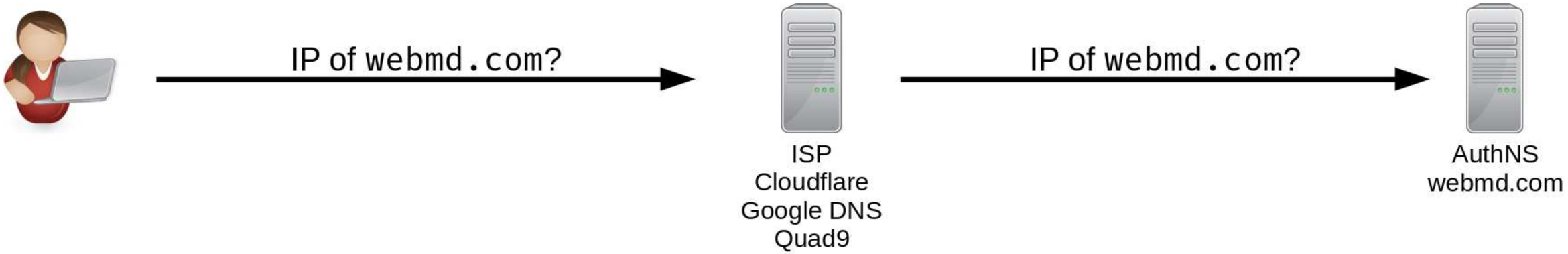
CISPA
HELMHOLTZ CENTER FOR INFORMATION SECURITY

Padding Ain't Enough: Assessing the Privacy Guarantees in Encrypted DNS

Jonas Bushart, Christian Rossow

Privacy of DNS



RFC 7858: Specification for DNS over Transport Layer Security (TLS)
RFC 8484: DNS Queries over HTTPS (DoH)

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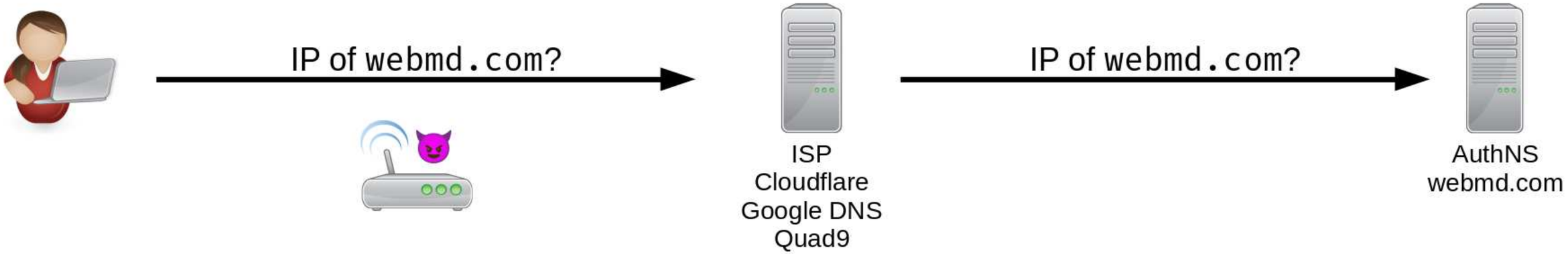

- Passive Adversary
  - Wi-Fi point, ISP, etc.

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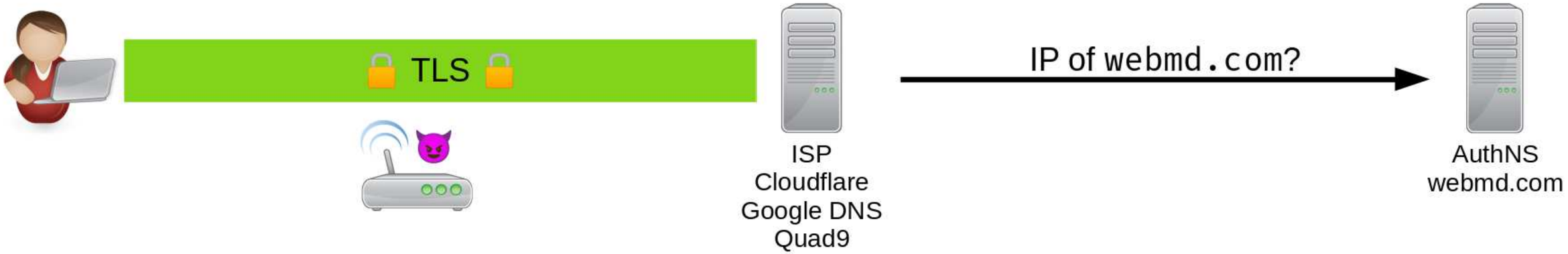

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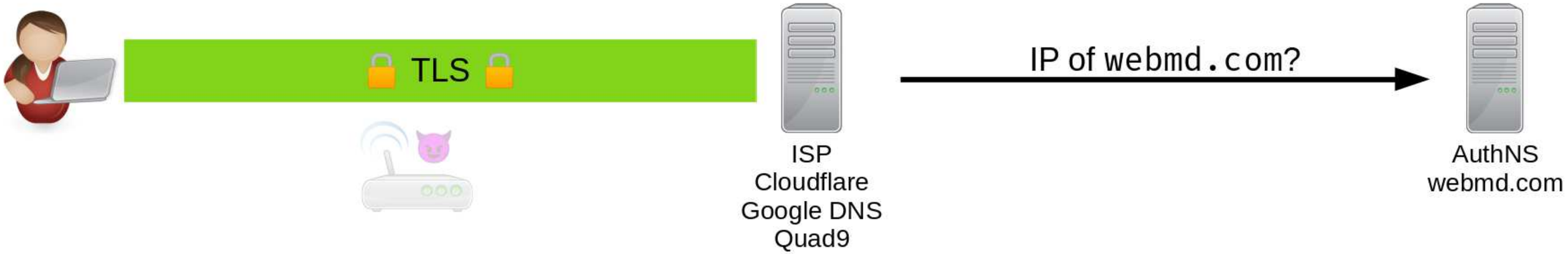

