Multi-operator DNSSEC signing system

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TU Darmstadt

ICANN69

Based on work published at ESORICS'20
with Anders Dalskov, Marcel Keller, Claudio Orlandi and Haya Shulman

Outline

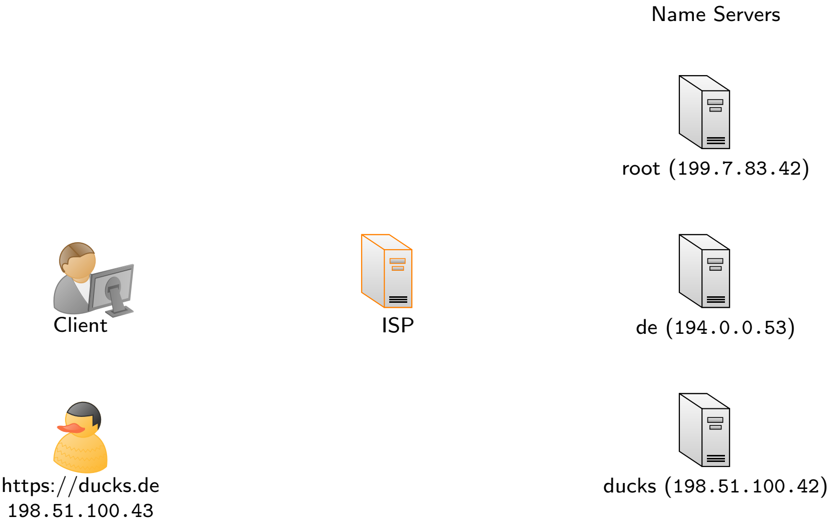
DNS

DNSSEC

Multi-operator DNSSEC signing system

DNS resolution

DNS is a protocol for mapping names to addresses



Name Servers

root (199.7.83.42)

Client

ISP

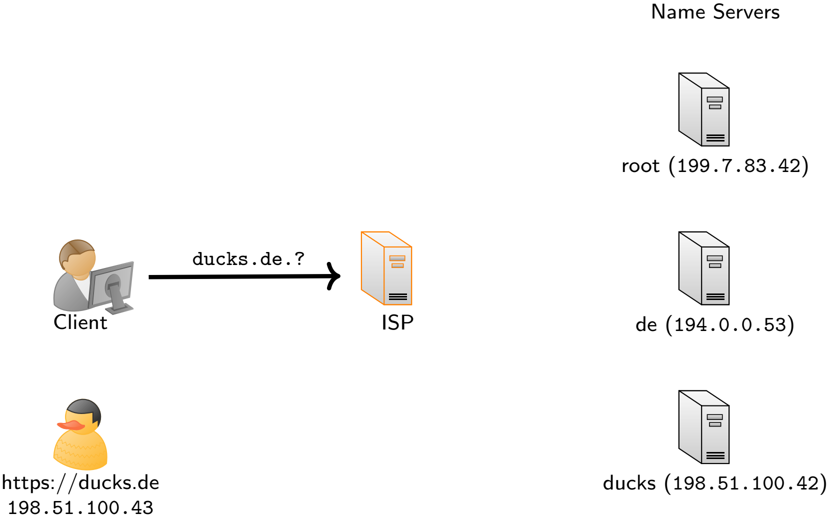
de (194.0.0.53)

https://ducks.de
198.51.100.43

ducks (198.51.100.42)

DNS resolution

Recursive query to the ISP



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de (194.0.0.53)

ducks (198.51.100.42)

Client

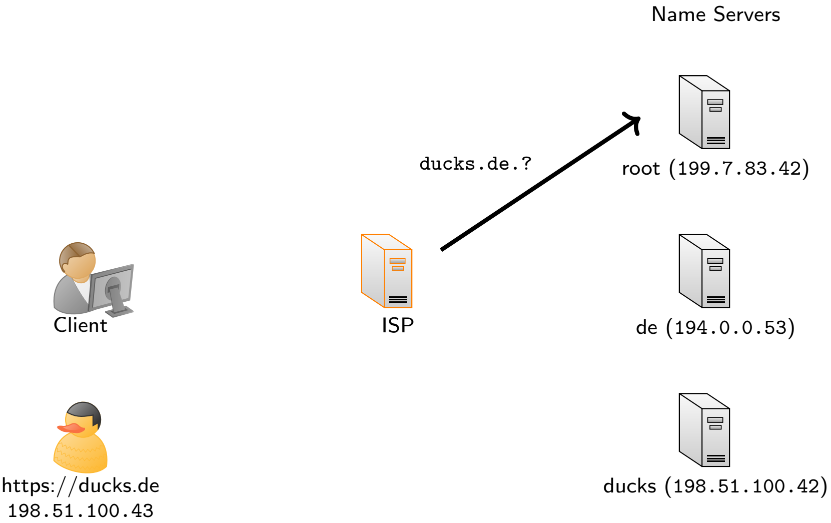
ducks.de.?

