NVRAM-aware Logging in Transaction Systems

Jian Huang

Karsten Schwan Moinuddin K. Qureshi

Logging Support for Transactions

Logging Support for Transactions

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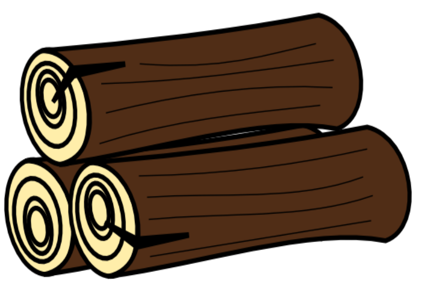
ATOMICITY CONSISTENCY ISOLATION DURABILITY

ARIES: Disk-Based Approach (TODS'92)



Write-ahead Logging

Logging Support for Transactions

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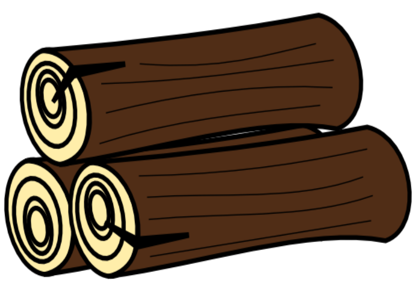

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Write-ahead Logging

Rollback

Logging Support for Transactions

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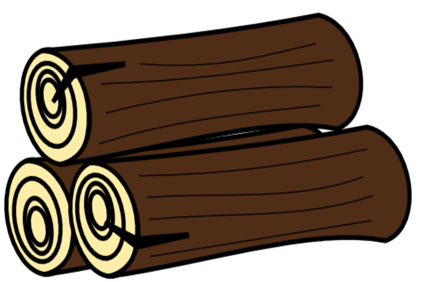

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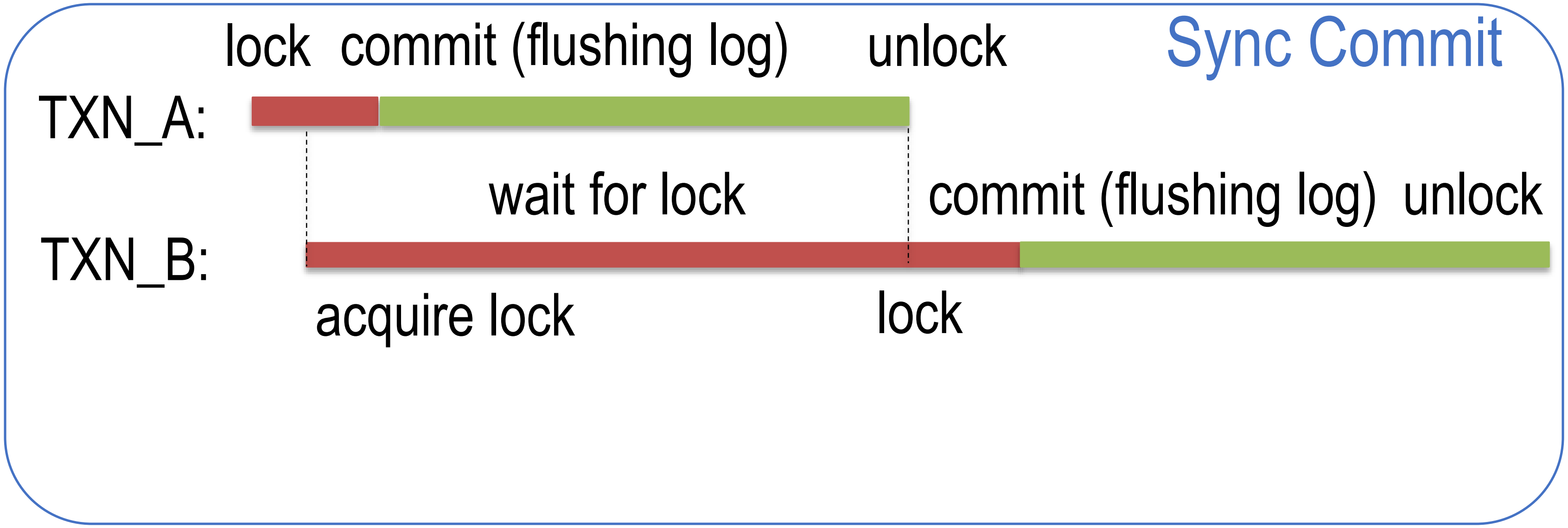
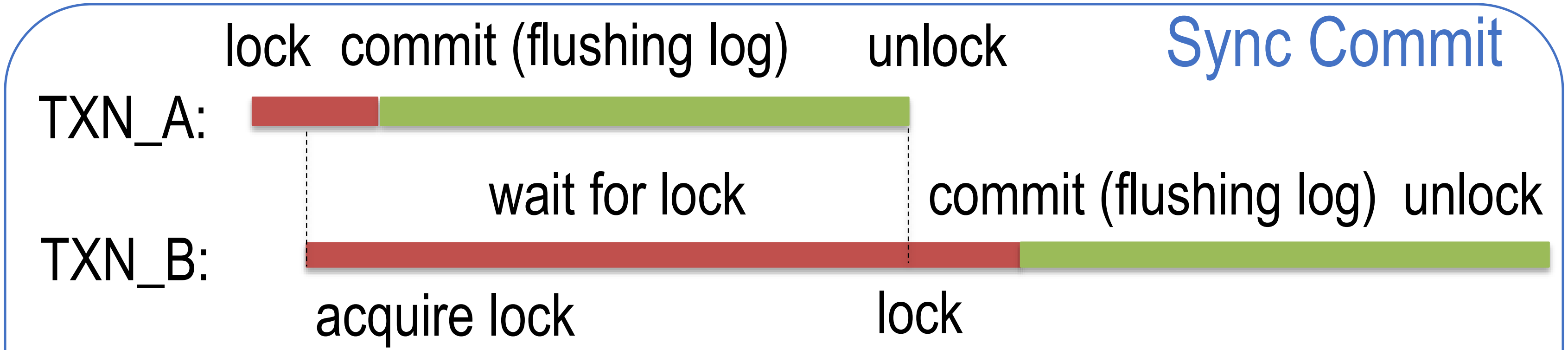
Write-ahead Logging | Rollback | Centralized Log Buffer

On the Logging Persistence

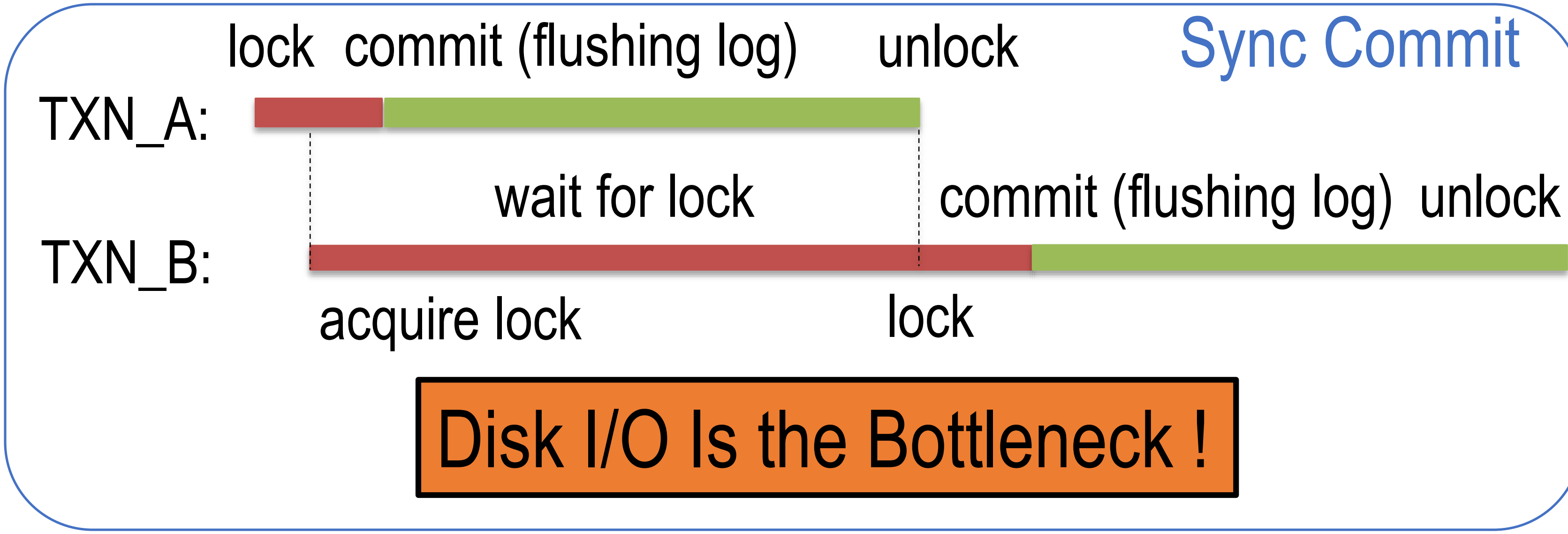


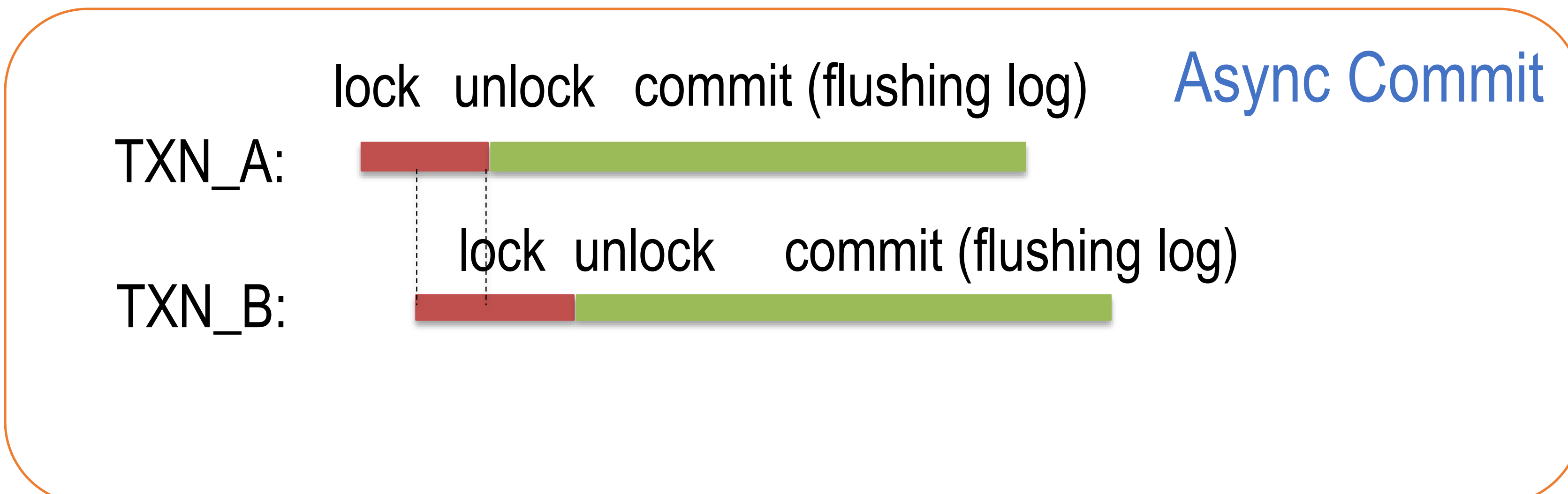
On the Logging Persistence



Disk I/O Is the Bottleneck !

On the Logging Persistence





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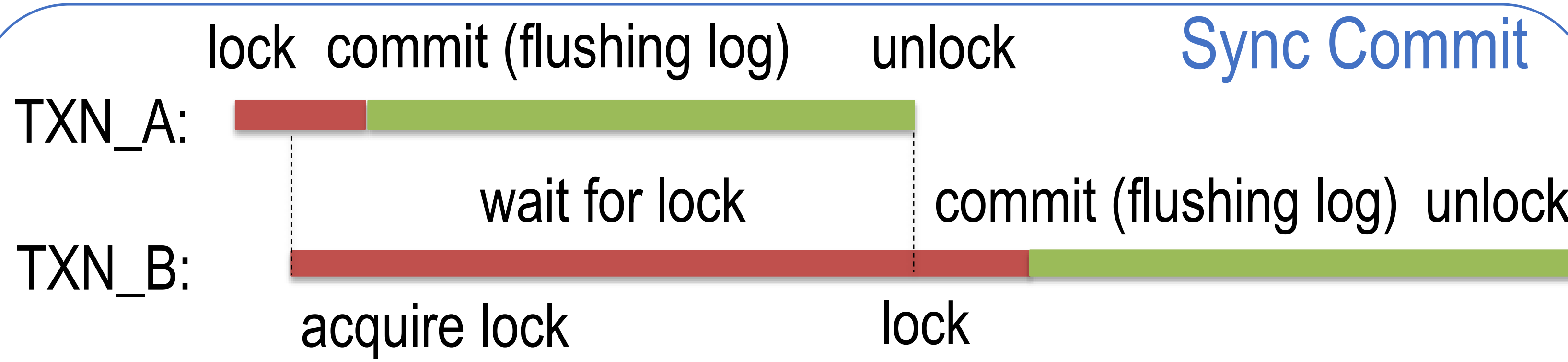

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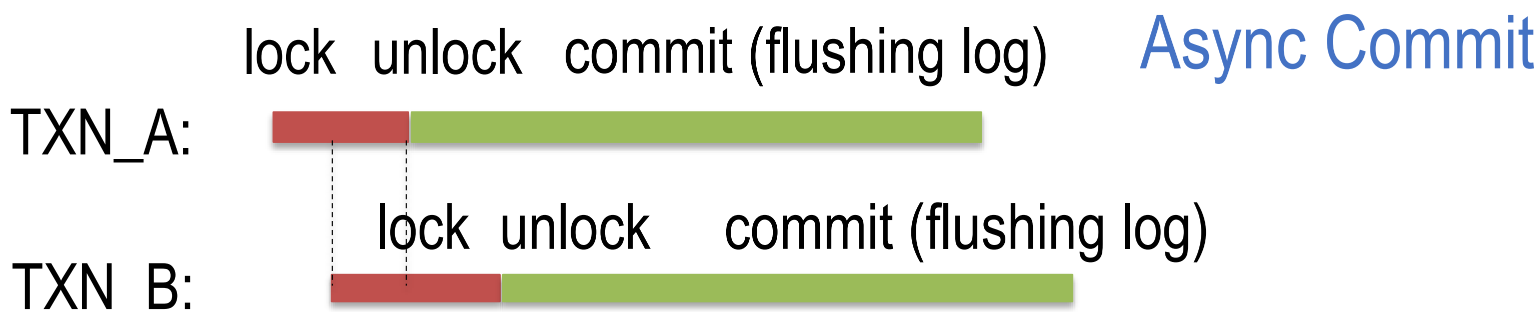


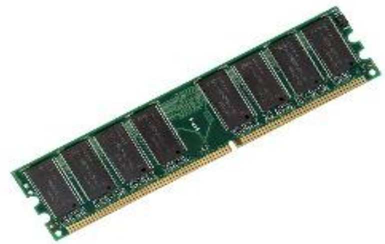
At the risk of partial data loss and incorrect result !

Rethink the Logging with NVRAM

Close to DRAM

Rethink the Logging with NVRAM

+



Close to DRAM

Byte Addressability

Rethink the Logging with NVRAM

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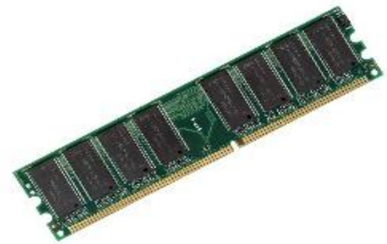

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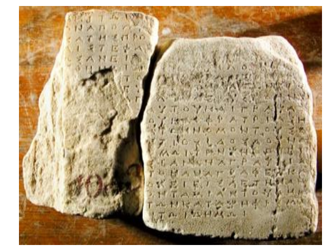
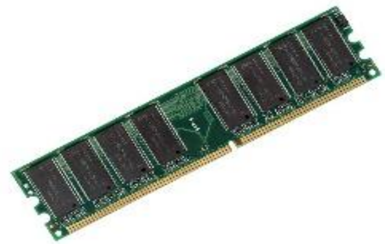


Close to DRAM

Byte Addressability

Non-Volatility

Rethink the Logging with NVRAM

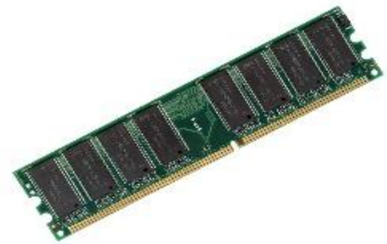


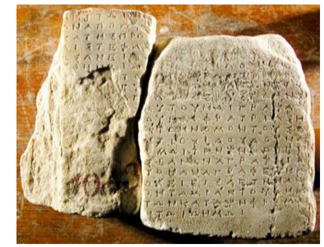
Close to DRAM + Byte Addressability + Non-Volatility

Disk-based logging

- Avoid frequent disk access
- Obtain sequential access pattern

Rethink the Logging with NVRAM





Close to DRAM + Byte Addressability + Non-Volatility

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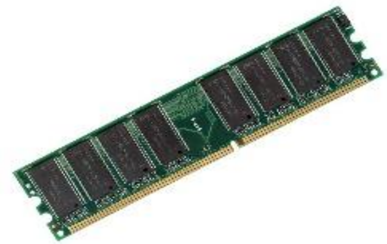
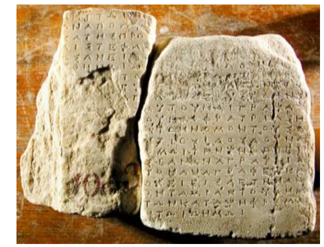
Flash-based logging

- Reduce log flushing time
- Atomic Write (OSDI'08)