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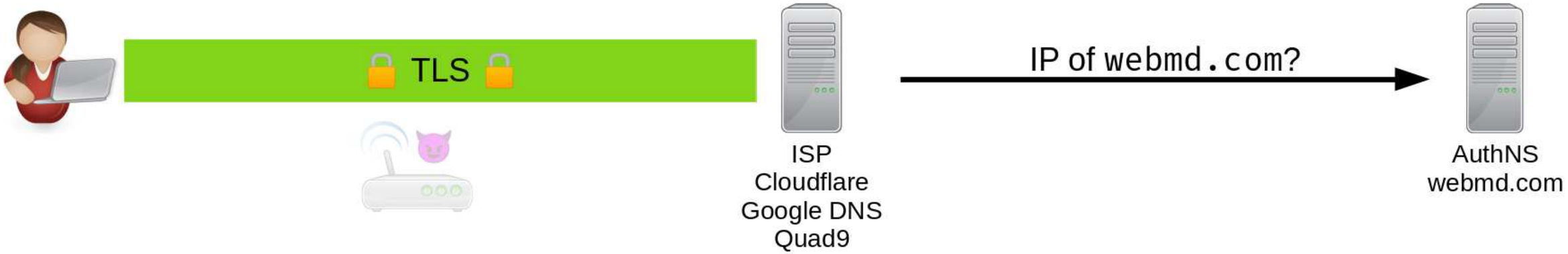

- Passive Adversary
  - Wi-Fi point, ISP, etc.
- Side-Channels

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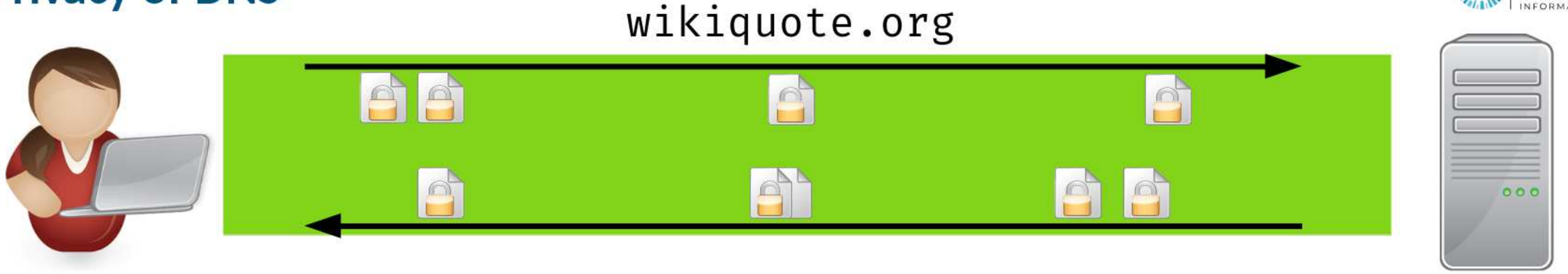

- Threat model like DoT/DoH

RFC 7830: The EDNS(0) Padding Option
RFC 8467: Padding Policies for Extension Mechanisms for DNS (EDNS(0))

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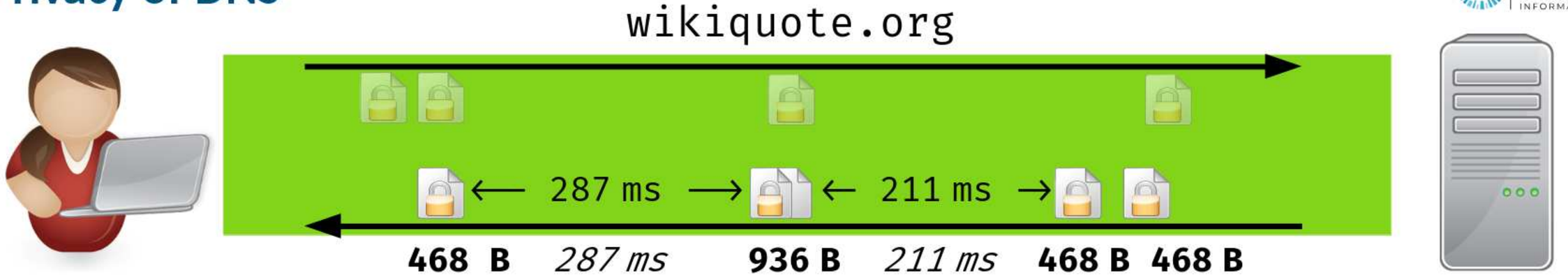

- RFC 8467: Block padding 128B / 468B
- Threat model like DoT/DoH

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Privacy of DNS

- RFC 8467: Block padding 128B / 468B
- k-NN with Edit-Distance
  - Customized weights
- Simple Neural Network
- Threat model like DoT/DoH

