Scalable Transaction Processing on Multicores [Shore-MT & DORA]

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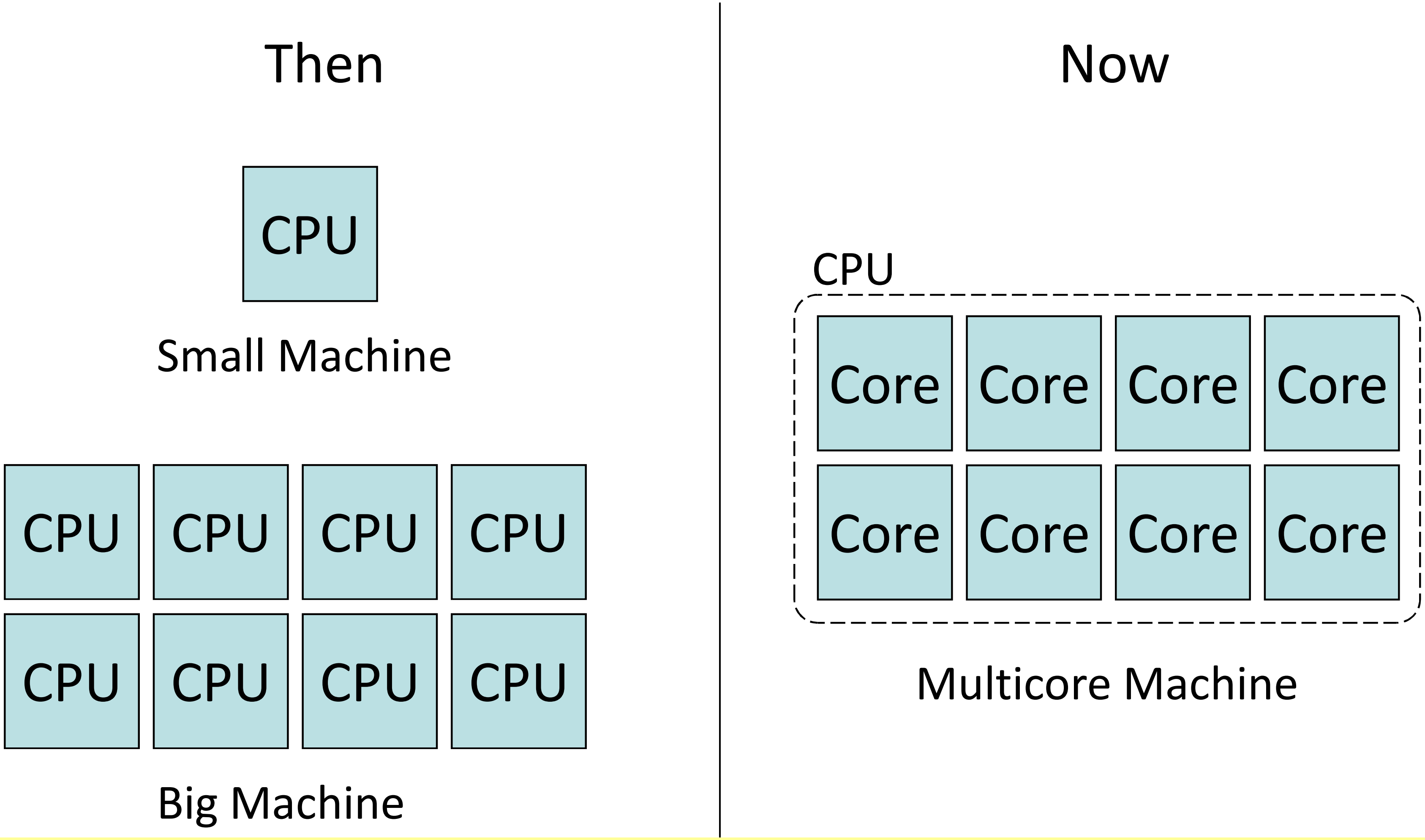
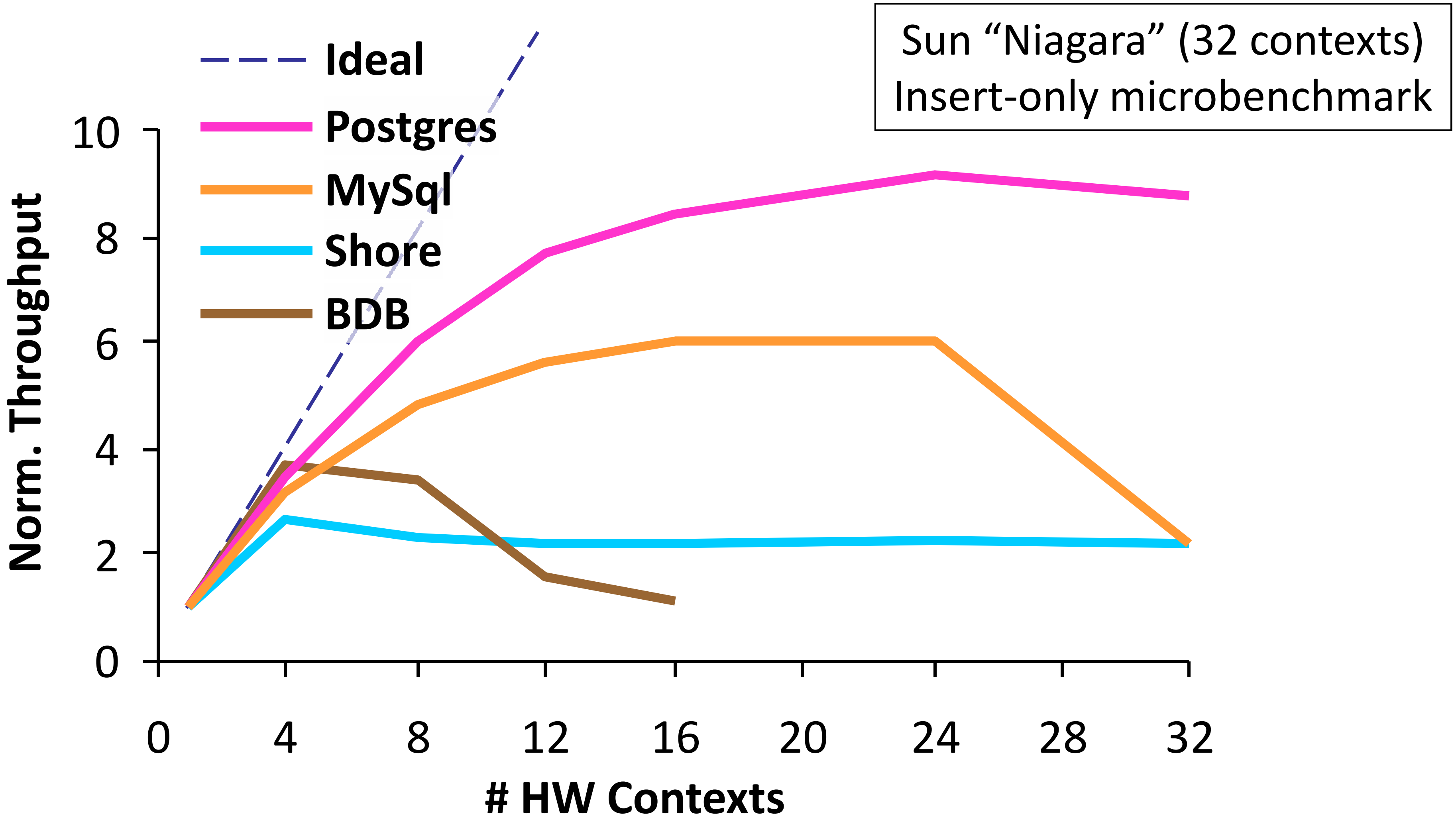
Multicore "cluster on a chip"



