PLP: Page Latch-free Shared-everything OLTP

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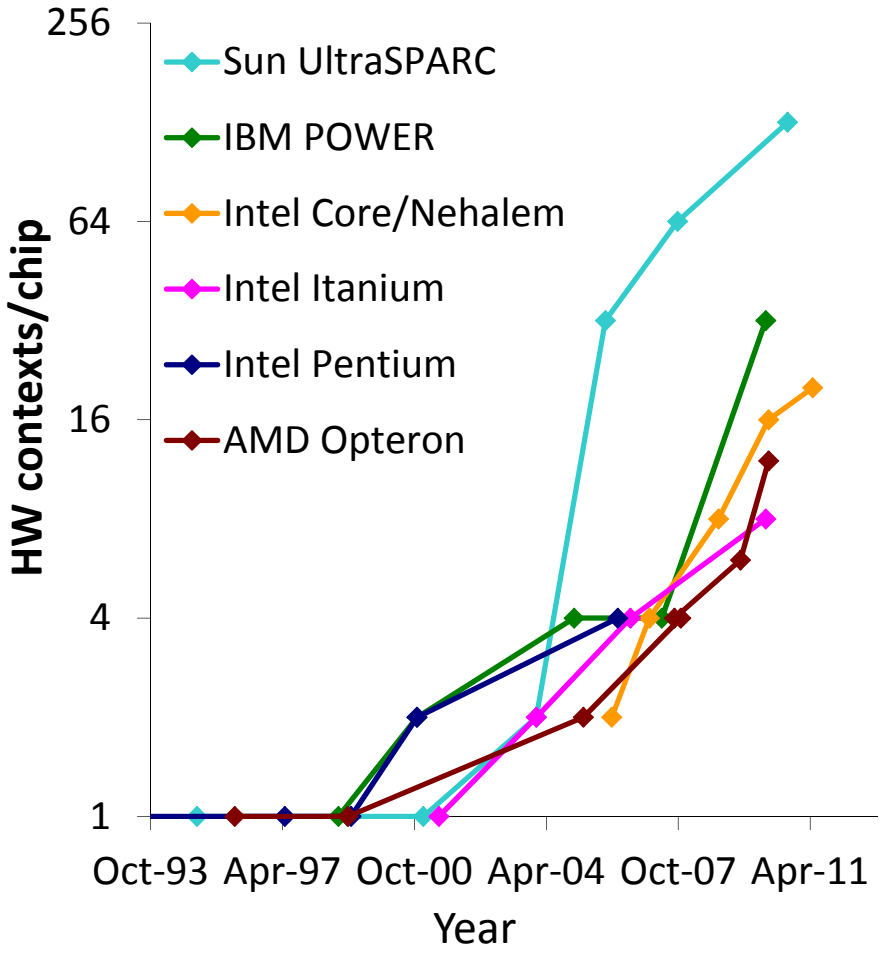
†IBM Almaden Research Center
‡École Polytechnique Fédérale de Lausanne
❖University of Toronto

DATA-INTENSIVE APPLICATIONS AND SYSTEMS

OLTP on Modern Hardware



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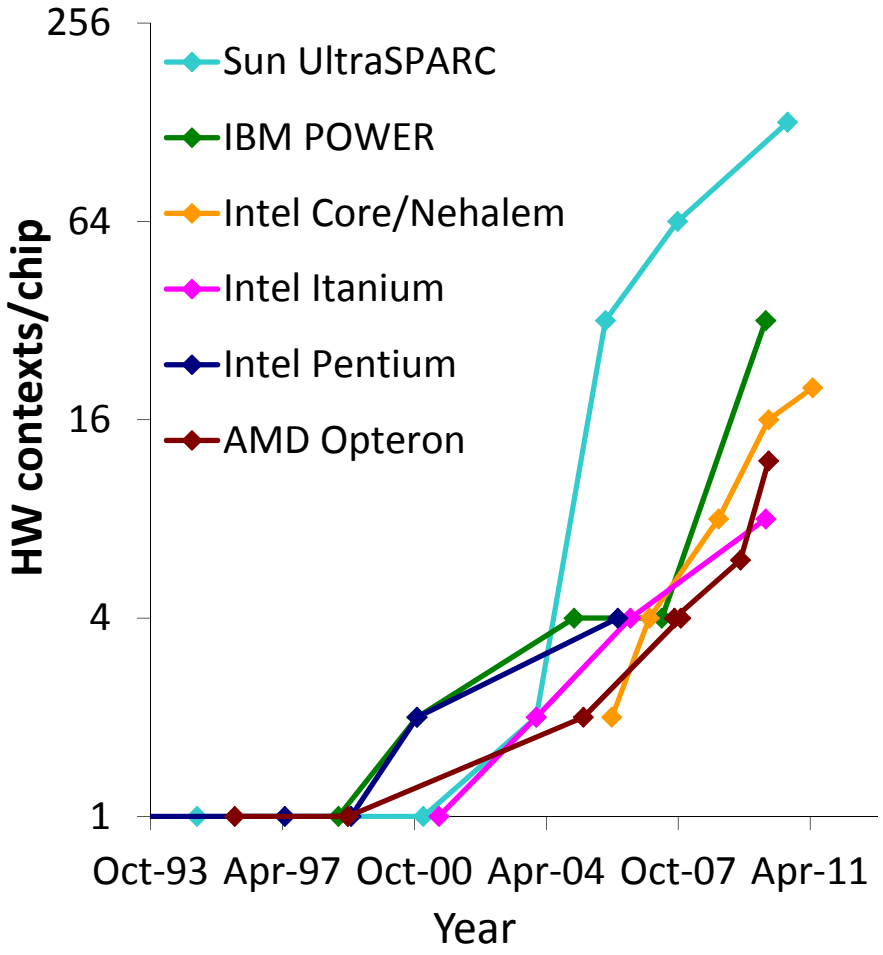
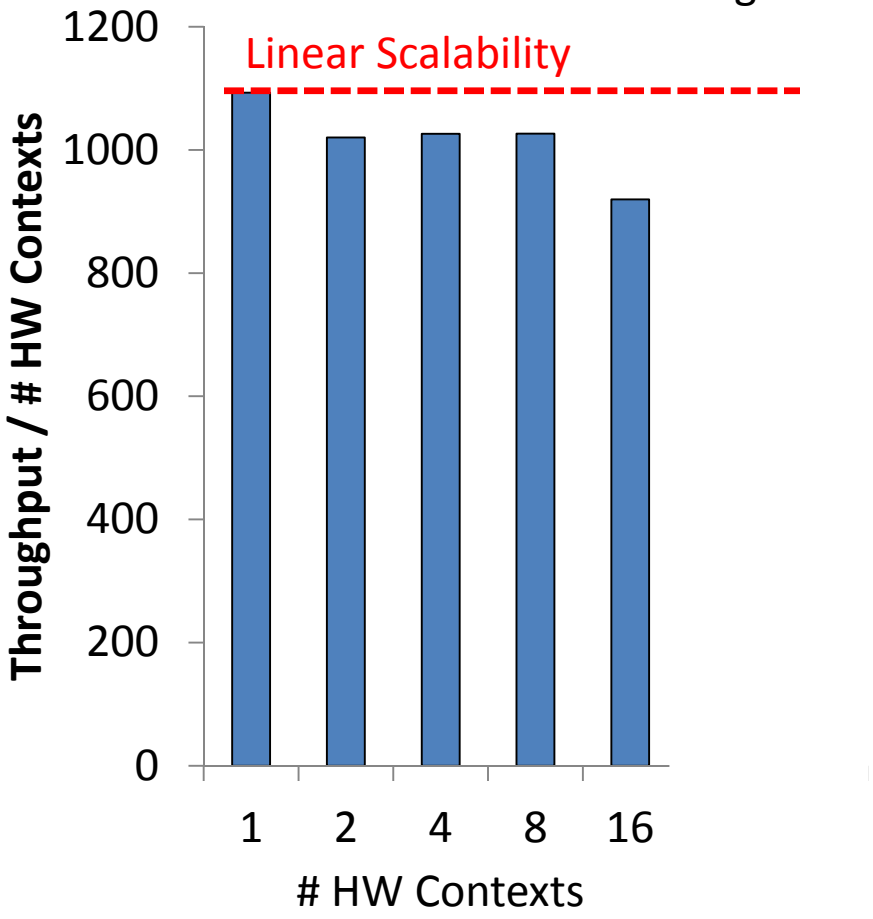


TATP – GetSubData
Sun Niagara T2



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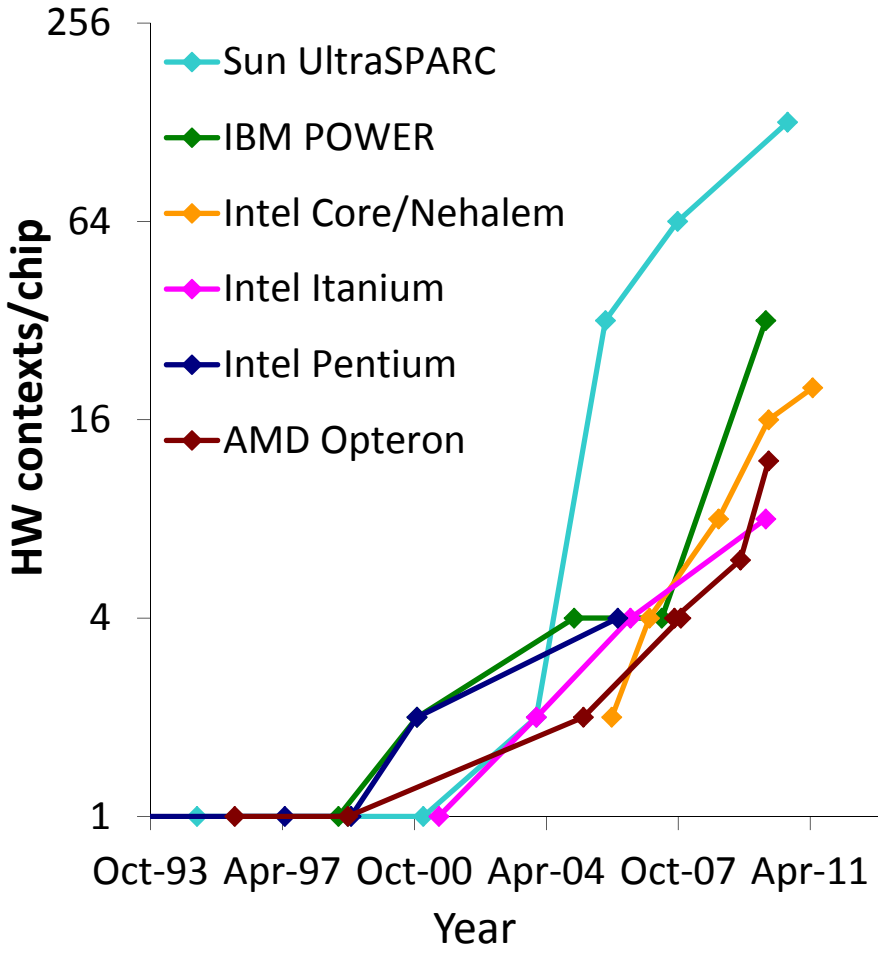

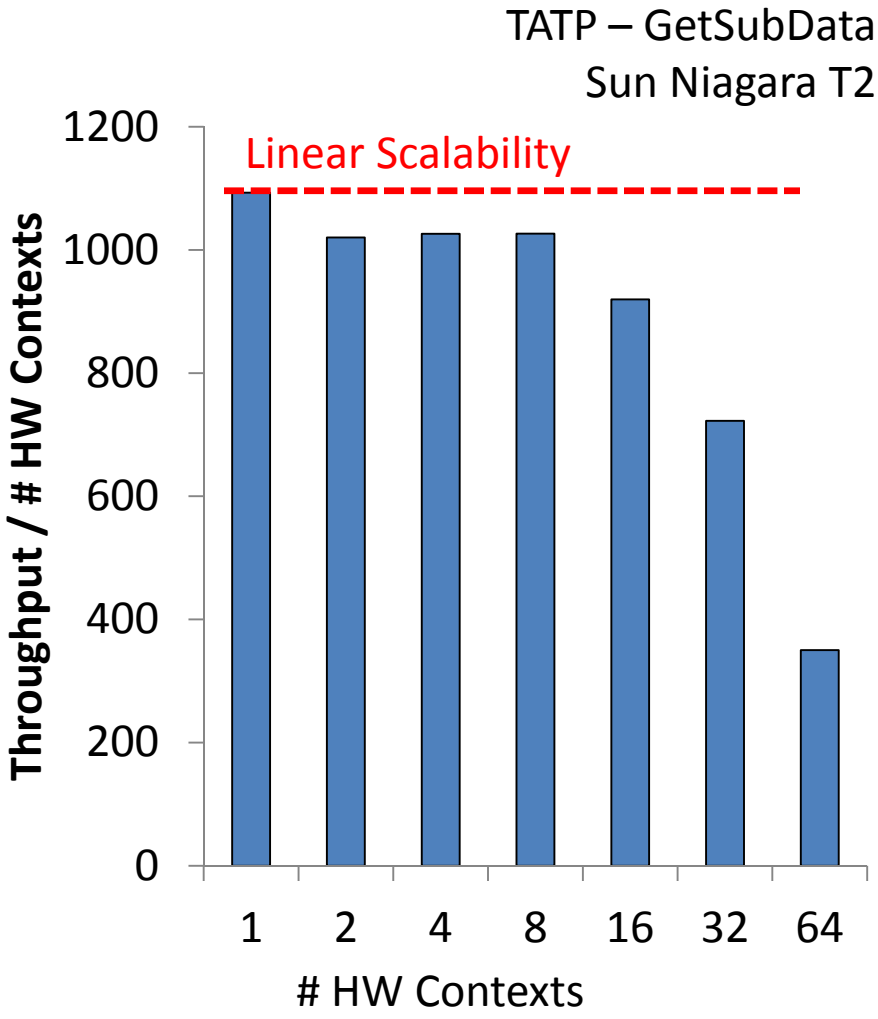

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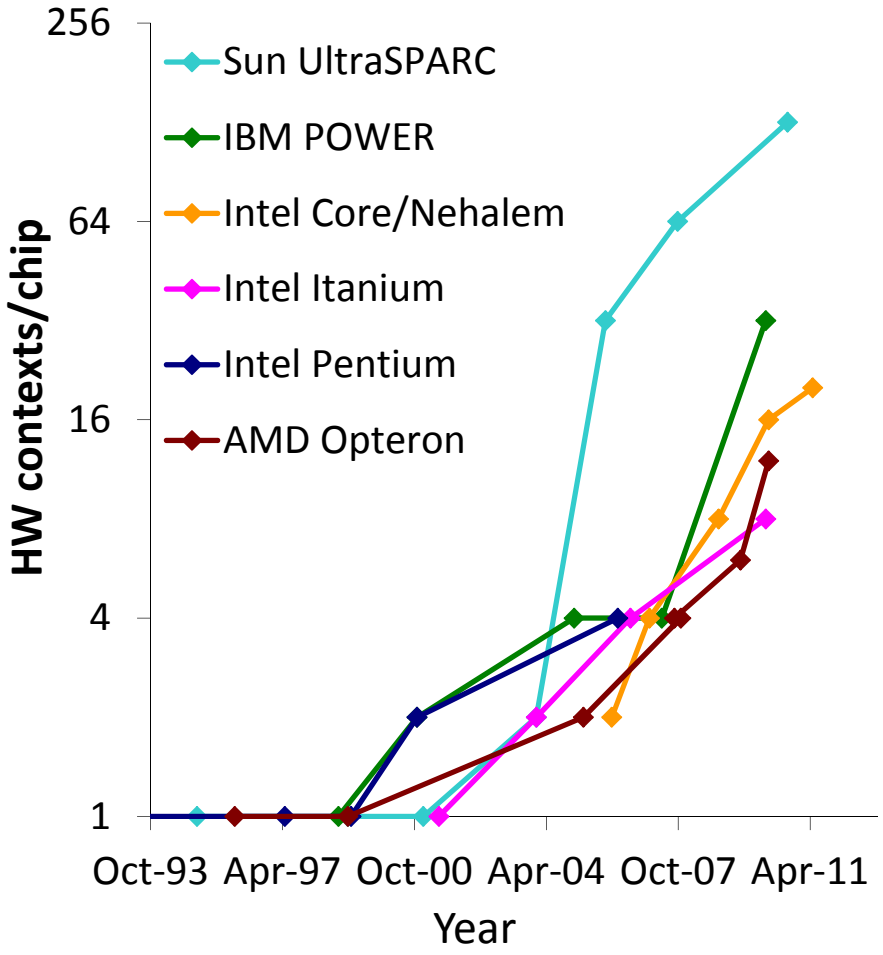
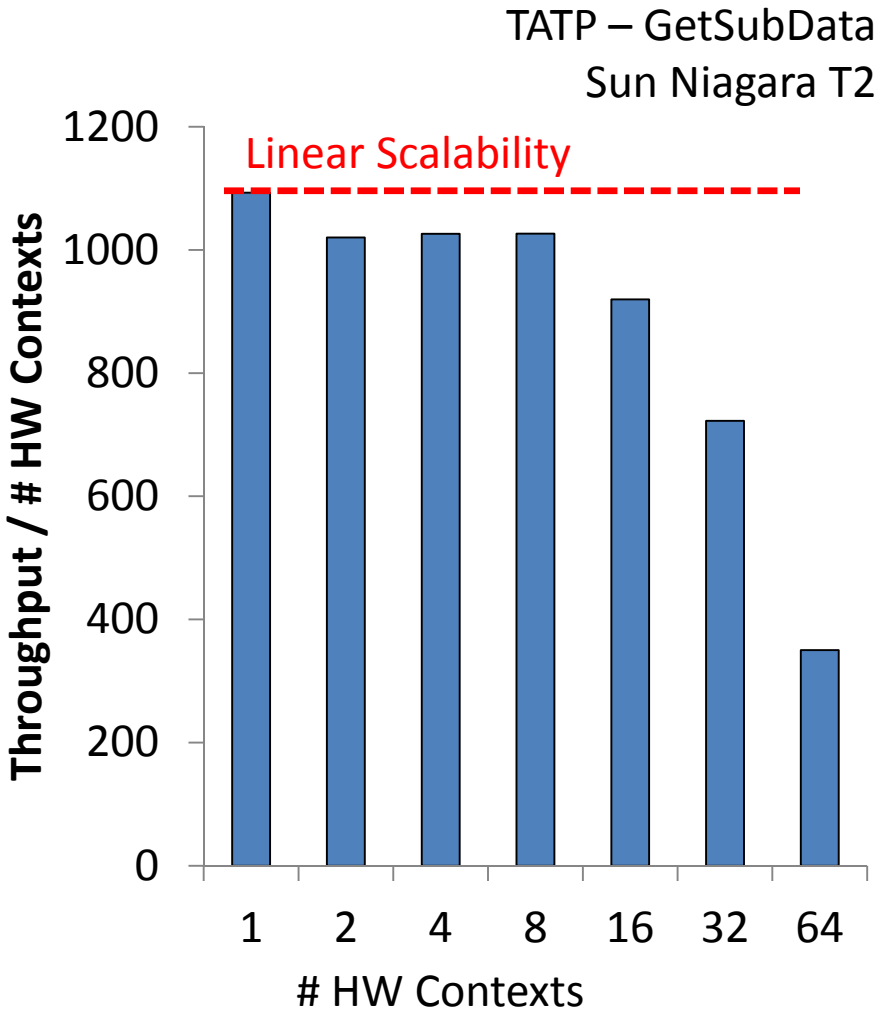
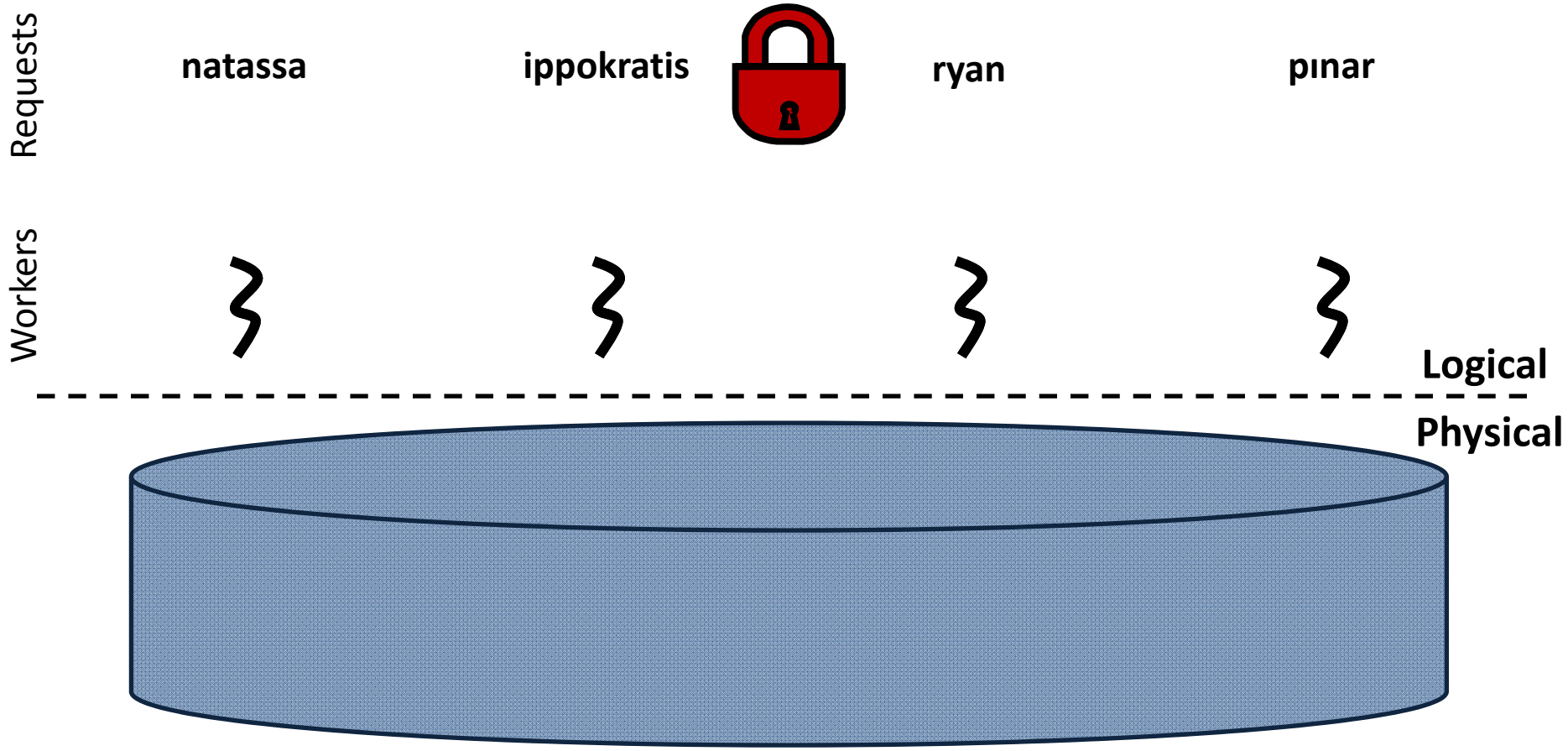




