Fine-Grained Access Control in Multi-Client Functional Encryption

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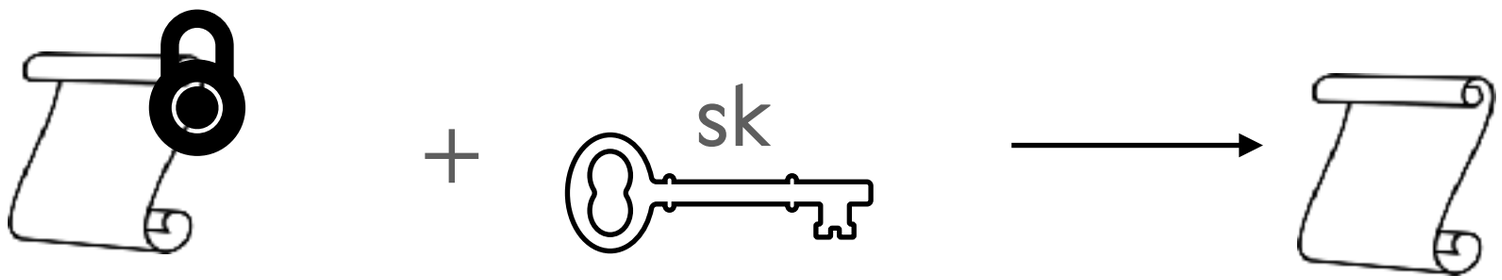
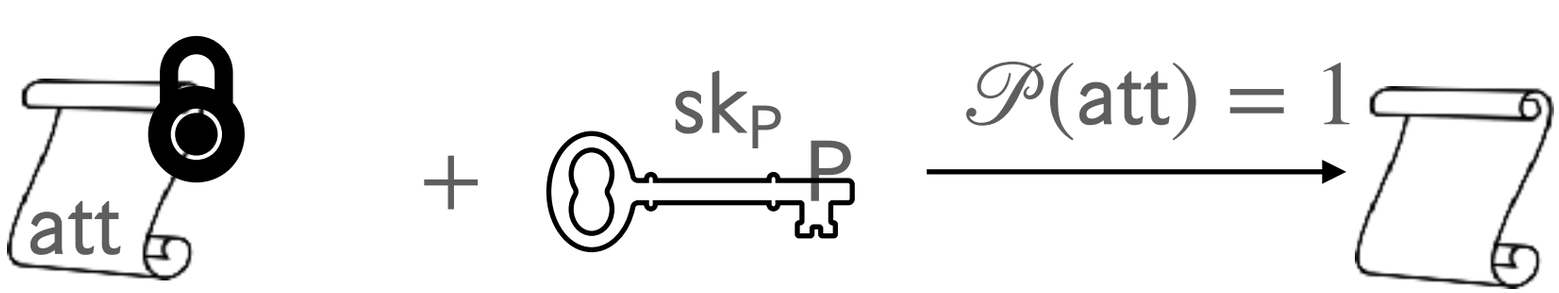
Outline

1. Motivation and Context
2. Related Works and Our Contributions
3. Technical Tools
4. Overview of Constructions

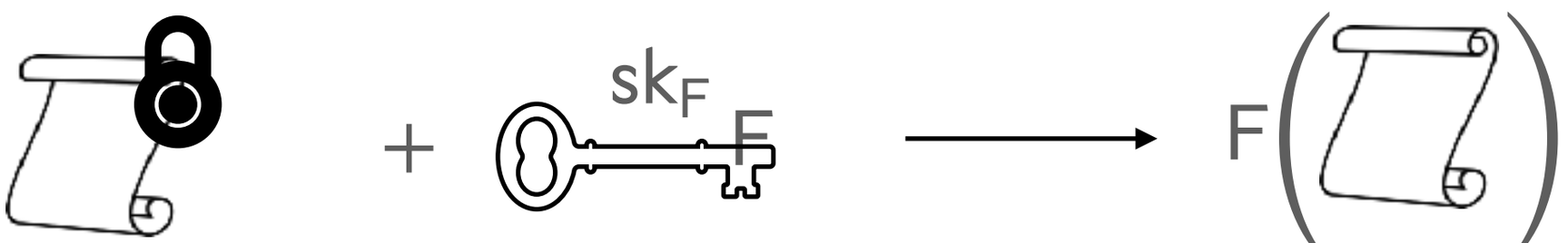
Motivation

Functional Encryption [O'N10,BSW11]





More control on



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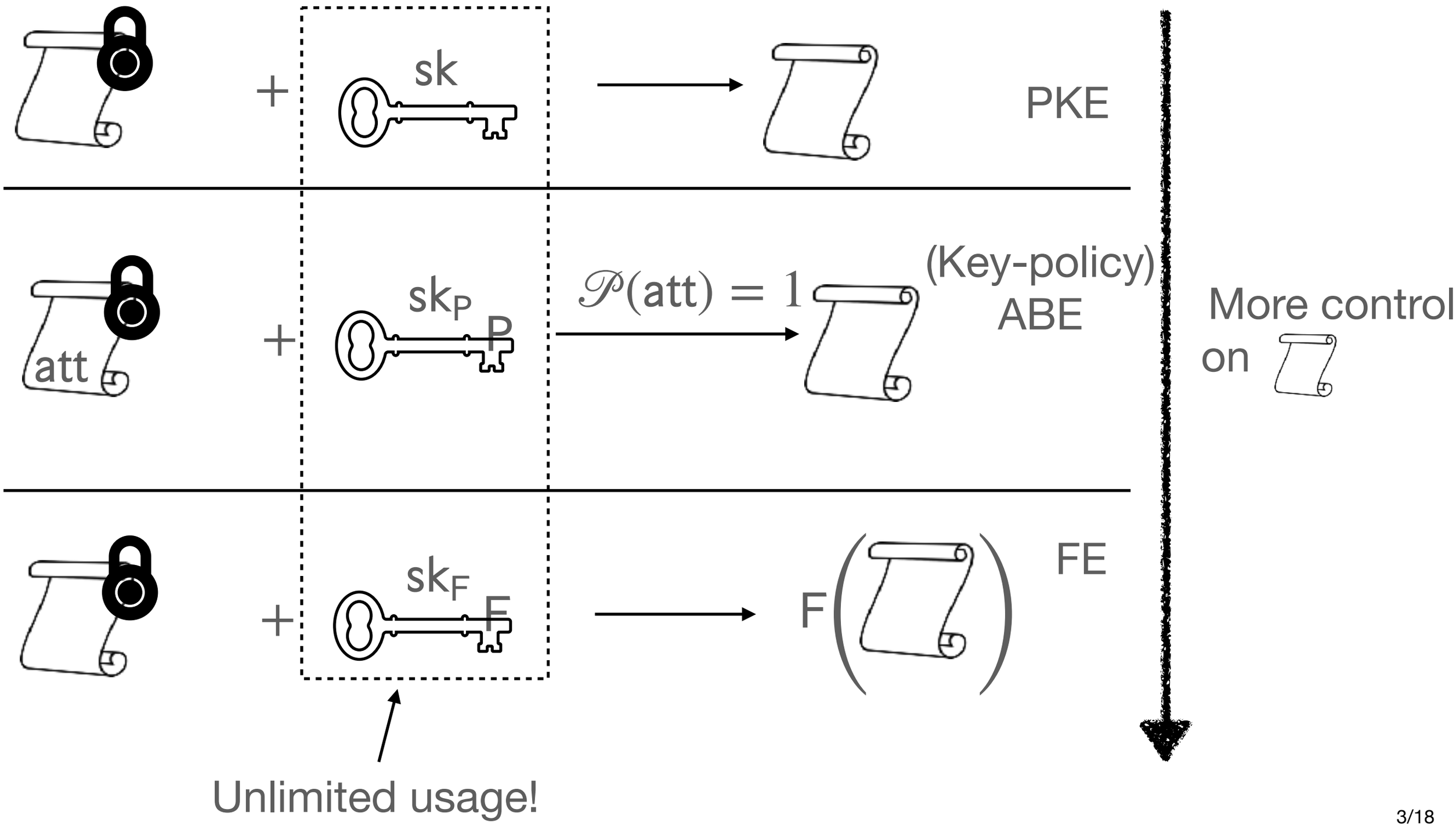

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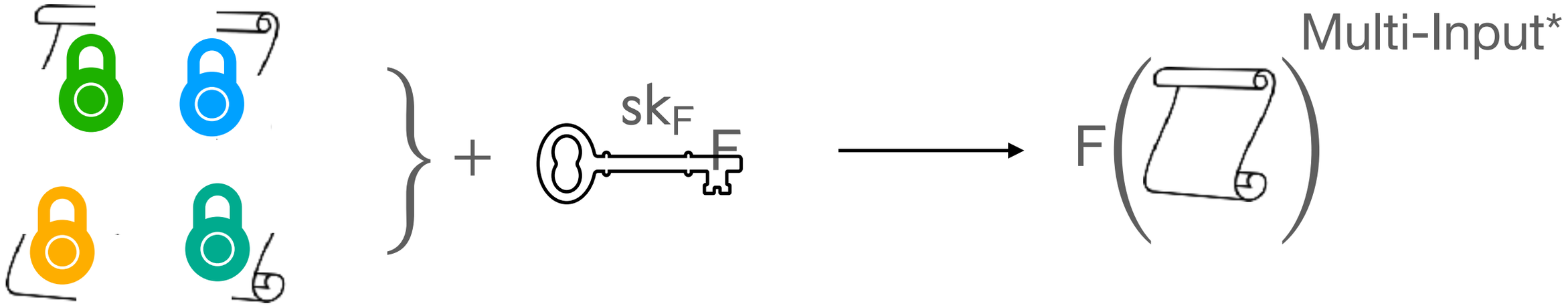
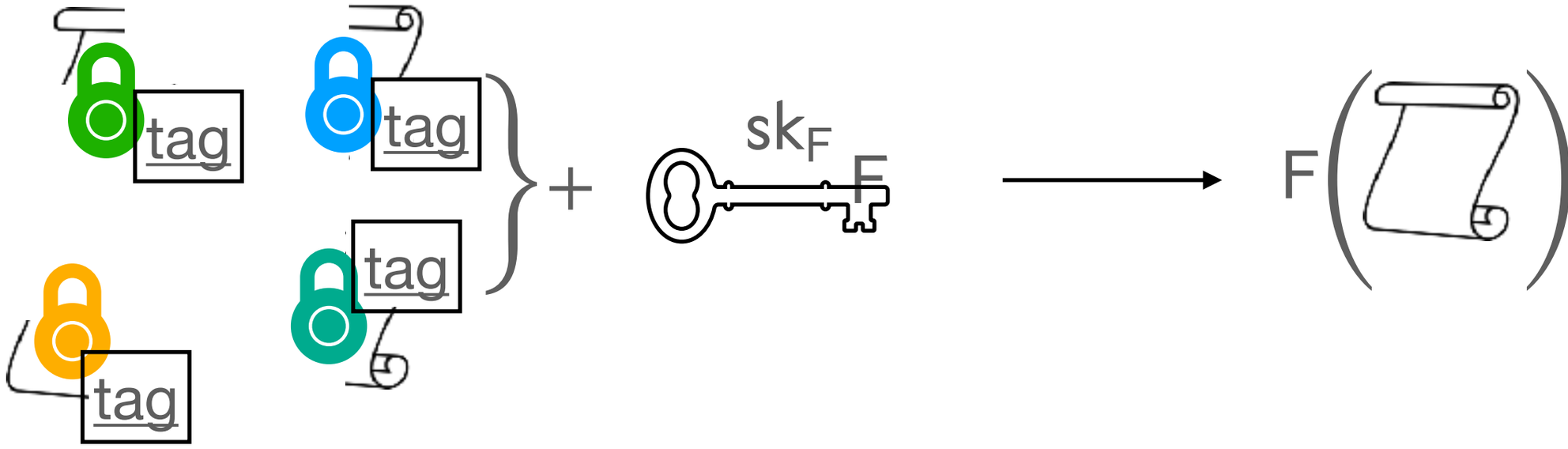
FE in Multi-User Setting [GGG+14, GKL+13]