- Parallelism of yesterday's "big" machine on one chip

Database Engine Scalability



- Best scalability just 30% of ideal

Shared Everything vs. Nothing

- Shared Everything
  - Hard to scale
- Shared Nothing
  - Multiple processes, physically separated data
  - Explicit contention control
  - Perfectly partition-able workload
  - Memory pressure: redundant data/structures

➧ Two approaches complimentary

➧ Focus on scalability of a single (shared everything) instance

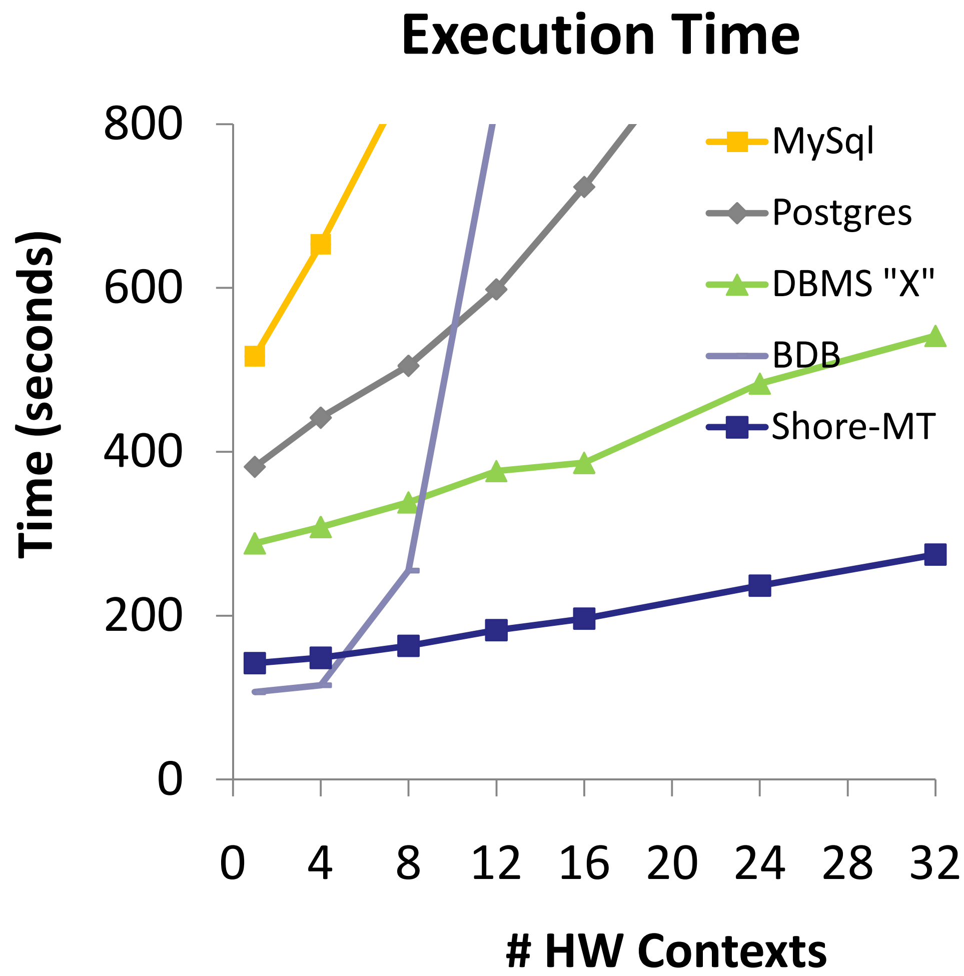
Shore-MT

[EDBT09]
[DaMoN08]

- **Multithreaded version of Shore**

- Why Shore?
- State-of-the-art DBMS features
- Two-phase row-level locking
- ARIES-style logging/recovery

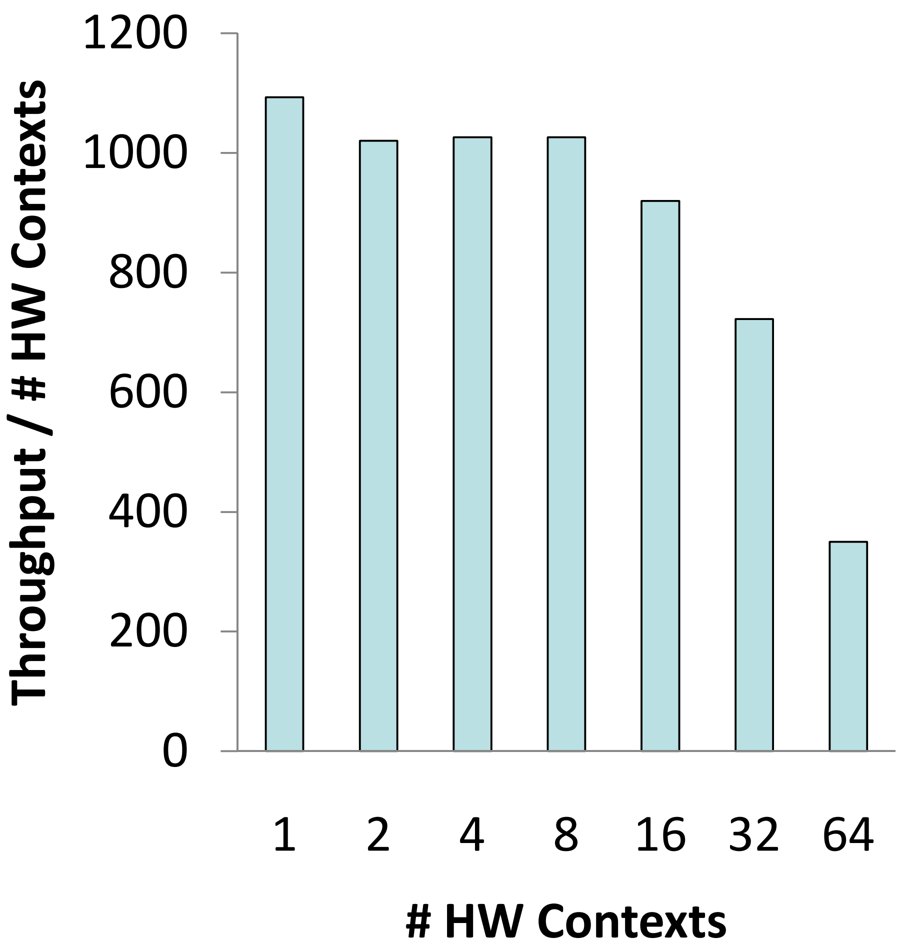
- Shore similar at instruction-level with commercial DBMSs