More HW Contexts != Higher Throughput

Shared-Everything



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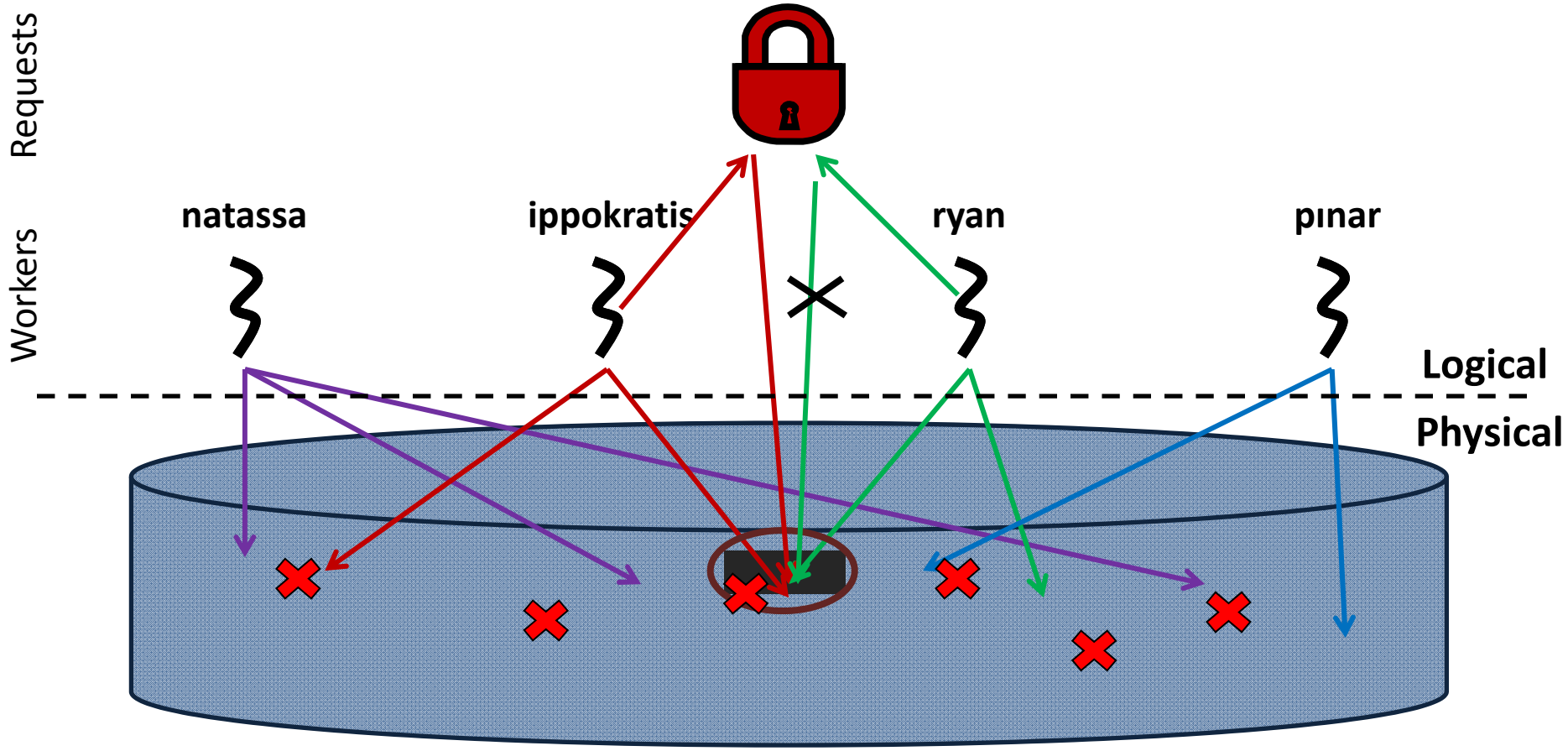

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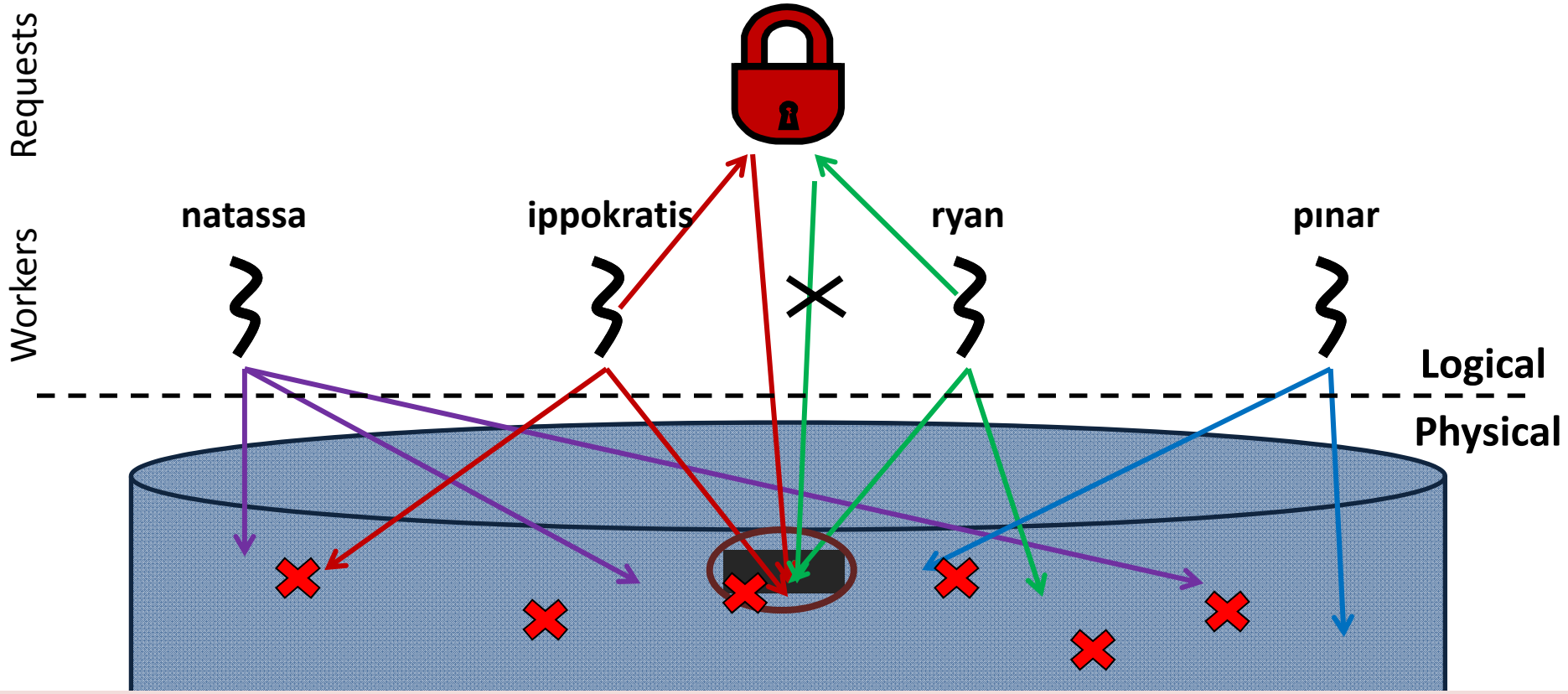
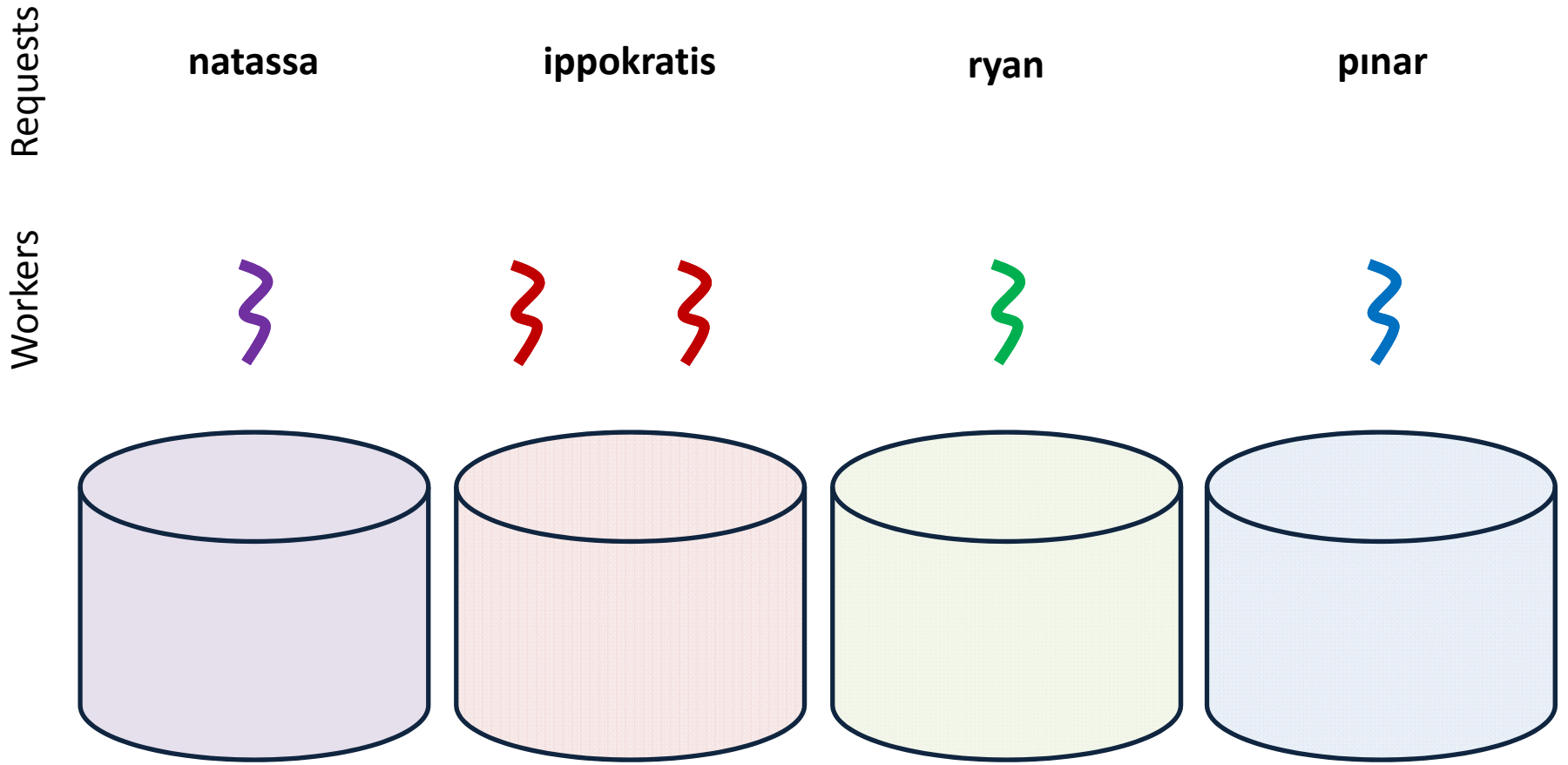


