Tracing a Linear Subspace

Application to Linearly-Homomorphic Group Signatures

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Outline

1 Linearly-Homomorphic Group Signatures
- Definition
- Construction

2 A Core Technique: Tracing Linear Subspaces
- Trivial Solution
- Improved Efficiency via Code-Based Construction

Linearly-Homomorphic Group Signatures

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$\mathsf{Sign}(\mathsf{sk}, \vec{m}_i) \to \sigma_i$

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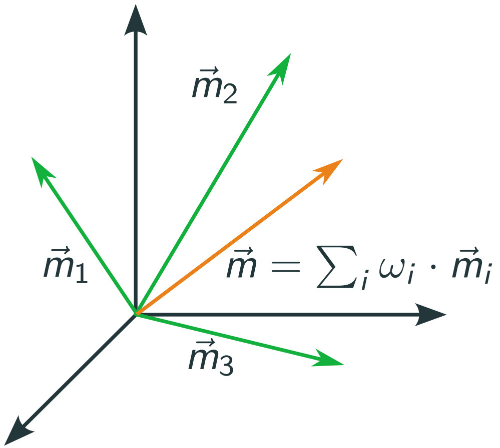

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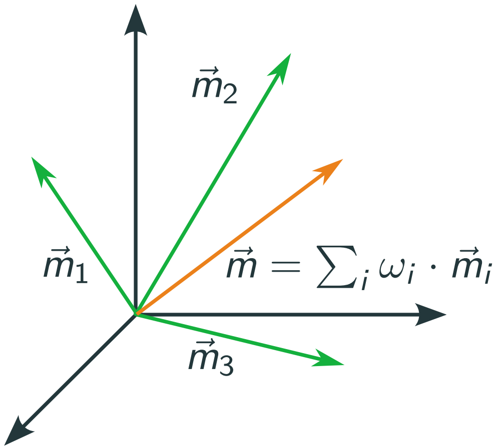
Security. EUF-CMA without trivial attacks



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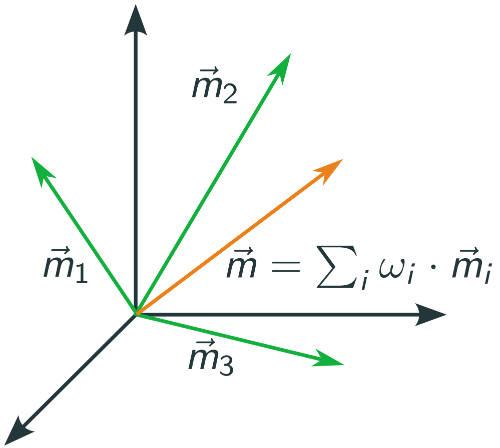

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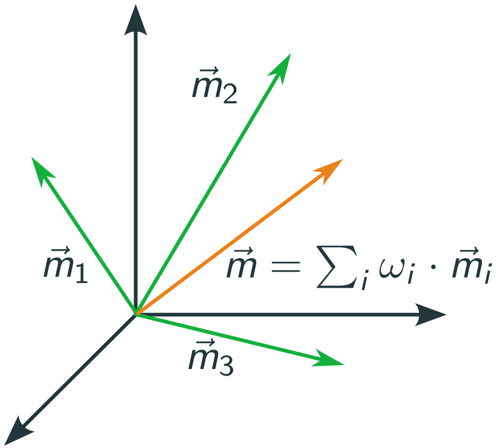

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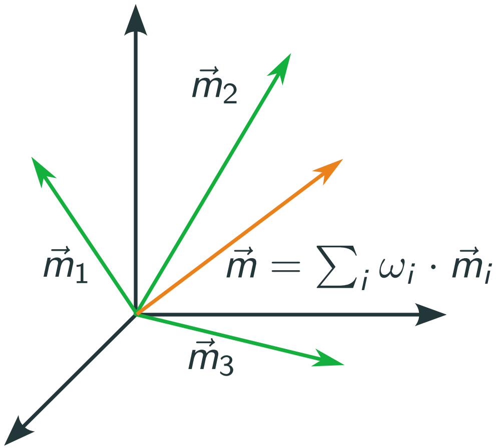

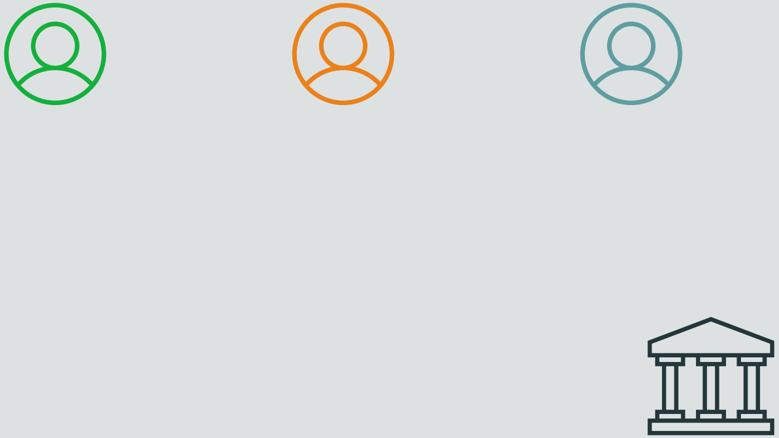

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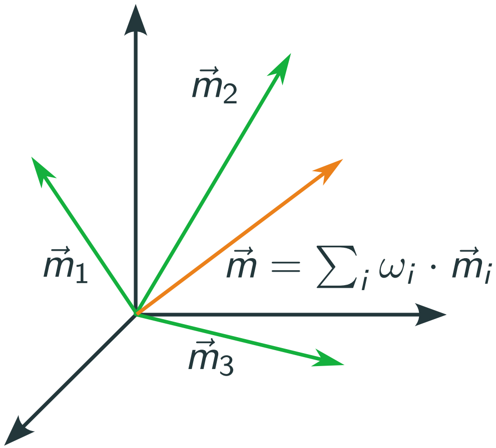

