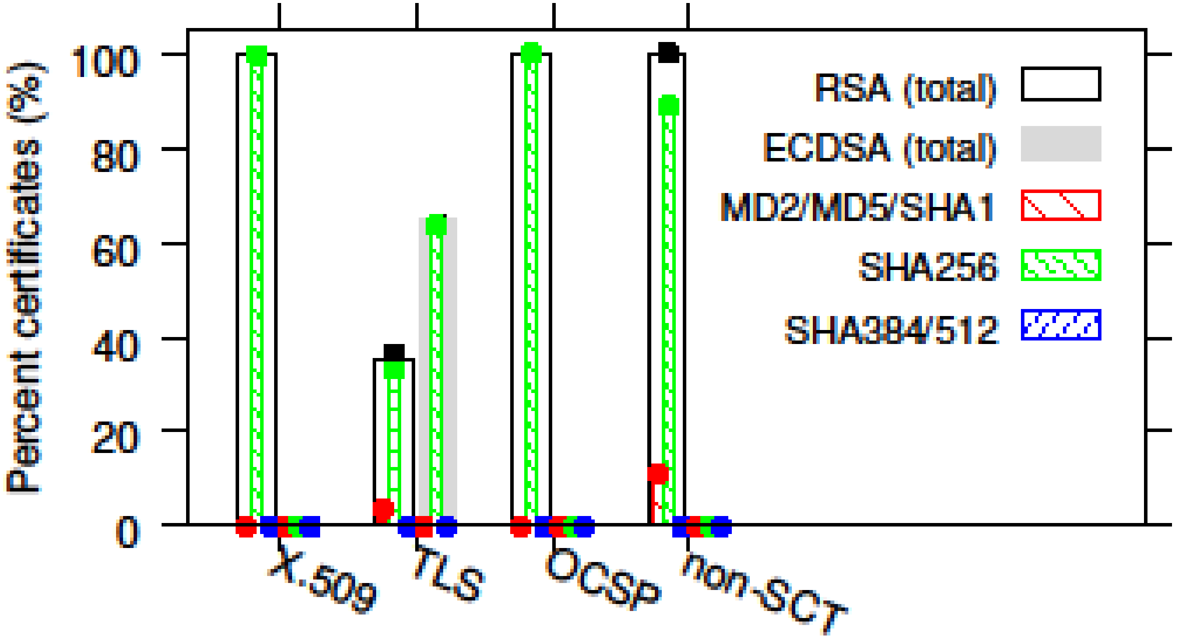
Signatures (and keys)



