Boosting the Security of Blind Signature Schemes

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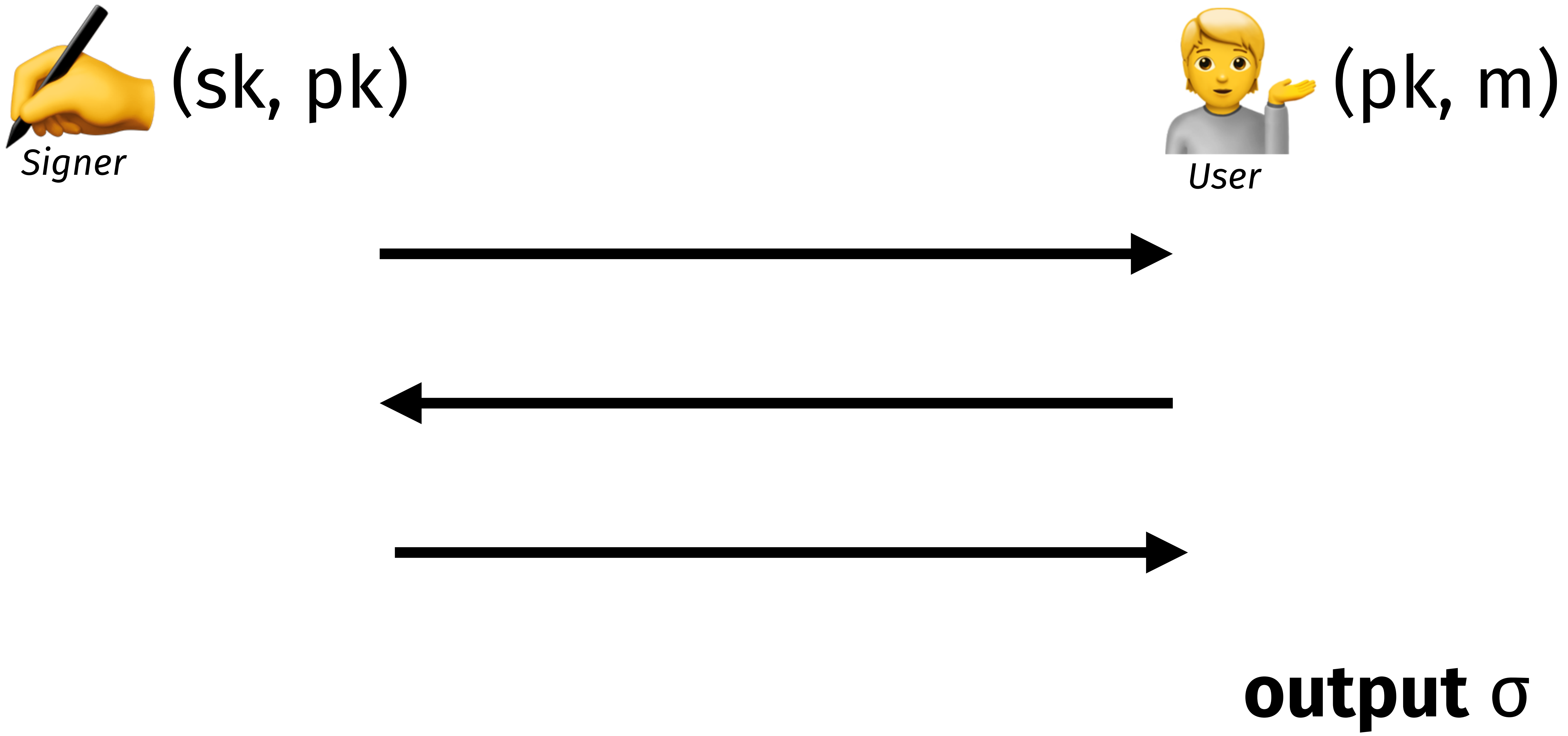
*Work done while at the University of Maryland, College Park

**Supported by the National Defense Science and Engineering Graduate (NDSEG) fellowship

Blind Signatures

Digital signatures where the signer learns nothing



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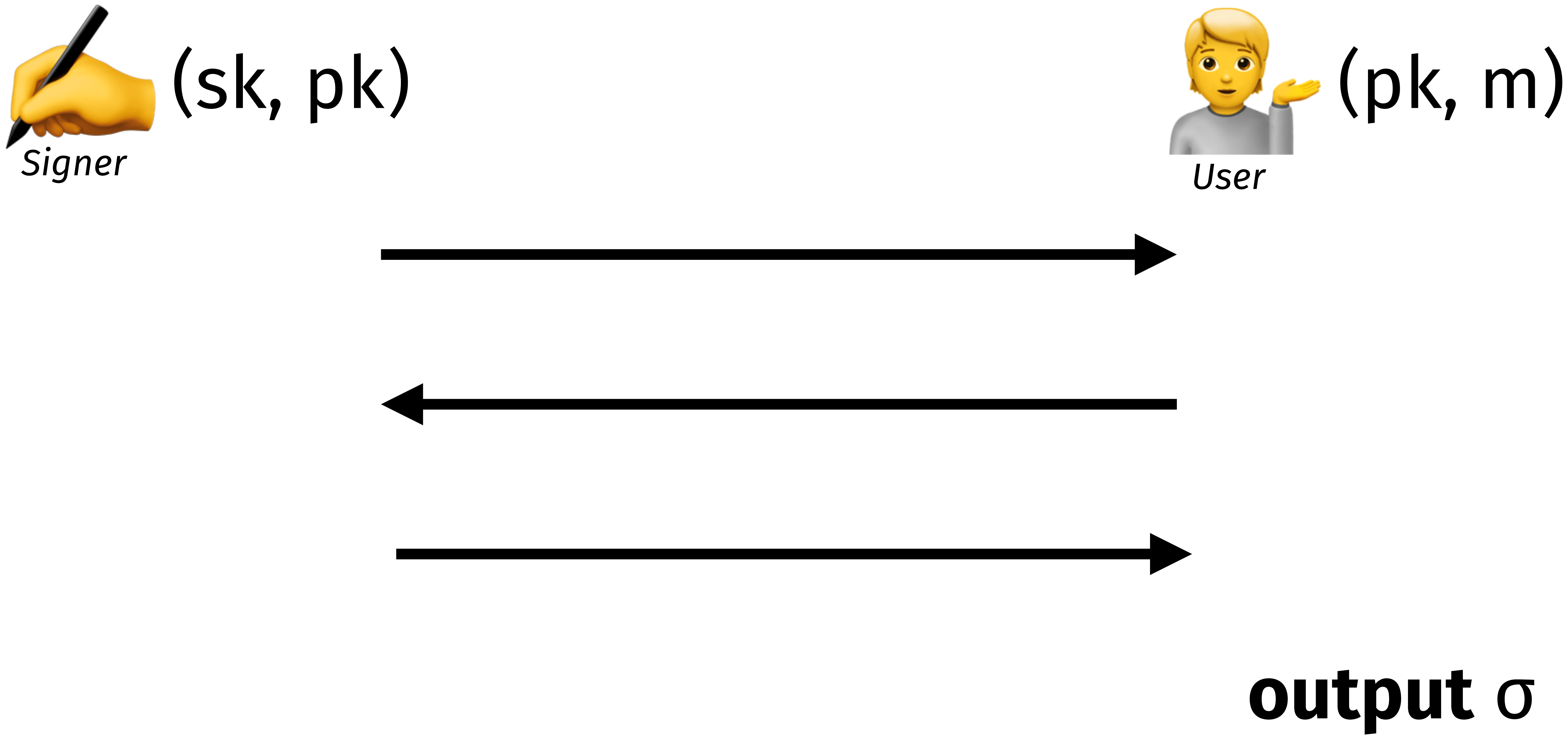

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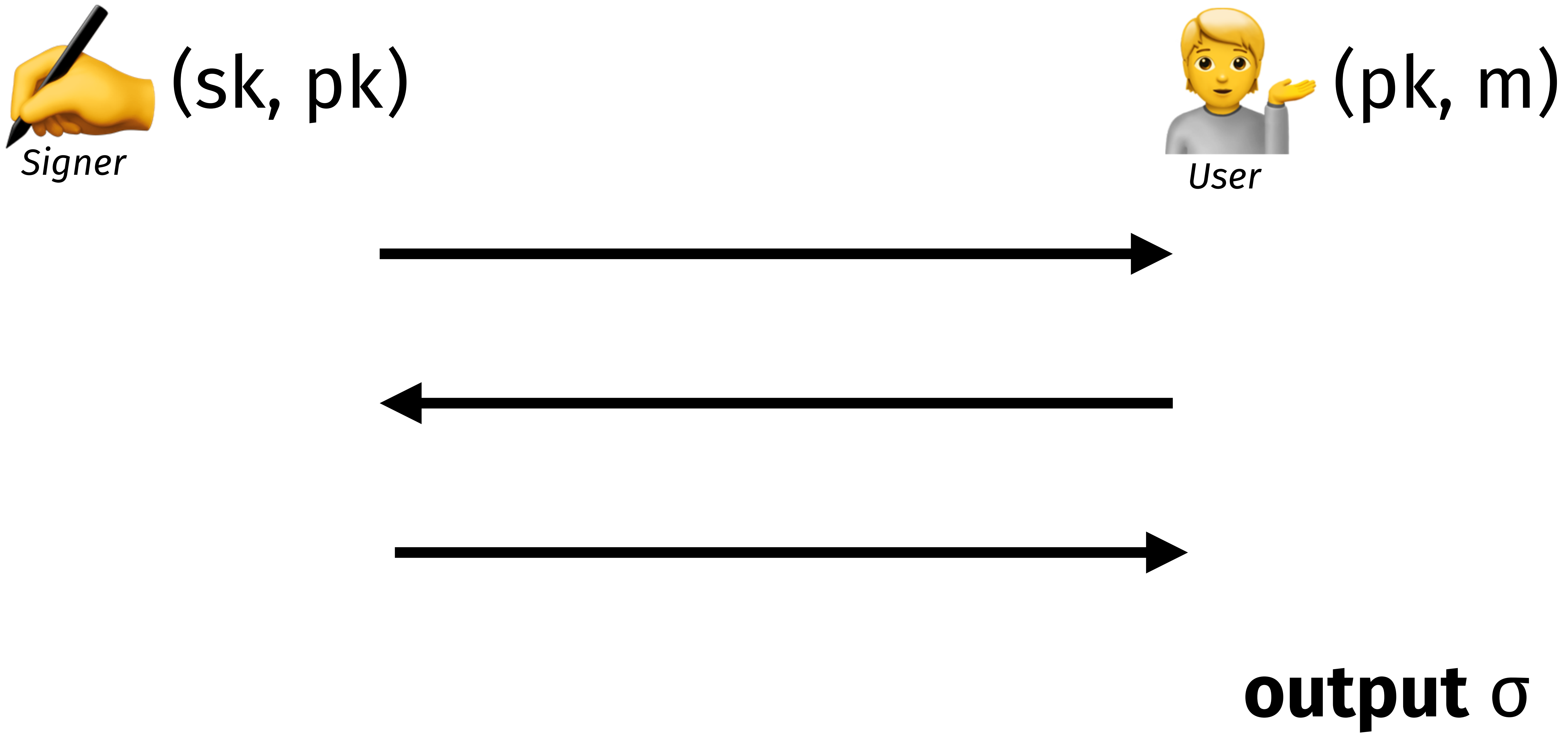

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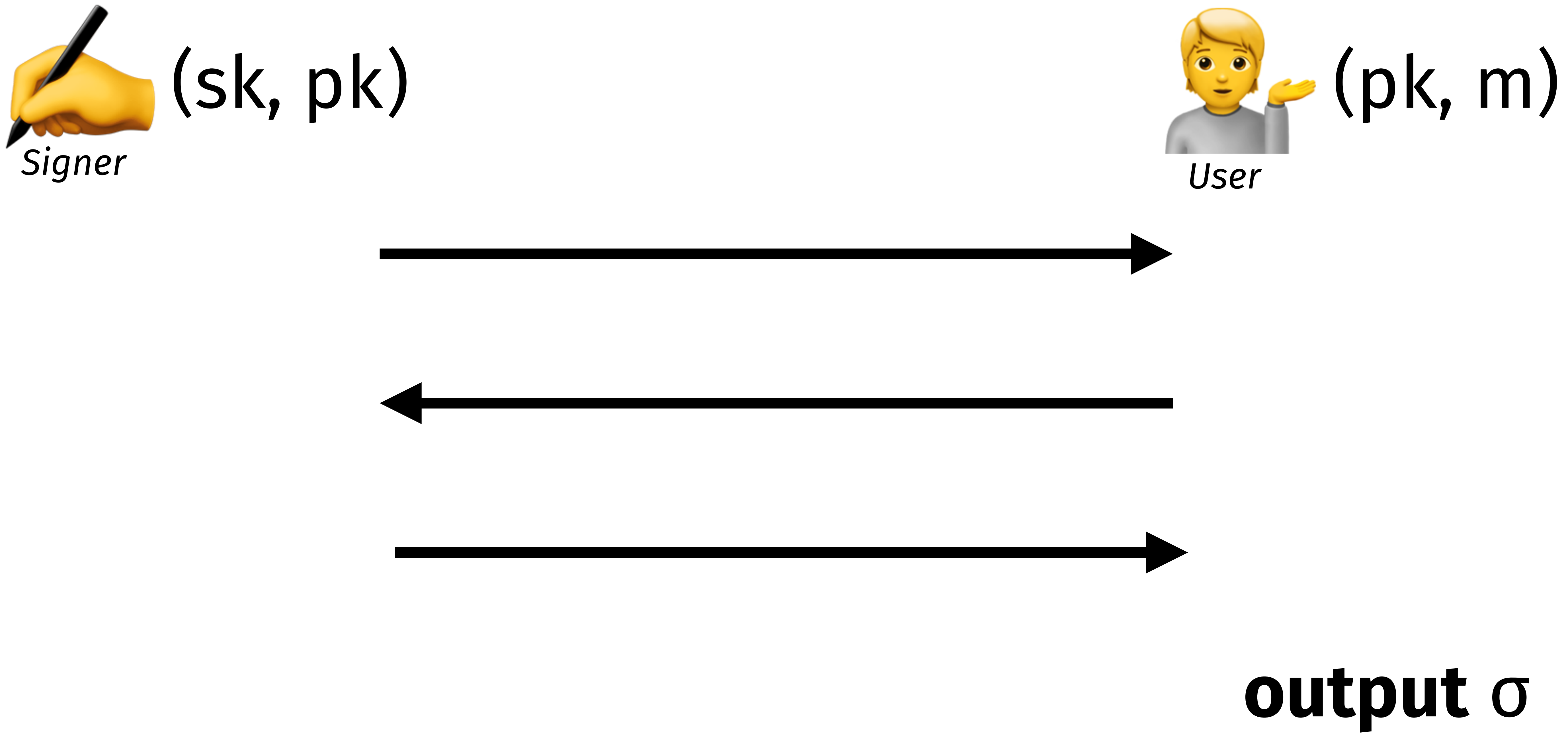

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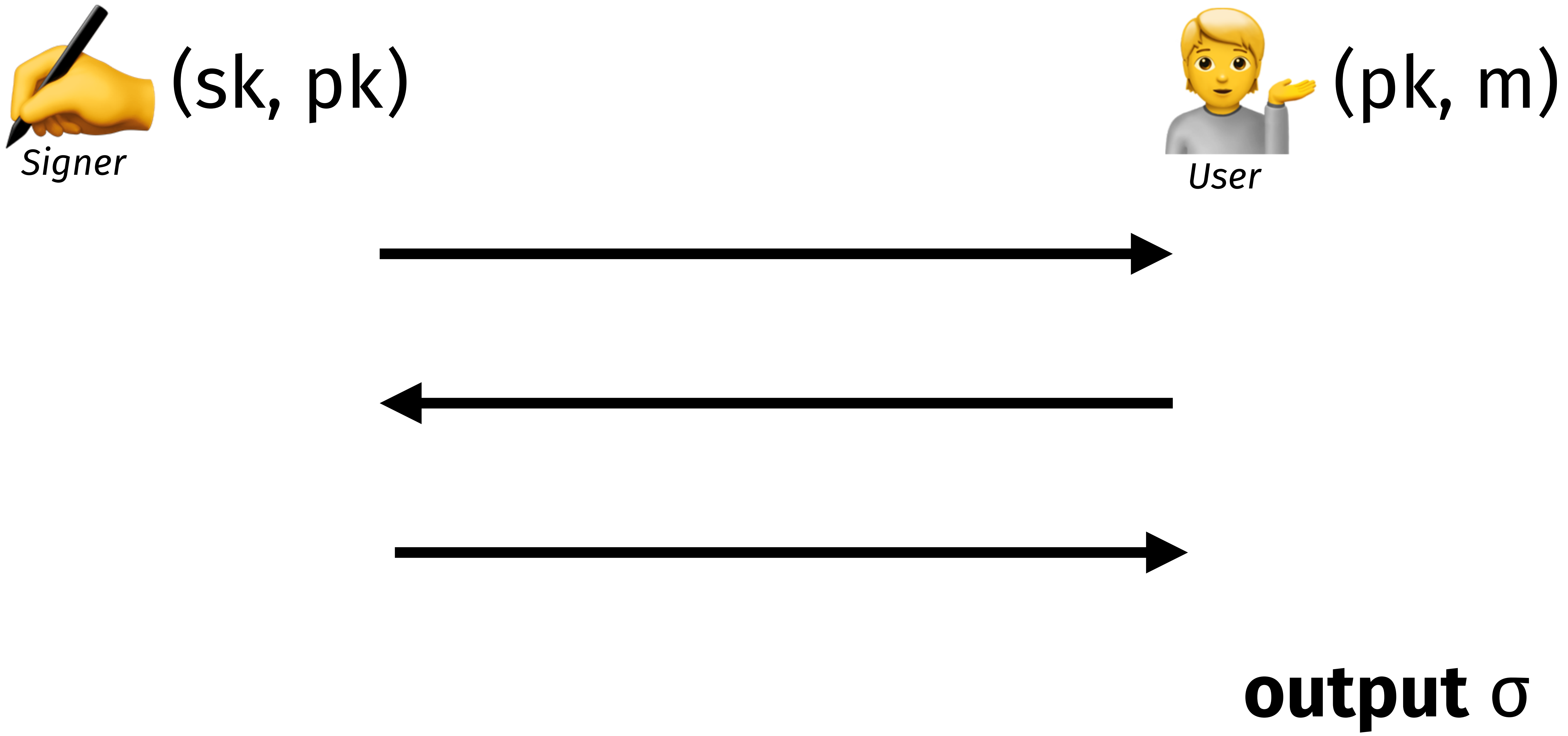

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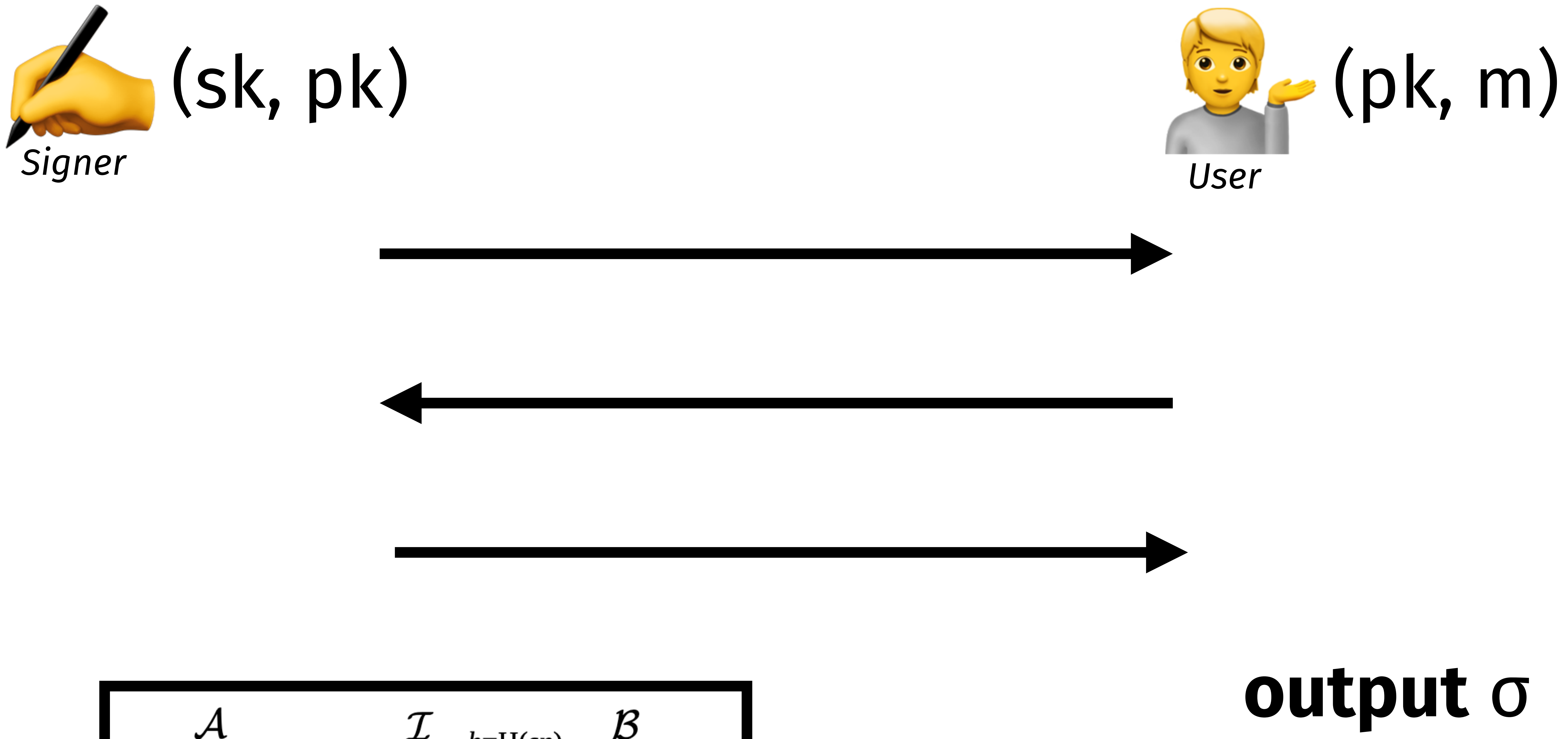

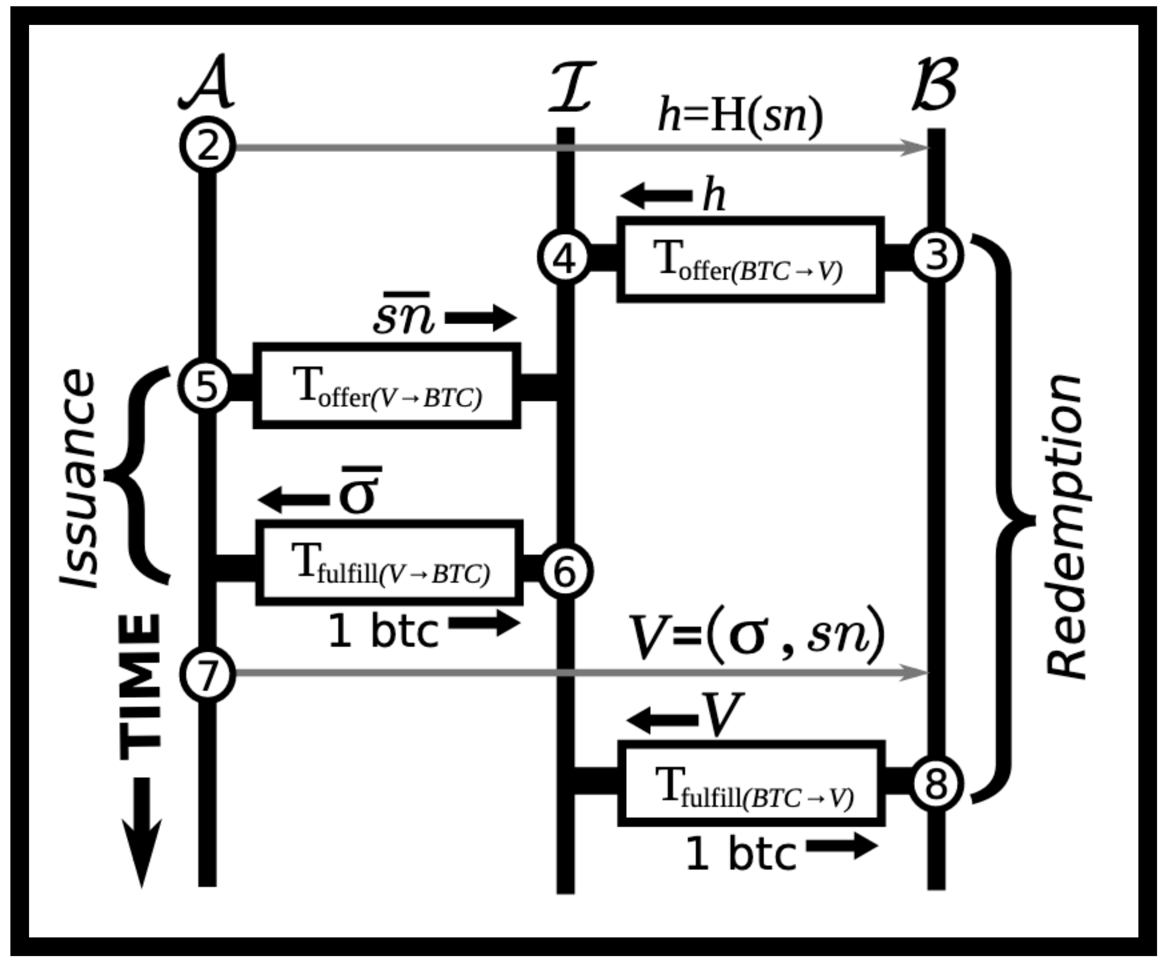

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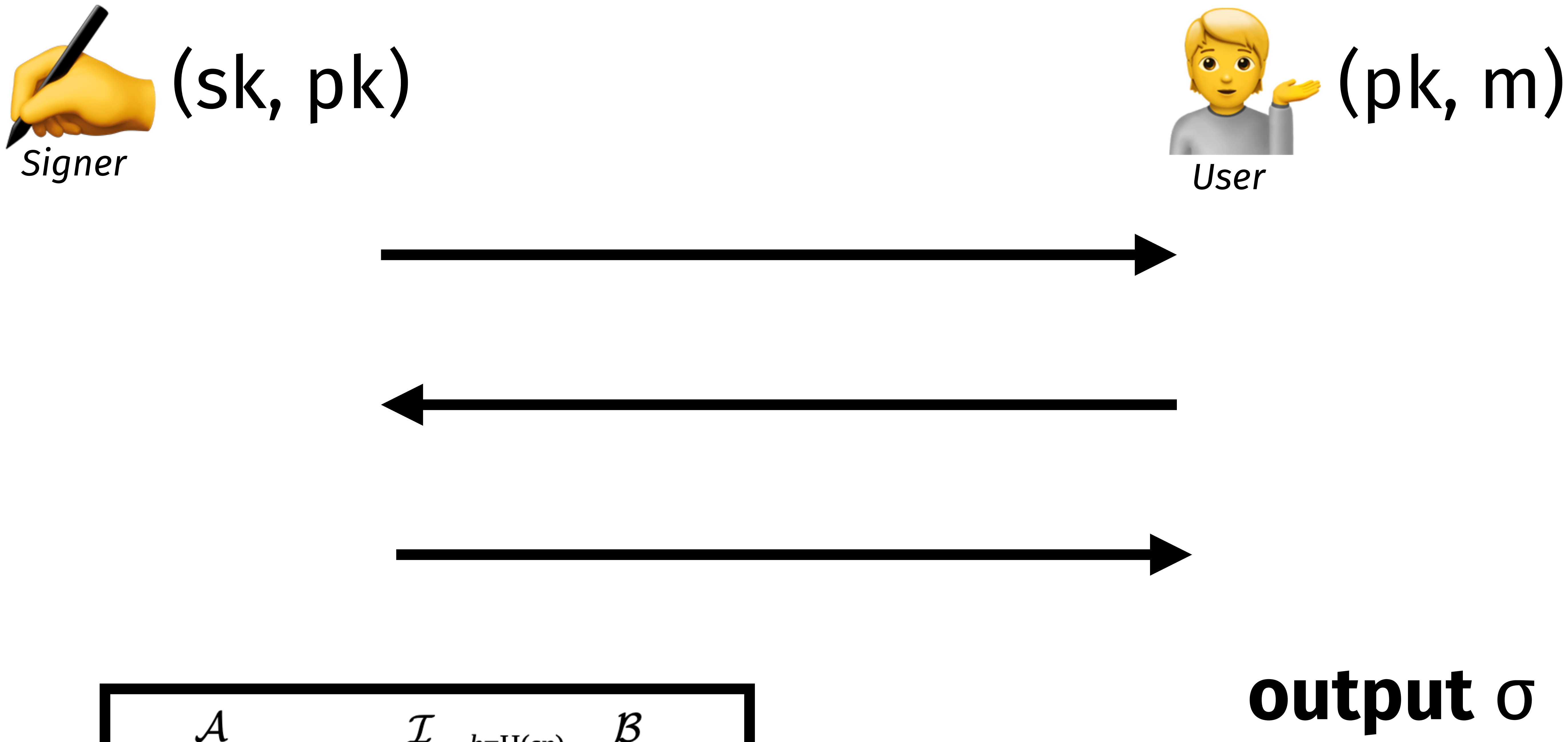

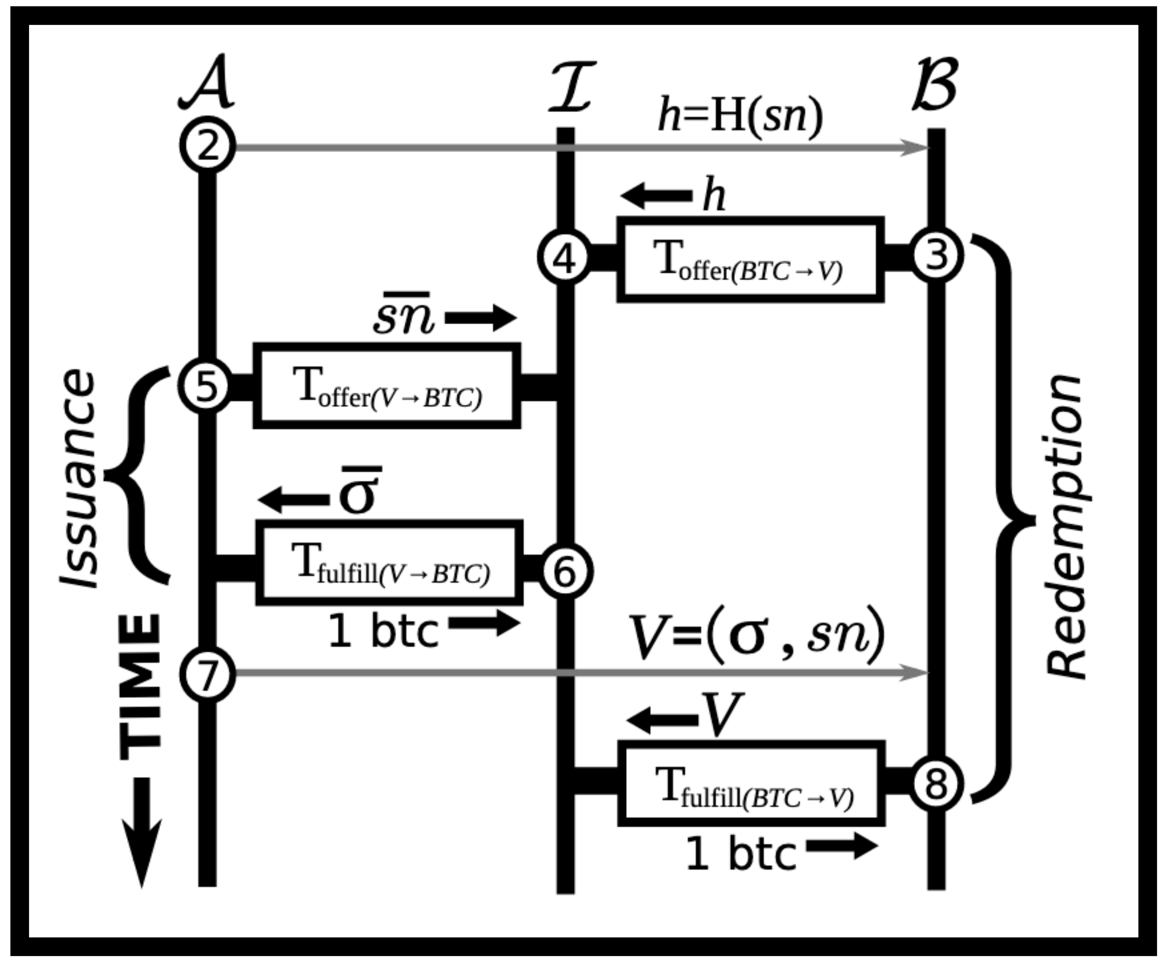

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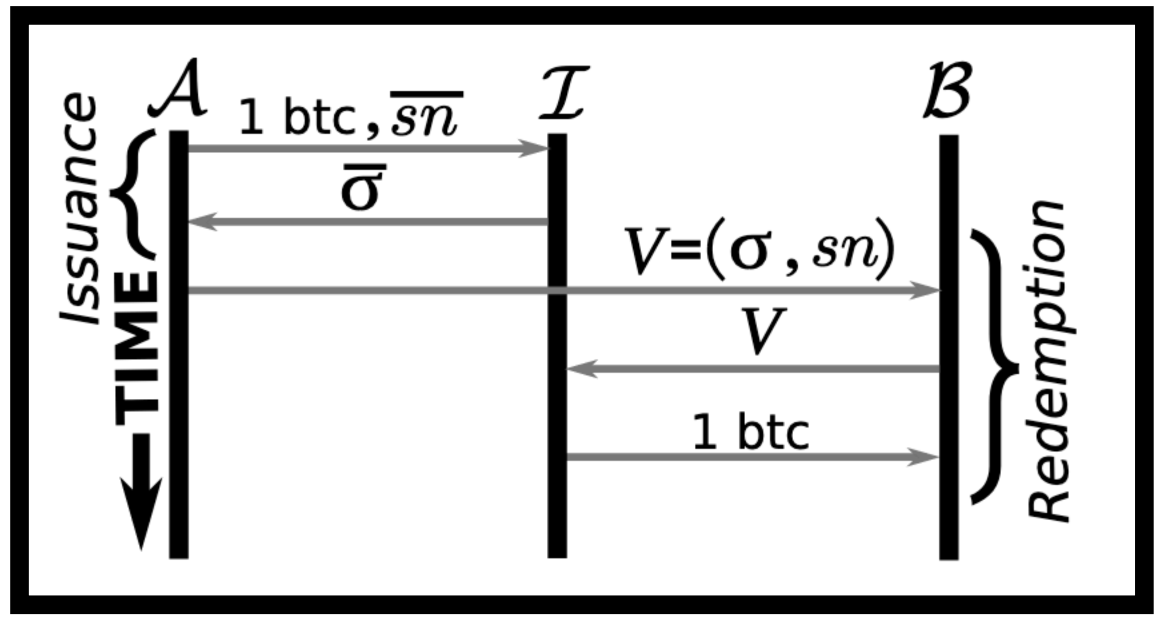

