FINE-GRAINED AND CONTROLLED REWRITING IN BLOCKCHAINS

Chameleon Hashing Gone Attribute-Based

David Derler (DFINITY), Kai Samelin (TÜV), Daniel Slamanig (AIT), Christoph Striecks (AIT)

RESEARCH IN DISTRIBUTED LEDGERS TECHNOLOGIES

- Massive progress beyond Bitcoin, very hyped in recent years

- Signs that hype is turning into extensive research within the *cryptographic* community
  - **(Cryptographic) research centers** are established

- **Many Cryptographic building blocks** are applied to DLs
  - zk-SNARKs, Multi-Signatures, Verifiable Random Functions/Delay Functions/Secret Sharing, Threshold Signatures, Multi-Party Computation, …

- Less research is known on **rewriting DLs** …

» **… wait, isn’t that counterintuitive?**

IMMUTABLE DATA IN THE BLOCKCHAIN

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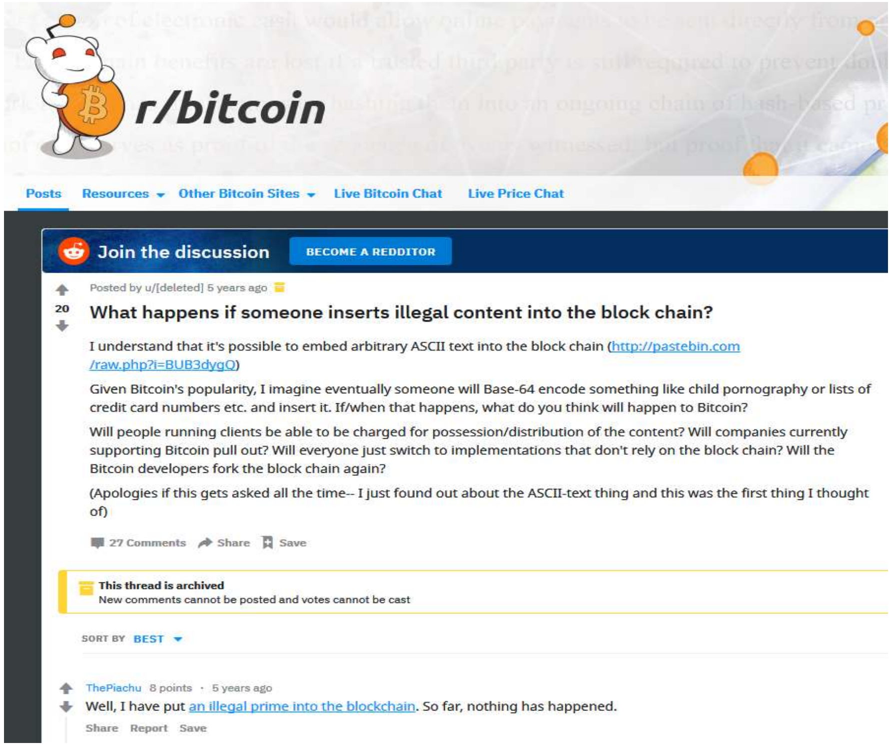

Sources: reddit.com; marketwatch.com; theguardian.com

IMMUTABLE DATA IN THE BLOCKCHAIN

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Child abuse imagery found within bitcoin's blockchain

Researchers discover illegal content within the distributed ledger, making possession of it potentially unlawful in many countries

Sources: reddit.com; marketwatch.com; theguardian.com

IMMUTABLE DATA IN THE BLOCKCHAIN

AUSTRIAN INSTITUTE OF TECHNOLOGY

A Quantitative Analysis of the Impact of Arbitrary Blockchain Content on Bitcoin

Roman Matzutt[1], Jens Hiller[1], Martin Henze[1], Jan Henrik Ziegeldorf[1], Dirk Müllmann[2], Oliver Hohlfeld[1], and Klaus Wehrle[1]

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[2] Data Protection Research Institute, Goethe University, Frankfurt/Main, muellmann@jur.uni-frankfurt.de

Abstract. Blockchains primarily enable credible accounting of digital events, e.g., money transfers in cryptocurrencies. However, beyond this original purpose, blockchains also irrevocably record *arbitrary* data, ranging from short messages to pictures. This does not come without risk for users as each participant has to locally replicate the complete blockchain, particularly including potentially harmful content. We provide the first systematic analysis of the benefits and threats of arbitrary blockchain content. Our analysis shows that certain content, e.g., illegal pornography, can render the mere possession of a blockchain illegal. Based on these insights, we conduct a thorough quantitative and qualitative analysis of unintended content on Bitcoin's blockchain. Although most data originates from benign extensions to Bitcoin's protocol, our analysis reveals more than 1600 files on the blockchain, over 99 % of which are texts or images. Among these files there is clearly objectionable content such as links to child pornography, which is distributed to all Bitcoin participants. With our analysis, we thus highlight the importance for future blockchain designs to address the possibility of unintended data insertion and protect blockchain users accordingly.

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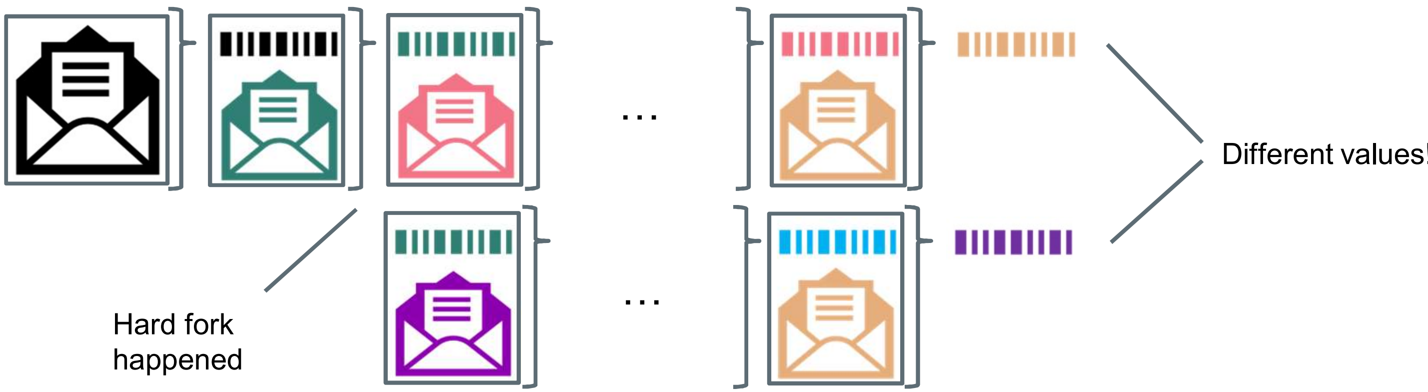
JUST DO A HARD FORK …

- Simple solution: **hard forks**, but *not* really useful (i.e., chain from change point has to be “re-written”)



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In **this work**, focus is on **transaction-level** rewriting.