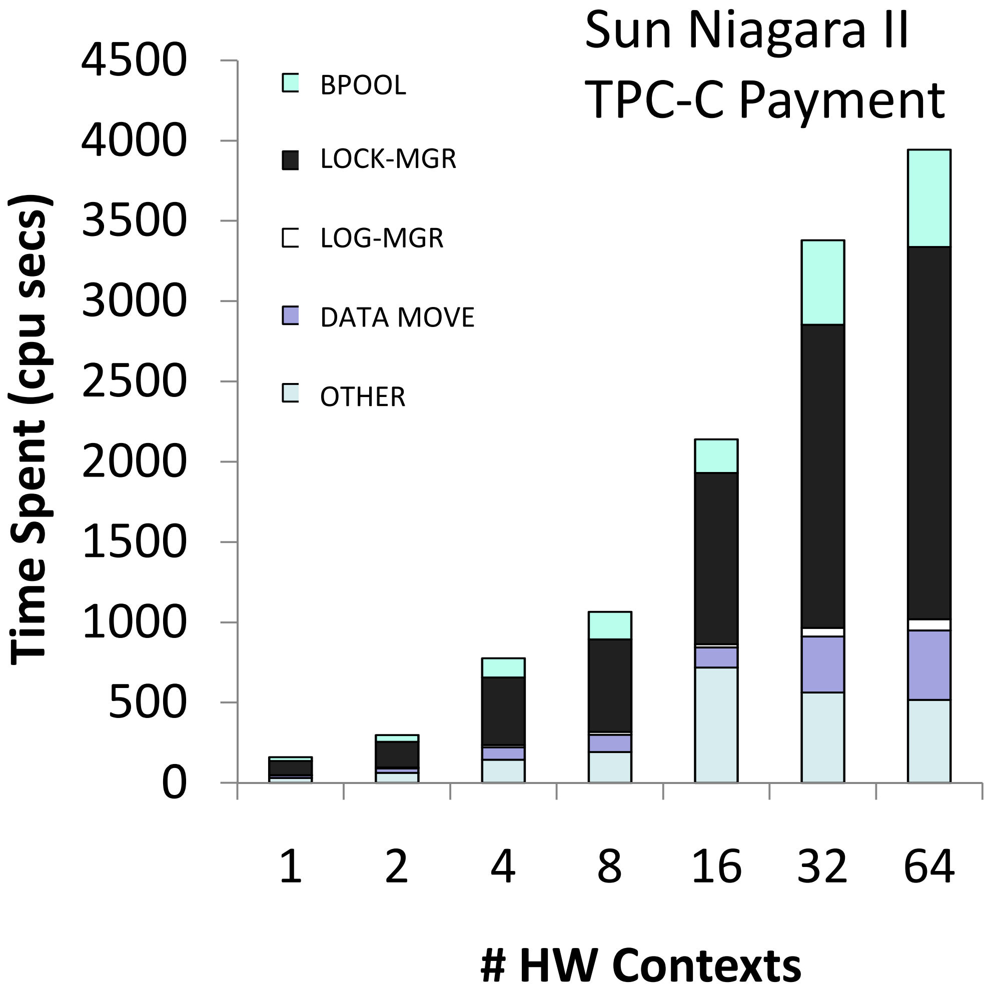


➡ High-performing, scalable conventional engine

➡ Available at: http://diaswww.epfl.ch/shore-mt/

Scalability on Even Higher Parallelism





- Lock manager overhead dominant
- Typical scenario: contention for compatible locks

Data-oriented Transaction Execution

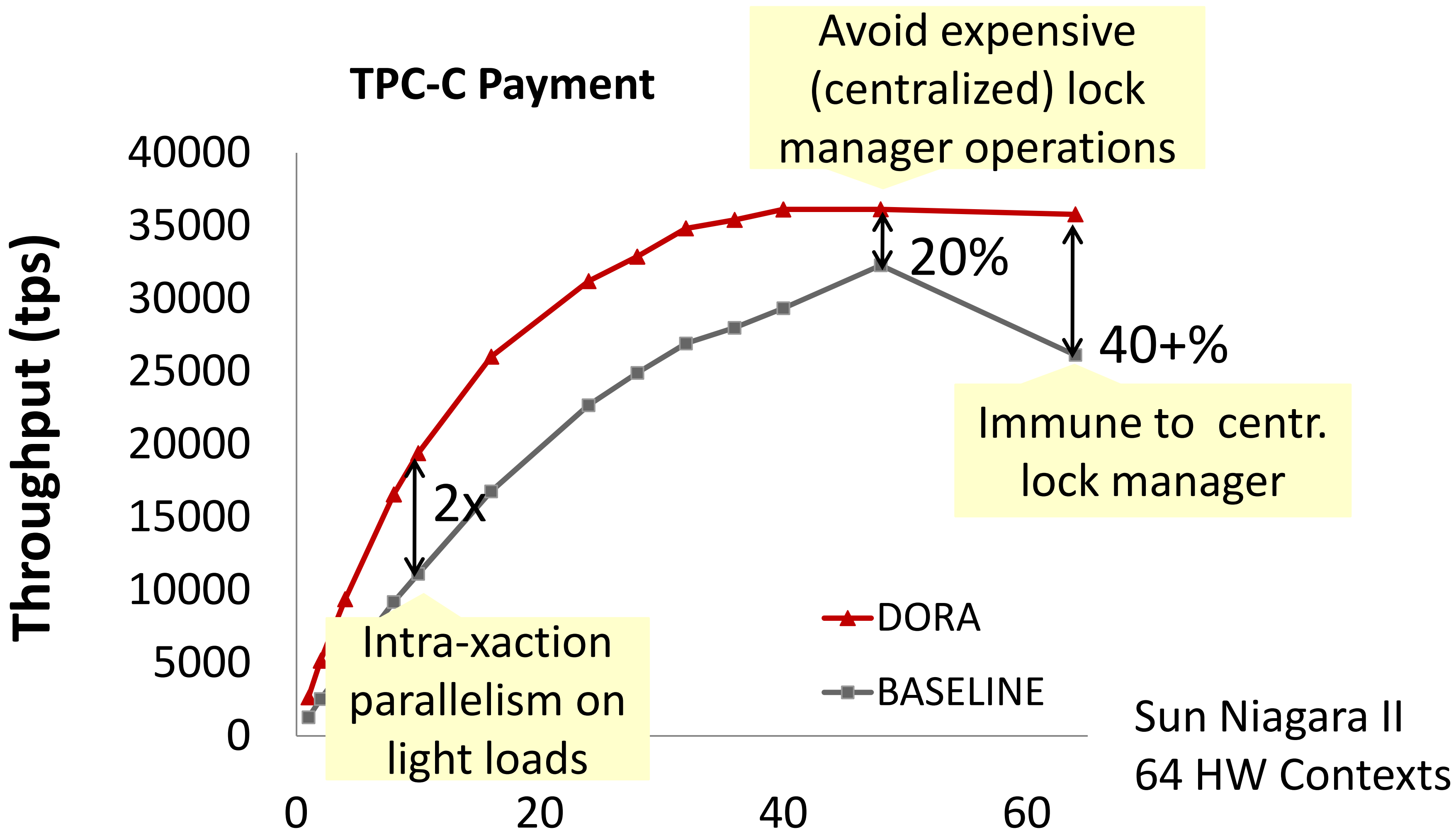
[PVLDB10]

- It is not the transaction which dictates what data the transaction-executing thread will access
- Break each transaction into smaller actions
  - Depending on the data they touch
- Execute actions by “data-owning” threads
- Distribute and privatize locking, data accesses across the chip