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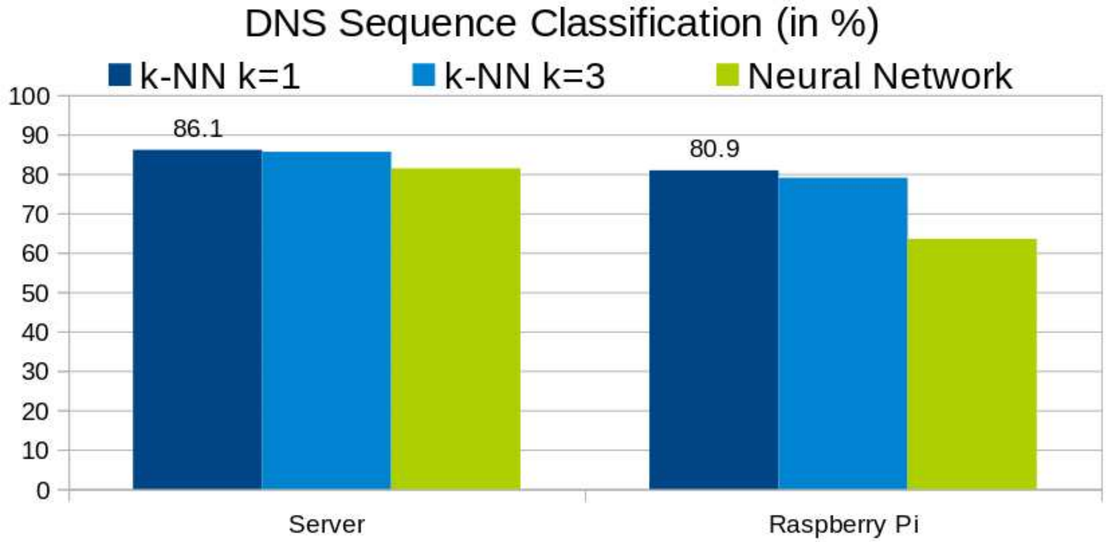
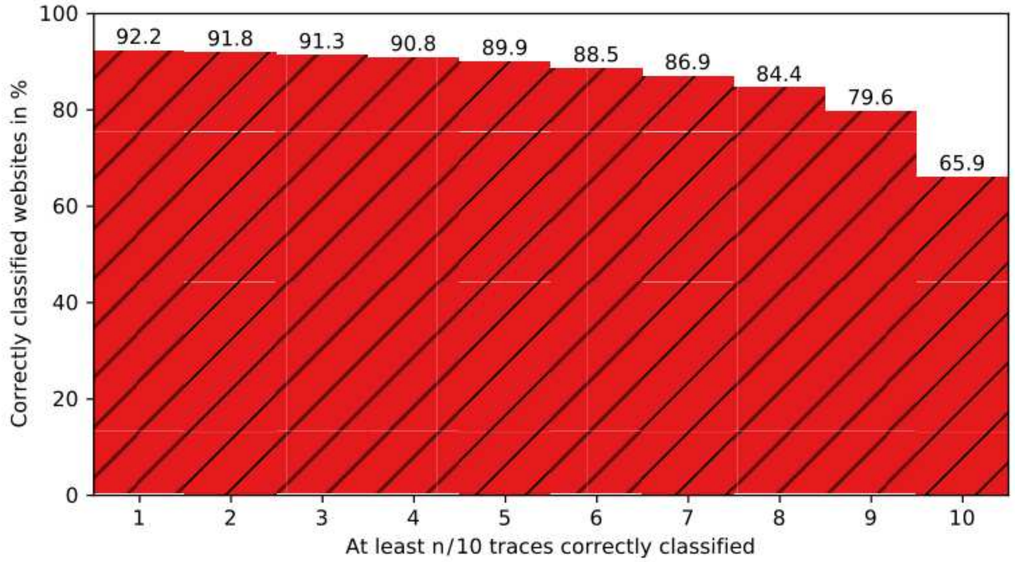
Evaluation: Closed World

- Adversary knows all websites

- Dataset
  - Tranco List
  - 9235 websites / 10 sequences
  - Pi: 7699 websites / 4 sequences
- unbound 1.1.1.1

