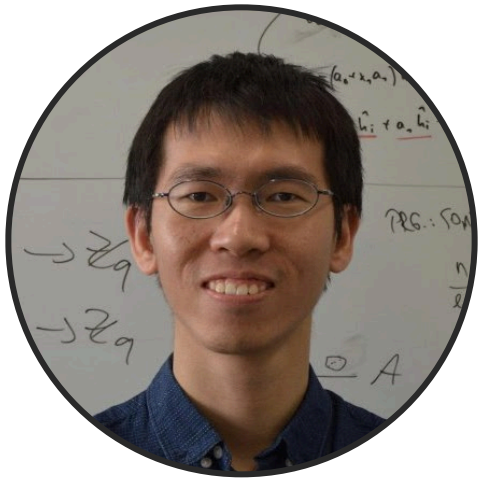
# Chopsticks:
## Fork-Free Two-Round Multi-Signatures from Non-Interactive Assumptions




Jiaxin Pan

NTNU

**Benedikt Wagner**

CISPA
HELMHOLTZ CENTER FOR INFORMATION SECURITY


# Multi-Signatures

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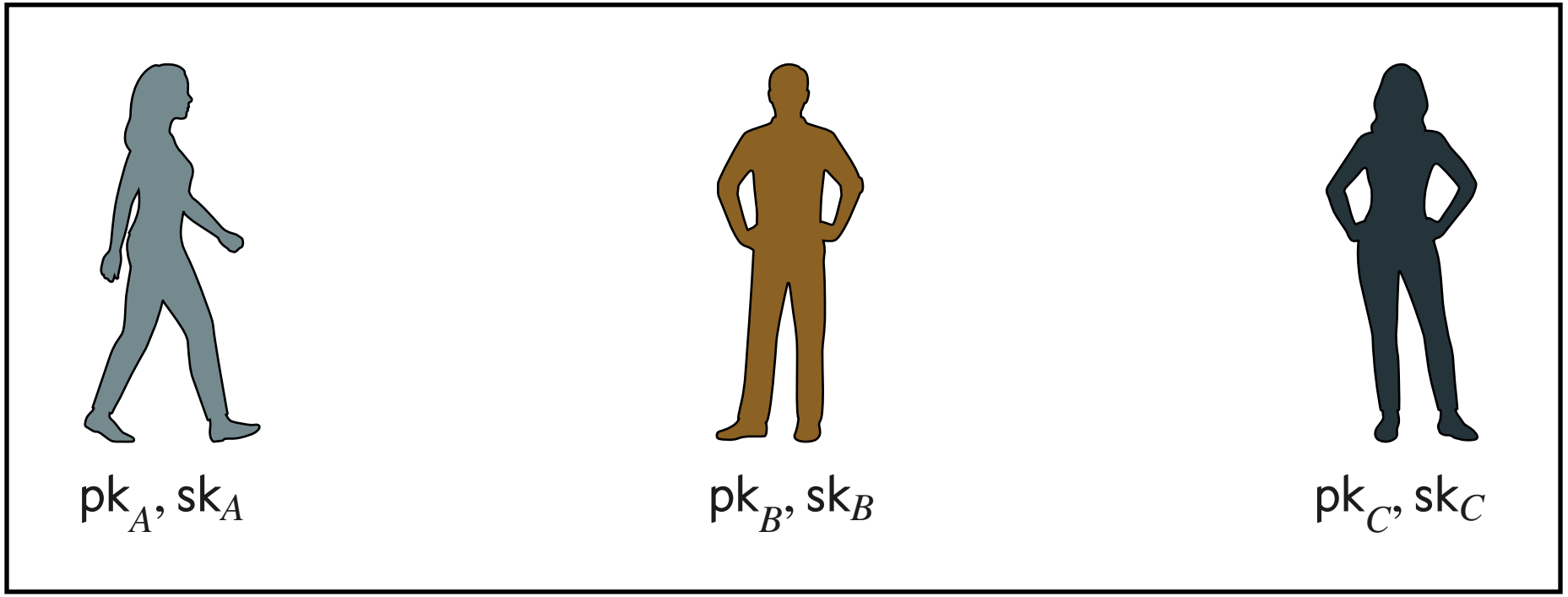

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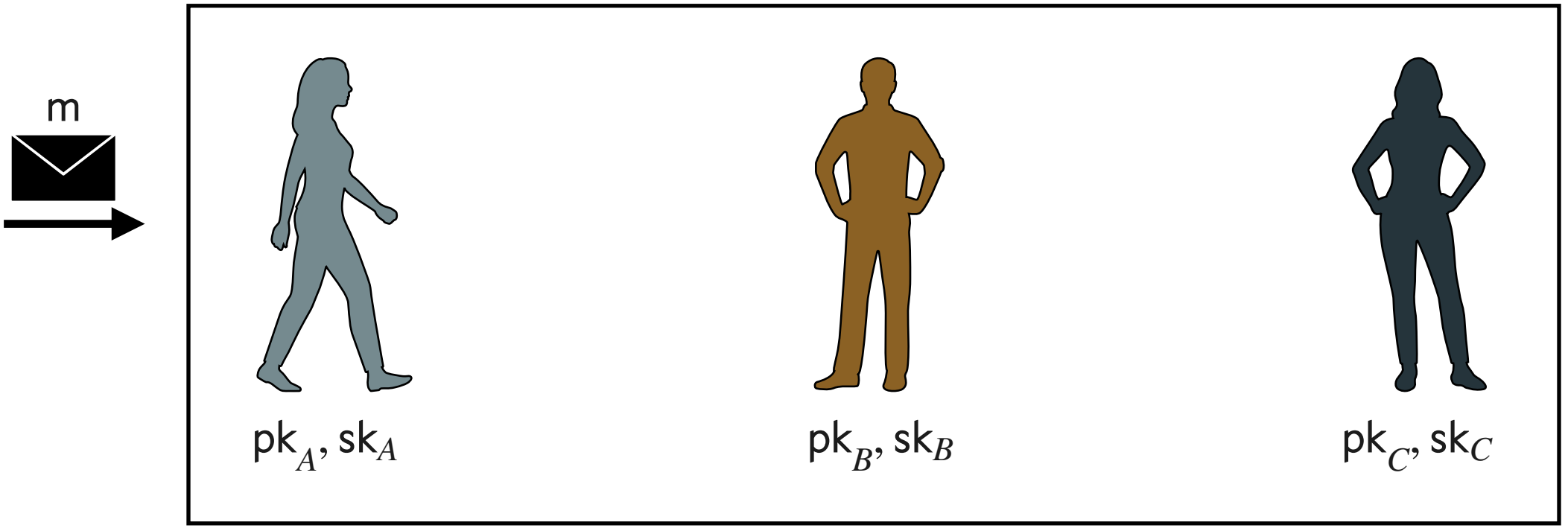

