SoK: Signatures With Randomizable Keys

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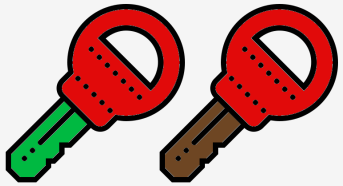
Digital Signatures

Digital Signatures



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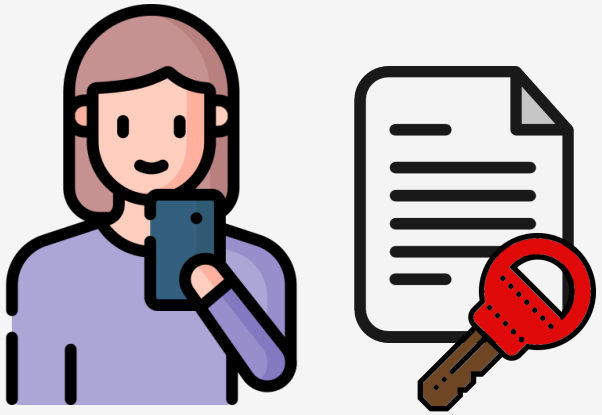

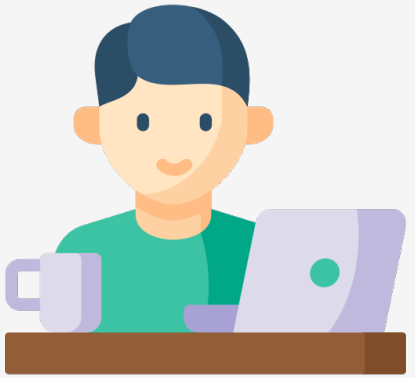

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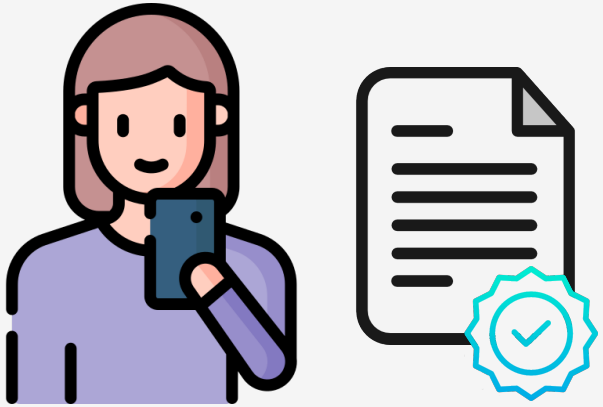

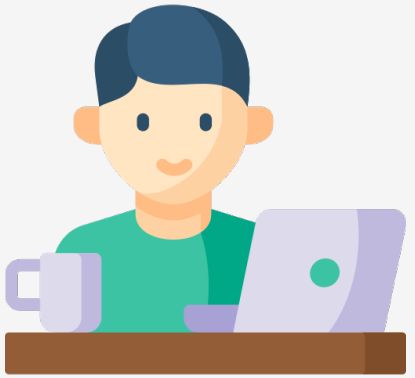

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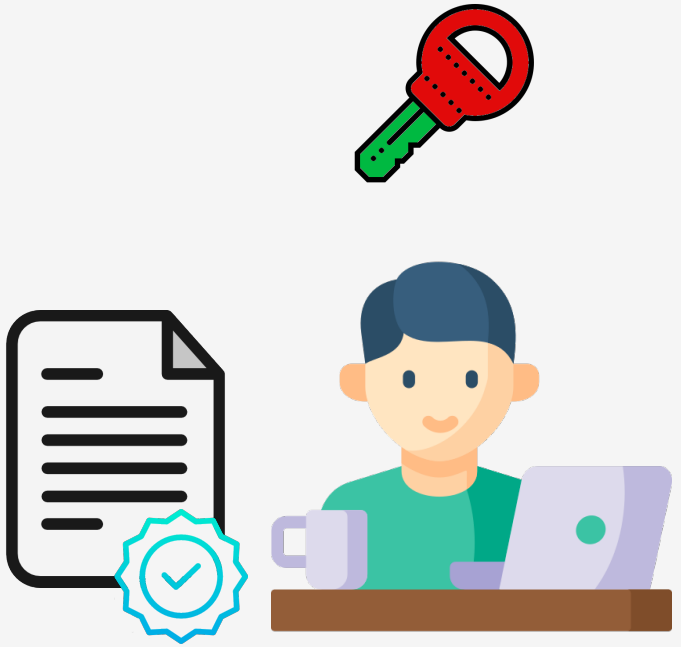

WebAuthn Application

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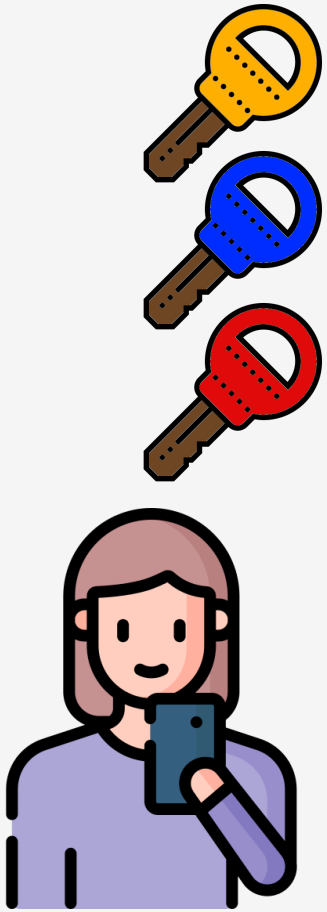

