# L-Store: A Real-time OLTP and OLAP System

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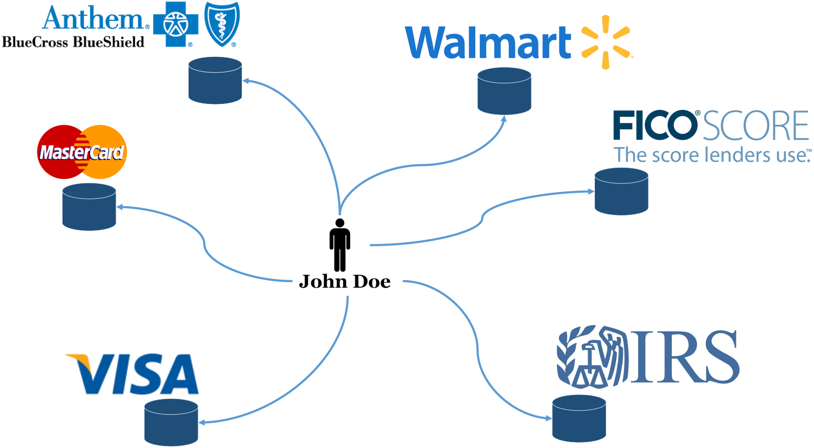
# Data Management at Macroscale: The Four V's of Big Data



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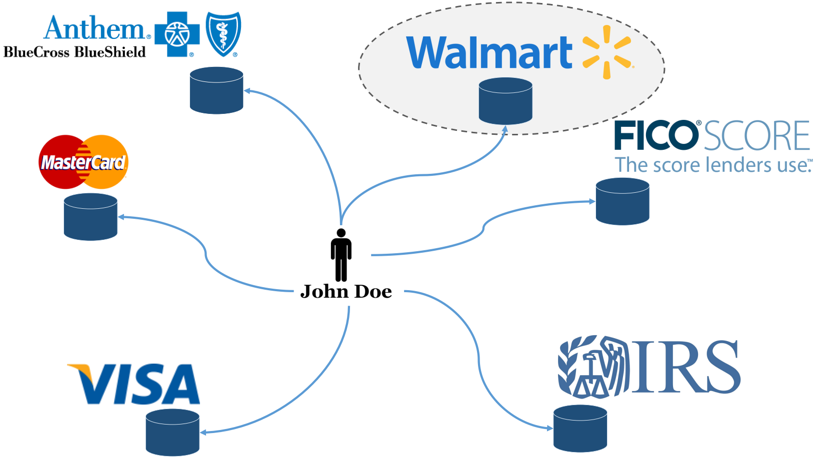
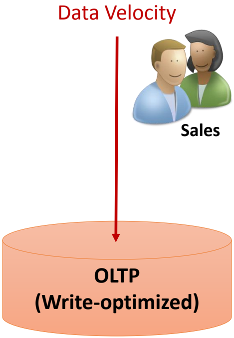


# Data Management at Microscale: Volume & Velocity




Walmart

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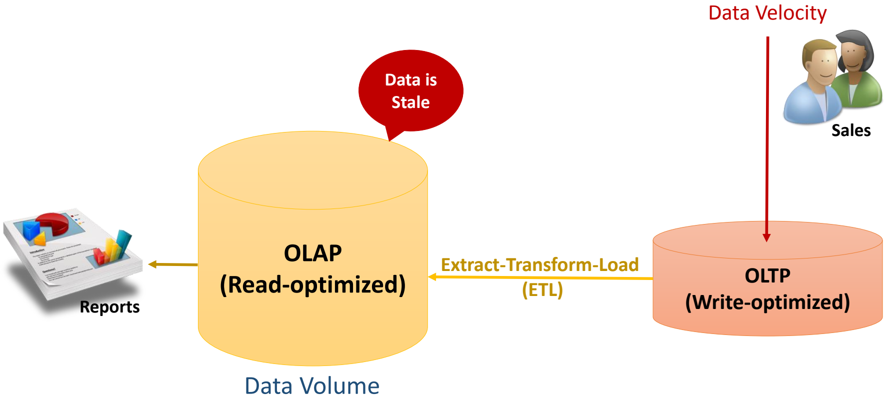