Ecash [Chaum83]

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- **No concurrency** [BL12, JLO97, KLX20]

Goal

Construct a blind signature scheme in the **ROM**, using **standard number-theoretic assumptions**, that is provably secure after:

1. Poly-many signatures
2. With arbitrary concurrency

Our Contribution

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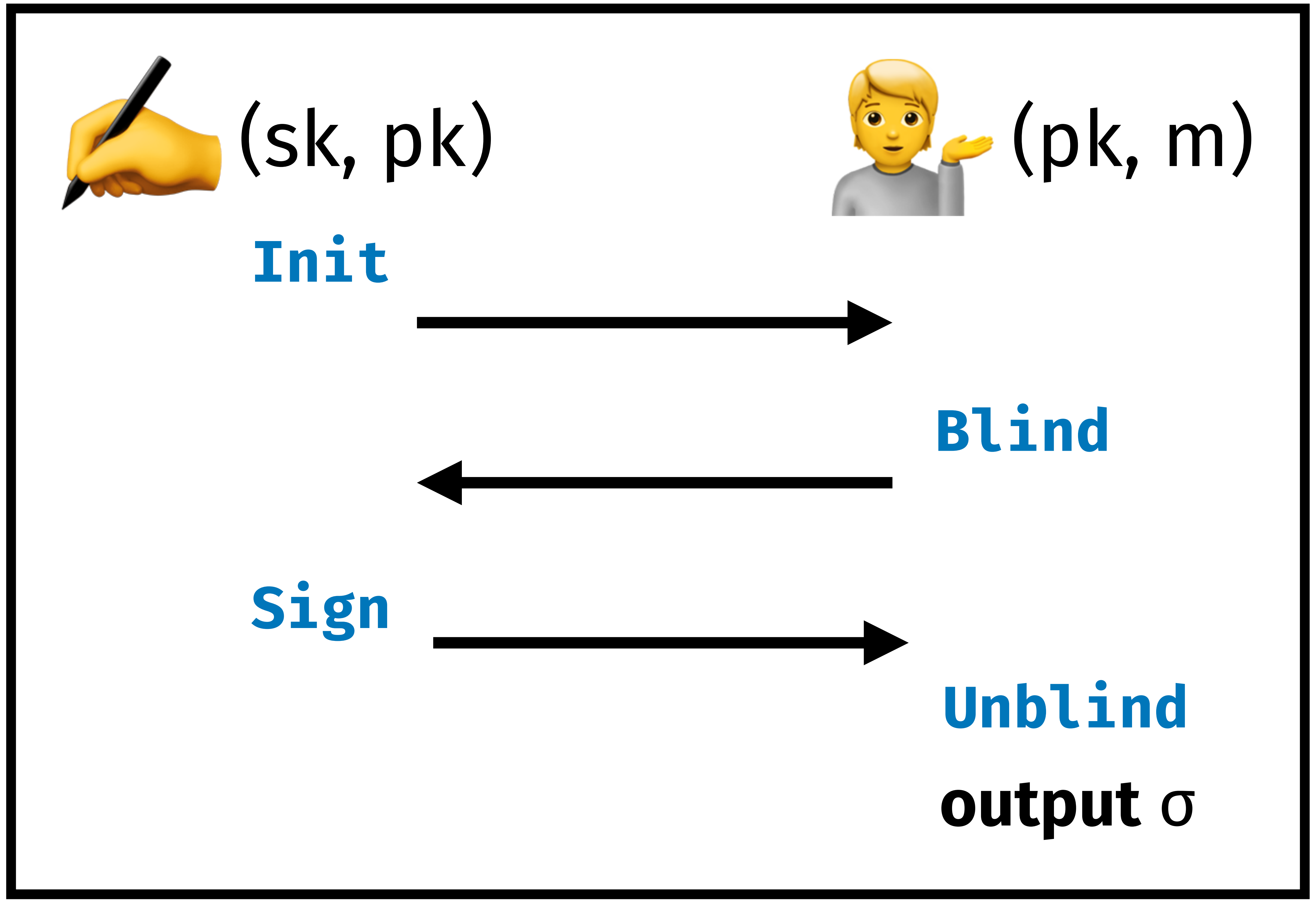
- ~5000 bit groups

Beginning: Pointcheval's Transform



Blind Okamoto-Schnorr. $O(\log(\kappa))$-OMUF

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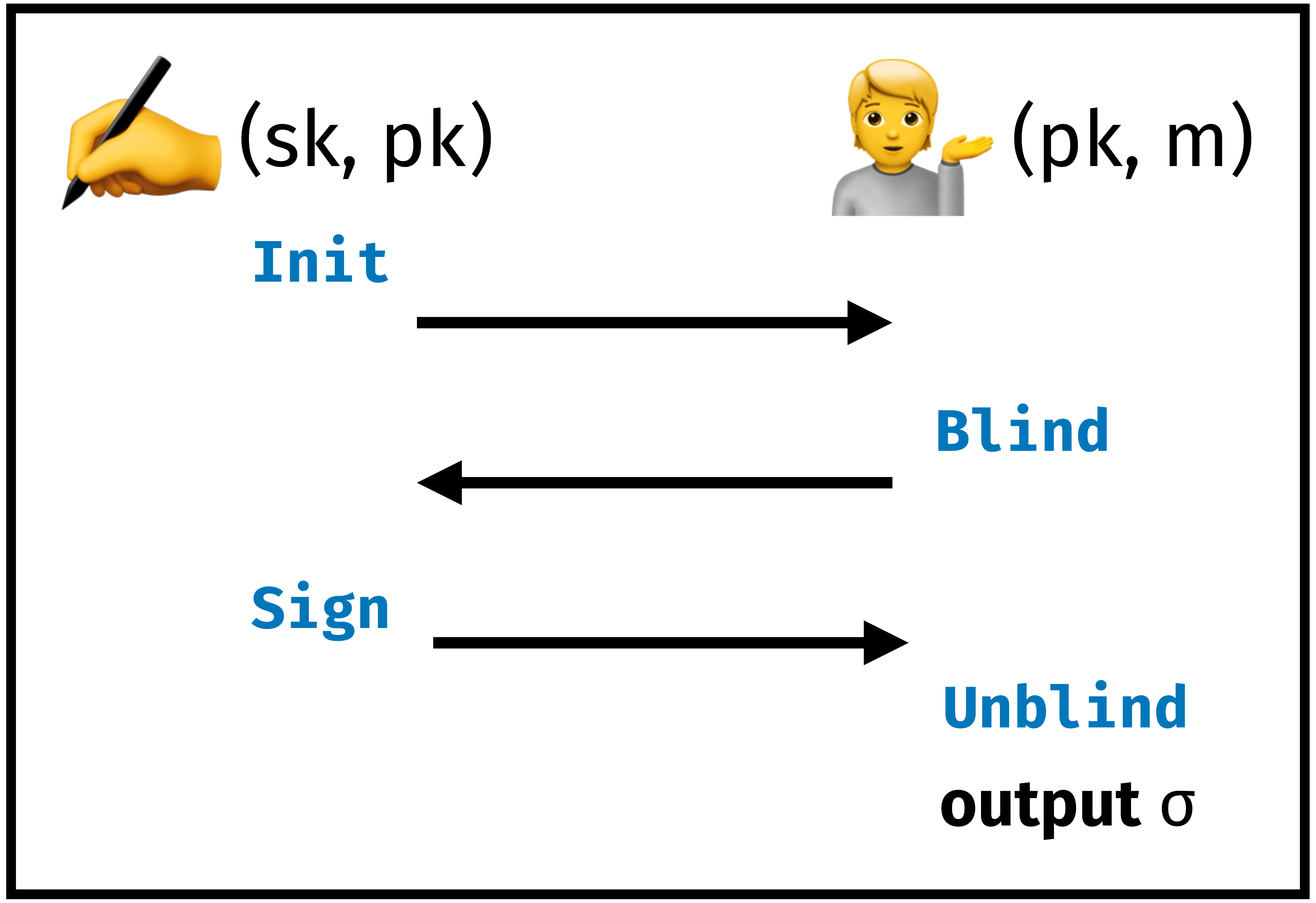

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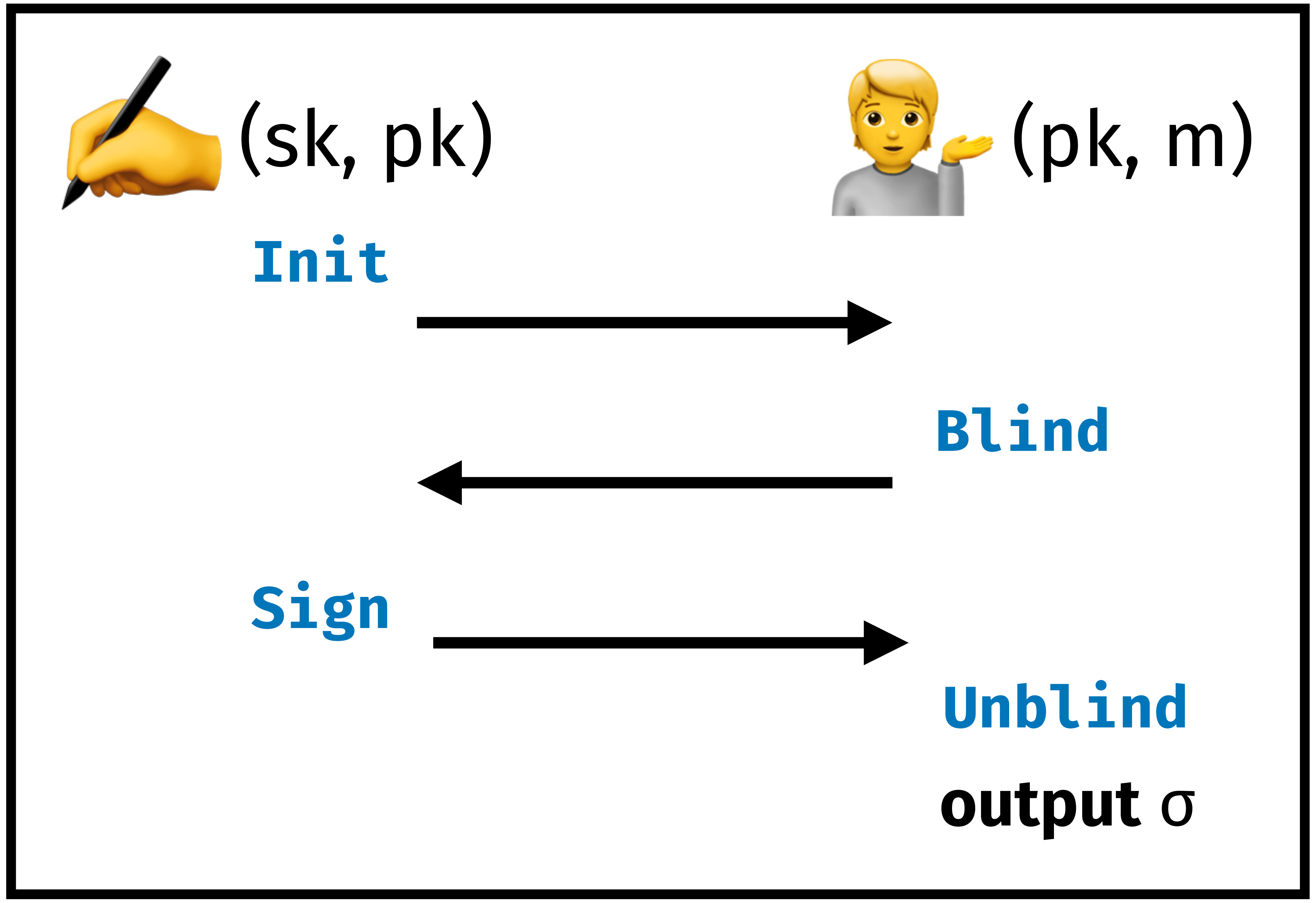

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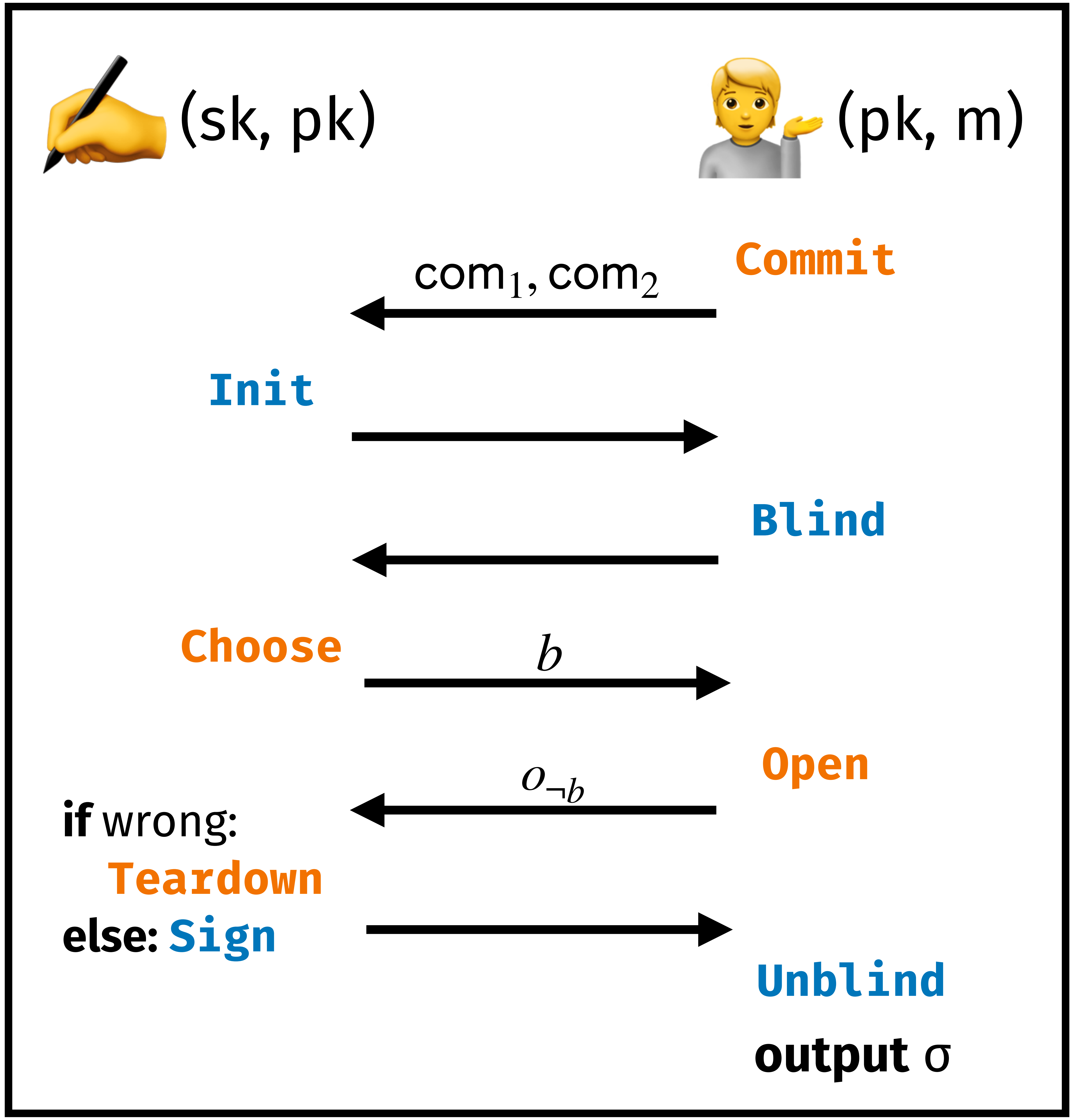

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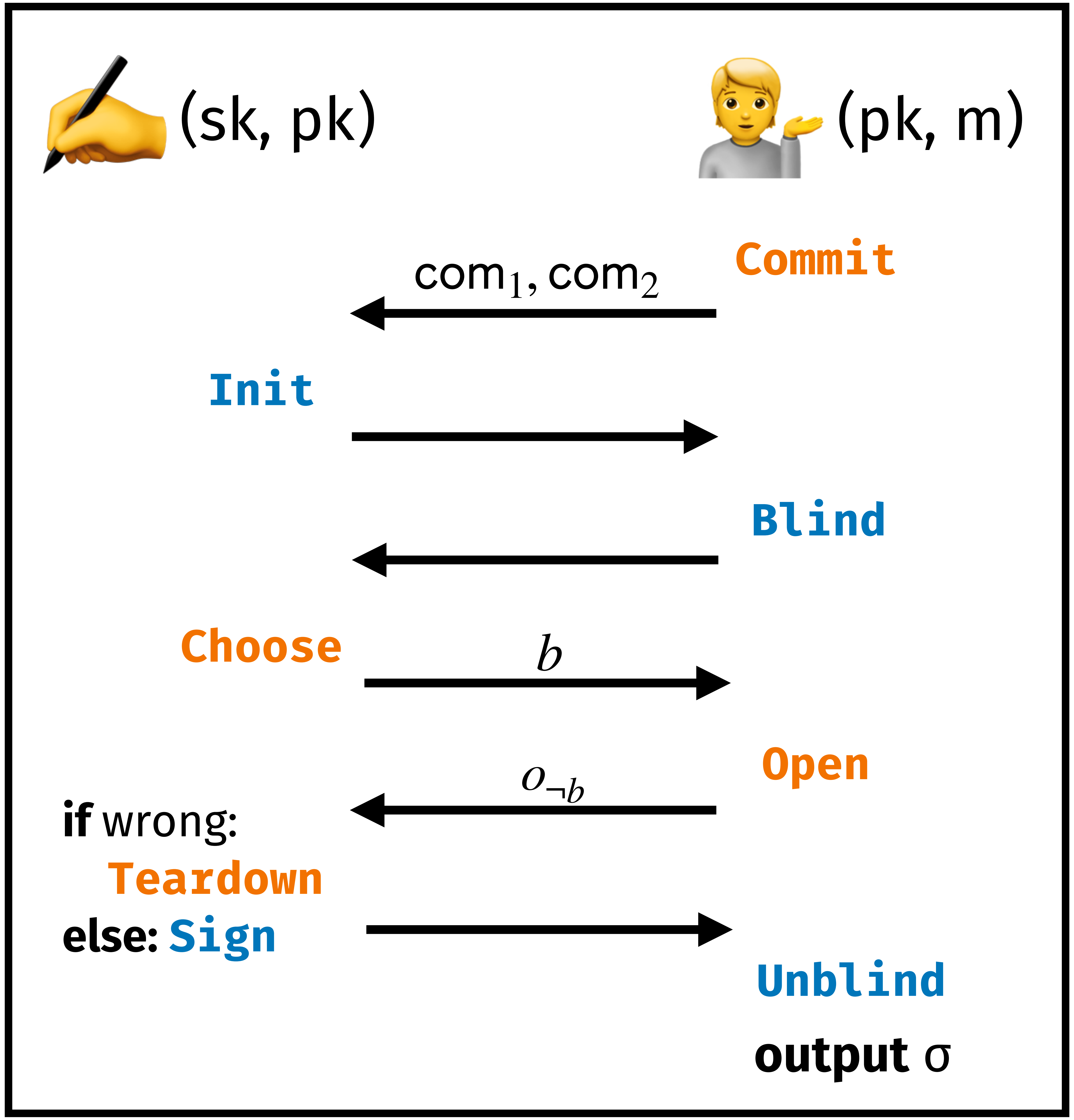

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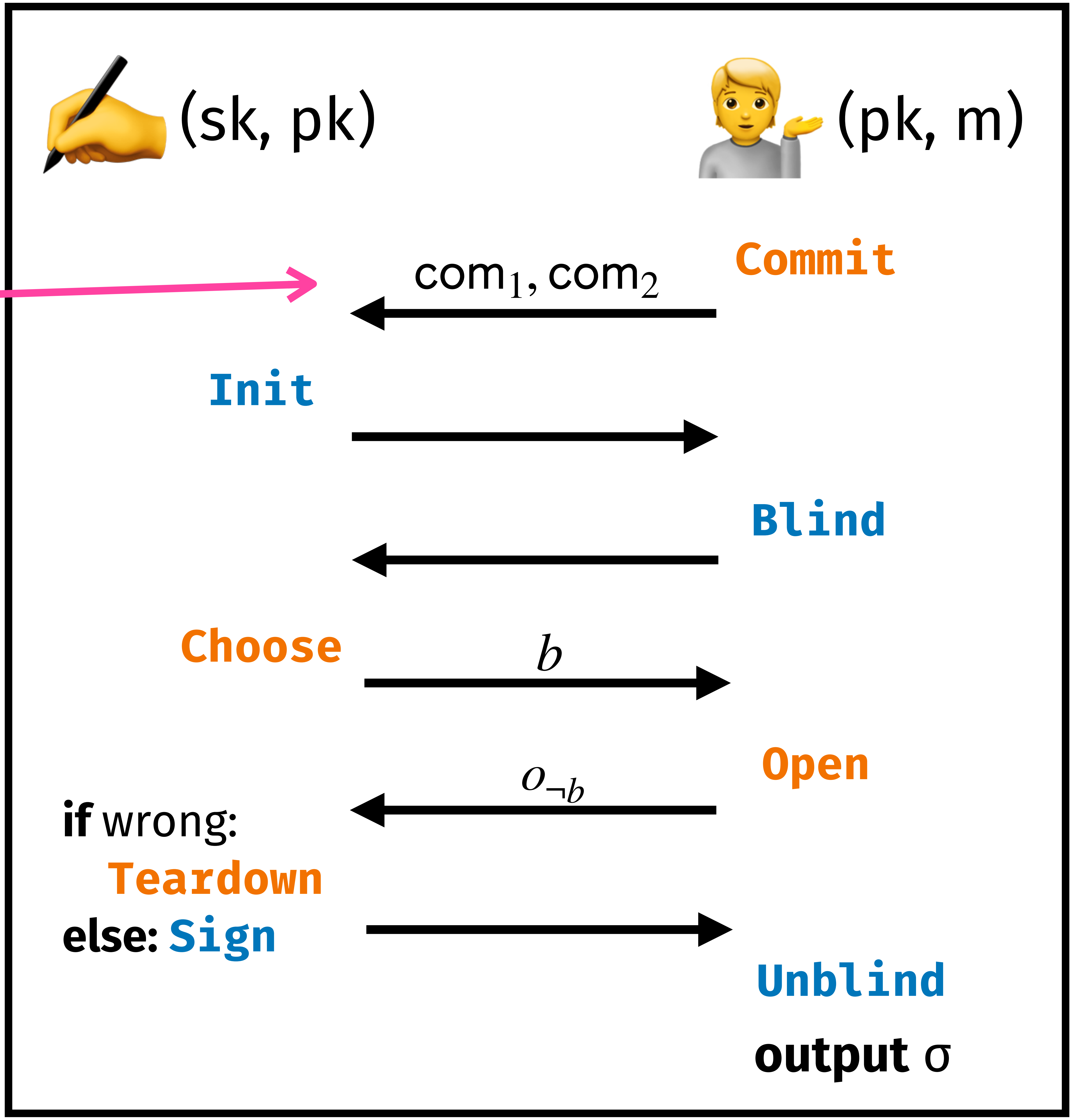

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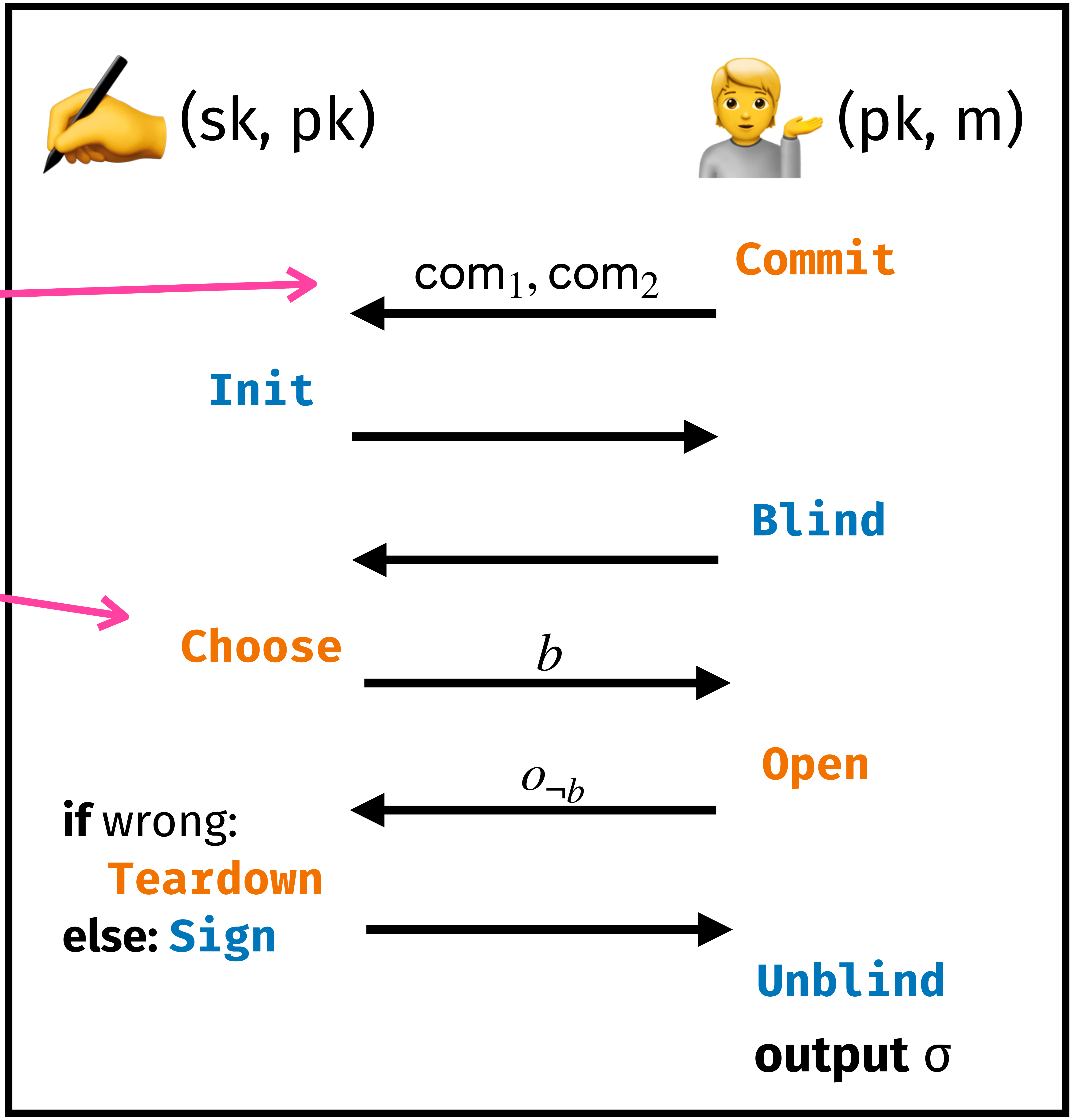

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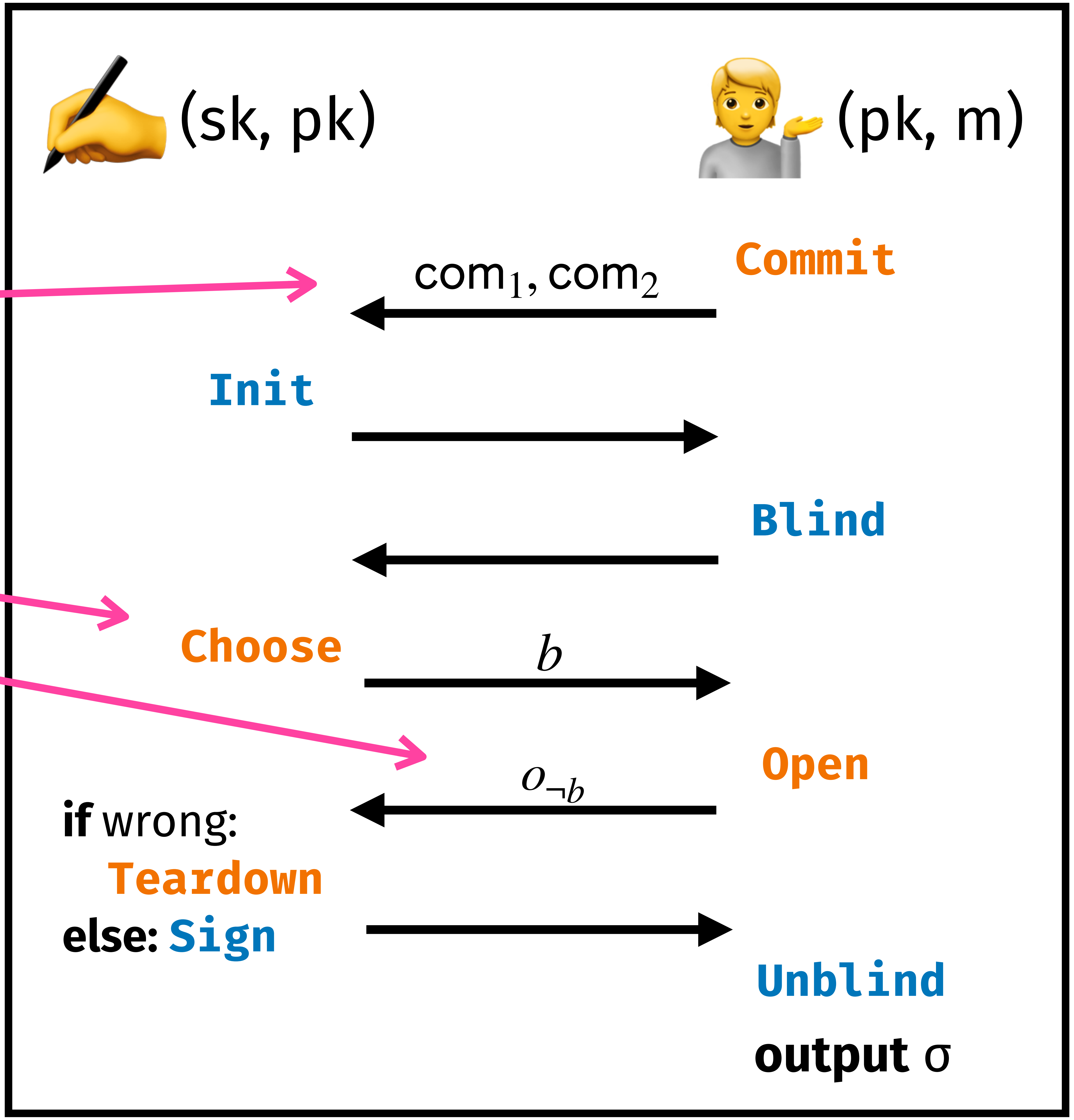

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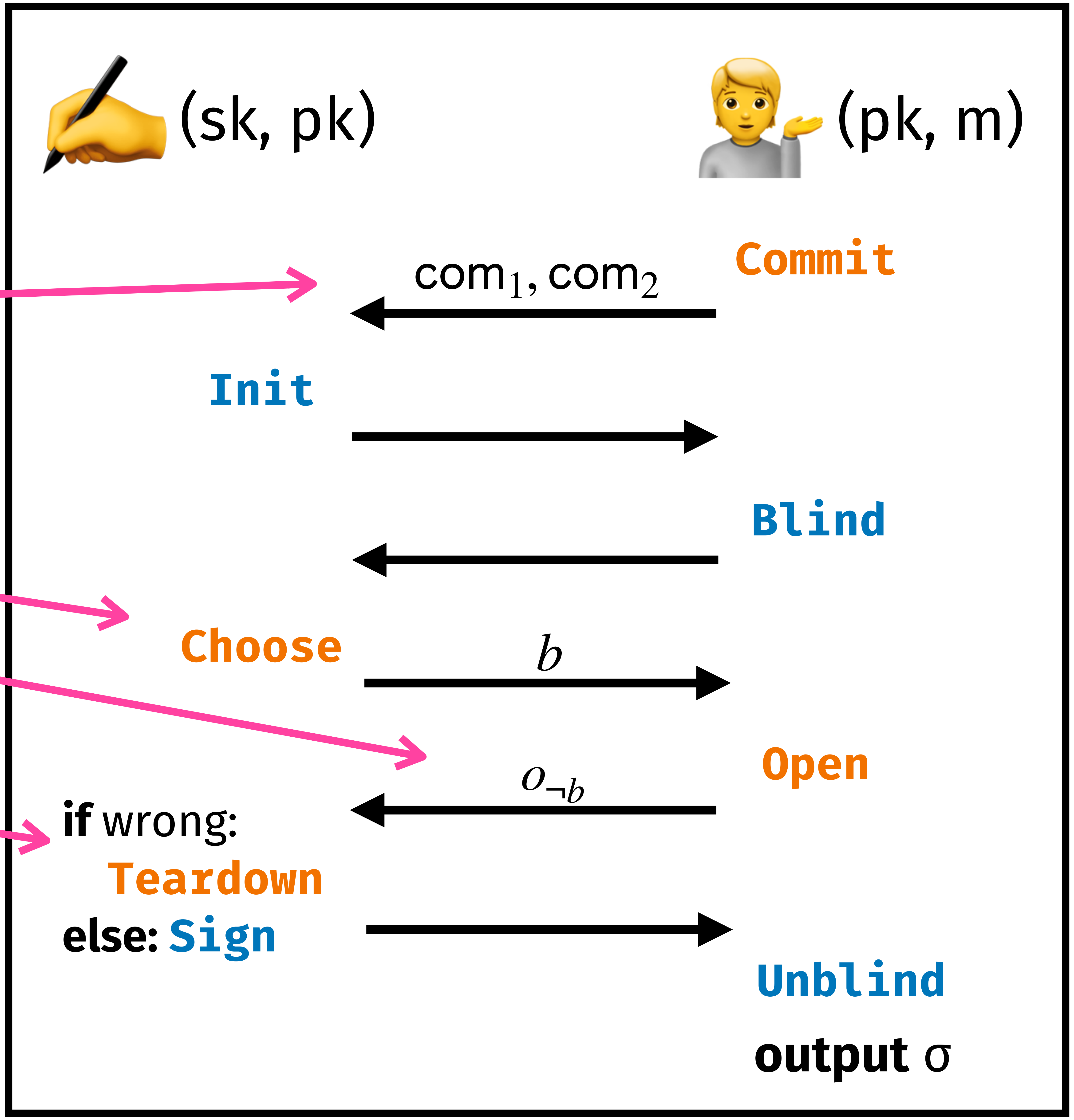
Signer checks the opening

