Efficient Asymmetric Message Franking in the Plain Model

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[2]National Institute of Advanced Industrial Science and Technology (AIST), Japan

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Summary

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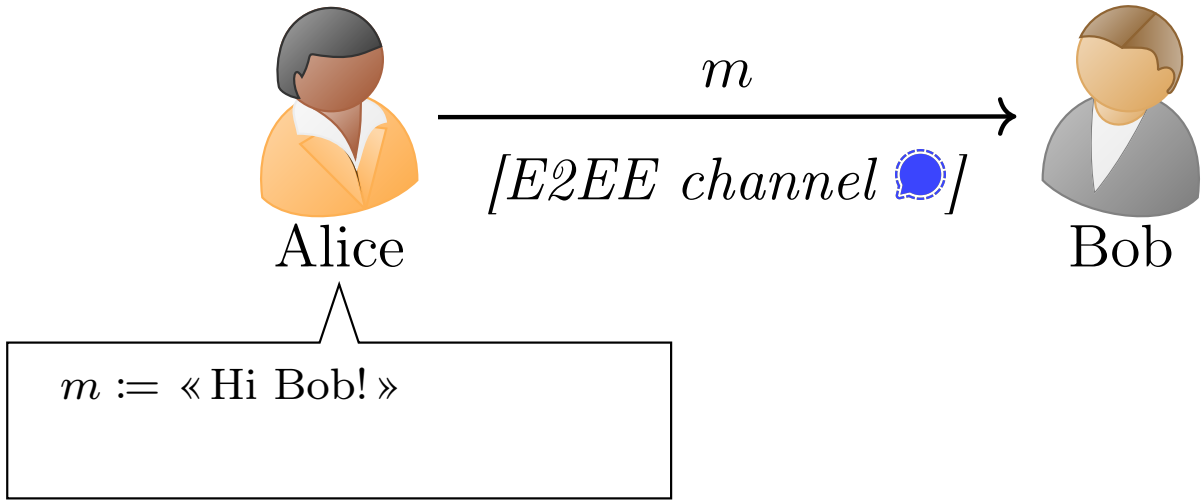
Asymmetric Message Franking: a moderation mechanism



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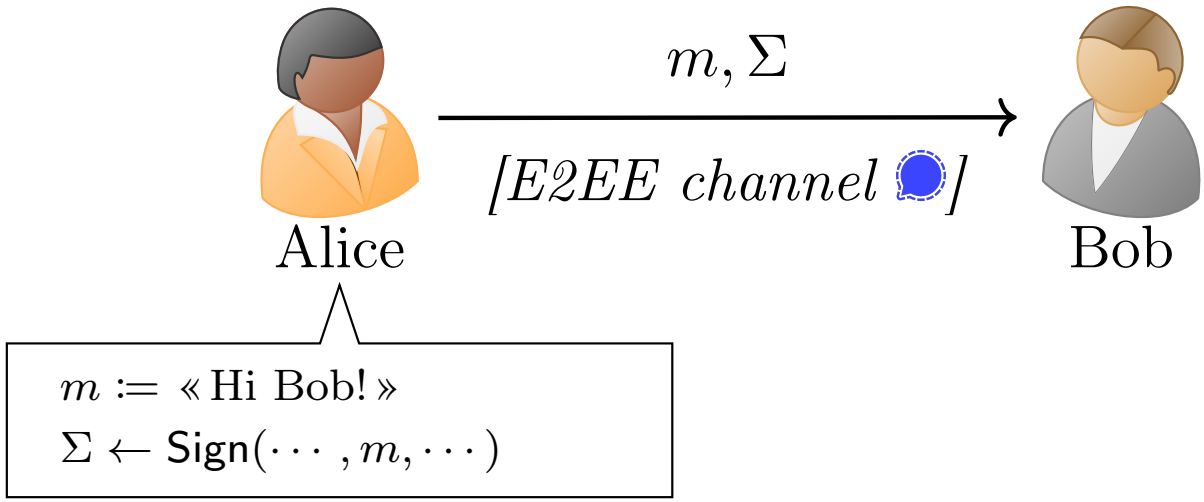

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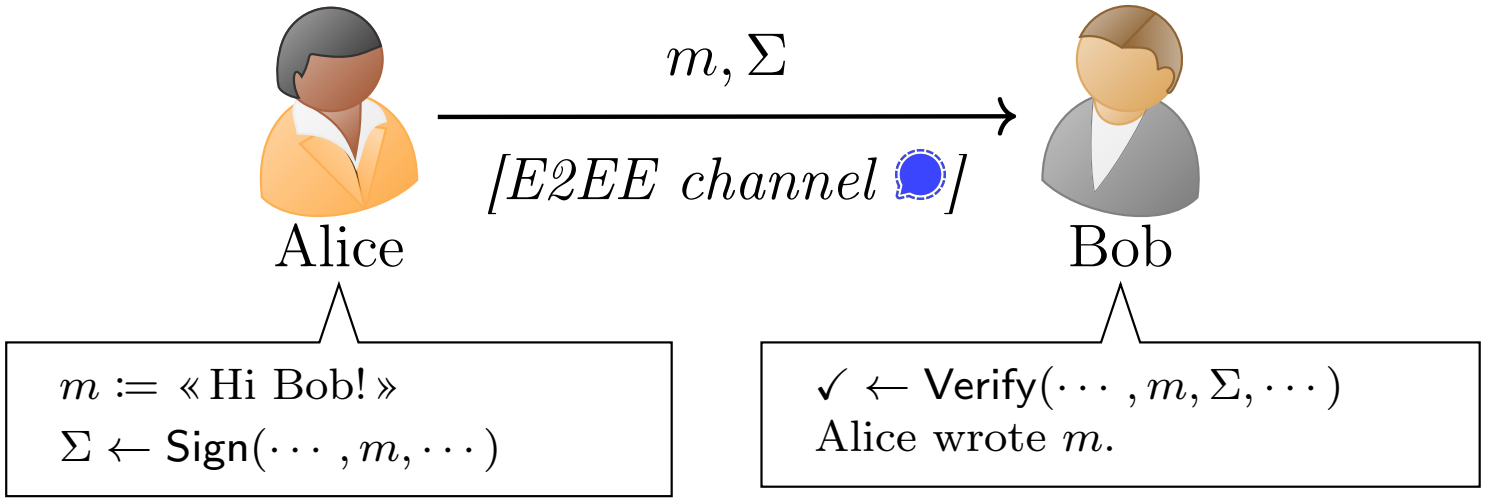

