Generalized Fuzzy Password-Authenticated Key Exchange from Error Correcting Codes

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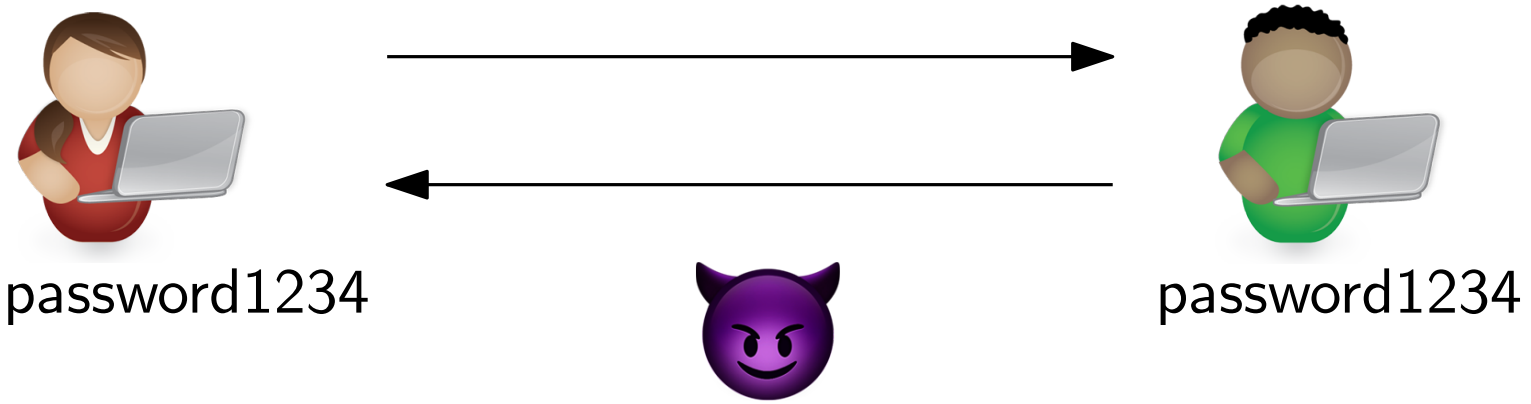
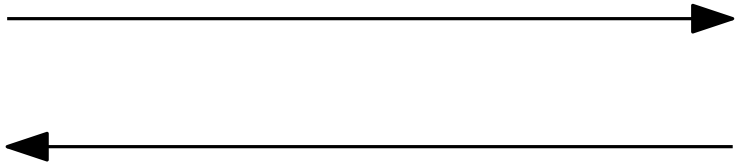
Password Authenticated Key Exchange (PAKE)



Password Authenticated Key Exchange (PAKE)

password1234



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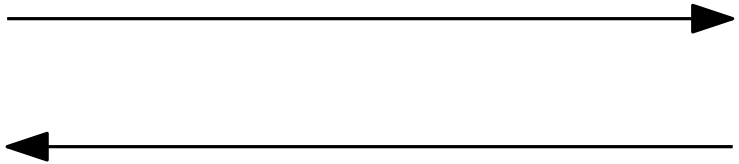

