Authenticated Key Exchange and Signatures with Tight Security in the Standard Model

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[3]Bergische Universität Wuppertal
[4]Norwegian University of Science and Technology

Authenticated Key Exchange

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Bob

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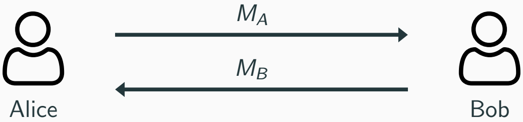

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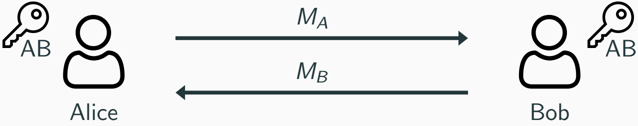

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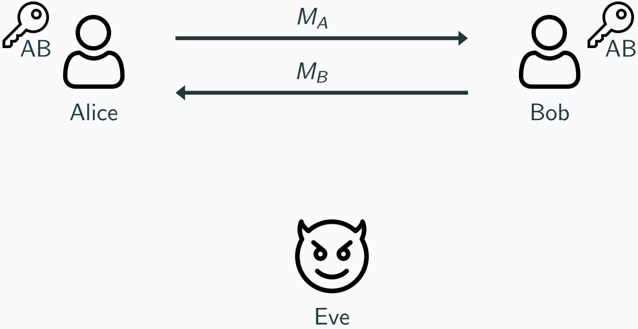

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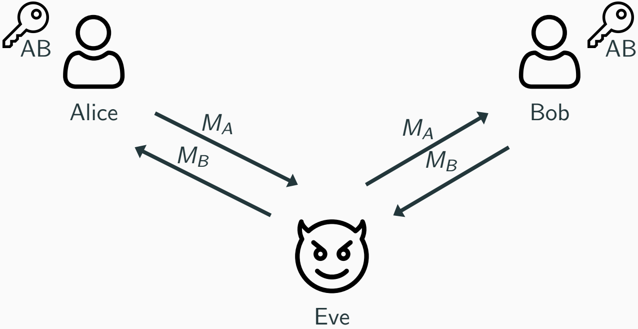

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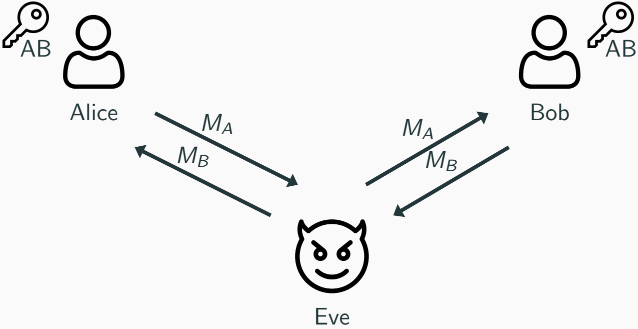

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- controls the network
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- reveals real session keys

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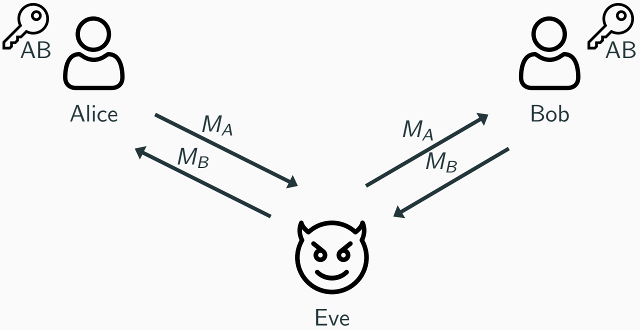

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- Authenticity
- Key Indistinguishability

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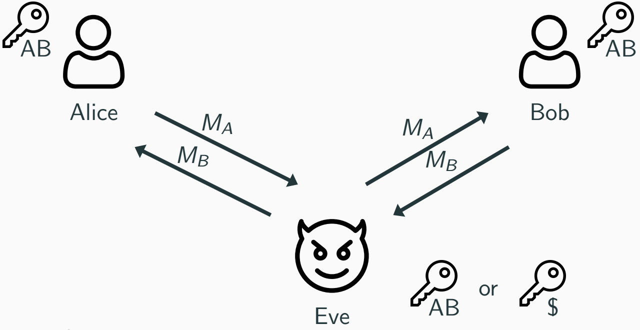

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Security is modelled as a game between a challenger and an adversary.