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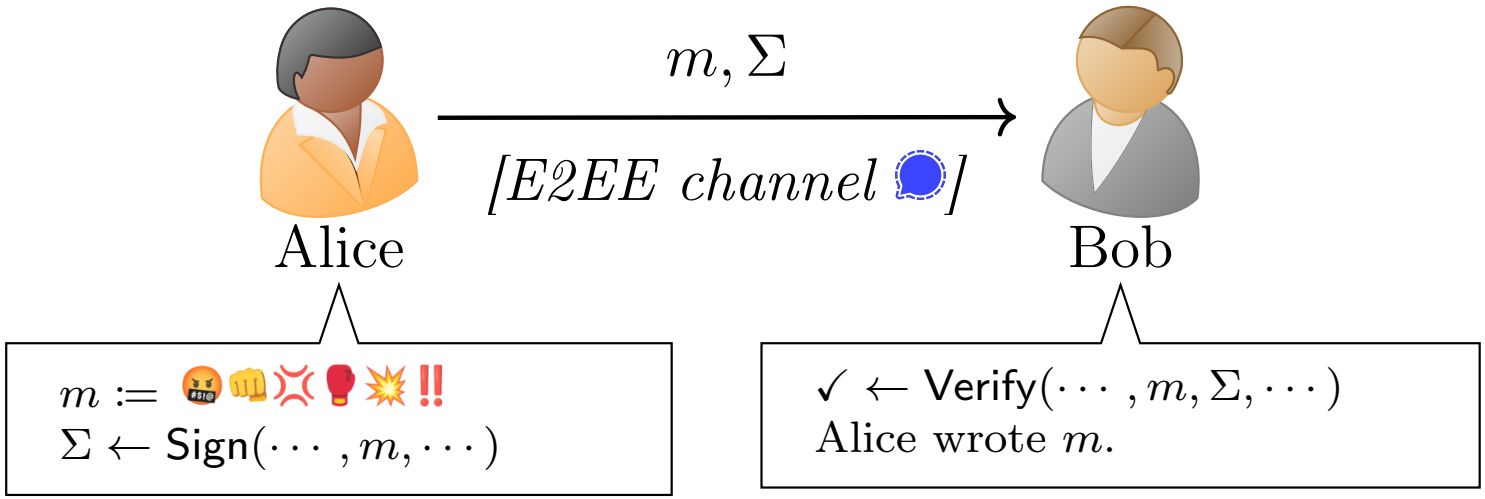

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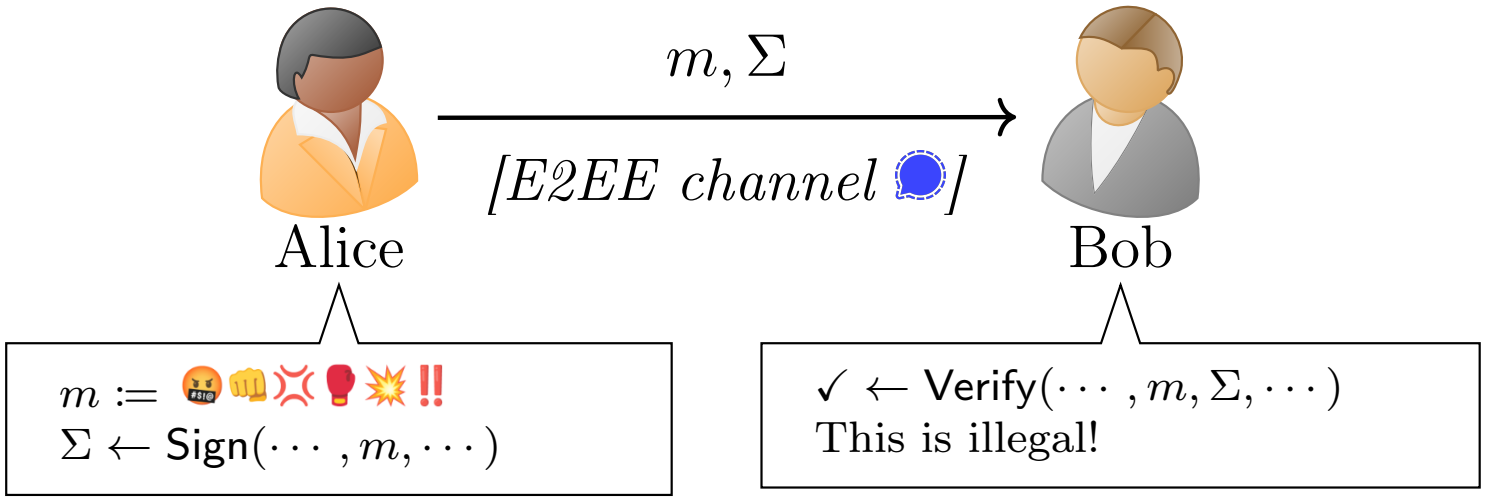

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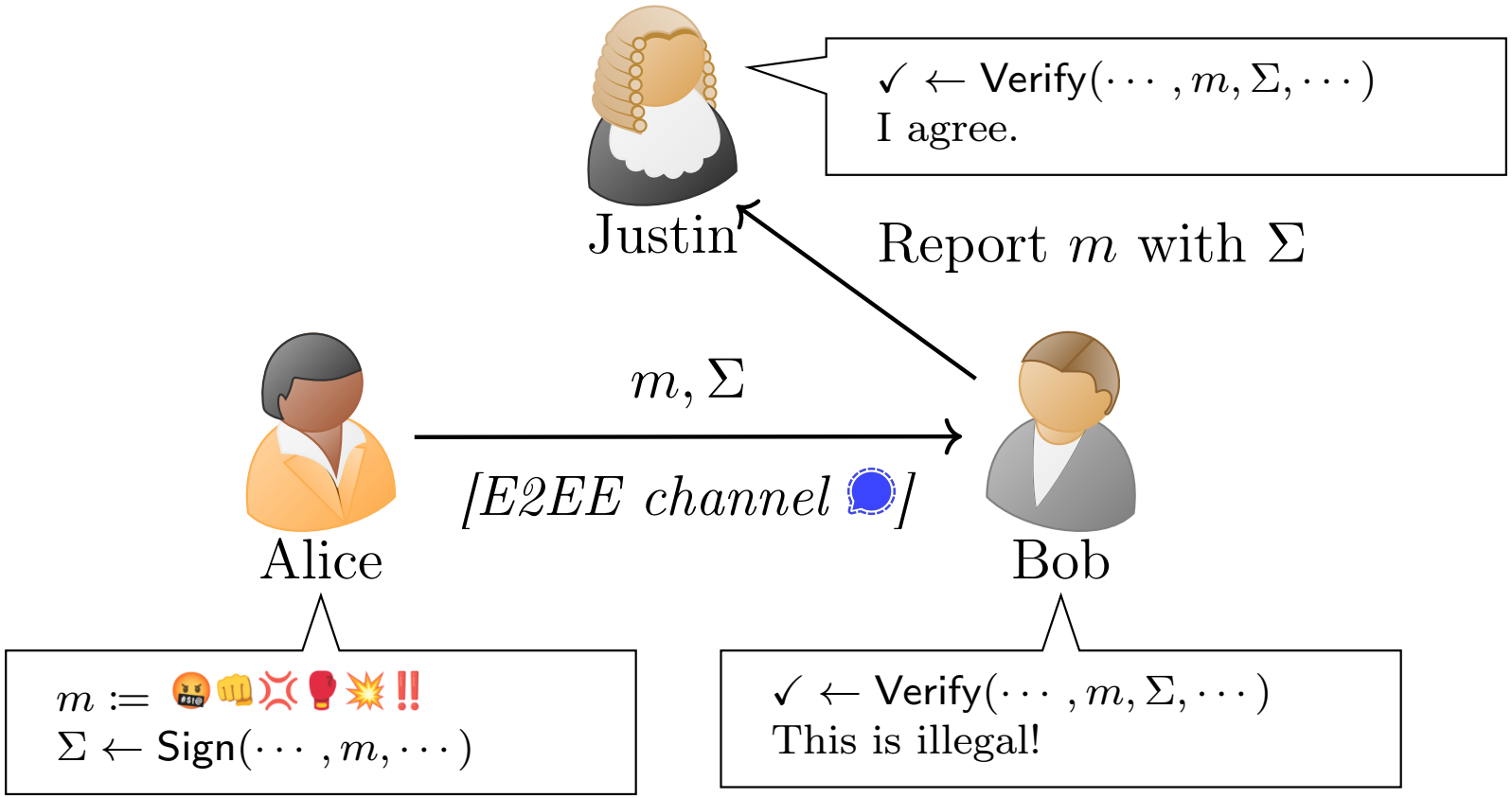