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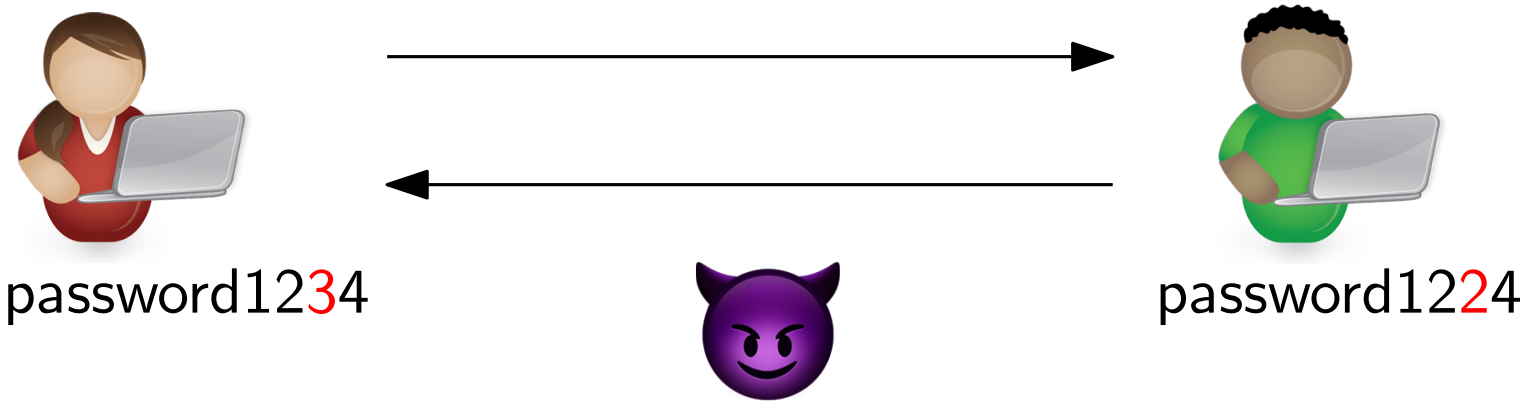
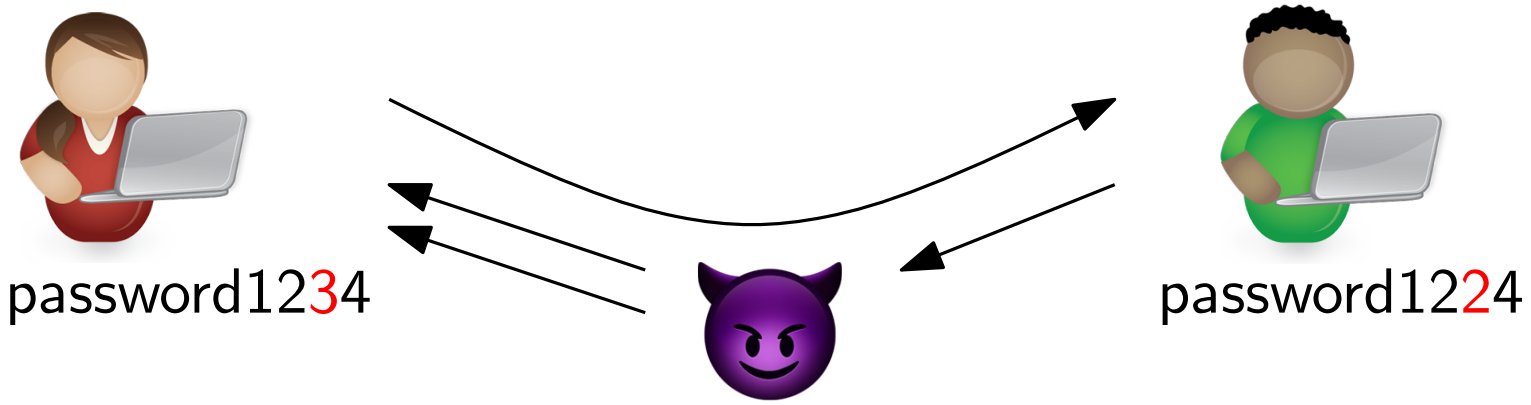
Fuzzy PAKE



- Typo tolerance
- Biometric readings as passwords
- Pairing of nearby IoT devices with sensor data as passwords

Fuzzy PAKE - Attack Model



- Same session-key, if and only if the passwords are close
- $\mathcal{A}$ should not learn anything about the passwords
- No offline attacks
- $\mathcal{A}$ should only have one password guess per session

Existing Approaches from [DHP+18]

- Garbled circuit based protocol for arbitrary distances
- Robust secret sharing based, for Hamming distance

