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THE ART OF POSSIBLE

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History-Free Sequential Aggregation of Hash-and-Sign Signatures

#RSAC

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Aggregate Signatures

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- Reduce bandwidth consumption
- Constrained devices
- Certificate chains
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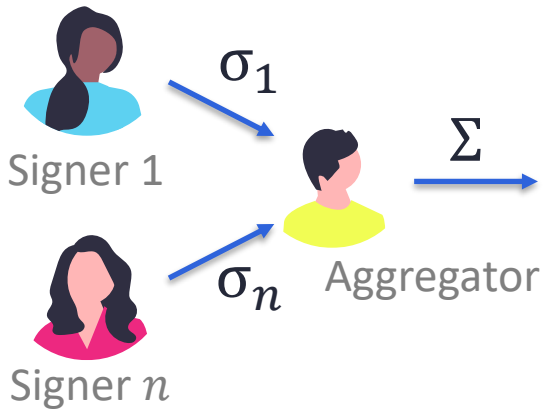
- General Aggregate Signature (AS)
  - Public aggregation by third party
  - No interaction required by signers
  - Construction based on bilinear pairings [BGLS03]



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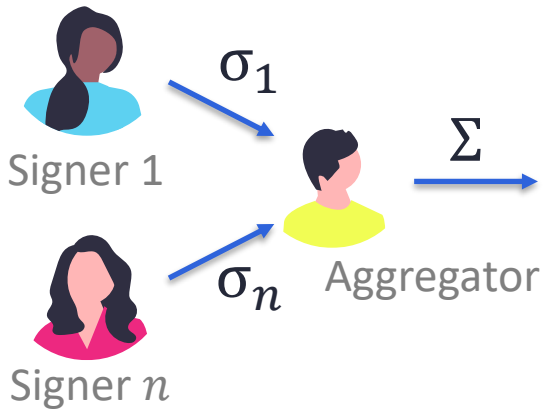

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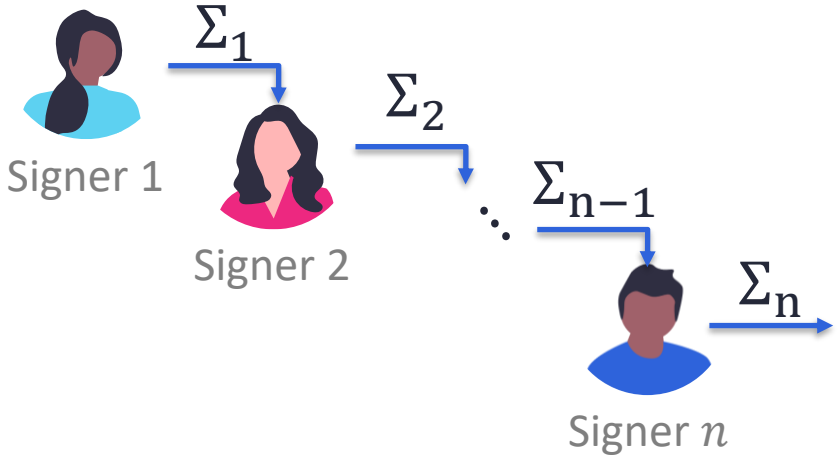

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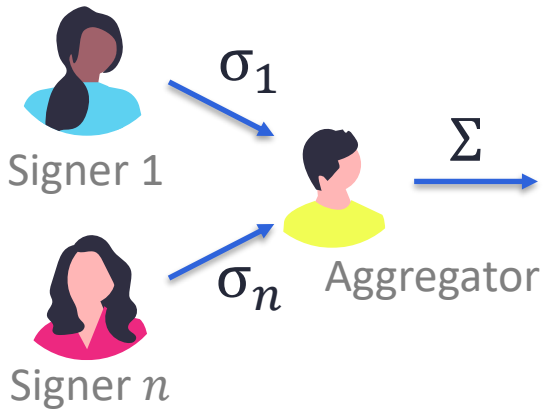

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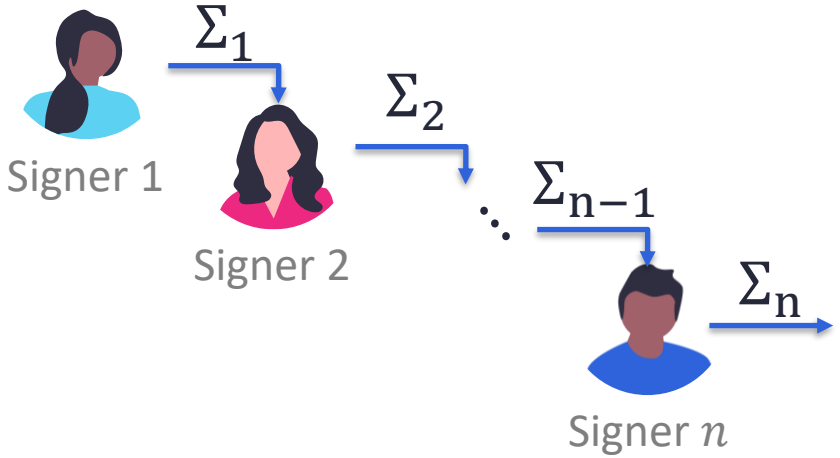