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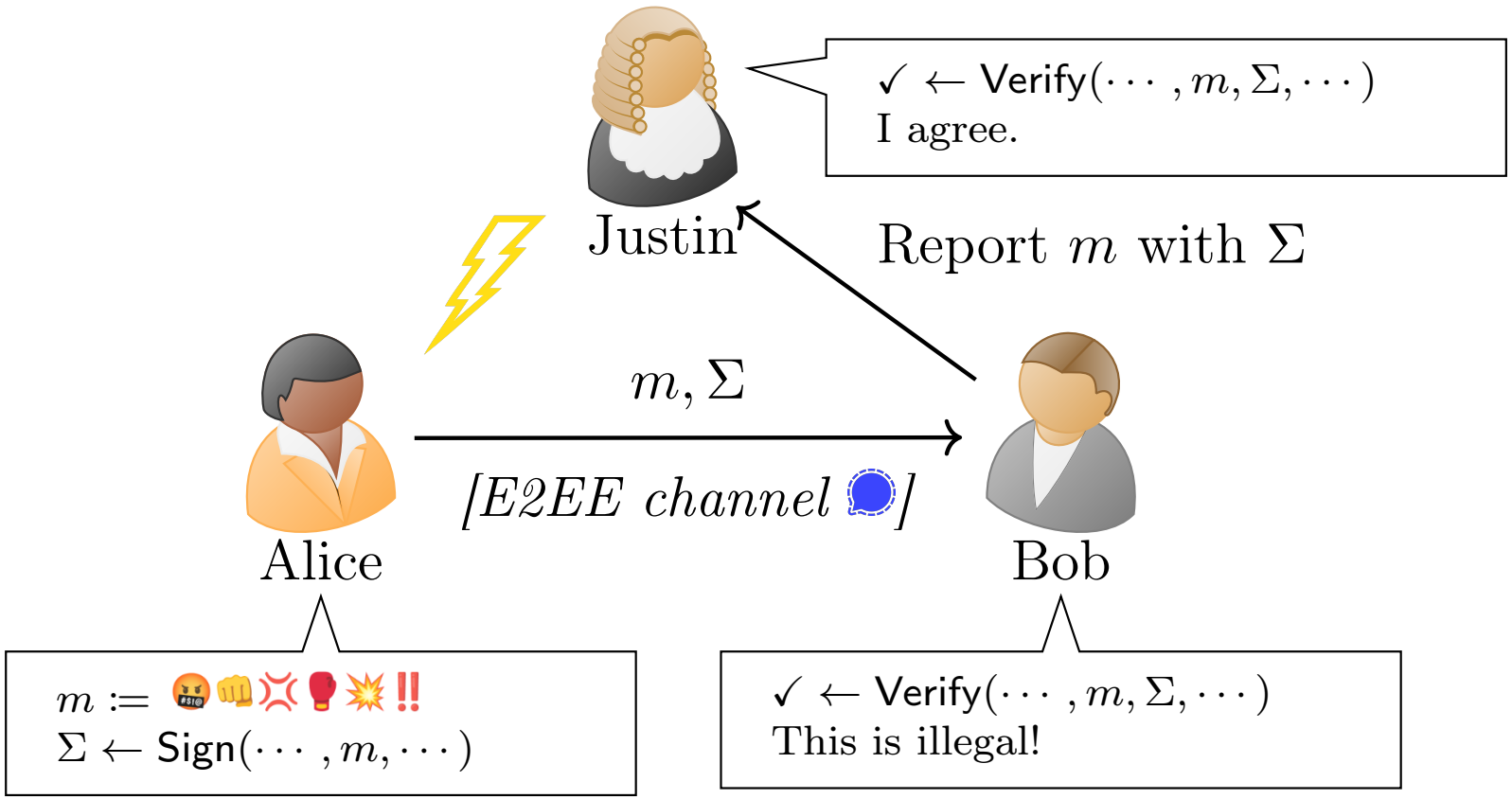