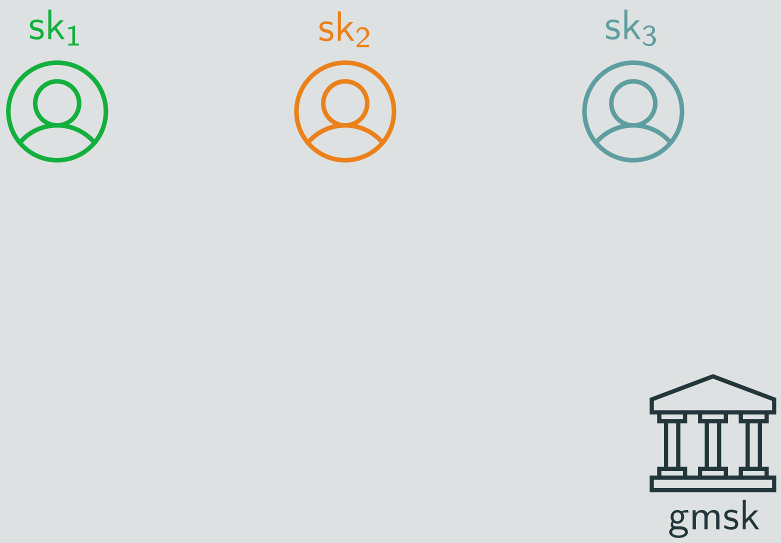

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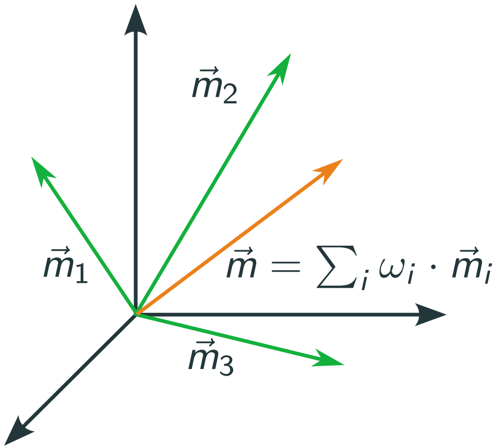

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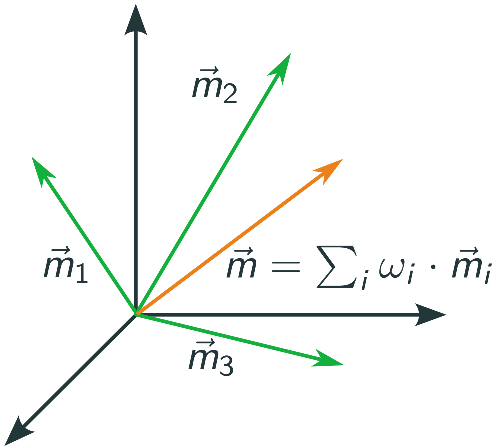

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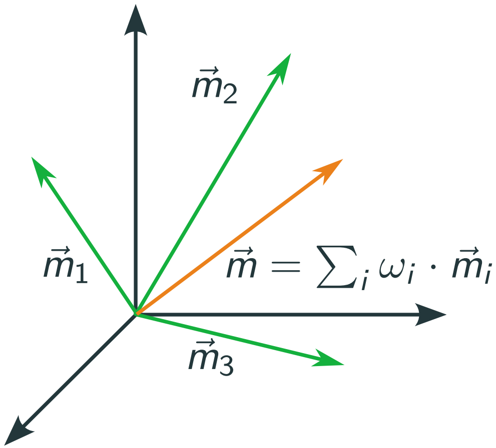

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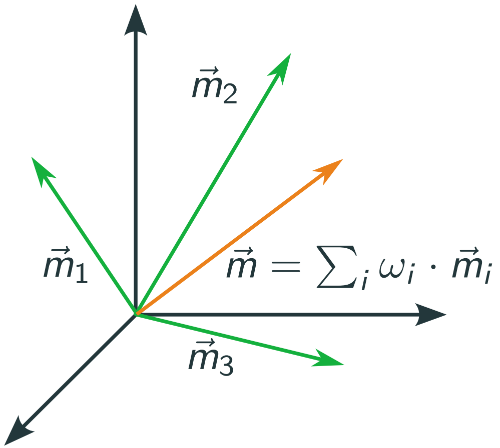

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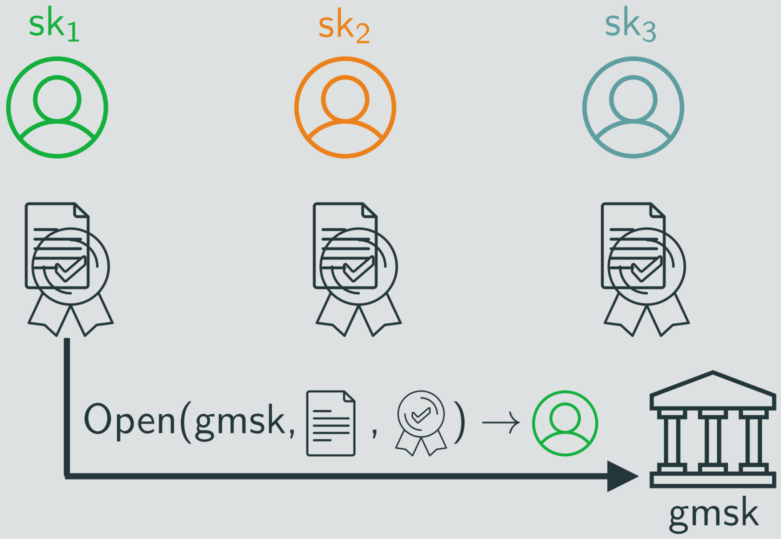

