NrOS: Effective Replication and Sharing in an Operating System

Ankit Bhardwaj, Chinmay Kulkarni, Reto Achermann, Irina Calciu,
Sanidhya Kashyap, Ryan Stutsman, Amy Tai, and Gerd Zellweger

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Kernel development is hard

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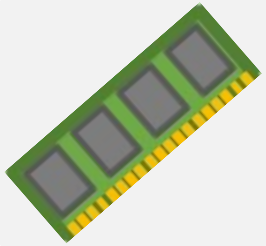
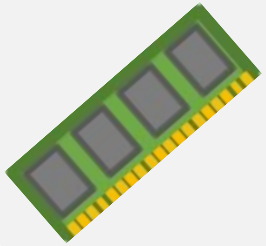


Manual memory management

Kernel development is hard



Manual memory management

Type-unsafe code

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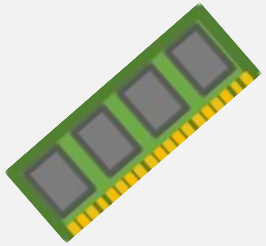

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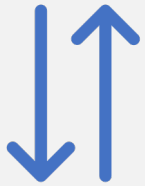
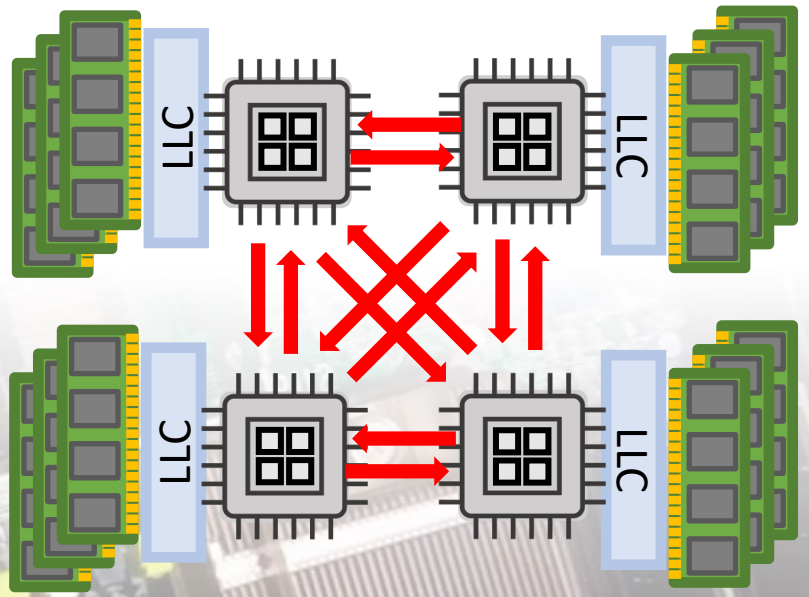


Complex and asynchronous event handling

Concurrency makes it harder

- Increasing core counts
- NUMA



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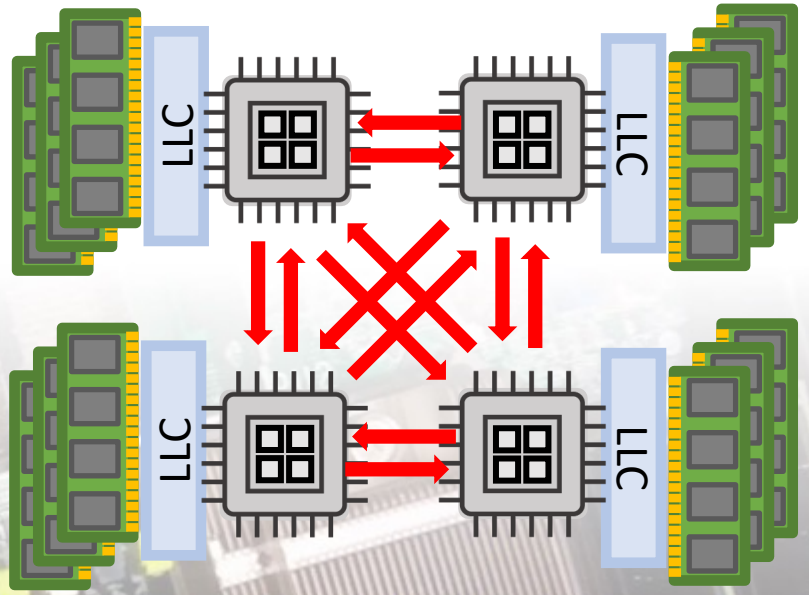
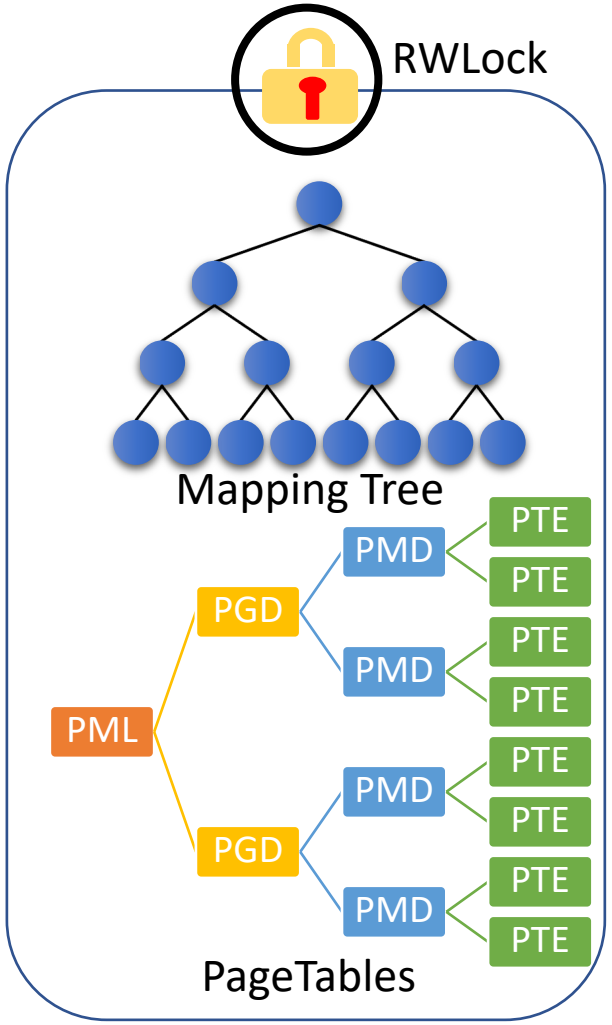
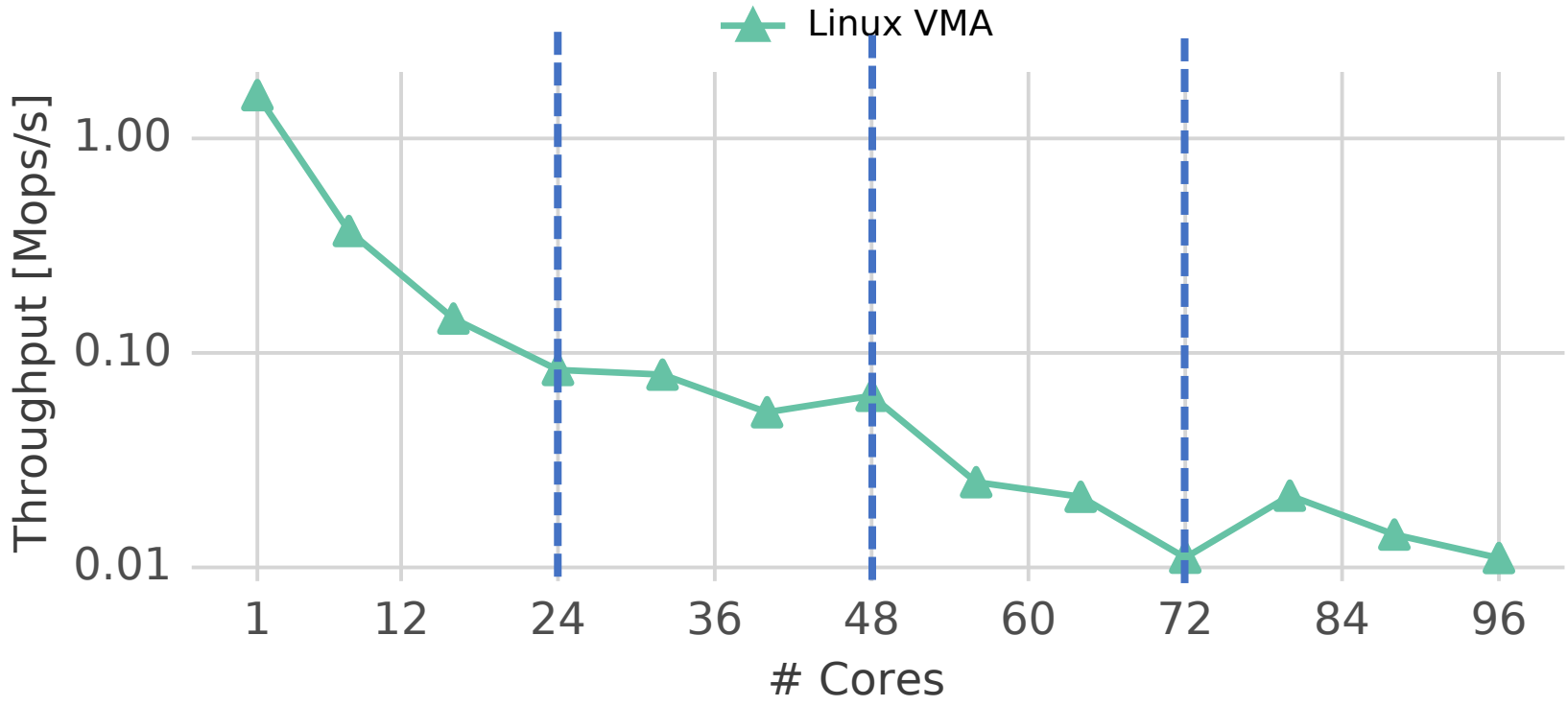


Solution: Use coarse locks around sequential data structures

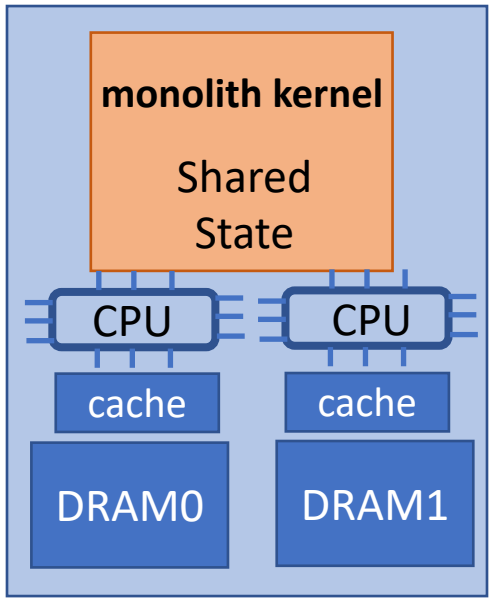
Simple & black-box approach

Big locks are bad for performance





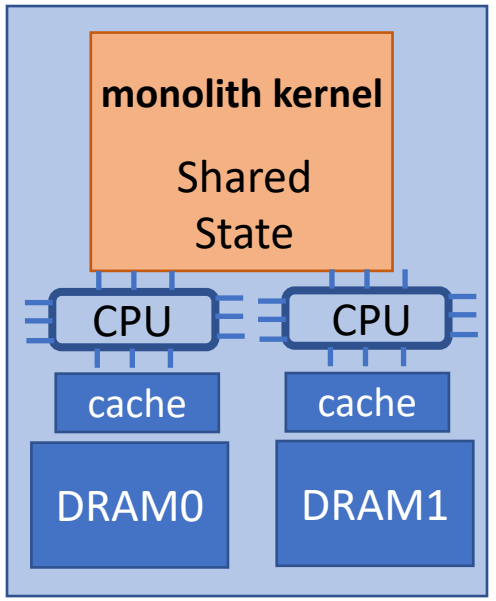
Mitigations in monolithic kernels



Mitigations in monolithic kernels

Monolithic kernels share state across cores

- Use fine-grained locking
- Lock-free data-structures
- Relativistic programming (RCU etc.)



Lots of additional complexity

Mitigations in monolithic kernels

[4.18,004/235] rds: fix two RCU related problems

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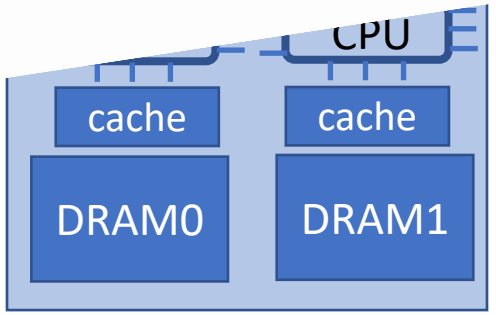
State	New, archived
Headers	show
Series	4.18.10-stable review
Related	show



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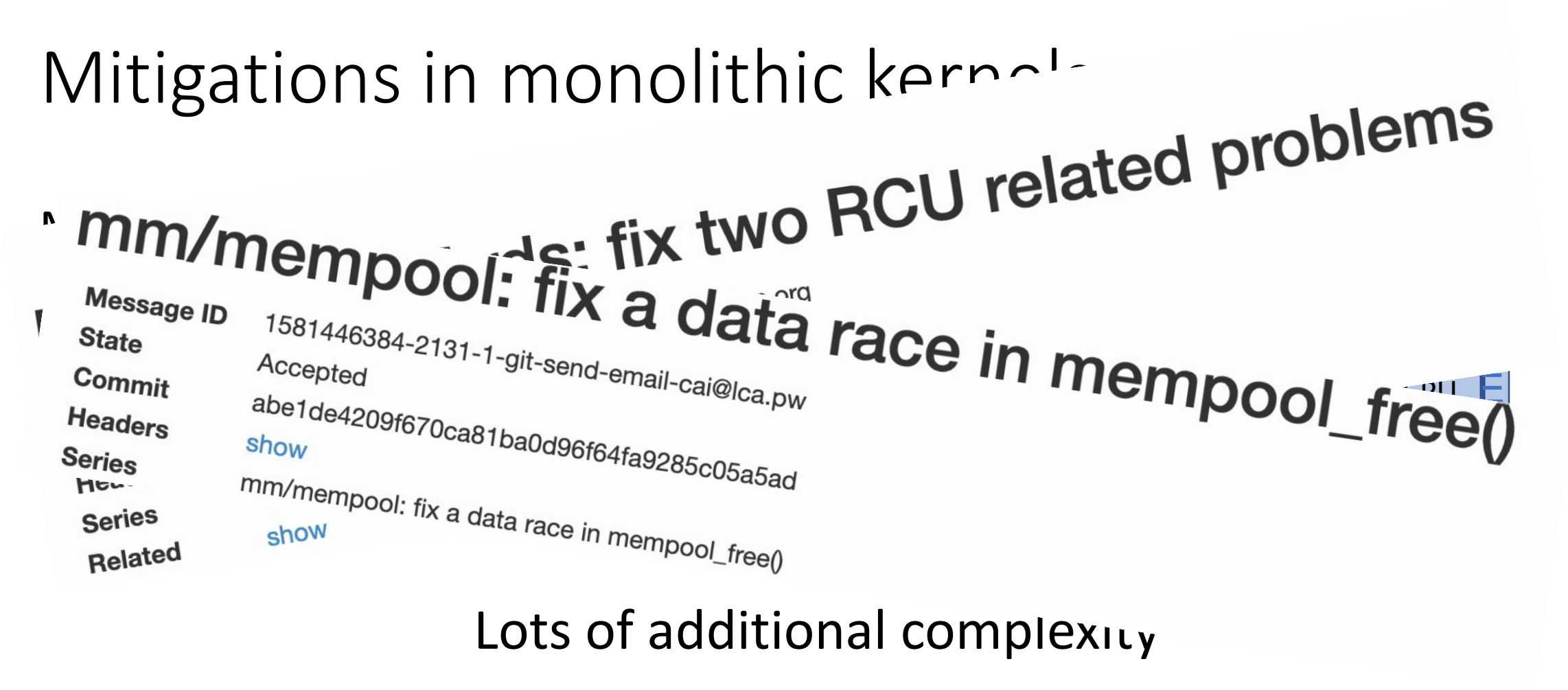

