The Wonderful World of Global Random Oracles

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Random Oracles are still practical!

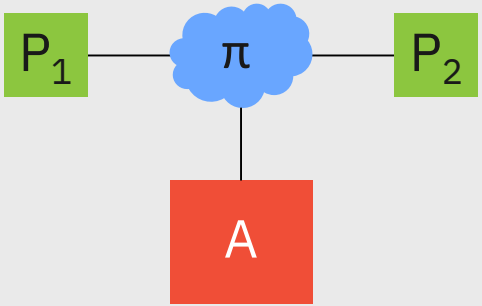
- Bellare & Rogaway ’93
- Model hash function as “random oracle”
  - On new input *m*, sample *h* uniformly from domain and output *h*

- Security proofs for many practical schemes
  - Signatures: Schnorr, RSA-FDH, RSA-PSS, …
  - Encryption: Fujisaki-Okamoto, …
  - Commitments: H(r, m)

- Canetti, Goldreich, Halevi: replacing RO with hash function does not guarantee security

UC Framework (Canetti ‘00)

Real world



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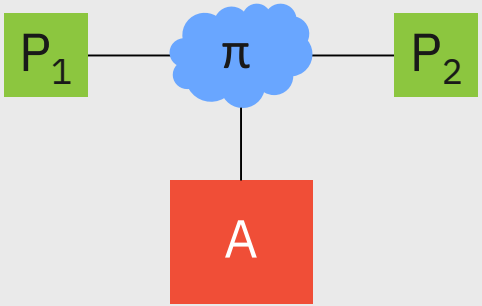

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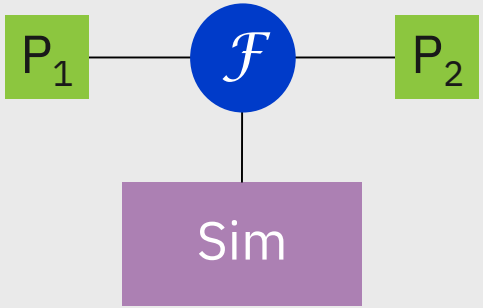

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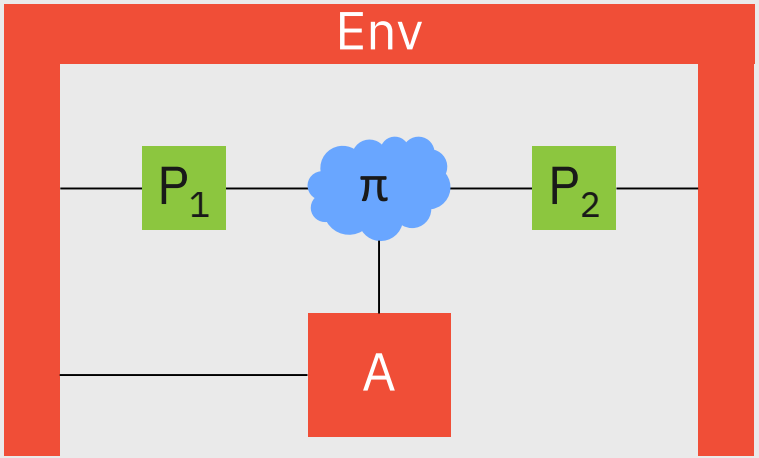

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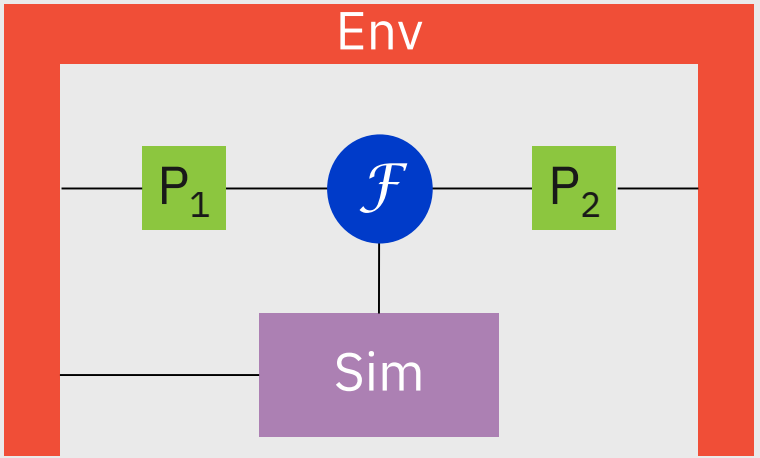

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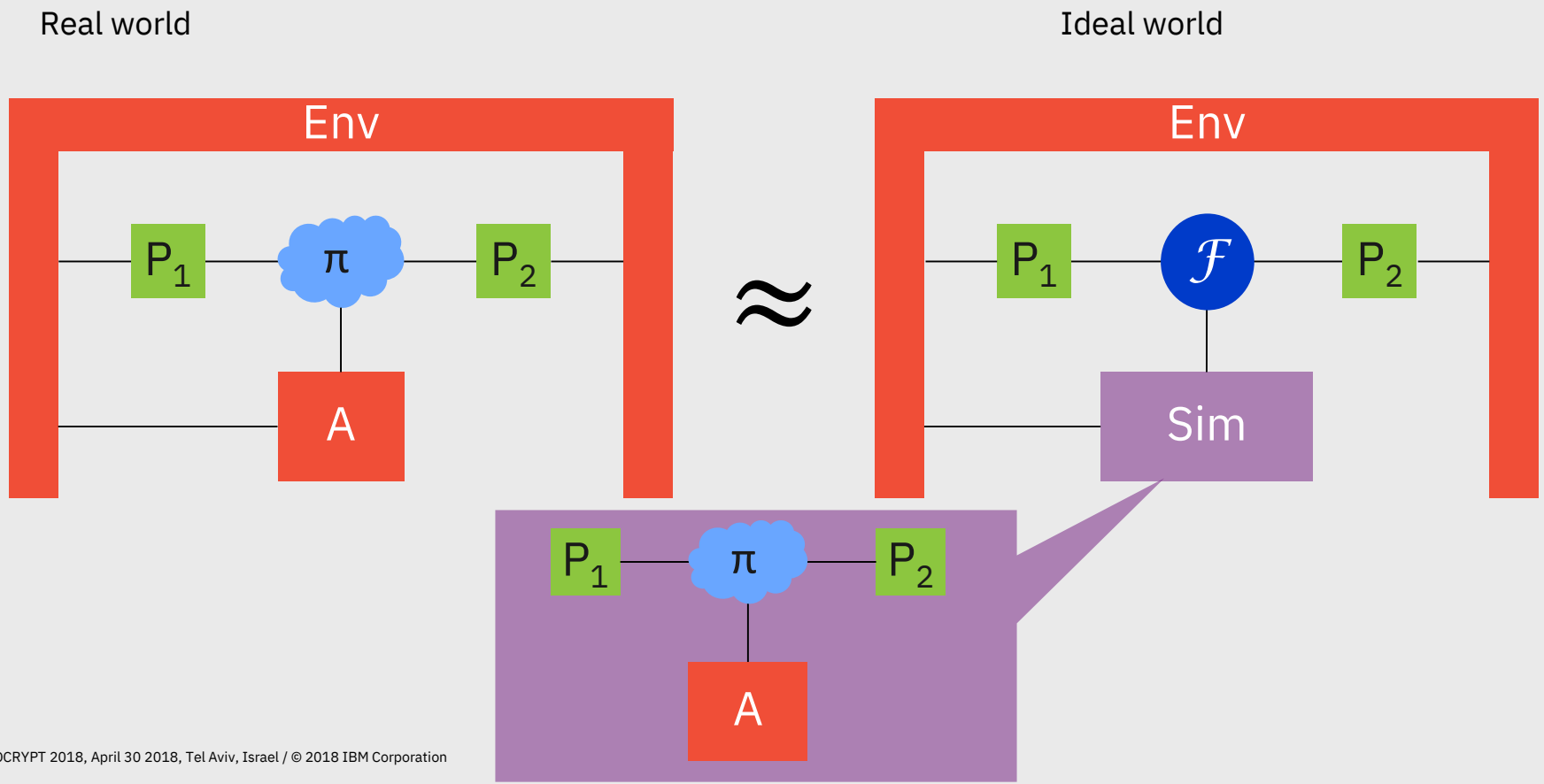

