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Toward a RESTful Information-Centric Web of Things: A Deeper Look at Data Orientation in CoAP

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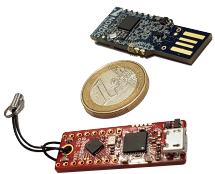
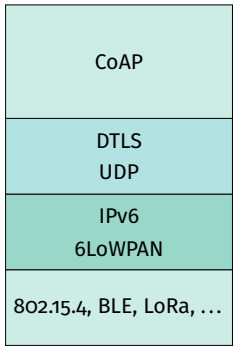
Common Web of Things Deployments

- Constrained IoT devices, gateway, cloud services





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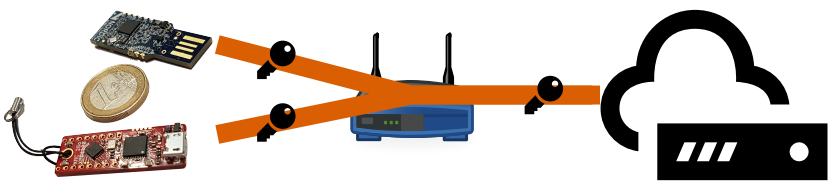

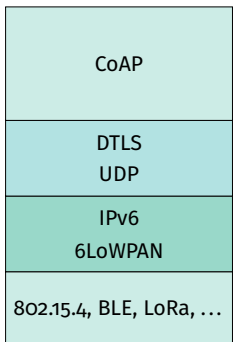

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- Stateful proxying and caching on gateway

Proxy	
CoAP	HTTP
DTLS	TLS
UDP	TCP
IPv6	
6LoWPAN	
802.15.4, BLE, LoRa, …	

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Standard CoAP features enable information-centric properties

Can we build a RESTful Web of Things with CoAP and information-centric properties?

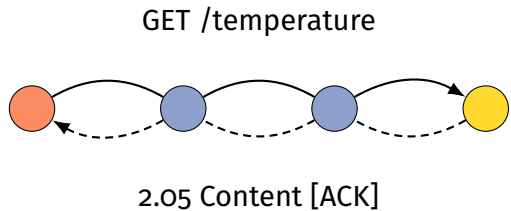
How will it perform?

Outline

Constructing an Information-centric Web of Things

Baseline: Plain CoAP Setup

- Request–Response **GET** method
- Piggybacked acknowledgments



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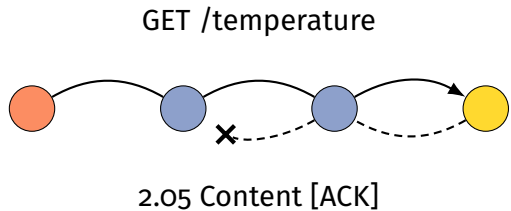

Baseline: Plain CoAP Setup

- Request–Response **GET** method
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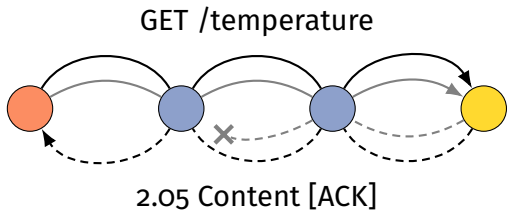
- End-to-end retransmissions



Information-centric Properties with Plain CoAP

- ☒ **Stateful forwarding**
- ☒ **Content caching**
- ☒ **Decoupling of data from location**
- ☒ **Content object security**

Extended CoAP Setup

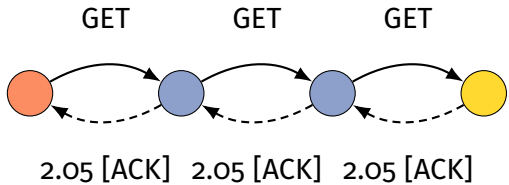
GET /temperature

2.05 Content [ACK]

Extended CoAP Setup

Stateful forwarding

- Proxy on each forwarding node



Extended CoAP Setup

Stateful forwarding

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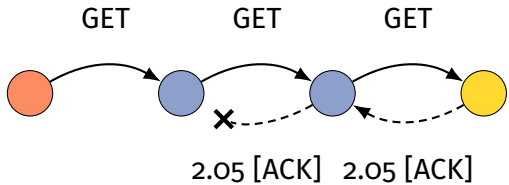

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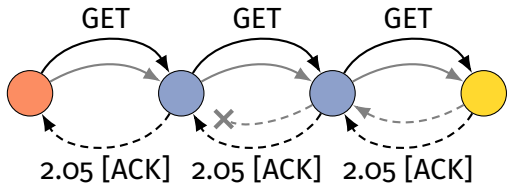

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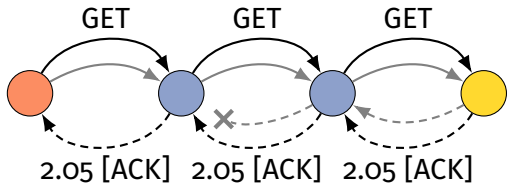
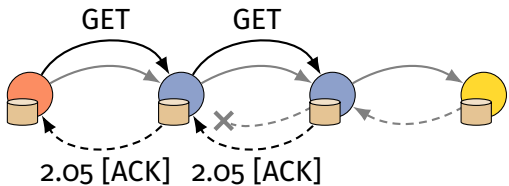


Content caching

- Shortened request path `[ICN'18]`
- Reduced retransmissions



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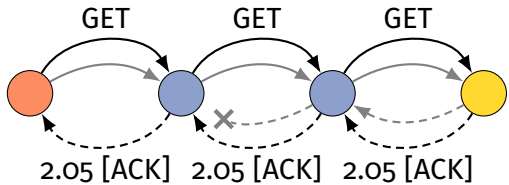

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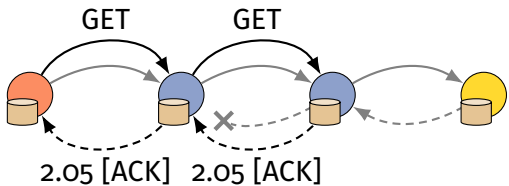

Decoupling of data from location

- Link-local IP addressing
- Forwarding via resource name

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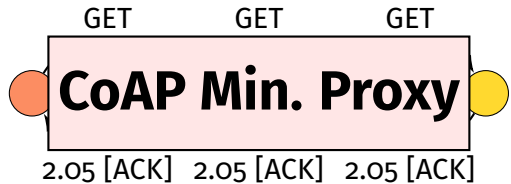

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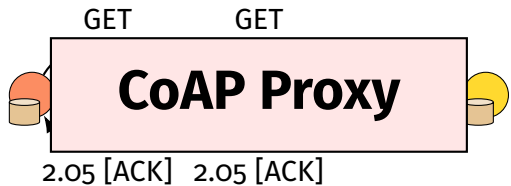

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Content Object Security with CoAP

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- Object Security for Constrained RESTful Environments
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Cacheability

- Strong message binding prevents cache hits for subsequent requests

→ We use retransmission caches to recover messages of same transaction

Information-centric Properties with CoAP Proxies

- ☑ **Stateful forwarding**
- ☑ **Content caching**
- ☑ **Decoupling of data from location**
- ☑ **Content object security**

