Automotive Group Key Agreement and Secure Service & Client Authentication Using DNSSEC with DANE

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Master Project

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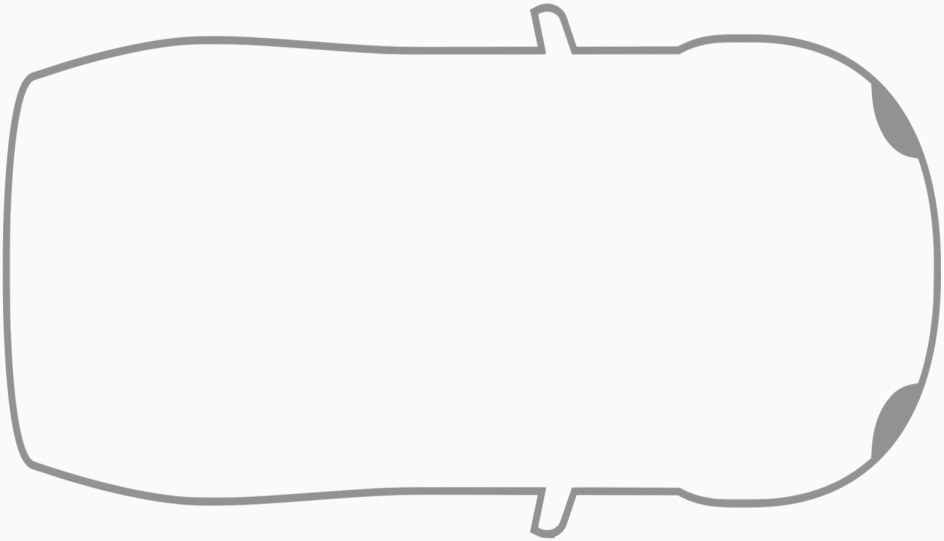
Outline

1. Introduction to In-Vehicle Networks
2. DNSSEC-based Service and Client Authenticity
3. Management of Group Keying
4. DNSSEC-based Authenticity and GKA Performance
5. Conclusion & Outlook

Future In-Vehicle Networks



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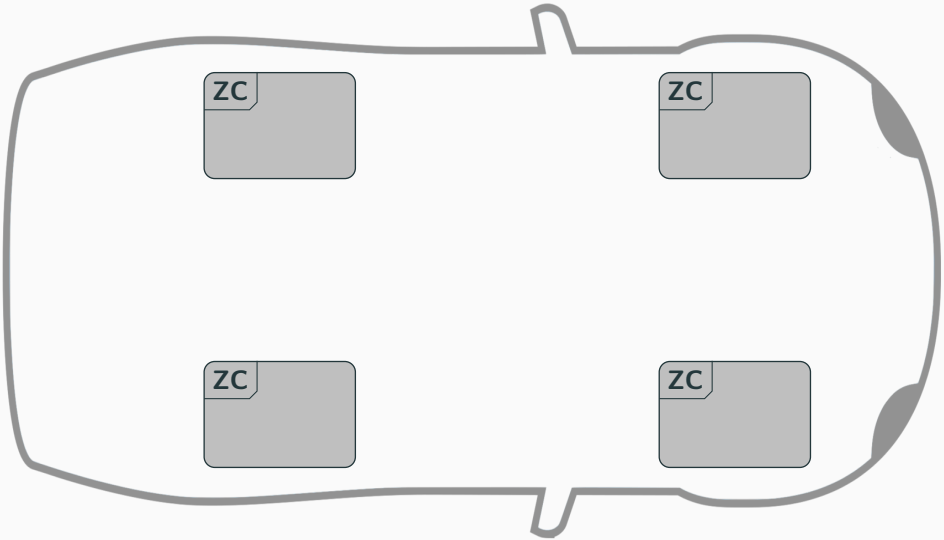

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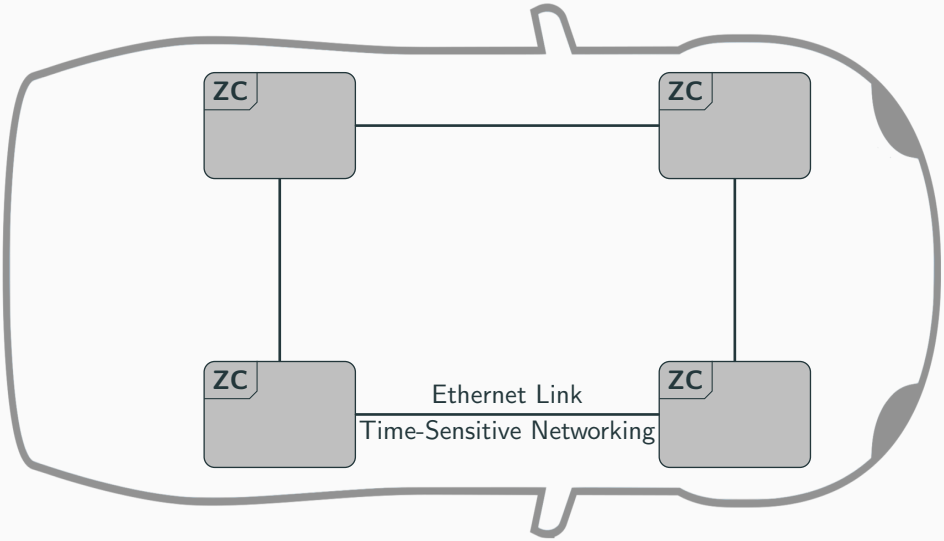

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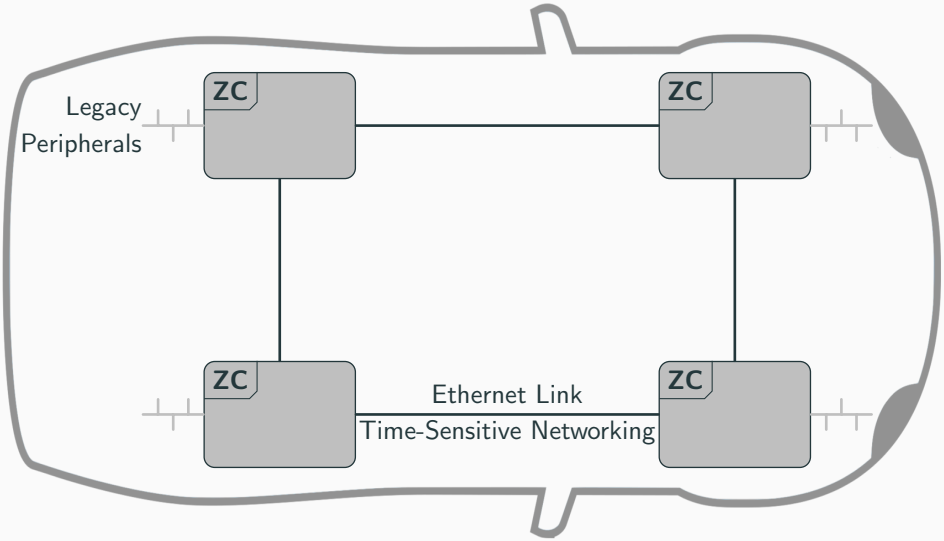

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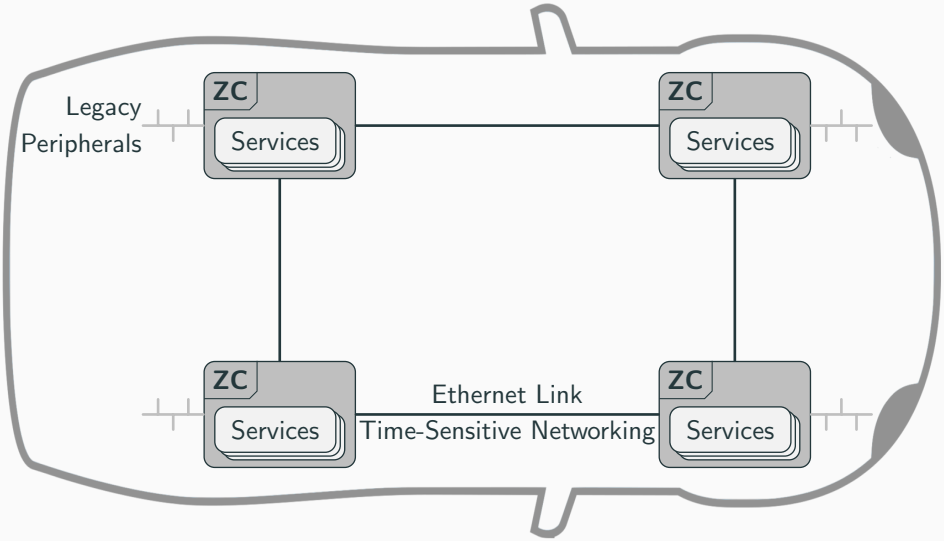

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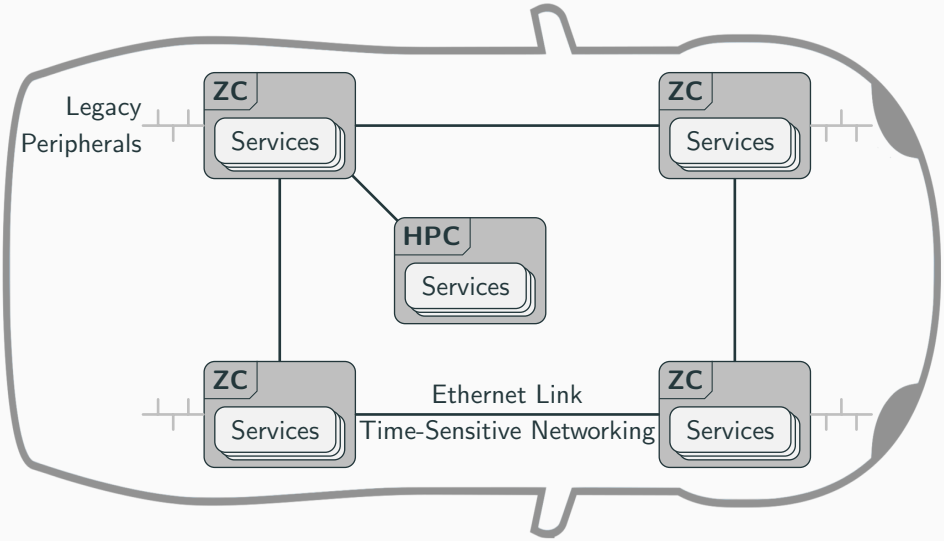

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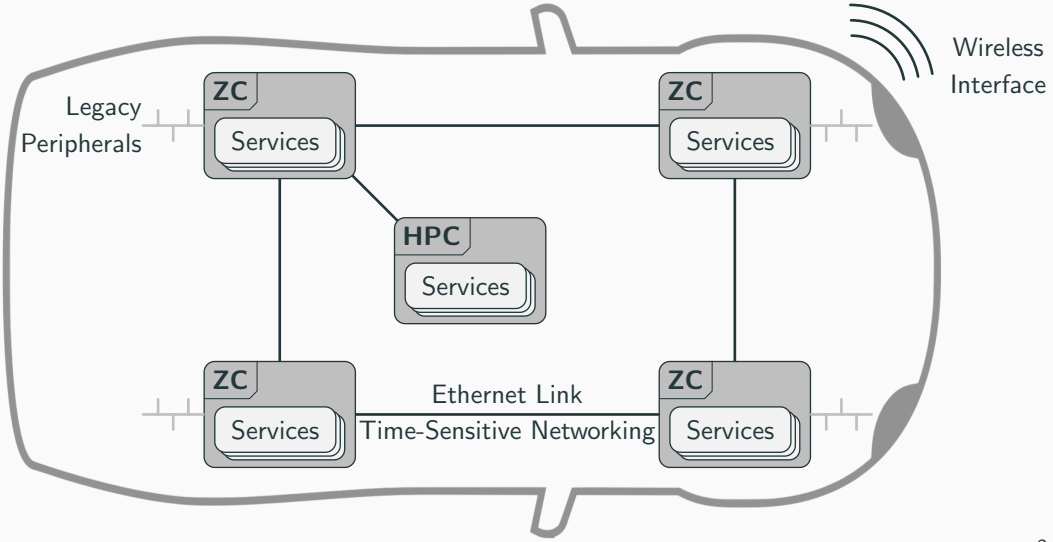