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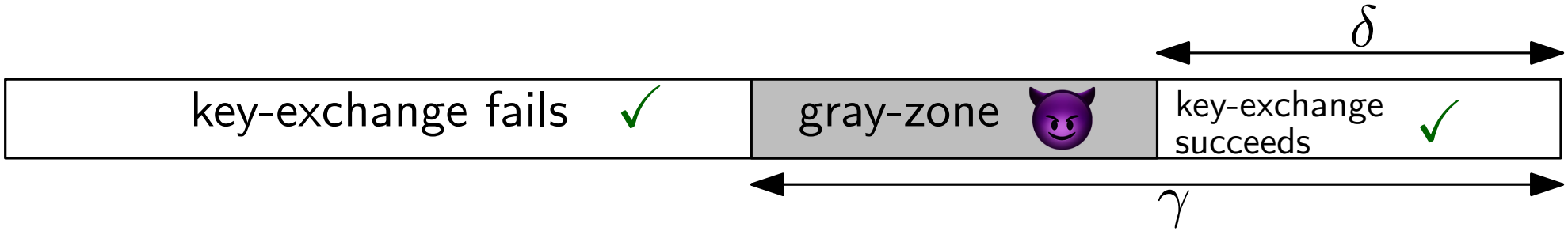

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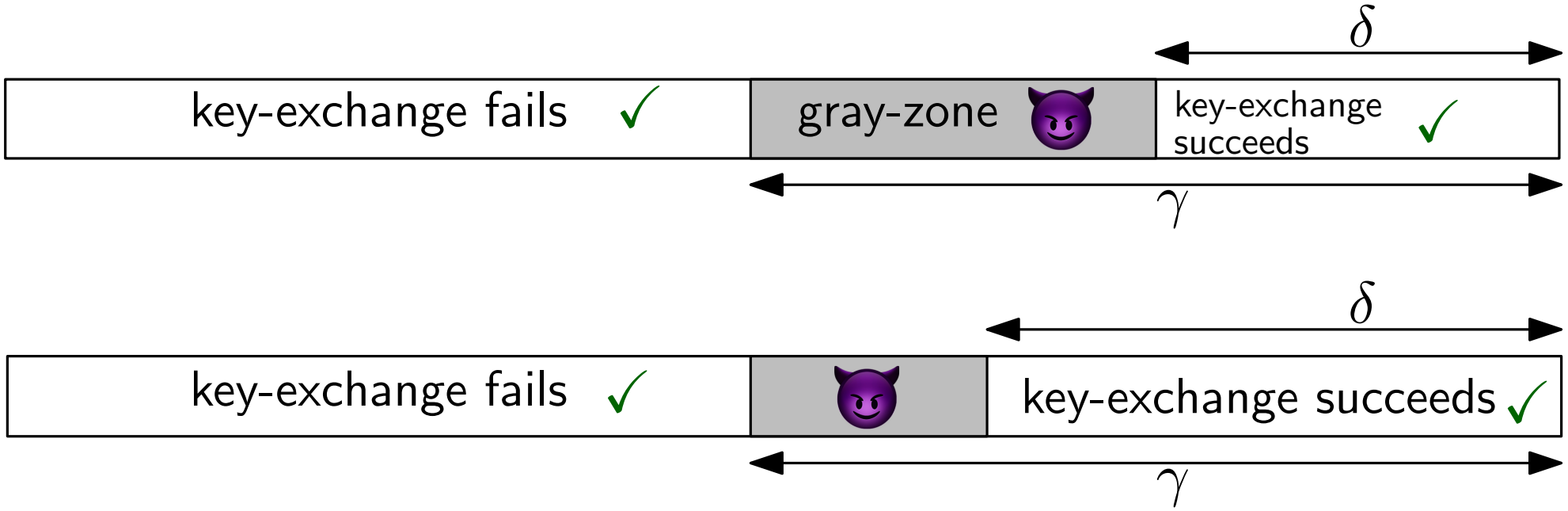

Intuition of the fPAKE-RSS protocol

$\mathsf{pw} = 0110$

$\mathsf{pw}' = 0100$

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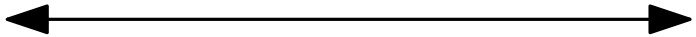
$$\begin{pmatrix} k_1 \\ k_2 \\ k_3 \\ k_4 \end{pmatrix}$$



