Policy-based signatures

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joint work with Mihir Bellare

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Overview

- New signature primitive
- Signer can only sign messages conforming to policy

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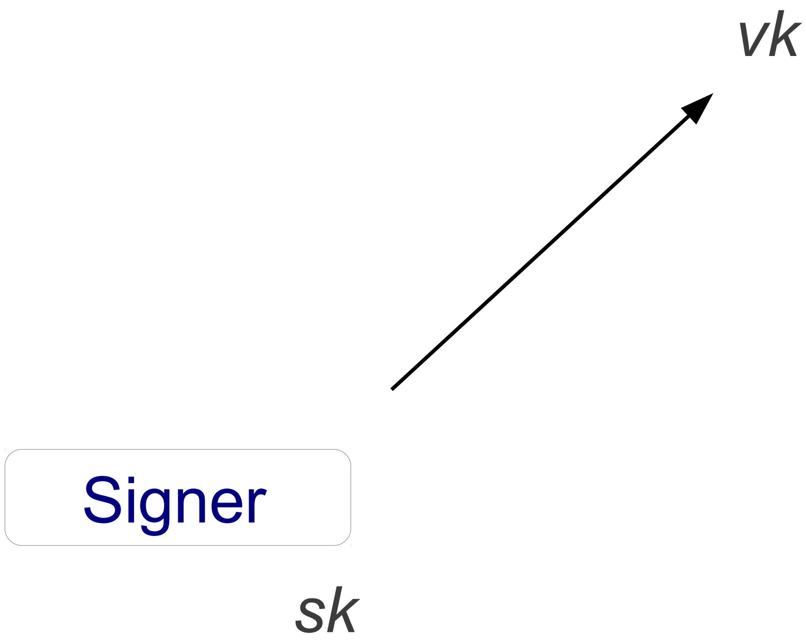
- Practical applications: use for corporations
- Theoretical: unification of existing work

Signatures



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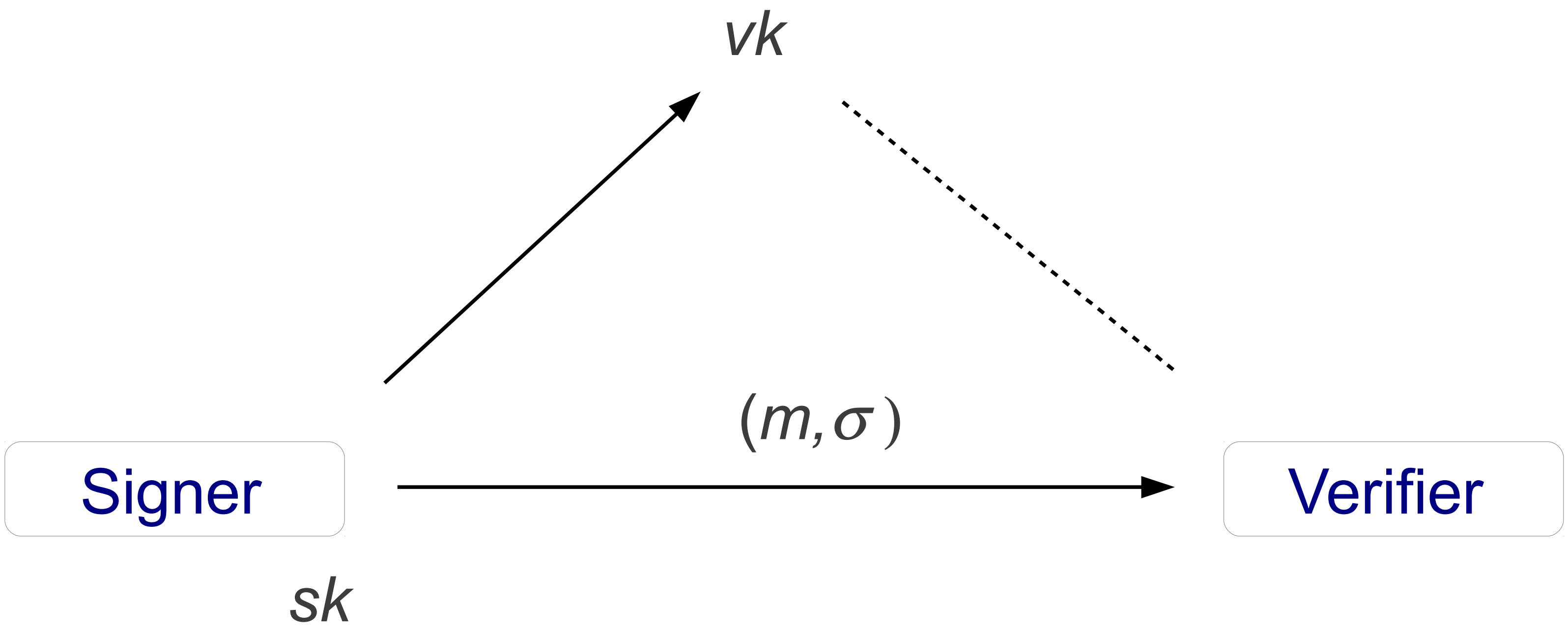
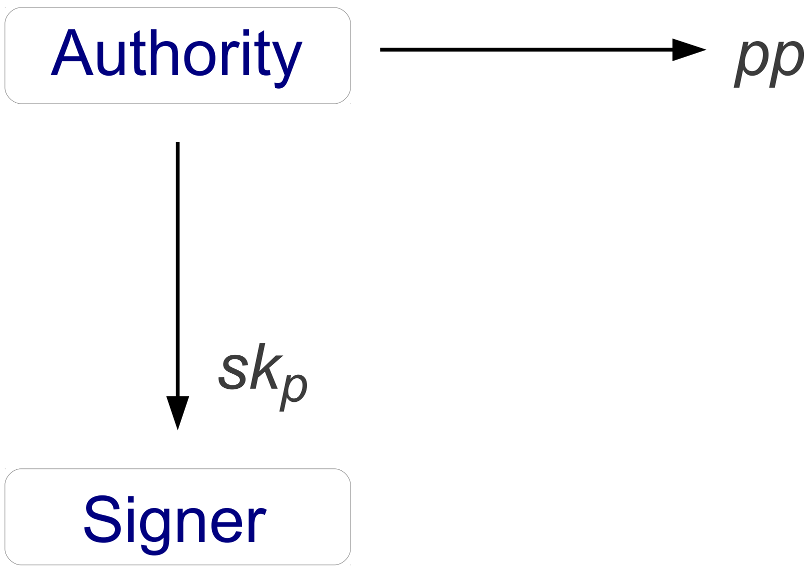
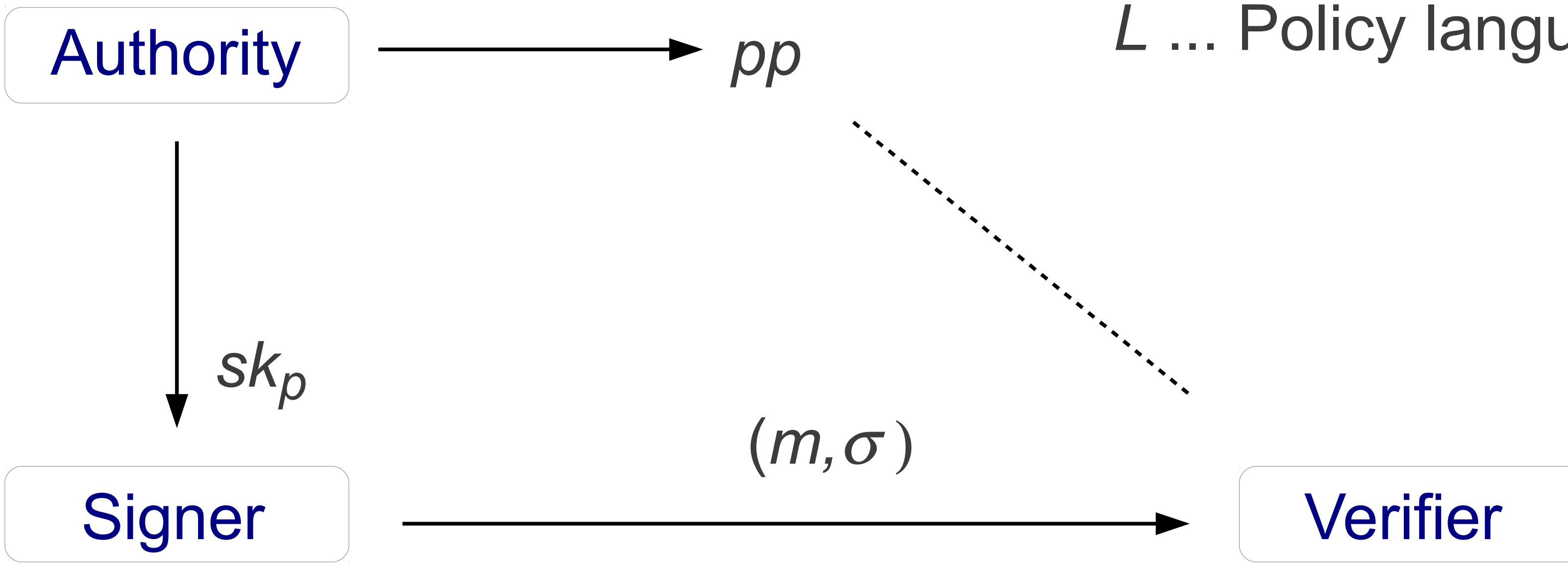


