SECURE CRYPTOGRAPHIC TOOLS FOR CLOUD & BLOCKCHAIN APPLICATIONS

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CSE Research and Technology Forum 2021

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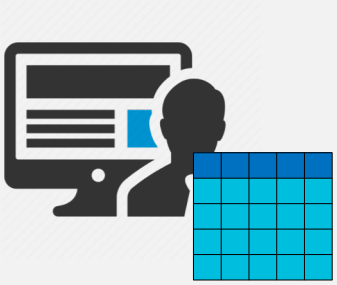
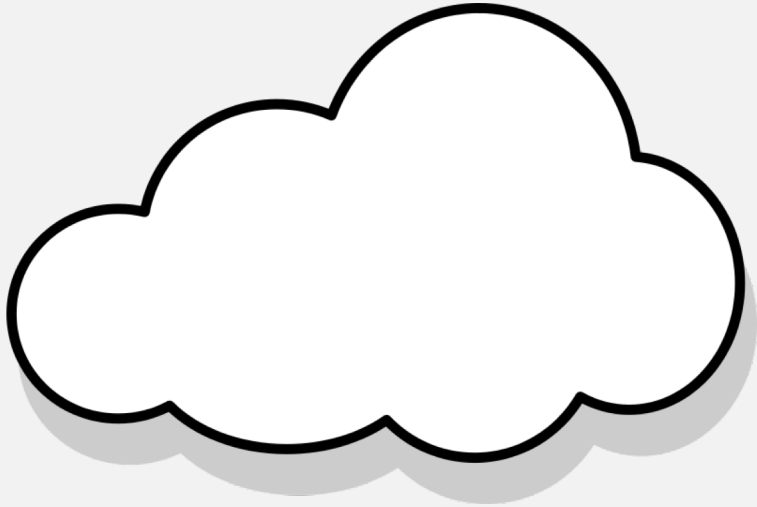
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

SEARCHING ON ENCRYPTED DATA

- Data outsourced to remote servers usually needs to be **encrypted** for privacy purposes





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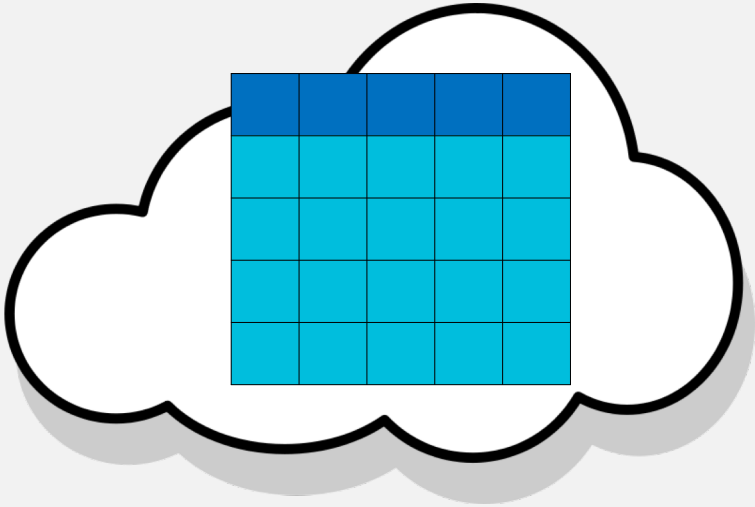

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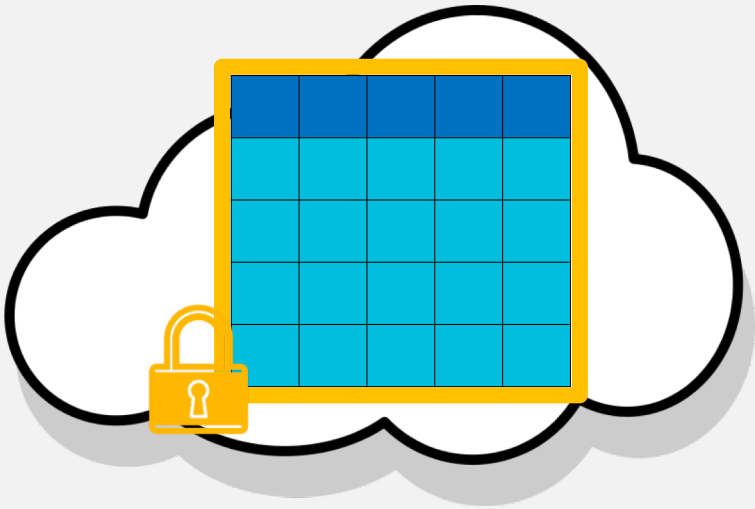