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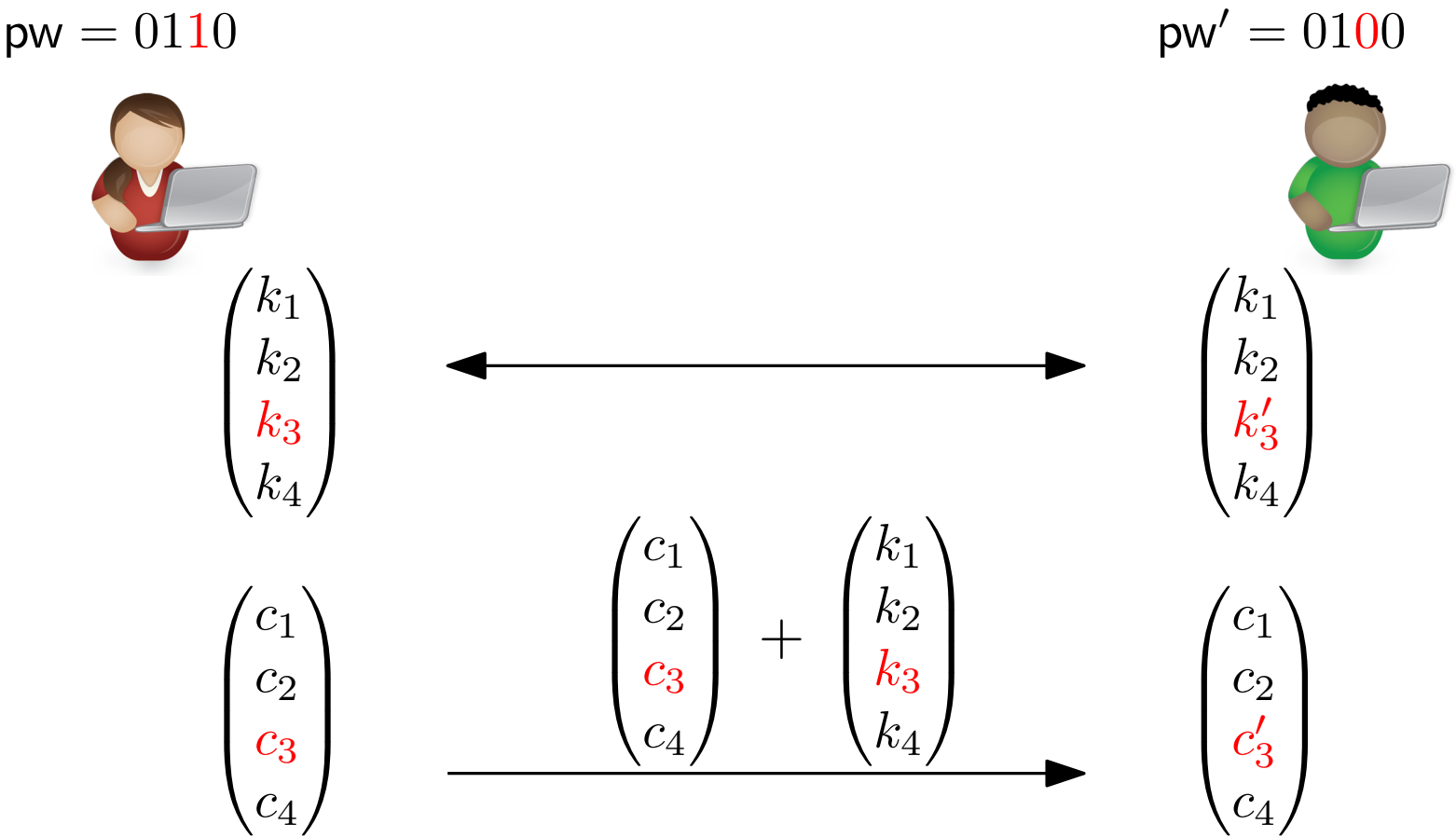
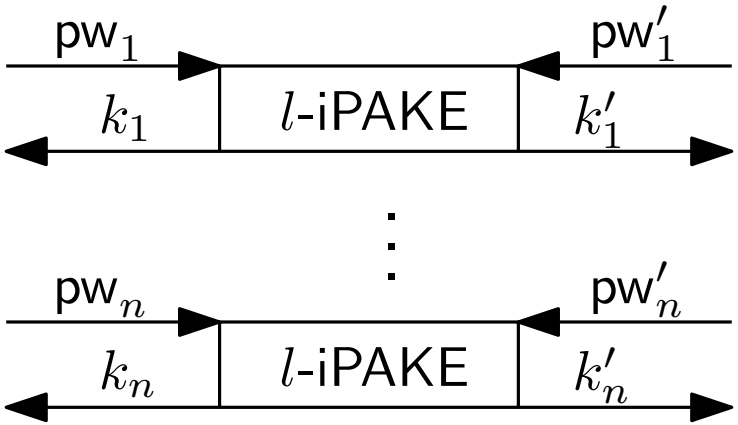