Rethink the Logging with NVRAM

 +  + 

Close to DRAM | Byte Addressability | Non-Volatility

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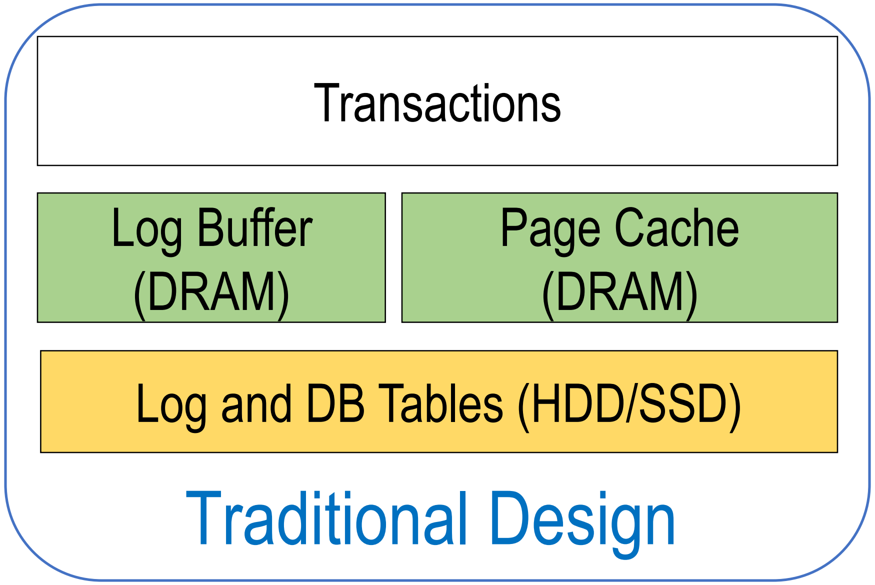
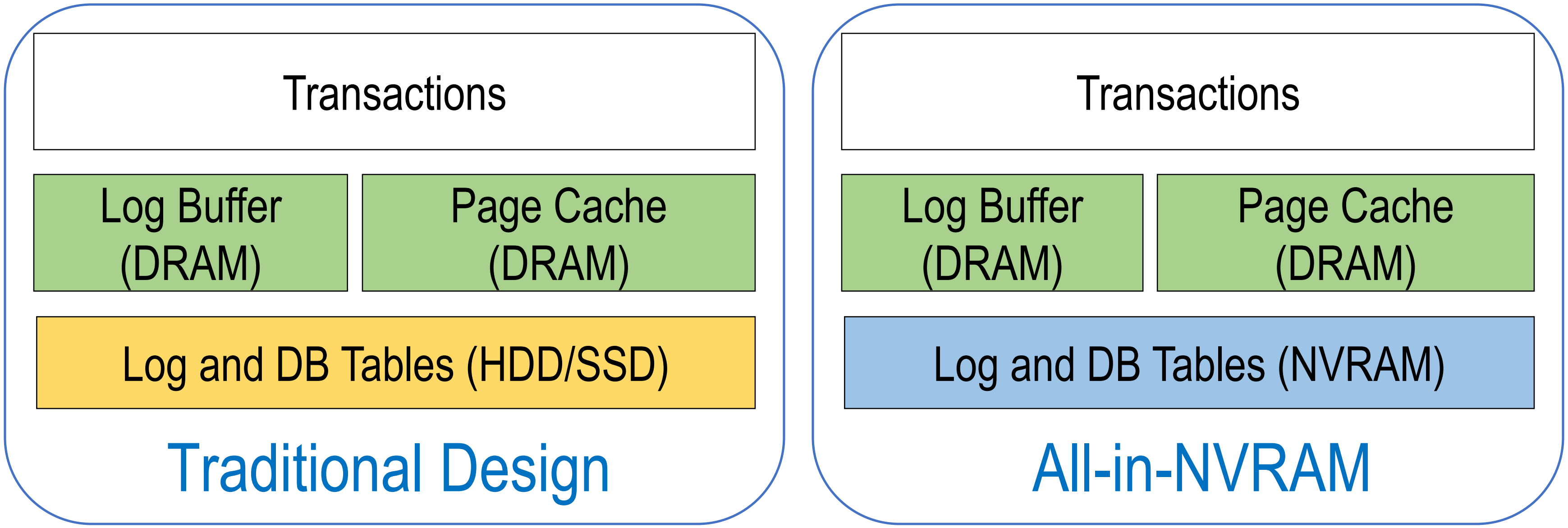
NVRAM-based

How to Use NVRAM in DB System?



How to Use NVRAM in DB System?



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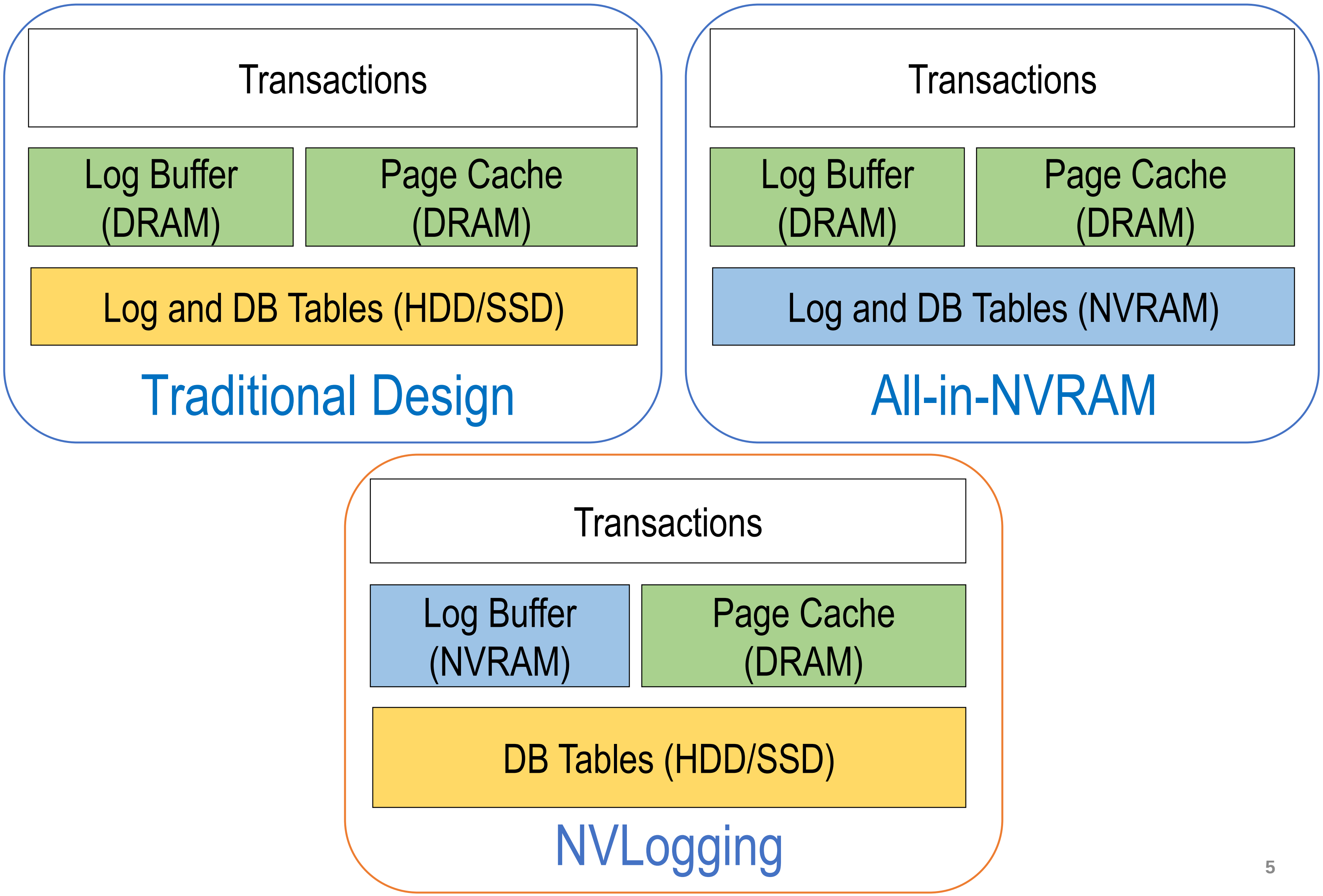

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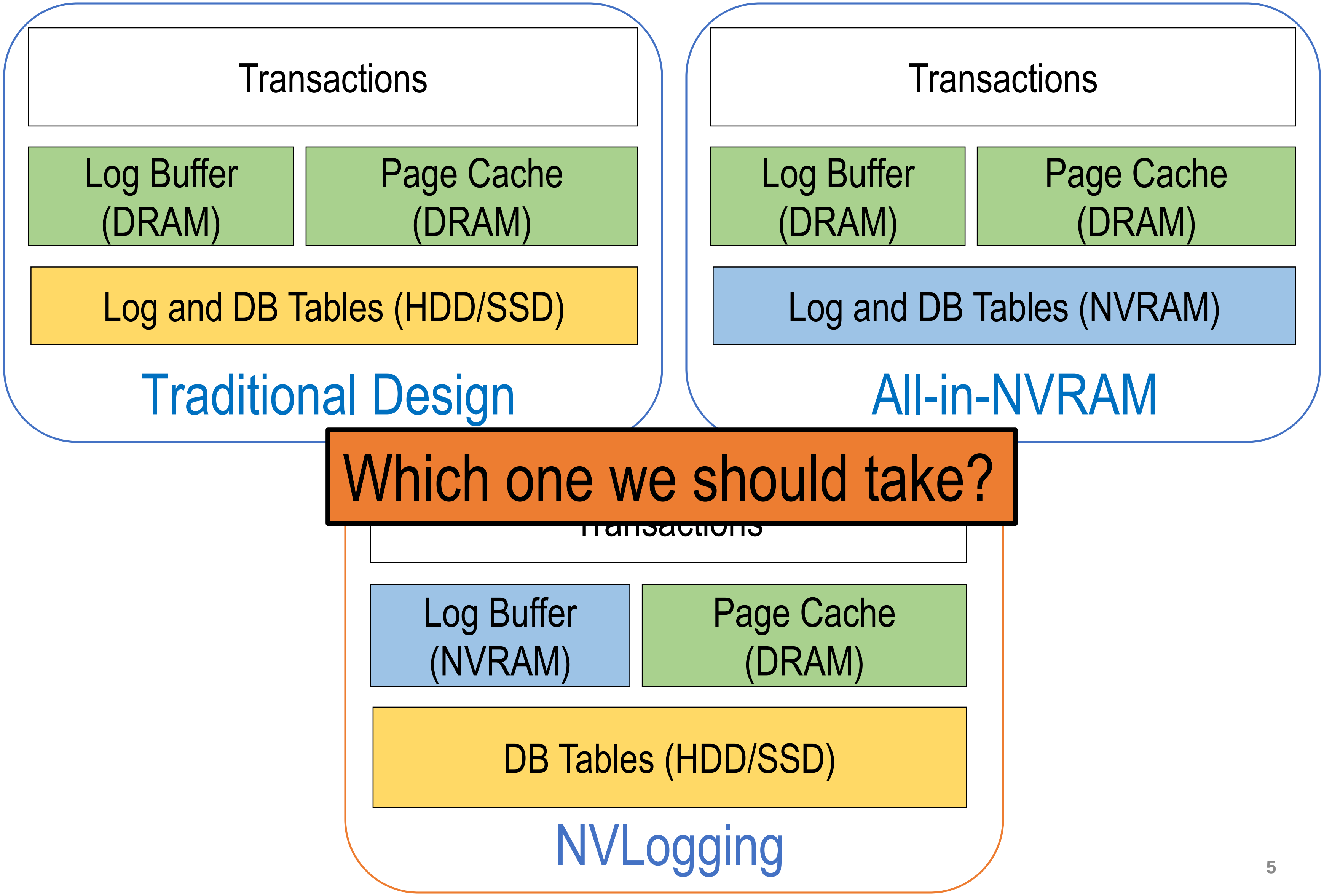

Using NVRAM in Cost-Effective Way

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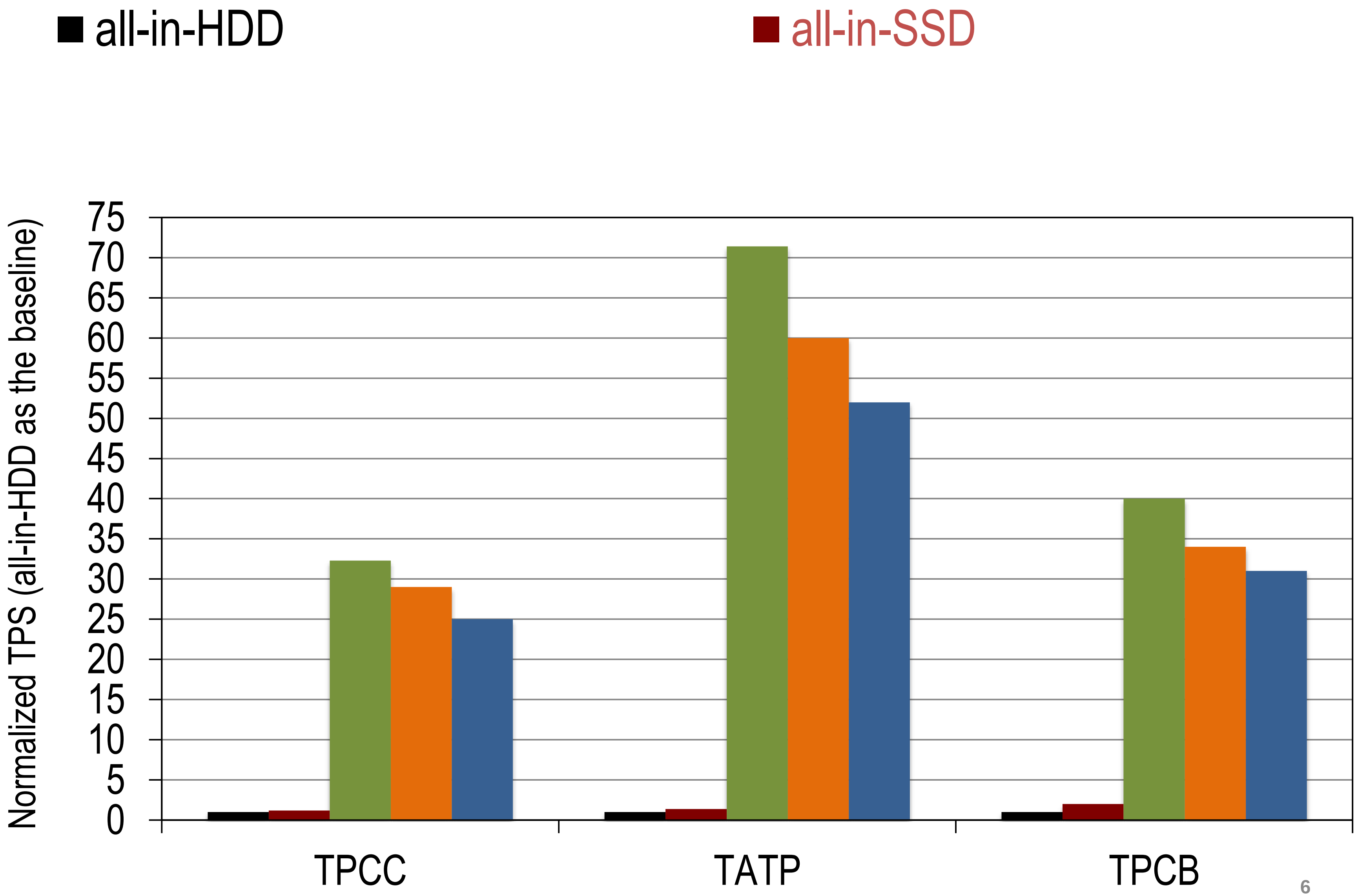

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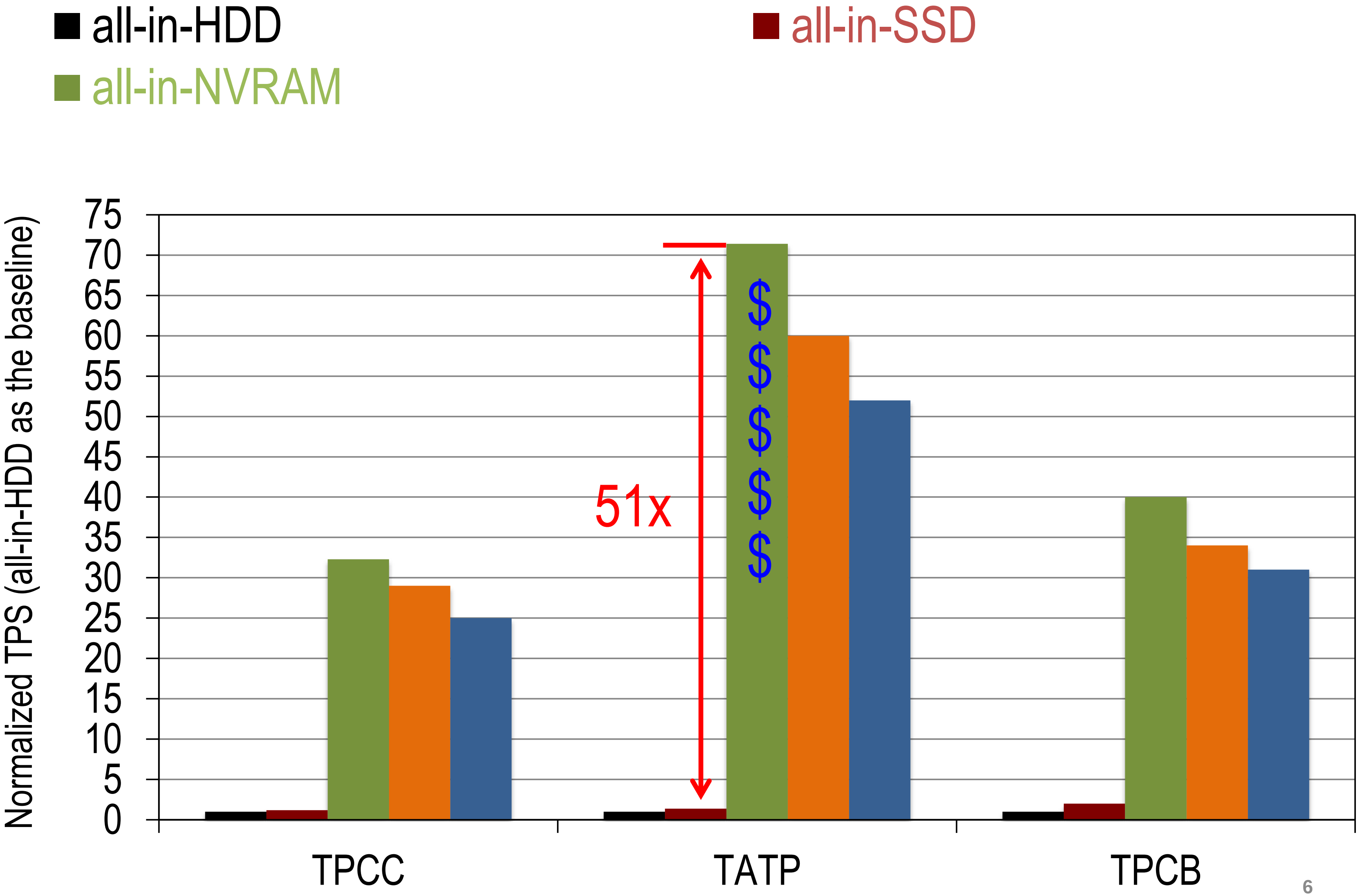