Policy-based signatures



Policy-based signatures

p ... Policy
L ... Policy language



only if $(p,m) \in L \subseteq \{0,1\}^* \times \{0,1\}^*$

Security

- Unforgeability:

  You can only sign a message *m* if you have a key for a policy *p* satisfied by *m*

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- Privacy:

  The signature does not reveal the policy

Theoretical Motivation

- Signature analog to functional encryption [BSW11]

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- Unification of existing notions for signatures with privacy:

  Group signatures [Cv91]

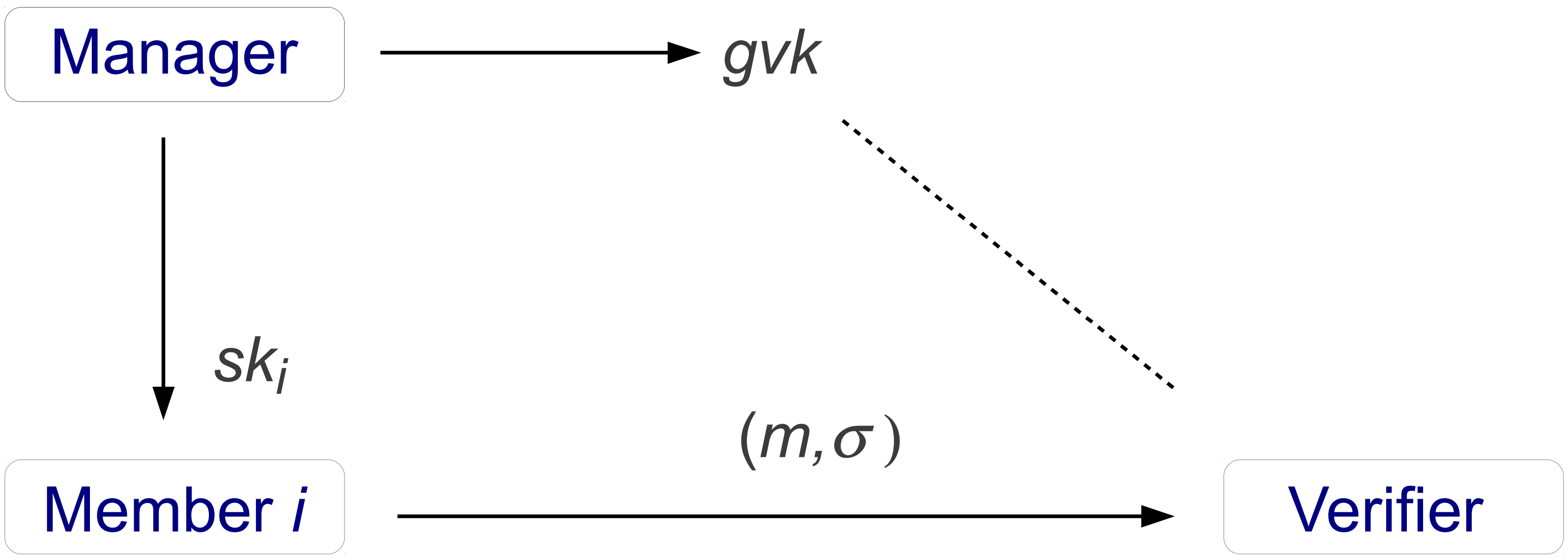
  (Anonymous) proxy signatures [MUO96,FP08]