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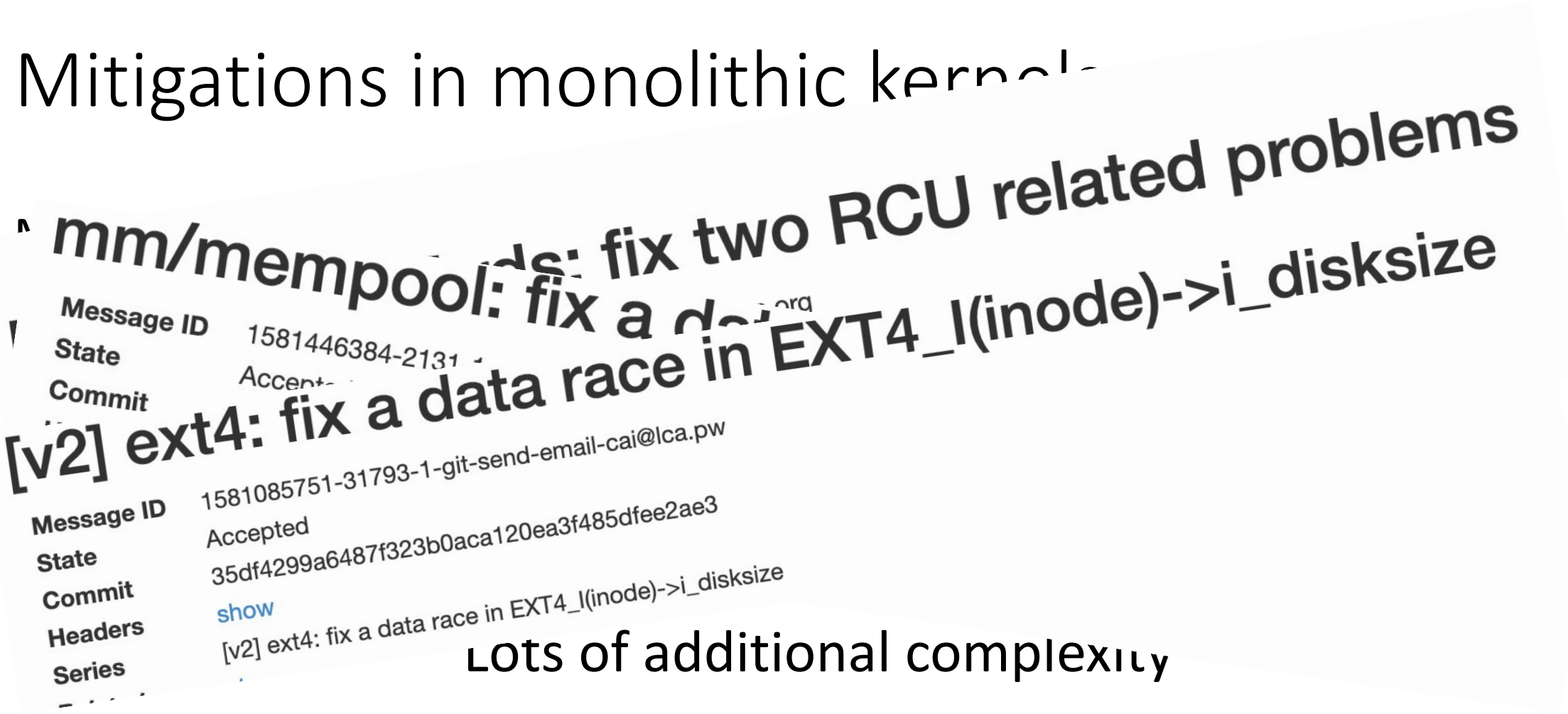

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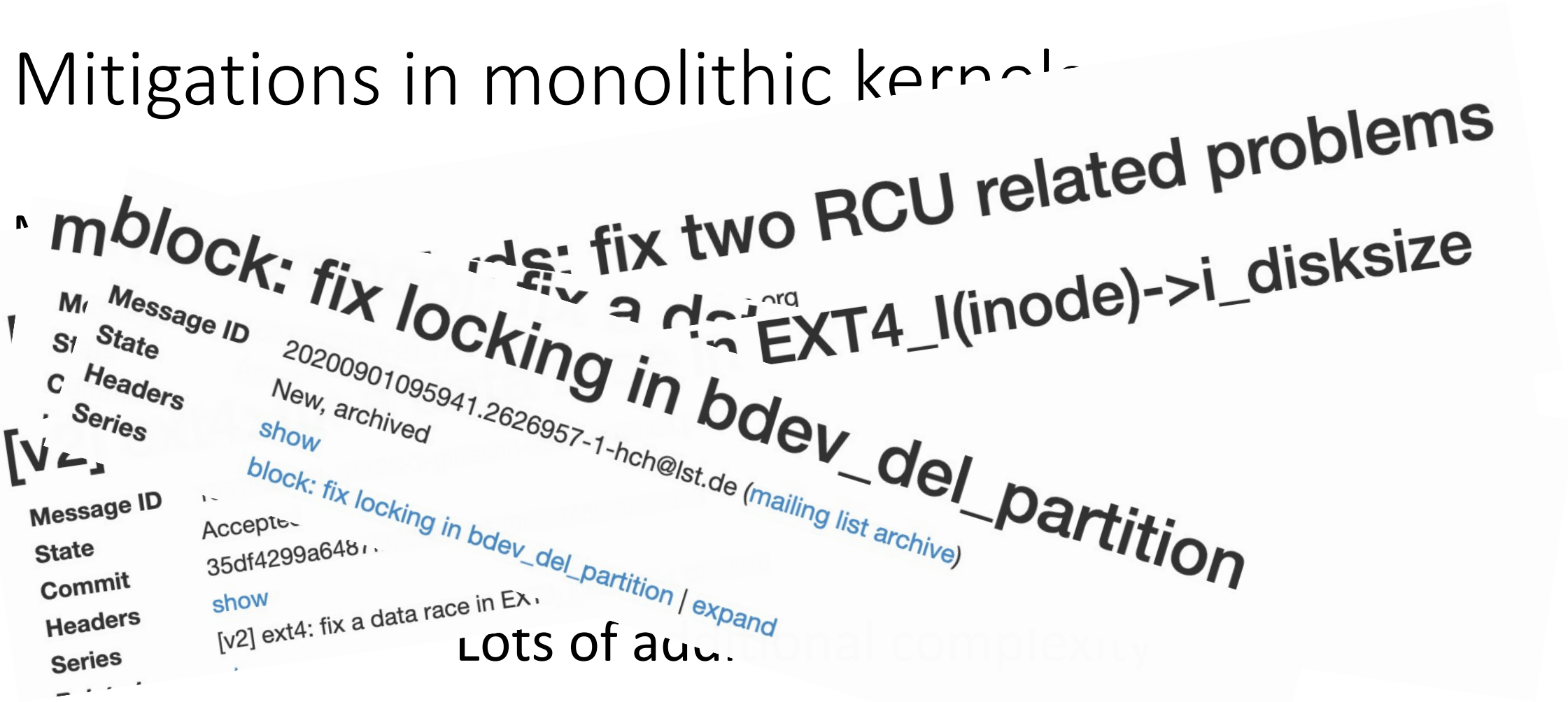
Mitigations in monolithic kernels



An error has occured.We dont even know what is it.So cant fix it ,
and you have restart your computer.By the way if you restart your ,
computer you will lose any unsaved information in all open applications.
In the other hand you dont have any other option :)

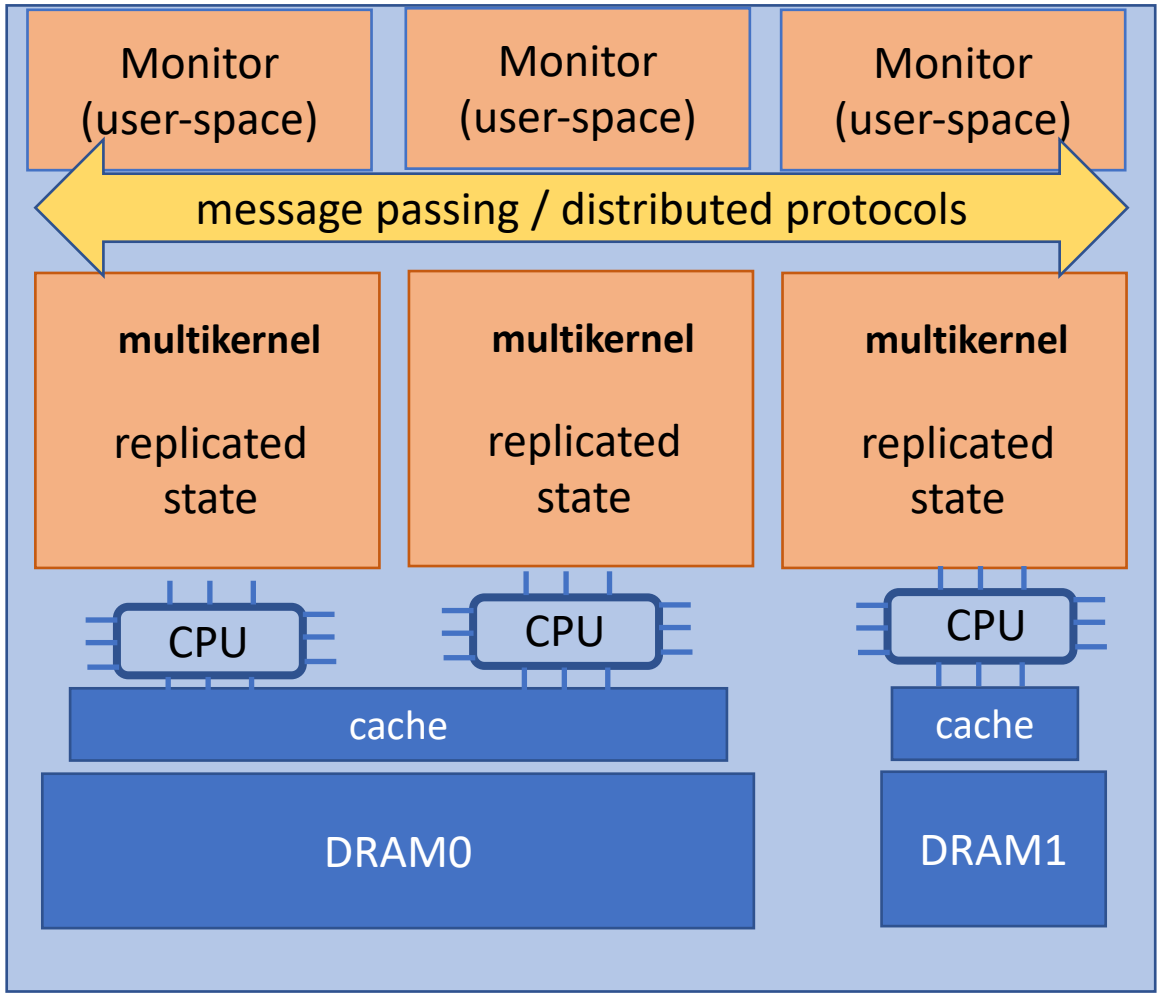
Press Enter to return to Windows(It wont work), or

Press CTRL+ALT+DEL to restart your computer.

Error : 0E : 016F : BFF9B3D4

Uni.Q Design

Multikernel: Barrelfish's approach



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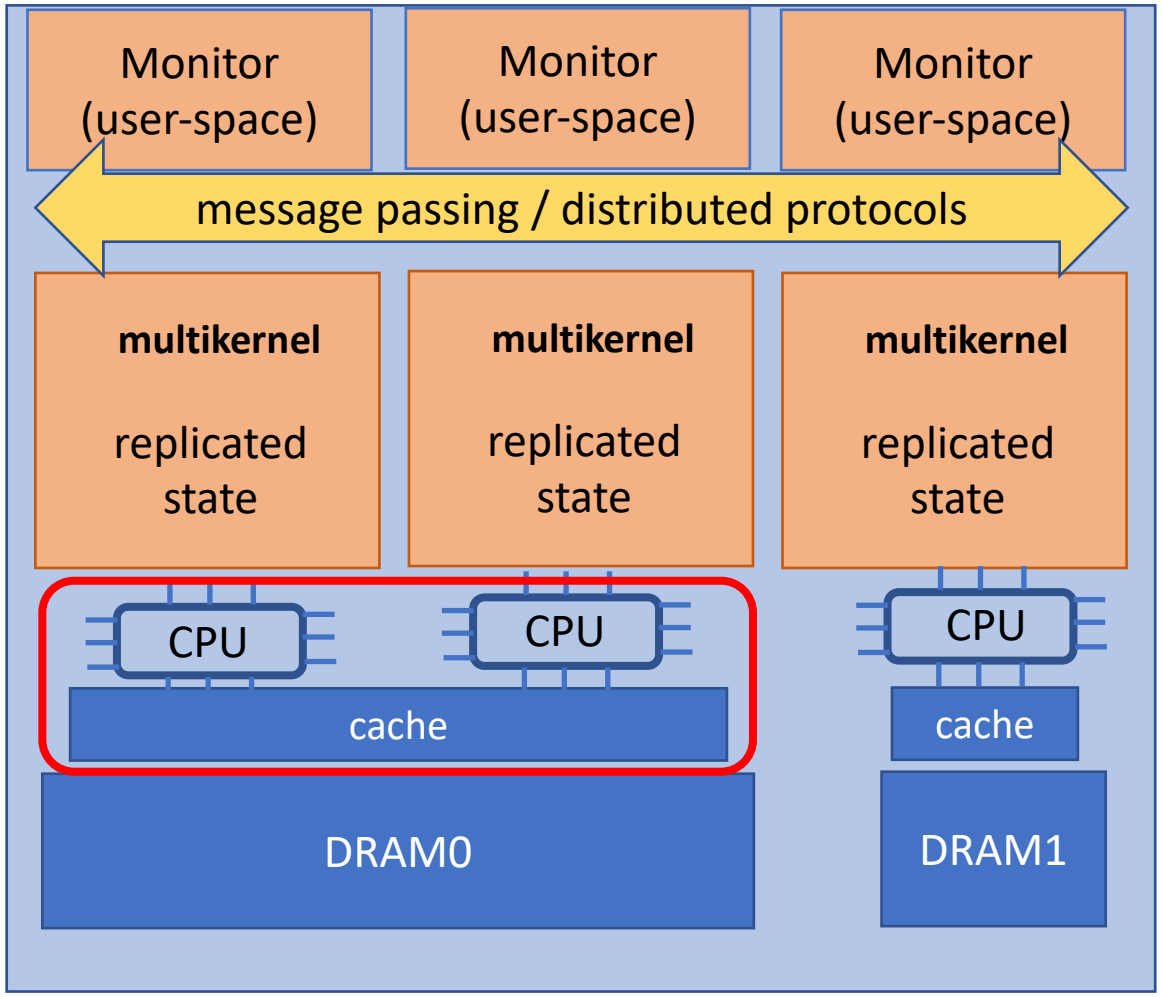
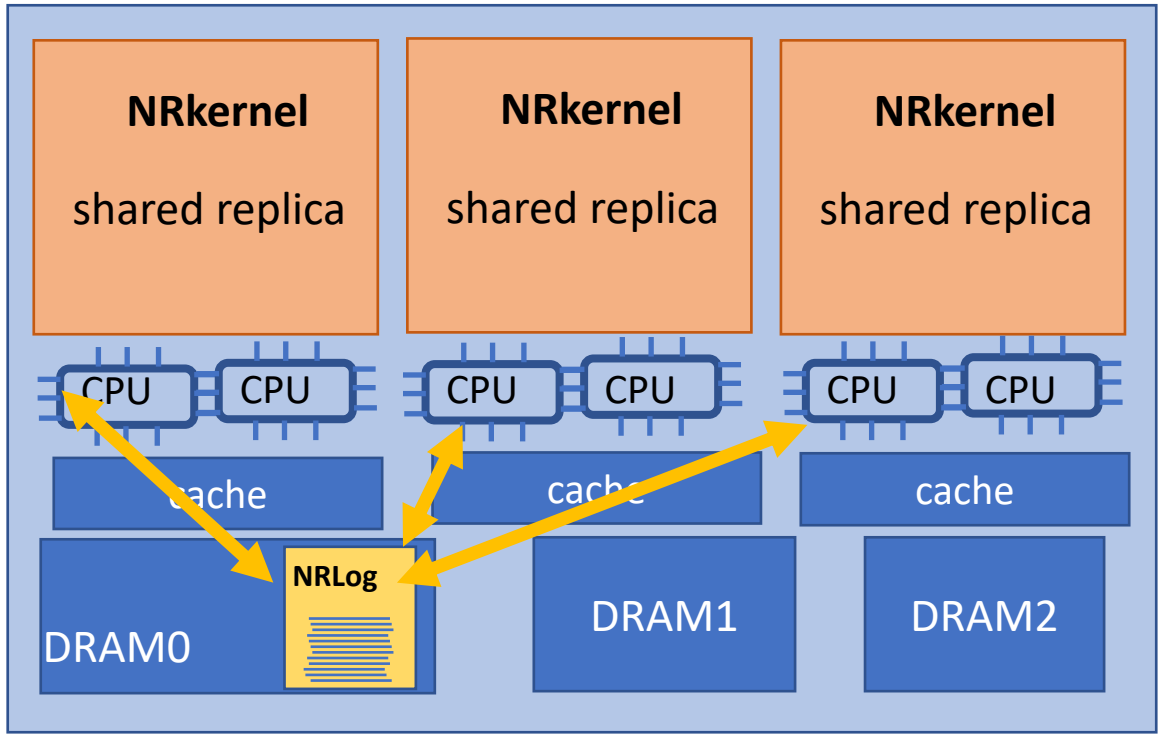
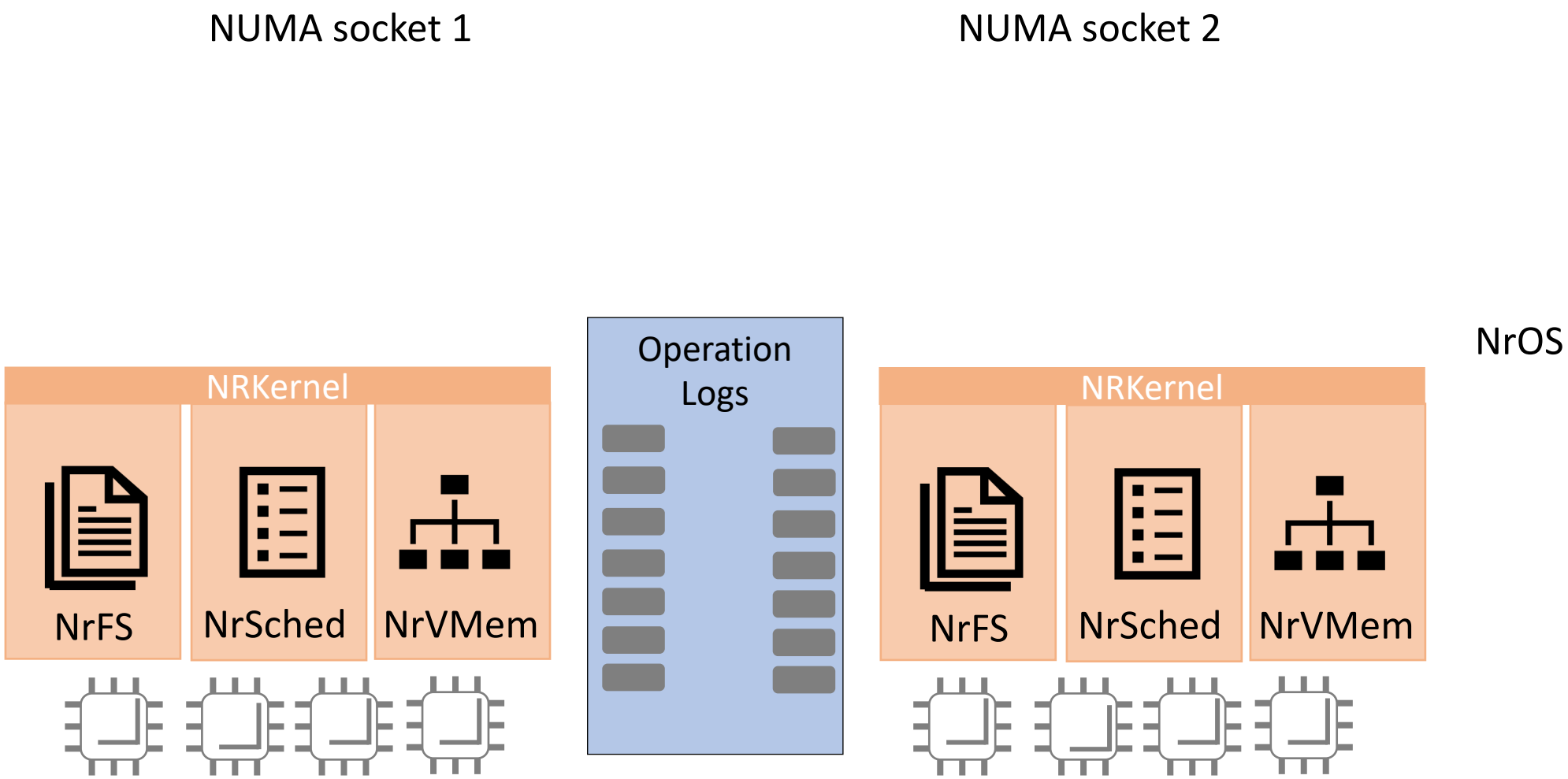


