ObliDB: Oblivious Query Processing for Secure Databases

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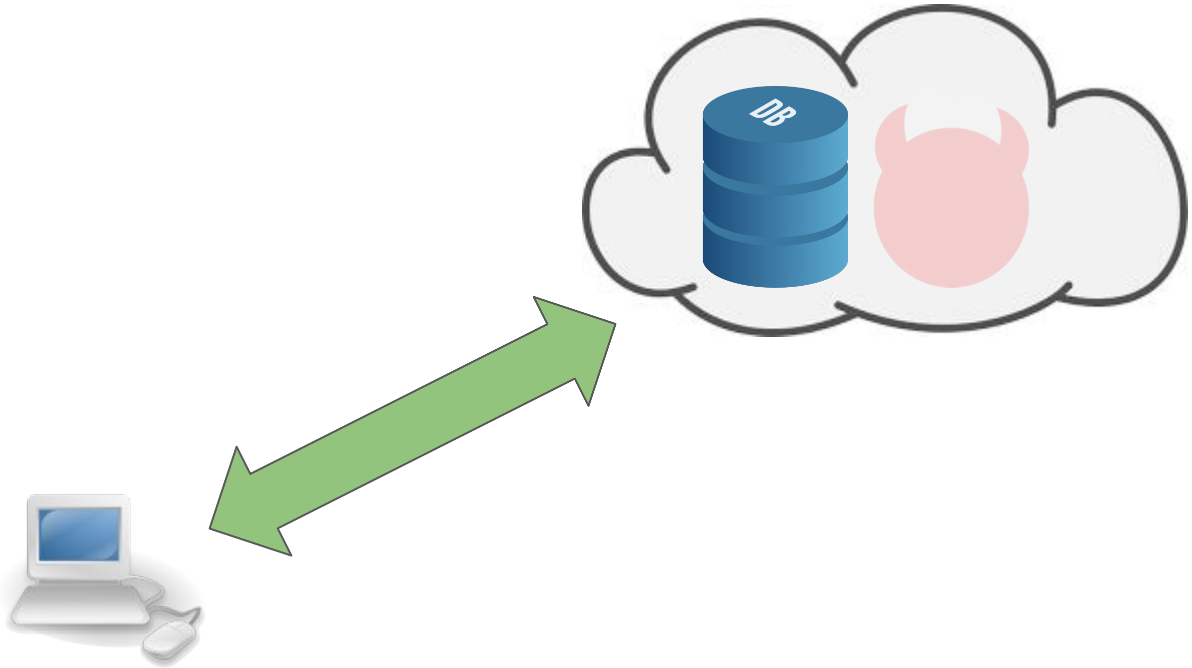
Private Data in the Cloud



Compromised cloud can:

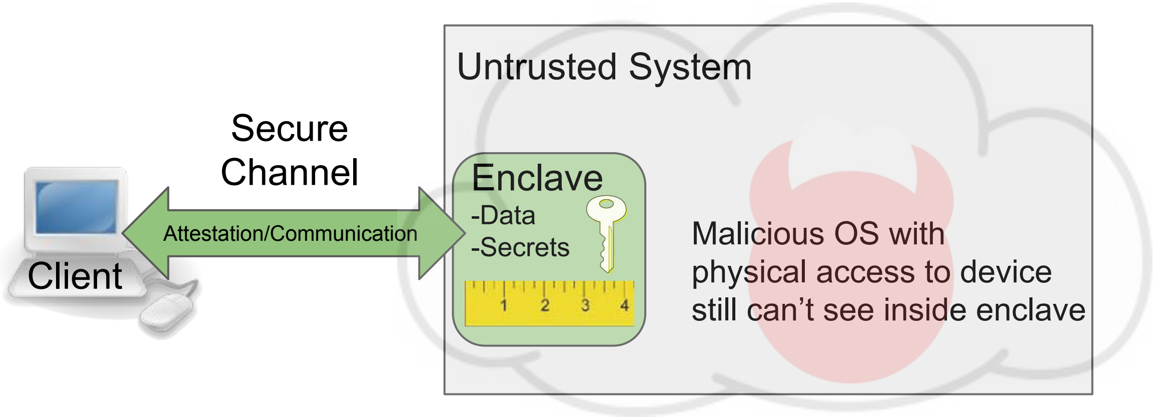
Read data
Read queries
Alter data

Hardware Enclaves

A trusted component in untrusted hardware

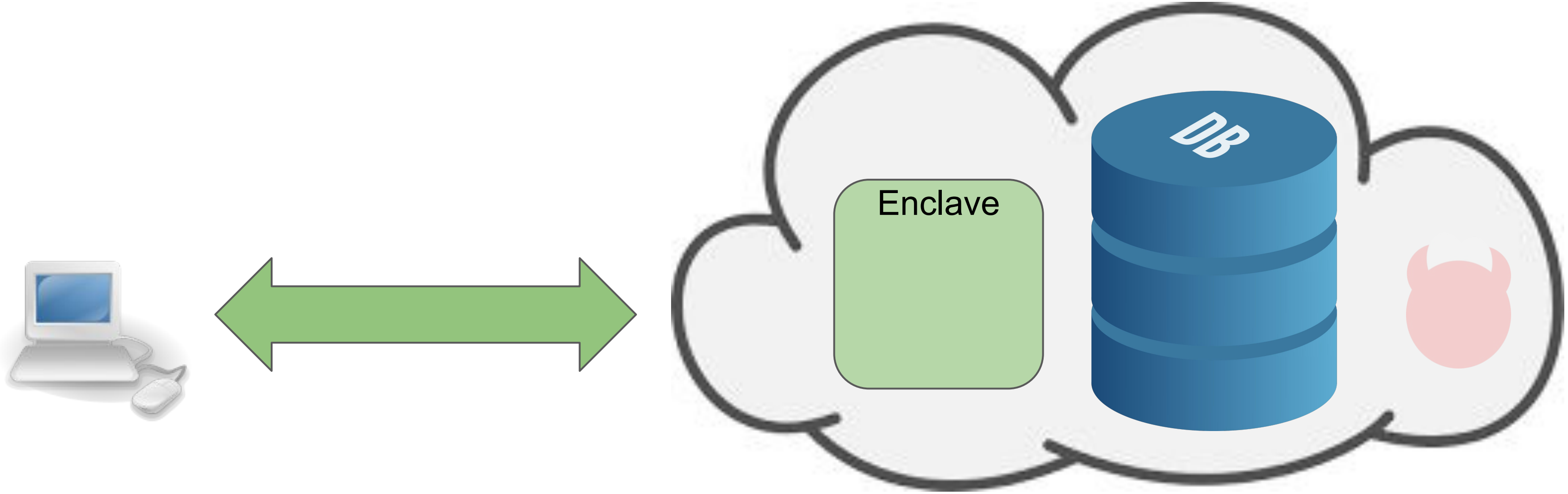
- Isolation through protected memory
- Authenticity through attestation

Currently available through Azure and IBM cloud, among others



Enclaves in the Cloud

Enclave memory is limited, but data is big!