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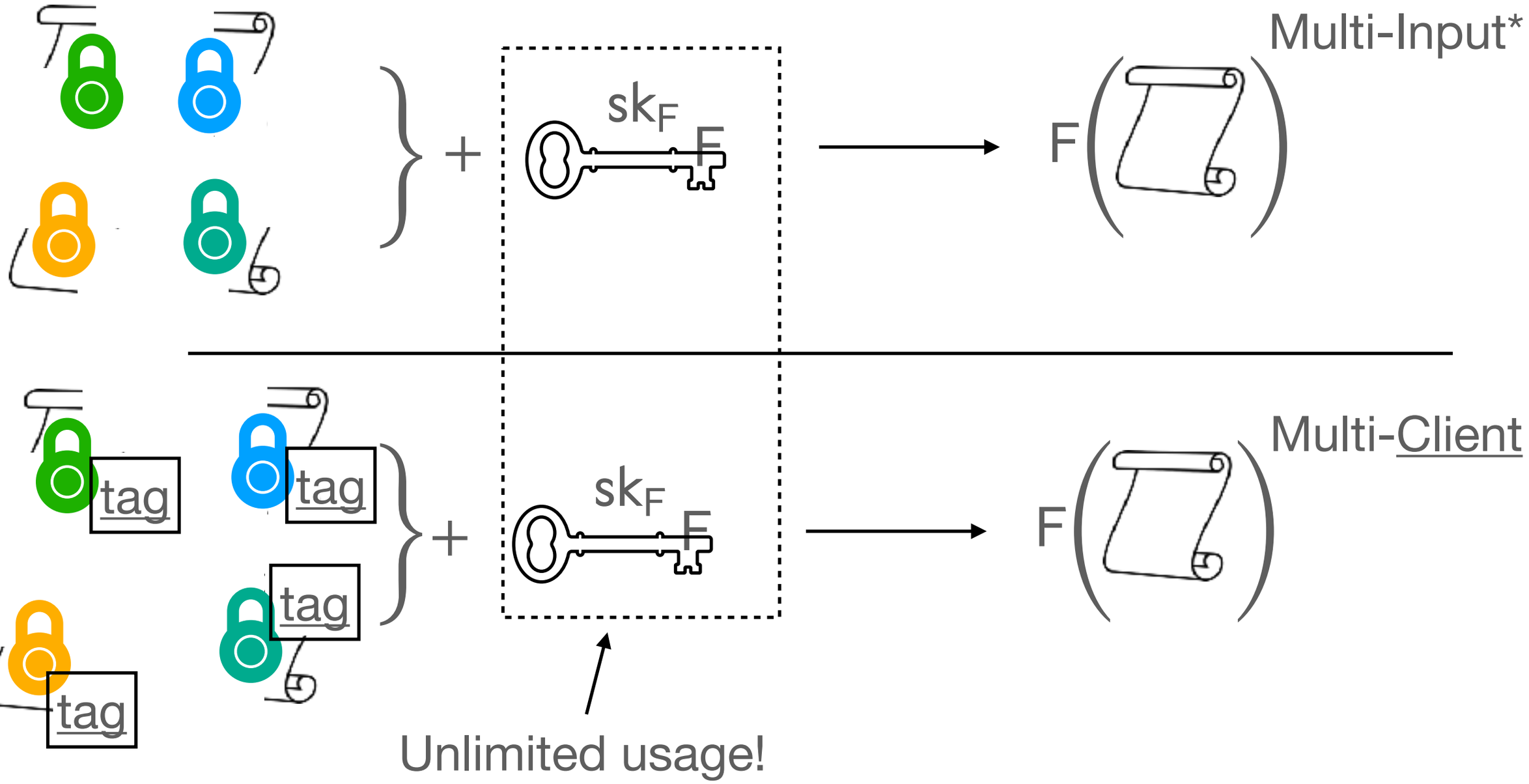

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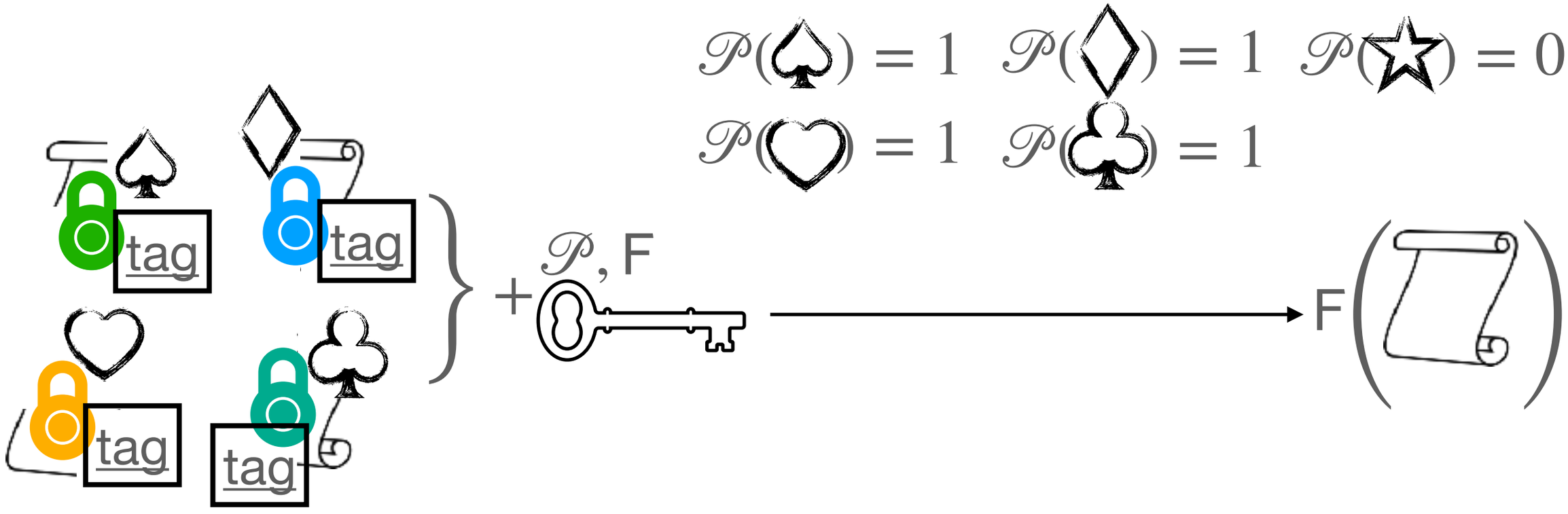
Controlling Decryption Keys in Multi-Client FE (MCFE)



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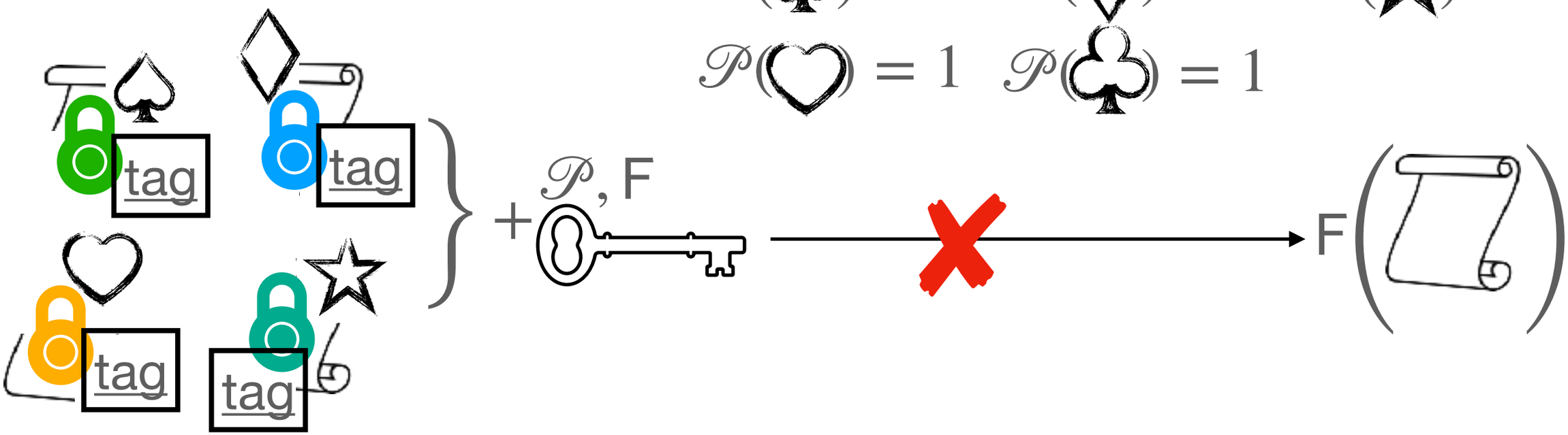
Controlling Decryption Keys in Multi-Client FE (MCFE)

$\mathscr{P}(\spadesuit) = 1 \quad \mathscr{P}(\diamondsuit) = 1 \quad \mathscr{P}(\star) = 0$

$\mathscr{P}(\heartsuit) = 1 \quad \mathscr{P}(\clubsuit) = 1$



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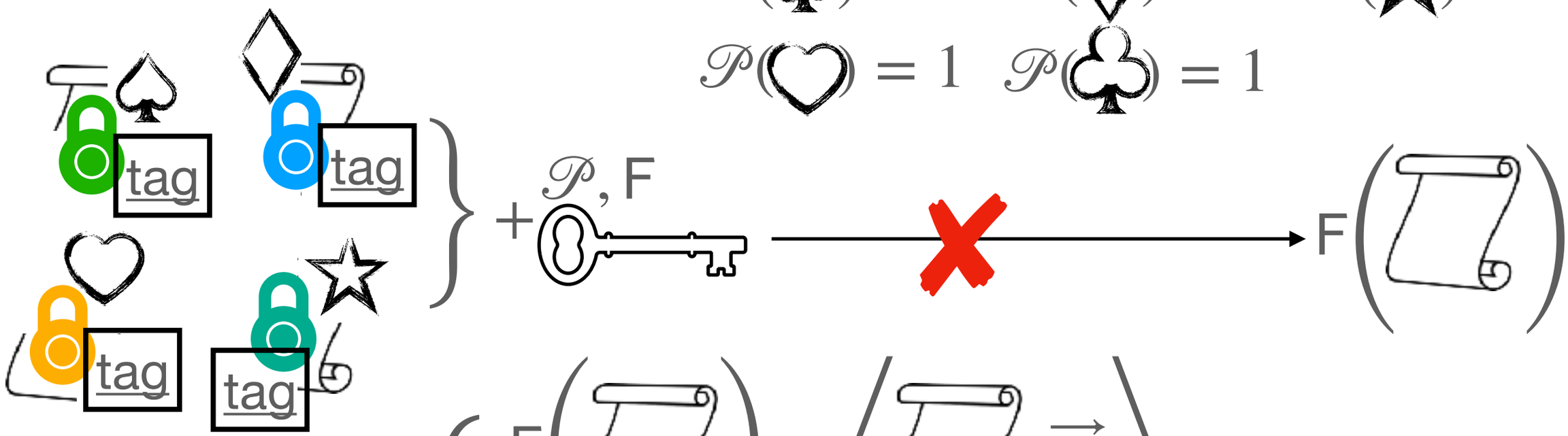

$$\begin{cases} \mathrm{F}(\quad) = \langle \quad, \vec{y} \rangle \\ \mathscr{P}\text{: } \textit{Linear Secret Sharing Schemes} \text{ (LSSS)} \end{cases}$$