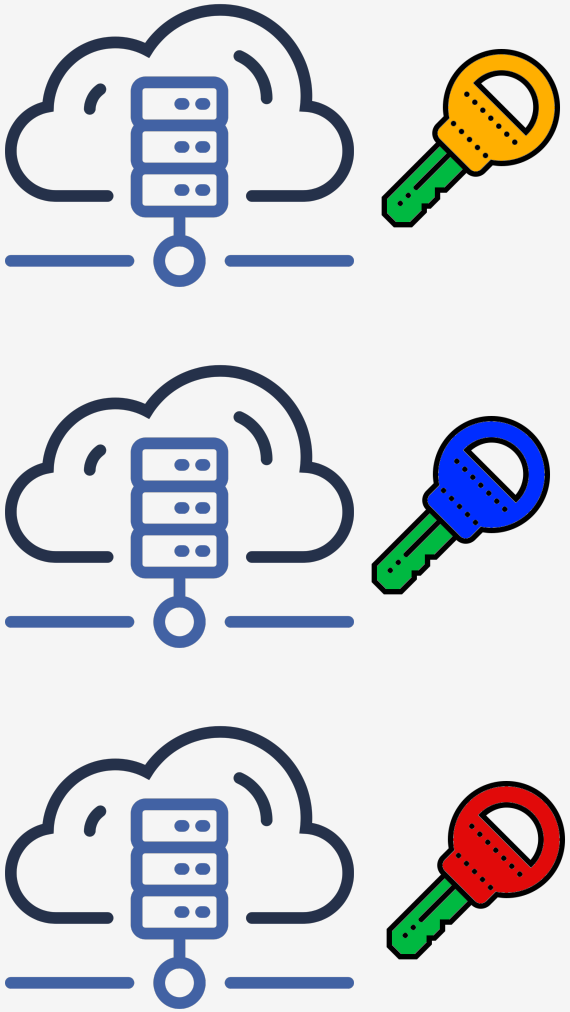

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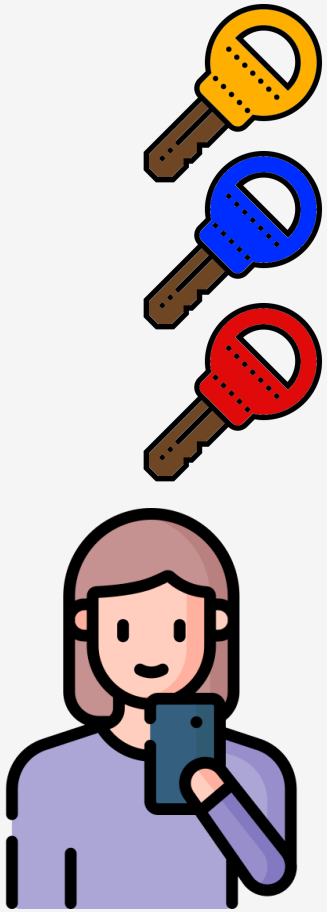
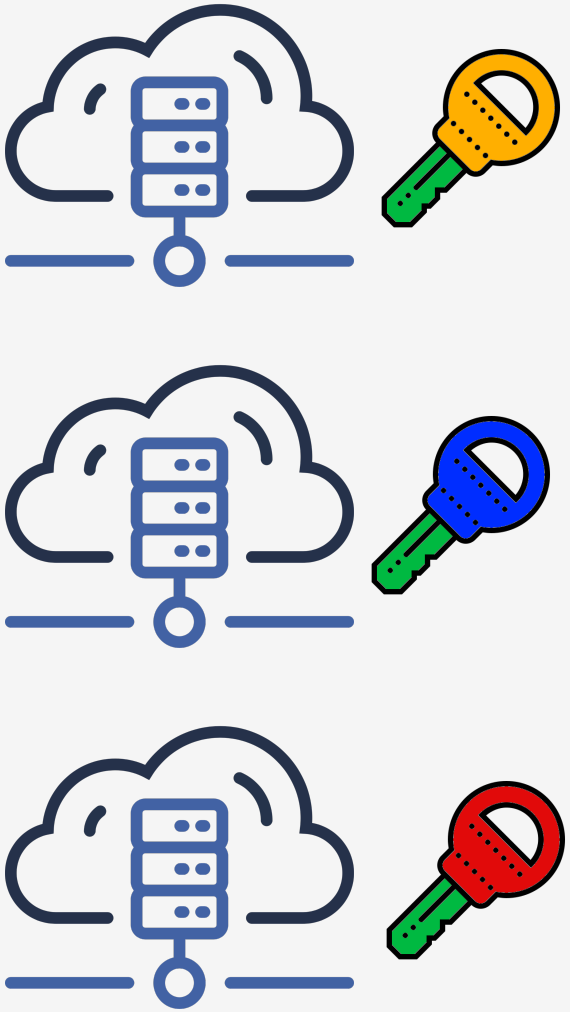


Can we do better?