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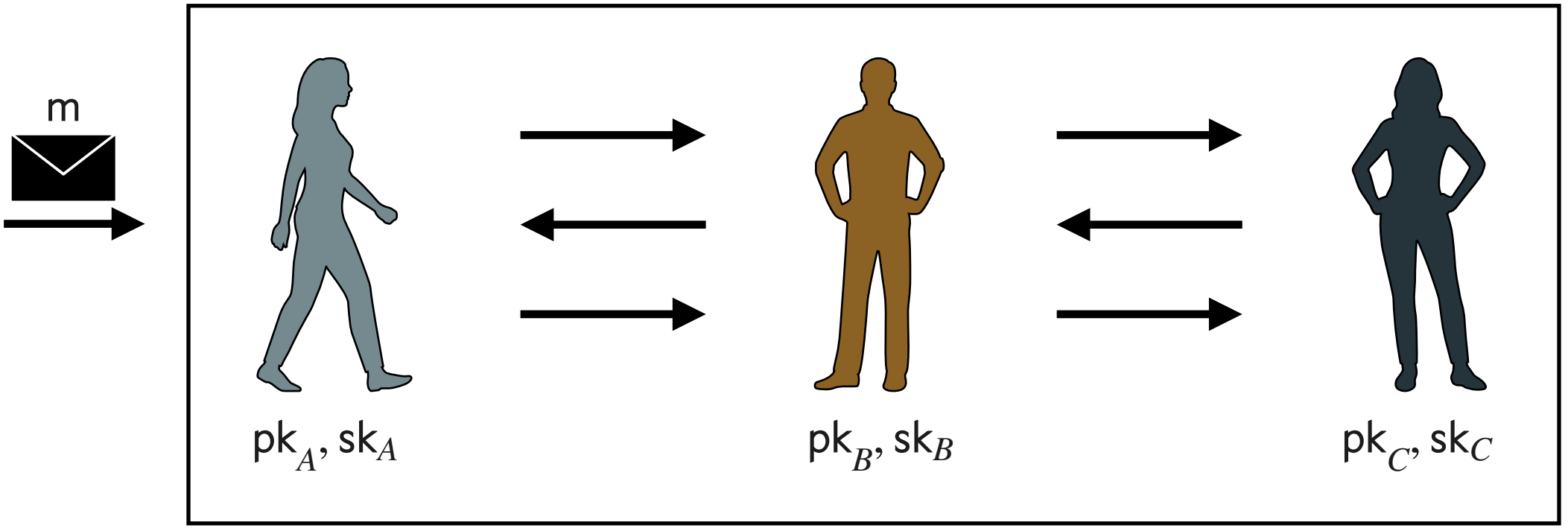