Motivation

Controlling Decryption Keys in Multi-Client FE (MCFE)

$\mathscr{P}(\spadesuit) = 1 \quad \mathscr{P}(\diamondsuit) = 1 \quad \mathscr{P}(\star) = 0$

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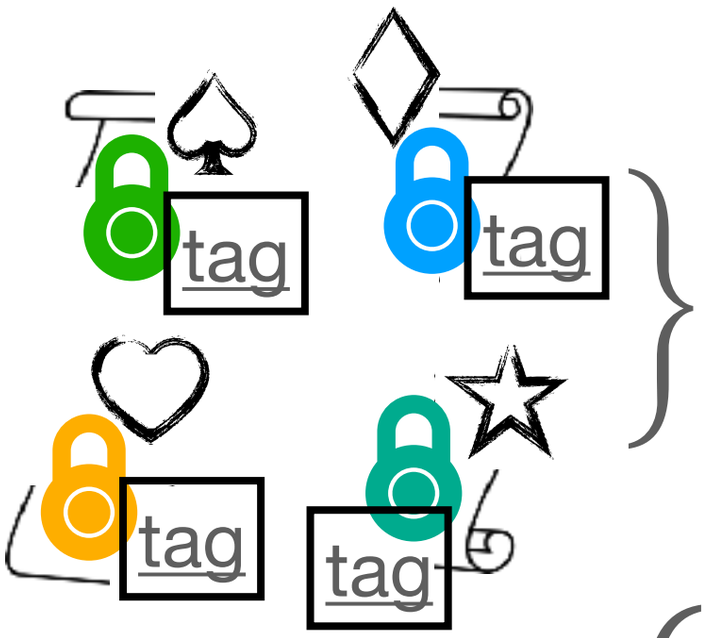
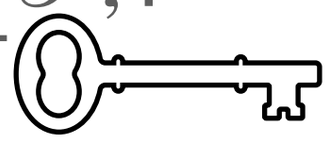
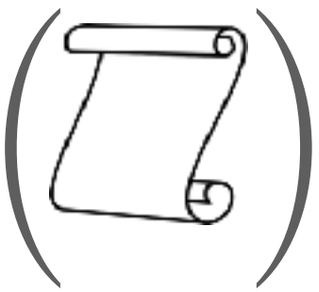


$+ \; \mathscr{P}, \mathsf{F}$ 

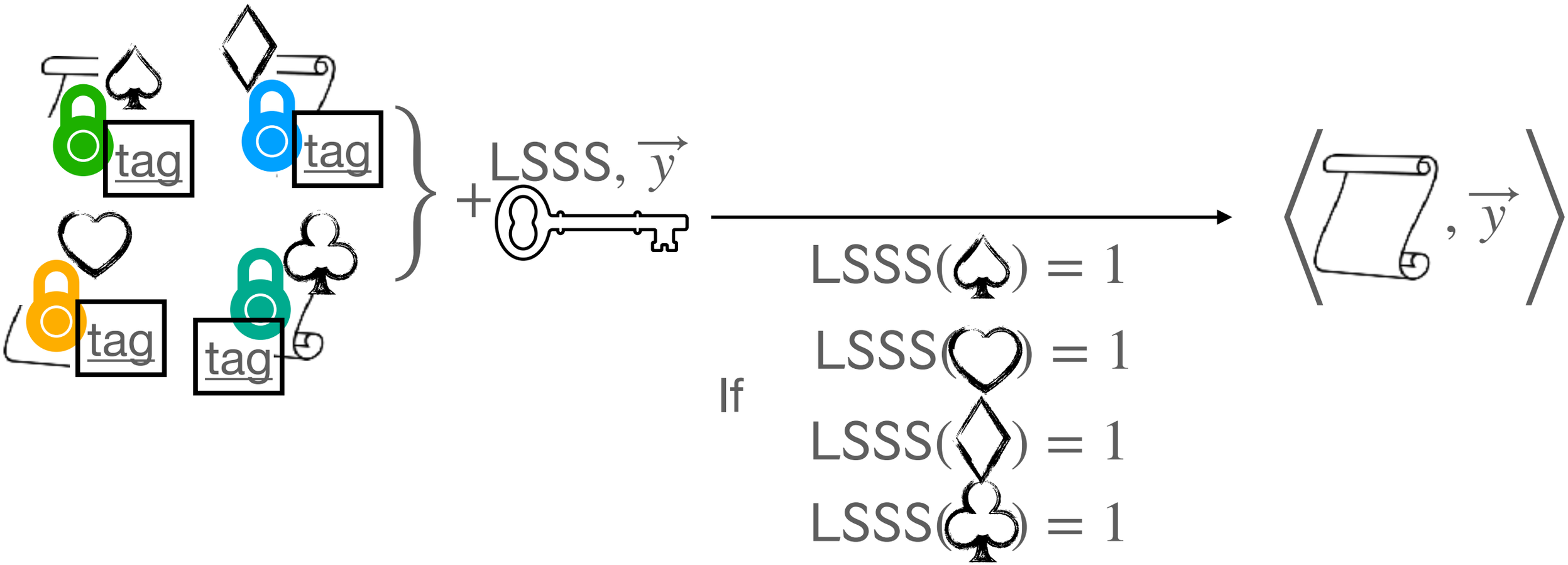
$\mathsf{F}\left(\text{  }\right)$

$$\begin{cases} \mathsf{F}\left(\text{  }\right) = \left\langle \text{  }, \vec{y} \right\rangle \\ \mathscr{P}\text{: } \textit{Linear Secret Sharing Schemes} \text{ (LSSS)} \end{cases}$$

Included in general MCFE if $\mathsf{F}(\cdot)$ can express the policy $\mathscr{P}$

Motivation

Controlling Decryption Keys - Why MCFE? 🤔



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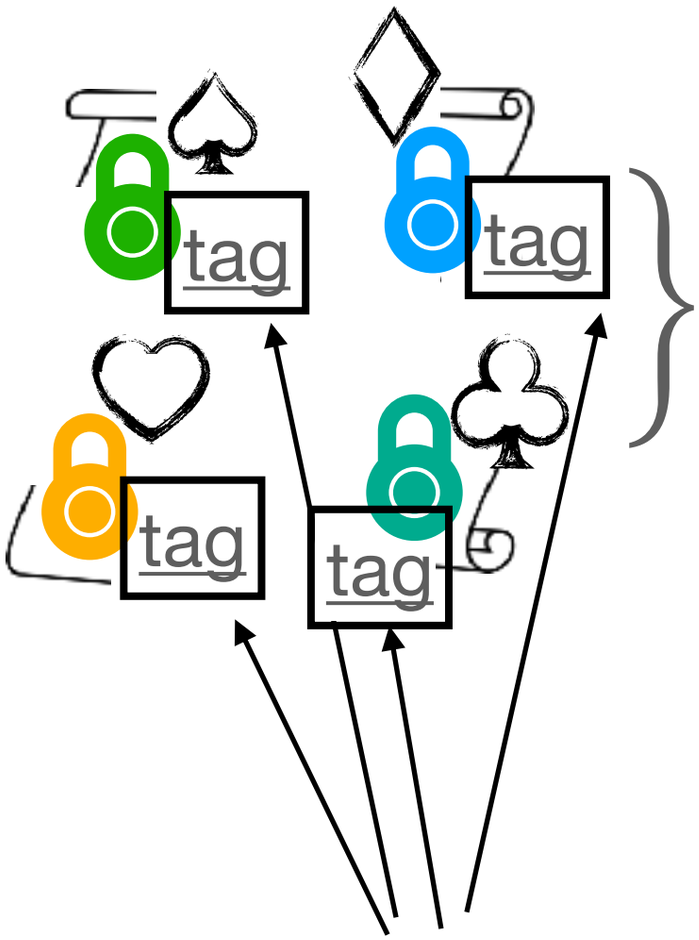

$+$ LSSS, $\vec{y}$

$\text{LSSS}(\spadesuit) = 1$

If $\text{LSSS}(\heartsuit) = 1$, $\text{LSSS}(\diamondsuit) = 1$, $\text{LSSS}(\clubsuit) = 1$

$\langle \quad , \vec{y} \rangle$

Hashed by H(tag) ⇒ Fixing and publishing H(tag), we obtain MIFE

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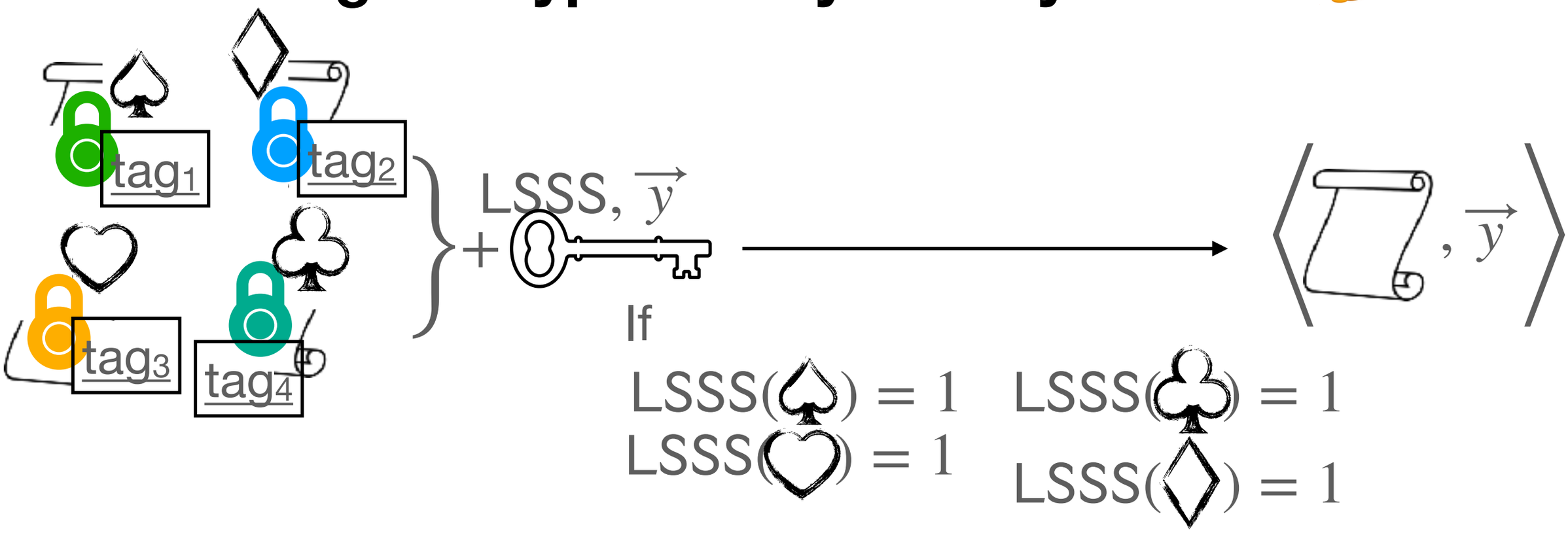