Digital Signatures: Single Master Key

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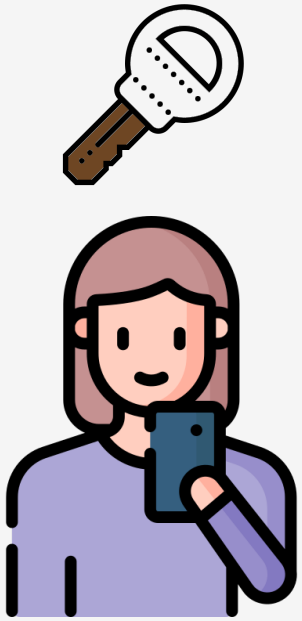

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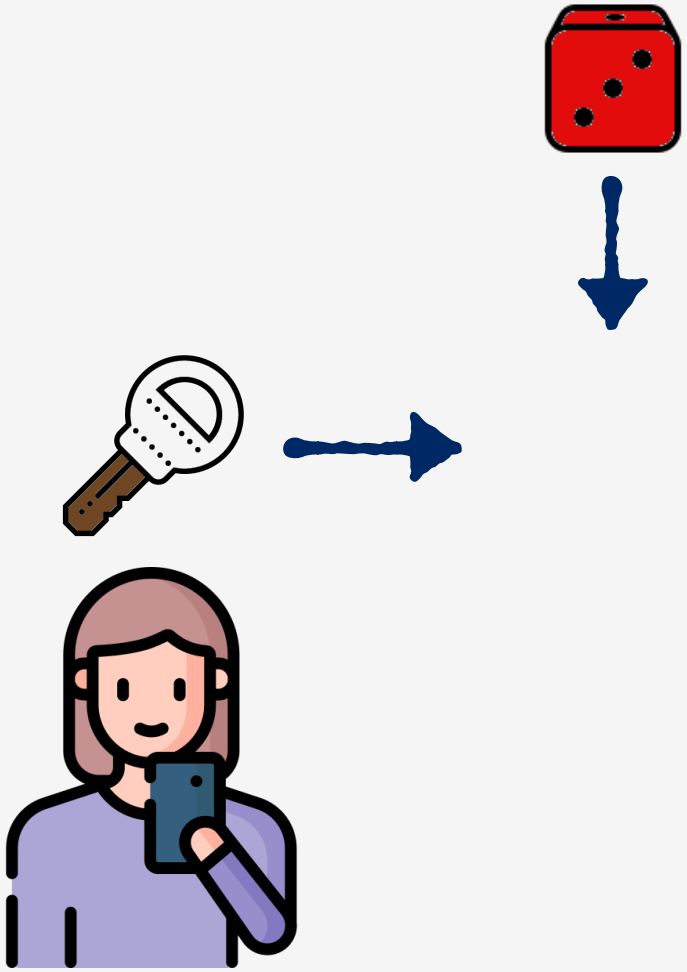

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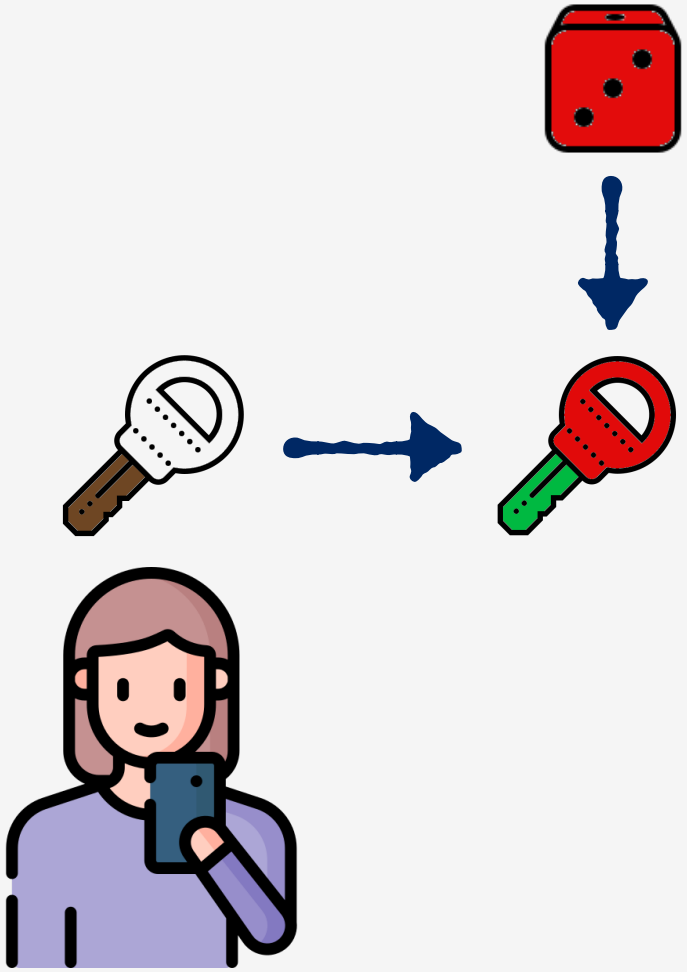