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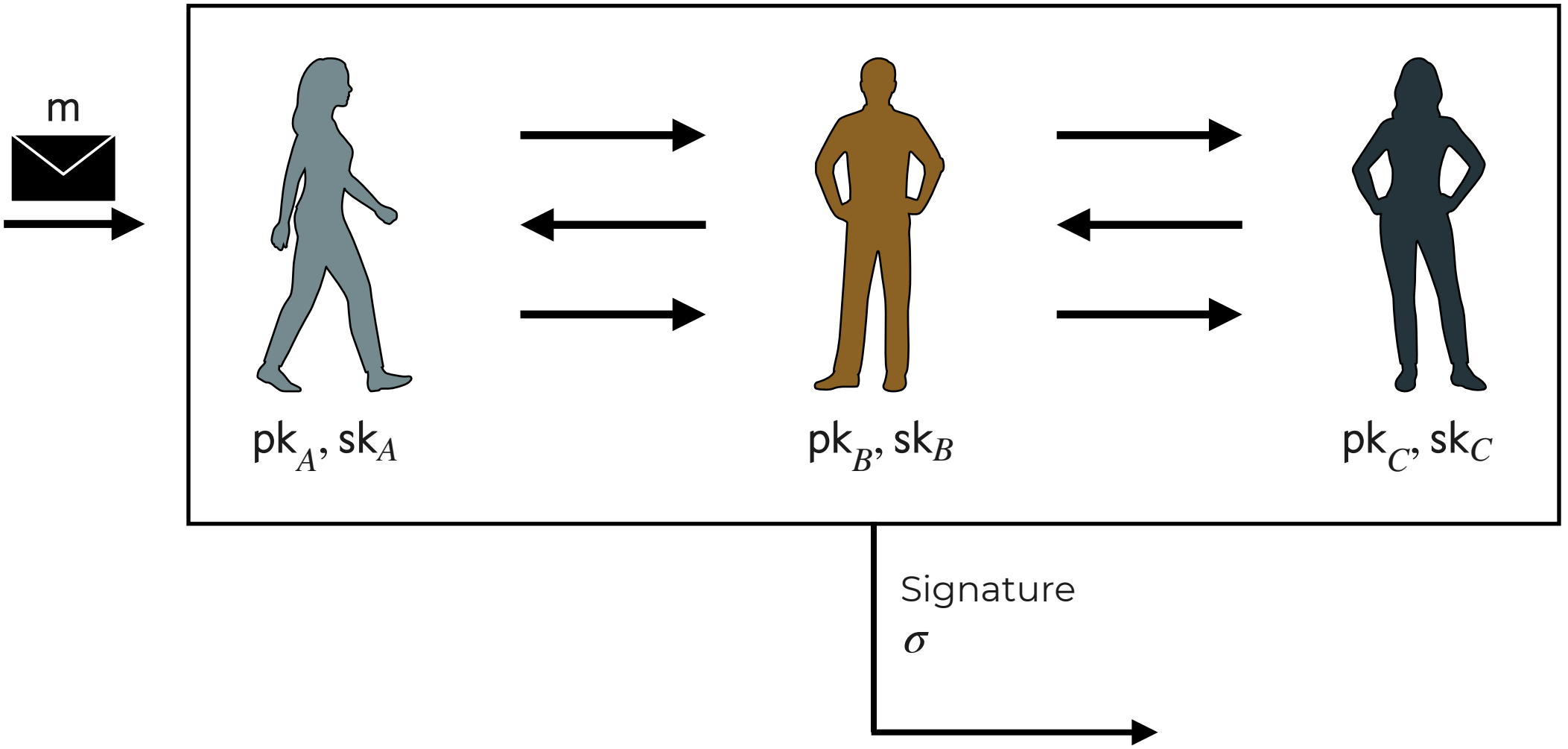

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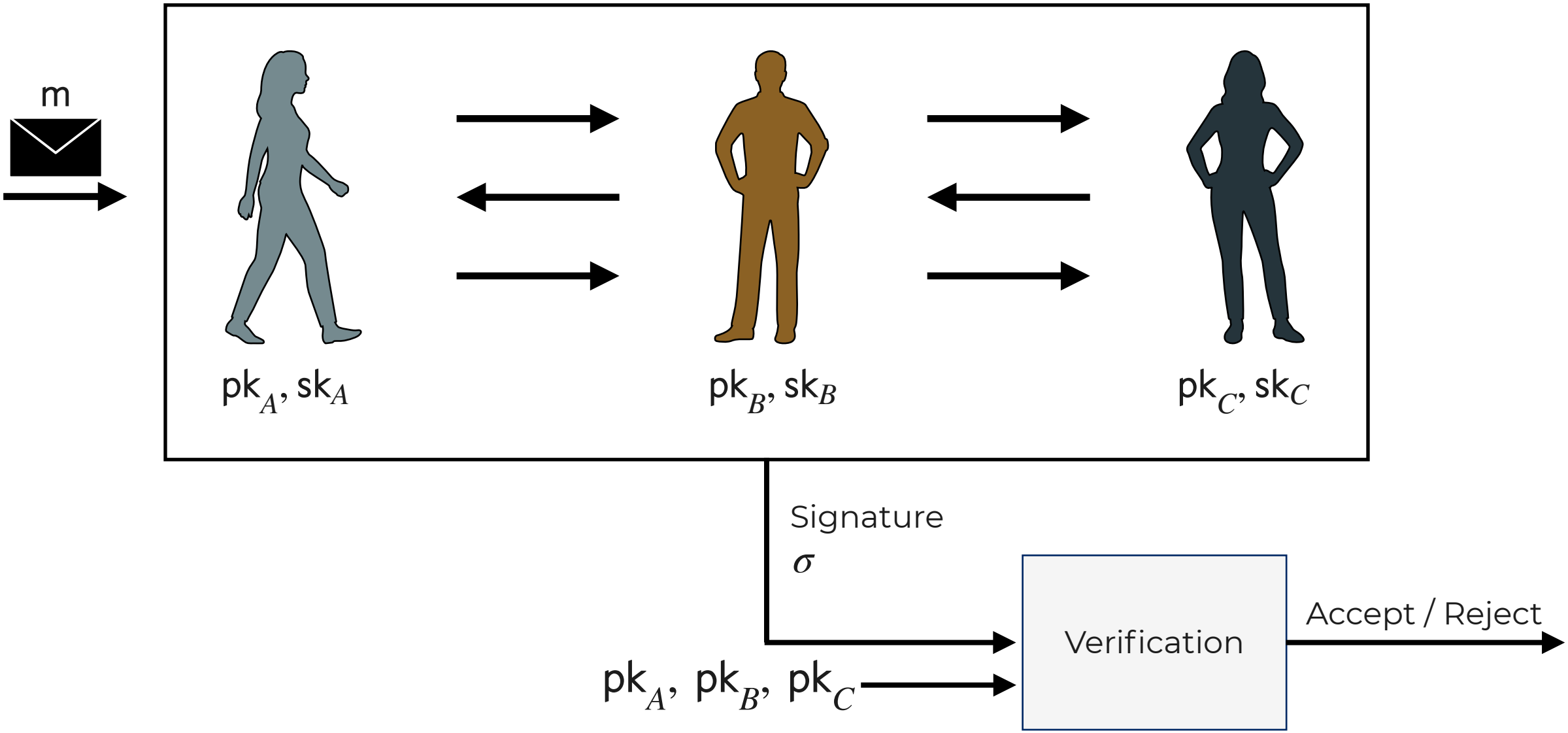