MIFE for
$\langle \cdot, \cdot \rangle$ with LSSS
$\Rightarrow$ MCFE for
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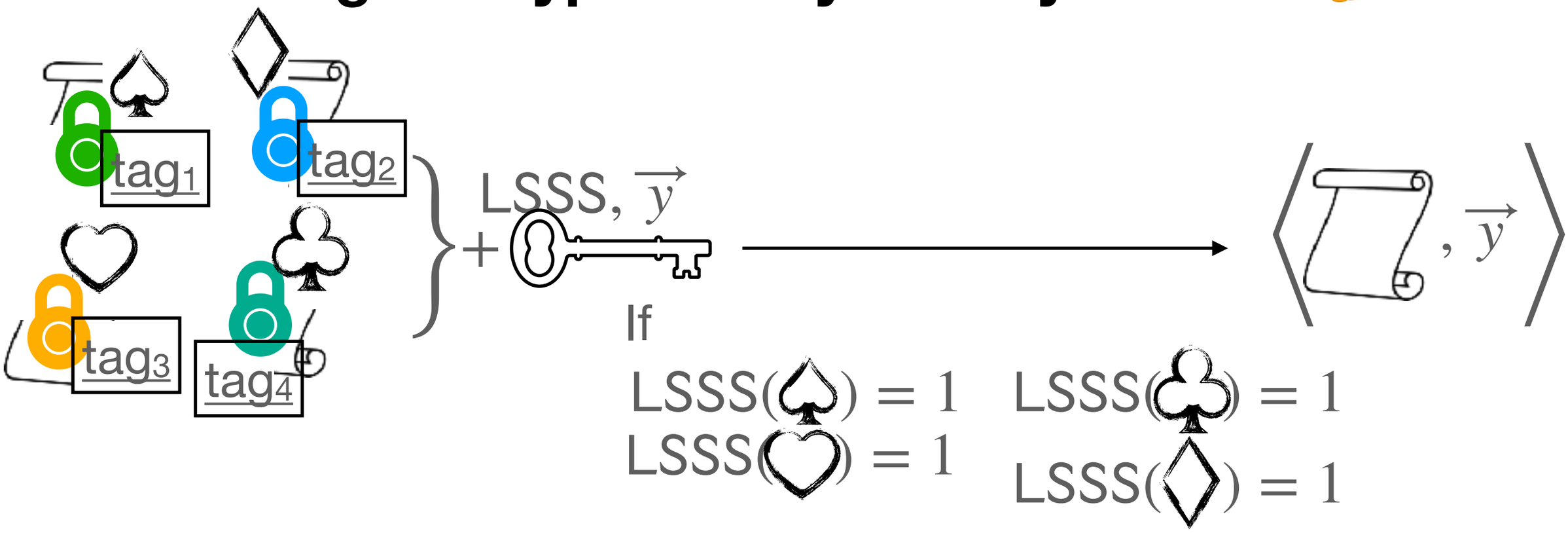

$\underline{\text{tag}_1}, \underline{\text{tag}_2}, \underline{\text{tag}_3}, \underline{\text{tag}_4}$
in ciphertext

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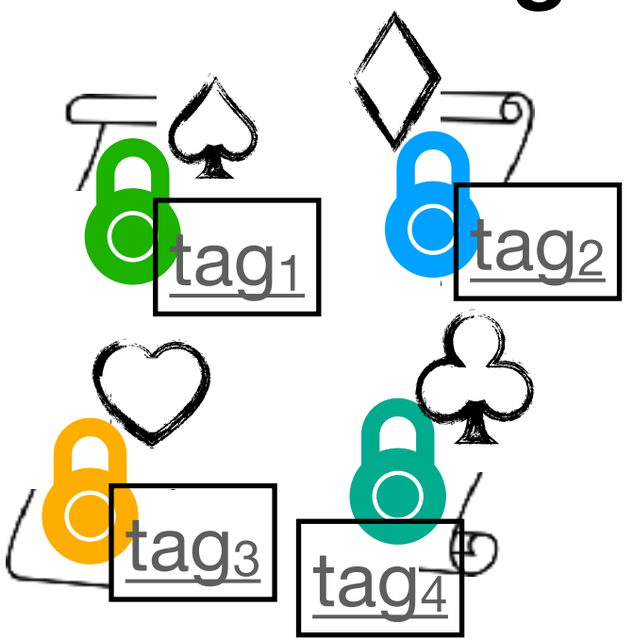

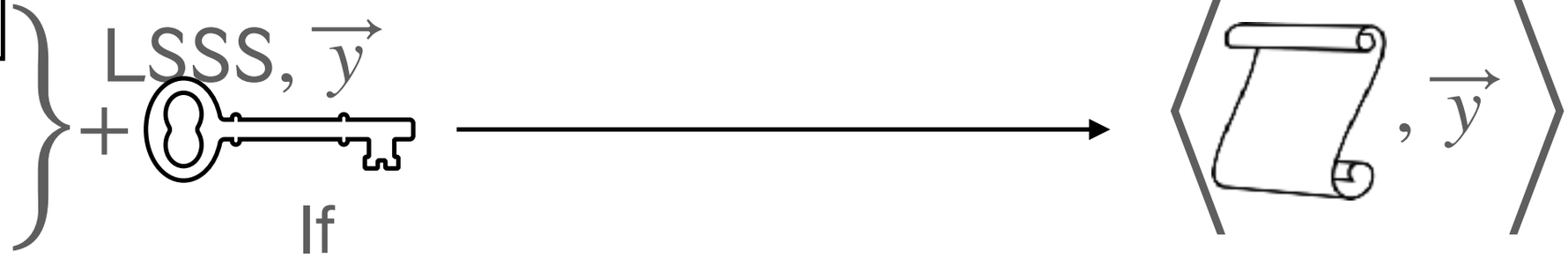

If

$\text{LSSS}(\spadesuit) = 1$ $\quad \text{LSSS}(\clubsuit) = 1$

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MIFE for
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$\underline{\text{tag}_1}, \underline{\text{tag}_2}, \underline{\text{tag}_3}, \underline{\text{tag}_4}$ in ciphertext $\longrightarrow$ Must check that $\underline{\text{tag}_1} = \underline{\text{tag}_2} = \underline{\text{tag}_3} = \underline{\text{tag}_4}$

Motivation

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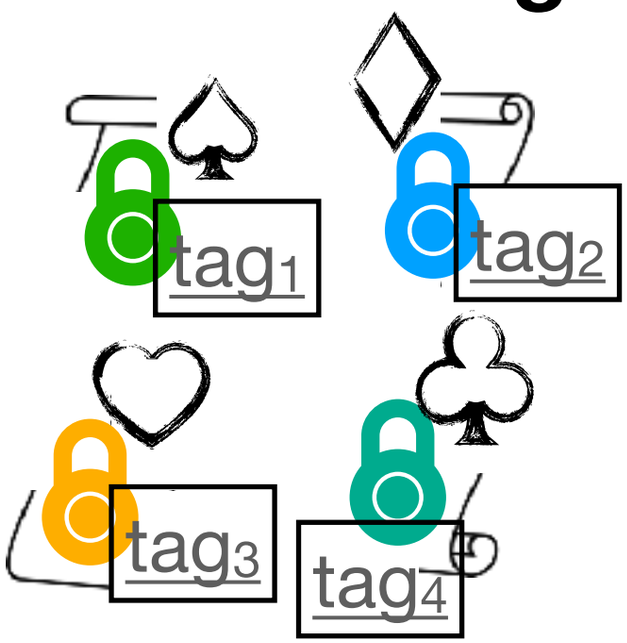

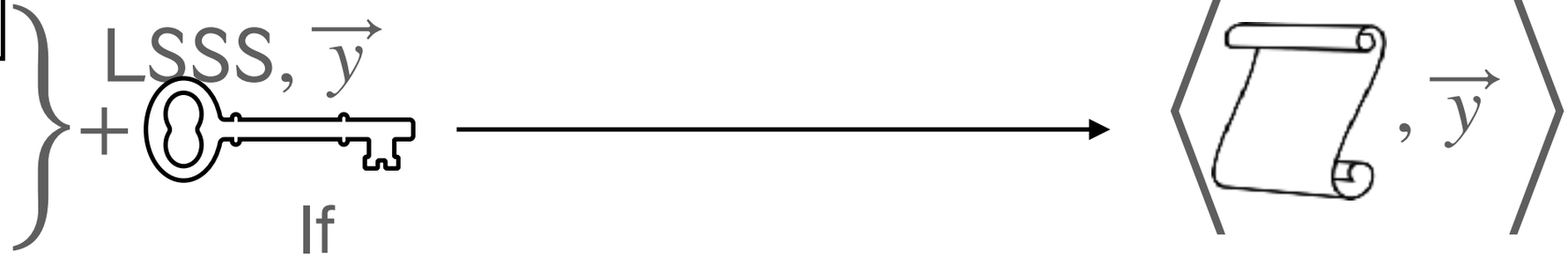

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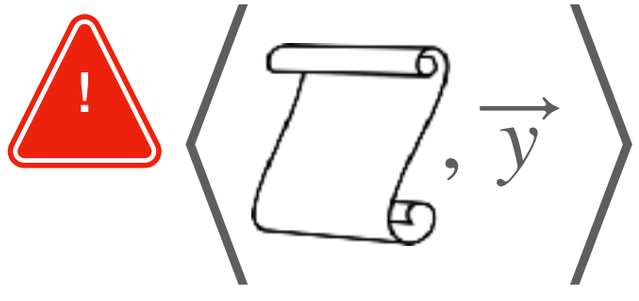
MIFE for $\langle \cdot , \cdot \rangle$ with LSSS

~~⇒~~ MCFE for $\langle \cdot , \cdot \rangle$ with LSSS?

$\underline{tag_1}, \underline{tag_2}, \underline{tag_3}, \underline{tag_4}$ in ciphertext → Must check that $\underline{tag_1} = \underline{tag_2} = \underline{tag_3} = \underline{tag_4}$

Infeasible in this case of



and LSSS

Motivation

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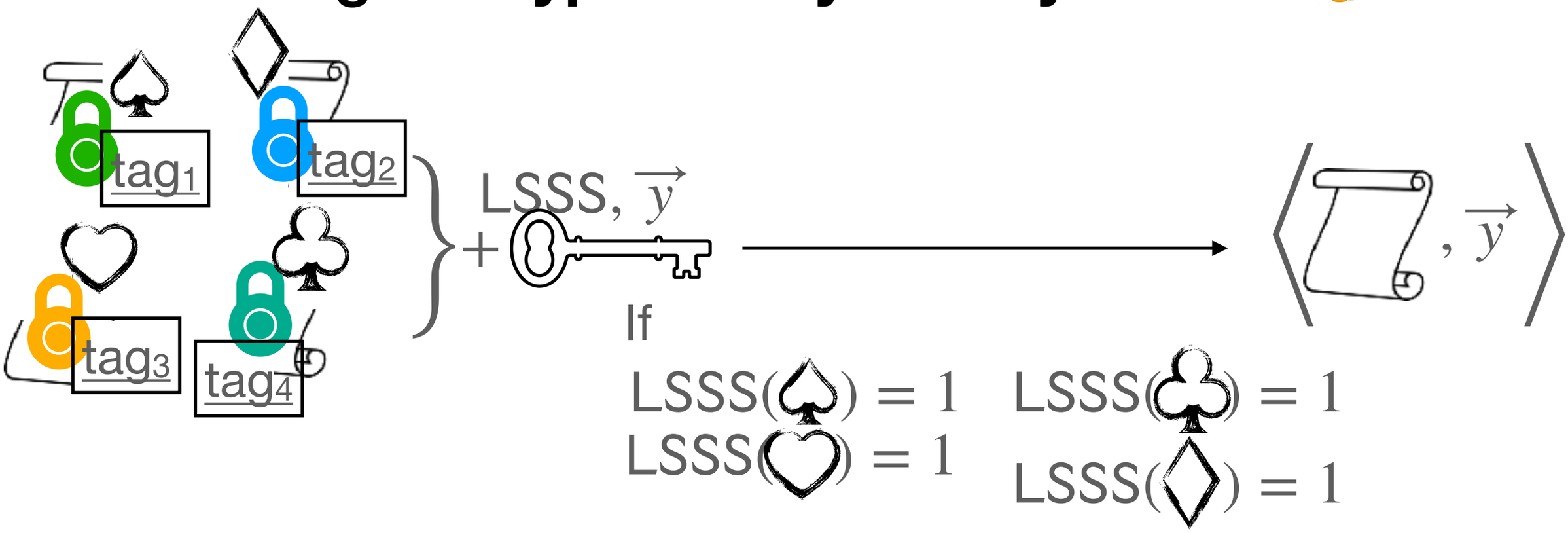