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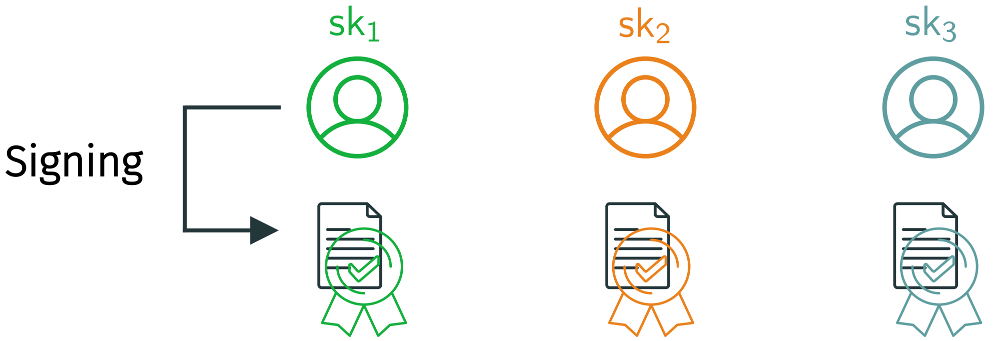

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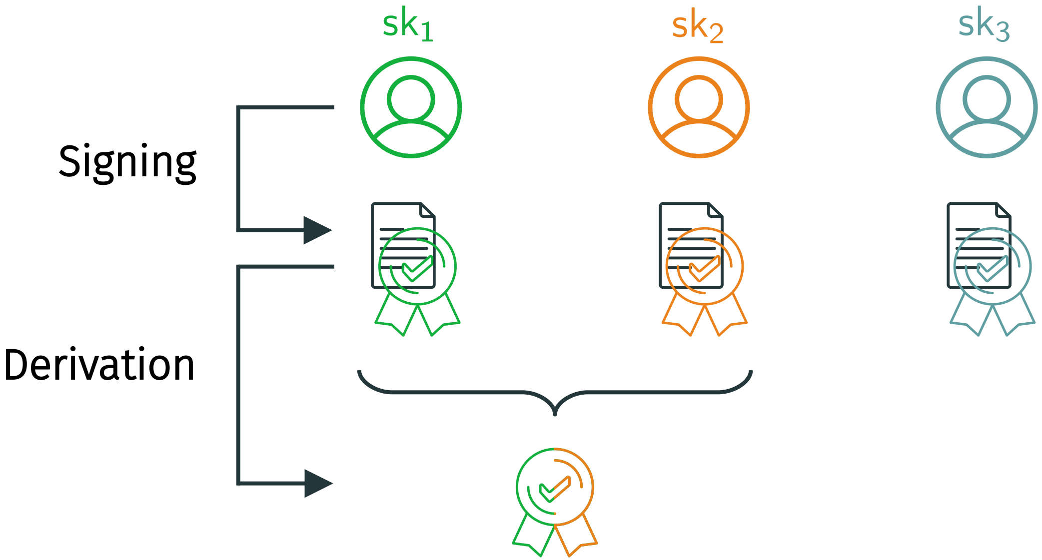

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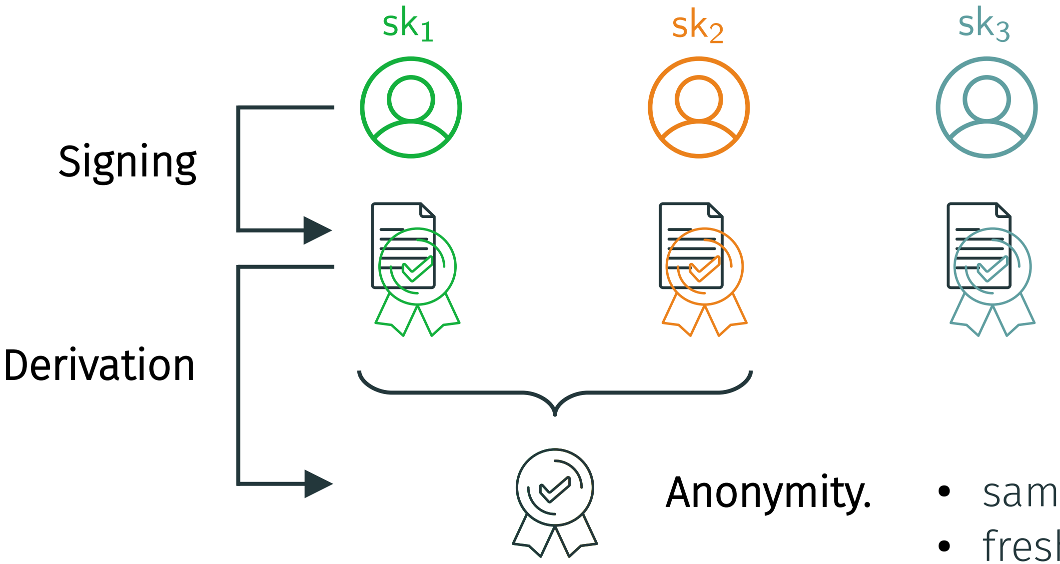