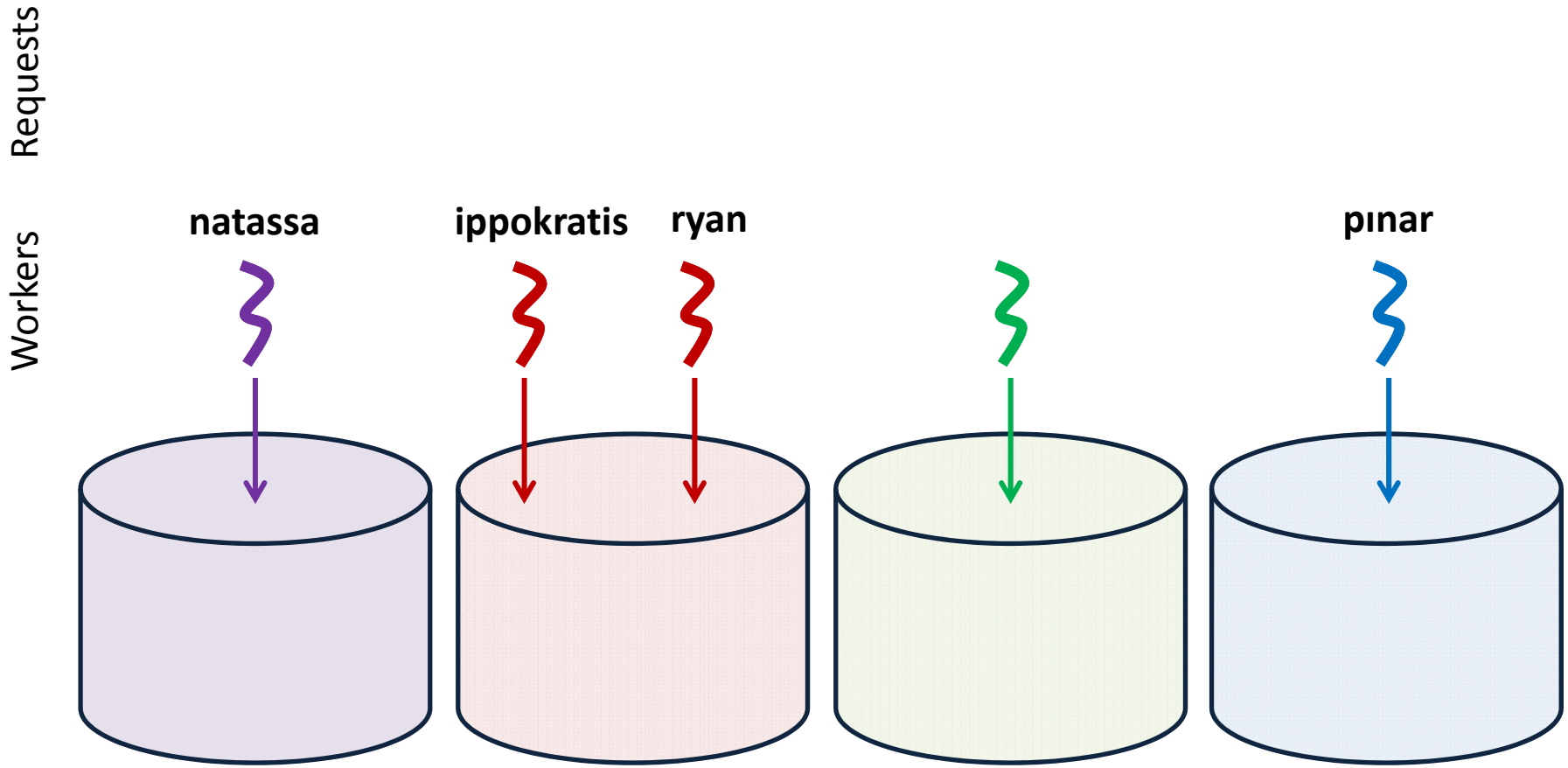
- Contention on shared data objects

Shared-Nothing – Physically Partitioned



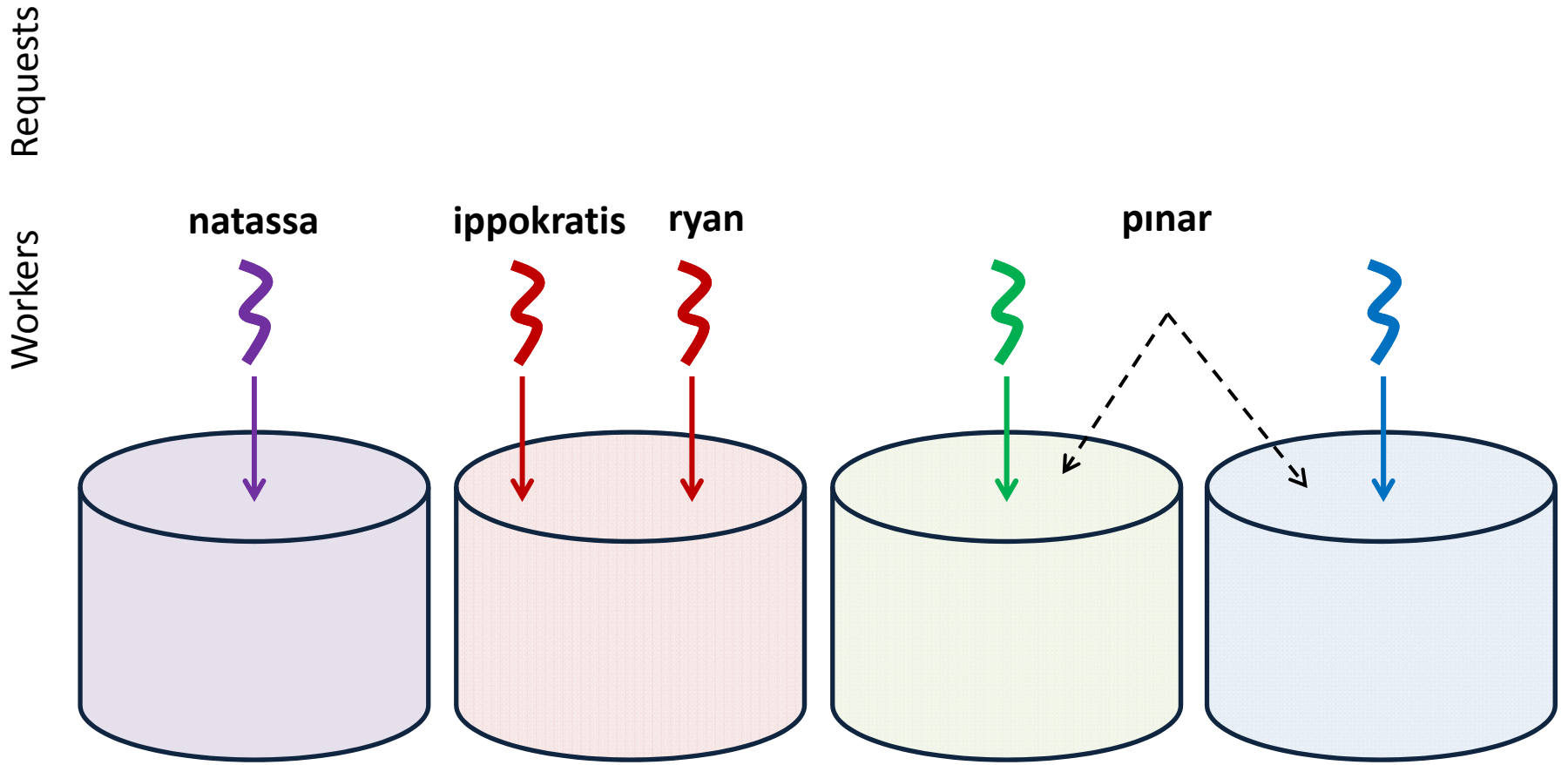
Shared-Nothing – Physically Partitioned

✓ Explicit contention control



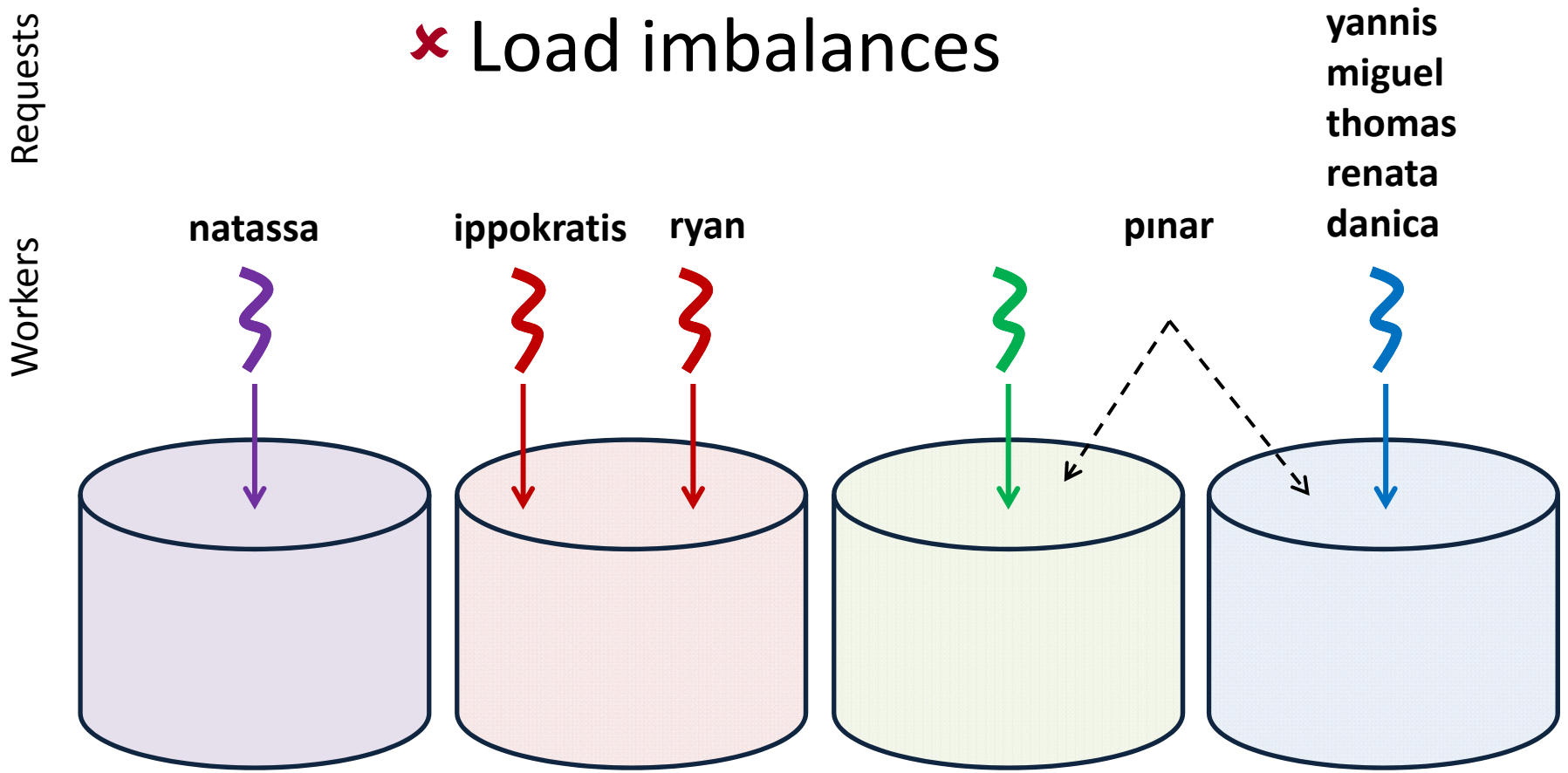
Shared-Nothing – Physically Partitioned

- ✓ Explicit contention control
- ✗ Distributed transactions



Shared-Nothing – Physically Partitioned

- ✓ Explicit contention control
- ✗ Distributed transactions
- ✗ Load imbalances



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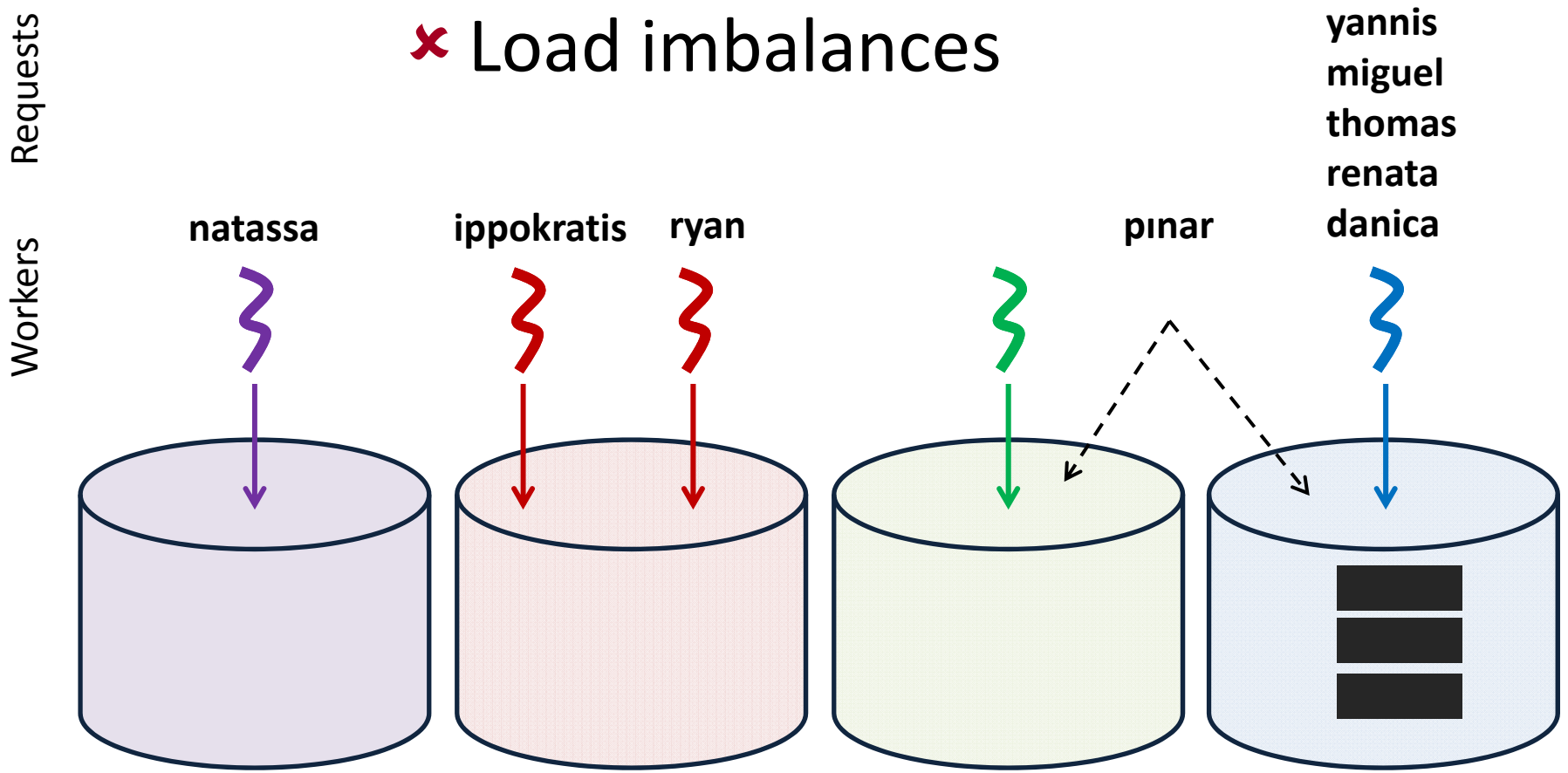
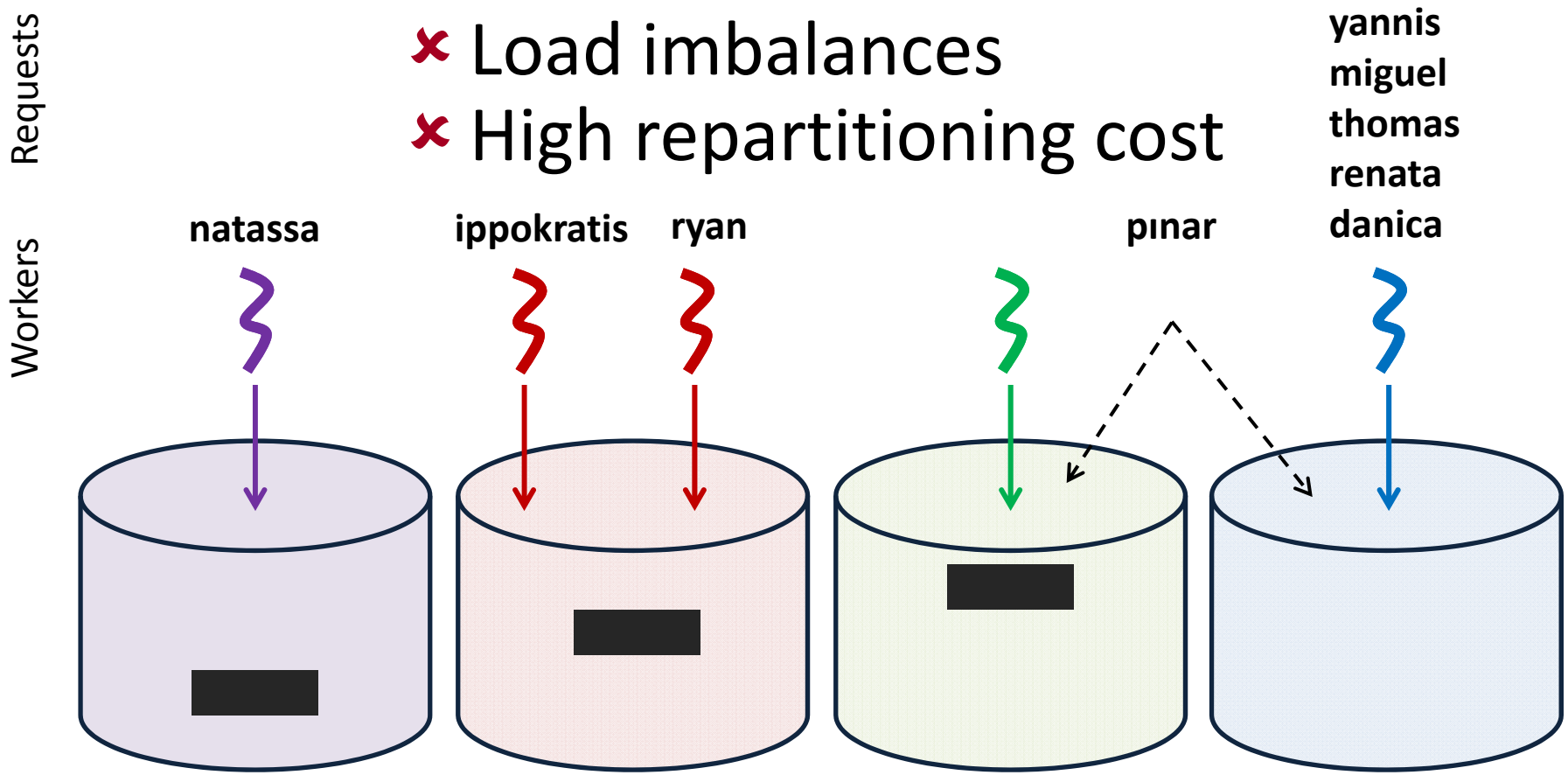


Shared-Nothing – Physically Partitioned

- ✓ Explicit contention control
- ✗ Distributed transactions
- ✗ Load imbalances
- ✗ High repartitioning cost



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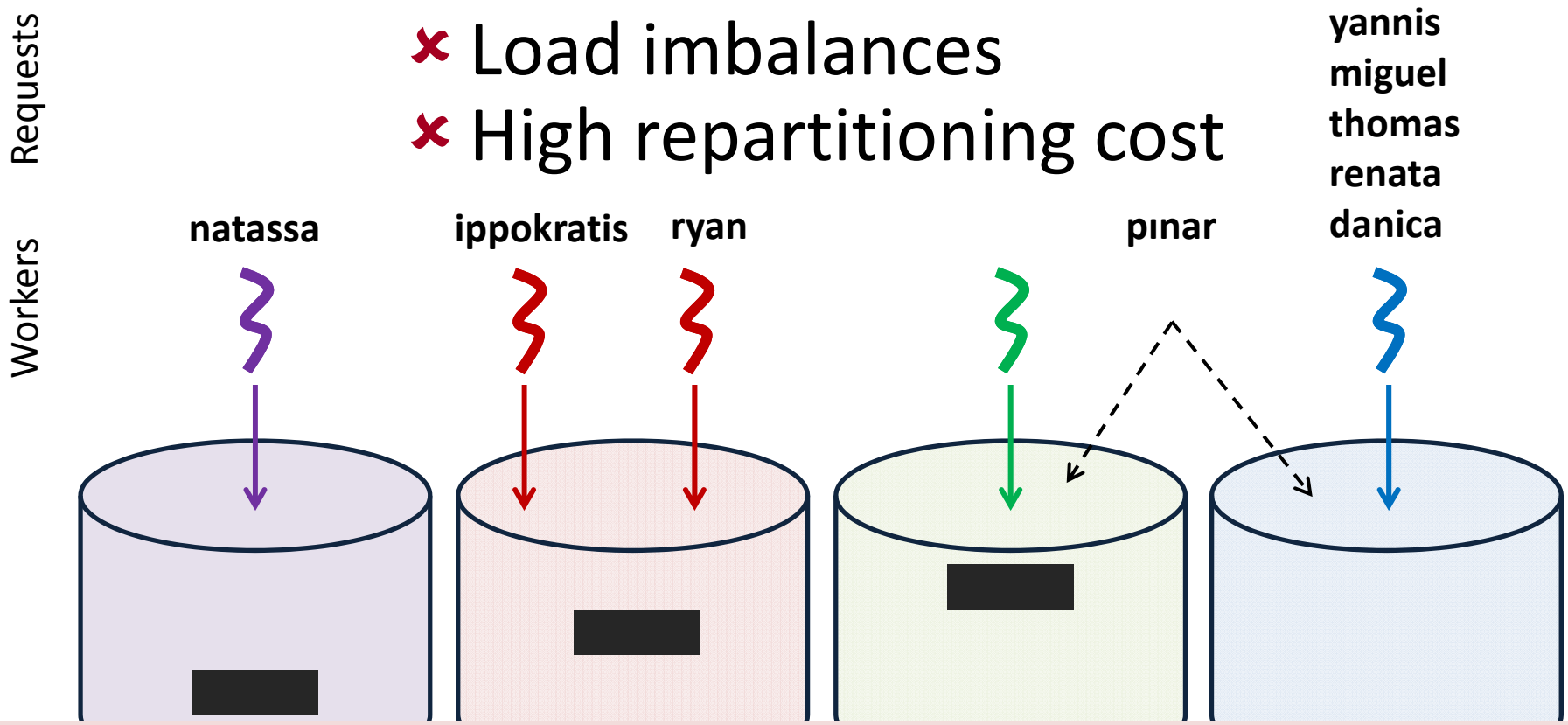
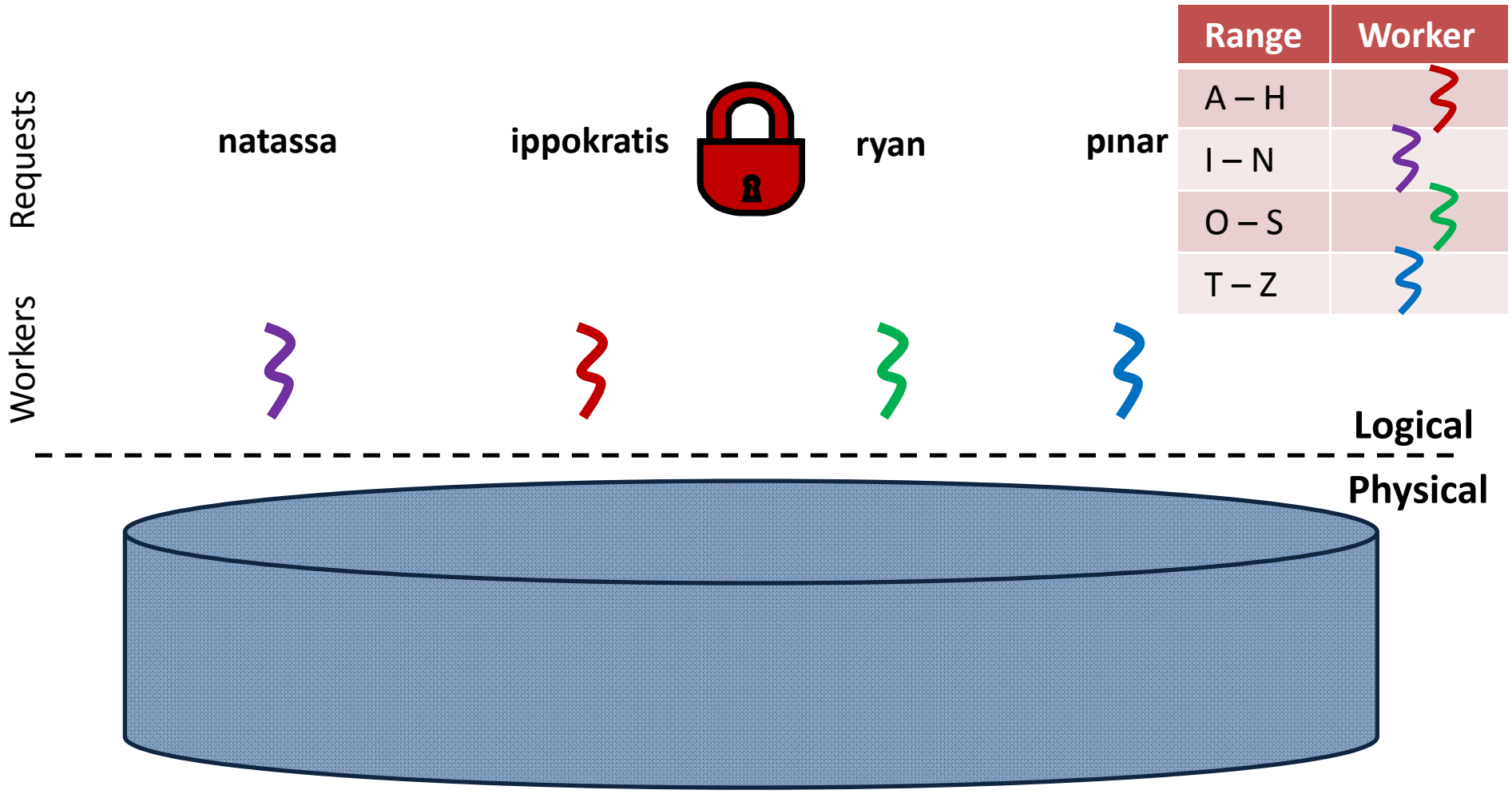