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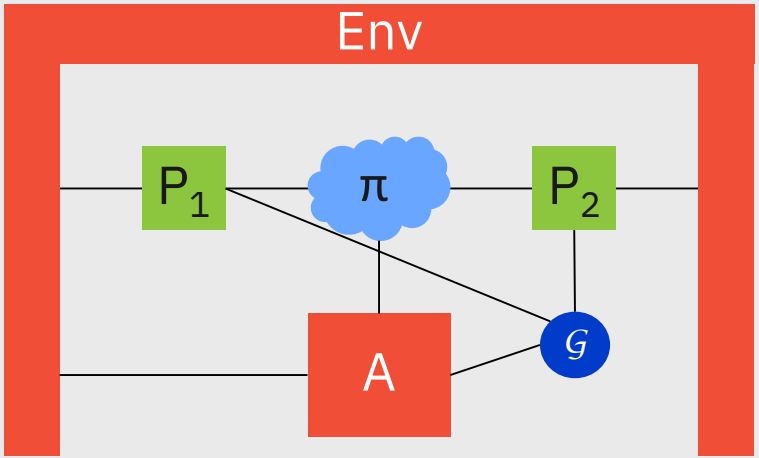
Real world with Hybrid $\mathcal{G}$



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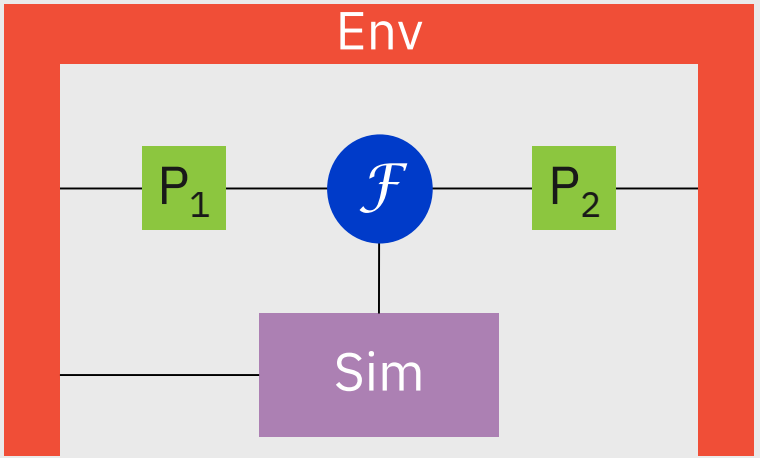

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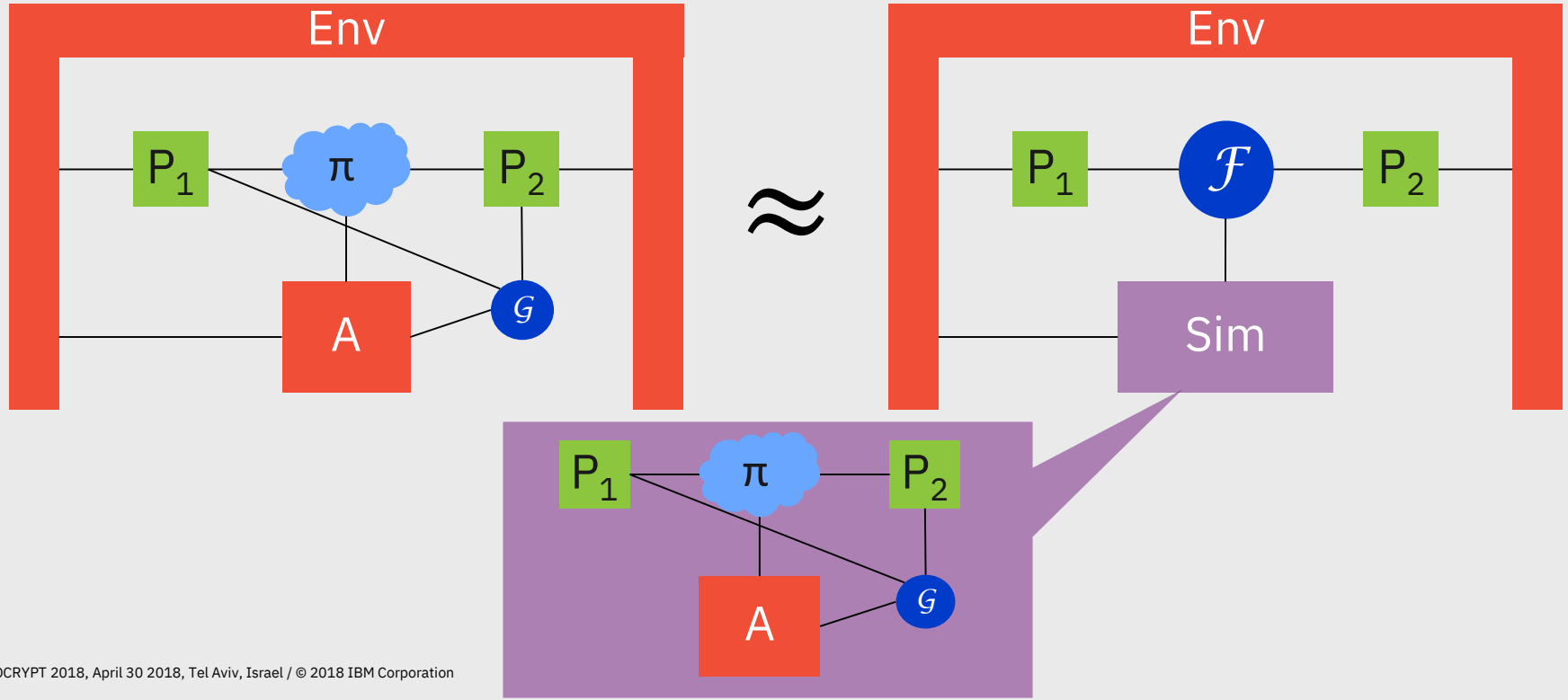

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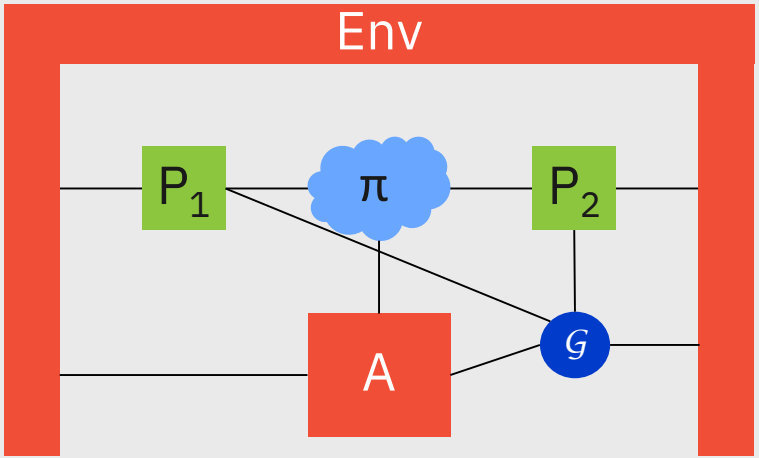

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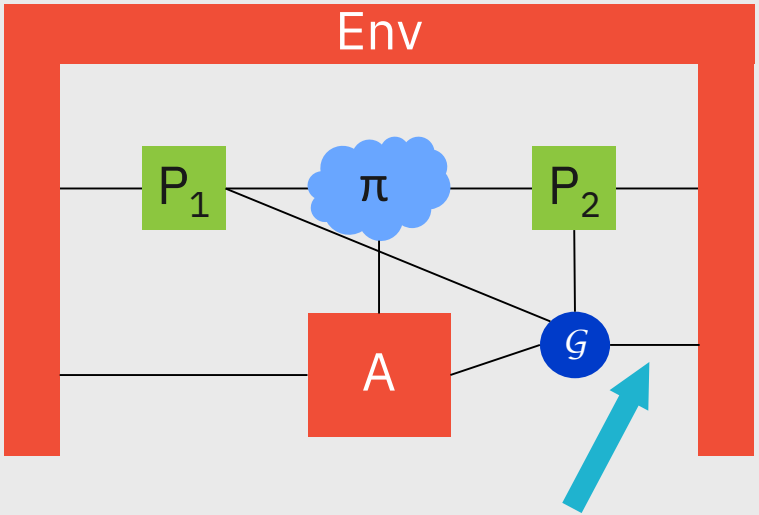