NRkernel: A log-based multikernel

- Sequential kernel data structures
- Unified black-box approach to concurrency
- Replicates NRkernel structures
  - NUMA-local accesses
- Benefits of both message passing and shared memory



NrOS Overview



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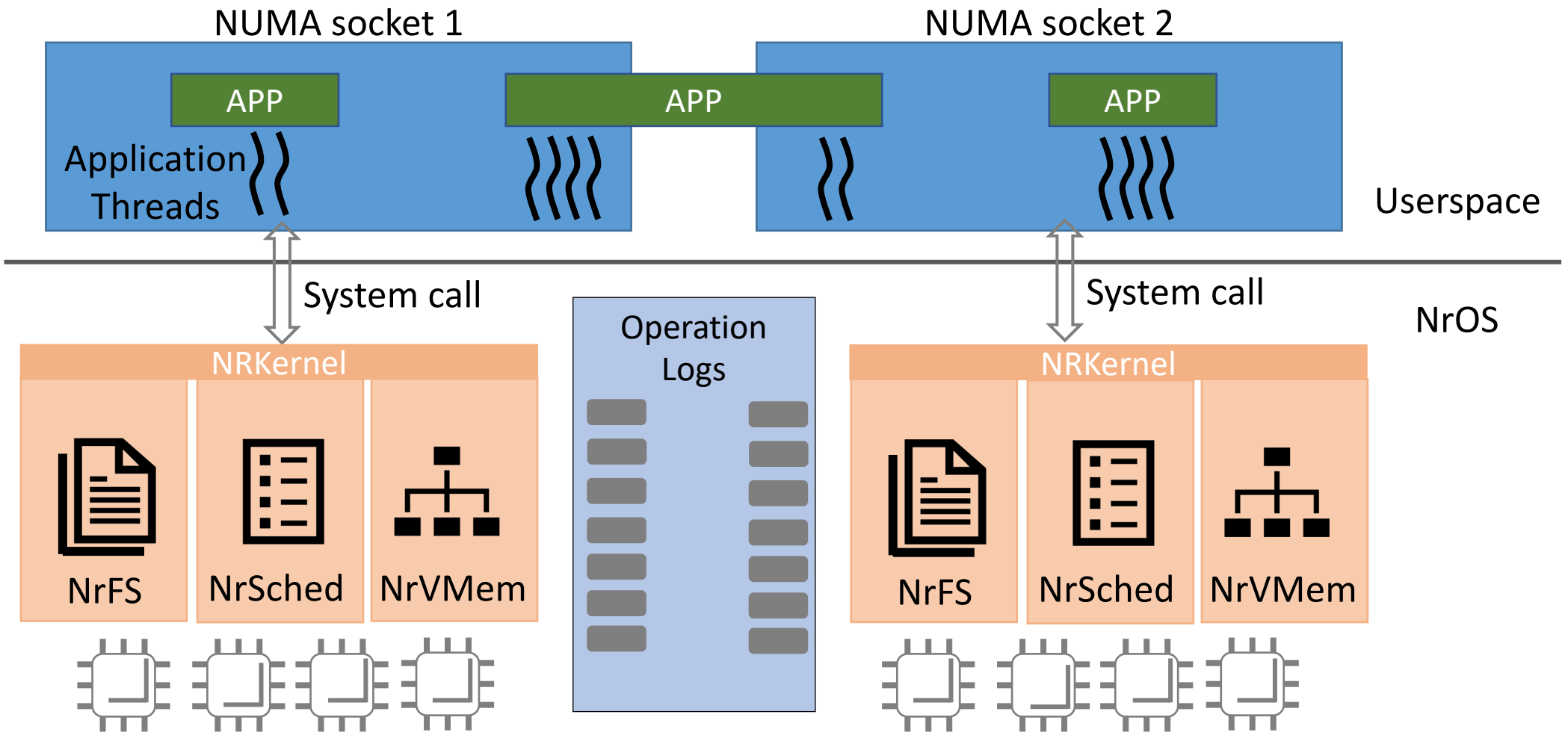
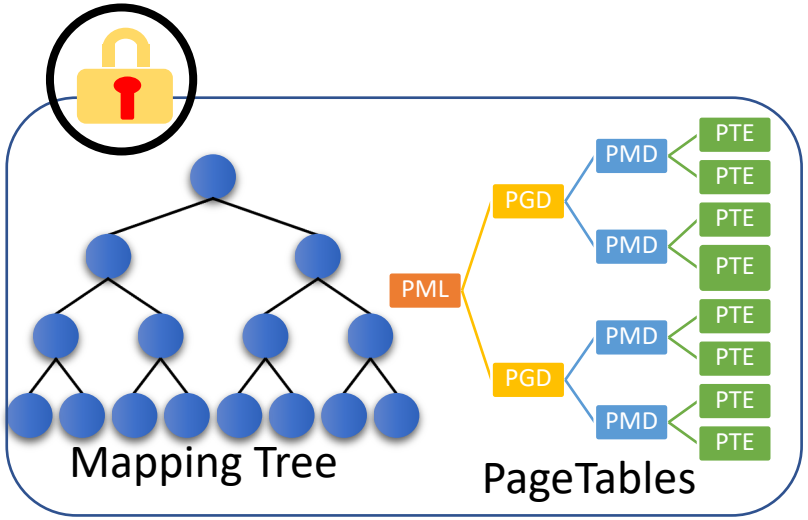


Node Replication: Log based replication

NUMA Node 1

NUMA Node 2

Node Replication: Log based replication



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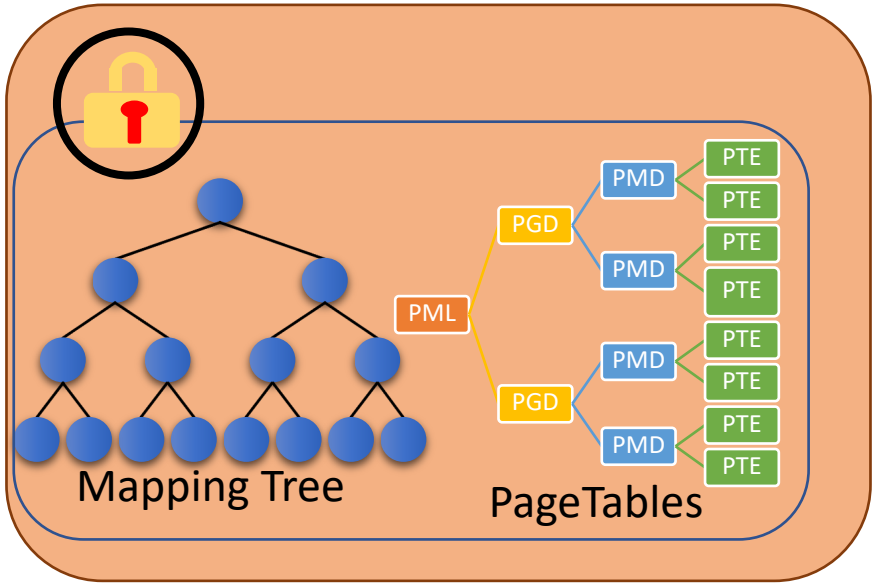

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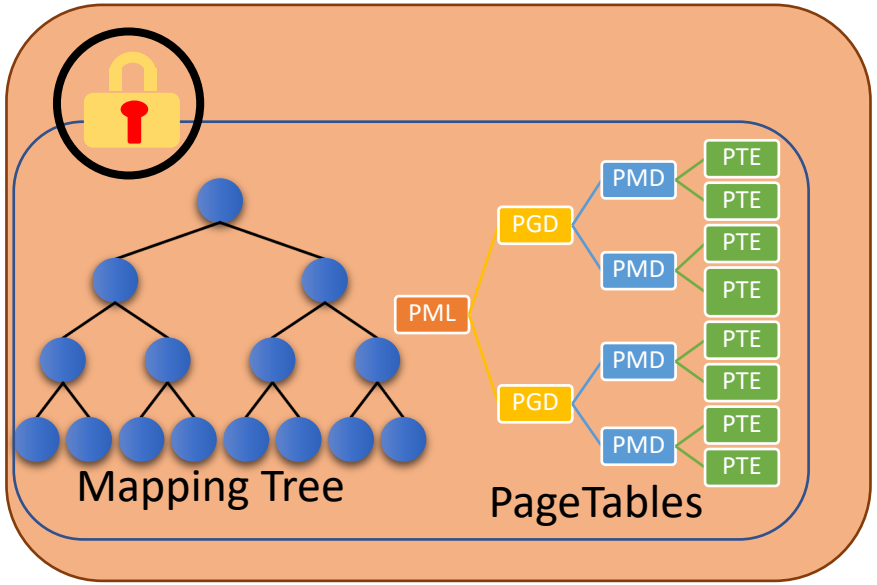

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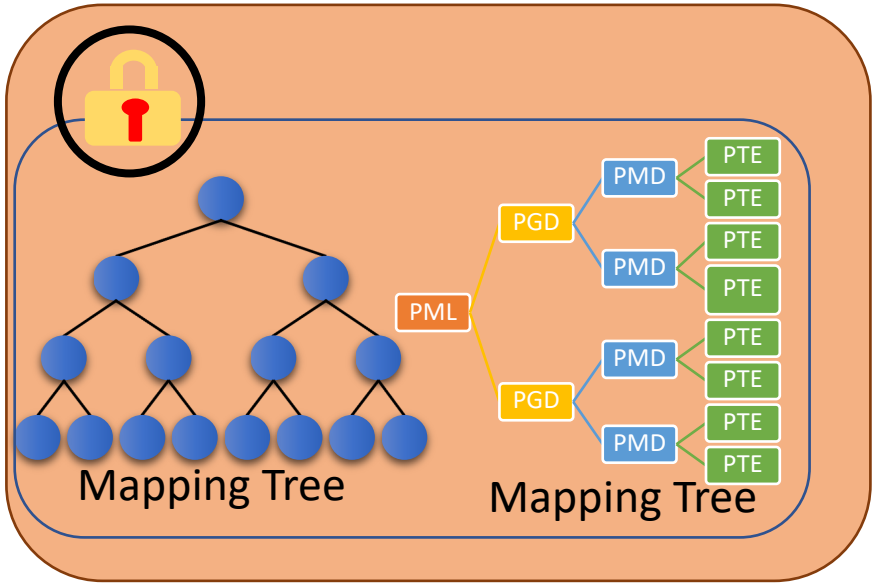
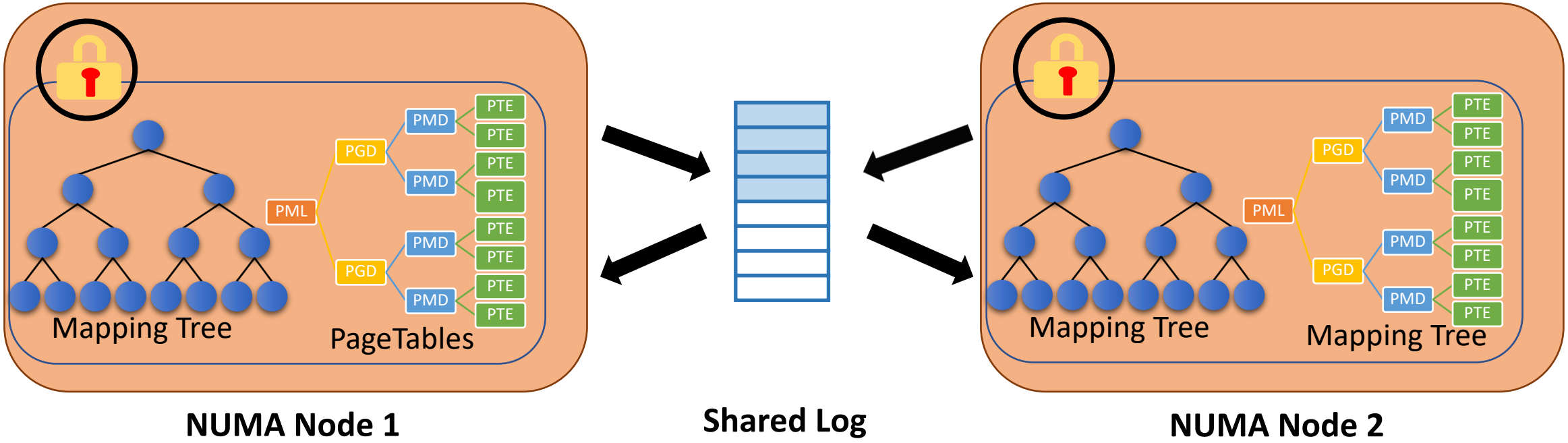