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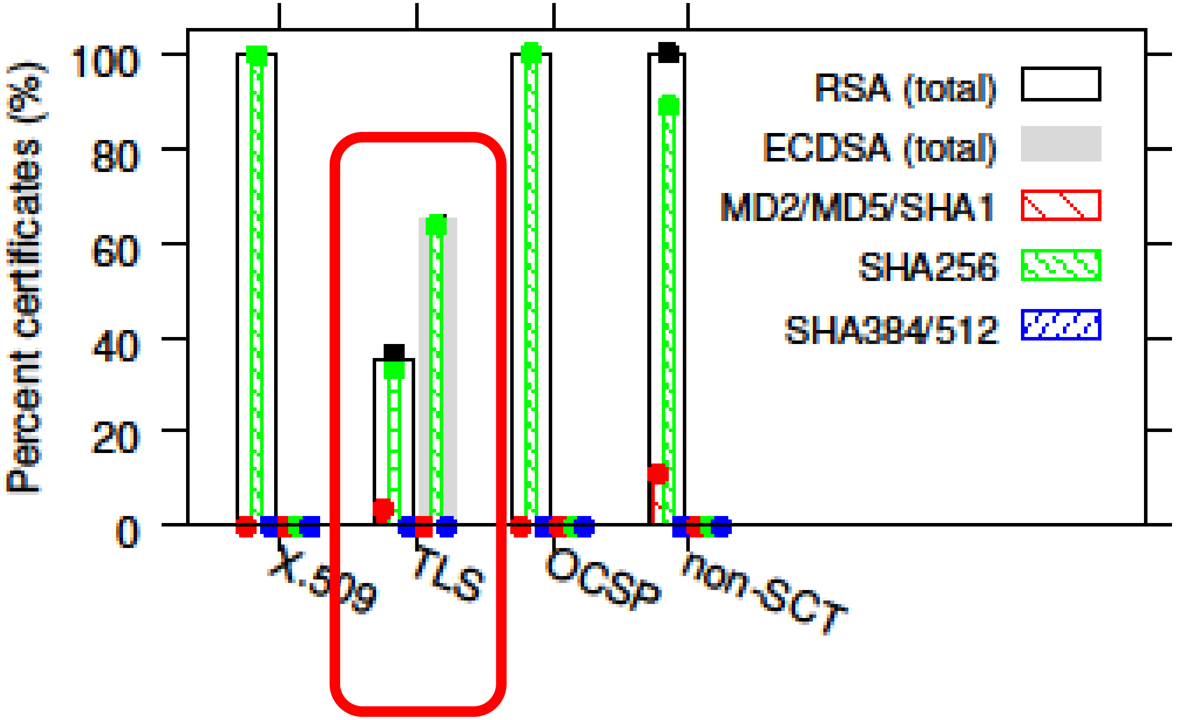

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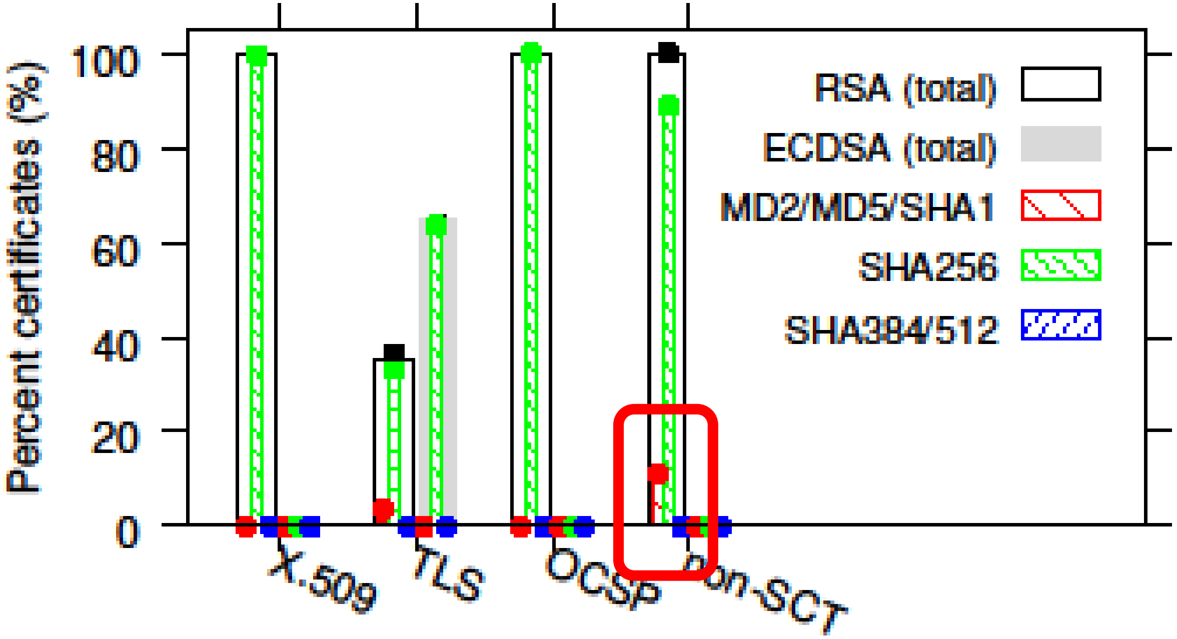