- **Success:** sign
- **Failure:** abort and **refuse to sign anything in the future**



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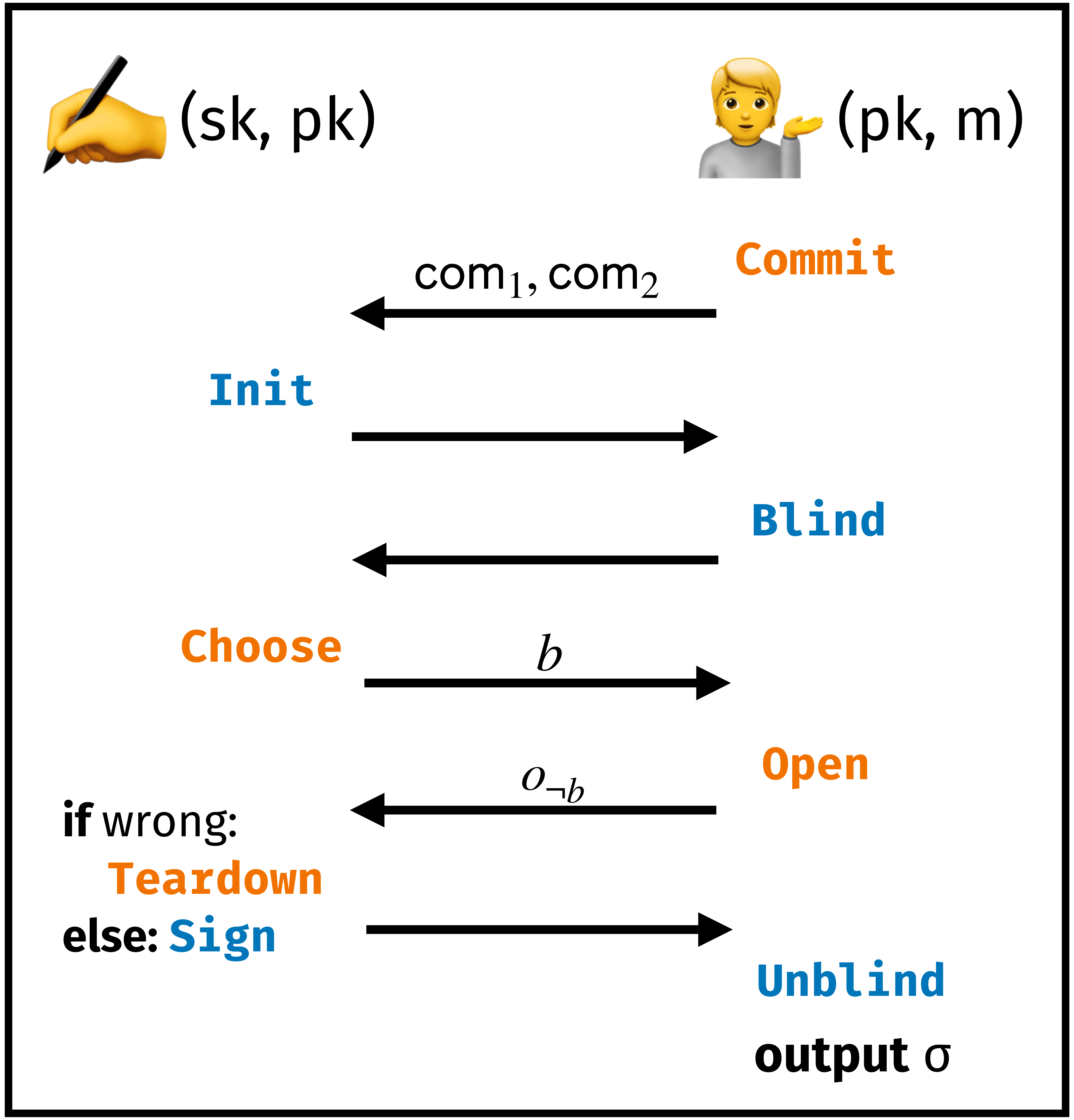

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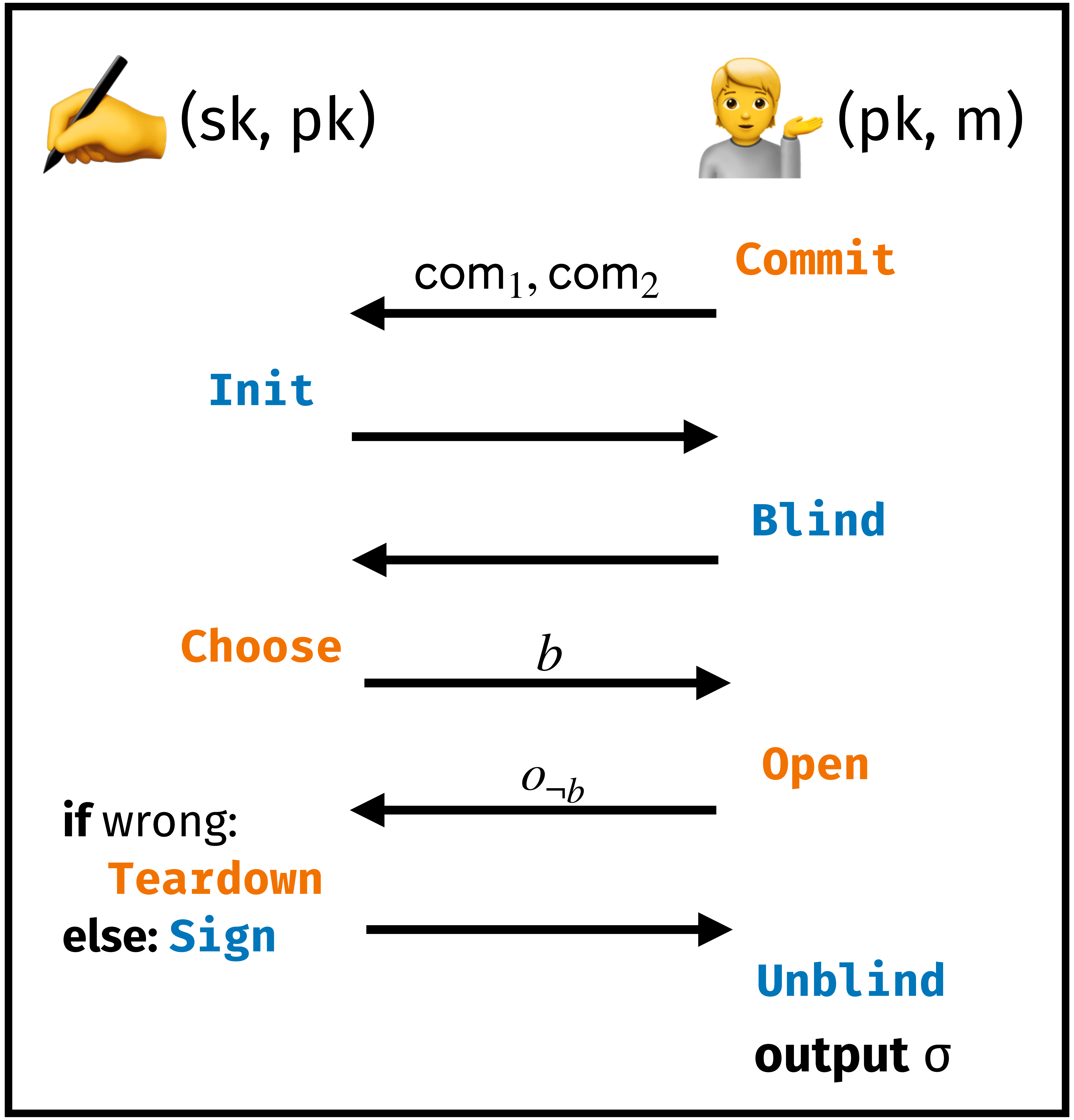

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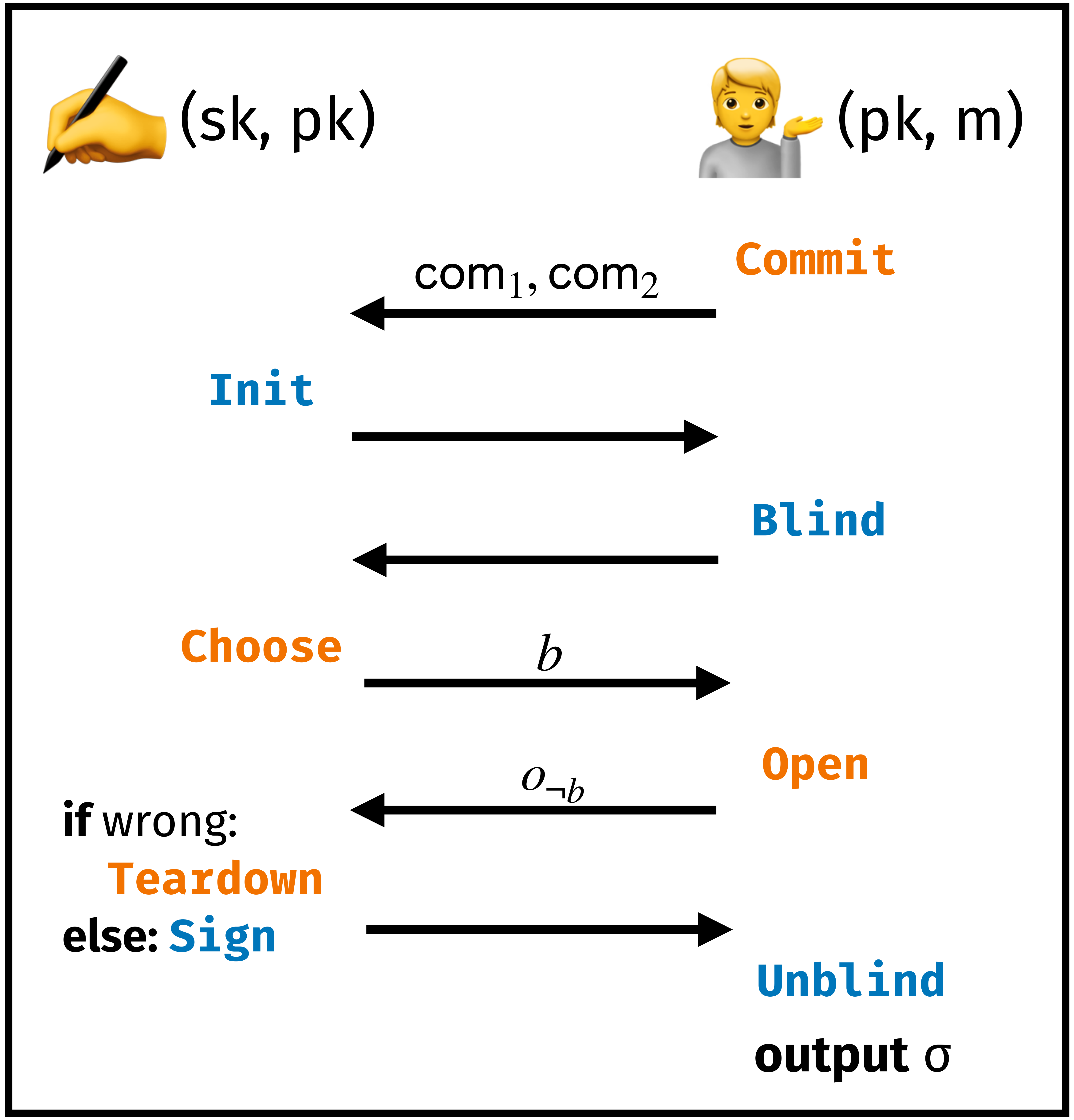

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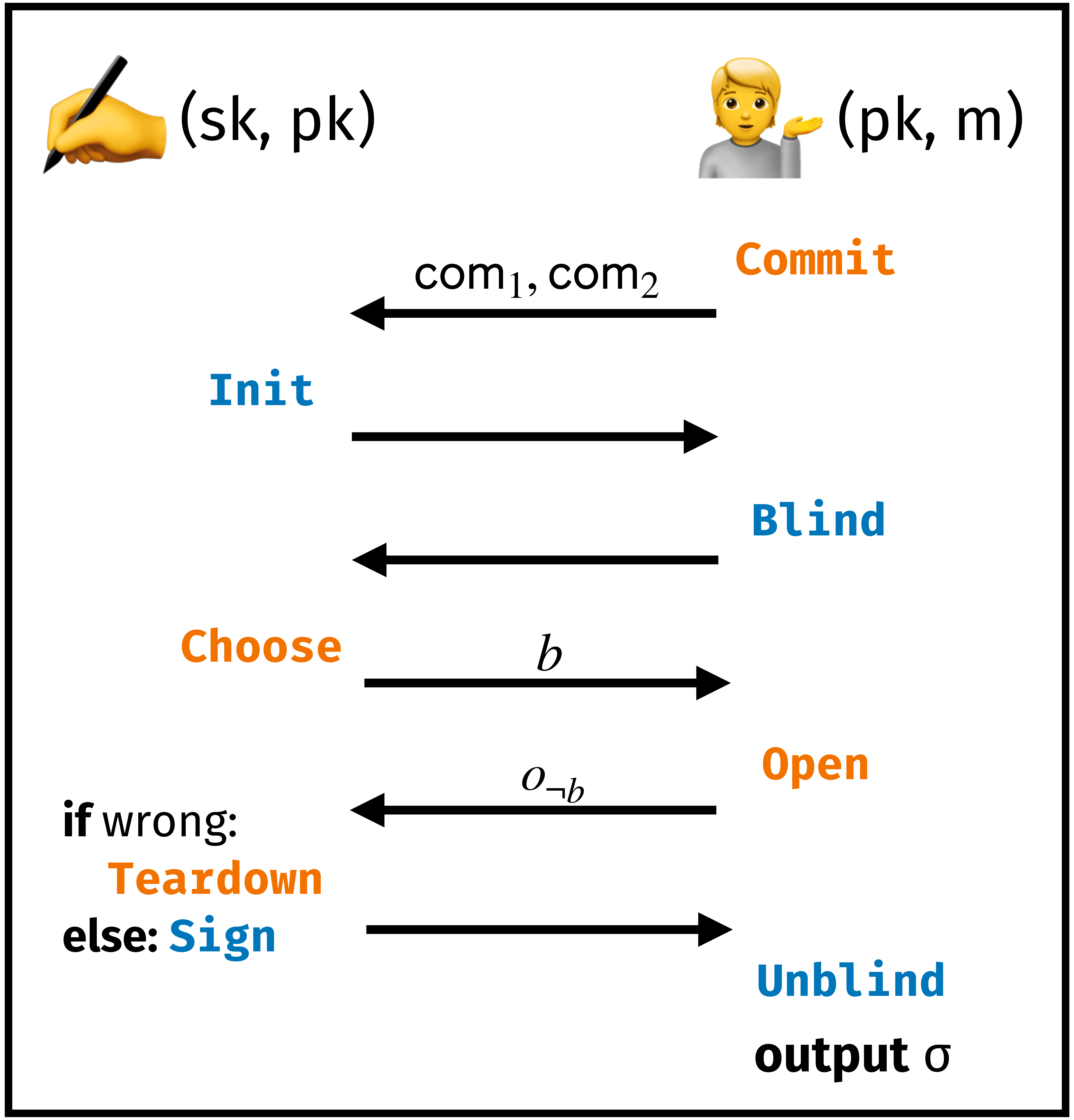

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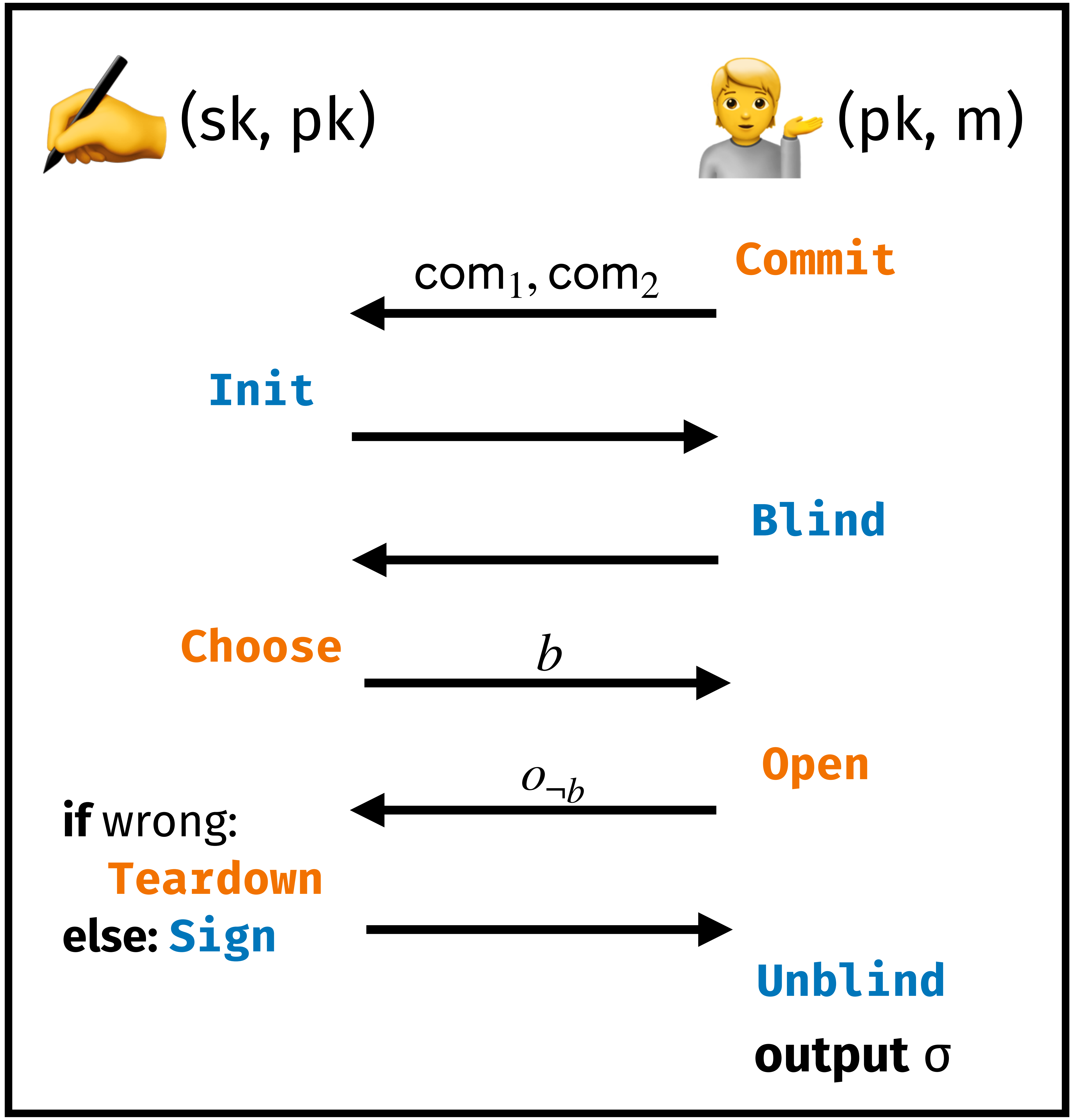
Cut and choose: make two commitments, and later open one at random: $\Pr[\text{cheat}] = 1/2$



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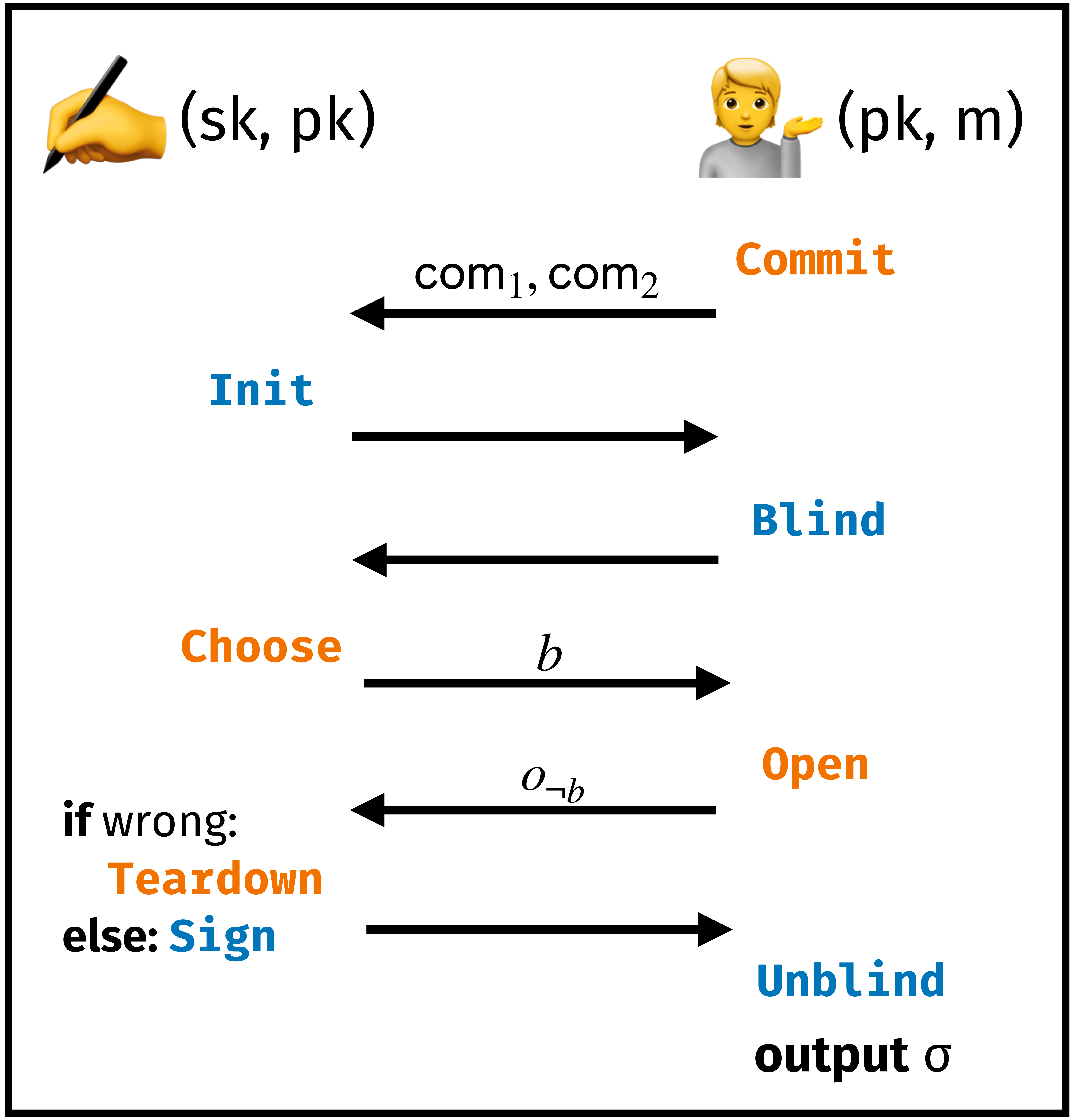

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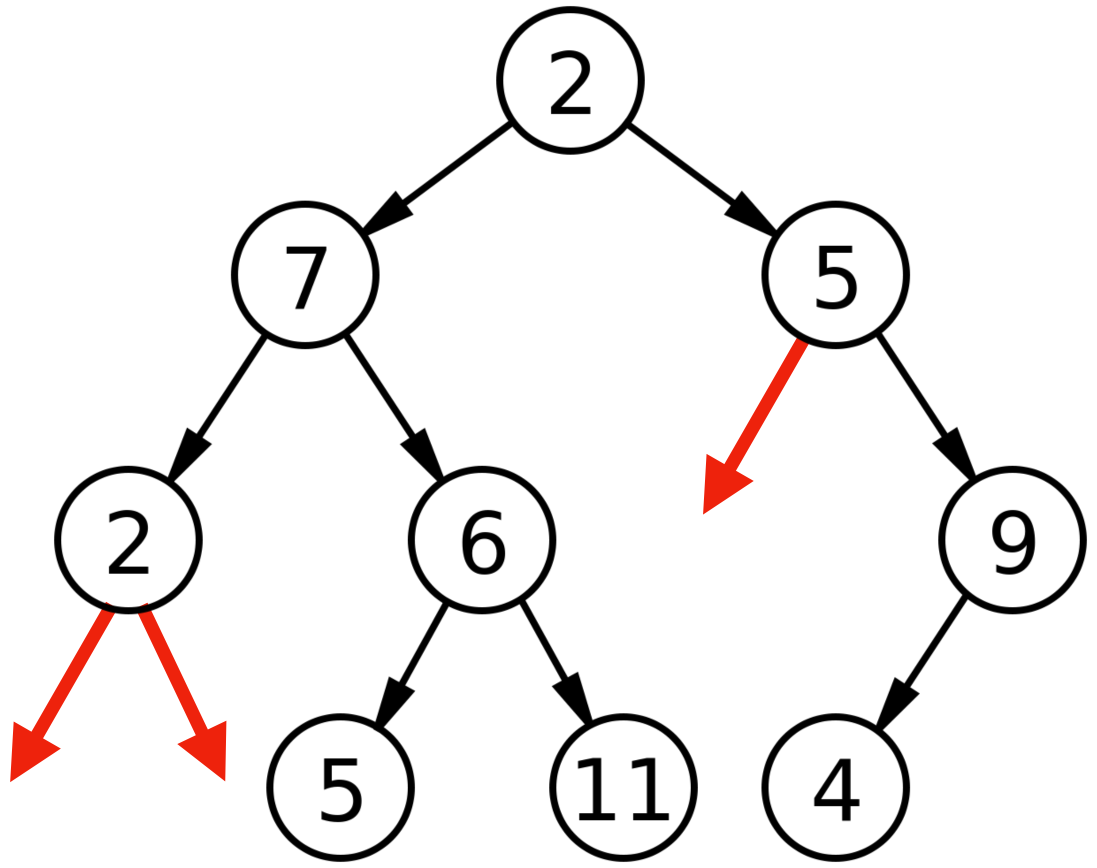

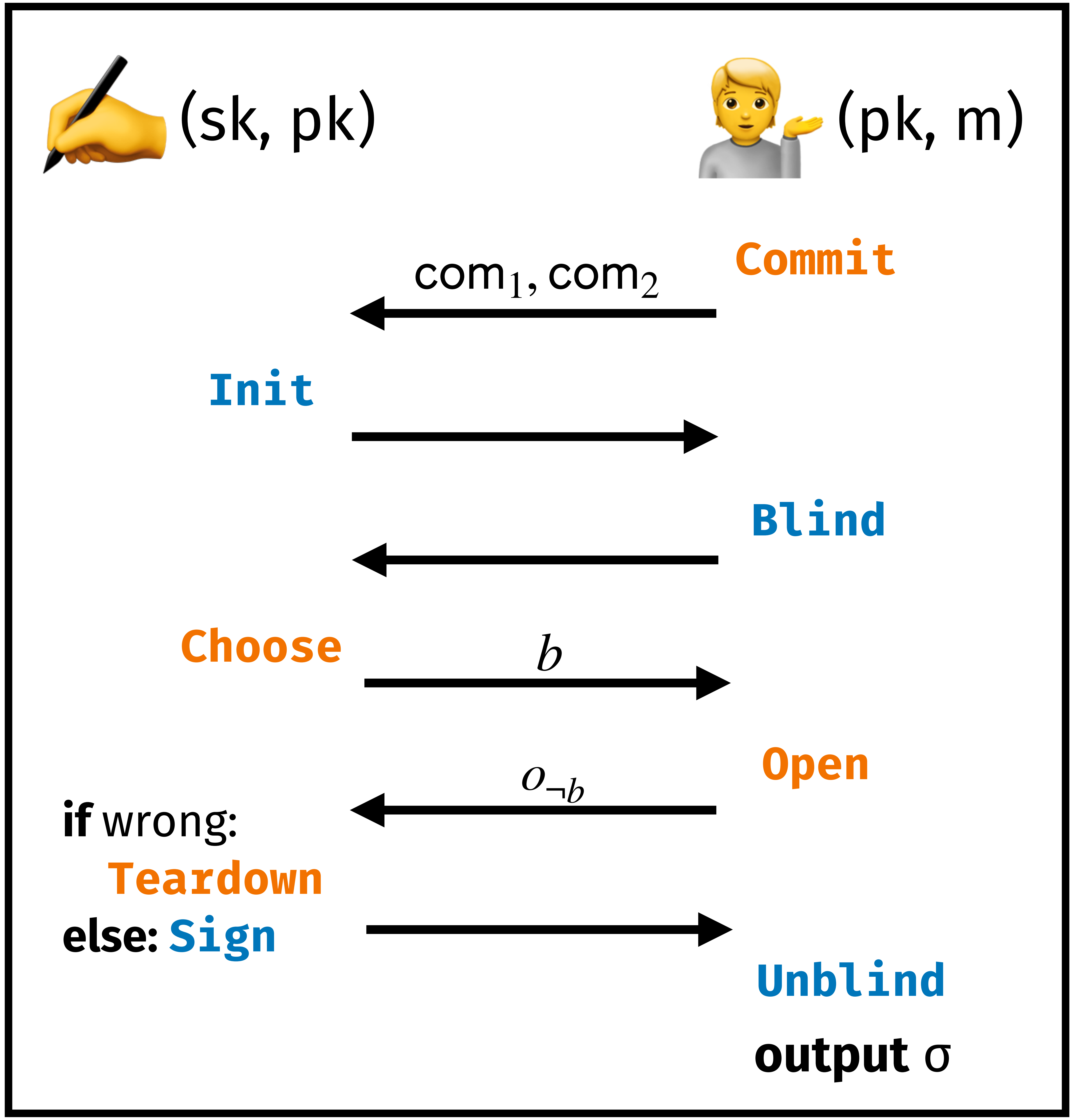

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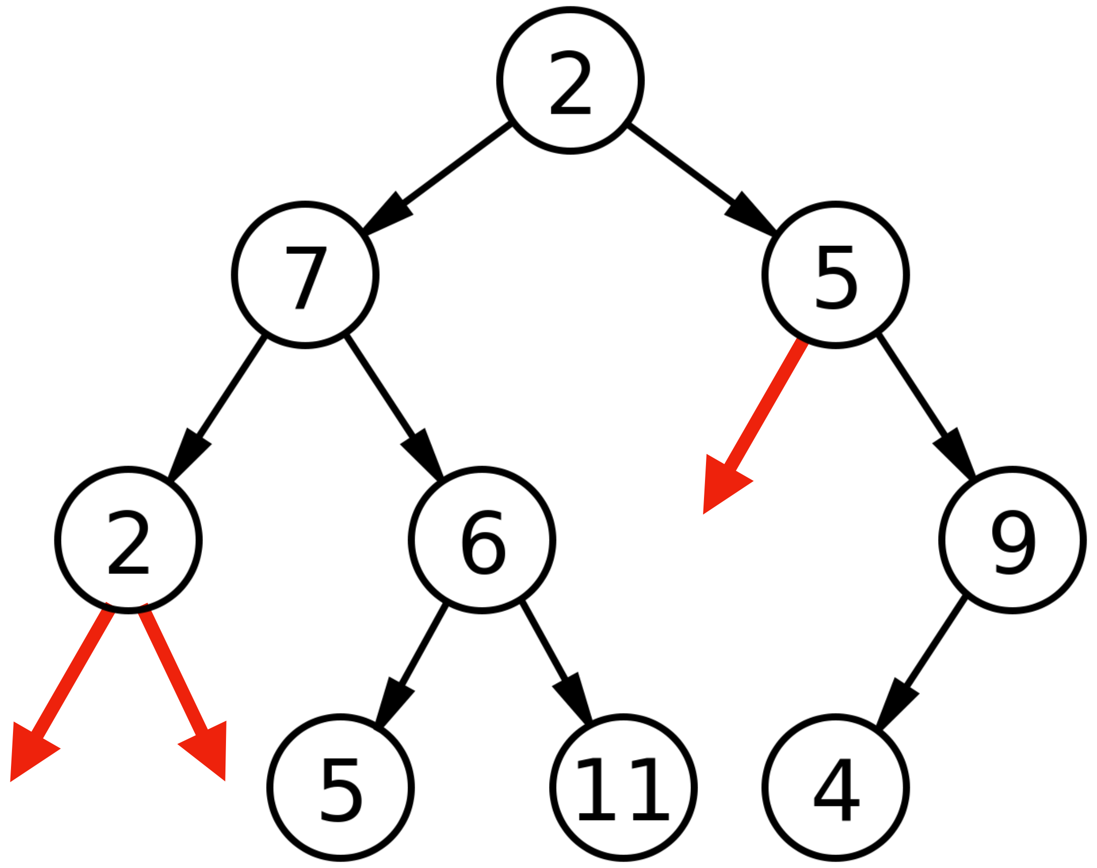

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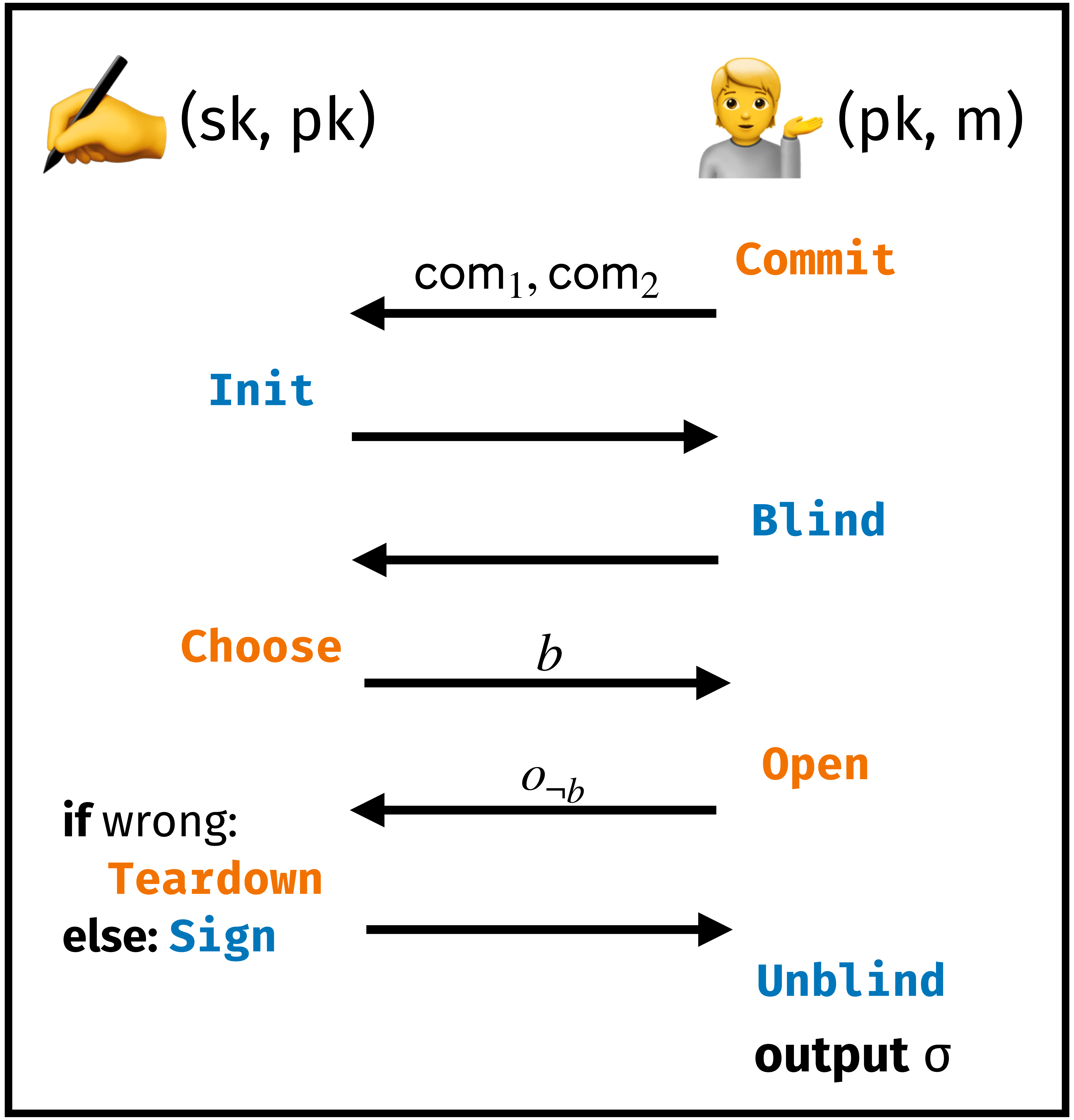

