Overview of Concurrency in L-Store: 2VCC - Two-version Concurrency Control

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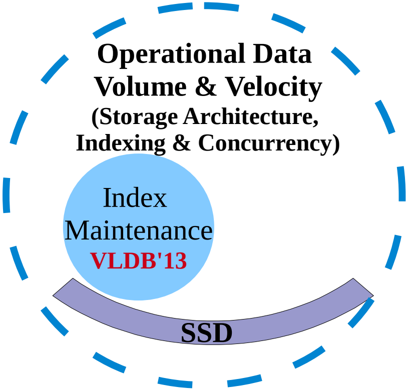
ECS165a - Winter 2023

Extending Storage Hierarchy with Indirection Layer



Reducing Index maintenance: Velocity Dimension

Observed Trends

In the absence of in-place updates in operational multi-version databases, the cost of index maintenance becomes a major obstacle to cope with data velocity.

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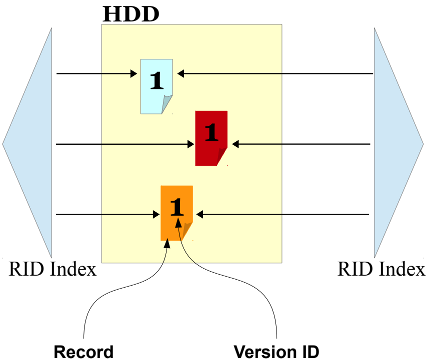
Decouple Logical and Physical Locations of Records to Reduce Index Maintenance

Traditional Multi-version Indexing: Updating Records



Updating random leaf pages

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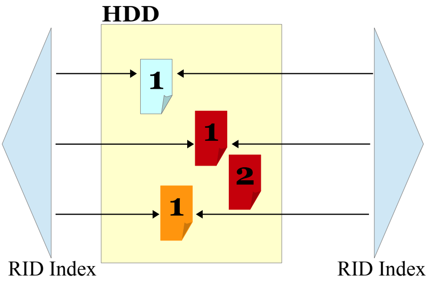

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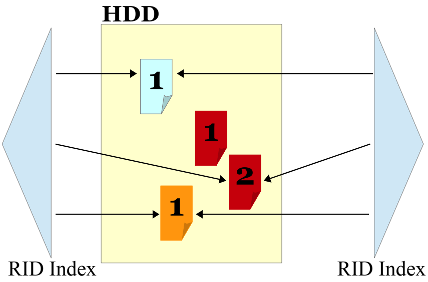

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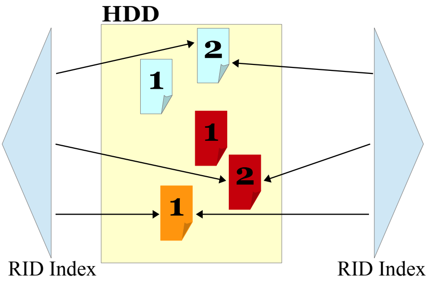

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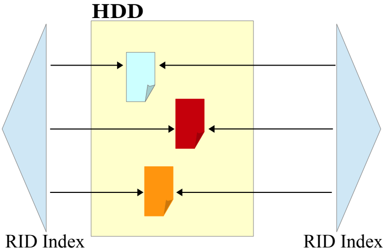

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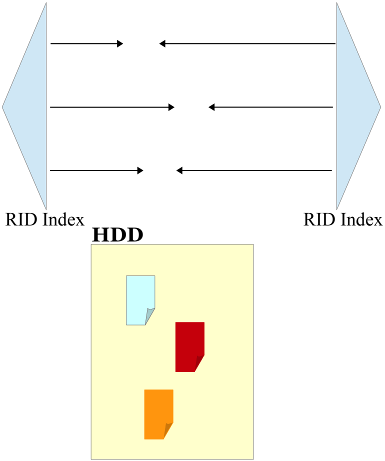

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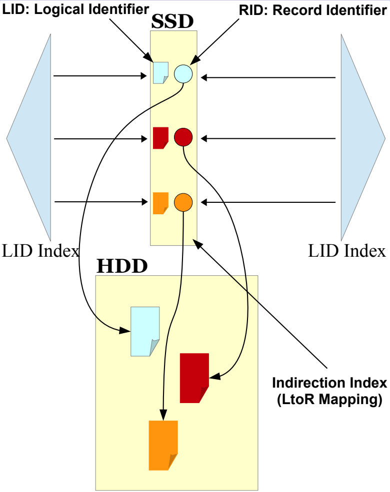