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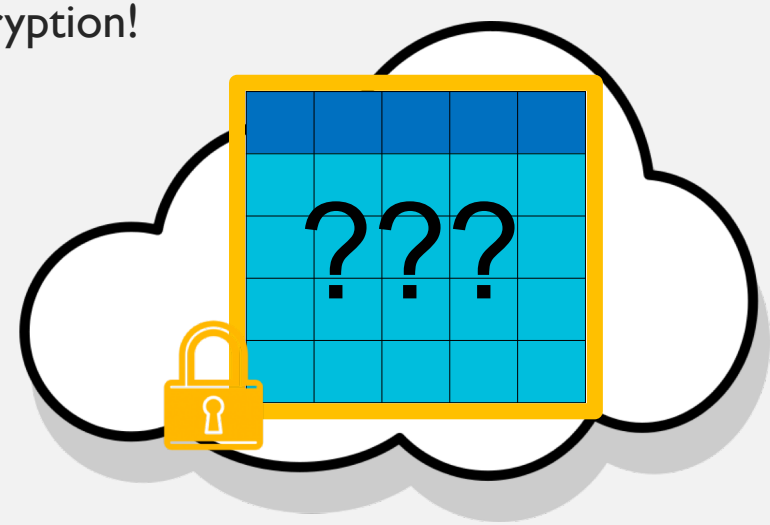
- **Impossible to query** it at the server due to encryption!
- Our solution: **Searchable Encryption**

```
SELECT * FROM TABLE
WHERE DEPT = “HR”
```



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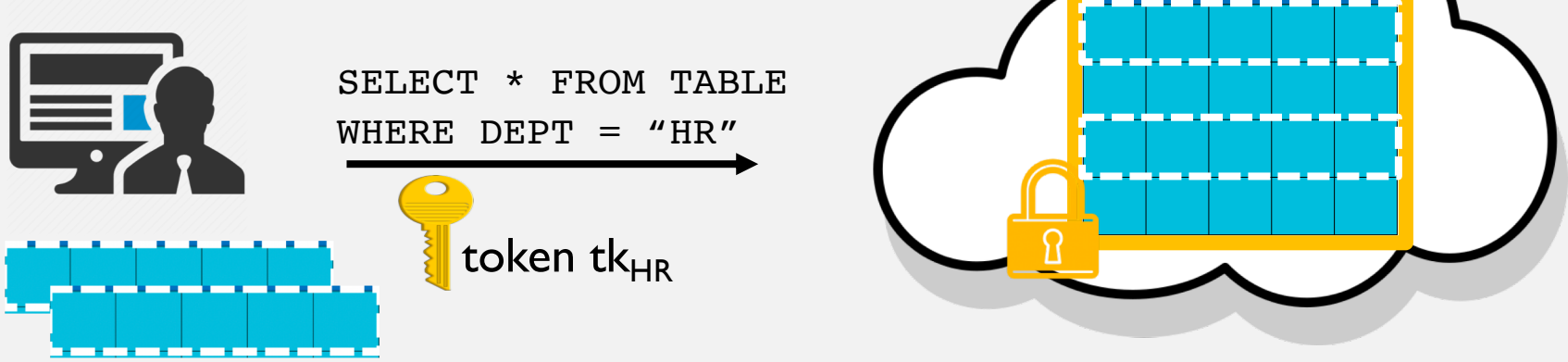