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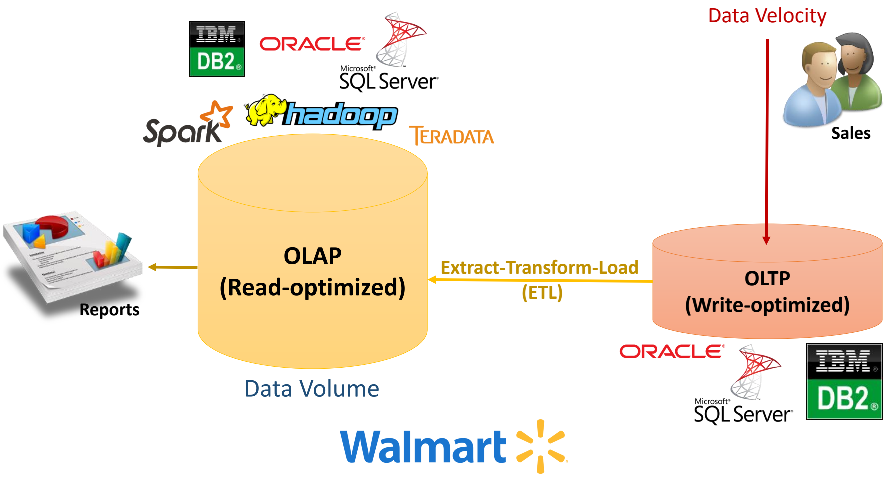
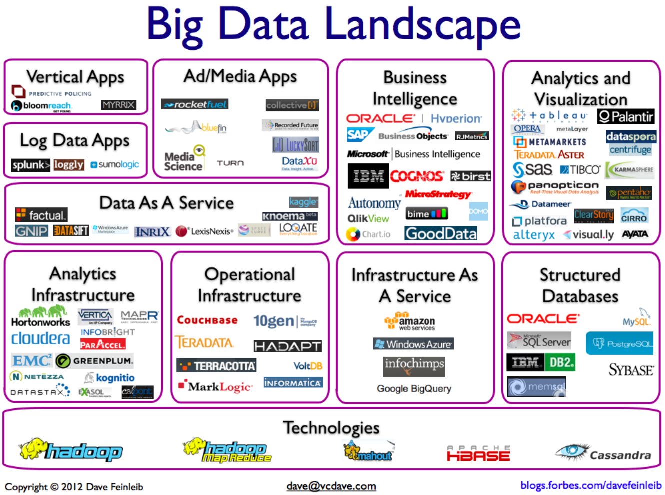


# One Size Does not Fit All As of 2012



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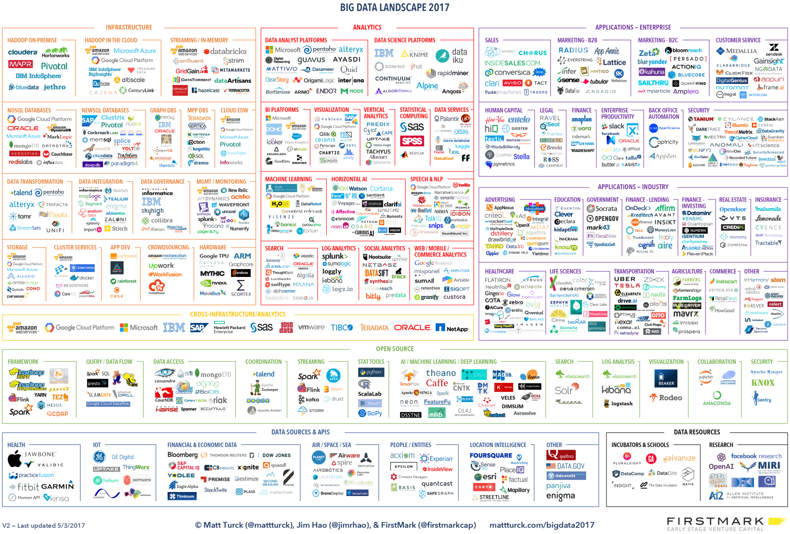