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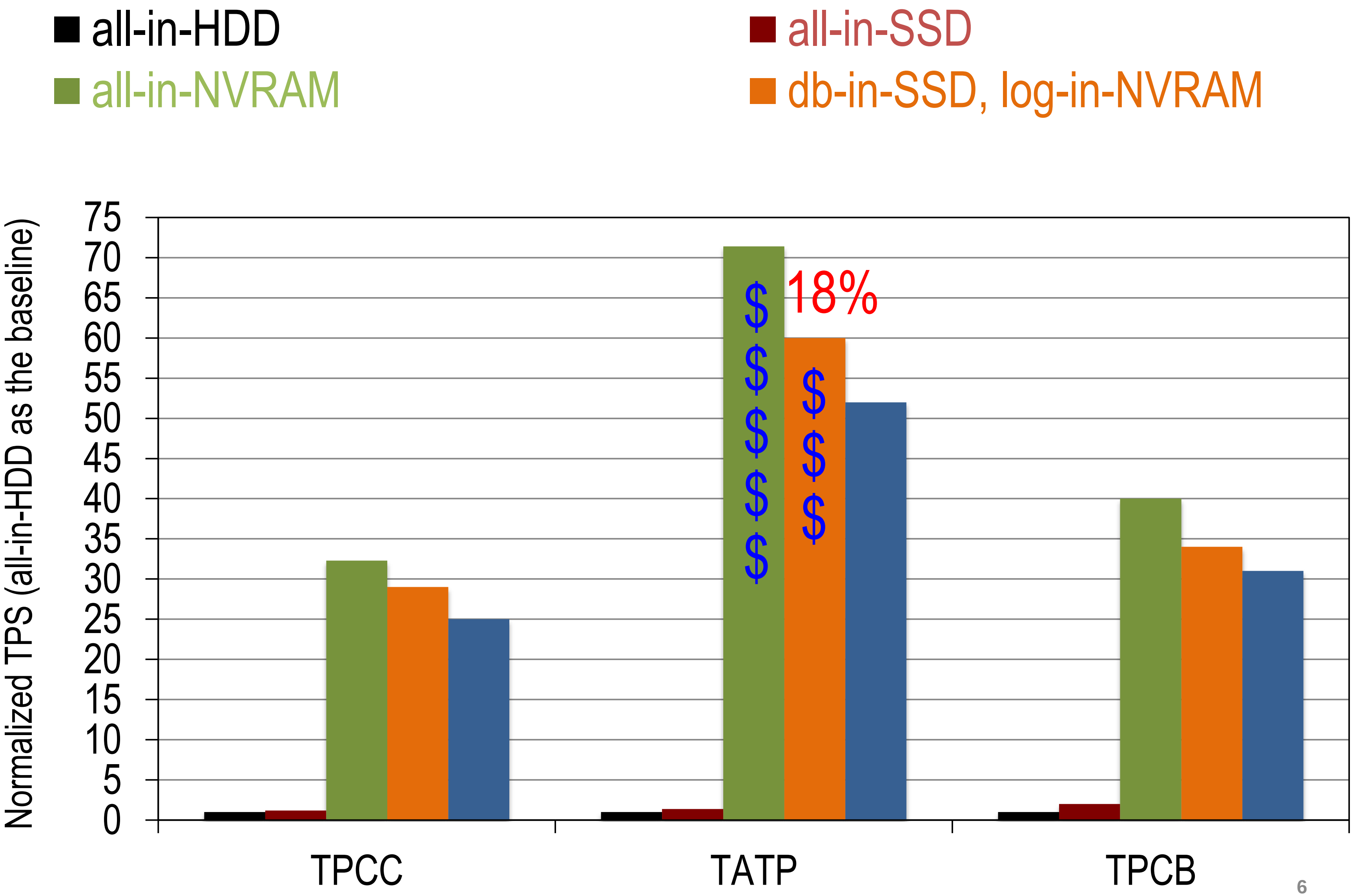

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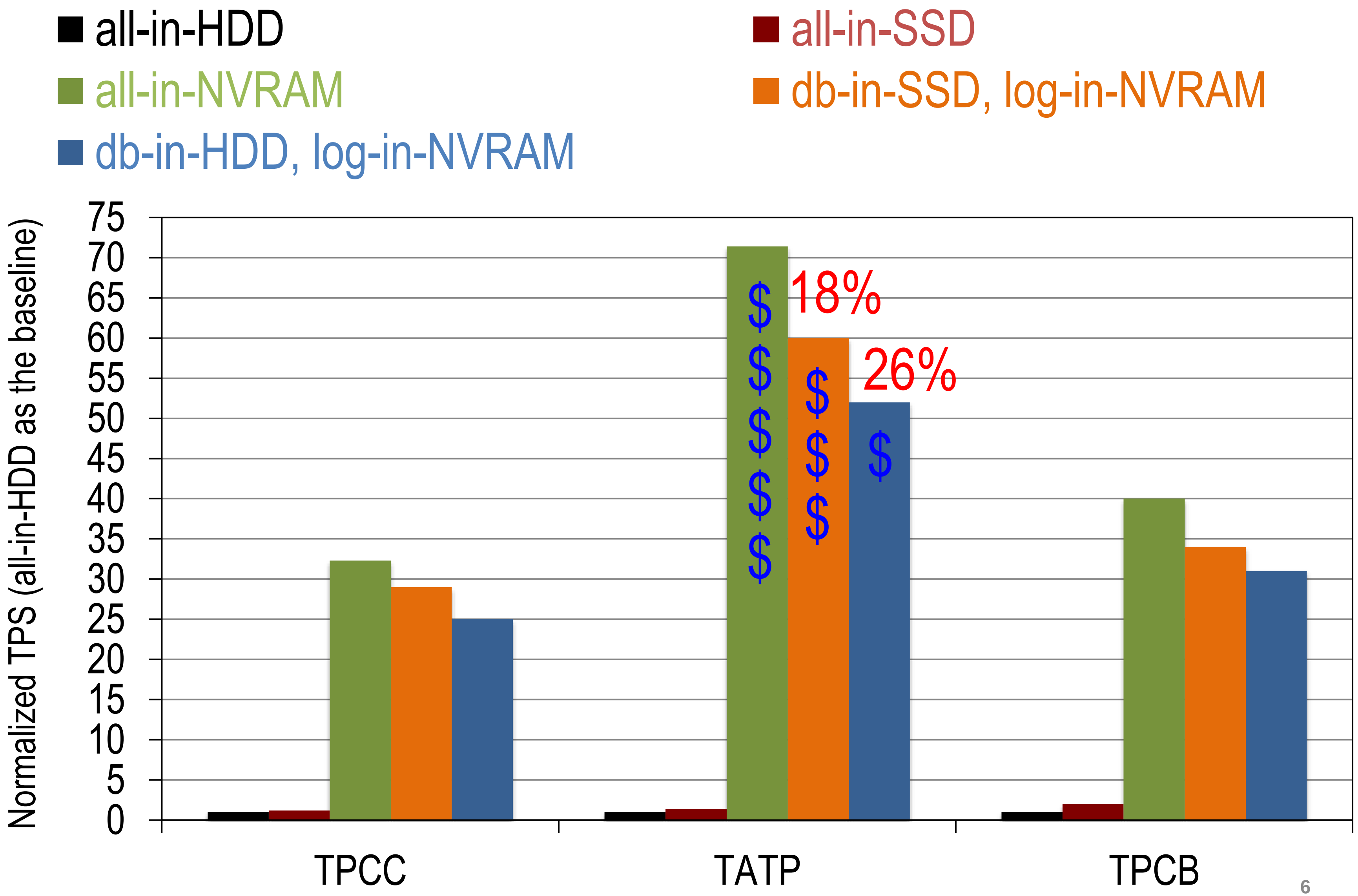

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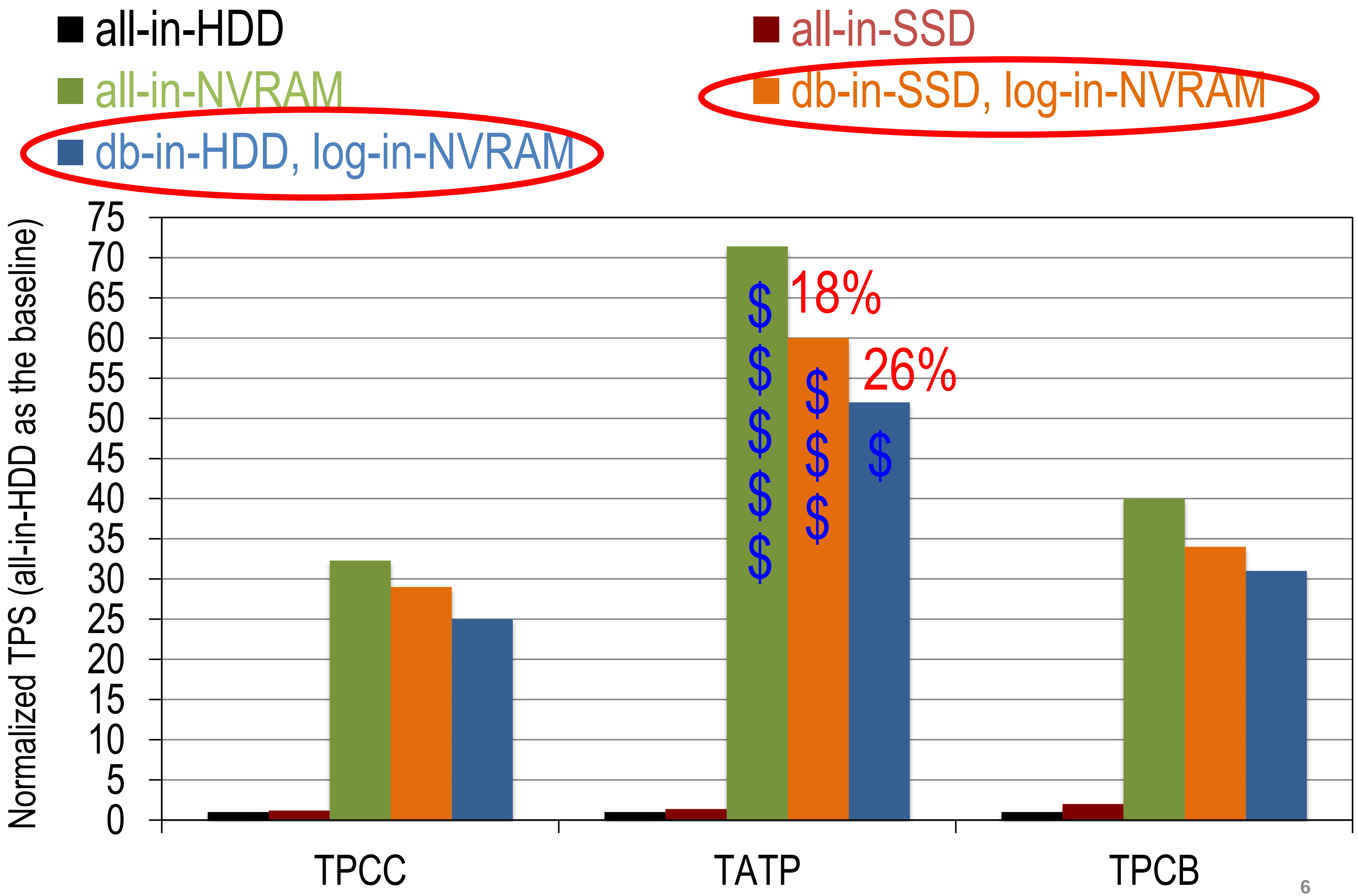

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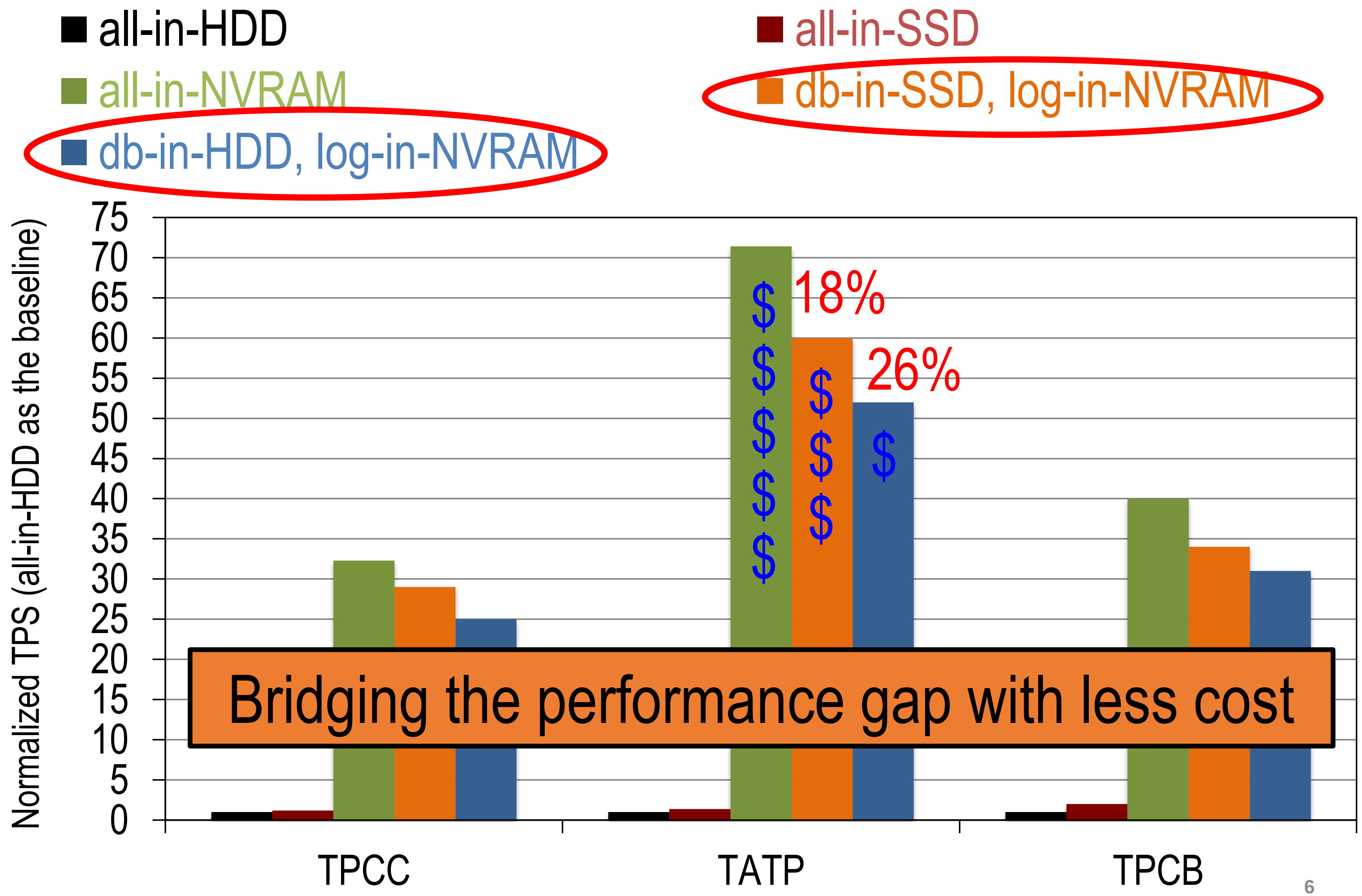
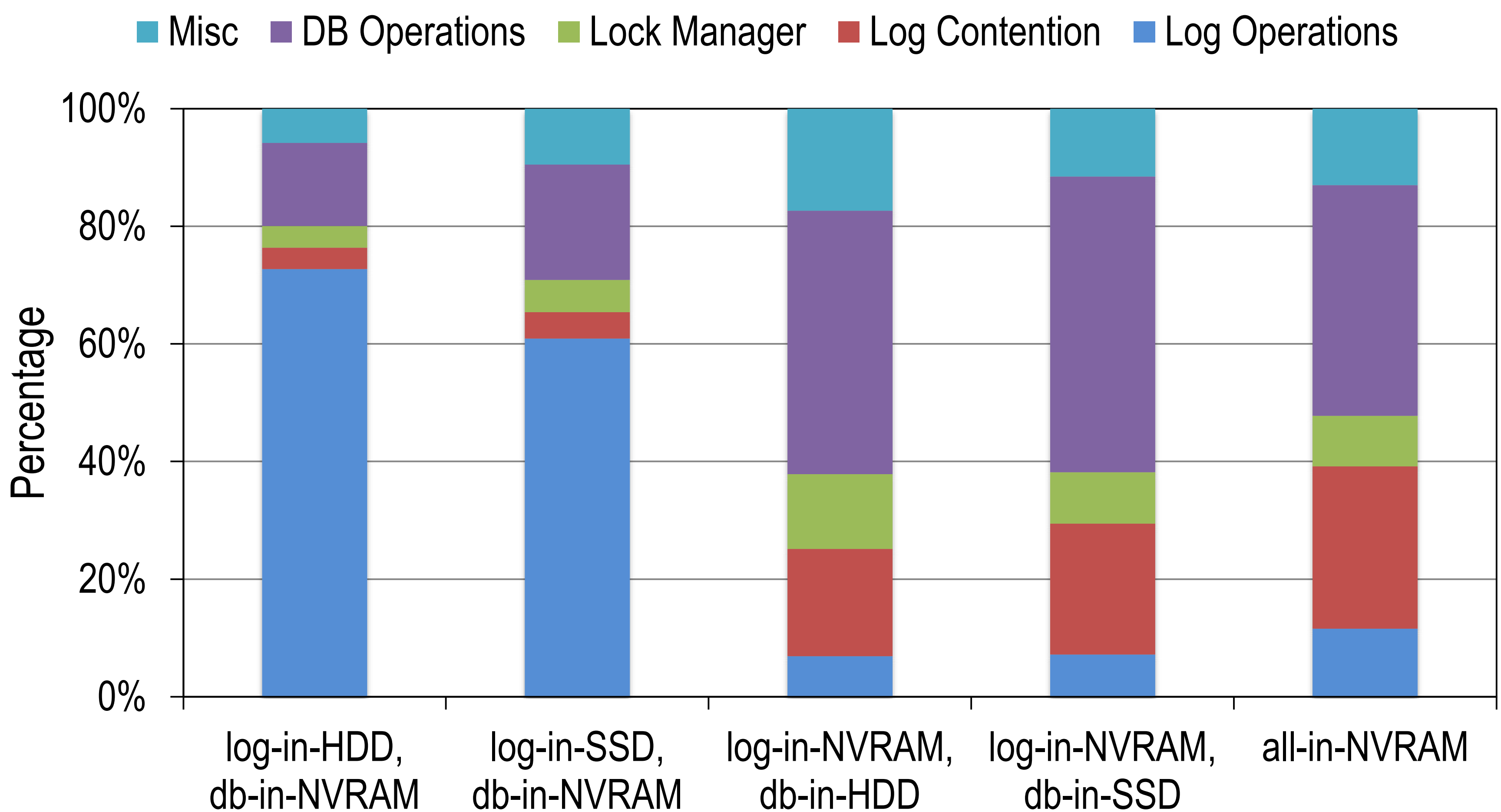