ISP

https://ducks.de
198.51.100.43

DNS resolution

Iterative query to the root NS



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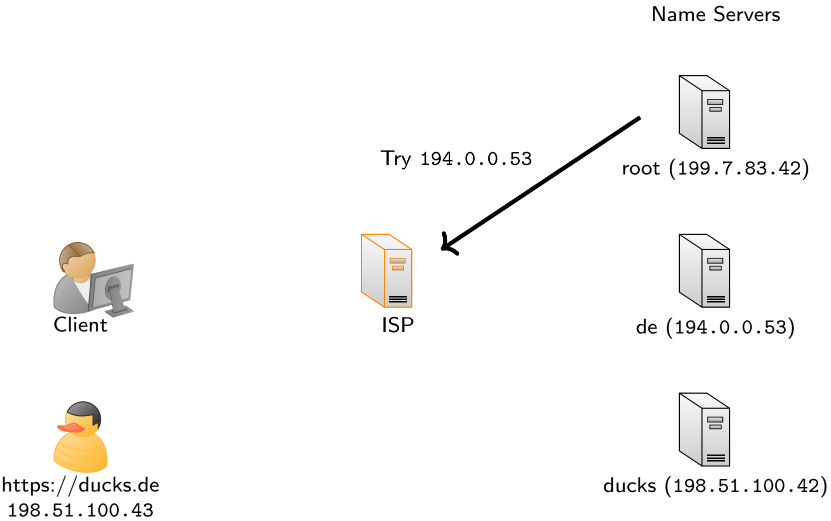

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Try 194.0.0.53

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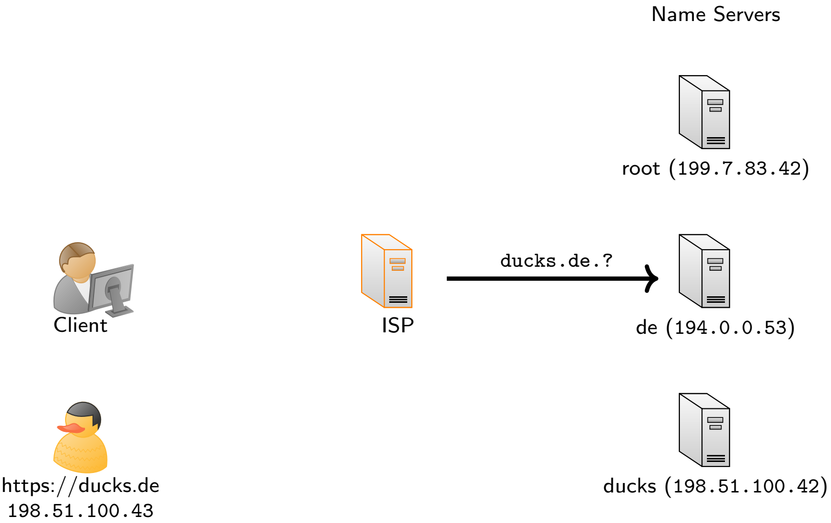
198.51.100.43

ducks (198.51.100.42)