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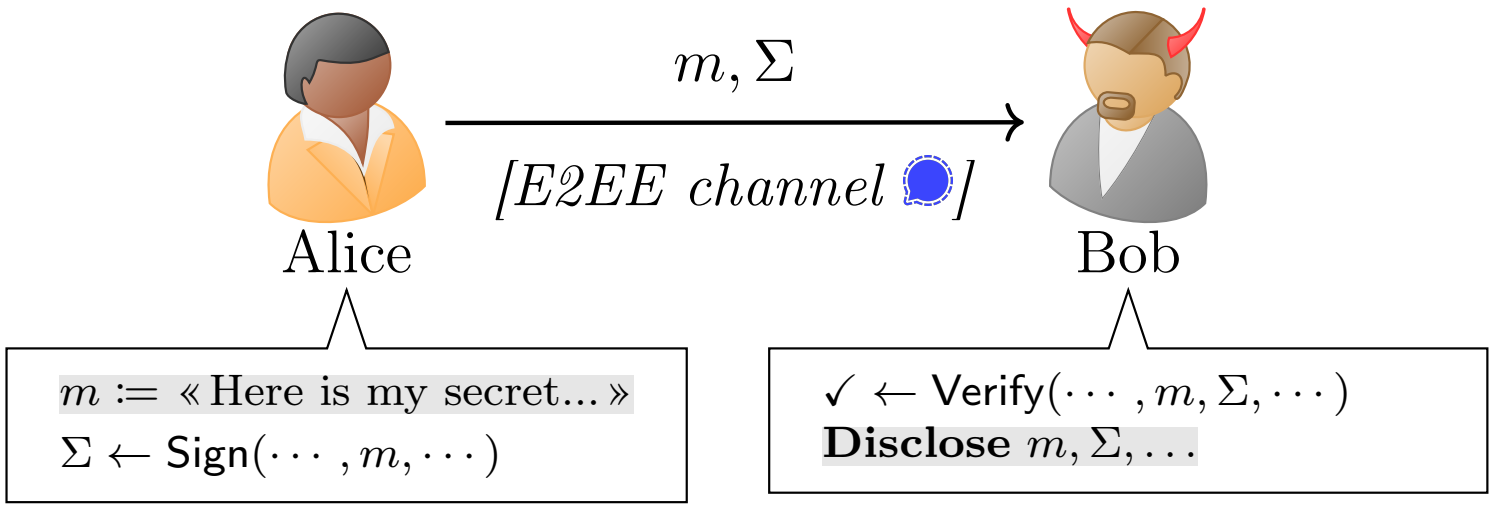
Asymmetric Message Franking: a moderation mechanism

No deniability!



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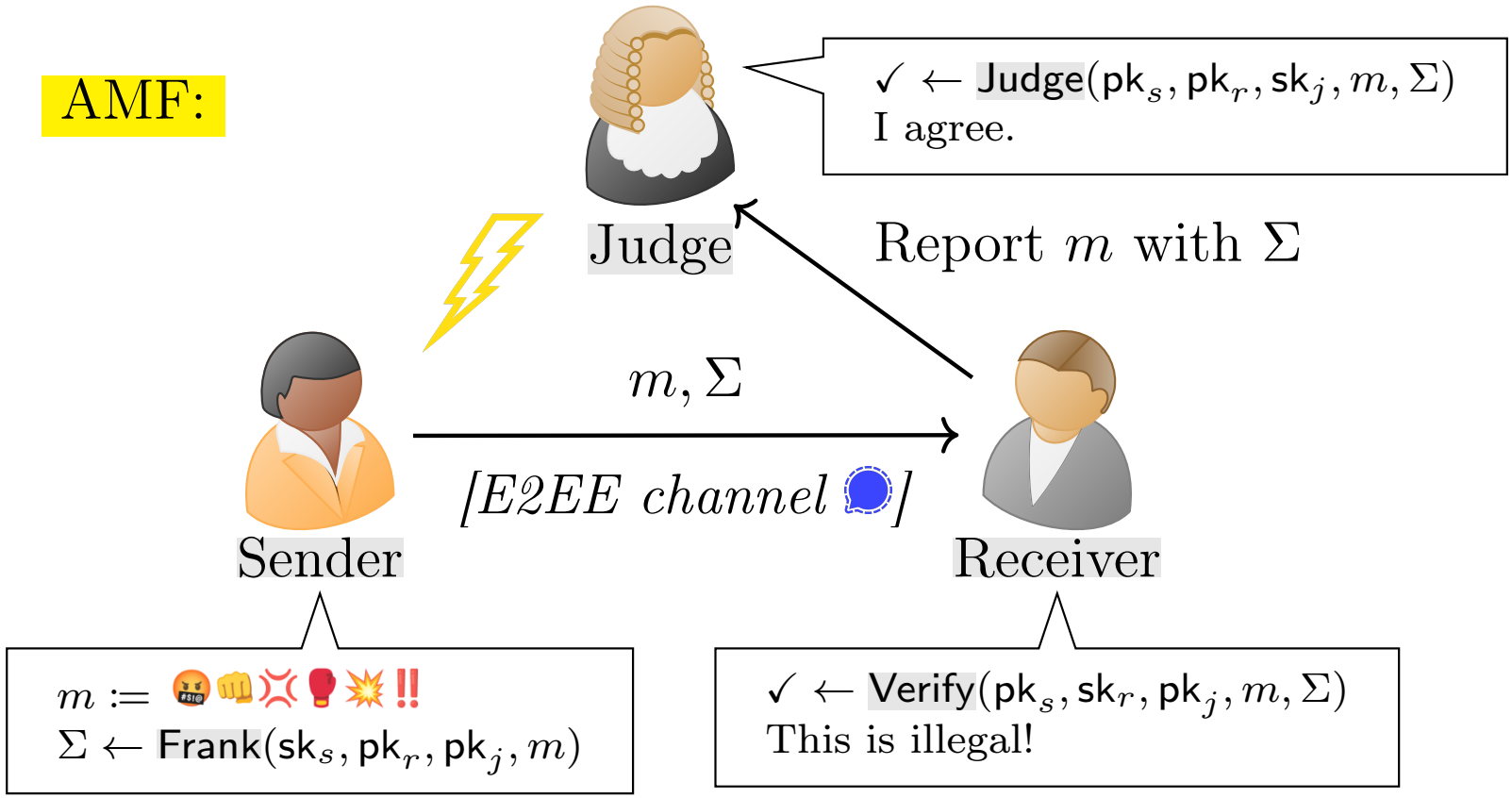