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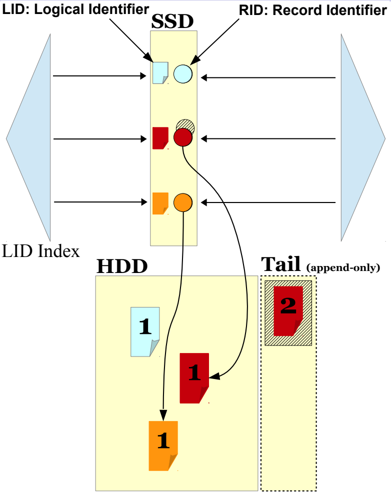

Eliminating random leaf-page updates

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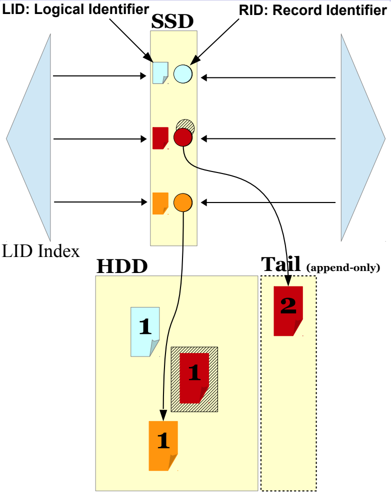

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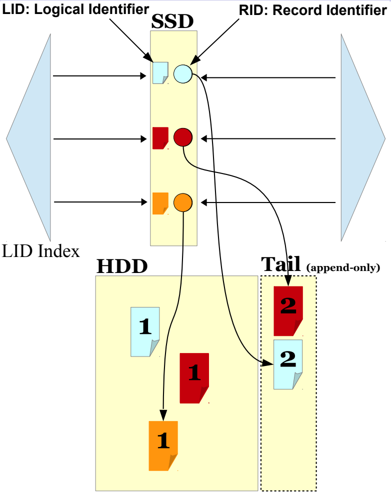


Eliminating random leaf-page updates

Analytical & Experimental Evaluations

Indirection Time Complexity Analysis

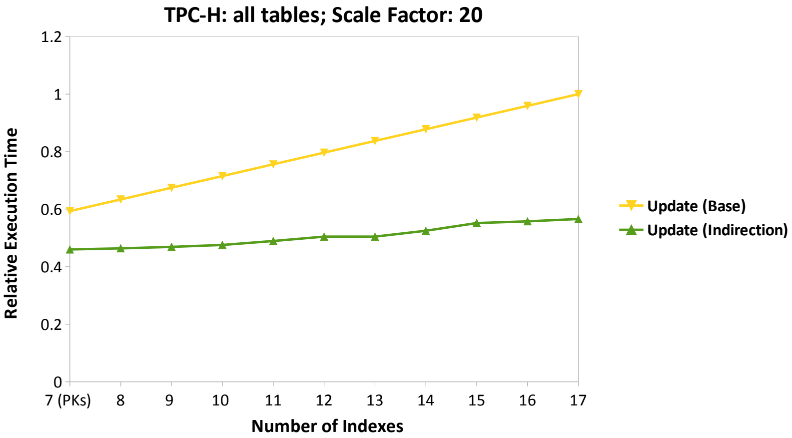
	Legend
K	Number of indexes
LB	LIDBlock size
M	Number of matching records

Method	Type	Imm. SSD	Def. SSD	Imm. HDD	Def. HDD
Base	Deletion	0	0	$2+K$	$\leq 1+K$
	Single-attr. update	**0**	**0**	$3+\mathrm{K}$	$\leq 2+\mathrm{K}$
	Insertion	0	0	$1+K$	$\leq 1+K$
	Search Uniq.	0	0	2	0
	Search Mult.	0	0	$1+M$	0
Indirection	Deletion	2	0	2	≤ 3
	Single-attr. update	**2**	**0**	**4**	≤ 3
	Insertion	$2+2K$	$2K/LB$	1	$\leq 1+2K/LB$
	Search Uniq.	2	0	2	0
	Search Mult.	$1+M$	0	$1+M$	0