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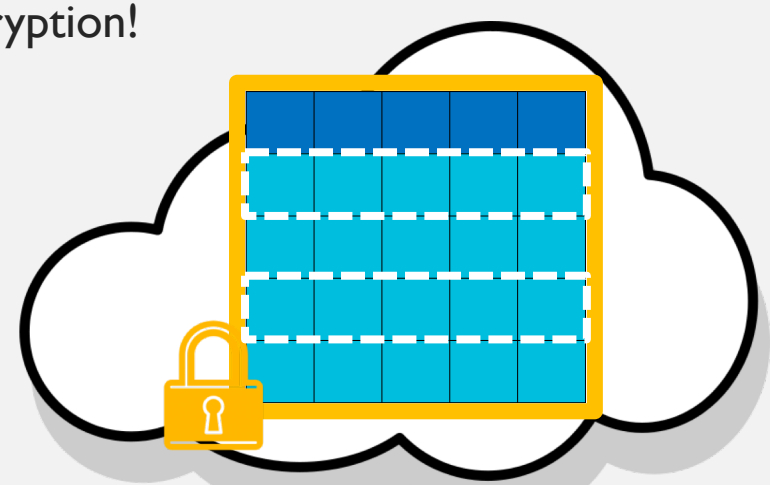
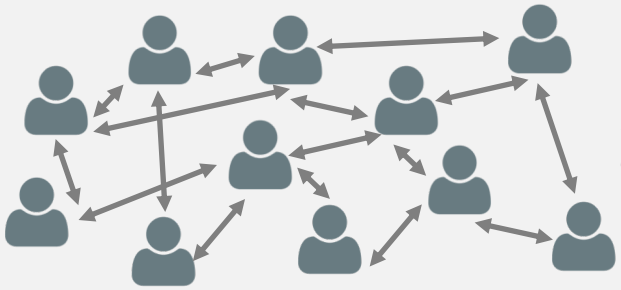


- Data remains always encrypted at the server → **Privacy**
- Separate tokens for each column or value → **Access control**
- Based on simple symmetric-key encryption → **Efficiency**
- Generalizes to data from **many users** or **complex queries**

Our scheme published in CCS 2018 is the state-of-the-art-dynamic SE:
→ Extracting 1000 records from a dataset of 1M takes less than 10ms

VERIFIABLE (PSEUDO-)RANDOMNESS

- Many decentralized applications require **user-provided randomness** for execution:



blockchain protocol with committee-based consensus

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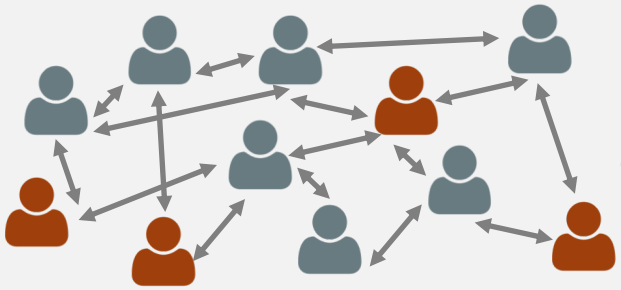

blockchain protocol with committee-based consensus

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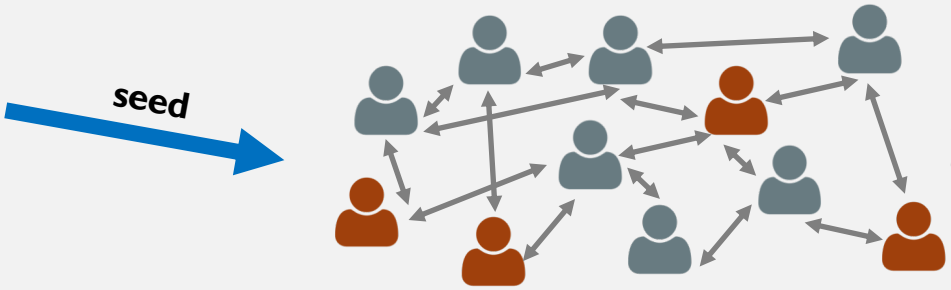

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Public key **pk**
Secret key **sk**

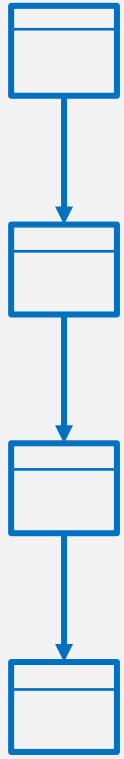
Random(**sk**, **seed**) → **val, proof**
Verify(**pk**, **seed**, **val**, **proof**) → **accept/reject**

- Each user computes "random" value **val**
- Everybody can verify **val** using **pk**

→ Our constructions are used in many deployed cryptocurrencies (e.g., ALGORAND with 600M USD market cap)
→ Currently being standardized by the **I**nternet **E**ngineering **T**ask **F**orce