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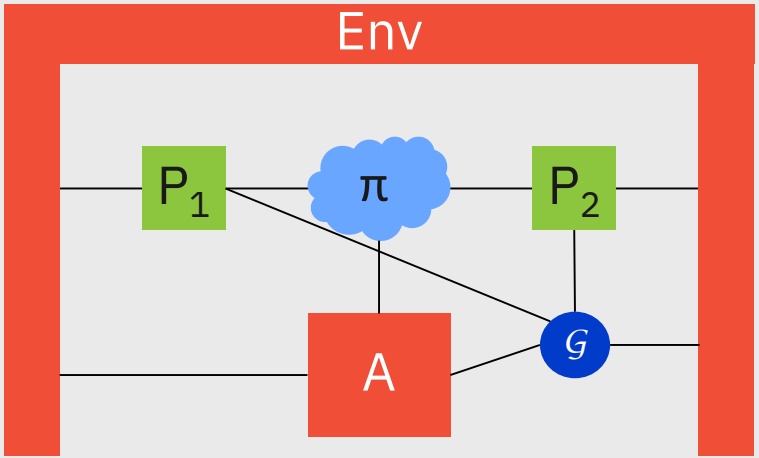

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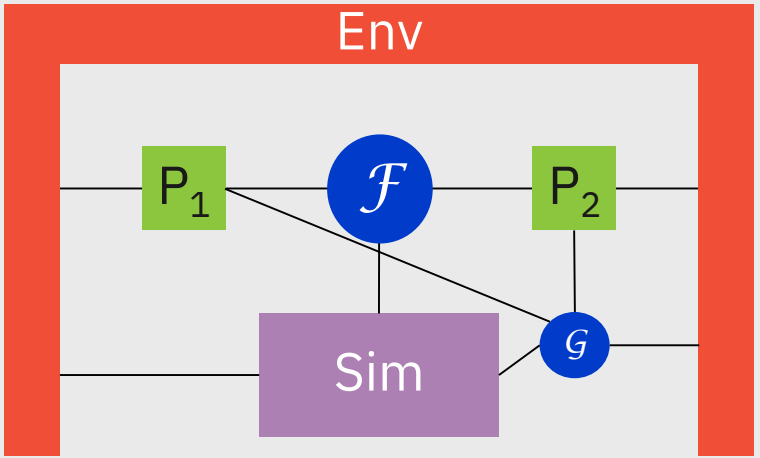

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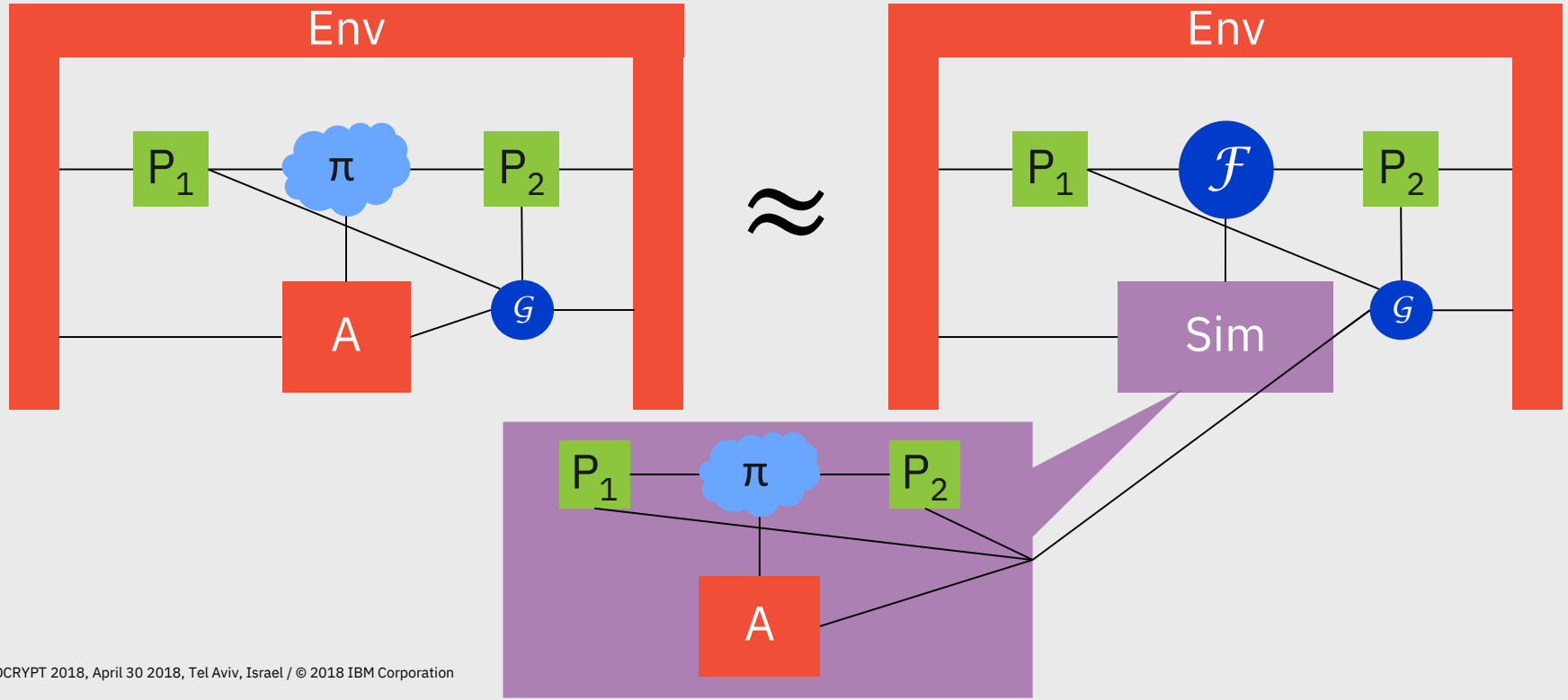

Global Random Oracles in UC

- Random oracle should model single hash function
- Canetti, Jain, Scafuro ‘14: Global RO in GUC
  - UC commitment from observable global RO
  - Definition of RO is quite involved
  - Most efficient schemes cannot be proven secure in their model

- What can we do with a natural global RO?
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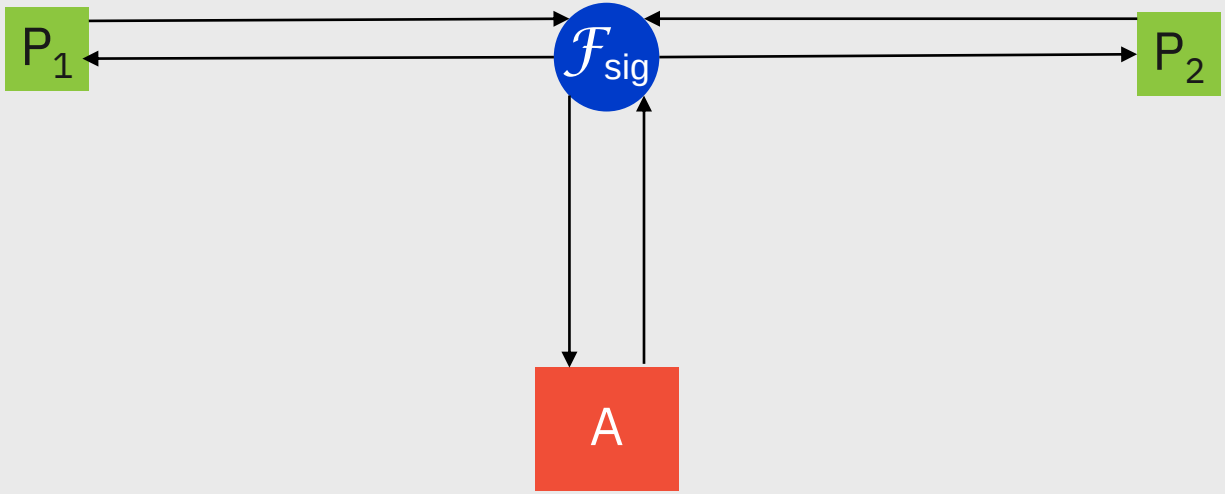
First result: Any EUF-CMA signature scheme in the ROM is a UC secure signature scheme with a strict global RO