PROTOTYPE OF EDITABLE BLOCKCHAINS

SEPTEMBER 20, 2016

Accenture Debuts Prototype of 'Editable' Blockchain for Enterprise and Permissioned Systems

Invention addresses blockchain 'immutability' challenges for permissioned systems, including the legal 'right to be forgotten,' human error, illegal actions

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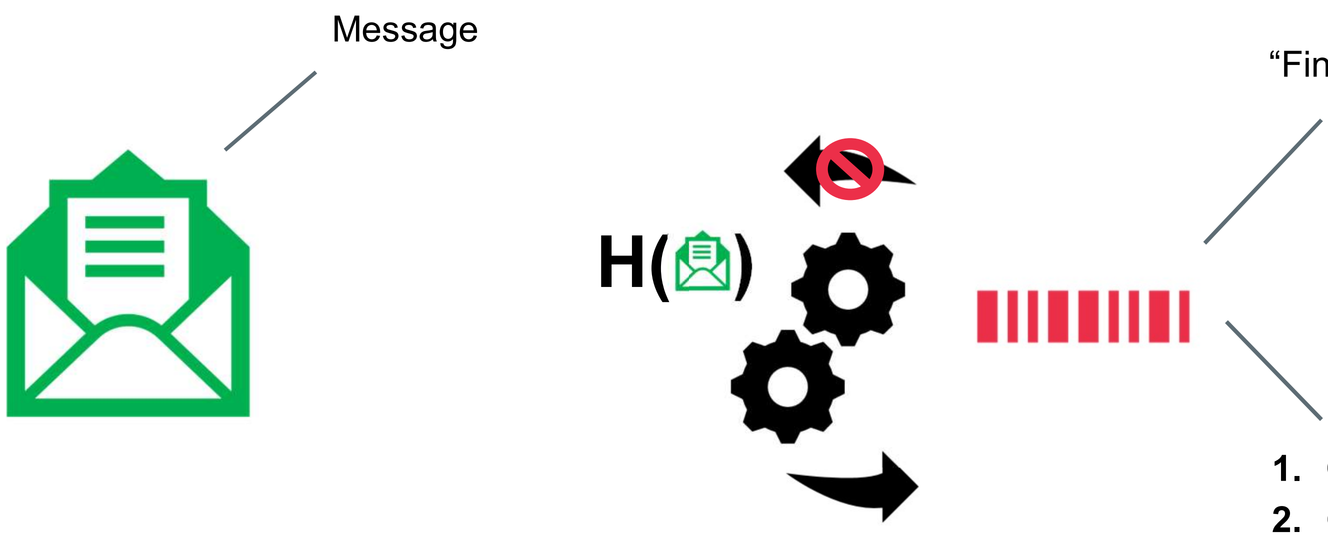
wrong and to meet new and changing regulatory and legal requirements, like the 'right to be forgotten' and other data-privacy and retention rules. An editable form of blockchain will make the technology more practical and useful for enterprise systems and accelerate its adoption. It combines the confidence that comes from immutability with the pragmatism required in an imperfect world."

"The clever work of the bitcoin creators and leaps of progress in applied cryptographic research are opening the door to bold new uses of blockchain," said Dr. Giuseppe Ateniese, a leading

CHAMELEON HASHING

Finding collisions for hash functions (if you know a trapdoor)

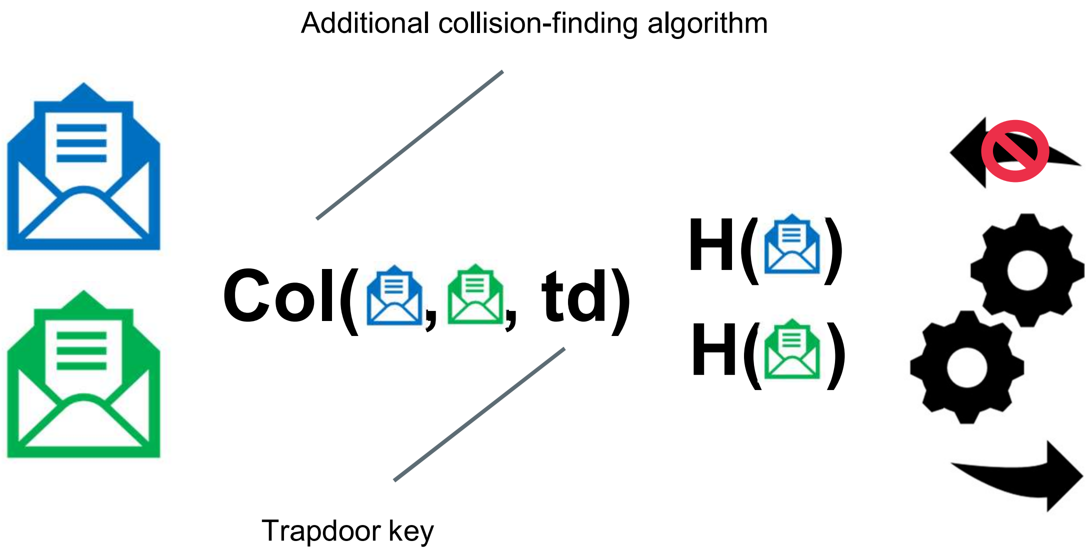
PRIMER: CRYPTOGRAPHIC HASH FUNCTIONS



1. **One-way**
2. **Collision-resistant**
3. **Short output**

Hash function are a central ingredient to DLs, e.g., RIPEMD-160 used in Bitcoin

CHAMELEON HASH (CH) FUNCTIONS



“Fingerprint”

1. One-way
2. Collision-resistant
3. Short output

*… but only if **td** is unknown.*

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- **Problem:** coarse-grained, if one is in possession of the trapdoor *td*, all security guarantees are lost

MAIN RESULT:
POLICY-BASED CHAMELEON HASHING

A new primitive for **fine-grained** hash-collision finding

POLICY-BASED CHAMELEON HASHING (PBCH)

- Enhances Chameleon Hashing with **attributes** and **access structure/policies**

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Mimics **fine-grained** collision finding
for **chameleon hashing** *and* **strong security guarantees**.