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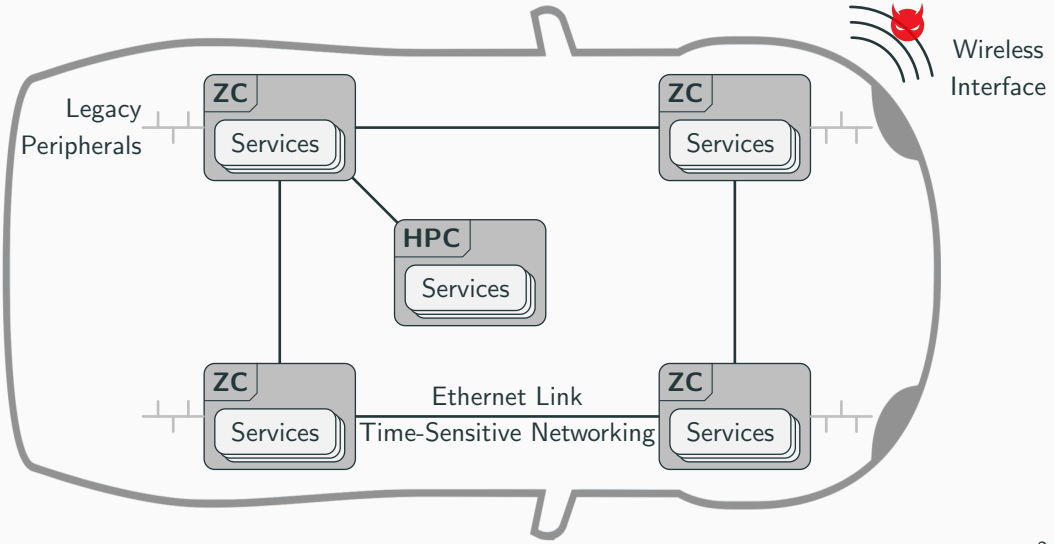

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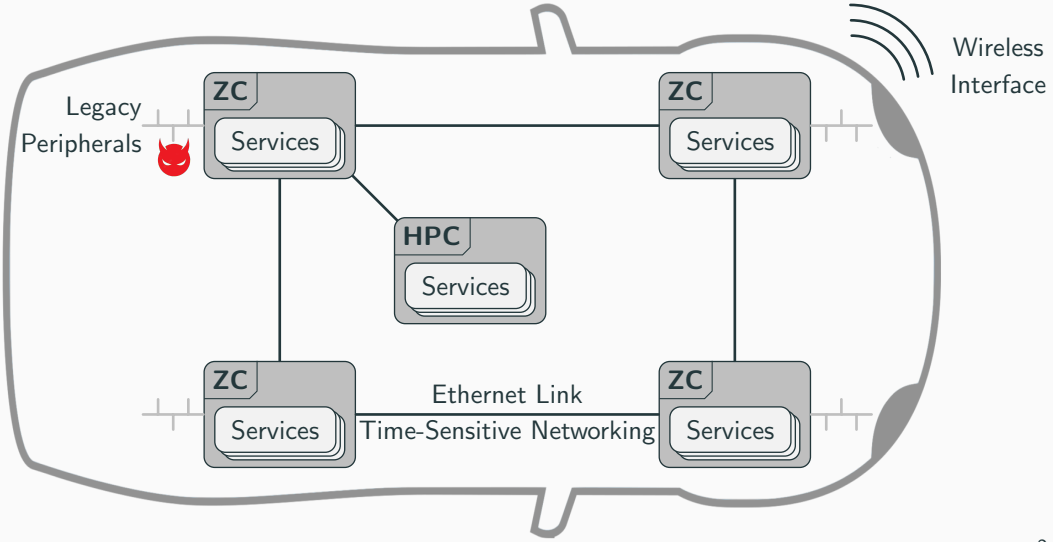

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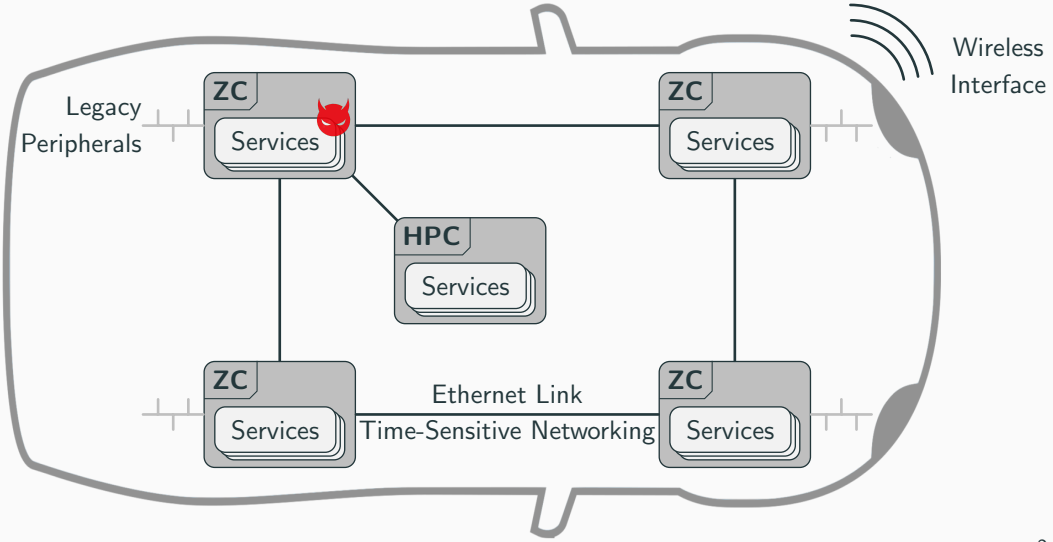

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→ GKA scheme following DH-based PFS like in TLS 1.3 or DTLS 1.3

Service and Client Authenticity Based on DNSSEC and DANE

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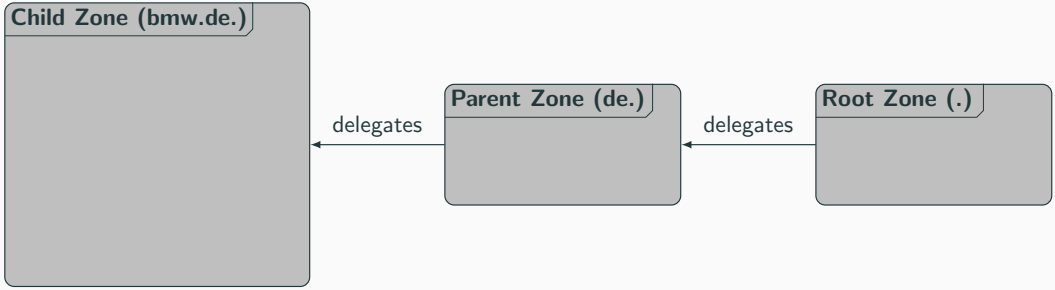

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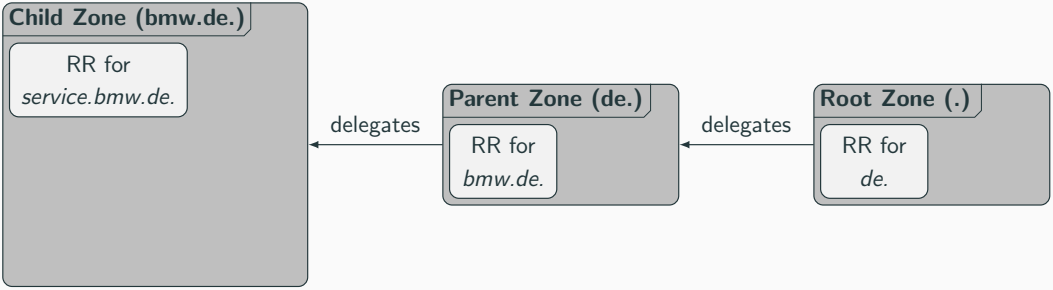

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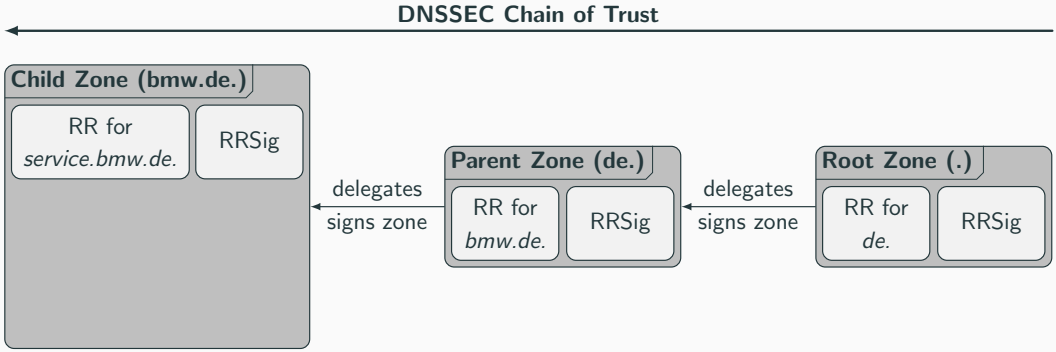

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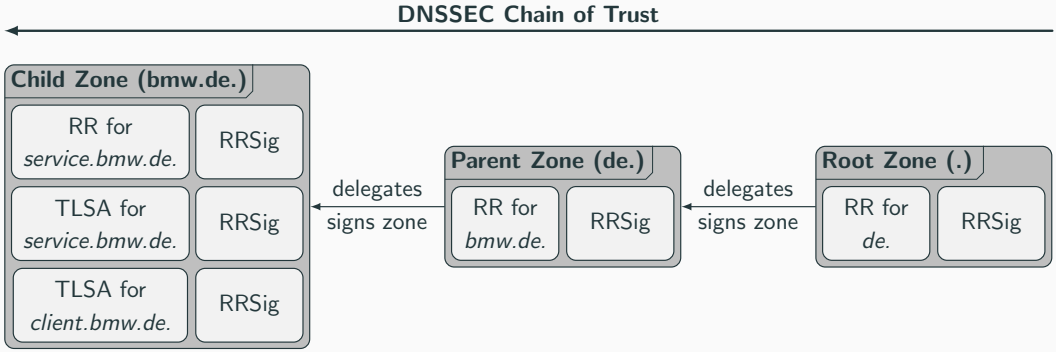

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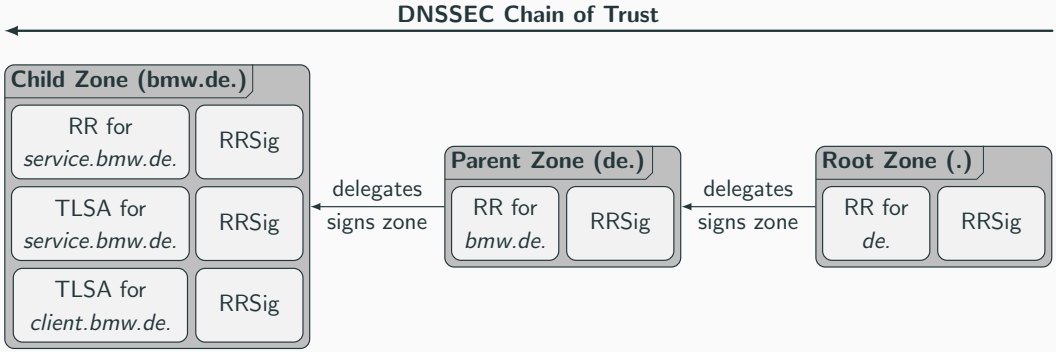

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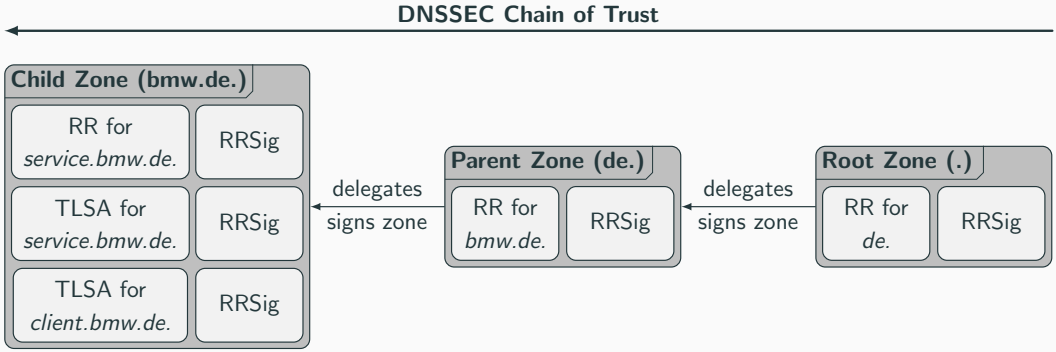

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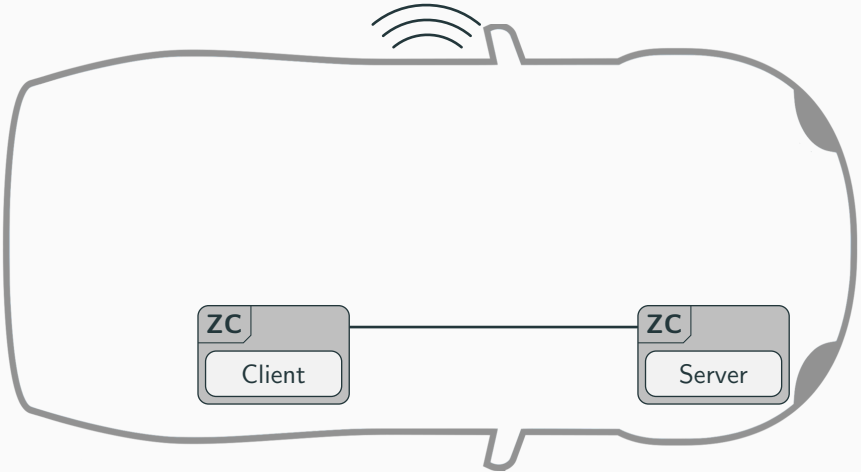
- Possibility for private DNSSEC namespaces