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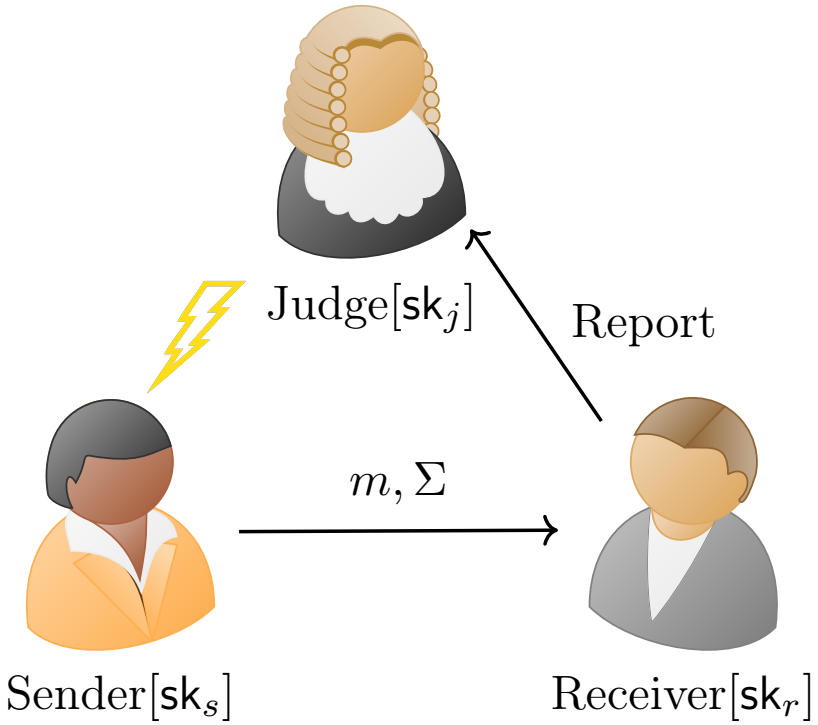
Security Properties of AMF



Correctness

- Correctness

Accountability

- Unforgability
- Receiver-Binding
- Sender-Binding

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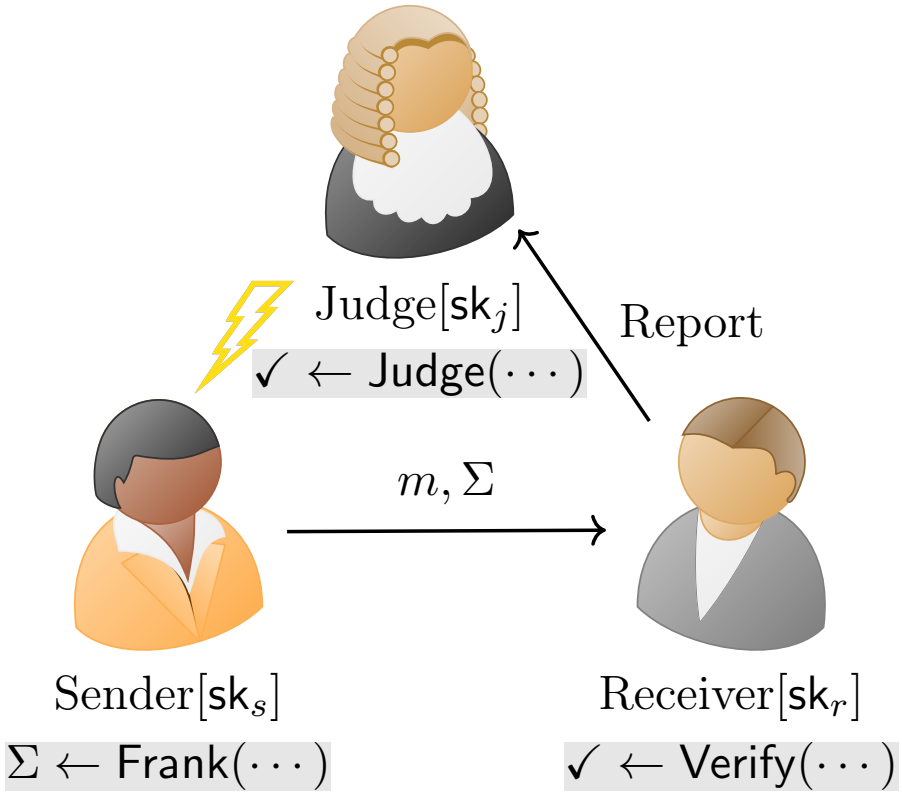

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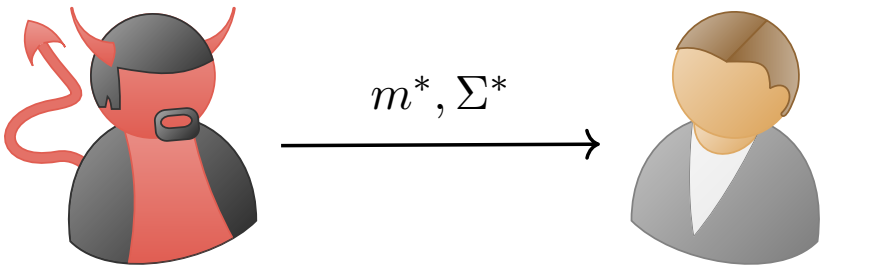
Security Properties of AMF

[Hard]



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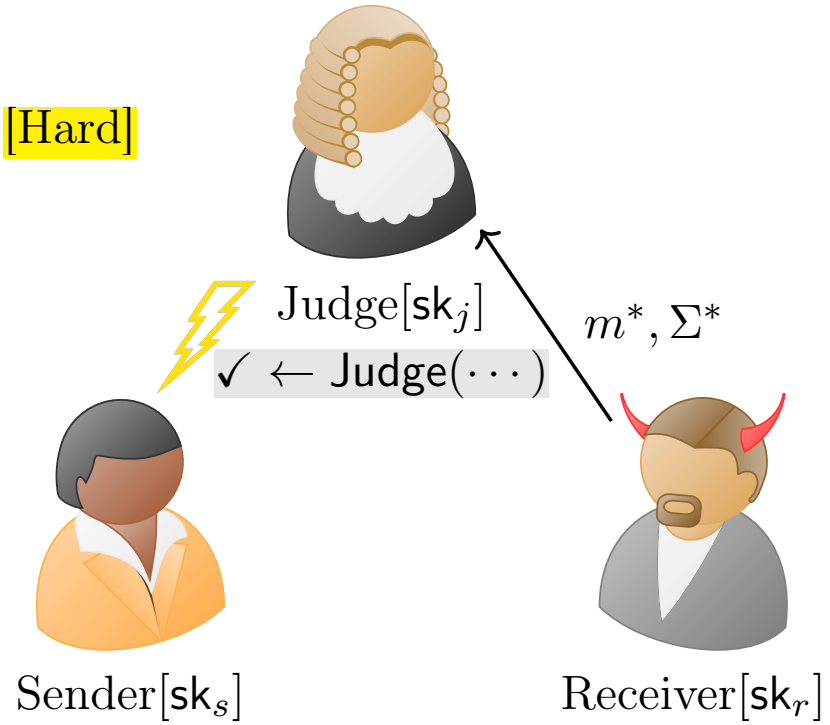