➡ New data-oriented execution model

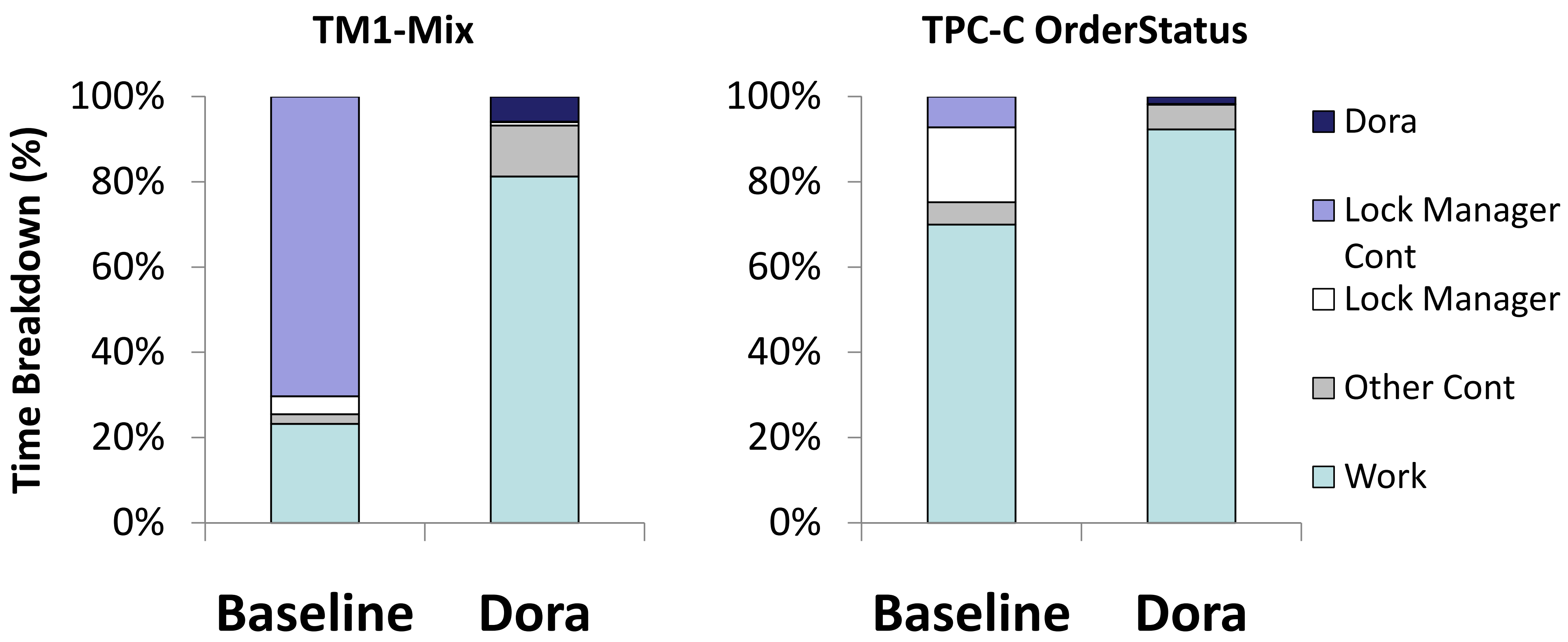
➡ Reduce overhead of locking and data accesses

DORA vs. Conventional – Throughput



- Higher performance in the entire load spectrum

DORA vs. Conventional – At 100% CPU

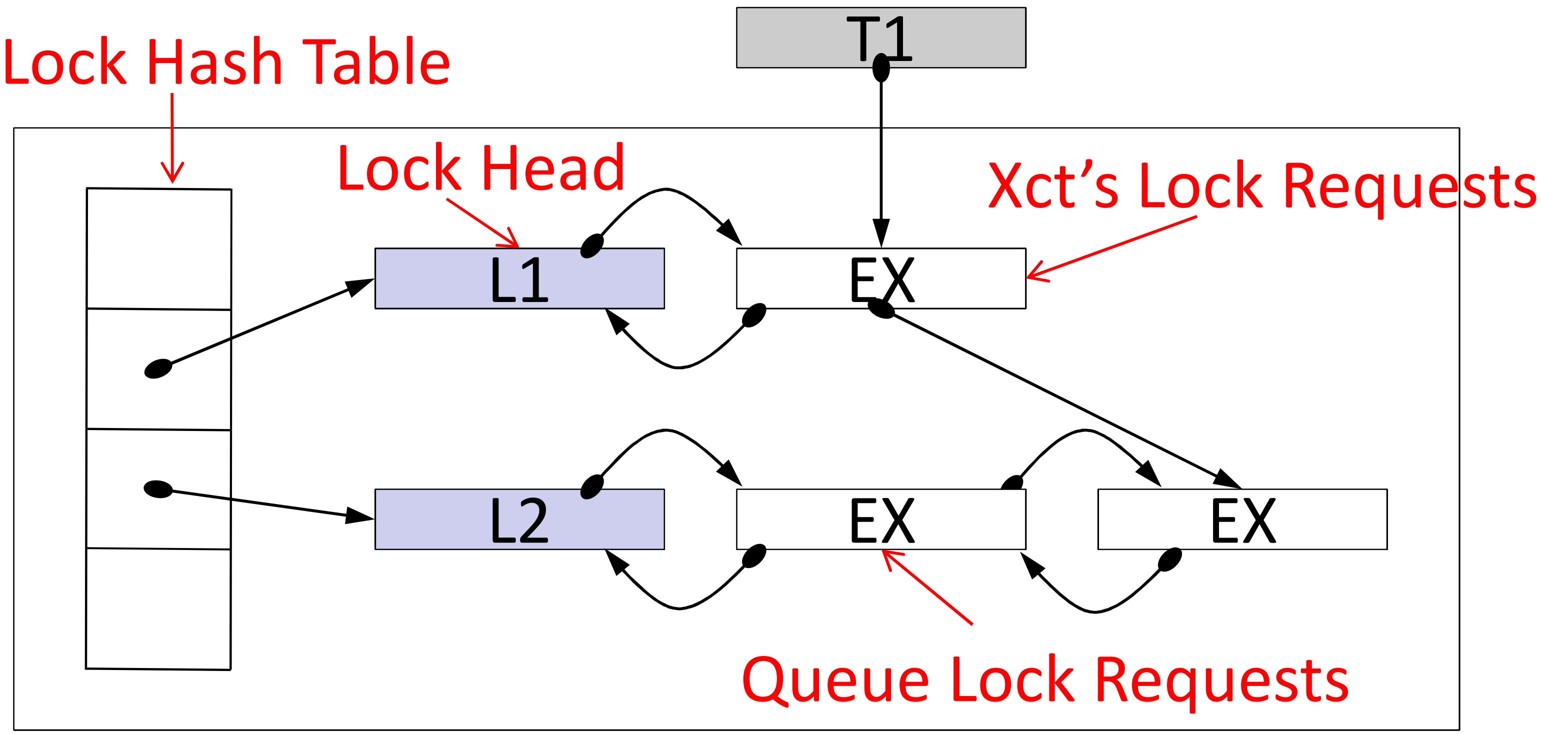


- Eliminate contention on the centr. lock manager
- Significantly reduced work (lightweight locks)

Roadmap

- Introduction
- **Conventional execution**
- Data-oriented transaction execution
- Evaluation
- Conclusions