Envisioned Deployment Scenario



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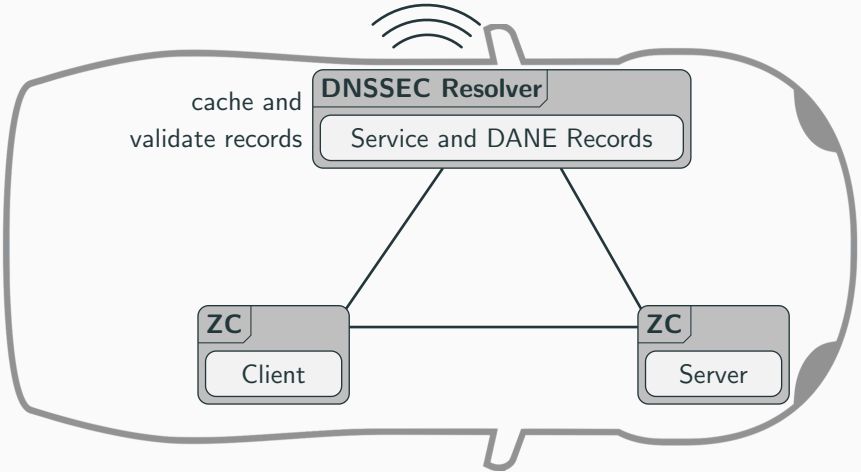

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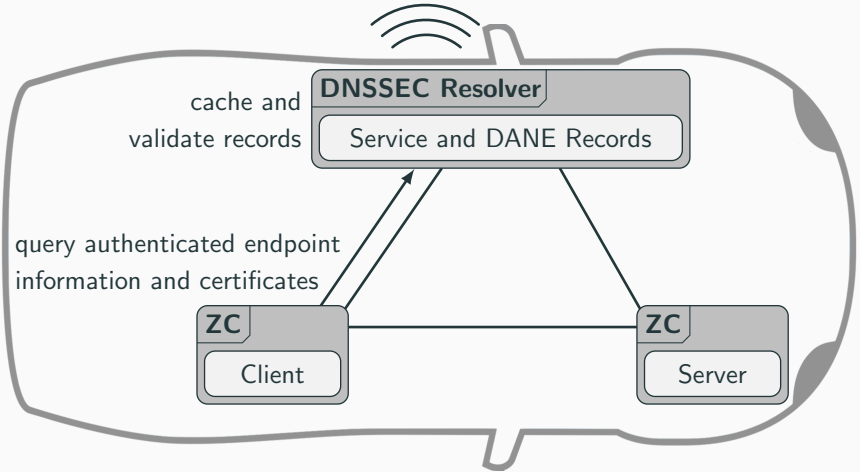

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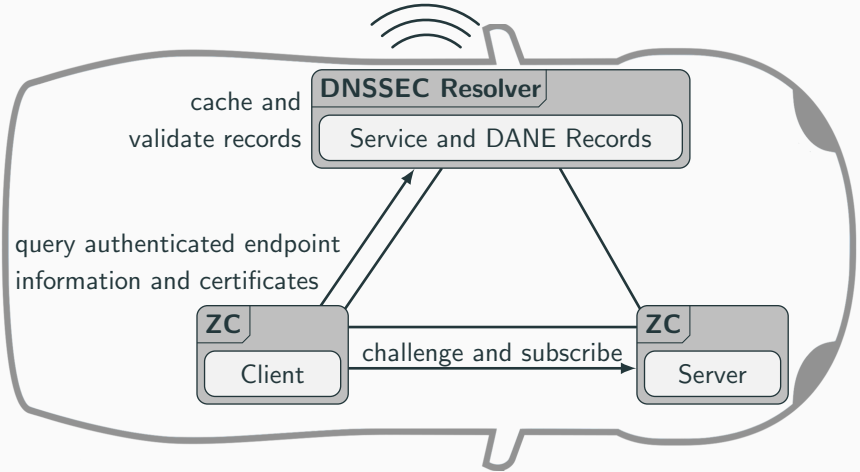

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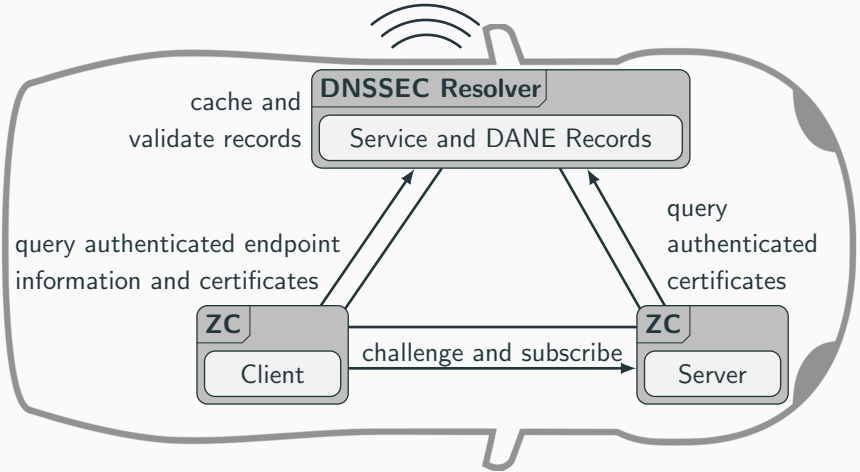

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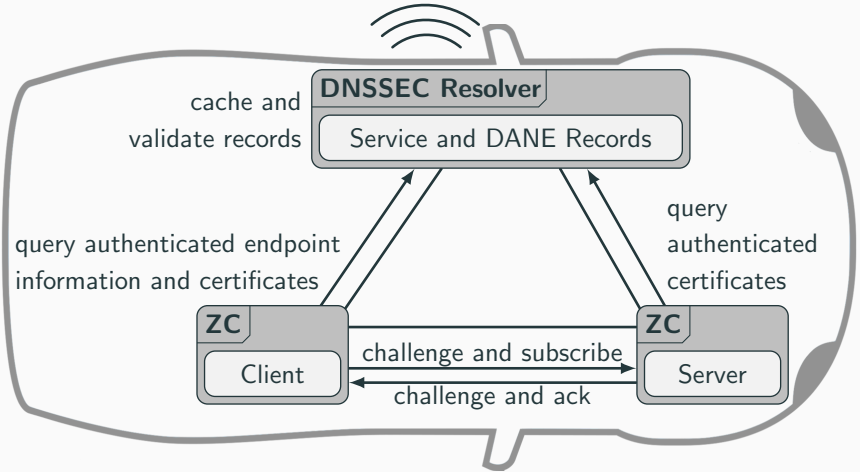

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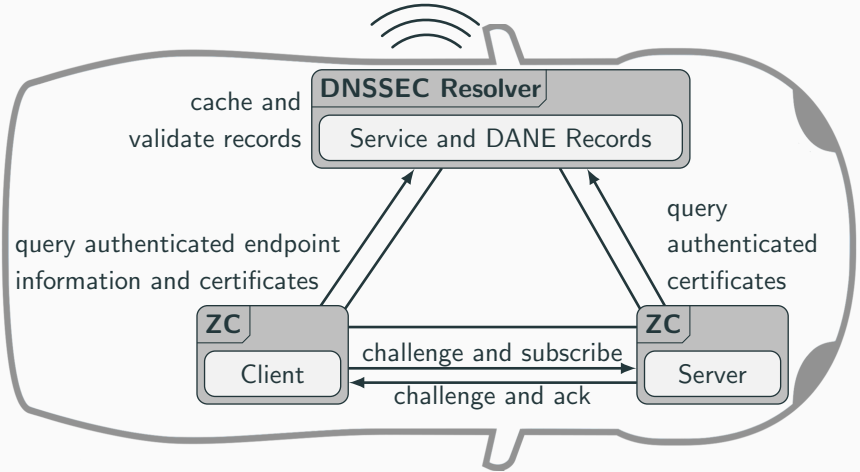

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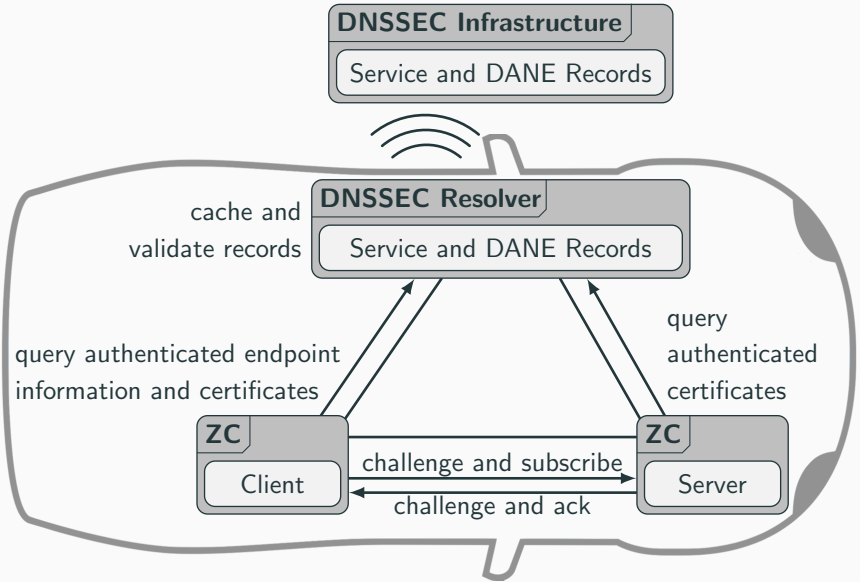

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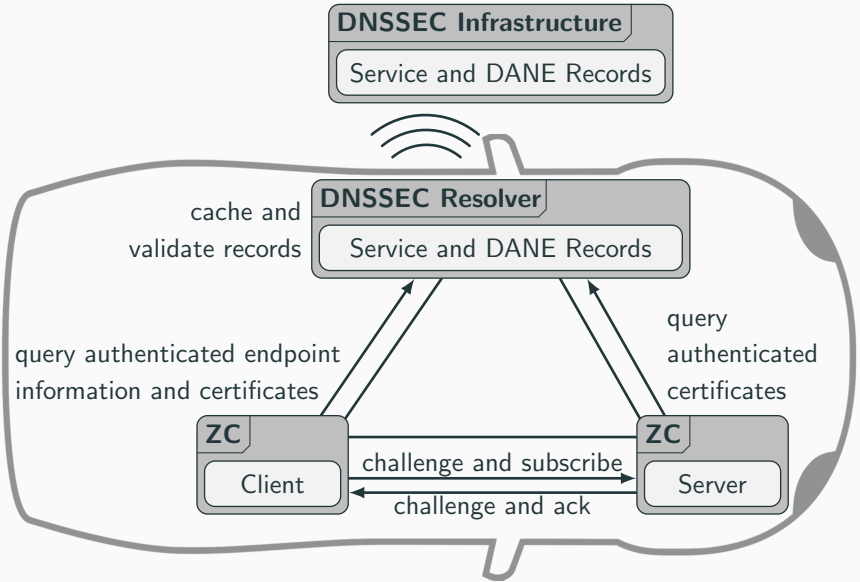

→ **Offline operation w/o pre-deployed certificates**

→ **Secure, established update scheme**

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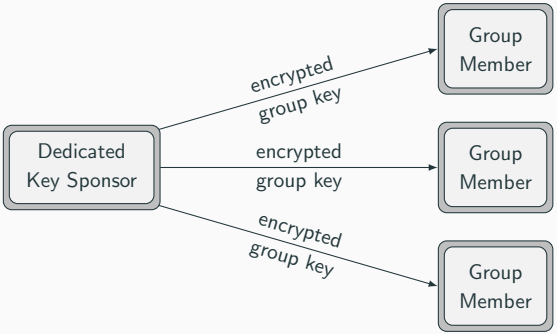

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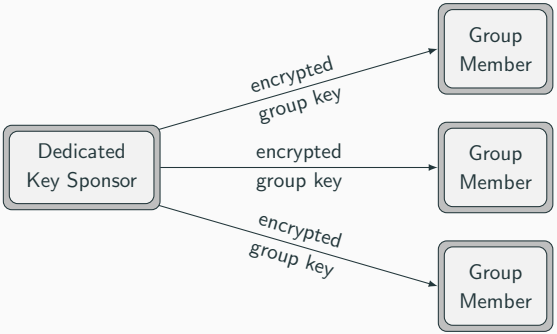

→ Less load on group members, but SPOF

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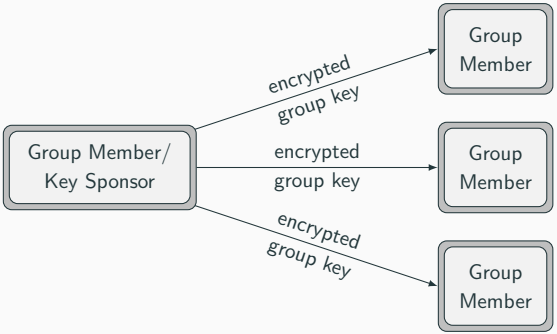