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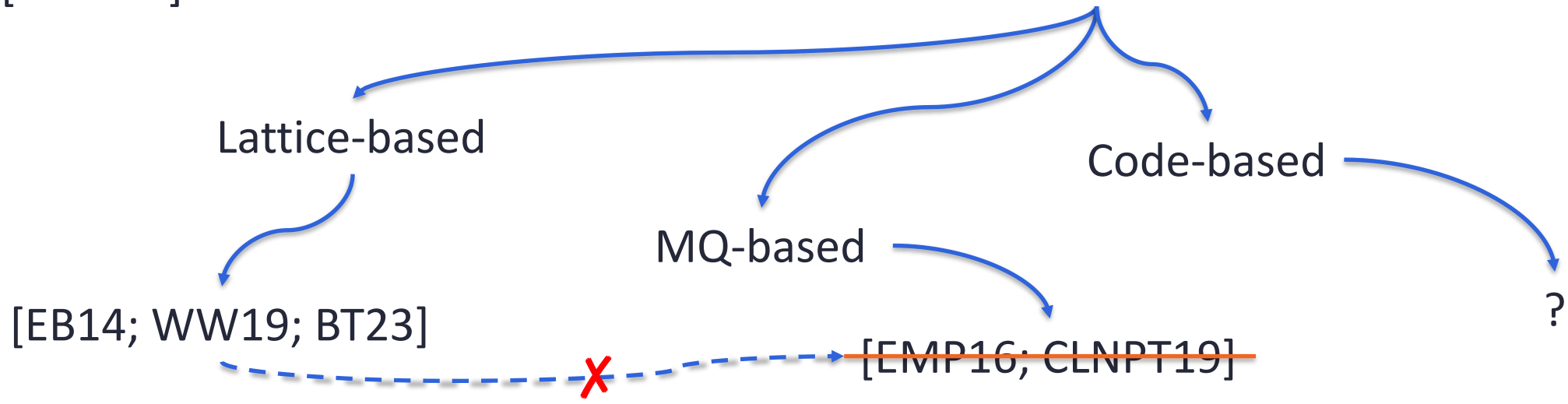

Can (S)AS be built from post-quantum assumptions? Yes, from lattices

SAS from Trapdoor Permutation

Full Domain Hash (FDH) signature from trapdoor permutation $\pi: \mathcal{X} \rightarrow \mathcal{X}$ and a suitable hash function $H: \{0,1\}^* \rightarrow \mathcal{X}$.

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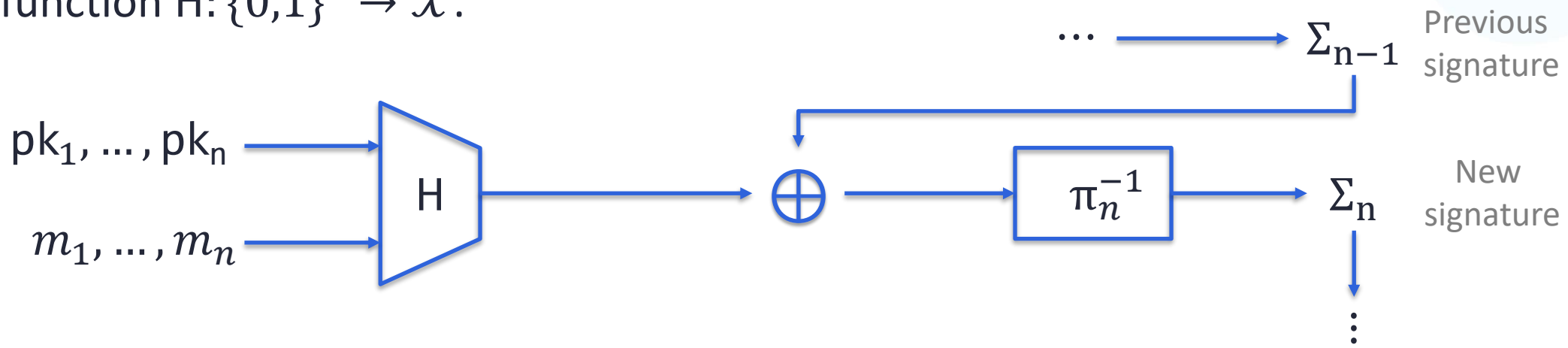

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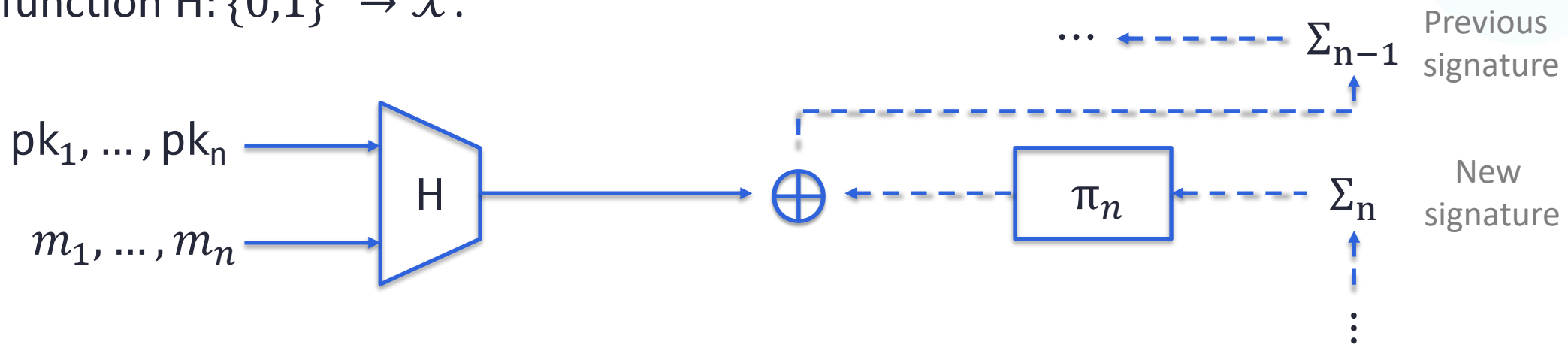

