Dresden University of Technology

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DNS over CoAP

Encrypted DNS for the Constrained IoT

DDI User Group Meeting • Sep 24, 2026 • Remote

Outline

Motivation

CoAP Crash Course

DNS over CoAP

Further Improvements

Conclusion & Outlook

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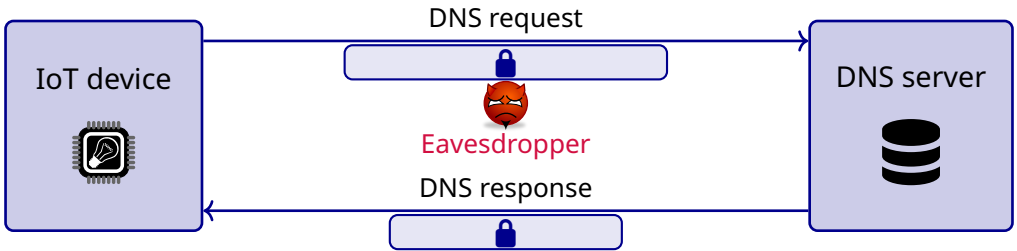
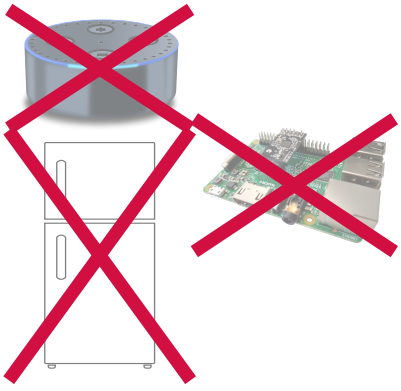


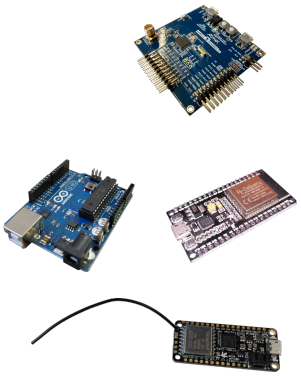
Countermeasure

Encrypt name resolution triggered by IoT devices against eavesdropping

Challenge I: Constrained IoT Nodes



Gigabytes
Terabytes



Kilobytes
Megabytes (at best!)

Challenge II: Constrained IoT Networks

- Low throughput, high packet loss, asymmetric link characteristics
- **High penalties on large packets** (link layer fragmentation)
- Typical data rates: **1 to 200 kBit/s**
- Typical frame sizes: **50 to 200 bytes**

Possible Solutions for Encrypted DNS

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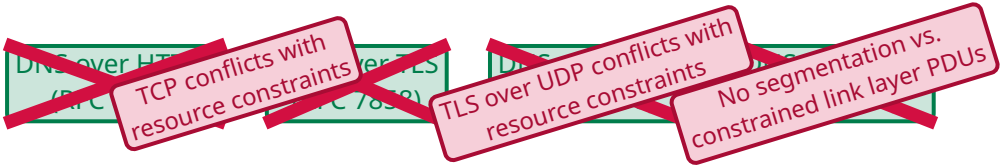

New Proposal: DNS over CoAP (RFC 9953)

- **Encrypted communication**
  - Datagram *Transport Layer* Security (DTLS)
  - *Object Security* for Constrained RESTful Environments (OSCORE)
- **Block-wise message transfer**
  - Lightweight segmentation into blocks of *equal length*
- **En-route caching**
  - Mitigation of high link-layer packet loss

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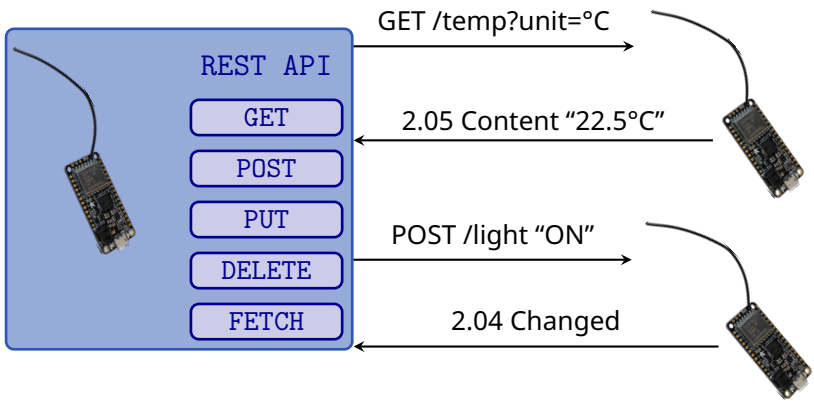
CoAP: The Constrained Application Protocol

“REST over UDP” ~ The HTTP for IoT



CoAP Security Modes

DTLS Datagram Transport Layer Security (≈ TLS over UDP)