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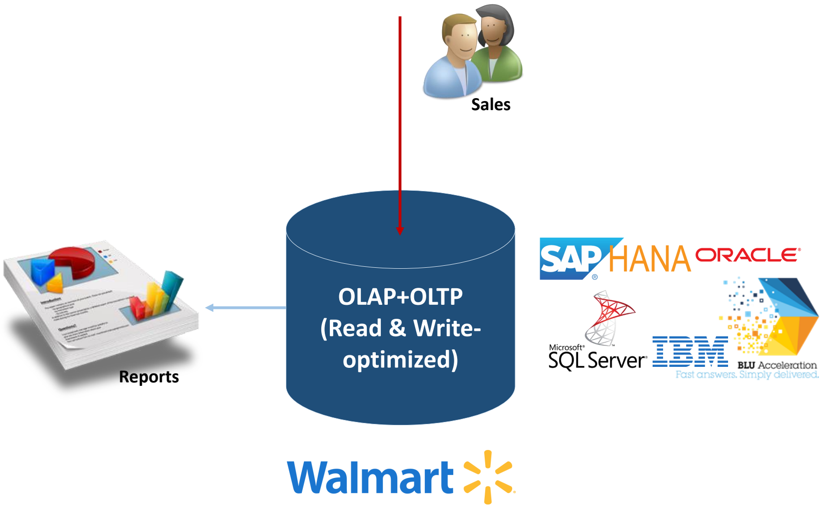
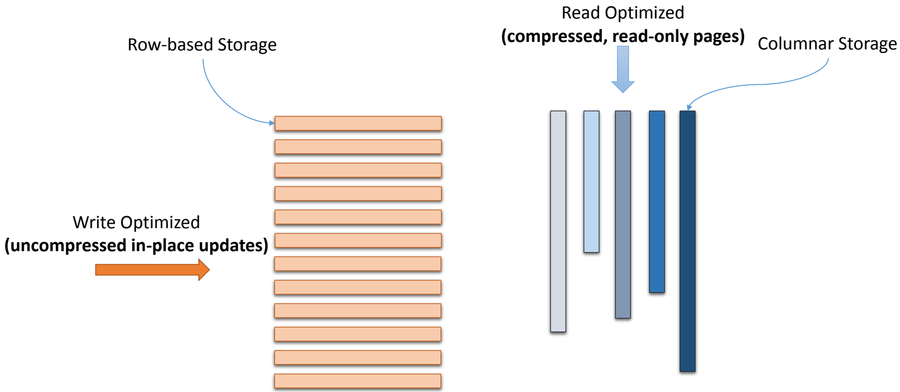


# Storage Layout Conflict




Write-optimized (i.e., uncompressed & row-based) vs. read-optimized (i.e., compressed & column-based) layouts

# Unifying OLTP and OLAP: Velocity & Volume Dimensions

## Observed Trends

In operational databases, there is a pressing need to close the gap between the write-optimized layout for OLTP (i.e., row-wise) and the read-optimized layout for OLAP (i.e., column-wise).

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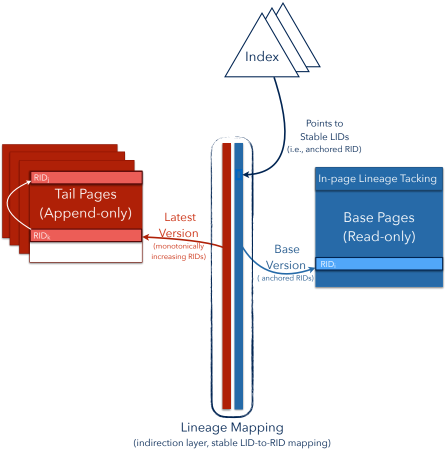
Introducing a *lineage-based storage architecture*, a contention-free update mechanism over a native columnar storage in order to

lazily and independently stage stable data from a write-optimized layout (i.e., OLTP) into a read-optimized layout (i.e., OLAP)

# Lineage-based Storage Architecture (LSA): Intuition




Physical Update Independence: De-coupling data & its updates
(reconstruction via in-page lineage tracking and lineage mapping)

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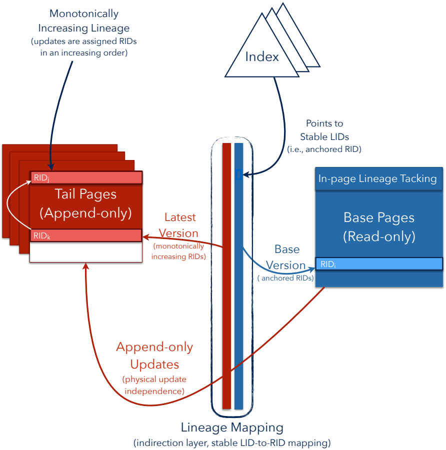


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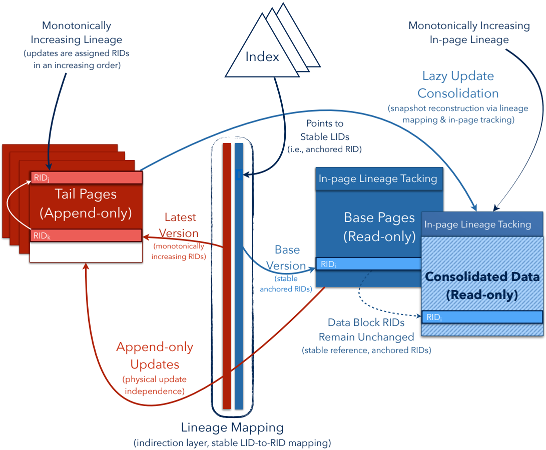