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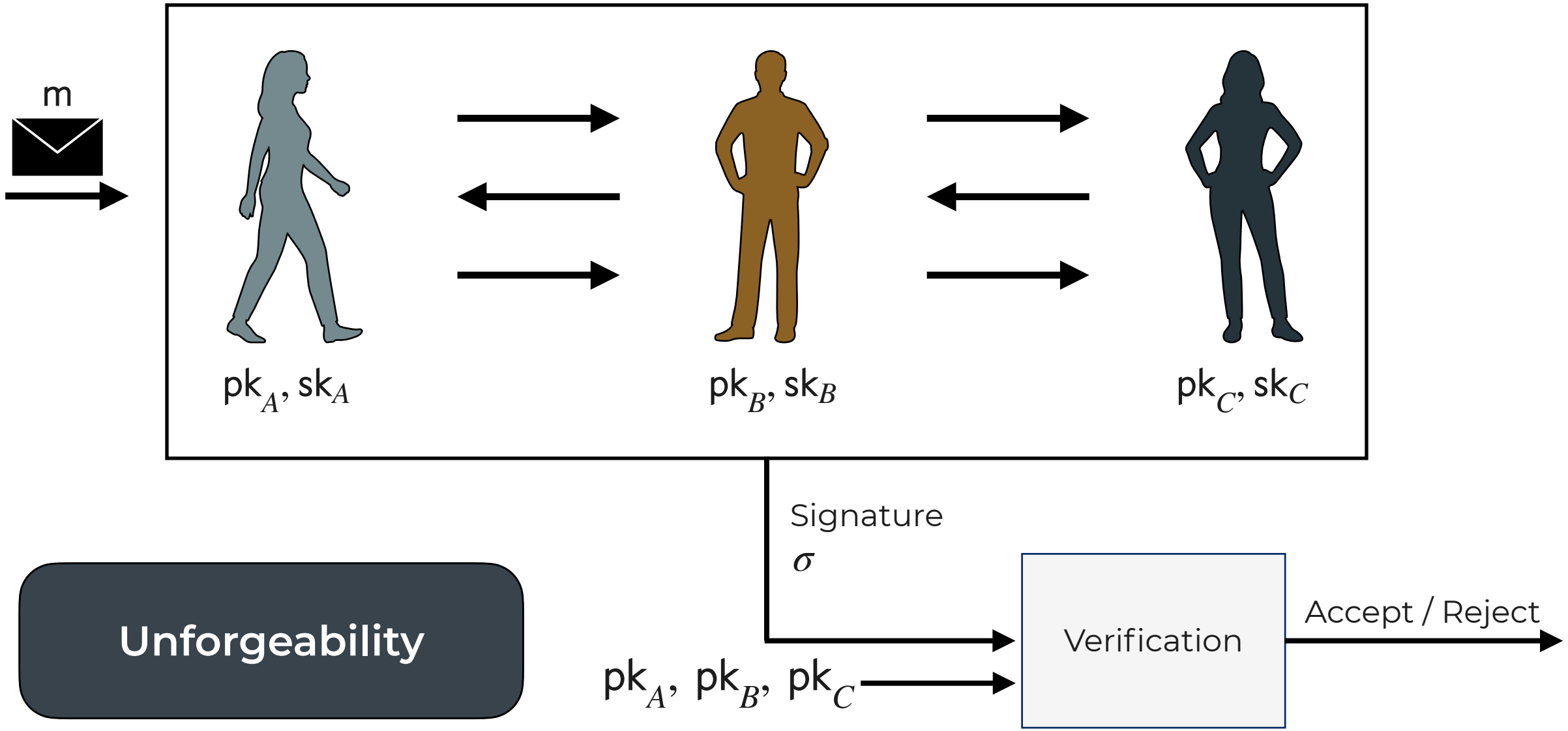


**Unforgeability**

# Multi-Signatures - Objectives

## Efficiency

## Functionality

## Security

# Multi-Signatures - Objectives

**Efficiency**

Signature Size

**Functionality**

**Security**

# Multi-Signatures - Objectives

**Efficiency**

- Signature Size
- Communication
- Round Complexity
- Computation

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# Multi-Signatures - Objectives

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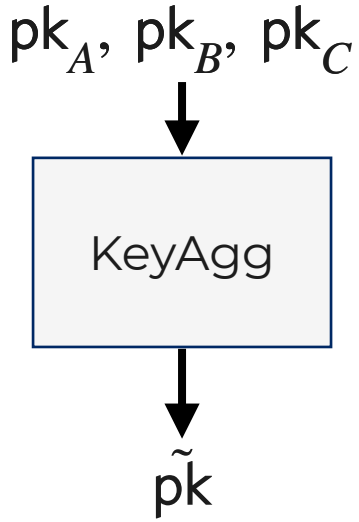