Protocol Performance Evaluation

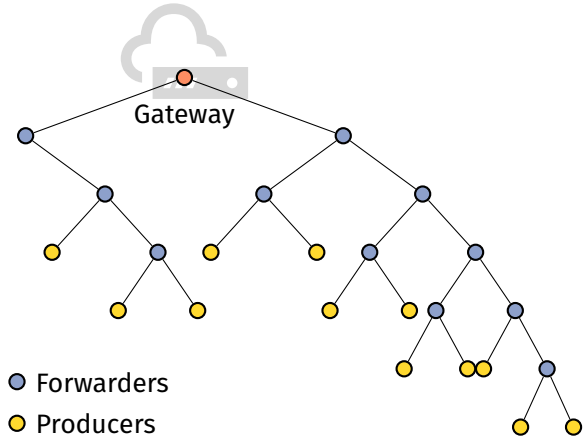
Testbed Setup

Hardware M3 node in IoT Lab testbed, IEEE 802.15.4

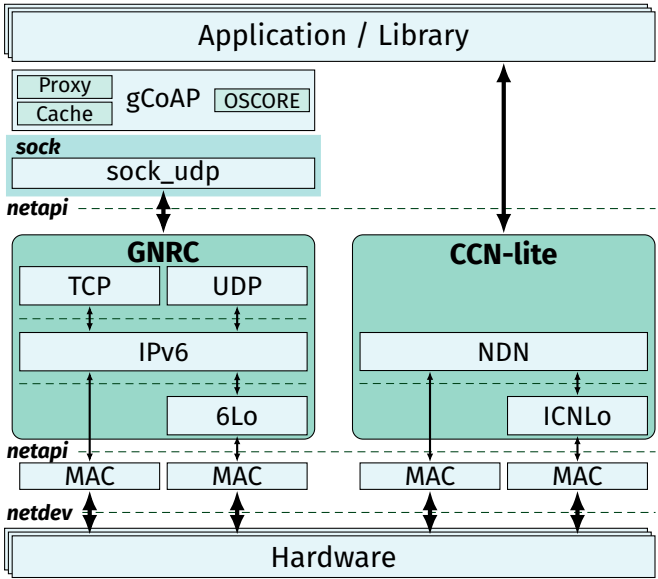
Software RIOT

Topology 12 producers, 11 forwarders

Scenario Gateway requests 2-byte temperature every $\approx$ 1 s



RIOT Network Stack



CoAP with Proxy

- Stateful proxying and caching in gCoAP

CoAP with OSCORE

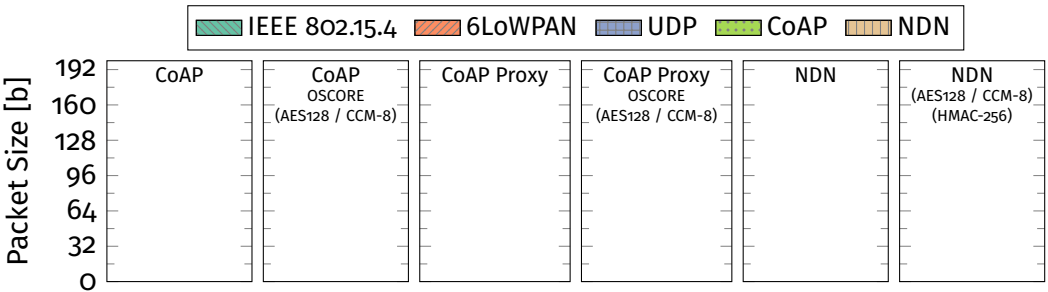
- gCoAP integrates libOSCORE package

NDN with CCN-lite

- CCN-lite integrates into RIOT networking

Packet Structure Dissection

- Maximum frame size for IEEE 802.15.4 is 127 bytes



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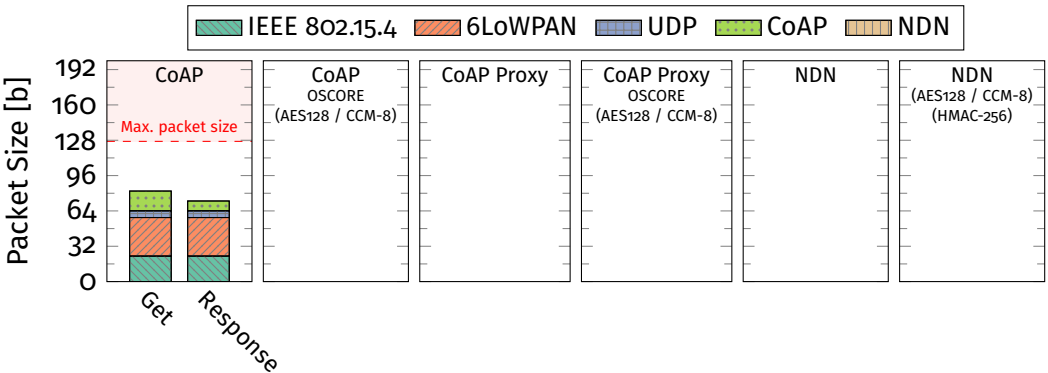

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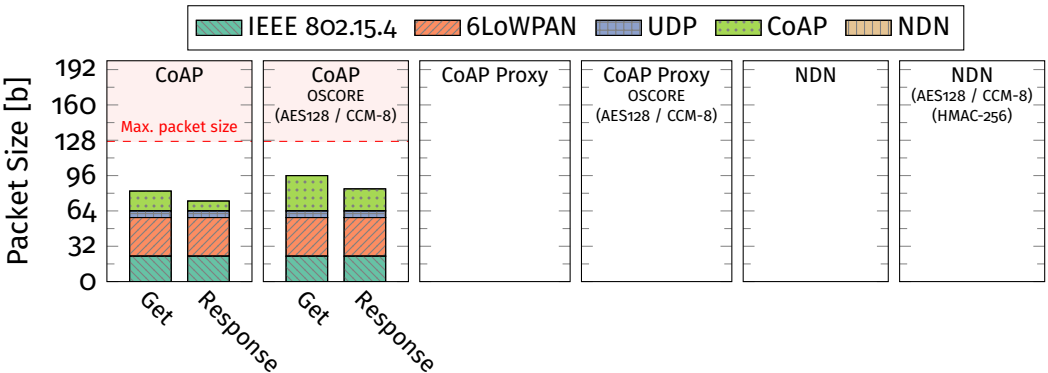