Great for some workloads, not all

Logically Partitioned



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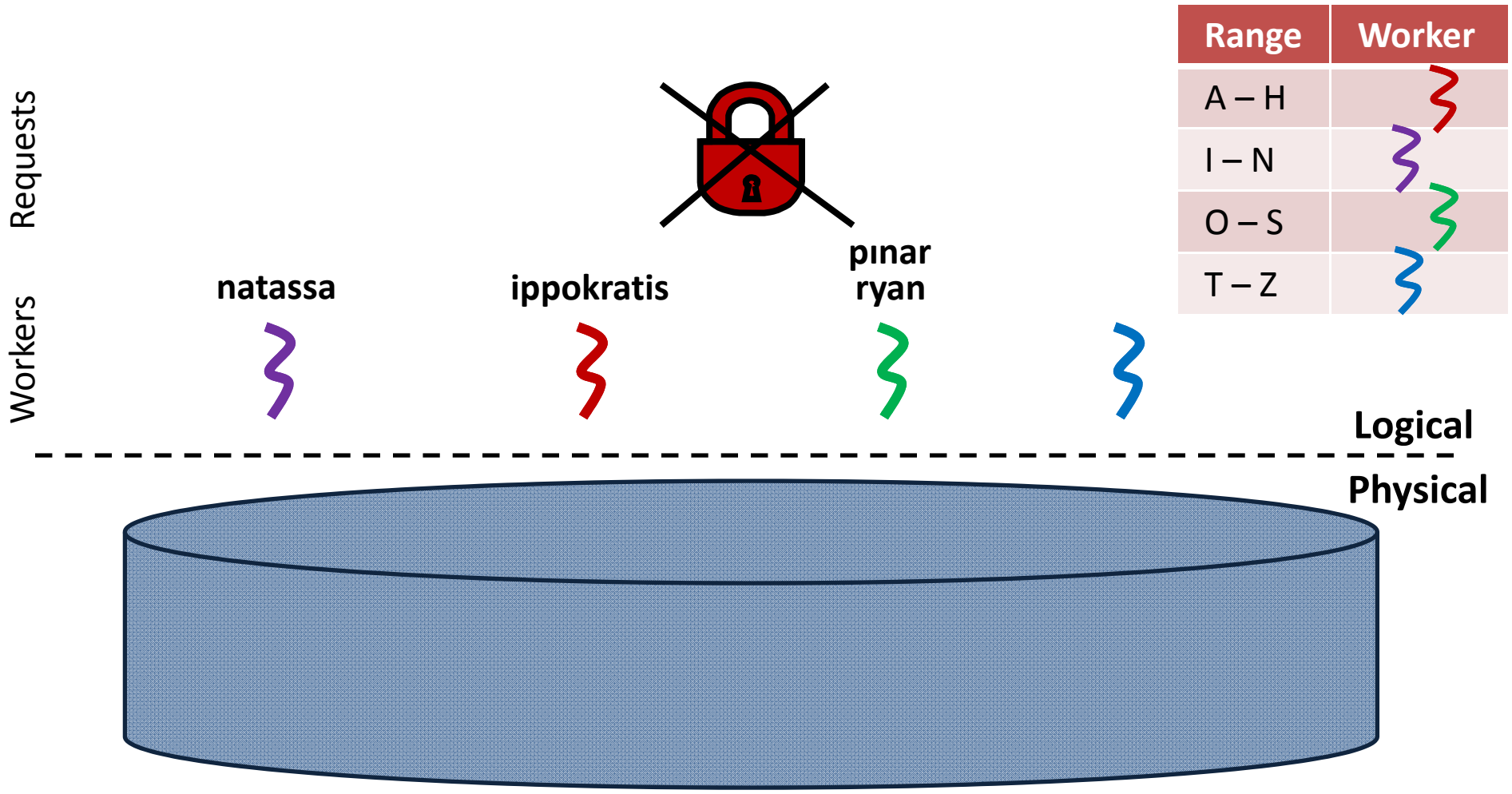
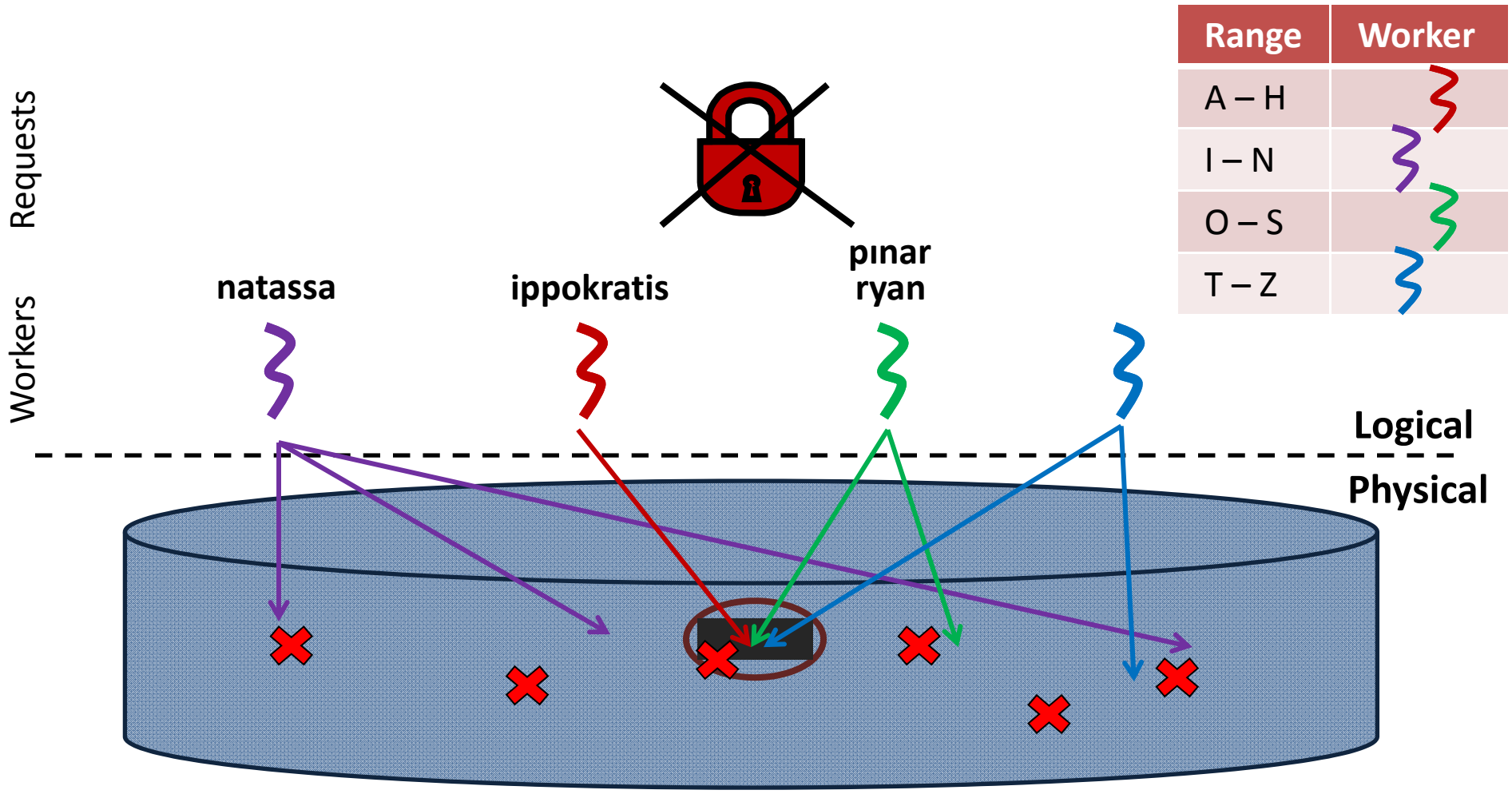
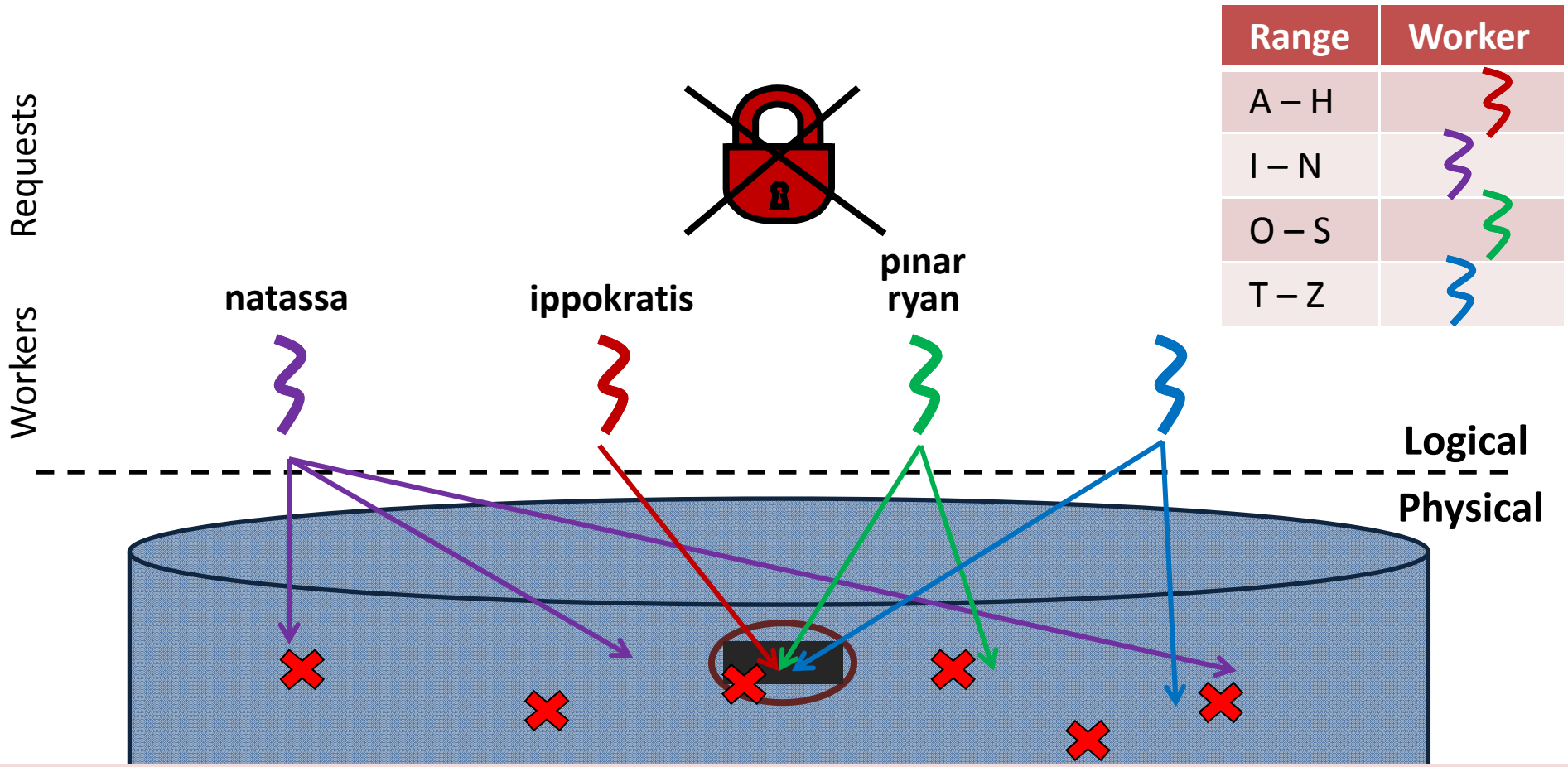


Logically Partitioned



Range	Worker
A – H	
I – N	
O – S	
T – Z	

Logically Partitioned



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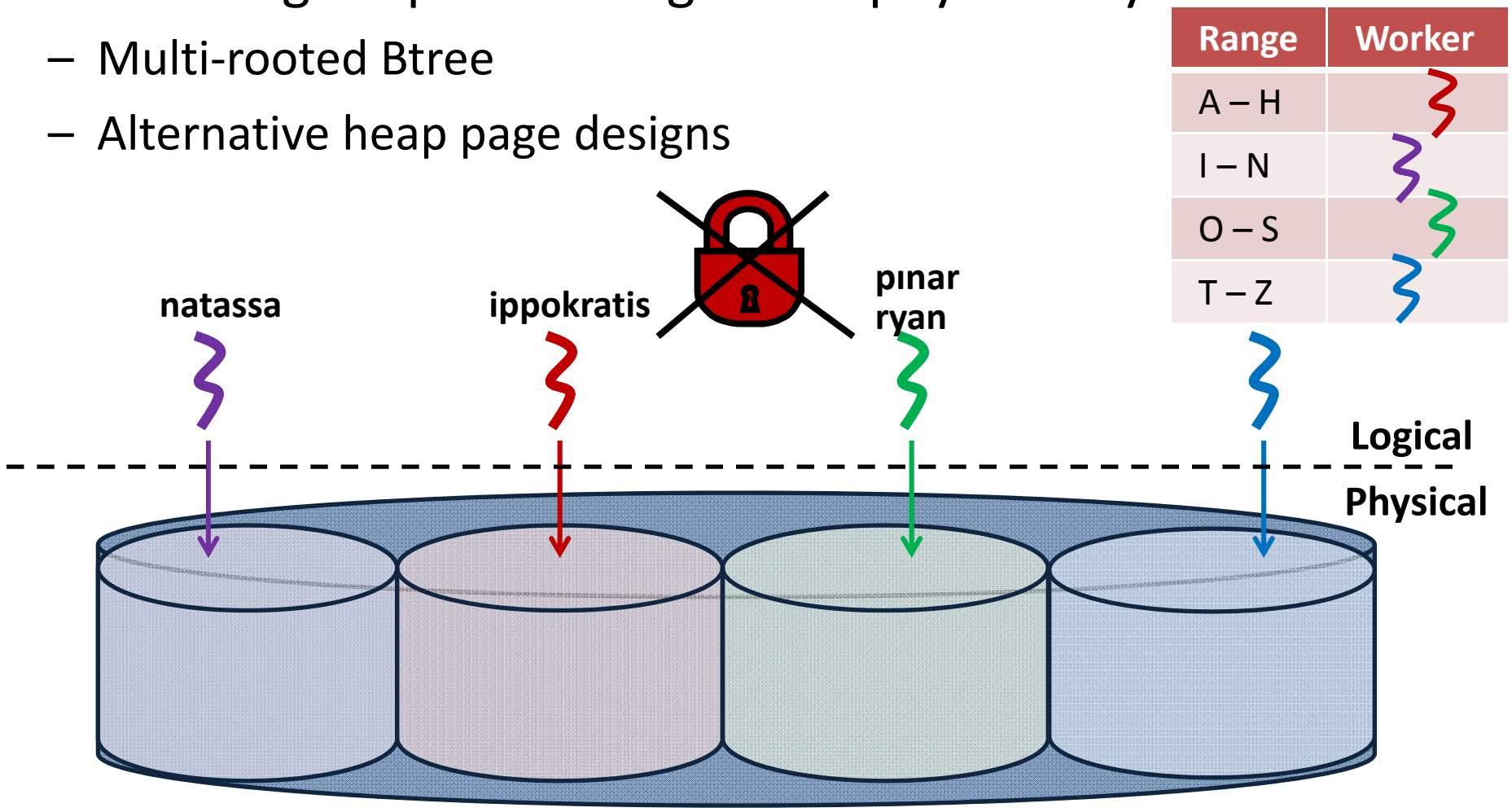
Contention at the **physical** layer

Physiological Partitioning

- Extends logical partitioning at the physical layer
  - Multi-rooted Btree
  - Alternative heap page designs



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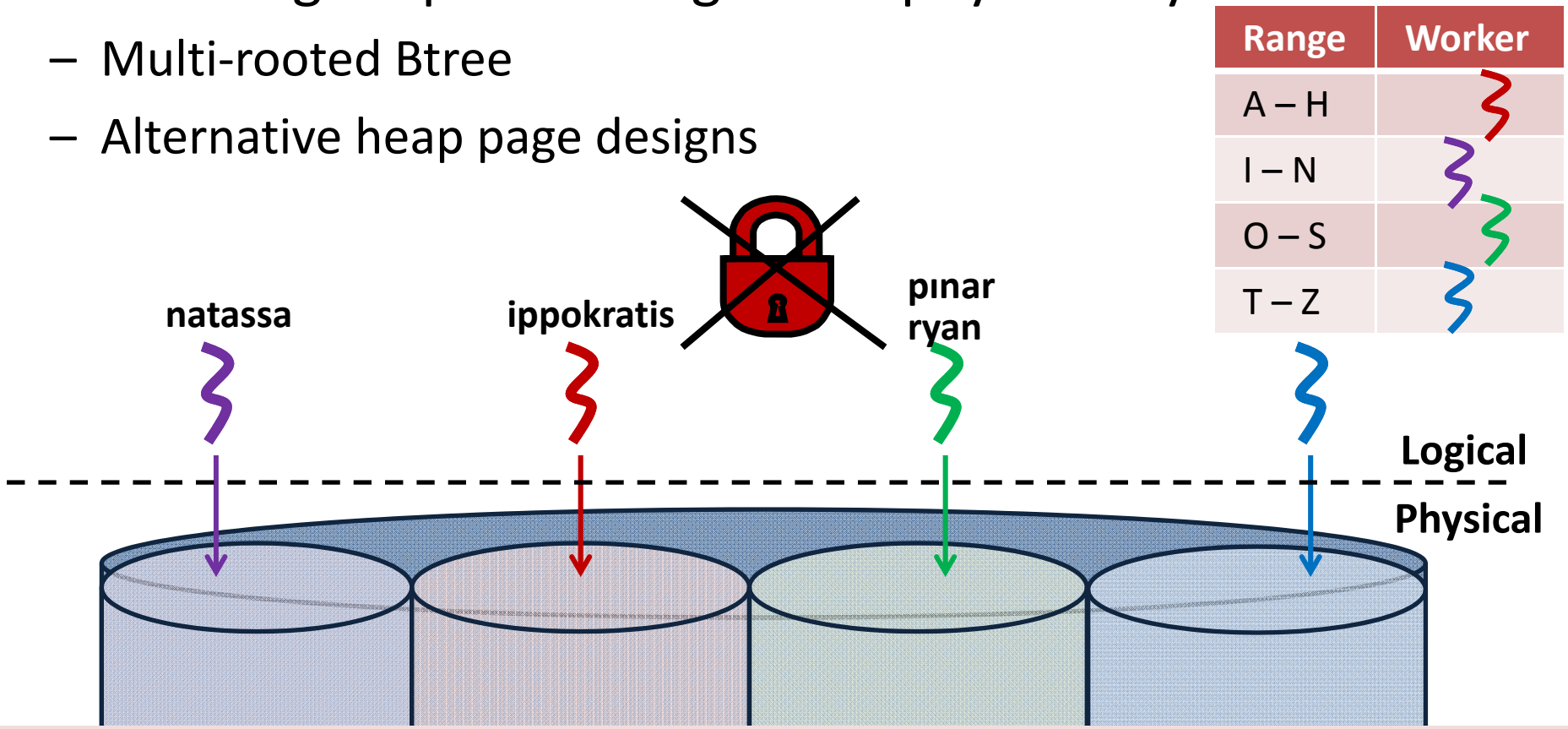


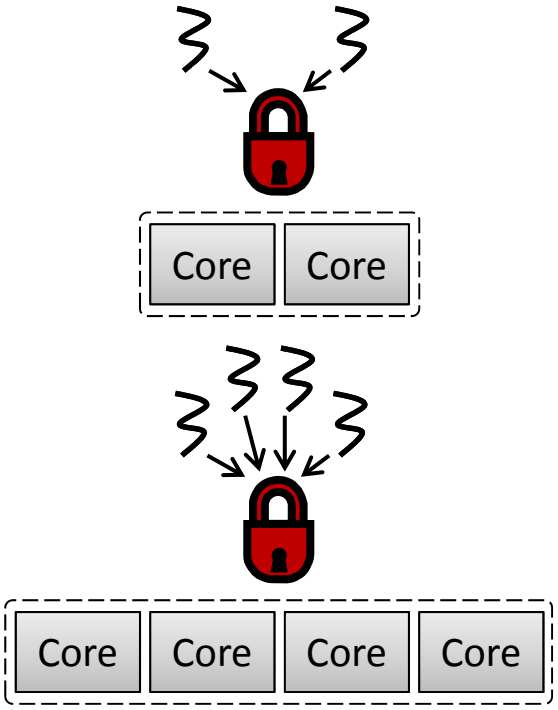
- ✓ Contention eliminated at both logical & physical layers
- ✓ Fast repartitioning

Outline

- Introduction
- **Types of Critical Sections**
- Physiological Partitioning (PLP)
- Results
- Conclusion