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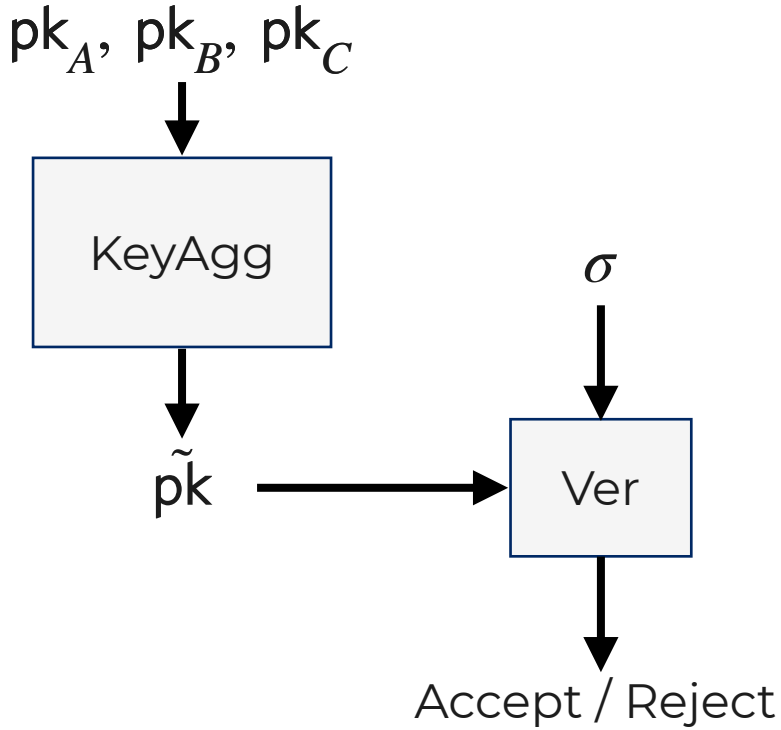


**Security**

# Multi-Signatures - Objectives

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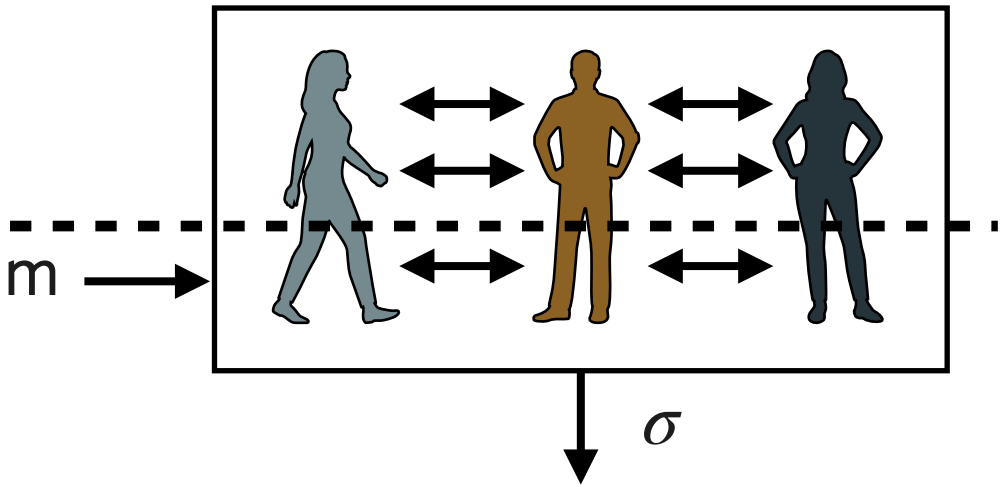

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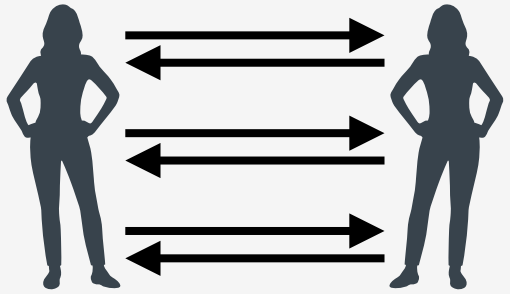
**Security**

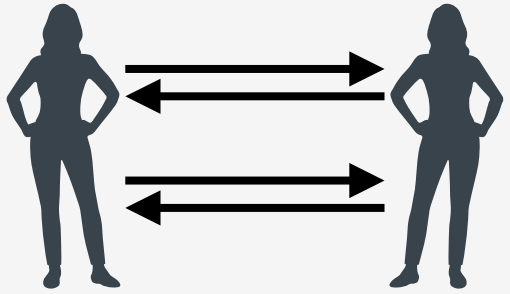
- Assumptions
- Security Loss

# State-of-the-Art

## 3 Rounds



## 2 Rounds





BN [CCS 06, BN], Musig [Asiacrypt 18, BDN, and DCC 19, MPS+], Musig-T [IJNC 21, FH], Musig2 [Crypto 21, NRS], HBMS [Asiacrypt 21, BD]

# State-of-the-Art

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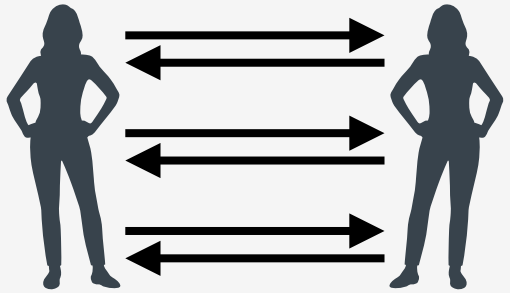
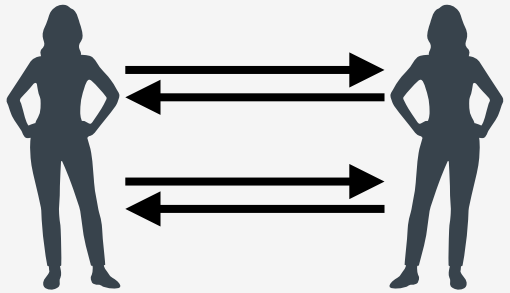