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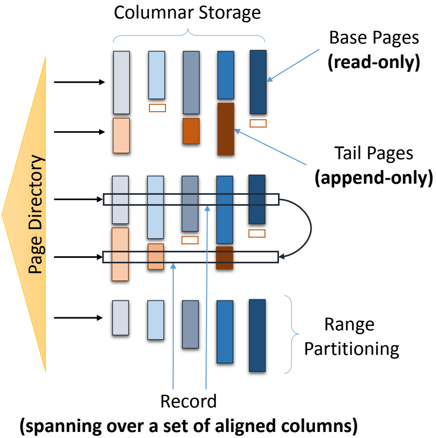
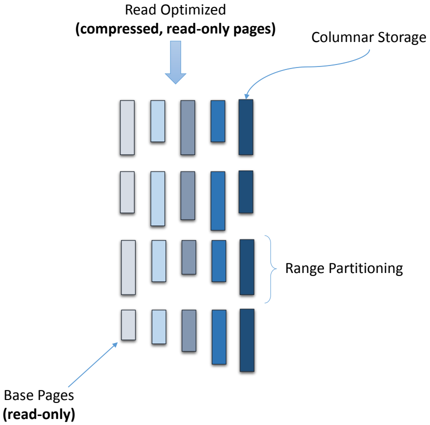
# Lineage-based Storage Architecture (LSA): Overview




Overview of the lineage-based storage architecture
(**base pages** and **tail pages** are handled identically at the storage layer)

# L-Store: Detailed Design




Records are range-partitioned and compressed into a set of ready-only **base pages** (accelerating analytical queries)

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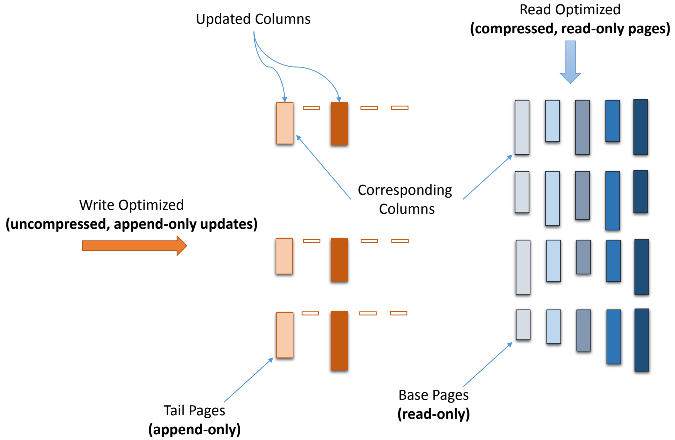


Recent updates for a range of records are clustered in their **tails pages** (transforming costly point updates into an amortized analytical-like query)

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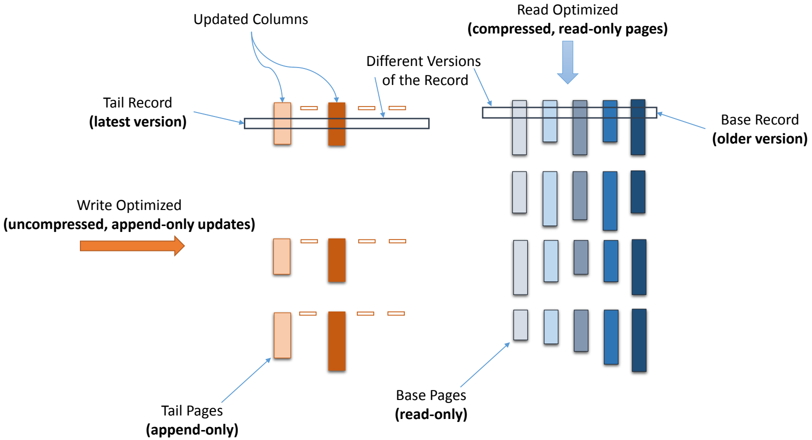


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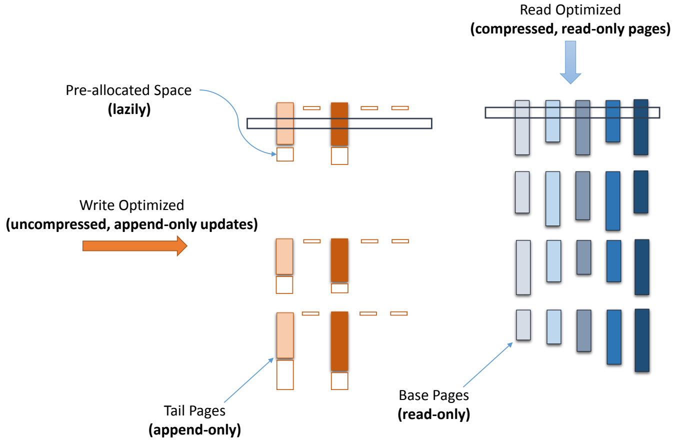