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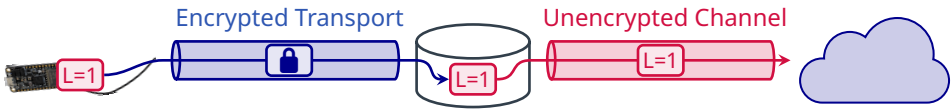

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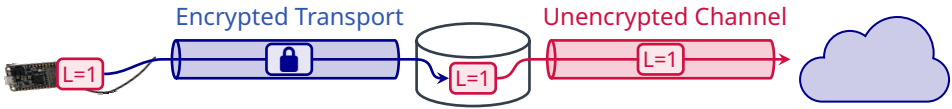

OSCORE Object Security for Constrained RESTful Environment

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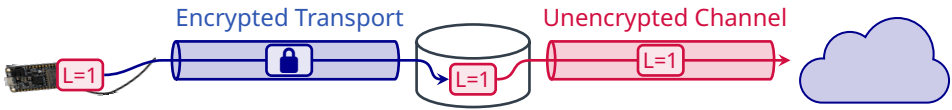

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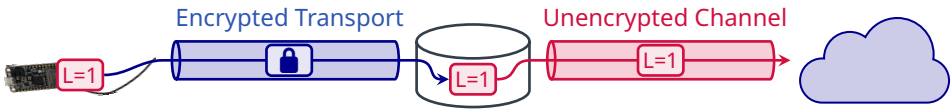

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- Uses Block1 (for requests) and Block2 (for responses) option to segment messages into equal size blocks

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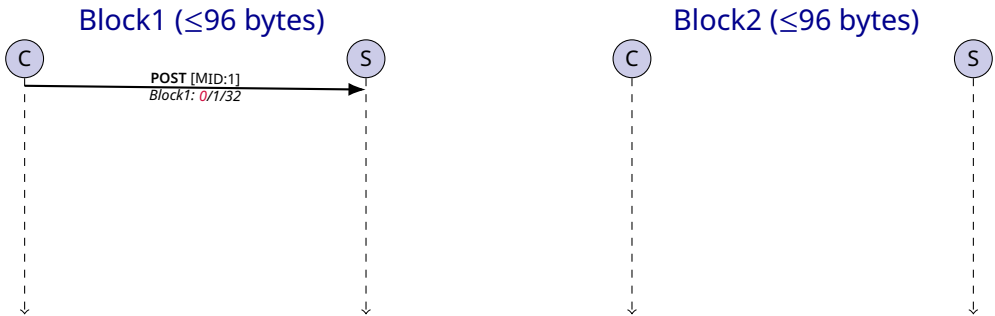

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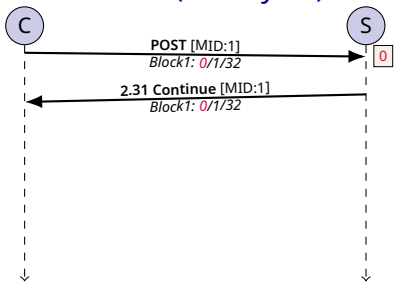

Block2 (≤96 bytes)

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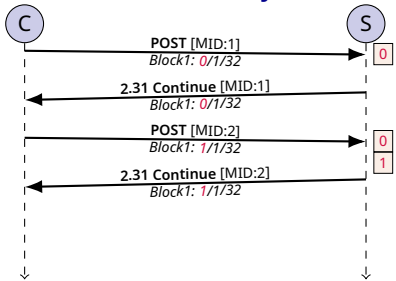

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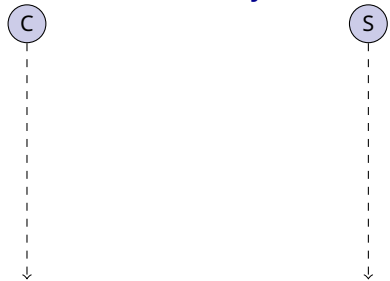

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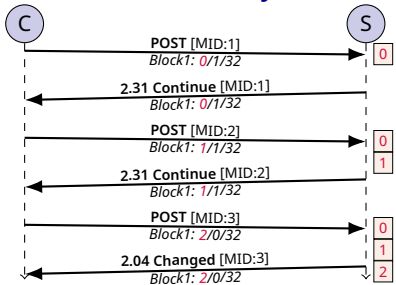

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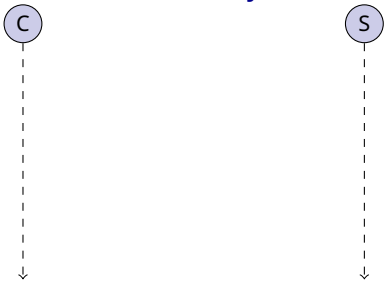

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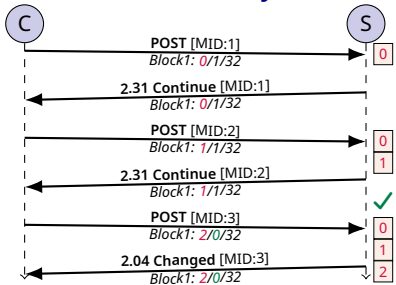