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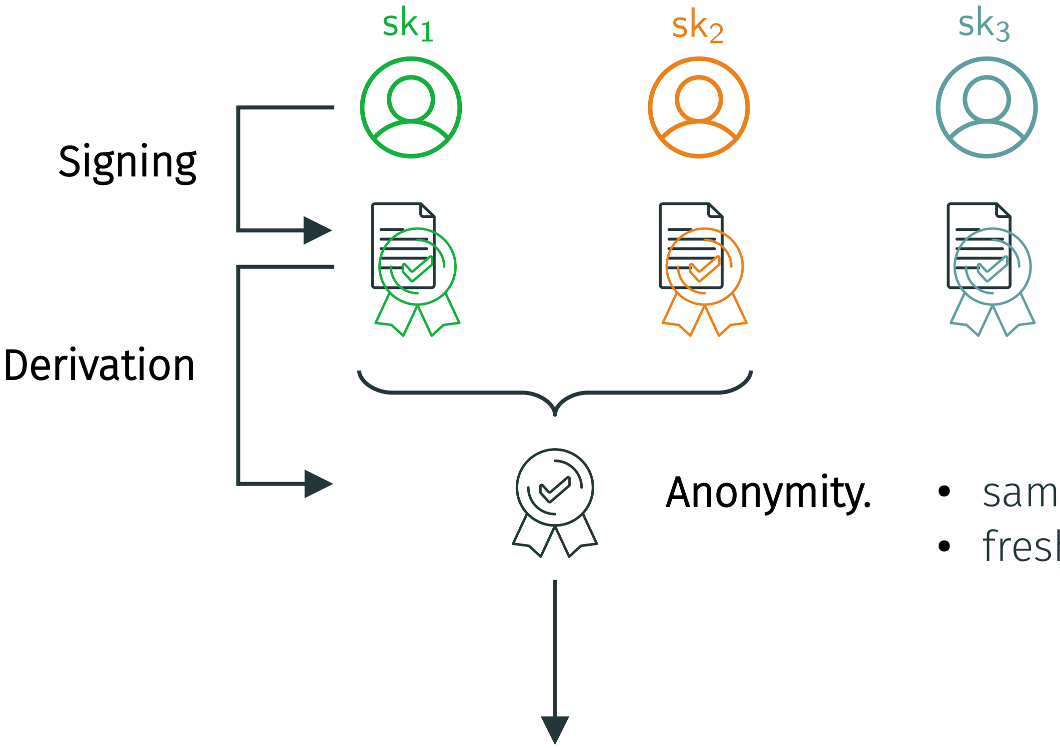

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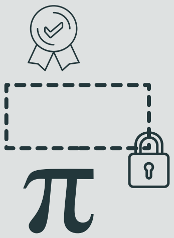

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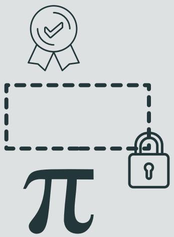

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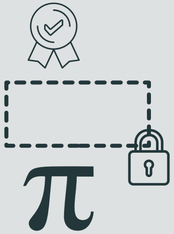

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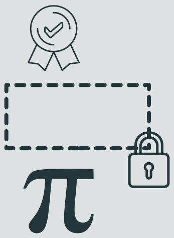

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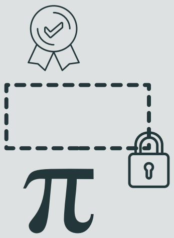

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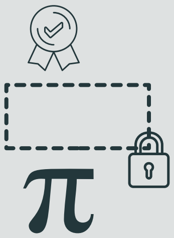

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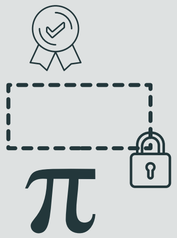

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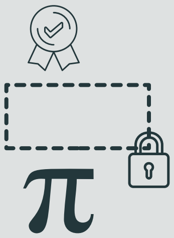

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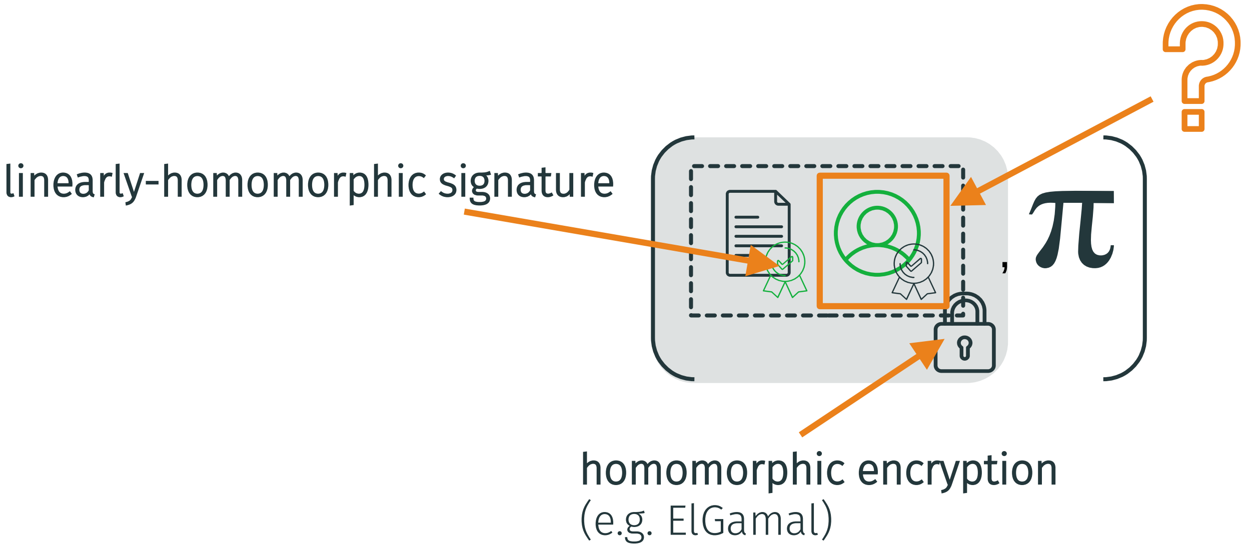