Bottlenecks Shifted from I/O to Software



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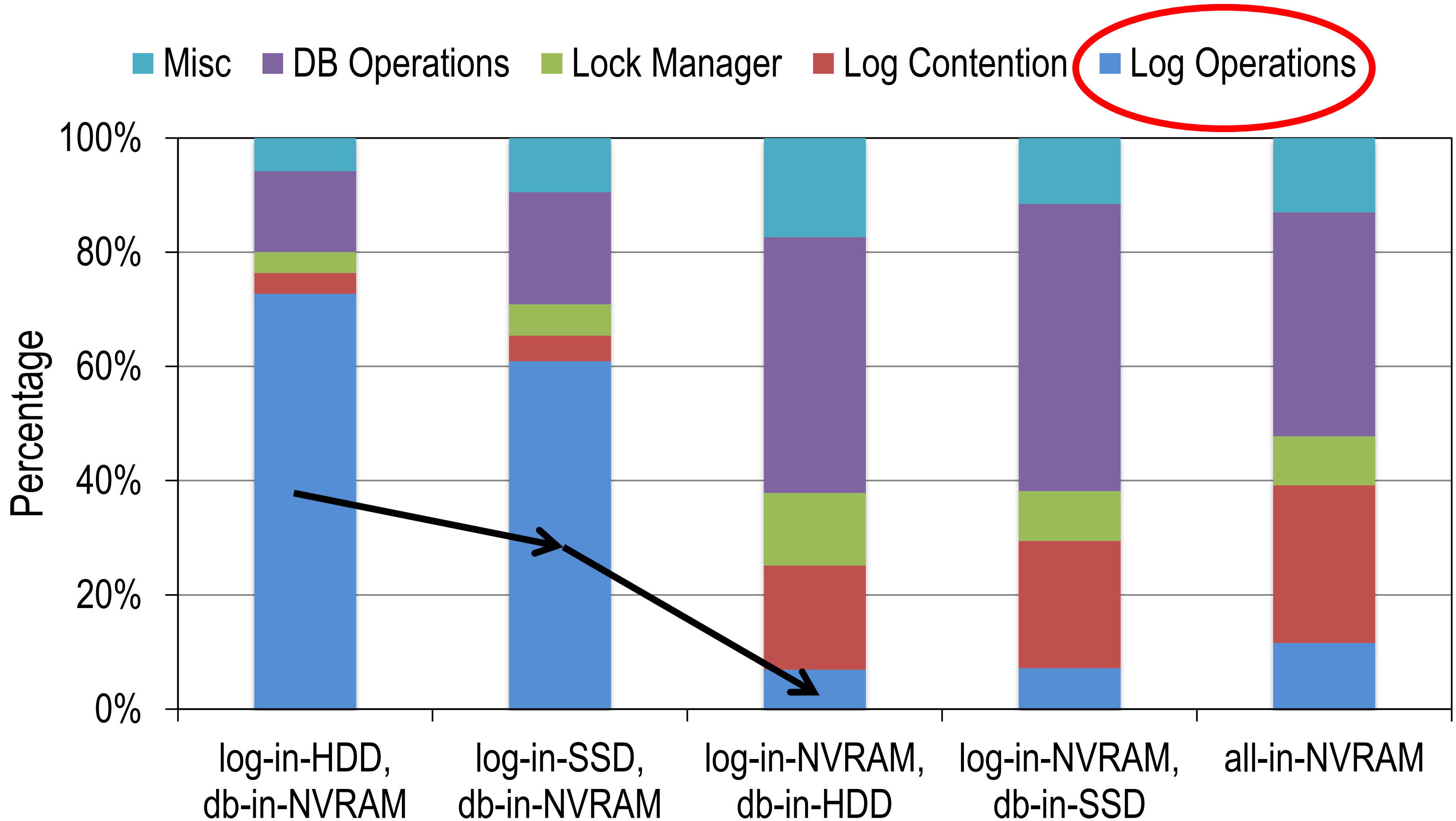

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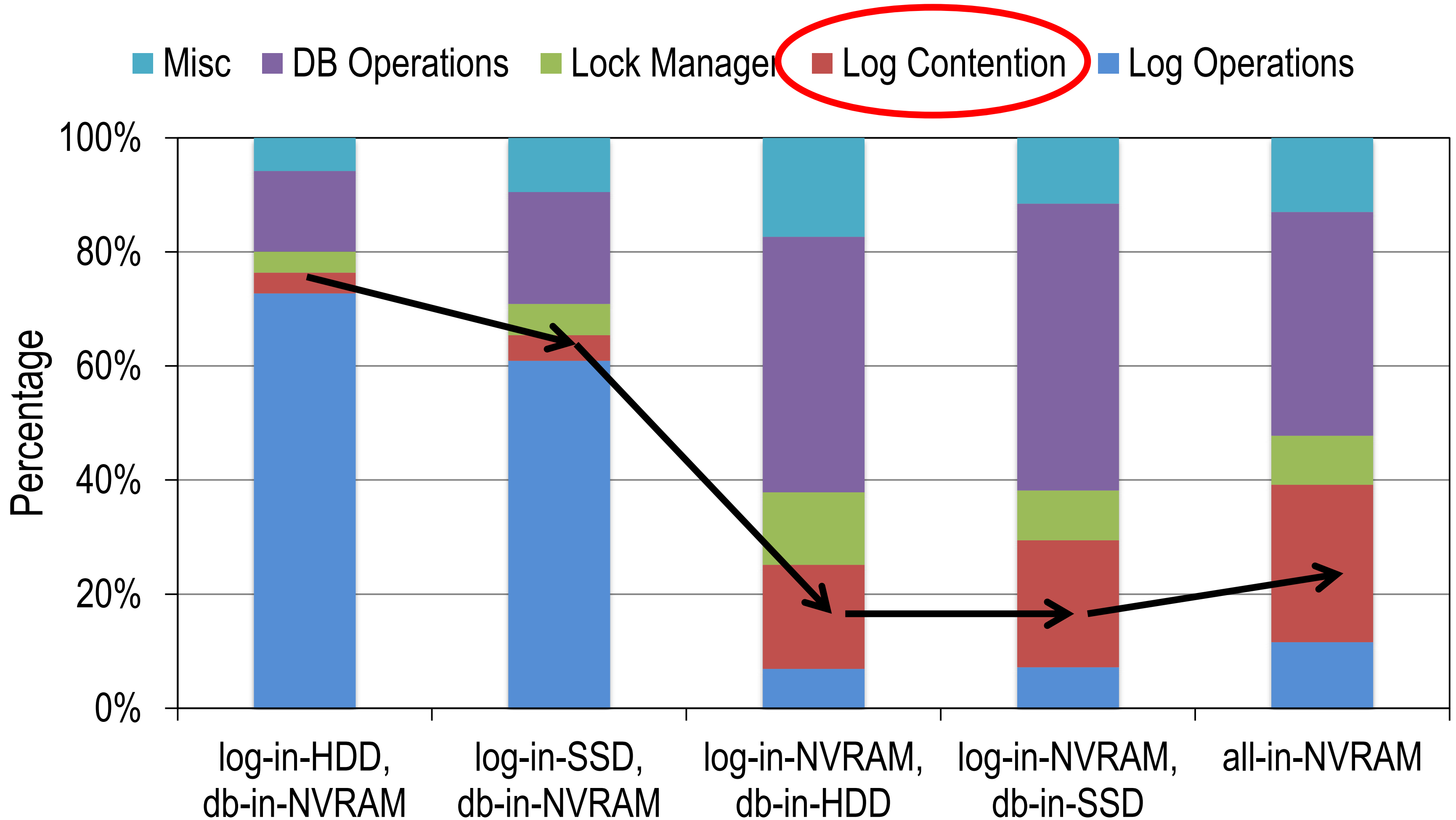
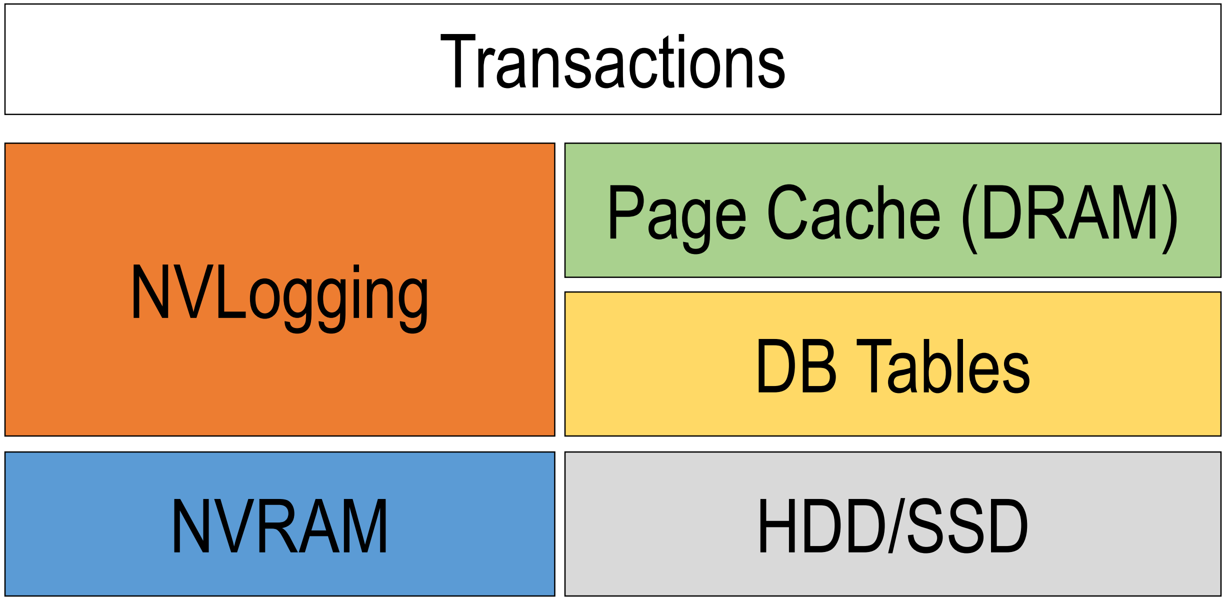


Software-induced overhead becomes the new bottleneck !

NVLogging: Redesign the Logging with NVRAM

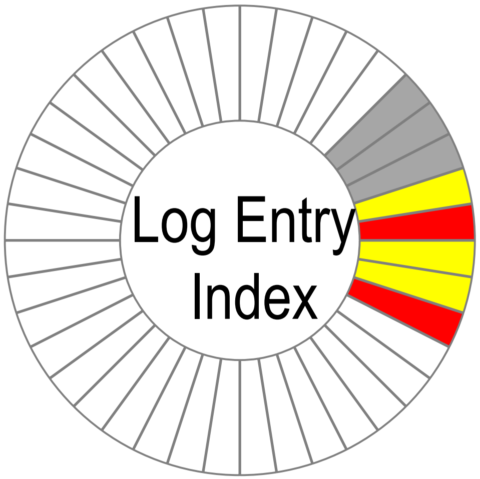


1. Use NVRAM in Cost-Effective Way
2. Avoid the Software Overhead
3. Minimal Code Modifications

Log Management in NVLogging

DRAM

NVRAM



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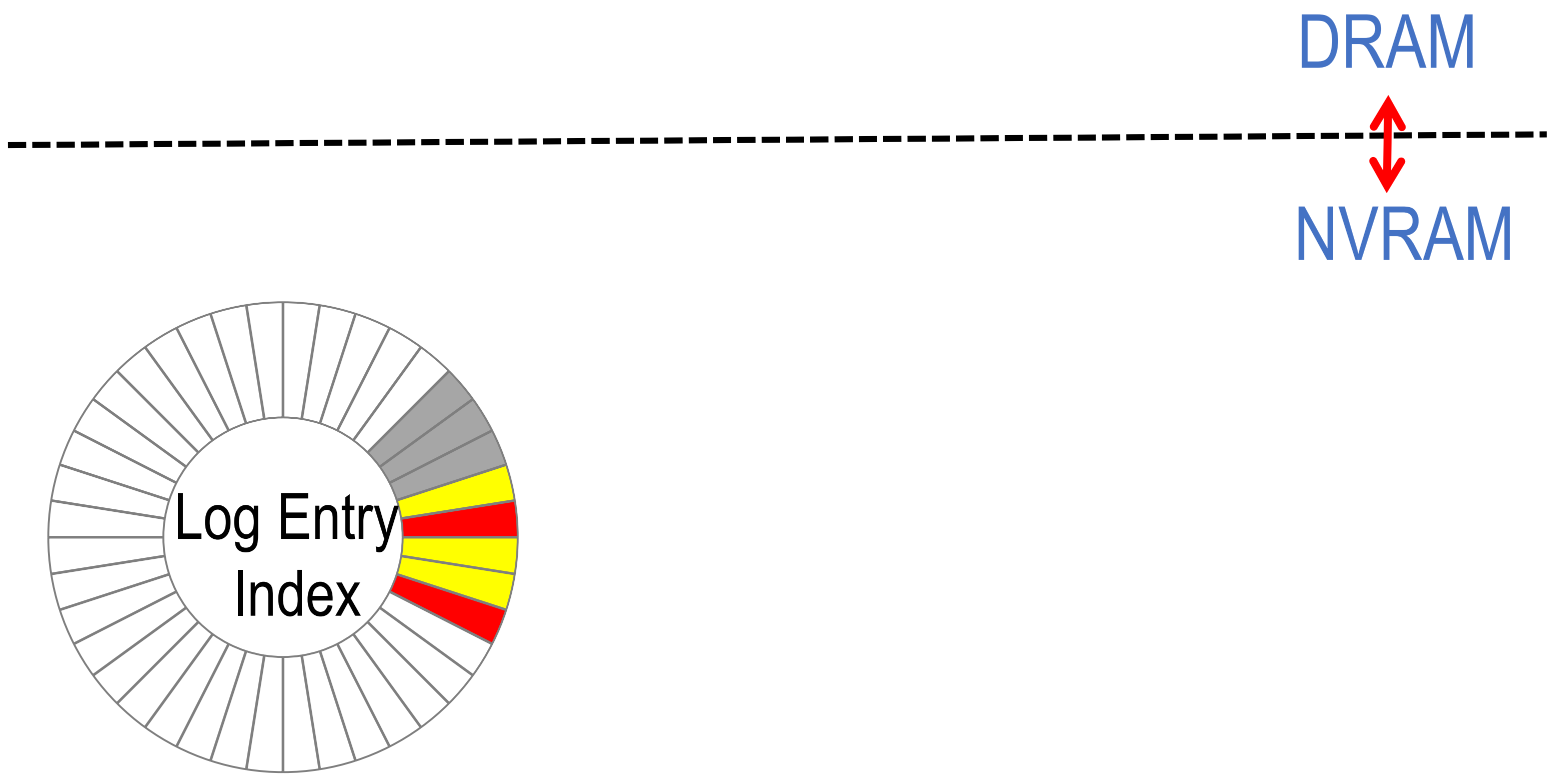

