Processing Encrypted Data in the Cloud

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Cloud Era

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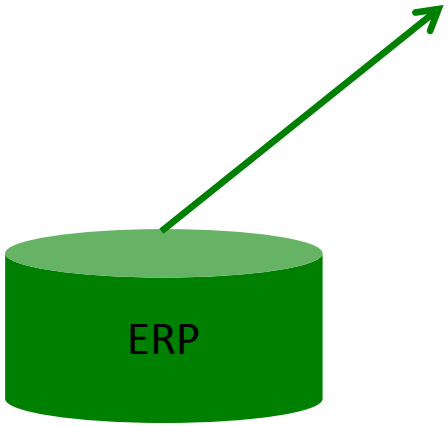
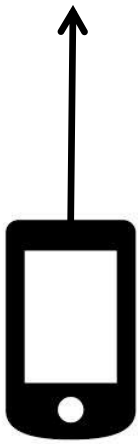
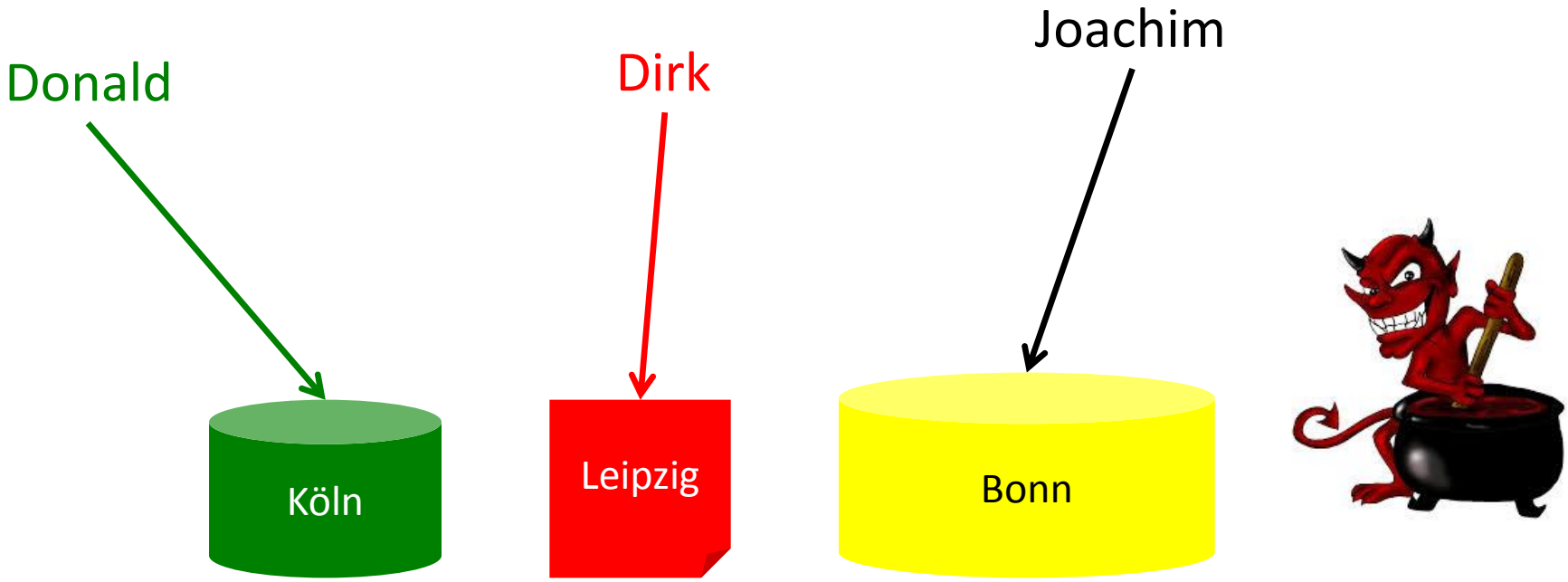