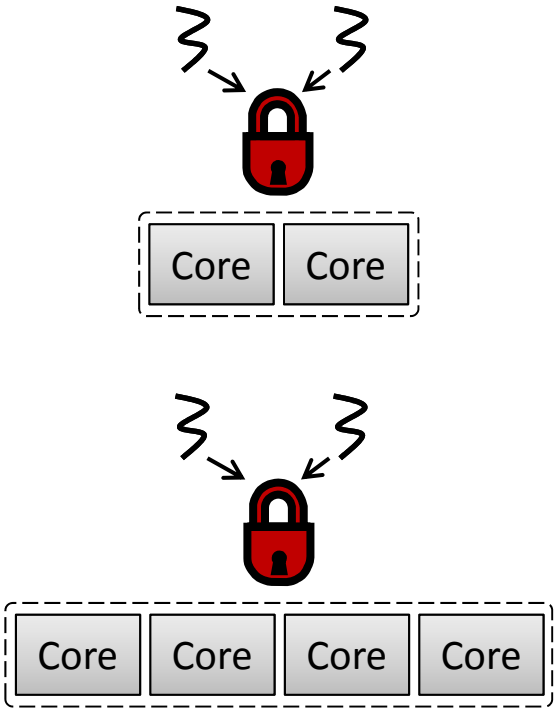
Critical Sections

Unscalable



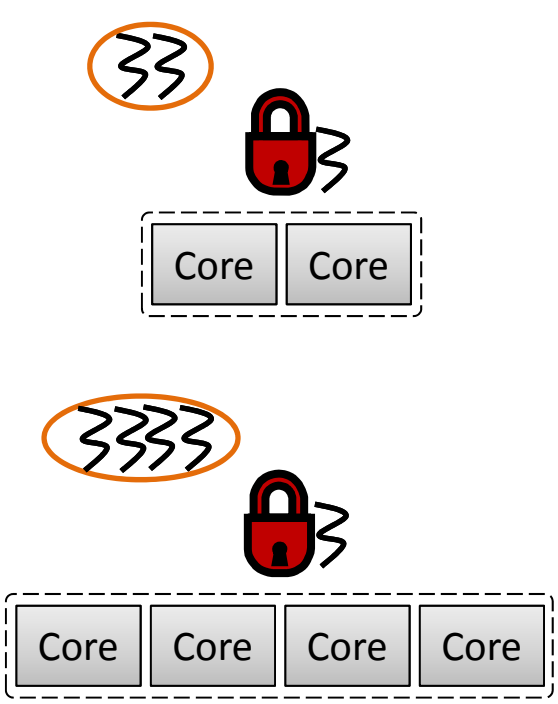
Locking, Latching

Fixed



Point-to-point communication

Composable



Logging

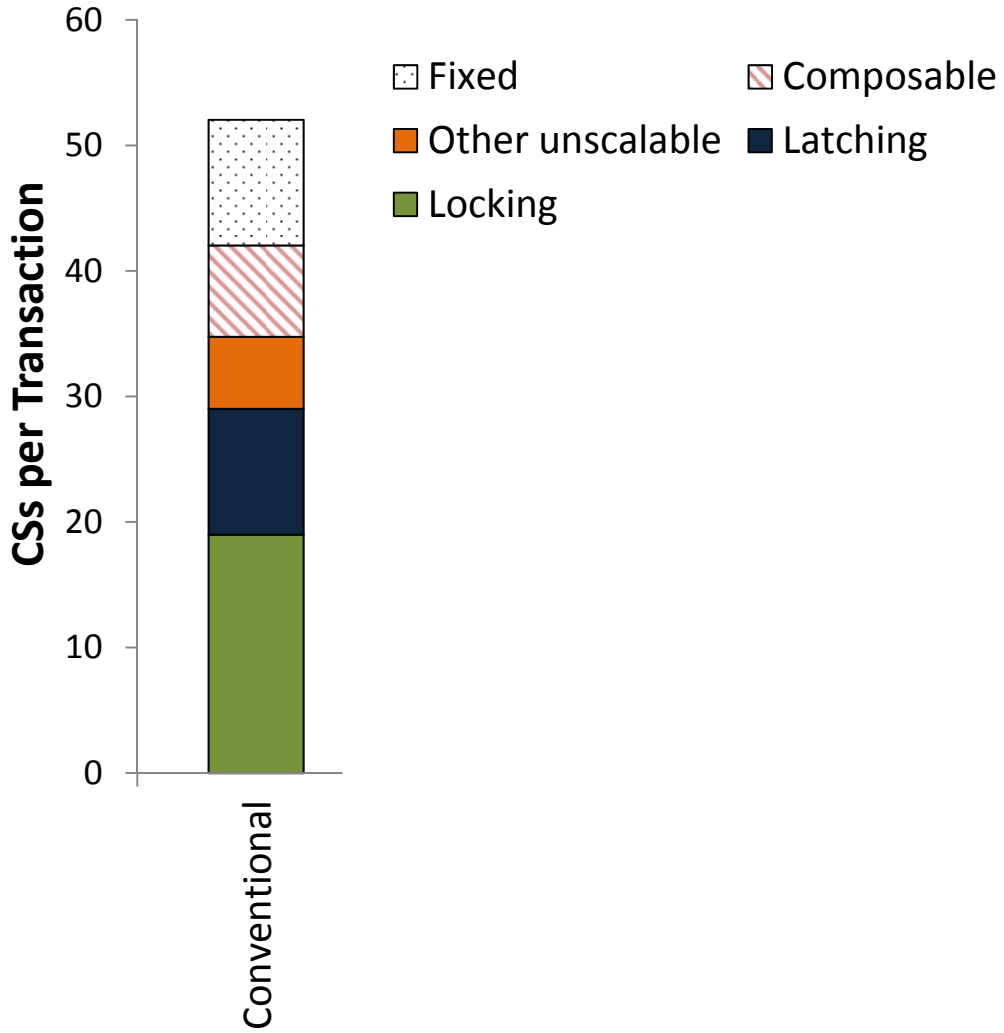
Unscalable → Fixed / Composable

Breakdown of the Critical Sections

…and its impact on performance

Probe one customer, update balance

4 socket Quad AMD



Breakdown of the Critical Sections

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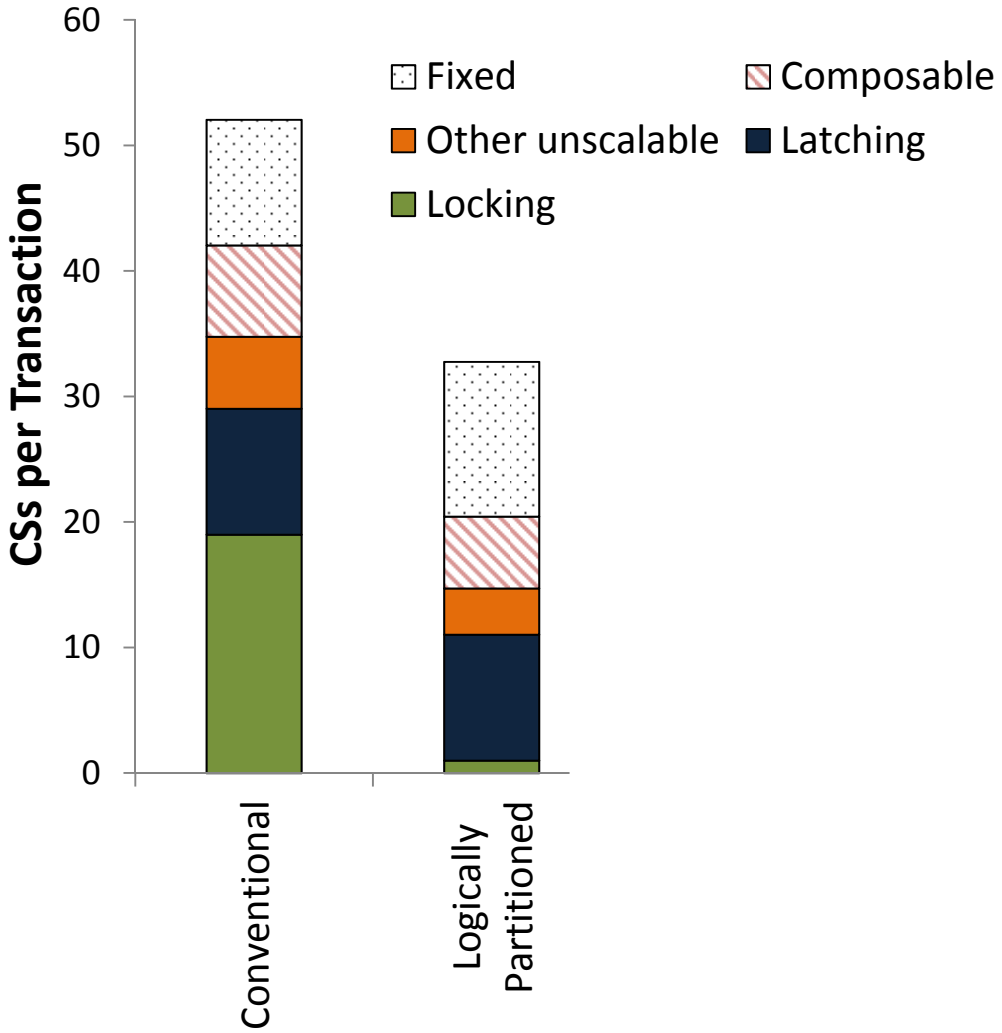

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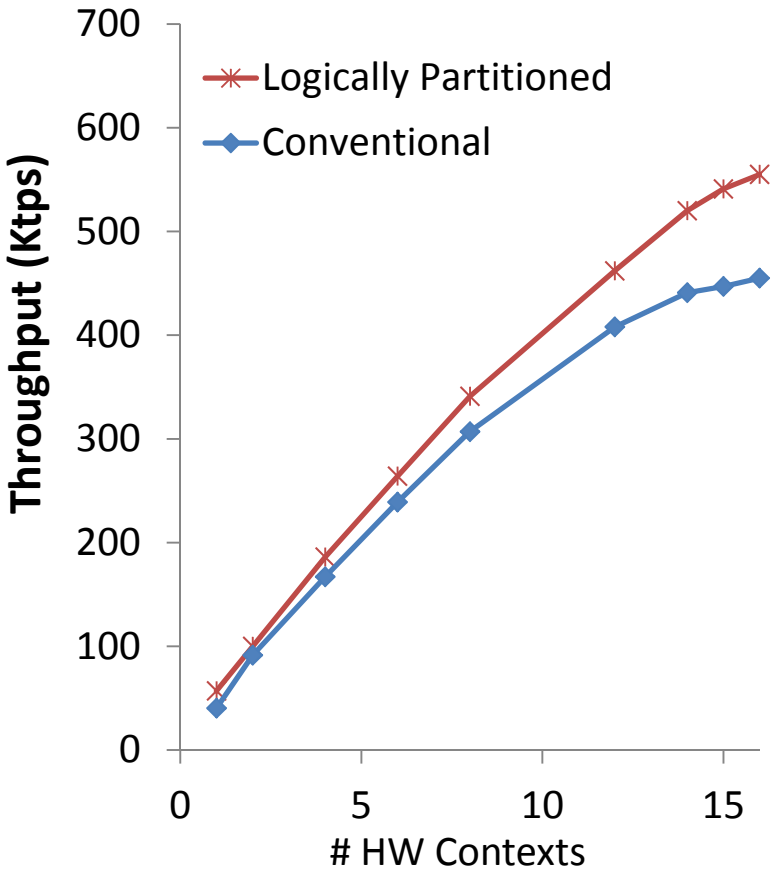

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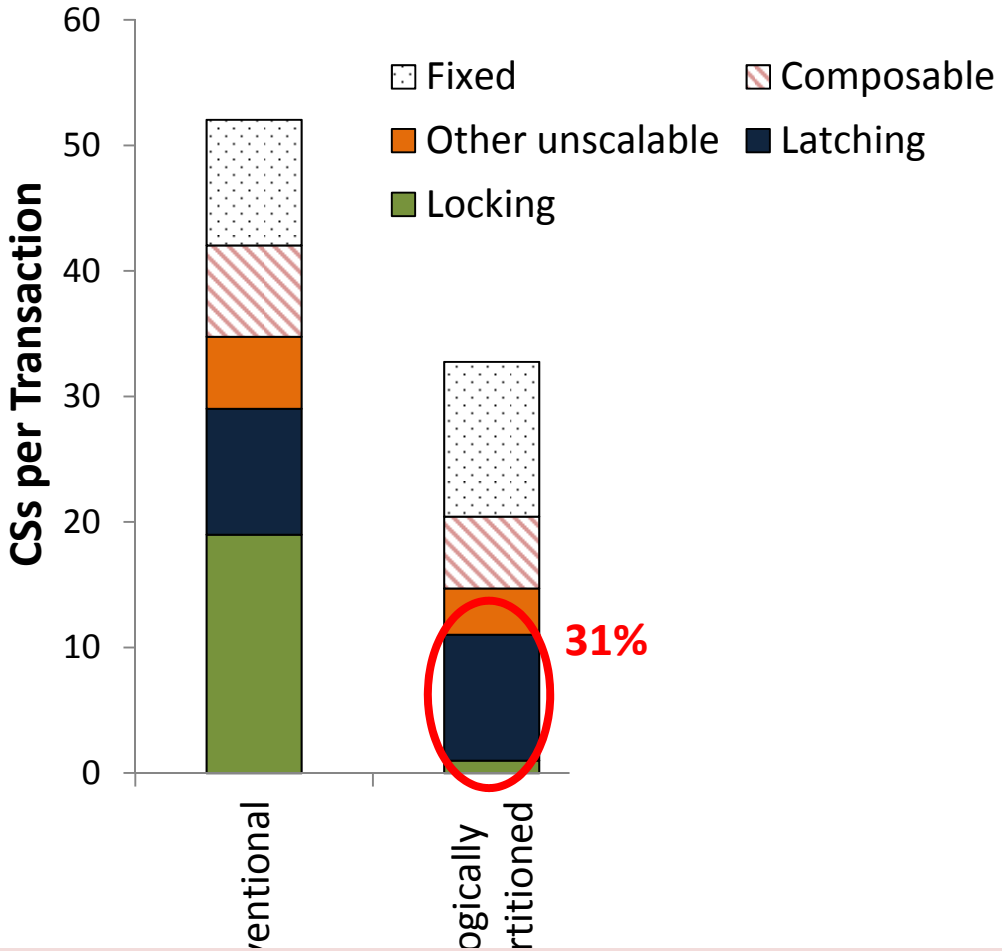

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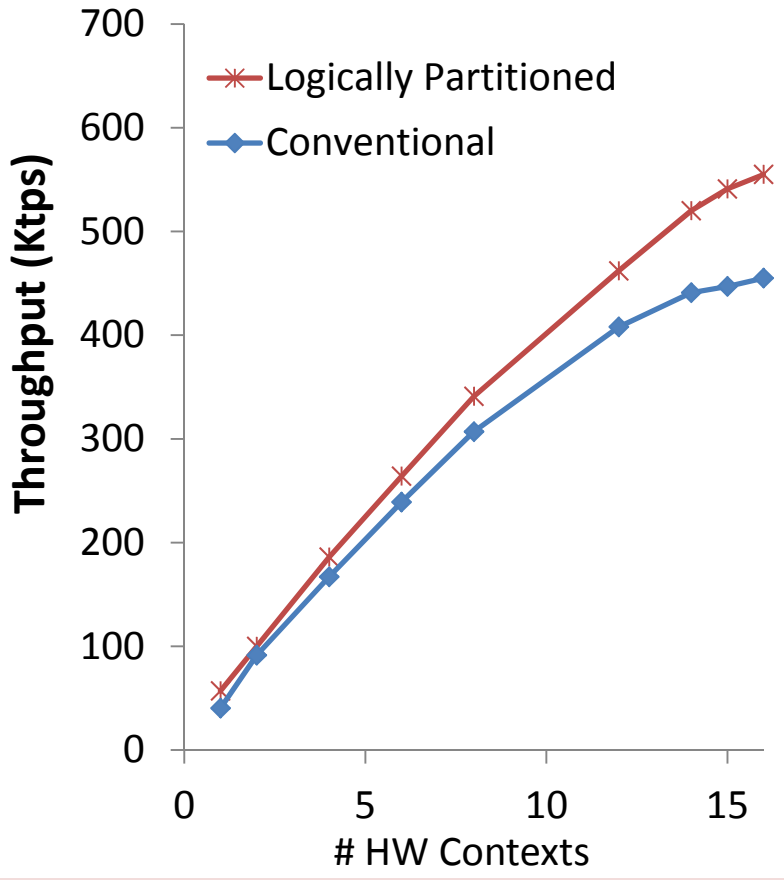

Latching related CSs remain with logical-partitioning

Outline

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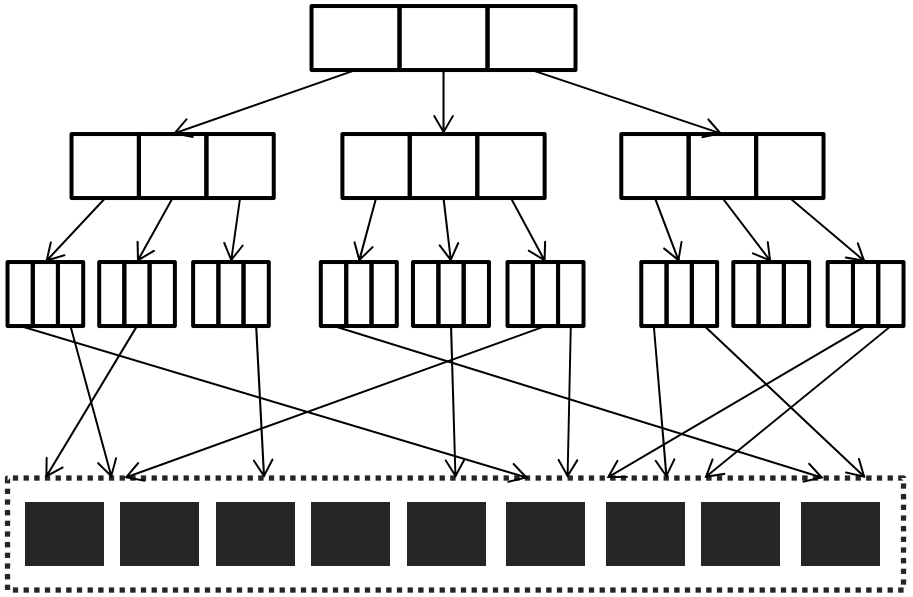
Physical Conflicts

Range	Worker
A – M	
N – Z	

Logical

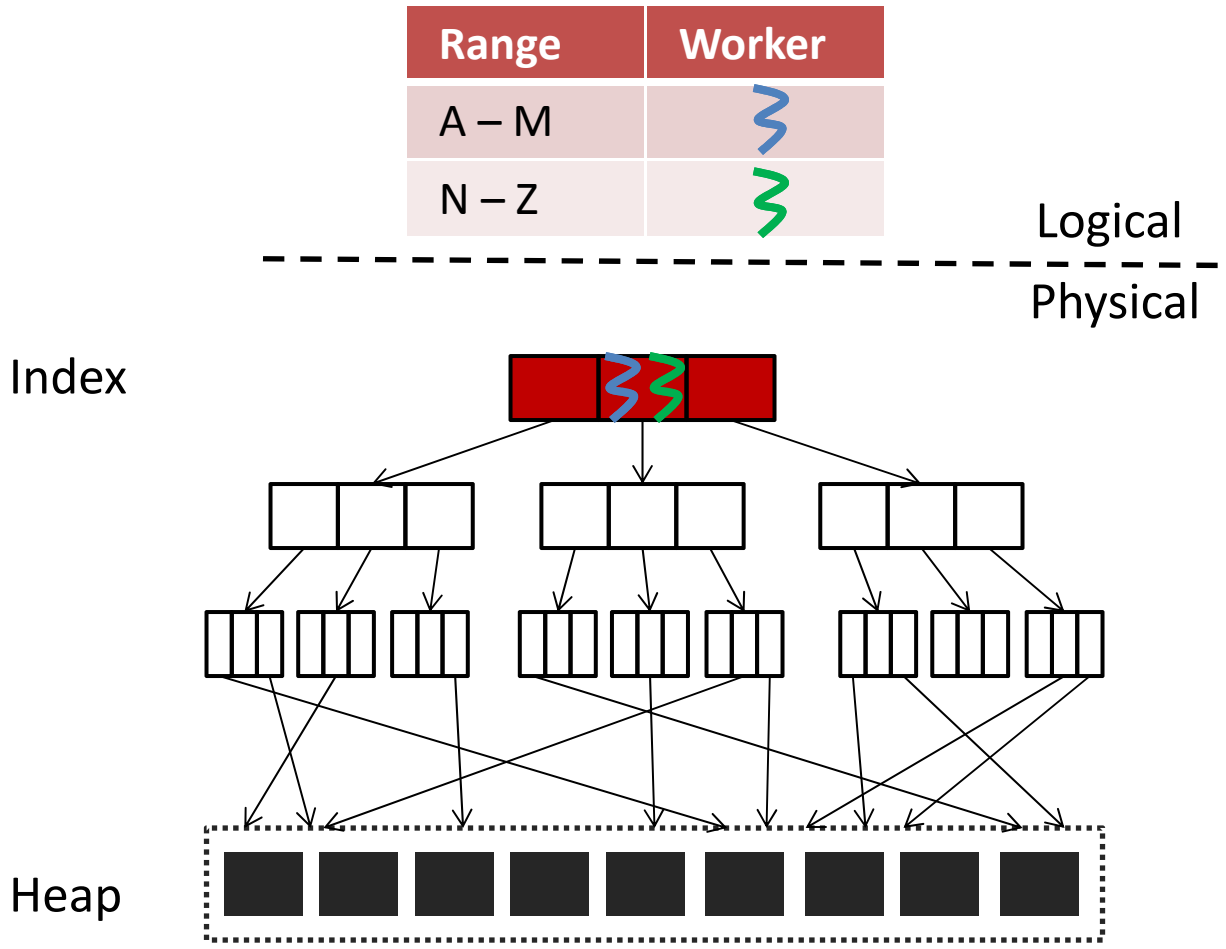
Physical

Index



Heap

Physical Conflicts



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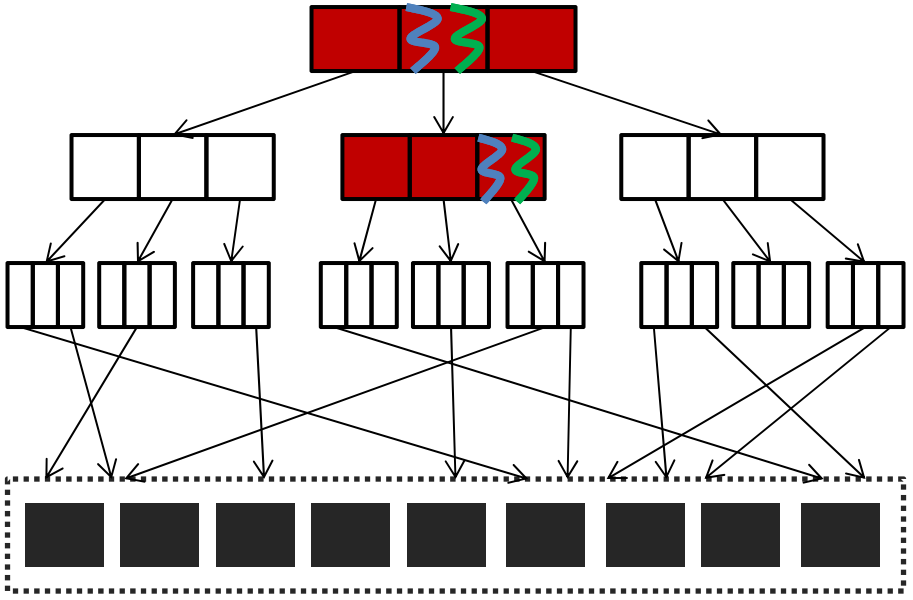