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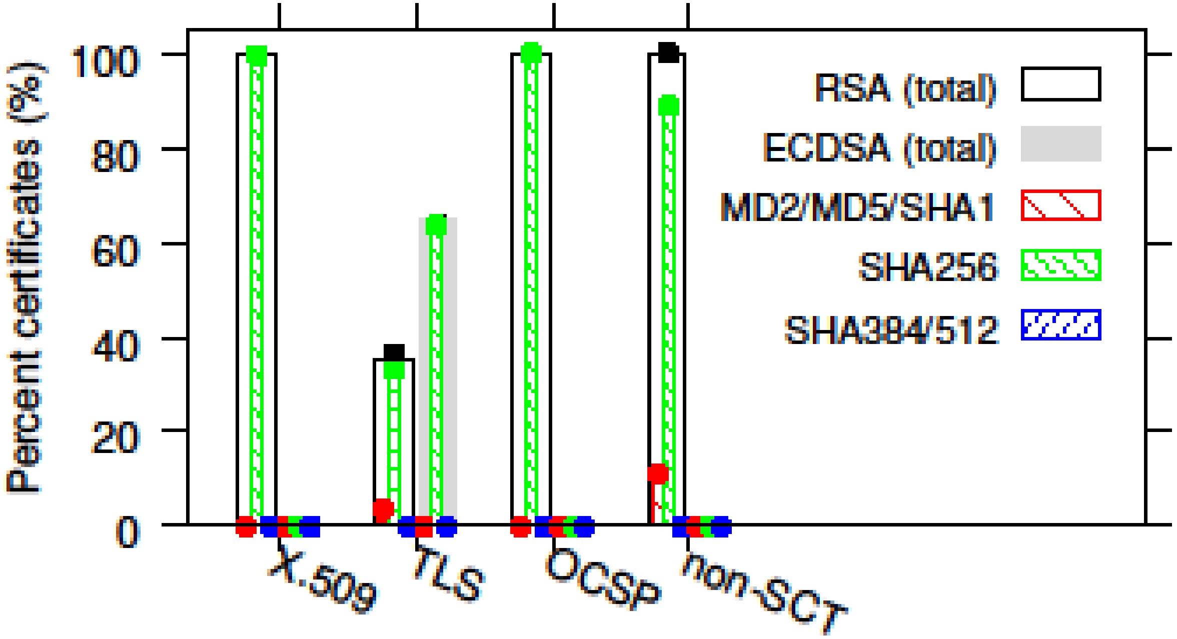

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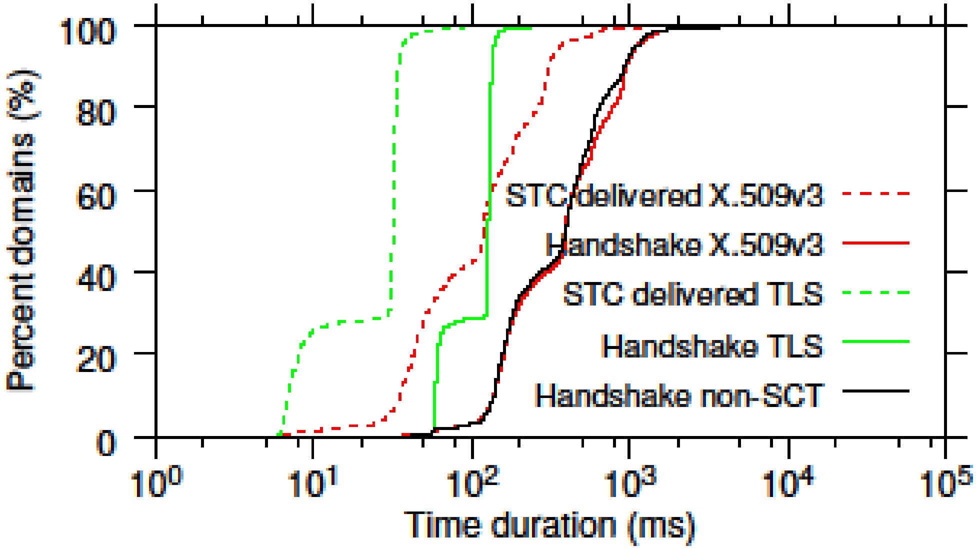
- TLS much faster than the other methods
- X.509v3 similar to non-SCT