NUMA Node 2

Node Replication: Log based replication



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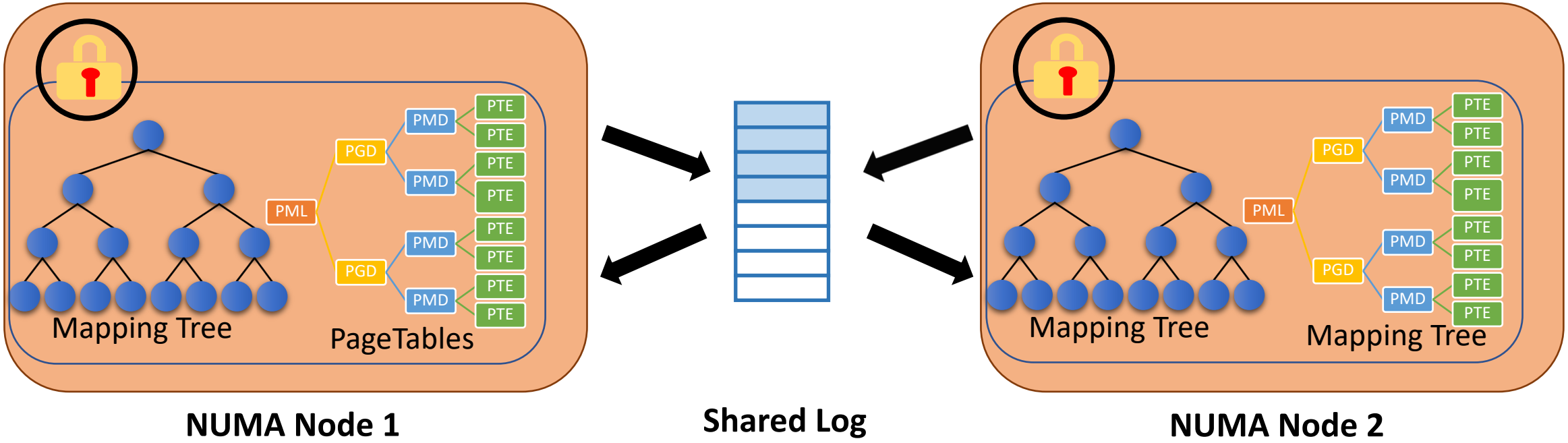
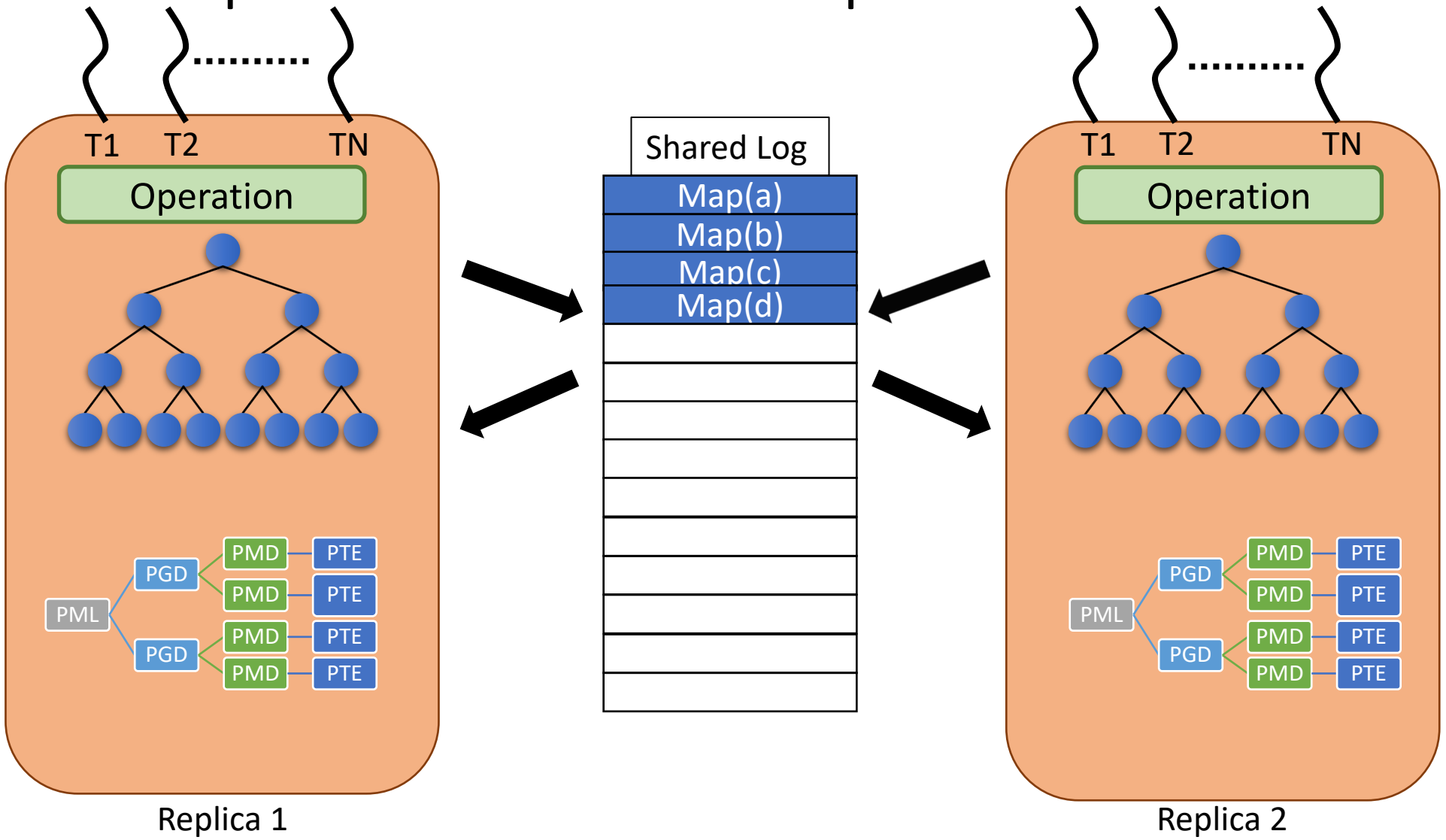


- Write operations replicate through the shared log
- Read operations access the local replica

Node Replication: Write Operation



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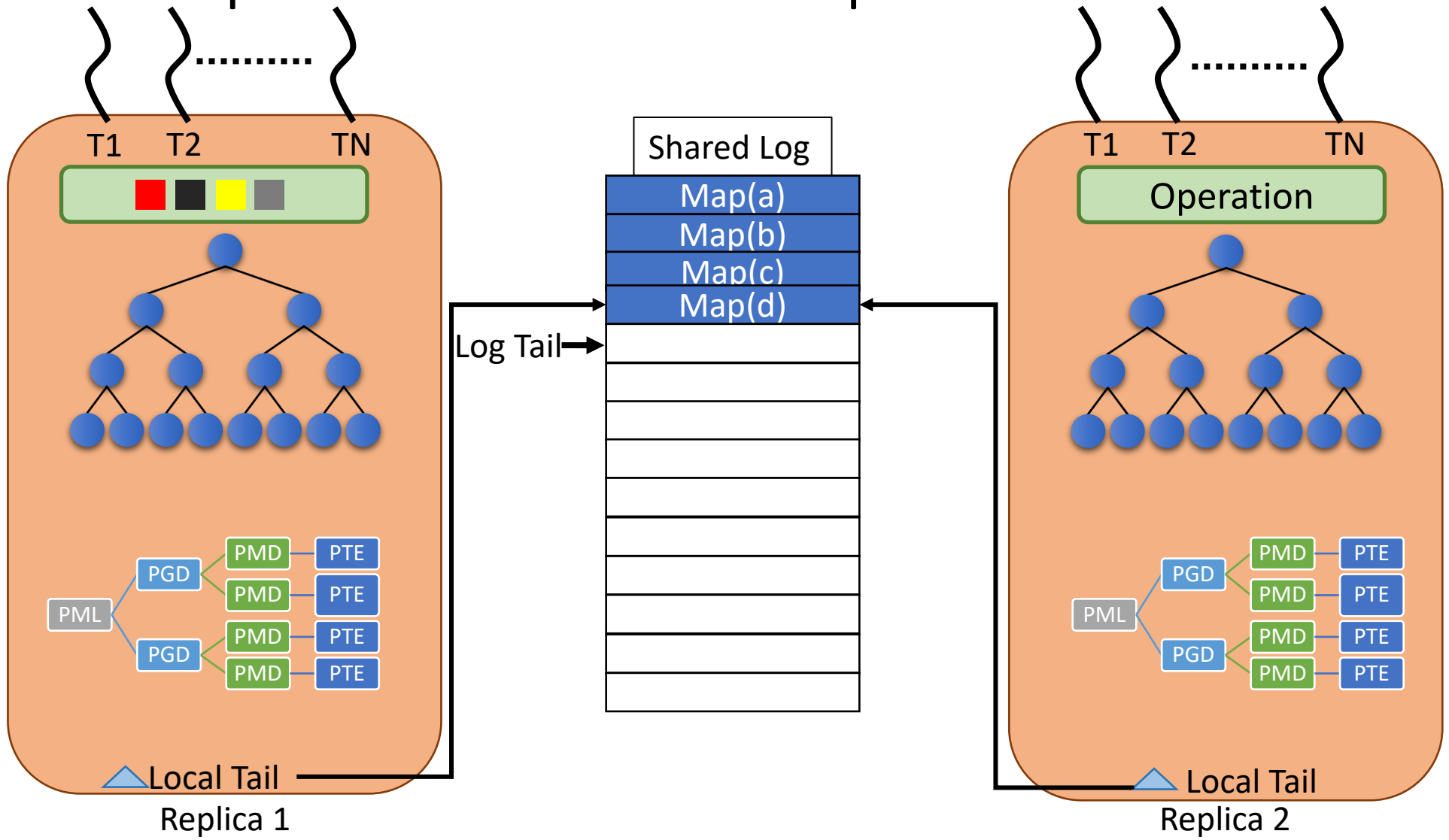

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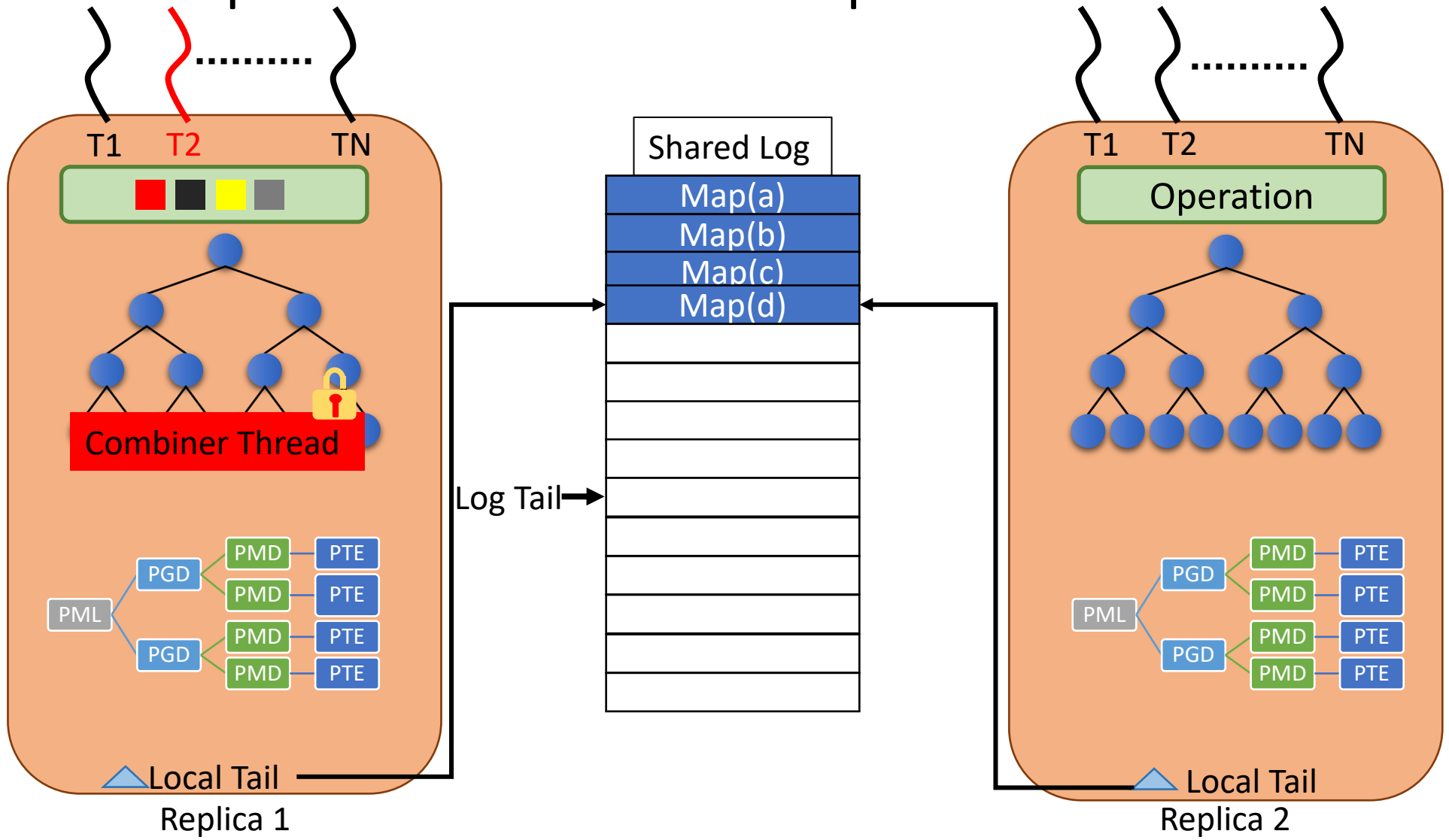

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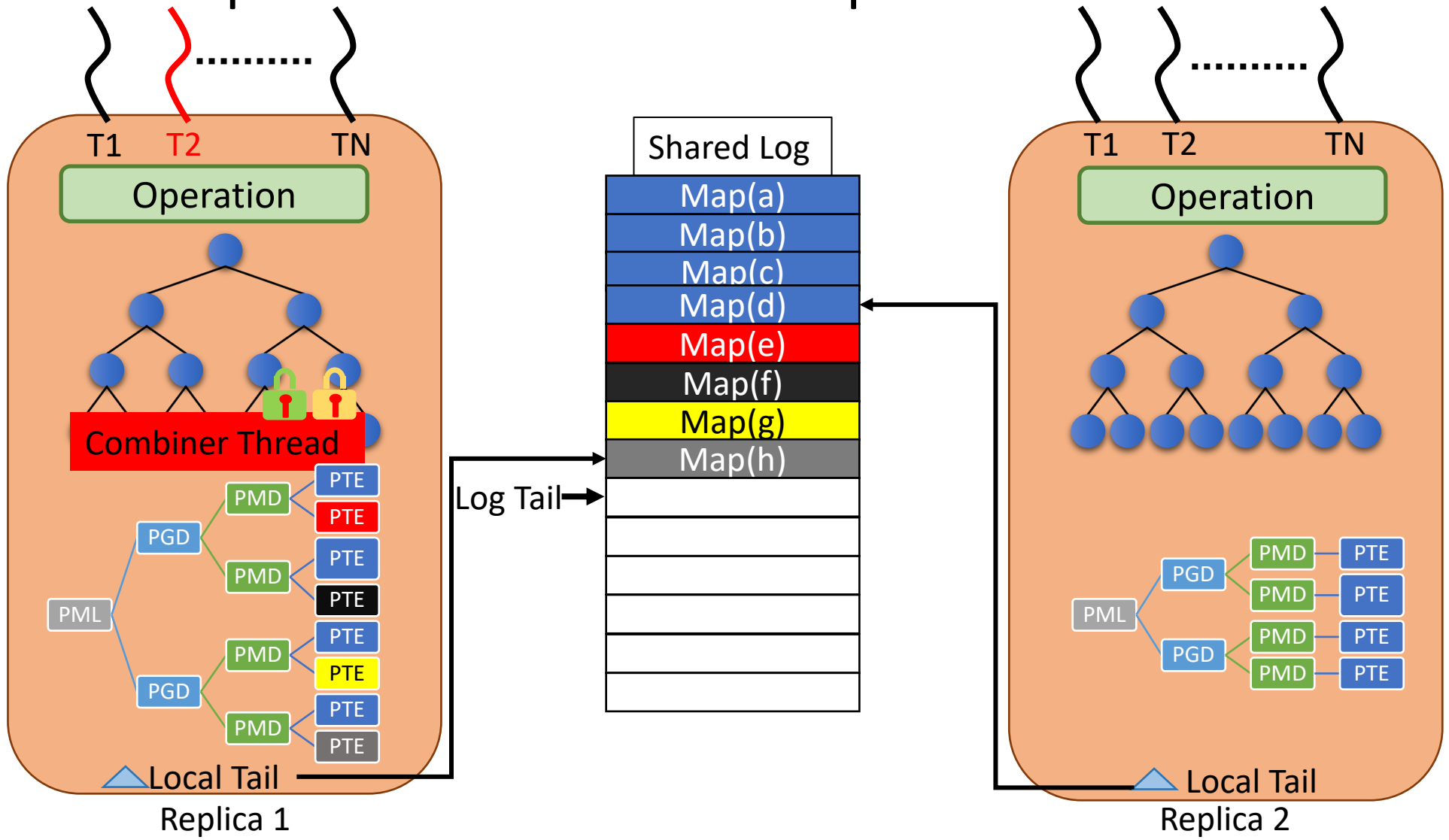