Alternative 1: Data in the Cloud

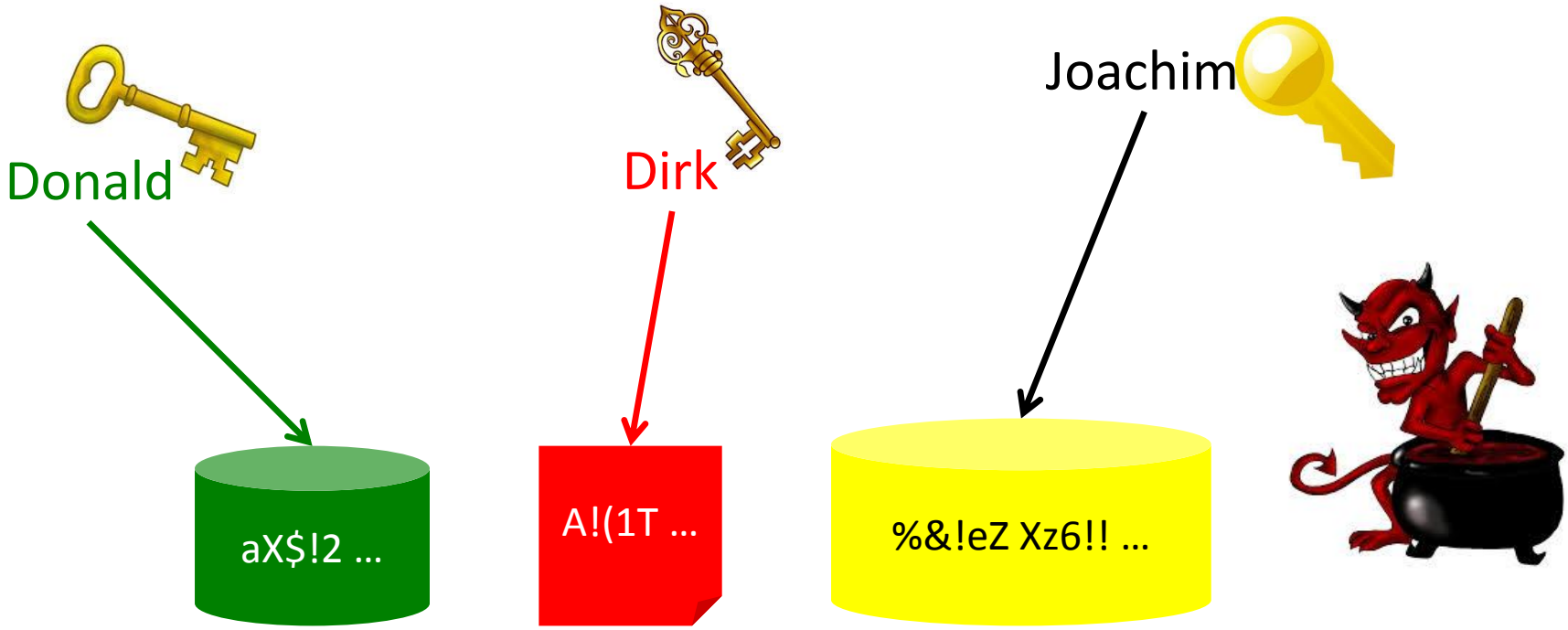


- **Data are not encrypted**
  - Great to process the data in the cloud ☺
  - Little protection against attackers ☹

Honest & Curious Attackers

- Are interested in your data
- Are not interested in disrupting your service
- Often internal and powerful
  - may have root privileges to machines
- Several examples recently with huge impact