**BN**

DLOG

$$\epsilon^2 \leq Q_H \epsilon'$$

**2 Rounds**





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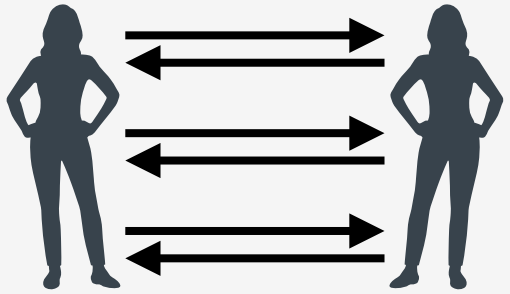
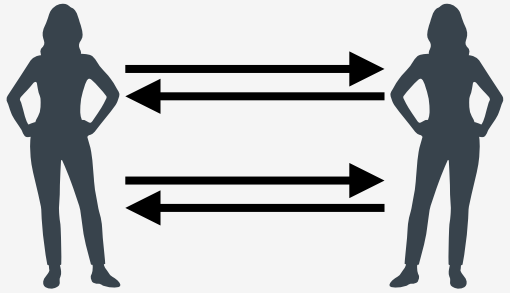


| **BN** | **BN** |
|---|---|
| DLOG | DDH |
| $\epsilon^2 \leq Q_H \epsilon'$ | $\epsilon \leq \epsilon'$ |

**2 Rounds**





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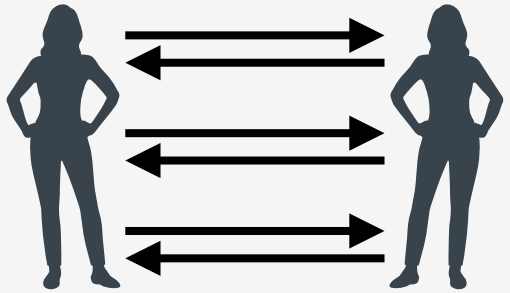
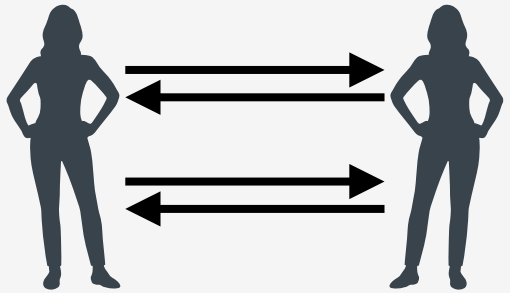


| BN | BN | Musig | Musig-T |
|---|---|---|---|
| DLOG | DDH | DLOG | DDH |
| $\epsilon^2 \leq Q_H \epsilon'$ | $\epsilon \leq \epsilon'$ | $\epsilon^4 \leq Q_H^3 \epsilon'$ | $\epsilon \leq \epsilon'$ |
| | | KA | KA |

**2 Rounds**



4 BN [CCS 06, BN], Musig [Asiacrypt 18, BDN, and DCC 19, MPS+], Musig-T [IJNC 21, FH], Musig2 [Crypto 21, NRS], HBMS [Asiacrypt 21, BD]

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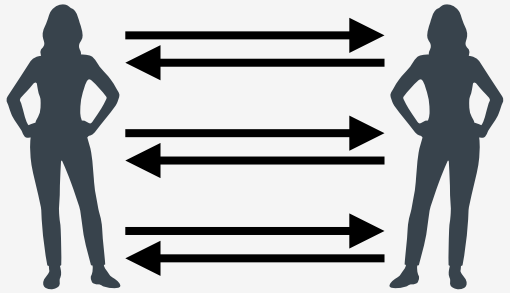

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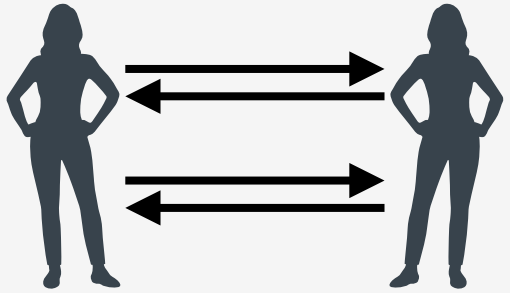

| Musig2 |
|---|
| OMDL |
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BN [CCS 06, BN], Musig [Asiacrypt 18, BDN, and DCC 19, MPS+], Musig-T [IJNC 21, FH], Musig2 [Crypto 21, NRS], HBMS [Asiacrypt 21, BD]

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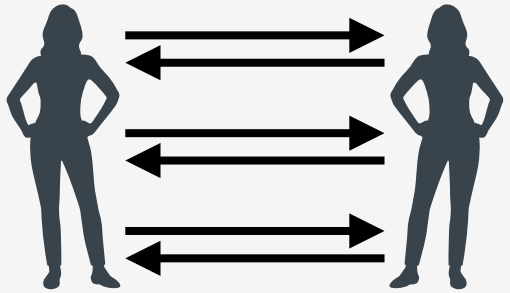

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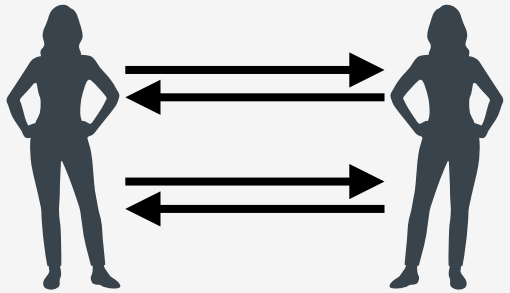

| Musig2 | HBMS |
|---|---|
| OMDL | DLOG |
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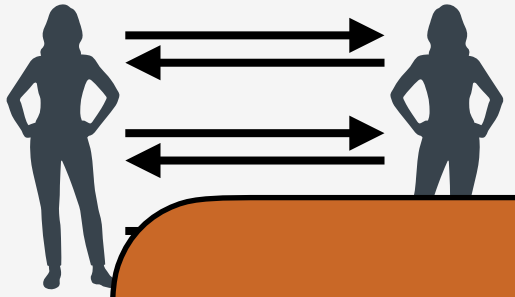