Recent updates are strictly appended, uncompressed in the pre-allocated space (eliminating the read/write contention)

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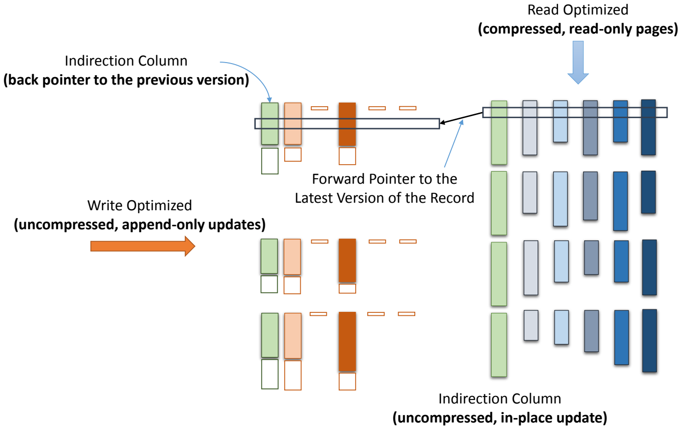


Achieving (at most) 2-hop access to the latest version of any record (avoiding read performance deterioration for point queries)

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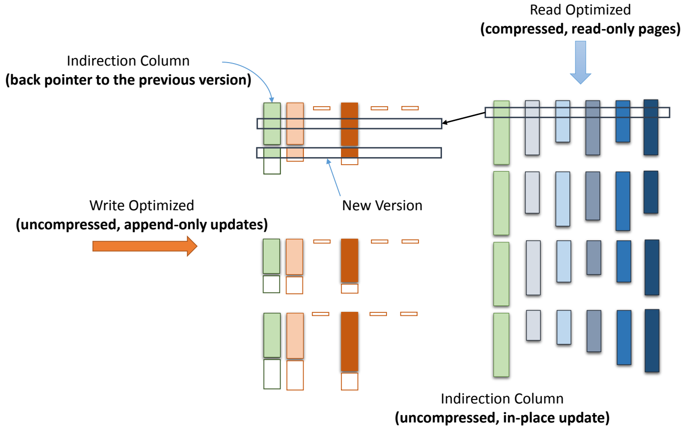


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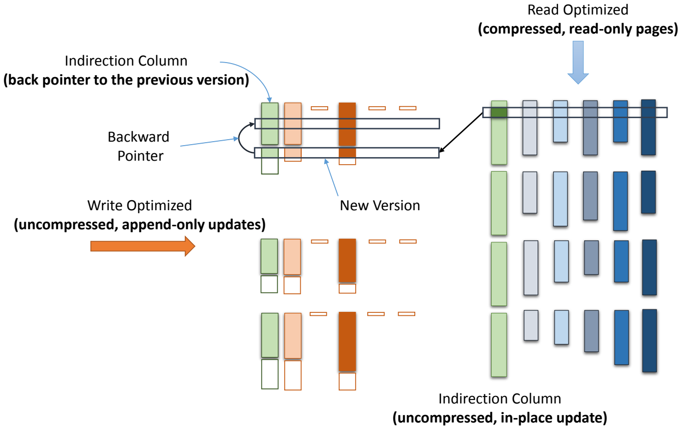