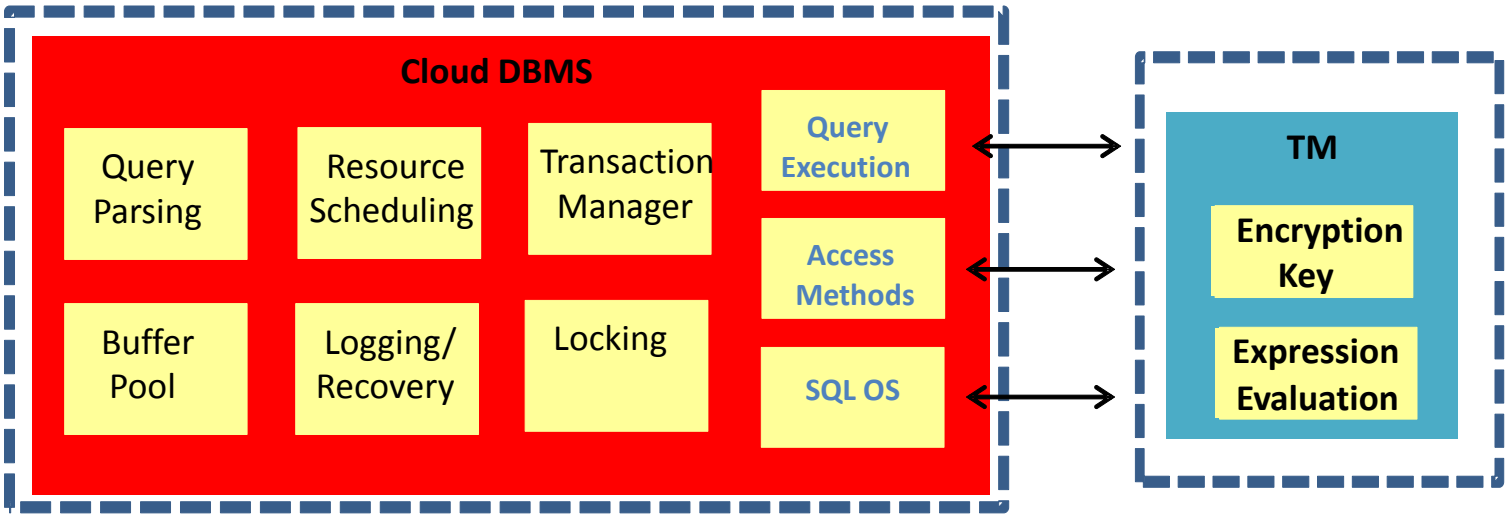
Alternative 2: Silos



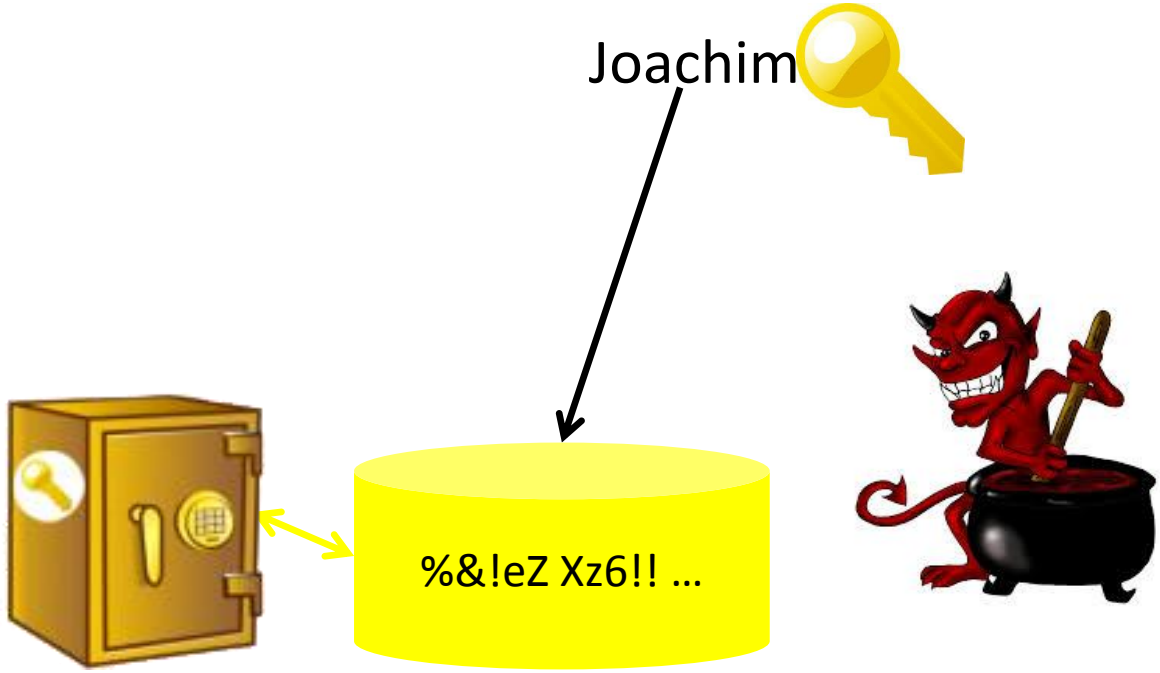
- **Data are encrypted**
  - A great deal of protection against attackers. ☺
  - Processing data outside of cloud results in high cost. ☹
  - No way to integrate data from multiple owners. ☹