Experimental Setting

- Hardware:
  - (2 × 8-core) Intel(R) Xeon(R) CPU E7-4820 @ 2.00GHz, 32GB, 2 × HDD, SSD Fusion-io
- Software:
  - Database: IBM DB2 9.7
  - Prototyped in a commercial proprietary database
  - Prototyped in Apache Spark by UC Berkeley
  - LIBGist v.1.0: Generalized Search Tree C++ Library by UC Berkeley (**5K LOC**) (Predecessor of Generalized Search Tree (GiST) access method for PostgreSQL)
  - **LIBGist^{mv} Prototype:** Multi-version Generalized Search Tree C++ Library over LIBGist supporting Indirection/LIDBlock/DeltaBlock (**3K LOC**)
- Data:
  - TPC-H benchmark
  - Microsoft Hekaton micro benchmark

Indirection: Effect of Indexes in Operational Data Stores



Substantially improving the update time ...

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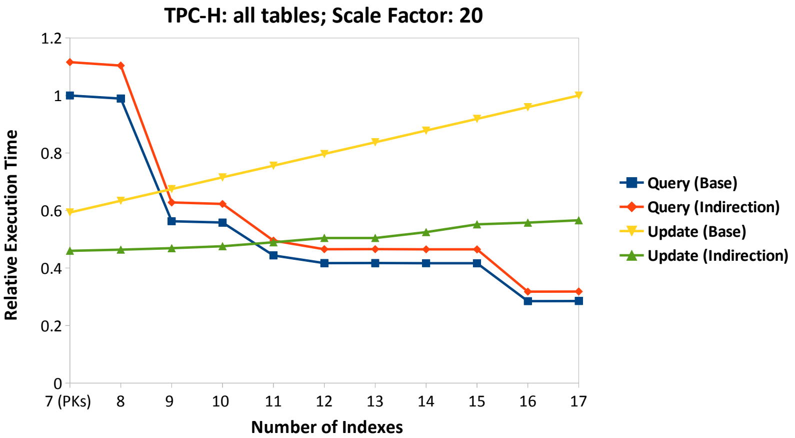
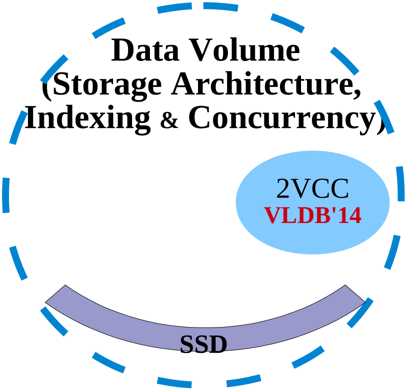


... Consequently affording more indexes and significantly reducing the query time

1. Data Velocity: Index Maintenance
2. Data Volume: MVCC Concurrency
3. Decentralized & Democratic Data Platform
4. References

Introducing Multi-version Concurrency Control



Generalized Concurrency Control: Volume Dimension

Observed Trends

In operational multi-version databases, there is a tremendous opportunity to avoid clashes between readers (scanning a large volume of data) and writers (frequent updates).

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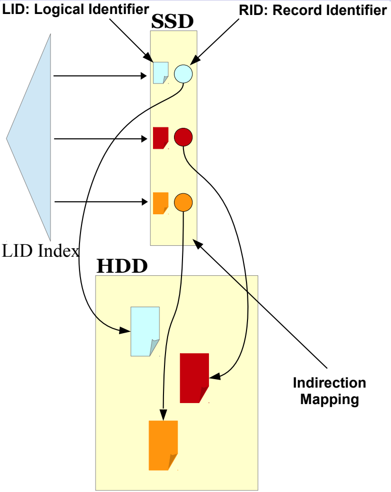
Decouple Readers/Writers to Reduce Contention

(Pessimistic and Optimistic Concurrency Control Coexistence)