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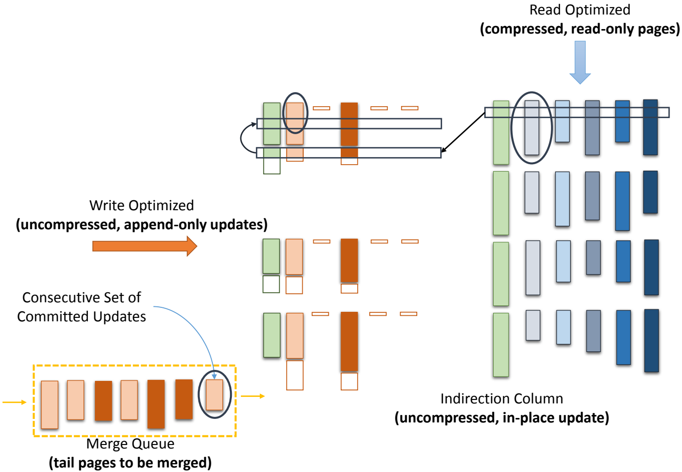
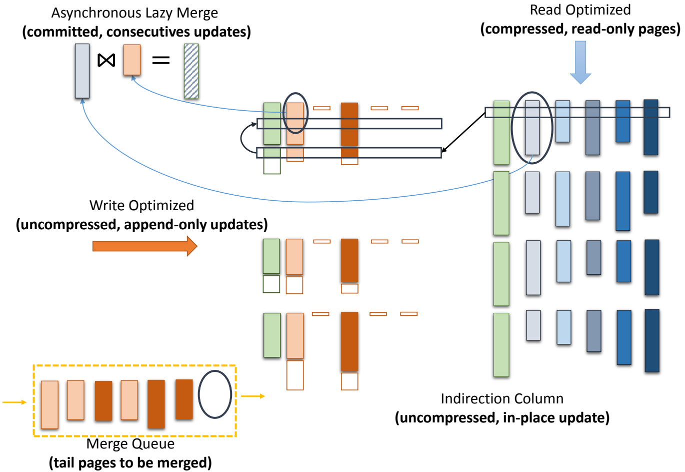
# L-Store: Contention-free Merge



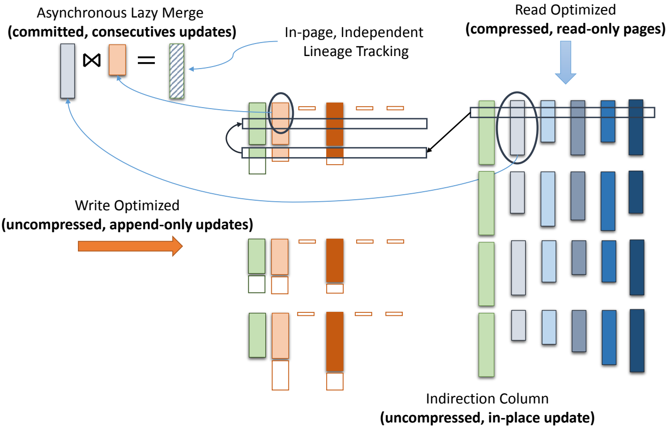

Contention-free merging of only stable data: read-only and committed data (no need to block on-going and new transactions)

# L-Store: Contention-free Merge



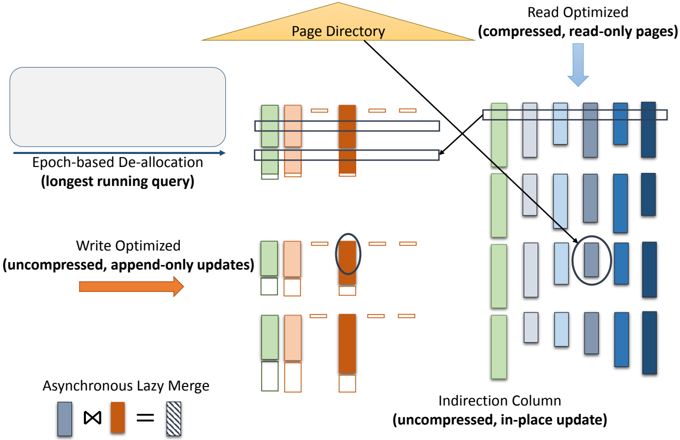

Lazy independent merging of **base pages** with their corresponding **tail pages** (resembling a local left outer-join of the base and tail pages)

# L-Store: Contention-free Merge




Independently tracking the lineage information within every page
(no need to coordinate merges among different columns of the same records)

# L-Store: Epoch-based Contention-free De-allocation




Contention-free page de-allocation using an epoch-based approach
(no need to drain the ongoing transactions)

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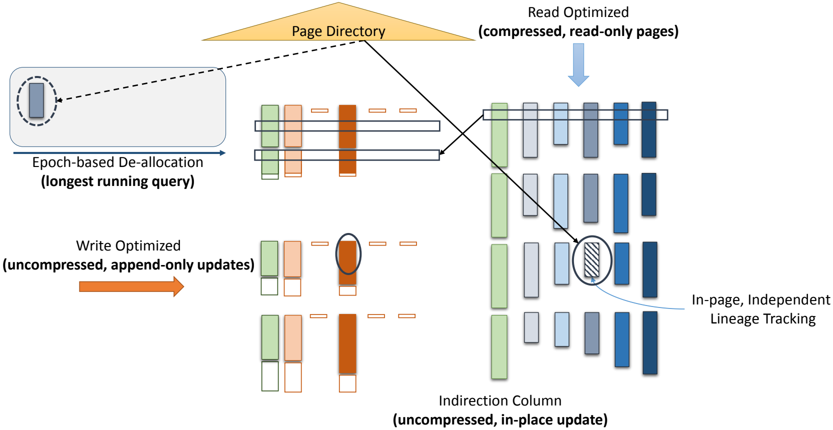