  Ring signatures, mesh signatures [RST01,Boy07]

  Attribute-based signatures [MPR11]

  Anonymous credentials [CL01,BCKL08]

Group signatures



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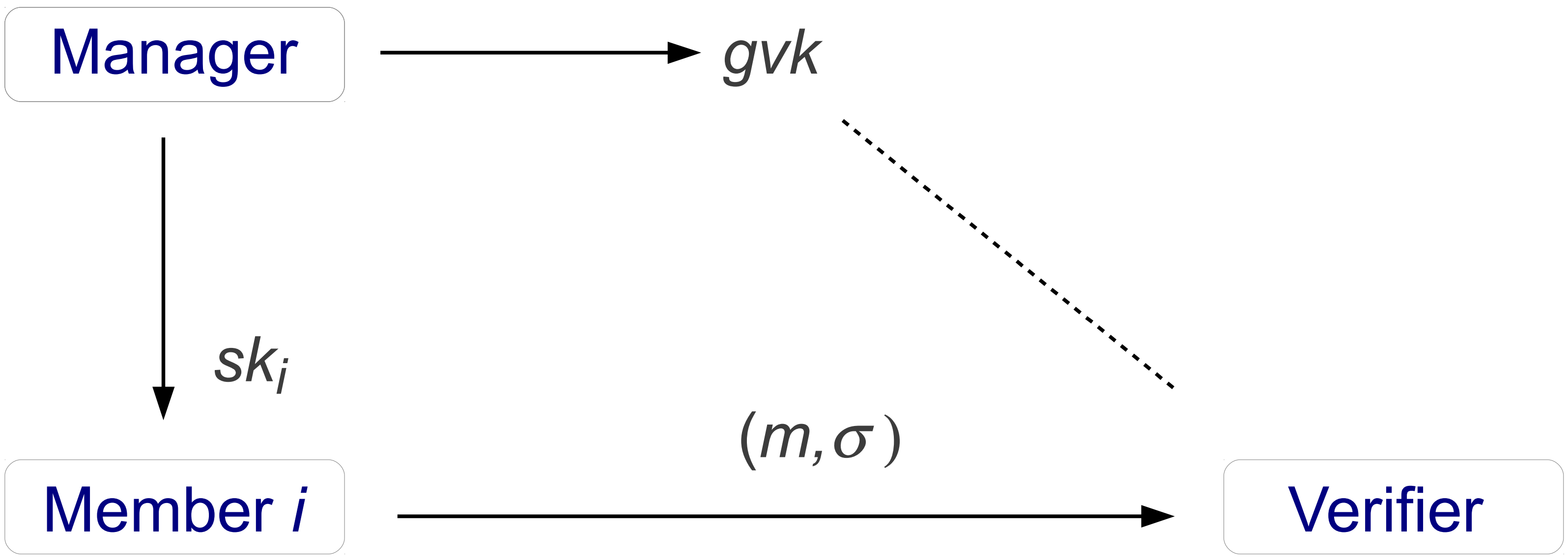

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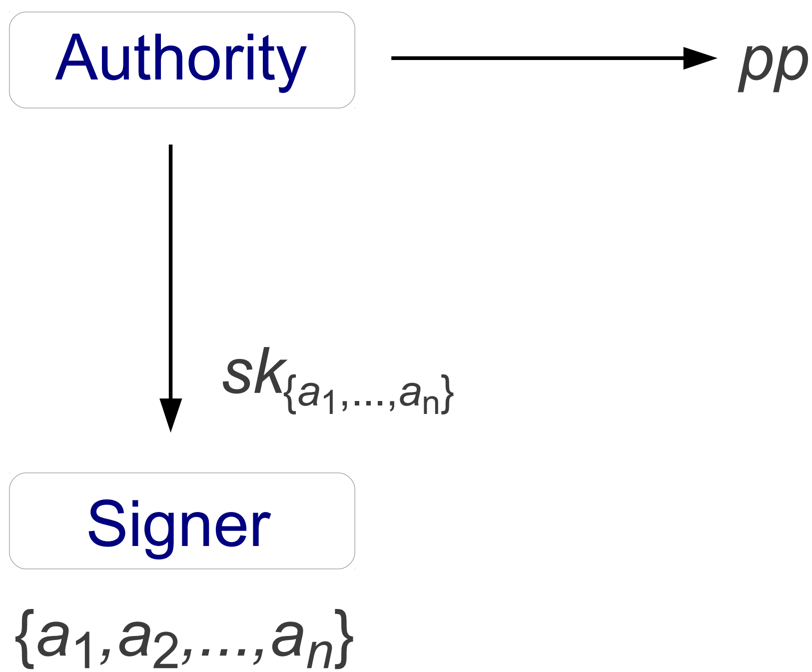
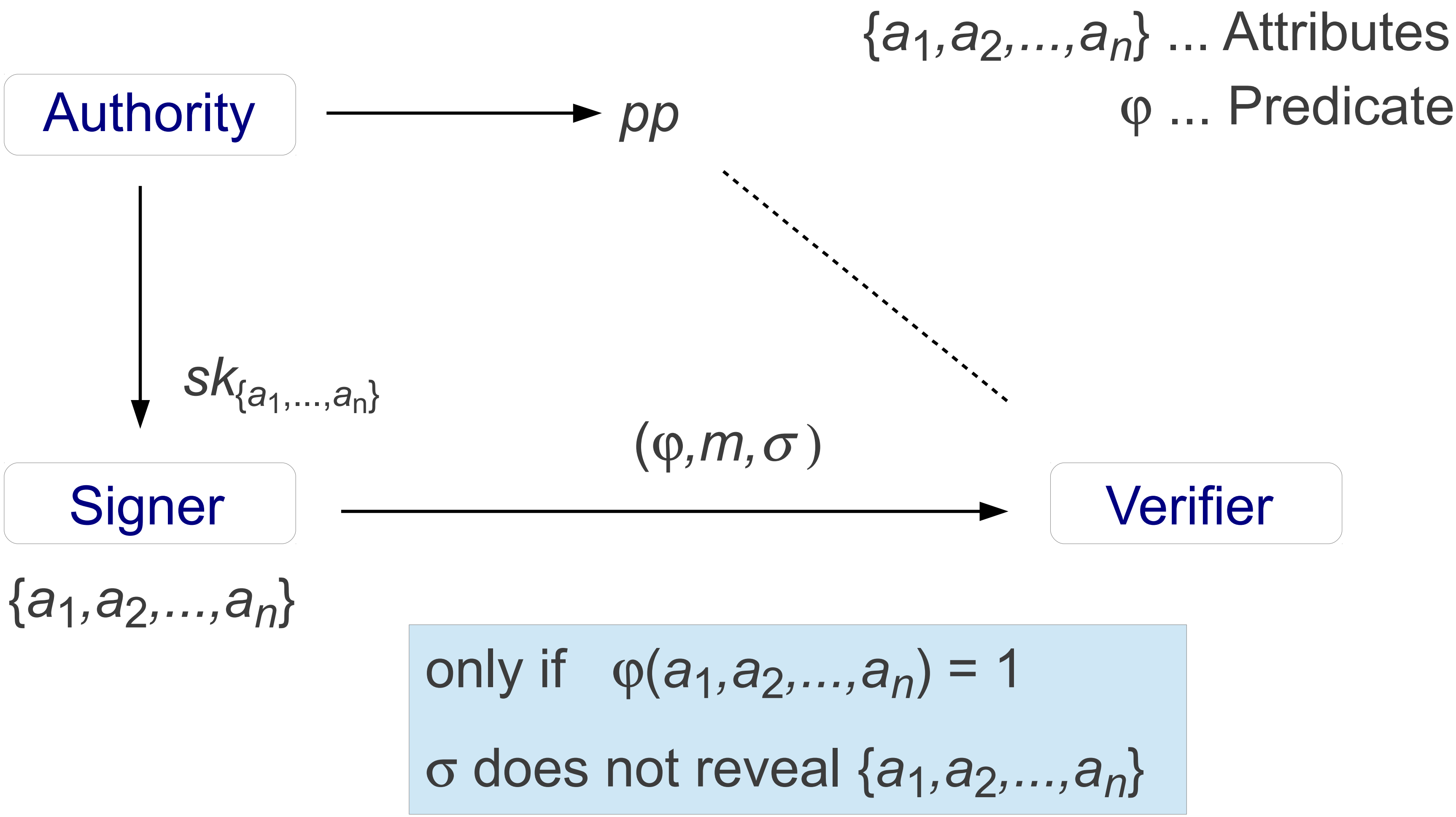