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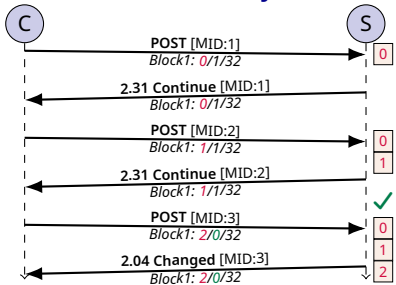

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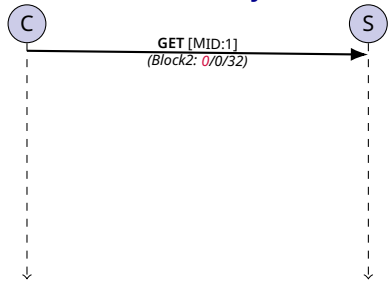

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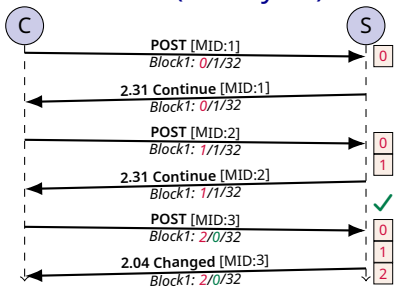

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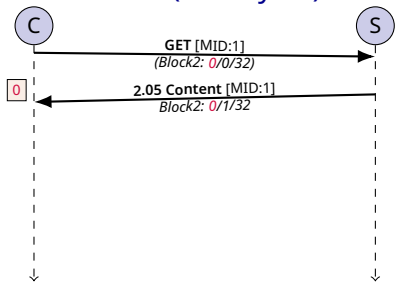

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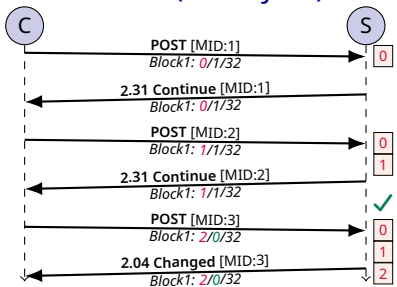

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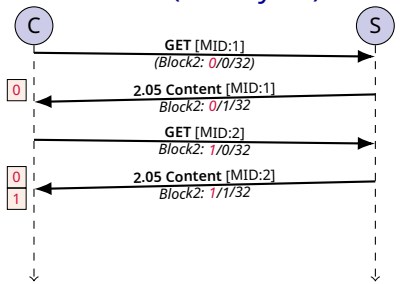

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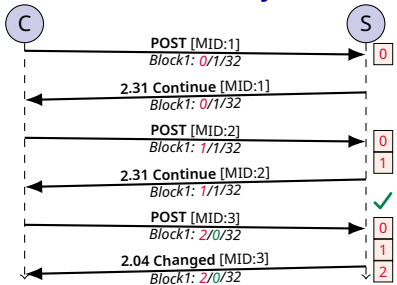

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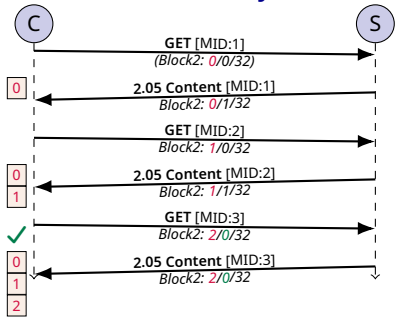