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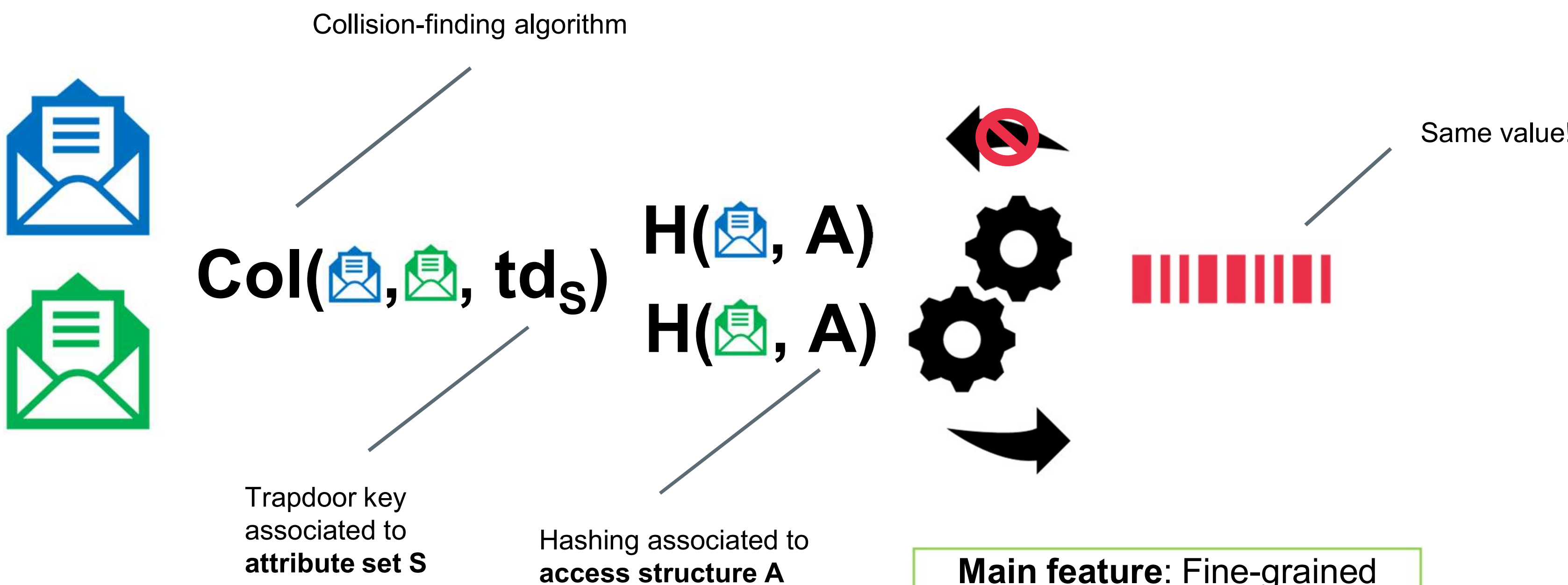
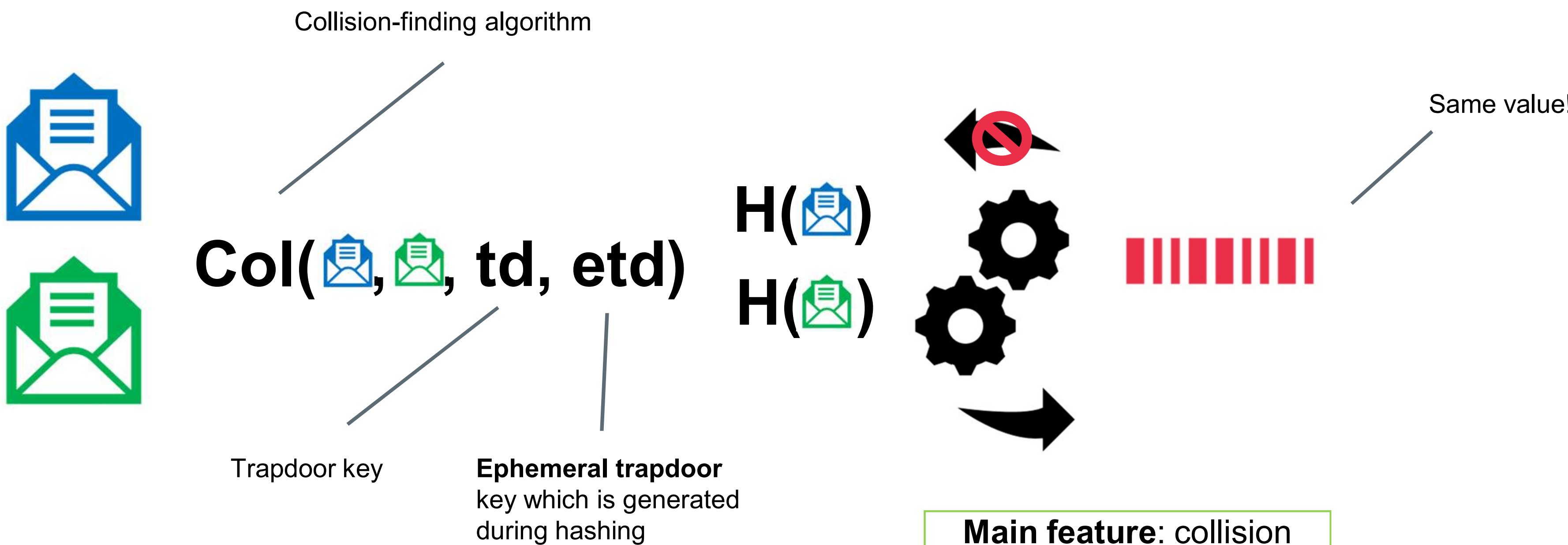


Main feature: Fine-grained collision finding if attribute set **S** fulfills the access structure **A**

INSTANTIATING PBCH

Combining Chameleon Hashing (with Ephemeral Trapdoors) and Attribute-Based Encryption

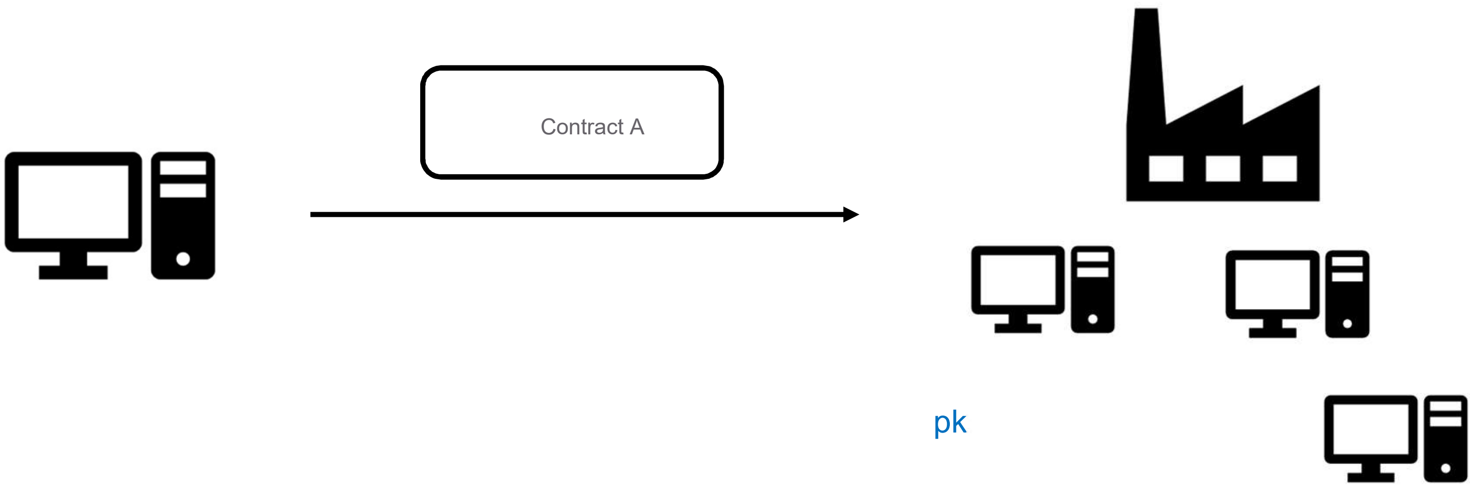
INGREDIENT 1: CHAMELEON HASHING WITH EPHEMERAL TRAPDOORS (CHET)



Main feature: collision finding possible if **td** and **etd** are present.