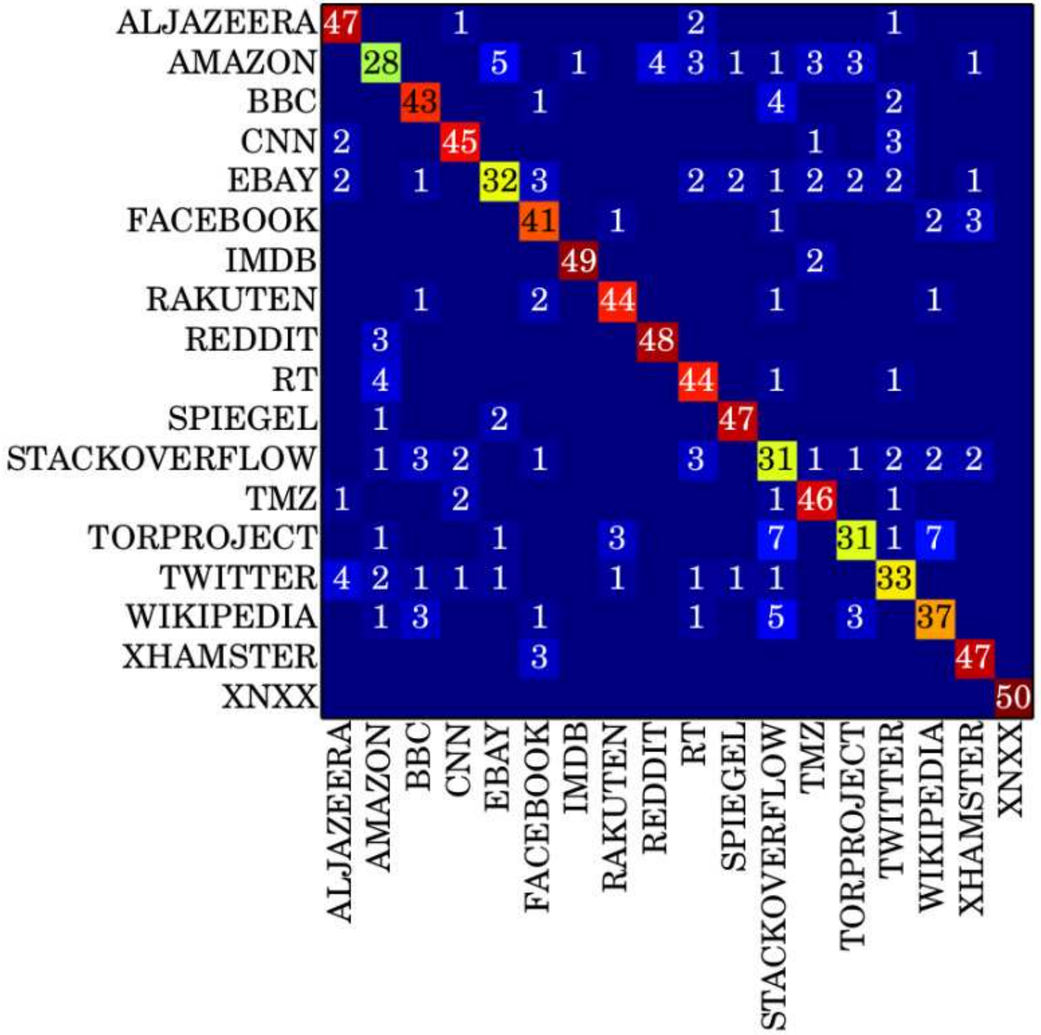


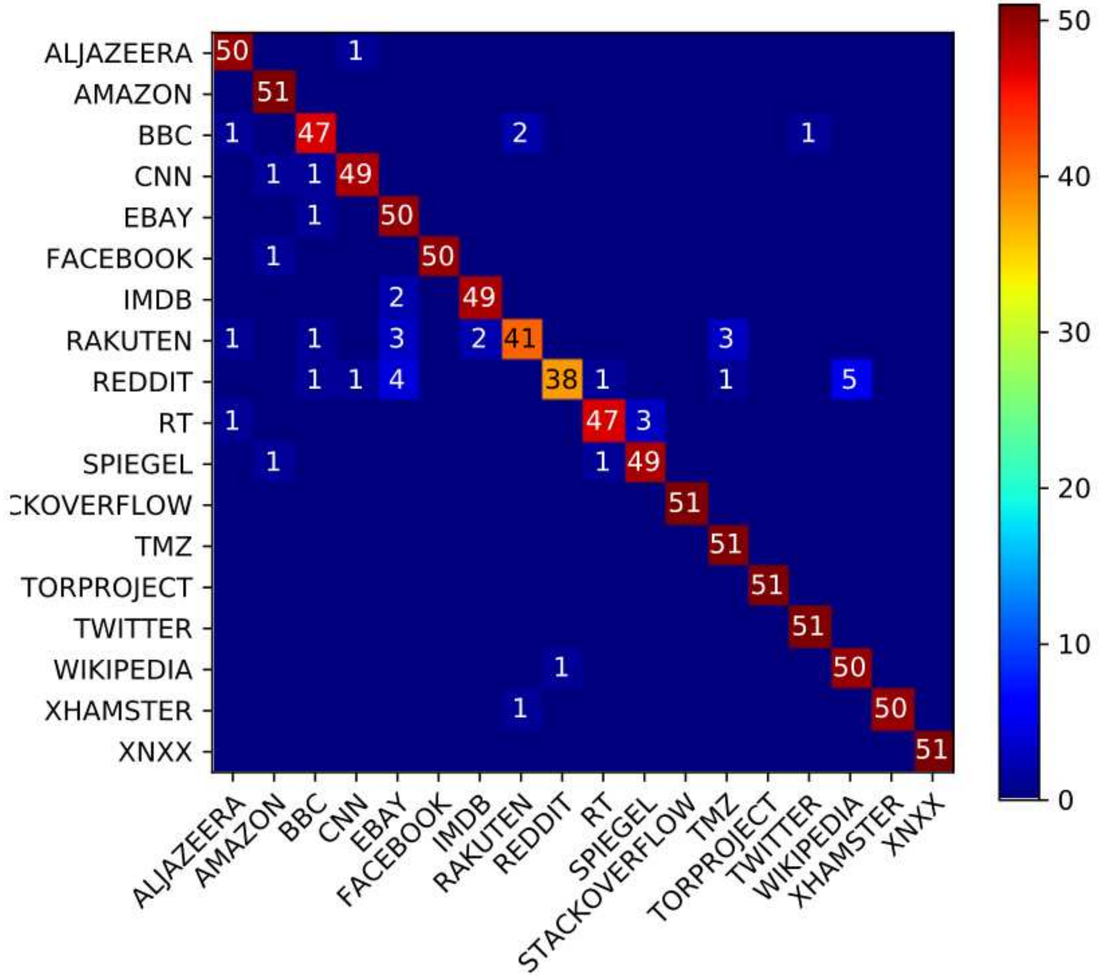


Website Classification

Evaluation: Subpage-Agnostic Domain Classification

Panchenko et al. (2016)





Panchenko et al. “Website Fingerprinting at Internet Scale” NDSS 2016

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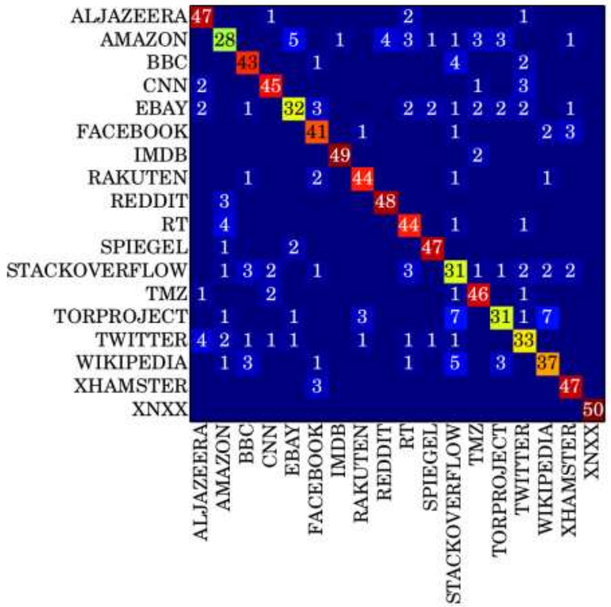
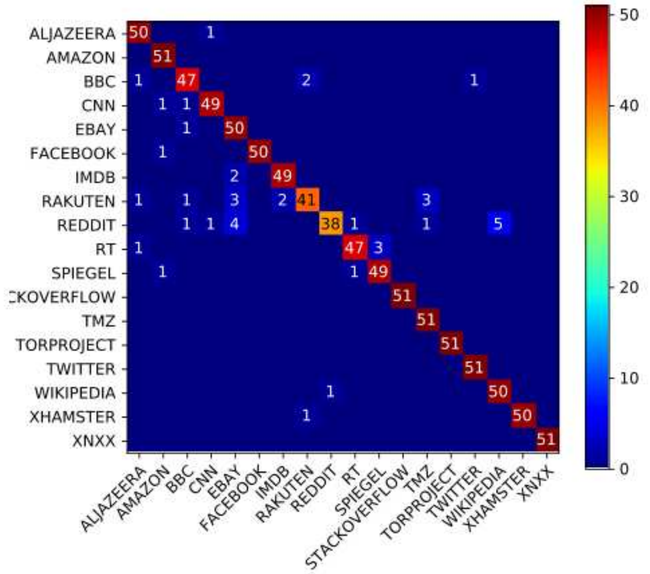


- Index page + 50 random
- 19.1 % vs. 4.7 % error
- Better on 15 / 18 domains
- HTTP
  - variable
  - Sizes + #Resources change
- DNS
  - “stable”
  - Resource domains are stable