2V-Indirection Indexing: Updating Records



Recap: Indirection technique for reducing index maintenance

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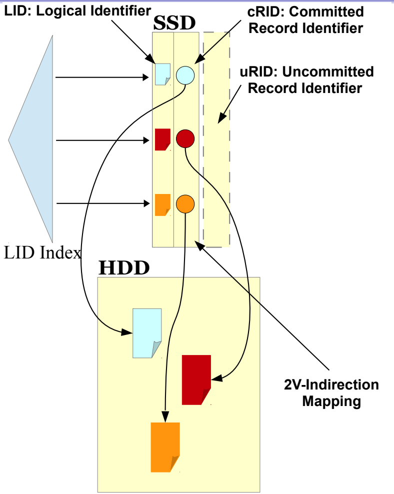

Extending the indirection to committed/uncommitted records

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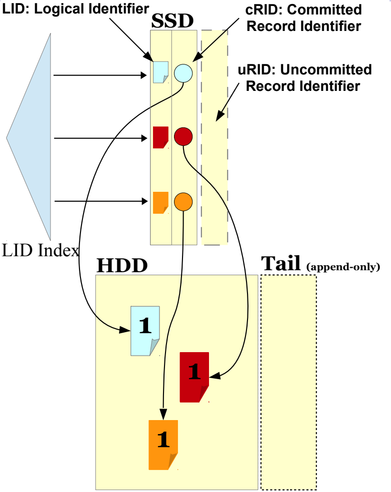

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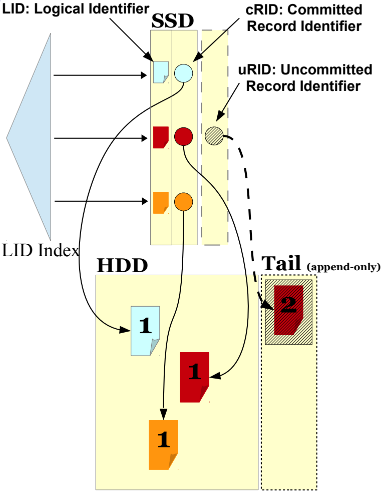

Decoupling readers/writers to eliminate contention

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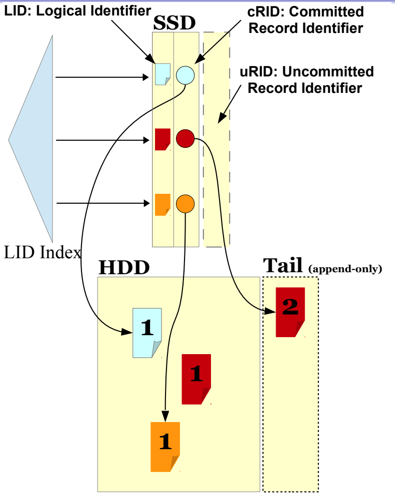

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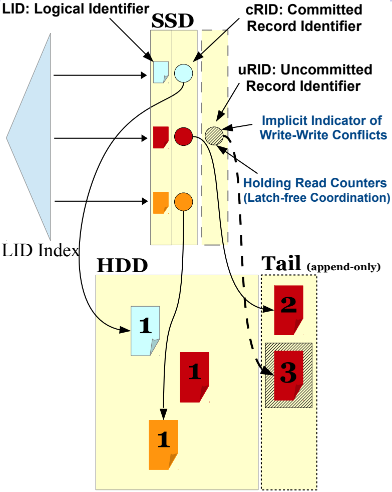

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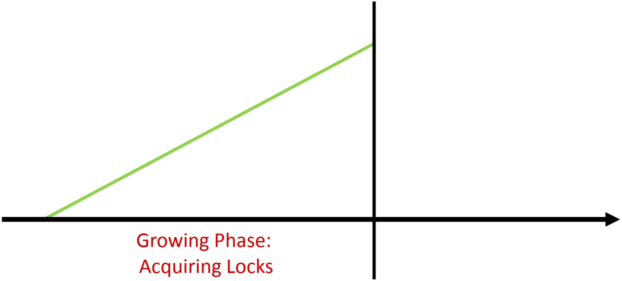
Overview of Two-version Concurrency Control Protocol