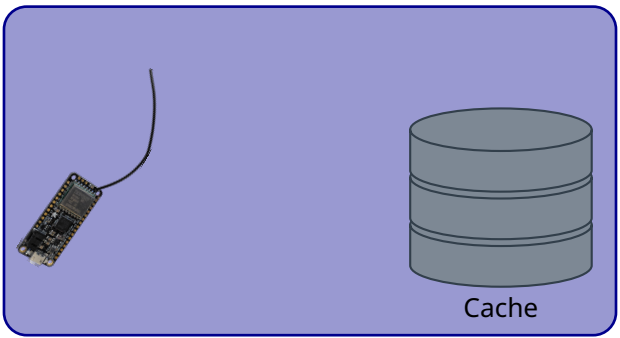
CoAP Caching

Client

Cache

Server

CoAP Caching



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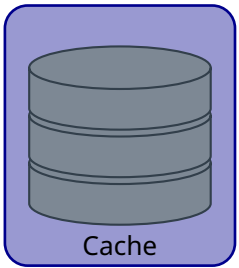
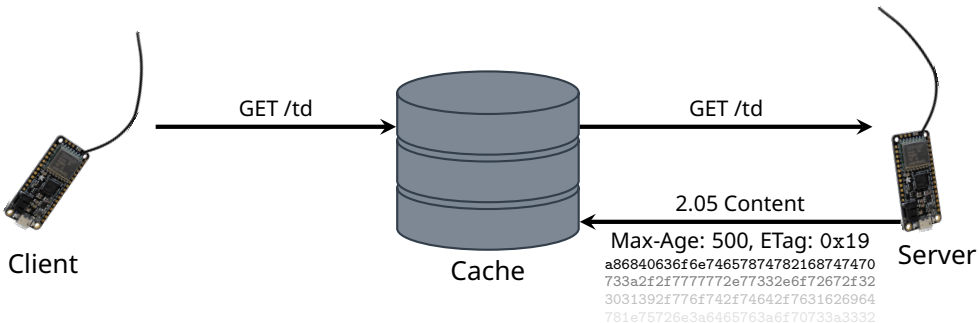


On proxy node

Server

CoAP Caching

Caching provides **decoupling from packet loss**



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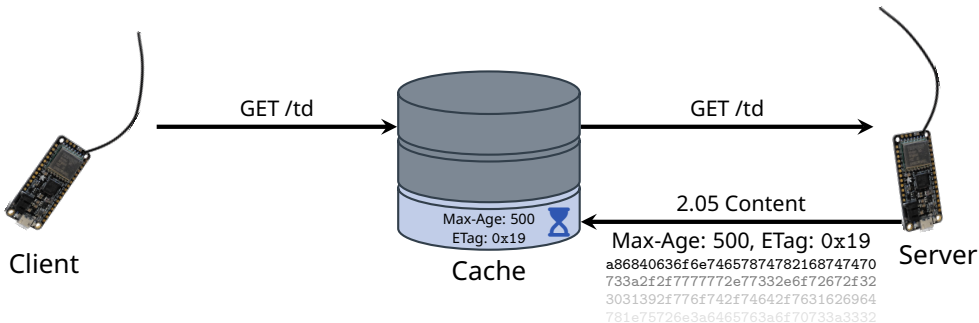

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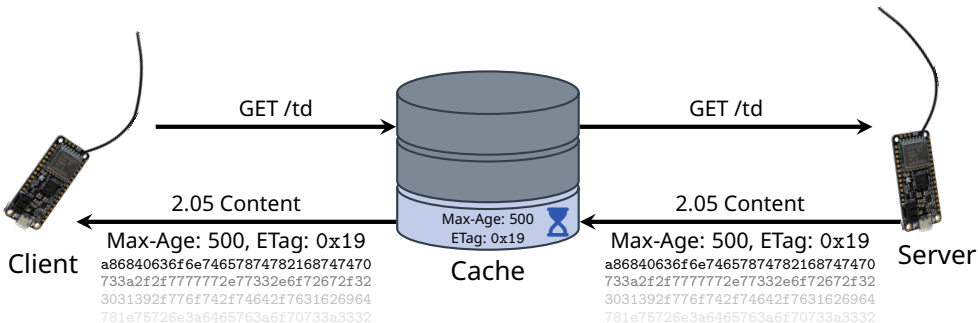

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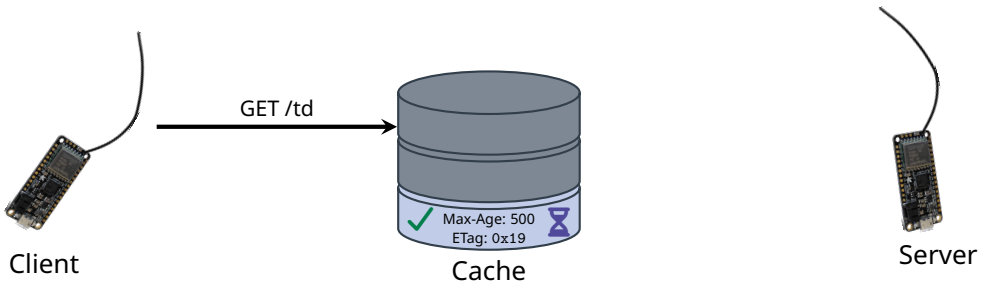

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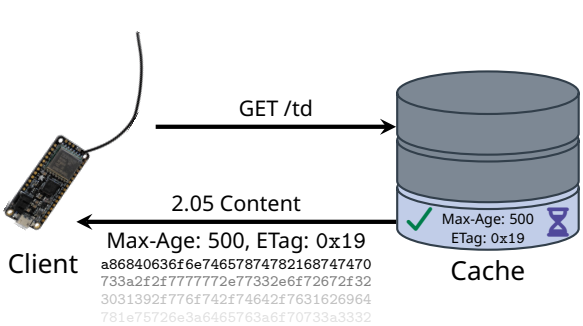