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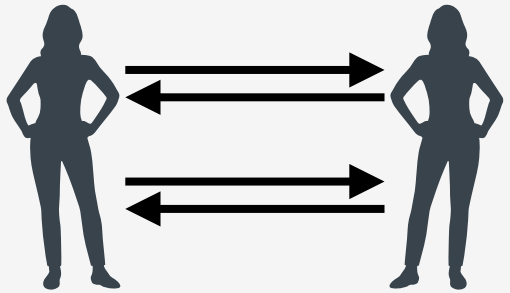
Is Rewinding Inherent for Two-round Schemes?

**2 Rou**



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*2 Rounds*

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Security Loss

*Avoid Rewinding*
*Ideally: Tight*

# Our Results

Round Complexity

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**Multi-Signature**

- 2 Rounds
- DDH Assumption
- $\epsilon \leq Q_S \epsilon'$
- Key Aggregation

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# Technical Part

# What we know so Far

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**Schnorr Identification**

$$R = F(r)$$

$$\longrightarrow$$

$$c$$

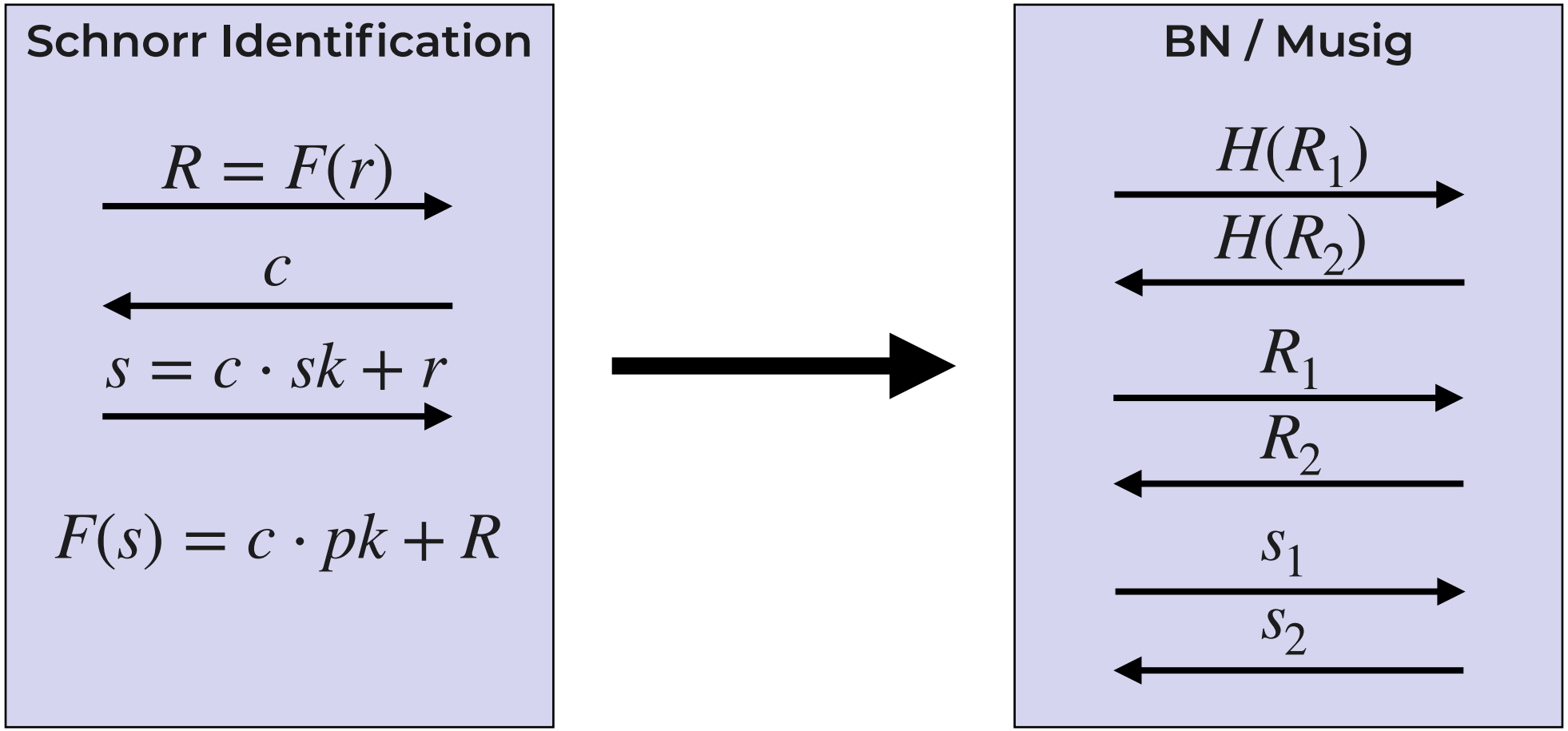
$$\longleftarrow$$

$$s = c \cdot sk + r$$

$$\longrightarrow$$

$$F(s) = c \cdot pk + R$$

# What we know so Far



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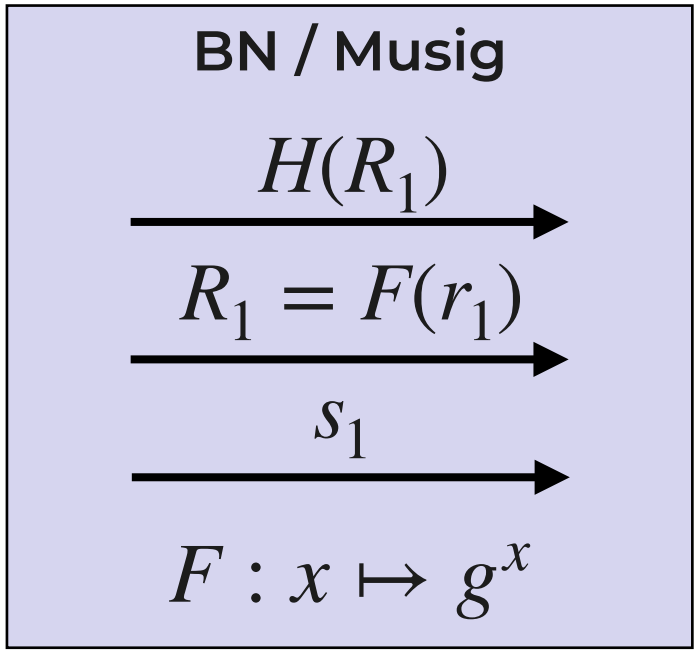

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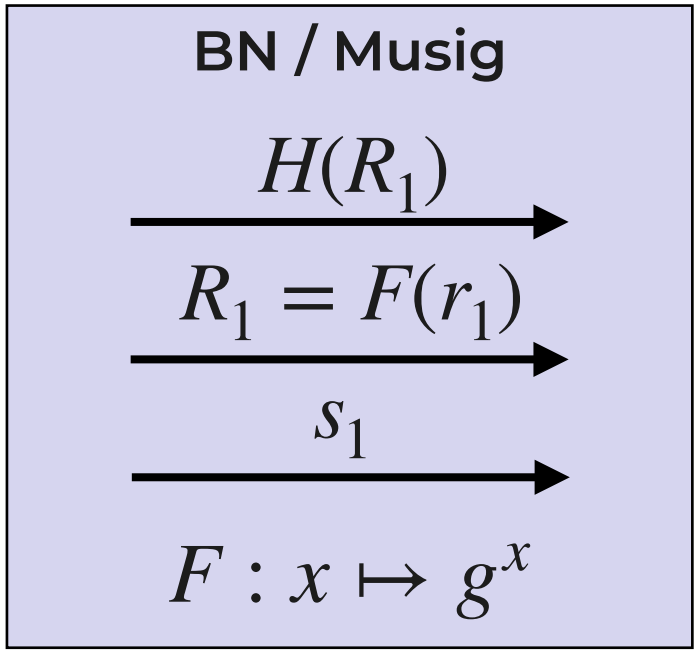