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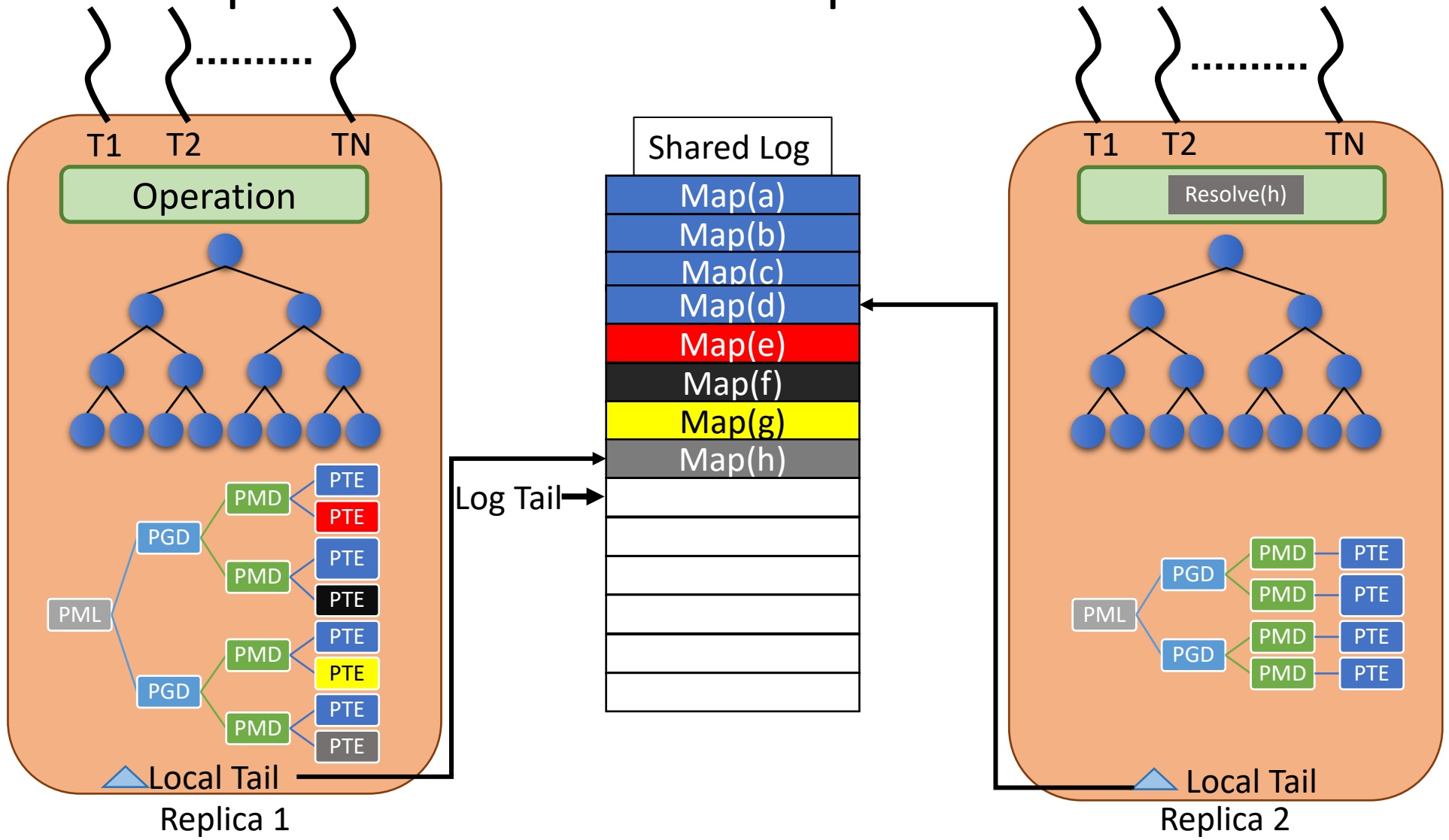

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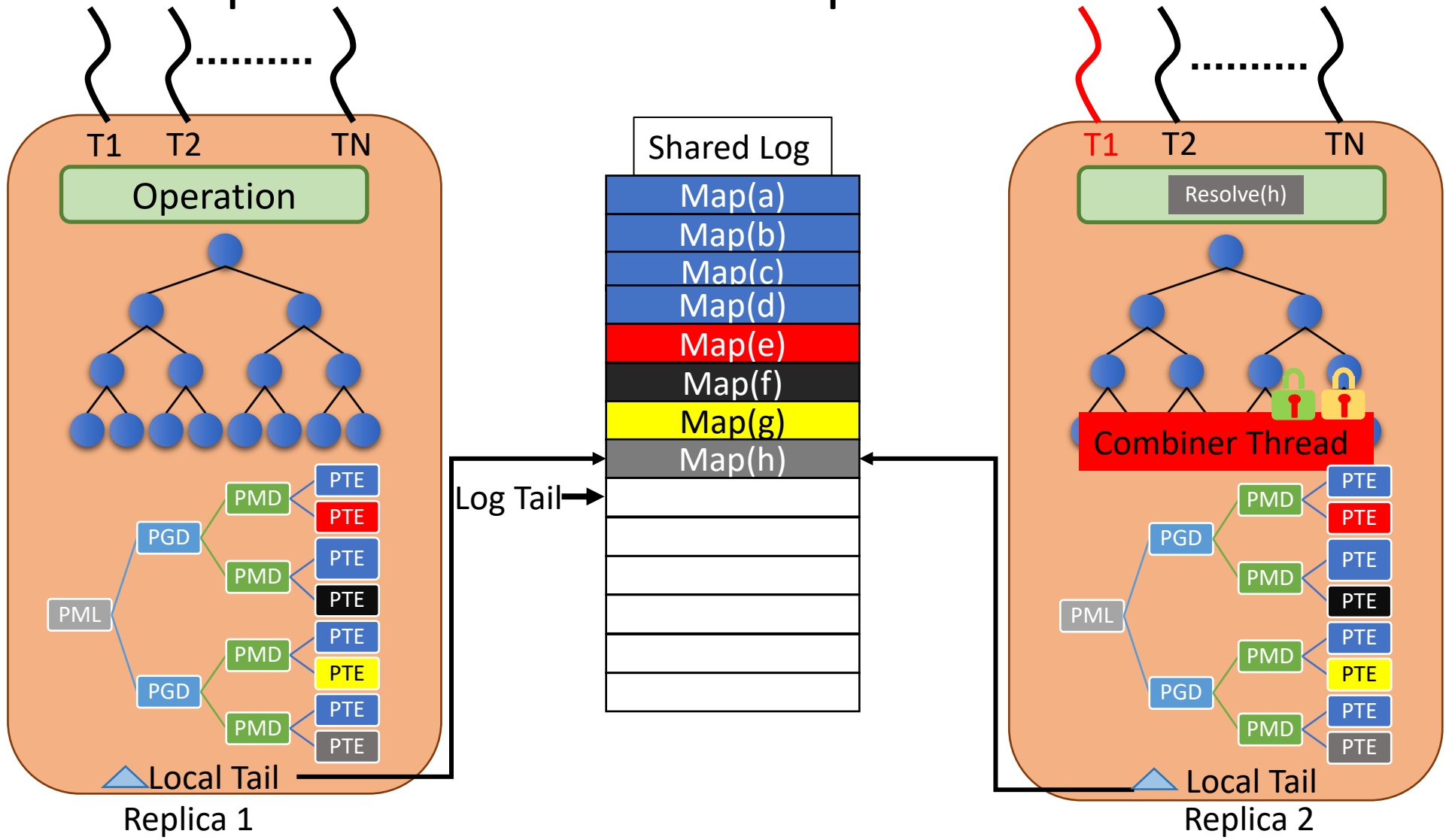

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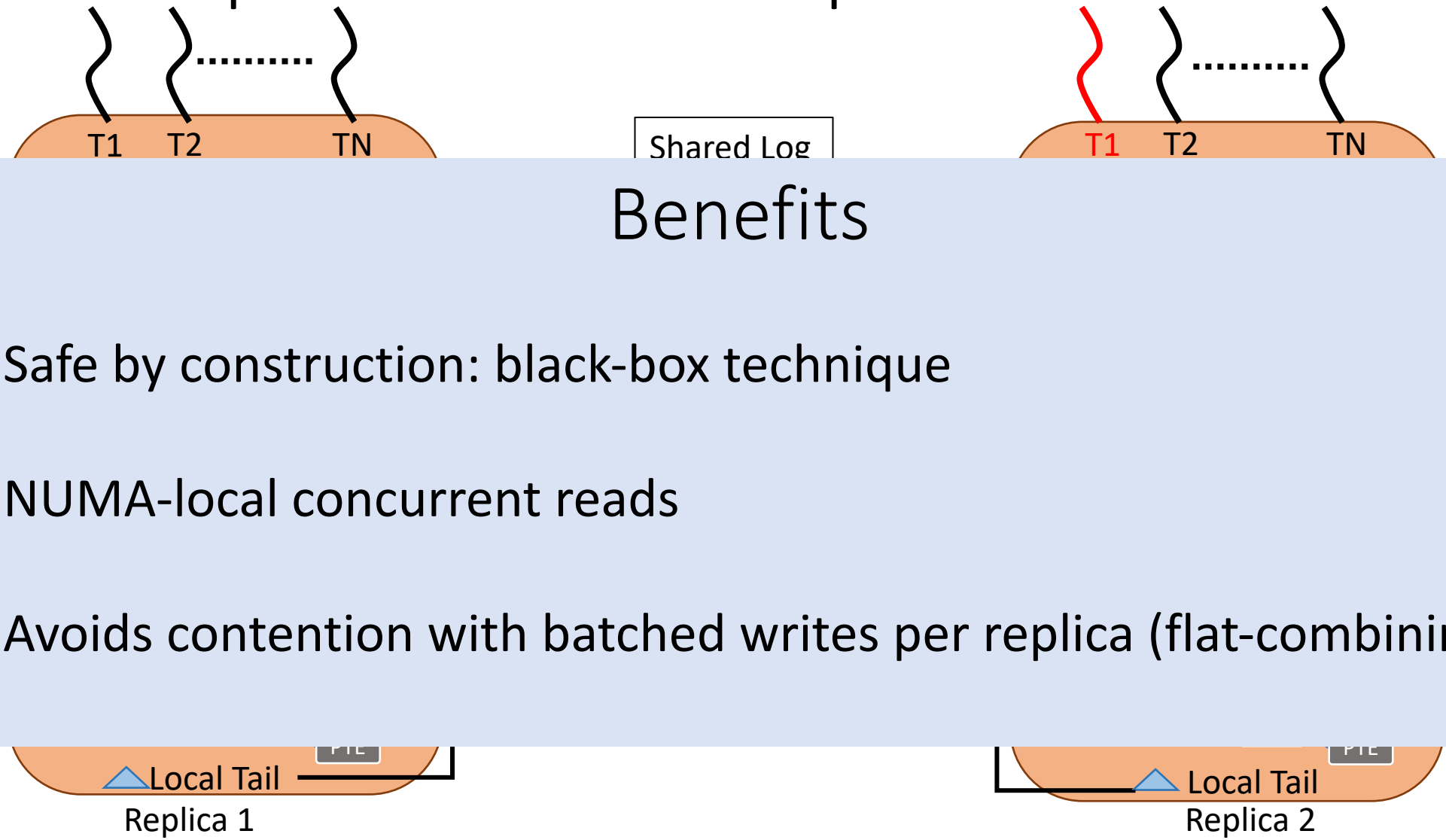
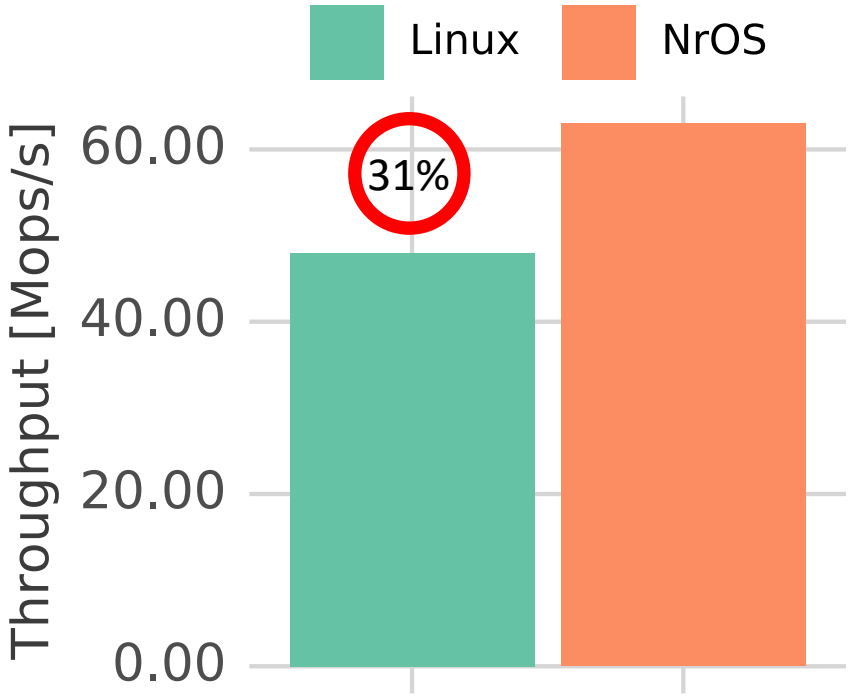


Benefits

- Safe by construction: black-box technique
- NUMA-local concurrent reads
- Avoids contention with batched writes per replica (flat-combining)

Memcached: Page-table replication benefits



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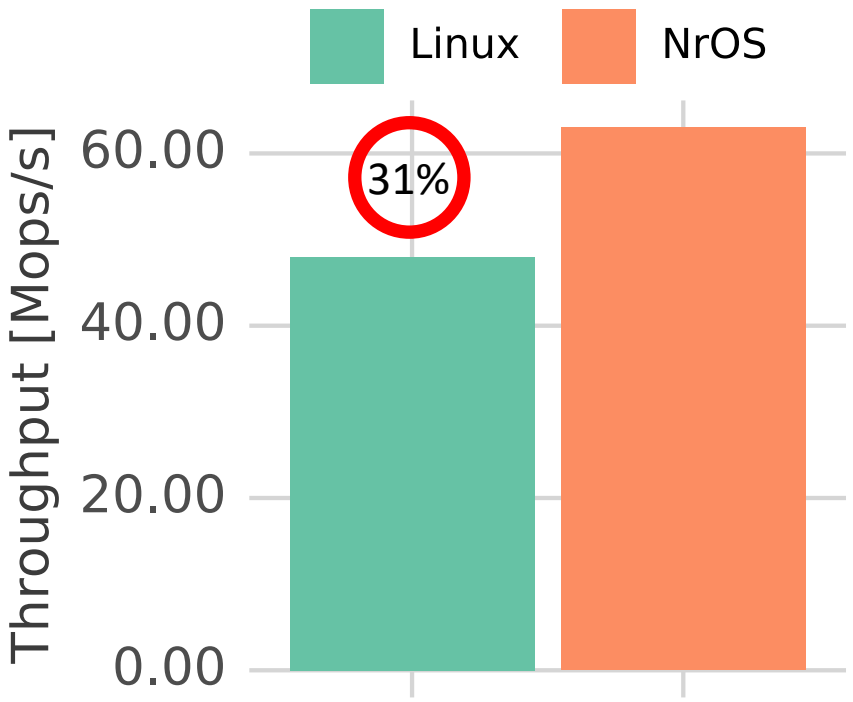
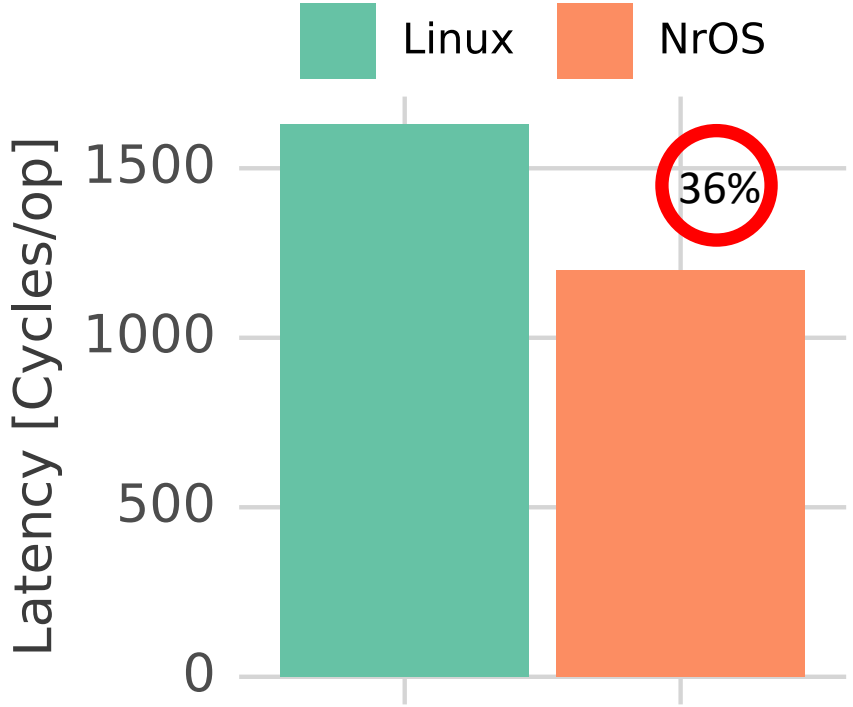
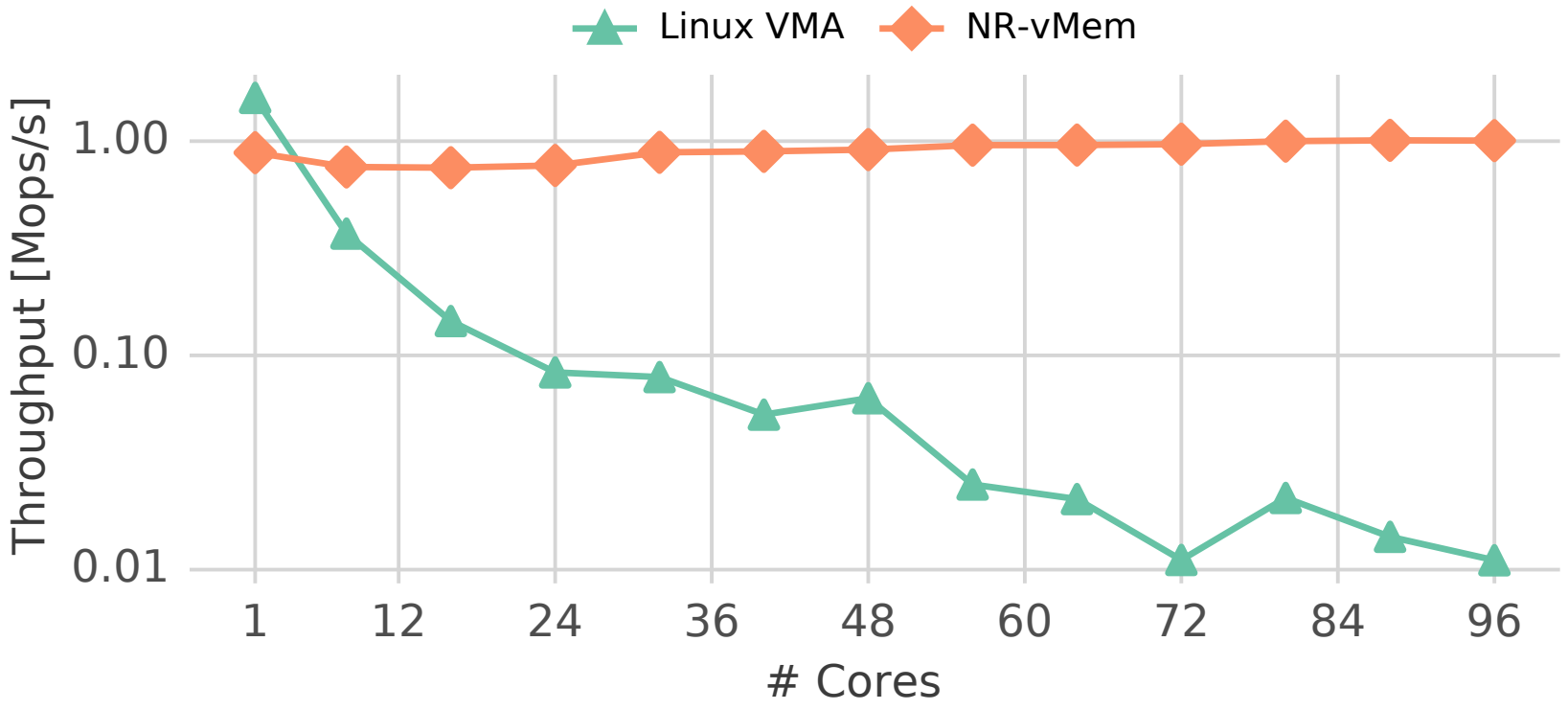