$\{a_1, a_2, \ldots, a_n\}$ ... Attributes

φ ... Predicate

Attribute-based signatures



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- Company with public key *vk*
- Employees get signing keys enabling signing
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  - Signing w.r.t policies like

$$\text{CEO} \vee (\text{board member} \wedge \text{manager})$$

Can we do better?

⇒ Public policies...

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Example:

Employee gets key with which she can sign contracts only with company *B.*

Definition of PBS

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- Policy languages:

  We allow any language in **NP**, defined by policy checker

$$\mathrm{PC} : ((p,m),w) \rightarrow \{0,1\}$$

$$(p,m) \in L(\mathrm{PC}) \;:\Leftrightarrow\; \exists\, w \in \{0,1\}^* : \mathrm{PC}((p,m),w) = 1$$

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- Algorithms:

  $\mathrm{Setup}(1^\lambda) \to (pp,msk)$

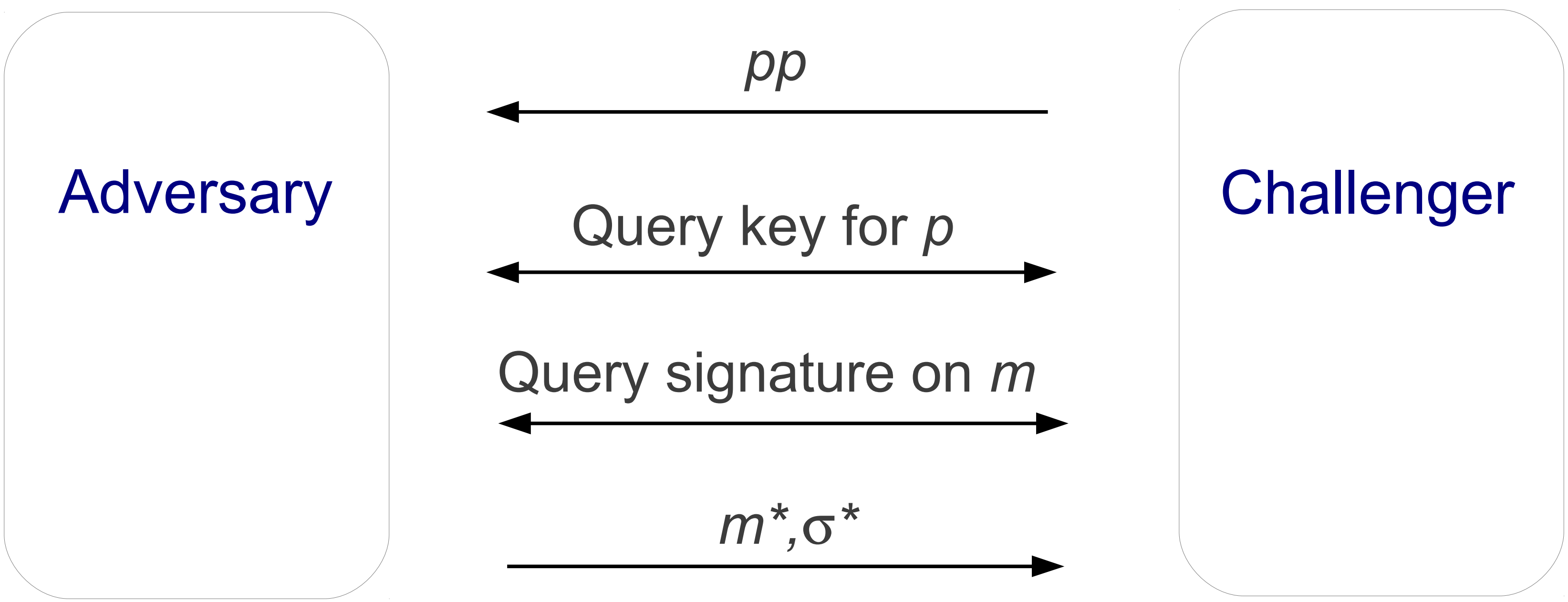
  $\mathrm{KeyGen}(msk,p) \to sk_p$

  $\mathrm{Sign}(sk_p,m,w) \to \sigma$

  $\mathrm{Verify}(pp,m,\sigma) \to b$

Unforgeability

- Game



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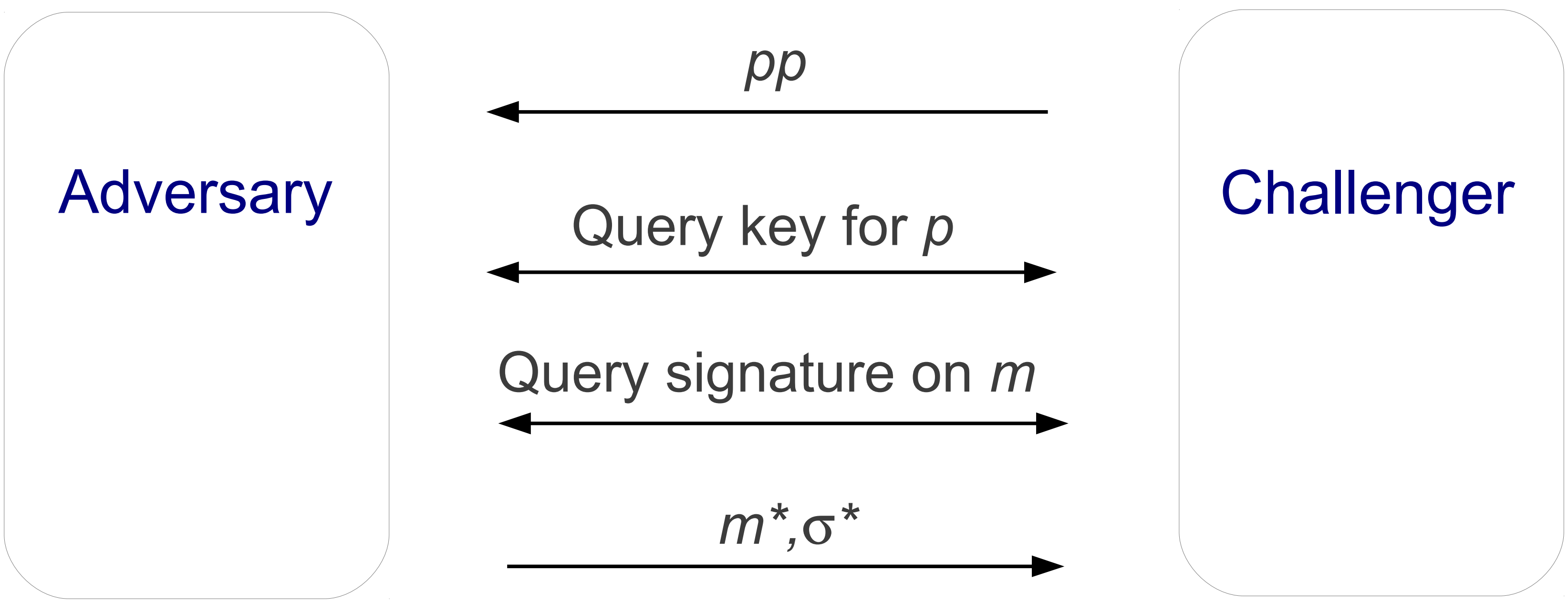

A wins if - Verify(pp, m^*, σ^*) = 1,
- no signature query for m^*,
- for all key queries for p: $(p, m^*) \notin L(\mathrm{PC})$

Indistinguishability

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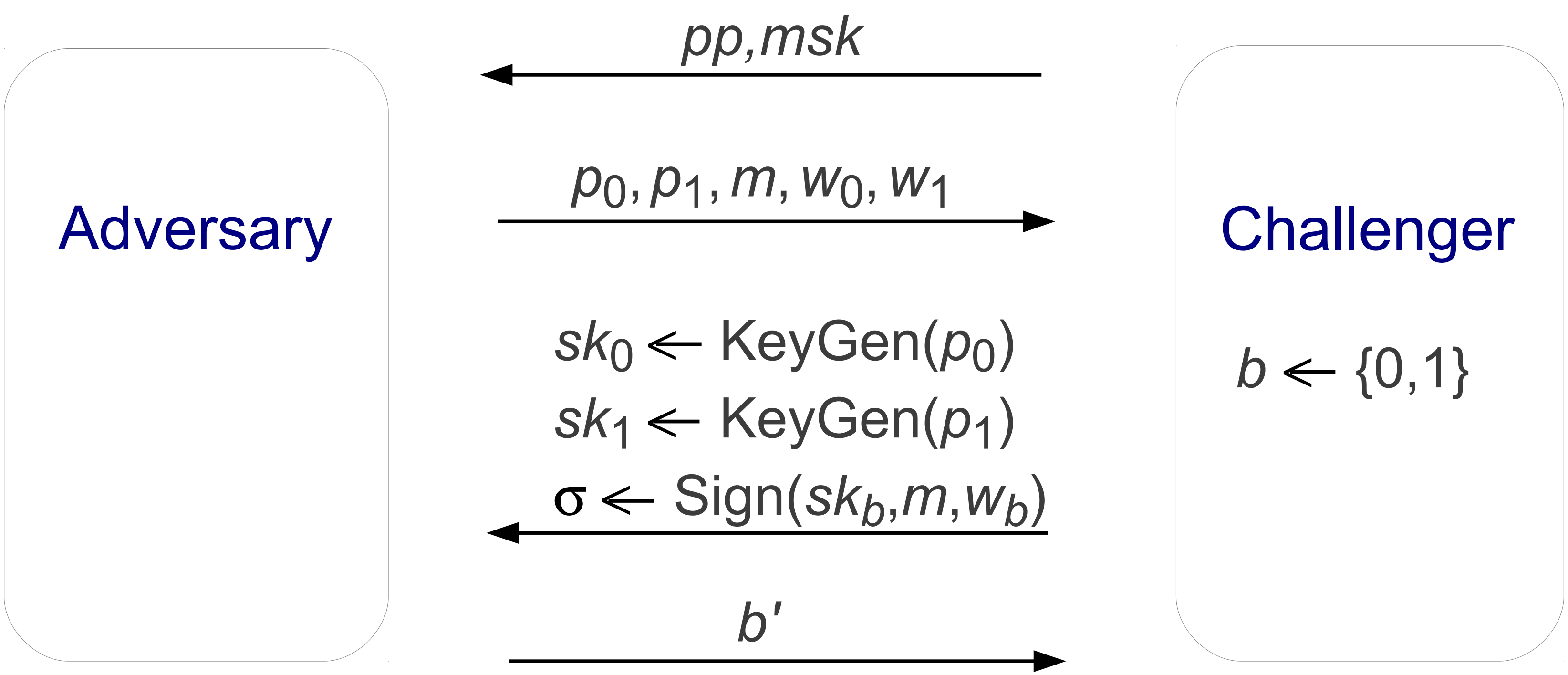