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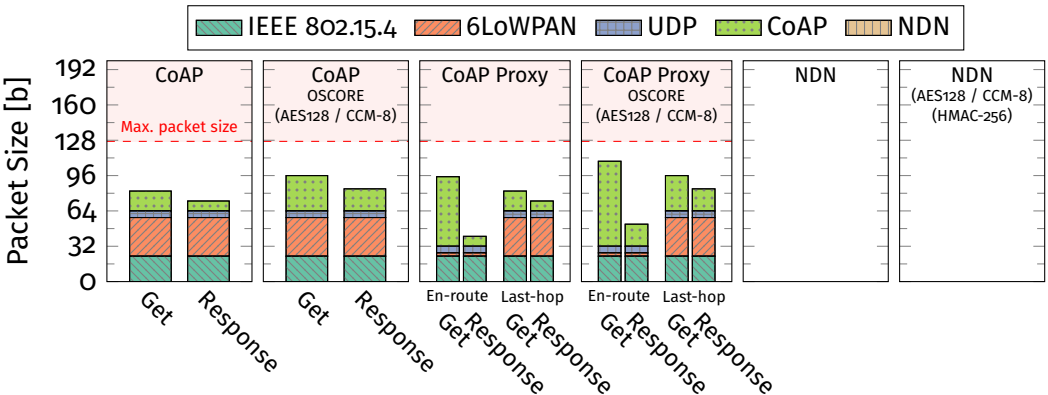

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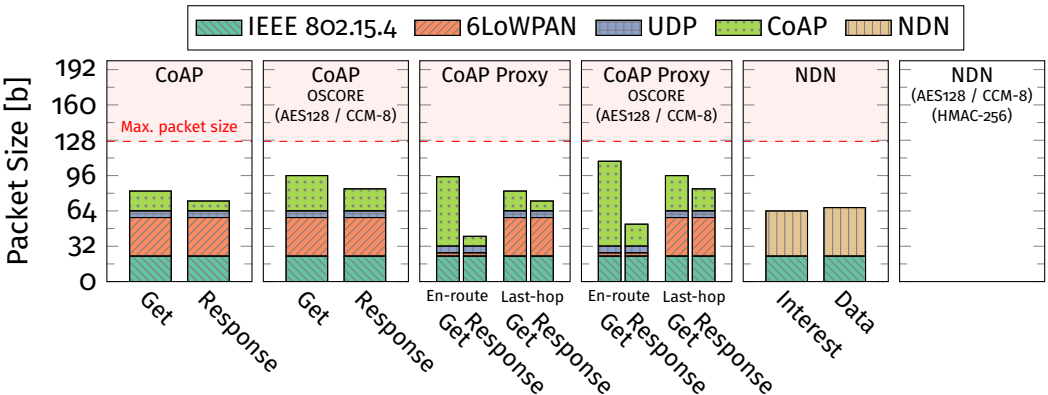

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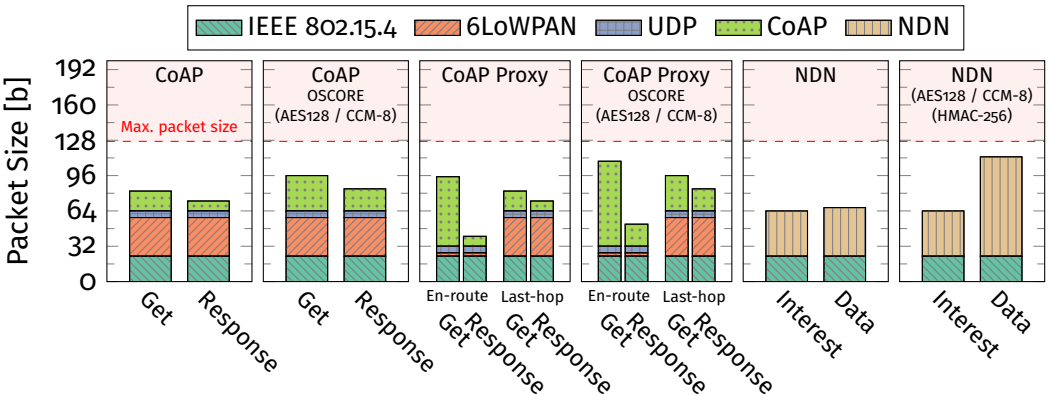

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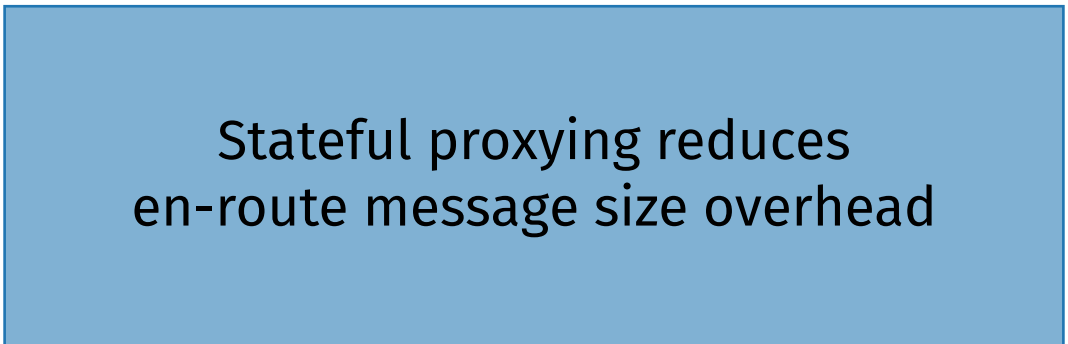

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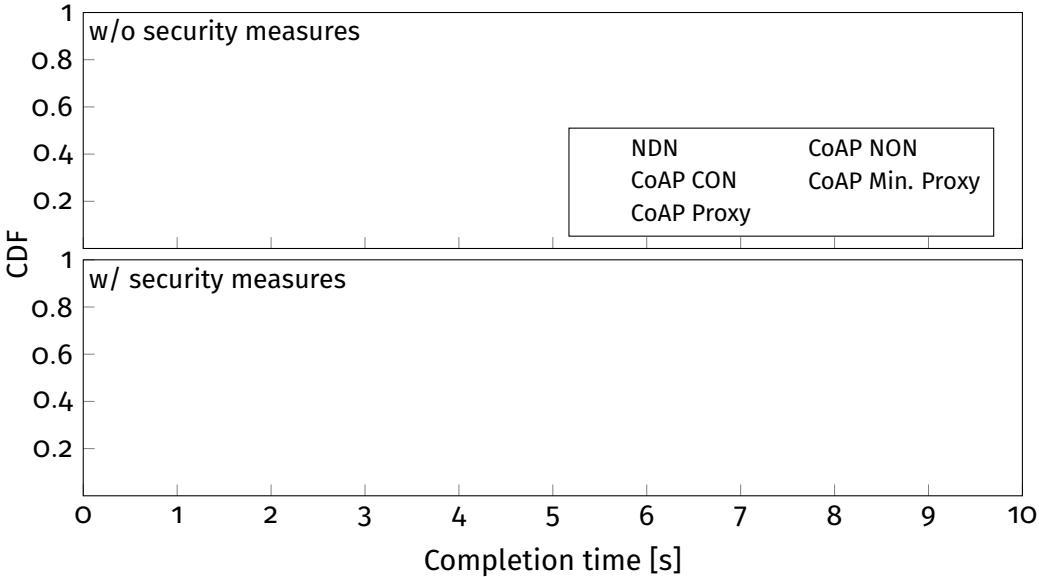