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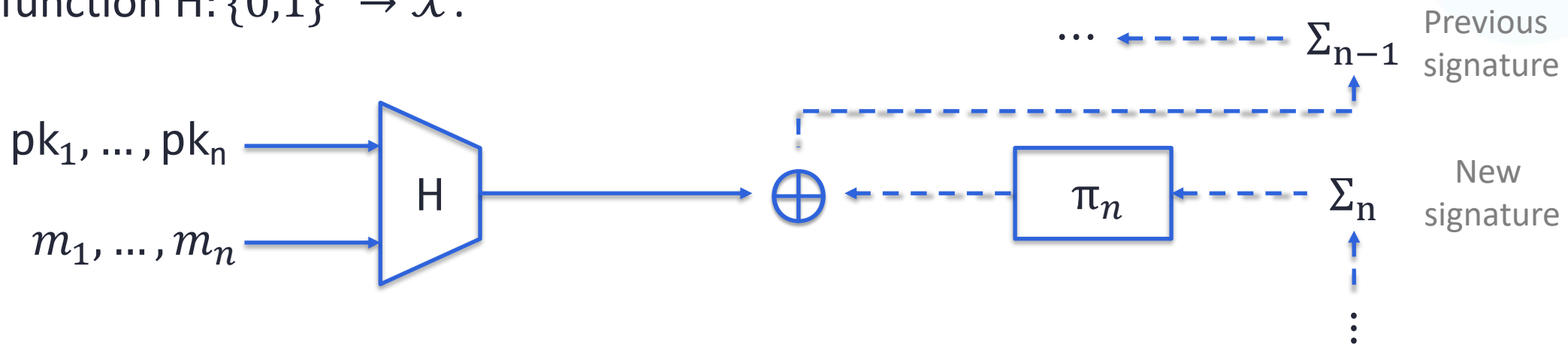

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Rigid transposition of FDH approach to post-quantum assumptions is impractical

Trapdoor Functions

A trapdoor function (TDF) is a tuple of three algorithm $(\mathrm{TrapGen}, \mathrm{F}, \mathrm{I})$:

- $\mathrm{TrapGen}(1^{\lambda})$: takes as input a security parameter 1^{λ} and generates an efficiently computable function $\mathrm{F}: \mathcal{X} \to \mathcal{Y}$ and a trapdoor I that allow to invert F.

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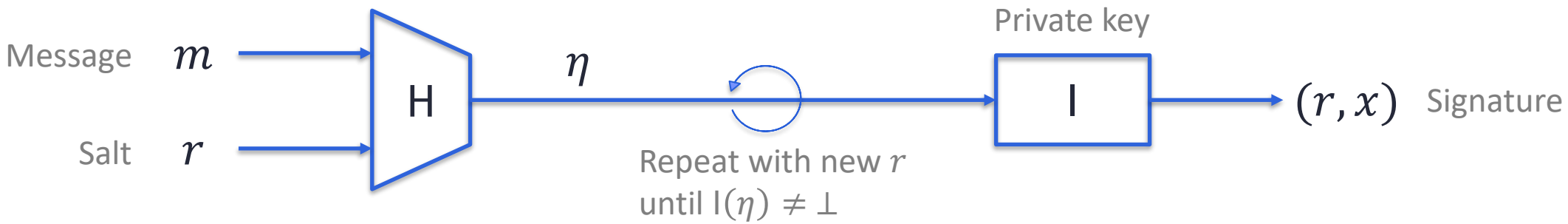
We can regain provable security using the probabilistic hash-and-sign with retry approach.

Probabilistic Hash-and-Sign with Retry

Signature from trapdoor function (F, I) and a suitable hash function $\mathsf{H}: \mathcal{X} \to \mathcal{Y}$.



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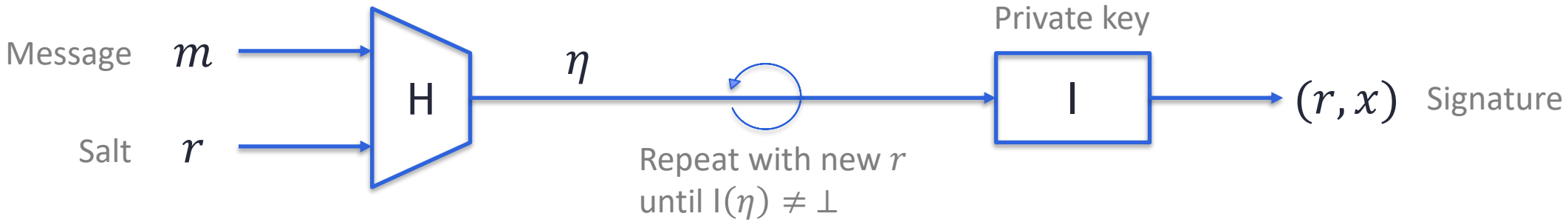