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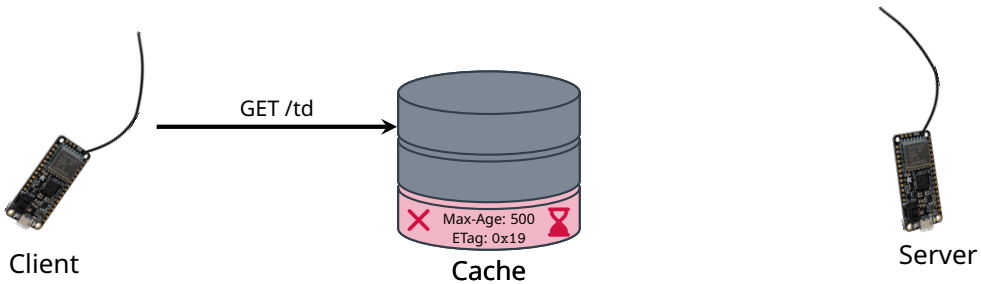

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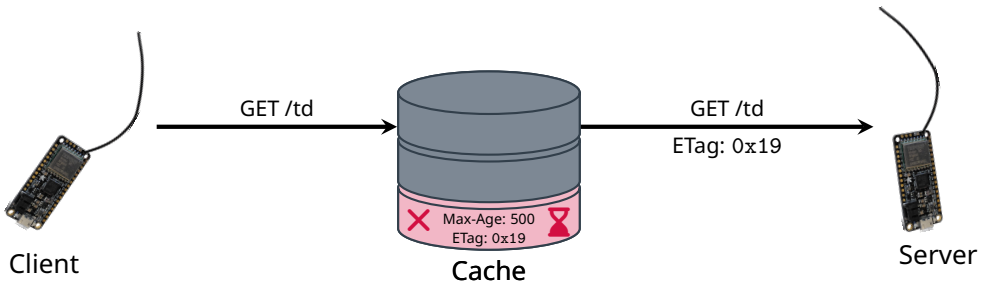

CoAP Caching

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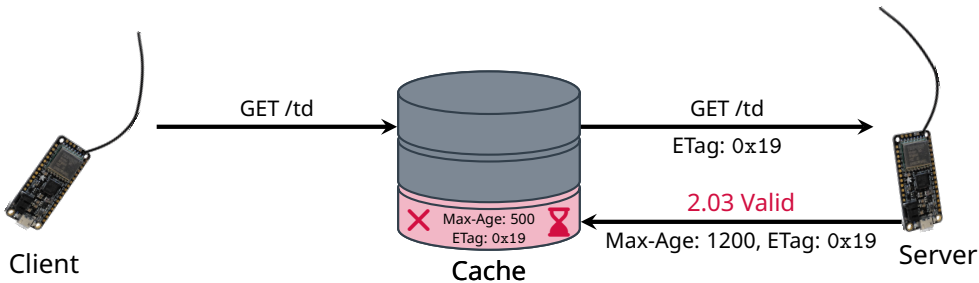

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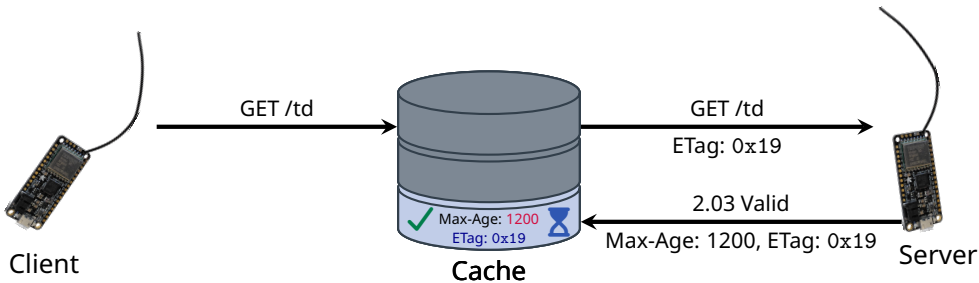

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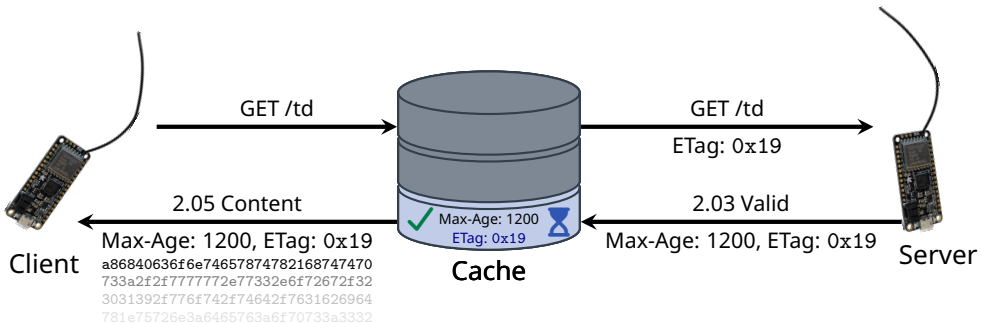