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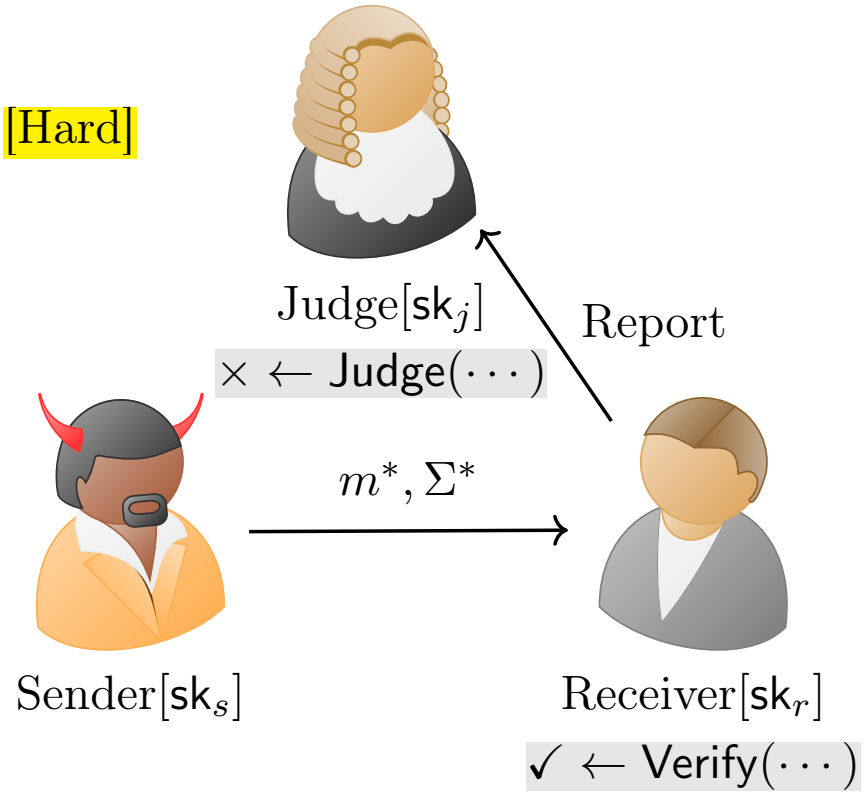

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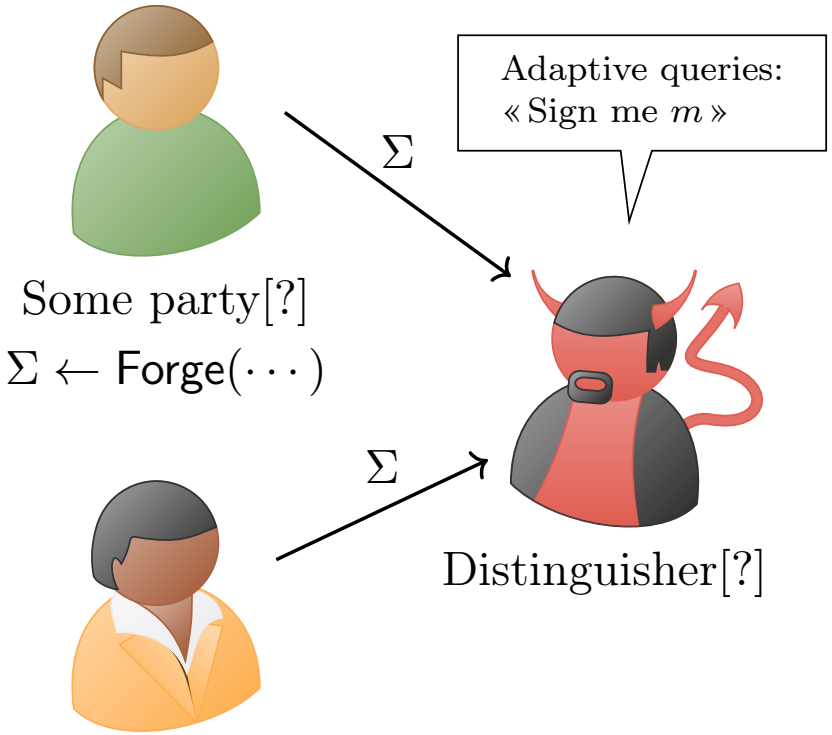

[Hard]

Deniability

- Universal Deniability
- Receiver Compromise Deniability
- Judge Compromise Deniability

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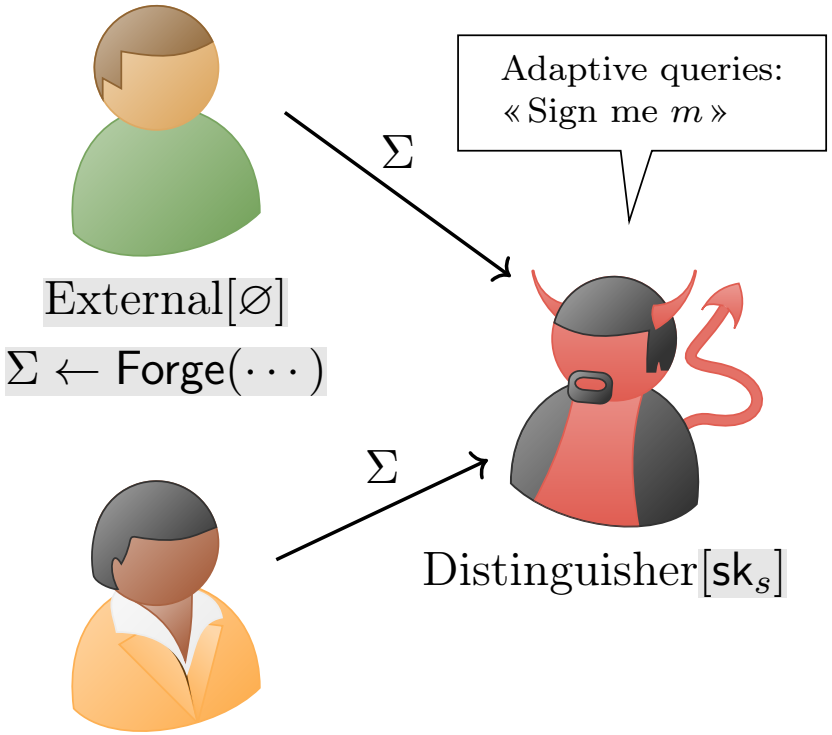