Attack on the fPAKE-RSS protocol

$\mathsf{pw} = \mathsf{pw}_1, \ldots, \mathsf{pw}_n$



$\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$

$\mathbf{K} := (k_1, \ldots, k_n)$
choose U at random
$\mathbf{C} \leftarrow \mathsf{Encode}(U)$
$\mathbf{E} := \mathbf{C} + \mathbf{K}$
$\sigma \leftarrow \mathsf{Sign}(\mathsf{sk}, \mathbf{E})$
session-key $:= U$

$\mathbf{E}, \sigma, \mathsf{vk}$

$\mathbf{K}' := (k_1, \ldots, k_n)$
verify signature
$\mathbf{C}' := \mathbf{E} - \mathbf{K}'$
$U' \leftarrow \mathsf{Decode}(\mathbf{C}')$
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Attack on the fPAKE-RSS protocol

$\mathsf{pw} = \mathsf{pw}_1, \ldots, \mathsf{pw}_n$

pw_1 — k_1 — l-iPAKE — k'_1 — pw'_1

pw_n — k_n — l-iPAKE — k'_n — pw'_n

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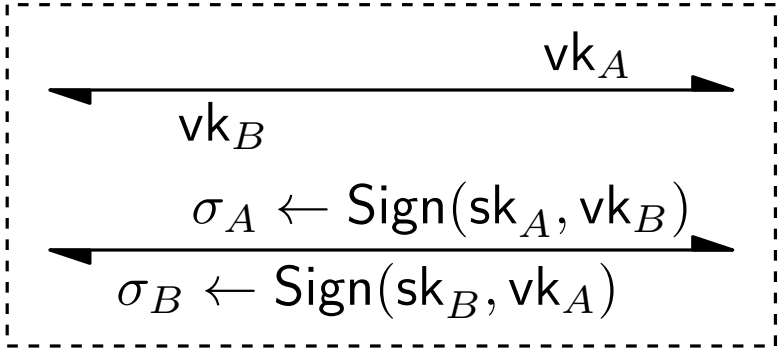
Summary of the Attack

- Requirements:
  - Both parties run the protocol
  - Both parties use the same password
  - The attacker actively interferes in the protocol
- Effect:
  - The attacker learns one bit of their choice of the password

Variations of the attack also work when the passwords are not identical

Overview of our fuzzy PAKE protocol

$\mathsf{pw} = \mathsf{pw}_1, \ldots, \mathsf{pw}_n$



$\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$

Overview of our fuzzy PAKE protocol

$\mathsf{pw} = \mathsf{pw}_1, \ldots, \mathsf{pw}_n$ $\qquad$ $\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$

vk_A

vk_B

$\sigma_A \leftarrow \mathsf{Sign}(\mathsf{sk}_A, \mathsf{vk}_B)$

$\sigma_B \leftarrow \mathsf{Sign}(\mathsf{sk}_B, \mathsf{vk}_A)$

$\mathbf{C} \leftarrow \mathsf{Encode}(\mathsf{secret})$
$\mathbf{E} := \mathsf{blind}(\mathbf{C})$
$h := H(\mathbf{C})$

$\mathbf{E}, h$

$\mathbf{C}' := \mathsf{unblind}(\mathbf{E})$
$L \leftarrow \mathsf{ListDecode}(\mathbf{C}')$
identify correct $\mathbf{C}$ via h
$\mathsf{secret} := \mathsf{Decode}(\mathbf{C})$