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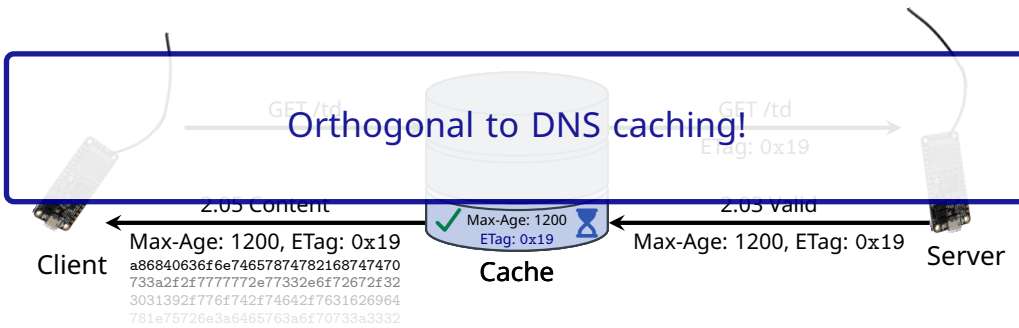

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- Just map the DoH methods **GET** and **POST** (RFC 8484)?

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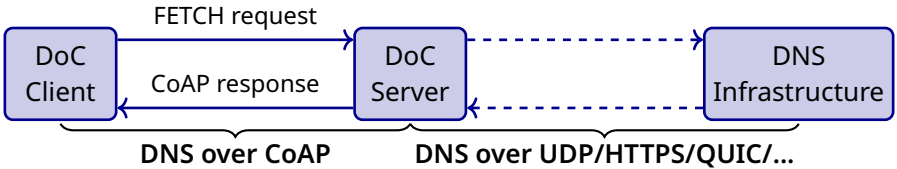
	HTTP	
	GET	POST
Responses cacheable	✓	✗
Application data carried in body	✗	✓
Block-wise transferable query	✗	✓

DNS over CoAP (DoC)

- Just map the DoH methods **GET** and **POST** (RFC 8484)?
- **FETCH** method in CoAP: best of both worlds (RFC 8132)

	CoAP		
	HTTP		
	GET	POST	FETCH
Responses cacheable	✓	✗	✓
Application data carried in body	✗	✓	✓
Block-wise transferable query	✗	✓	✓

DNS over CoAP (DoC): Example Query



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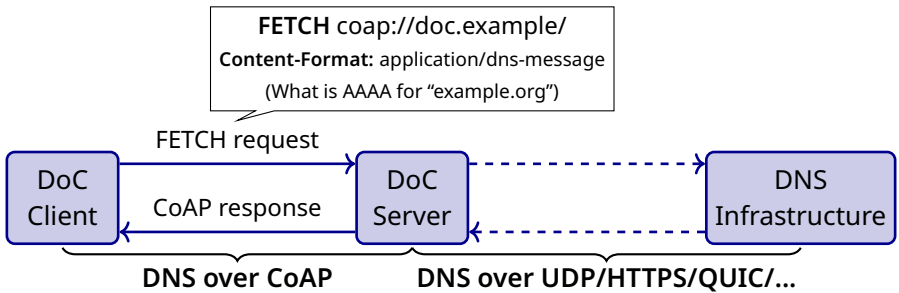

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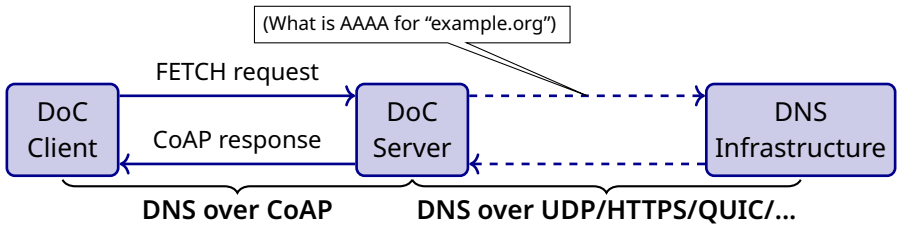

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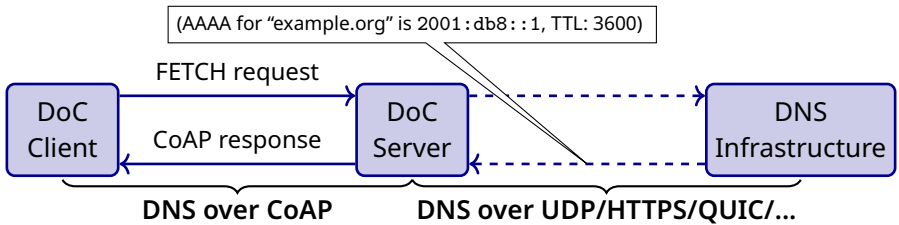