Two-phase locking (2PL) consisting of growing and shrinking phases

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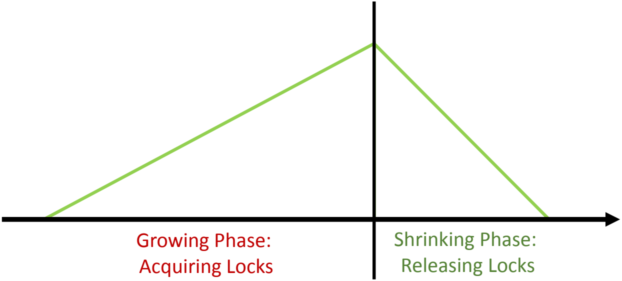

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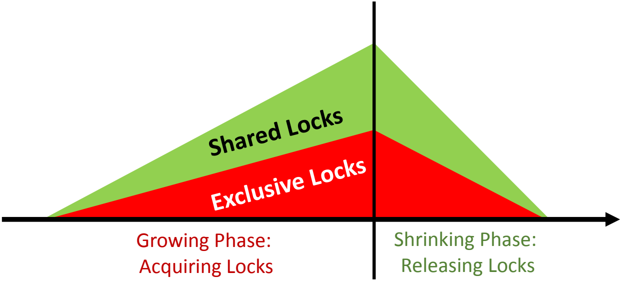

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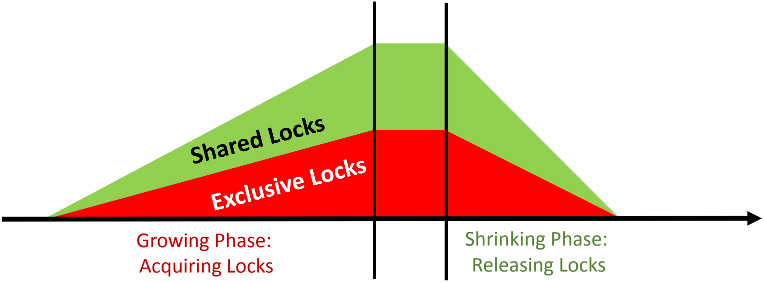

Extending 2PL with certify phase

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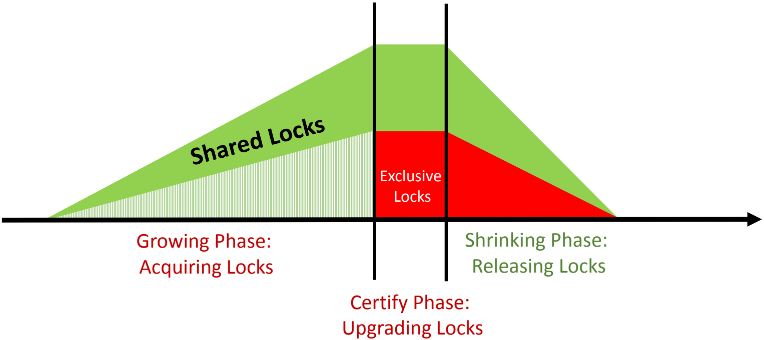

Exclusive locks held for shorter period (inherently optimistic)

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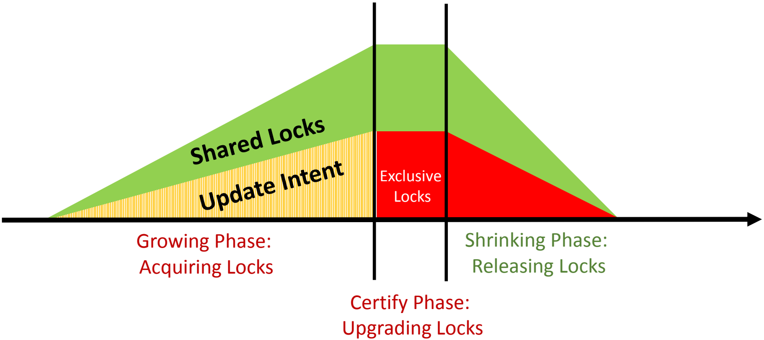