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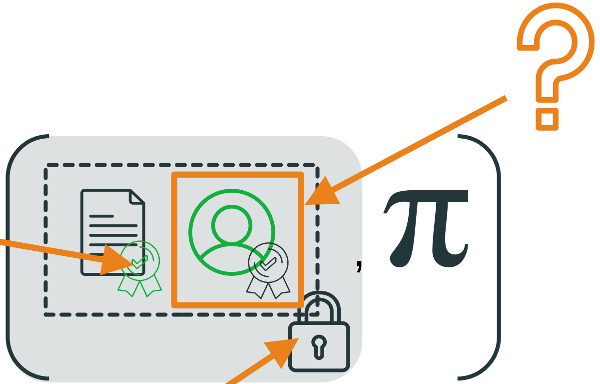

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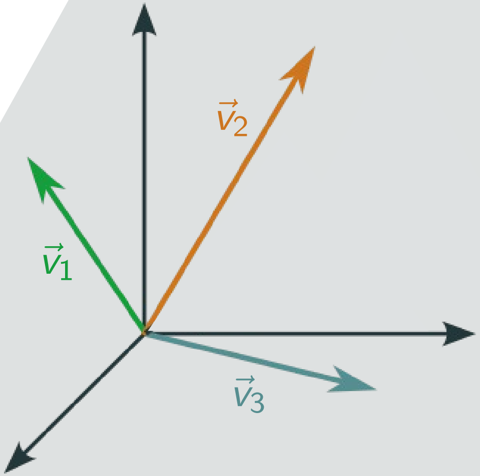

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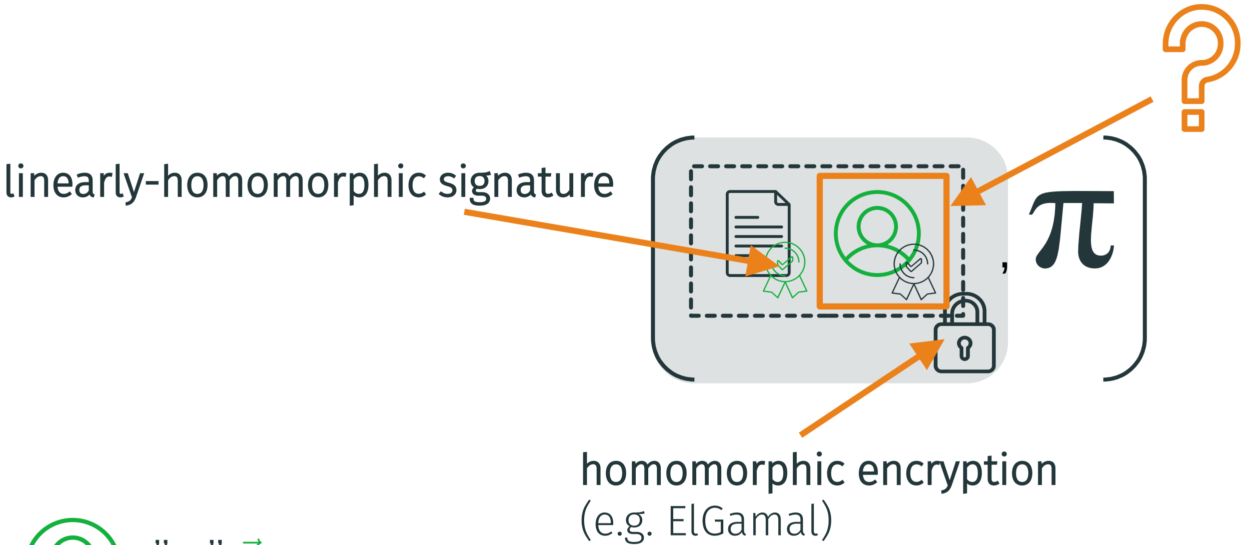

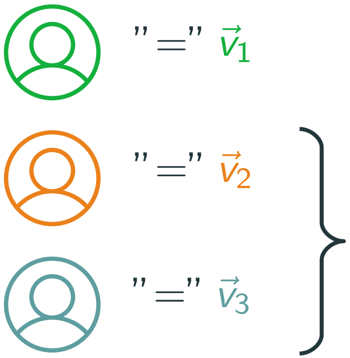

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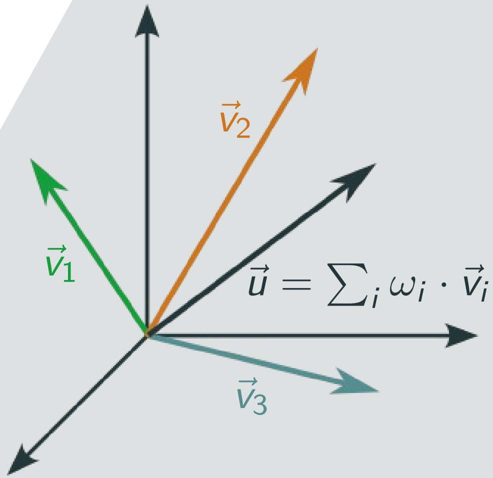