Signatures in UC



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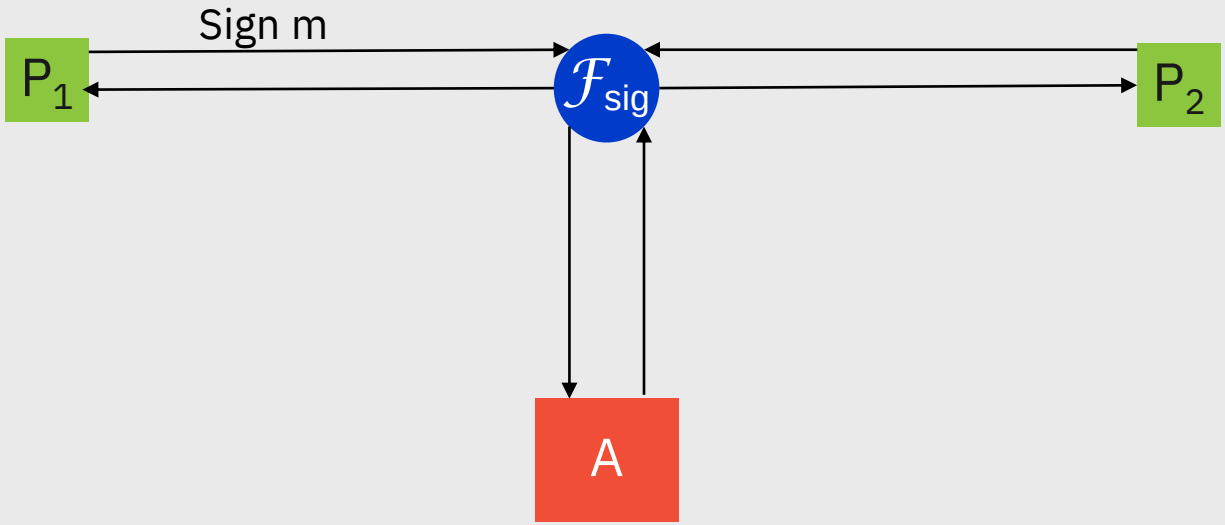

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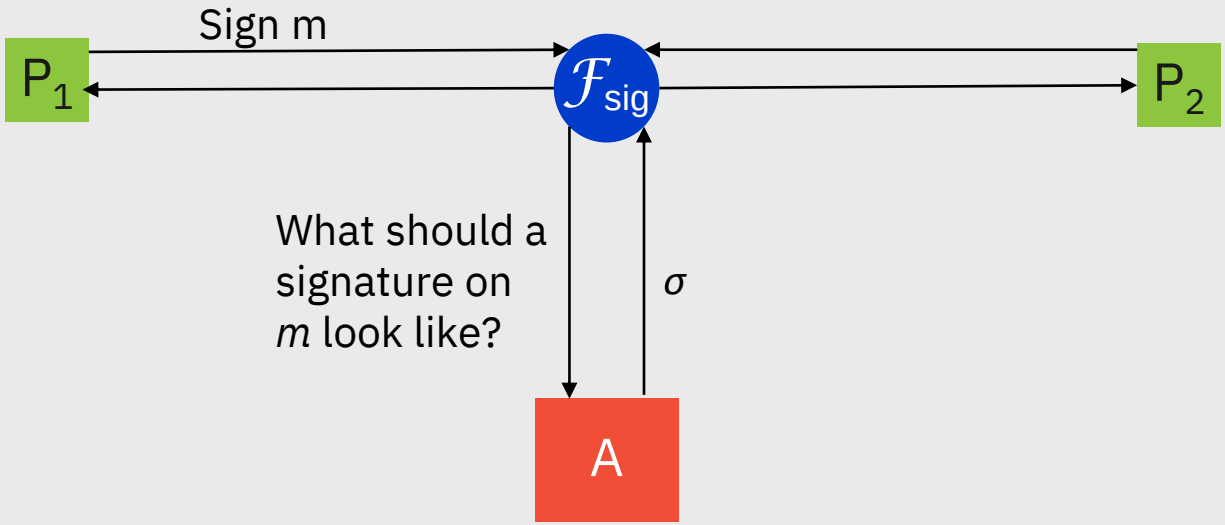

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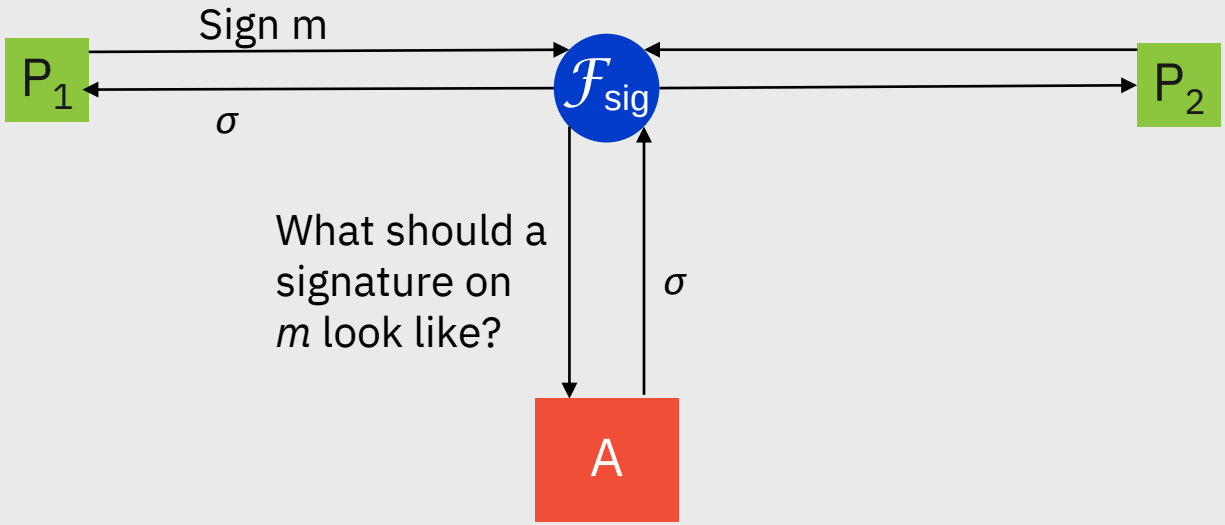

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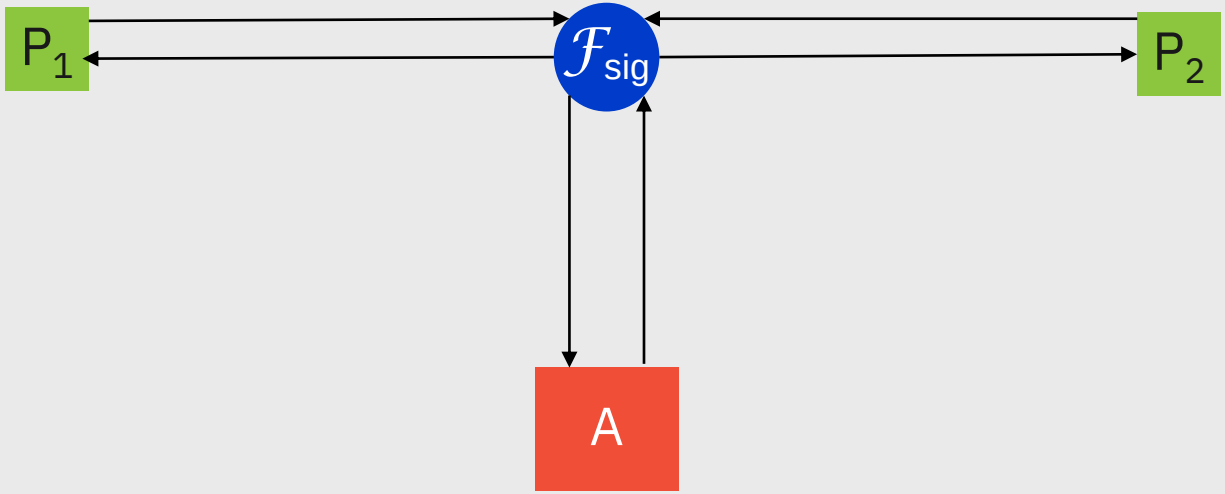