Cipherbase: Secure Co-processor

- Idea: Farm out computation on encrypted data to co-processor
- Most database work on commodity hardware (cheap & fast)
  - Logging, Locking / Synchronization, Buffer Management, Scheduling etc.
  - Expressions on encrypted or (partially) homomorphically encrypted data
- Secure co-processor evaluates expressions on encrypted data
  - Arithmetic, Comparisons and Intrinsics (MIN, MAX etc.)
  - Trusted Code Base easy to verify

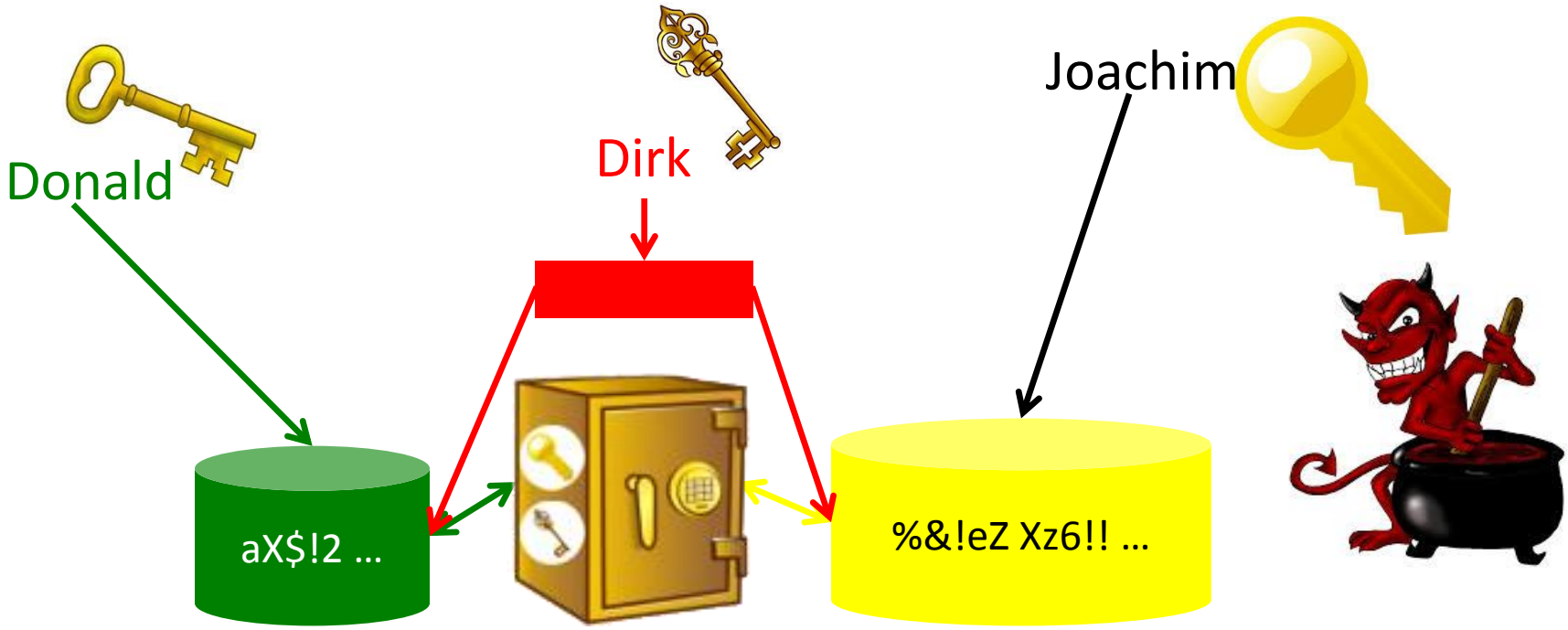


Cipherbase: Use Case 1



- **Data encrypted in the cloud. Good protection. ☺**
- **Data processed in the cloud: cheap & fast. ☺**