NR-VMem: Combining helps



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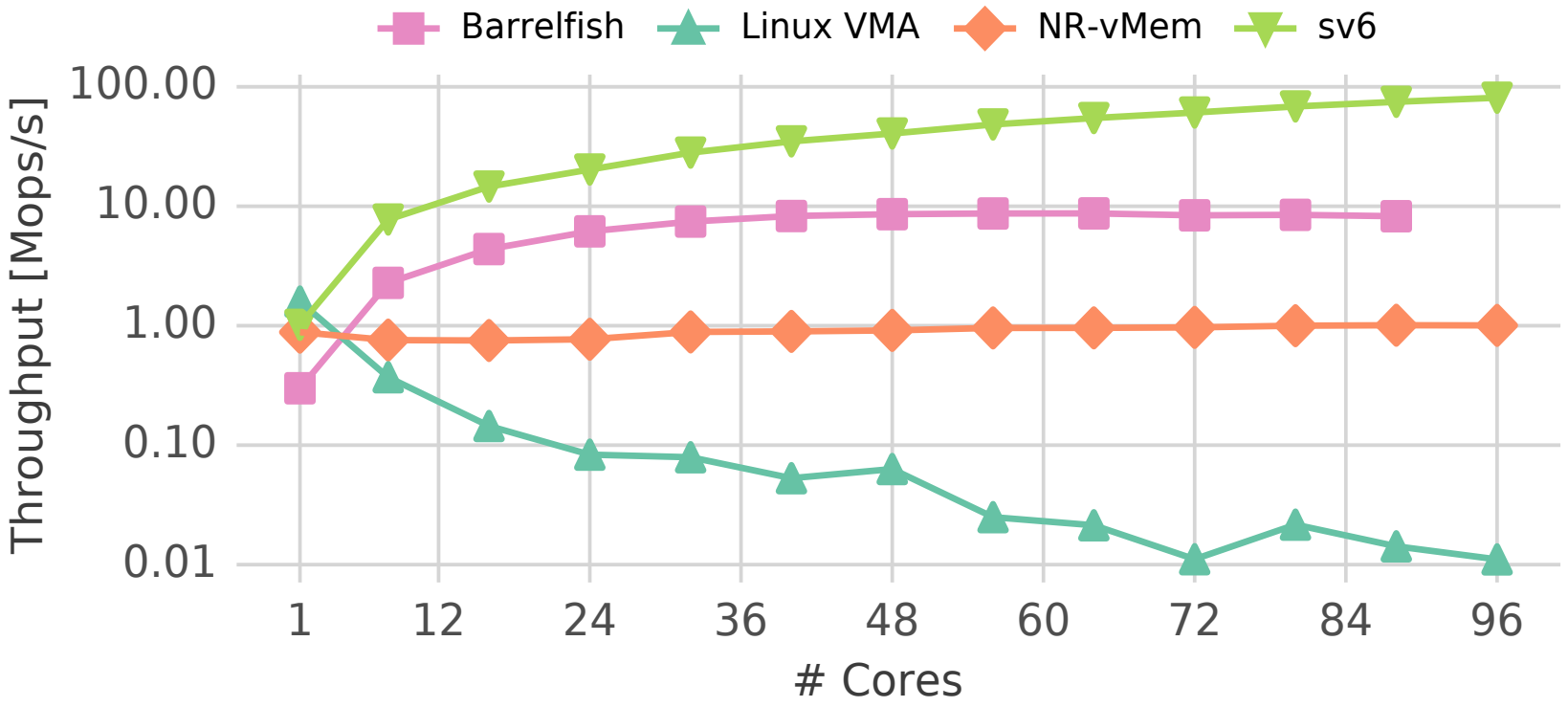
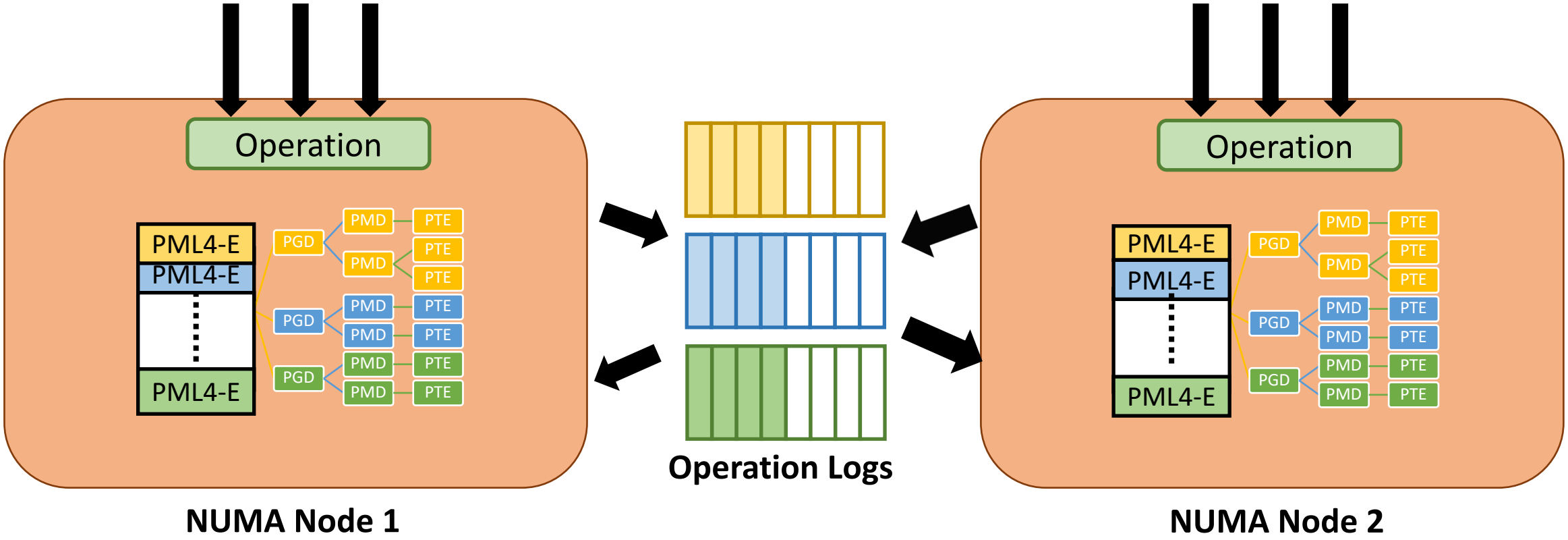


Concurrent Node Replication (CNR)



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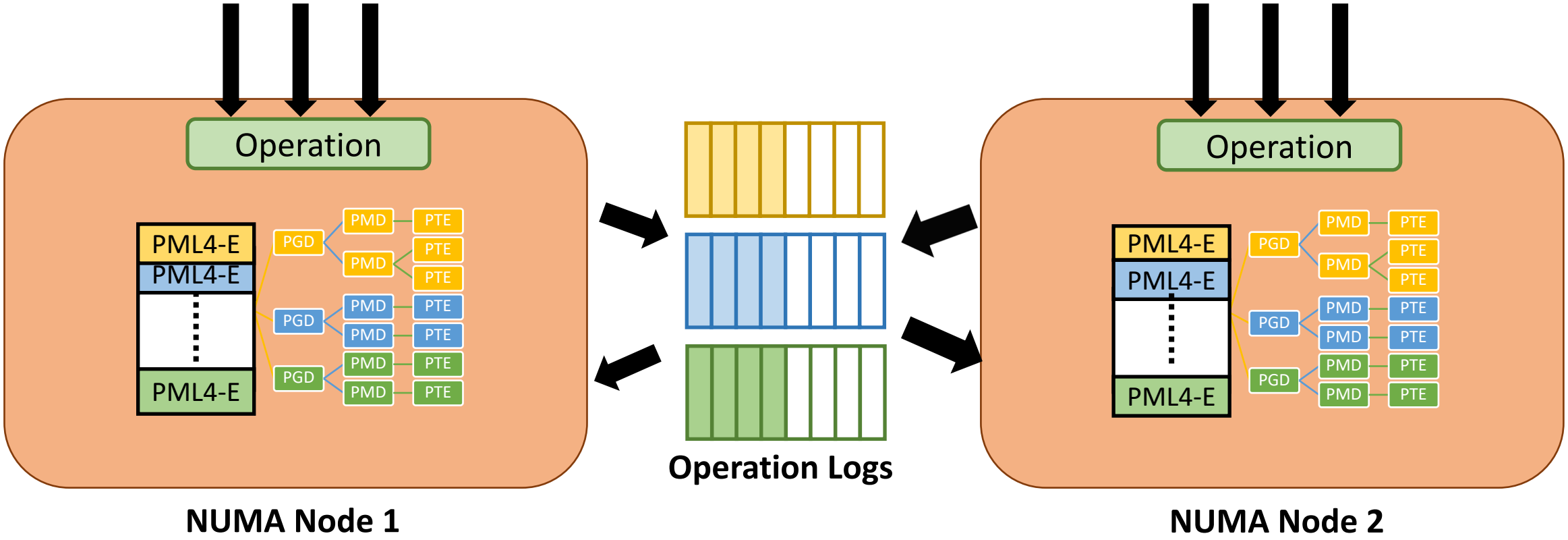
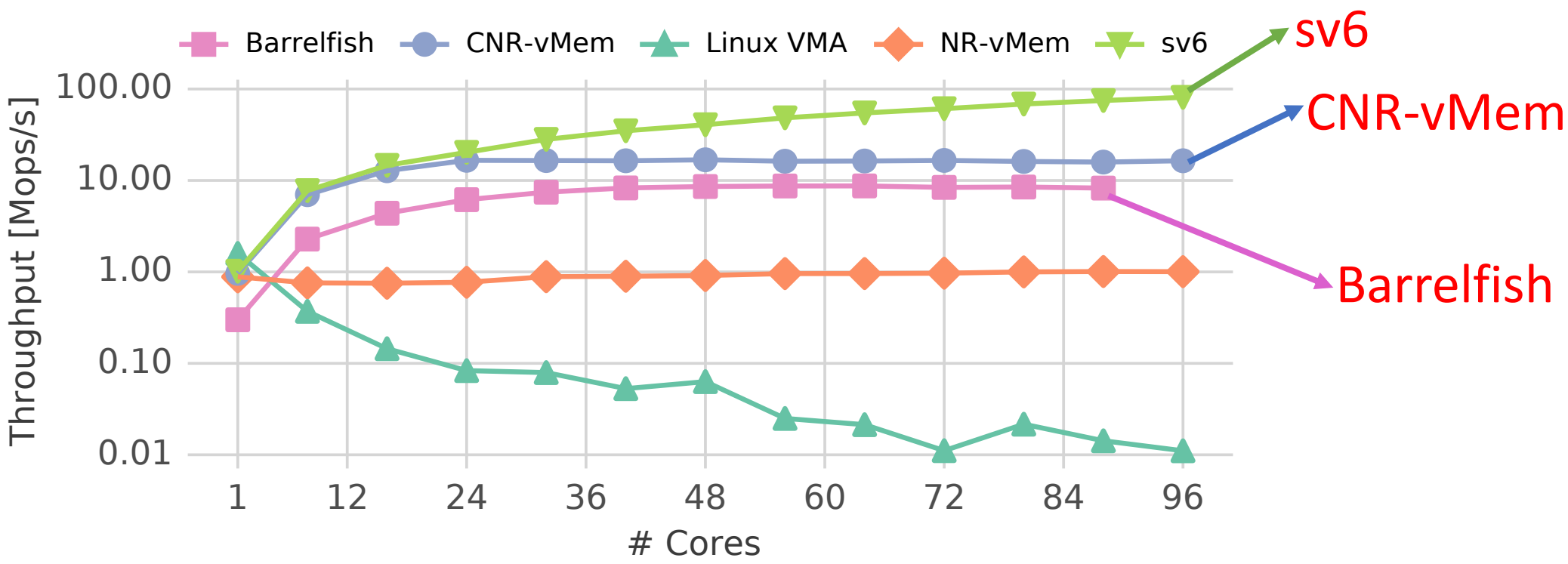


- Commutative operations can map to different logs
- Conflicting operations map to the same log

CNR-VMem: Scalable, NUMA-local PageTables



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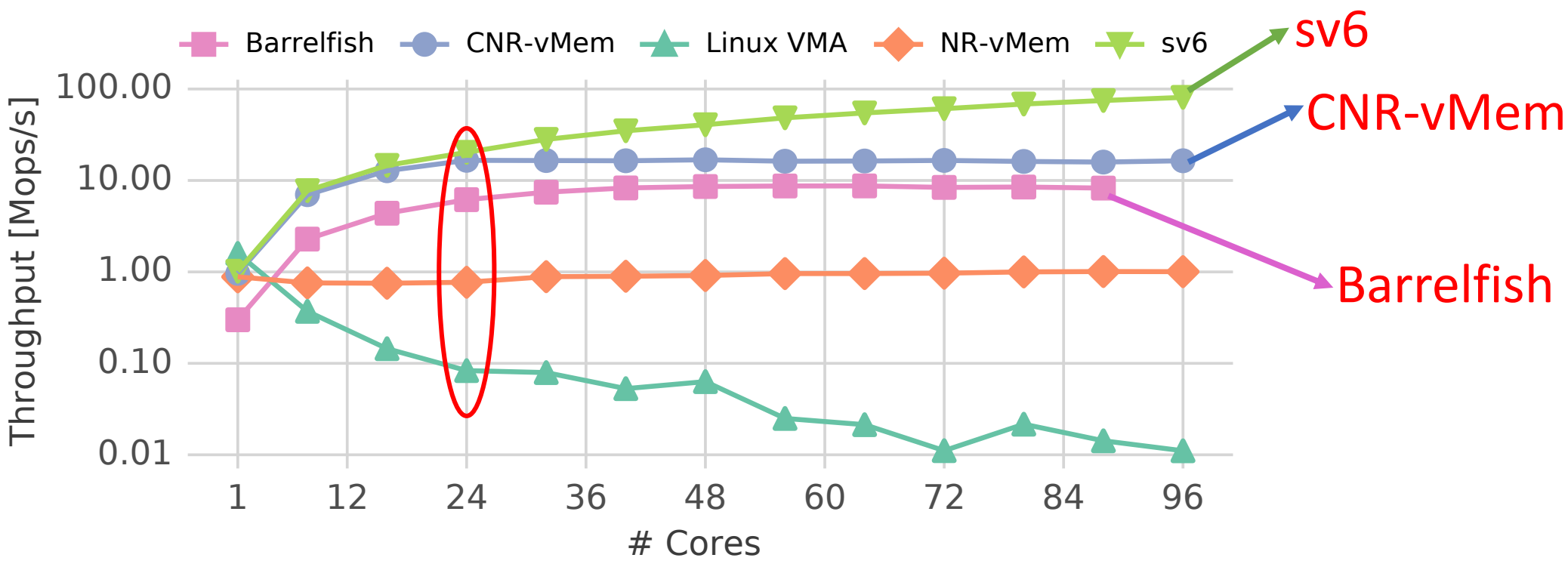