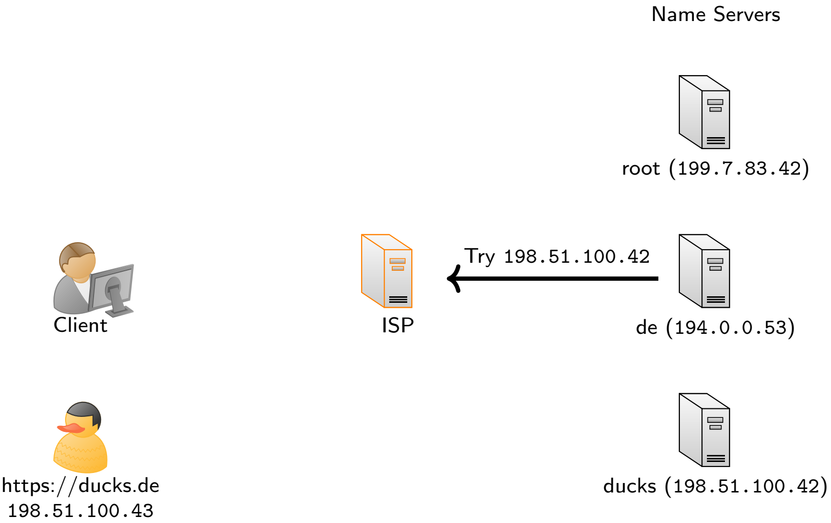
DNS resolution

Iterative query to the de NS



DNS resolution

Iterative query to the de NS



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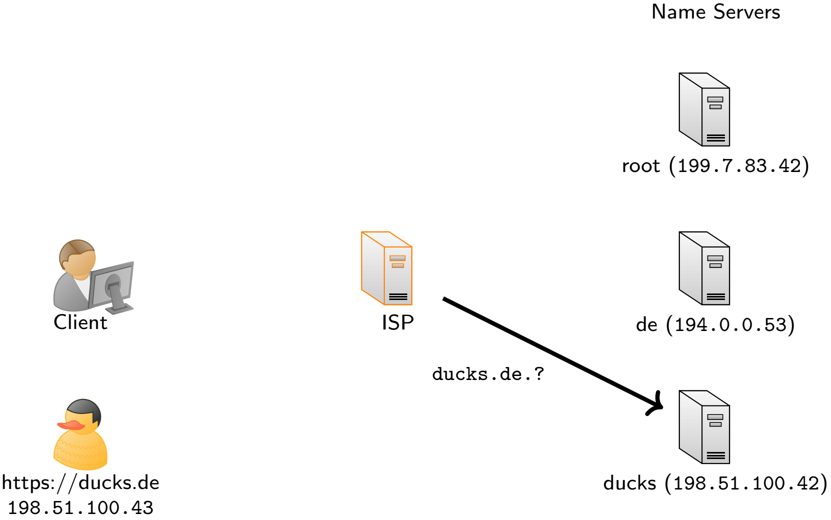
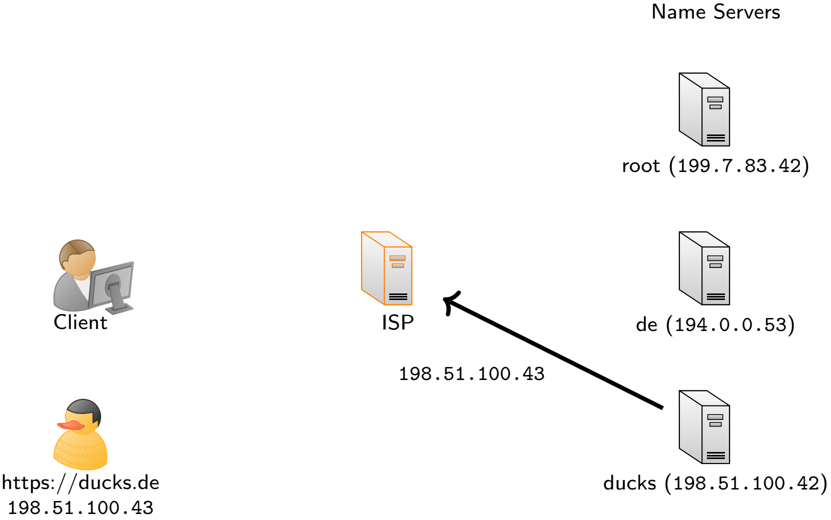


DNS resolution

Iterative query to the ducks NS



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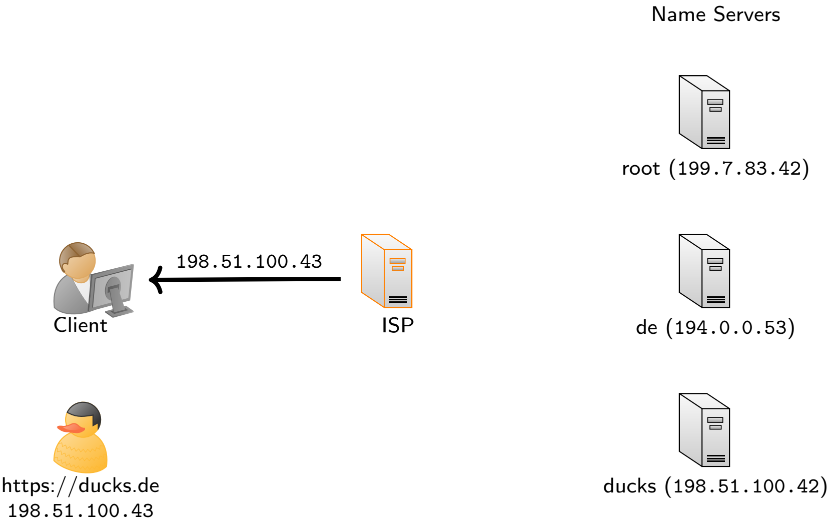
DNS resolution