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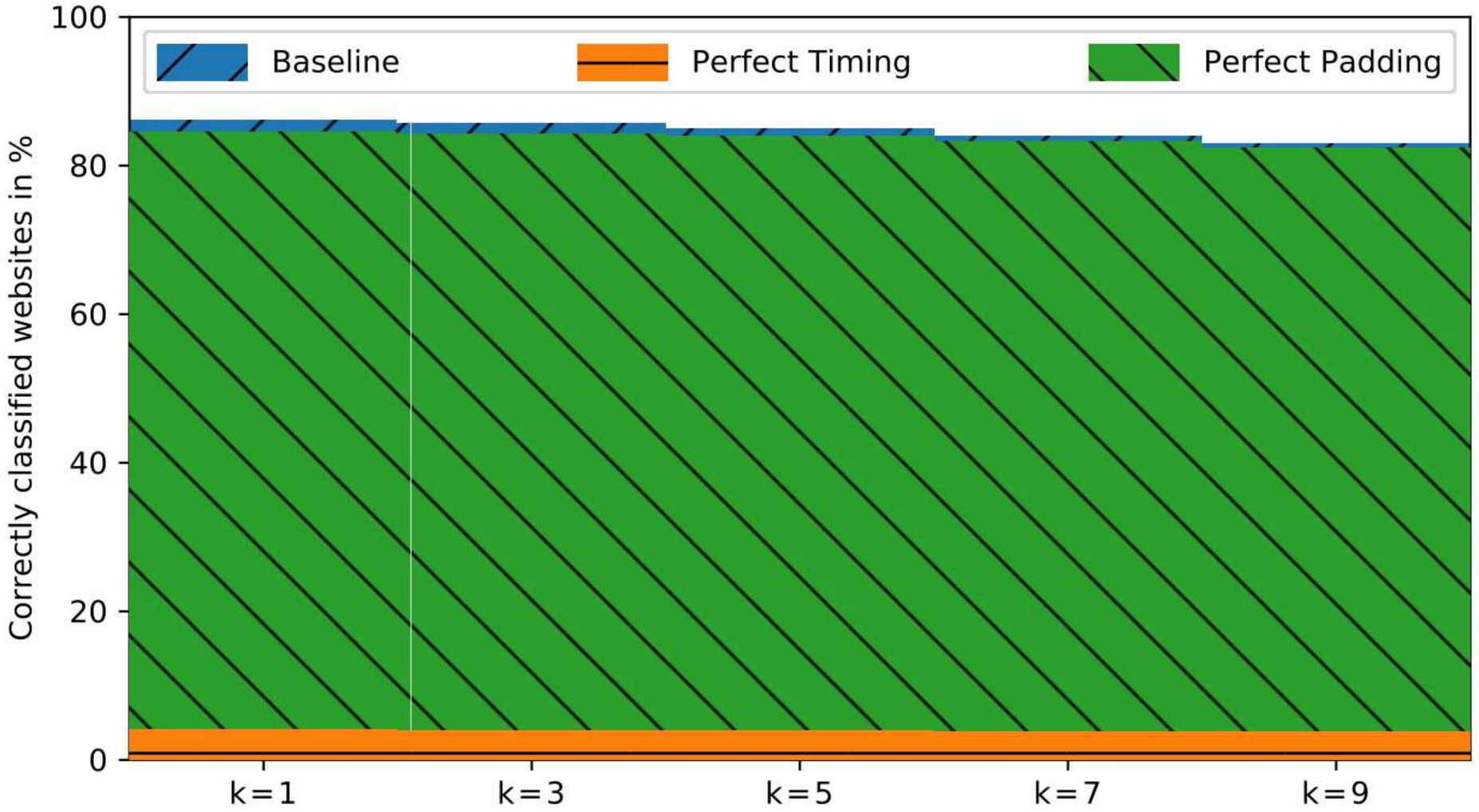
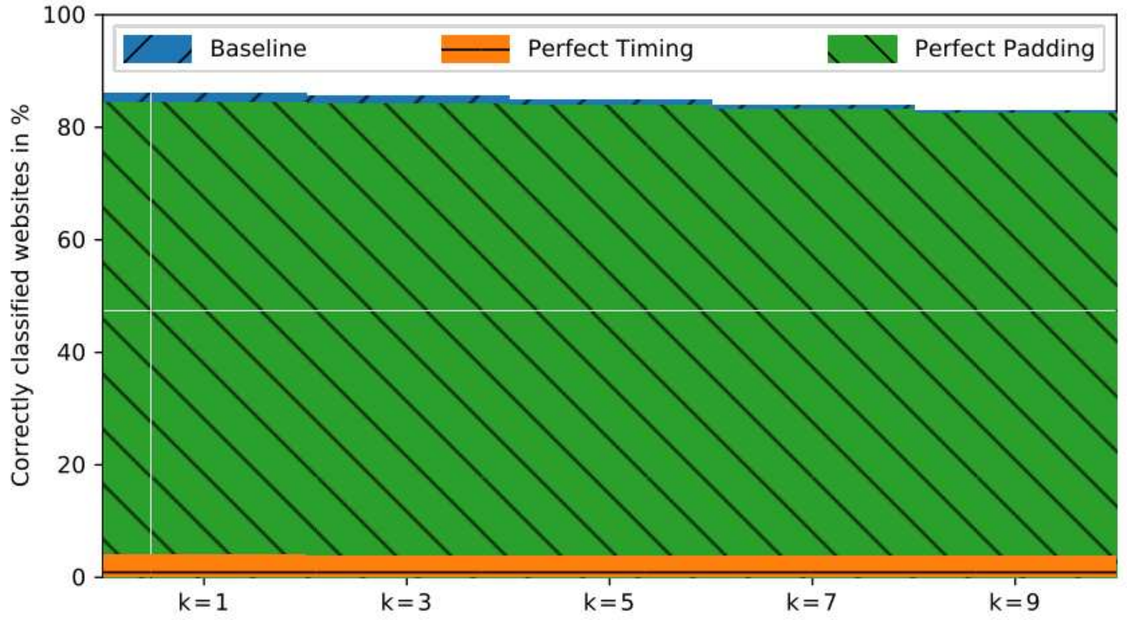
Countermeasures