ZERO-KNOWLEDGE SMART CONTRACTS

- Smart contracts are programs that are stored and executed **on the blockchain**



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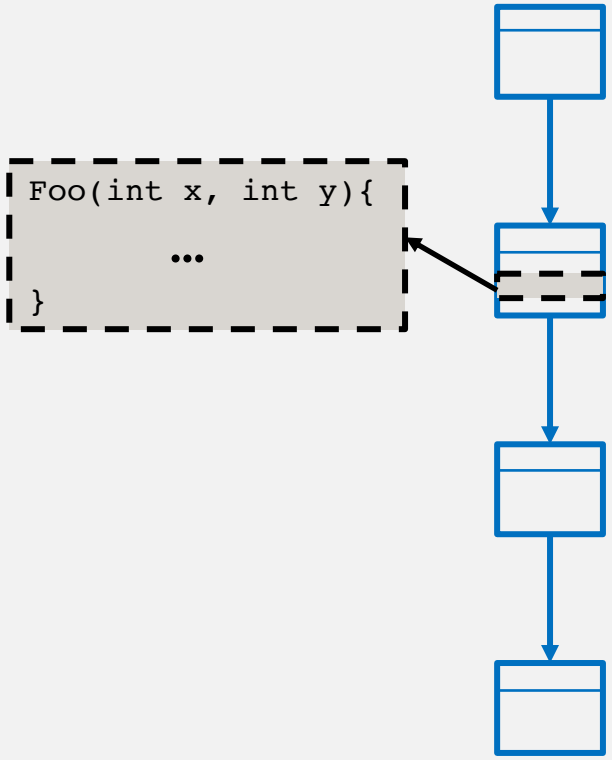

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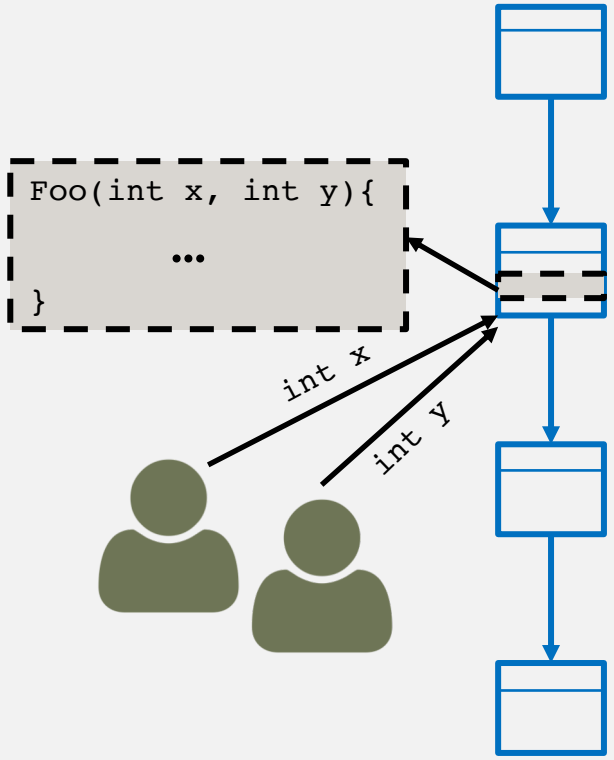

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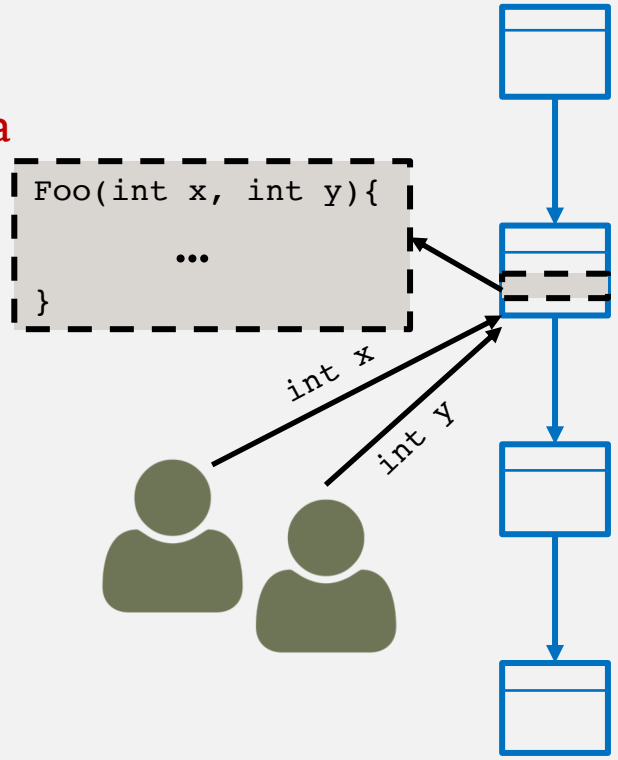