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Infeasible in this case of $\langle \cdot, \vec{y} \rangle$ and LSSS

More details in Sect. 3.1 of our paper

Our Goal

Constructing Multi-Client Functional Encryption Schemes for Inner Products, With Access Control using LSSS

Related Works and Our Contributions

FE + Access Control in the Multi-User Regime

[ACGU20]

- From pairings and LWE
- $\mathscr{P}$: *Monotone Span Programs*
- F: *Inner Products*
- (Multi-Input) Generic from single-client, **adaptive** security in standard model
- **Quadratic** total communication

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Our work

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  ⇒ (Multi-Input) **adaptive** security in standard model, **linear** total comm.

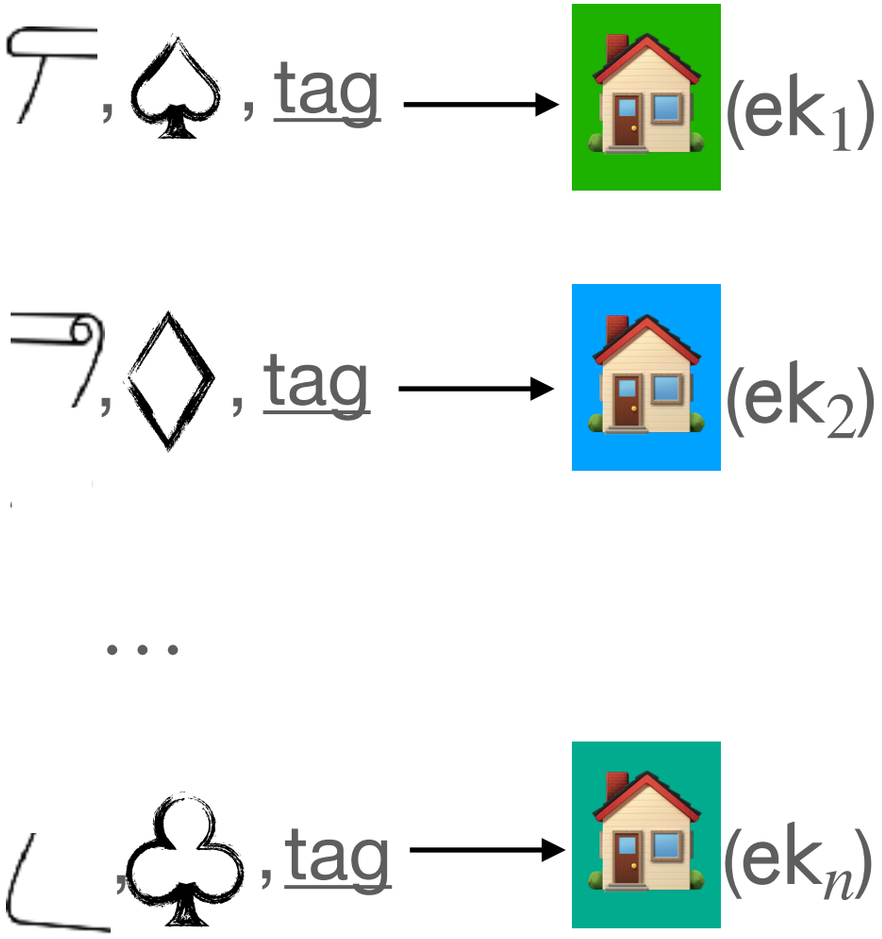
Definition

MCFE with Fine-Grained Access Control

$(\mathscr{P}$: LSSS) (♠) (♢) (♣)

Access Control: AC-K $\times$ AC-Ct$_1$ $\times$ AC-Ct$_2$ $\times \cdots \times$ AC-Ct$_n$ $\rightarrow \{0,1\}$

$\mathscr{P}, \overrightarrow{y}$ ⟶ ⚖(msk)



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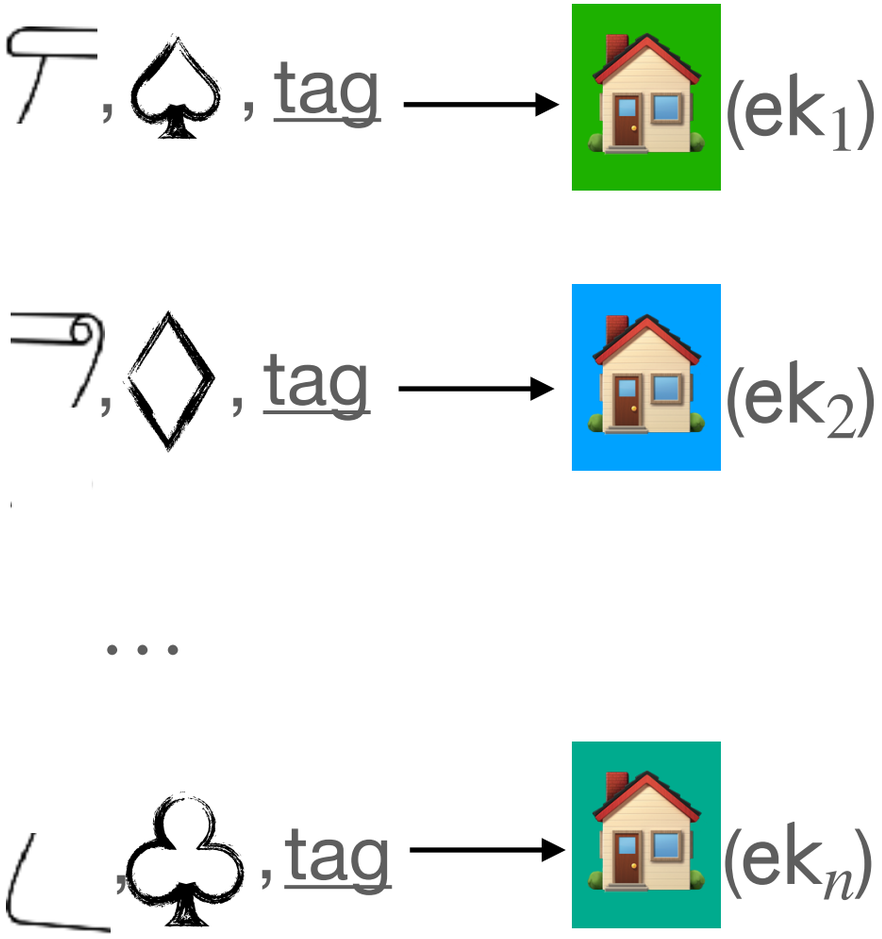

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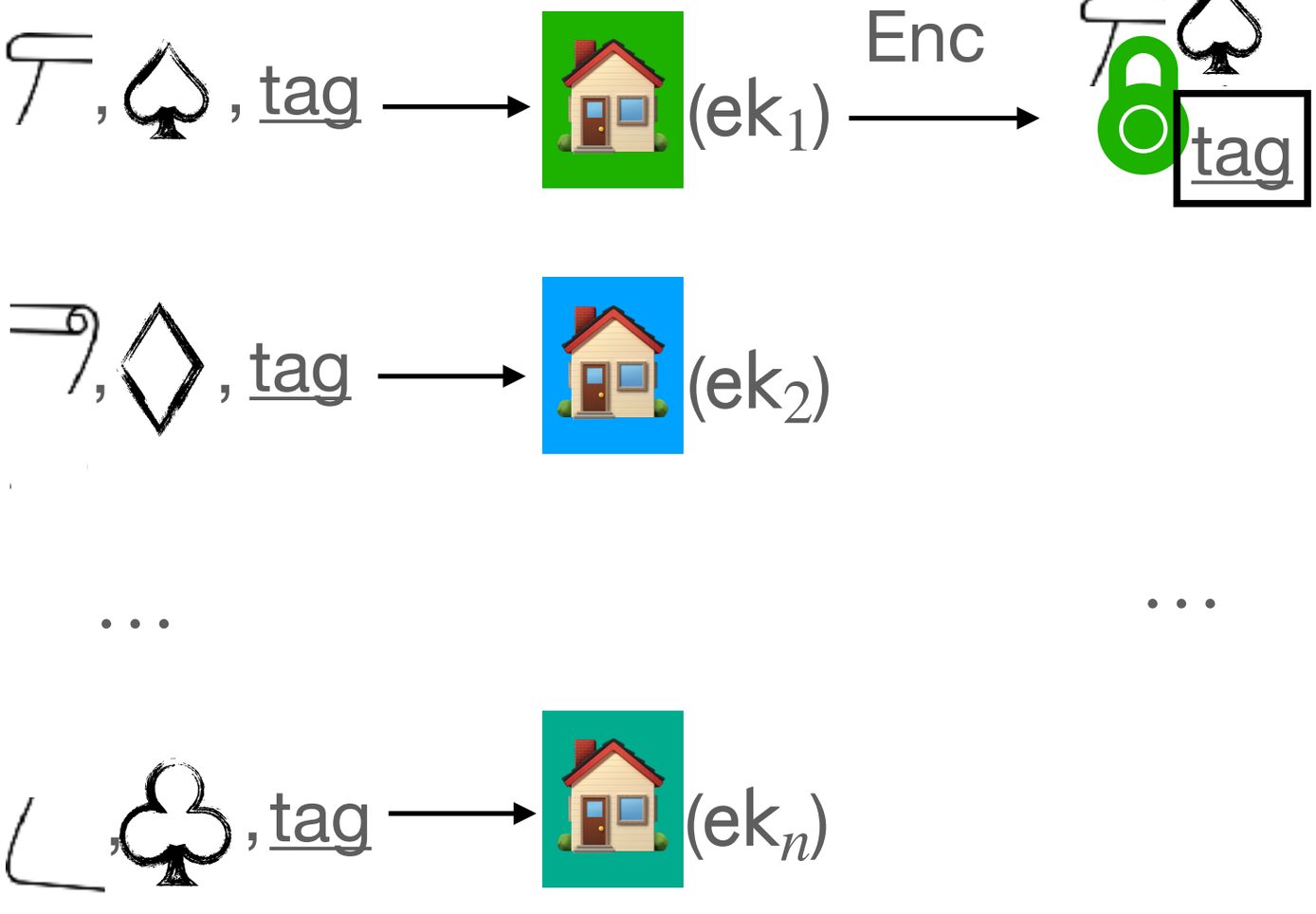