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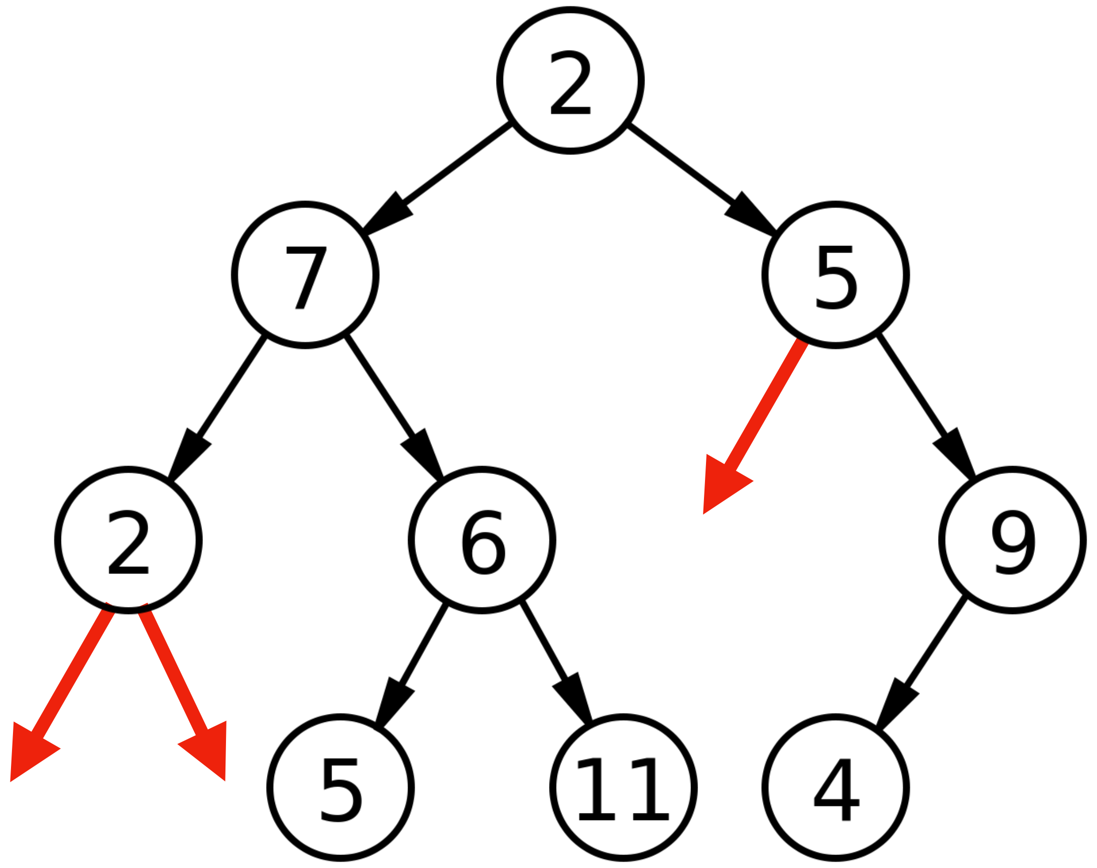

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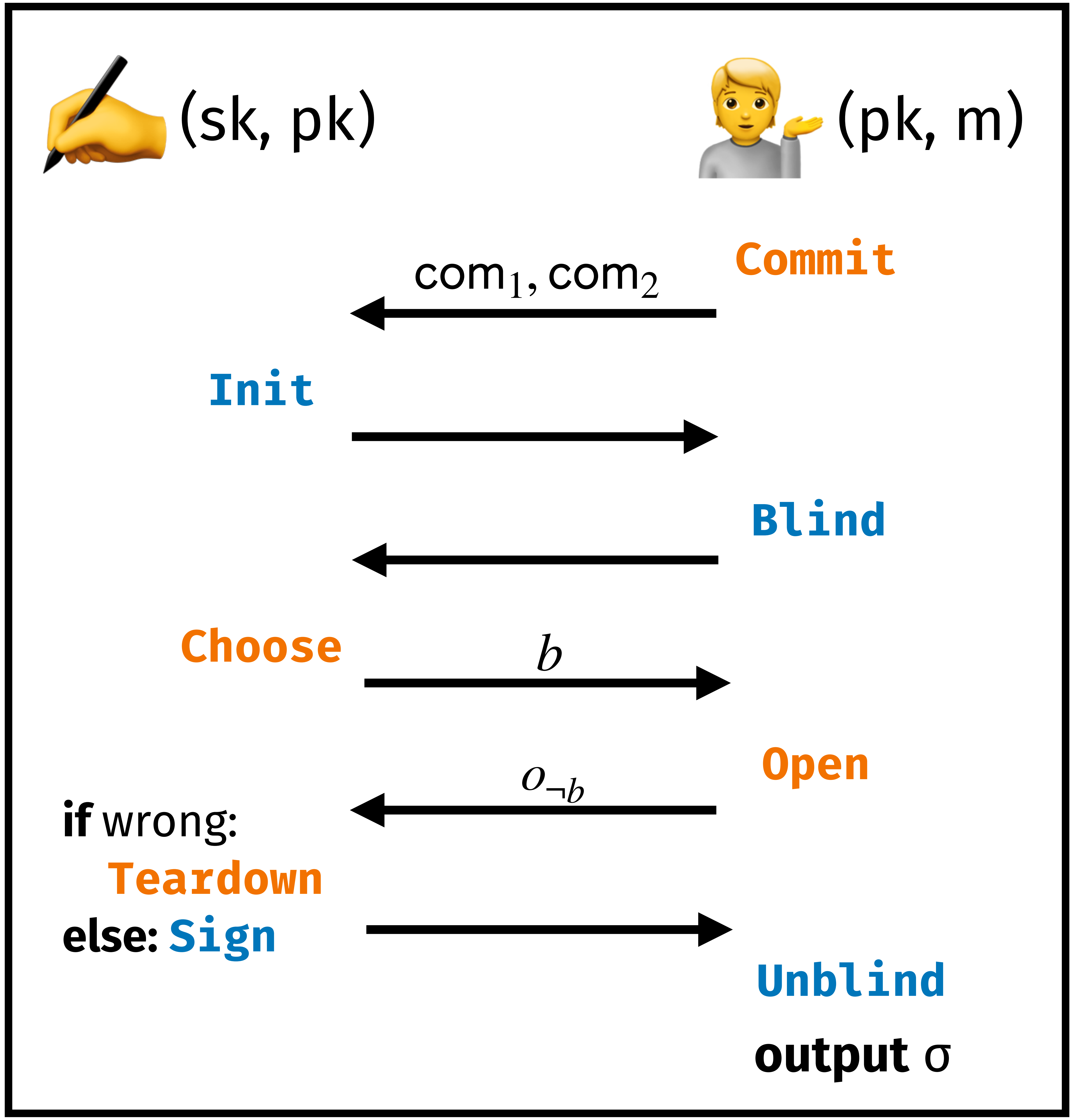

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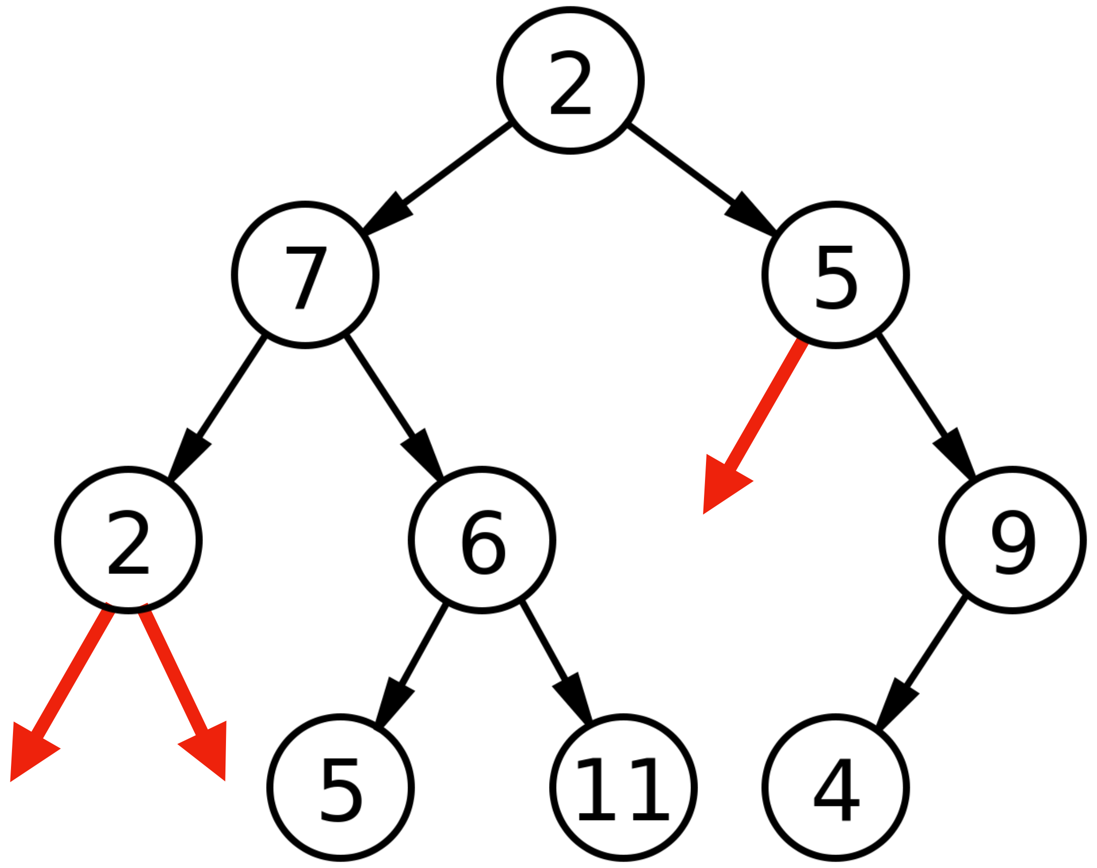

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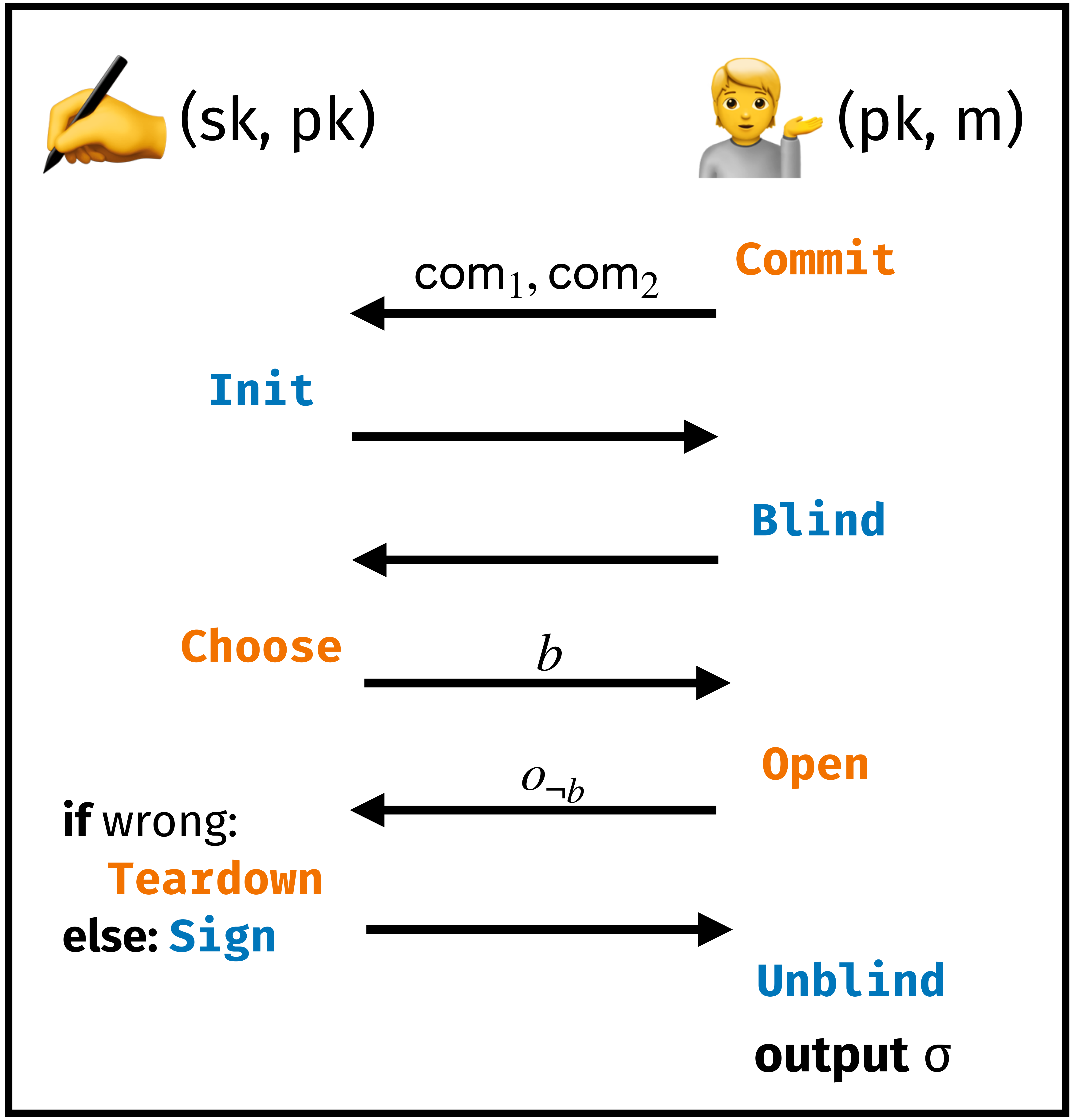

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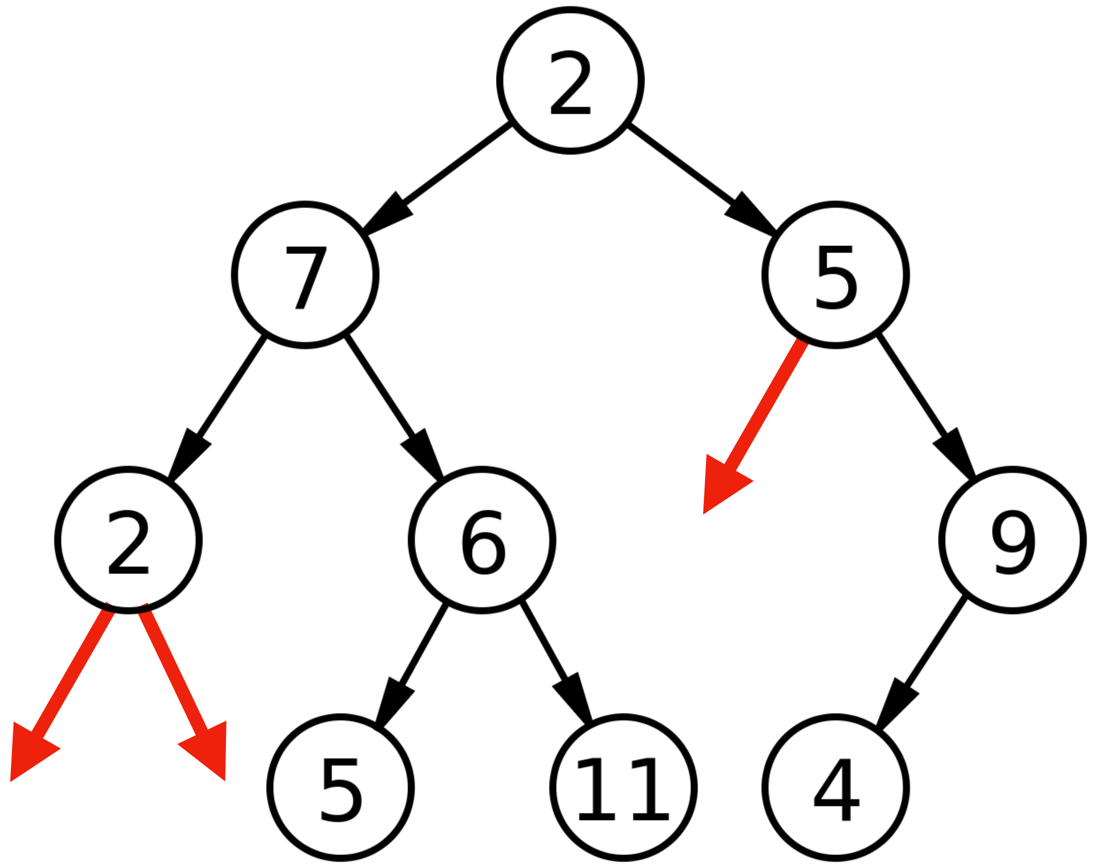

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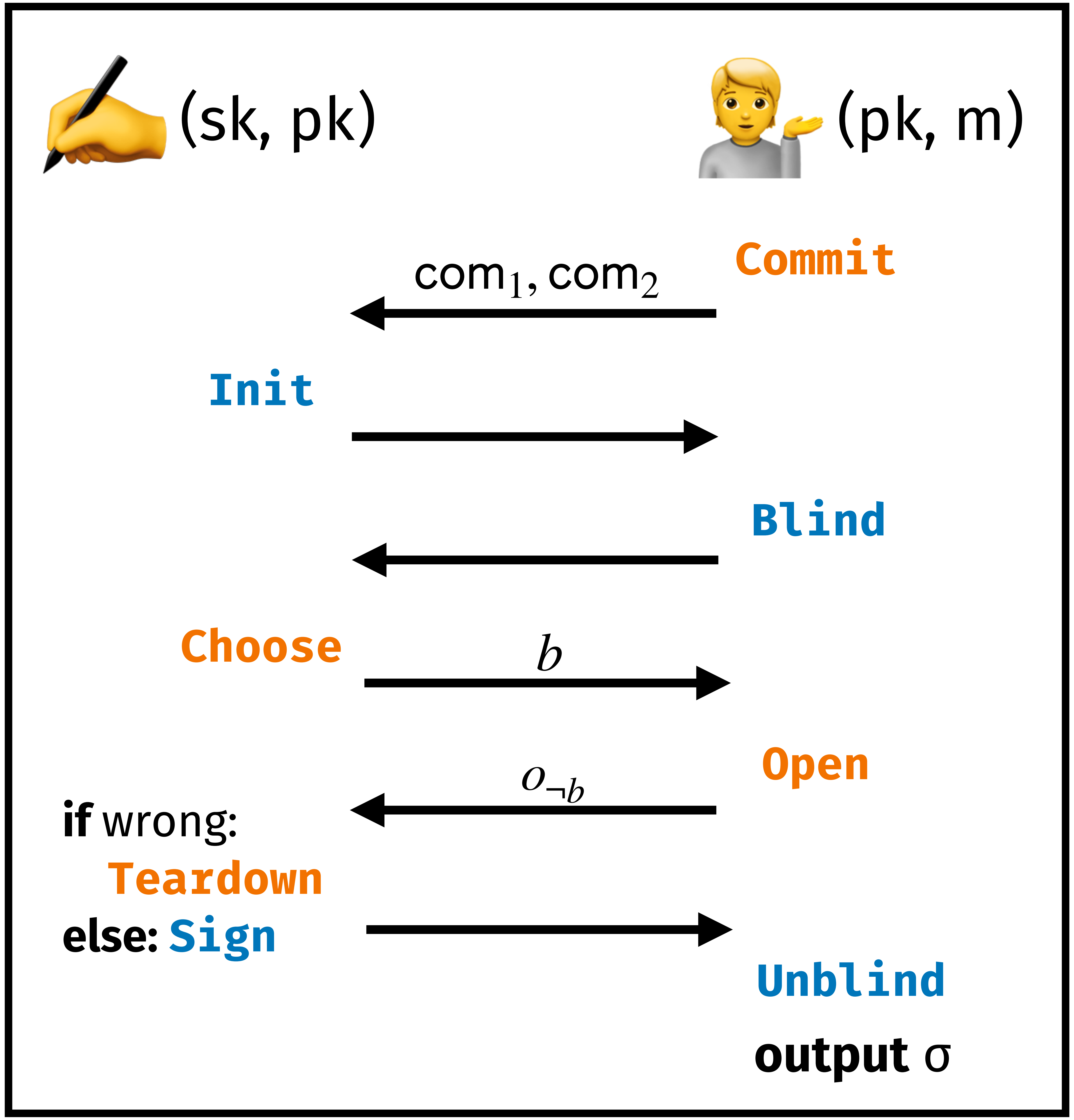

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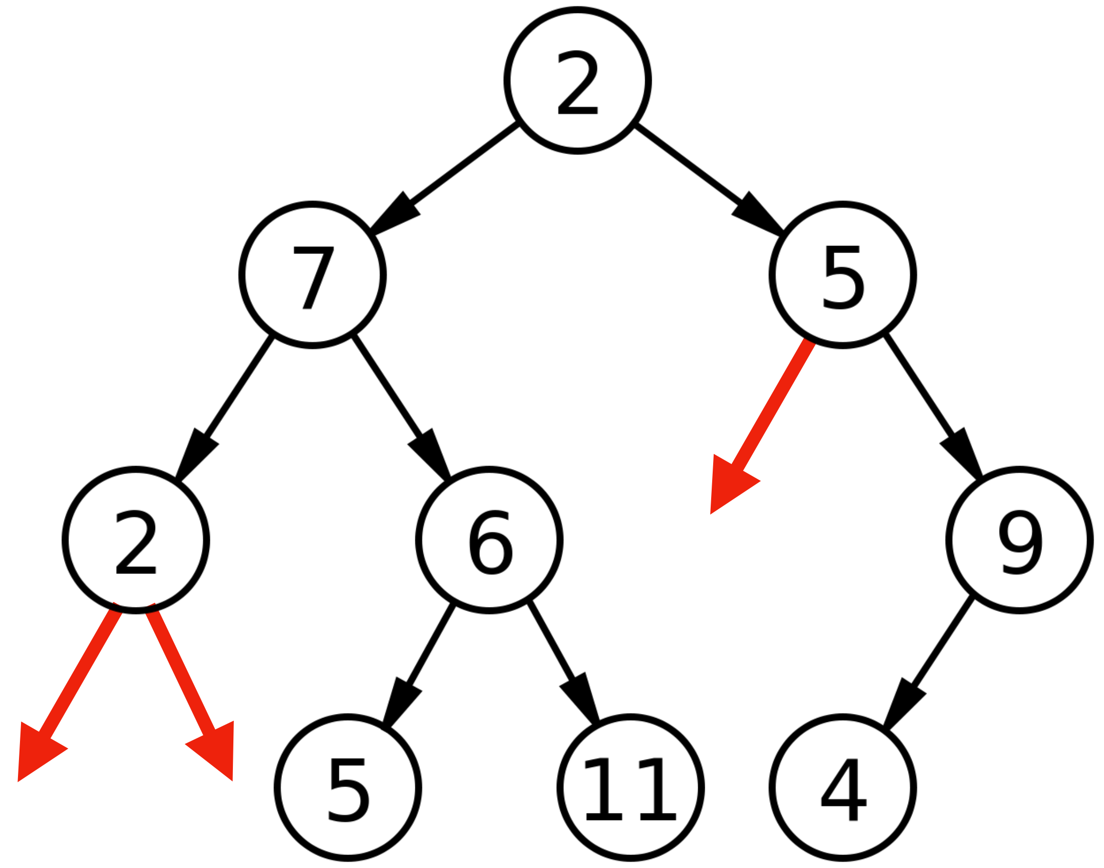

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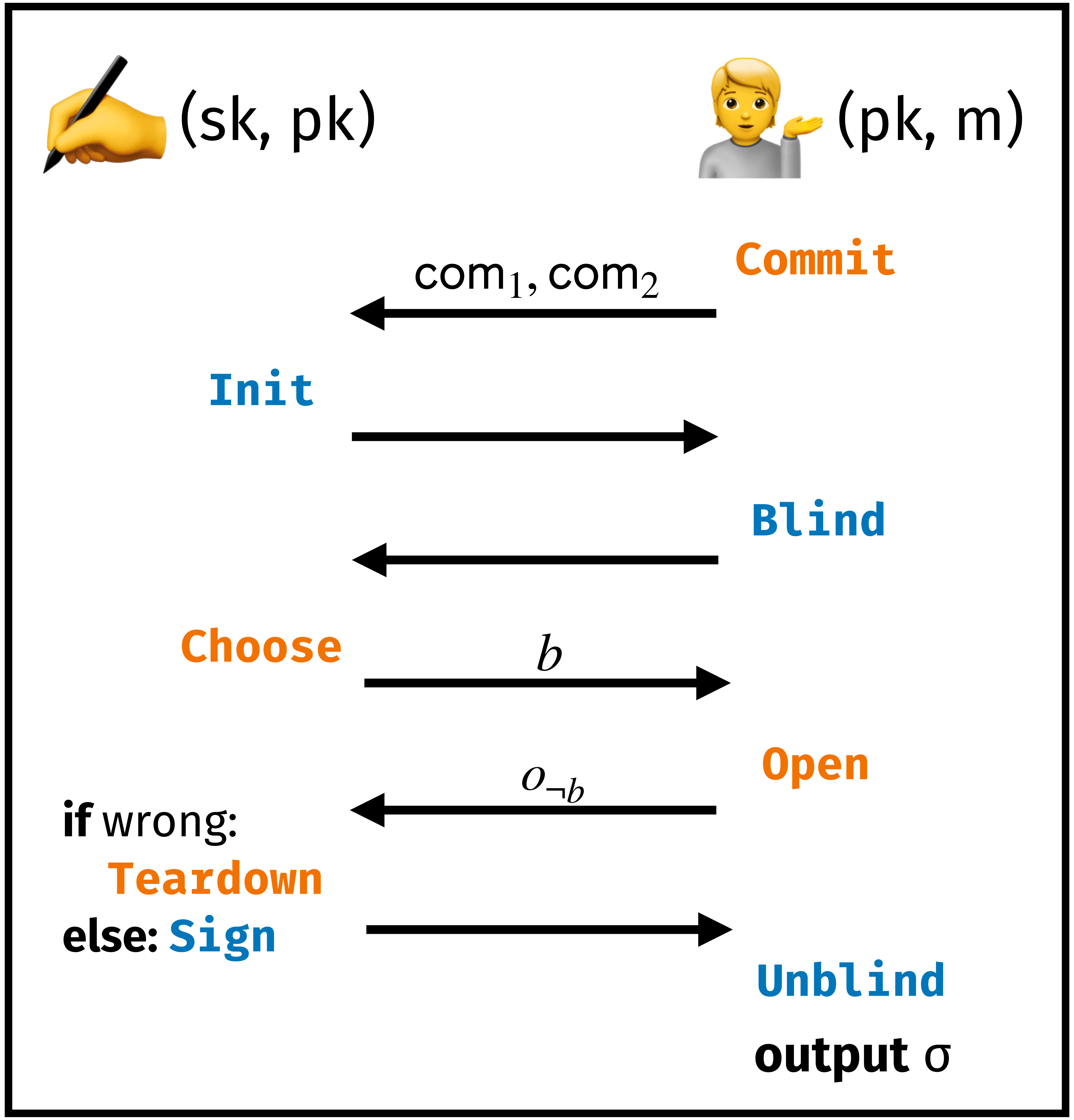

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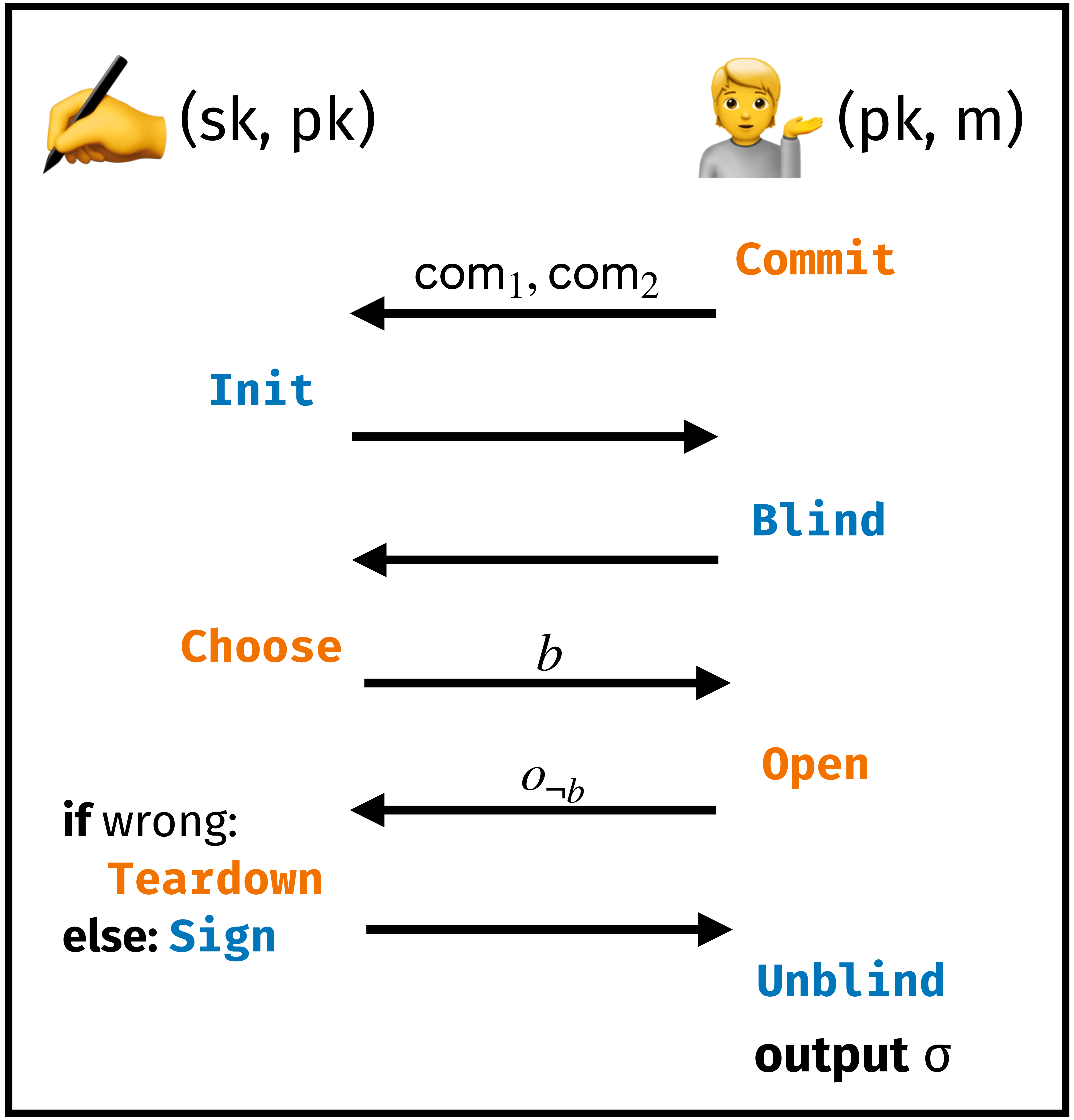

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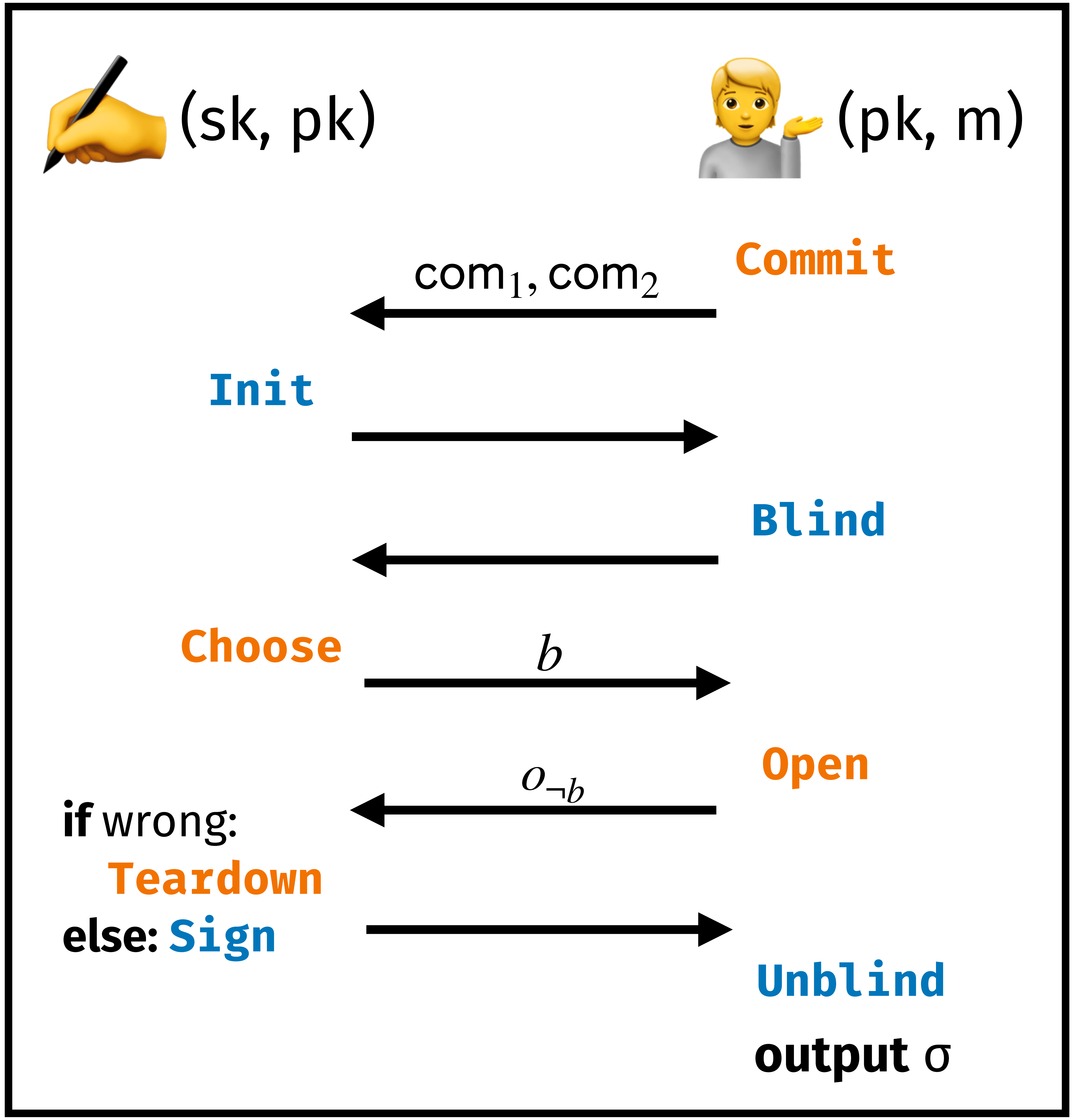
Protocol depends on how many sessions have begun