ISP responds to the recursive query



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198.51.100.43

Client

ISP

https://ducks.de
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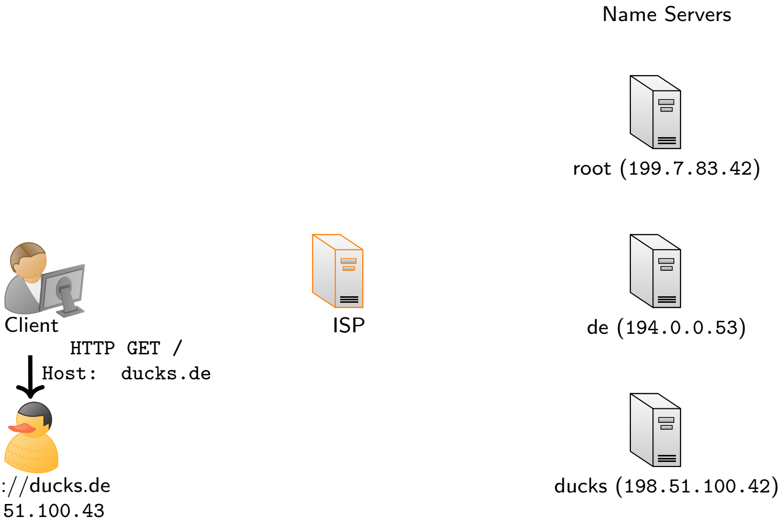
DNS resolution

HTTP request



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HTTP GET /
Host: ducks.de

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DNS Insecurity

Poisoning/Spoofing is possible

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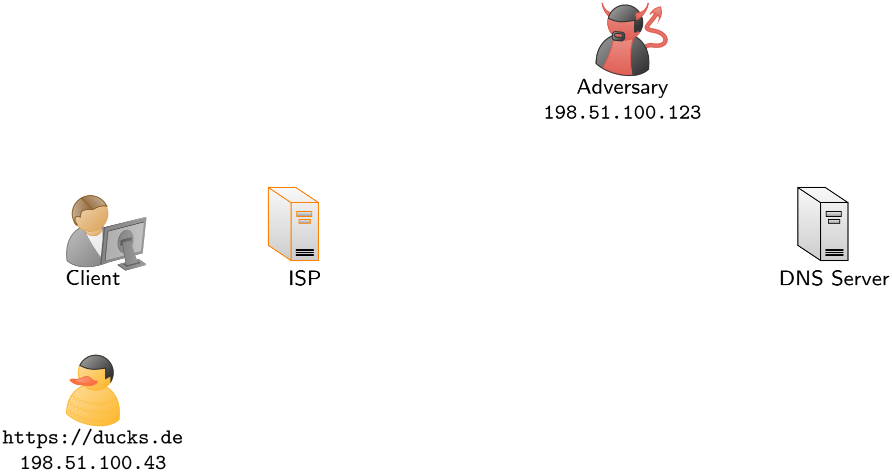

Adversary
198.51.100.123

Client

ISP

DNS Server

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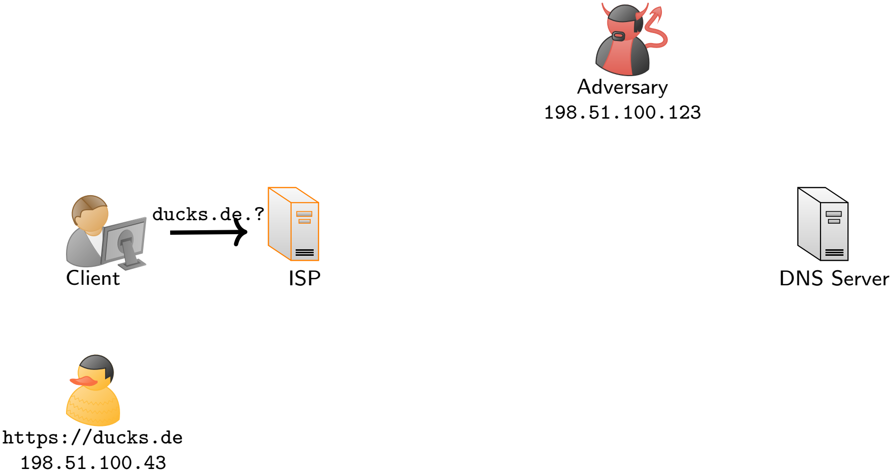