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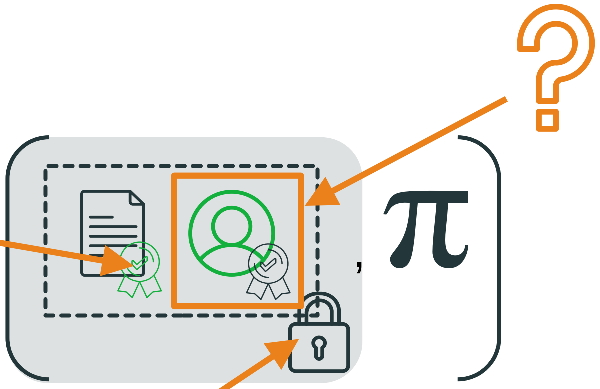
linearly-homomorphic signature



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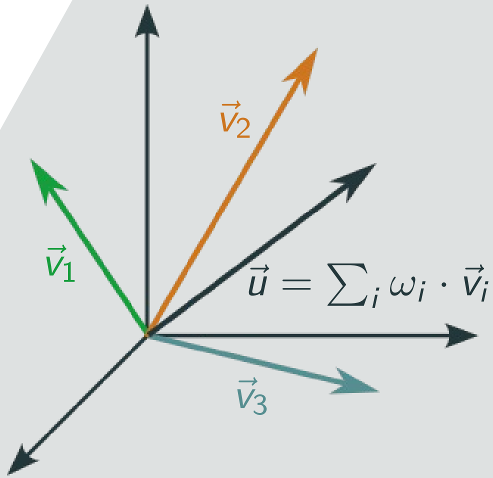

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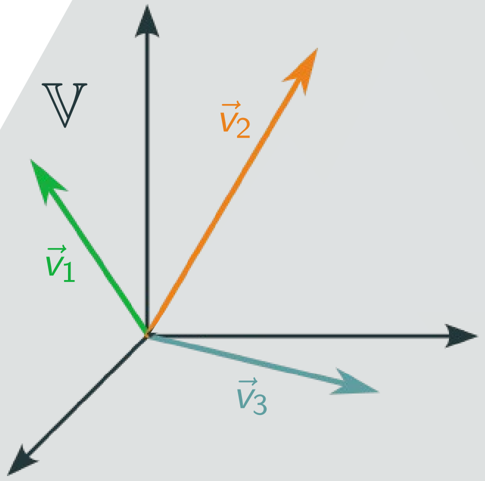

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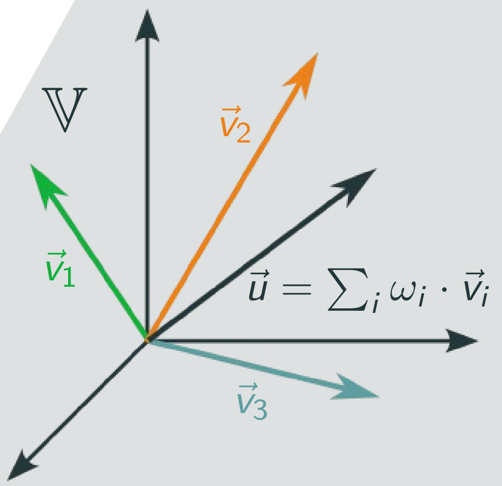

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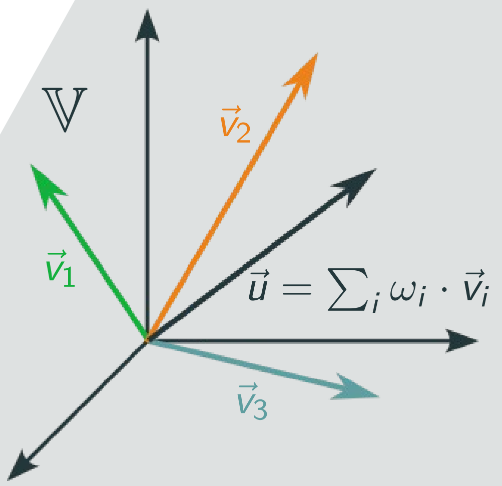

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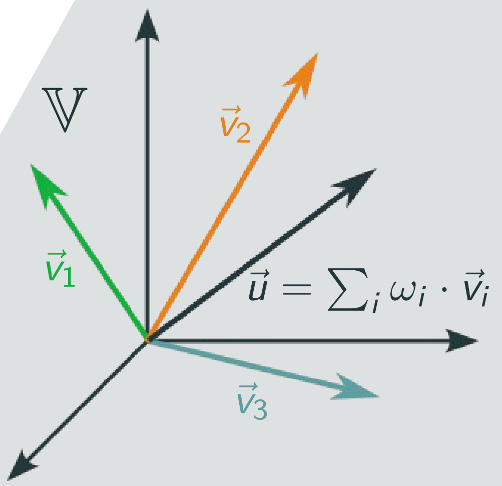

“Tracing” a Linear Subspace

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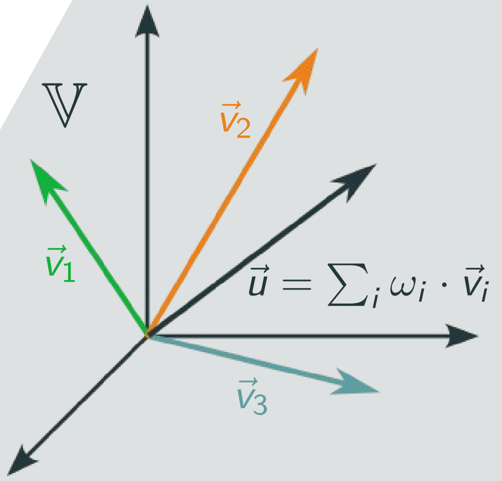