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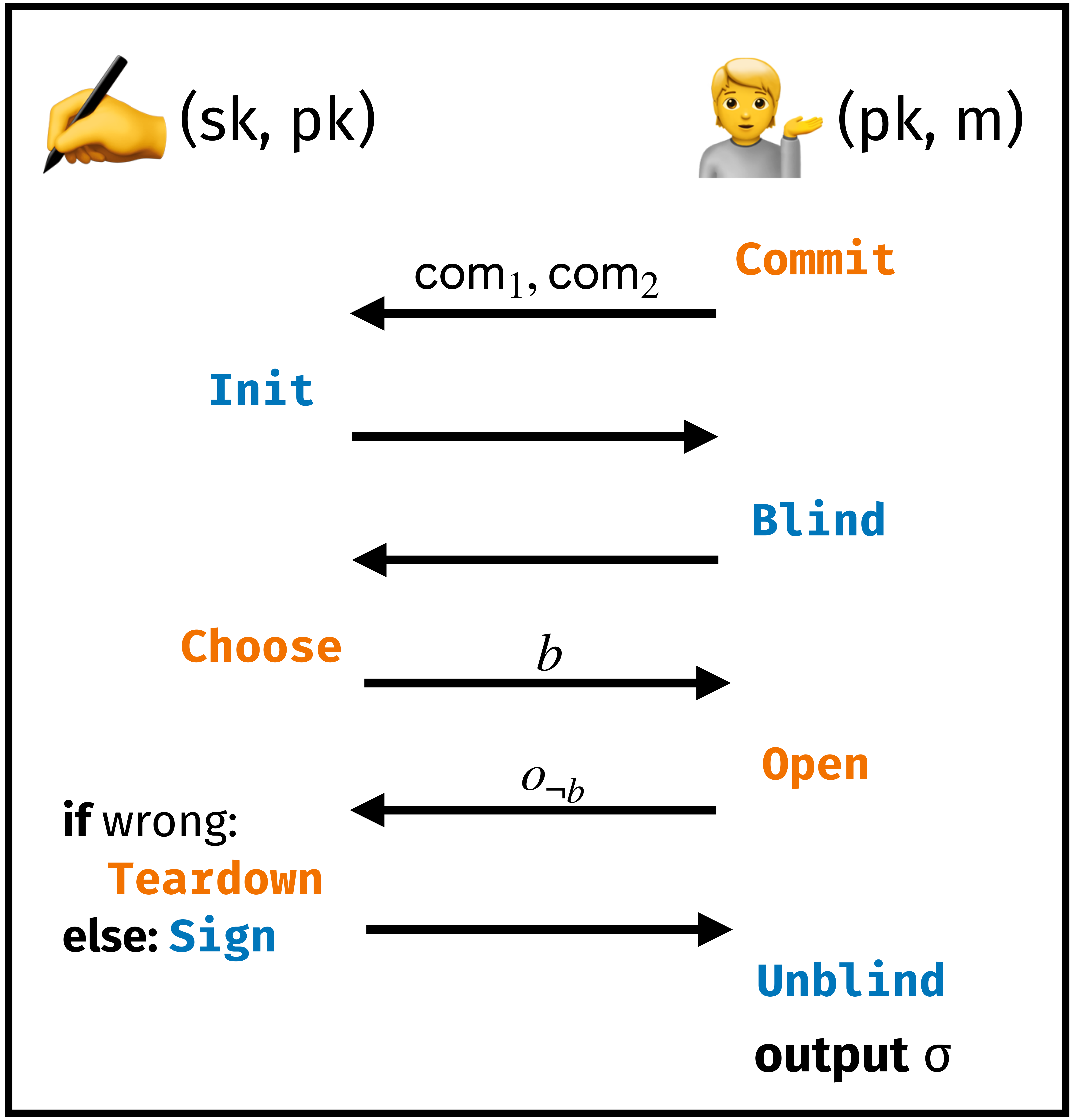

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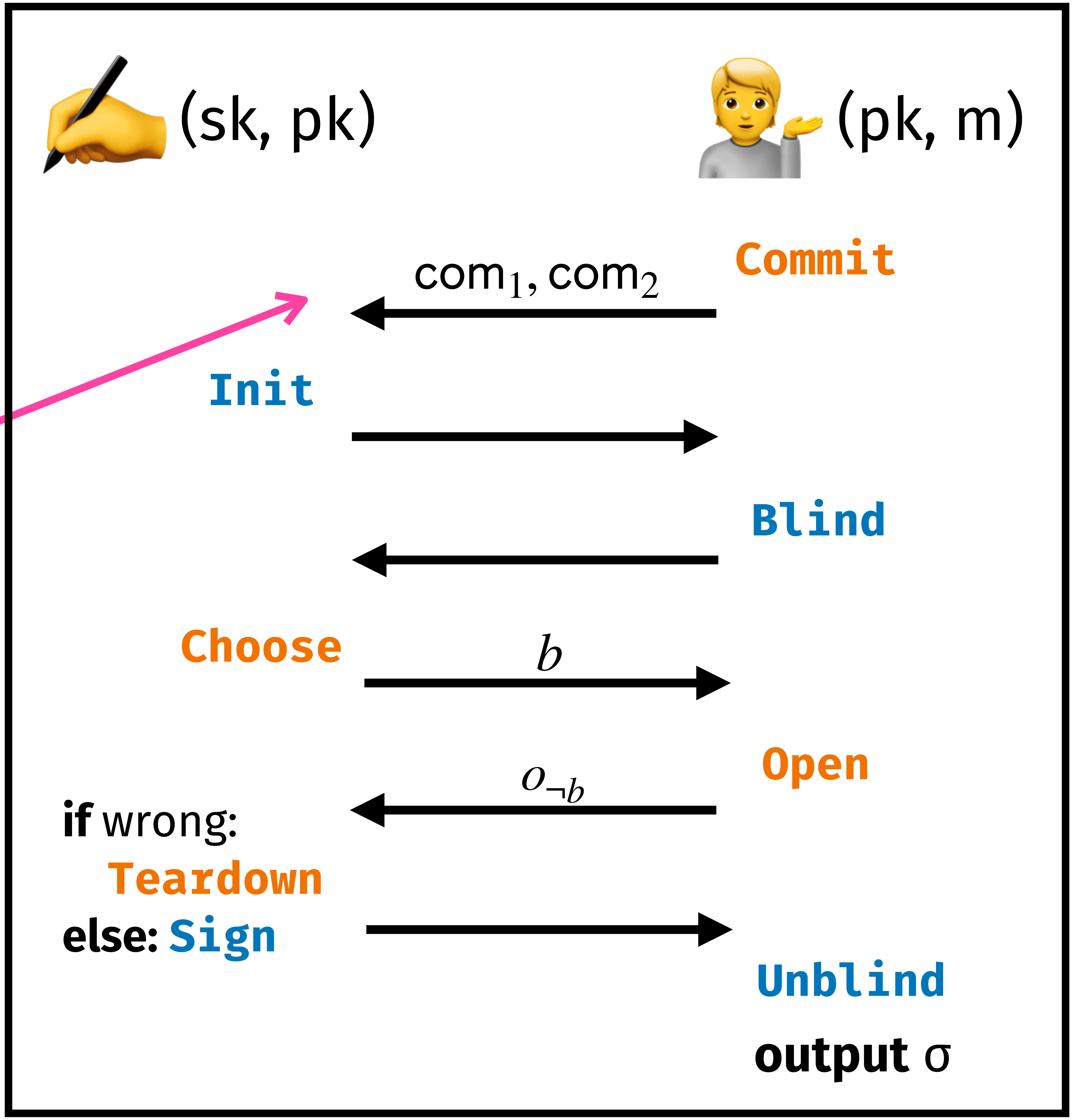

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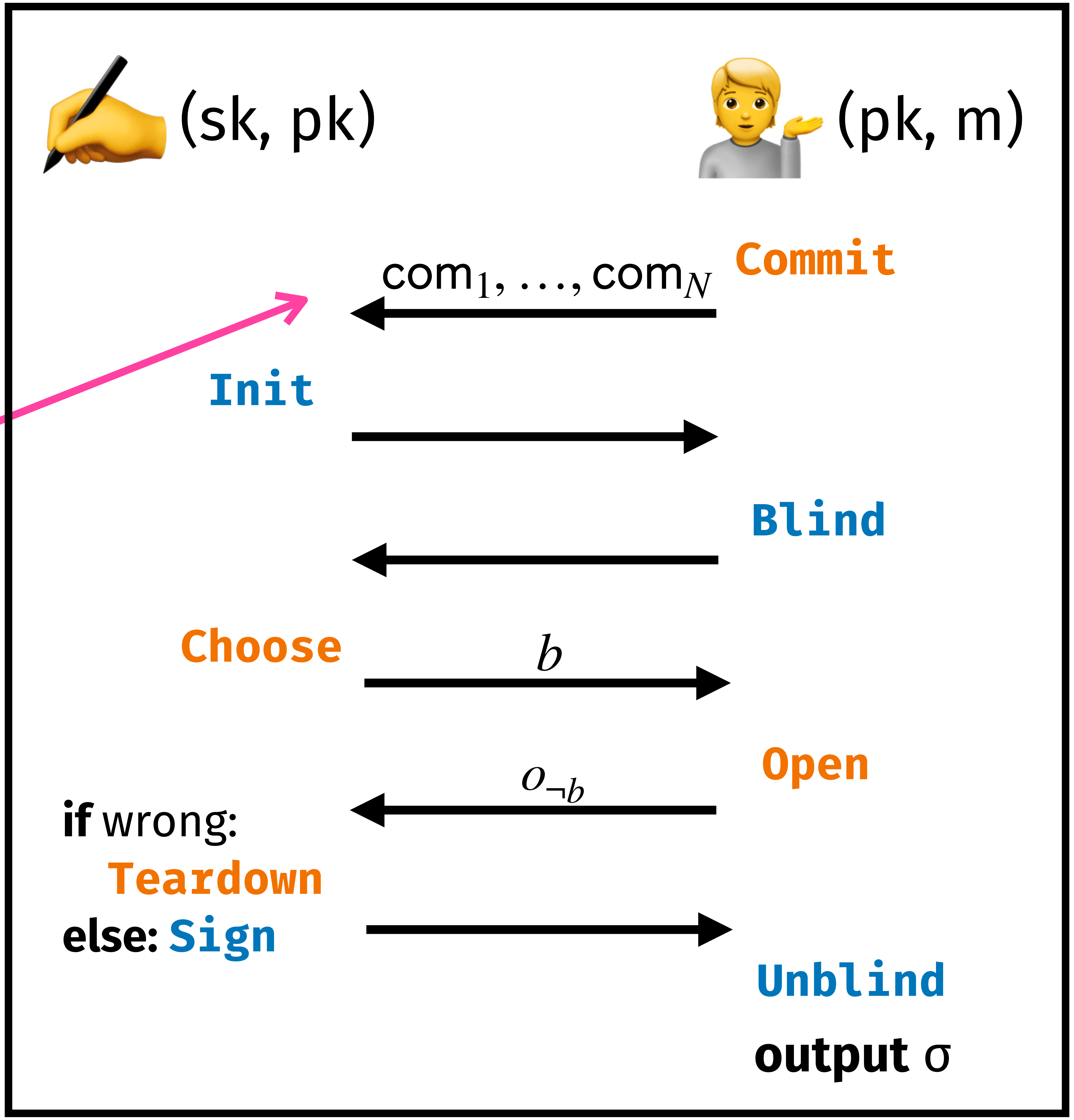

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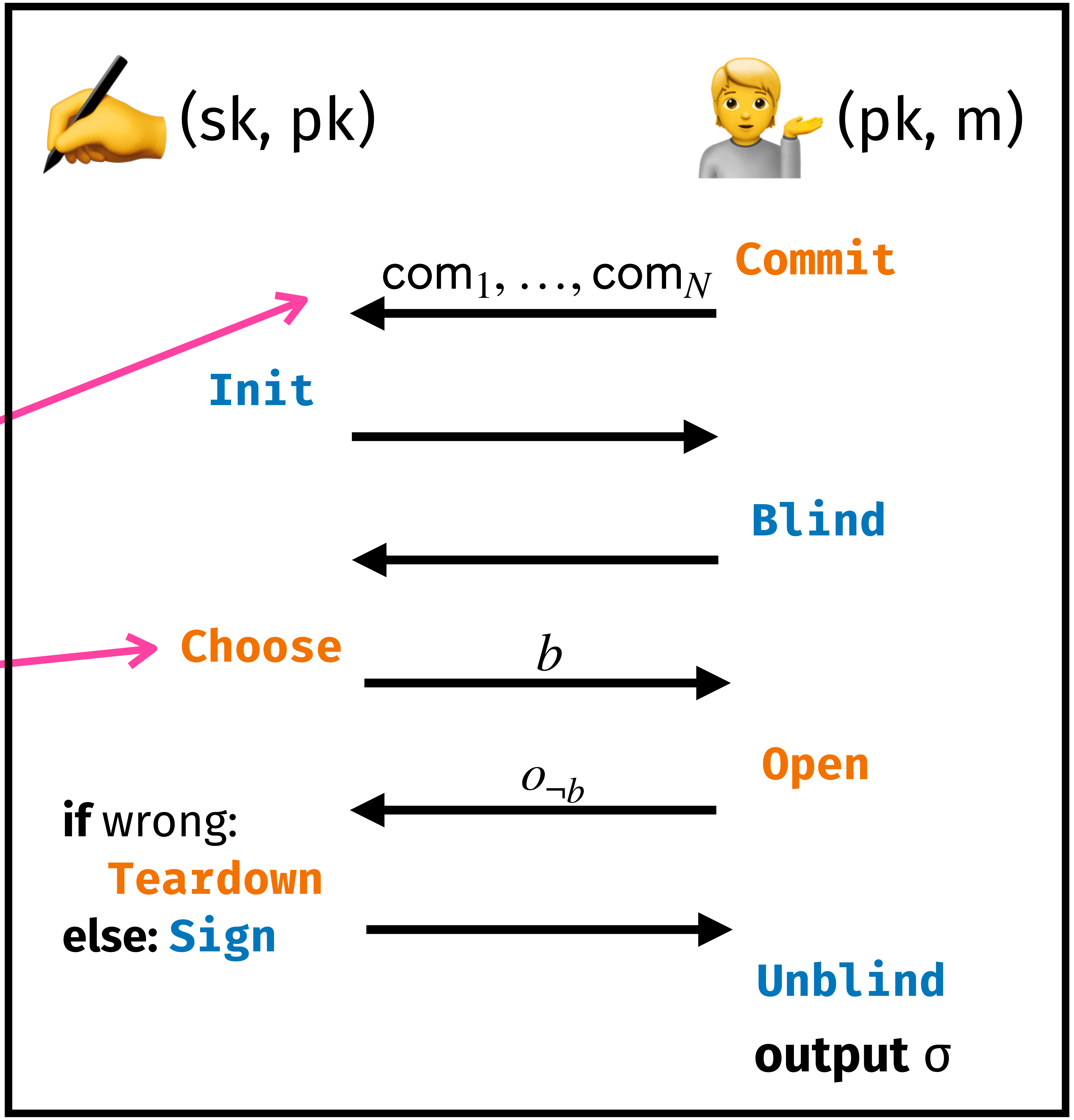

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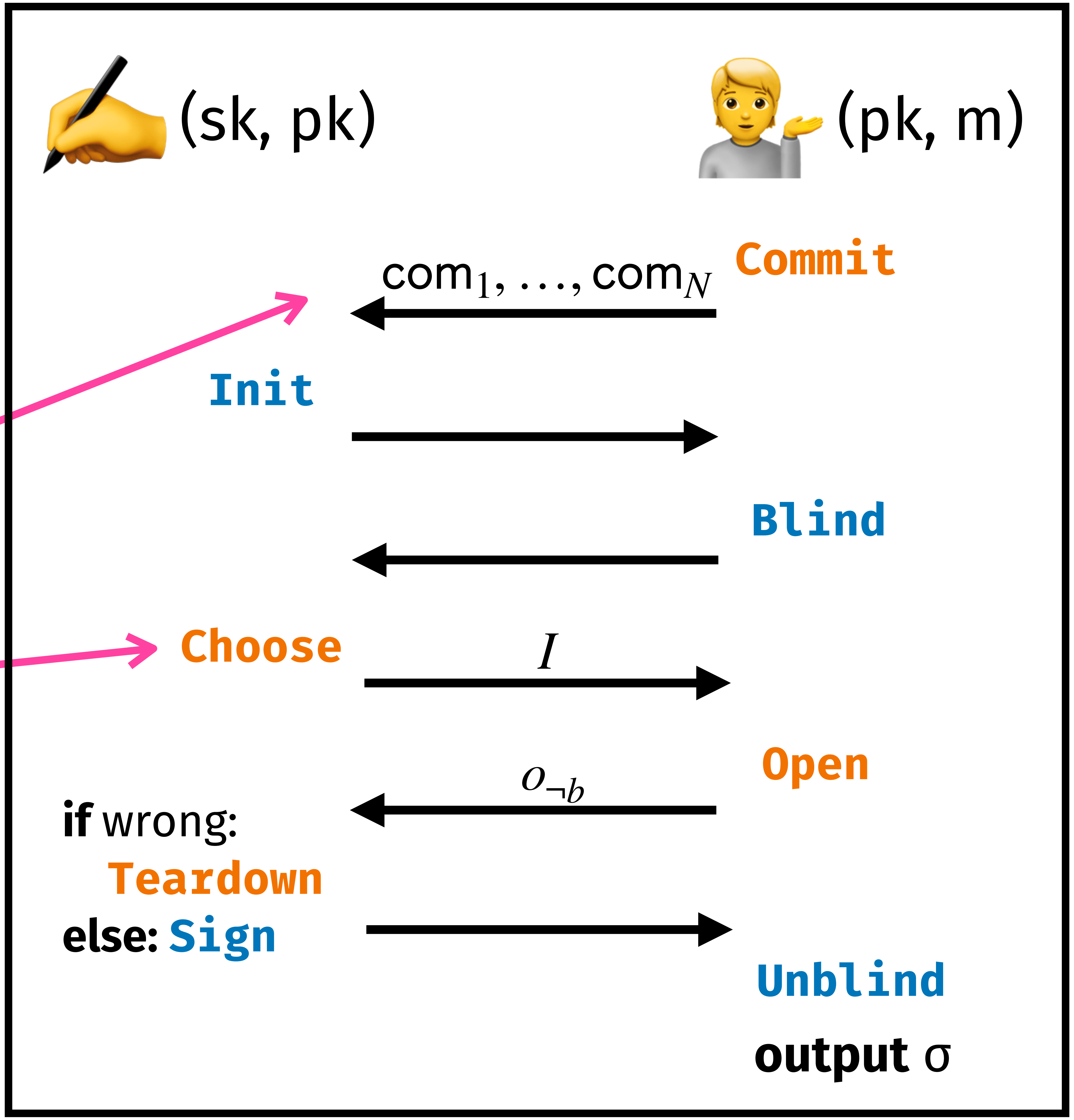

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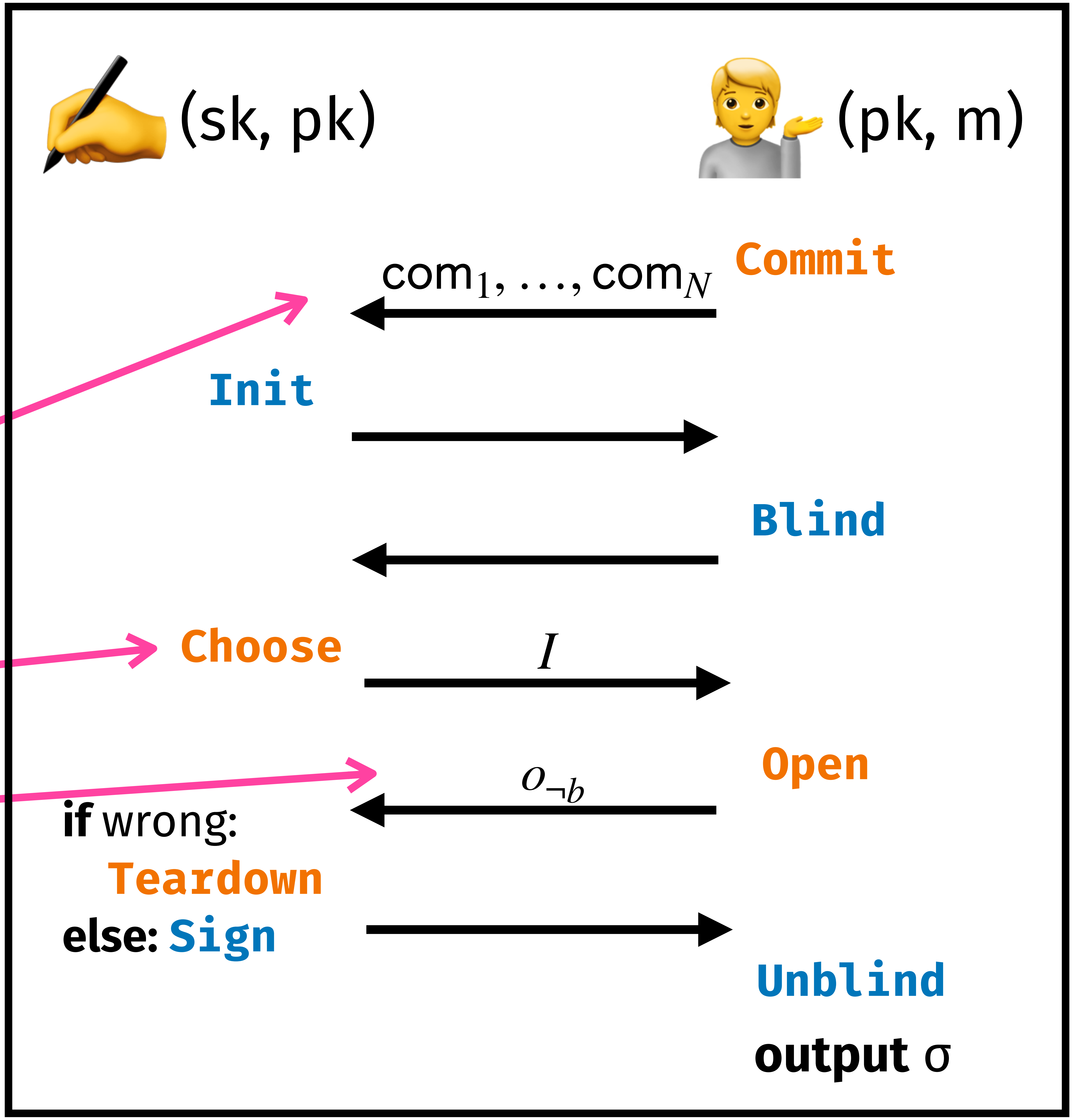

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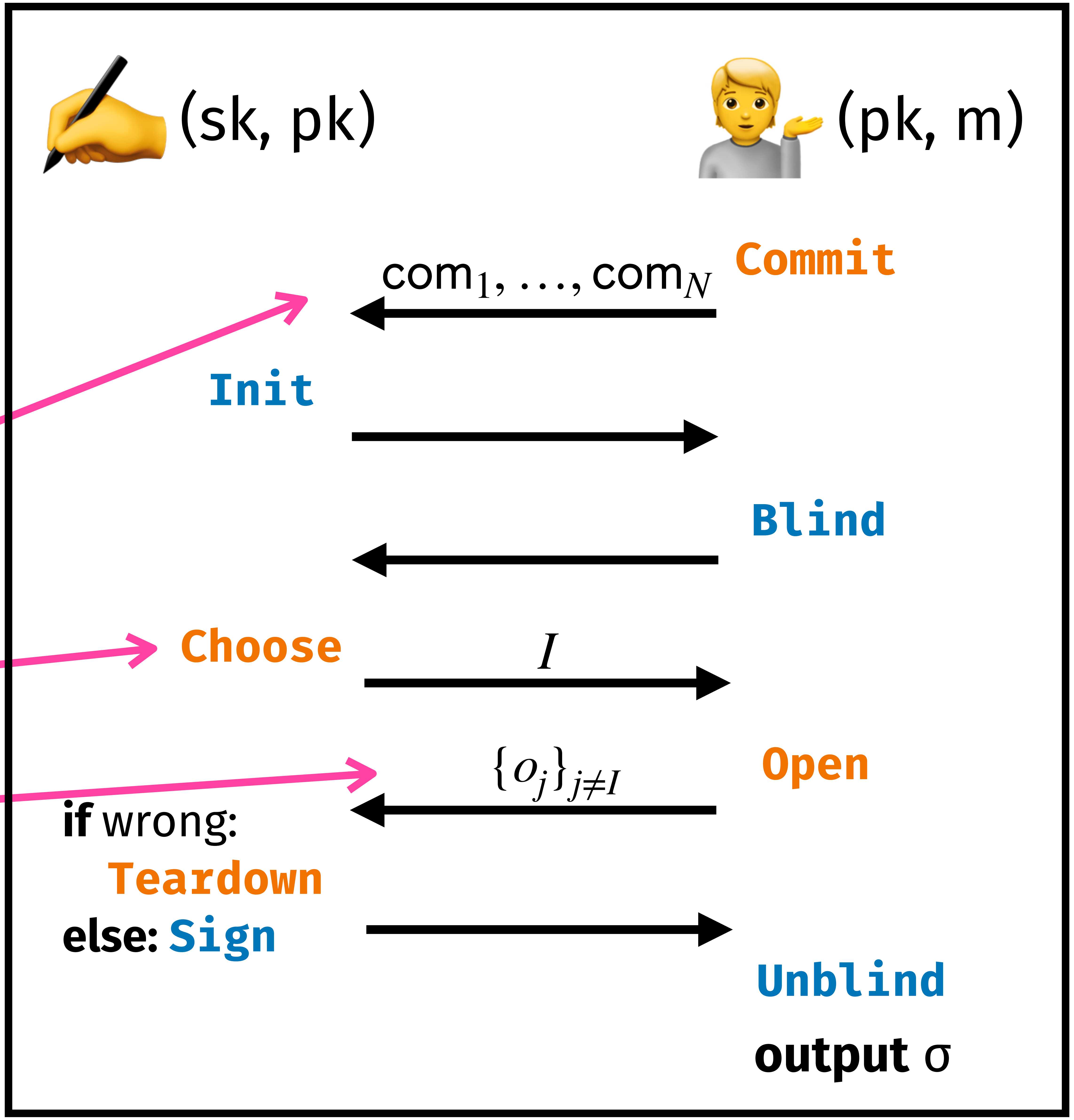

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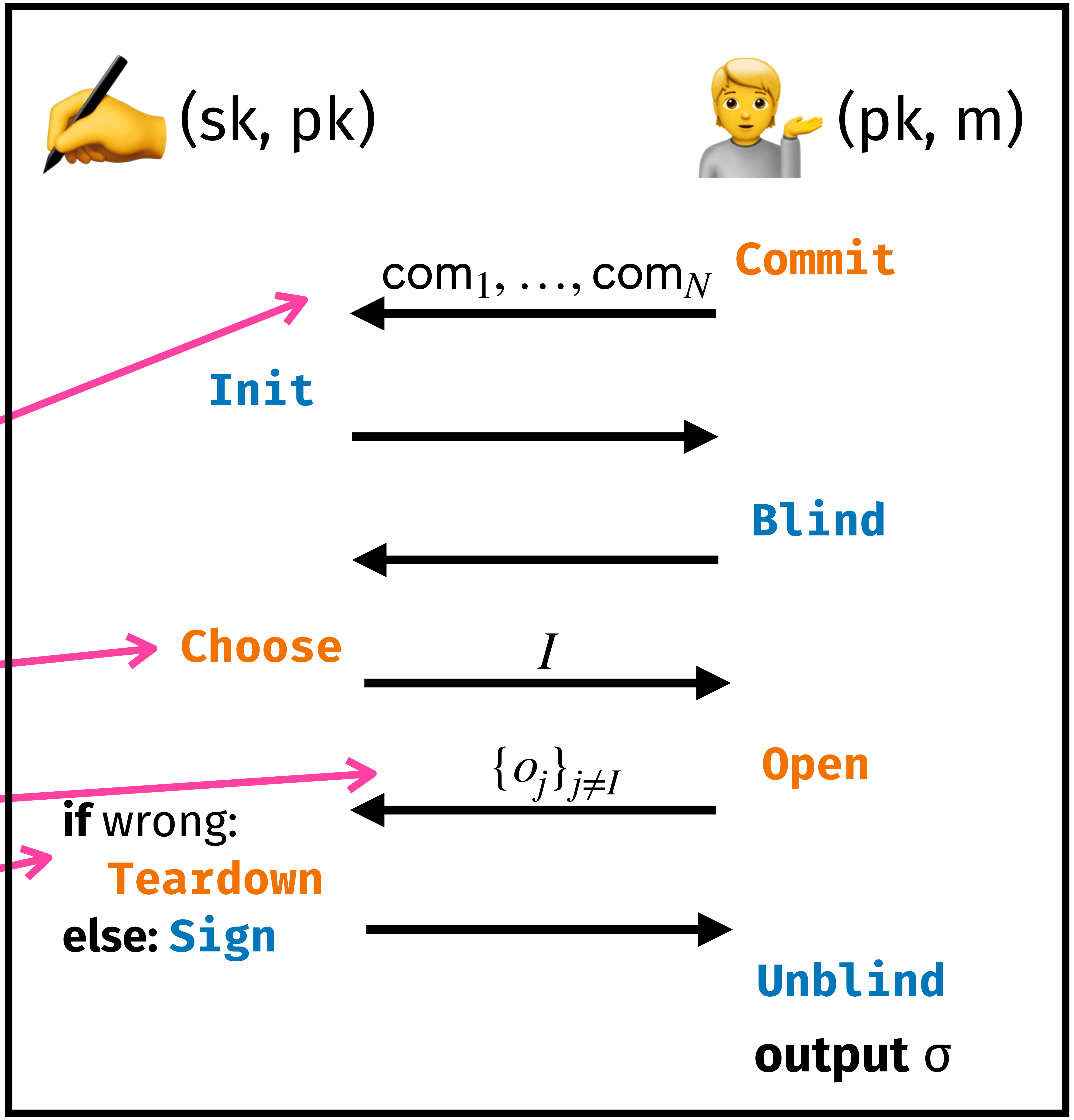
User opens all but the I-th com