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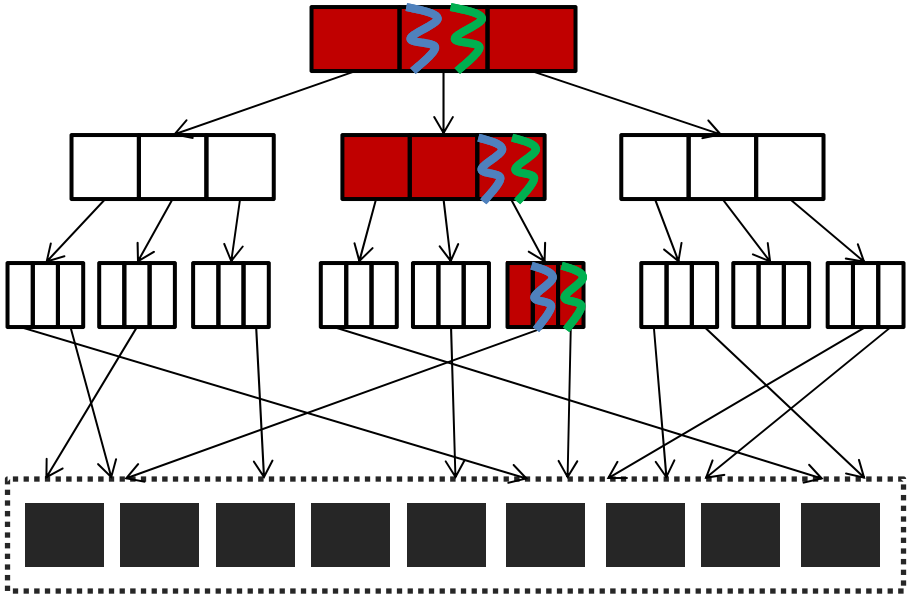

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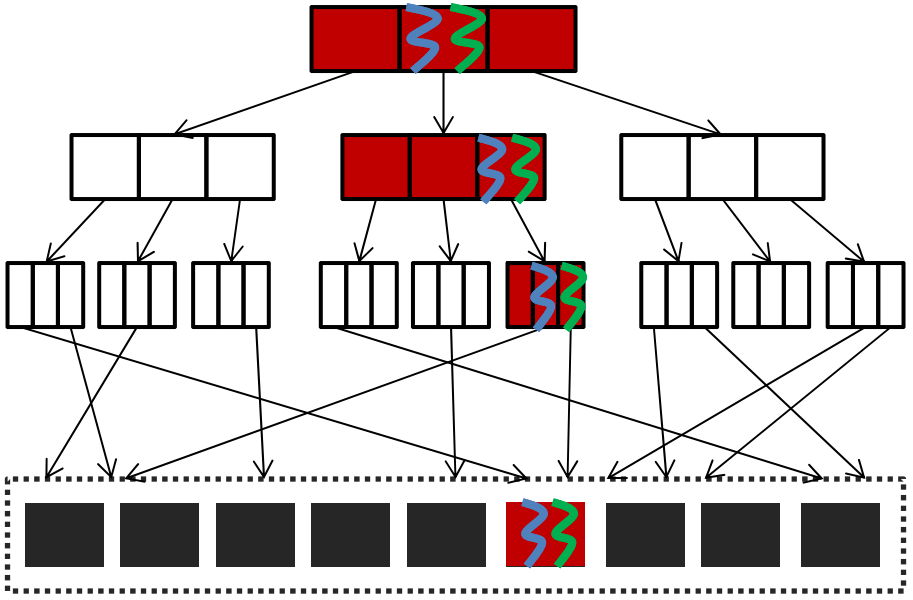

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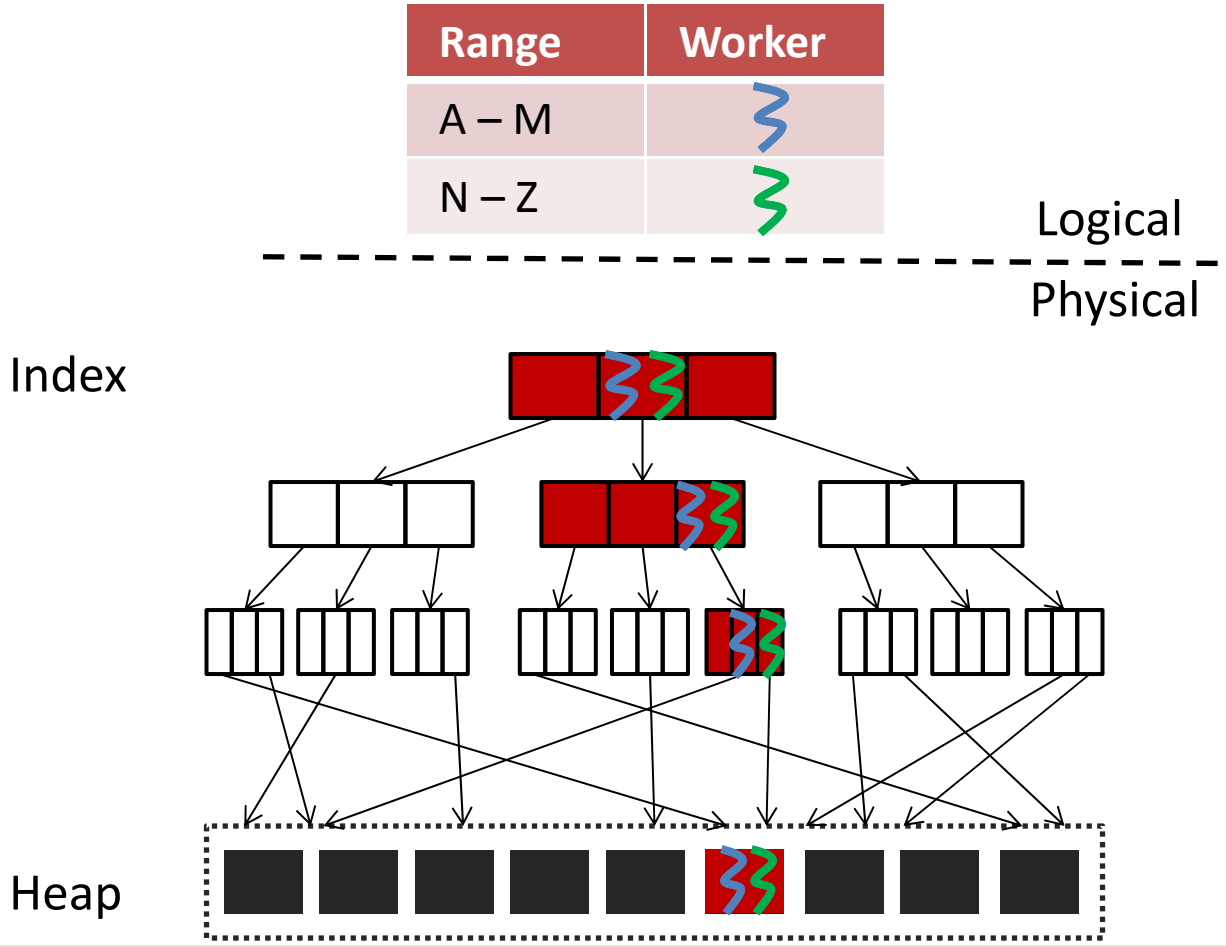
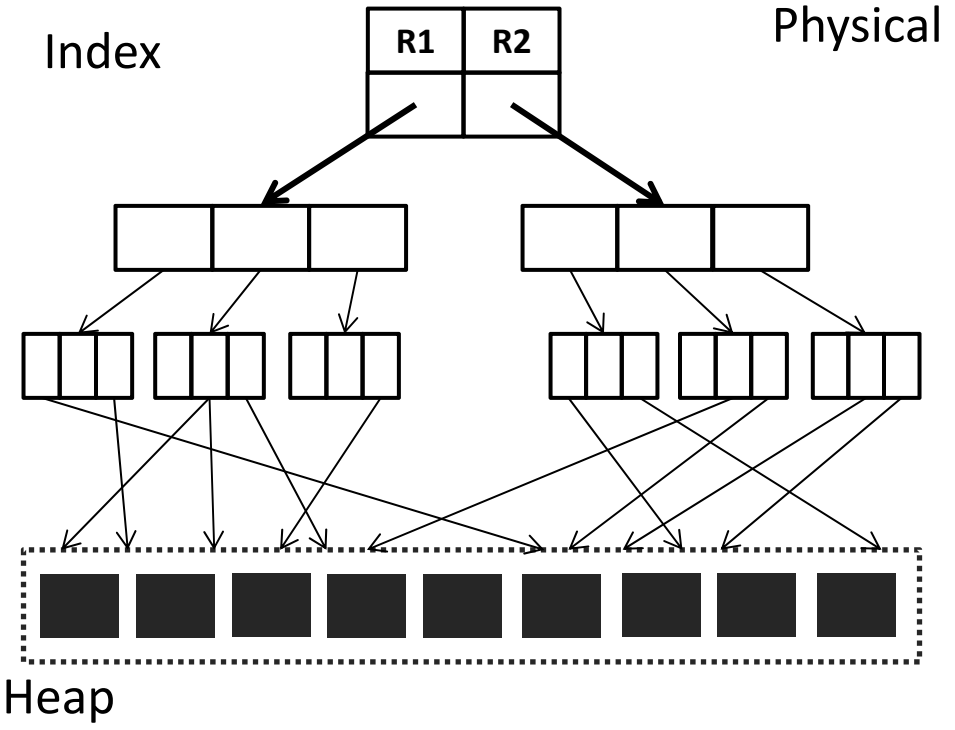


Conflicts on both index & heap pages

Physiological Partitioning (PLP)

Range	Worker
R1: A – M	
R2: N – Z	



- Multi-rooted Btree
  - Routing table is the root

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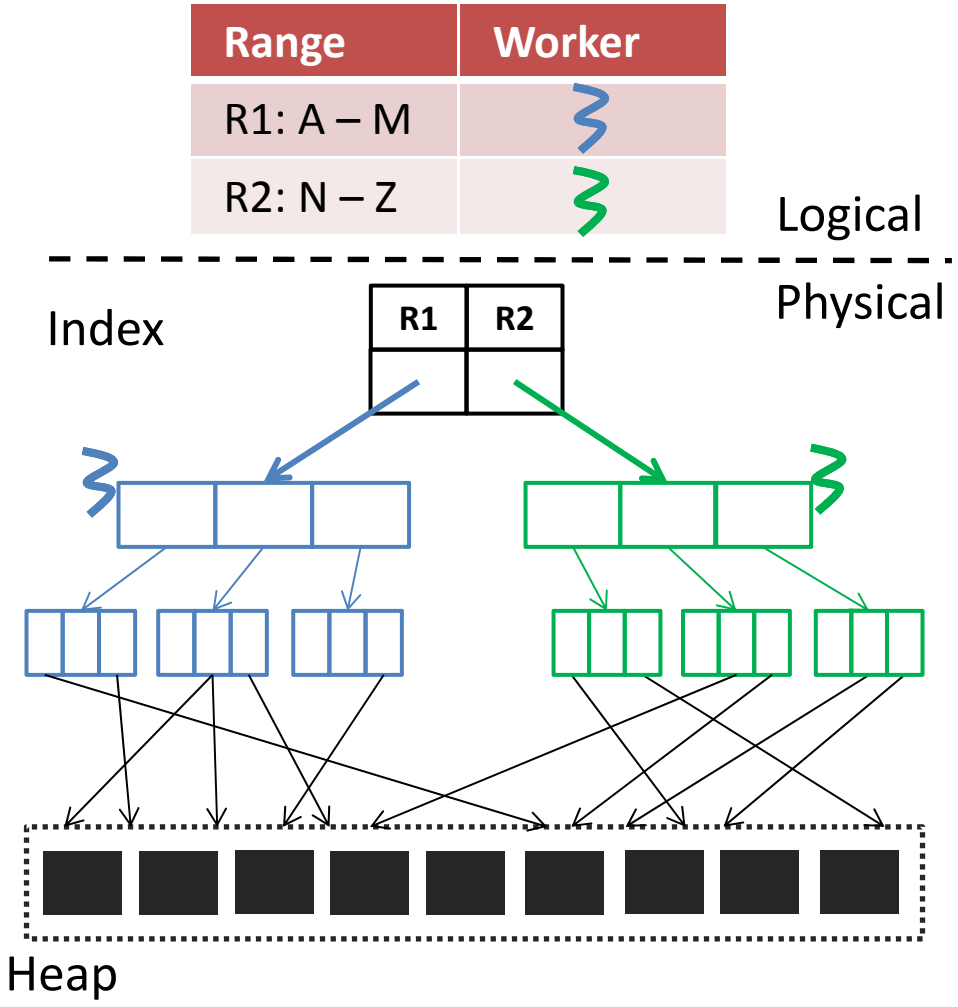

- Multi-rooted Btree
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- ✓ Both logical & physical partitioning
- ✓ Reduces contention on index root
- ✓ Parallel structure modification operations
- ✓ Fast index repartitioning

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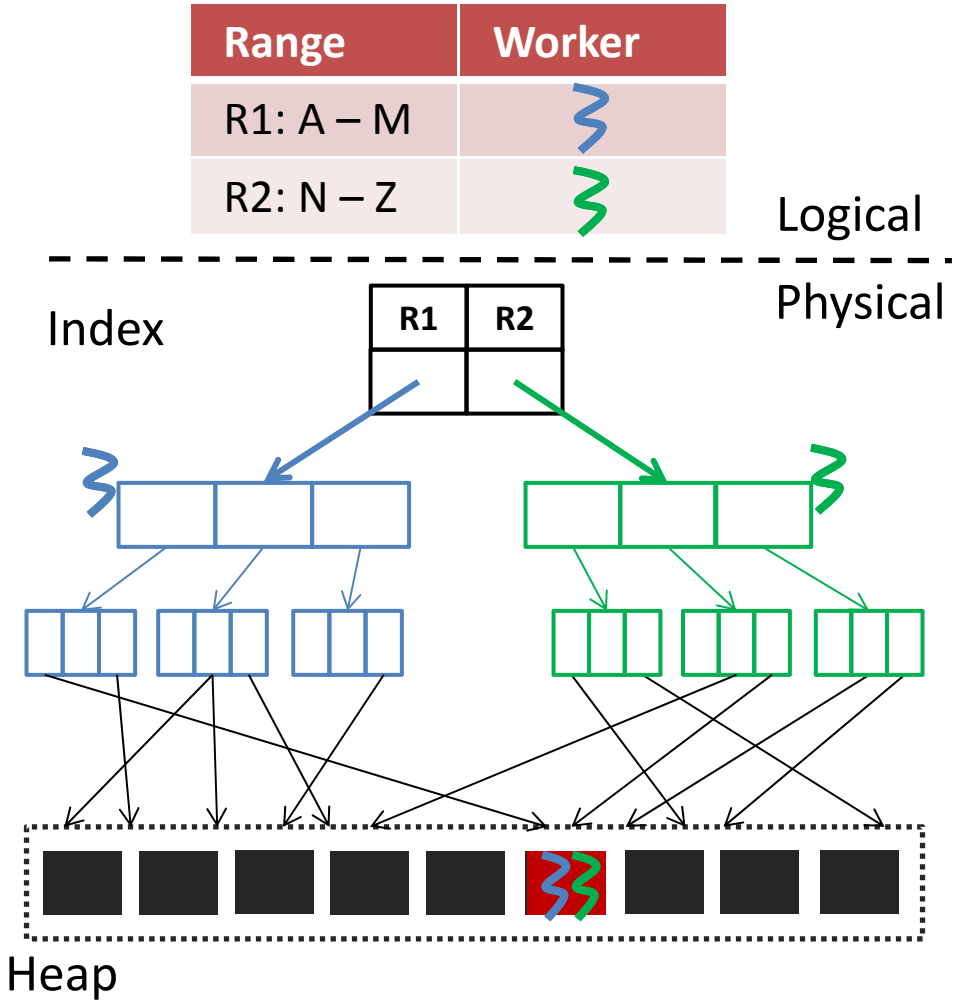

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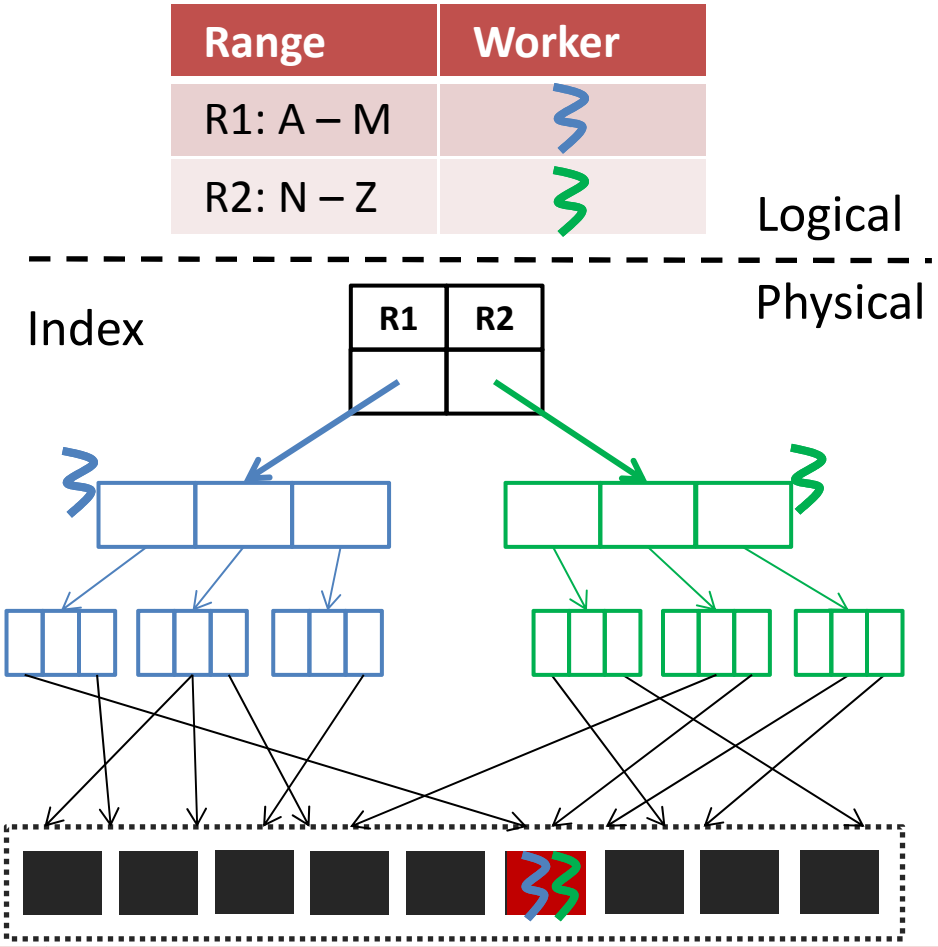

- Multi-rooted Btree
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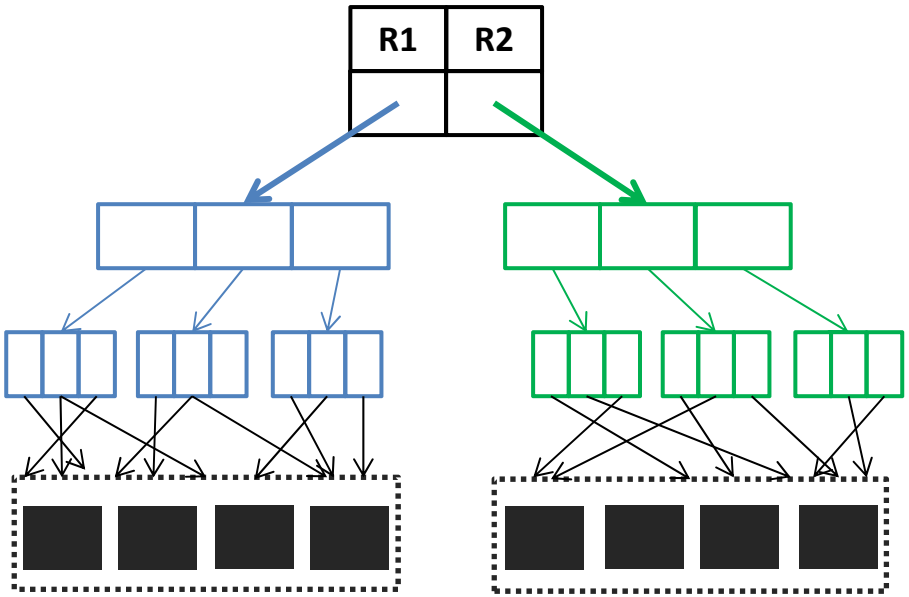
✓ No need to latch index pages