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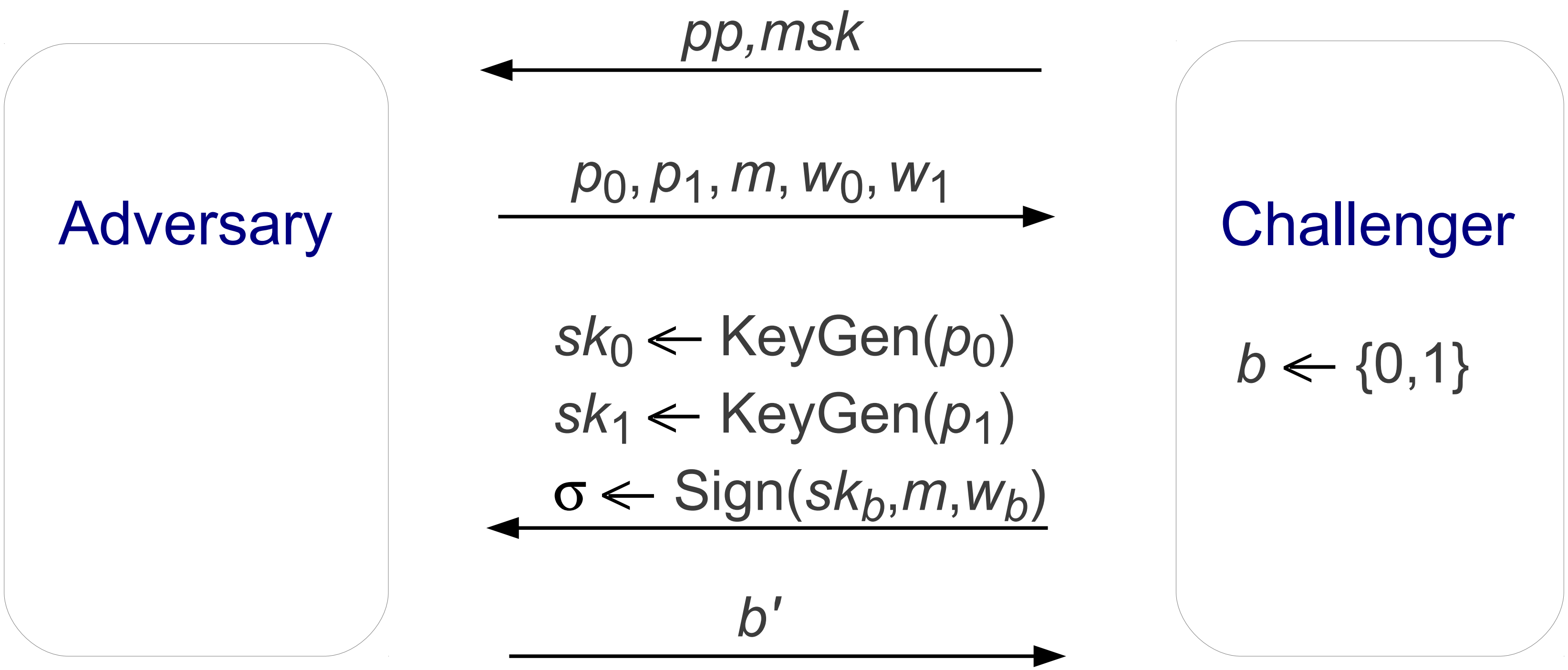

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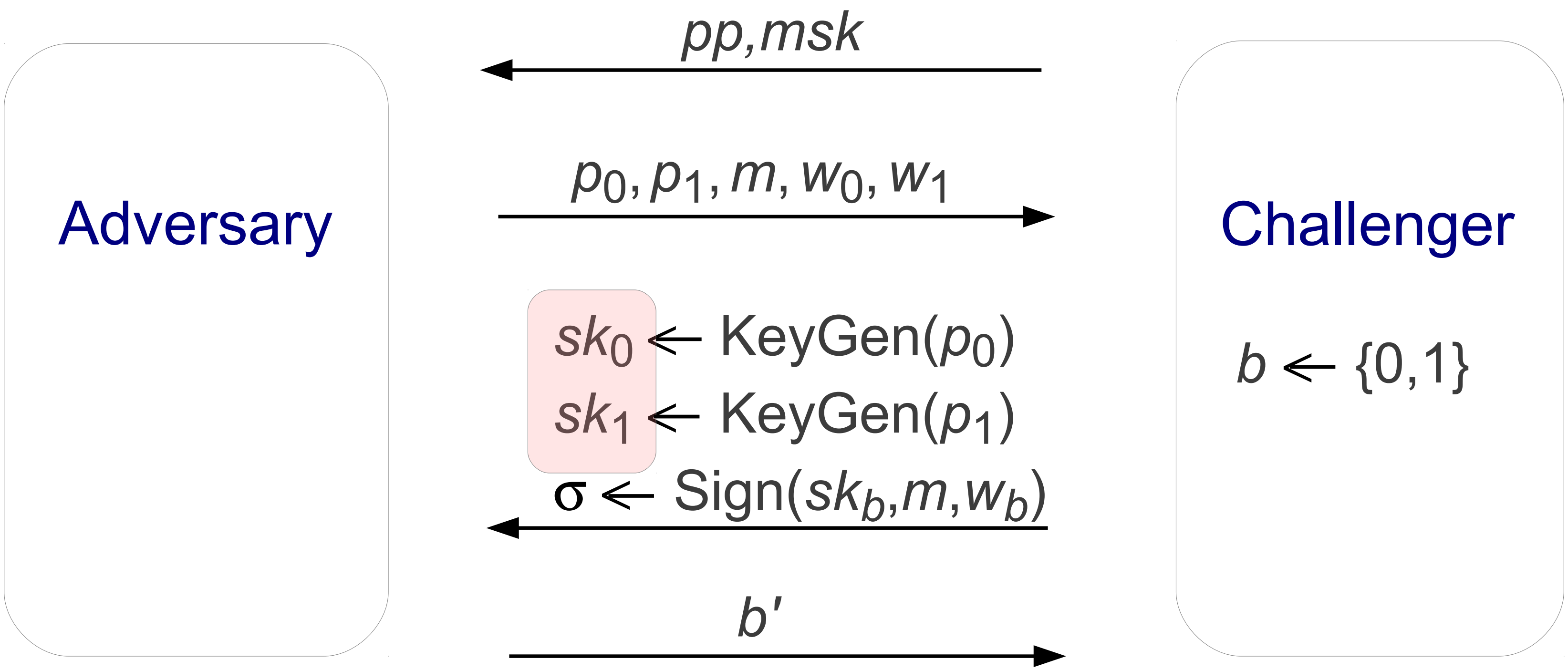