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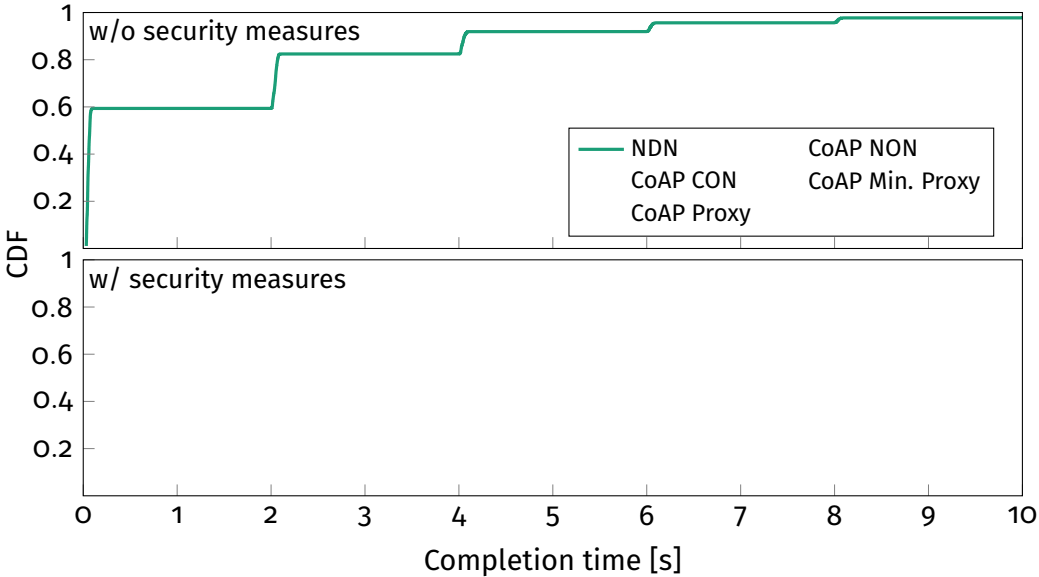

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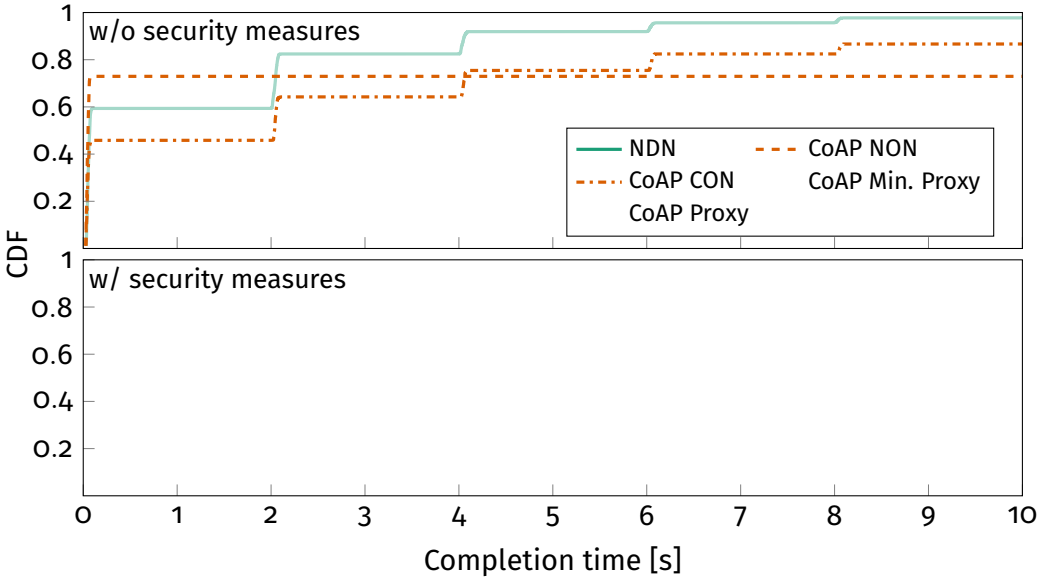

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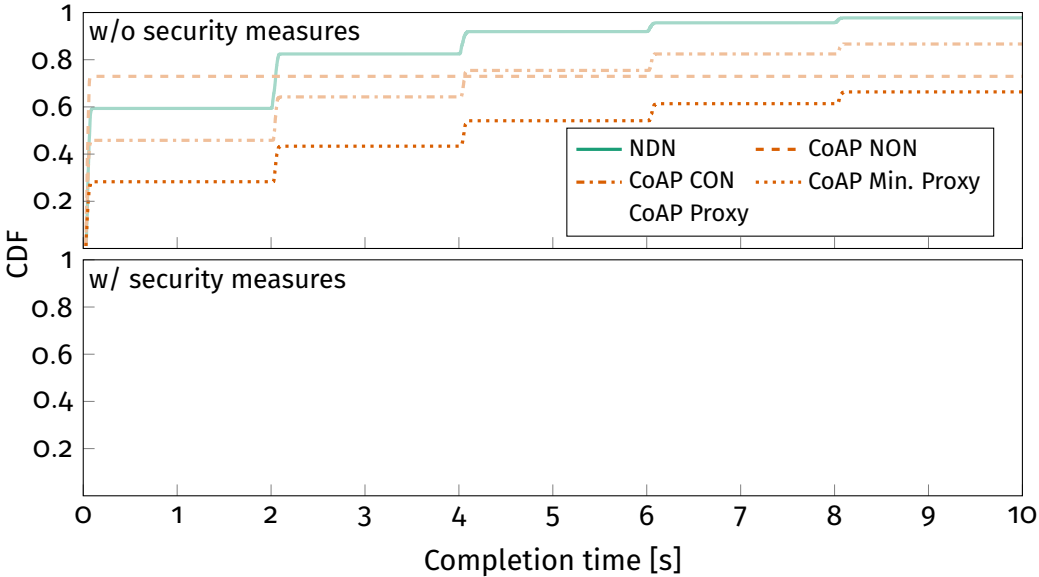

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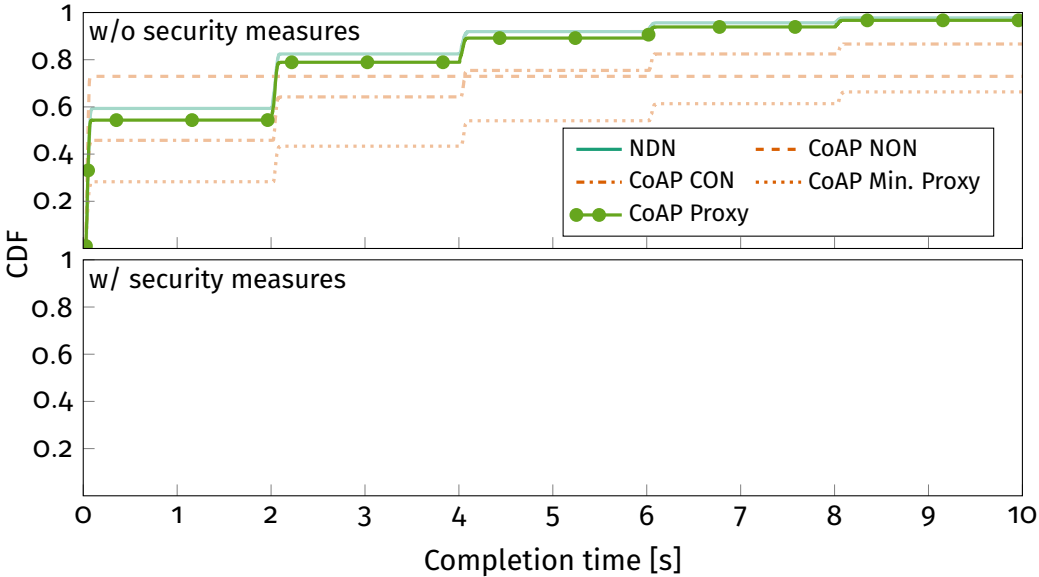