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Relevance: tells us how to choose system parameters

Difficulties in Proving Tight AKE

The commitment problem

- Need to be able to answer *key-reveal* and *test* queries for all sessions
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Long-term key reveals and tightly-secure signatures

- Signatures to achieve explicit authentication
- Need to answer adaptive *corrupt* queries and output secret signing keys
- At the same time: extract the solution to a hard problem from a signature forgery

Comparison with Previous Work

	Efficient	Standard Model	Tight Proof	Ephemeral State Reveal
BHJKL15				
GJ18				
CCGJJ19				
LLGW20				
JKRS21				
This work				

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JKRS21	(✓)	✗	✓	✓
This work	(✓)	✓	(✓)*	✓

*Non-tight only with respect to a symmetric primitive when allowing state reveals

Our AKE Protocol

AKE

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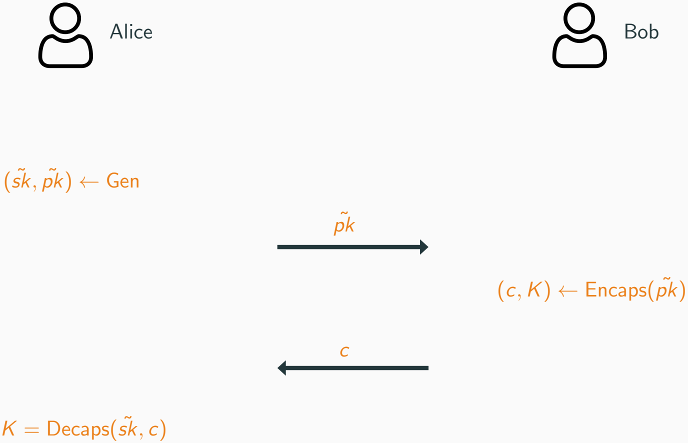
Bob

AKE[KEM]



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$(\tilde{sk}, \tilde{pk}) \leftarrow \mathrm{Gen}$

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$K = \mathrm{Decaps}(\tilde{sk}, c)$

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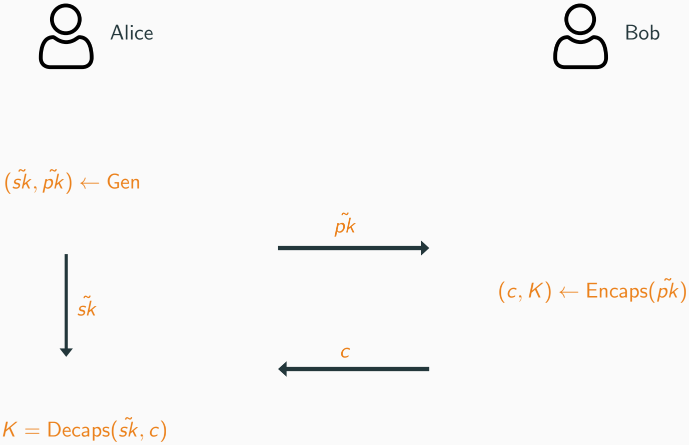

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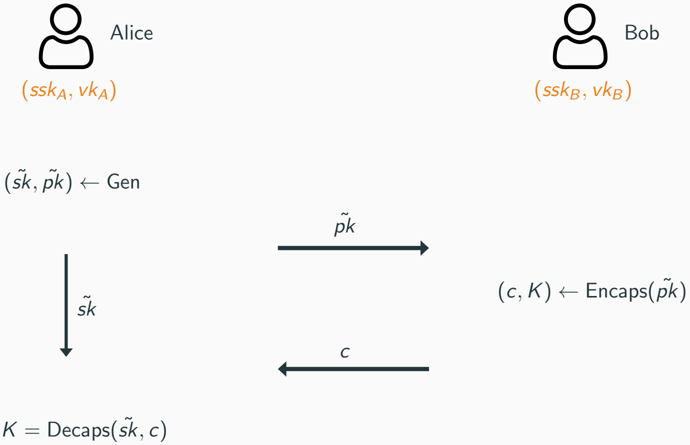

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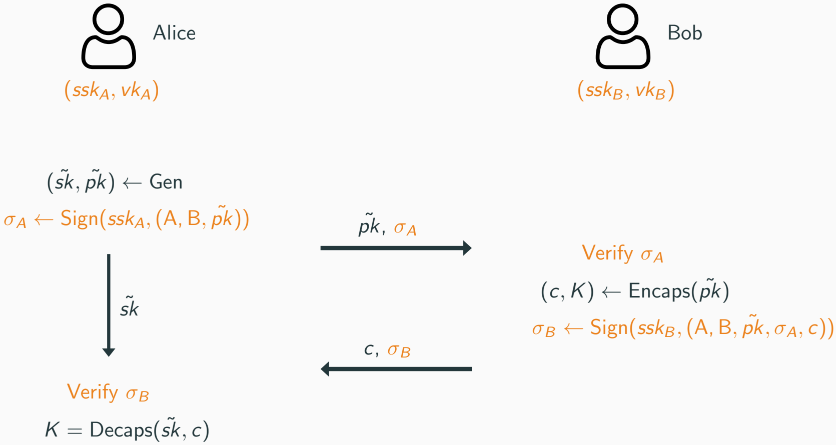

