Benchmarking Geo-Distributed Databases using the SmallBank benchmark

Author: Cirtog Filip-Andrei
Responsible professor: Dr. Asterios Katsifodimos
Supervisor: Oto Mraz

TU Delft
Delft University of Technology

Introduction

Distributed & Geo-distributed Databases power global platforms:

- E-commerce (Amazon), Finance (US Bank), Social Media (Facebook)

Challenge on geo-distributed databases:

- Complex design trade-offs.
- Unclear which systems perform best under specific workloads or at global scale.

Academy vs Industry:

- TPC-C [1] → Too simple key-value operations, with half involving access to a single row [2].
- YCSB-T [3] → Assumes a centralized warehouse model and cannot create data hotspots [2].

Project Goal:

- Compare Calvin [4], SLOG [5], Detock [6], Janus [7] using the SmallBank benchmark [8].

Research Question

How do geo-distributed databases perform under the **SmallBank becnhmark [8]** in terms of throughput, latency, abort rate and bytes transferred across different scenarios.

Background

Calvin → Master sequencer to immediately process and forward transaction batches to replicas, reducing latency.

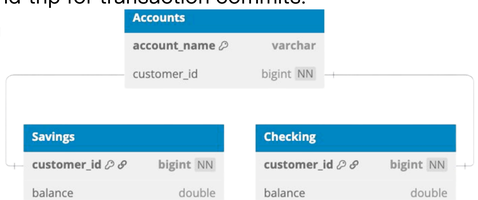
SLOG → Assigns each data item a home region. Low-latency single home transactions but uses a global ordering system for multi-home transactions.

Detock → Eliminates global ordering and uses a graph-based concurrency control protocol, reducing round-trip latencies and resolving deadlocks without transaction abortion.

Janus → Similar to Detock but slower due to synchronous data replication across regions, requiring at least one round-trip for transaction commits.

SmallBank workload replicates a bank environment:

- Balance
- DepositChecking
- TransactSaving
- Amalgamate
- WriteCheck

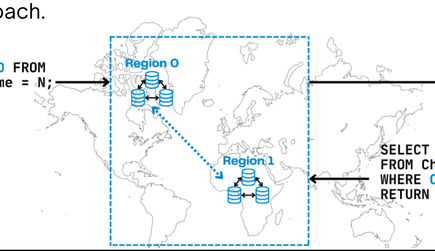


Implementation

Since Detock does not support dependent transactions, we implemented a two-phase approach.

PHASE 1

```
SELECT CustomerID FROM
Account WHERE Name = N;
```

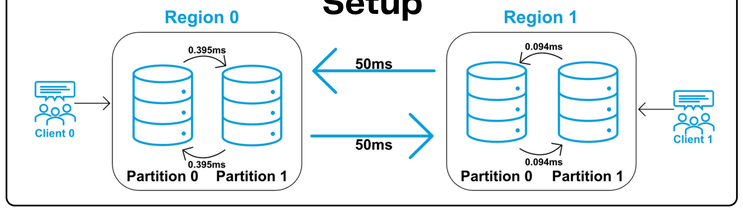


CustomerID

```
SELECT CheckingBalance, SavingsBalance
FROM Checking, Savings
WHERE CustomerID = Account. CustomerID;
RETURN CheckingBalance + SavingsBalance
```