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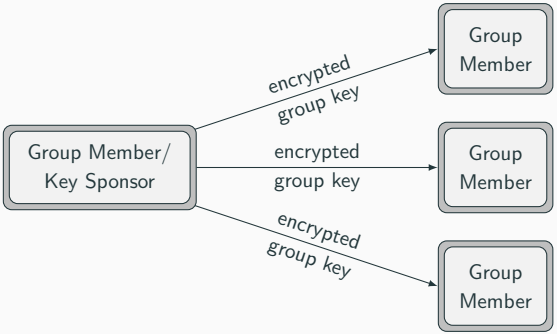

→ More load on group members who sponsor the group key, but is more robust against host failures

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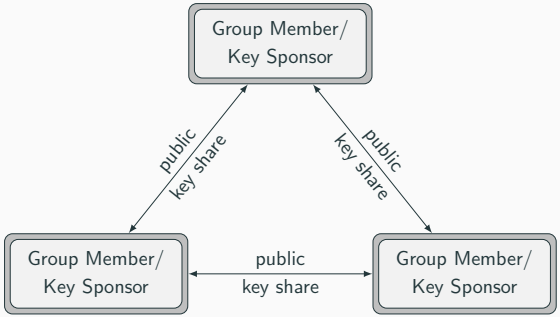

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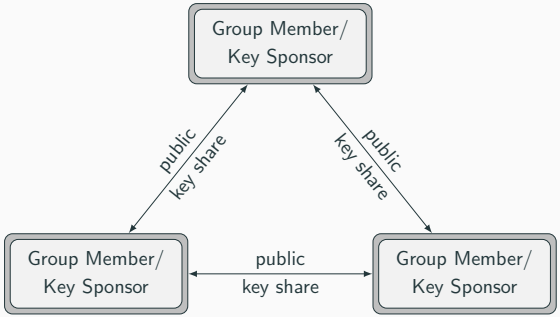

→ More load on all group members since all of them are involved and additional communication rounds for synchronizing, but allows key agreement without a secure channel (e.g., DH)

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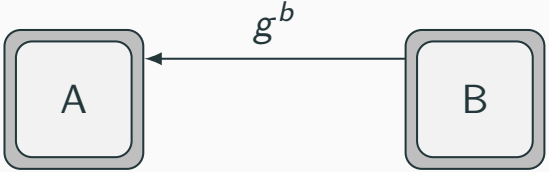

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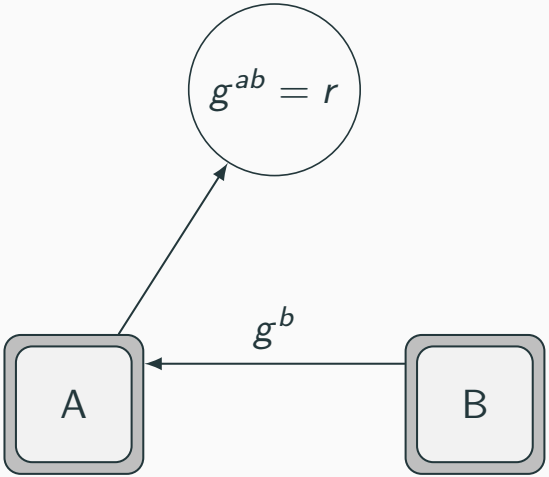

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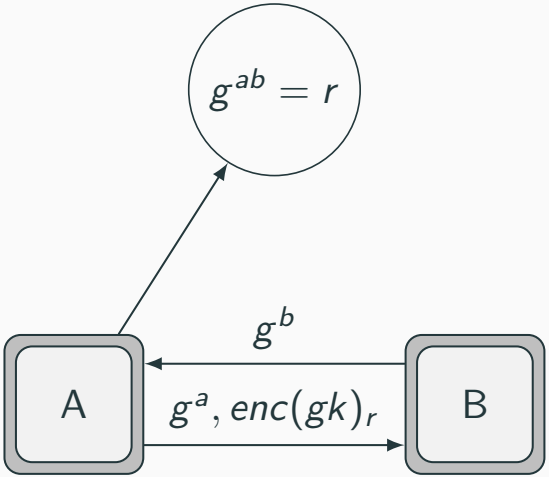

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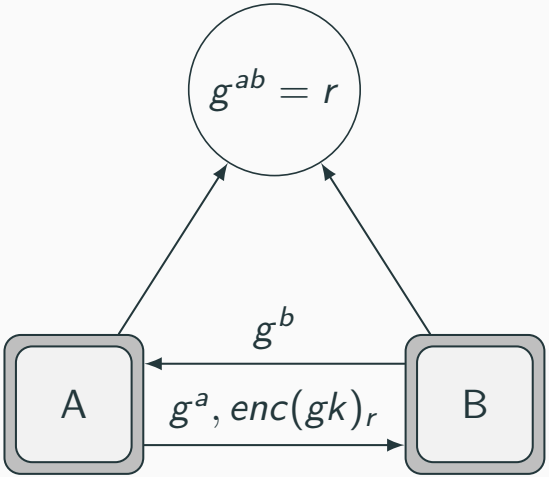

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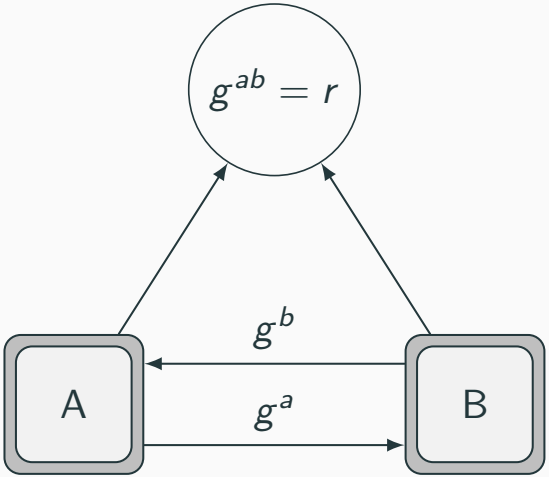

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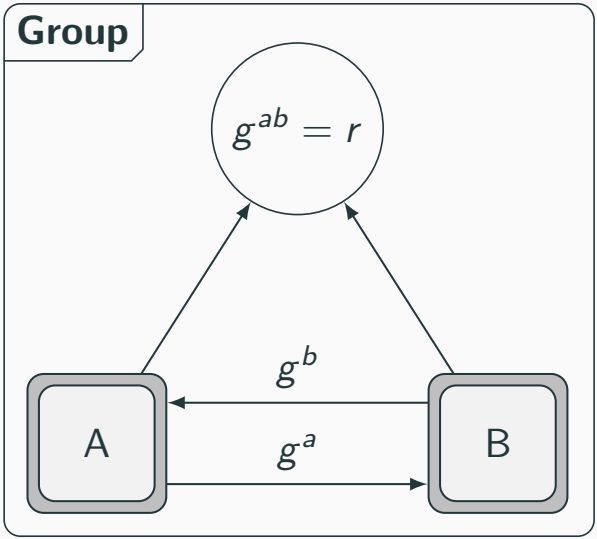

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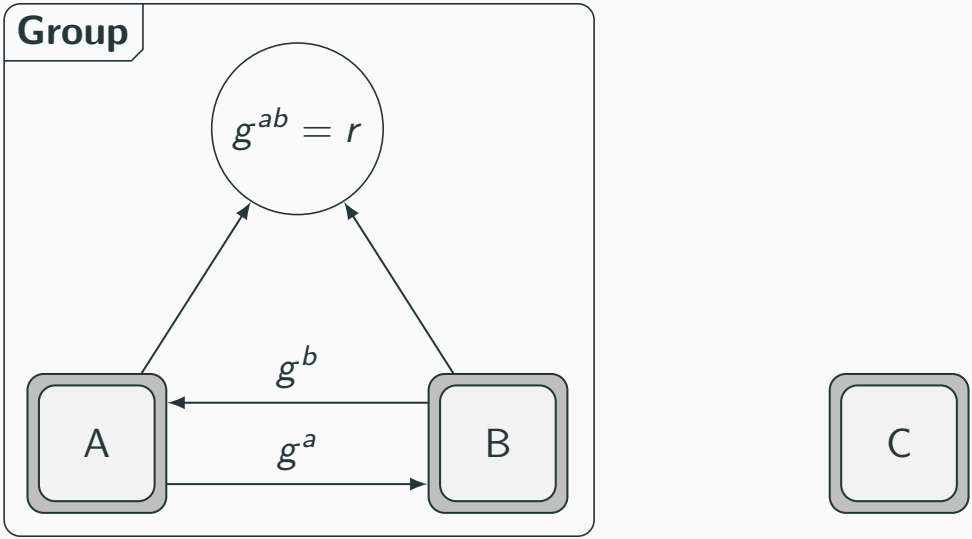

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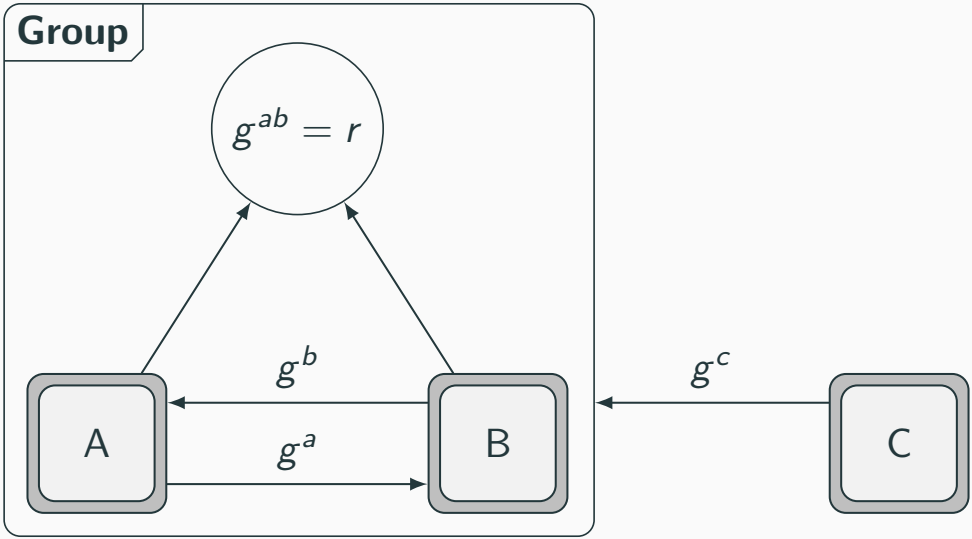

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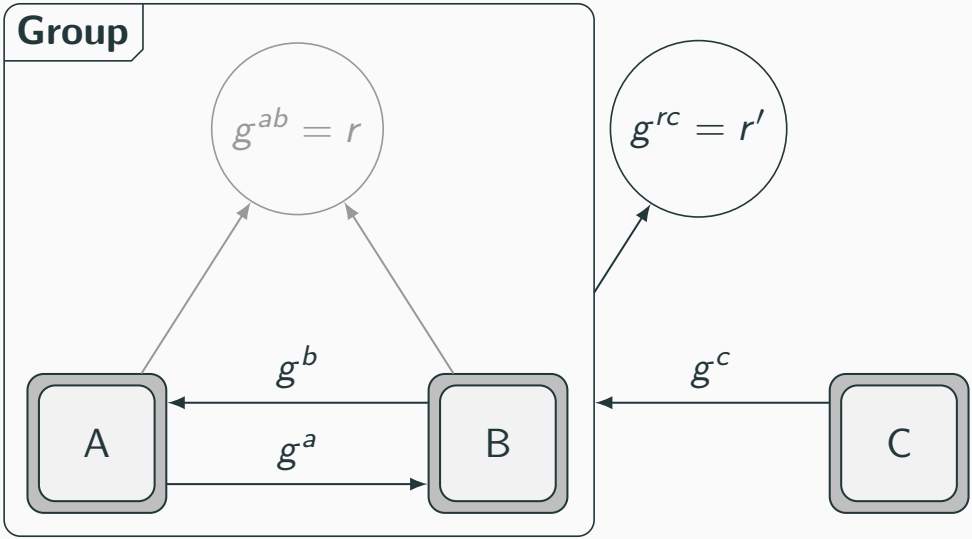