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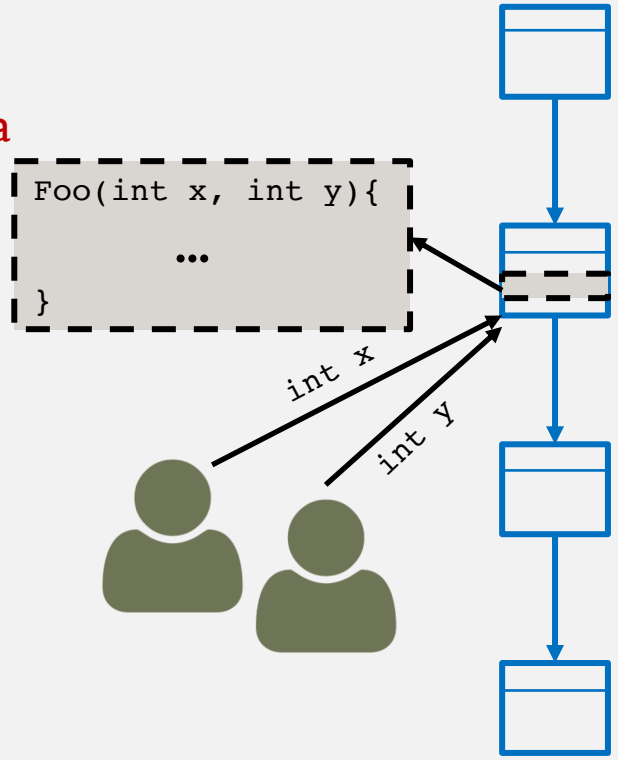

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- Input data is provided via blockchain transactions
  - → publicly visible to everyone!
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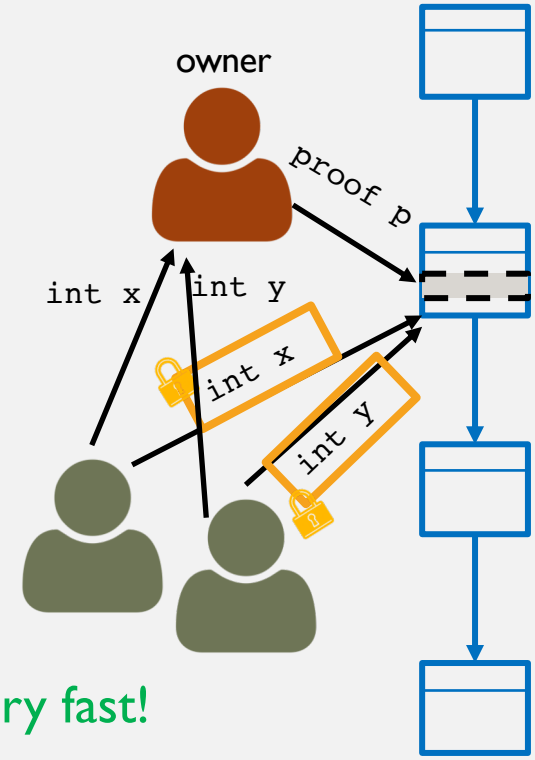
- Our solution: **Zero-knowledge proofs**
- Data is encrypted on the chain and **only revealed to the smart contract owner**
- Owner evaluates contract and provides a zero-knowledge proof for the **validity**
  - → nothing is revealed publicly about the data
  - → saves effort as verifying the proof can be very fast!



Our scheme published in USENIX 2020 achieves the shortest proofs:
→ 160 bytes proof for any smart contract and verify takes 2ms