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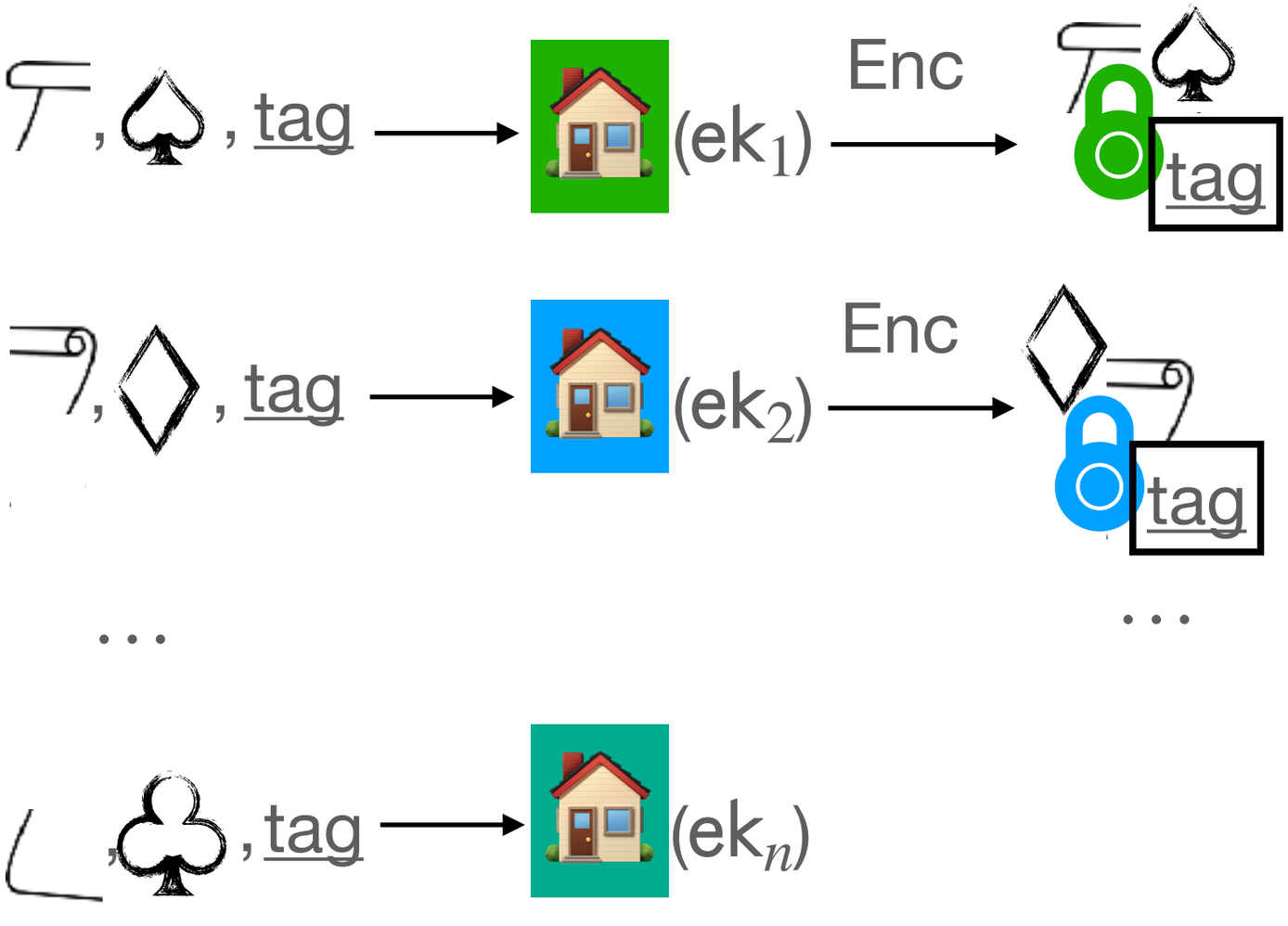

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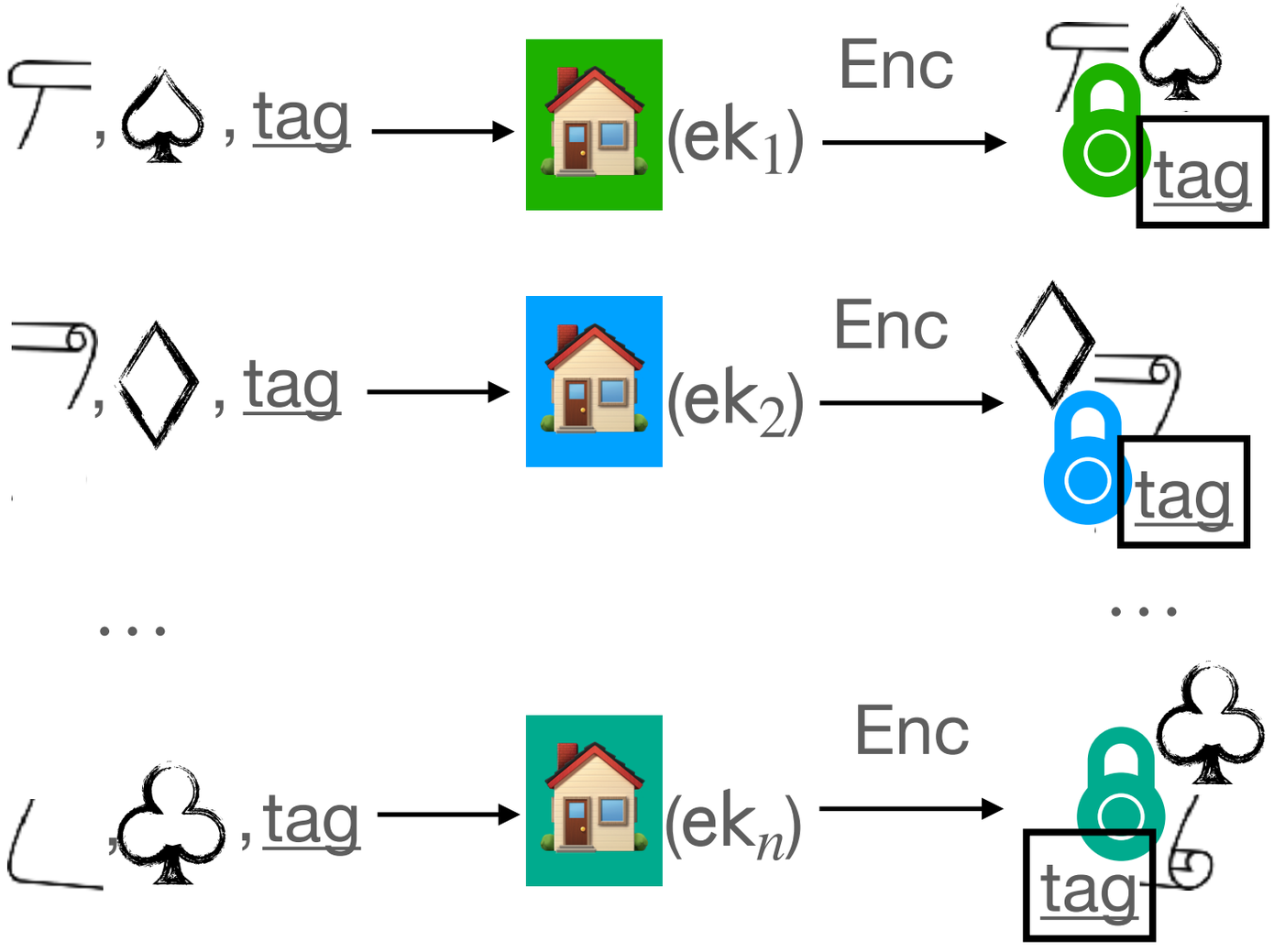

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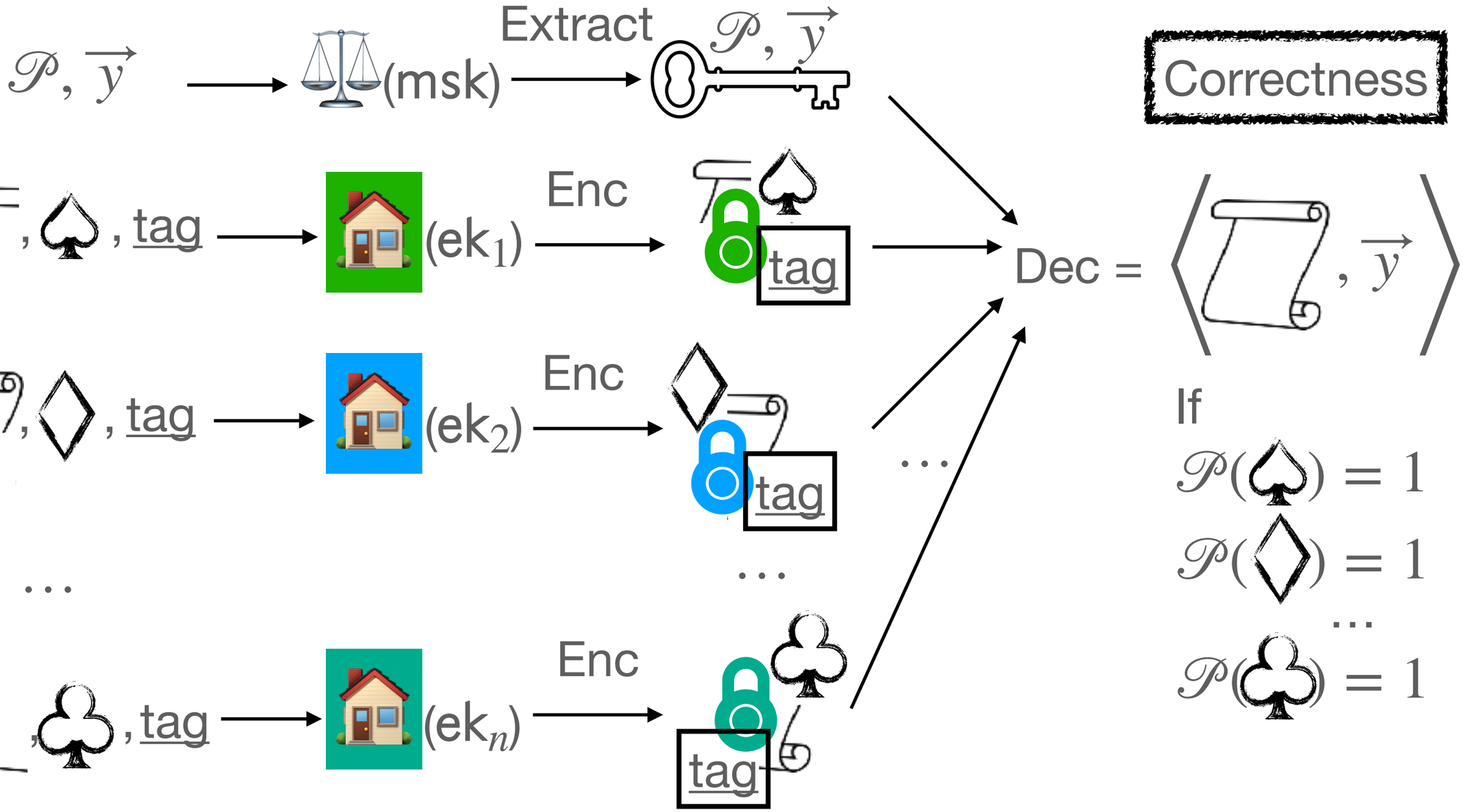

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$$\text{AC-K} \times \text{AC-Ct}_1 \times \cdots \times \text{AC-Ct}_i \times \cdots \times \text{AC-Ct}_n \to \{0,1\}$$

Challenger: $b \leftarrow^{\$} \{0,1\}$

Security

(msk)

(ek$_1$)

…

(ek$_i$)

(ek$_2$)

Adversary

Definition

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Security

(msk)

Extract($\mathscr{P}$, $\overrightarrow{y}$)

(ek_1)

...