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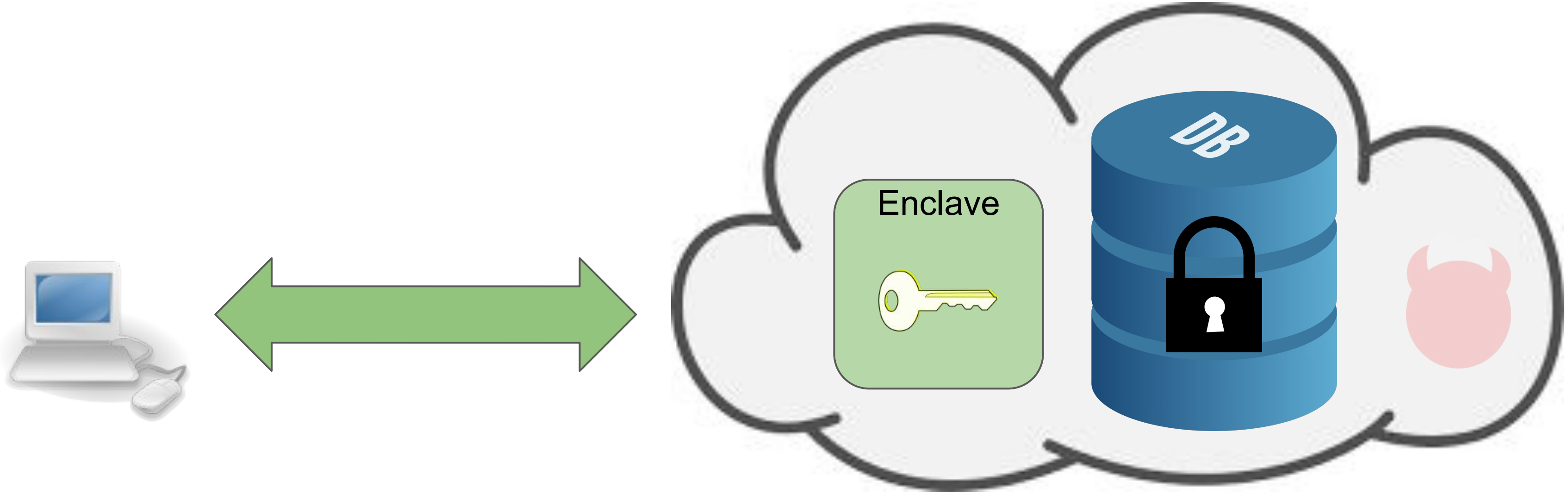
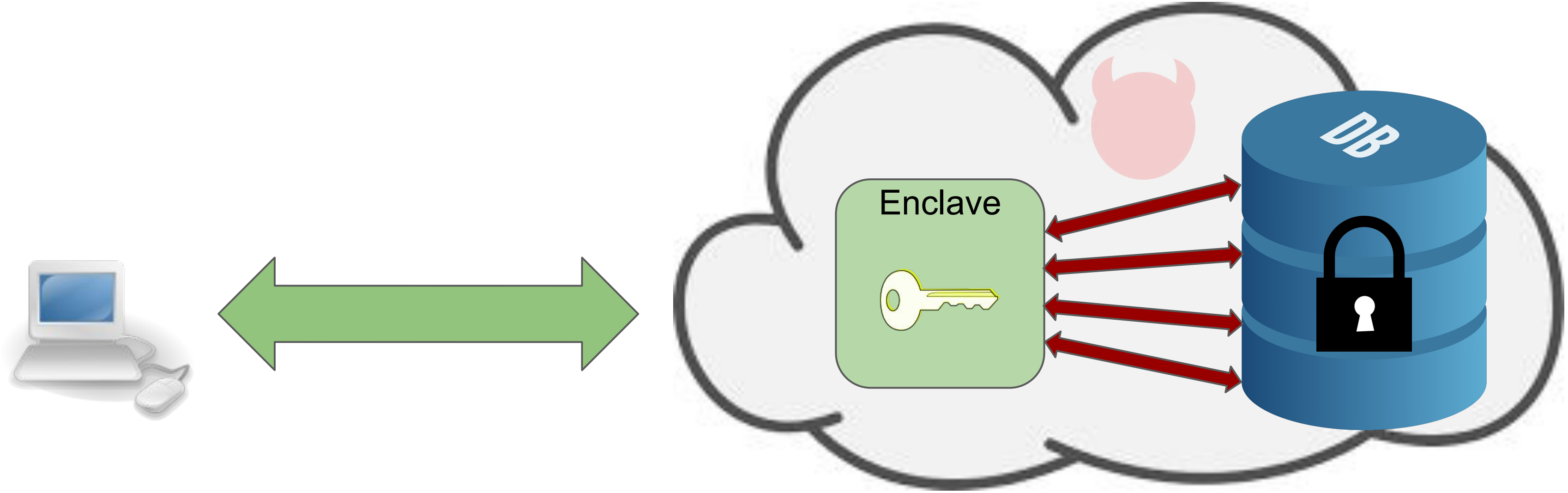


Enclaves in the Cloud

Malicious attacker can observe access patterns to encrypted data!