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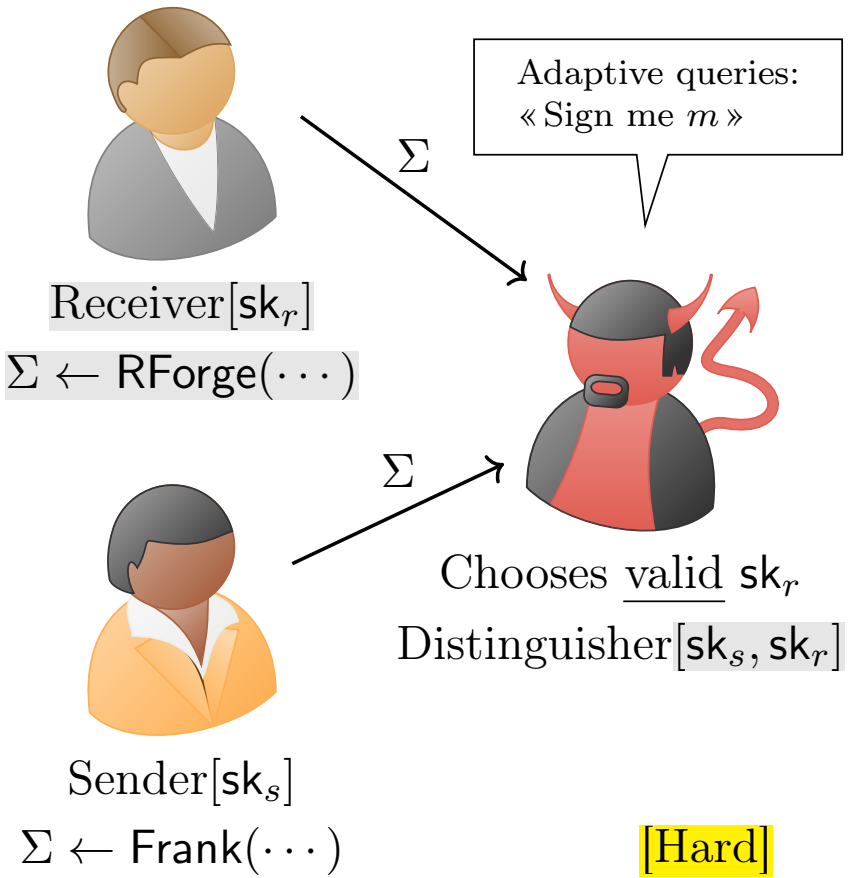

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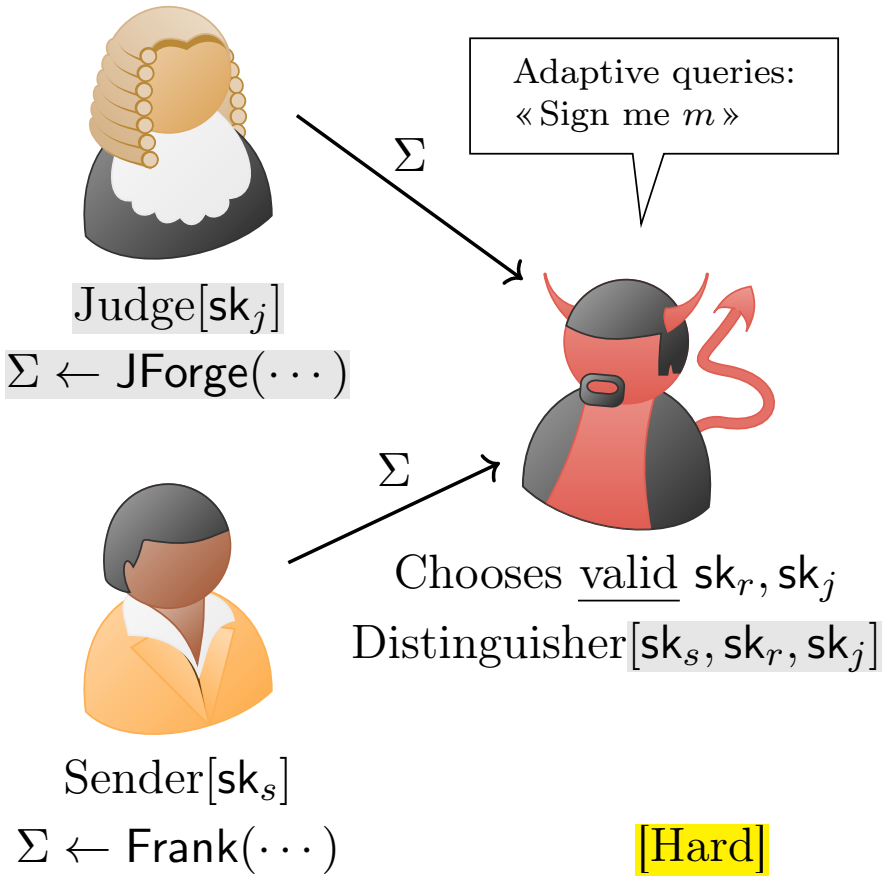

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State of the Art

Main Related work

- [TGL+19] Asymmetric Message Franking: Content Moderation for Metadata-Private End-to-End Encryption, CRYPTO'19: **seminal work and first construction**
- [LZH+23] Asymmetric Group Message Franking: Definitions and Constructions, EuroCrypt'23: **context of group messaging and slightly different approach**

Technique: signature of knowledge derived from a Sigma protocol made non-interactive using the *Fiat-Shamir heuristic*.

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Our Results [new]

Generic construction from signature, PKE and ZAP proofs

- Plain model
- Tight security
- Instantiation from various assumptions (incl. lattice-based)

(Somewhat) efficient construction from group-based assumptions

- Plain model
- 47 group elements (vs. ∼800 for generic construction)
- From group-based assumptions (requires pairings)

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Summary

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Generic Construction: Starting Point

Signing algorithm	Signer's knowledge	Expected output	
		 Verify	 Judge
 Frank	sk_s	✓	✓
 Forge	$\varnothing$	×	×
 RForge	sk_r	✓	×
 JForge	sk_j	✓	✓

Expected output derived from AMF security properties

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Generic Construction: Starting Point

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		 Verify	 Judge
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1) Mimic expected output

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2) Use encryption to parsimoniously disclose information

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RForge	sk_r	1	0
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	$\mathsf{Enc}_{\mathsf{sky}}(\sigma \text{ or } 0)$ $\hookrightarrow \mathbf{c}_\sigma$	$\mathsf{Enc}_{\mathsf{ek}_r}(b_r)$ $\hookrightarrow \mathbf{c_r}$	$\mathsf{Enc}_{\mathsf{ek}_j}(b_j)$ $\hookrightarrow \mathbf{c_j}$

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3) Add ZAP proof to hide author and prevent cheating

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$\pi \leftarrow$ ZAP proof that the 3 ciphertexts follow one of the row using judge ZAP randomness zr_j