(ek_i)

(ek_2)

Adversary

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(msk)

(ek$_1$)

...

(ek$_2$)

(ek$_i$)

Extract($\mathscr{P}$, $\overrightarrow{y}$)

Corrupt(i)

ek$_i$

Adversary

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Security

Extract($\mathscr{P}$, $\overrightarrow{y}$)

Corrupt(i)

ek_i

Chall($i, x_{0,i}, x_{1,i}, tag,$ ♡)

Enc($x_{b,i}, tag,$ ♡)

Adversary

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ek_i

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Enc($x_{b,i}, tag,$ ♡)

$(i, x_i, tag',$ ♡)

Enc($x_i, tag',$ ♡)

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Security

$b' \in \{0,1\}$

Adversary

(msk)

Extract($\mathscr{P}$, $\overrightarrow{y}$)

(ek_1)

...

(ek_i)

(ek_2)

Corrupt(i)

ek_i

Chall($i, x_{0,i}, x_{1,i}, tag,$ ♡)

Enc($x_{b,i}, tag,$ ♡)

($i, x_i, tag',$ ♡)

Enc($x_i, tag',$ ♡)

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Security

$b' \in \{0,1\}$

Adversary

- **AD**/SEL Chall
- **DYN**/STAT Corruption

(msk)

Extract($\mathscr{P}$, $\overrightarrow{y}$)

(ek_1)

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...

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Corrupt(i)

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$b' \in \{0,1\}$

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Extract($\mathscr{P}$, $\vec{y}$)

(ek_1)

...

(ek_i)

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Corrupt(i)

ek_i

Chall($i, x_{0,i}, x_{1,i}, tag,$ ♡)

Enc($x_{b,i}, tag,$ ♡)

$(i, x_i, tag',$ ♡)

Enc($x_i, tag',$ ♡)

$\mathscr{P}, \vec{y}$

$\mathscr{P}$ allows decrypting

$\Rightarrow \langle \vec{x}_0 - \vec{x}_1, \vec{y} \rangle = 0$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathscr{B} = \begin{bmatrix} \\ \\ \\ \dots \\ \\ \\ \end{bmatrix} \in GL_N(\mathbb{Z}_q)$$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathscr{B} = \begin{bmatrix} \\ \\ \\ \cdots \\ \\ \\ \end{bmatrix} ; \left(\mathscr{B}^{-1}\right)^{\dagger} = \begin{bmatrix} \\ \\ \\ \cdots \\ \\ \\ \end{bmatrix} \in GL_N(\mathbb{Z}_q)$$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

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$\cdot g_1$ $\cdot g_2$

$$\mathbf{B} = \begin{bmatrix} \\ \\ \\ \cdots \\ \\ \\ \\ \end{bmatrix}_1 \in \mathbb{G}_1^{N \times N} ; \quad \mathbf{B}^* = \begin{bmatrix} \\ \\ \\ \cdots \\ \\ \\ \\ \end{bmatrix}_2 \in \mathbb{G}_2^{N \times N}$$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathbf{B} = \begin{bmatrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{bmatrix}_1 ; \quad \mathbf{B}^* = \begin{bmatrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{bmatrix}_2$$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathbf{B} = \begin{bmatrix} \\ \\ \\ \dots \\ \\ \\ \end{bmatrix}_1 ; \quad \mathbf{B}^* = \begin{bmatrix} \\ \\ \\ \dots \\ \\ \\ \end{bmatrix}_2$$

$$(x_1, .., x_n) \cdot \mathbf{B}$$

$$(x_1 \mid \dots \mid x_n)_{\mathbf{B}} \in \mathbb{G}_1^N$$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathbf{B} = \begin{bmatrix} \cdots \\ \cdots \end{bmatrix}_1 \quad ; \quad \mathbf{B}^* = \begin{bmatrix} \cdots \\ \cdots \end{bmatrix}_2$$

$(x_1, .., x_n) \cdot$ ↓ $\quad (x_1 \mid \ldots \mid x_n)_{\mathbf{B}} \in \mathbb{G}_1^N$

$(y_1, .., y_n) \cdot$ ↓ $\quad (y_1 \mid \ldots \mid y_n)_{\mathbf{B}^*} \in \mathbb{G}_2^N$

Technical Tools

Dual Pairing Vector Spaces [Okamoto,Takashima'10,12]

Prime-order (additive) bilinear group: $(\mathbb{G}_1, \mathbb{G}_2, \mathbb{G}_t, g_1, g_2, g_t, e, q), N \in \mathbb{N}$

Public vectors Private vectors

$$\mathbf{B} = \begin{bmatrix} \cdots \\ \cdots \end{bmatrix}_1 ; \quad \mathbf{B}^* = \begin{bmatrix} \cdots \\ \cdots \end{bmatrix}_2$$

$(x_1, .., x_n) \cdot$ $(y_1, .., y_n) \cdot$

$(x_1 \mid \ldots \mid x_n)_{\mathbf{B}} \in \mathbb{G}_1^N$ $(y_1 \mid \ldots \mid y_n)_{\mathbf{B}^*} \in \mathbb{G}_2^N$

$\times$

$[\![x_1 y_1 + \cdots + x_n y_n]\!]_t$

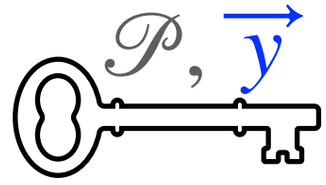
Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P} : \text{LSSS})$

$\text{AC-K} \times \text{AC-Ct} \rightarrow \{0,1\}$

$= (x_1, \ldots, x_n)$



$\mathscr{P}, \overrightarrow{y}$

$S = (s_1, .., s_n)$

$U = (u_1, .., u_n)$

$$\text{Ciphertext} \begin{cases} \left([\![\omega(s_i + \mu u_i) + x_i]\!]_1 \right)_{i \in [n]} \\ \overrightarrow{c}_{att} = (\cdots | \psi | 0 | \cdots)_{\mathbf{F}} \quad ; \quad \overrightarrow{c}_0 = (\omega | \mu\omega | \psi | 0)_{\mathbf{H}} \end{cases}$$

$$\overrightarrow{k}^*_{att} = (\cdots | a_{att} | 0 | \cdots)_{\mathbf{F}^*}; \quad \overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle | \langle U, \overrightarrow{y} \rangle | a_0 | 0)_{\mathbf{H}^*}$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

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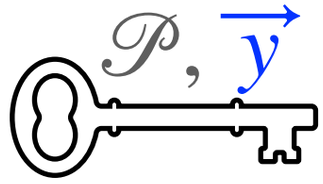

$S = (s_1, .., s_n)$

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$$\text{Ciphertext} \begin{cases} \left([\![\omega(s_i + \mu u_i) + x_i]\!]_1 \right)_{i \in [n]} \\ \overrightarrow{c}_{att} = (\cdots | \psi | 0 | \cdots)_{\mathbf{F}} \quad ; \quad \overrightarrow{c}_0 = (\omega | \mu\omega | \psi | 0)_{\mathbf{H}} \end{cases}$$

Key-Policy, $(a_{att})_{att} \leftarrow \text{LSSS-Share}(a_0)$

$$\overrightarrow{k}^*_{att} = (\cdots | a_{att} | 0 | \cdots)_{\mathbf{F}^*}; \quad \overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle | \langle U, \overrightarrow{y} \rangle | a_0 | 0)_{\mathbf{H}^*}$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P} : \text{LSSS})$

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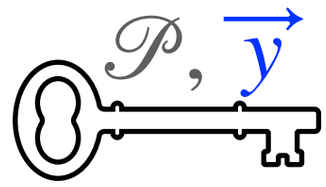

$S = (s_1, .., s_n)$

$U = (u_1, .., u_n)$

Randomness

Ciphertext $\begin{cases} \left([\![\omega(s_i + \mu u_i) + x_i]\!]_1 \right)_{i \in [n]} \\ \overrightarrow{c}_{att} = (\cdots \mid \psi \mid 0 \mid \cdots)_{\mathbf{F}} \quad ; \end{cases}$

$\overrightarrow{c}_0 = (\omega \mid \mu\omega \mid \psi \mid 0)_{\mathbf{H}}$

Key-Policy, $(a_{att})_{att} \leftarrow \text{LSSS-Share}(a_0)$

$\overrightarrow{k}^*_{att} = (\cdots \mid a_{att} \mid 0 \mid \cdots)_{\mathbf{F}^*}; \qquad \overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle \mid \langle U, \overrightarrow{y} \rangle \mid a_0 \mid 0)_{\mathbf{H}^*}$

ALS key

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P} : \text{LSSS})$

$\text{AC-K} \times \text{AC-Ct} \to \{0,1\}$

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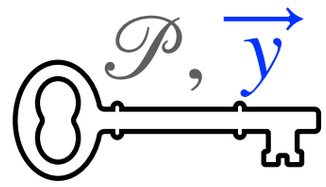

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$\overrightarrow{c}_0 = (\omega \mid \mu\omega \mid \psi \mid 0)_{\mathbf{H}}$

Key-Policy, $(a_{att})_{att} \leftarrow \text{LSSS-Share}(a_0)$

$\overrightarrow{k}^*_{att} = (\cdots \mid a_{att} \mid 0 \mid \cdots)_{\mathbf{F}^*}$;

$\overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle \mid \langle U, \overrightarrow{y} \rangle \mid a_0 \mid 0)_{\mathbf{H}^*}$

$$\Rightarrow \sum_{att \in \text{LSSS-Reconstr}} \overrightarrow{c}_{att} \times \overrightarrow{k}^*_{att}$$

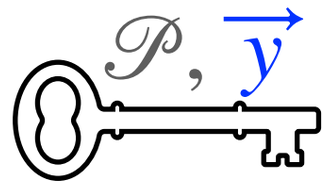
$$= [\![\sum_{att \in \text{LSSS-Reconstr}} \psi a_{att}]\!]_t = [\![\psi a_0]\!]_t$$

ALS key

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P}$: LSSS)
AC-K × AC-Ct → $\{0,1\}$


$= (x_1, \ldots, x_n)$


$S = (s_1, .., s_n)$
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Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

$\overrightarrow{k}^*_{att} = (\cdots \mid a_{att} \mid 0 \mid \cdots)_{\mathbf{F}^*}$; $\overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle \mid \langle U, \overrightarrow{y} \rangle \mid a_0 \mid 0)_{\mathbf{H}^*}$

$$\Rightarrow \sum_{att \in \text{LSSS-Reconstr}} \overrightarrow{c}_{att} \times \overrightarrow{k}^*_{att}$$
$$= [\![\sum_{att \in \text{LSSS-Reconstr}} \psi a_{att}]\!]_t = [\![\psi a_0]\!]_t$$

$$\Rightarrow \overrightarrow{c}_0 \times \overrightarrow{k}^*_0$$
$$= [\![\omega \langle S + \mu U, \overrightarrow{y} \rangle]\!]_t + [\![\psi a_0]\!]_t$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P}$: LSSS)
AC-K × AC-Ct → $\{0,1\}$


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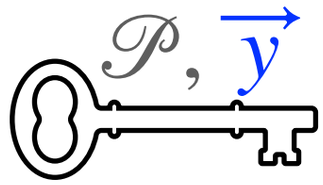