Due to Camenisch et al. (PKC 2017)

INGREDIENT 2:
ATTRIBUTE-BASED ENCRYPTION (ABE)



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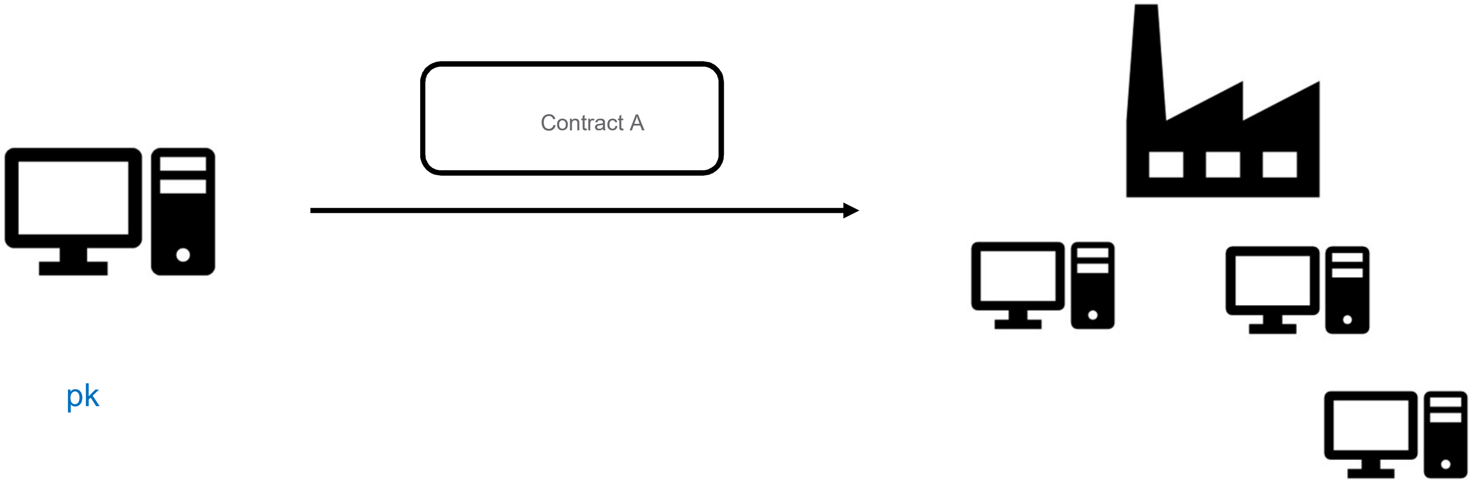

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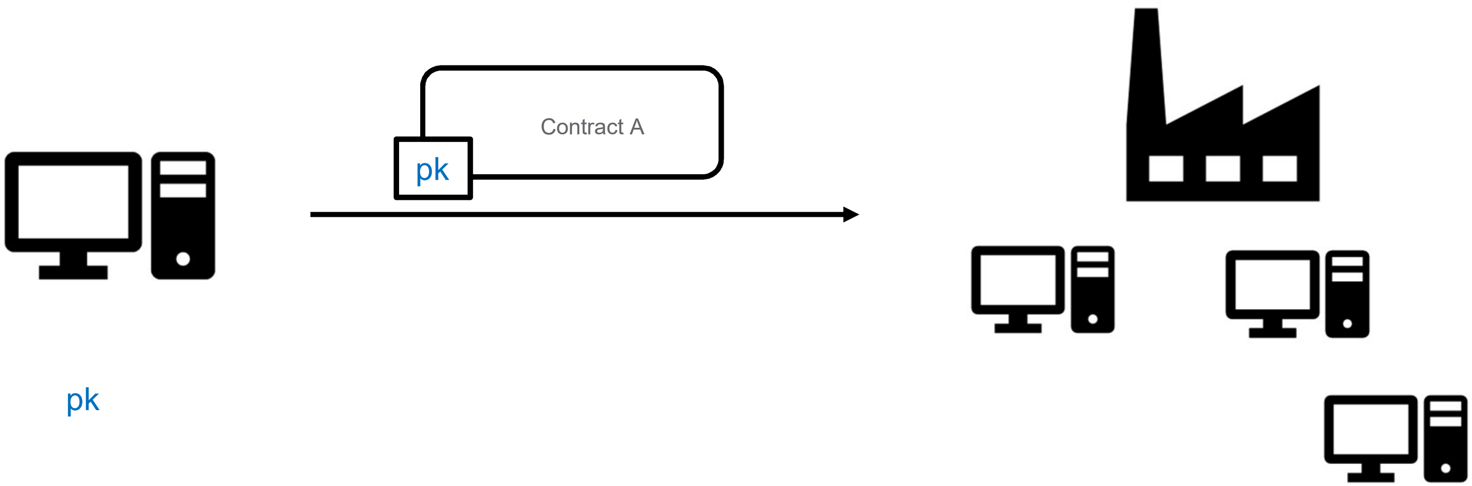

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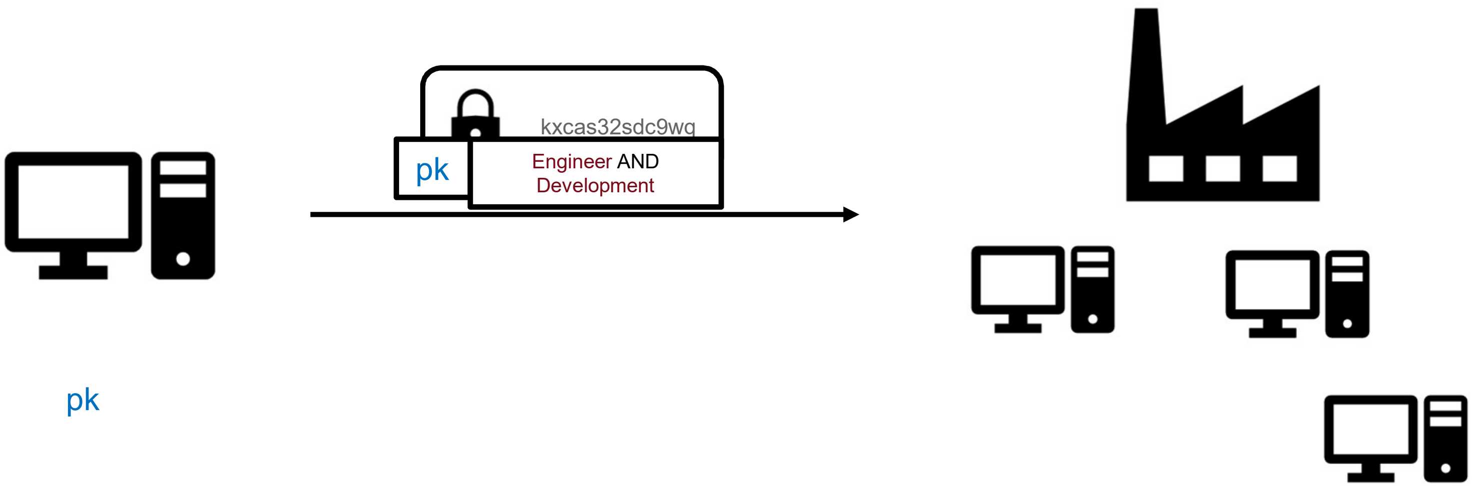