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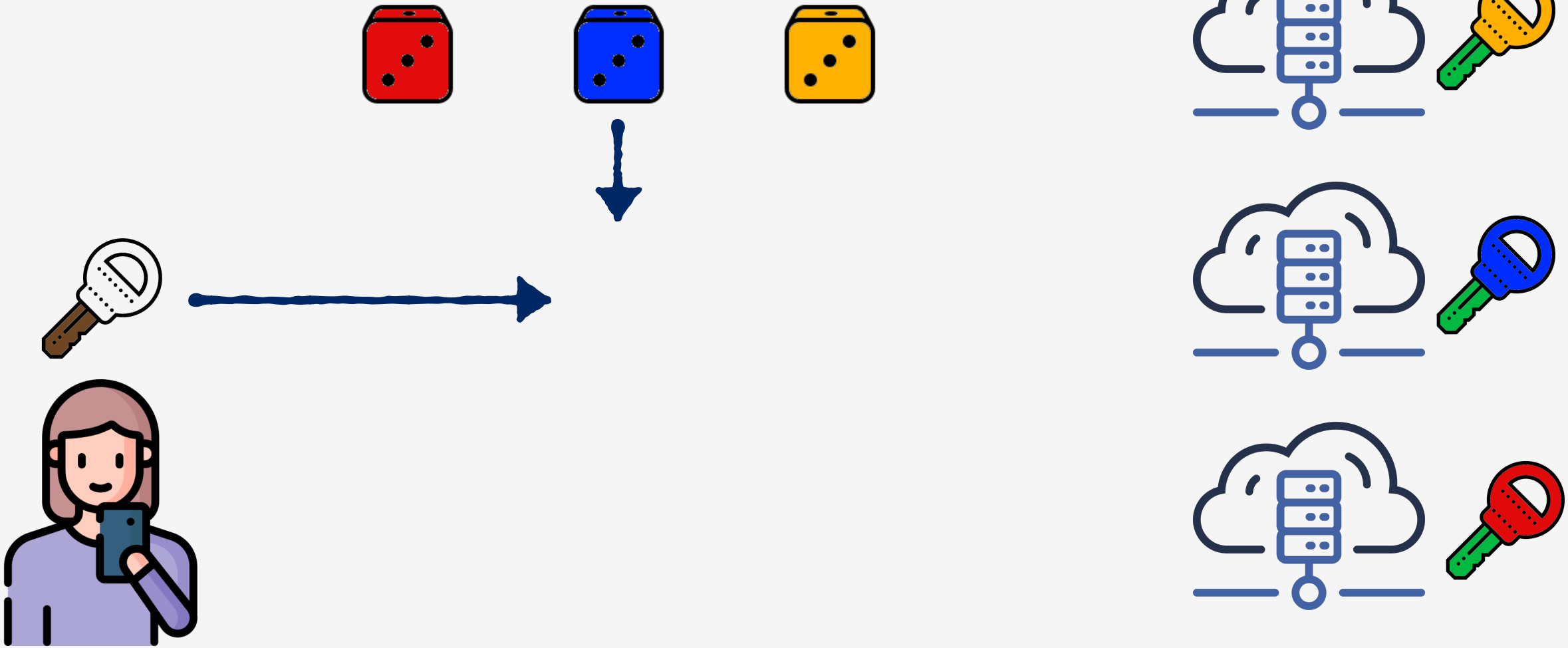

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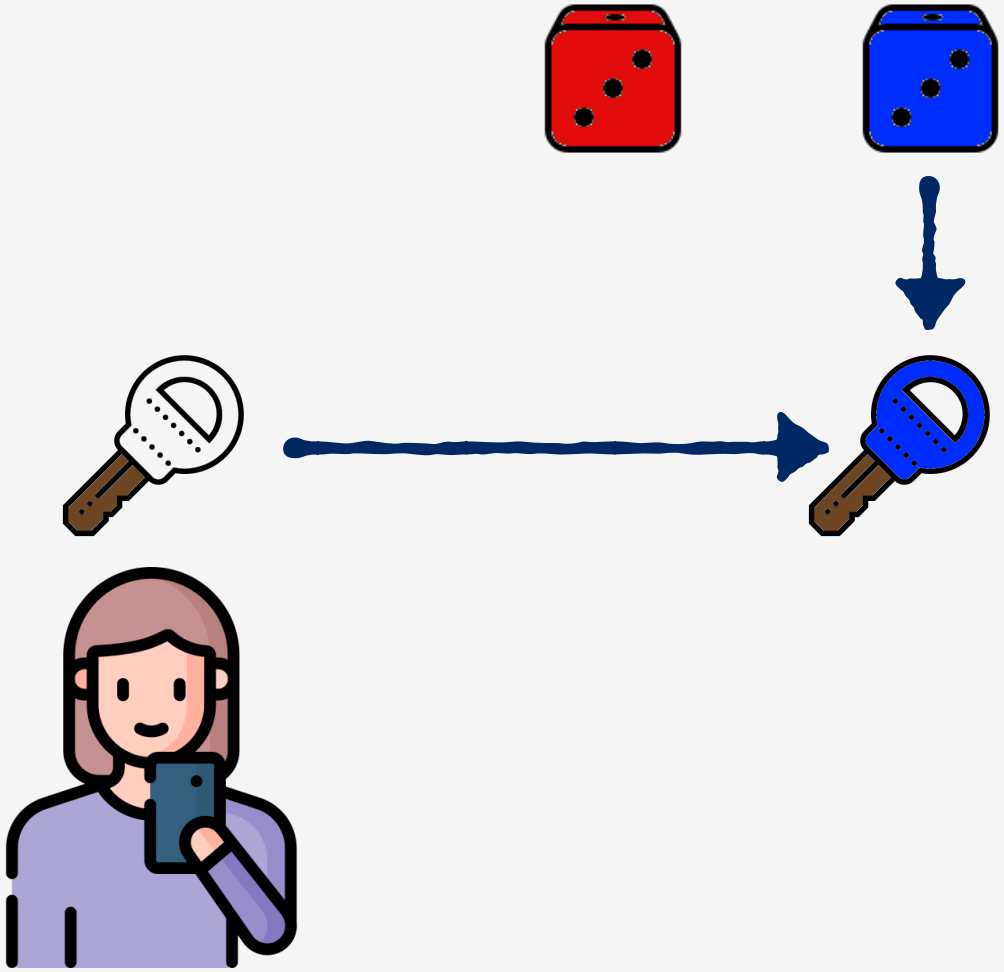
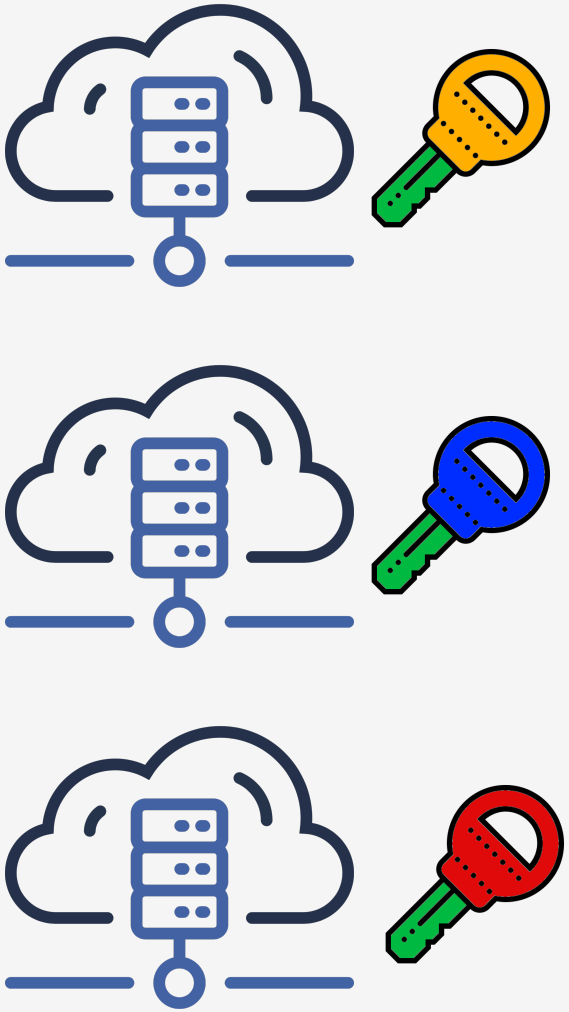
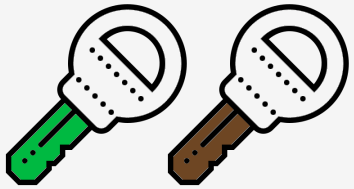