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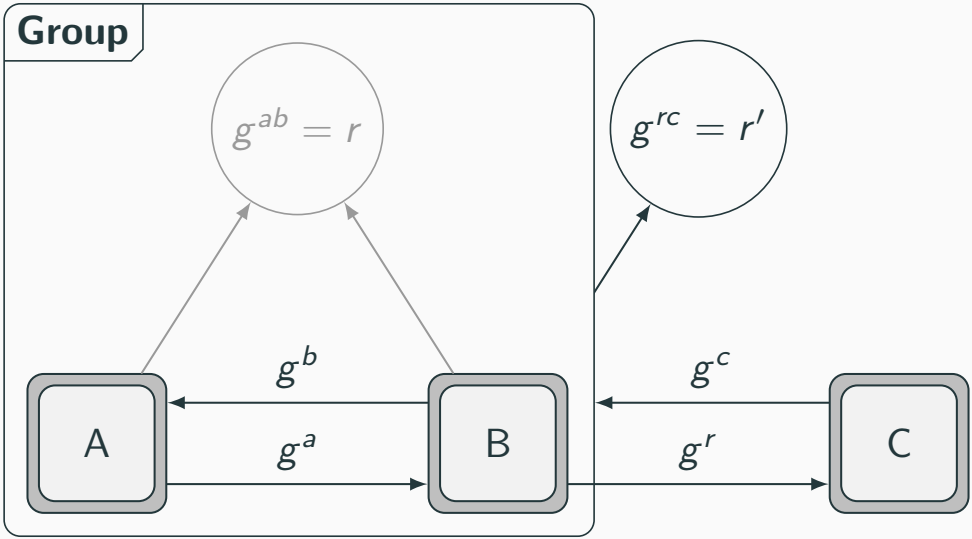
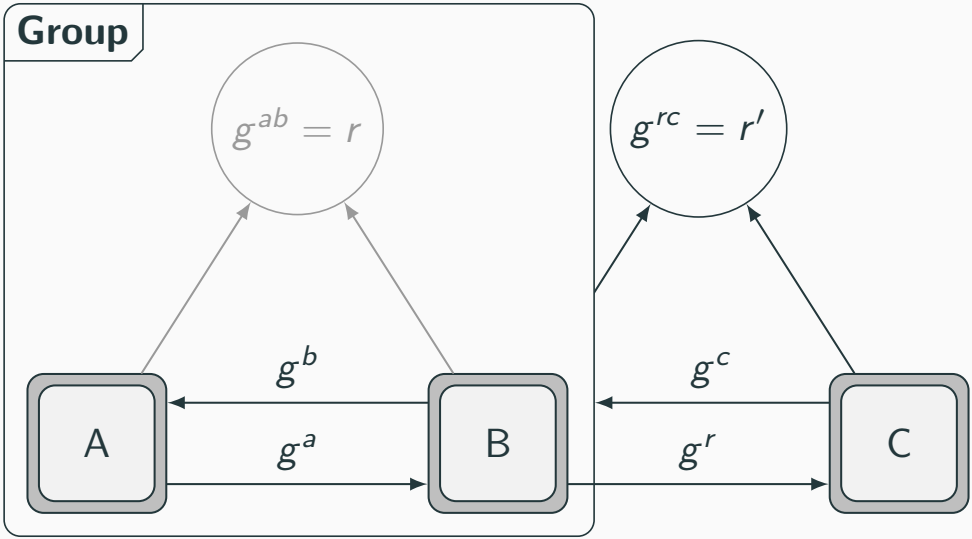
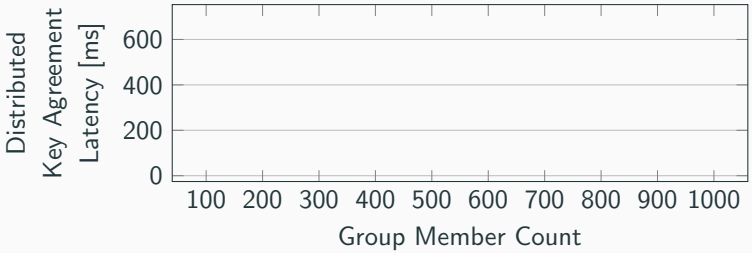
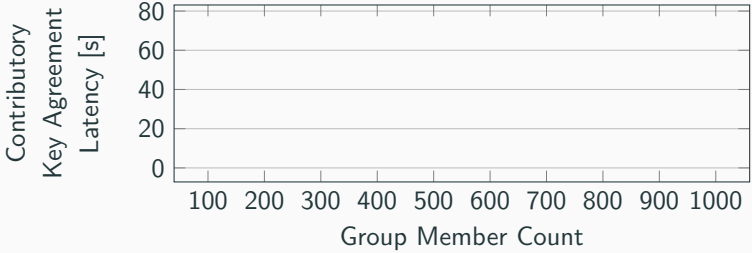


Contributory Diffie-Hellman Group Key Agreement Example



Diffie-Hellman Performance: Distributed vs. Contributory





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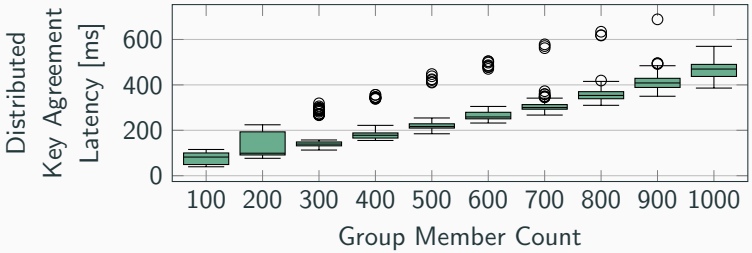

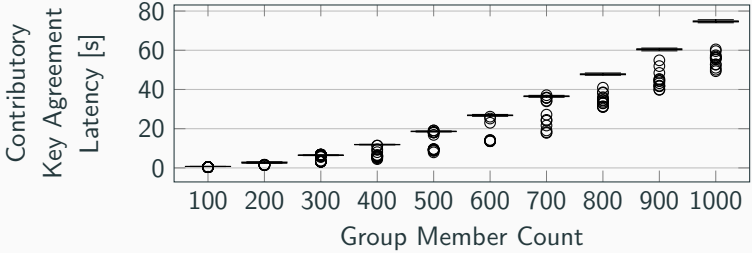

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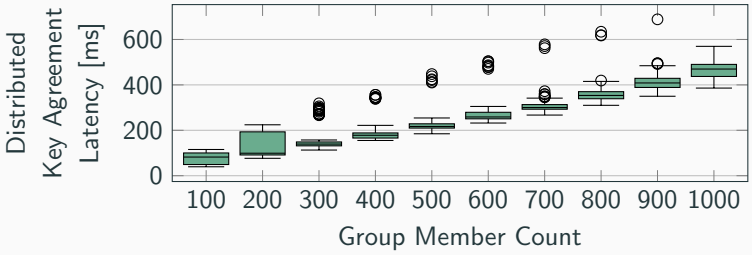
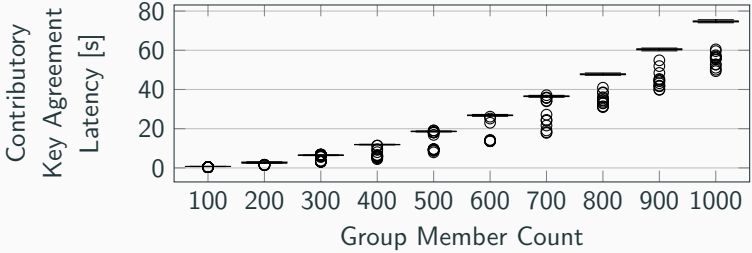
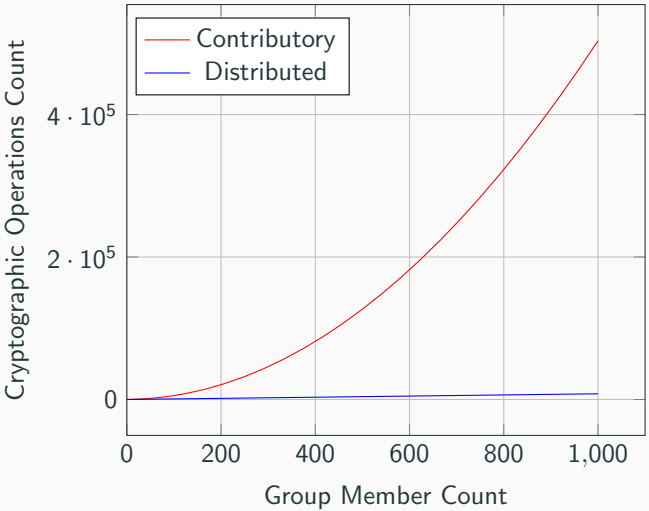




→ **The distributed key agreement latency remains in the ms range while the contributory key agreement begins significantly earlier in the seconds range**

Diffie-Hellman Cryptographic Operations Count: Distributed vs. Contributory



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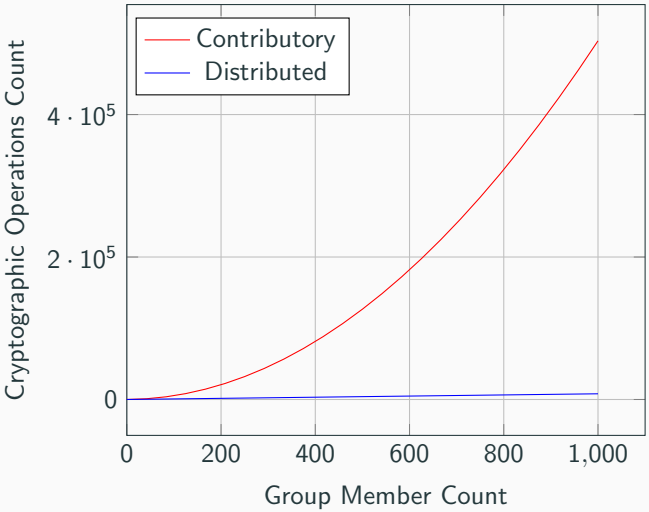
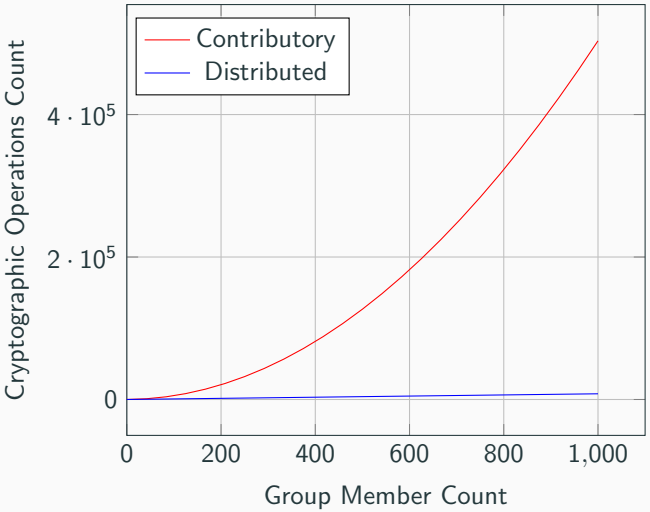


→ **The distributed approach involves just the key sponsor and the joining group member**

Diffie-Hellman Cryptographic Operations Count: Distributed vs. Contributory

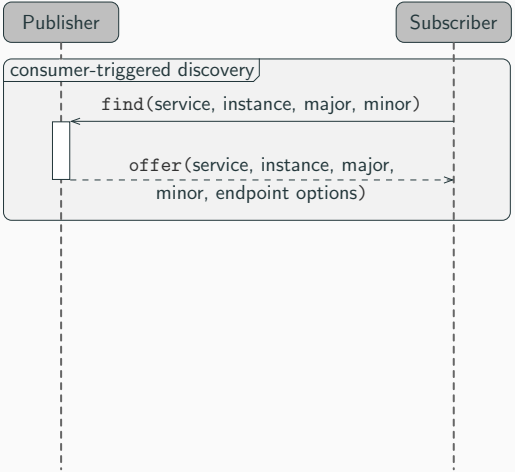


→ **The distributed approach involves just the key sponsor and the joining group member**

→ **The contributory approach also involves group members who have already joined in addition to the key sponsor and the joining group member**

SOME/IP Service Discovery

SOME/IP Service Discovery



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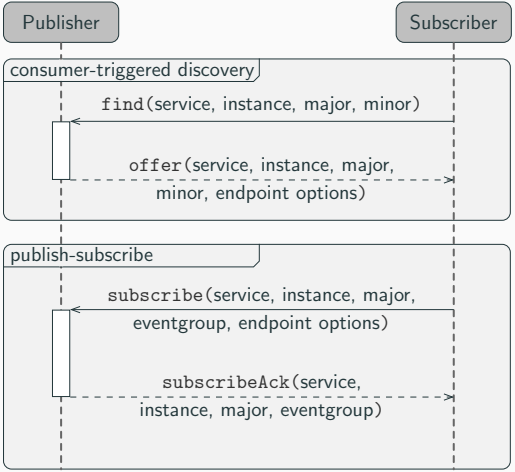