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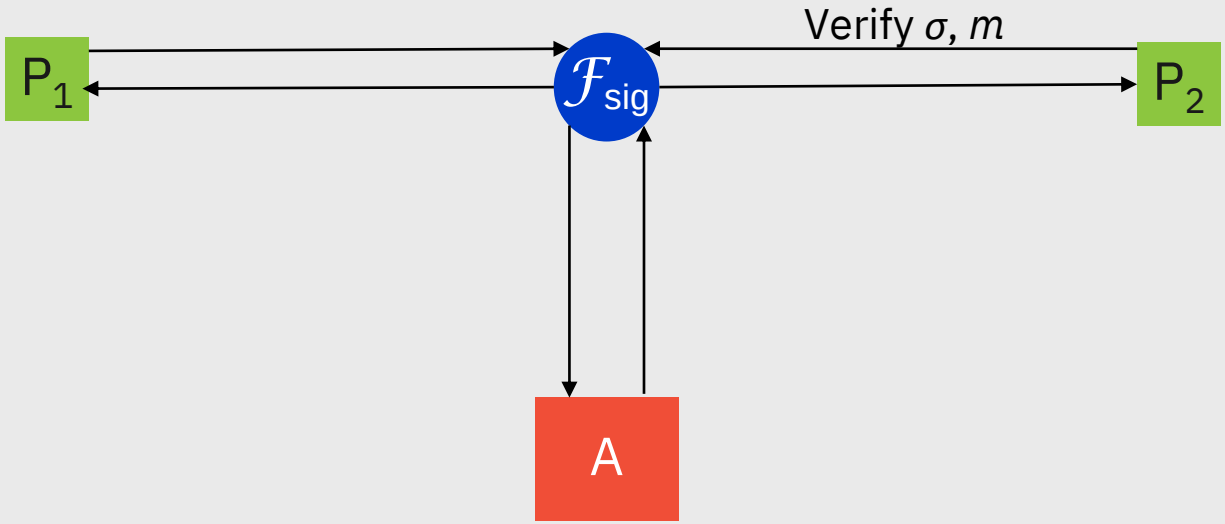

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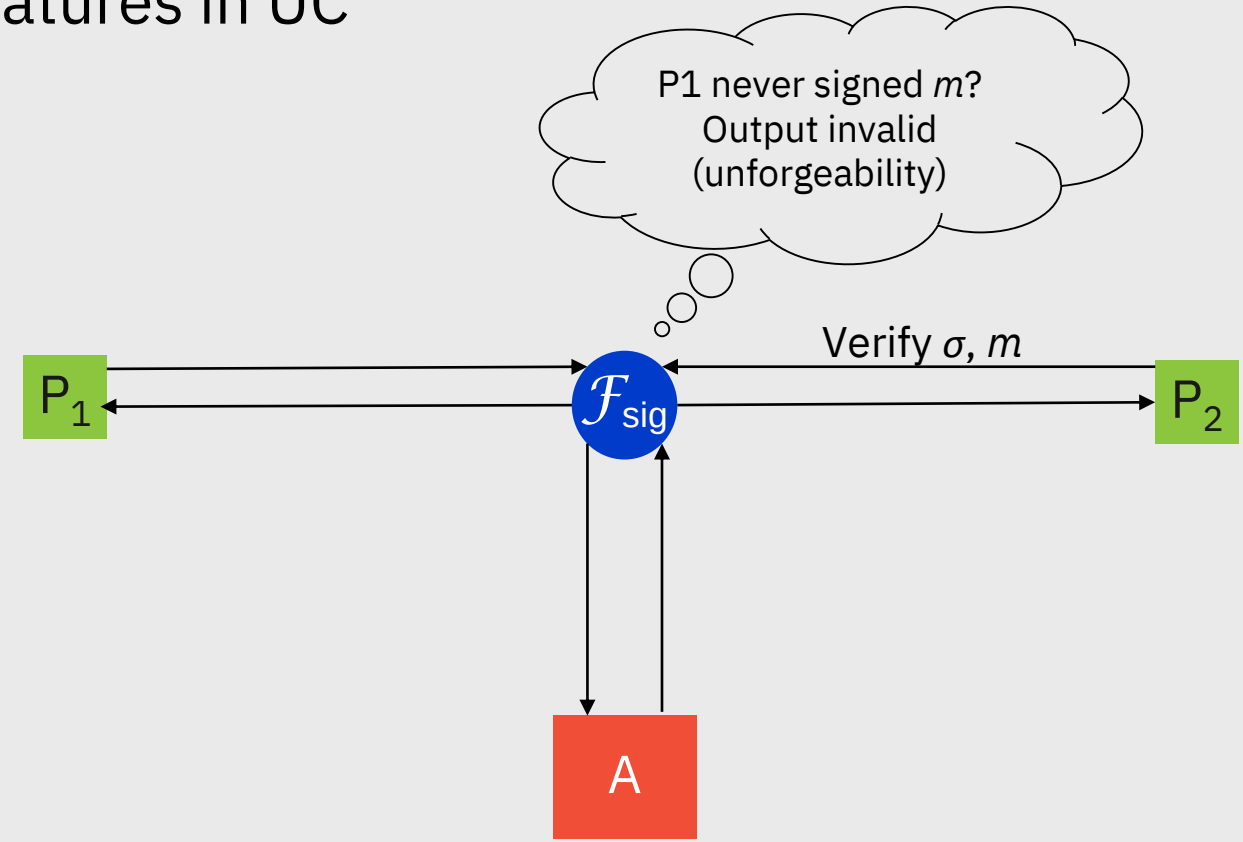

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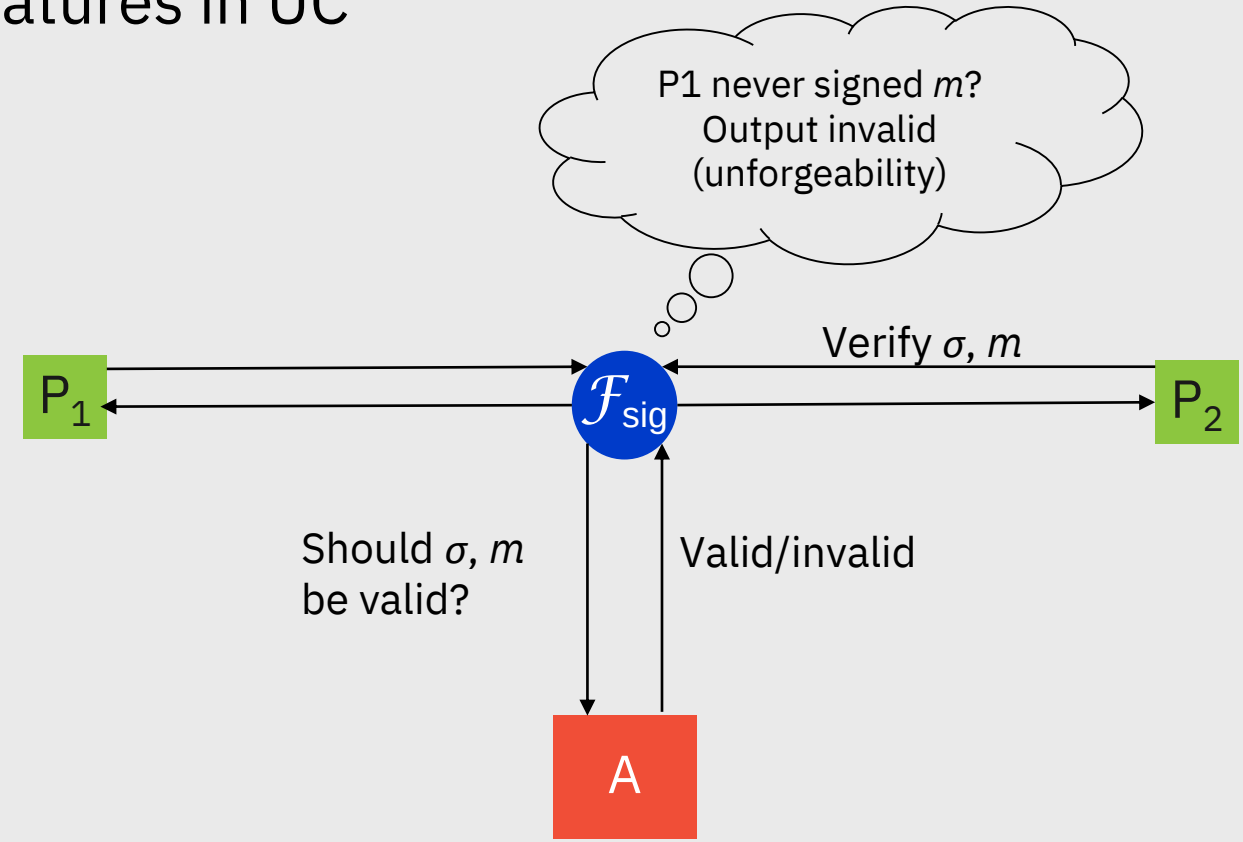