✗ Still need to latch heap pages

Heap Pages : Alternatives

PLP-Partition



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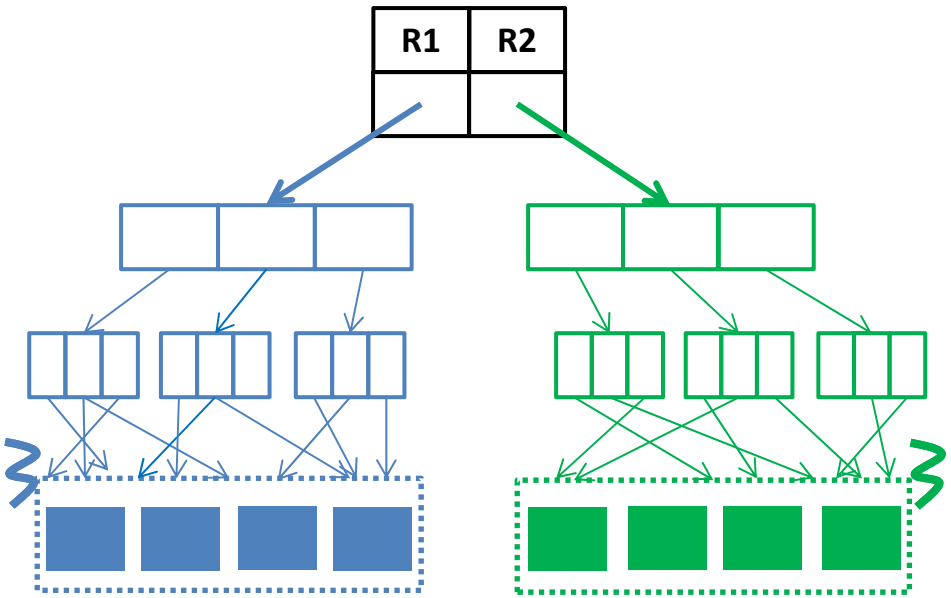

- Two-step record inserts
- Repartitioning worst-case: Scan entire partition

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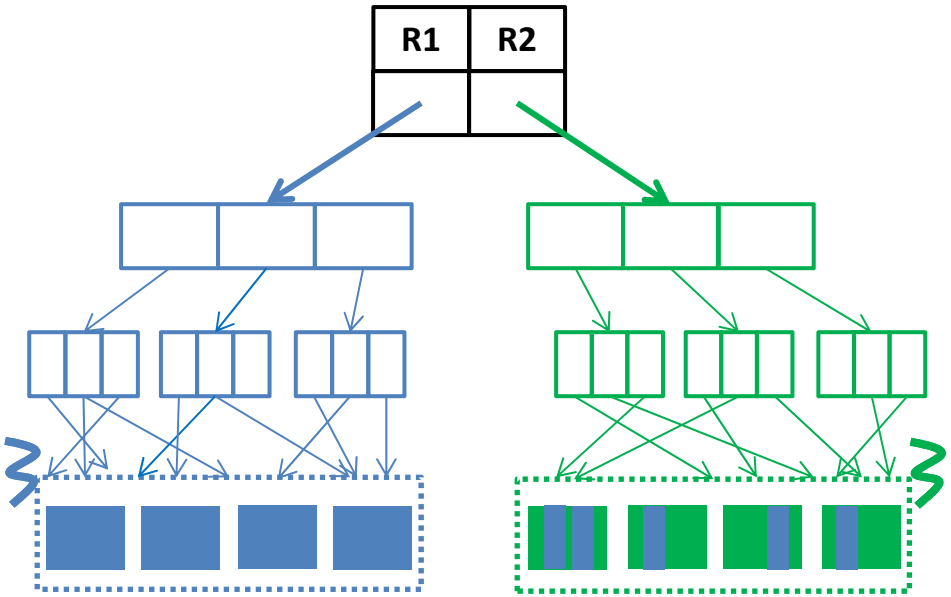

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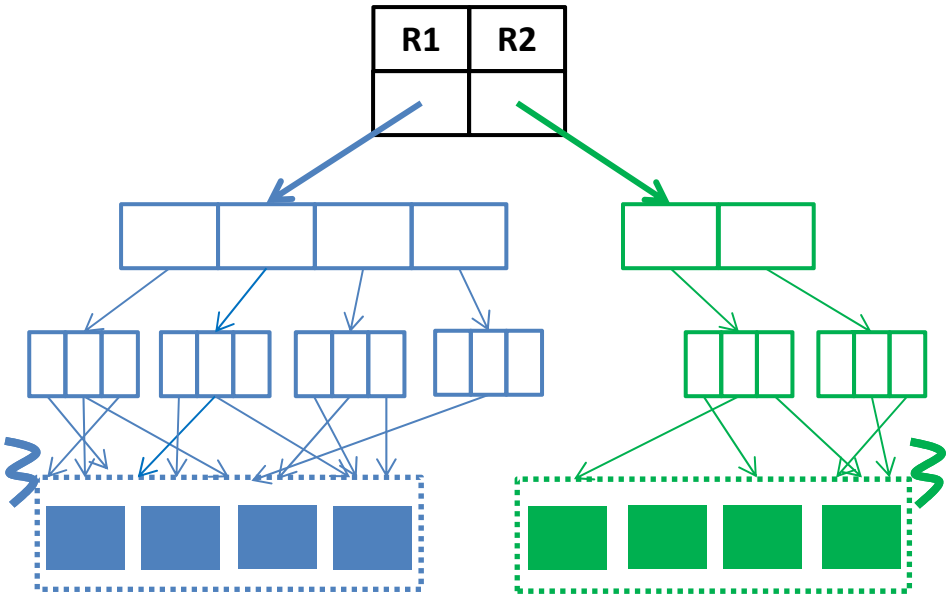

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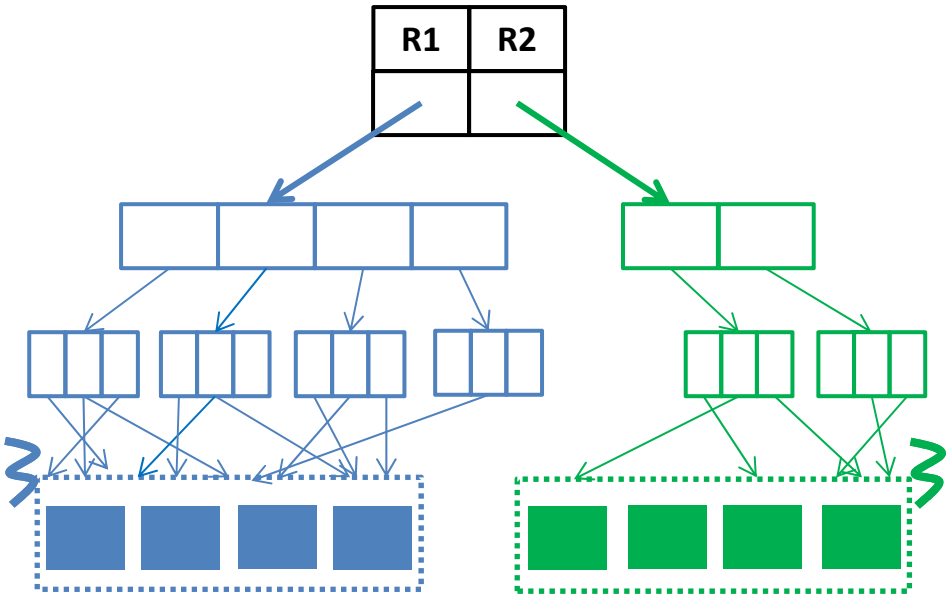
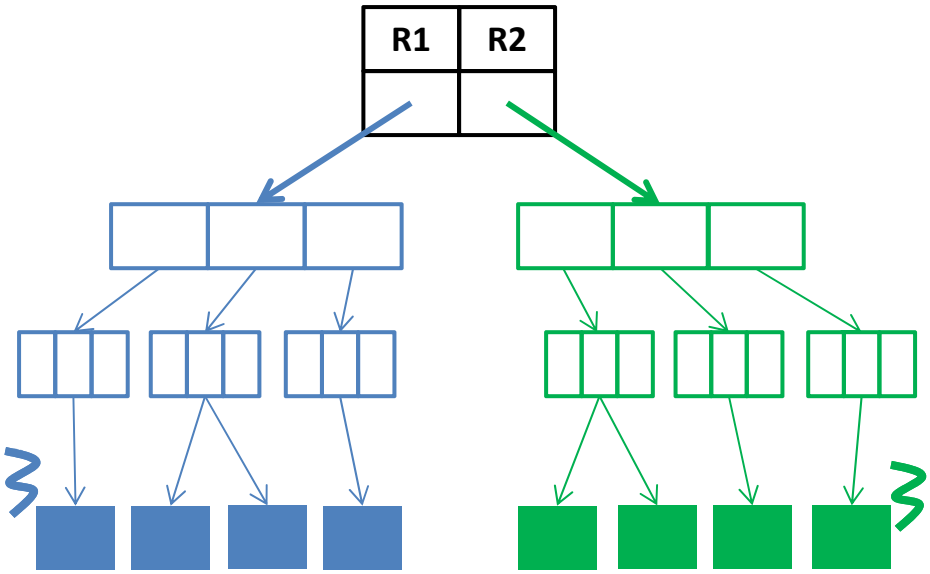


- ✘ Two-step record inserts
- ✘ Repartitioning worst-case: Scan entire partition

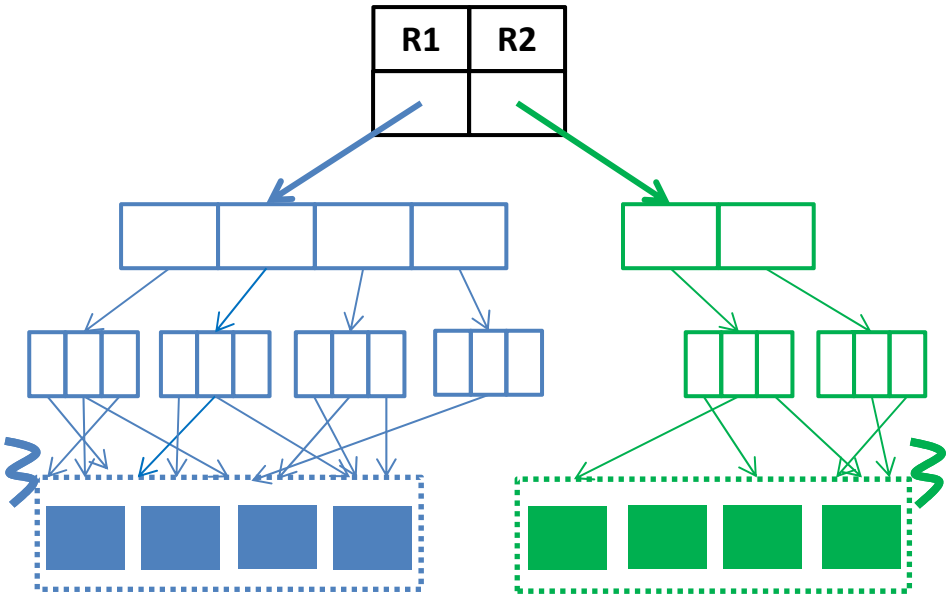
PLP-Leaf



- ✘ Two-step record inserts
- ✘ Fragmentation
- ✓ Repartitioning worst-case: Scan few pages

Heap Pages : Alternatives

PLP-Partition



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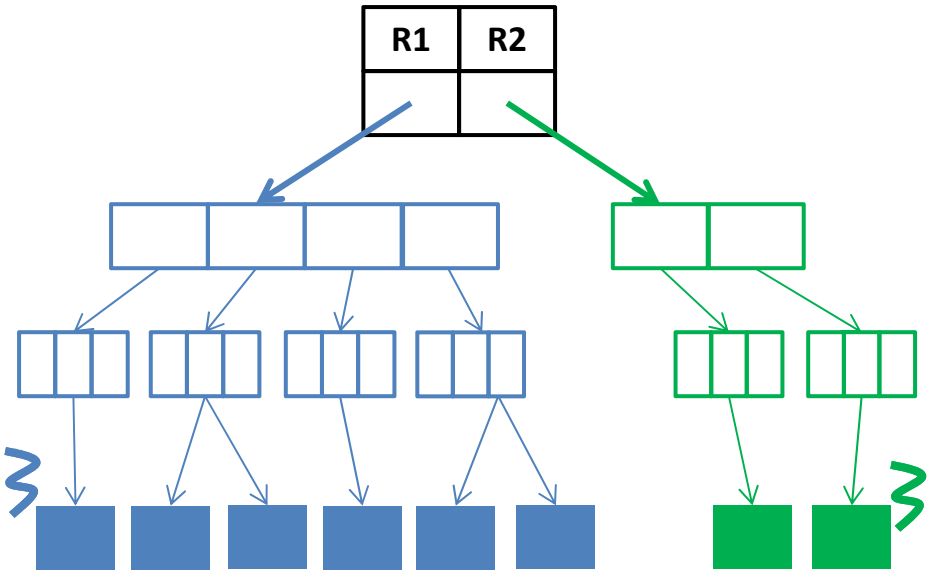

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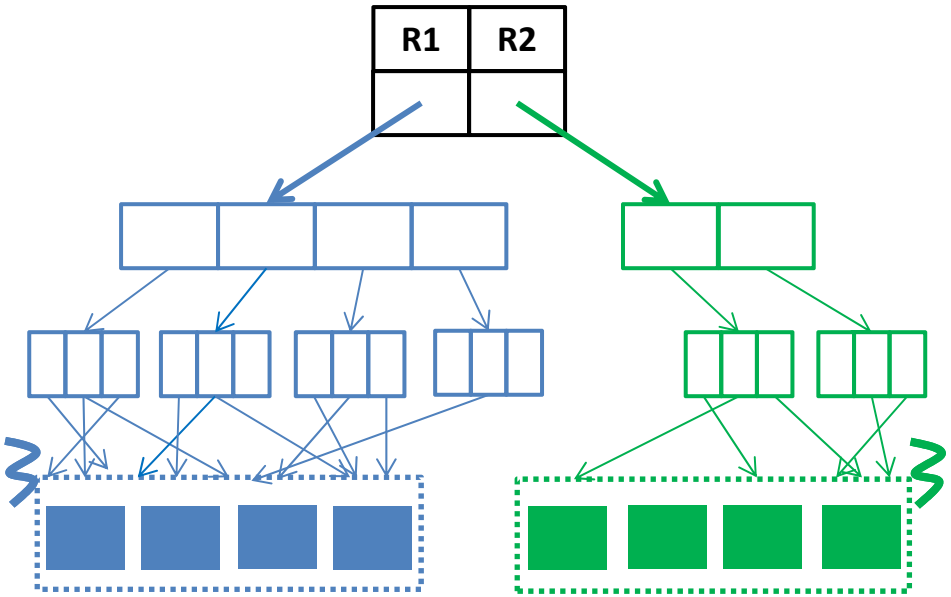

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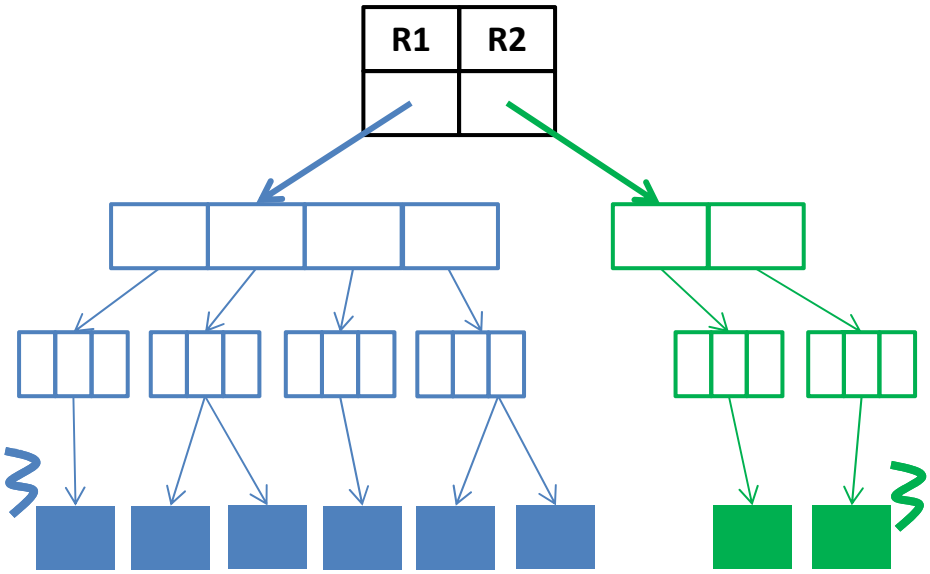


- ✘ Two-step record inserts
- ✘ Fragmentation
- ✓ Repartitioning worst-case: Scan few pages

✓ Latch free OLTP

Outline

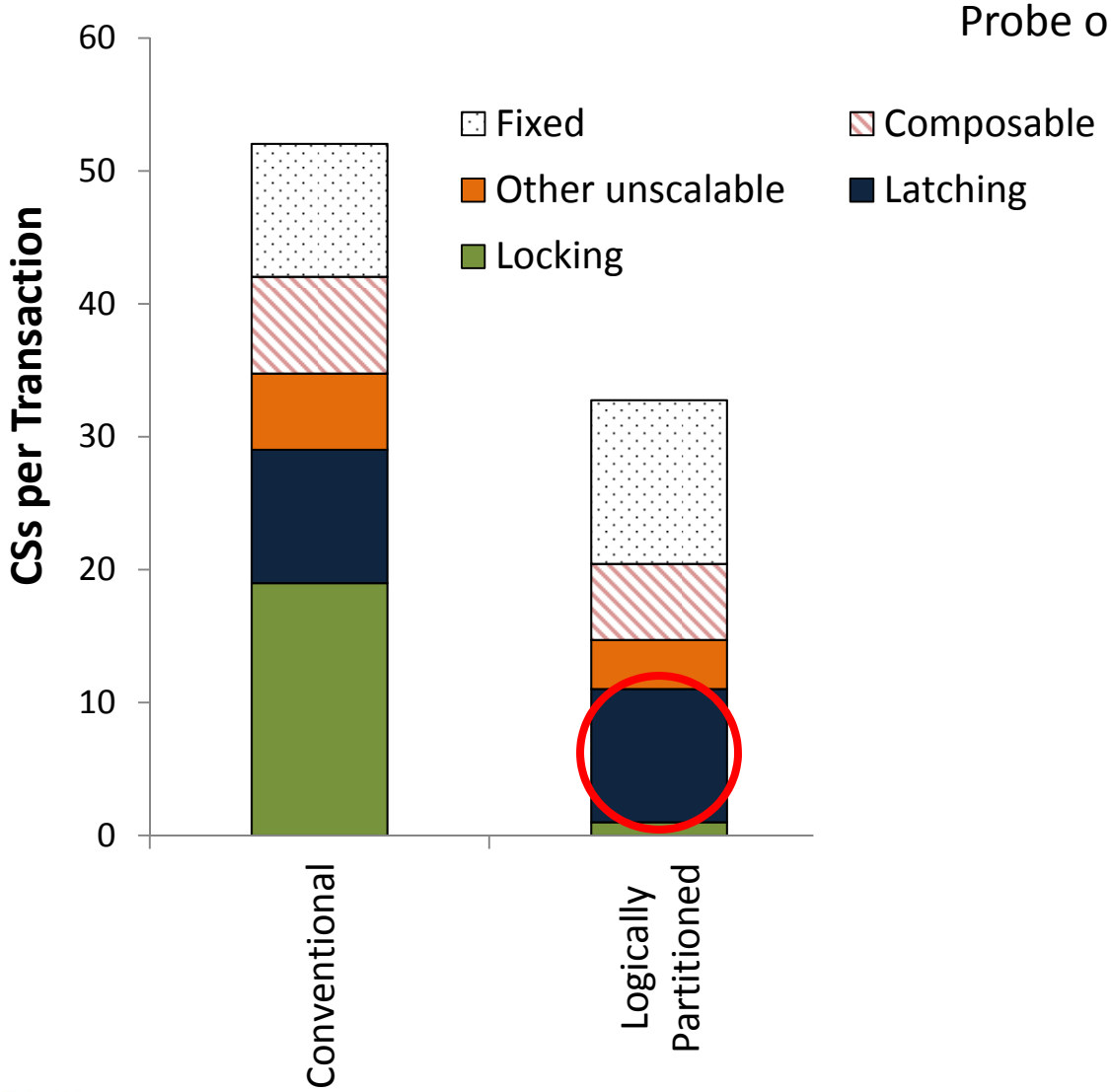
- Introduction
- Types of Critical Sections
- Physiological Partitioning (PLP)
- **Results**
- Conclusion

Setup

- All prototypes built on top of Shore-MT
  - State-of-the-art open-source DBMS
- Machines used
  - Sun Niagara T2, 64 HW ctxs
    - In order, 1.4GHz, 64GB RAM
  - 4 socket quad-core AMD Opteron, 16 HW ctxs
    - OoO, 2.4GHz, 64GB RAM
- #Partitions = #HW contexts available