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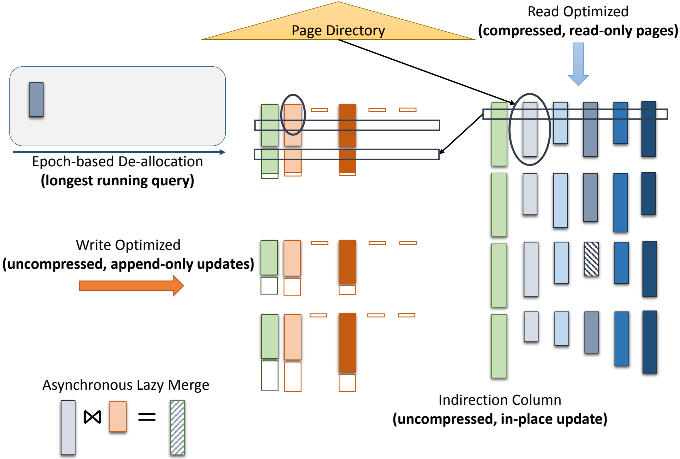


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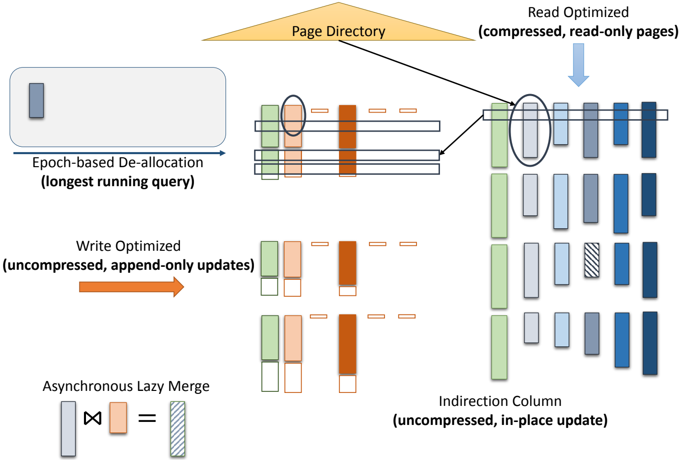


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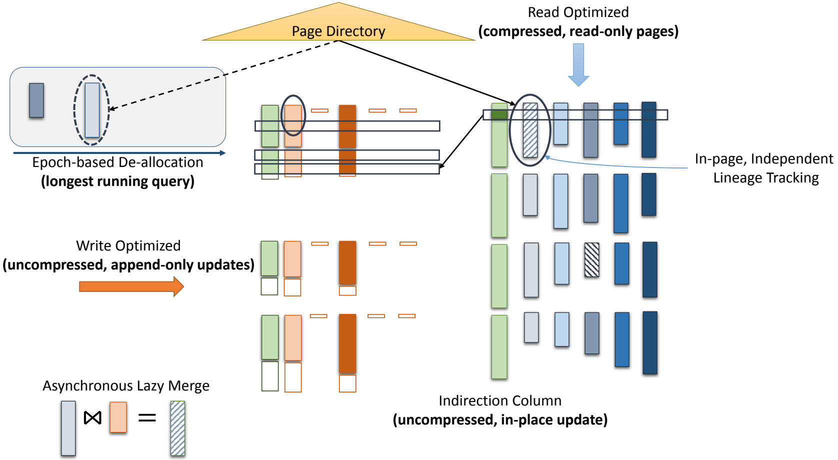


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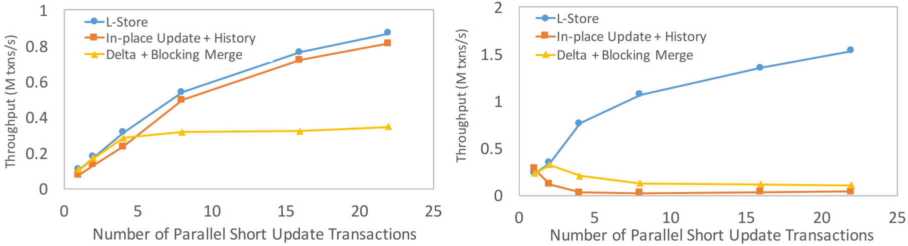
# Experimental Analysis