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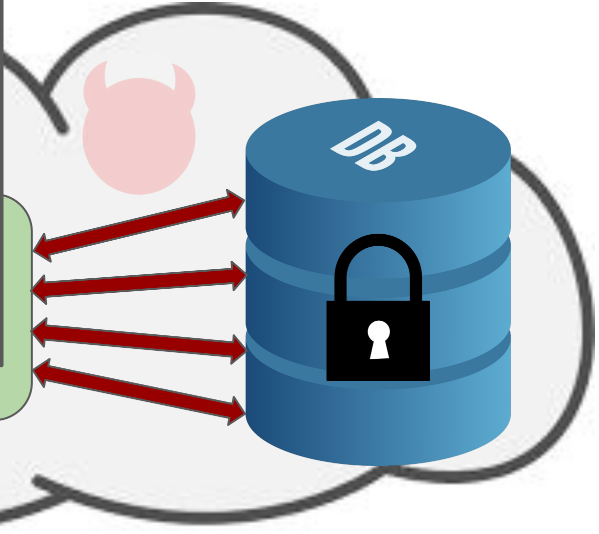

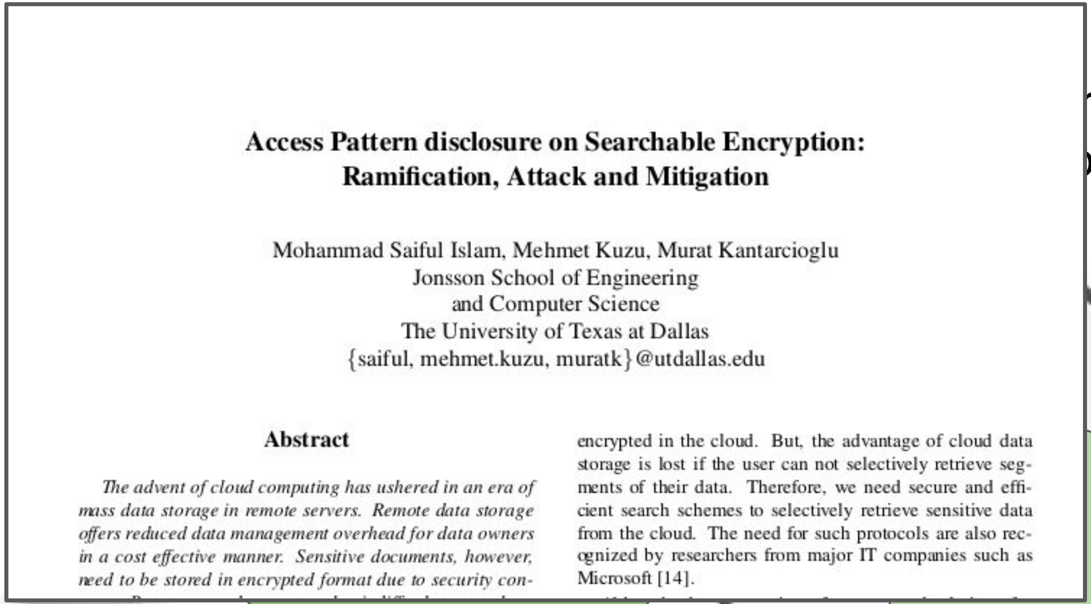

Access Pattern disclosure on Searchable Encryption: Ramification, Attack and Mitigation

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Abstract

The advent of cloud computing has ushered in an era of mass data storage in remote servers. Remote data storage offers reduced data management overhead for data owners in a cost effective manner. Sensitive documents, however, need to be stored in encrypted format due to security con-

encrypted in the cloud. But, the advantage of cloud data storage is lost if the user can not selectively retrieve segments of their data. Therefore, we need secure and efficient search schemes to selectively retrieve sensitive data from the cloud. The need for such protocols are also recognized by researchers from major IT companies such as Microsoft [14].