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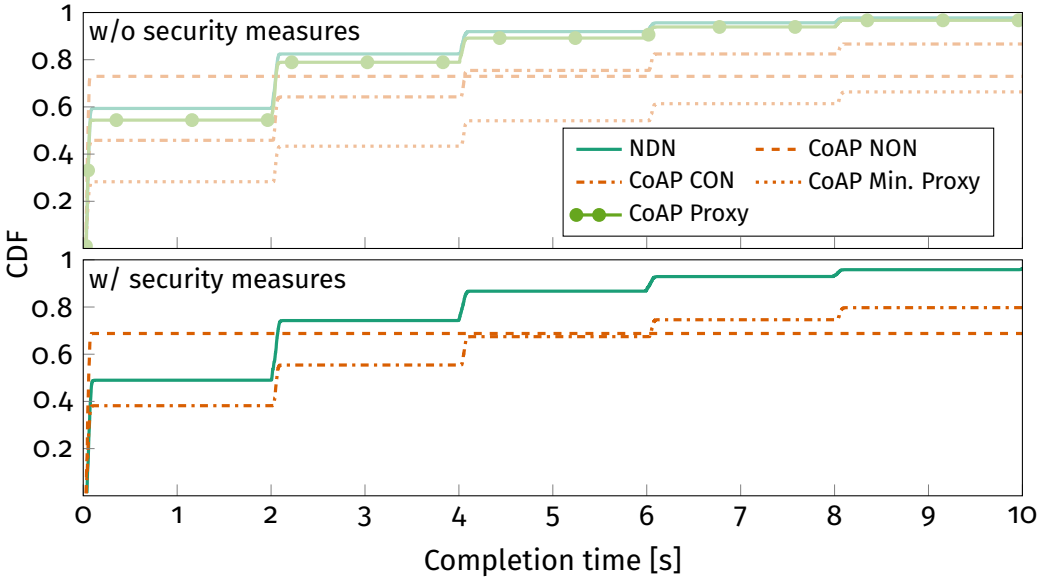

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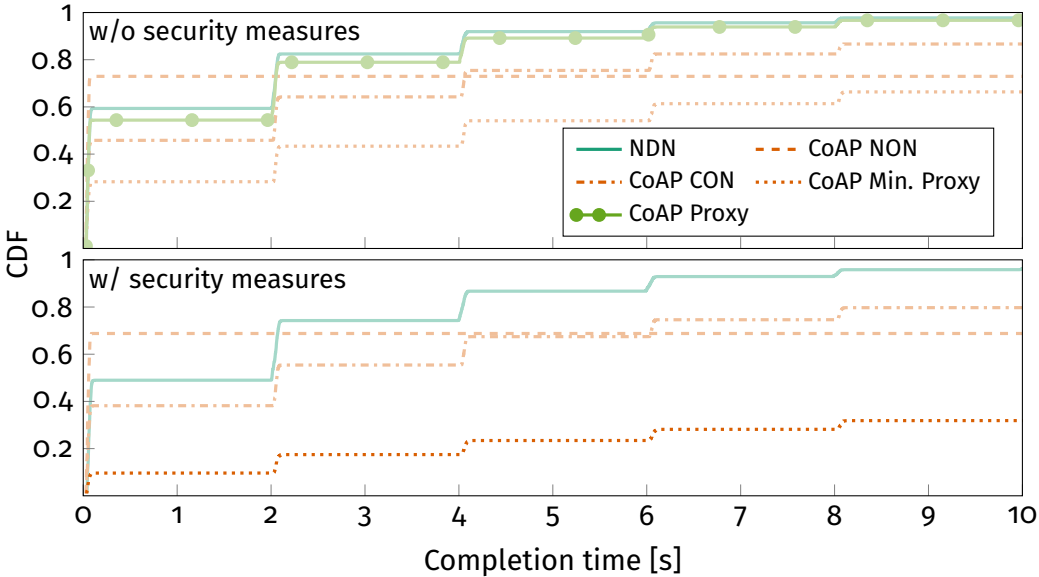

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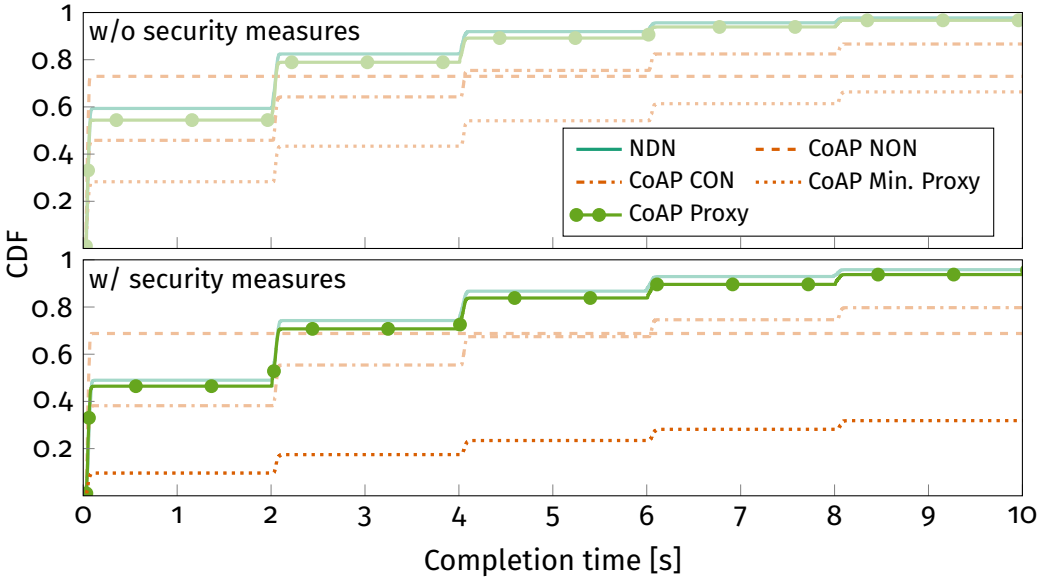