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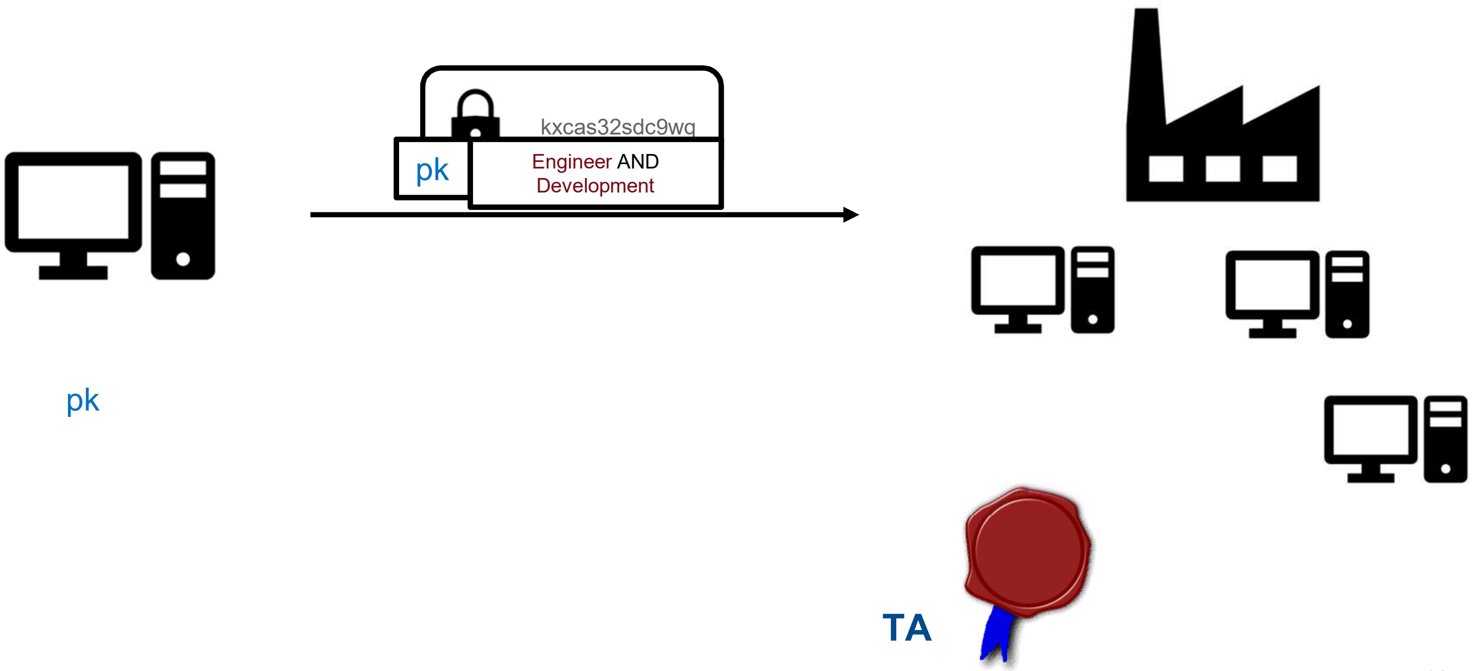

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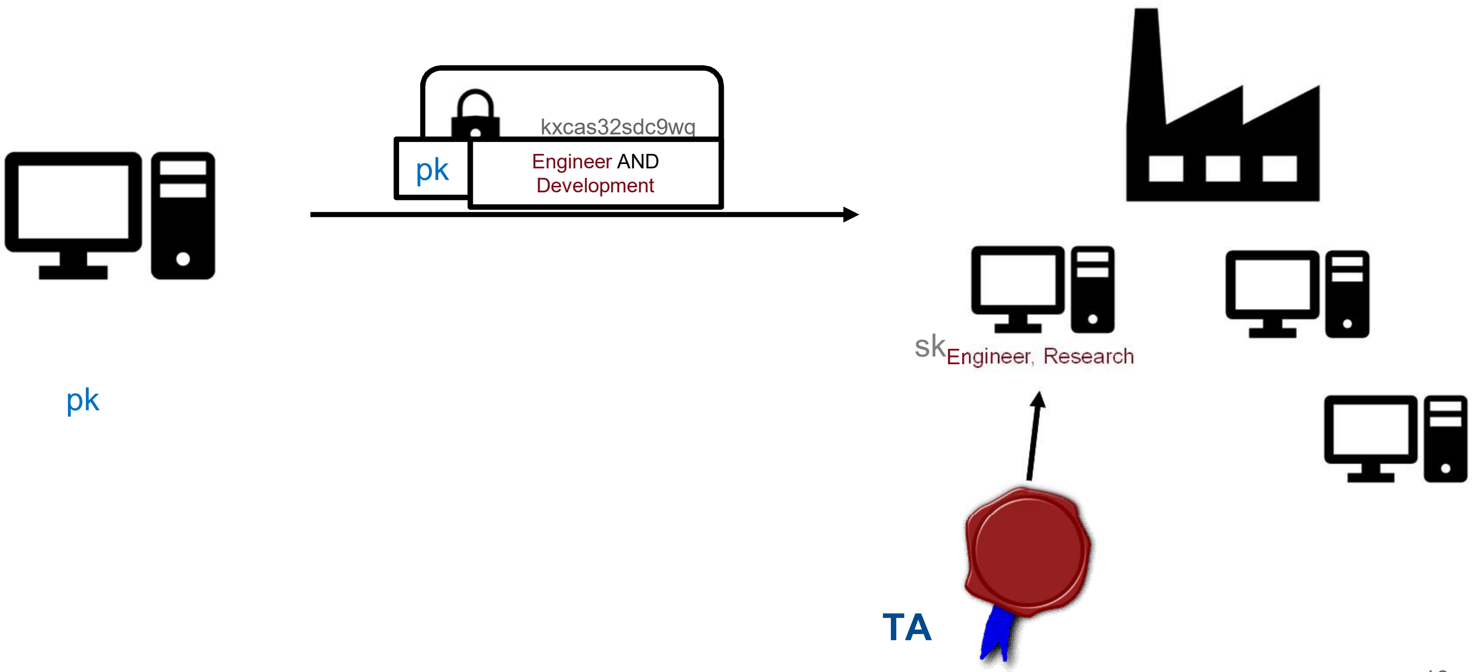