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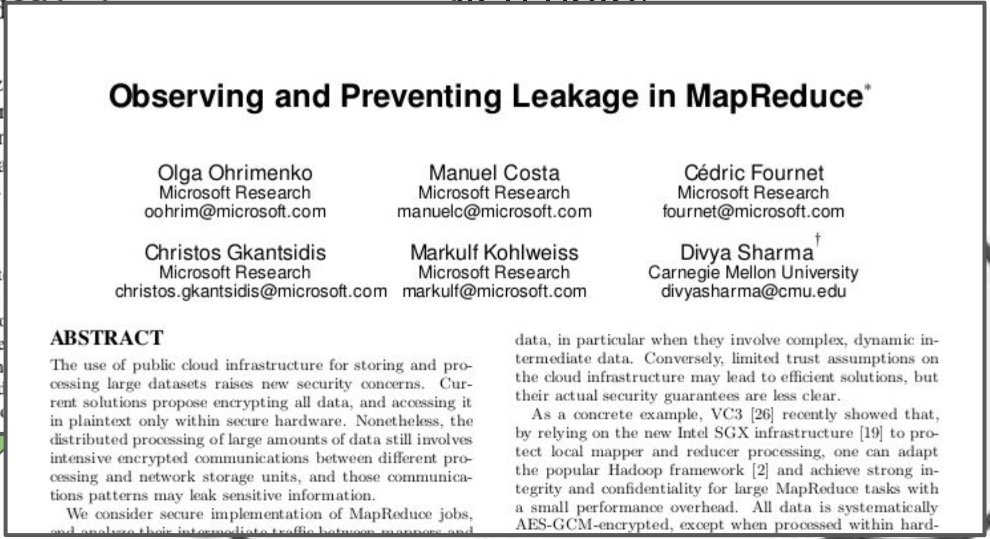

Observing and Preventing Leakage in MapReduce*

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ABSTRACT

The use of public cloud infrastructure for storing and processing large datasets raises new security concerns. Current solutions propose encrypting all data, and accessing it in plaintext only within secure hardware. Nonetheless, the distributed processing of large amounts of data still involves intensive encrypted communications between different processing and network storage units, and those communications patterns may leak sensitive information.

We consider secure implementation of MapReduce jobs,

data, in particular when they involve complex, dynamic intermediate data. Conversely, limited trust assumptions on the cloud infrastructure may lead to efficient solutions, but their actual security guarantees are less clear.

As a concrete example, VC3 [26] recently showed that, by relying on the new Intel SGX infrastructure [19] to protect local mapper and reducer processing, one can adapt the popular Hadoop framework [2] and achieve strong integrity and confidentiality for large MapReduce tasks with a small performance overhead. All data is systematically AES-GCM-encrypted, except when processed within hard-

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Observing and Preventing Leakage in MapReduce*

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Breaking Web Applications Built On Top of Encrypted Data

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ABSTRACT

We develop a systematic approach for analyzing client-server applications that aim to hide sensitive user data from untrusted servers. We then apply it to Mylar, a framework that uses multi-key searchable encryption (MKSE) to build Web applications on top of encrypted data.

We demonstrate that (1) the Popa-Zeldovich model for MKSE does not imply security against either passive or active attacks; (2) Mylar-based Web applications reveal users' activity on the server but not interfering with its operations), and active attacks involving arbitrary malicious behavior. We then work backwards from these adversarial capabilities to models. This approach uncovers significant challenges and security-critical decisions faced by the designers of BoPETs: how to partition functionality between the clients and the server, which data to encrypt, which access patterns can leak sensitive information, and more.

We then apply our methodology to a recent BoPET called

"A persistent passive attacker can extract even more information by observing an application's access patterns … In our case study applications, this reveals users' medical conditions, genomes, and contents of shopping carts"

Naive SELECT is not oblivious!

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Watching when we write to the output table reveals exactly which rows of the input table we select!