Typical Lock Manager

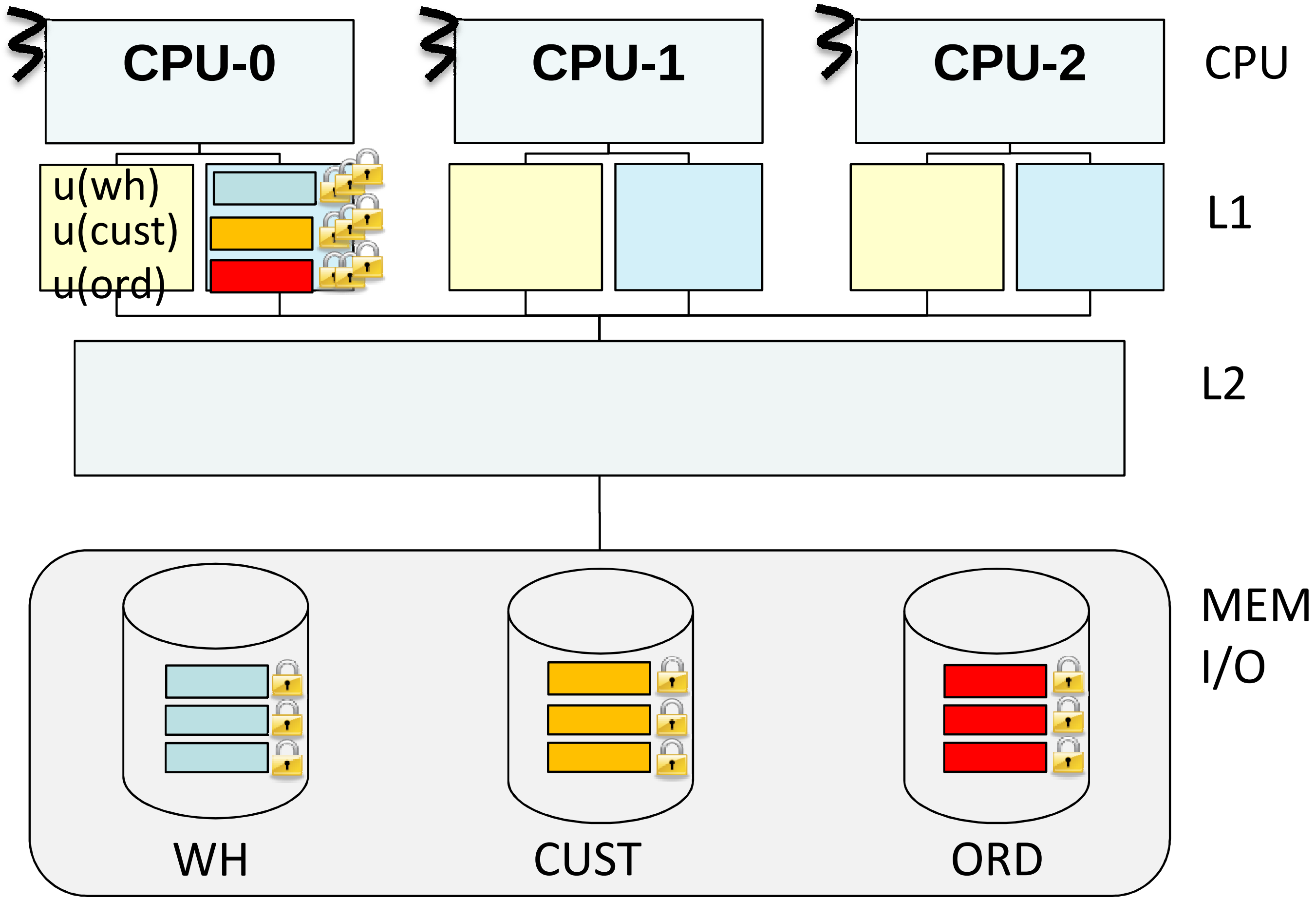


The higher the HW parallelism → Longer Queues of Requests → Longer CSs → Higher Contention

Conventional - Example

Transaction:

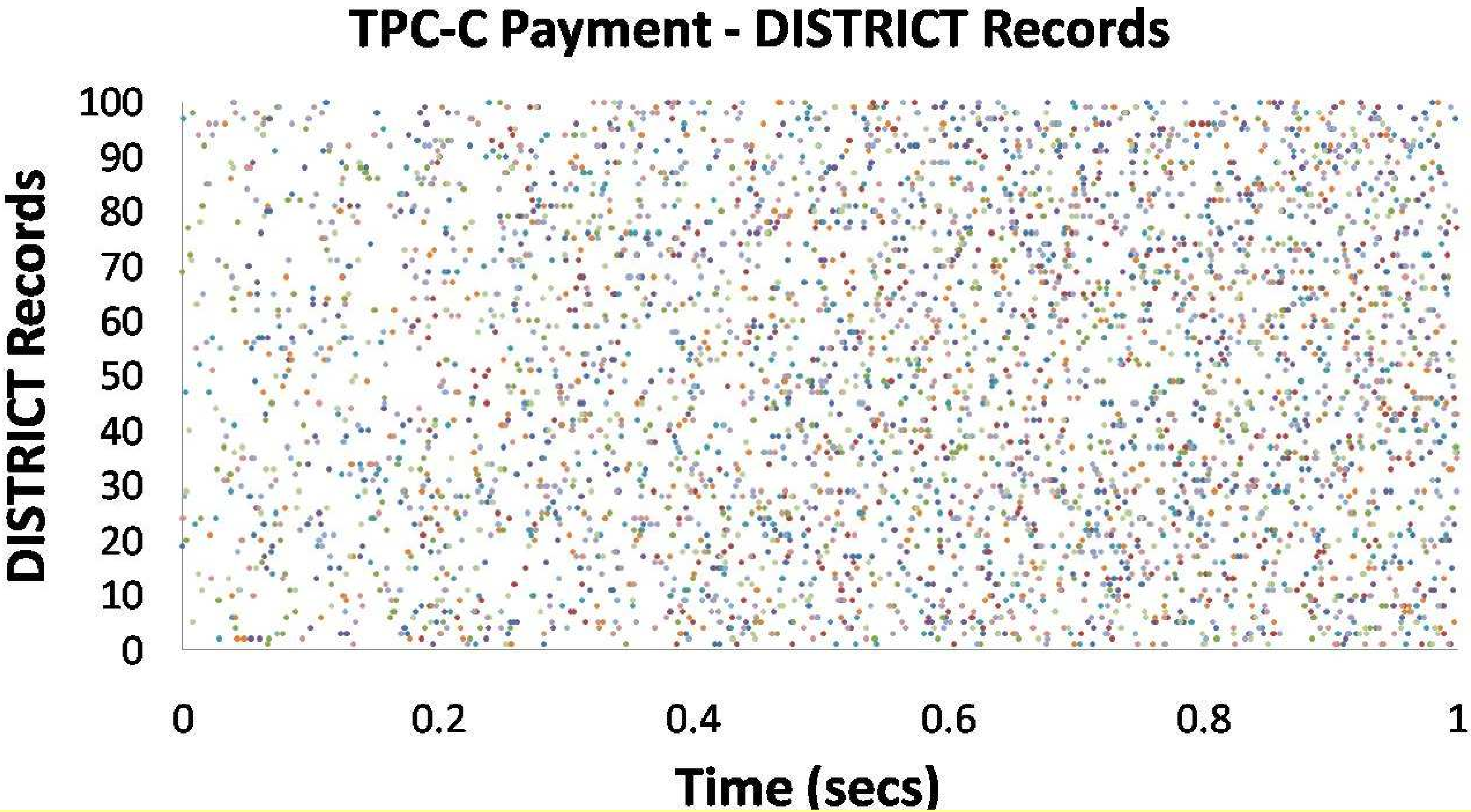
I	D
u(wh)	
u(cust)	
u(ord)	