Digital Signatures: Single Master Key

Digital Signatures: Public Randomization



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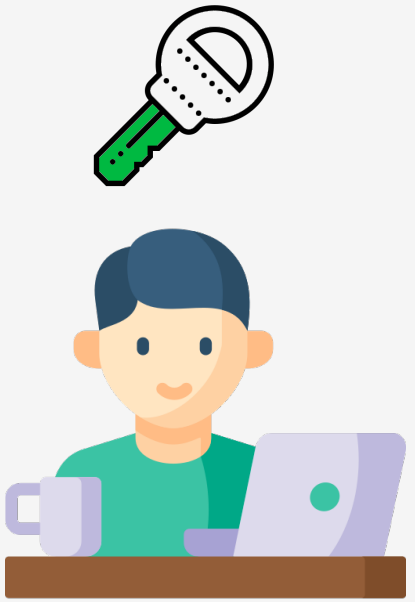

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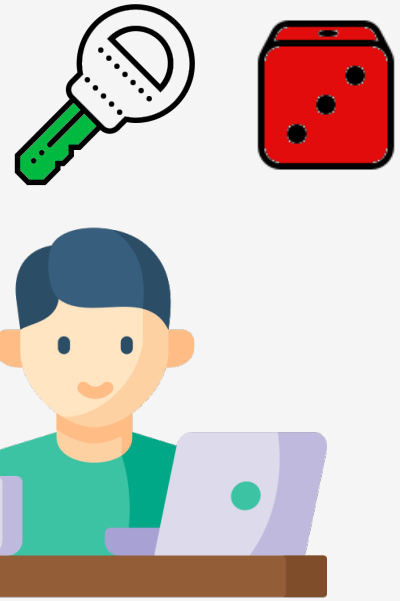

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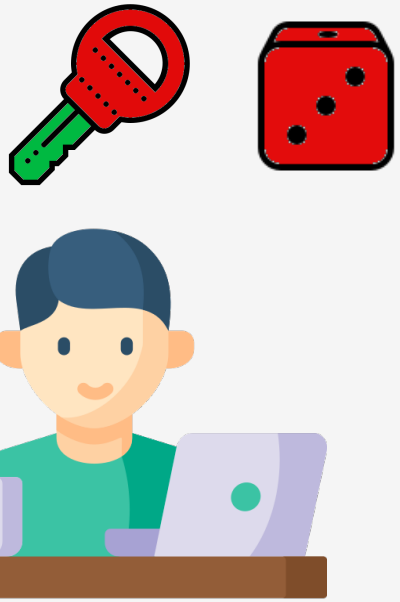

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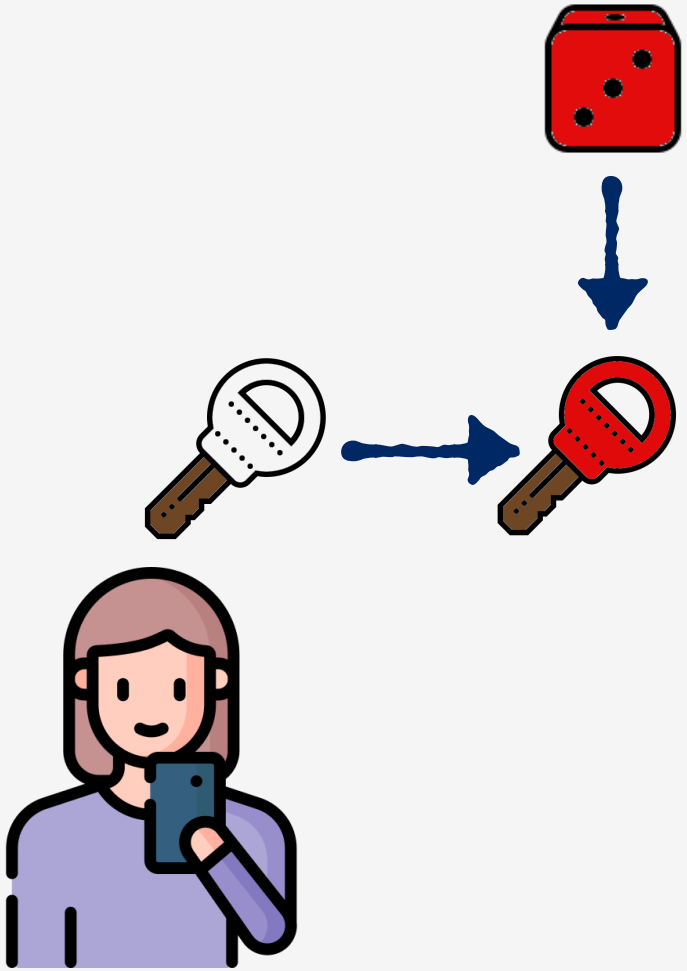