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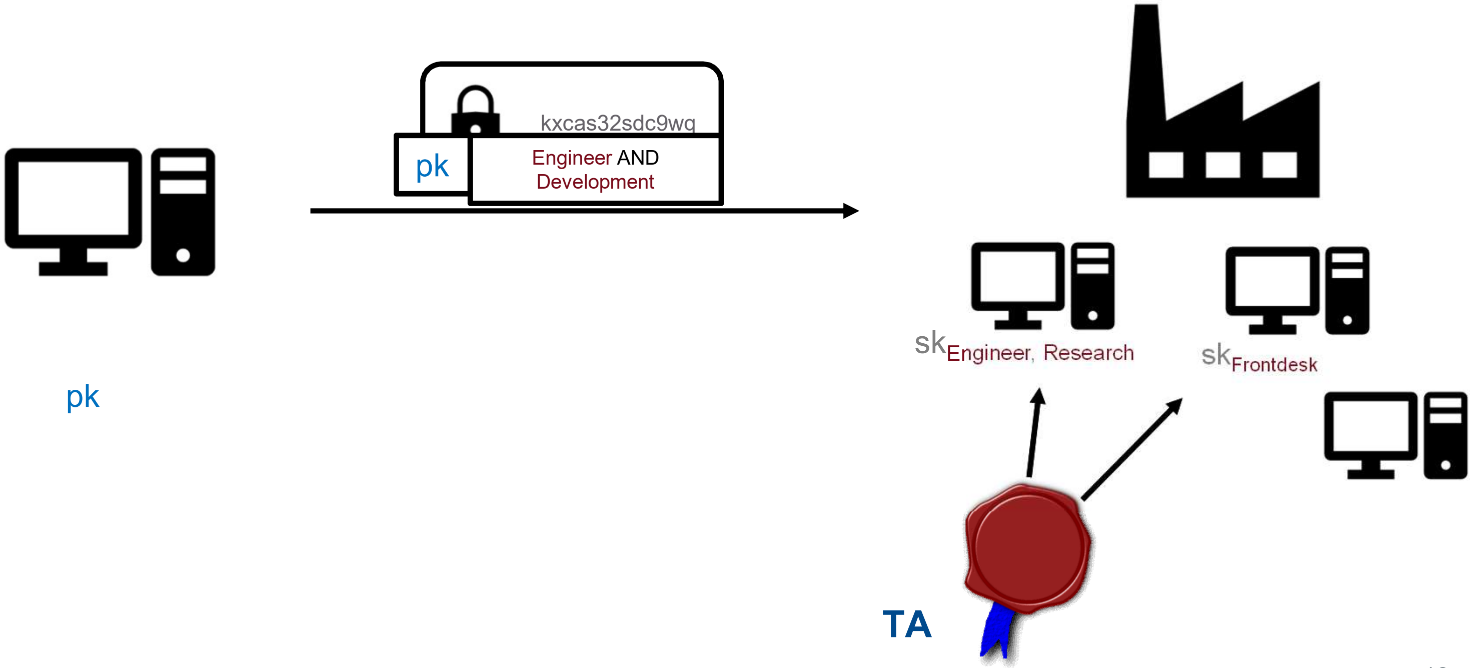

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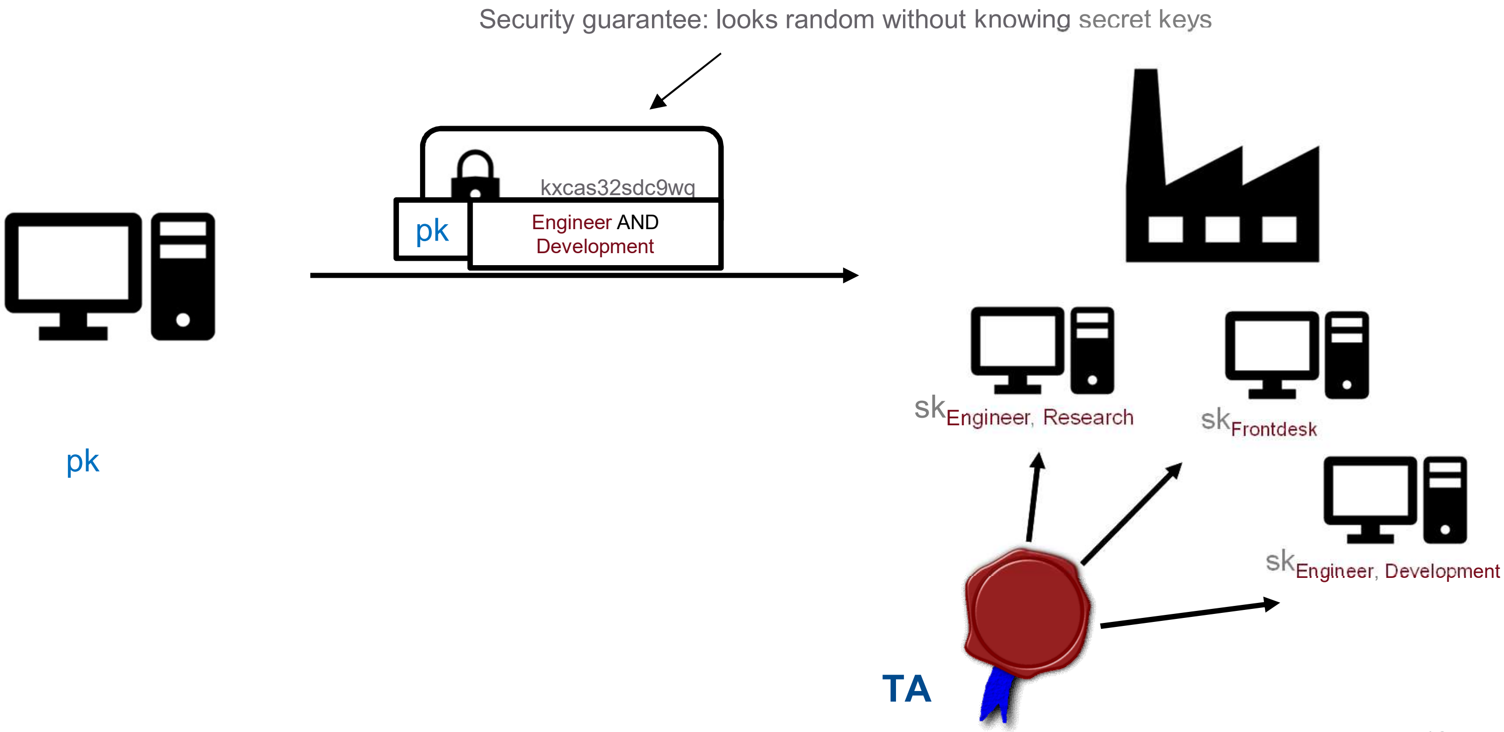