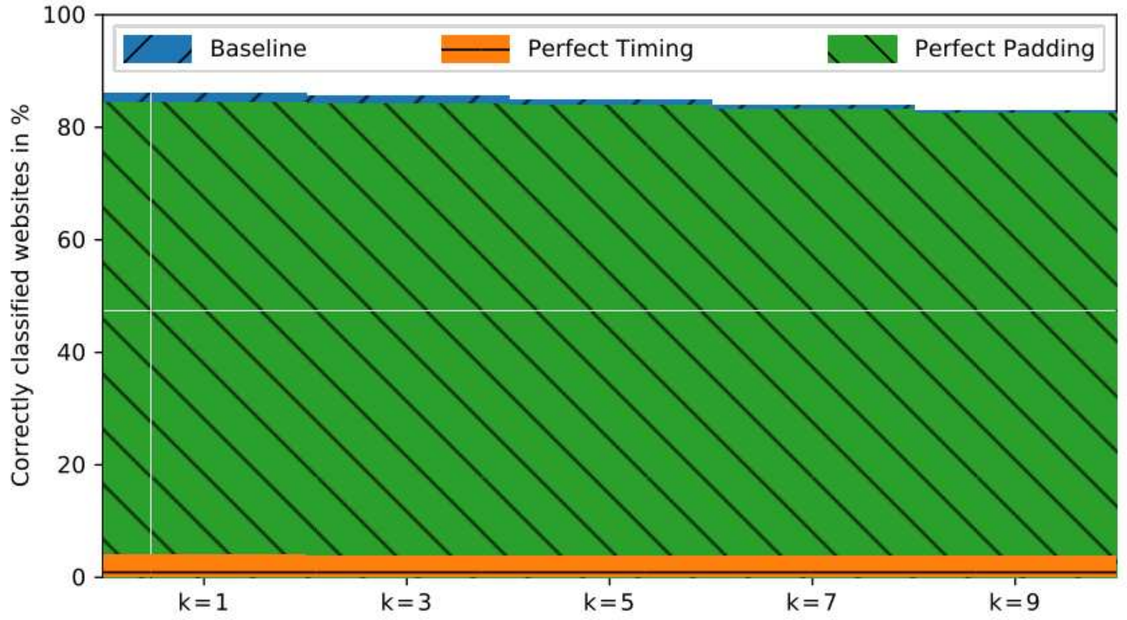
Countermeasures

- More entropy: Timing
- Existing padding scheme is great
  - 99.76 % are 468 bytes



Countermeasures

- More entropy: Timing
- Existing padding scheme is great
  - 99.76 % are 468 bytes
- Timing Defenses
  - Constant-Rate
  - Adaptive Padding[1]



[1] Shmatikov and Wang, “Timing analysis in low-latency mix networks: Attacks and defenses.” 2006

Countermeasures: Overheads

- Constant-Rate (CR)
  - Latency + Bandwidth Overhead
- Adaptive Padding (AP)
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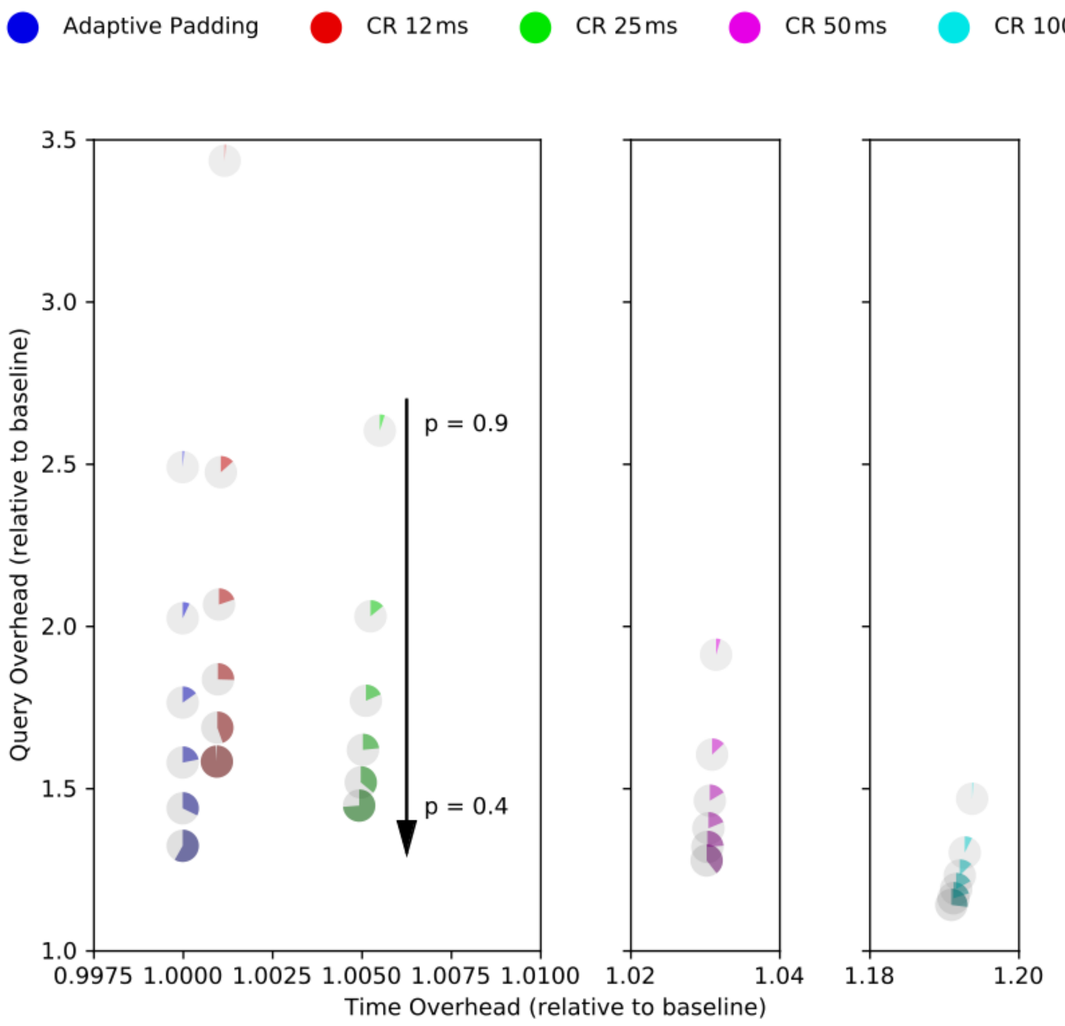