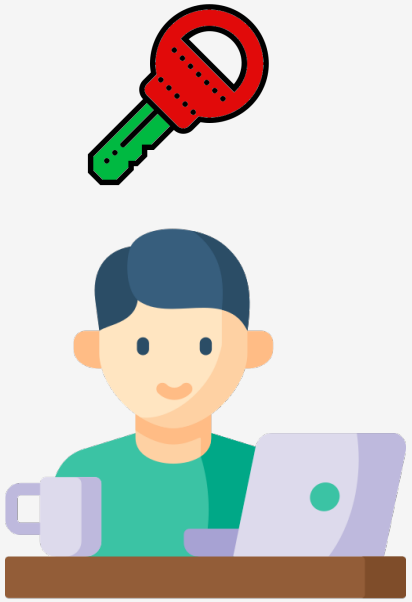

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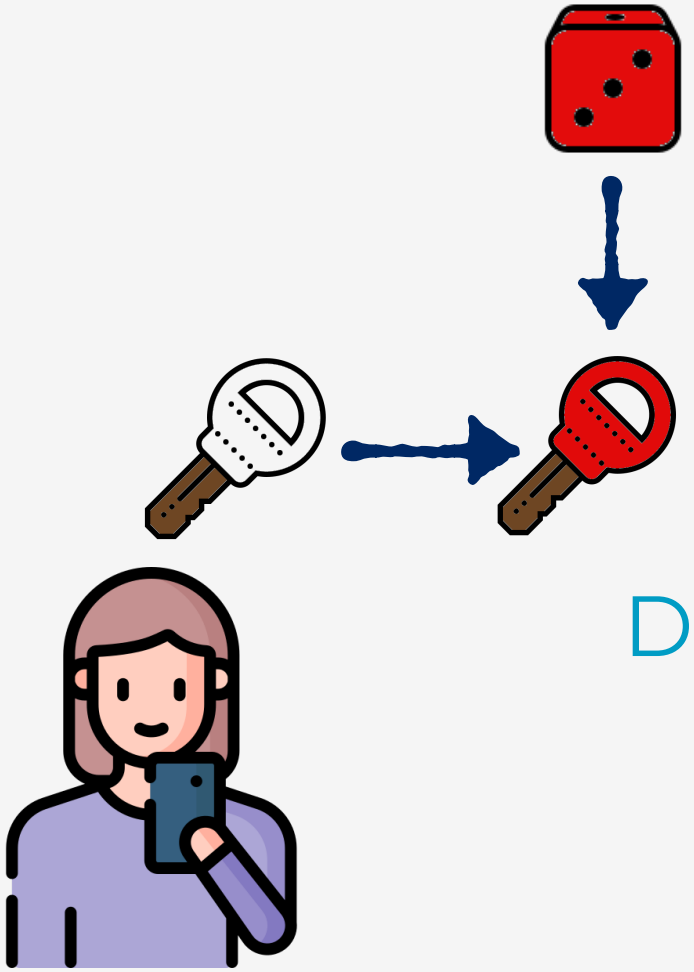
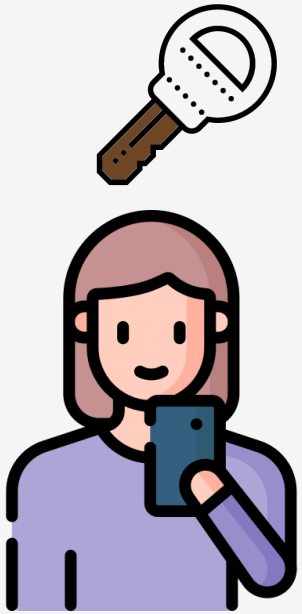


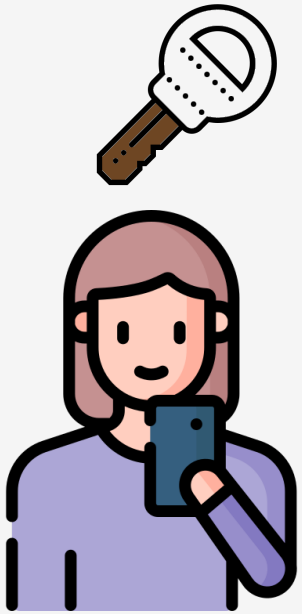
Deterministic Wallets

Stealth Addresses

Digital Signatures: Randomizing Signature



Digital Signatures: Randomizing Signature



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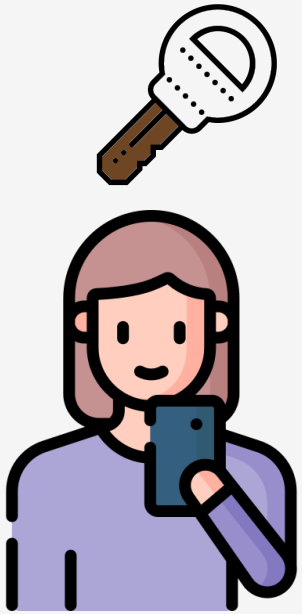