Breakdown of the Critical Sections

Probe one customer, update balance



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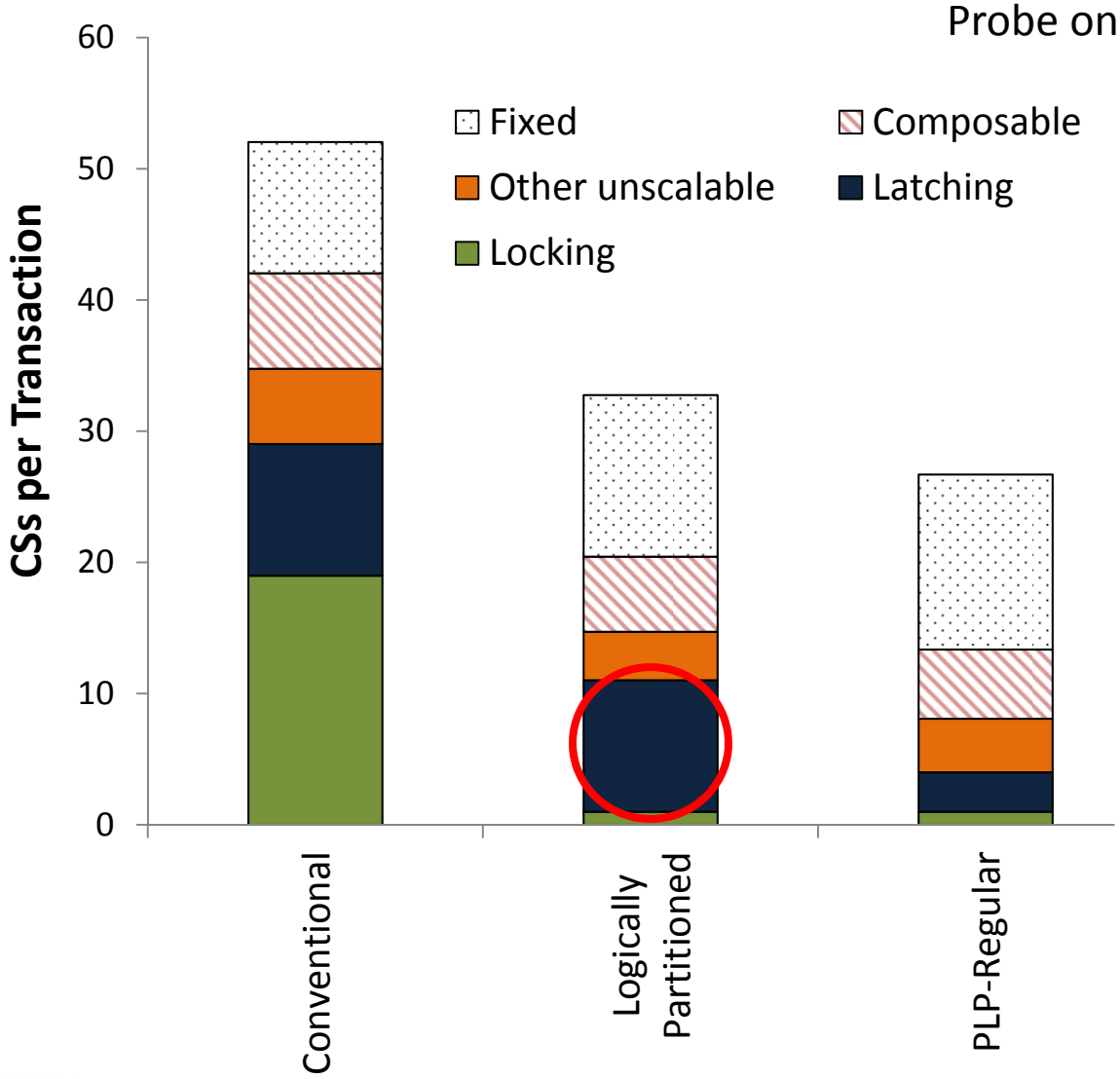

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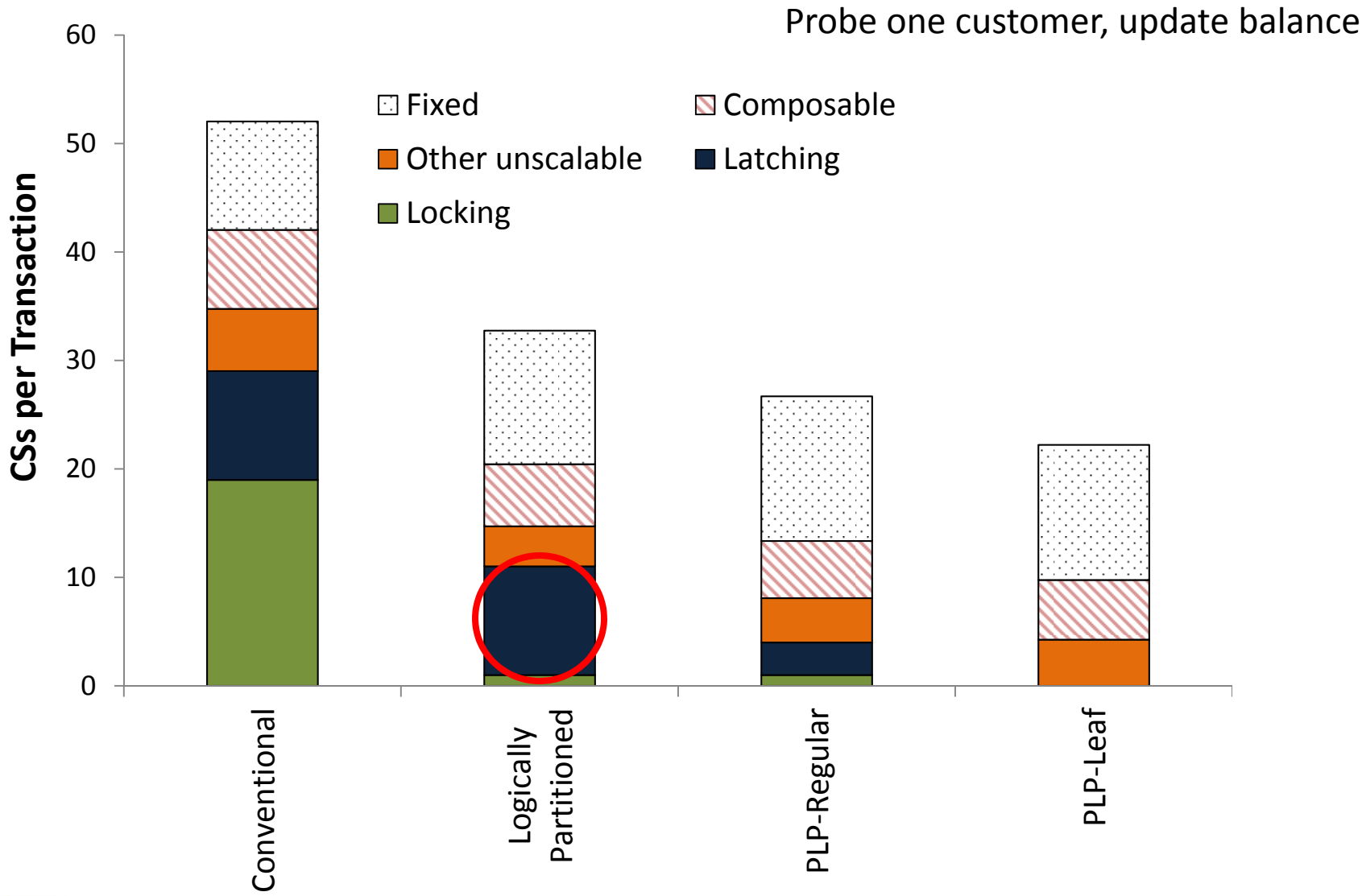

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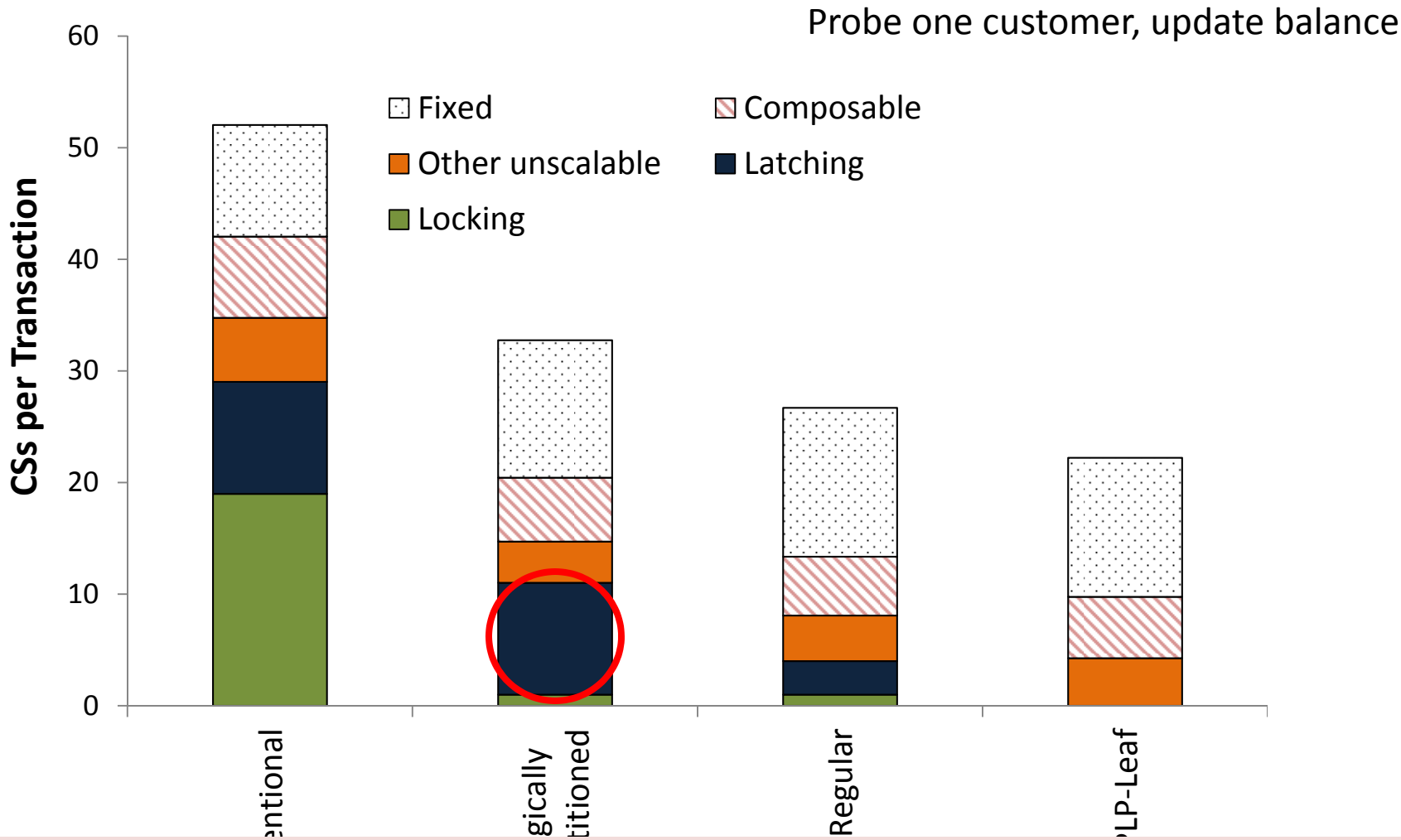


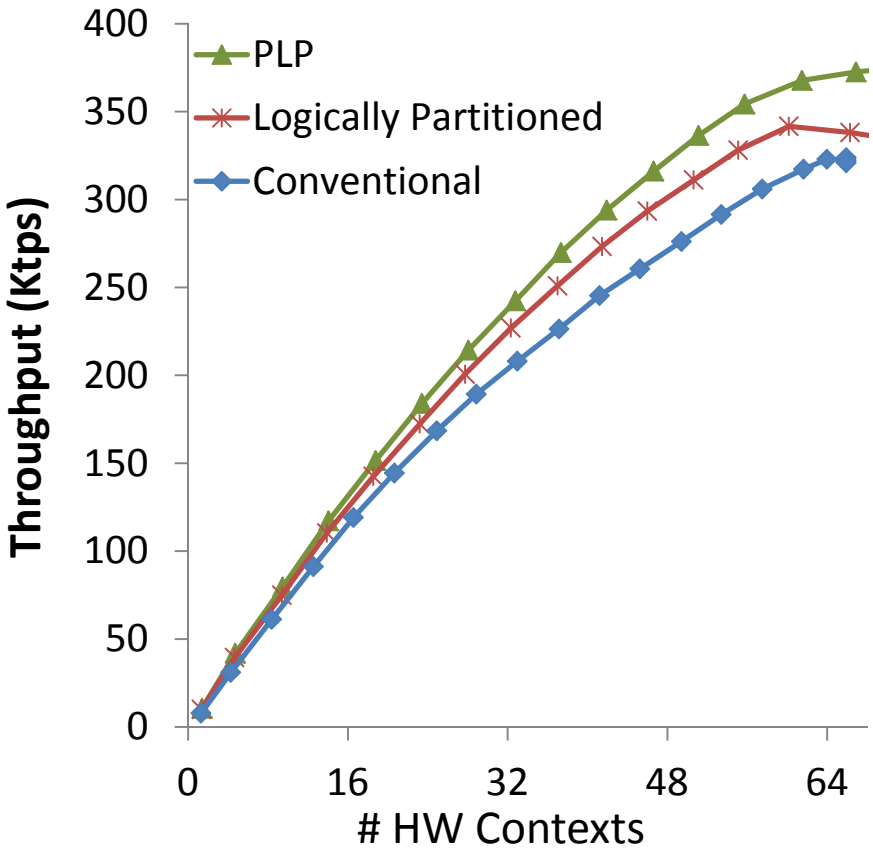
PLP eliminates majority of the unscalable CSs

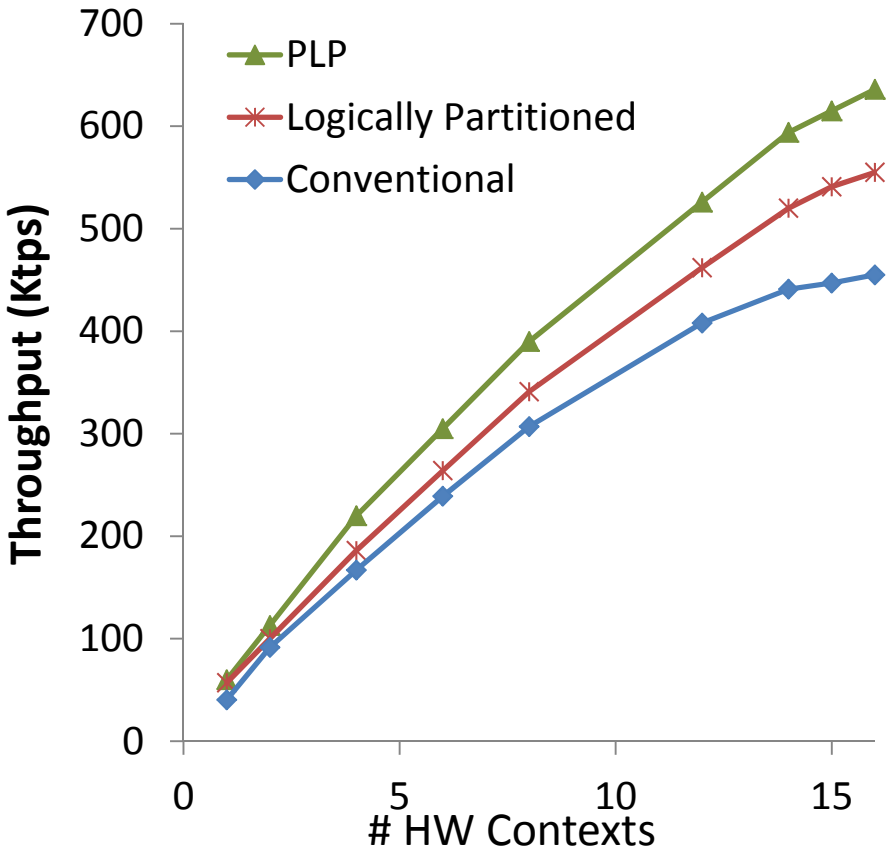
Performance on Multicores

Sun Niagara T2
64 HW ctxs, in order, 1.4GHz

TATP – GetSubData

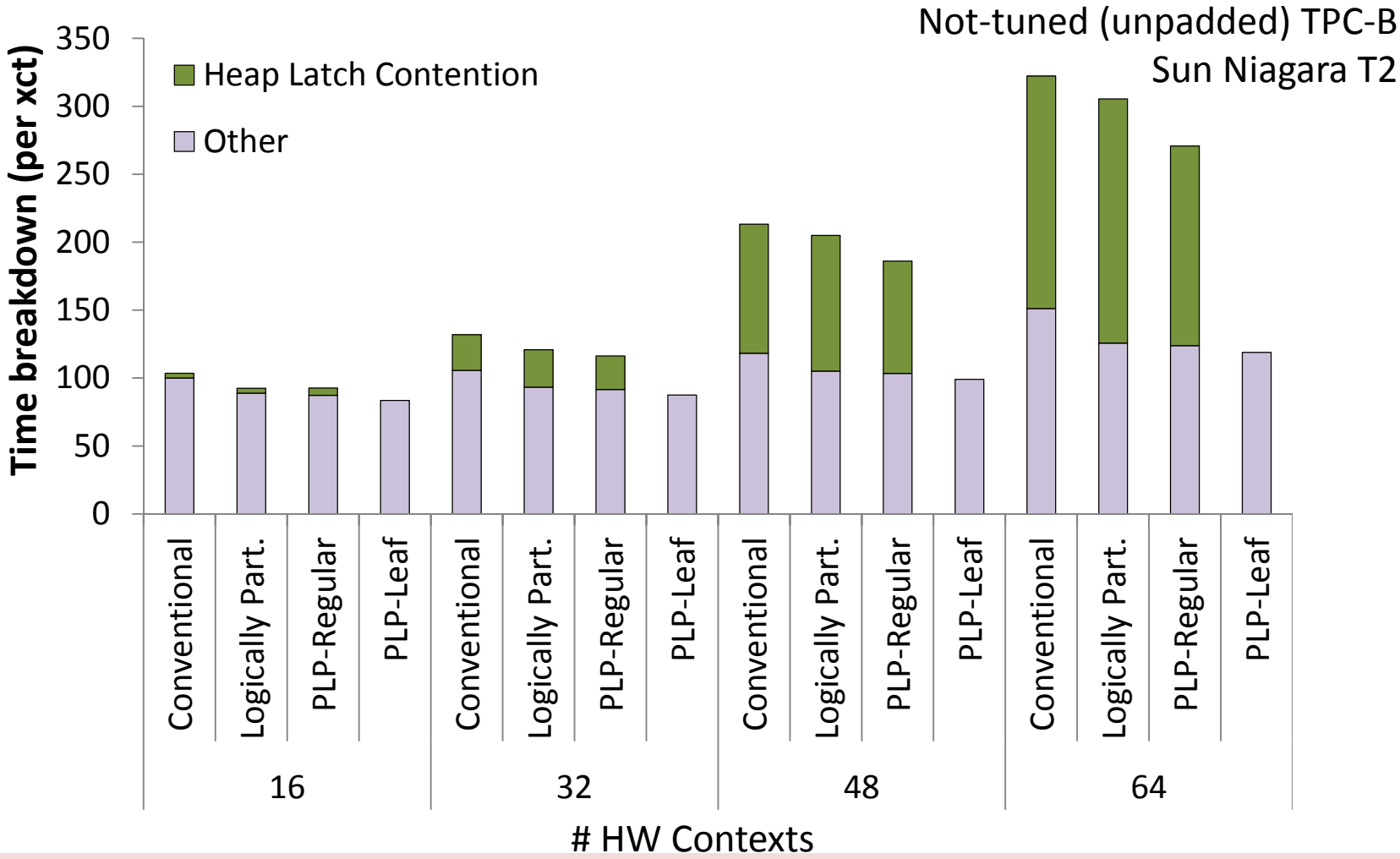
4 socket Quad AMD
16 HW ctxs, OoO, 2.8GHz





Benefits increase with faster hardware

Contention for heap pages



Avoids heap false sharing problems

Repartitioning Cost

Scenario: Splitting a partition to two (466MB)
1 primary and 1 secondary index
8KB pages, 100B records, 32B keys, 3-level B+tree

	Heap Records Moved	Primary & Secondary Index (Updates, Inserts, Deletes)
Shared-nothing		
PLP-Partition		
PLP-Leaf		

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DATA-INTENSIVE APPLICATIONS AND SYSTEMS

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PLP-Leaf: low repartitioning cost + latch-free

Conclusion

- Multicores expose the bottlenecks of DBMSs
- Understanding the critical sections is crucial
  - Identify the harmful ones and eliminate them
- Physiological partitioning
  - Apply the right partitioning at both logical & physical layers
  - Thread local locks & latch free data accesses
  - Eliminate majority of unscalable critical sections
  - Benefits of shared-nothing with easy repartitioning

Thank you!