Signer checks the opening

Success: sign

Failure: abort



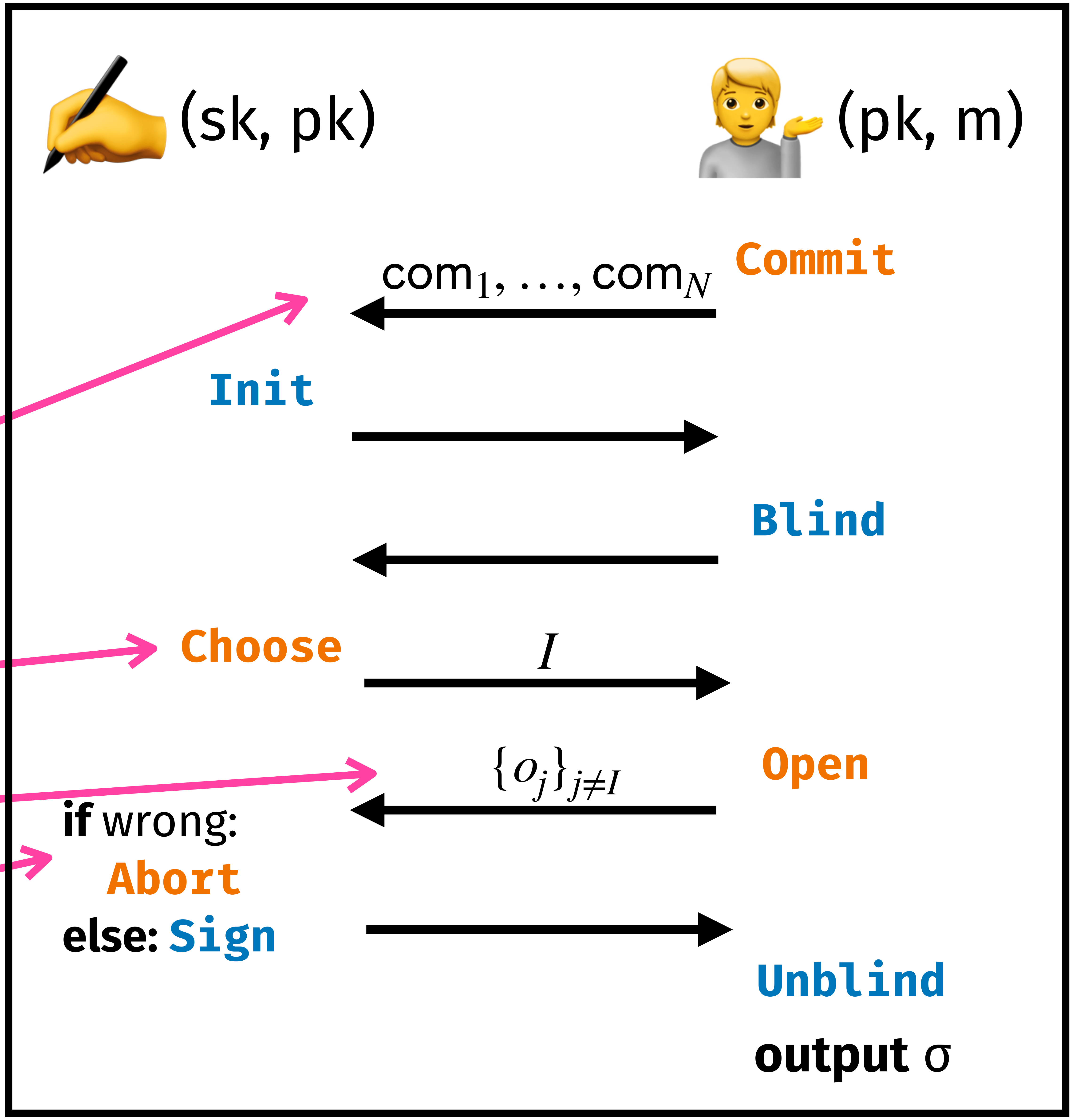
Our Transform

Construction

Protocol depends on how many sessions have begun

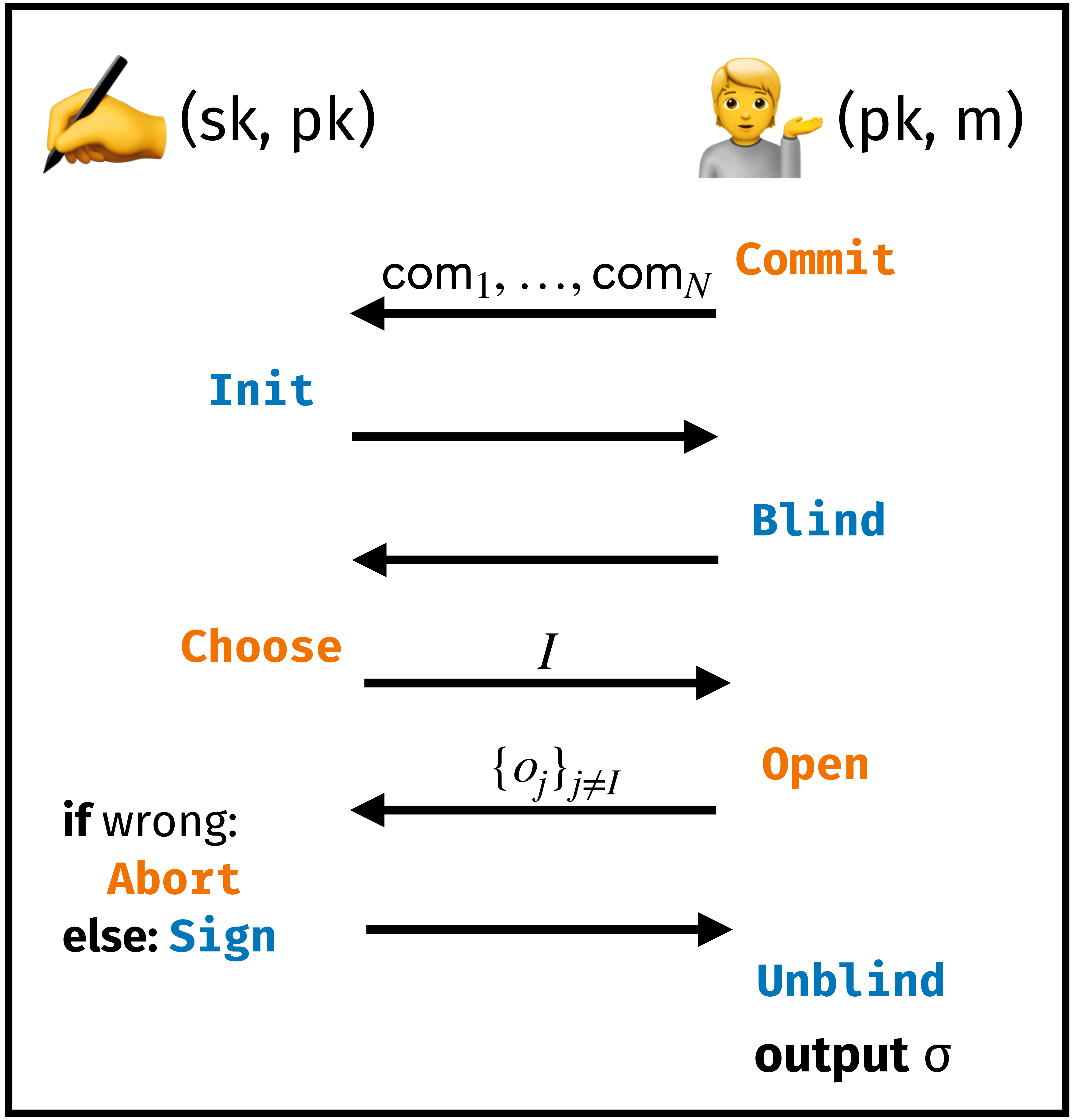
In session N:

- User commits to N sets of random coins
- Signer picks an I
- User opens all but the I-th com
- Signer checks the opening
  - **Success:** sign
  - **Failure: abort**



Our Transform

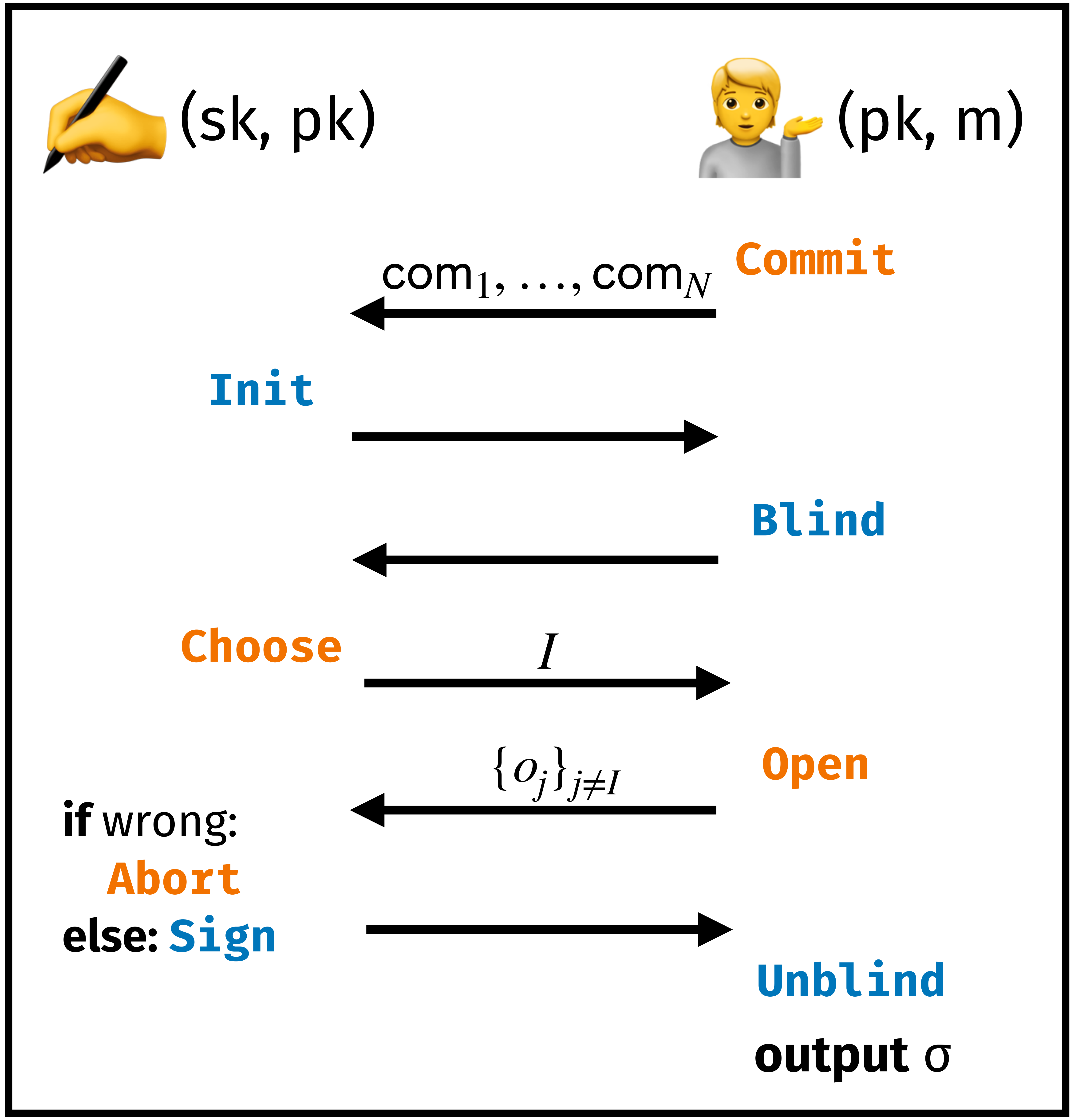
Analysis - OMUF



Our Transform

Analysis - OMUF

Recall: Underlying scheme is only secure when #cheats = $O(\log(\kappa))$



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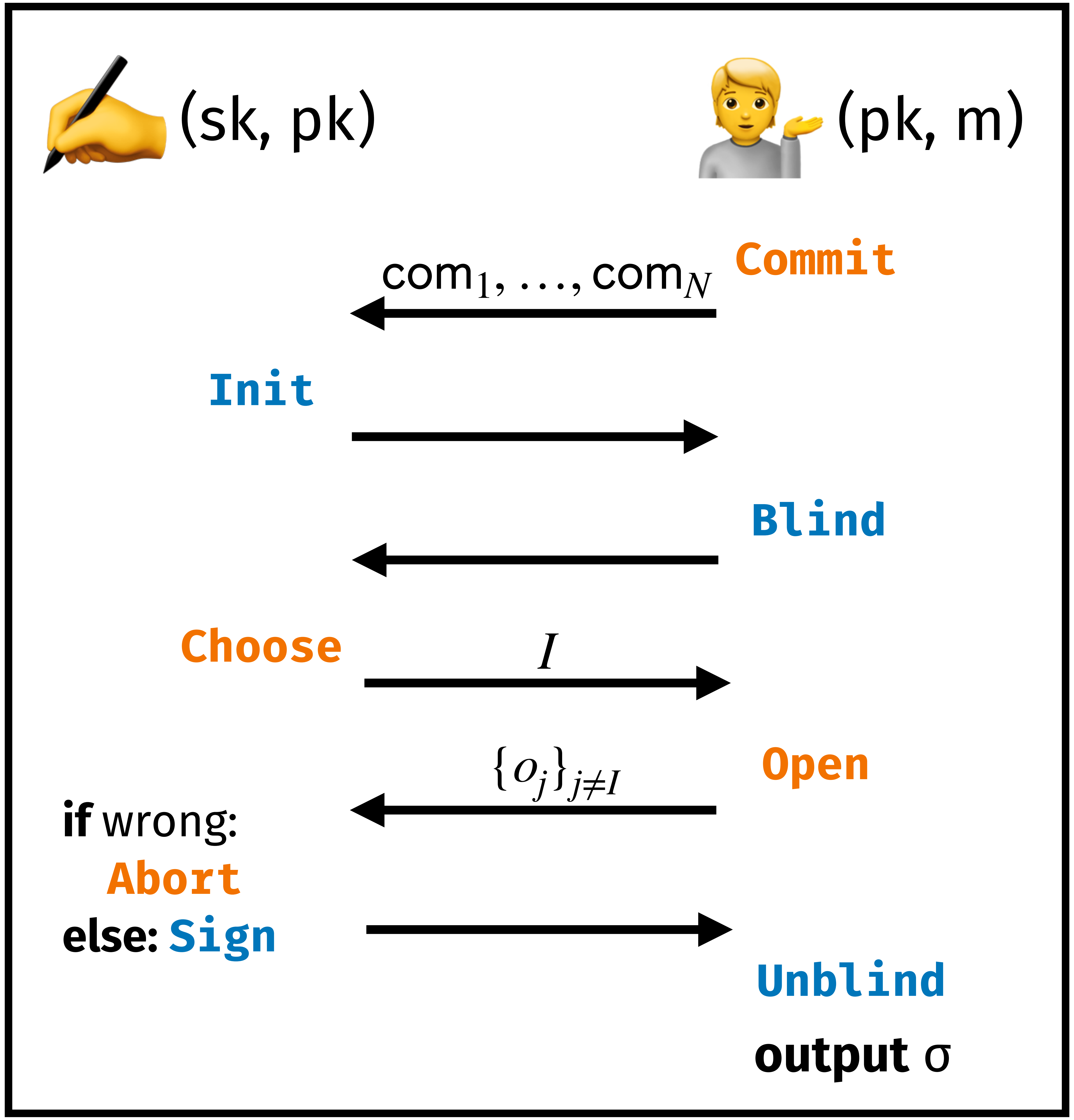

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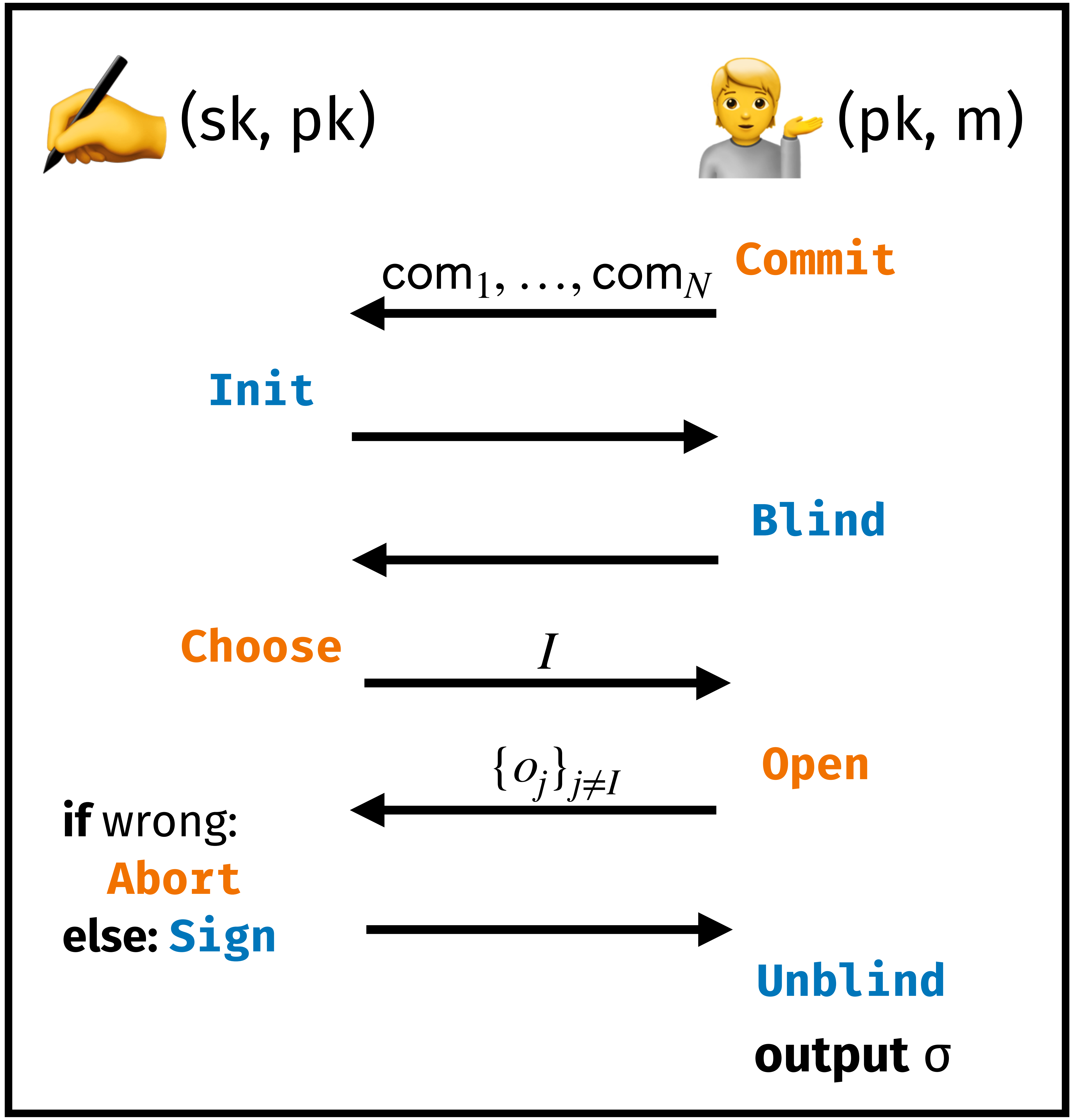

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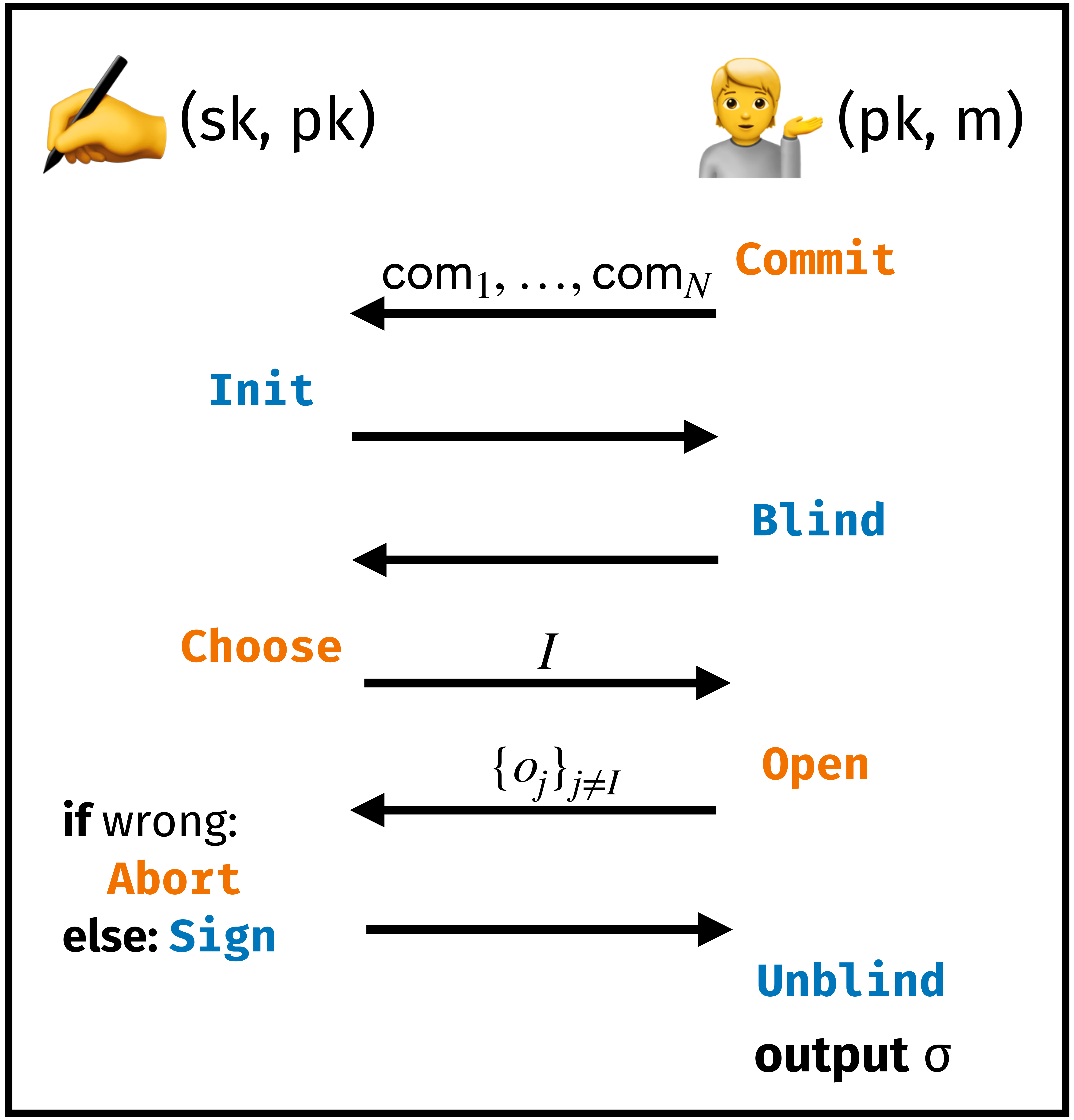

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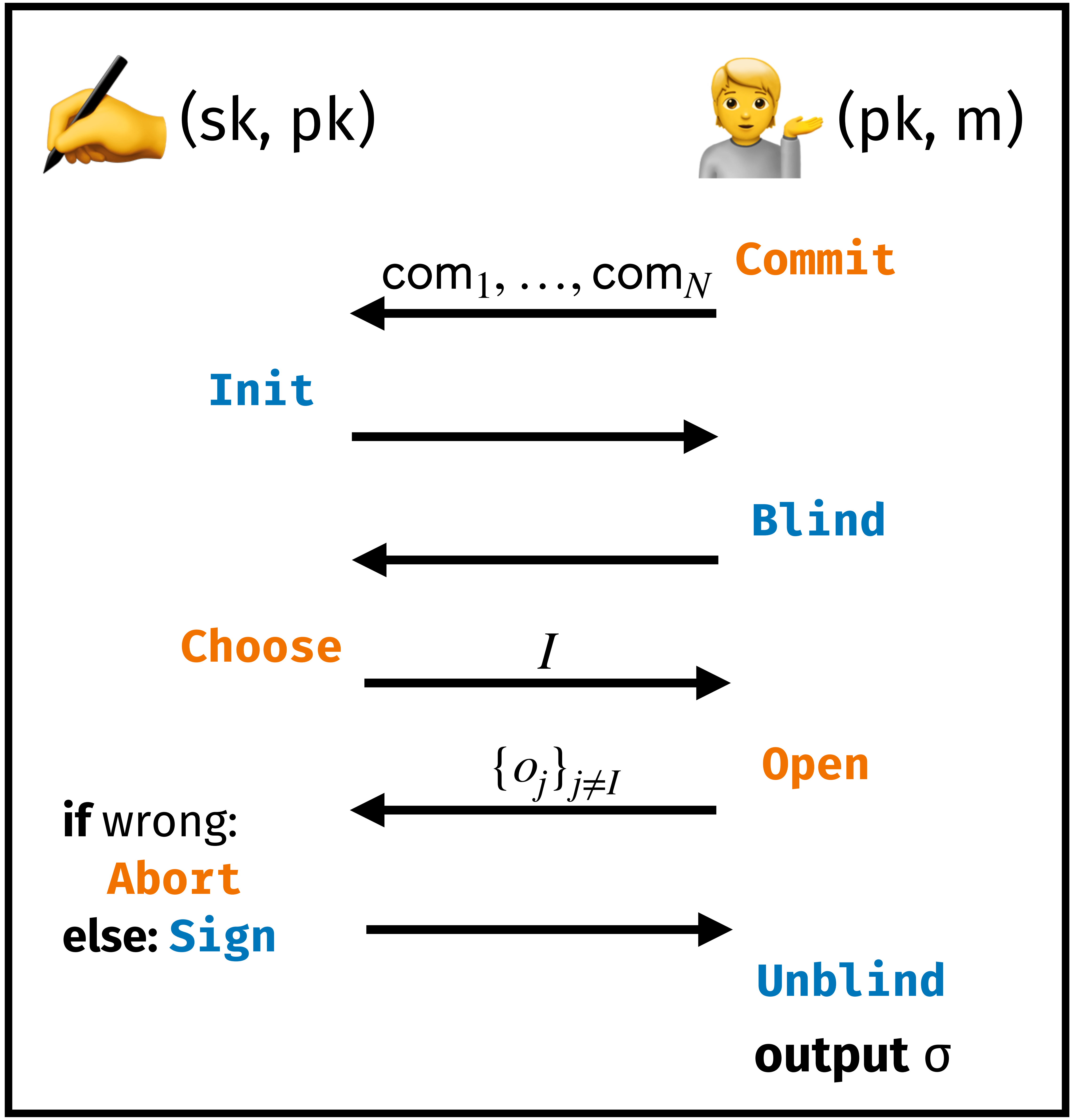

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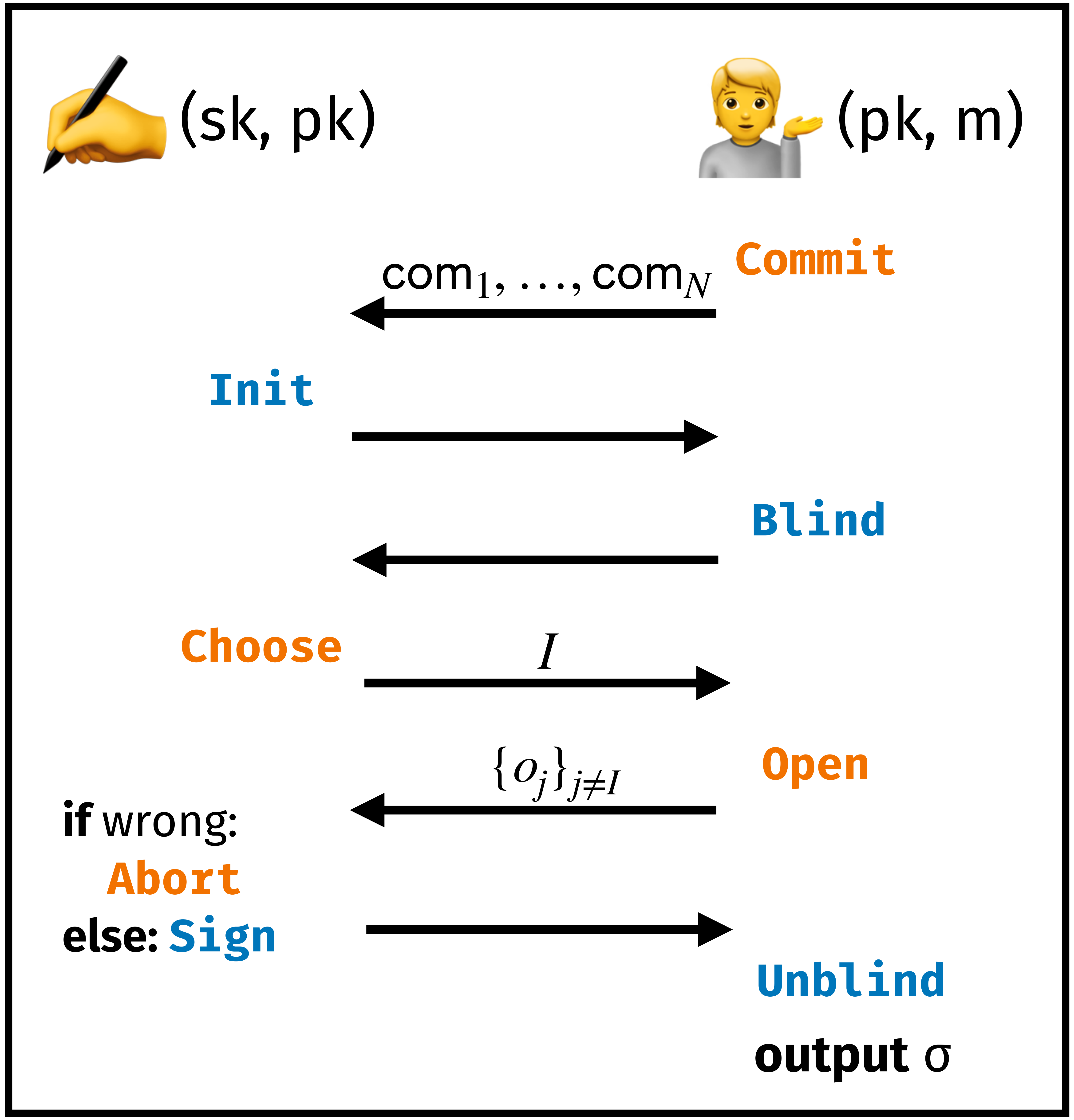

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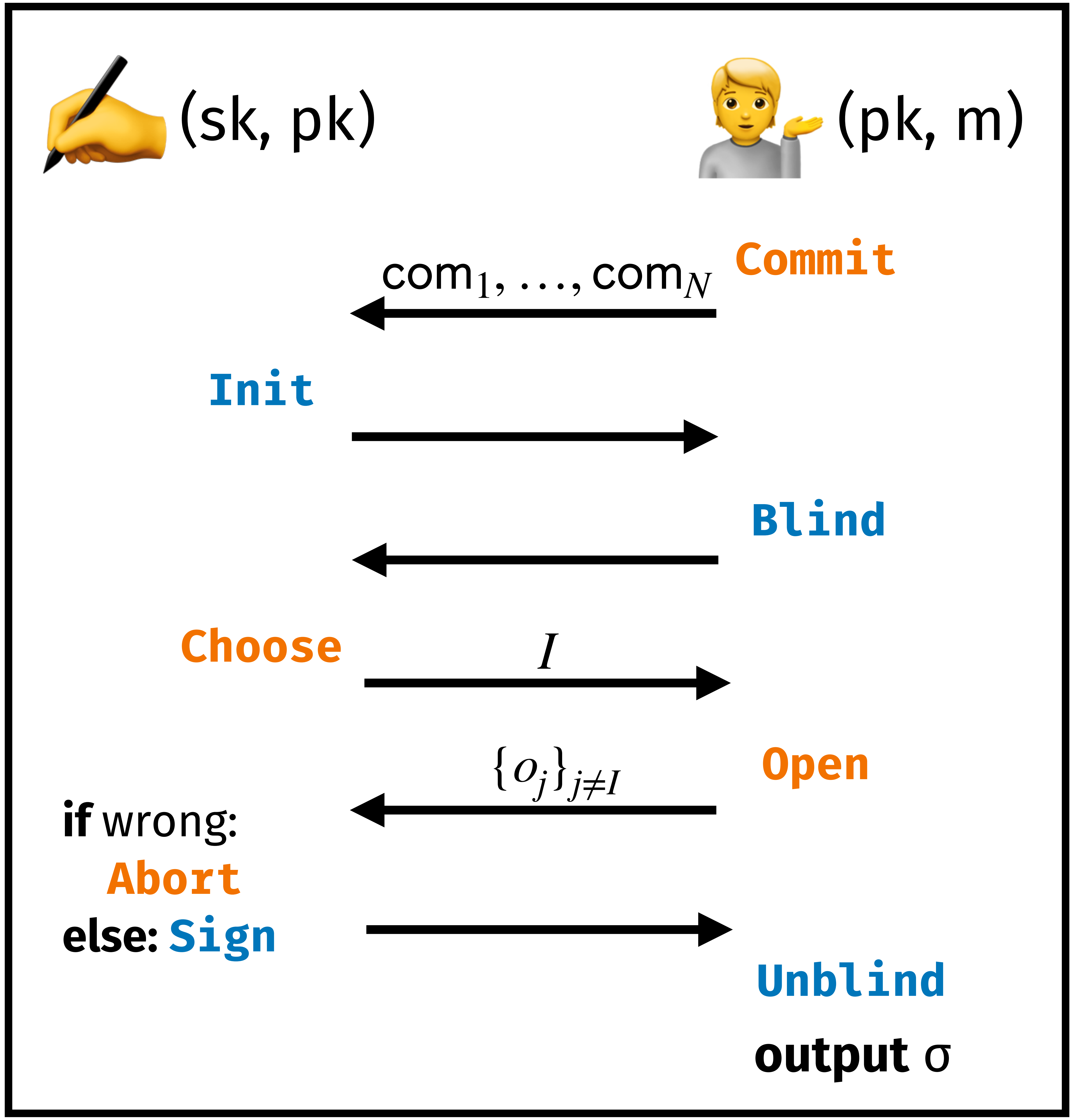

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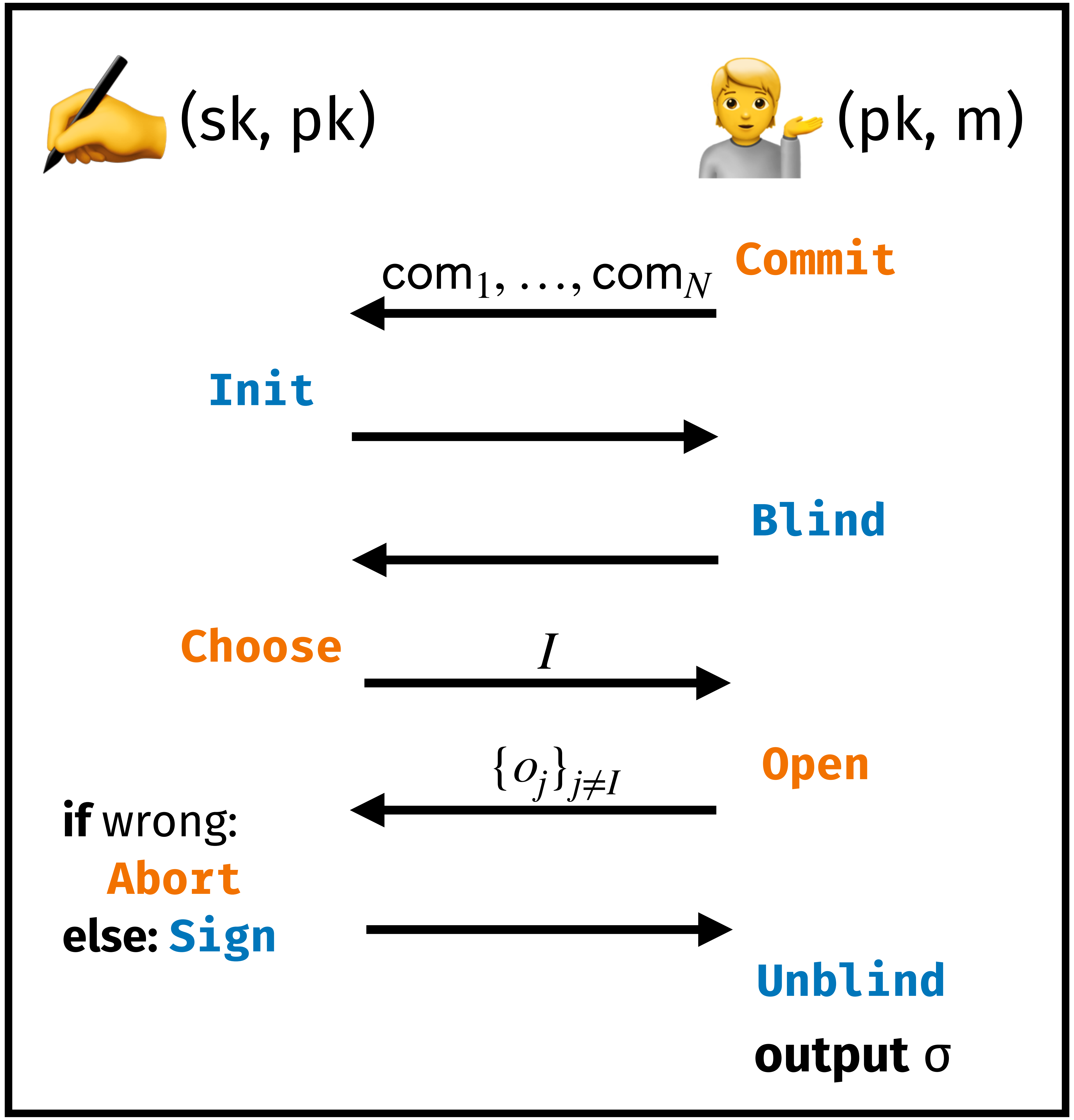