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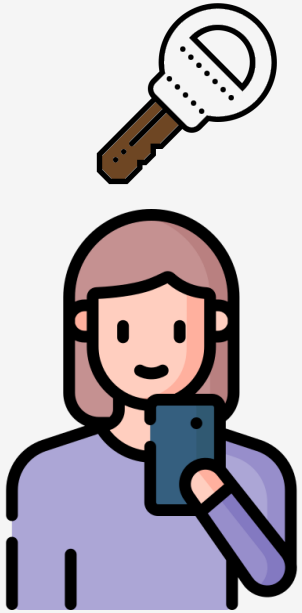
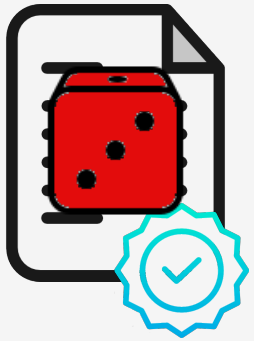
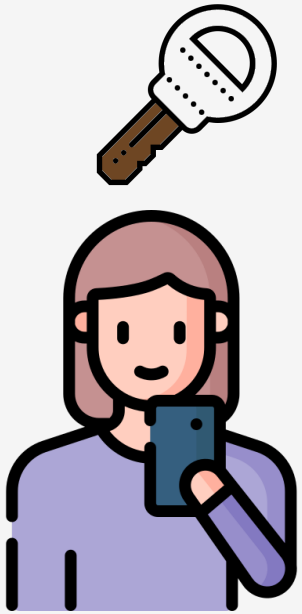




Digital Signatures: Randomizing Signature



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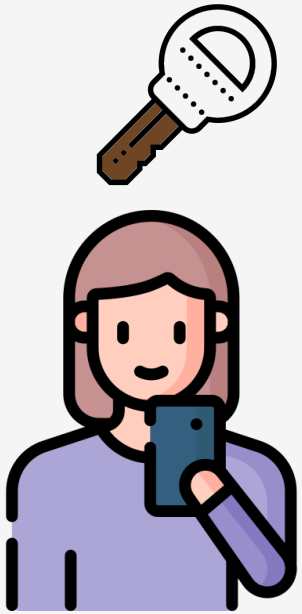

Digital Signatures: Different Notions

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* Sok (in Polish) = Juice

Our Contribution

- Introduce signatures with randomizable keys
  - extend digital signatures
  - parametrizable security properties

- Revisit prior work and how it relates to our syntax and model

- Show what is required for specific applications

New Algorithms: Randomization and Adaptation

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- Separate algorithms to randomize secret/public key (RandSK & RandPK)
  - take as input the original key and key randomizer
  - outputs randomized key, e.g., pk’ = T(pk, r)

New Algorithms: Randomization and Adaptation

- Separate algorithms to randomize secret/public key (RandSK & RandPK)
  - take as input the original key and key randomizer
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- Optional adaptation algorithm
  - takes as input signature, public key and key randomizer
  - outputs signature valid under pk’
  - adapted signatures look like fresh signatures - (perfect) adaptation

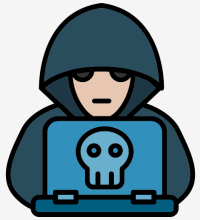
New Security Properties

- Unforgeability - no forged signatures
- Unlinkability - randomized public keys are not linkable to original ones
- Unextractability - cannot go back to original public key even knowing the key randomizer

Security Properties: α-Unforgeability

(sk,pk)

pk



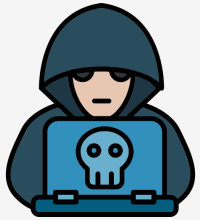
Security Properties: α-Unforgeability

(sk,pk)

get key randomizer

r

pk



Security Properties: α-Unforgeability

(sk,pk)

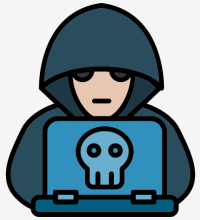
get key randomizer

r

m, r

σ valid under pk' = T(pk,r)

pk



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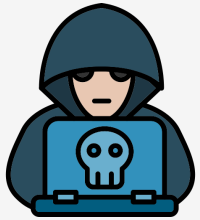


m, r

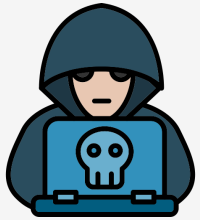
σ valid under pk' = T(pk,r)

from Oracle (if α=0)

Security Properties: α-Unforgeability

(sk,pk)

pk



get key randomizer

r

m, r

σ valid under pk' = T(pk,r)

from Oracle (if α=0)

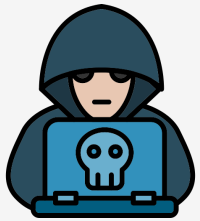
.
.
.

m*, σ*, r*

Security Properties: α-Unforgeability

(sk,pk)

pk



get key randomizer

r

m, r

σ valid under pk' = T(pk,r)

from Oracle (if α=0)

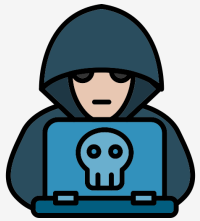
.
.
.