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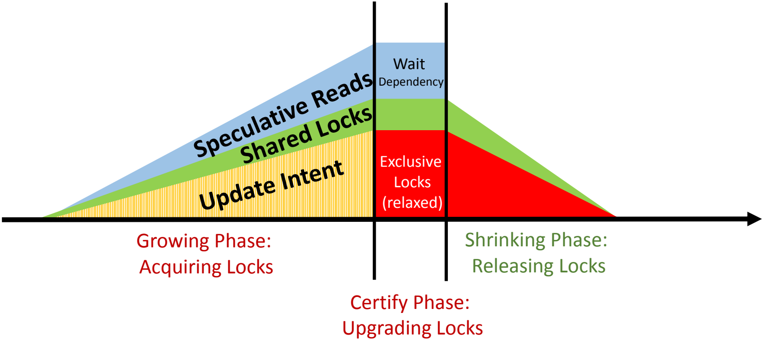

Relaxed exclusive locks to allow speculative reads (increased optimism)

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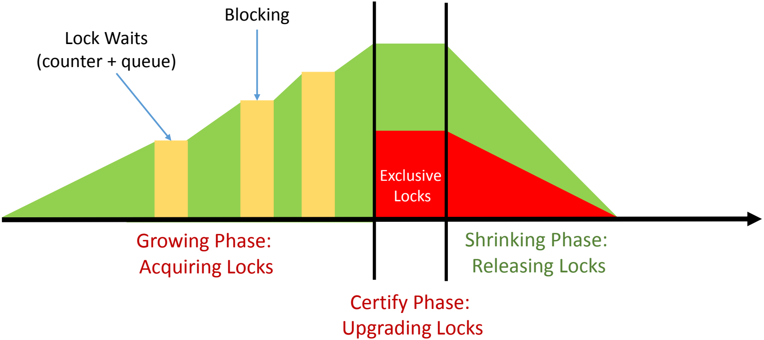
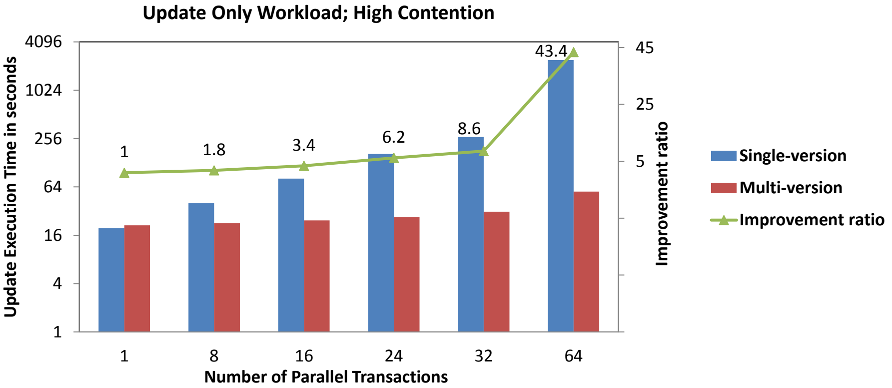


Trade-offs between blocking (i.e., locks) vs. non-blocking (i.e., read counters)

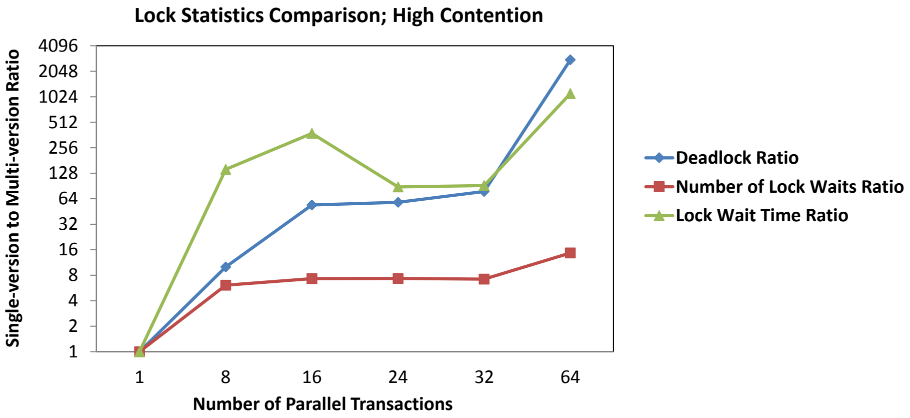
Experimental Analysis

2VCC: Effect of Parallel Update Transactions



Substantial gain by reducing the read/write contention & using non-blocking operations