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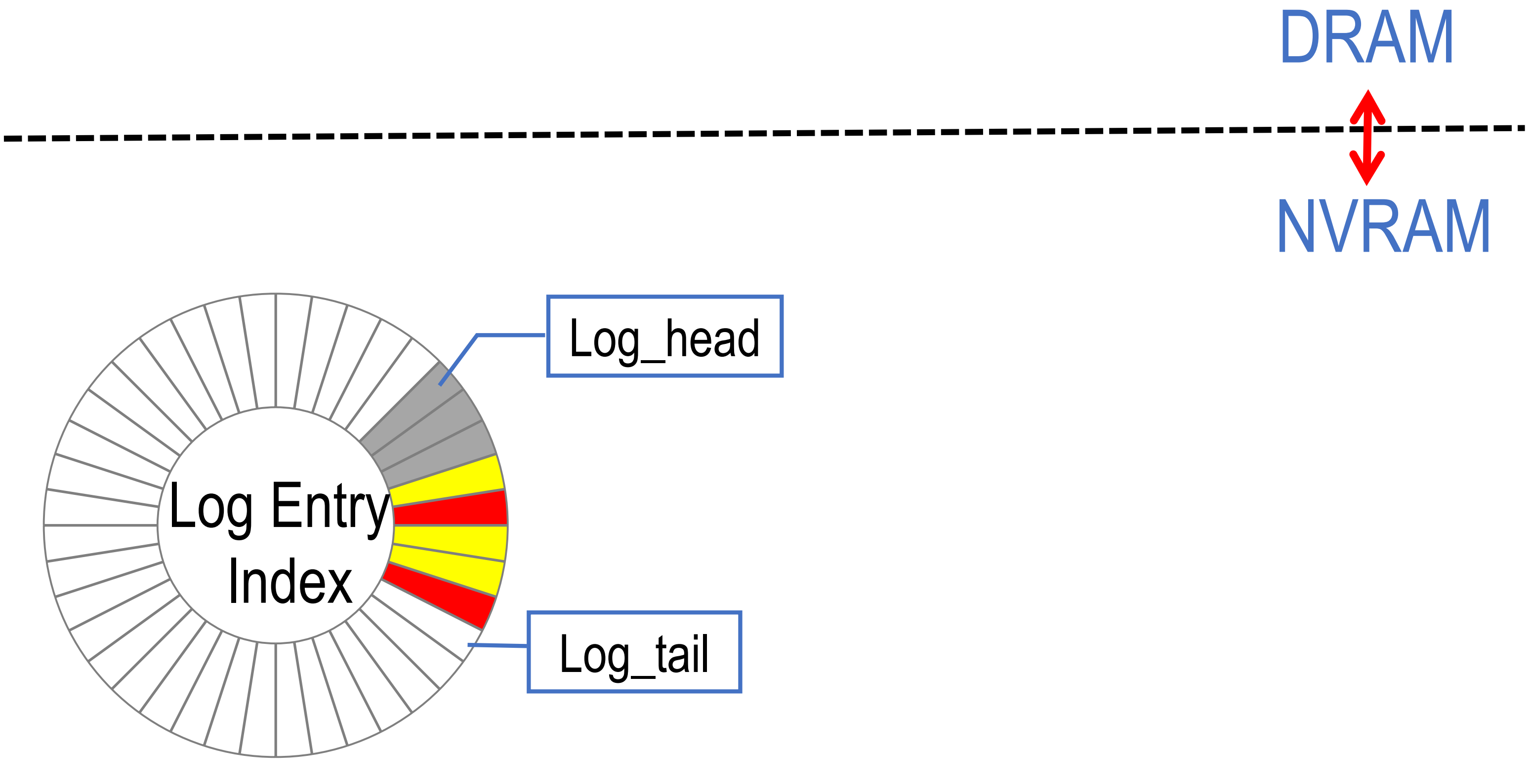

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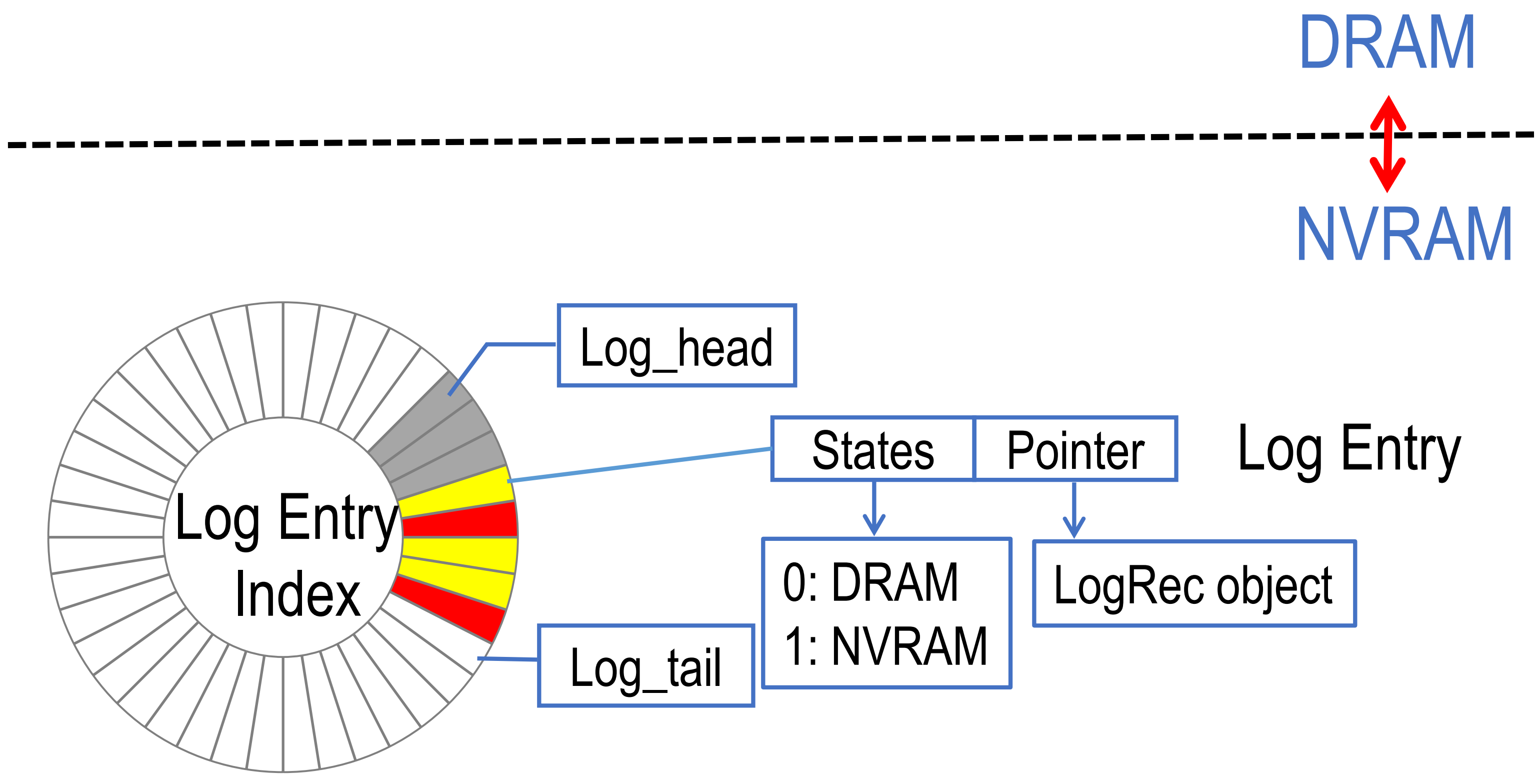

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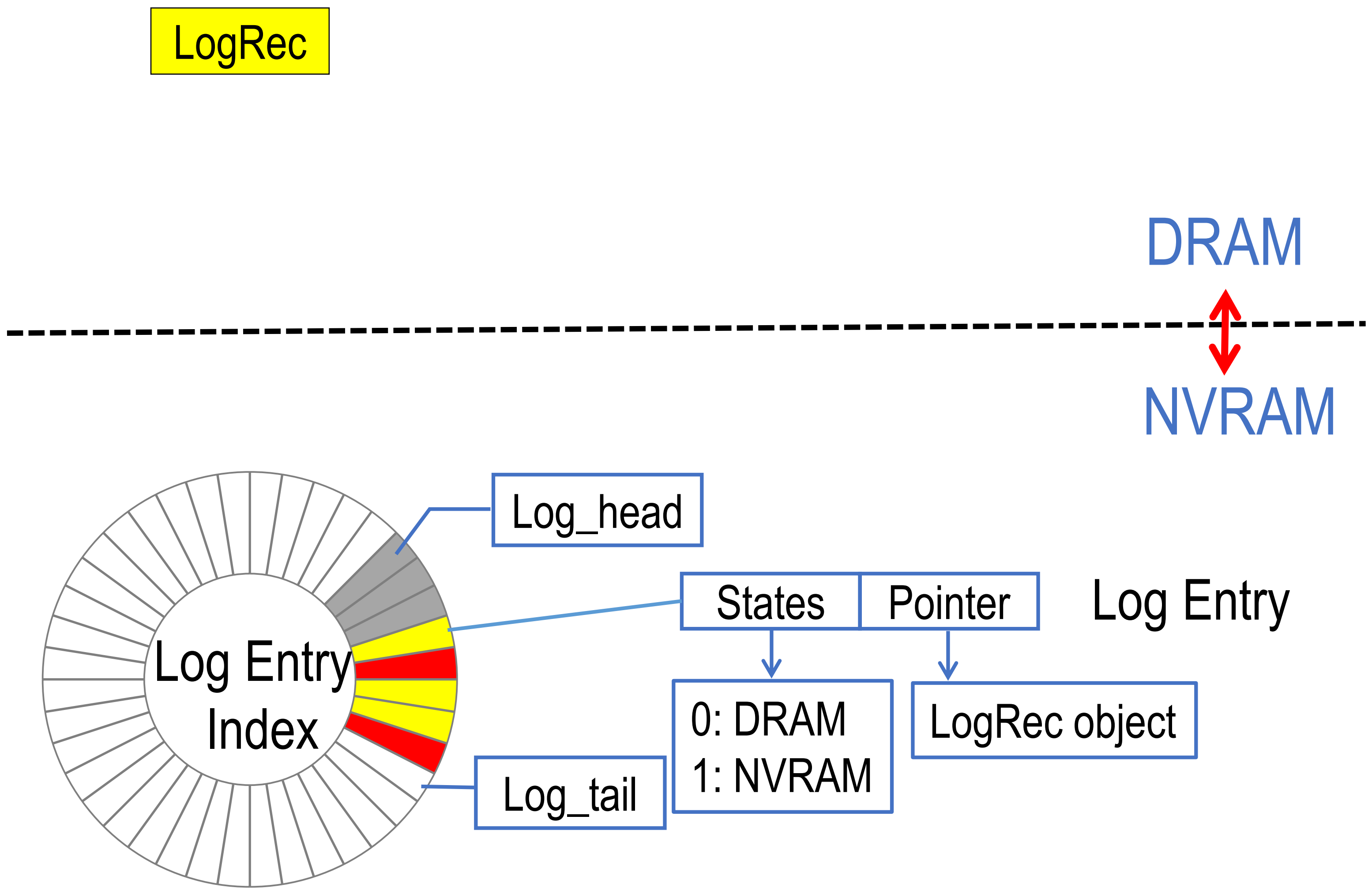

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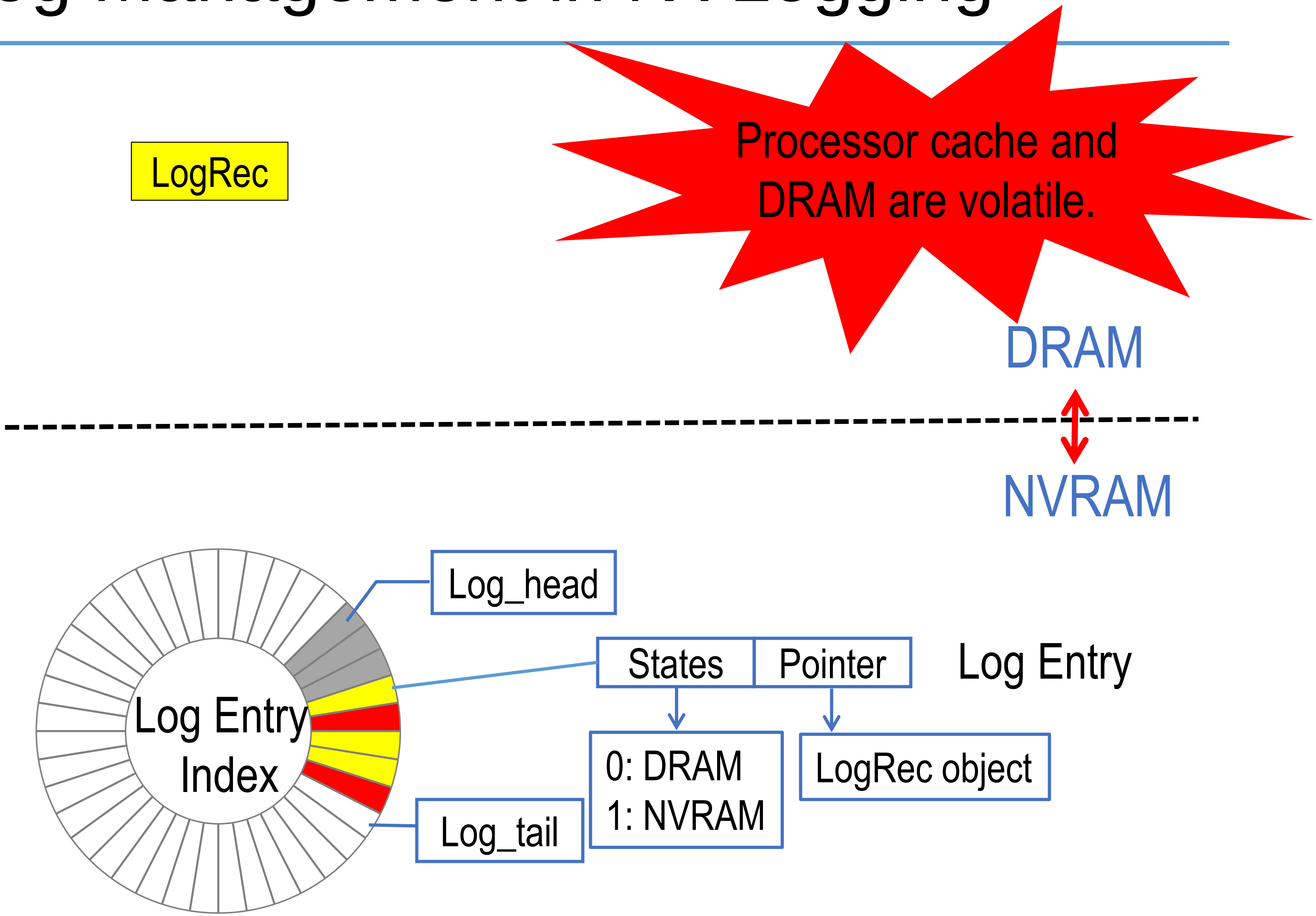