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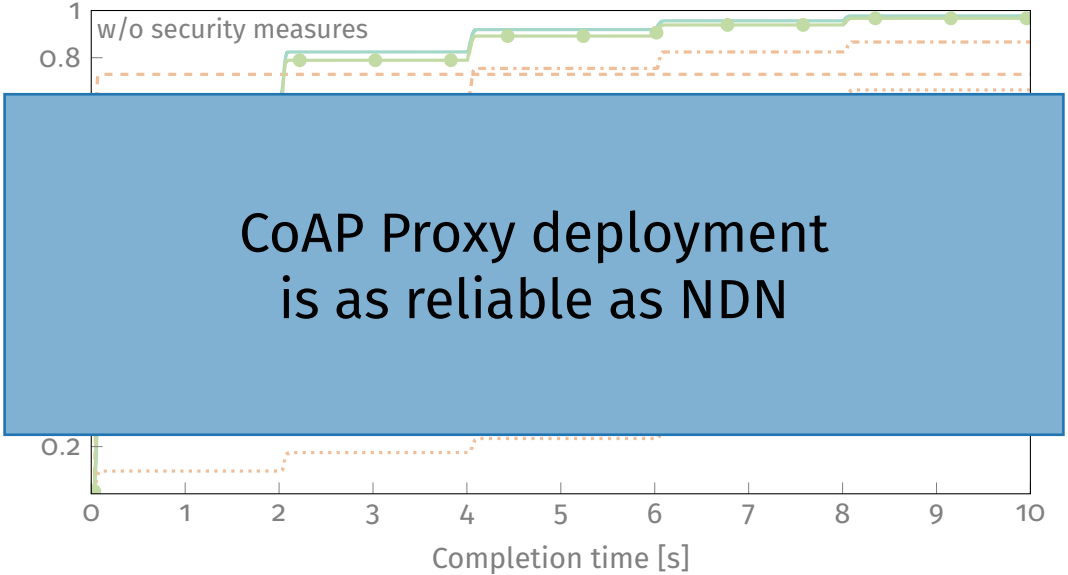
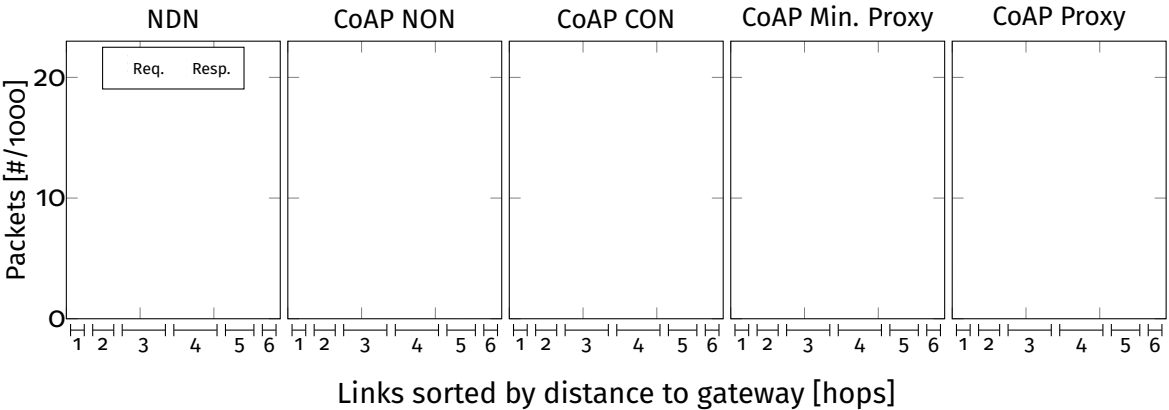


CoAP Proxy deployment
is as reliable as NDN

Link Stress for the Secured Protocol Variants



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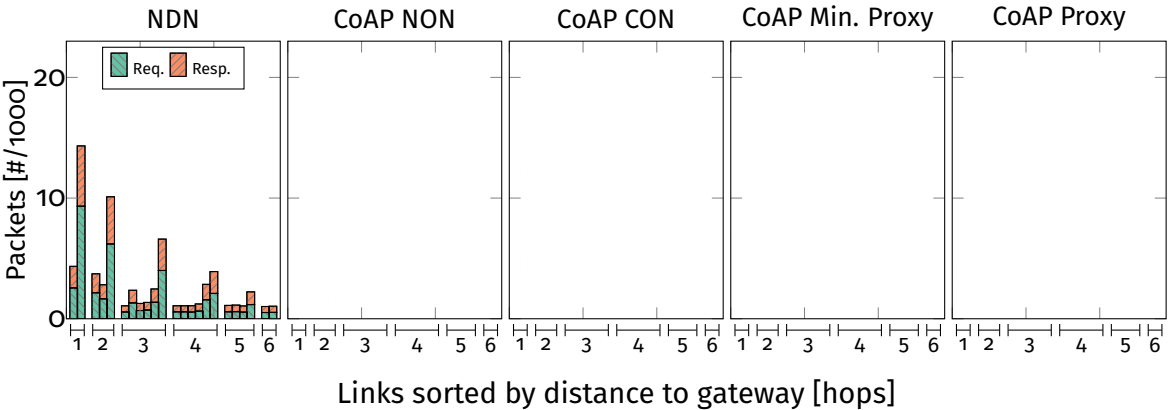

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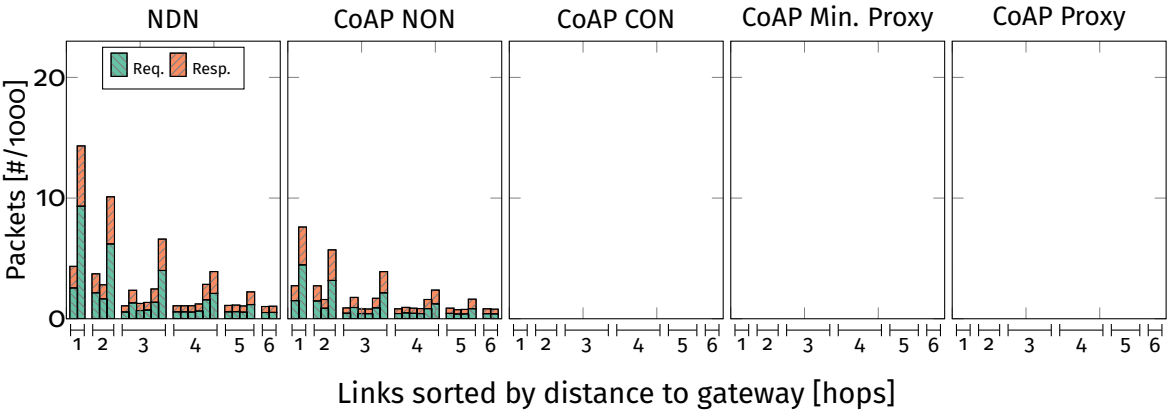