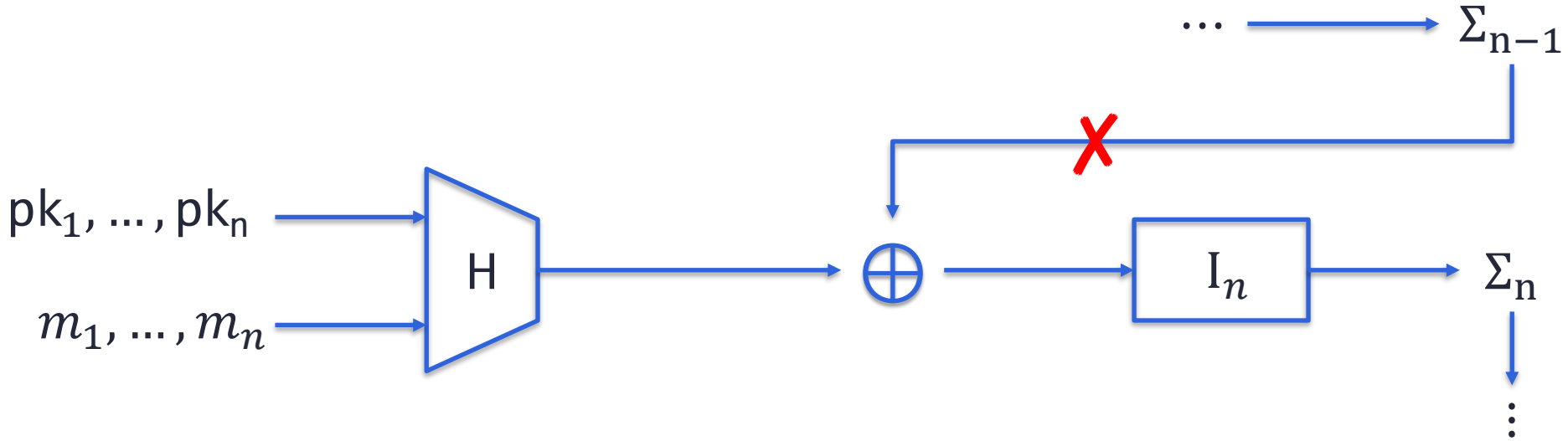
The security of the scheme is based on the one-wayness of F and the following additional property [KX24]:

The output of the signing algorithm (r,x) is such that:

1. The salt r is indistinguishable from $r \leftarrow_R \{0,1\}^{\lambda}$.
2. The signature x is indistinguishable from $x \leftarrow_R \mathcal{X}$.

Generalize SAS Schemes

- Consider a generic trapdoor function (F, I) with F: $\mathcal{X} \rightarrow \mathcal{Y}$.



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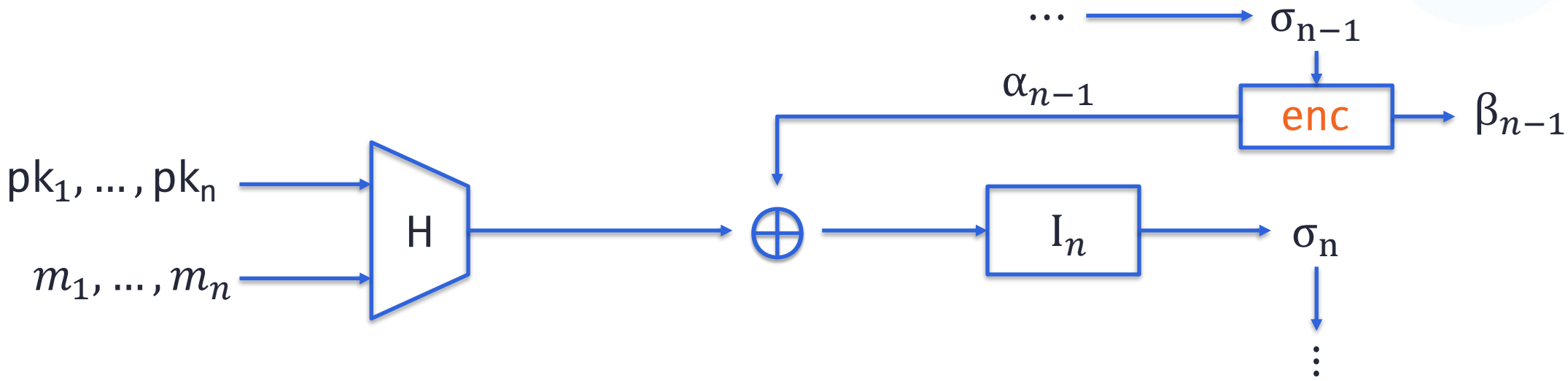