5/10 DNS Sequences correct

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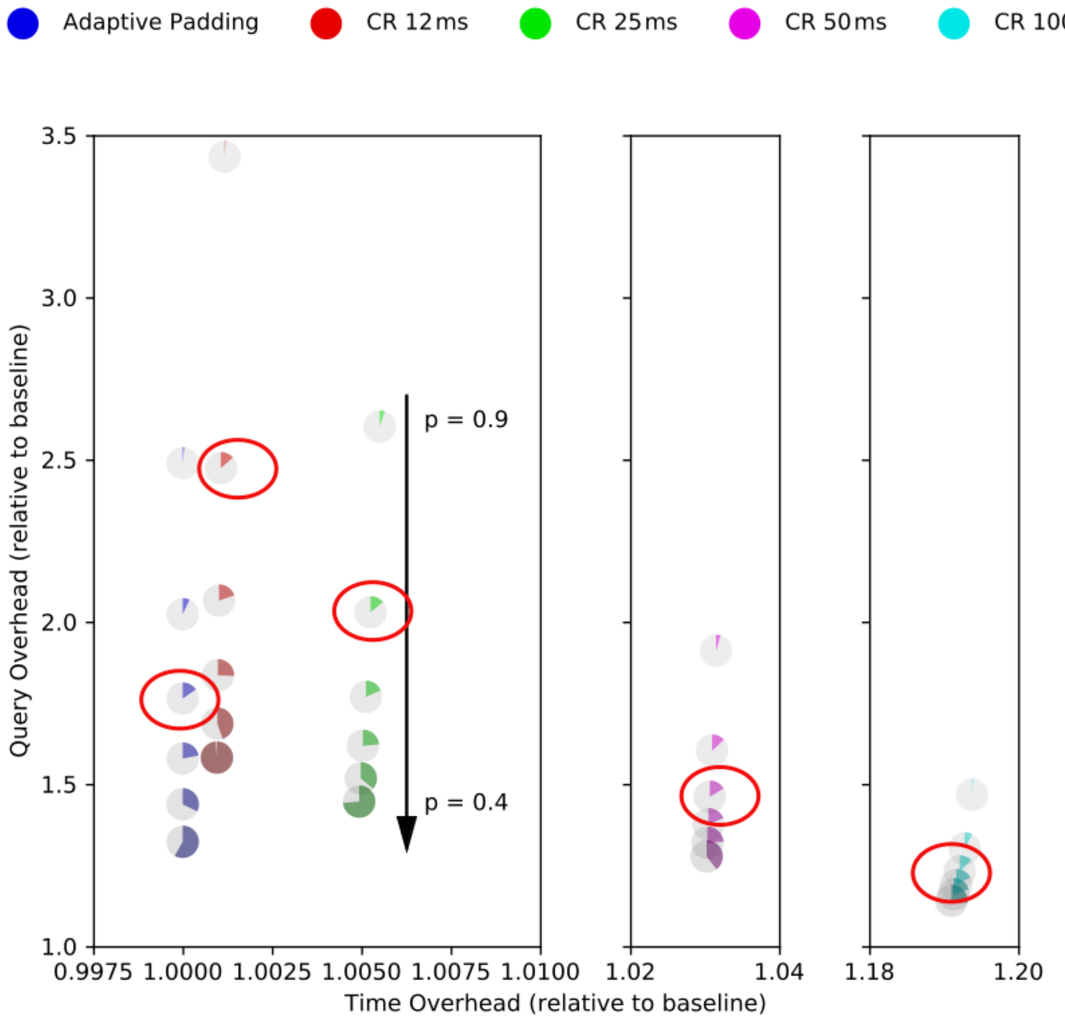

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Countermeasures: Overheads

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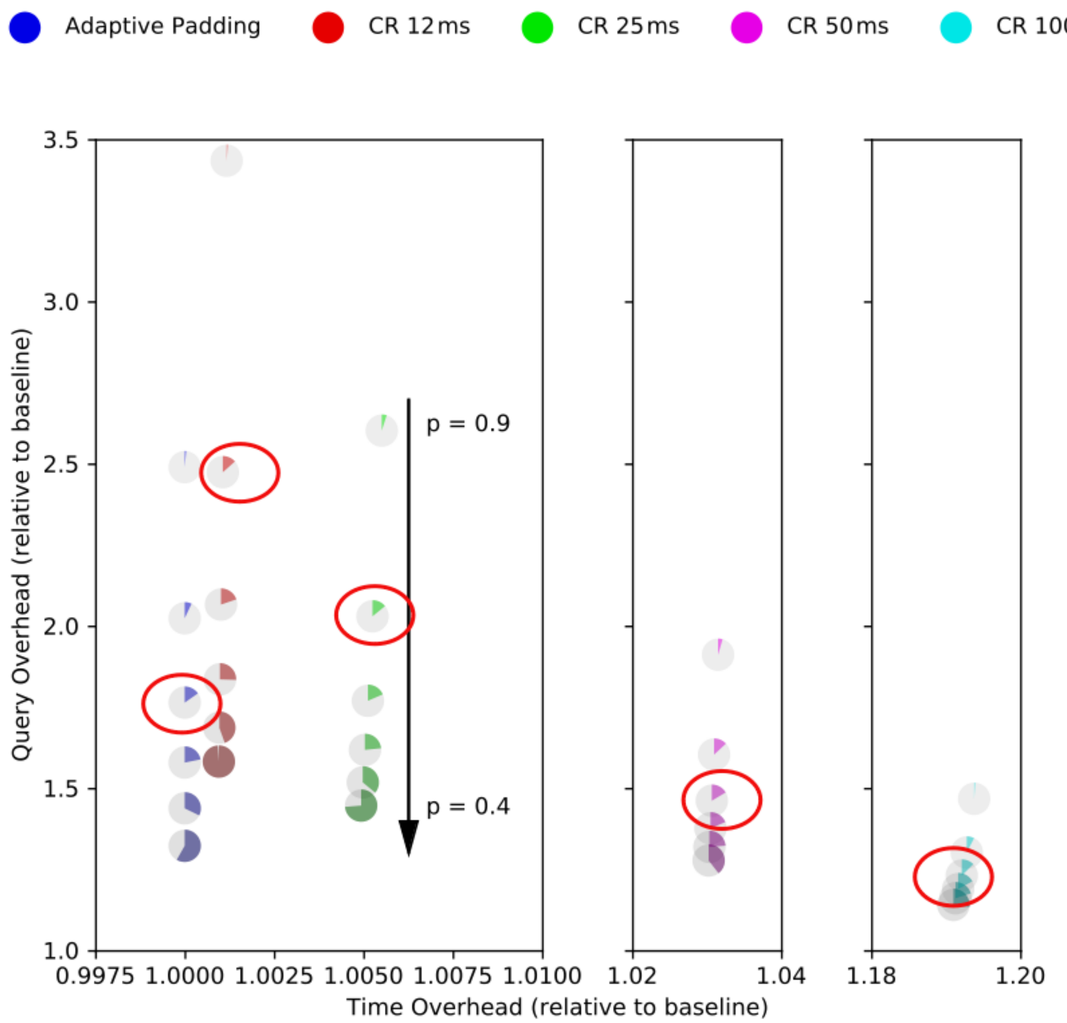
- Good Defenses
  - Interactive use → AP
  - Constrained use → CR