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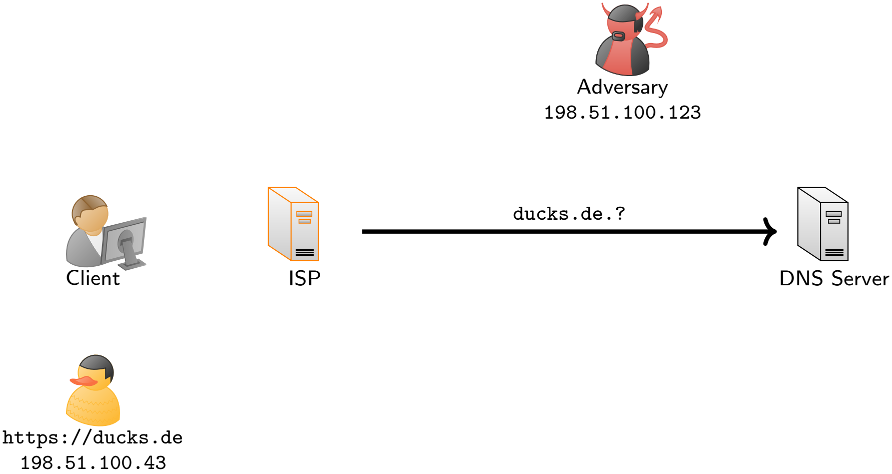

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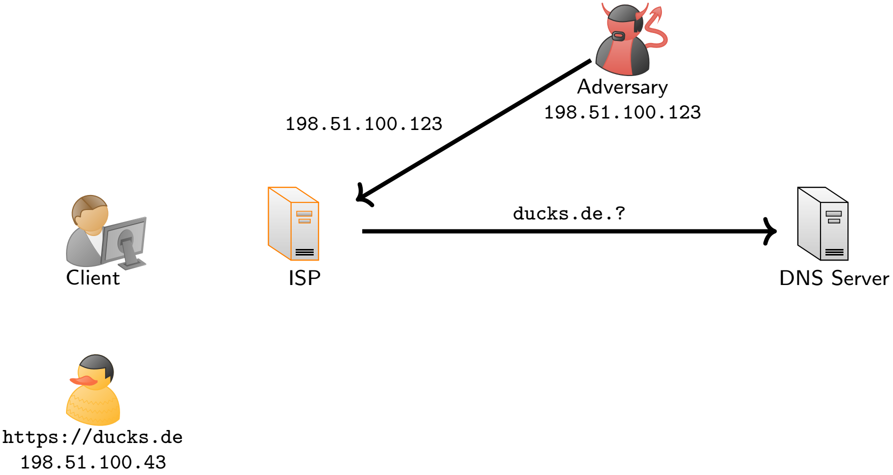

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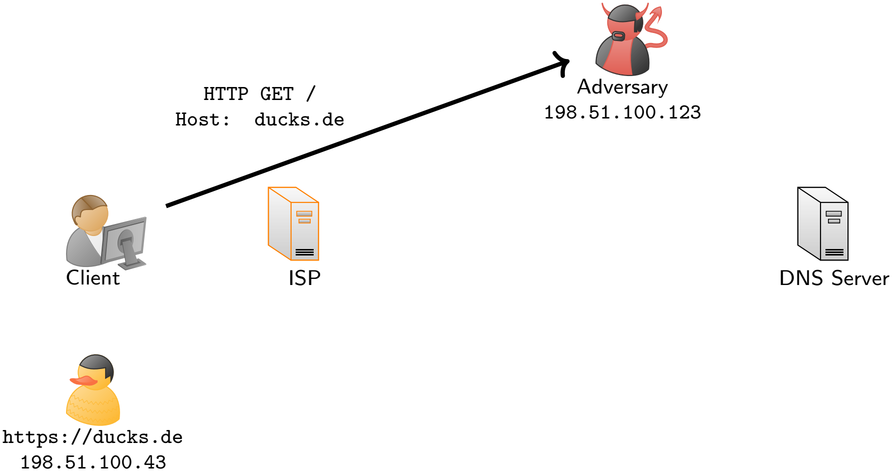

Outline

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Multi-operator DNSSEC signing system