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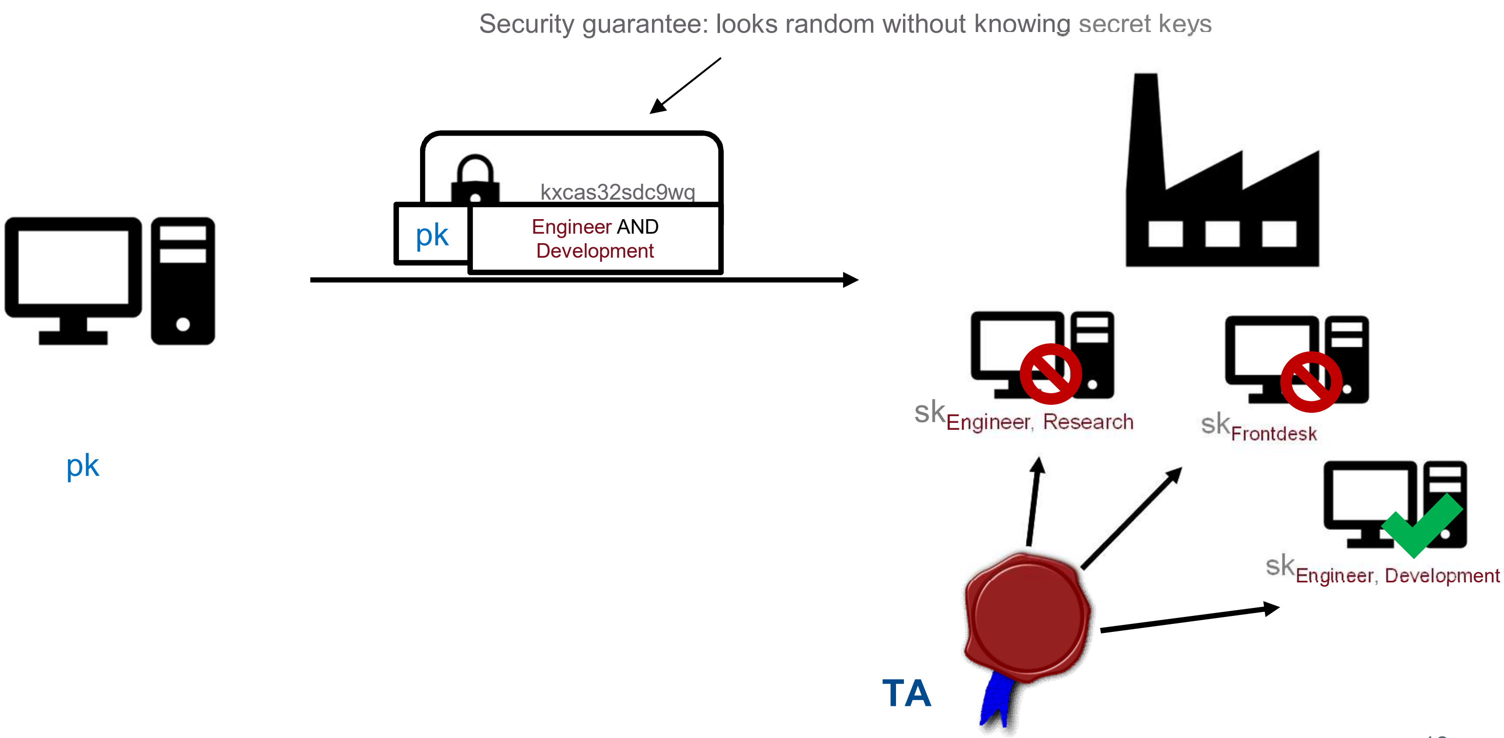

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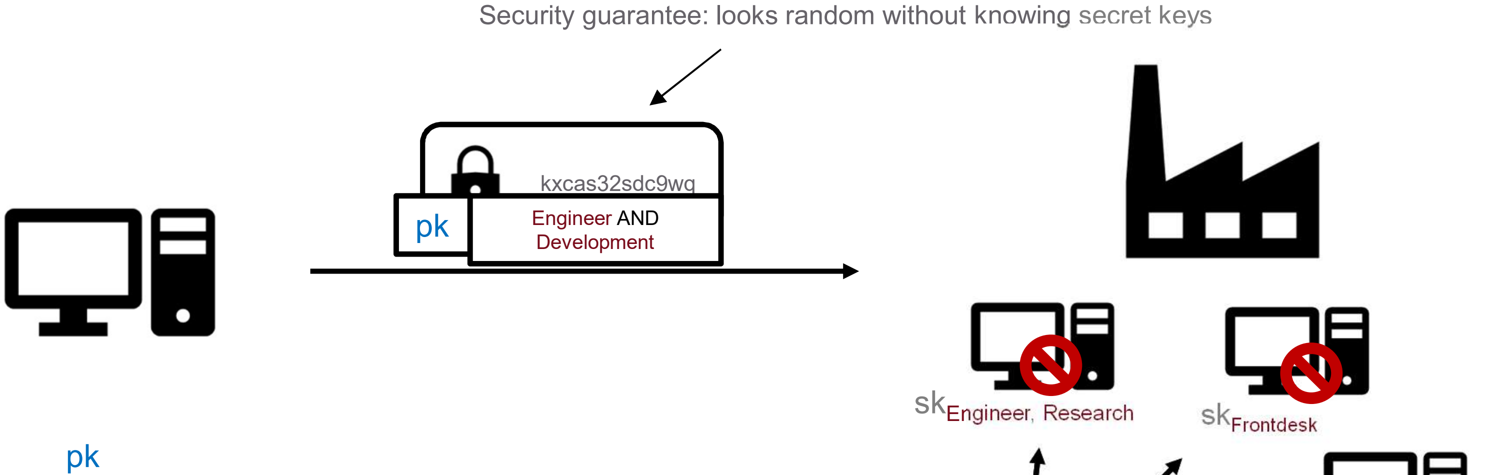
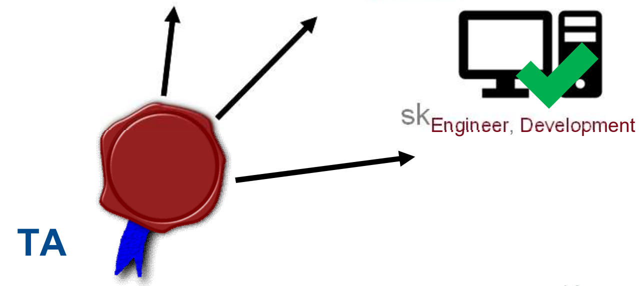
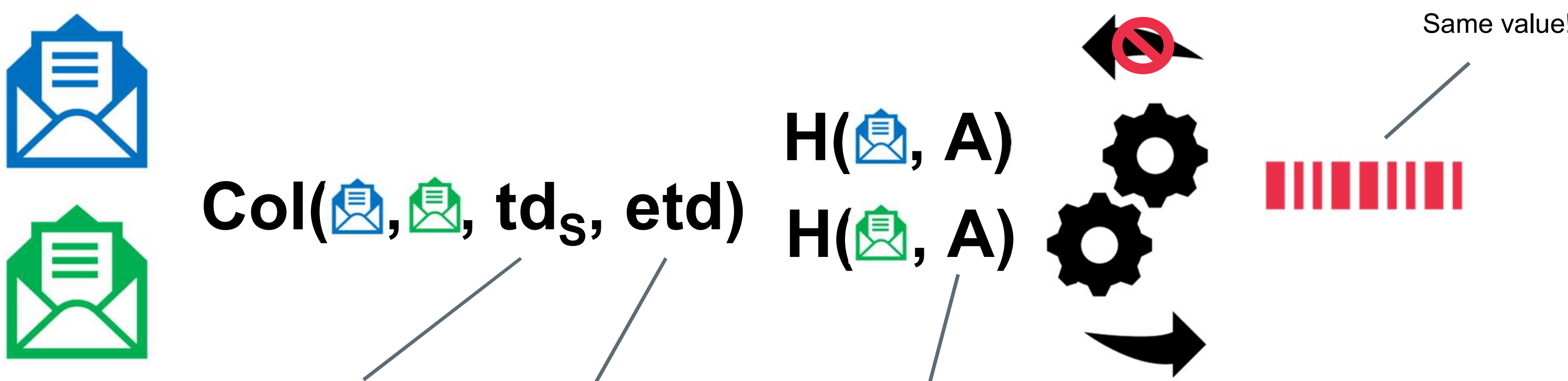