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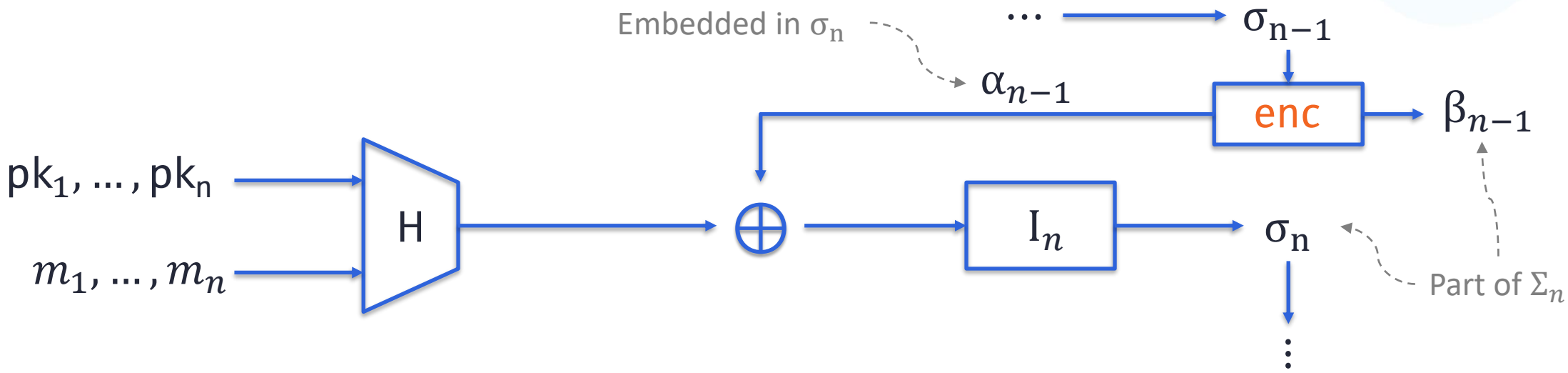

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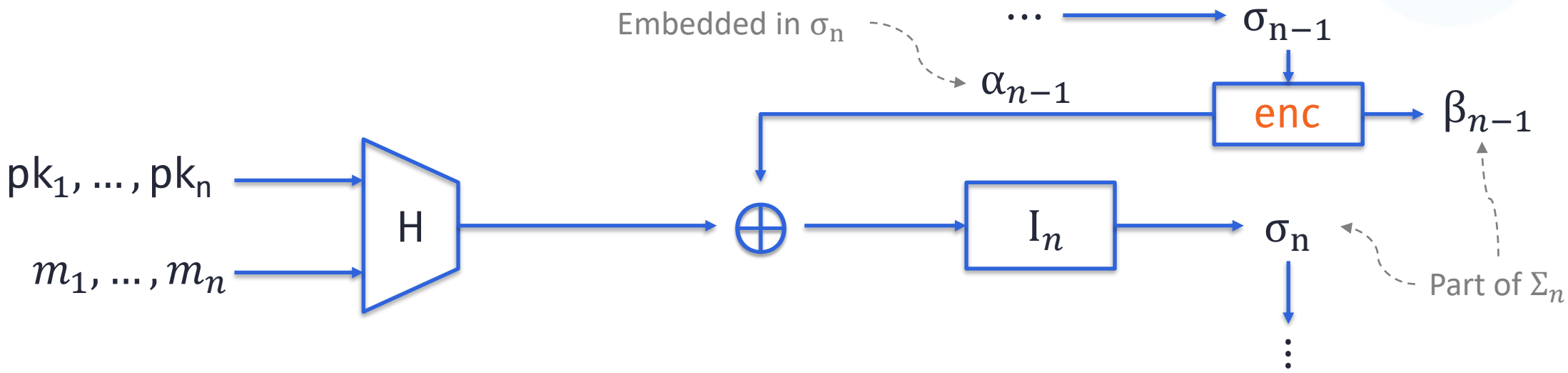

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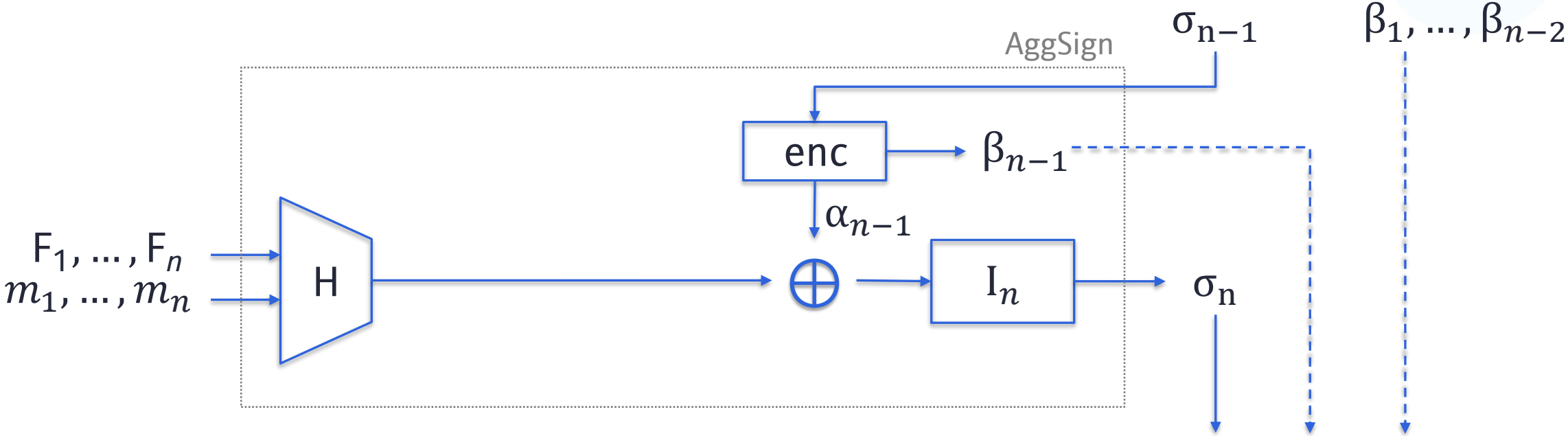
False in general!

Steps to Provable Security

The following aggregate scheme is **not** provably secure (and sometimes provably insecure) with generic TDF.