Cipherbase: Use Case 2

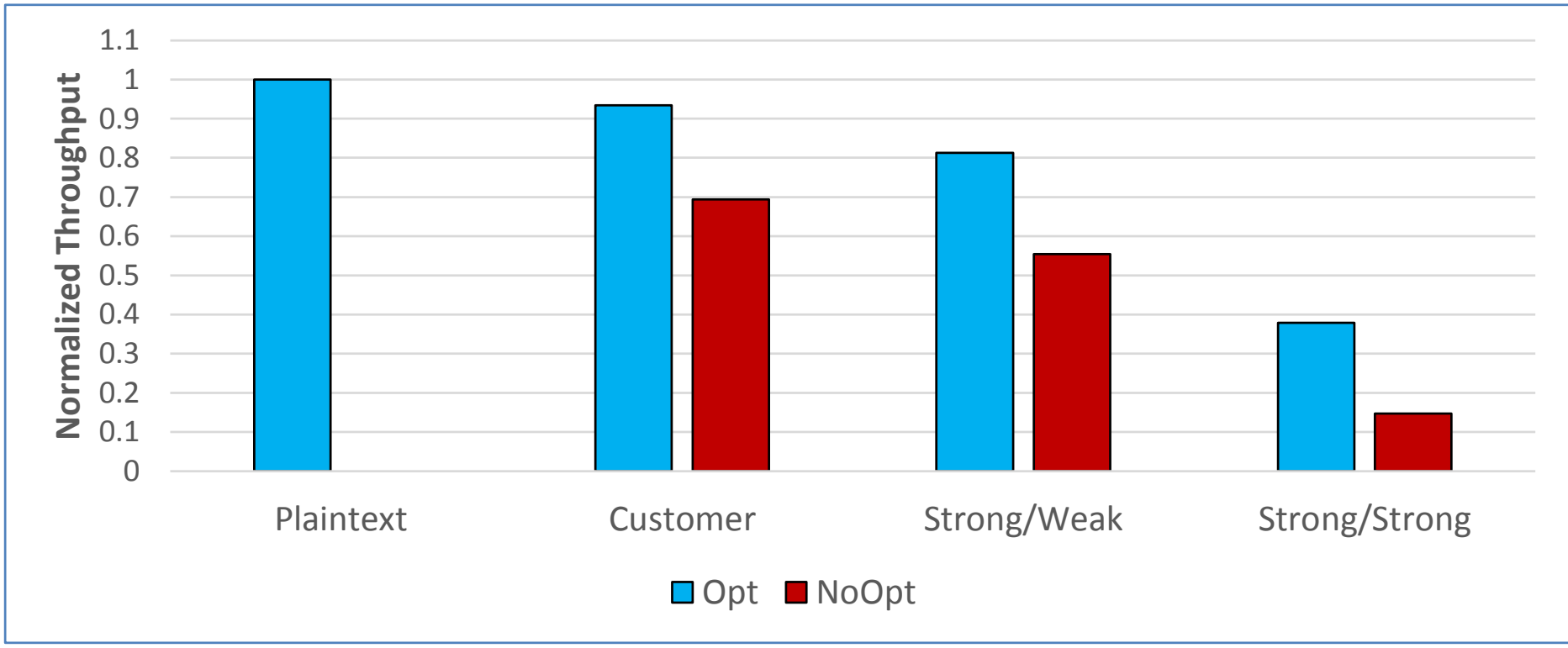


- **Donald, Joachim authorize Dirk for his query.**
- **Dirk only sees (aggregated) results. Dirk does not see base data.**
- **Donald, Joachim only see their own data.**
- **Scales to data from millions of users.**

Why trust trusted Hardware?

- Three options
  - Dedicated co-processors: e.g., IBM 4970
  - Extensions to commodity processors: Intel SGX
  - Custom hardware: FPGAs
- We chose FPGAs
  - no operating system (less software to trust)
  - open source the layout
  - available and cheap

TPC-C Results



Summary

- Goal: Generality, Performance, Security
- Only way to achieve goal today is with HW
- HW is becoming available
- Careful HW/SW co-design for good performance