Toward Obliviousness

Prior work solves *pieces* of the obliviousness problem very well

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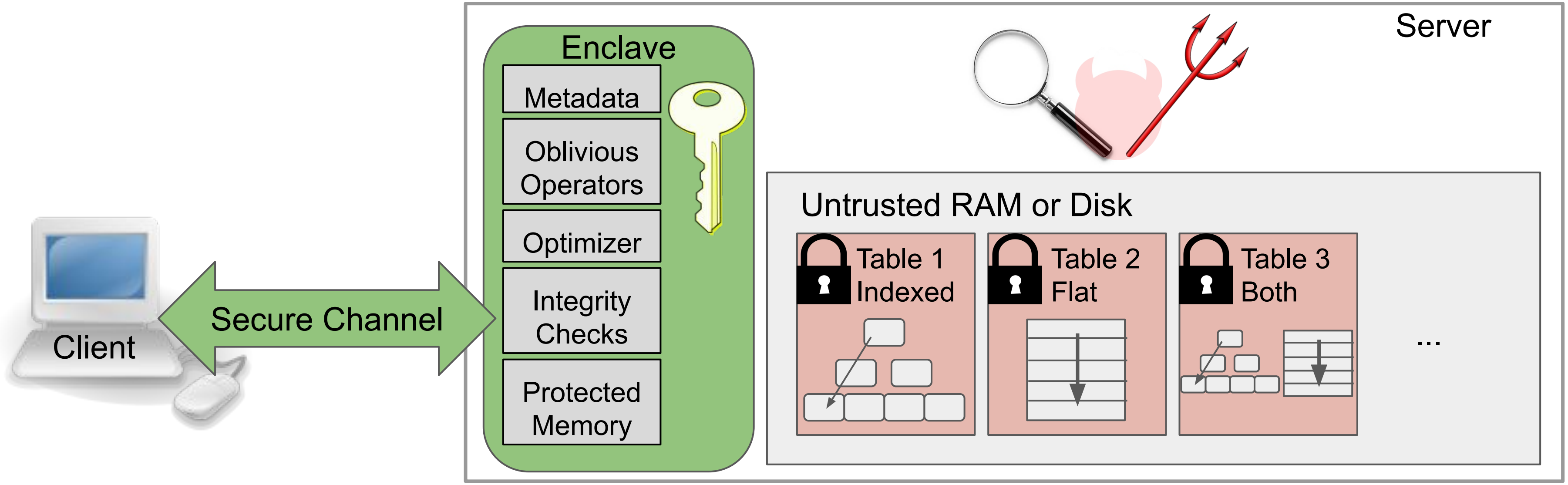
This work: ObliDB, first system to provide obliviousness for general database read workloads over multiple access methods

ObliDB Overview

- Tables stored encrypted in unprotected memory, enclave only holds metadata
- Two oblivious storage methods: flat tables and *oblivious indexes*
- Supports most SQL operations
- Various algorithms for each operation - can pick best option at runtime



Security Guarantees

ObliDB protects data and query parameters against an attacker with full control of the OS and VMM

- Detects any malicious attempt to tamper with data
- Leaks only query selectivity, table sizes (including intermediate tables), and query plan
- Optional padding mode available to hide table sizes and query selectivity
- **Assumption:** limited oblivious memory pool

Oblivious Operators

- Selection
  - Small
  - Large
  - Continuous
  - Hash
- Grouping and Aggregation
- Joins
  - Oblivious hash join
  - Oblivious sort-merge join (from Opaque)
  - Zero oblivious memory sort-merge join

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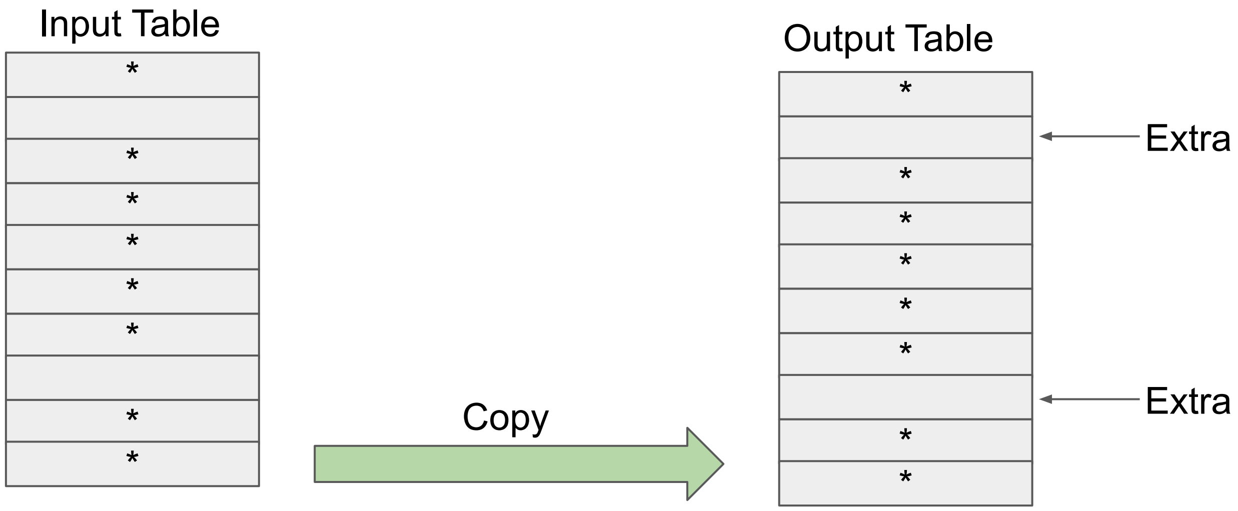
Oblivious SELECT