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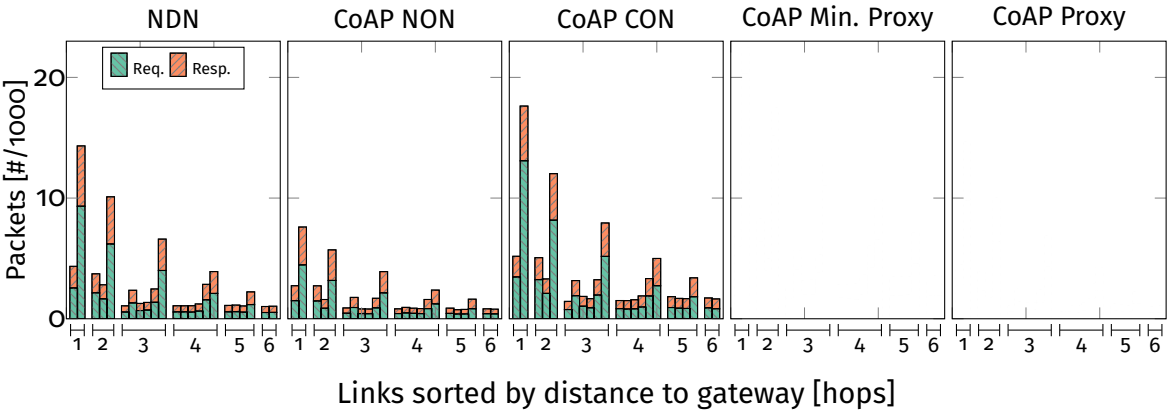

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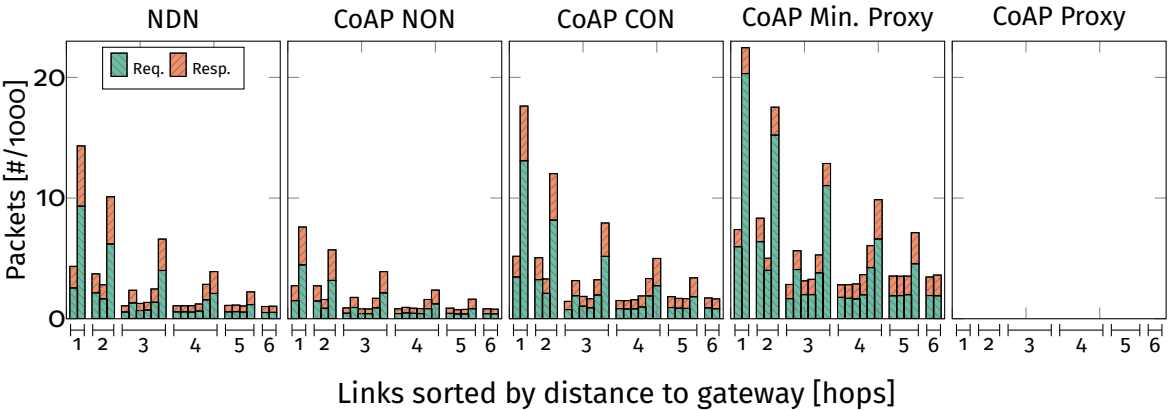

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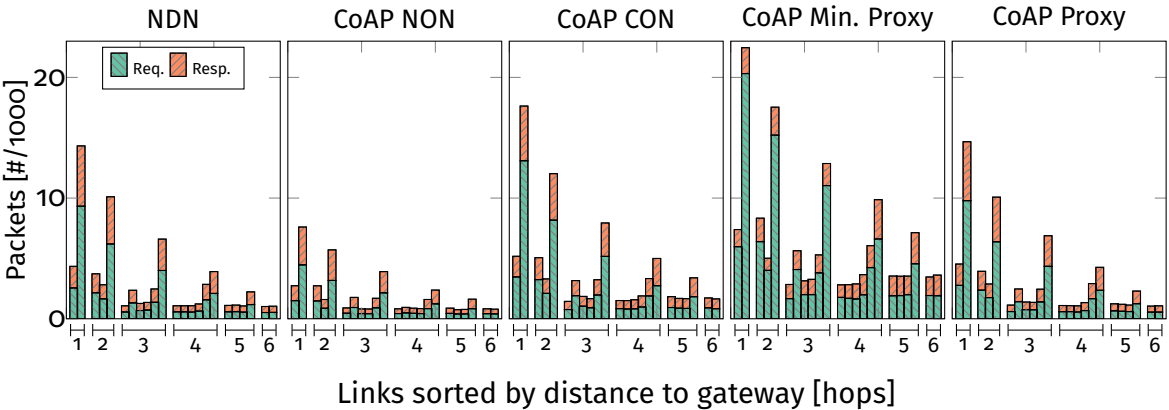

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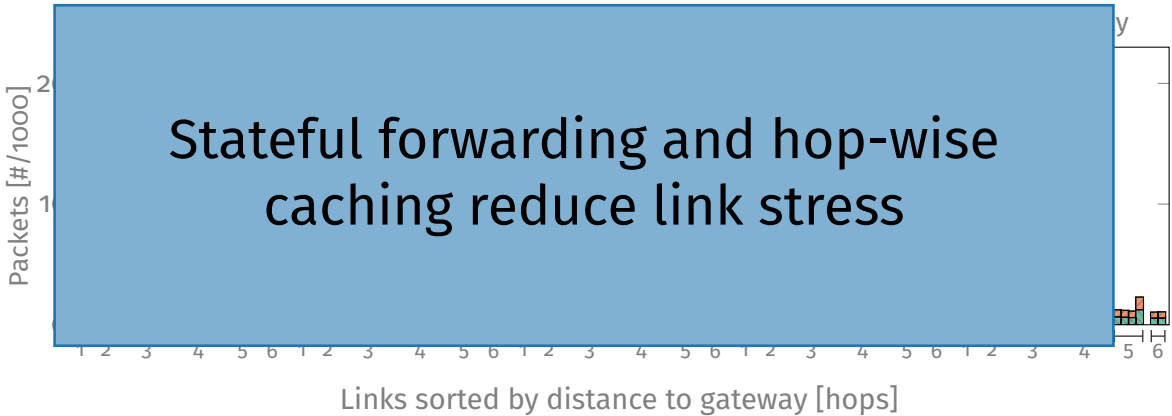
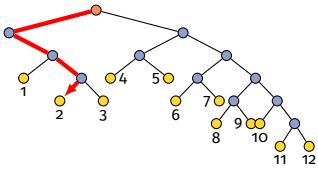
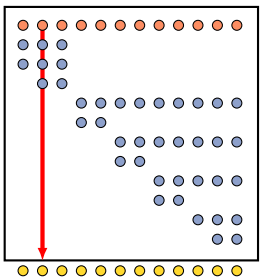


Stateful forwarding and hop-wise caching reduce link stress

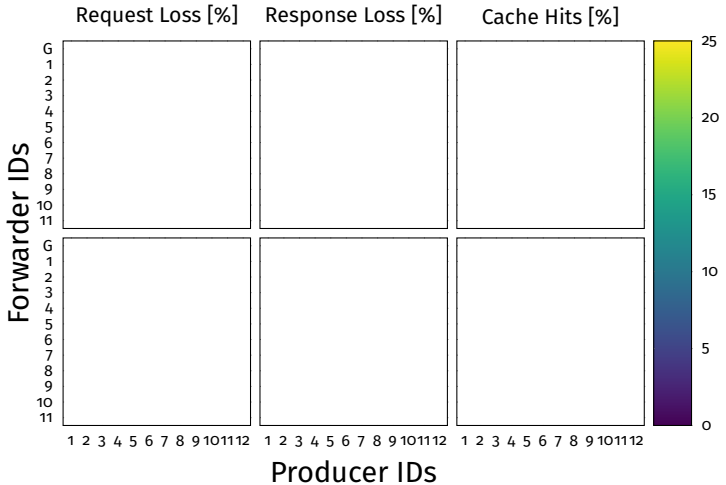
Cache Utilization for the Secured Protocol Variants