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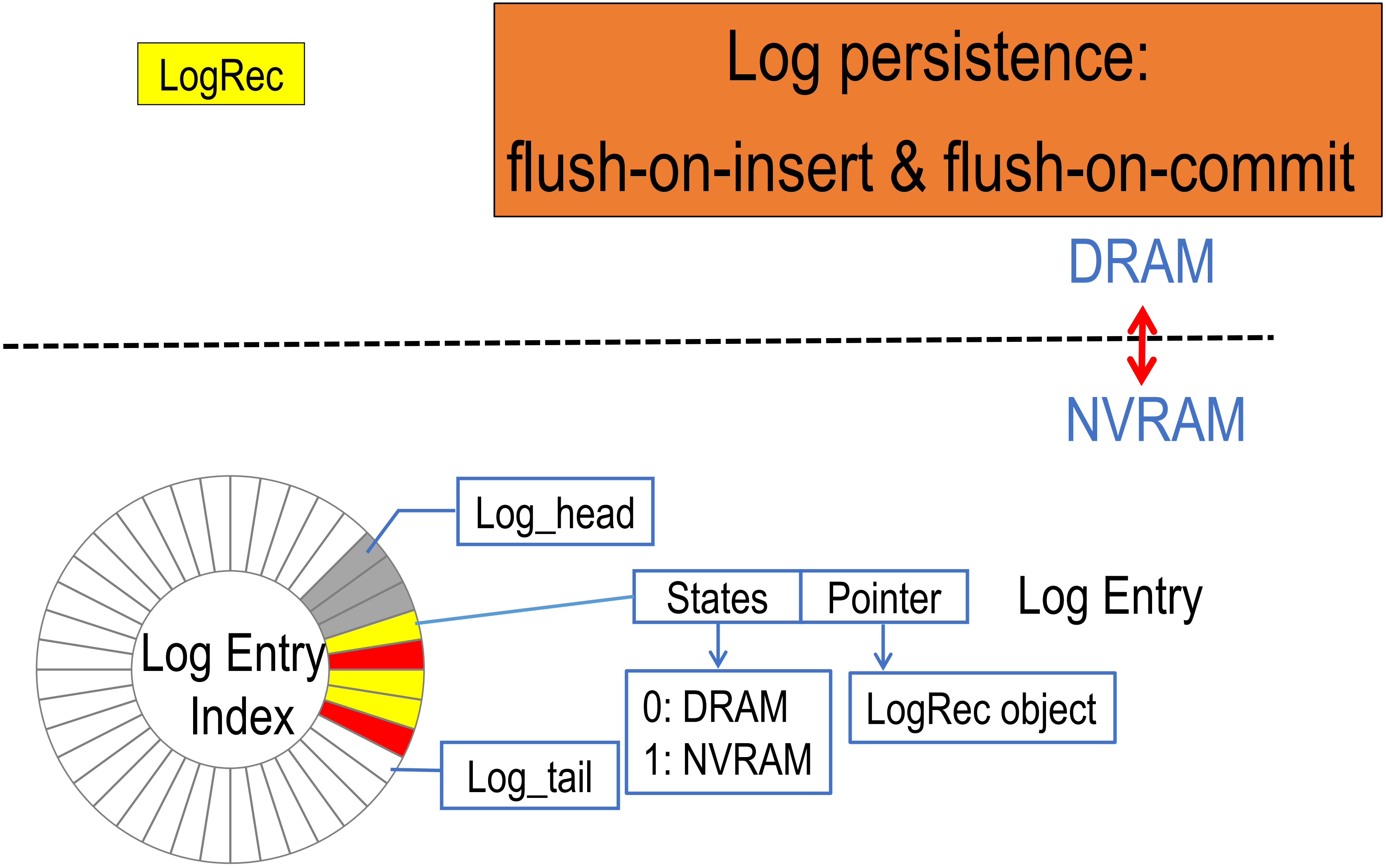
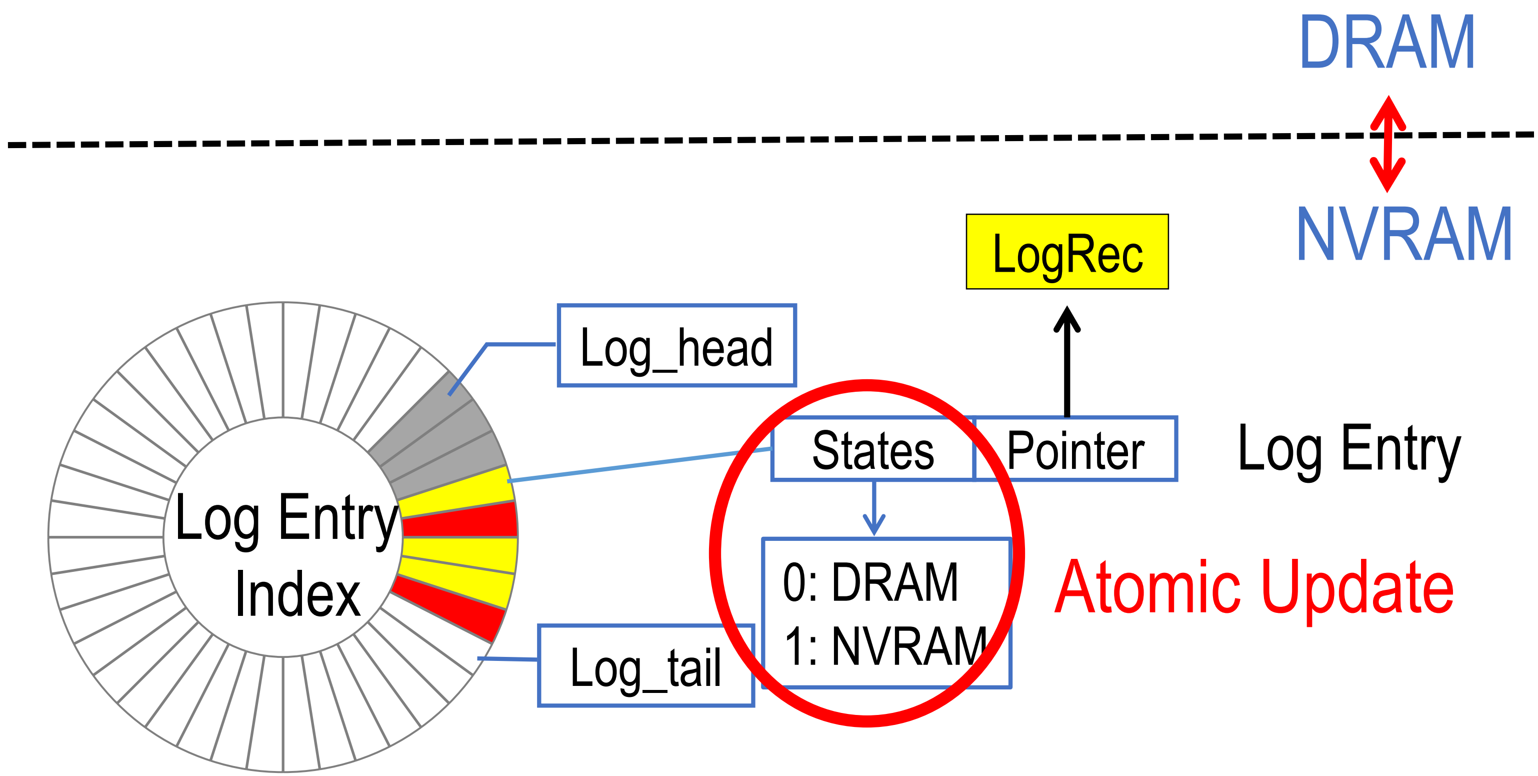


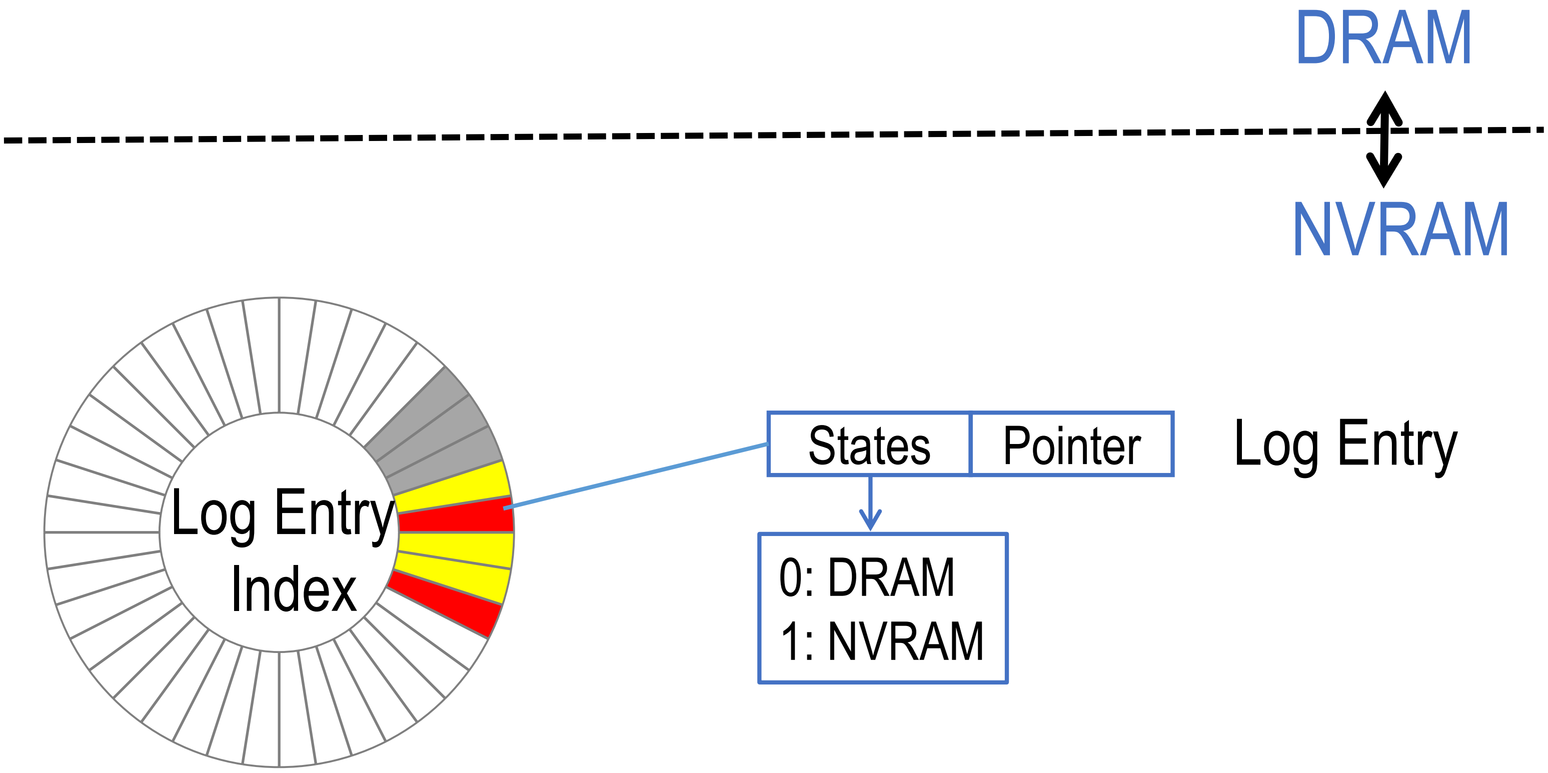
Log Management in NVLogging

Log persistence:

flush-on-insert & flush-on-commit



Avoid Log Contention with Per-Transaction Logging



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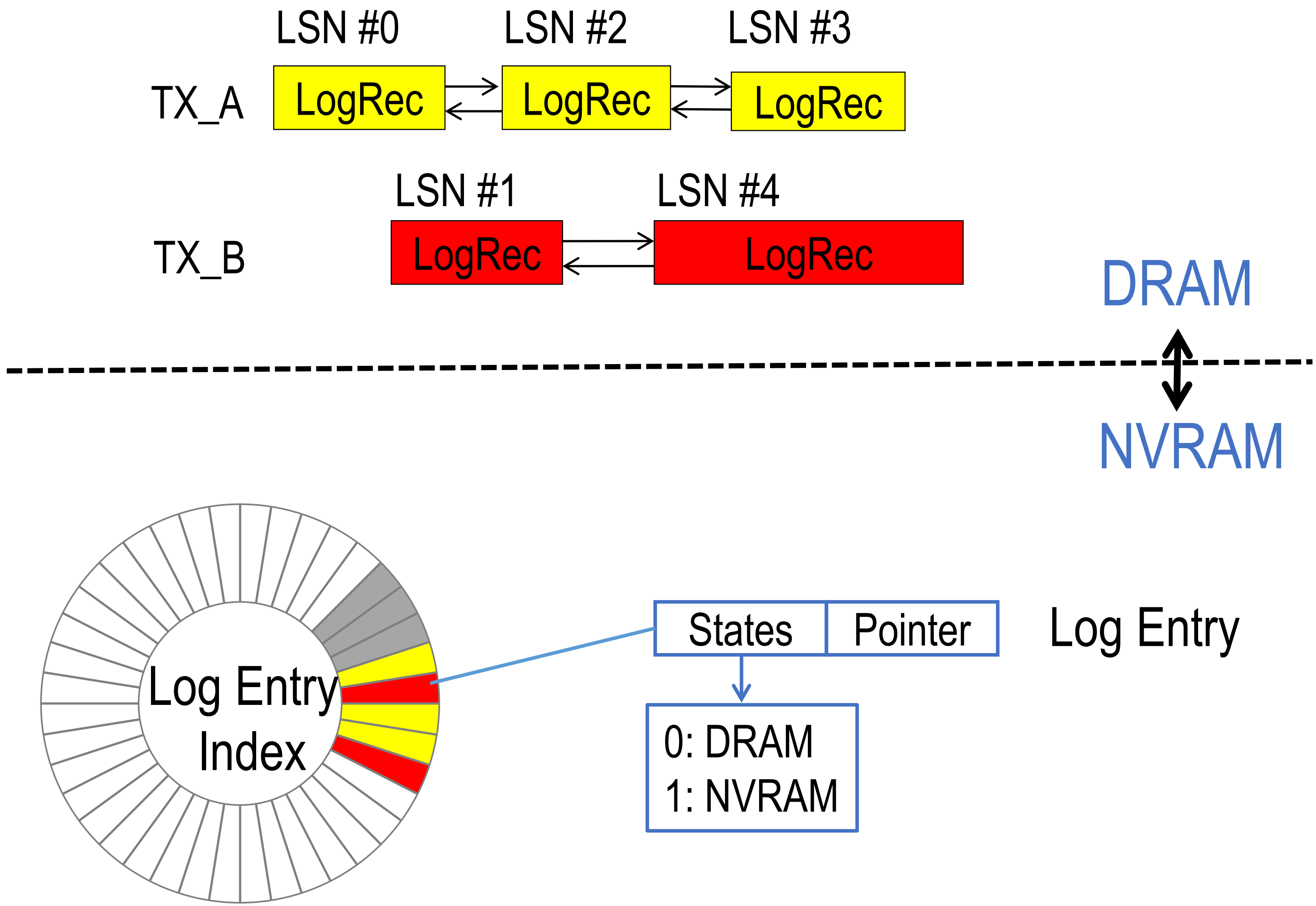

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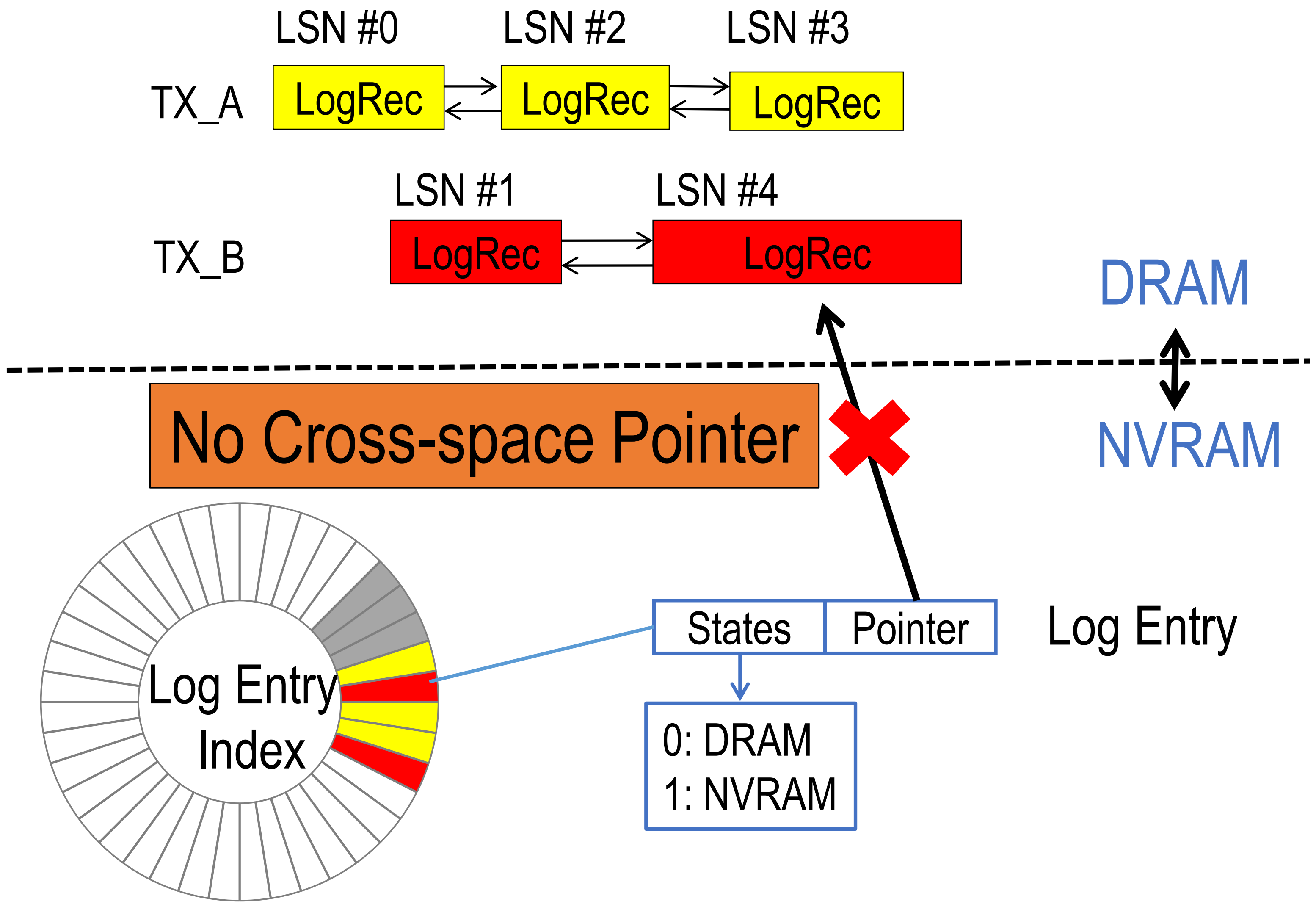