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  $\Rightarrow$ Extraction-based definition

Extr+Sim $\Rightarrow$ UF+IND

Constructions of PBS

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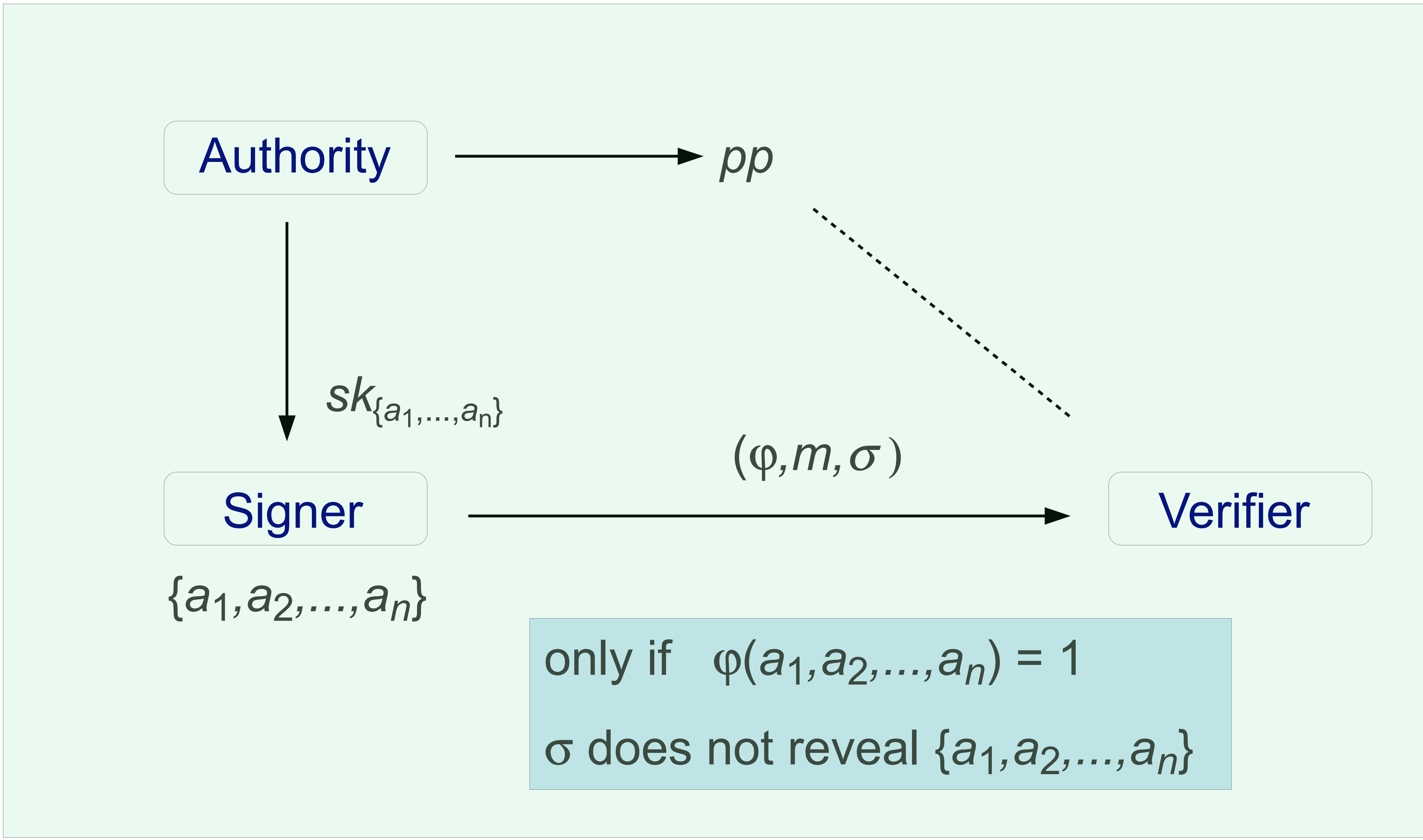
- Efficient construction

  based on - structure-preserving signatures [AFG+10]
  - Groth-Sahai proofs [GS08]

  for policy languages over **pairing groups**
  (policies define pairing-product equations)