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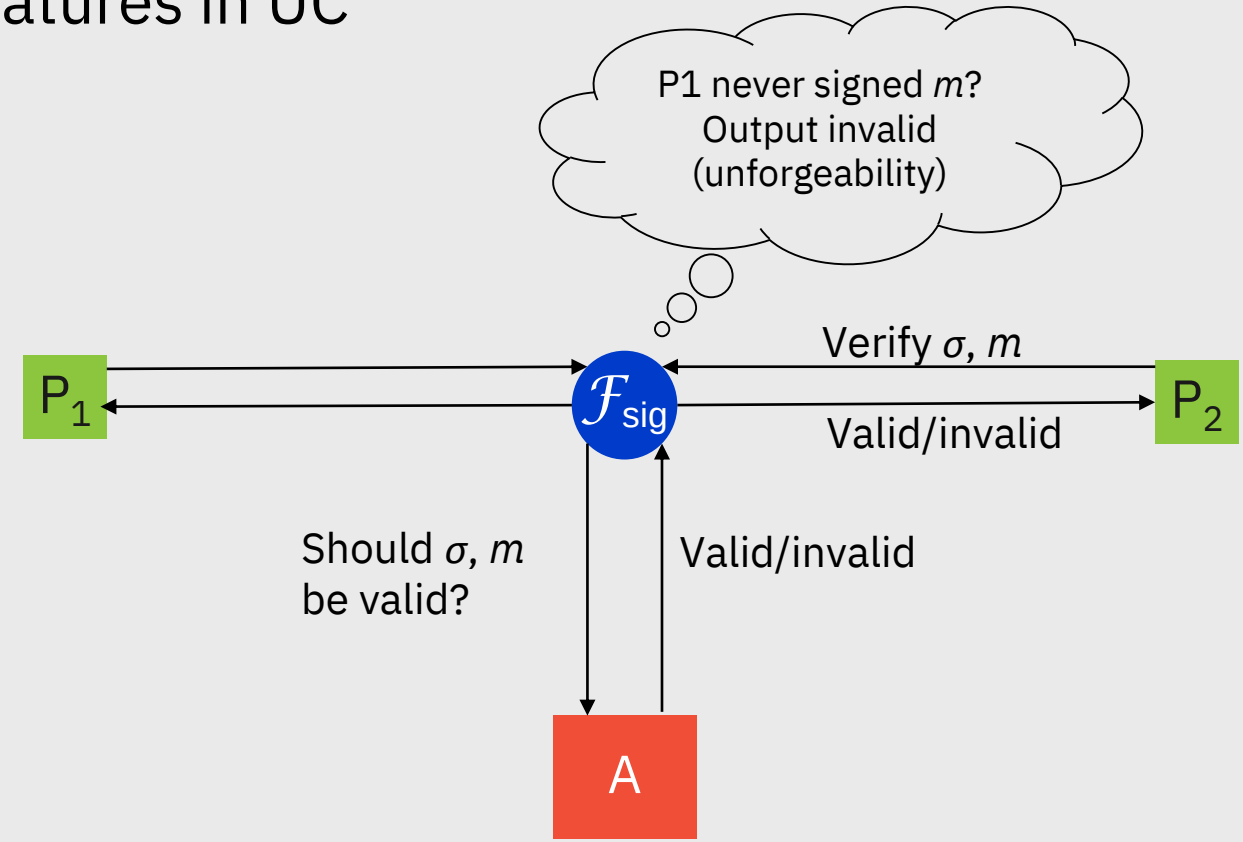

Signatures from strict global RO: simulator

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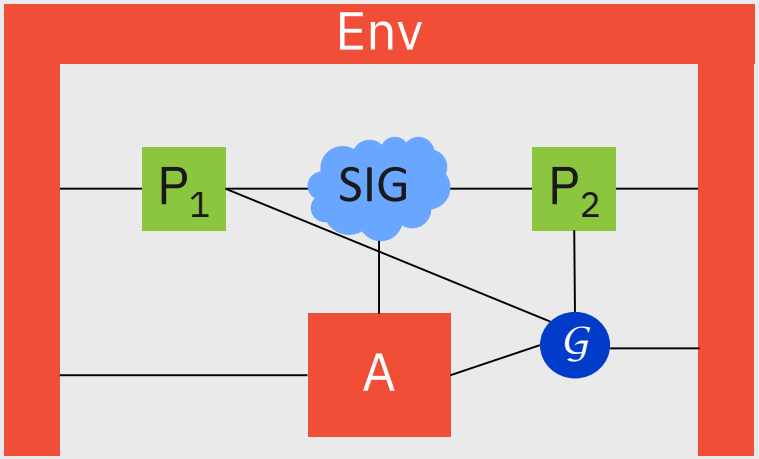

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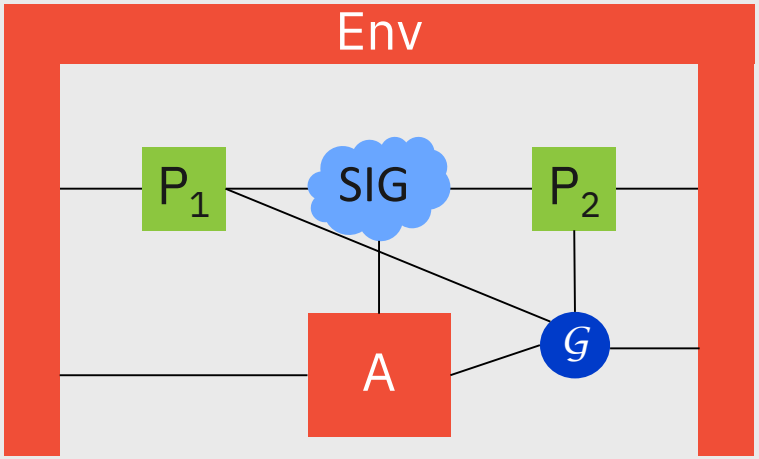

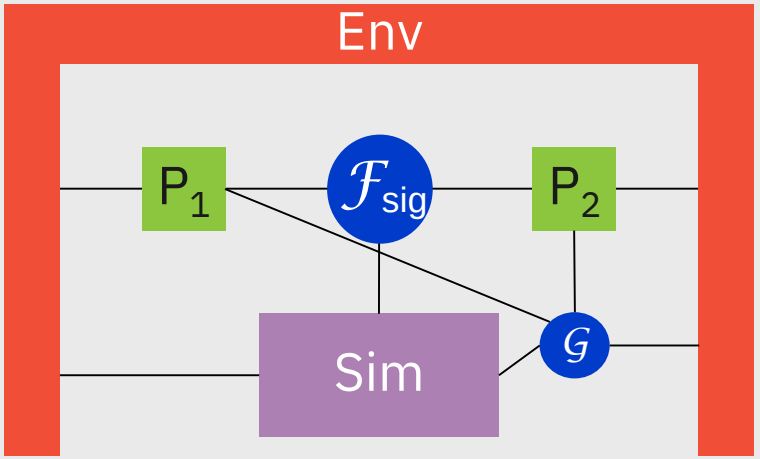

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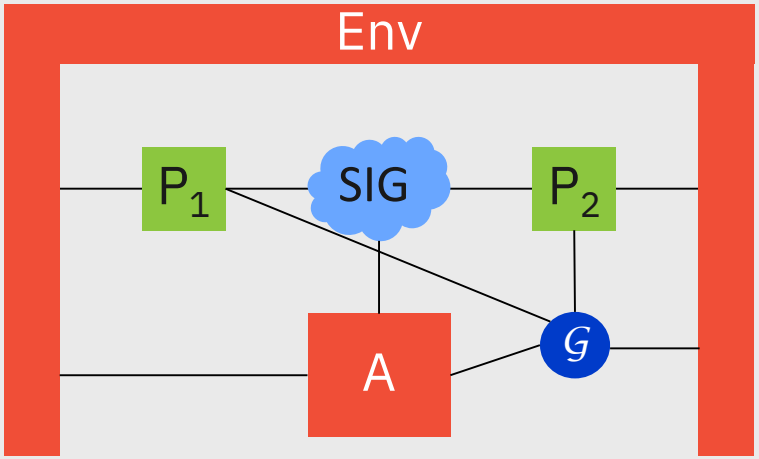