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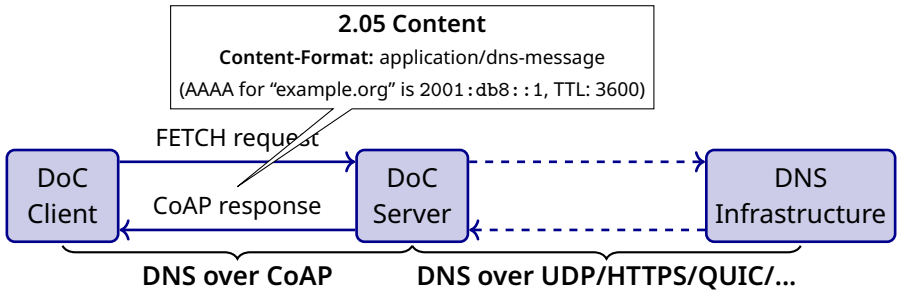

Benefits of DoC

- As performant or slimmer as other UDP-based encrypted DNS solutions (e.g. DoDTLS, DoQ, …)
- When using Object Security (OSCORE): ≈ ½ memory usage & build size from Transport-Security-based solutions
- Comparable privacy guarantees to DoH
- Batteries included: Discoverable via SVCB records (RFC 9460), DHCP, RAs, etc. (RFC 9463) from the start

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Concise DNS Message Representation

Constrained Networks, e.g., IEEE 802.15.4 with PDU of 127 bytes

Name Length	
2 chars	(minimum)

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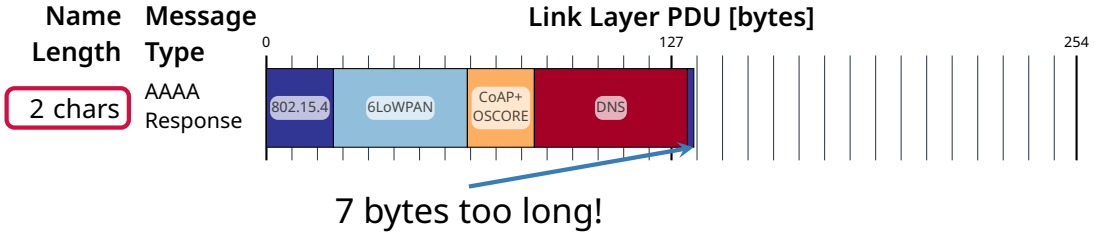
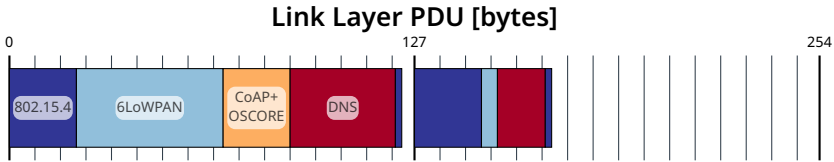


Further Improvements

Concise DNS Message Representation

Constrained Networks, e.g., IEEE 802.15.4 with PDU of 127 bytes

Name Length	Message Type
2 chars	AAAA Response

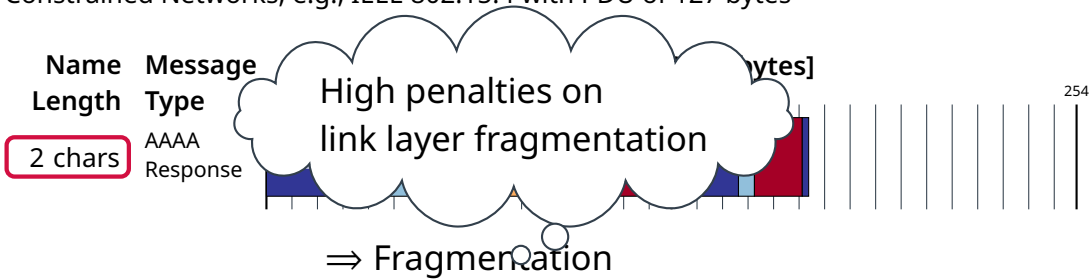


⇒ Fragmentation

Further Improvements

Concise DNS Message Representation

Constrained Networks, e.g., IEEE 802.15.4 with PDU of 127 bytes



Further Improvements

Concise DNS Message Representation

Concise DNS messages are needed

`application/dns+cbor`

Media Type and Content-Format

(*i.e.*, usable with both DoC and DoH)

`https://datatracker.ietf.org/doc/draft-lenders-dns-cbor/`

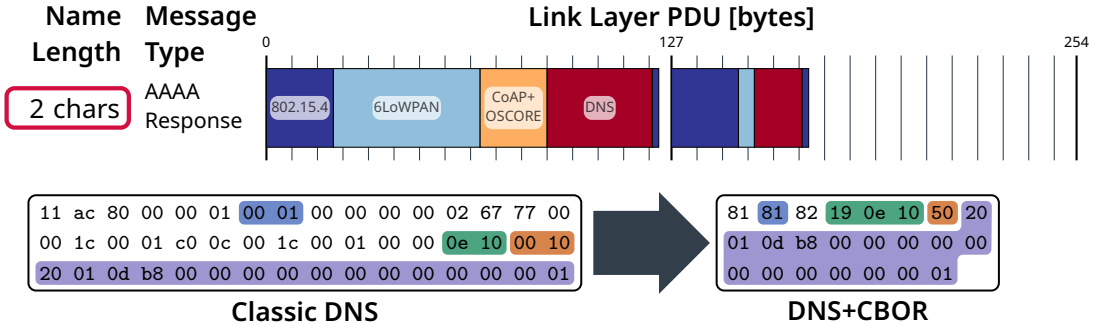
Objectives:

- Concise encoding of DNS messages using existing implementation (CBOR)
- Omits (redundant) DNS fields in DNS queries and responses
- Provides (optional) address and name compression using Packed CBOR

Further Improvements

Concise DNS Message Representation

Constrained Networks, e.g., IEEE 802.15.4 with PDU of 127 bytes



Further Improvements

Concise DNS Message Representation

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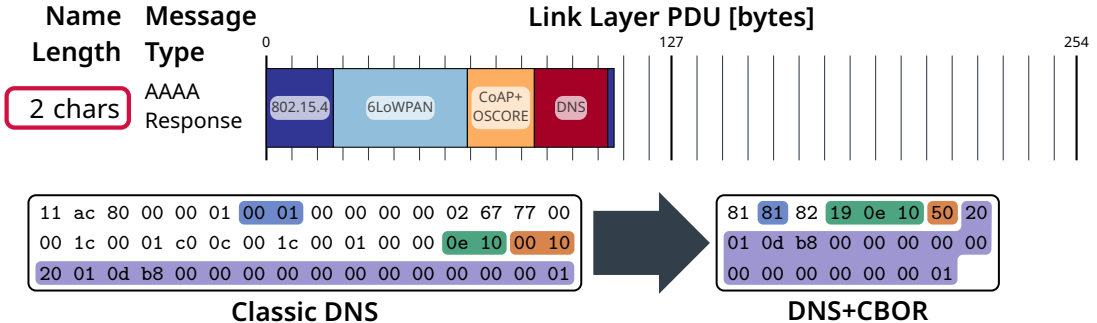

Outline

Motivation

CoAP Crash Course

DNS over CoAP

Further Improvements

Conclusion & Outlook

Conclusion & Outlook

Secure & privacy-friendly DNS is ready for the constrained IoT:

- DoC with FETCH provides encrypted, cachable, and segmentable DNS
- En par in resolution time with existing UDP-based transfer protocols
- DNS over OSCORE outperforms DNS over DTLS, CoAPS, or QUIC
  both in packet and memory size

Outlook:

- CBOR-based DNS message format for smaller packet size
- Oblivious DNS over CoAP in the works
- Encrypted multicast DNS (i.e. DNS-SD/Bonjour/Avahi) could be an option

Implementations?

- Unbound Resolver WIP: `https://github.com/NLnetLabs/unbound/pull/1252`
- Client in RIOT OS `https://api.riot-os.org/group__net__gcoap__dns.html`

We want your help!

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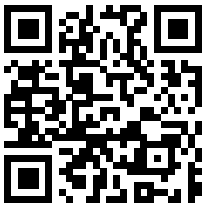

Further Reading I


M. S. Lenders, C. Amsüss, C. Gündogan, M. Nawrocki, T. C. Schmidt, and M. Wählisch. Sep. 2023.
Securing Name Resolution in the IoT: DNS over CoAP.
Proceedings of the ACM on Networking (PACMNET) 1, CoNEXT2 September 2023), 6:1–6:25.
doi:10.1145/3609423


M. S. Lenders, C. Amsüss, C. Gündoğan, T. C. Schmidt, and M. Wählisch. Mar. 2026.
DNS over CoAP (DoC).
RFC 9953. IETF.
doi:10.17487/RFC9953

Further Reading II


M. S. Lenders, C. Bormann, M. Gütschow, T. C. Schmidt, and M. Wählisch. Jul. 2026. *A Concise Binary Object Representation (CBOR) of DNS Messages*. Internet-Draft – work in progress 18. IETF. https://datatracker.ietf.org/doc/html/draft-lenders-dns-cbor-18


M. S. Lenders, T. C. Schmidt, and M. Wählisch. Jul. 2026. Secrets Best Not Shared: DNS Privacy Enhancements for the Constrained IoT. In *Proc. of the 11th IEEE European Symposium on Security and Privacy (EuroS&P)*. IEEE, Piscataway, NJ, USA, 1475–1494. doi:10.1109/EuroSP68448.2026.00094

Further Reading III


M. S. Lenders, C. Bormann, T. C. Schmidt, and M. Wählisch. Aug. 2026.
A Leaner and Faster Web: How CBOR Can Improve Dynamic Content Encoding in JSON and DNS over HTTPS.
IEEE Transactions on Network and Service Management (TNSM) (2026).
doi:10.1109/TNSM.2026.3722114
Early Access.