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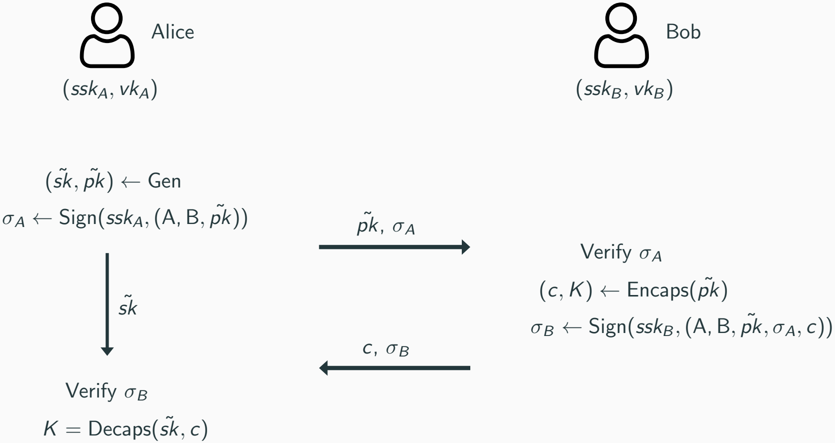

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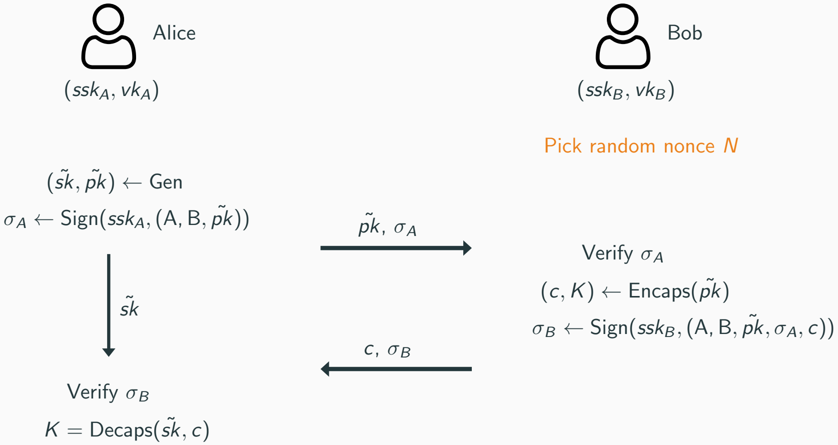

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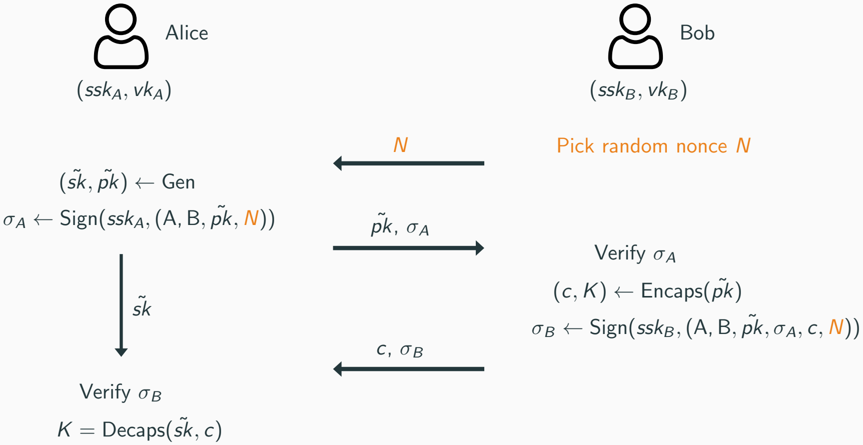

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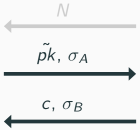

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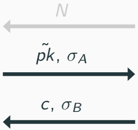

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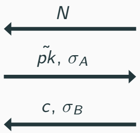

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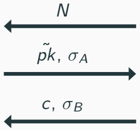

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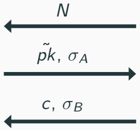