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- Data integrity: data was not changed in transit

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- Origin authentication: data originated from the owner

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Basically certificates for DNS

DNSSEC deployment issues

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Studies [1][2] have found that

[1] A Longitudinal, End-to-End View of the DNSSEC Ecosystem (USENIX '17)

[2] One Key to Sign Them All Considered Vulnurable: Evaluation of DNSSEC in the Internet (NSDI '17)

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  - E.g., one key shared by $> 132\,000$ domains
- Default is 1024-bit RSA
  - Most keys 1024-bit, with $\sim$10K domains use 512-bit RSA

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DNSSEC in practice

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- Should use ECDSA instead of RSA
  - Shorter signatures at better/same security
  - Reduces the chance of packet fragmentation[1]

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DNSSEC in practice

DNSSEC

- Should use ECDSA instead of RSA
  - Shorter signatures at better/same security
  - Reduces the chance of packet fragmentation[1]

- Support multiple DNS operators
  - provides DDoS protection[2]
  - better availability

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[2] E.g., attacks on Dyn and NS1 in 2016

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DNSSEC

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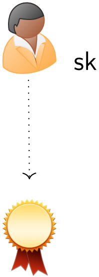
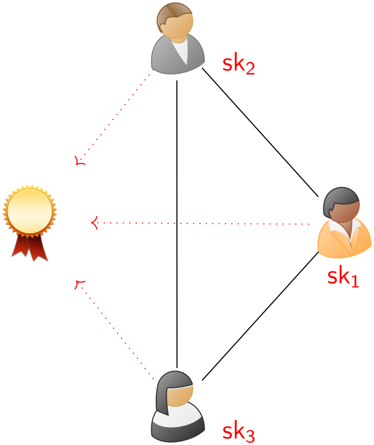
Traditional Signatures



Threshold Signatures

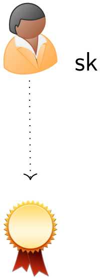
$\{\mathsf{sk}_1, \mathsf{sk}_2, \mathsf{sk}_3\} \leftarrow \mathit{Share}(\mathsf{sk})$



MPC

Threshold Signatures

Traditional Signatures



Indistinguishable

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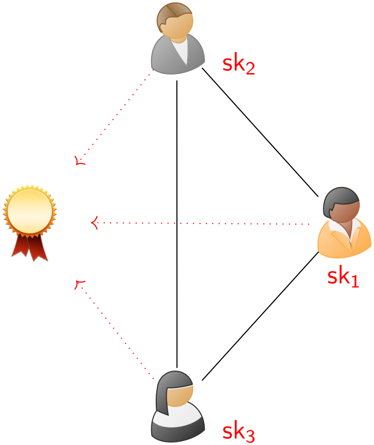
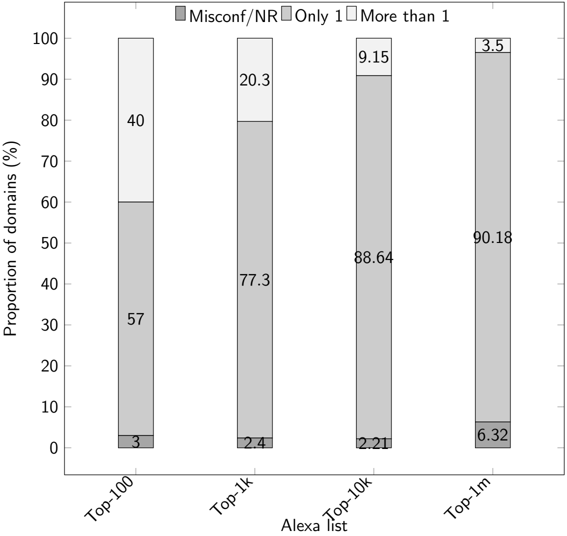


Measurement



Threshold signatures for DNSSEC

Zone signing with Threshold ECDSA

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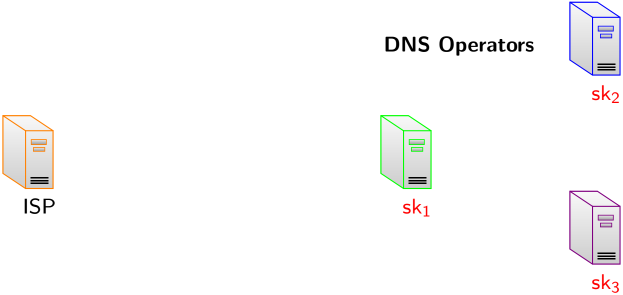