Gateway



Producers



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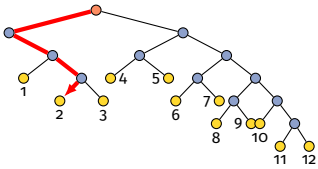

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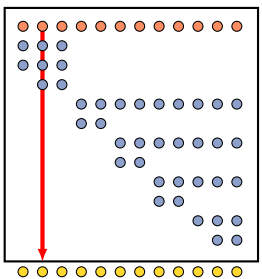

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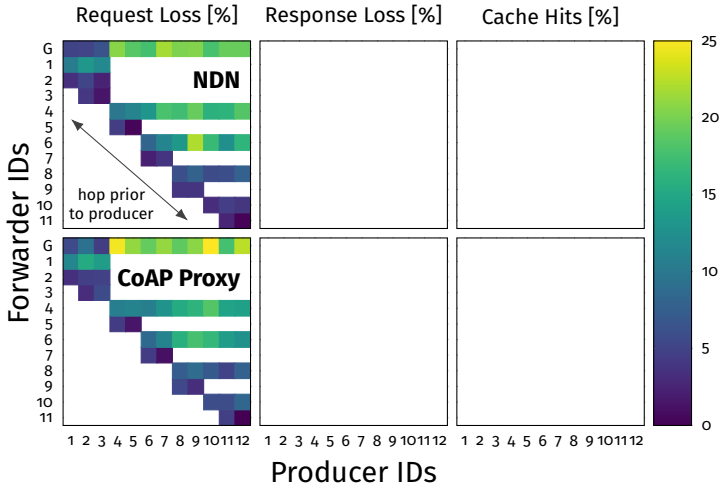
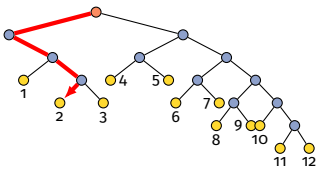
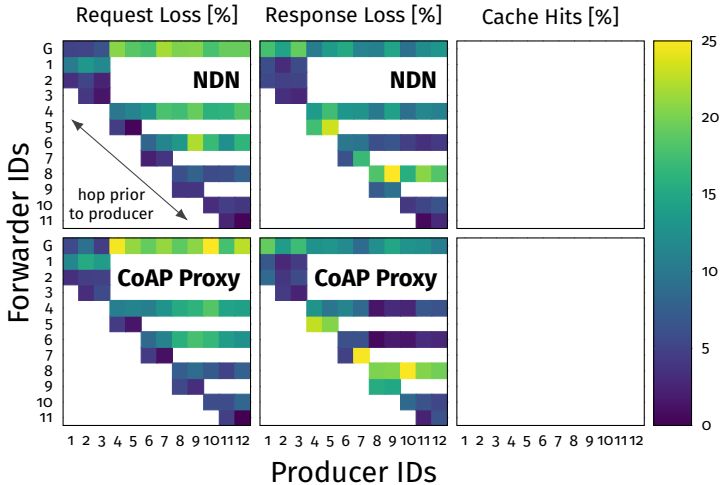
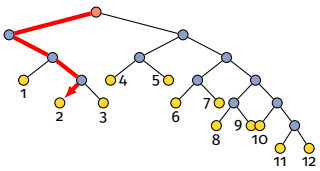


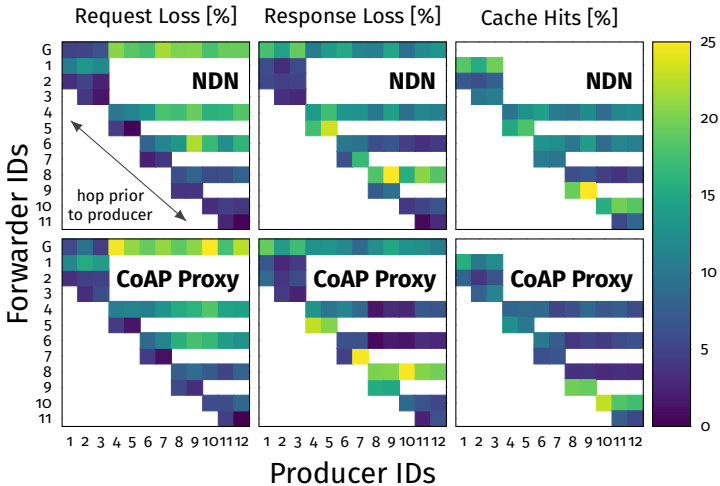
Cache Utilization for the Secured Protocol Variants



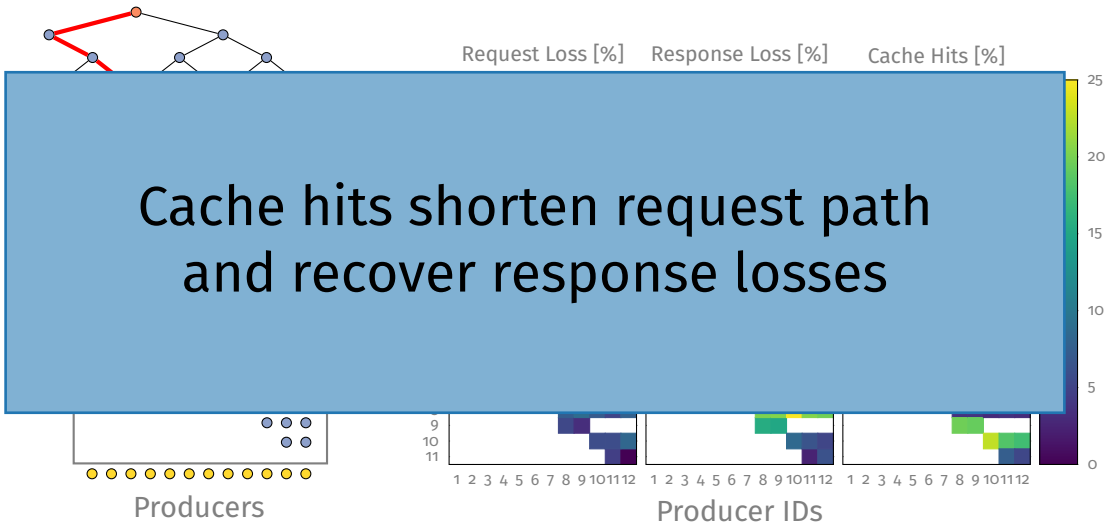


Cache Utilization for the Secured Protocol Variants





Cache Utilization for the Secured Protocol Variants



Conclusion & Outlook

Takeaways

- Information-centric WoT can be built with CoAP standard features
- Stateful forwarding and hop-wise caching improves reliability for CoAP
- Deployment chance for ICN principles in existing IoT infrastructure

Next Steps

- Explore ICN forwarding and caching policies in the context of CoAP
- Investigate multicast properties for an information-centric Web of Things

Thank You!

We support reproducible research.

https://github.com/inetrg/ACM-ICN-2020-COAP