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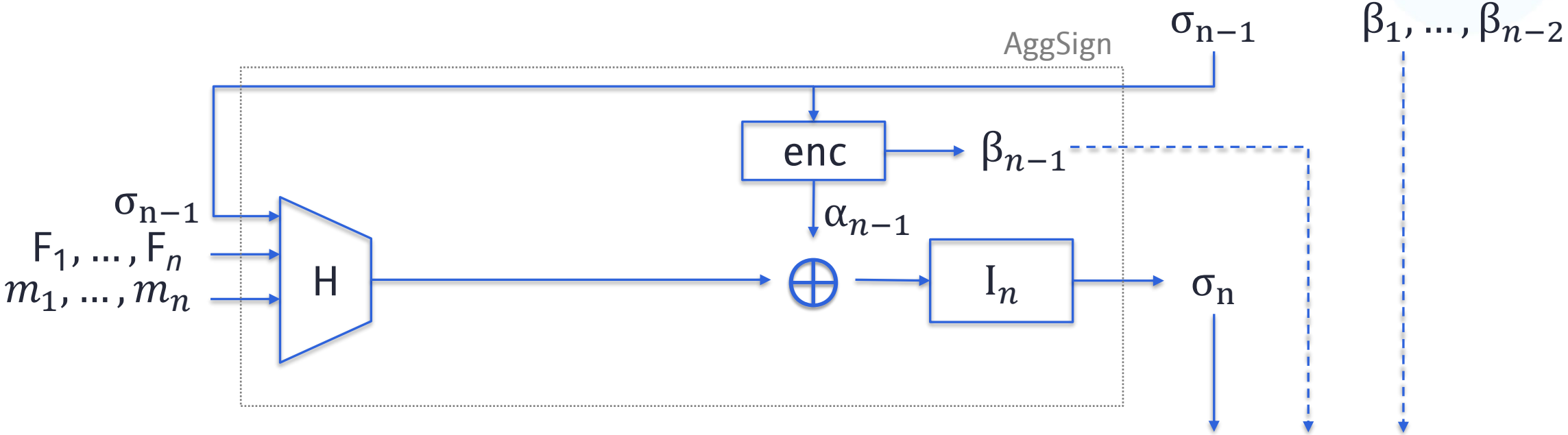

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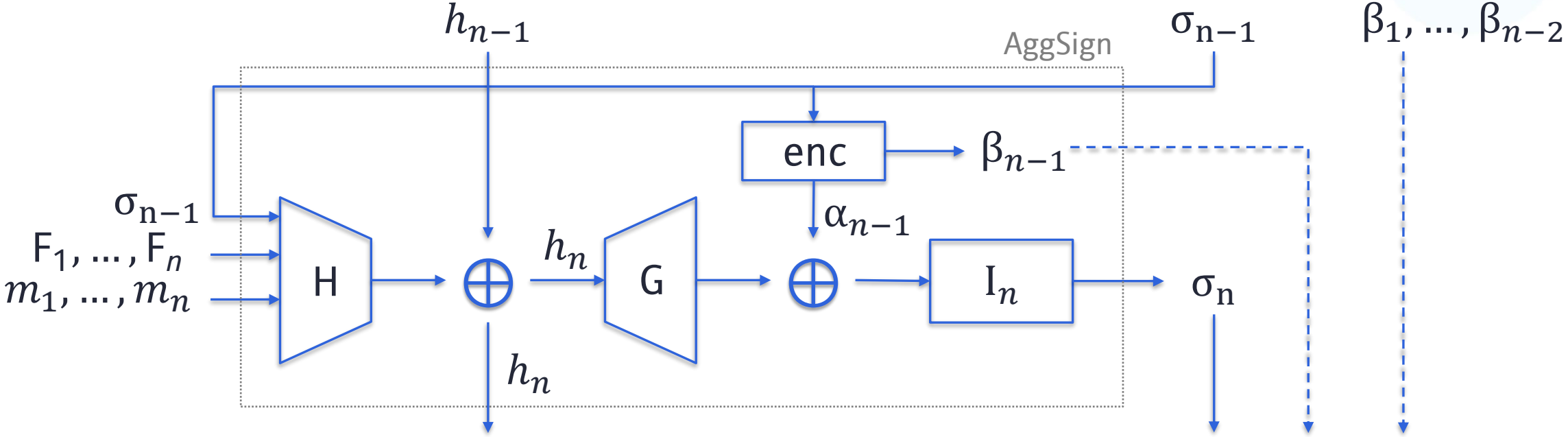