2VCC: Effect of Parallel Update Transactions



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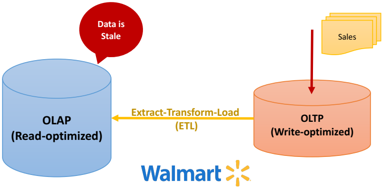
Recap: Data Management Challenges at Microscale

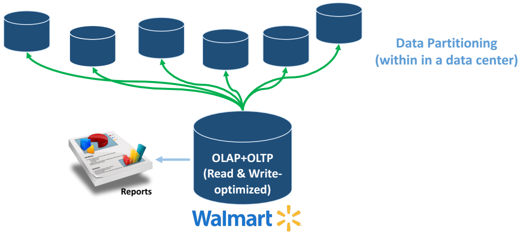


OLTP and OLAP data are isolated at microscale

Recap: Data Management Challenges at Microscale

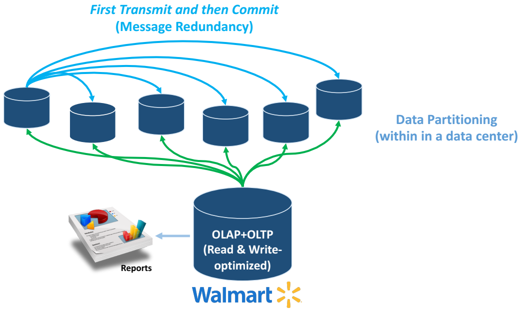
First step is to unify OLTP and OLAP

Platform Scaling: Data Partitioning



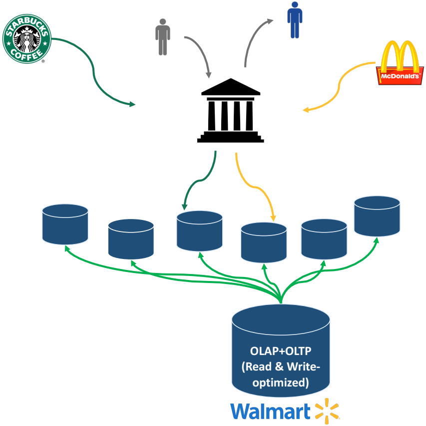
Moving towards distributed environment

Platform Scaling: Non-blocking Agreement Protocols



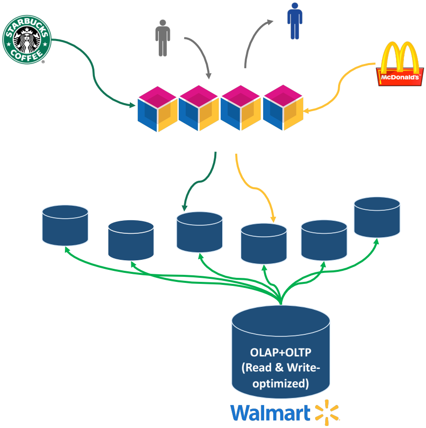
Message redundancy vs. latency trade-offs [EasyCommit, EDBT'18]

Central Control: Data Gate Keeper



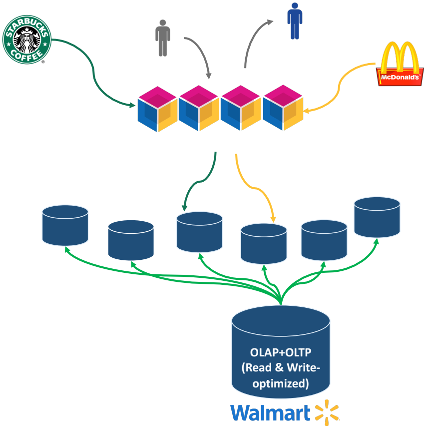
Conform to trusting the central authority and governance

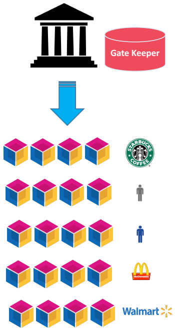
Decentralized Control: Removing Data Barrier



Seek trust in *decentralized* and *democratic* governance [PoE (EDBT'21), RCC (ICDE'21)]