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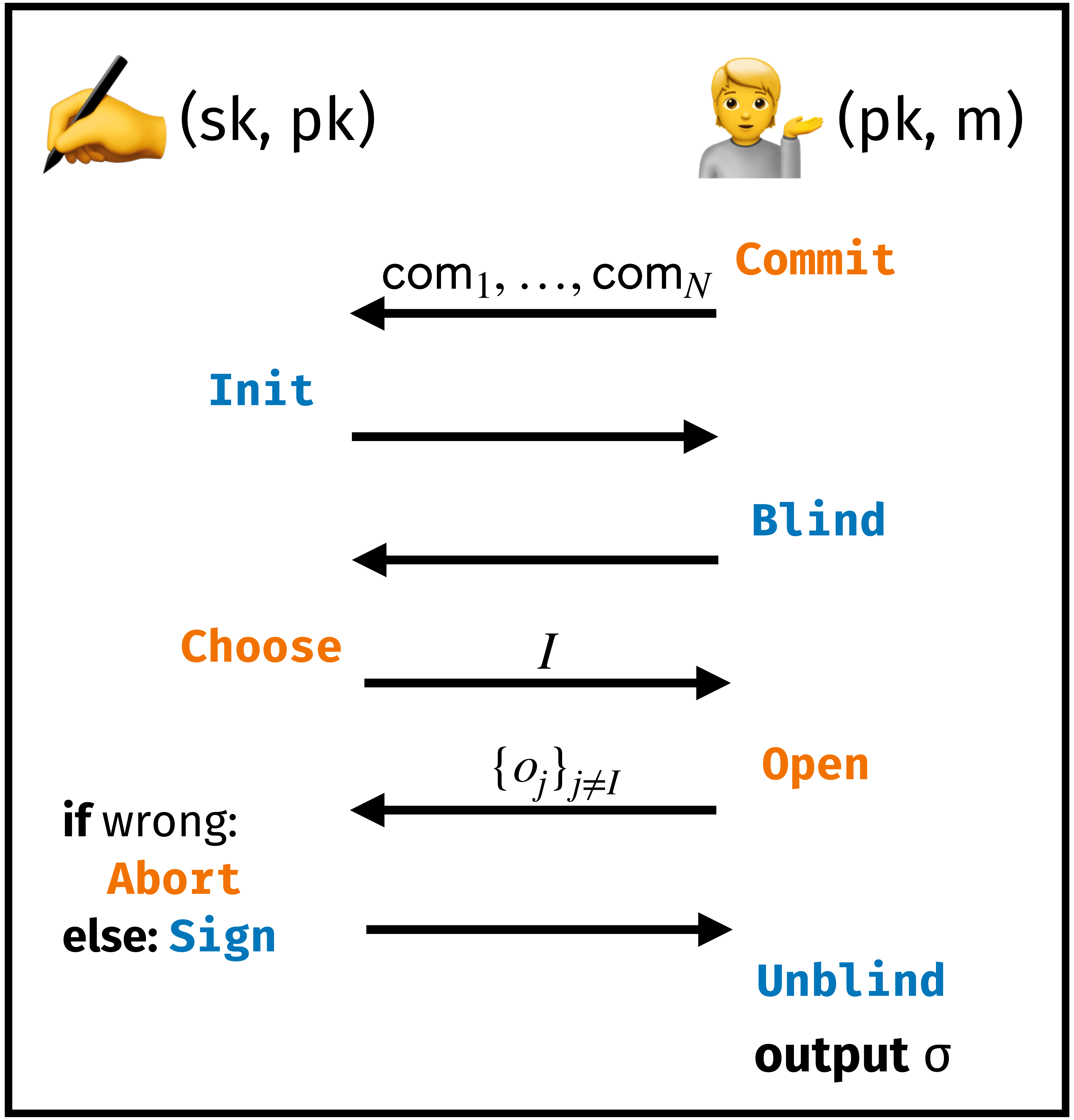
Without teardown, after s sessions,

$$\mathbb{E}[\#\text{cheats}] = \sum_{N=2}^{s+1} \frac{1}{N} \leq \ln(s+1)$$



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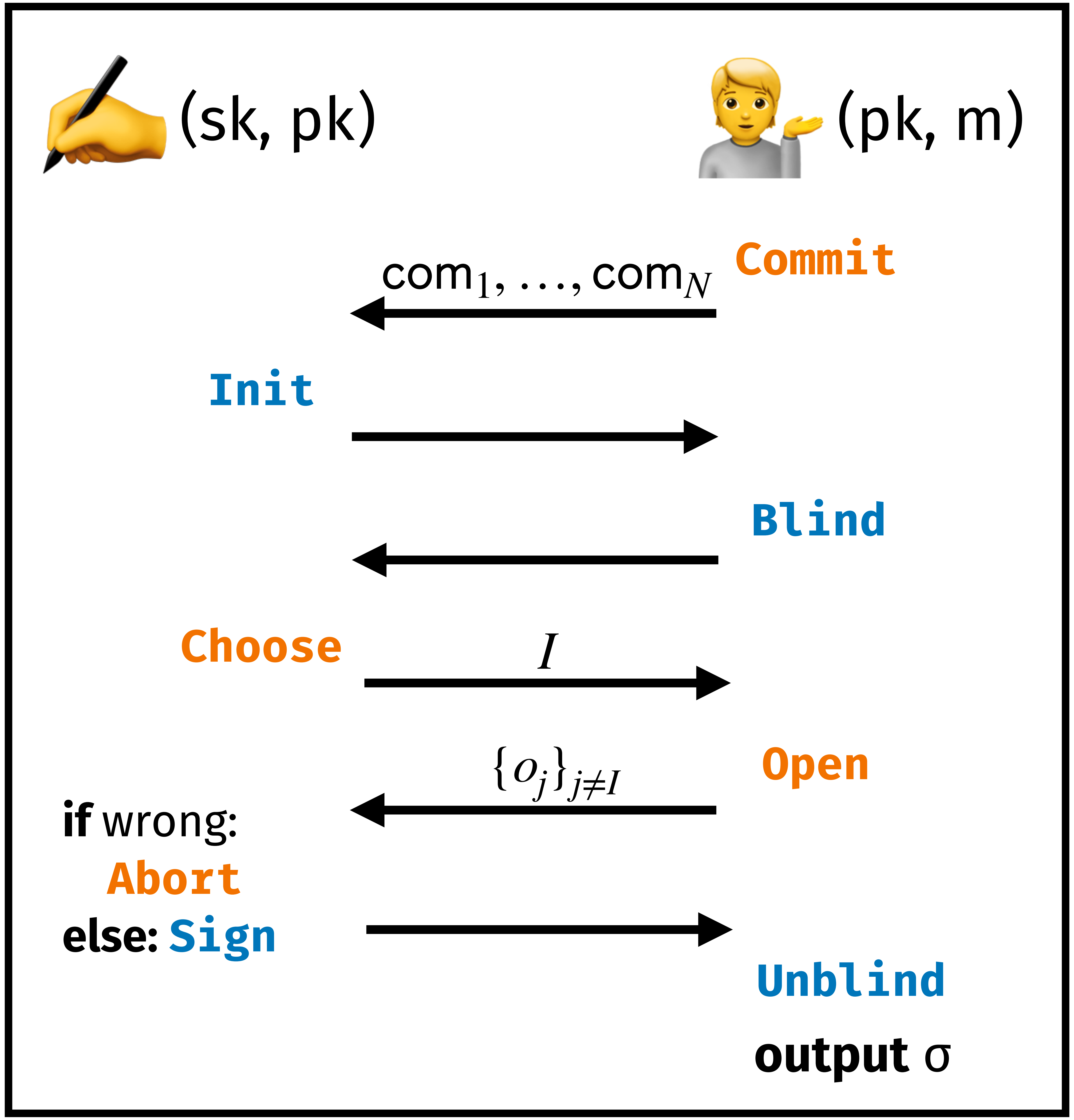
Tail bound: within $O(\log(\kappa))$ w.h.p



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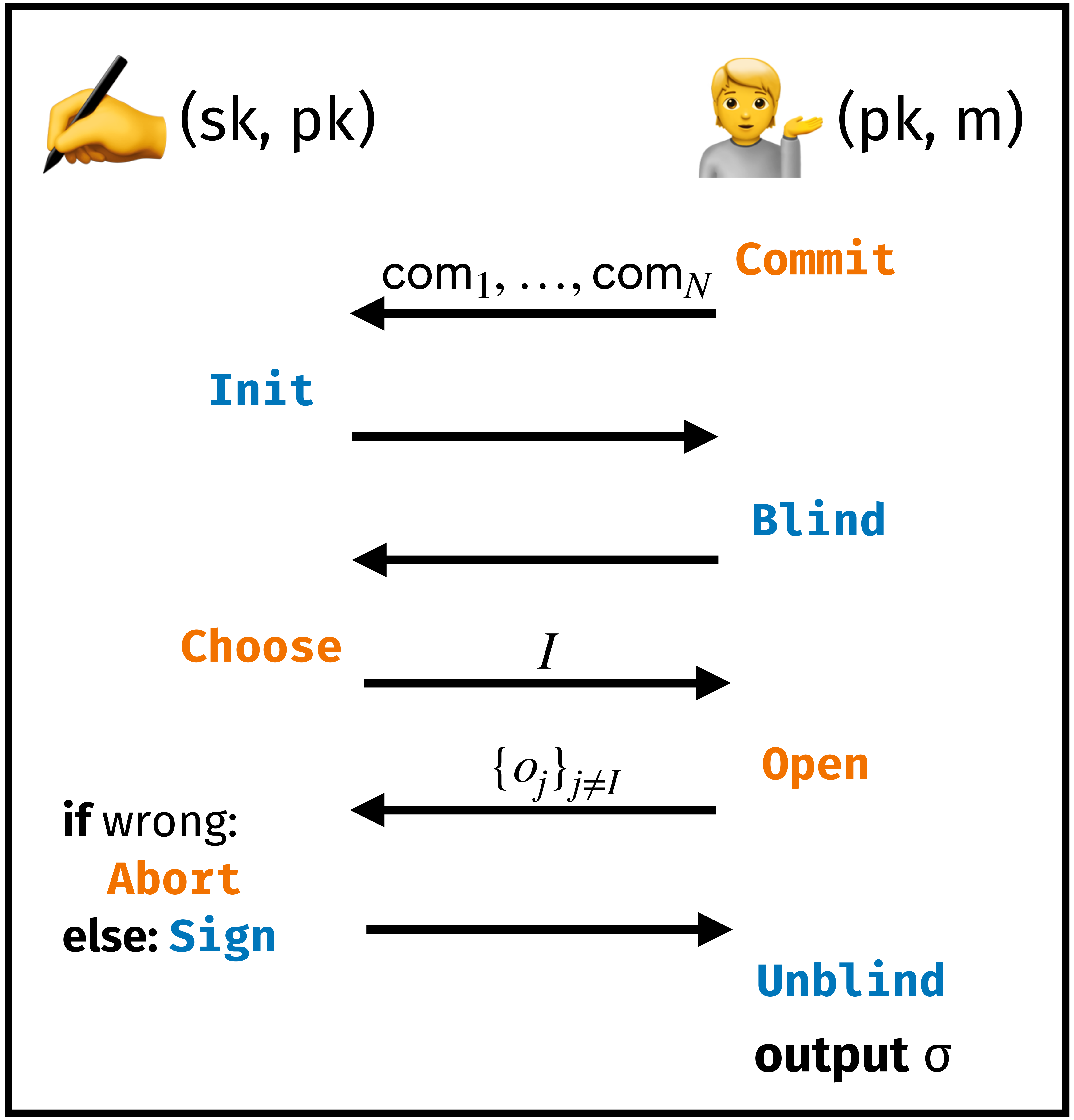
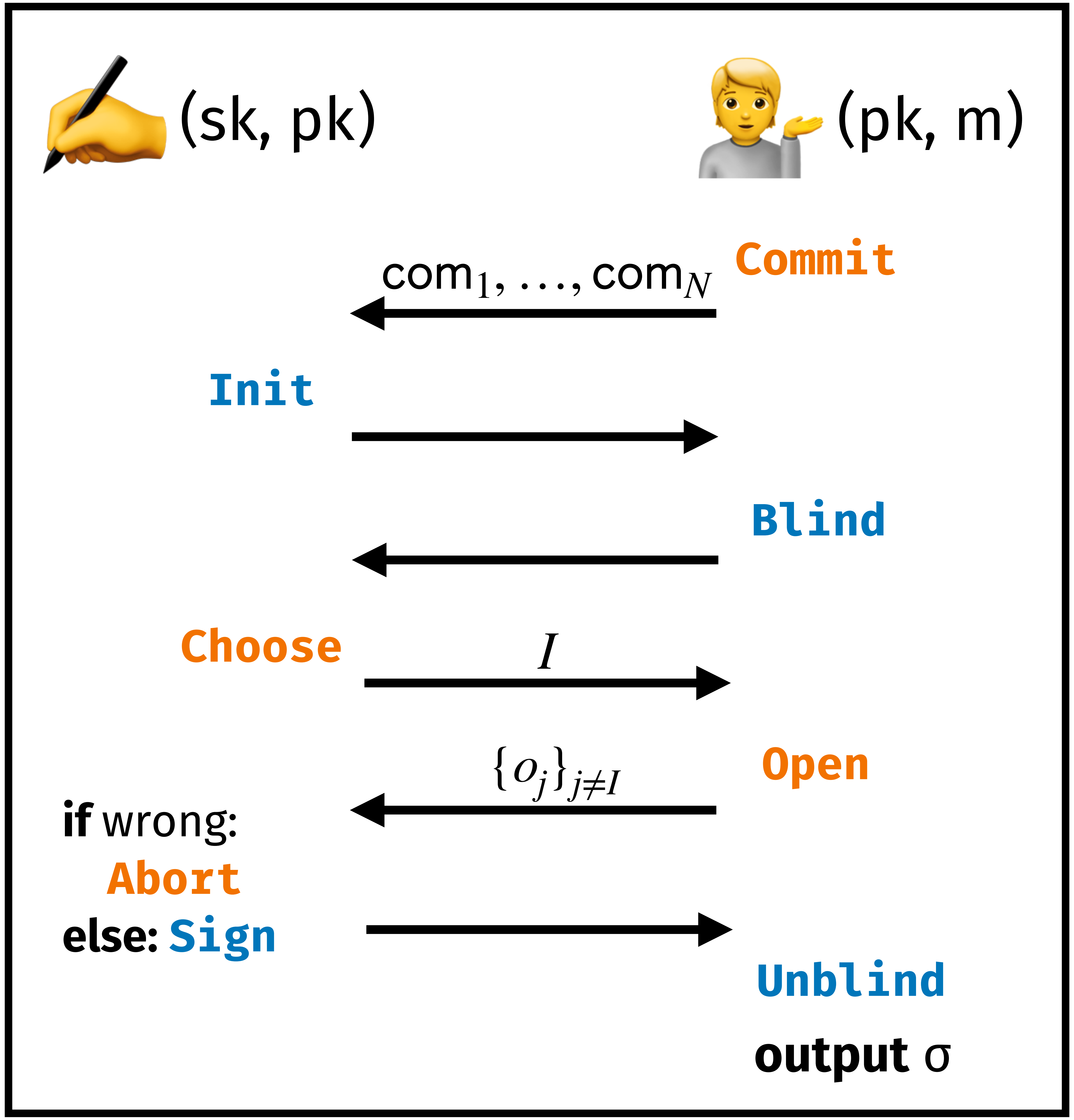
Tail bound: within $O(\log(\kappa))$ w.h.p

Thus, our scheme is $\text{poly}(\kappa)$**-OMUF without teardowns**



Our Transform

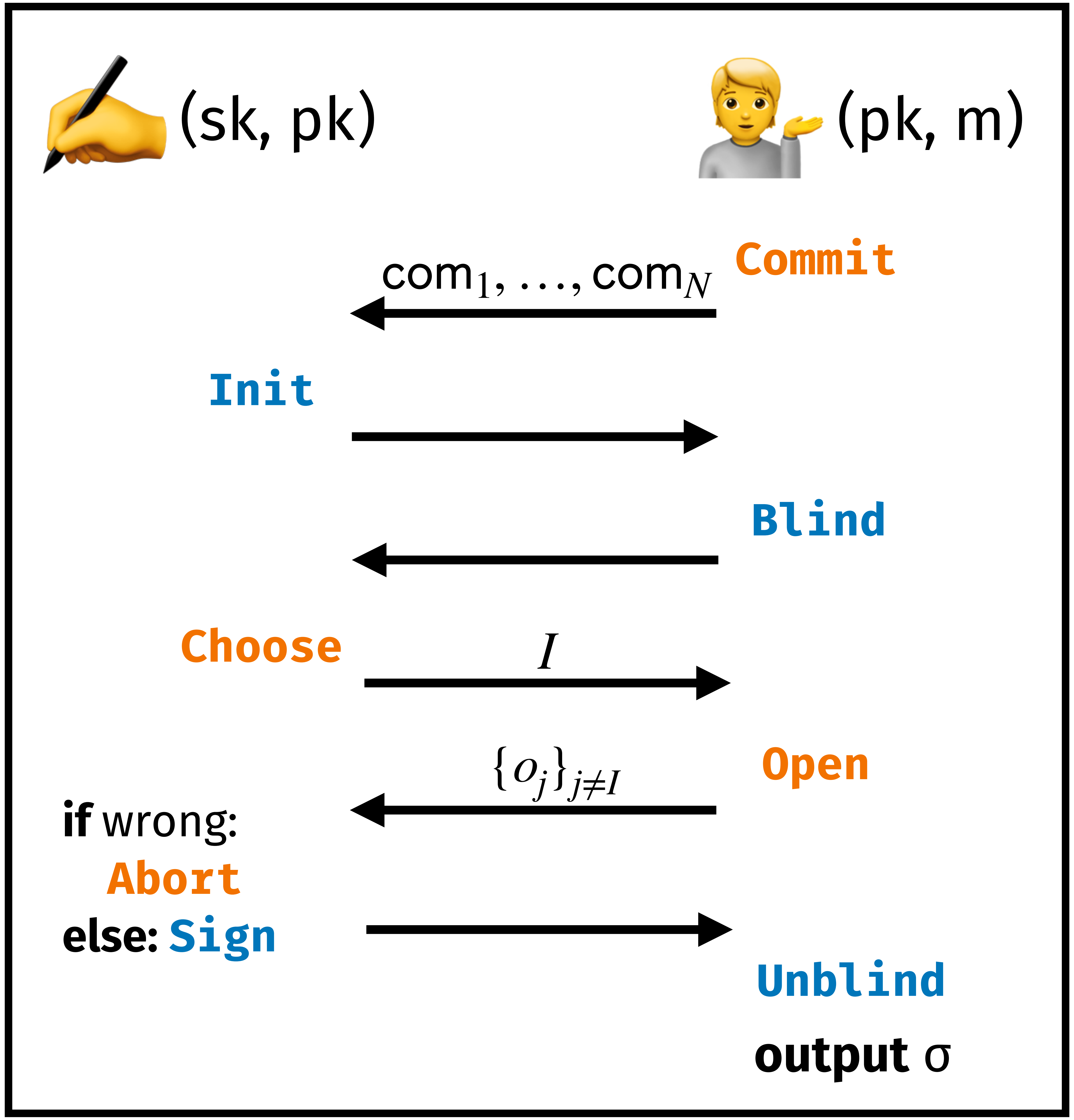
Analysis - Concurrency



Our Transform

Analysis - Concurrency

Previously

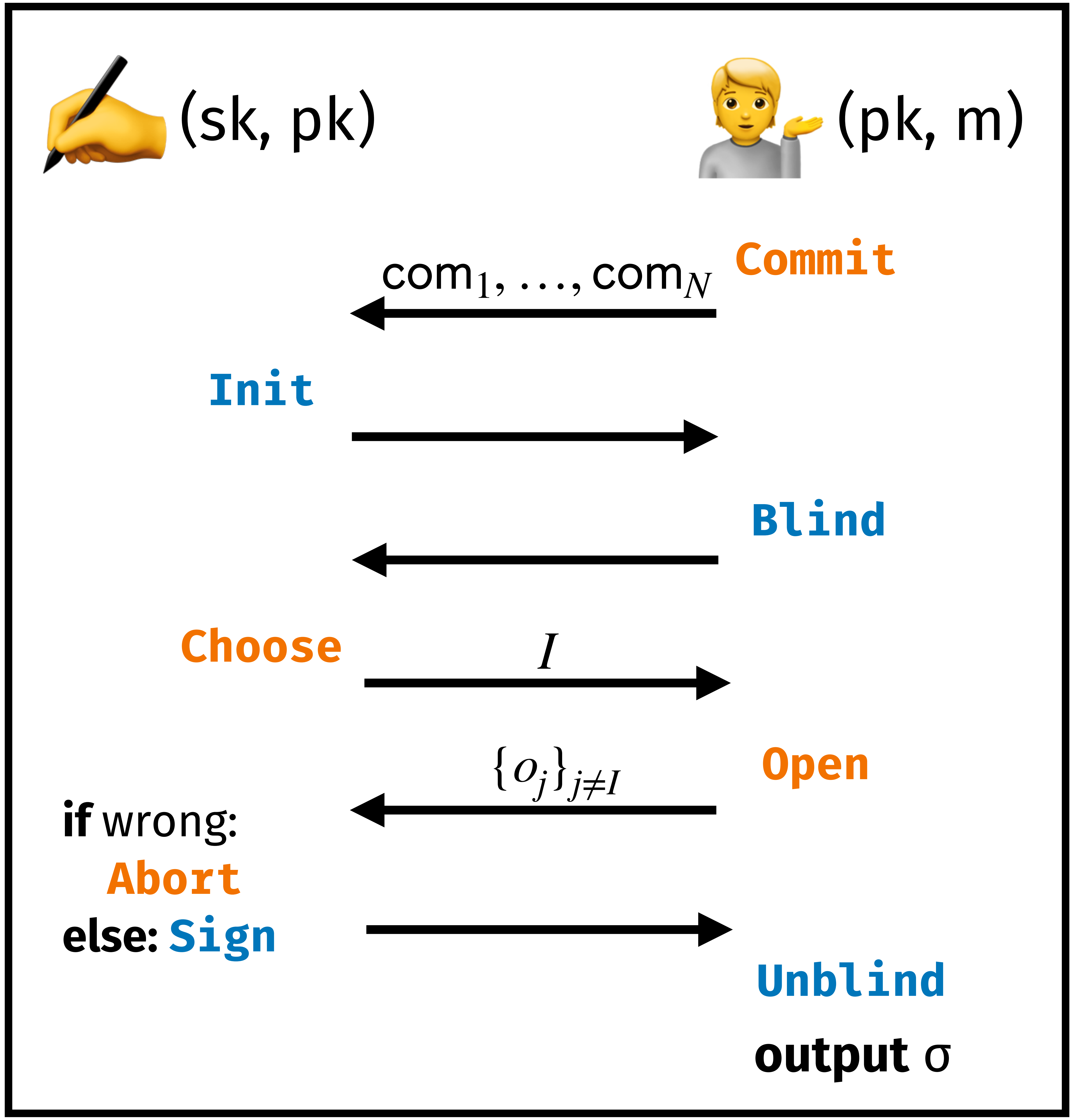


Our Transform

Analysis - Concurrency

Previously

Supported **parallel sessions:** a session cannot advance faster than its predecessors



Our Transform

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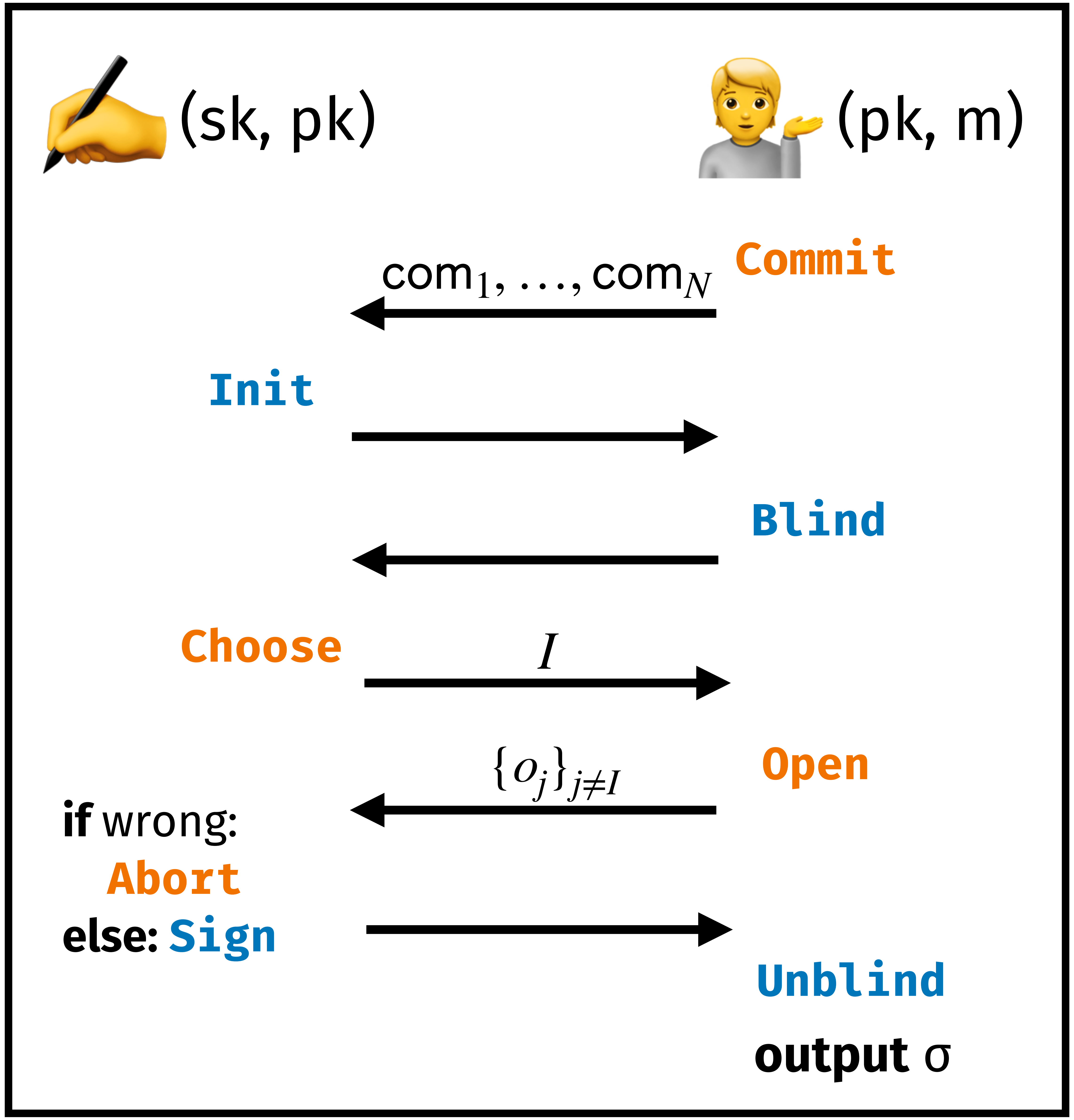

Our Transform

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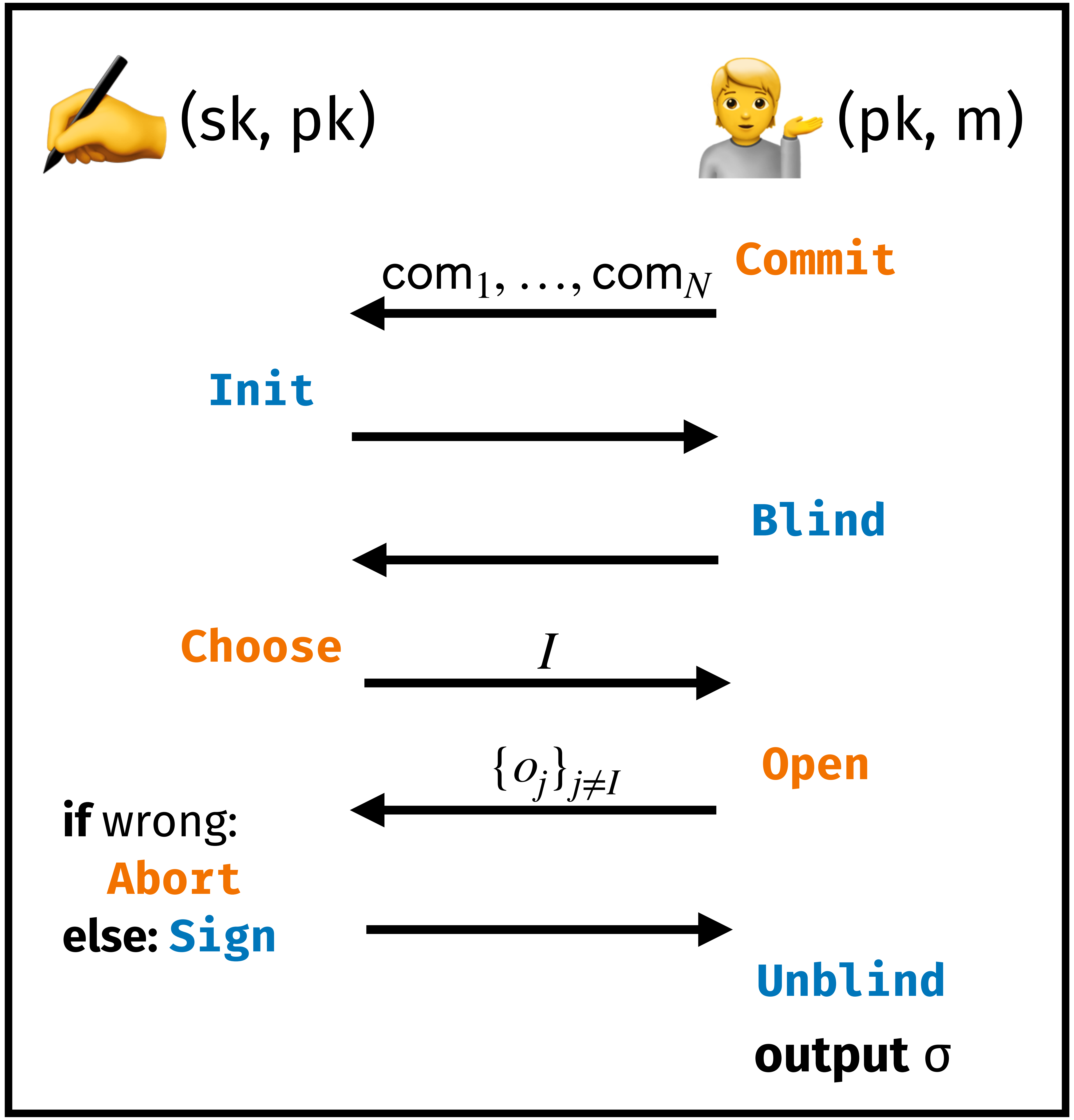
If N is incremented atomically every session, **we get arbitrary concurrency**



Our Transform

Analysis - Concurrency

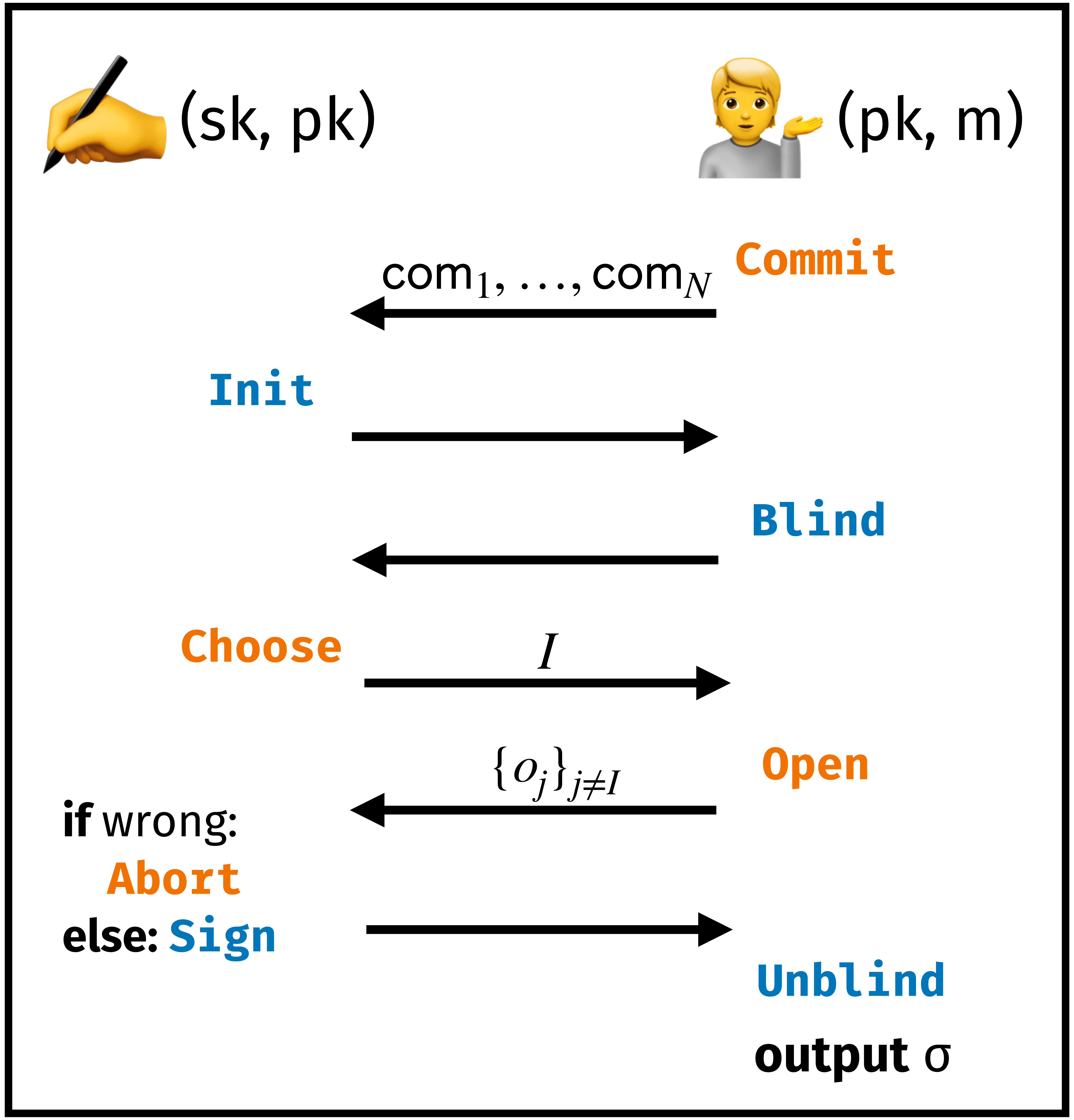
Previously

Supported **parallel sessions:** a session cannot advance faster than its predecessors