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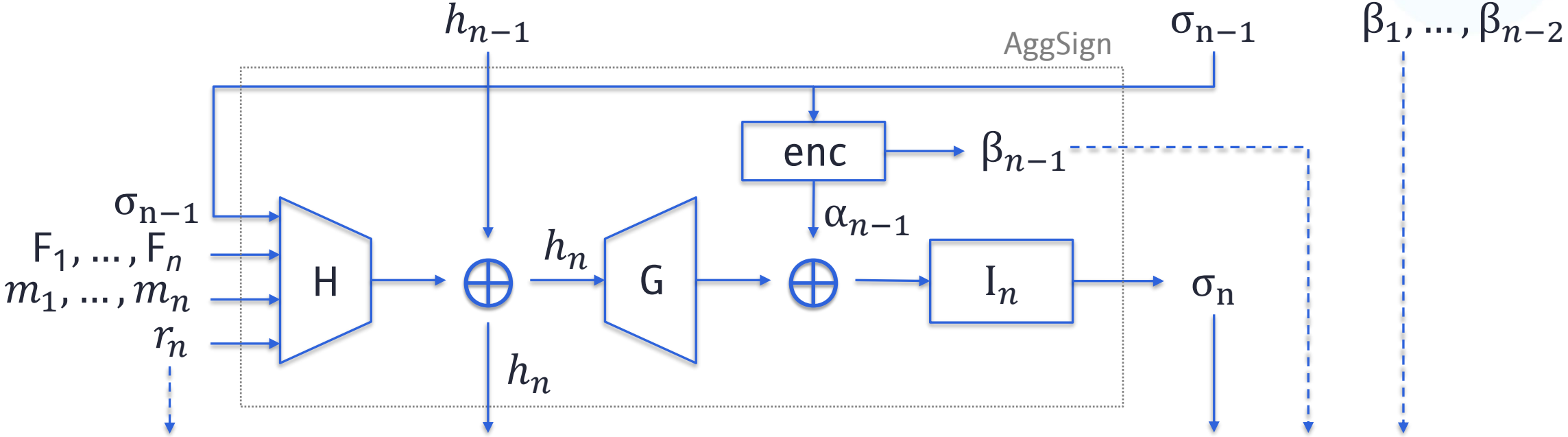

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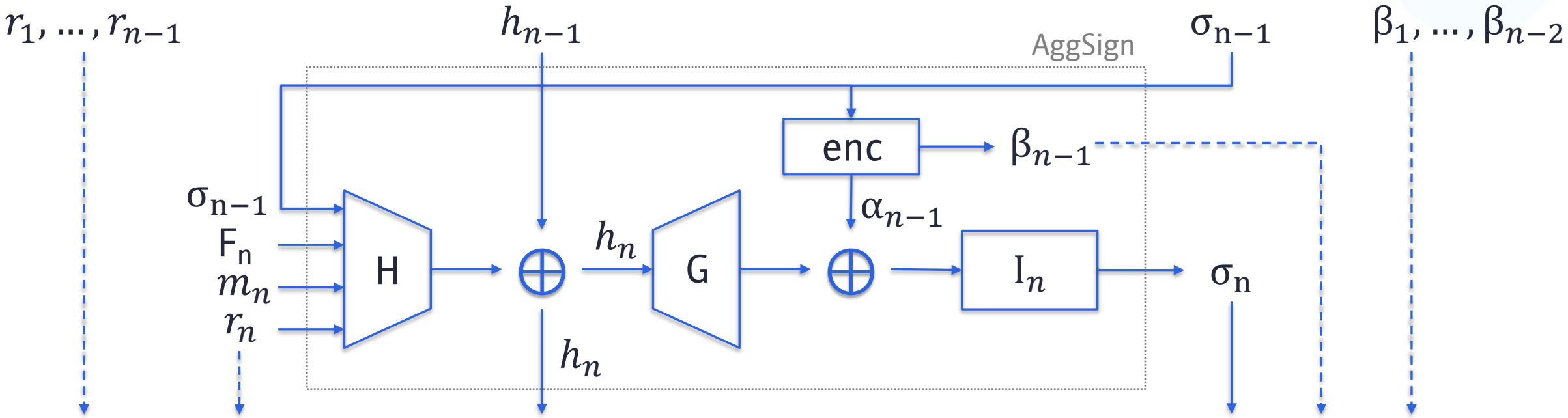
- If σ_{n-1} is part of the input to H it is not possible to directly retrieve it during verification.
- Failure on I_n may leak information.

A Secure SAS Scheme

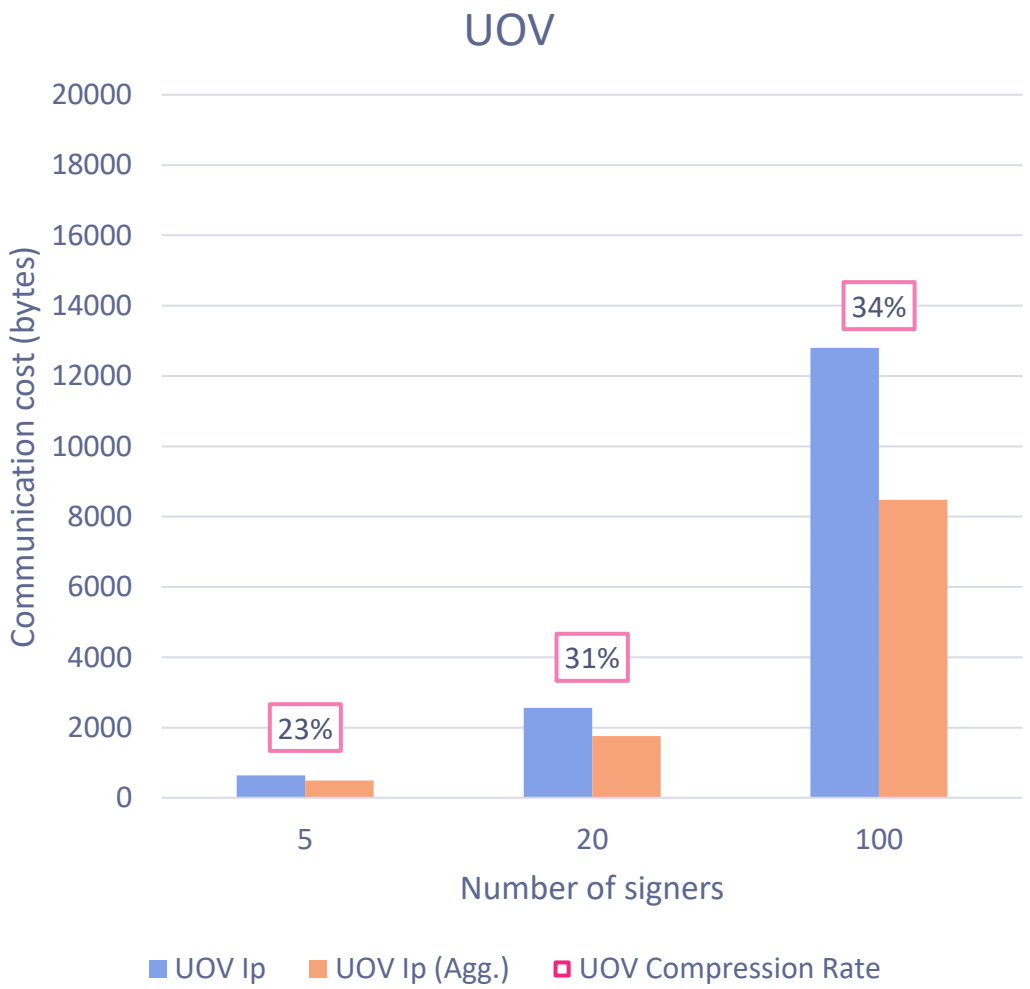
The following aggregate scheme is provably secure in the ROM with generic TDF.