DNS Operators

Threshold signatures for DNSSEC

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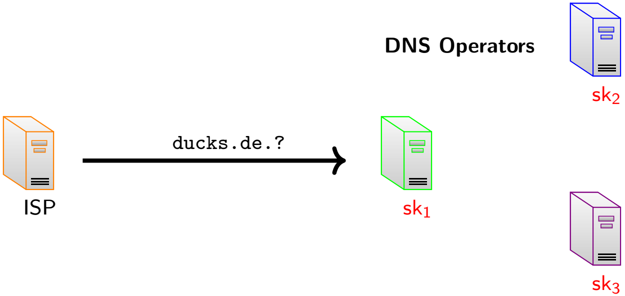

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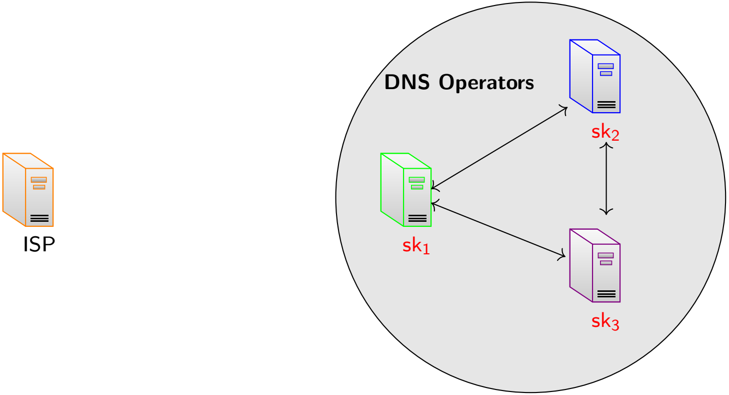

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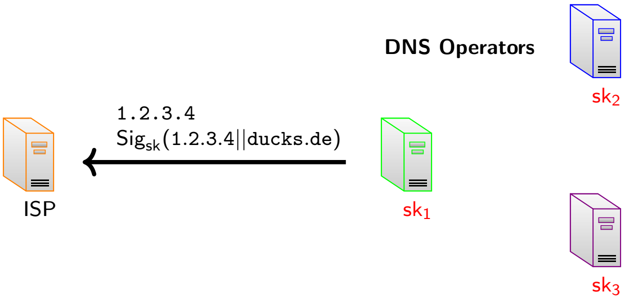

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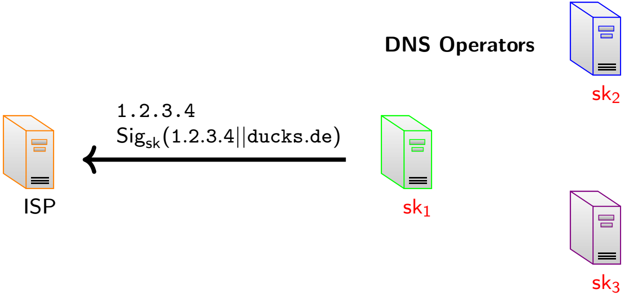

Threshold signing should not be much more expensive than regular DNSSEC

ECDSA

$$s = k^{-1}(H(M) + \mathsf{sk} \cdot r_x)$$

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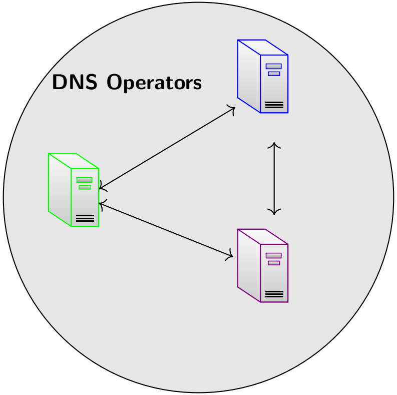
Threshold ECDSA