Now

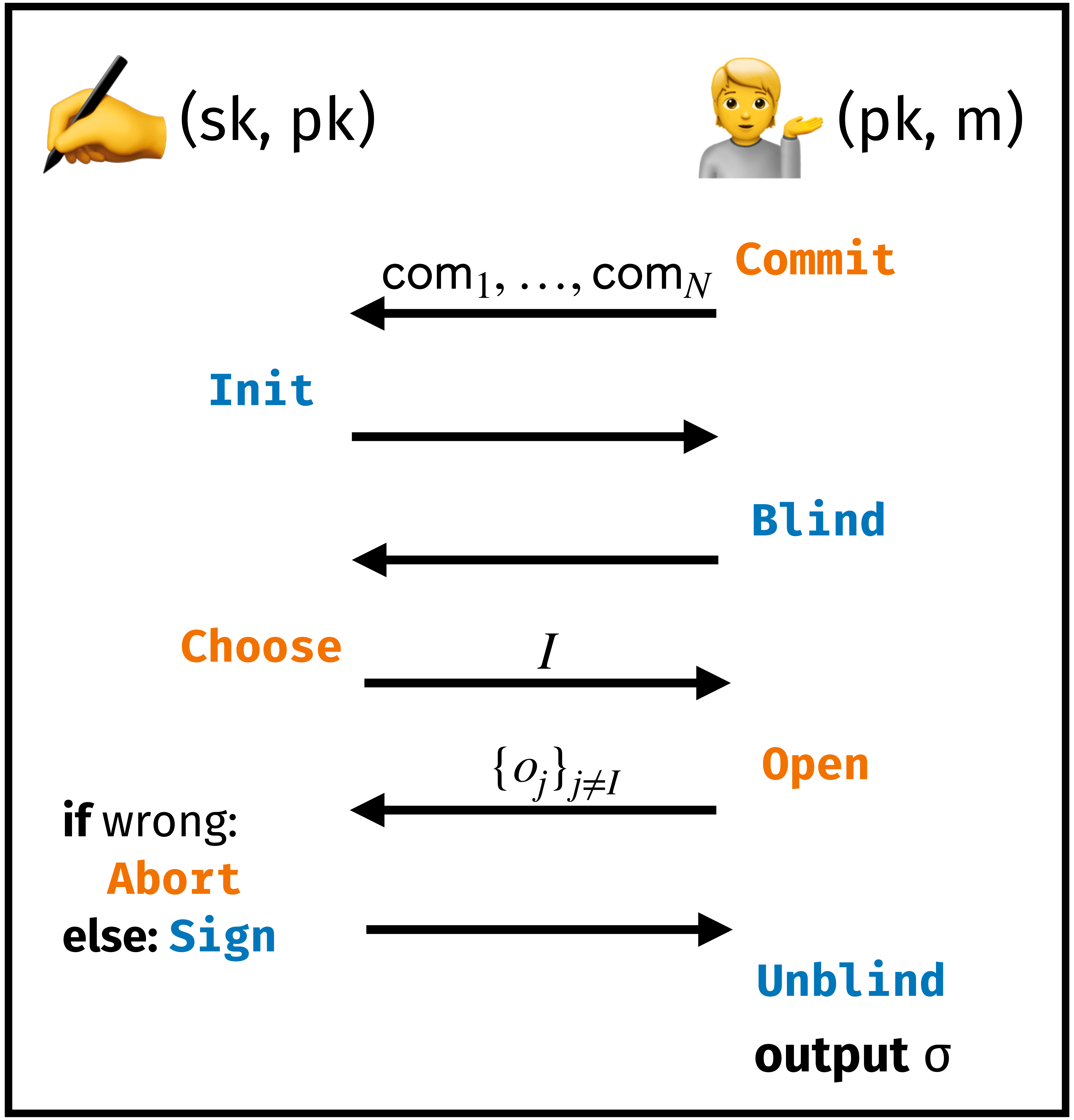
If N is incremented atomically every session, **we get arbitrary concurrency**

Can be improved: only increment N every time a user is caught cheating



Our Transform

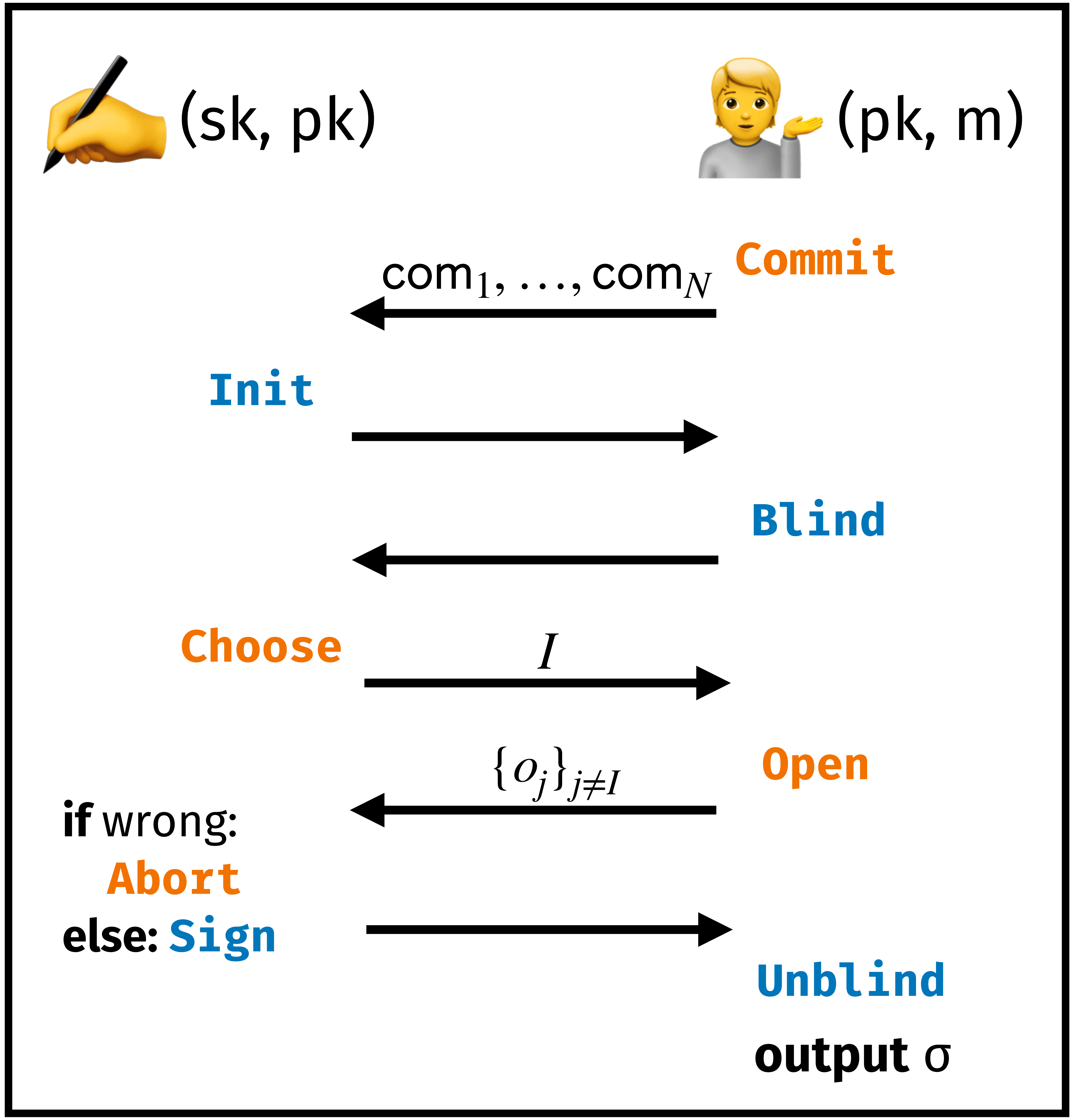
Analysis - Genericity



Our Transform

Analysis - Genericity

Previously

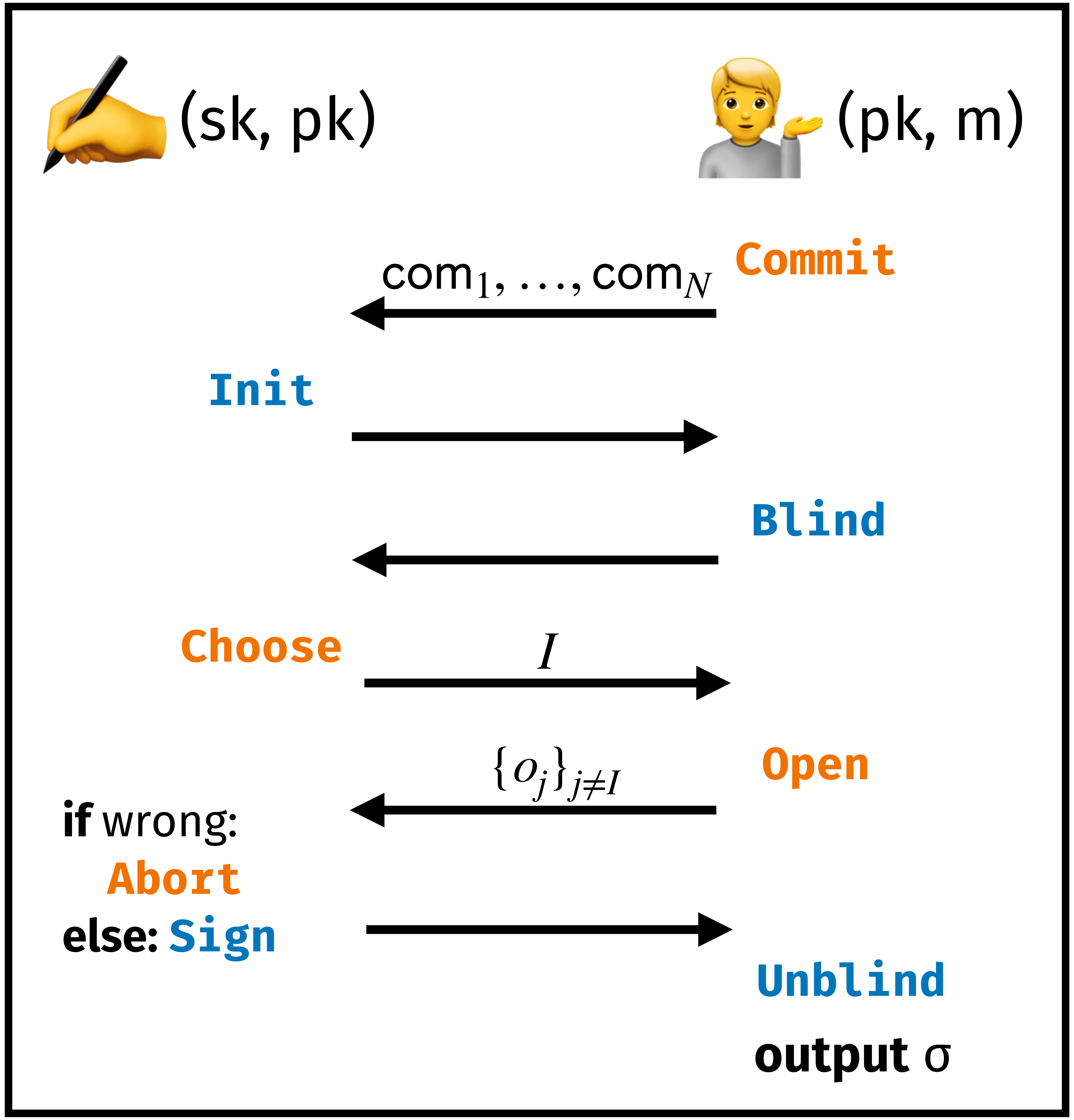


Our Transform

Analysis - Genericity

Previously

Not generic. Only defined for Okamoto-Schnorr



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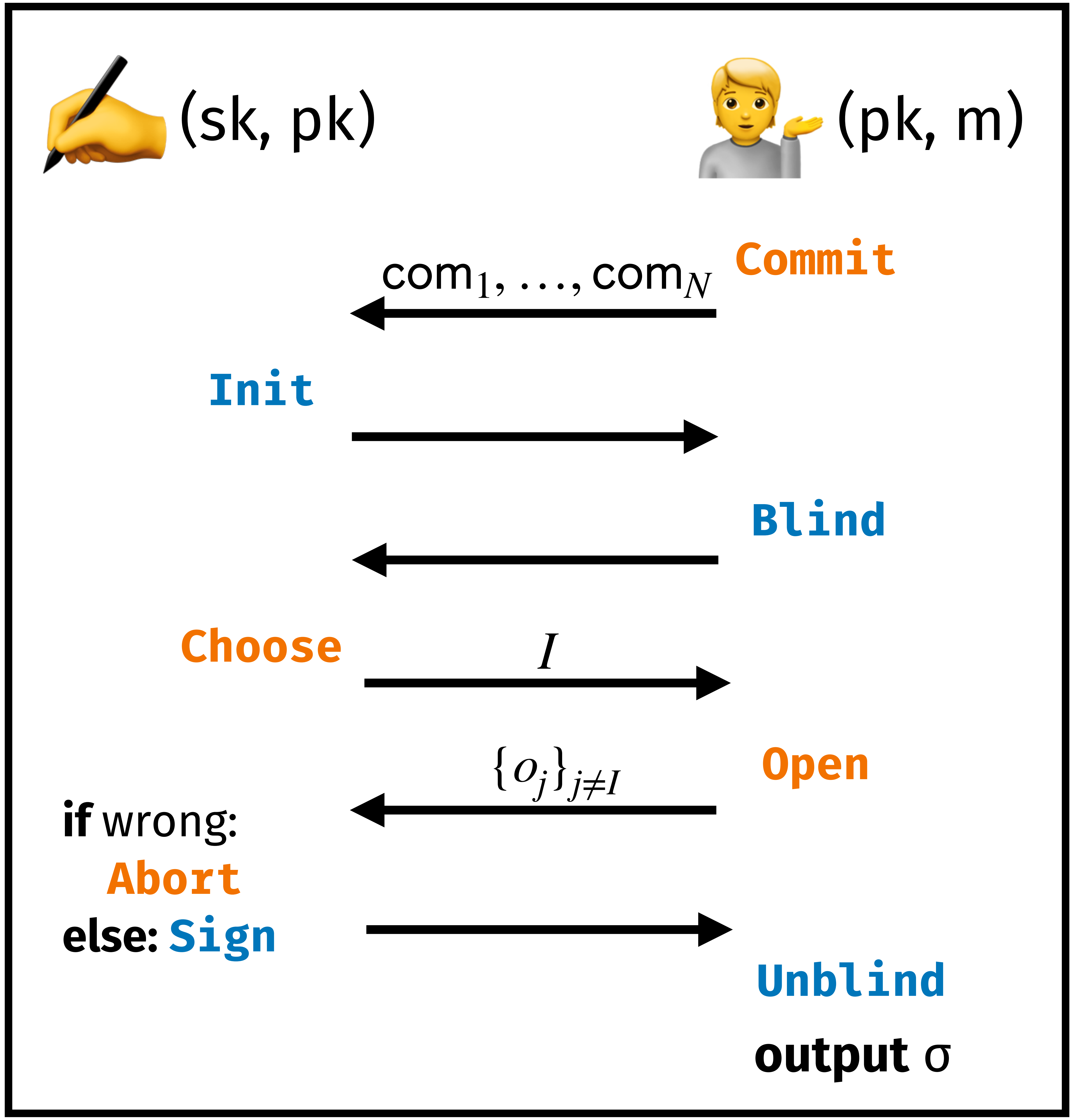

Our Transform

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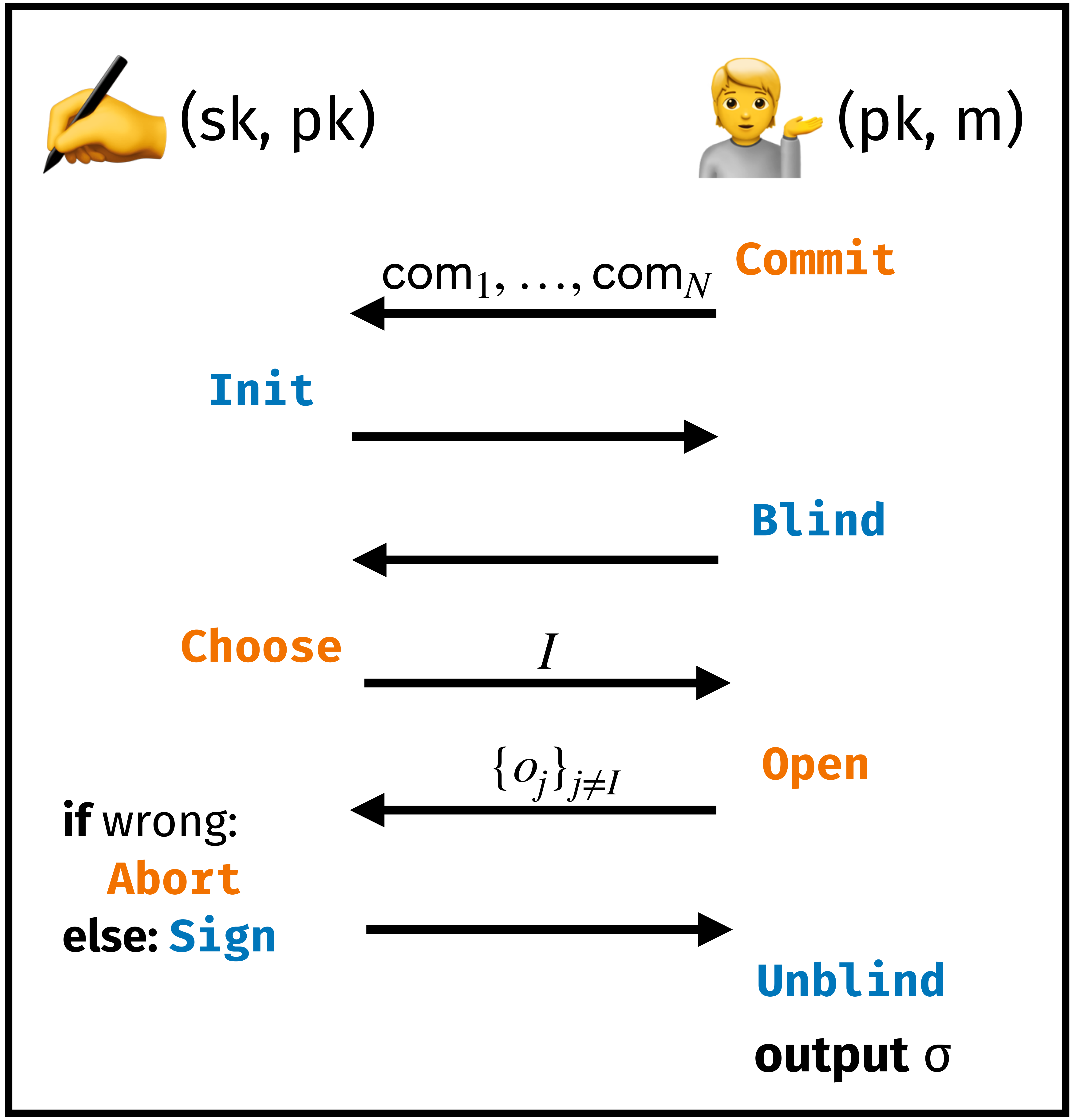
Generic for any algebraic hash function with homomorphic properties



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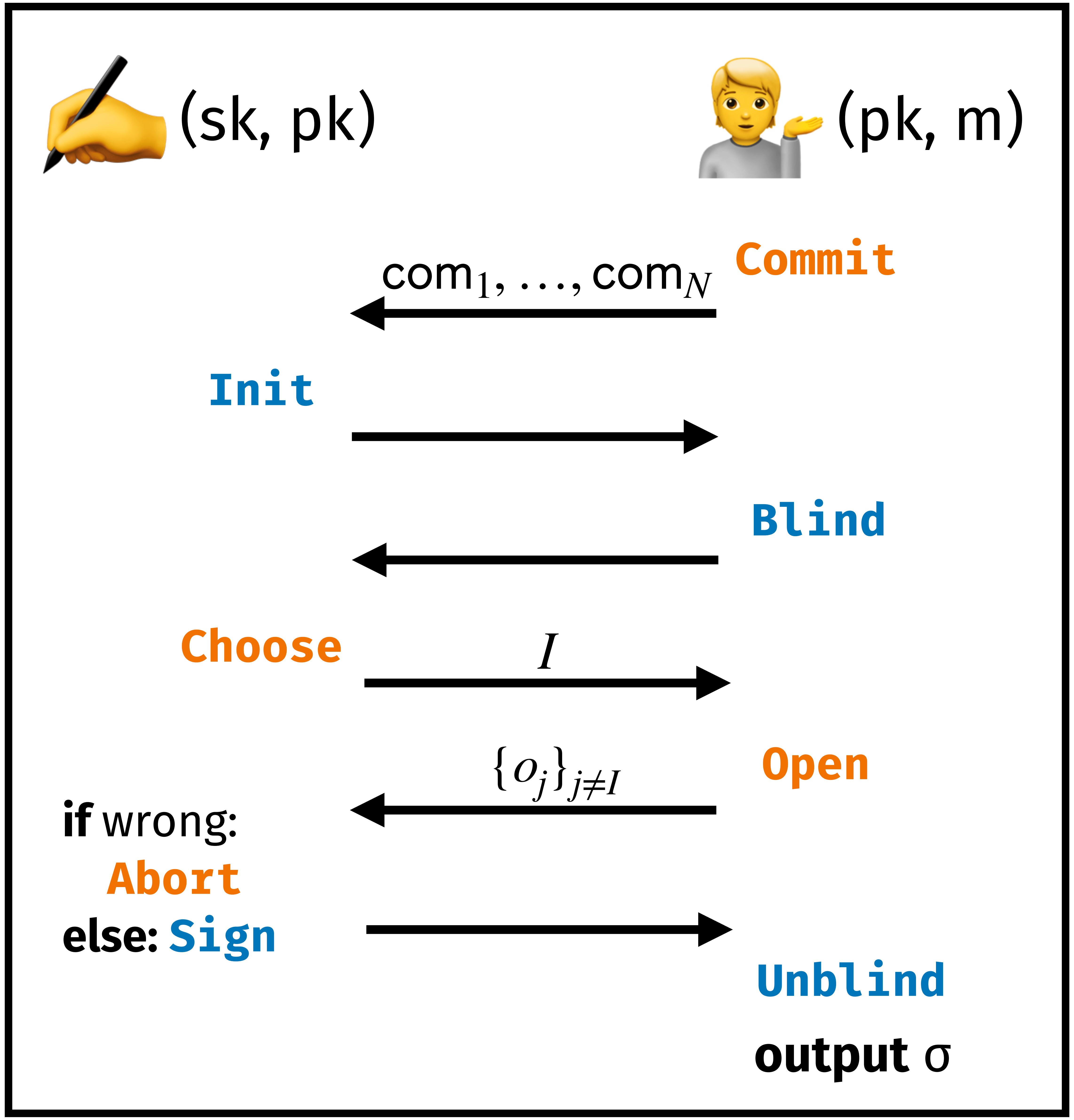

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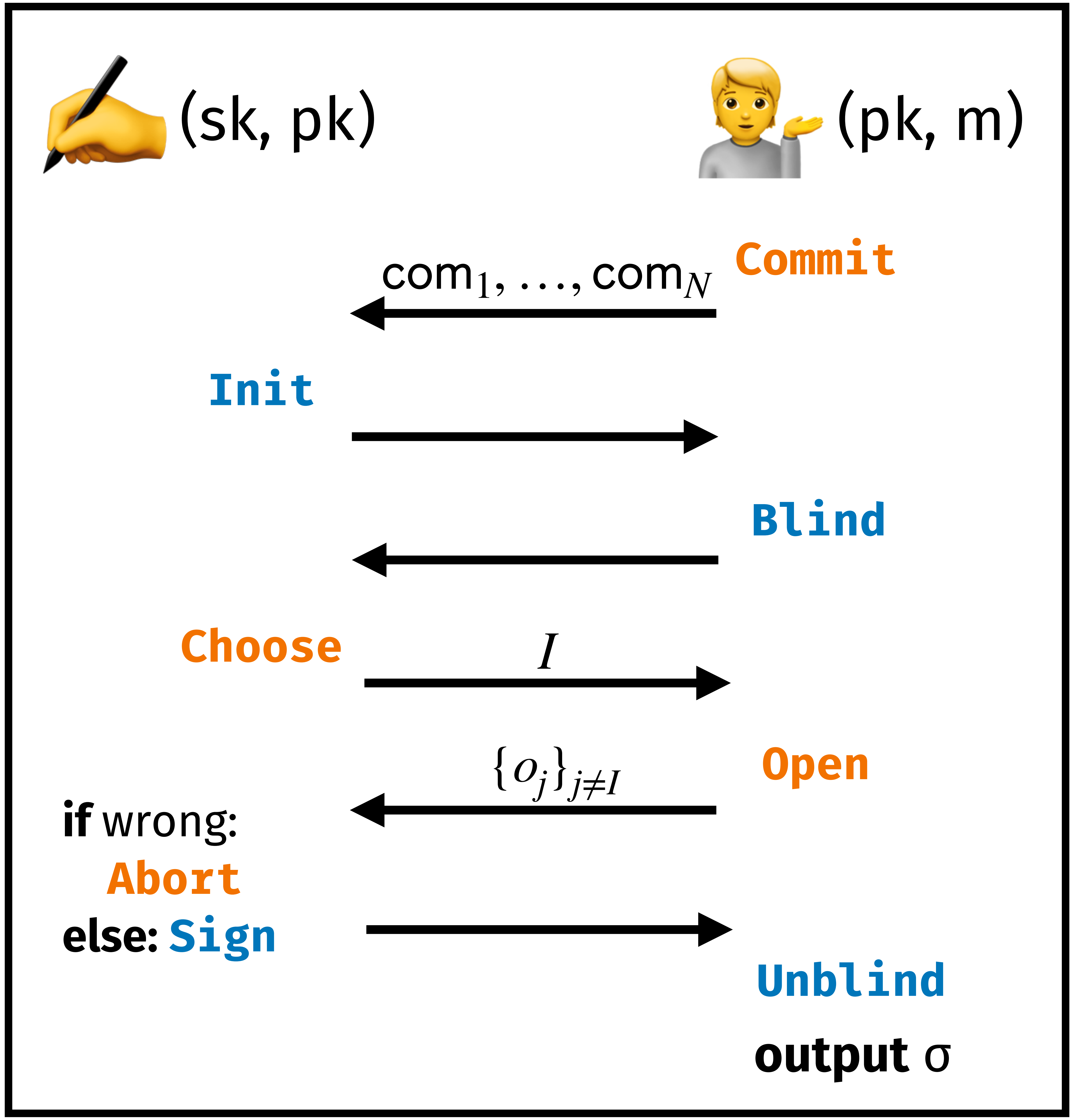

Our Transform

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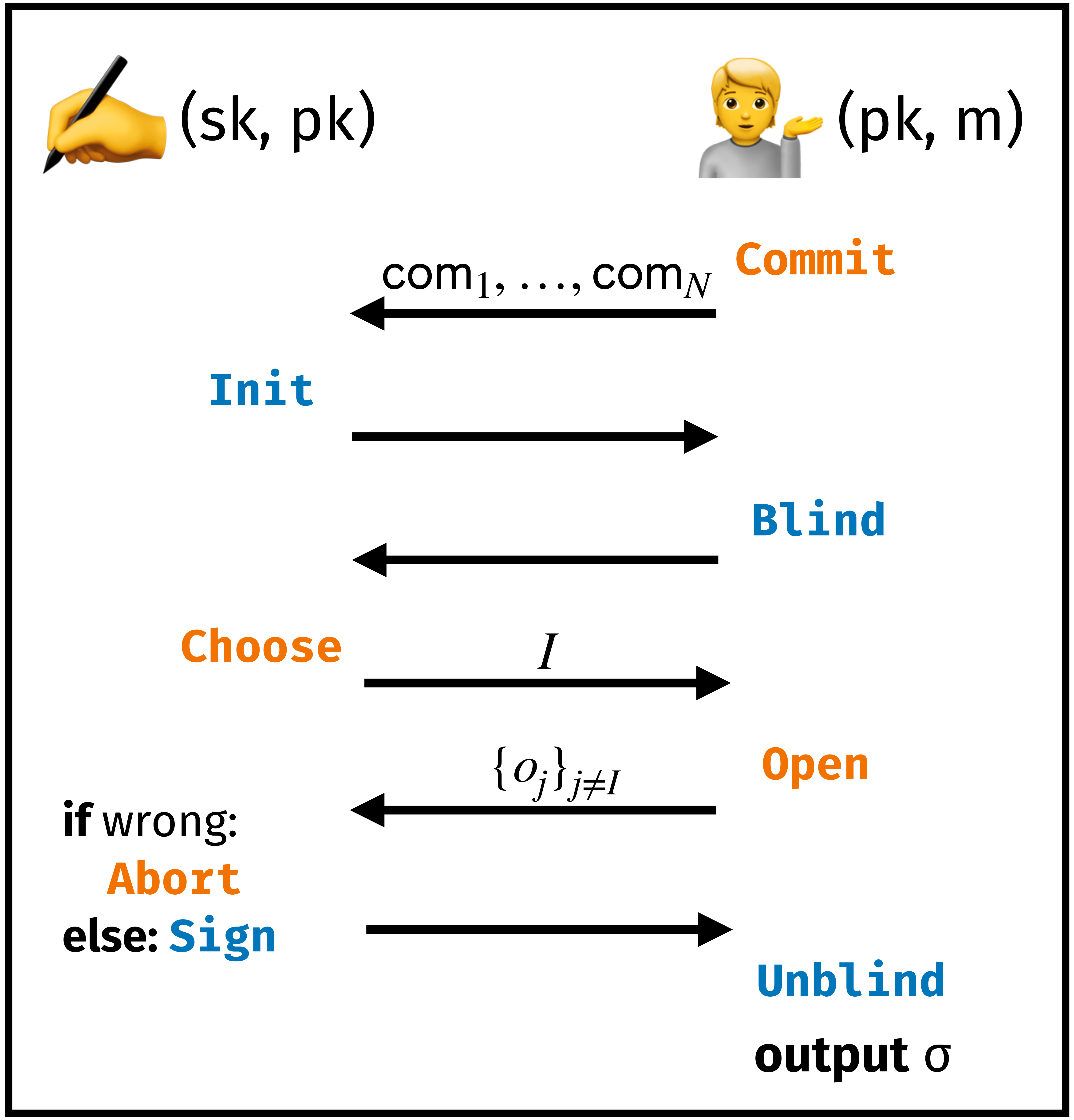

Our Transform

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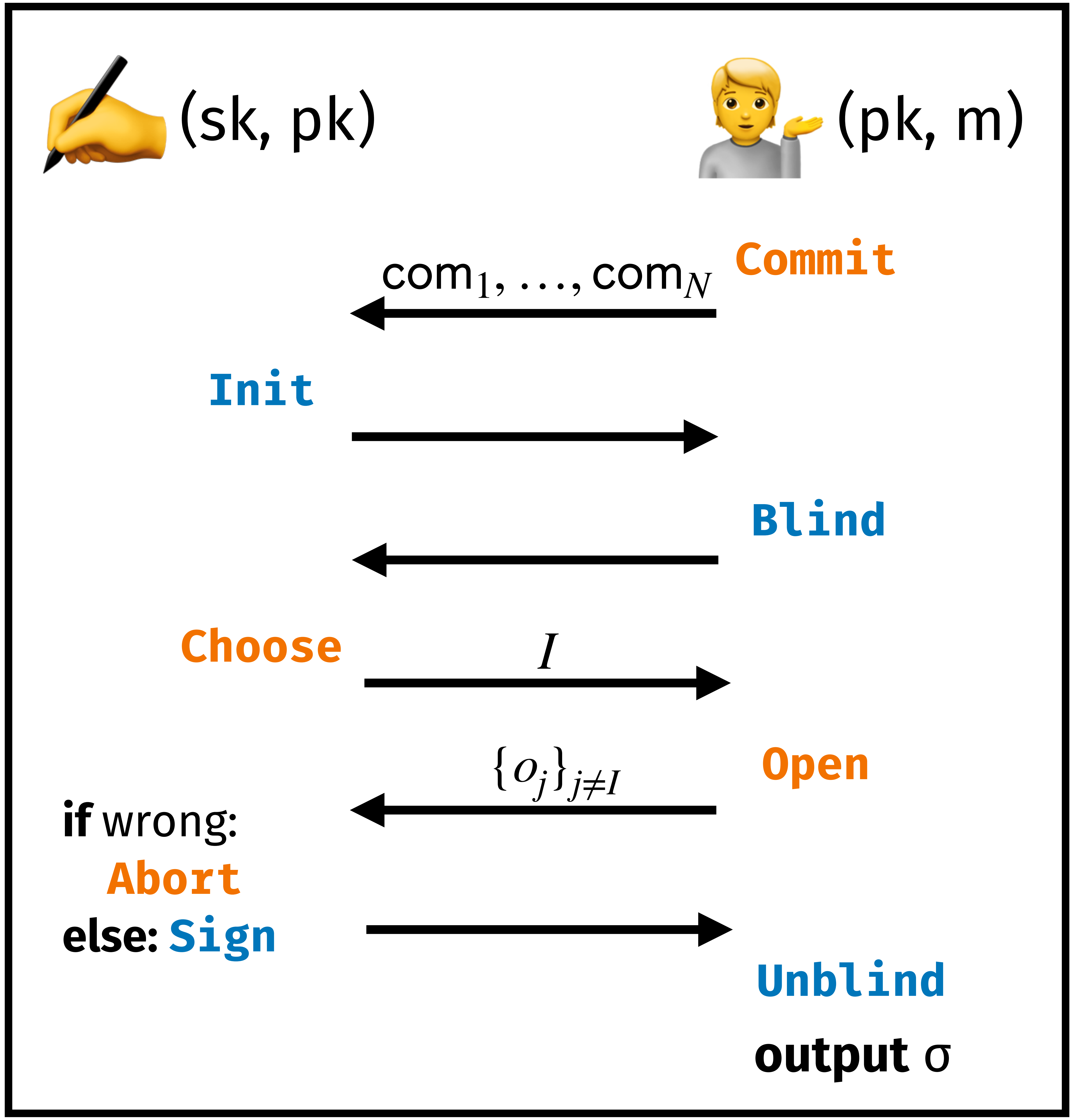

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Thank you!

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