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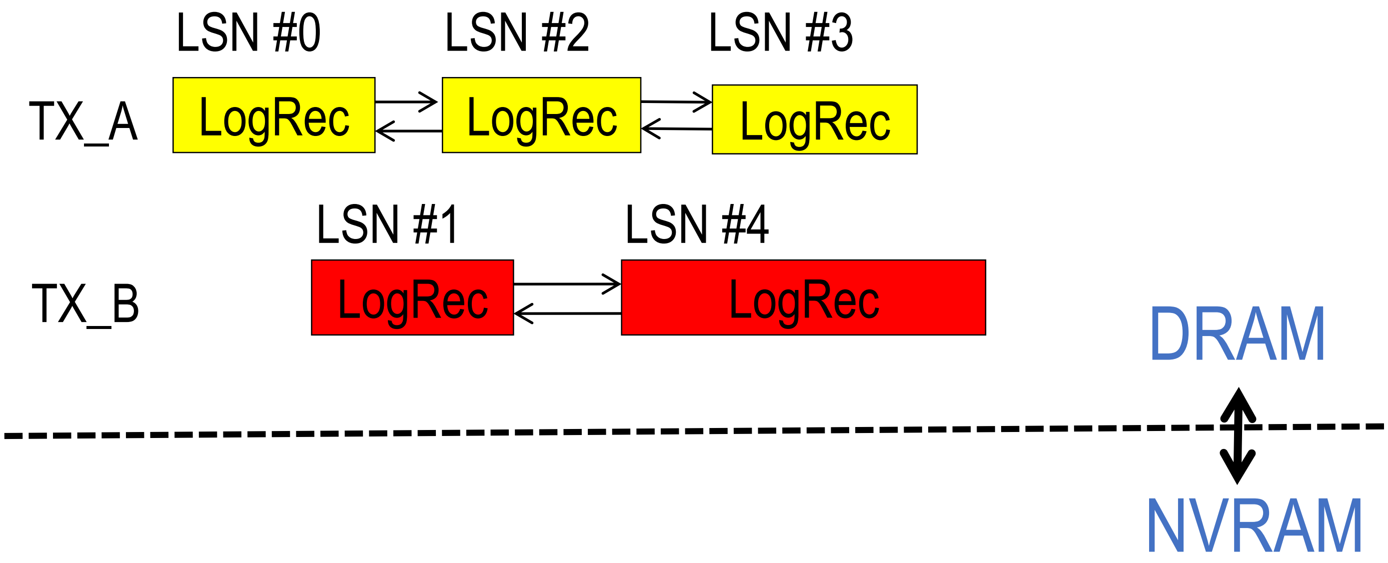
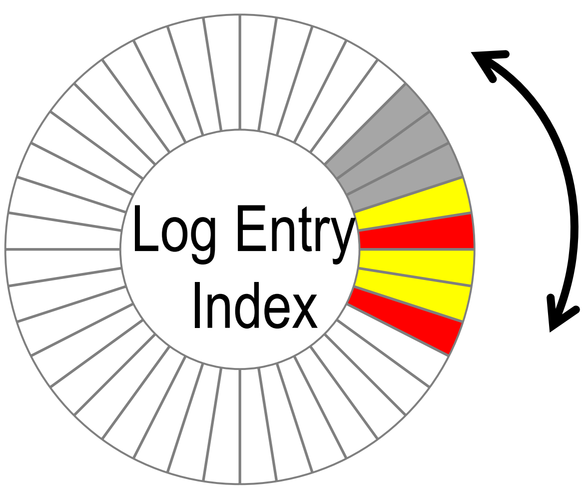
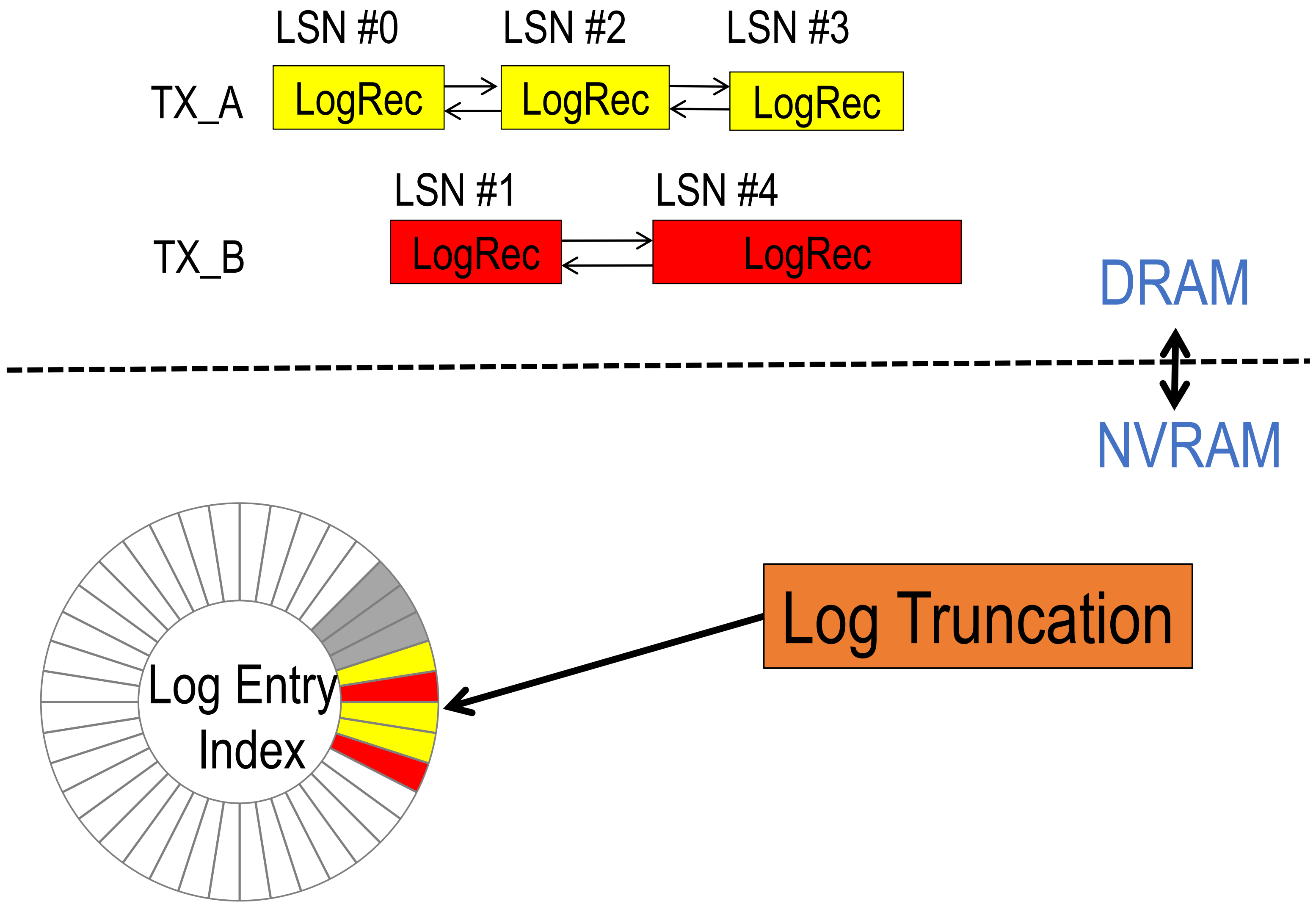




Recovery

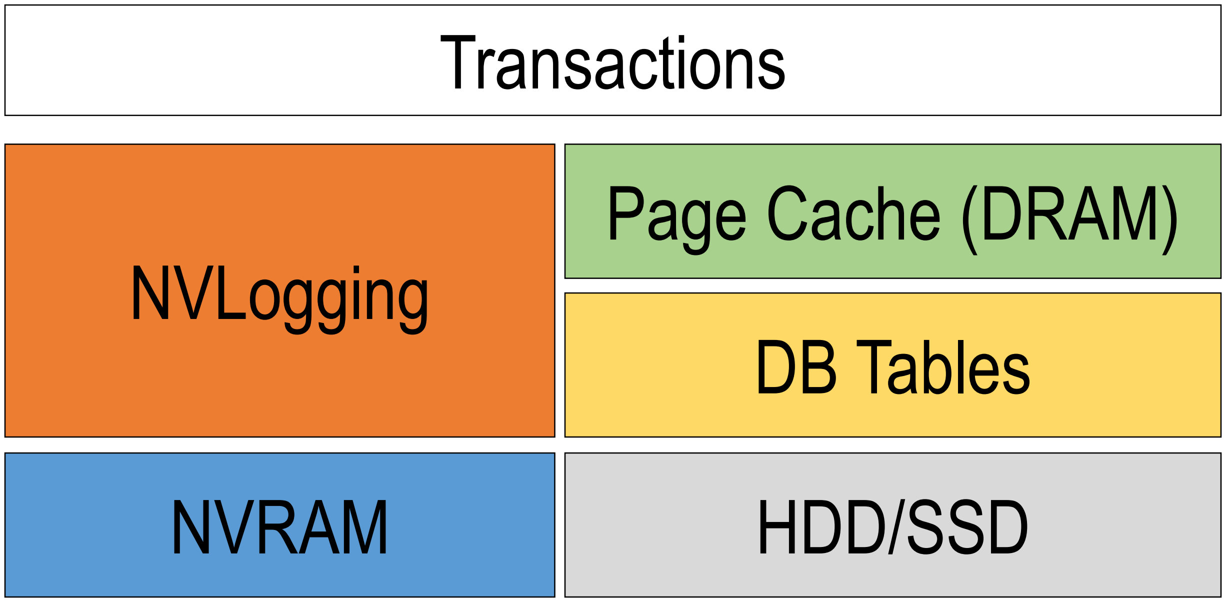
Using back pointer to access log objects

Avoid Log Contention with Per-Transaction Logging



Implementation and Experimental Setup

Shore-MT + Shore-Kits Benchmark



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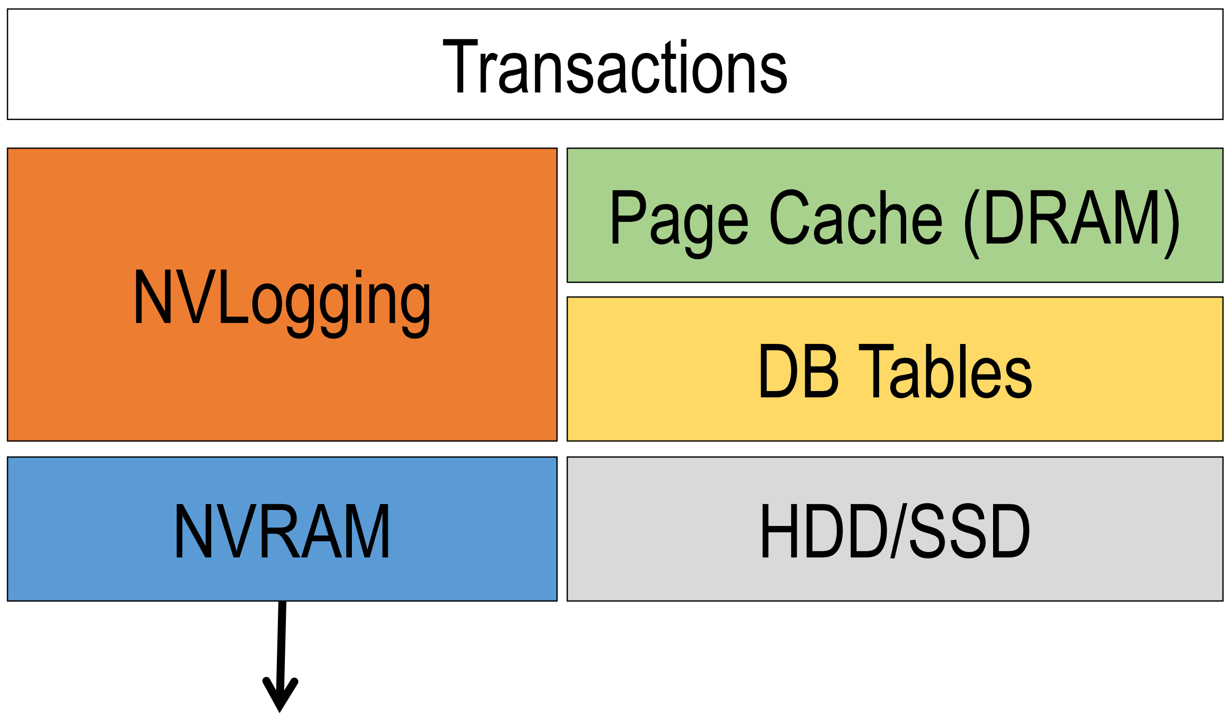
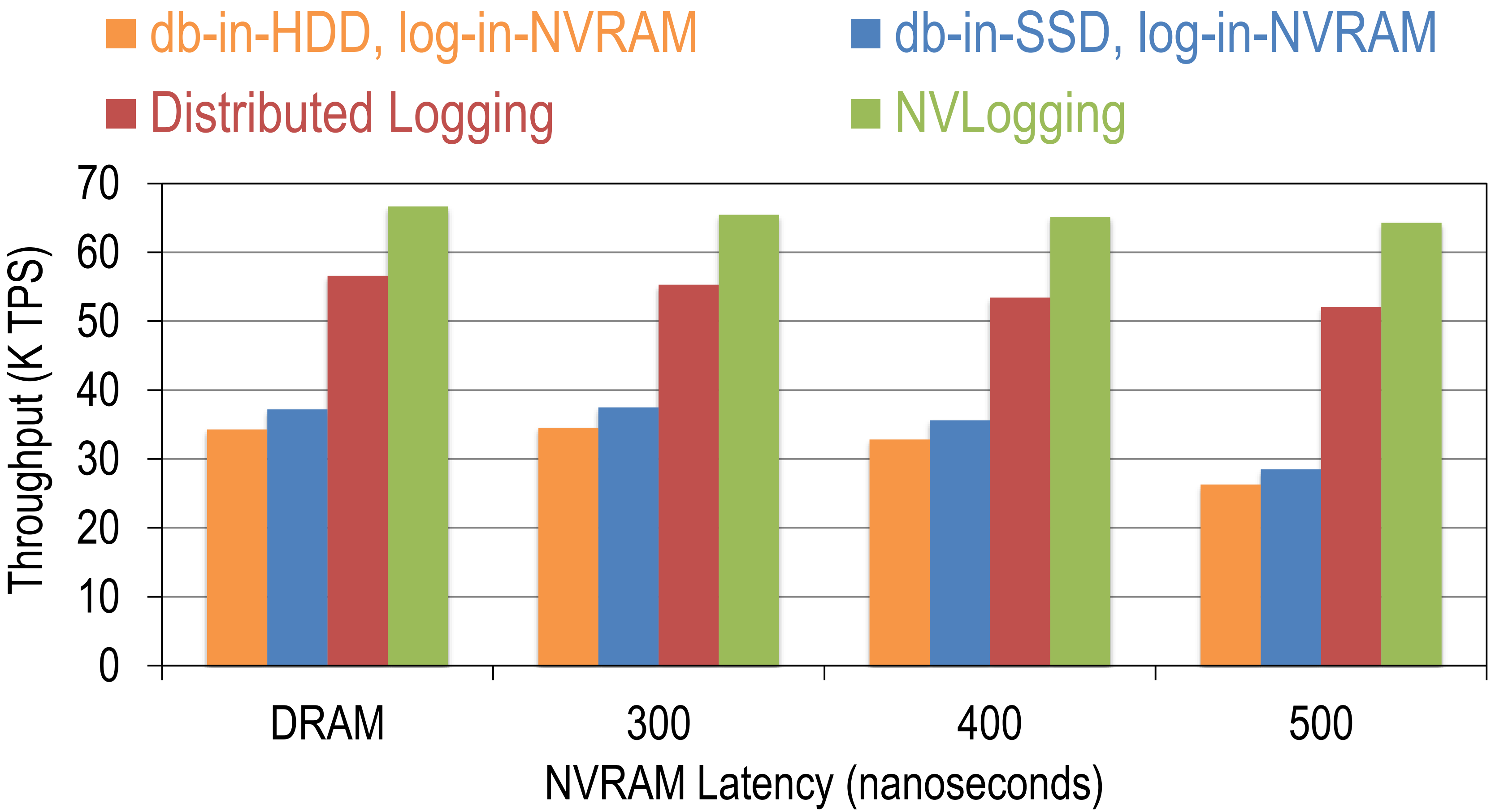


Intel Persistent Memory Emulator Platform

Xeon-EP @ 2.6 GHz, 64 GB DRAM + 256 GB NVRAM

Benefits on Throughput with TPCB



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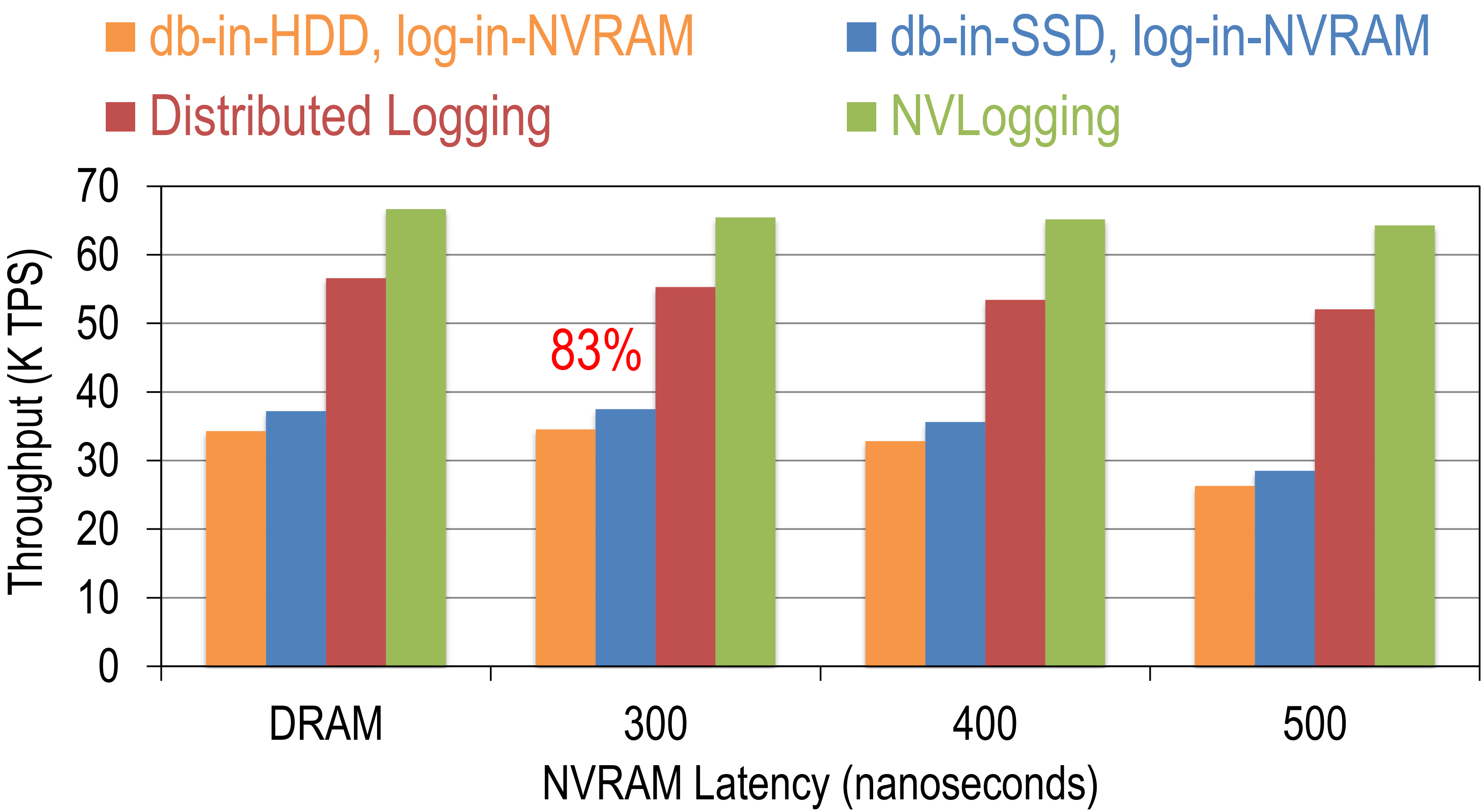