$S = (s_1, .., s_n)$
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Ciphertext $\begin{cases} \left([\![\omega(s_i + \mu u_i) + x_i]\!]_1 \right)_{i \in [n]} \xrightarrow{\cdot\, y_i} \sum_{i=1}^{n} \xrightarrow{} [\![\omega \langle S + \mu U, \overrightarrow{y} \rangle]\!]_t + [\![\langle \overrightarrow{x}, \overrightarrow{y} \rangle]\!]_t \\ \overrightarrow{c}_{att} = (\cdots \mid \psi \mid 0 \mid \cdots)_{\mathbf{F}} \quad ; \quad \overrightarrow{c}_0 = (\omega \mid \mu\omega \mid \psi \mid 0)_{\mathbf{H}} \end{cases}$

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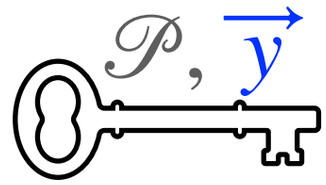
Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

$(\mathscr{P}$: LSSS)
$\text{AC-K} \times \text{AC-Ct} \to \{0,1\}$


$= (x_1, \ldots, x_n)$


$S = (s_1, .., s_n)$
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$$\overrightarrow{k}^*_{att} = (\cdots \mid a_{att} \mid 0 \mid \cdots)_{\mathbf{F}^*}; \qquad \overrightarrow{k}^*_0 = (\langle S, \overrightarrow{y} \rangle \mid \langle U, \overrightarrow{y} \rangle \mid a_0 \mid 0)_{\mathbf{H}^*}$$

$$\Rightarrow \sum_{att \in \text{LSSS-Reconstr}} \overrightarrow{c}_{att} \times \overrightarrow{k}^*_{att}$$
$$= [\![\sum_{att \in \text{LSSS-Reconstr}} \psi a_{att}]\!]_t = [\![\psi a_0]\!]_t$$

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Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K $\times$ AC-Ct $\rightarrow \{0,1\}$, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

$[\![\omega(s_i + \mu u_i) + x_{b,i}]\!]_1$, $\Delta x_i = x_{0,i} - x_{b,i}$, $(a'_{att})_{att} \leftarrow$ LSSS-Share(a'_0)

Changes using Basis changes In DPVS

$$\overrightarrow{c}_{att} = (\cdots | \psi | \tau \Delta x_1 z_{att} | \cdots | \tau \Delta x_n z_{att})_{\mathbf{F}}$$

$$\overrightarrow{k}^*_{att} = (\cdots | a_{att} | a'_{att} y_1 / z_{att} | \cdots | a'_{att} y_n / z_{att})_{\mathbf{F}^*}$$

$$\overrightarrow{c}_0 = (\omega | \mu\omega | \psi | \tau \Delta x_1 | \cdots | \tau \Delta x_n)_{\mathbf{H}}$$

$$\overrightarrow{k}^*_0 = (\cdots | a_0 | a'_0 y_1 | \cdots | a'_0 y_n)_{\mathbf{H}^*}$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K × AC-Ct → {0,1}, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

$[\![\omega(s_i + \mu u_i) + x_{b,i}]\!]_1$, $\Delta x_i = x_{0,i} - x_{b,i}$, $(a'_{att})_{att} \leftarrow$ LSSS-Share(a'_0)

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Random z_{att}

$$\overrightarrow{c}_0 = (\omega | \mu\omega | \psi | \tau \Delta x_1 | \cdots | \tau \Delta x_n)_{\mathbf{H}}$$

$$\overrightarrow{k}^*_0 = (\cdots | a_0 | a'_0 y_1 | \cdots | a'_0 y_n)_{\mathbf{H}^*}$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

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$$\overrightarrow{k}^*_0 = (\cdots | a_0 | a'_0 y_1 | \cdots | a'_0 y_n)_{\mathbf{H}^*}$$

$(\overrightarrow{k}^*_{att}, \overrightarrow{k}_0)$ can't decrypt: ABE technique

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

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Random z_{att}

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ok $(\overrightarrow{k}^*_{att}, \overrightarrow{k}_0)$ can't decrypt: ABE technique

! $(\overrightarrow{k}^*_{att}, \overrightarrow{k}_0)$ can decrypt $\Rightarrow \langle \Delta x, \overrightarrow{y} \rangle = 0$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K × AC-Ct → {0,1}, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

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ok $(\overrightarrow{k}^*_{att}, \overrightarrow{k}_0)$ can't decrypt: ABE technique ← ? **Adaptive Security** 🤔

! $(\overrightarrow{k}^*_{att}, \overrightarrow{k}_0)$ can decrypt $\Rightarrow \langle \Delta x, \overrightarrow{y} \rangle = 0$ ← ?

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K × AC-Ct → {0,1}, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

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Adaptive Security 🤔

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

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$$\overrightarrow{k}^*_0 = (\cdots | a_0 | r'_0 y_1 | \cdots | r'_0 y_n)_{\mathbf{H}^*}$$

$$\overrightarrow{c}_0 = (\omega | \mu\omega | \psi | \tau \Delta x_1 | \cdots | \tau \Delta x_n)_{\mathbf{H}}$$

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K × AC-Ct → {0,1}, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

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n coordinates

Technical Overview - Single-Client

AB-IPFE for LSSS - Adaptive Security, linear ciphertext's size

AC-K × AC-Ct → {0,1}, Key-Policy, $(a_{att})_{att} \leftarrow$ LSSS-Share(a_0)

$[\![\omega(s'_i + \mu u'_i) + x_{0,i}]\!]_1$, $\Delta x_i = x_{0,i} - x_{b,i}$, $(a'_{att})_{att} \leftarrow$ LSSS-Share(a'_0)

Changes using Basis changes In DPVS

$$\overrightarrow{c}_{att} = (\cdots | \psi | \tau \Delta x_1 z_{att} | \cdots | \tau \Delta x_n z_{att})_{\mathbf{F}}$$

$$\overrightarrow{k}^*_{att} = (\cdots | a_{att} | a'_{att} y_1 / z_{att} | \cdots | a'_{att} y_n / z_{att})_{\mathbf{F}^*}$$

$$\overrightarrow{k}^*_0 = (\cdots | a_0 | r'_0 y_1 | \cdots | r'_0 y_n)_{\mathbf{H}^*}$$

$$\overrightarrow{c}_0 = (\omega | \mu\omega | \psi | \tau \Delta x_1 | \cdots | \tau \Delta x_n)_{\mathbf{H}}$$

$$|\text{ciphertext}| = nd + 2n + 7d + 3$$

Technical Overview - Single-Client

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Vector's length

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#att's needed in ciphertext

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More details in Sect. 5.3 of our paper

Vector's length

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#att's needed in ciphertext

E.g.: $d = 1$ for Identity-based Control

Towards Multi-Client - “Compress-and-Duplicate”

MC-AB-IPFE for LSSS - Adaptive Security, linear total communication

$(\mathscr{P}$: LSSS)

$$\text{AC-K} \times \text{AC-Ct}_1 \times \cdots \times \text{AC-Ct}_i \times \cdots \times \text{AC-Ct}_n \to \{0,1\}$$

More details in Sect. 5.2 of our paper

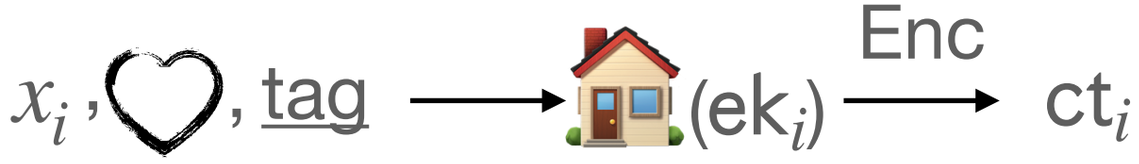
“Compress” in $(\mathbf{F}, \mathbf{F}^*)$

$$\vec{k}^*_{i,att} = (\cdots \mid a_{att} \mid a'_{att} y_i / z_{att} \mid 0..0)_{\mathbf{F}^*}$$

“Duplicate”$(\mathbf{H_i}, \mathbf{H_i^*})$

$$\vec{k}^*_{i,0} = (\cdots \mid a_0 \mid r'_0 y_i \mid 0..0)_{\mathbf{H_i^*}}$$

$\Theta(1)$ aux coordinates per i,att



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$$\vec{c}_{i,att} = (\cdots \mid \psi_i \mid \tau \Delta x_i z_{att} \mid 0..0)_{\mathbf{F}}$$

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Hash(tag) as RO

Towards Multi-Client - “Compress-and-Duplicate”

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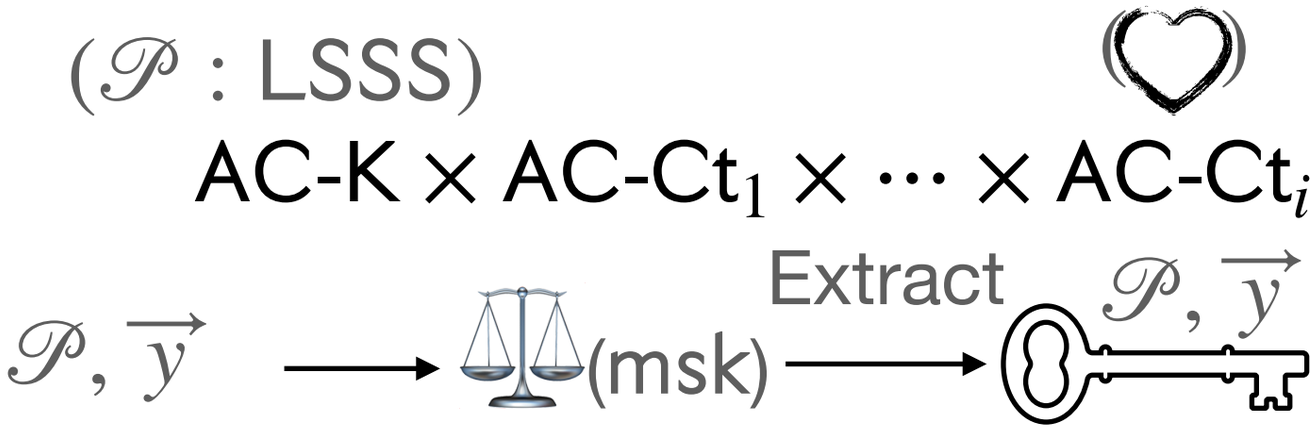

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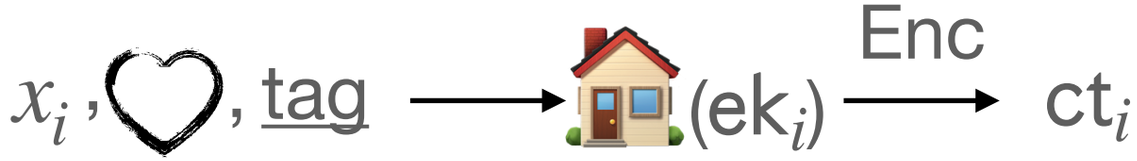

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“Duplicate”$(\mathbf{H_i}, \mathbf{H_i^*})$

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$$\vec{c}_{i,0} = (\omega \mid \omega' \mid \psi_i \mid \tau \Delta x_i \mid 0..0)_{\mathbf{H_i}}$$

Hash(tag) as RO

$$|\text{ciphertexts}| = 8nd + 5n$$

Conclusion

MCFE Candidates for Inner Products with LSSS, achieving Adaptive Security in ROM and Linear Total Communication

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MCFE Candidates for Inner Products with LSSS, achieving Adaptive Security in ROM and Linear Total Communication

Thanks to
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