# Experimental Settings

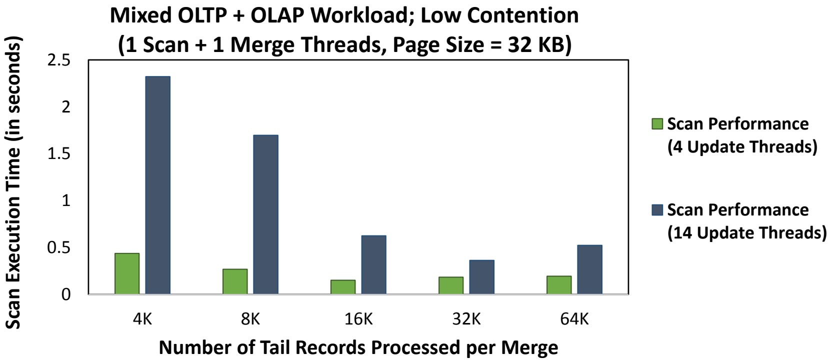
- Hardware:
  - 2 × 6-core Intel(R) Xeon(R) CPU E5-2430 @ 2.20GHz, 64GB, 15 MB L3 cache
- Workload: Extended Microsoft Hekaton Benchmark
  - Comparison with *In-place Update* + *History* and *Delta* + *Blocking Merge*
  - Effect of varying contention levels
  - Effect of varying the read/write ratio of short update transactions
  - Effect of merge frequency on scan
  - Effect of varying the number of short update vs. long read-only transactions
  - Effect of varying L-Store data layouts (row vs. columnar)
  - Effect of varying the percentage of columns read in point queries
  - Comparison with log-structured storage architecture (*LevelDB*)

# Effect of Varying Contention Levels



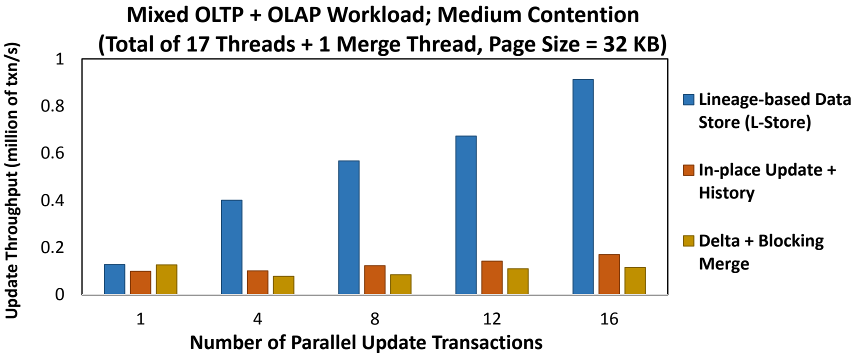

Achieving up to **40**$\times$ as increasing the update contention

# Effect of Merge Frequency on Scan Performance



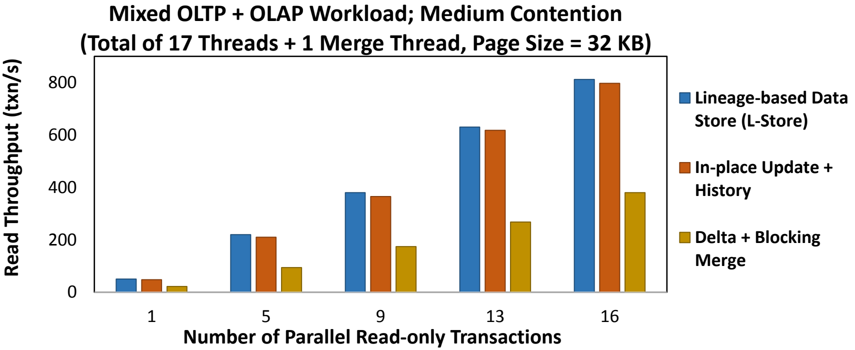

Merge process is essential in maintaining efficient scan performance

# Effect of Mixed Workloads: Update Performance




Eliminating latching & locking results in a substantial performance improvement

# Effect of Mixed Workloads: Read Performance




Coping with tens of update threads with a single merge thread

# L-Store Key Contributions

- Unifying OLAP & OLTP by introducing lineage-based storage architecture (LSA)
- LSA is a native multi-version, columnar storage model that lazily & independently stages data from a write-optimized layout into a read-optimized one
- Contention-free merging of only stable data without blocking ongoing or incoming transactions
- Contention-free page de-allocation without draining ongoing transactions
- L-Store outperforms in-place update & delta approaches by factor of up to **8**$\times$ on mixed OLTP/OLAP workloads and up to **40**$\times$ on update-intensive workloads

Questions?

**Thank you!**

Exploratory Systems Lab (ExpoLab)

Website: https://msadoghi.github.io/