m*, σ*, r*

Adv wins iff

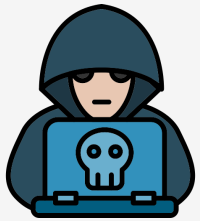
- σ* valid for pk* = T(pk,r*)
- r* from Oracle (if α=0)

Security Properties: (α,β,γ)-Unlinkability



Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0) β=0
(sk1,pk1)



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(sk0,pk0) β=1
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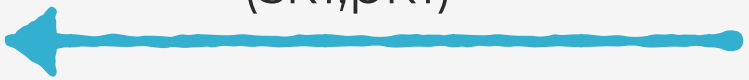

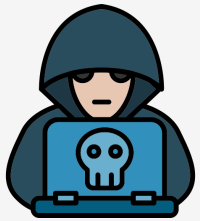

Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0) β=0
(sk1,pk1)

picks bit b and r

(sk0,pk0) β=1
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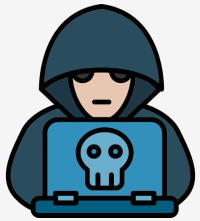

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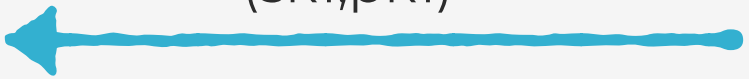

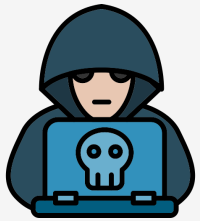

picks bit b and r

sk* = RandSK(skb,r)
pk* = RandPK(pkb,r)

Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0) β=0
(sk1,pk1)

(sk0,pk0) β=1
(sk1,pk1)

picks bit b and r

sk* = RandSK(skb,r)
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(pk0, pk1, pk*)

Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0) β=0
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(pk0, pk1, pk*)

signing oracle

Security Properties: (α,β,γ)-Unlinkability

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picks bit b and r

sk* = RandSK(skb,r)
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(pk0, pk1, pk*)

signing oracle

b*

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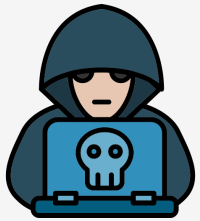

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(pk0, pk1, pk*)

signing oracle

b*

Adv wins iff b = b*

Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0)
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β=0

(sk0,pk0)
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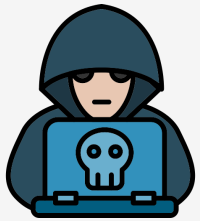
β=1



picks bit b and r

sk* = RandSK(skb,r)
pk* = RandPK(pkb,r)

(pk0, pk1, pk*)

signing oracle

no queries (if γ=0)
for key pk* (if γ=1)
for all keys (if γ=3)

b*

Adv wins iff b = b*

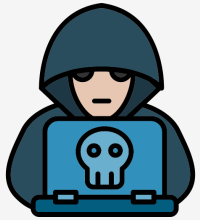
Security Properties: (α,β,γ)-Unlinkability

(sk0,pk0)
(sk1,pk1)

β=0

(sk0,pk0)
(sk1,pk1)

β=1



picks bit b and r

sk* = RandSK(skb,r)
pk* = RandPK(pkb,r)

(pk0, pk1, pk*)

signing oracle

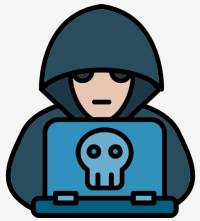
no queries (if γ=0)
for key pk* (if γ=1)
for all keys (if γ=3)

b*

Adv wins iff b = b*

Public parameters generated honestly (α=0) or by adversary (α=1)

Security Properties: (α,β)-Unextractability



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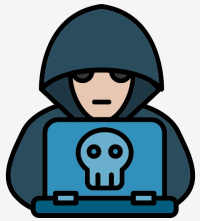
(sk1,pk1)



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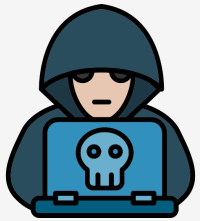

picks bit b and r (if β=0)

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(sk0,pk0)
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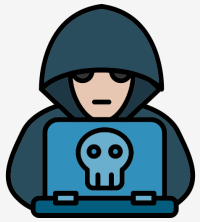
r β=1



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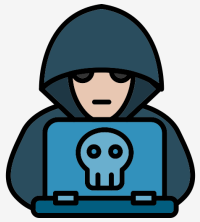

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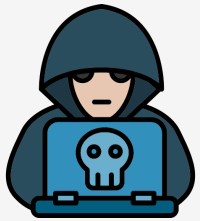

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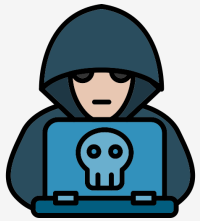

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signing oracle

Security Properties: (α,β)-Unextractability

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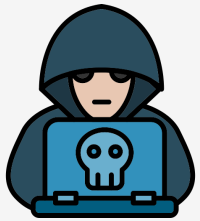

picks bit b and r (if β=0)

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pk*, r

signing oracle access to all keys

Security Properties: (α,β)-Unextractability

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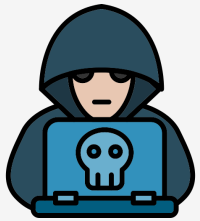
r β=1



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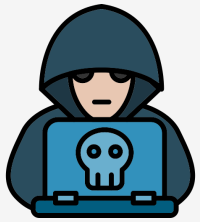

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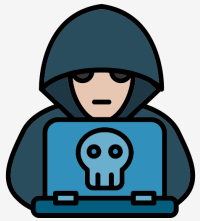

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BLS Signatures - Next Talk

- Support perfect adaptation
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See paper for full systematization

Thank you for your attention