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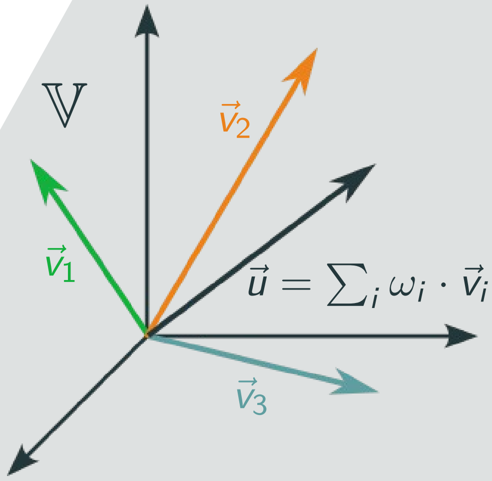

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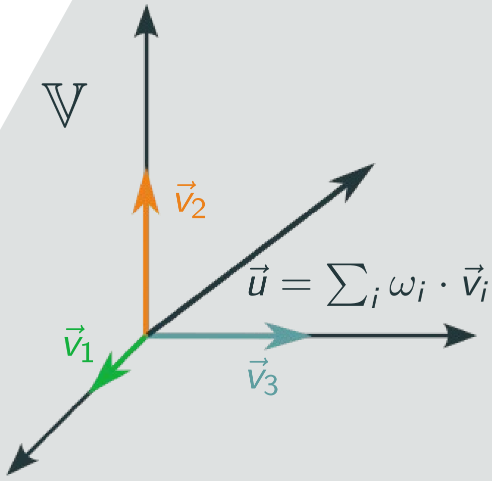

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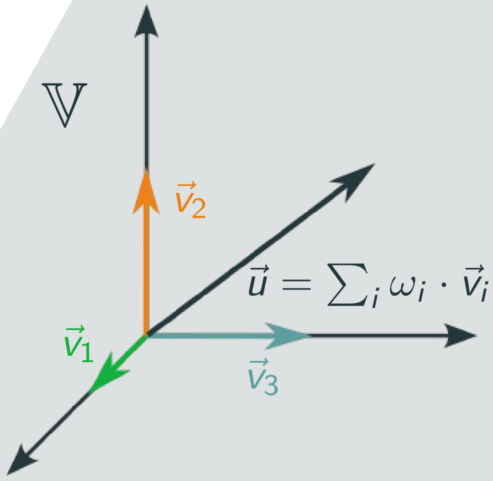
Note: trivial solution is *optimal* but *inefficient*



Tracing against Bounded Collusions

Relaxation of traceability: introduce an upper bound c on the maximum size of collusions

- never accuse honest user
- correct opening for collusions of size $\leq c$

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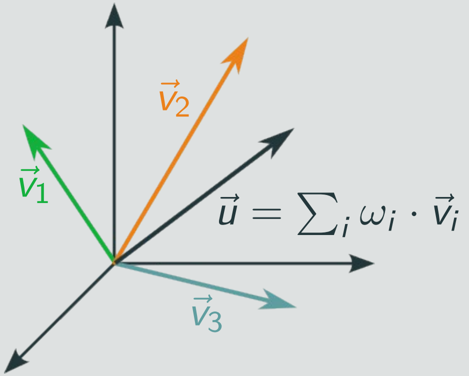

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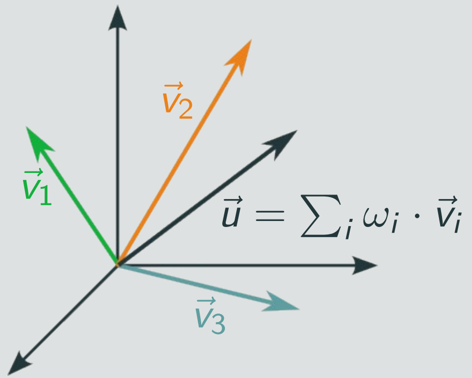

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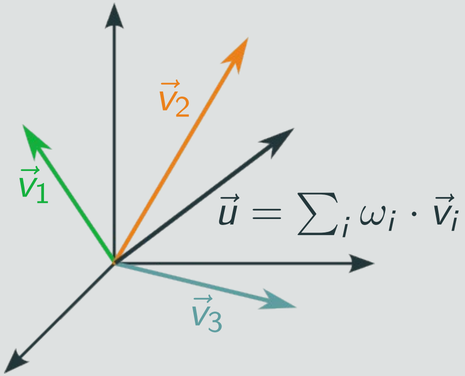

Efficiency comparison:

- trivial solution $\mathcal{O}(n)$
- our work $\mathcal{O}(c^2 \cdot \log(n/\varepsilon))$ ($\varepsilon =$ maximum acceptable error probability)

Linear-Subspace Tracing: Under the Hood (if time permits...)