I = Instruction

D = Data

Conventional - Access Pattern



- Unpredictable access pattern
- Source of contention

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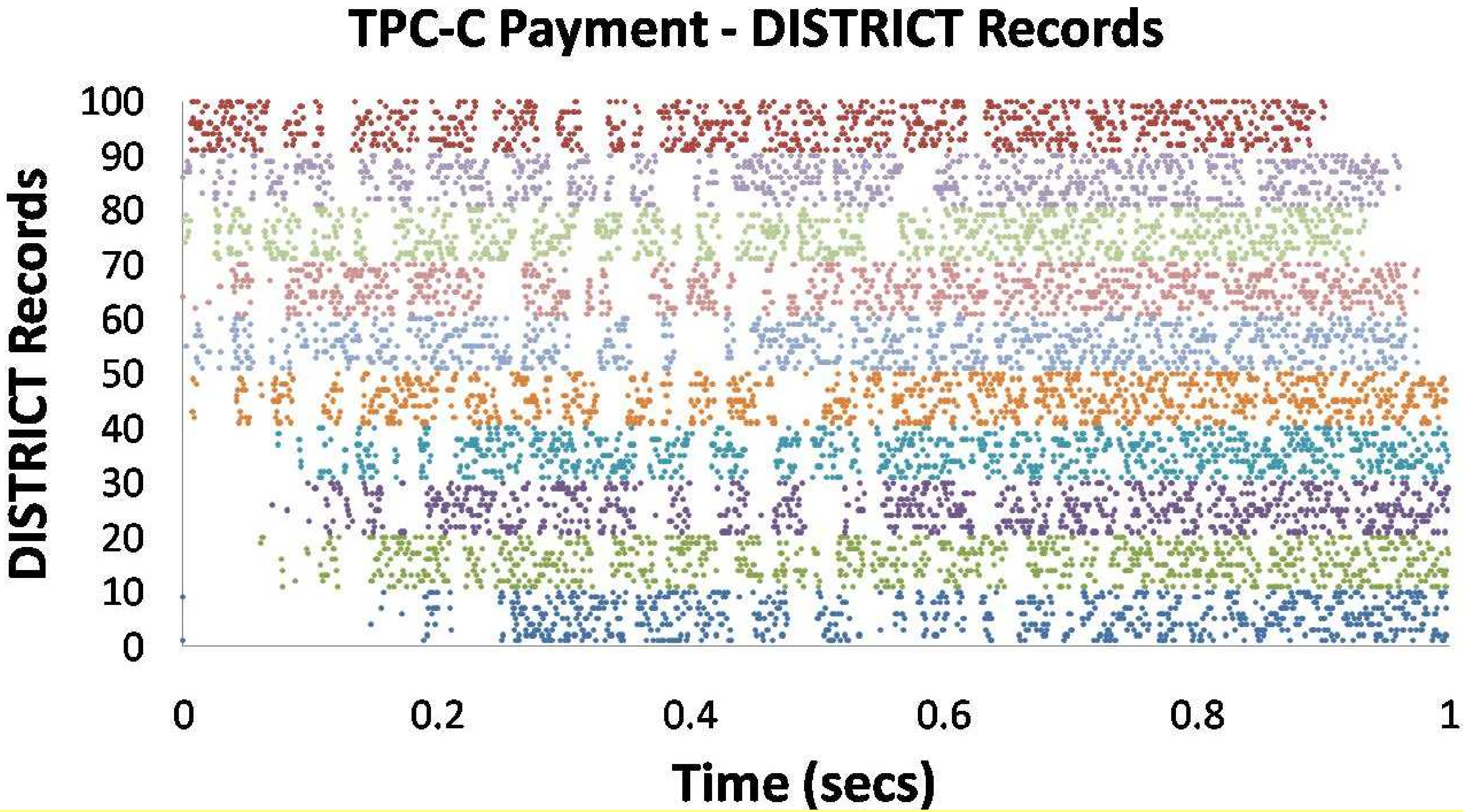
Dora - Access Pattern

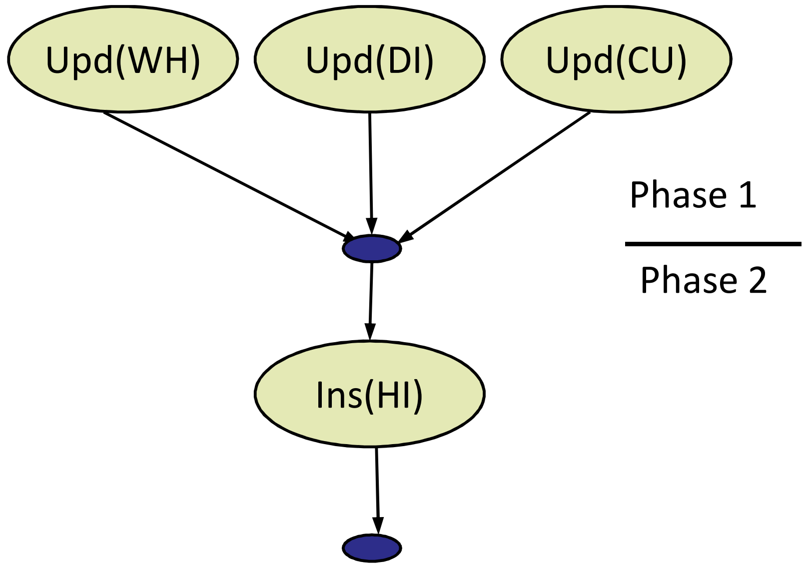


- Predictable access patterns
- Optimizations possible (e.g. no centralized locks)

Transaction Flow Graph

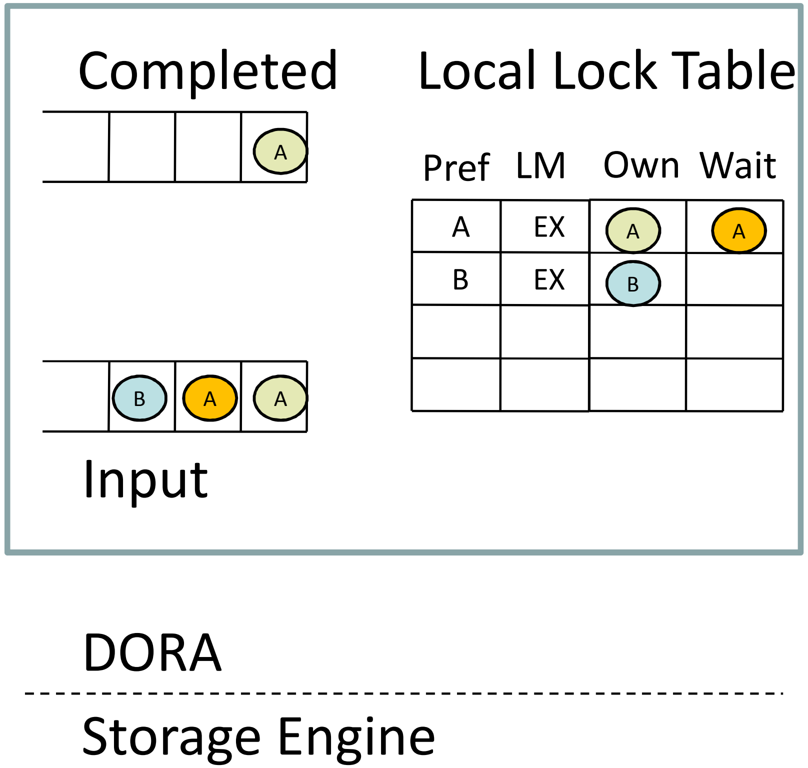
- Each transaction input is a graph of Actions & RVPs
- Actions
  - Identified by:
  - Table/Index it is accessing
  - Subset of primary key
- Rendezvous Points
  - Decision points (commit/abort)
  - Separate different phases
  - Counter of the # of actions to report
  - Last to report initiates next phase
  - Enqueue the actions of the next phase