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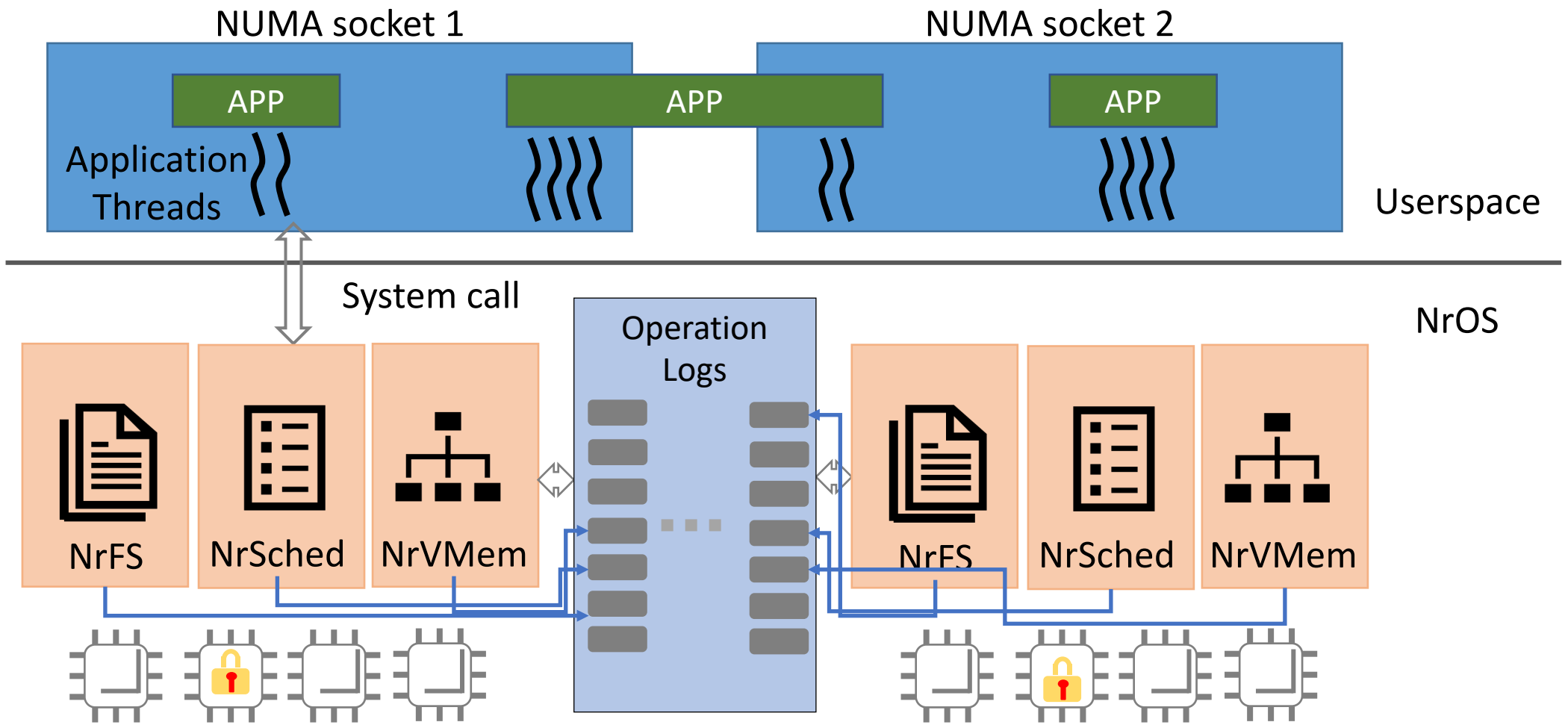

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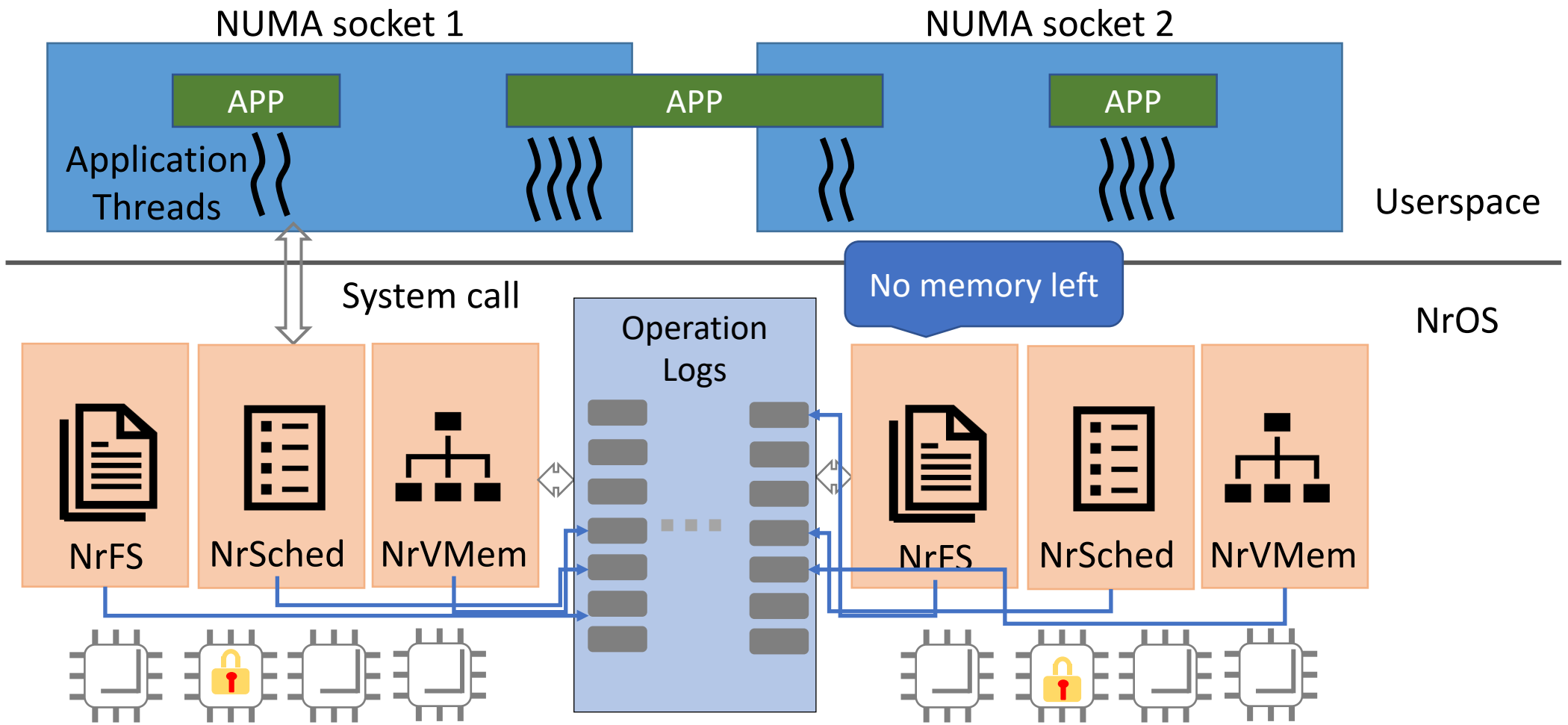

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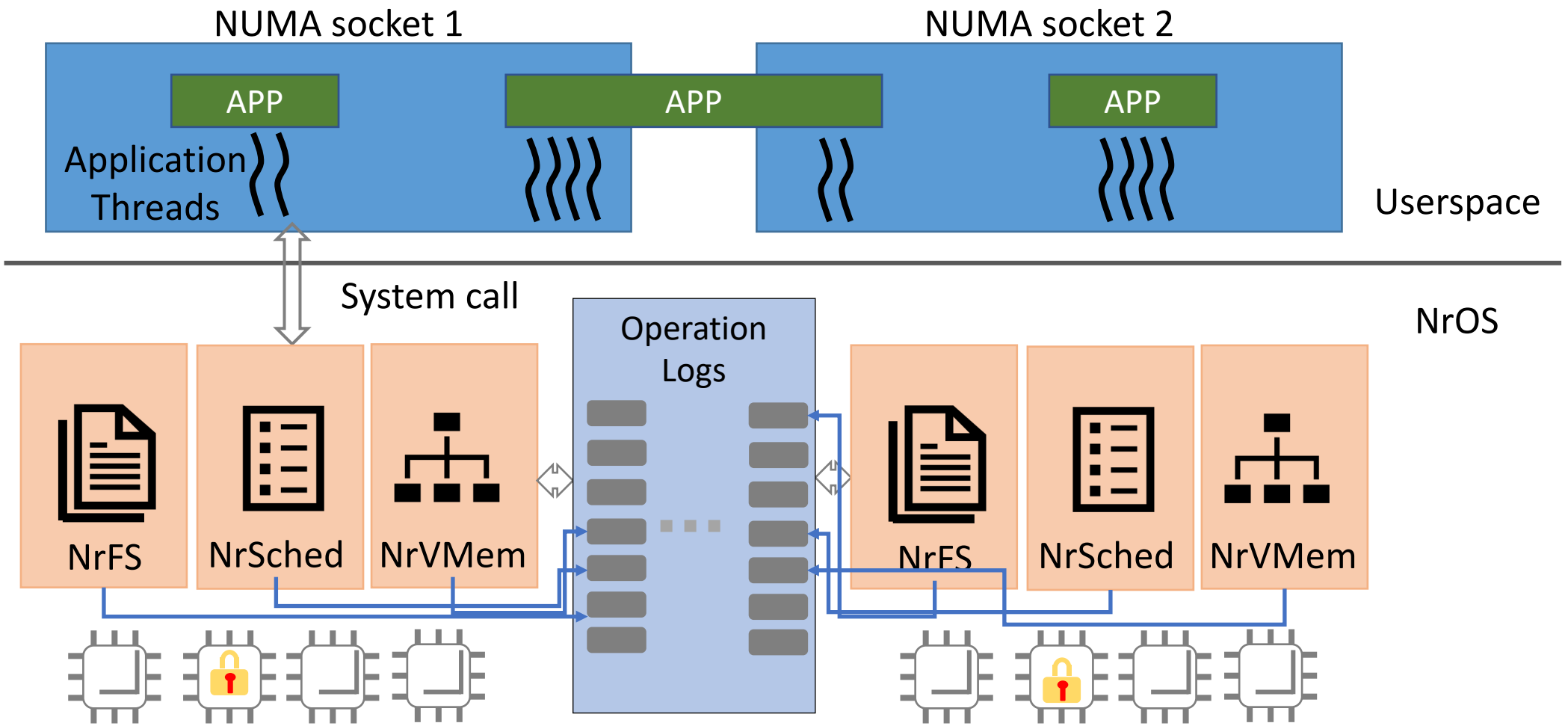

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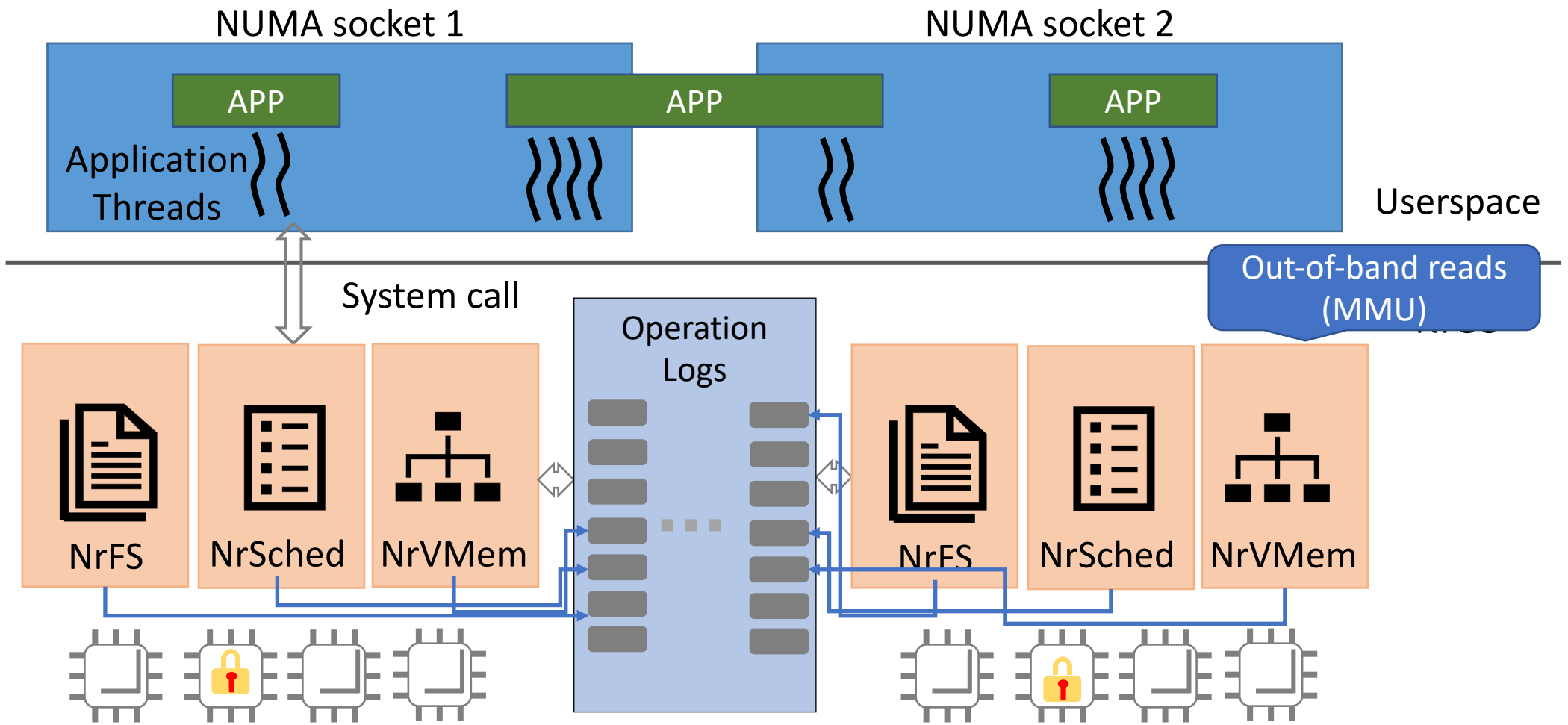

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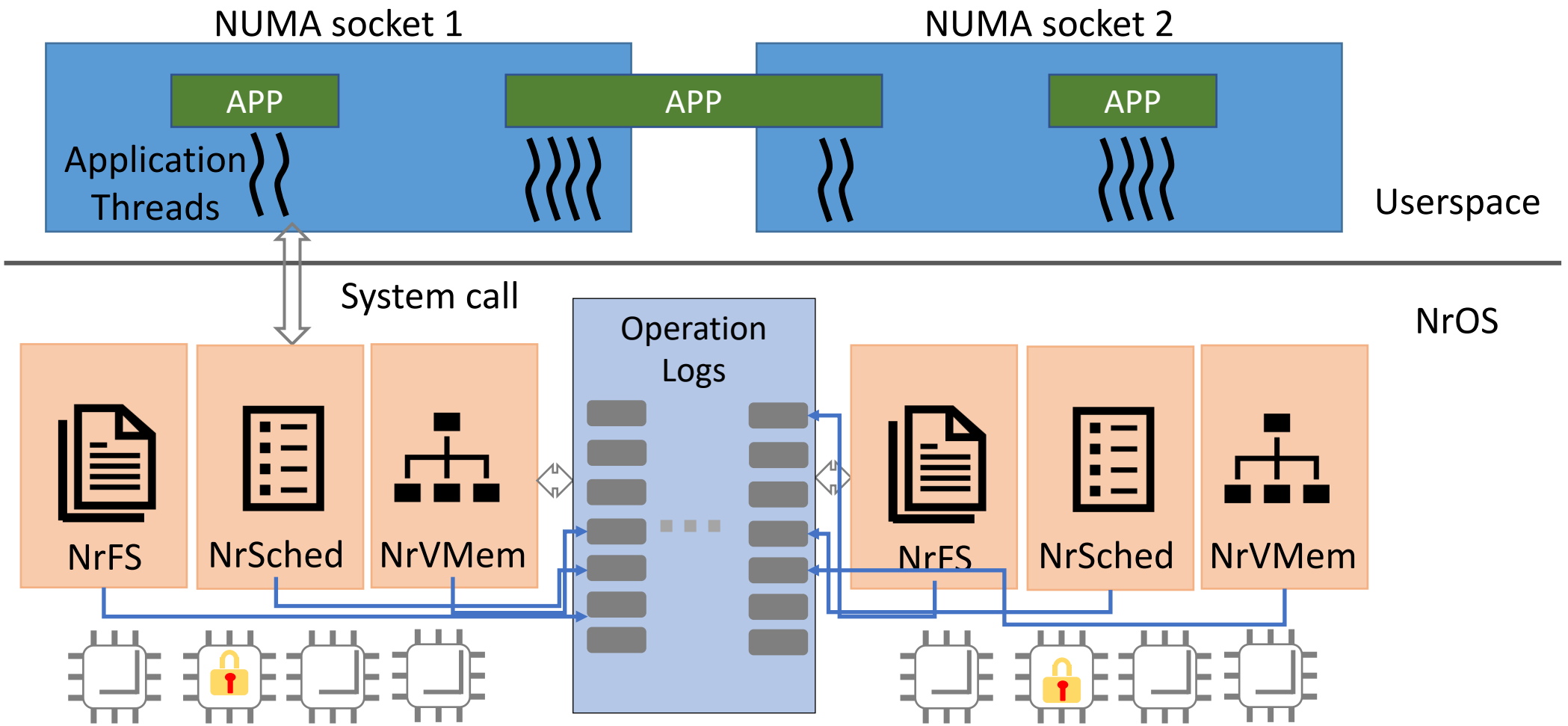