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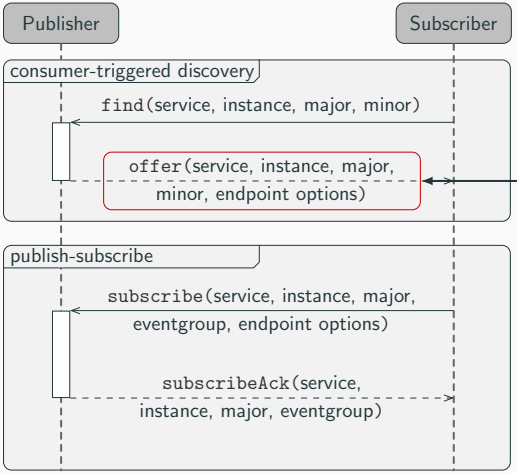
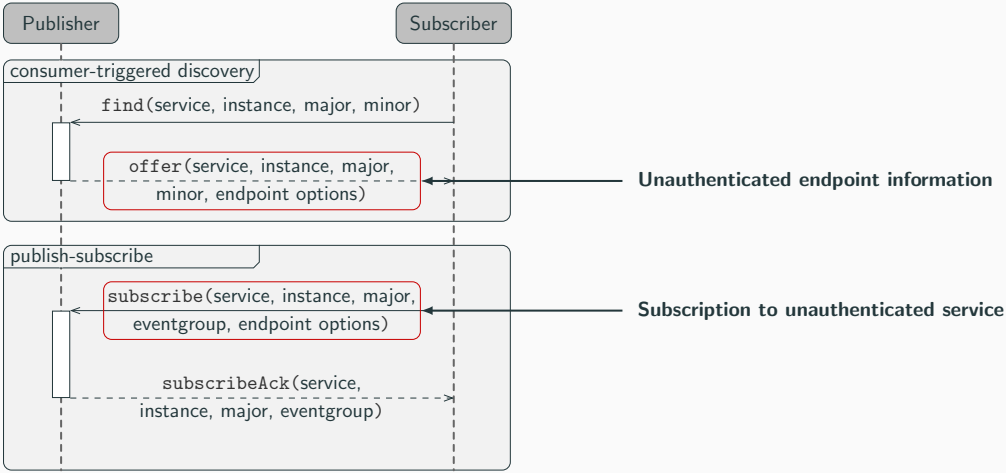


Unauthenticated endpoint information

SOME/IP Service Discovery



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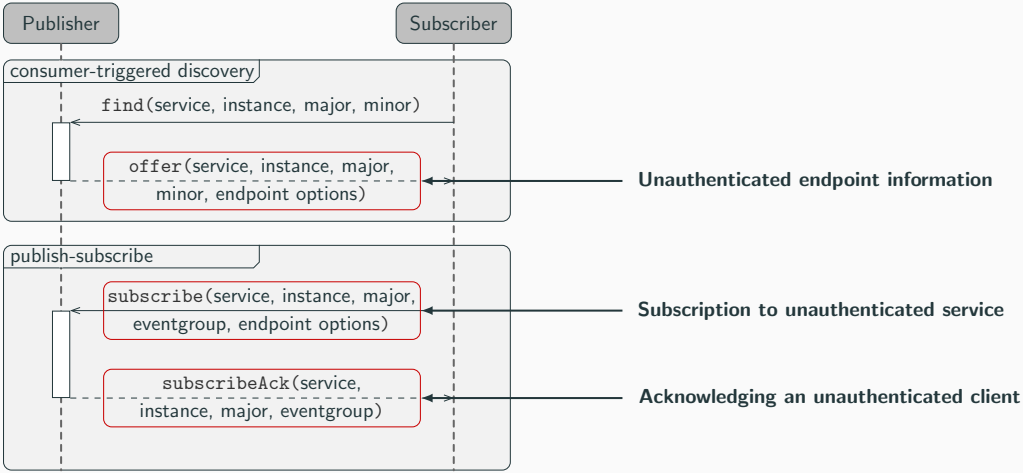

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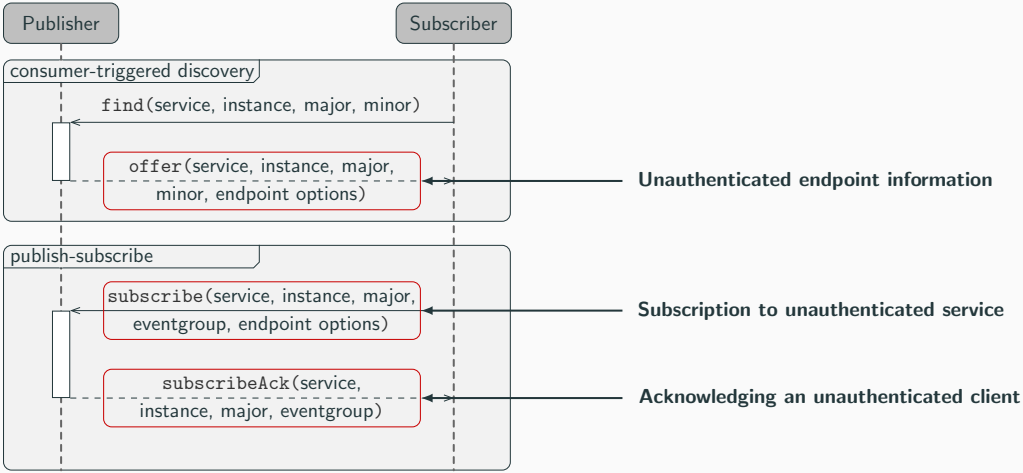
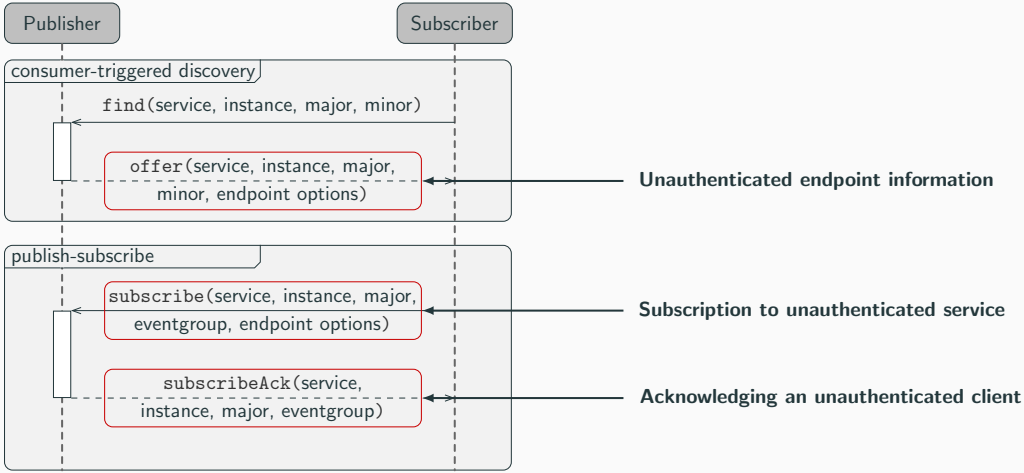


→ **SOME/IP lacks authenticity, key agreement mechanisms and encryption**

SOME/IP Service Discovery



→ **SOME/IP lacks authenticity, key agreement mechanisms and encryption**

→ **Distributed DH GKA fits better than the contributory scheme**

Our Approach: DNSSEC and Distributed GKA in SOME/IP Service Discovery

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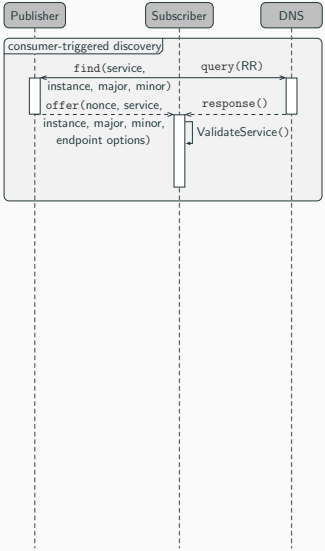

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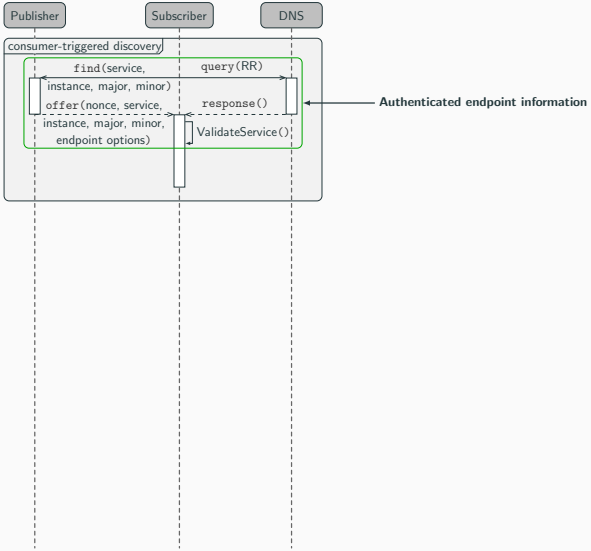

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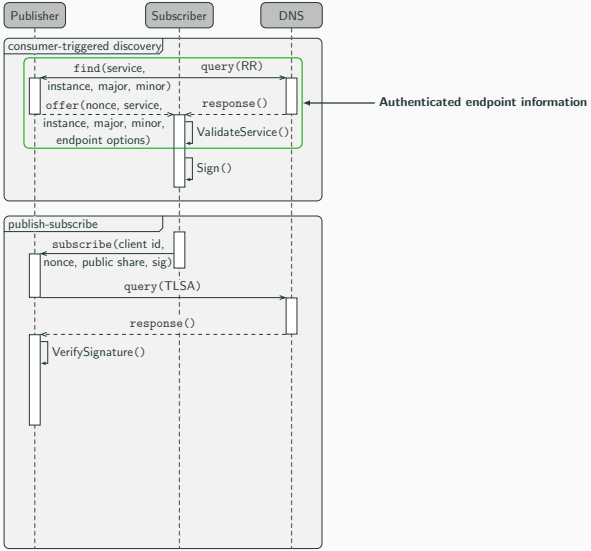

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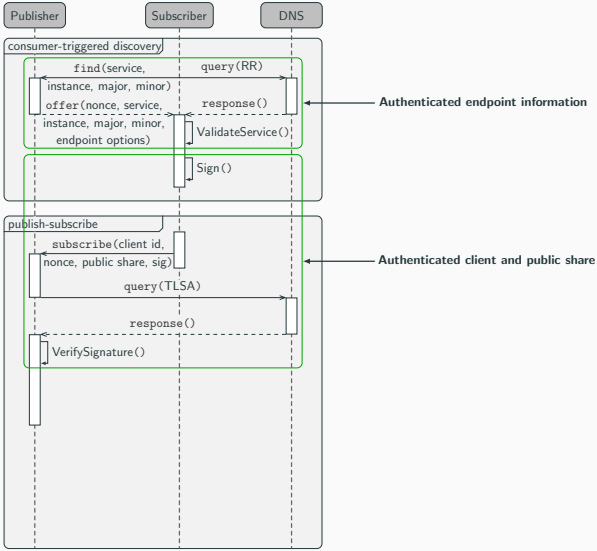

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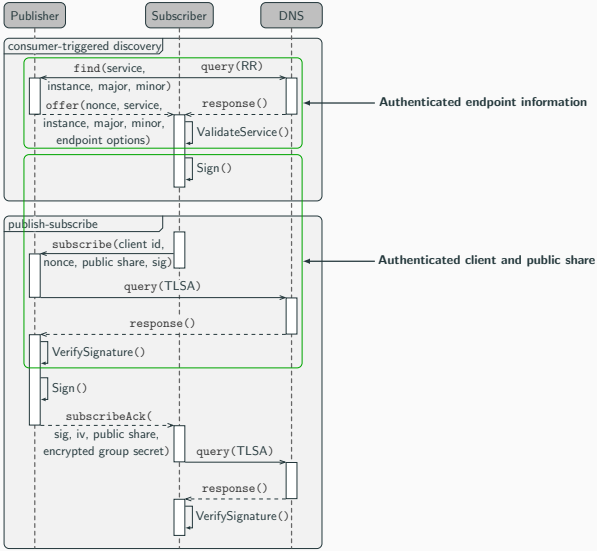

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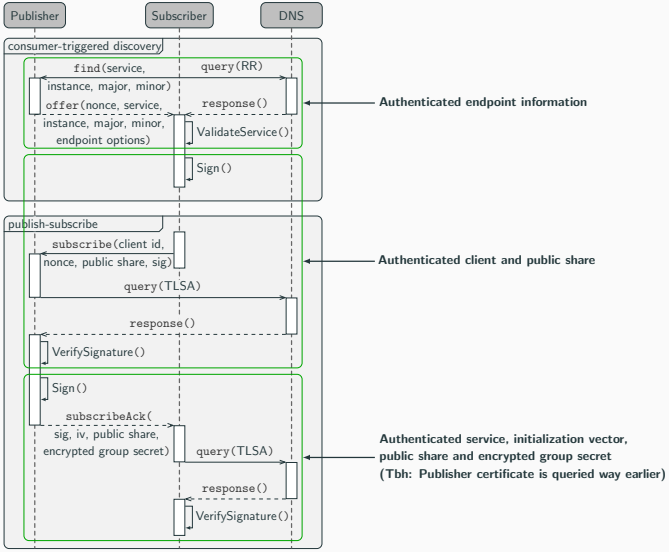