PHASE 2

Setup



Results

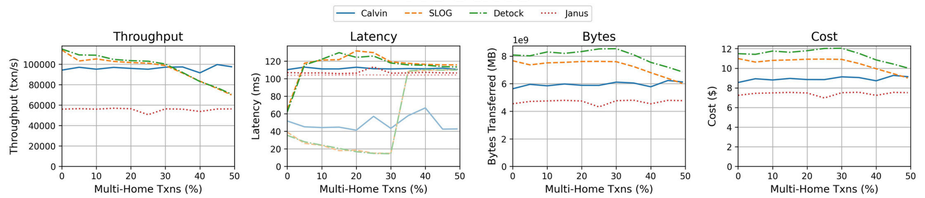


Figure 1: Comparison of results on the baseline scenario

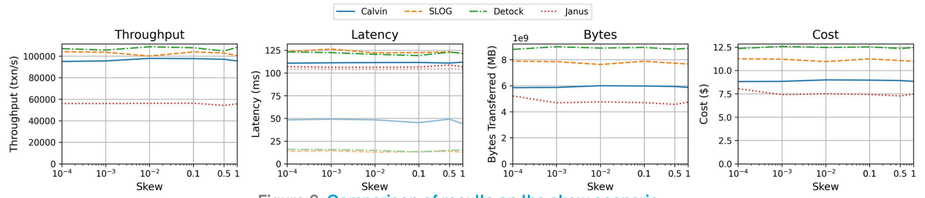


Figure 2: Comparison of results on the skew scenario

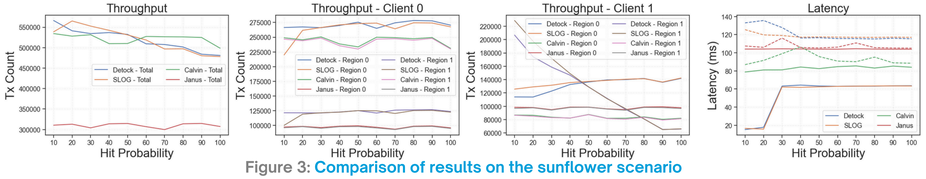


Figure 3: Comparison of results on the sunflower scenario

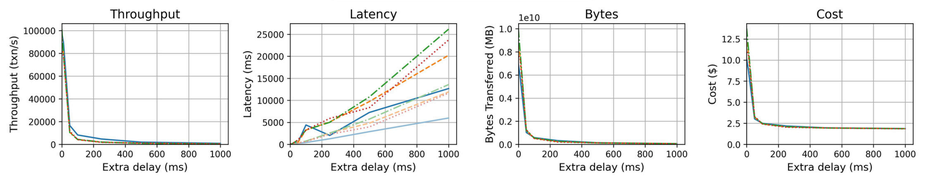


Figure 4: Comparison of results on the scalability scenario

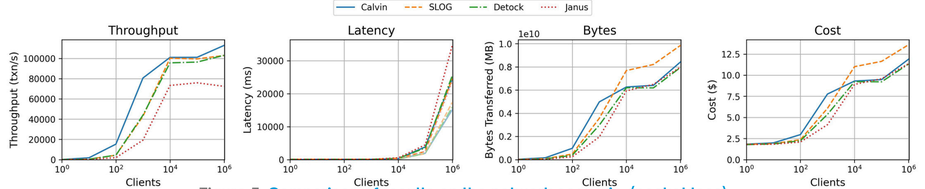


Figure 5: Comparison of results on the network scenario. (packet loss)

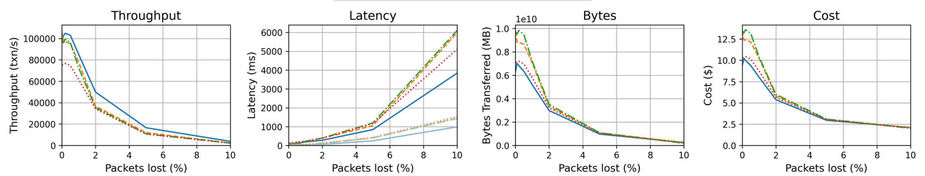


Figure 6: Comparison of results on the network scenario. (network delay)

Findings

Calvin

- Strongest performance at **high MH%**, highest throughput.
- But real-world MH% is usually low → Calvin falls behind **Detock** and **SLOG.**
- Cheaper than **Detock** and **SLOG.**

Detock

- Slightly outperforms **SLOG** in most cases.
- Graph-based concurrency control → excels under **high contention.**

Janus

- Consistently lowest throughput and highest latency.
- **Coordination round-trip** is a major bottleneck.

Other

- All systems perform similarly on **network latency, packet loss,** and **scalability tests.**

Discussion

Advantages

- Customizable Multi-Home and Multi-Partition Parameters
- Highlights Communication and Throughput Trade-offs
- Controlled Data Hotspot Generation

Limitations

- Dependent transactions
- Transaction Simplicity

Conclusion

Overall, the SmallBank benchmark shows that Detock and SLOG perform best, having high throughput and low latency. In contrast, Calvin proves more effective in environments with a high proportion of multi-home transactions and shows a lower cost of operation. In contrast, Janus shows the weakest performance across all scenarios.

References

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