TPC-C Payment

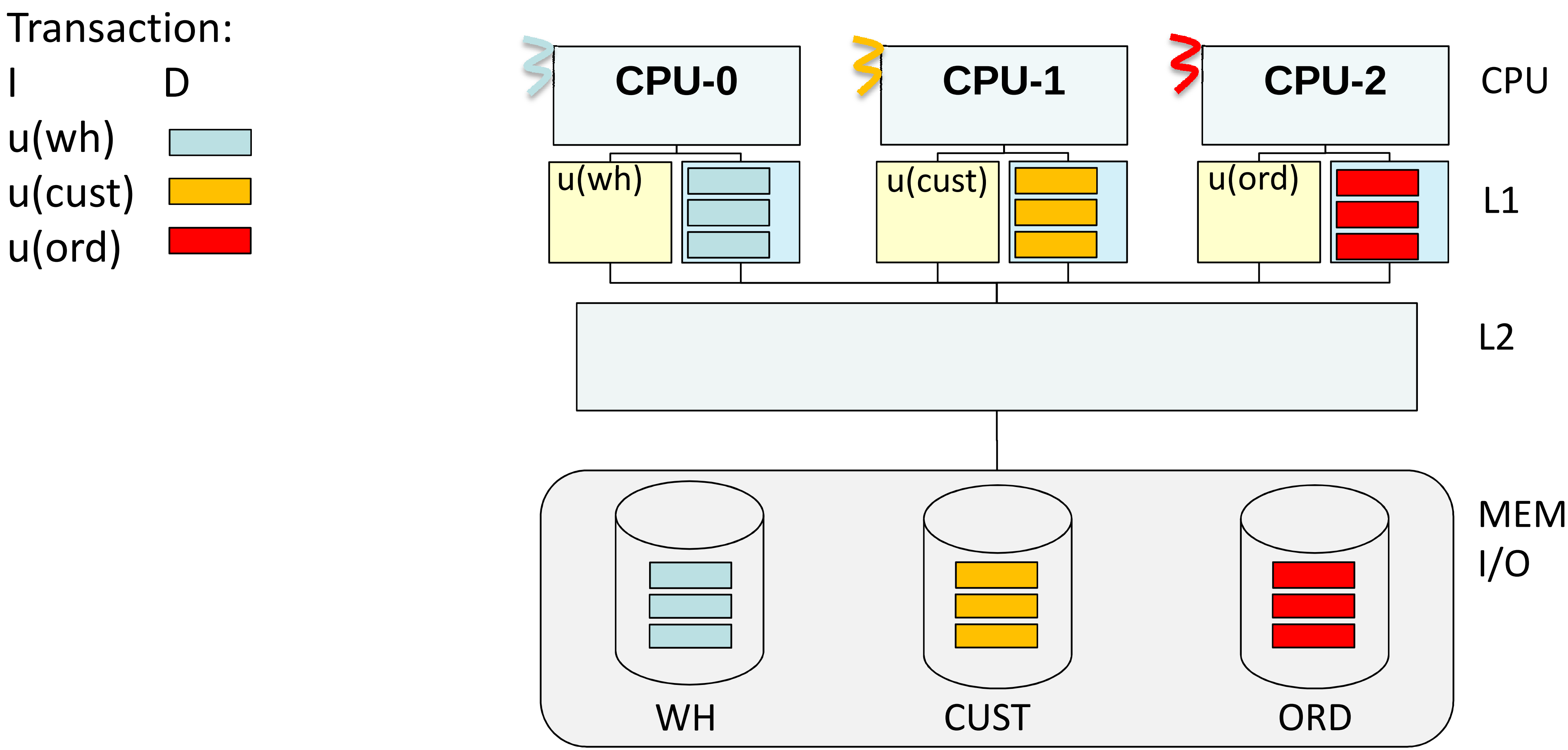


Partitions & Executors

- Partitions at each table
  - Local lock table
    - Map {partof(Key), LockMode}
    - List of blocked actions
  - Input queue
    - New actions
  - Completed queue
    - On xct commit/abort
    - Remove from local lock table
- Executor thread
  - Loop completed/input queue
  - Asynchronous communication / event-based



Dora - Example



- Centralized lock free
- Improved data reuse

Dora vs. Shared-nothing

- No physical partition of data
- No duplicated data structures
- Smaller memory footprint
- A single log manager
- No need for distributed transactions
  - No need for 2PC

➡ Dora is NOT a shared-nothing system

➡ Combines benefits of both

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Experimental Setup

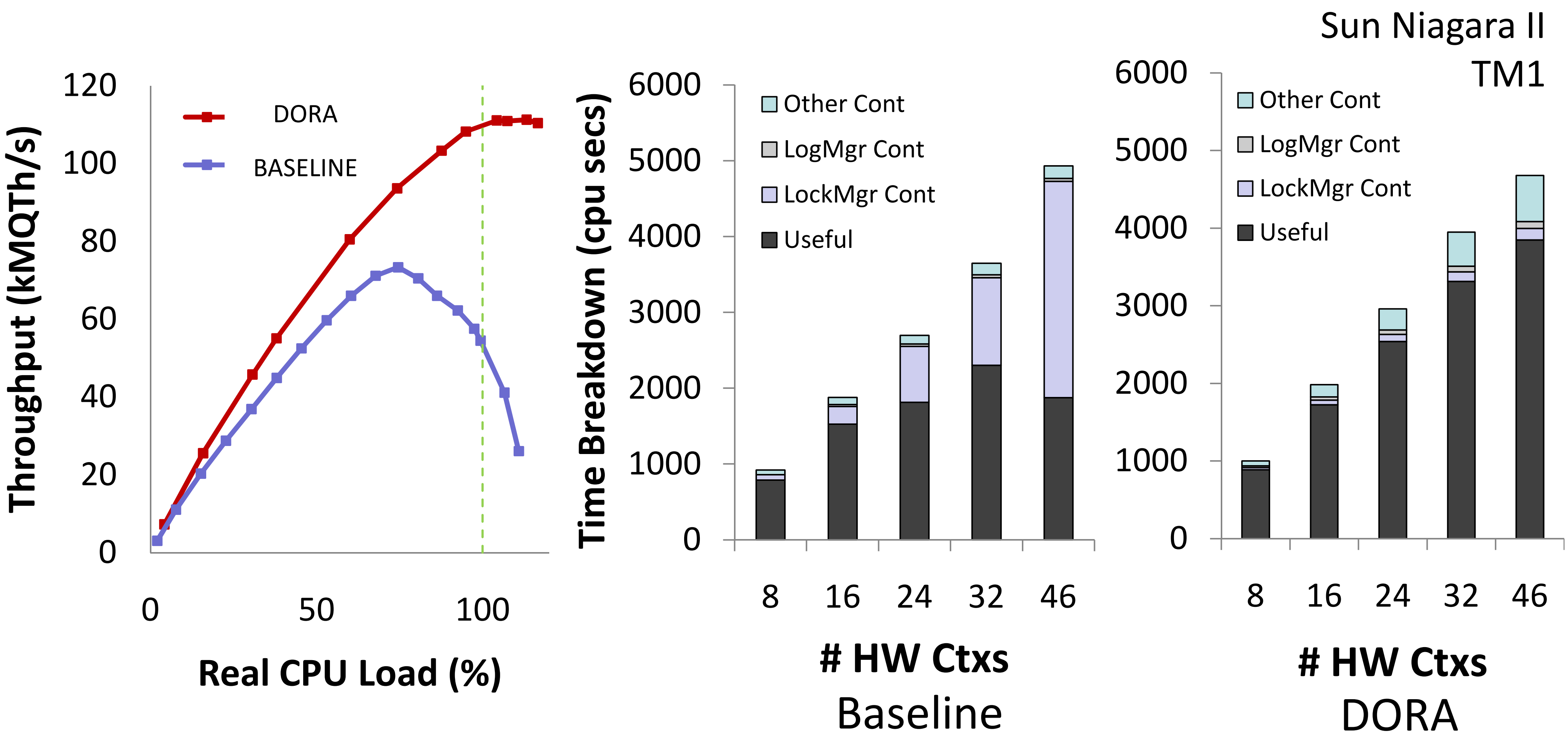
Hardware

- Sun Niagara II processor
- 8 cores with 8 HW contexts per core (64 HW ctxs)
- 32 GB main memory