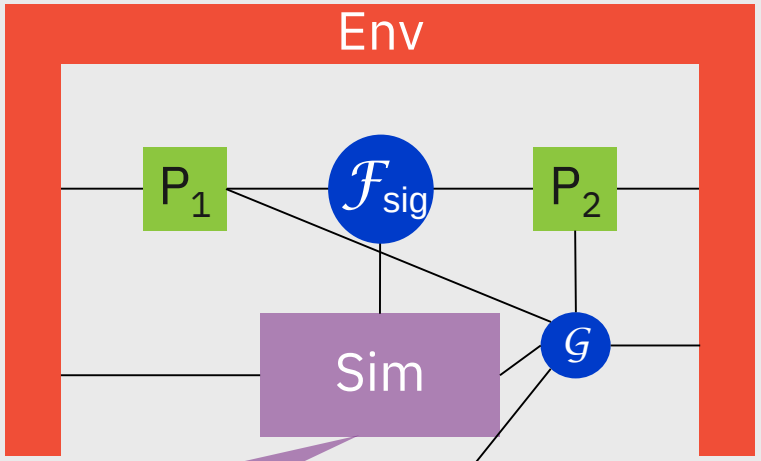

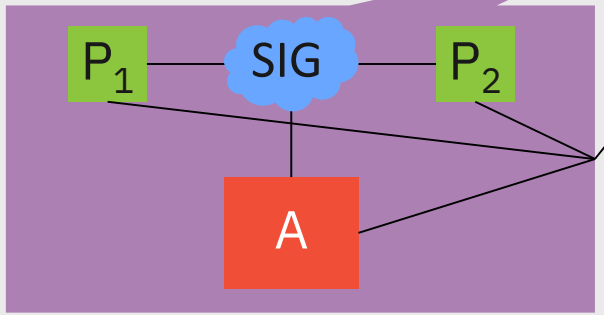

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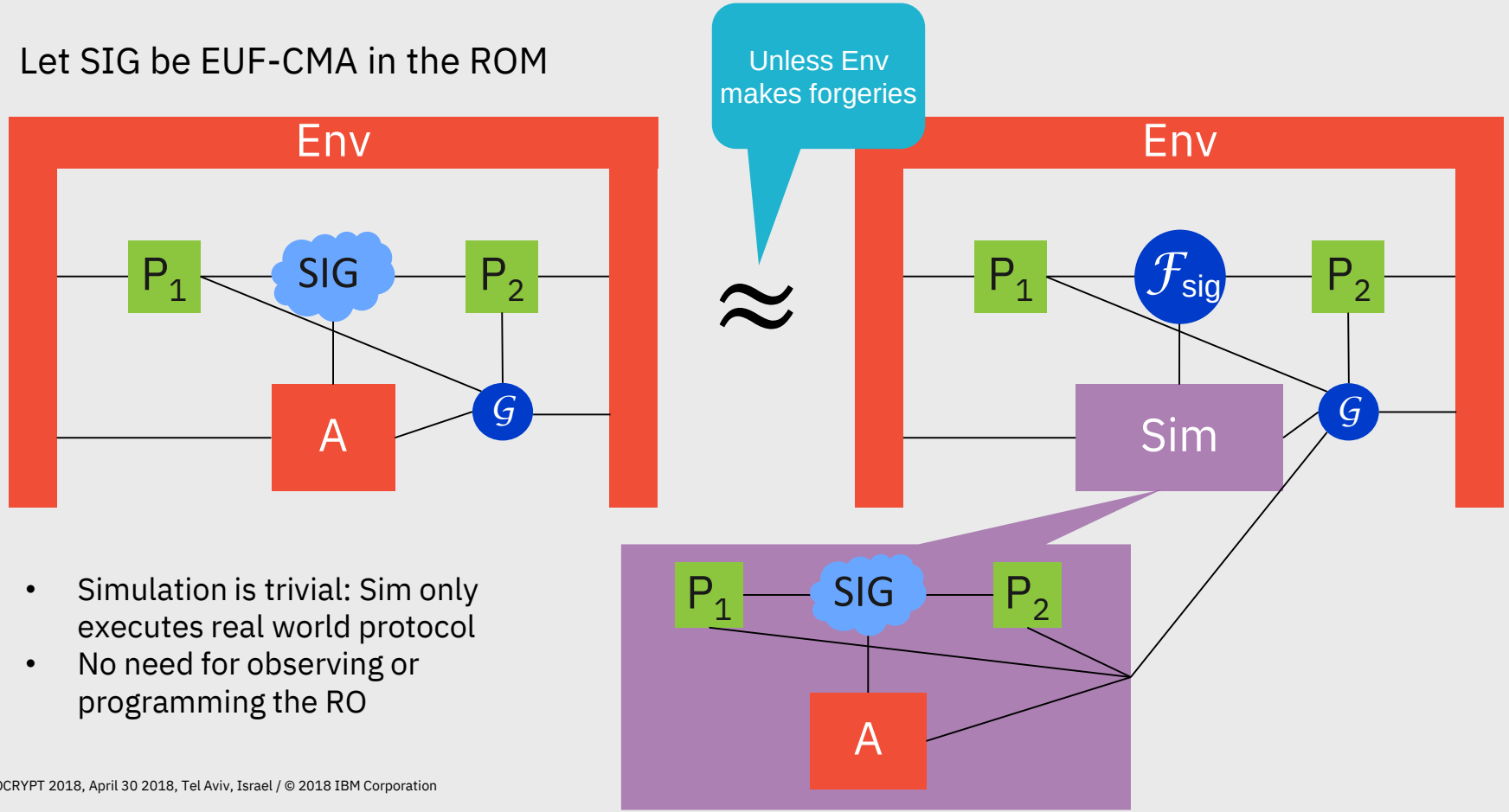

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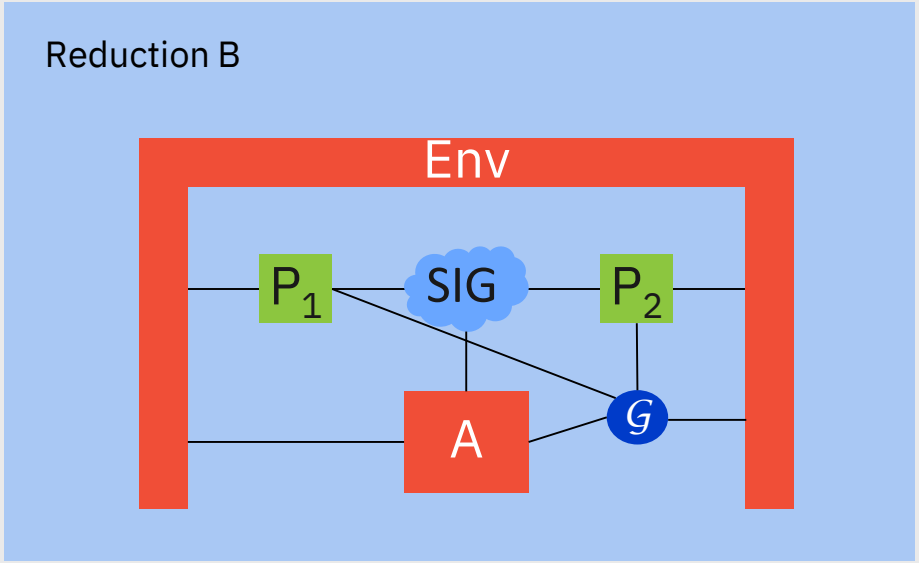
- B breaks EUF-CMA of SIG



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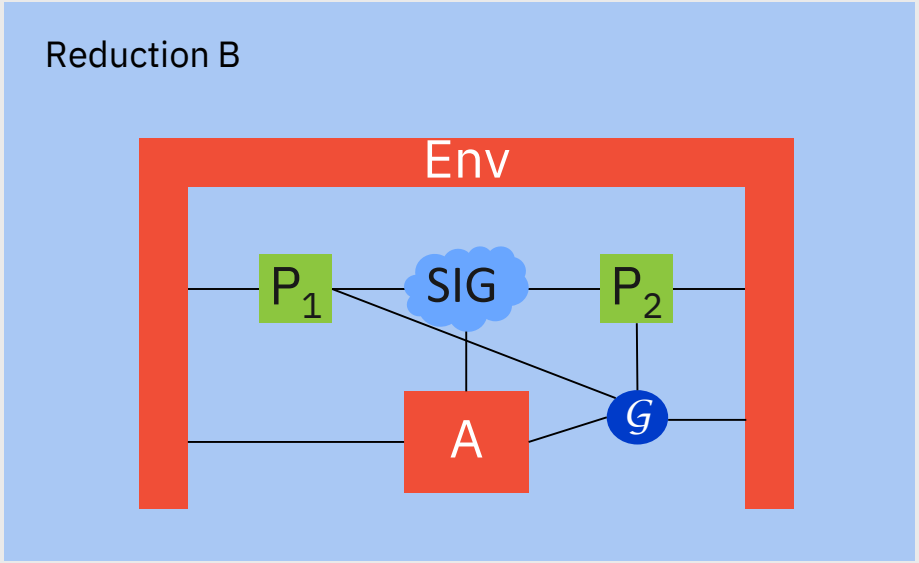