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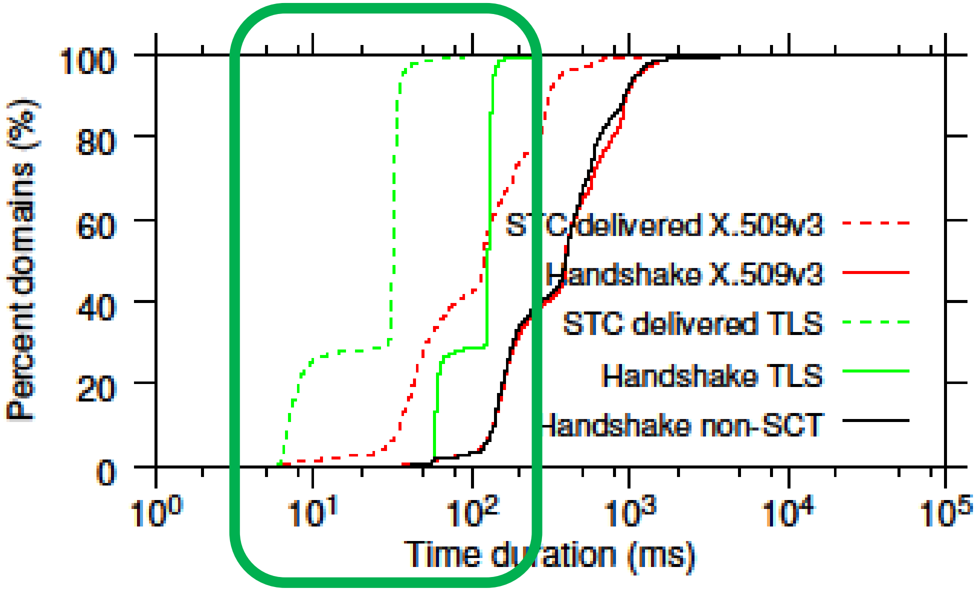

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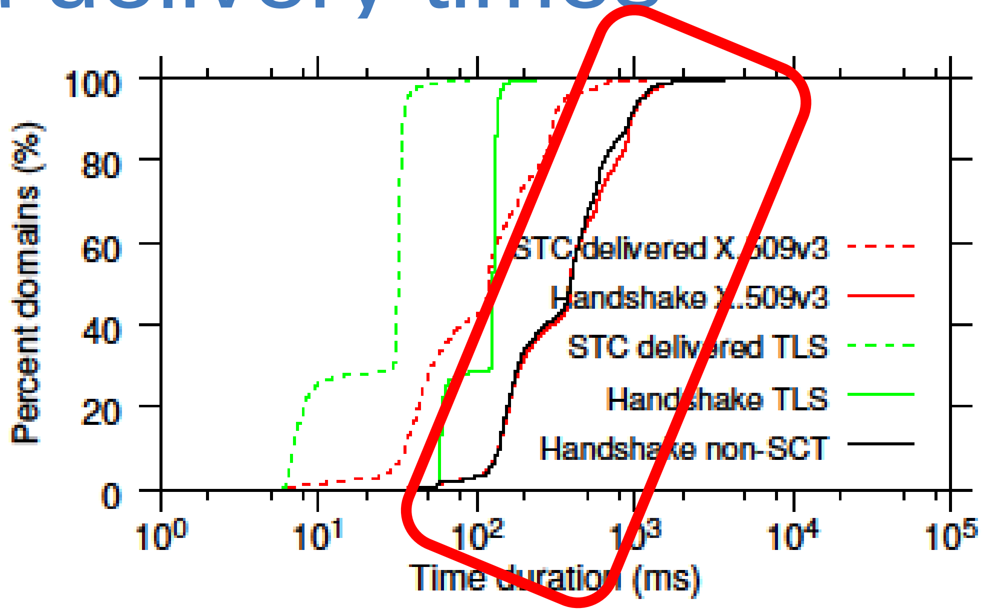