**Three Rounds**

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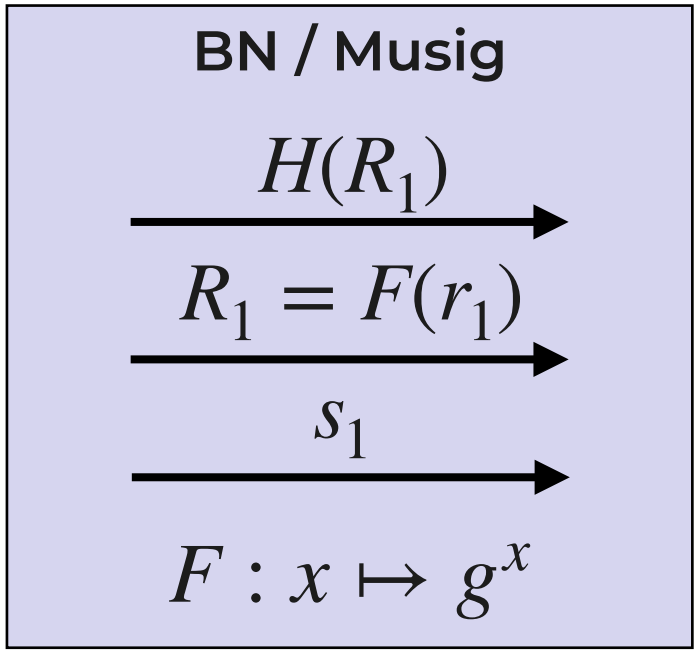


**Three Rounds**

**Rewinding**

# What we know so Far

**BN / Musig**

$$\xrightarrow{H(R_1)}$$

$$\xrightarrow{R_1 = F(r_1)}$$

$$\xrightarrow{s_1}$$

$$F : x \mapsto g^x$$

Lossy Identification

**BN-Tight/Musig-Tight**

$$F : x \mapsto (g^x, h^x)$$

**Three Rounds**

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[9] Lossy Identification [Eurocrypt 12, AFLT], DOTT [PKC 21, DOTT]

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Homomorphic
Trapdoor Commitment

**BN-Tight/Musig-Tight**

$$F : x \mapsto (g^x, h^x)$$

**Three Rounds**

**DOTT**

$$\mathrm{com}(R_1)$$

$$s_1,\ \mathrm{open}$$



Lossy Identification [Eurocrypt 12, AFLT], DOTT [PKC 21, DOTT]

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Commitment

- From DLOG or DDH
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Require **Weak** Trapdoor

# Summary

# Summary and Open Problems

**Multi-Signature**

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Preprocessing?

Other Assumptions? Lattices?