Workloads

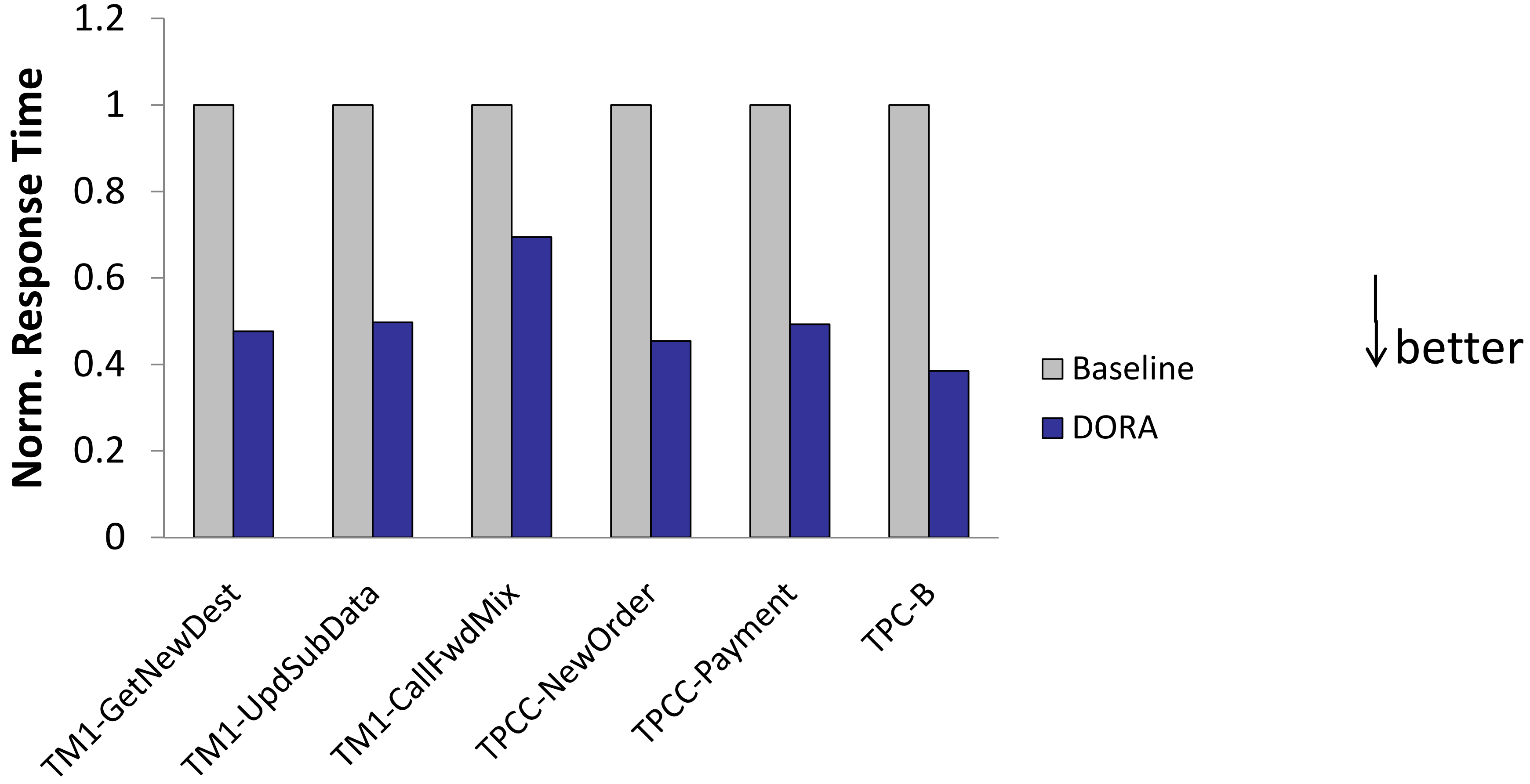
- Update-intensive, short-running transactions
- TPC-C – 100 warehouses (13GB)
- TM1 – 1M subscribers (1.5GB)

Eliminating contention on the lock mgr



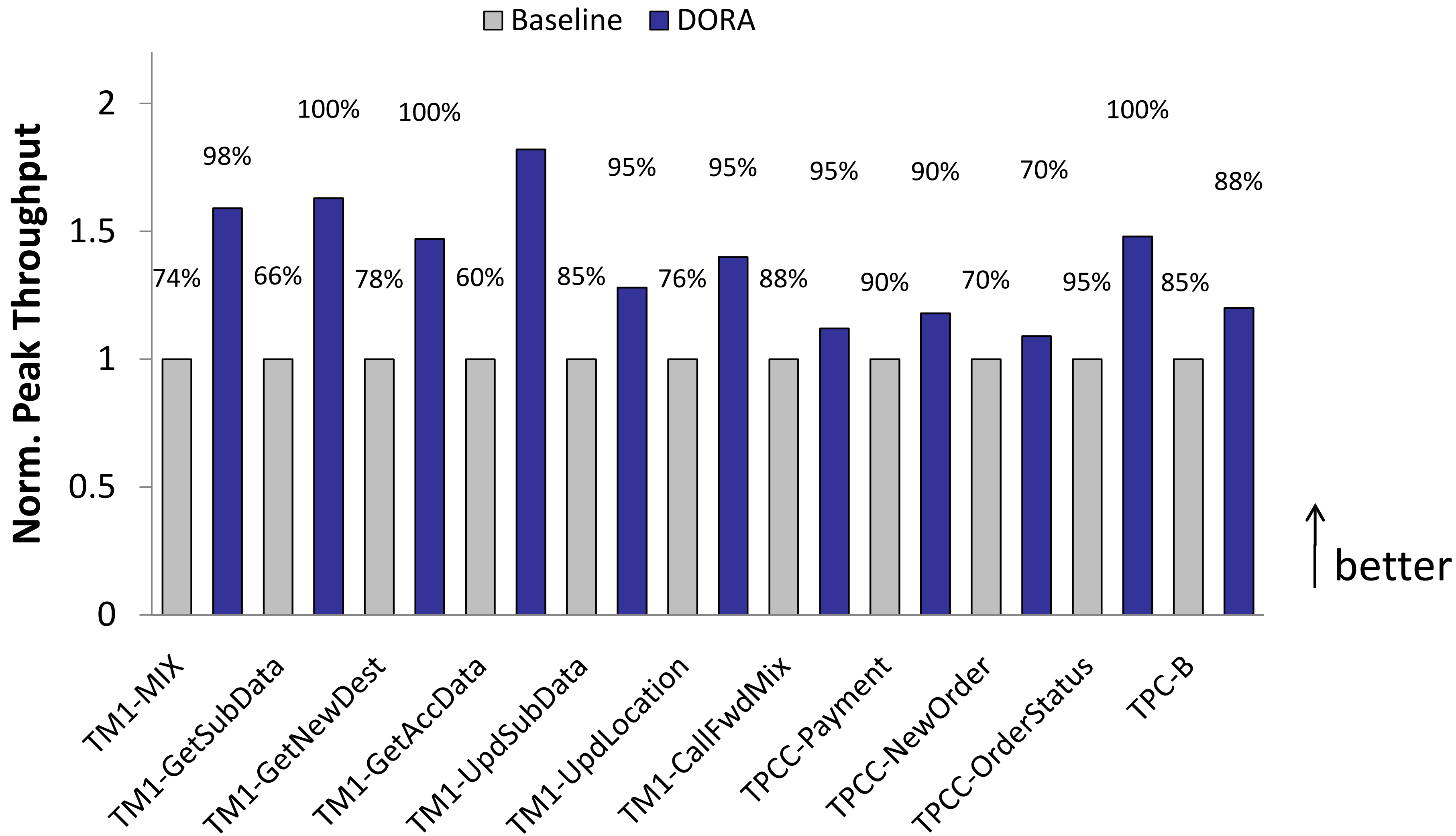
- Eliminates contention on the lock manager
- Linear scalability to 64 HW ctxs
- Immune to oversaturation

Response time for single client



- Exploits intra-xct parallelism
- Lower response times on low-load

Peak Performance



- Higher peak performance
- Always close to 100% CPU utilization

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Summary

- Large number of active threads stress scalability of database system
- Data-oriented transaction execution
- Benefits of shared-nothing w/o physical data partitioning
- Small modifications on a conventional storage engine
- Higher performance on the entire load spectrum