Properties:

- Enables **fine-grained** one-to-many communication
- Enforces access control on the cryptographic level
- Need of pk-related authority **TA** that distributes secret keys

PUTTING EVERYTHING TOGETHER



Main feature: collision finding possible if ABE secret key for **S** that fulfills access structure **A** for encrypted **etd** is known.

POLICY-BASED CHAMELEON HASHING (PBCH)

$\mathsf{Gen}(k)$: Outputs the secret key $sk_{\mathsf{PBCH}} \leftarrow (msk_{\mathsf{ABE}}, sk_{\mathsf{CHET}})$ and public key $pk_{\mathsf{PBCH}} \leftarrow (pk_{\mathsf{ABE}}, pk_{\mathsf{CHET}})$.

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$\mathsf{Verify}(pk_{\mathsf{PBCH}}, m, h, r)$: Return 1 if $\mathsf{Verify}_{\mathsf{CHET}}(pk_{\mathsf{CHET}}, h, h_{\mathsf{CHET}}, r_{\mathsf{CHET}})$, else 0.

$\mathsf{Col}(sk_S, m, m', h, r)$: Outputs randomness $r' \leftarrow \mathsf{Adapt}_{\mathsf{CHET}}(sk_{\mathsf{CHET}}, etd, m, m', h, r_{\mathsf{CHET}})$, for $etd \leftarrow \mathsf{Dec}_{\mathsf{ABE}}(sk_{\mathsf{ABE},S}, C_A)$.

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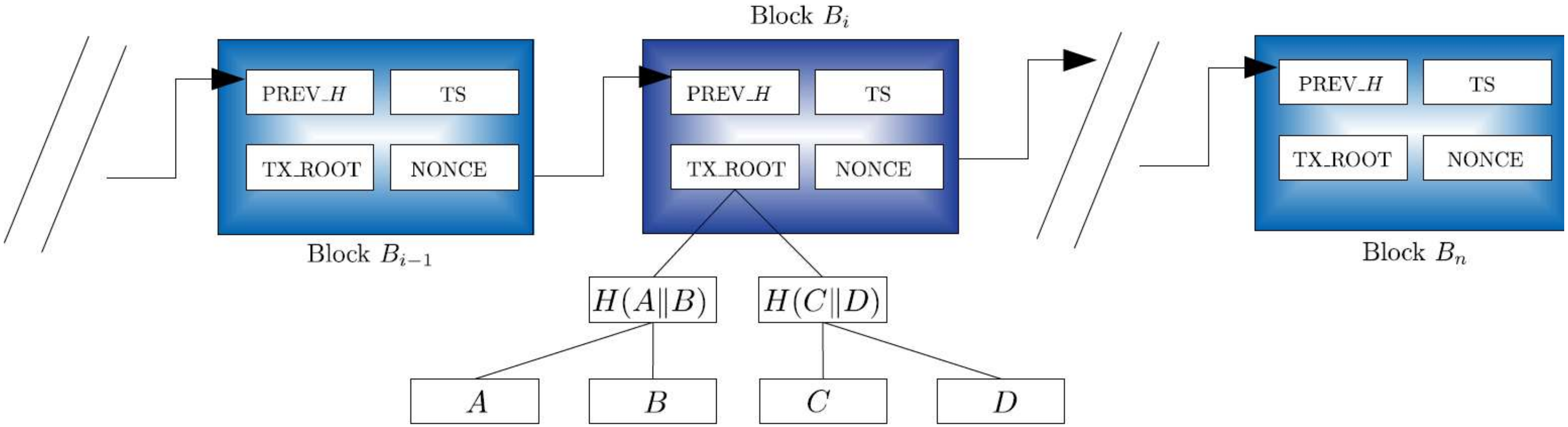
Ephemeral trapdoor *etd* can only be accessed with ABE **secret key for attributes** which fulfill **the ciphertext access structure**.

HIGH-LEVEL EXAMPLE



$A \leftarrow H(\mathbf{h})$ $B \leftarrow H(T_{i,2})$ $C \leftarrow H(T_{i,3})$ $D \leftarrow H(T_{i,4})$

$(\mathbf{h}, r_i) \leftarrow \mathsf{PBCH.Hash}(\mathsf{pk}, T_{i,1}, \mathbb{A})$

CONCLUSION

- **Editing/re-writing** DLs interesting aspect to consider
  - Possible on block level and transaction level

- New primitive **Policy-Based Chameleon Hashing (PBCH)** to allow fine-grained re-writing on the **transaction** level in DLs

- Open questions
  - Who generates the trapdoor for chameleon hashes?
    - Ateniese et al. propose to use multi-party computation protocol
  - Can we get rid of such a requirement and build a fully decentralized solution based on chameleon hashing?

THANK YOU!

Daniel.Slamanig@ait.ac.at

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

SECREDAS
Digital Privacy
Safety & Security