Our fuzzy PAKE protocol

$\mathsf{pw} = \mathsf{pw}_1, \ldots, \mathsf{pw}_n$ $\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$

set up split authenticated channel

Our fuzzy PAKE protocol

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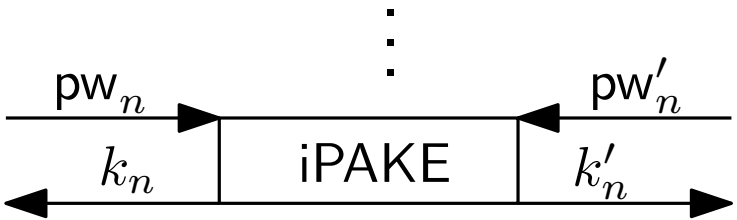
$\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$



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$\mathsf{pw}' = \mathsf{pw}'_1, \ldots, \mathsf{pw}'_n$

pw_1 — k_1 — iPAKE — k'_1 — pw'_1

$\mathbf{K} := (k_1, \ldots, k_n)$

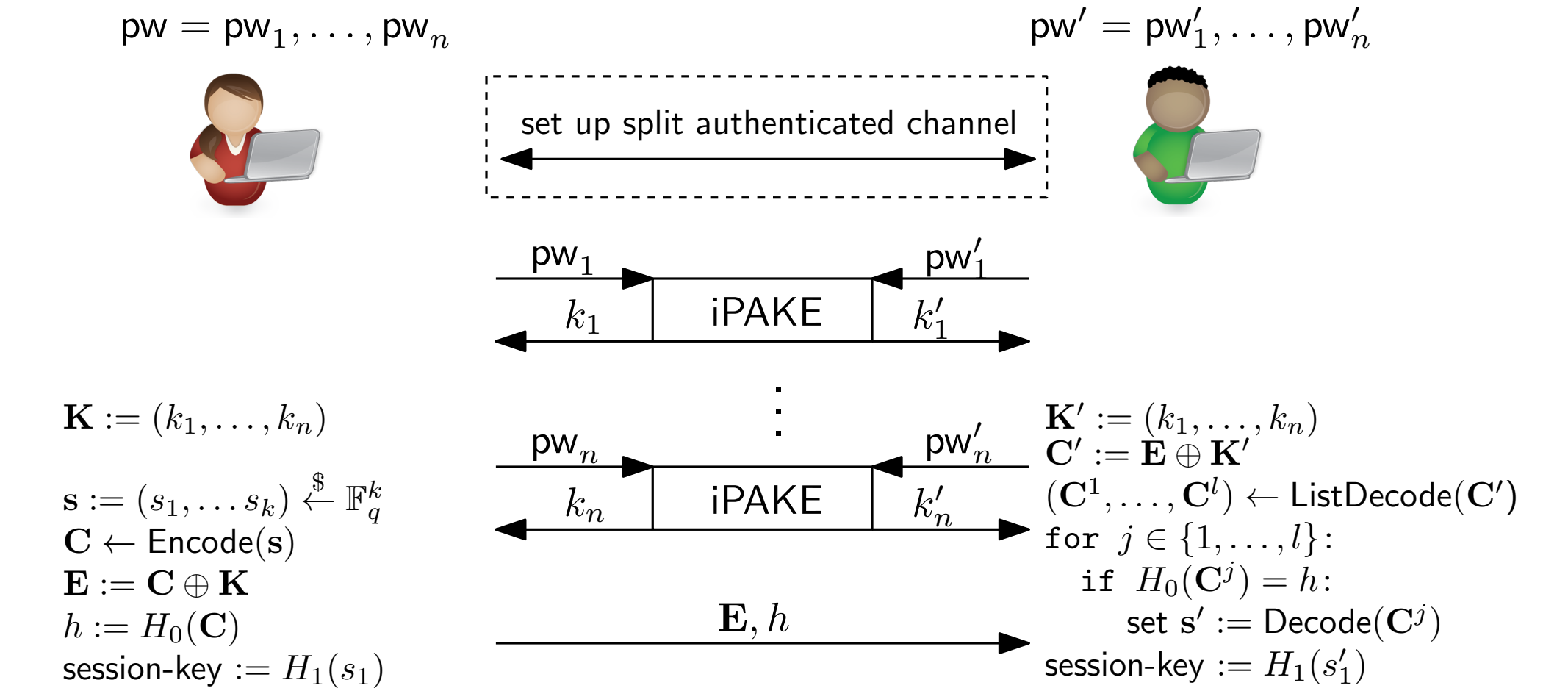
$\mathbf{s} := (s_1, \ldots s_k) \xleftarrow{\$} \mathbb{F}_q^k$
$\mathbf{C} \leftarrow \mathsf{Encode}(\mathbf{s})$
$\mathbf{E} := \mathbf{C} \oplus \mathbf{K}$
$h := H_0(\mathbf{C})$
$\mathsf{session\text{-}key} := H_1(s_1)$