Add construction tricks to achieve provable security

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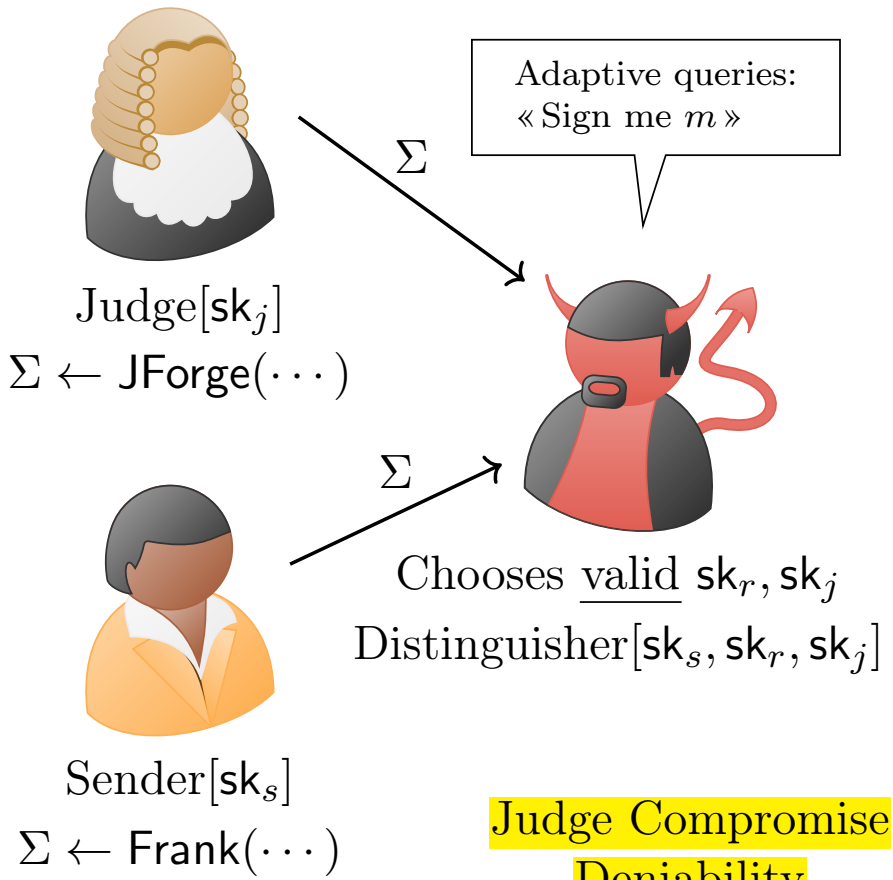
Why using judge random coins for the ZAP proof?



Judge Compromise Deniability

ZAP proofs

Subversion-resistant witness indistinguishable

→ WI remains even with maliciously chosen first message

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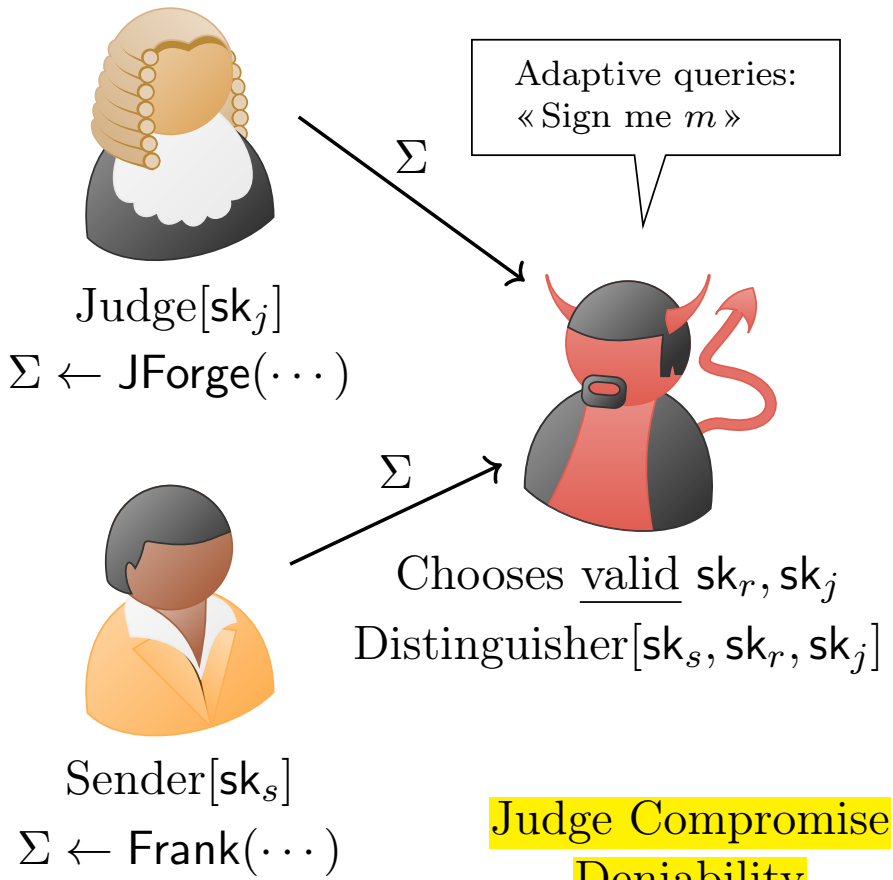

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Instantiations

With this construction we obtain:

- A tightly secure AMF scheme from standard group-based assumptions

Problem: signature size ($\sim$ 800 group elements using group-based building blocks and Groth-Sahai proof system)

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Reduce signature size: our approach

Use ZAP proof system for restricted class of languages

- ZAP for NP languages: $\times$ (too inefficient)
- ZAP for linear languages: $\times$ (need an OR, and because of impossibility results on unforgeable signature [DHH+21])
- ZAP for algebraic language [CH20]: ✓
  $\rightarrow$ contains linear languages and disjunctions

Embed authenticity into the ZAP

- No more signature to encrypt, the proof *is* the signature
- Use proof-based Waters-like signature (inspired by [DH26])

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Waters-like signature in more detail

bit i of $\mathcal{M}$	0	1	2	3	4	5	6	$\cdots$	λ
$\mathsf{sk} \in \mathbb{Z}_p :=$	1	0	0	0	0	0	0	$\cdots$	0
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Waters-like signature in more detail

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$C_{\text{hash}} := \sum(\cdots) = ?$

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$\mathsf{pk}' :=$	C'_0	C'_1	C'_2	C'_3	C'_4	C'_5	C'_6	$\cdots$	C'_λ
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Concrete results

	Signature size†	PK size†	Model
[TGL+19]	9 GE + 6 S	1 GE	RO
Generic construction§	∼800 GE	7 GE	Plain
Efficient construction	47 GE	$\mathcal{O}(\lambda)$ GE	Plain

Comparison of different group-based AMF schemes

†: GE = Group element / S = scalar in $\mathbb{Z}_p$

§: Using Groth-Sahai NIWI and trusted setup

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Questions?

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