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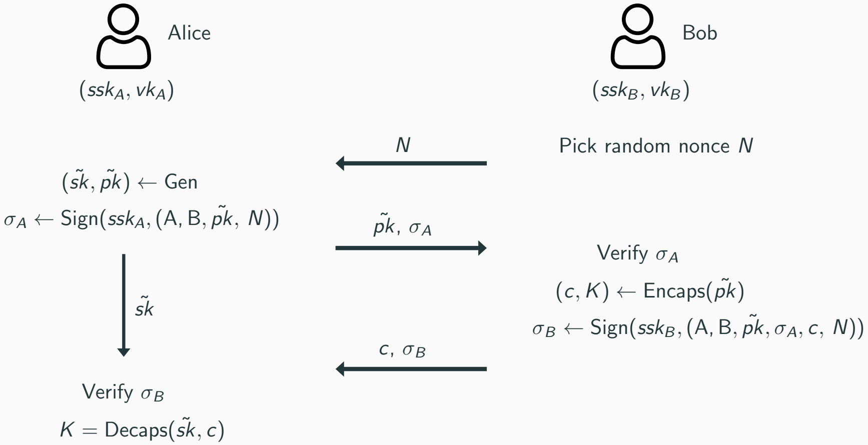
Security against State Reveal

AKE[KEM, SIG, Nonce]



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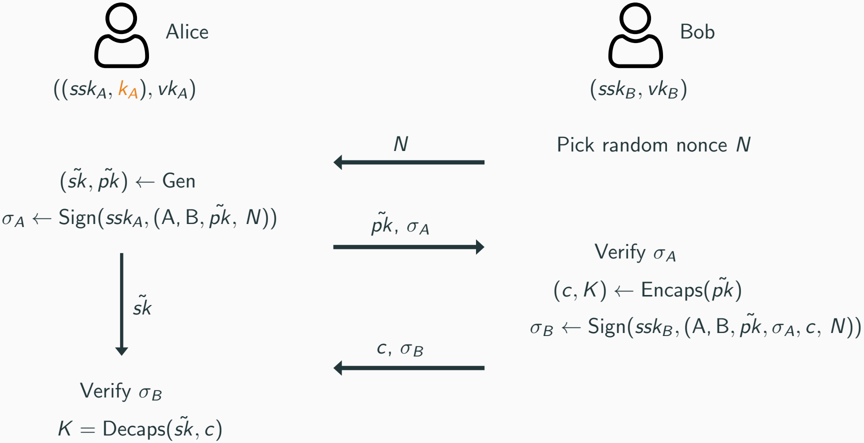

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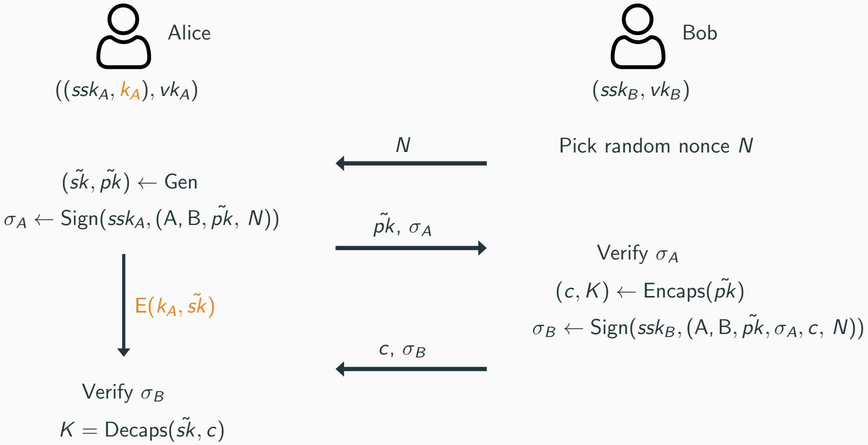

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Yet another commitment problem

- After a state reveal, we don't know whether the adversary will later *corrupt* the user or *test* the session.
- Need to know all ephemeral secret key hidden inside the state.

Enhanced Security Requirements

KEM: additional algorithm $\text{Encaps}^*(sk) \to (c^*, K^*)$

- $\text{Encaps} \approx_c \text{Encaps}^*$ for many key pairs, even given secret keys
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Symmetric Encryption: standard CPA security

Tightly-Secure Signatures

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Still efficient: $|vk| = 1|\mathbb{G}|$, $|\sigma| = 5|\mathbb{G}|$ (instantiated under SXDH)

Summary

Contributions

- A new efficient and tight AKE protocol in the standard model.
- Security in a stronger security model, when allowing a non-tight reduction to the symmetric primitive.
- The first efficient and tightly-secure signature scheme supporting corruptions.

ePrint: `ia.cr/2021/863`

References

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