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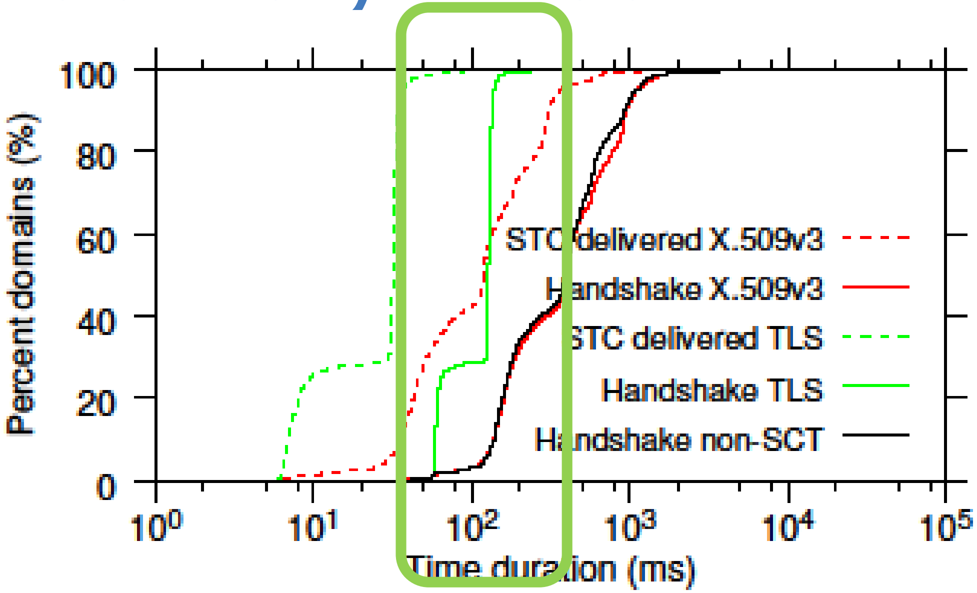
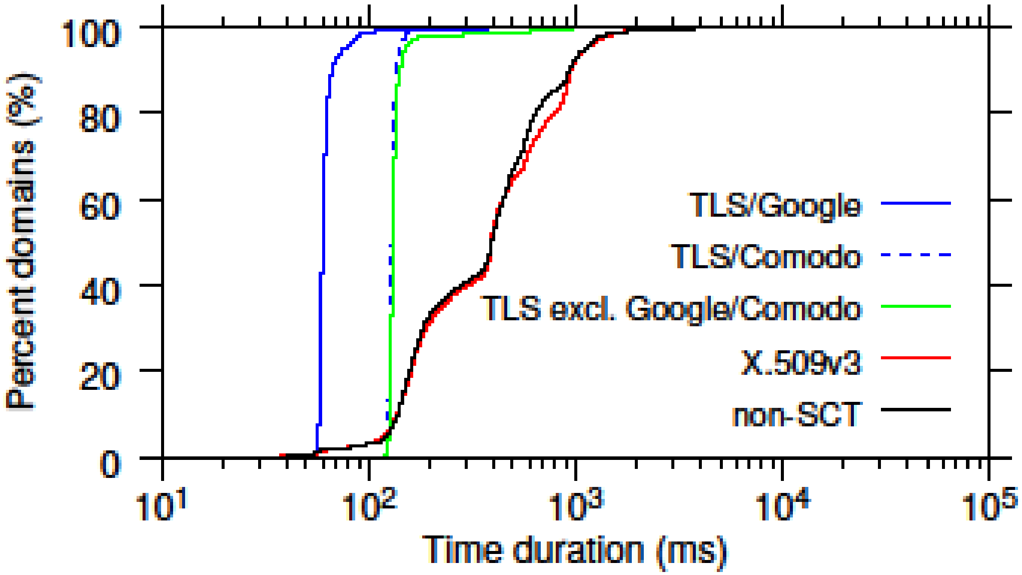
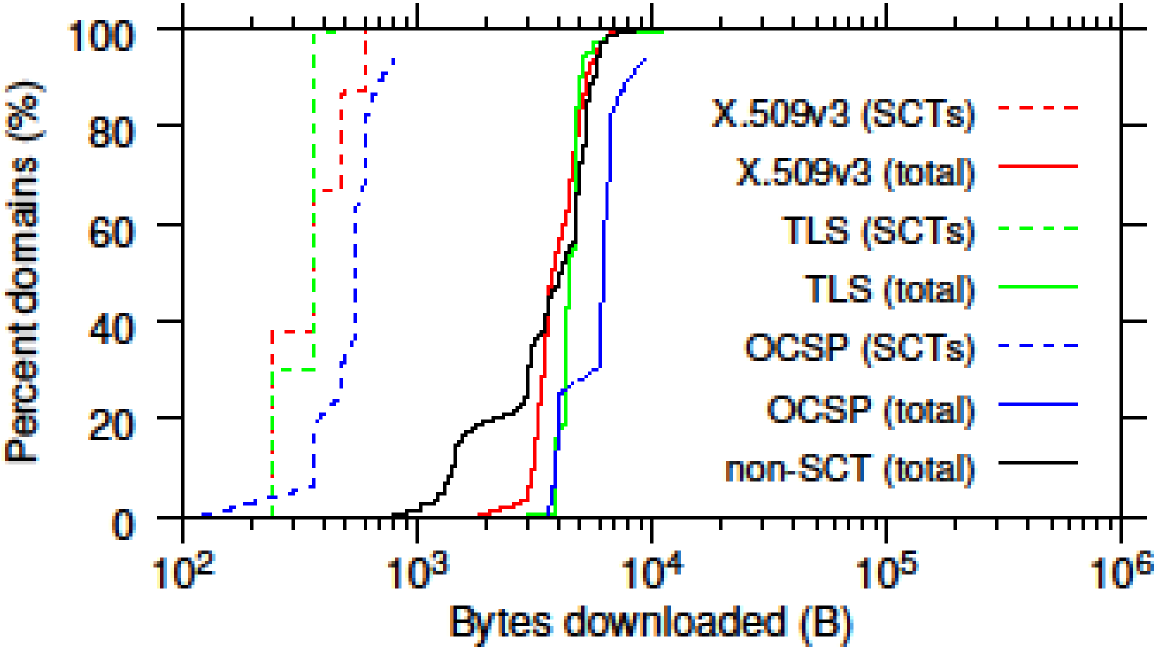


- Google fastest, with short tail
- Comodo and other TLS domains both outperform X.509 domains



Byte overhead



- The SCT bundles have negligible byte overhead
- Otherwise SCT byte differences mostly due to bundle sizes and other differences dominated by the certificates themselves (keys included)

Conclusions

- SCT analysis: current status and trend
  - Two snapshots (May and Oct. 2017) of Alexa top-1M
- SCT usage is highest among the very top domains, hopefully pushing others to follow
  - Majority of domains selects simplest solution (X.509v3)
  - Fastest delivery method (TLS) is used by organizations (e.g., Google) that appear to provide much faster connection establishment and handshake times
- SCT delivery has low overhead
- Positive and encouraging trends in the adoption
  - Overall increase in use of SCTs
  - Use of SCTs goes hand-in-hand with a reduced use of weak signatures and public keys
  - Big players such as Google are pushing the adoption

Thanks for listening!

Server-side Adoption of Certificate Transparency

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