- This works, because Sim does not need observability/programmability
- Similar results for CCA2-PKE in ROM

• Adaptively secure PKE (non-committing encryption)

- Simulator needs programmability (Nielsen, Crypto ‘02)
- Define programmable global RO with explicit “program” interface
- Camenisch et al. (CSF ‘17) secure with programmable global RO

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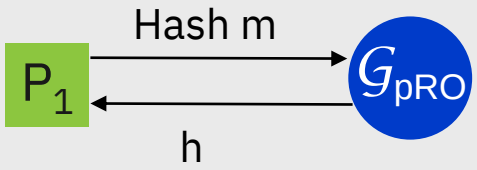

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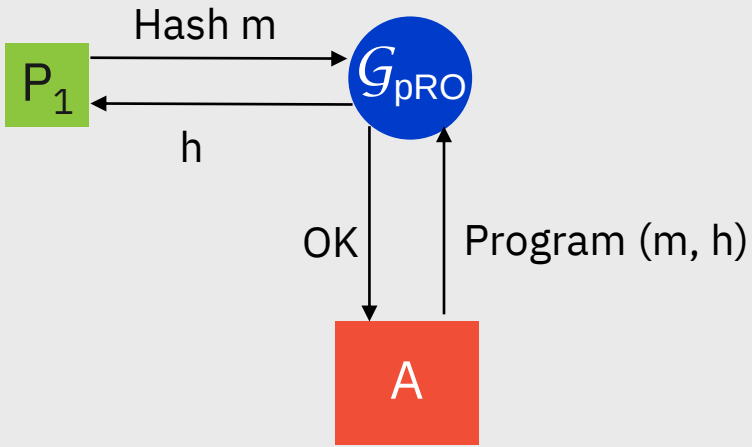

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- Simulator needs extra power (Canetti, Fischlin 01)
- CJS14
  - “Restricted” Observable RO
  - 2 round commit and 2 round opening
- What about $c = H(r, m)$

- Extend Restricted observable RO with restricted programmability
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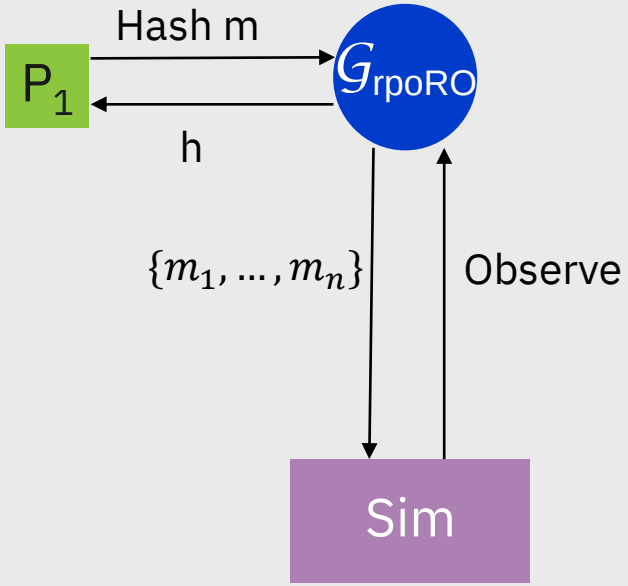

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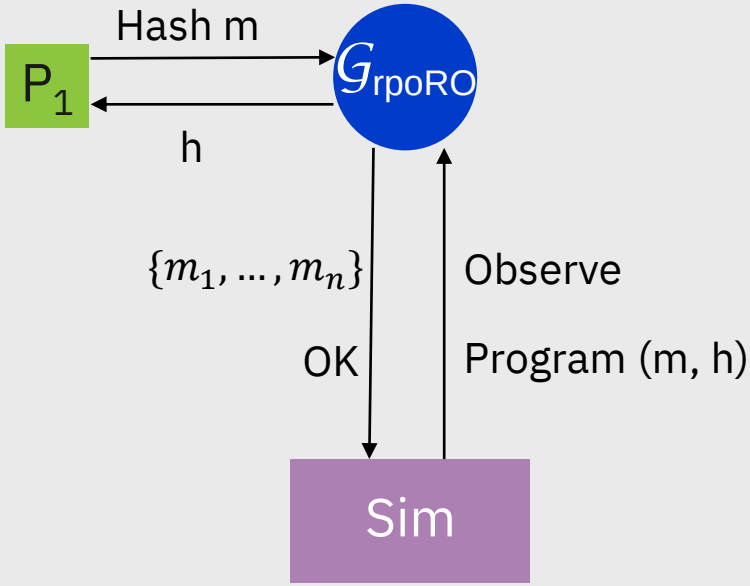

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Signatures,
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Programmable GRO
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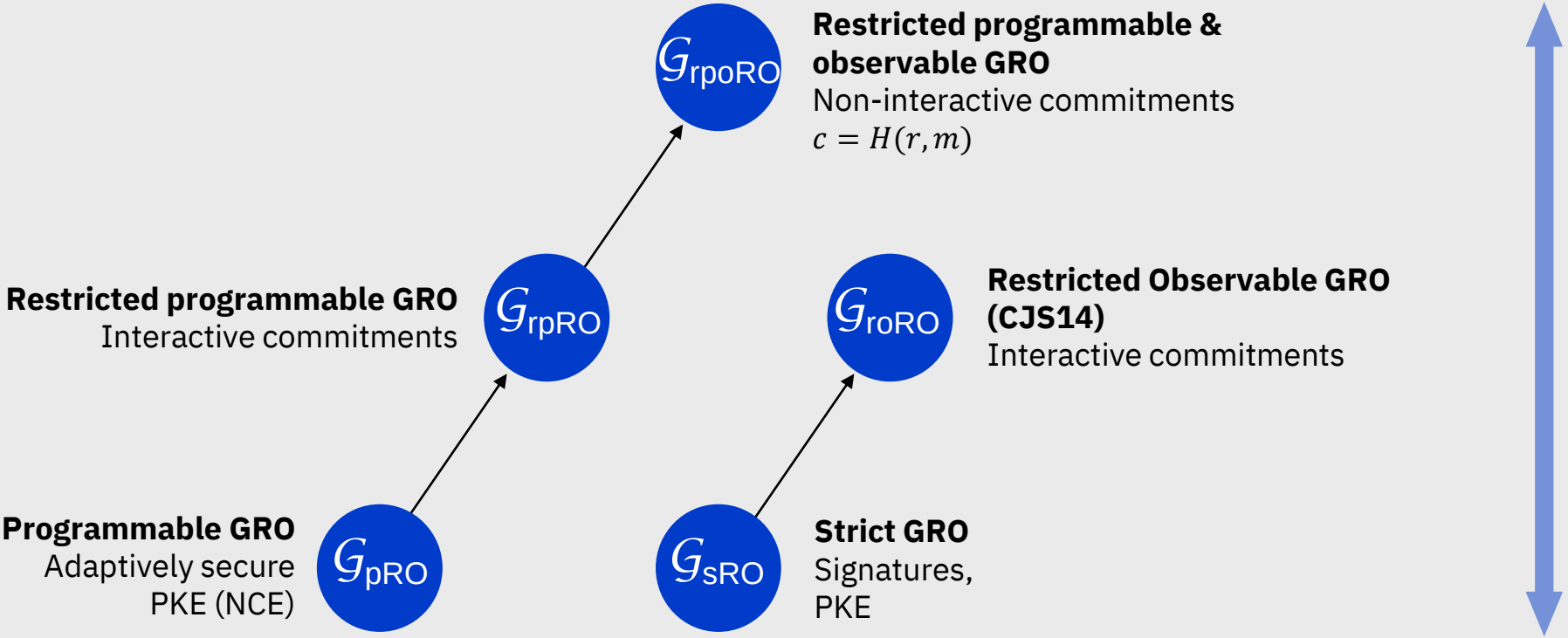

More natural modeling
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