$$s = H(M)[k^{-1}] + [\mathsf{sk} \cdot k^{-1}] \cdot r_x$$

Threshold Signature in 3 phases



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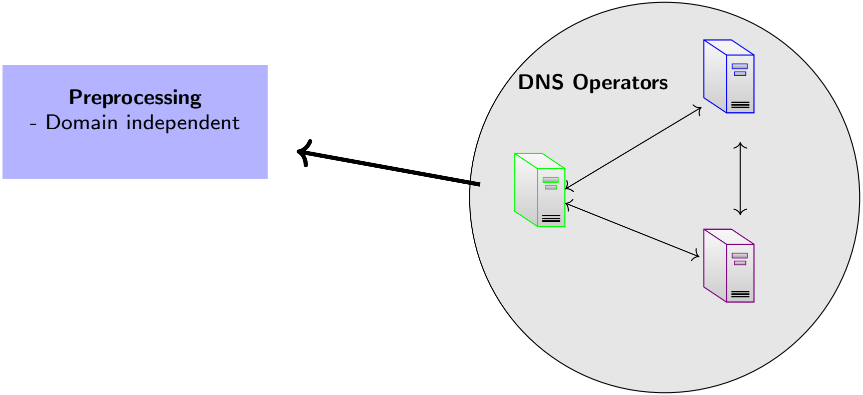
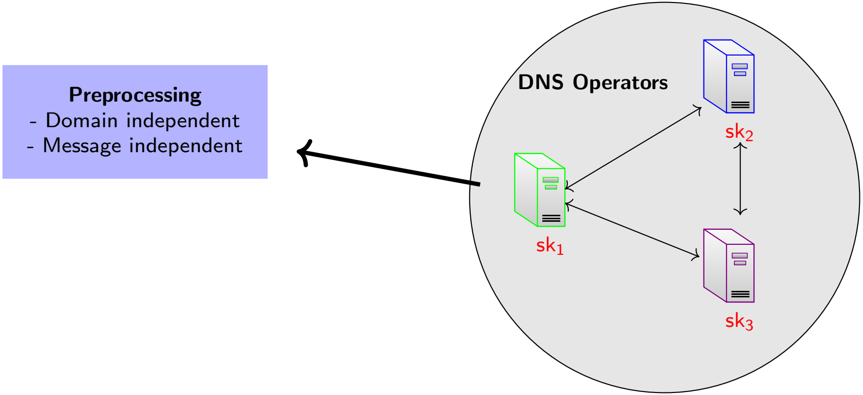


Preprocessing
- Domain independent

DNS Operators

Threshold Signature in 3 phases



Preprocessing
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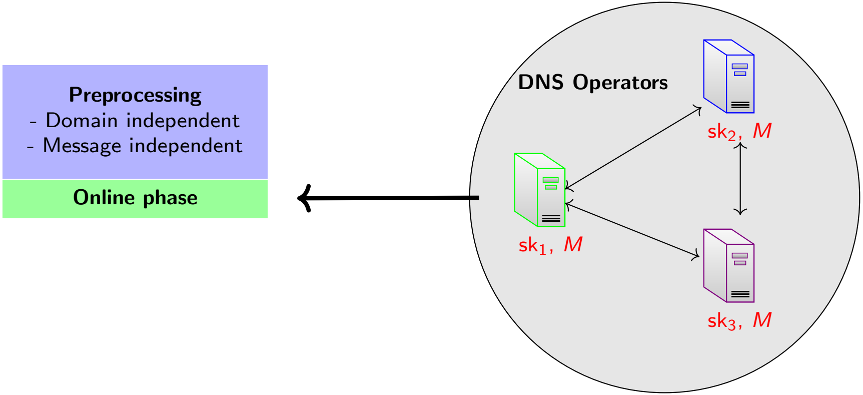

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Online phase

DNS Operators

$\mathsf{sk}_1,\ M$

$\mathsf{sk}_2,\ M$

$\mathsf{sk}_3,\ M$

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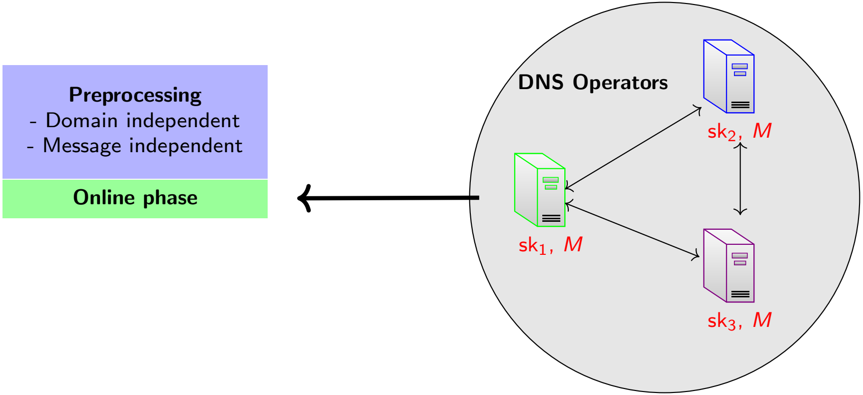

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Full paper: `ia.cr/2019/889`