pw_n — k_n — iPAKE — k'_n — pw'_n

$\mathbf{K}' := (k_1, \ldots, k_n)$

$\mathbf{E}, h$

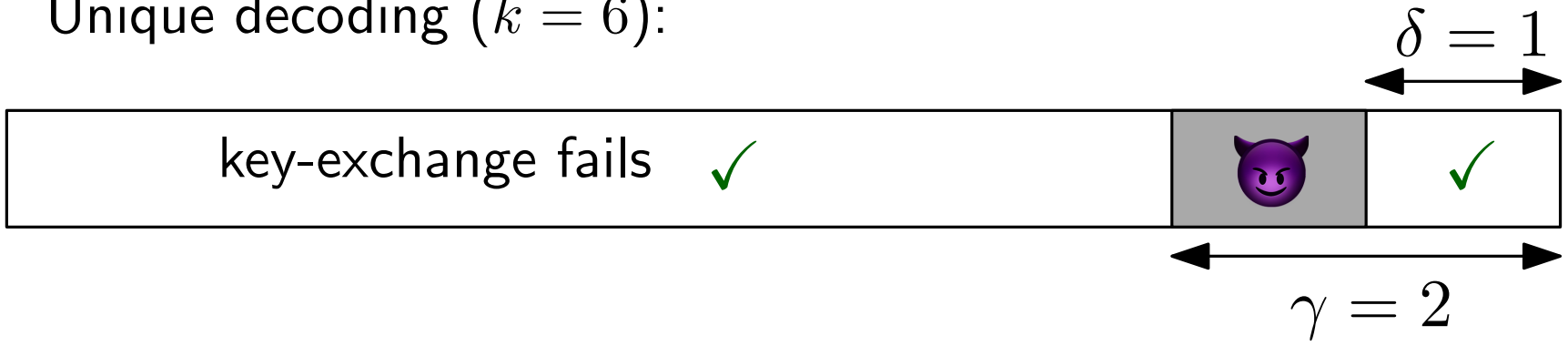
Our fuzzy PAKE protocol



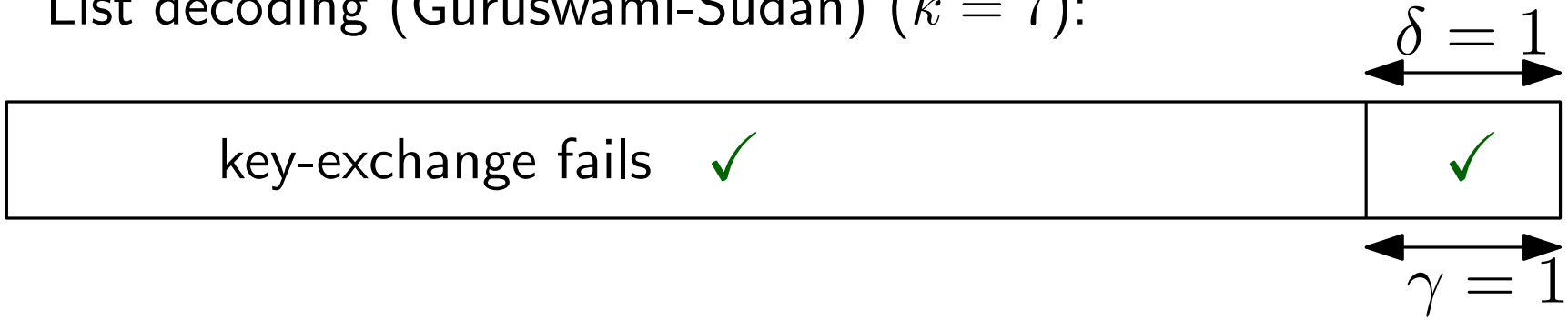
Improvements through list decoding

Correcting 1 error of an 8 character password (with an $[n, k]$ Code)