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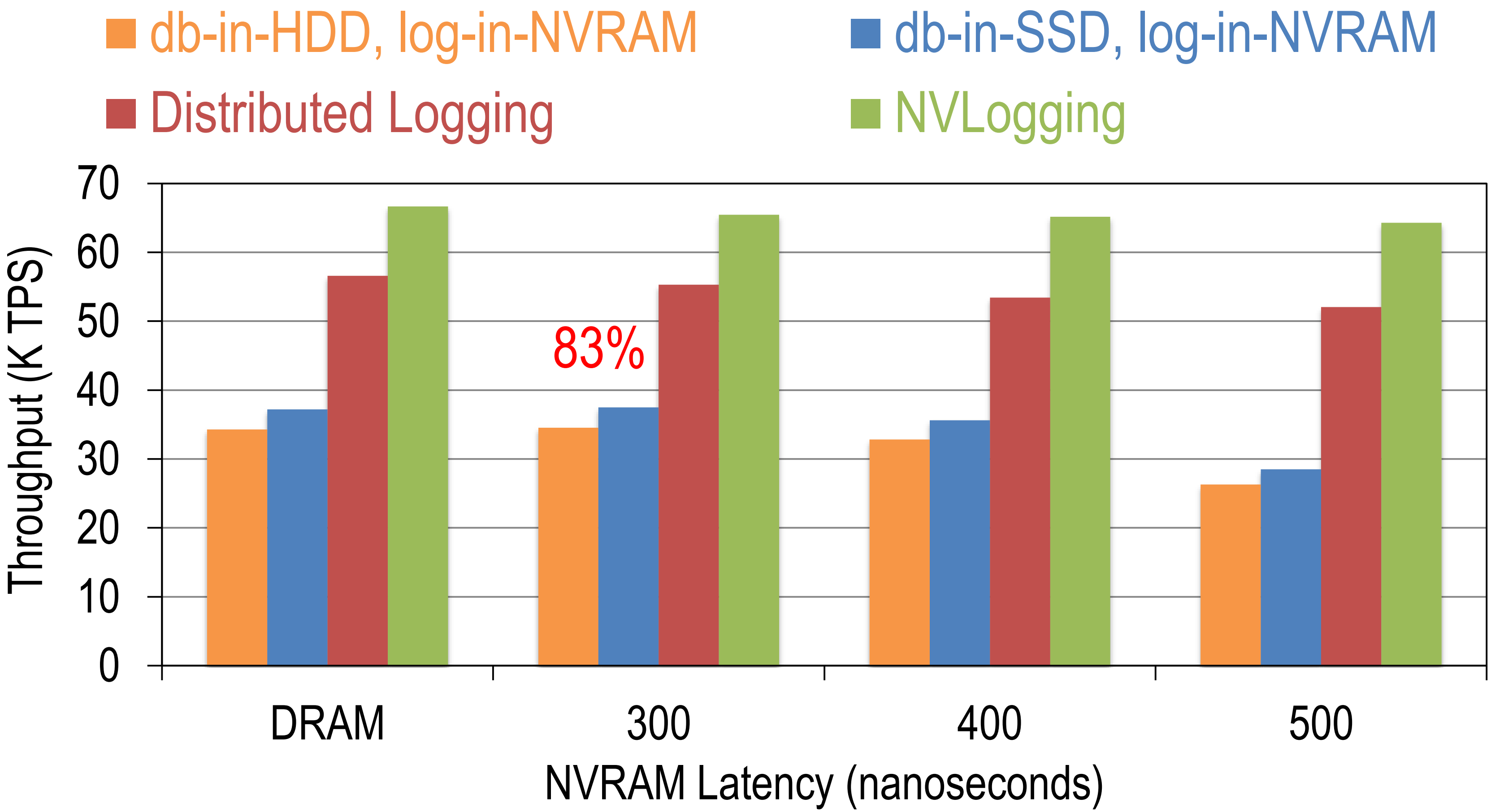
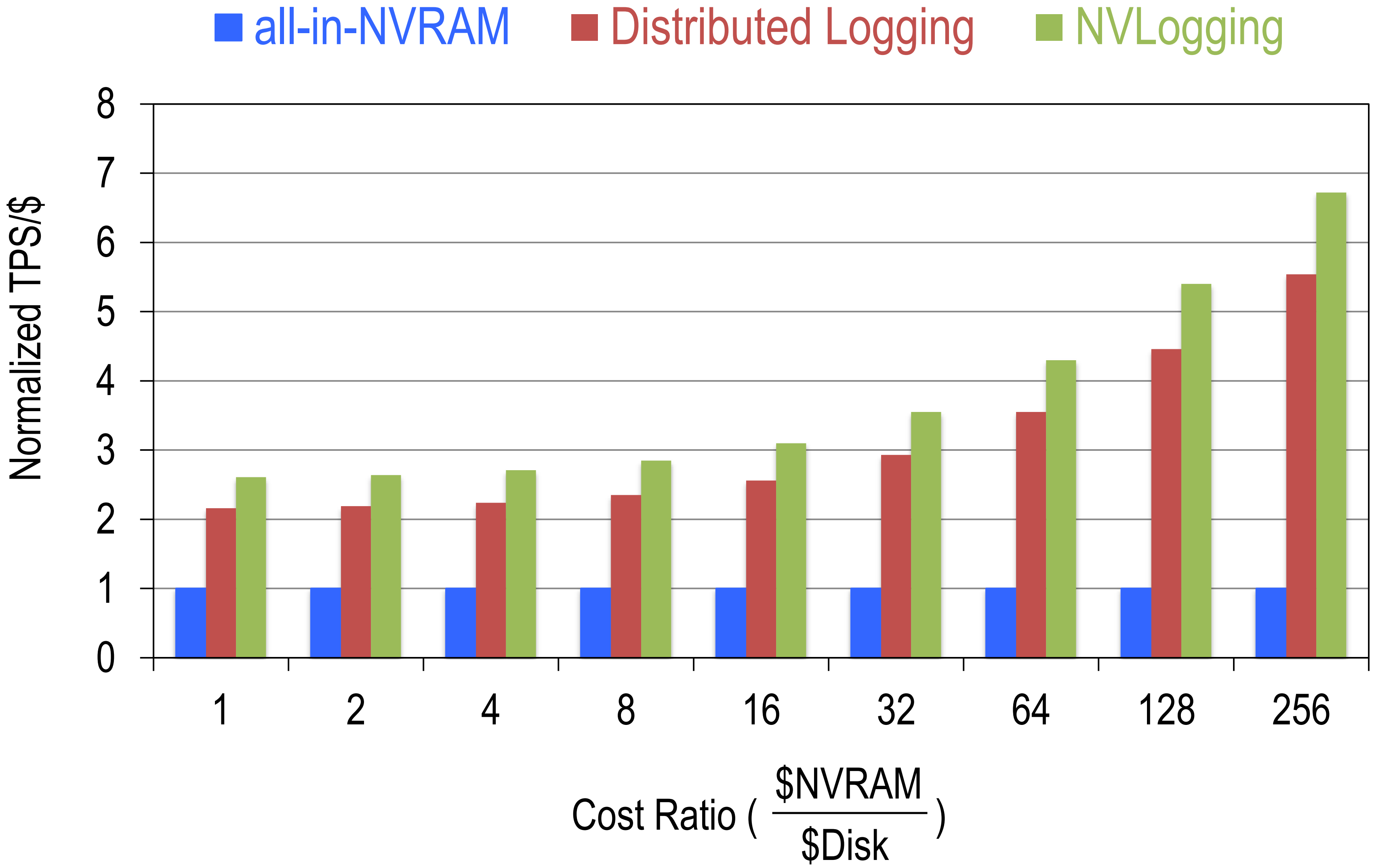


NVLogging improves TPS by 2.3x,
compared to the baseline (db-in-SSD, log-in-NVRAM)

Benefits on Cost Savings



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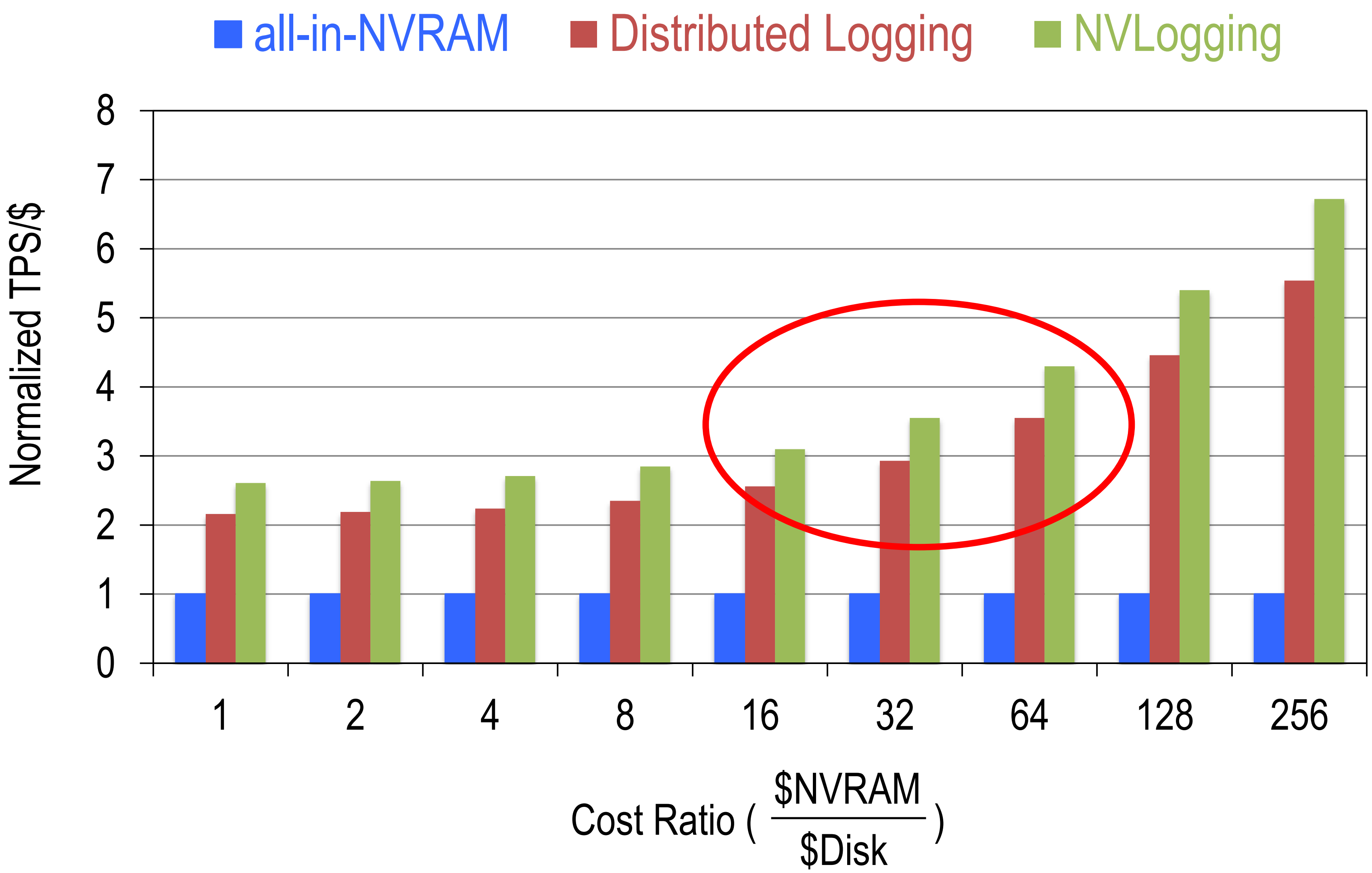

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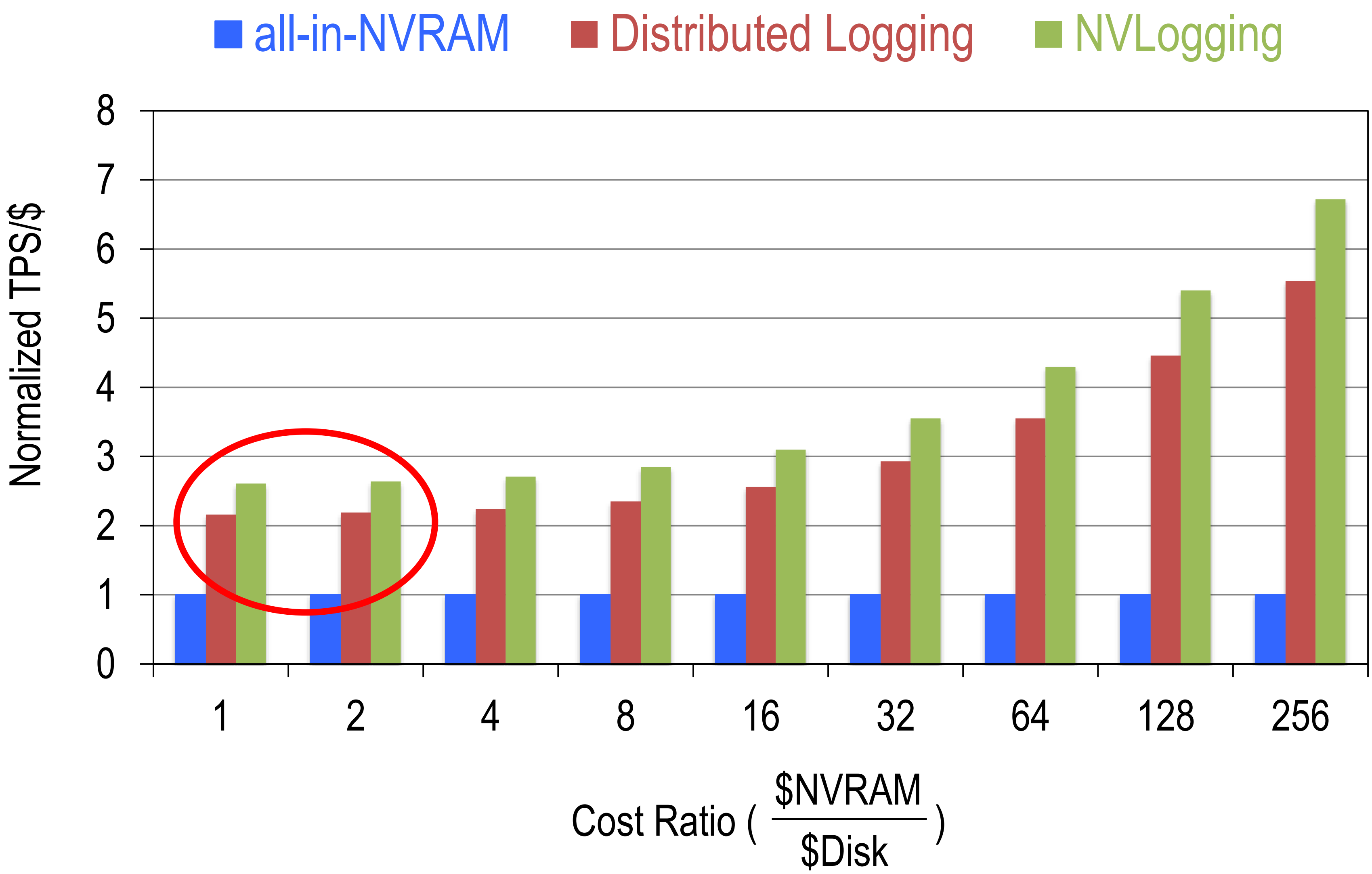
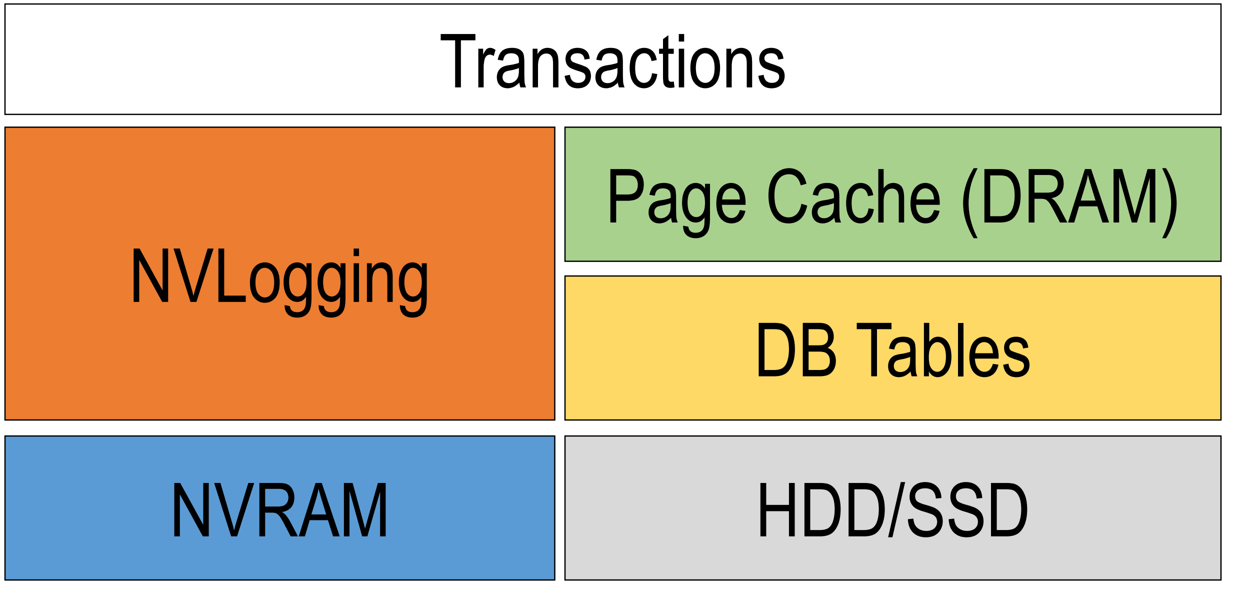


Conclusion



1 **Cost-effective Solution for DB system**

Higher TPS/$

2 **Per-transaction Logging with NVRAM**

Exploit NVRAM's both non-volatility and byte-addressability

Thanks!

Jian Huang

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Karsten Schwan   Moinuddin K. Qureshi

Q&A