Primitives from PBS

Attribute-based signatures from PBS



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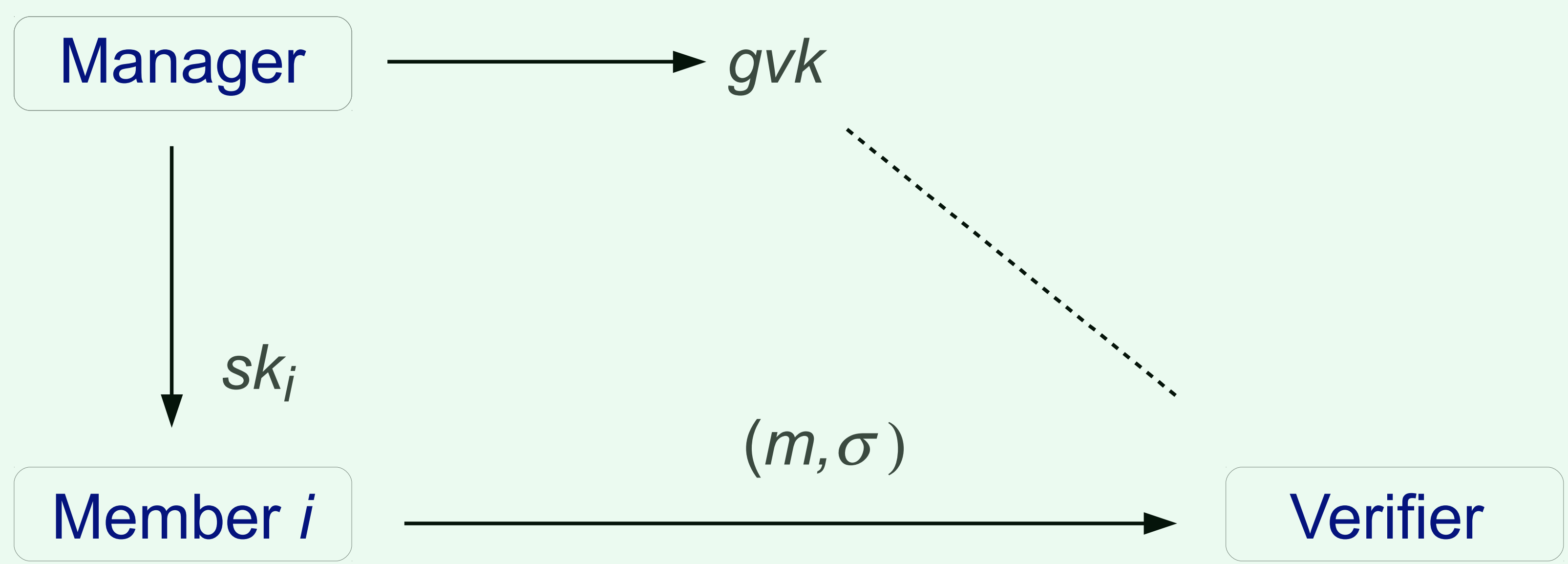

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$$\sigma \xrightarrow{\text{Manager}} i$$

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Verify: verify PBS Open$(dk,(c,\sigma))$: decrypt c

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- Signatures of knowledge [CL06]

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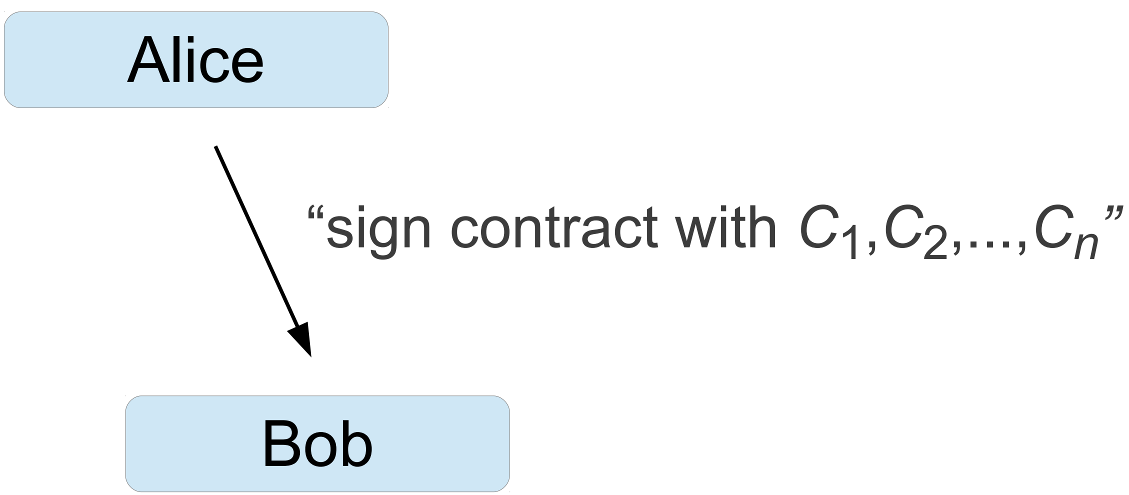

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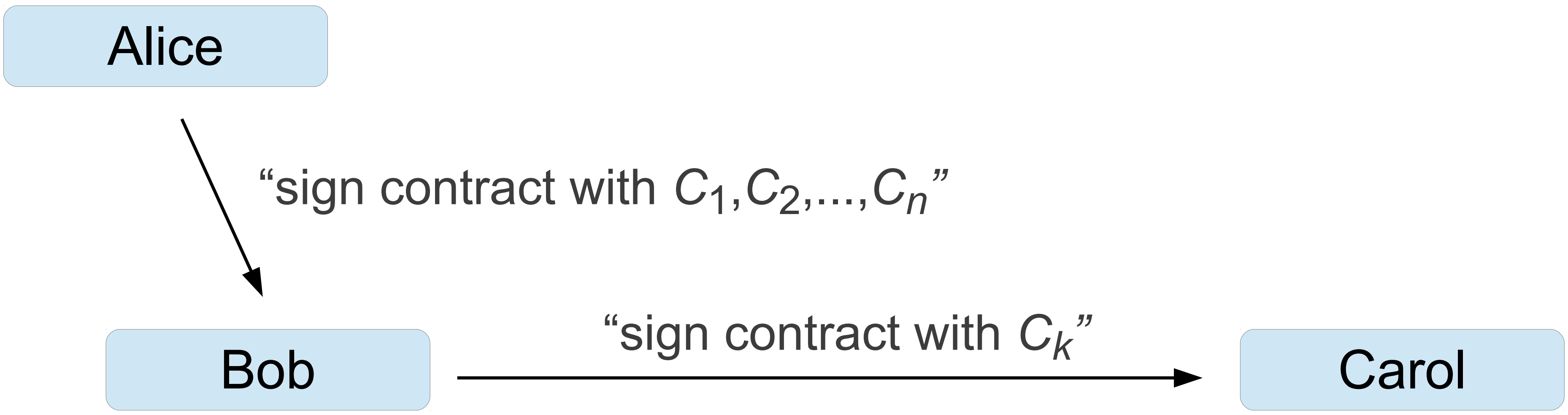

Thank you

PBS from SSE-NIZK

- Simulation-sound extractable NIZK:
  - prove membership for **NP** languages

- Authority has signature key pair (vk,sk)
- sk_p is signature on p
- PBS-signature on m is SSE-NIZK proof that $(vk,m) \in L$ defined by

$$((vk,m),(p,sig,w)) \in R_L \quad \Leftrightarrow$$

$$((p,m),w) \in \mathrm{PC} \wedge \mathrm{Verify}(vk,p,sig) = 1$$