Unique decoding ($k = 6$):



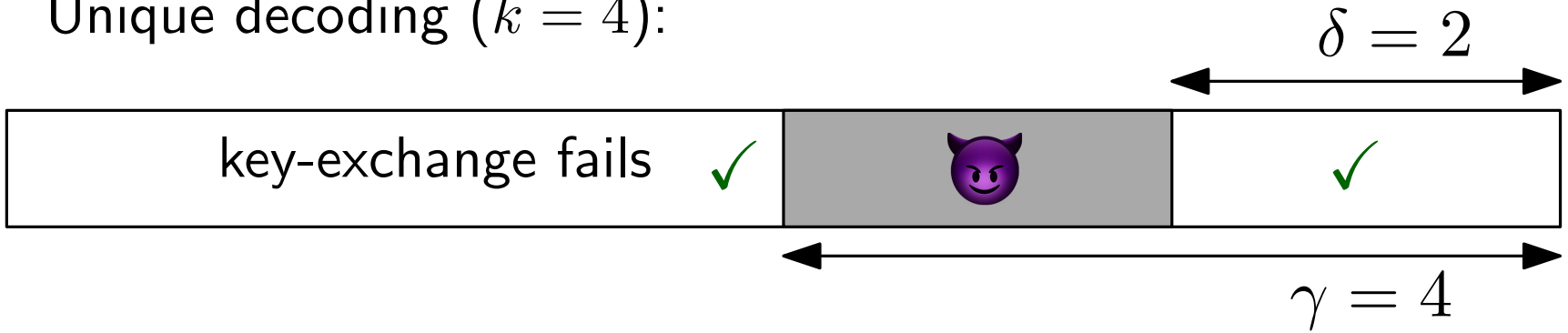
List decoding (Guruswami-Sudan) ($k = 7$):



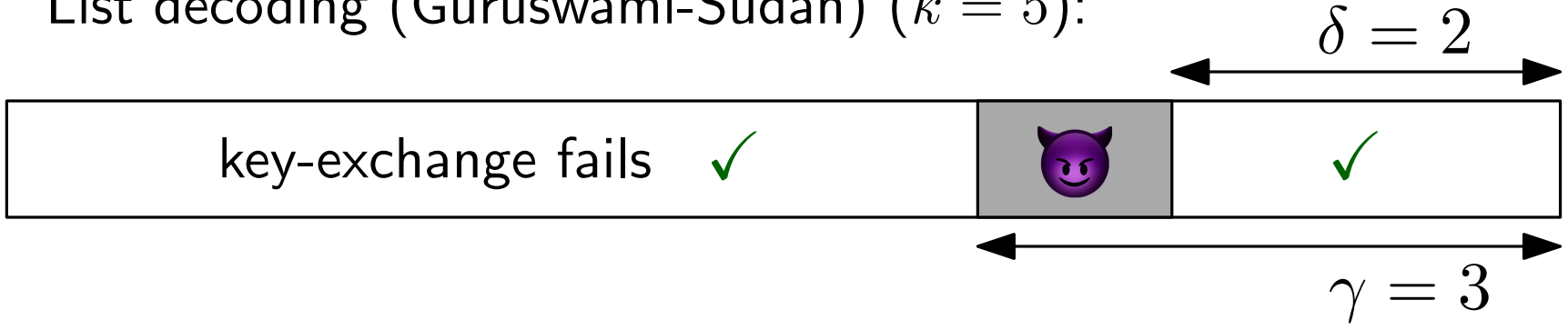
Improvements through list decoding

Correcting 2 error of an 8 character password (with an $[n, k]$ Code)

Unique decoding ($k = 4$):



List decoding (Guruswami-Sudan) ($k = 5$):



Questions

Paper at ia.cr/2023/1415