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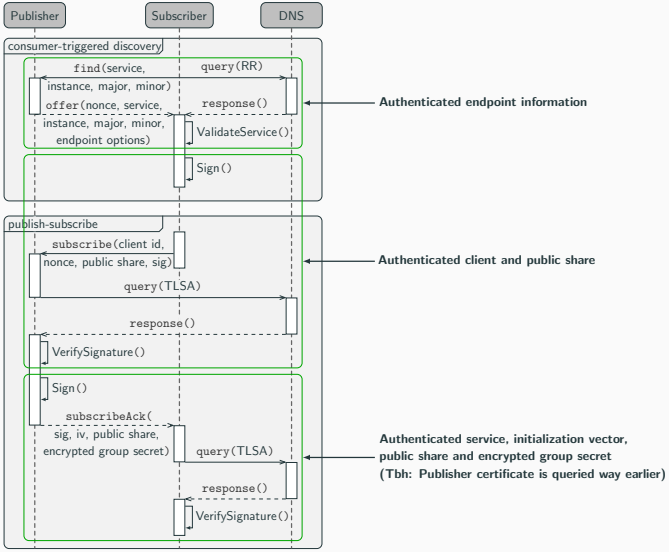

→ **DNSSEC with DANE ensures authenticity and integrity of endpoint information and certificates**

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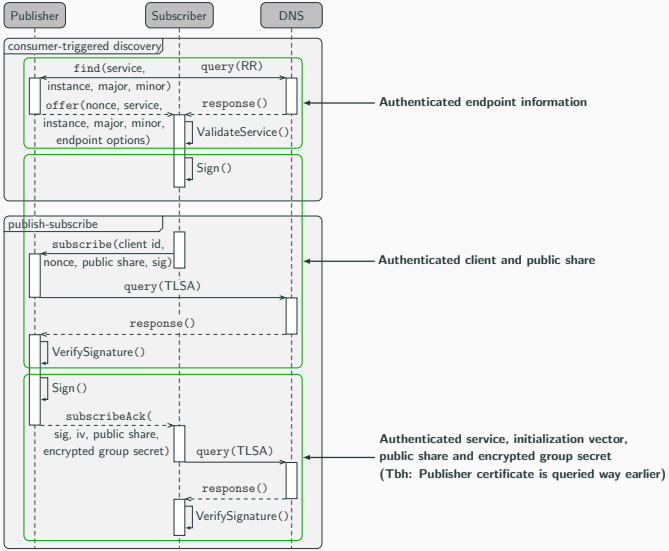

→ **DNSSEC with DANE ensures authenticity and integrity of endpoint information and certificates**

→ **Challenge-response mechanism ensures publisher and subscriber authenticity**

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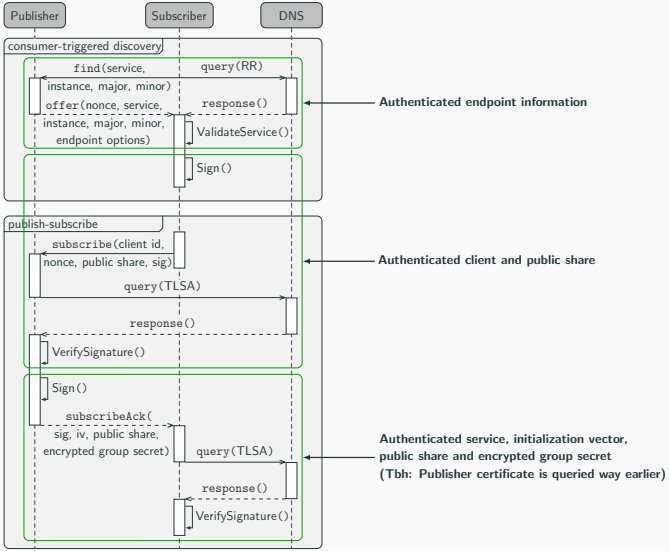

→ DNSSEC with DANE ensures authenticity and integrity of endpoint information and certificates

→ Challenge-response mechanism ensures publisher and subscriber authenticity

→ Seamless distributed Diffie-Hellman group key agreement enables encryption of subsequent SOME/IP session traffic

DNSSEC and GKA Implementation in SOME/IP Service Discovery

- Implementation based on vsomeip reference implementation
- Integrated standard DNS resolver in vsomeip
- Integrated standard cryptographic operations and algorithms for service and client authentication as well as for seamless distributed Diffie-Hellman group key agreement

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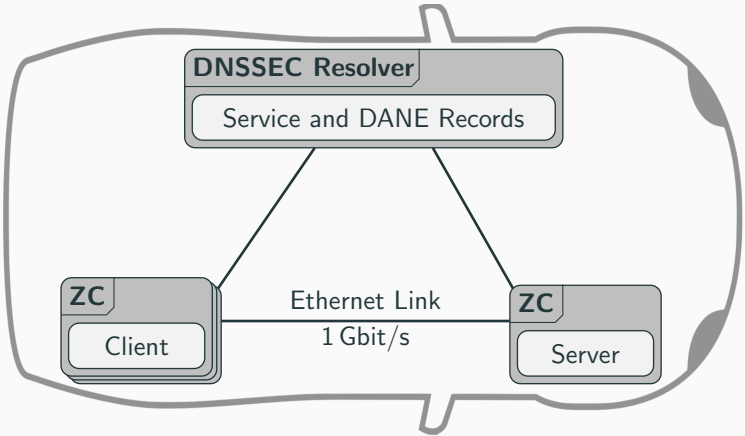
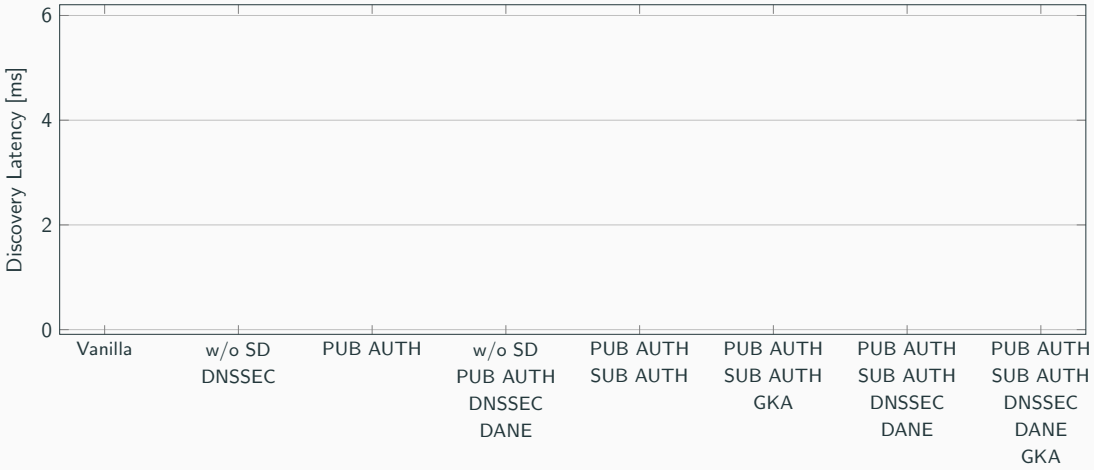


Performance Analysis Based on SOME/IP Reference Implementation with One Publisher and One Subscriber



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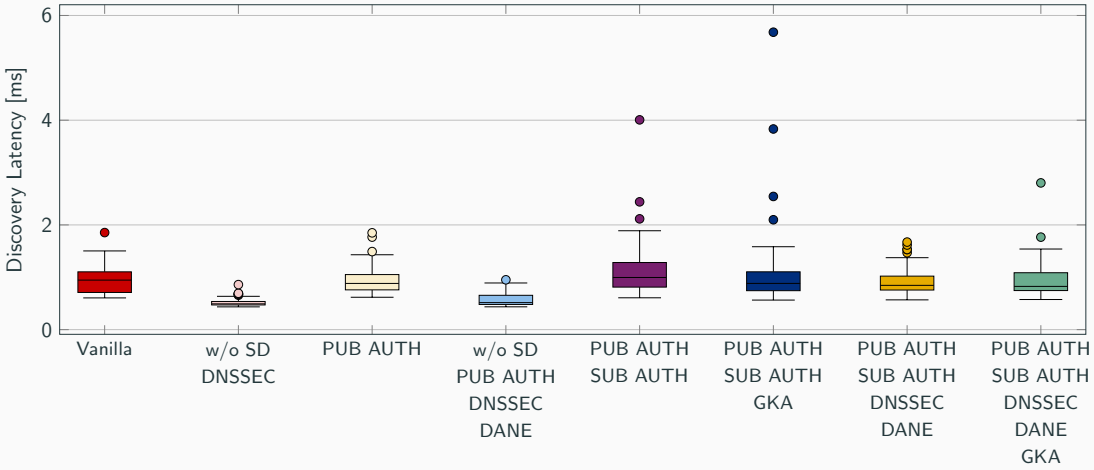

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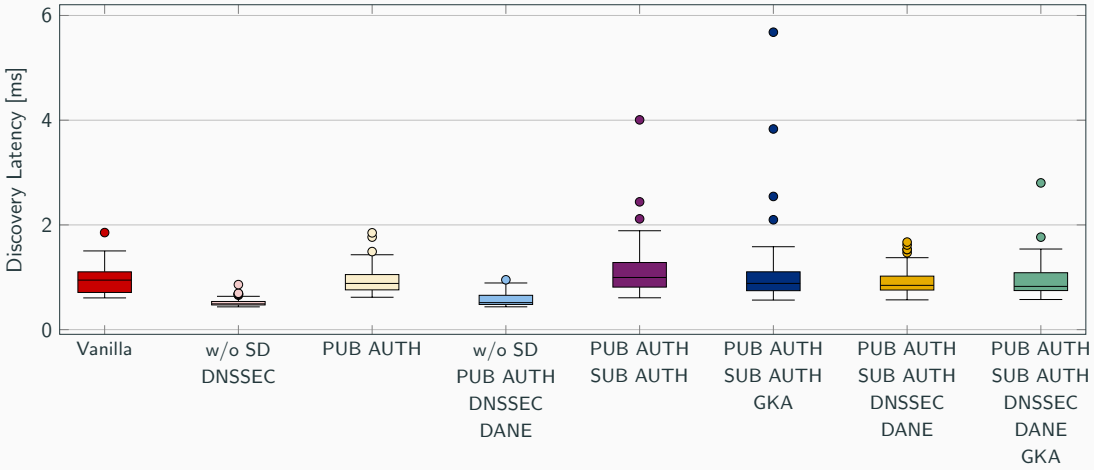

→ **No significant penalty on discovery performance**

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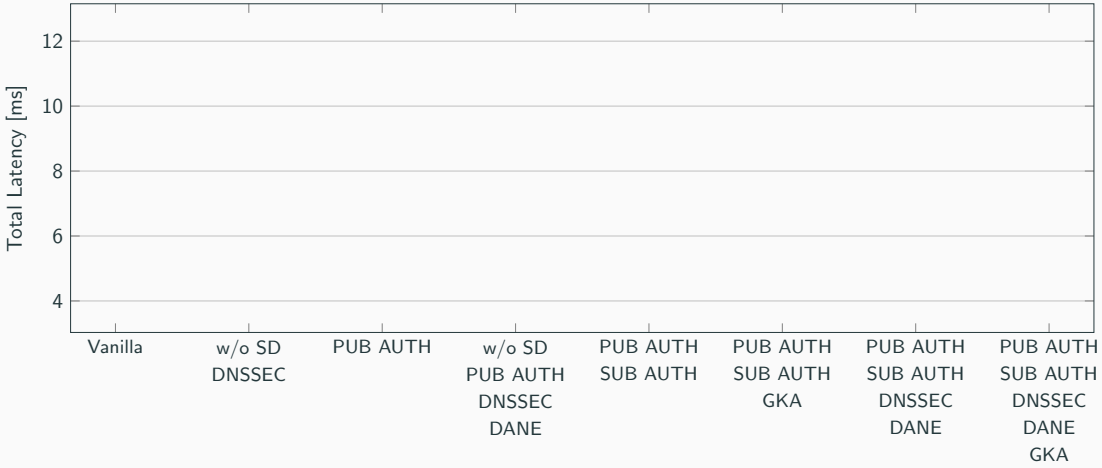

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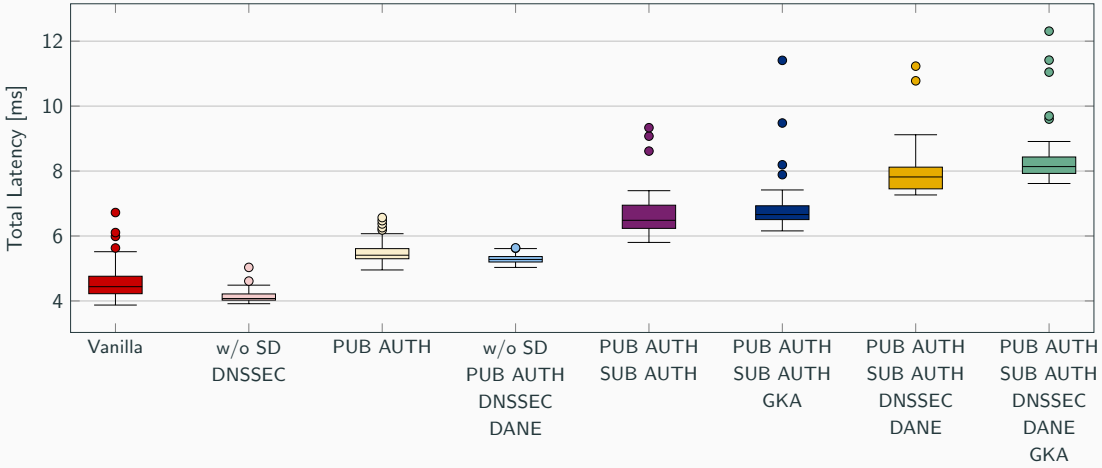