“Large” SELECT Algorithm: use when almost the whole table is selected



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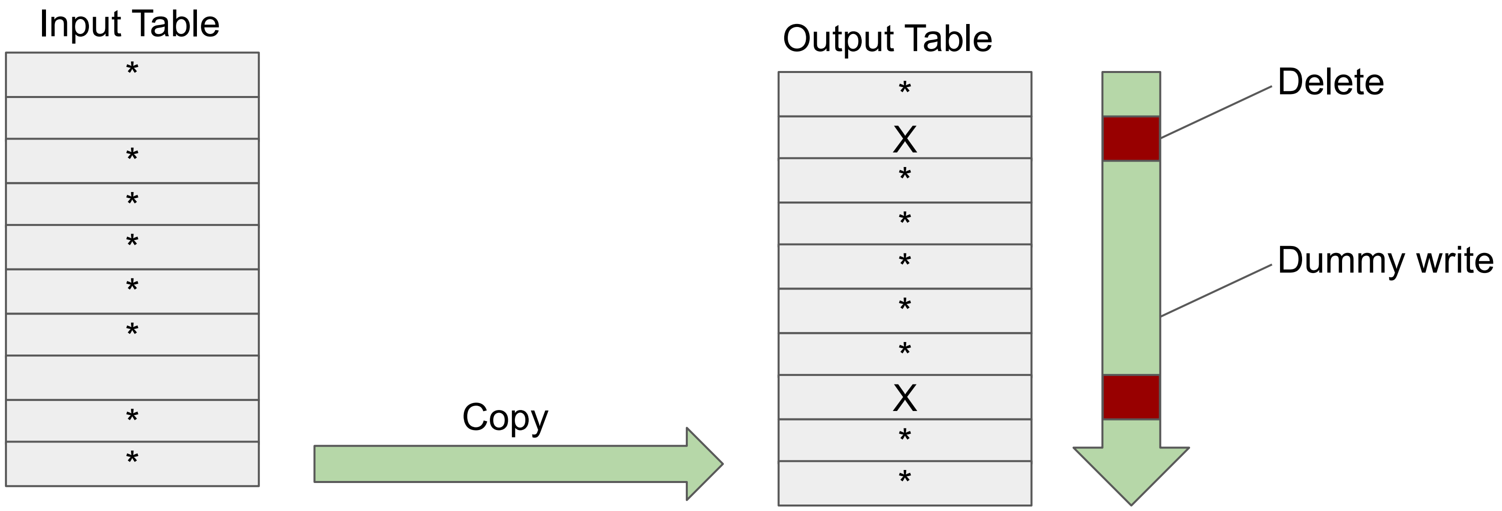