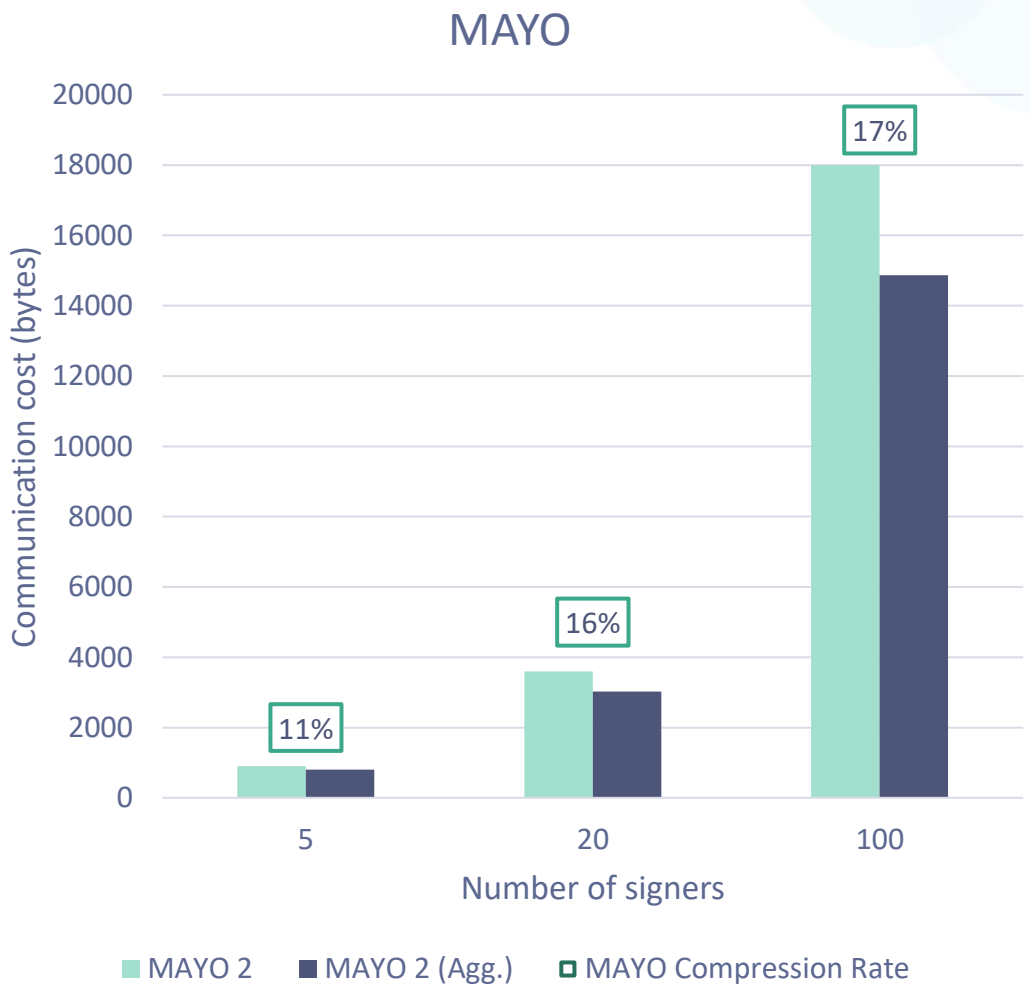


Compared with the previous construction

- Good: is provable secure (but not fully *black-box*).
- Good: is an **history-free** SAS scheme.
- Bad: the full n party signature has an overhead of length $2\lambda + n\lambda$.

Benchmarking





Conclusion

Hash-and-Sign Aggregation

- Many post-quantum trapdoor signatures are built from the hash-and-sign with retry approach.
- The same issues regarding provable security are also encountered for aggregated signatures.

Our Protocol

- Generalizes existing constructions for non-trapdoor functions.
- Recovers probable security with only a small overhead.
- The effectiveness of aggregation varies depending on the scheme and is generally not optimal.

Thank you for your attention!

References I

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