Analogy to IPP (and fingerprinting) codes:

- vectors $\longleftrightarrow$ codewords
- linear combinations $\longleftrightarrow$ descendants

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$\uparrow$

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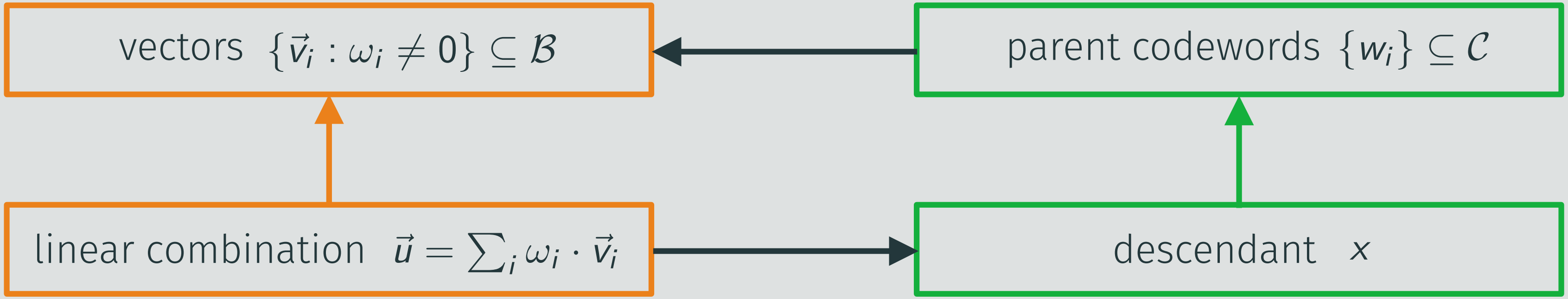

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IPP codes trace only a *single* parent,
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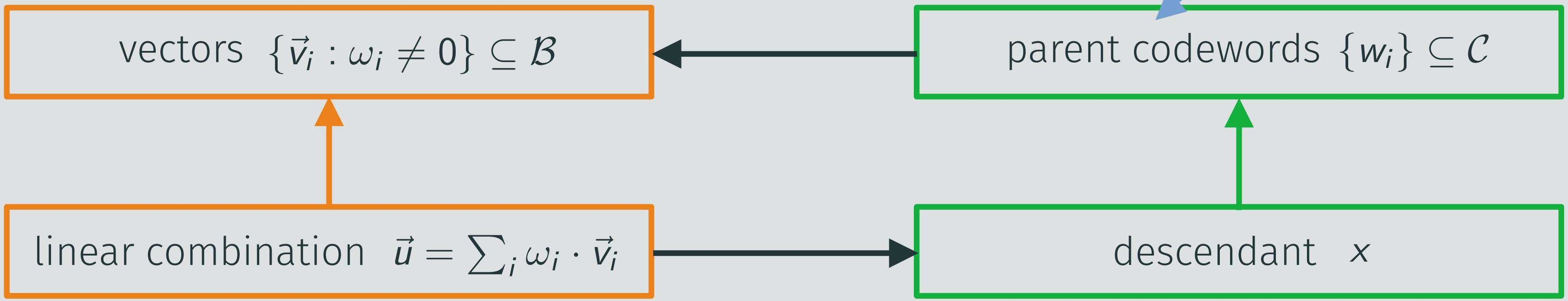

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$$\begin{tikzcd}
\text{vectors } \{\vec{v}_i : \omega_i \neq 0\} \subseteq \mathcal{B} & \text{parent codewords } \{w_i\} \subseteq \mathcal{C} \arrow[l] \\
\text{linear combination } \vec{u} = \sum_i \omega_i \cdot \vec{v}_i \arrow[u] \arrow[r] & \text{descendant } x \arrow[u]
\end{tikzcd}$$

To hide “bad” linear combinations,
we need a hard discrete logarithm ...

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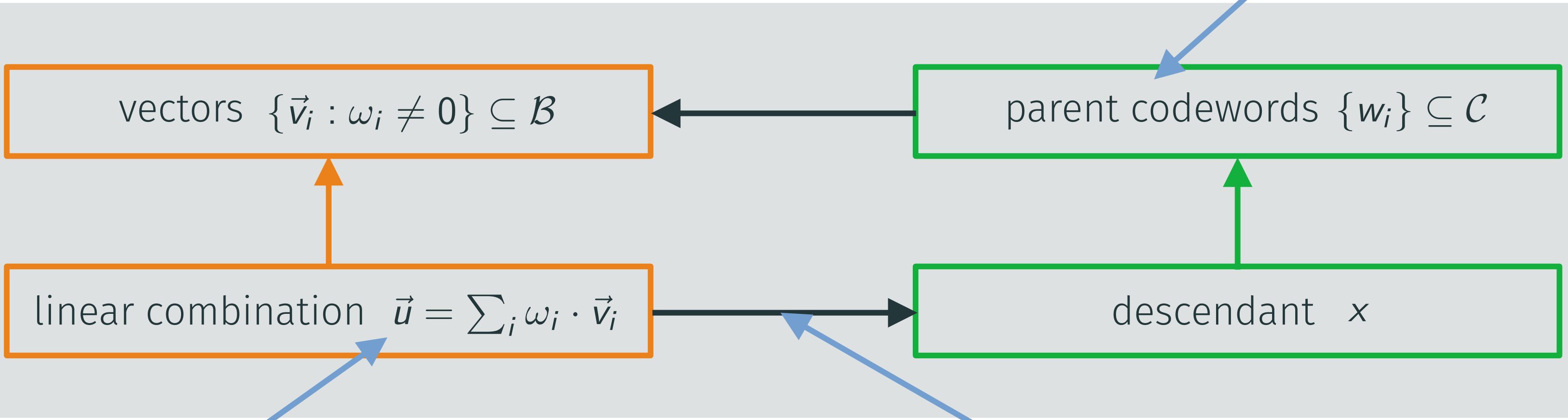

To hide “bad” linear combinations, we need a hard discrete logarithm ...

... but then extracting the descendant is quite challenging ...

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