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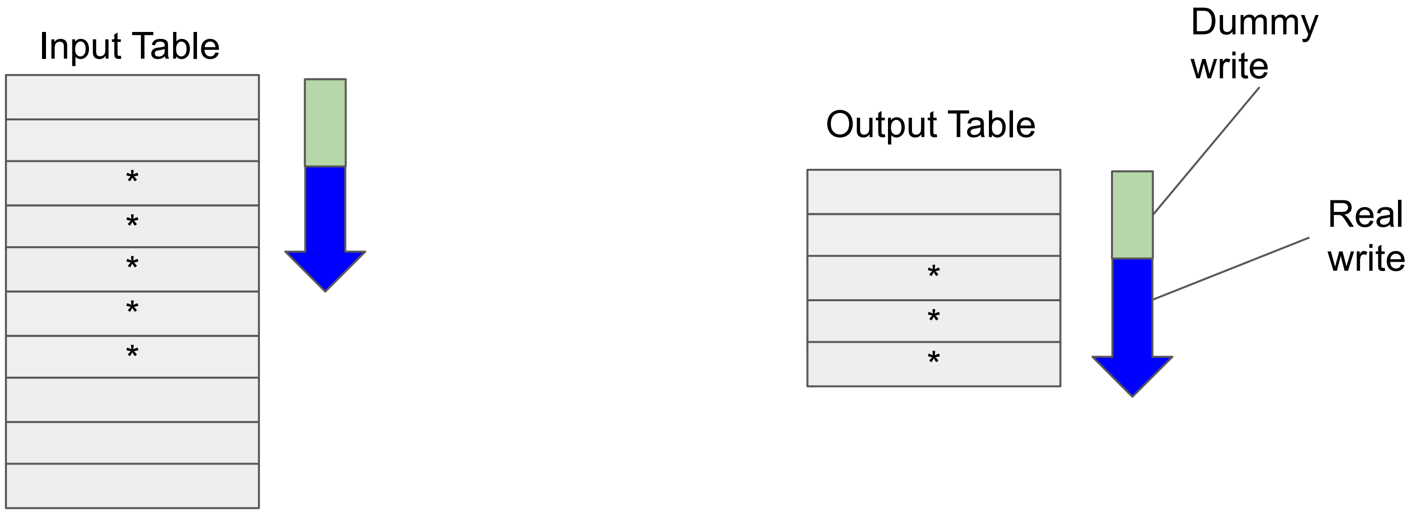

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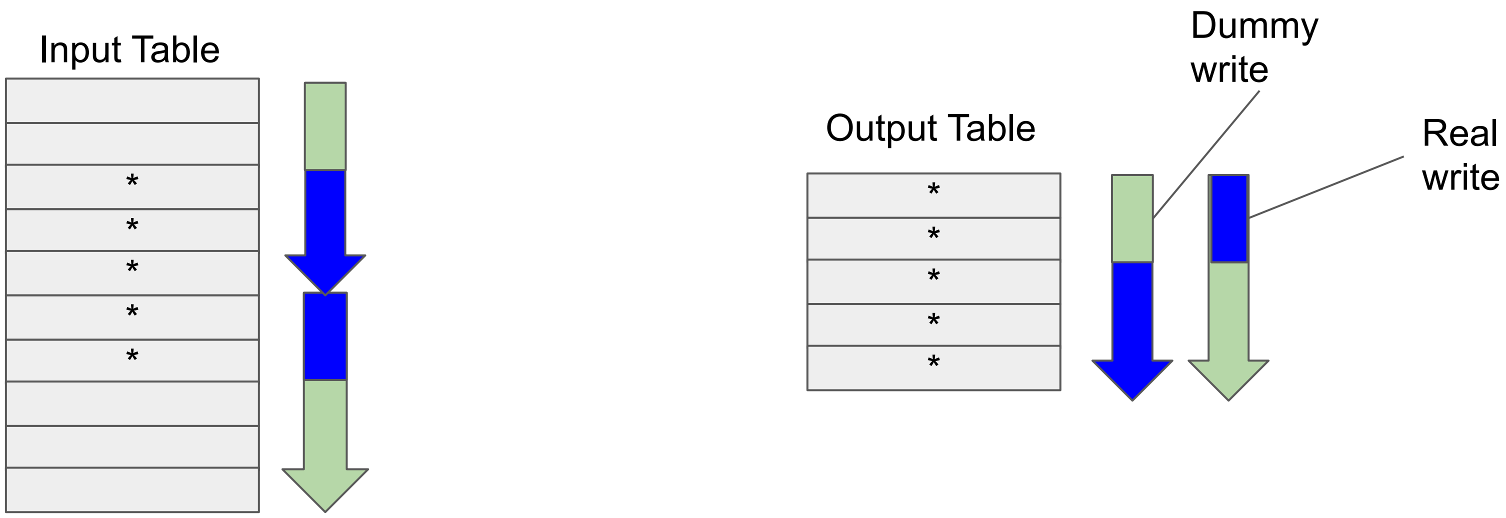

ObliDB

Performance highlights:

- 1.1-19x faster than Opaque (on Big Data Benchmark queries)
- Within 2.6x of Spark SQL (on Big Data Benchmark queries)

See paper for system details, more oblivious operators, and full evaluation

Paper: `http://www.vldb.org/pvldb/vol13/p169-eskandarian.pdf`

Source Code: `https://github.com/SabaEskandarian/ObliDB`

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