Democratic Control: Removing Trust Barrier





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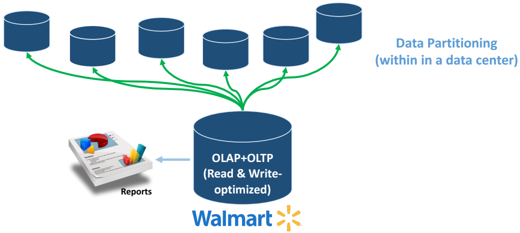
Global-scale Reliable Platform over Unreliable Hardware



Self-managed infrastructure

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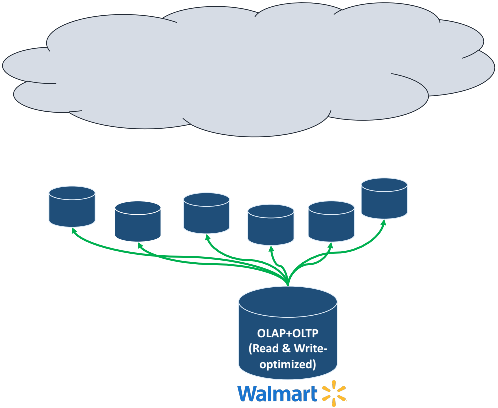

Cloud-managed infrastructure (trust the provider)

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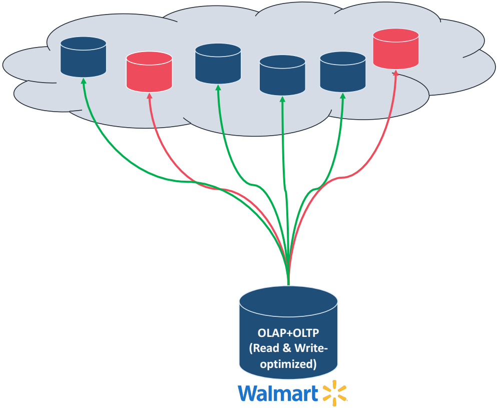

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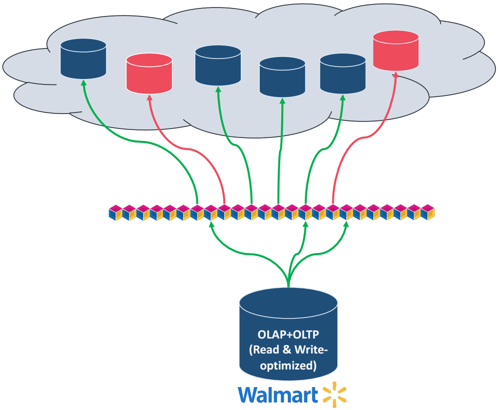

Light-weight, fault-tolerant, trusted middleware [Blockplane, (ICDE'18)]

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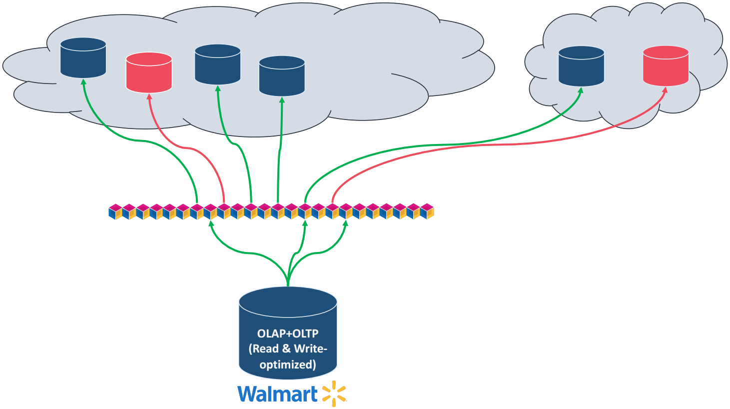

Global Scale fault-tolerant protocols [GeoBFT (VLDB'20), Delayed Replication (ICDT'20)]

Questions?

Thank you!

Exploratory Systems Lab (ExpoLab)
Website: https://expolab.org/

ExpoLab Creativity Unfolded

ResilientDB Security, Privacy Reloaded

Related Publications (Patents Omitted)

- I. Abdelaziz, A. Fokoue, O. Hassanzadeh, P. Zhang, M. Sadoghi.
  Large-scale structural and textual similarity-based mining of knowledge graph to predict drug-drug interactions.
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