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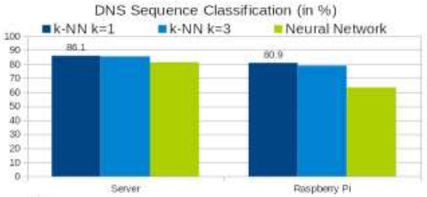

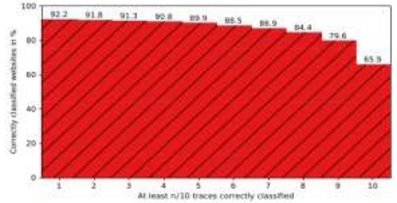

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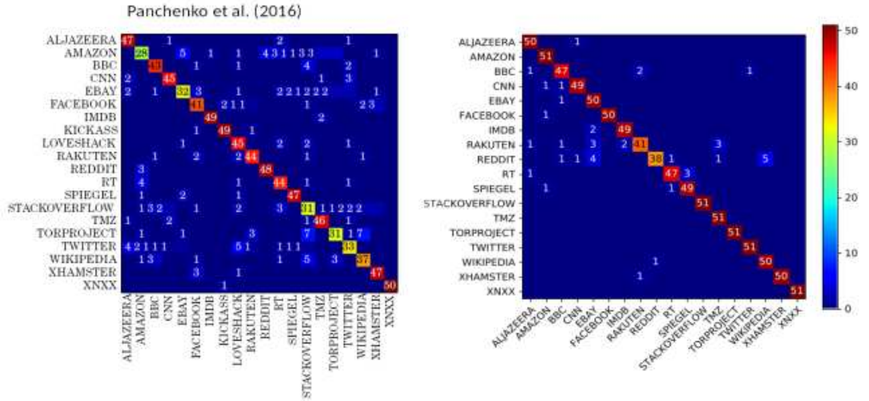

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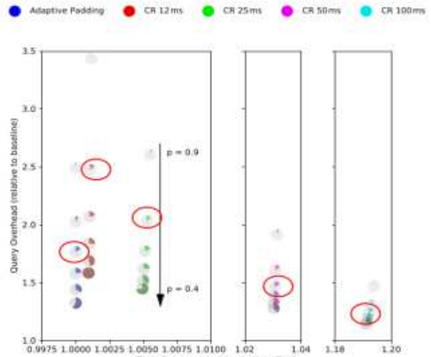

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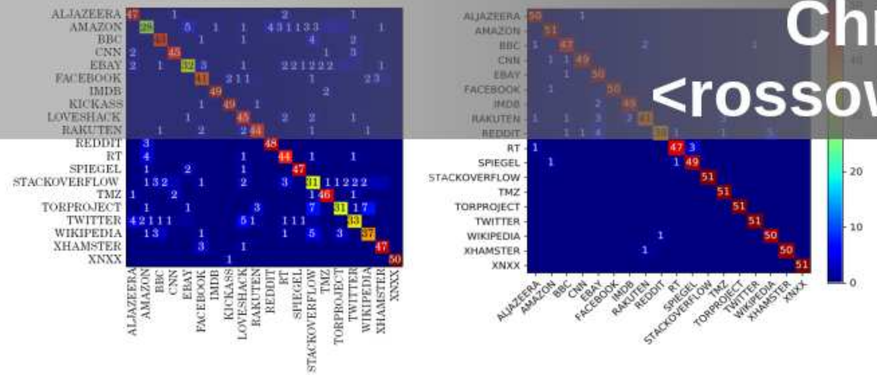

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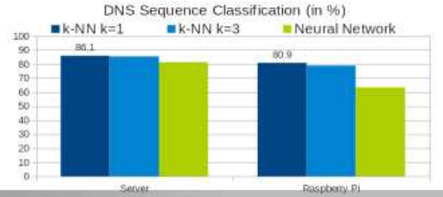

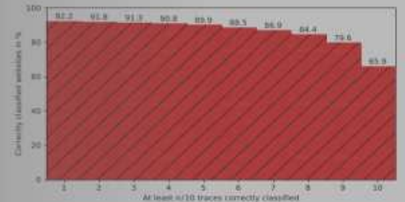

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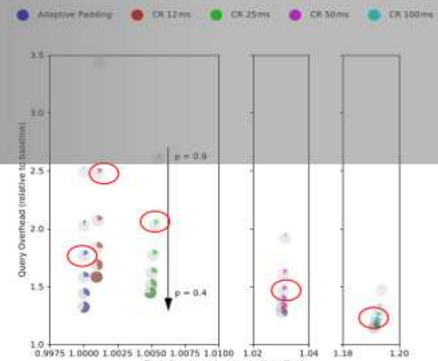

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Thank You!

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Christian Rossow
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