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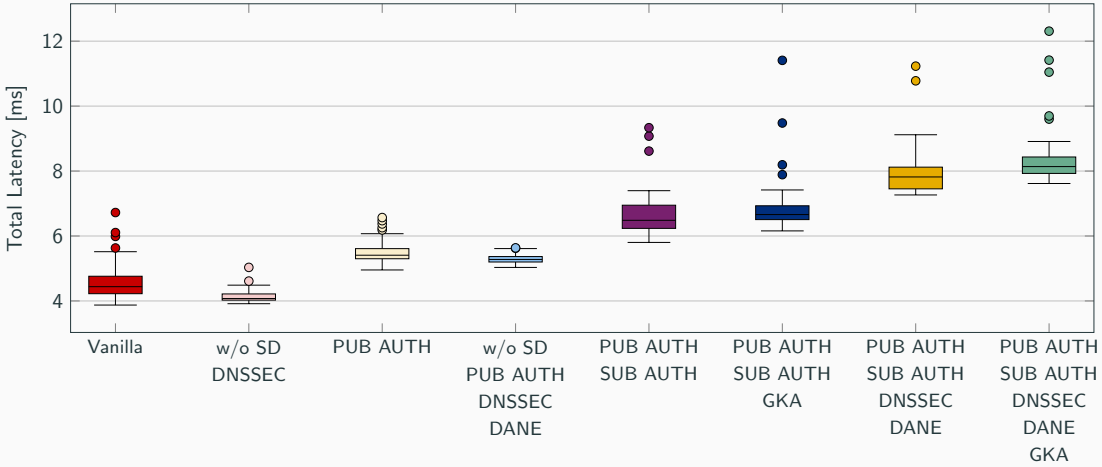
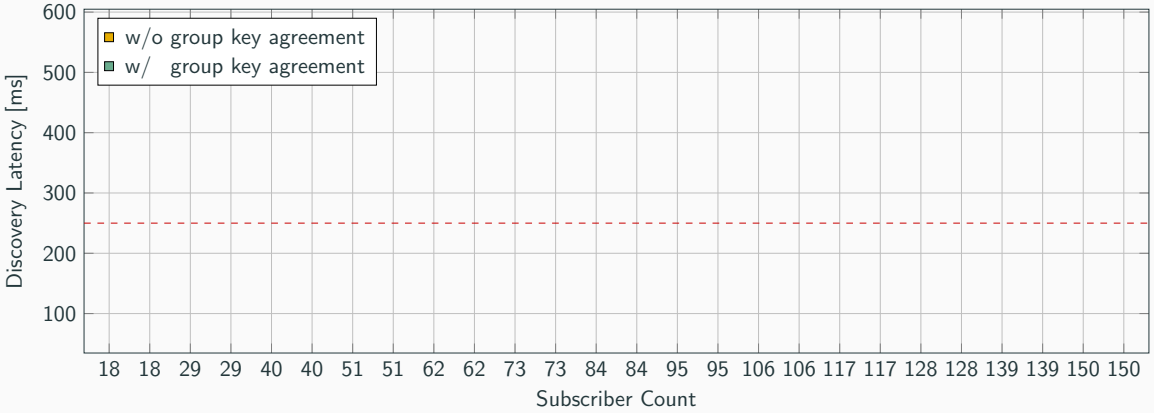


→ **Penalty in performance due to the request of subscriber certificates compared to pre-deployed certificates**

Performance Analysis Based on SOME/IP Reference Implementation with One Publisher and Multiple Subscribers (PUB/SUB AUTH, DNSSEC, DANE, GKA)



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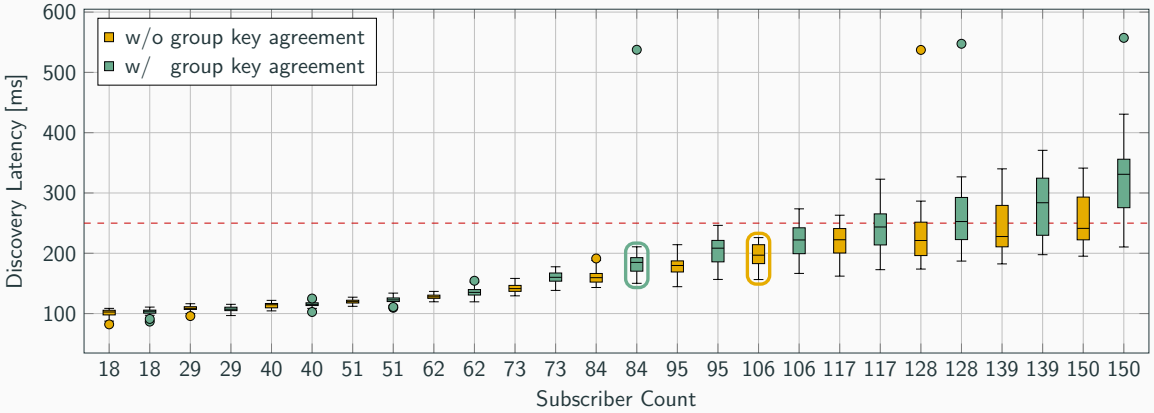

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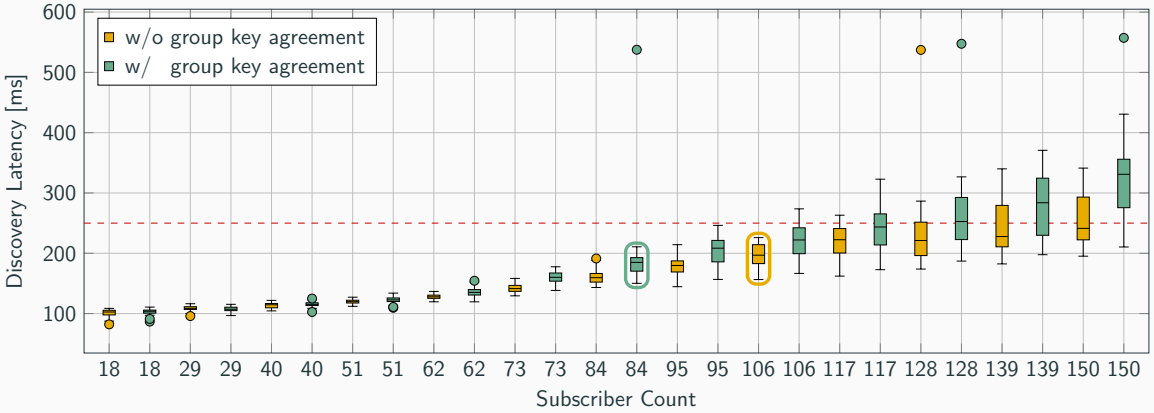

→ **Discovery latency for subscriber counts of 106 without GKA and 84 with GKA remain below the satisfactory user experience threshold**

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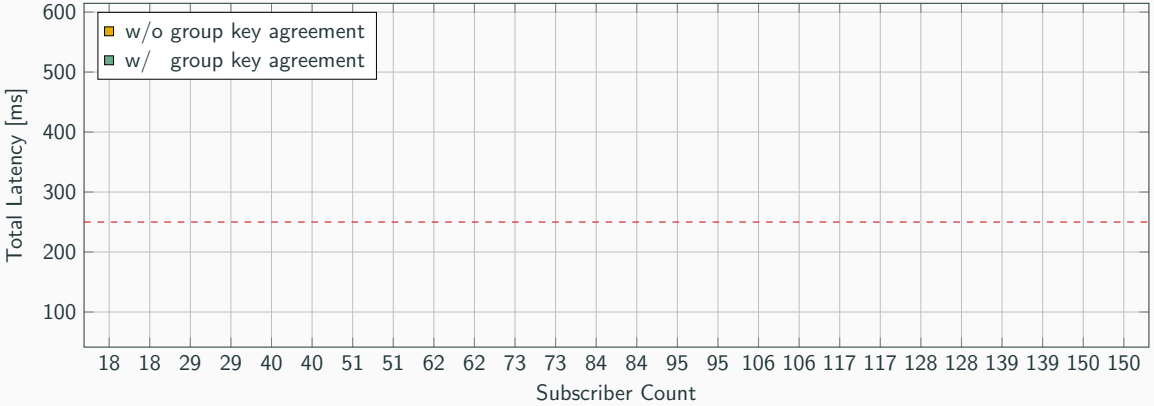

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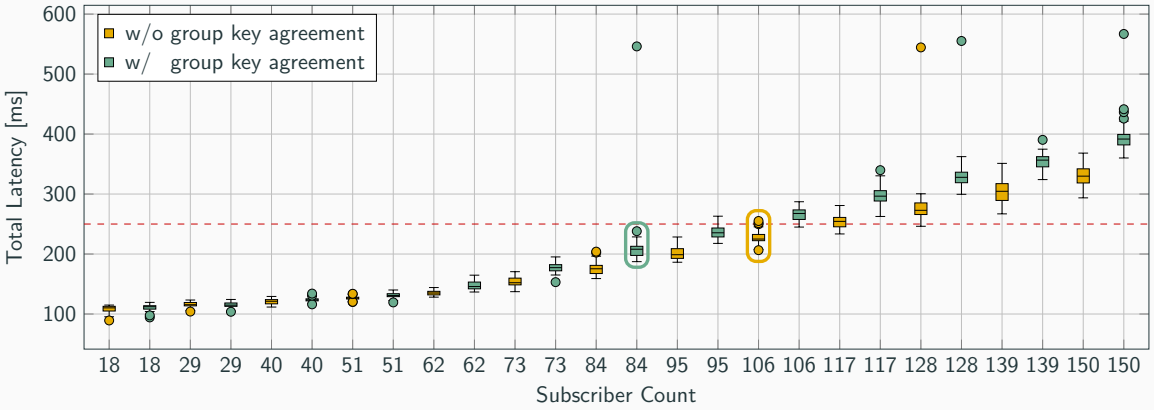

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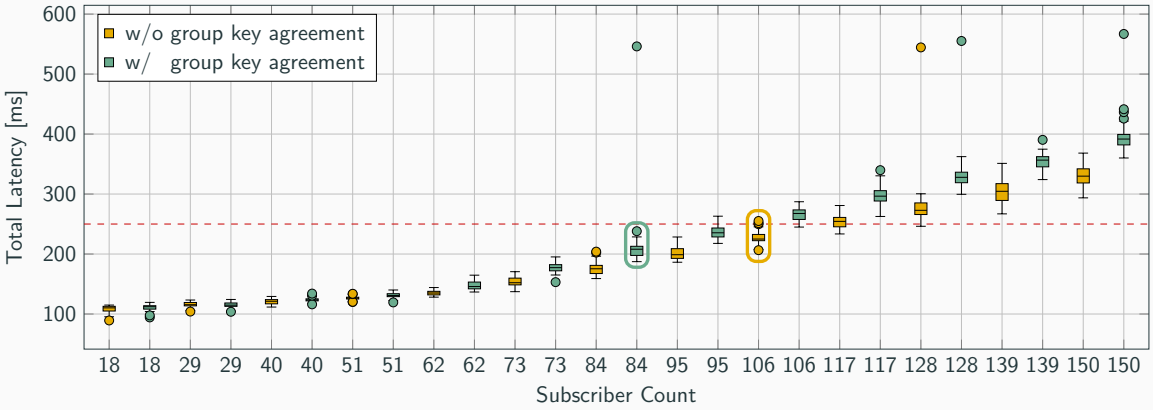

→ **Subscriber counts of 106 without GKA and 84 with GKA comply with satisfactory user experience, which likely improves with parallelization on actual nodes and cryptographic hardware acceleration**

Benefits of DNSSEC-based Authenticity and Distributed DH GKA

- Over 15 years of operational experience of DNSSEC
- Hardened for global deployment
- Pre-deployed certificates not needed
- Established mechanisms for key and certificate management
- Assured service and client authenticity using a challenge-response mechanism
- Scalable without delay penalty for service discovery
- Established mechanisms for seamless integrated group encryption key distribution

Conclusion & Outlook

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Summary

- SOME/IP is widely accepted but lacks service authenticity
- DNSSEC with DANE contribute a robust security solution and key management
- DNS namespace preserving SOME/IP SD query properties
- Endpoint authentication with a challenge-response mechanism
- Group Key Agreement complies with current security requirements

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Future Work

- Security design and assessment for remaining SOME/IP service primitives
- Operational guidelines for namespace management and service updates
- Evaluation of scalability in a production-grade vehicle
- Risk assessment of storing encryption keys in unprotected memory
- Assessment of which services actually require which type of security measures

Automotive Group Key Agreement and Secure Service & Client Authentication Using DNSSEC with DANE

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Dept. Computer Science, Hamburg University of Applied Sciences, Germany