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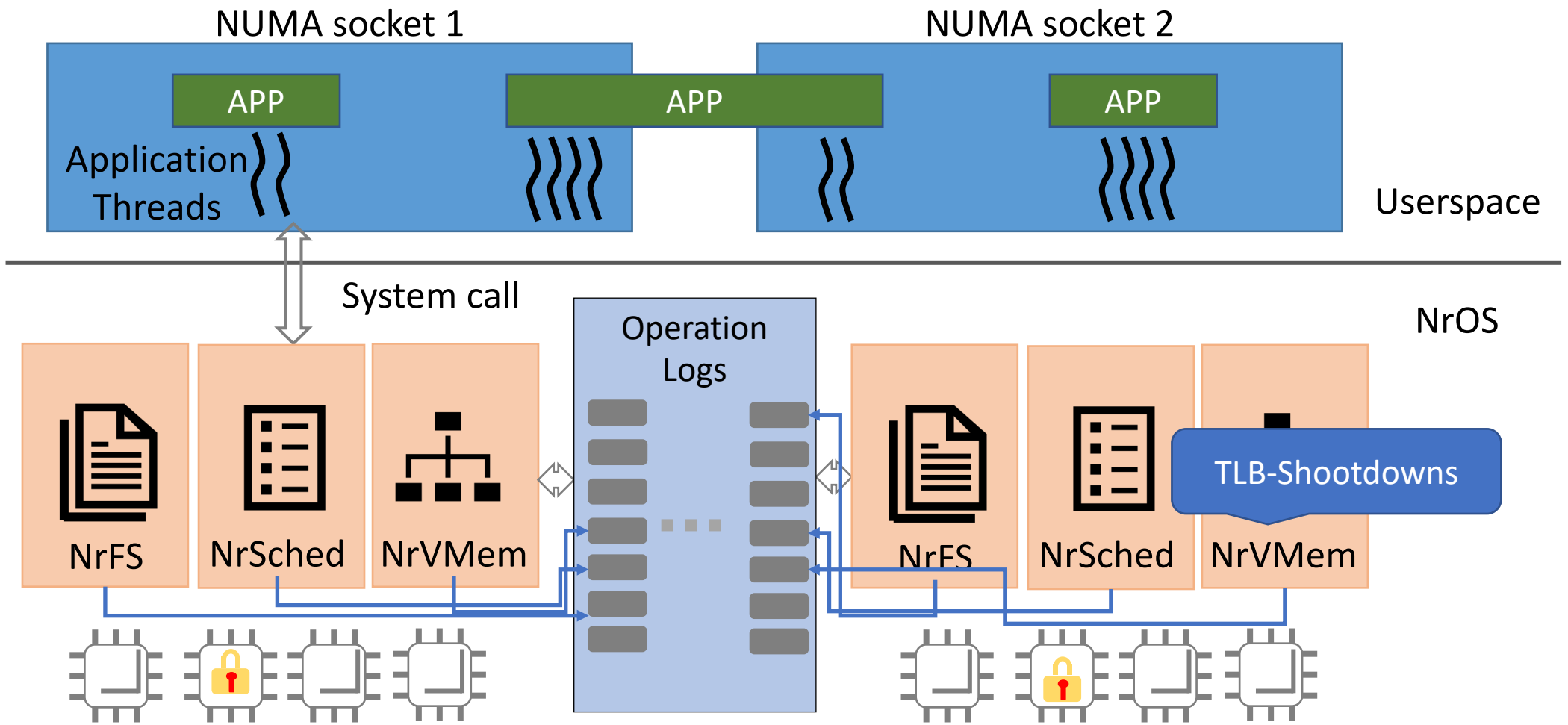

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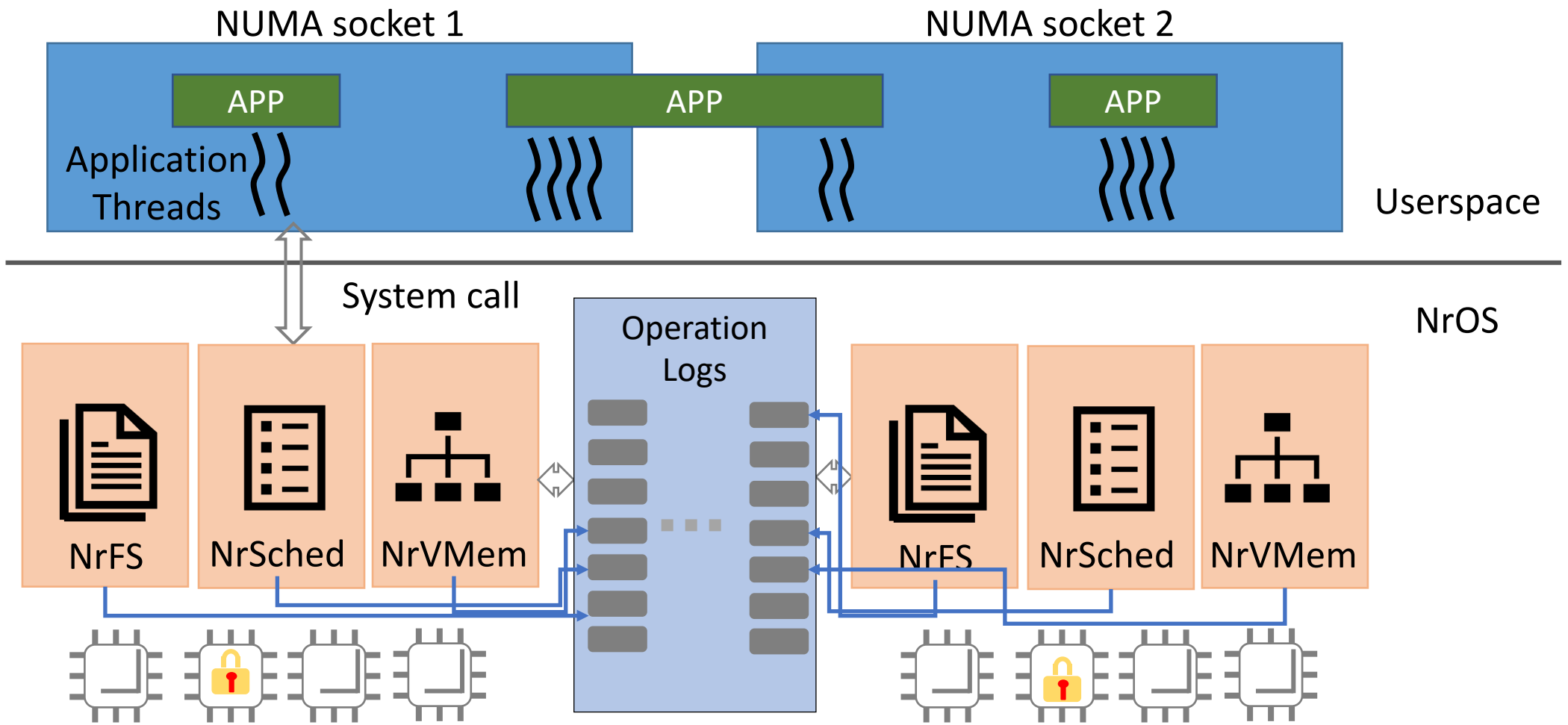

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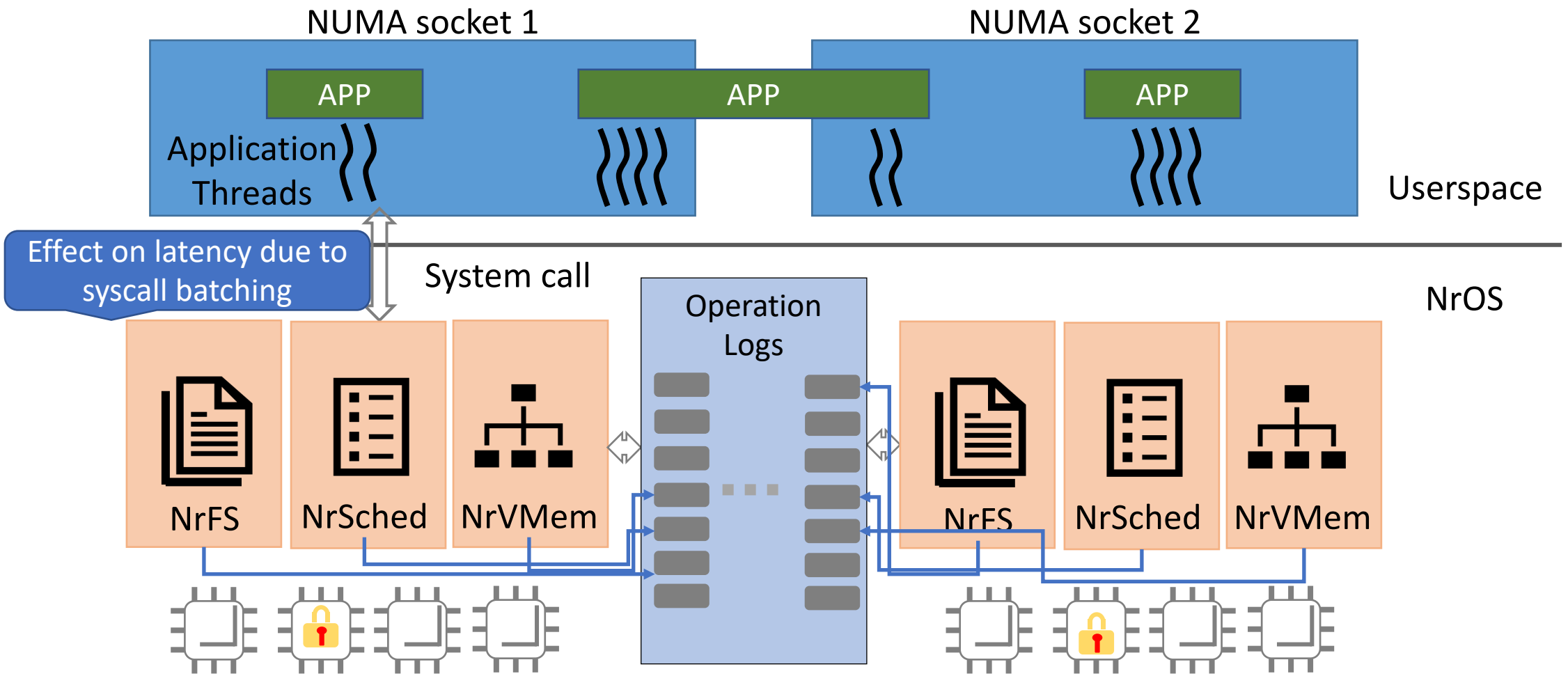

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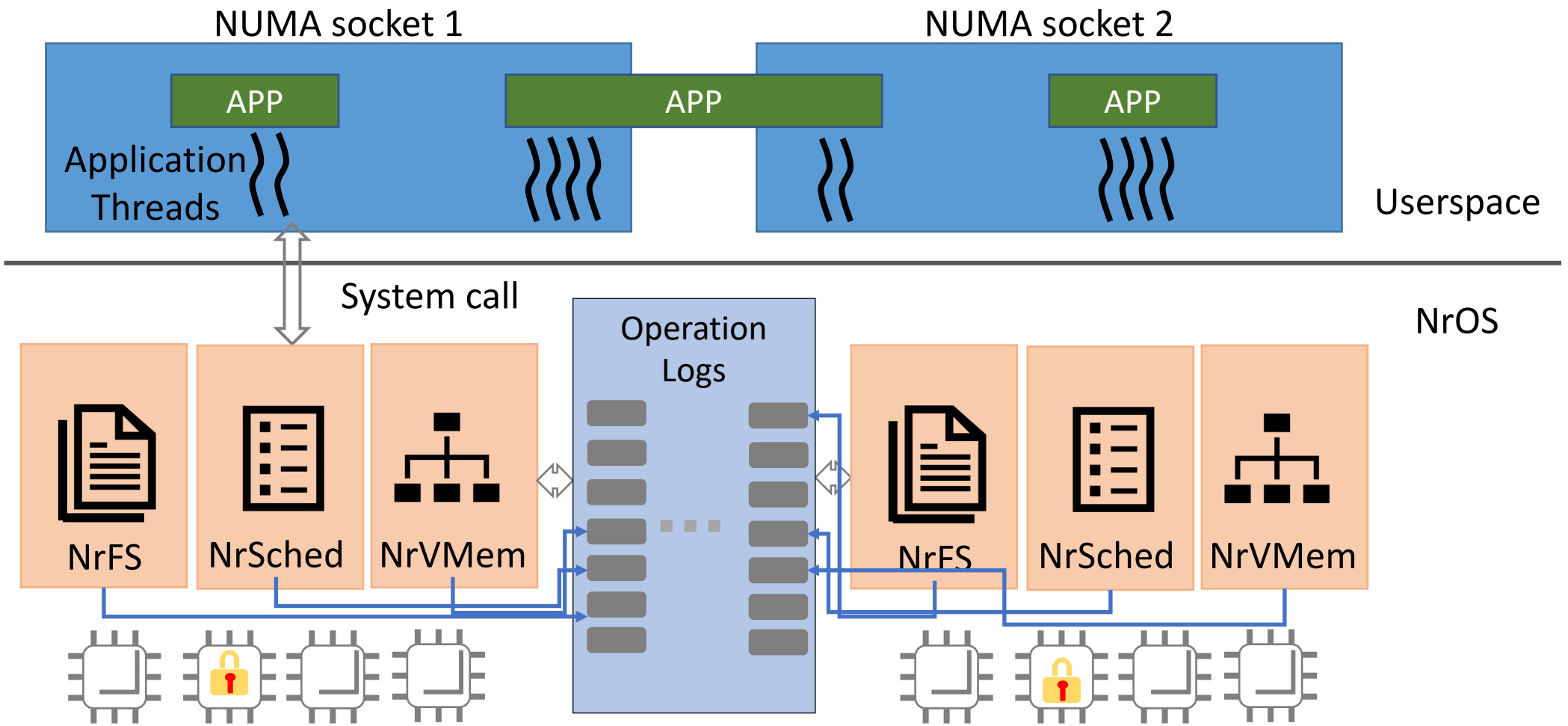

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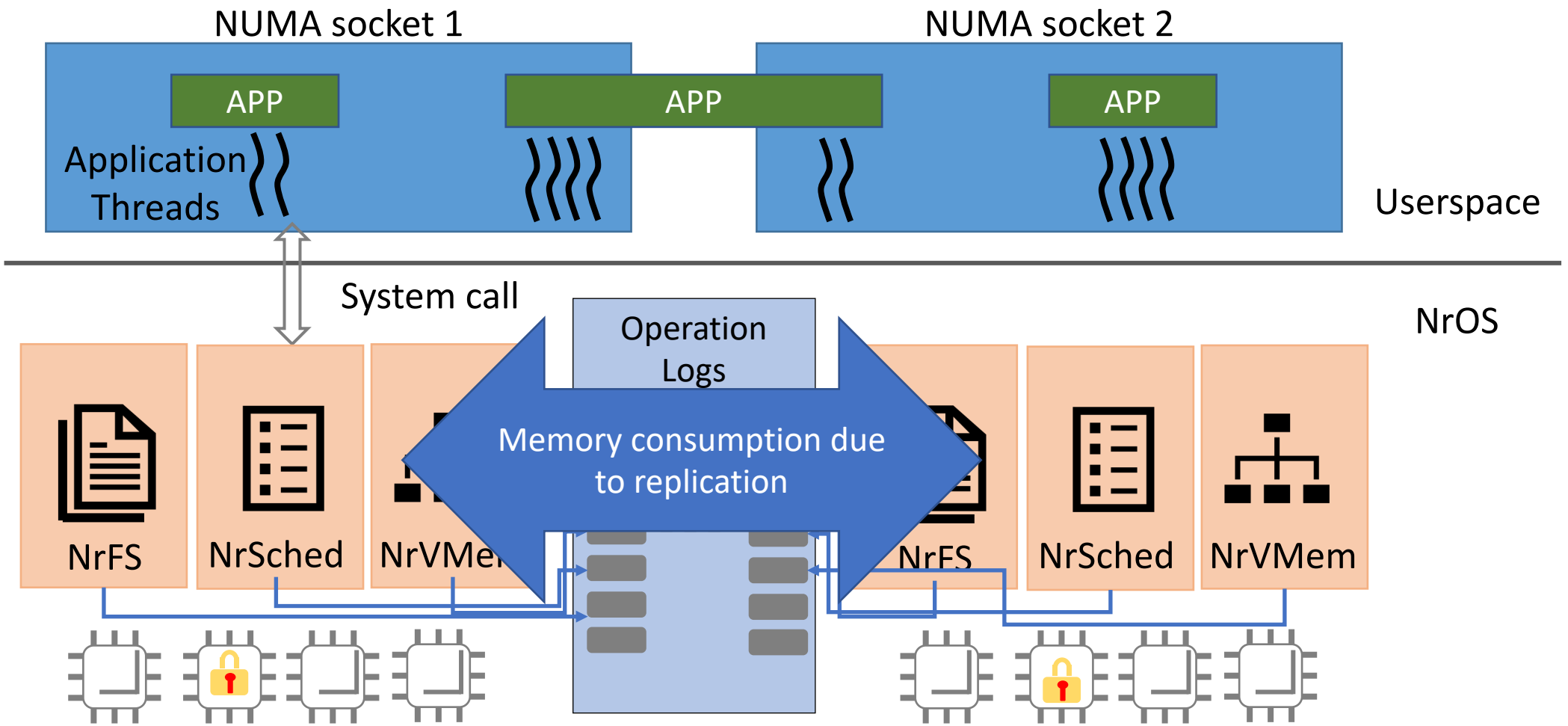

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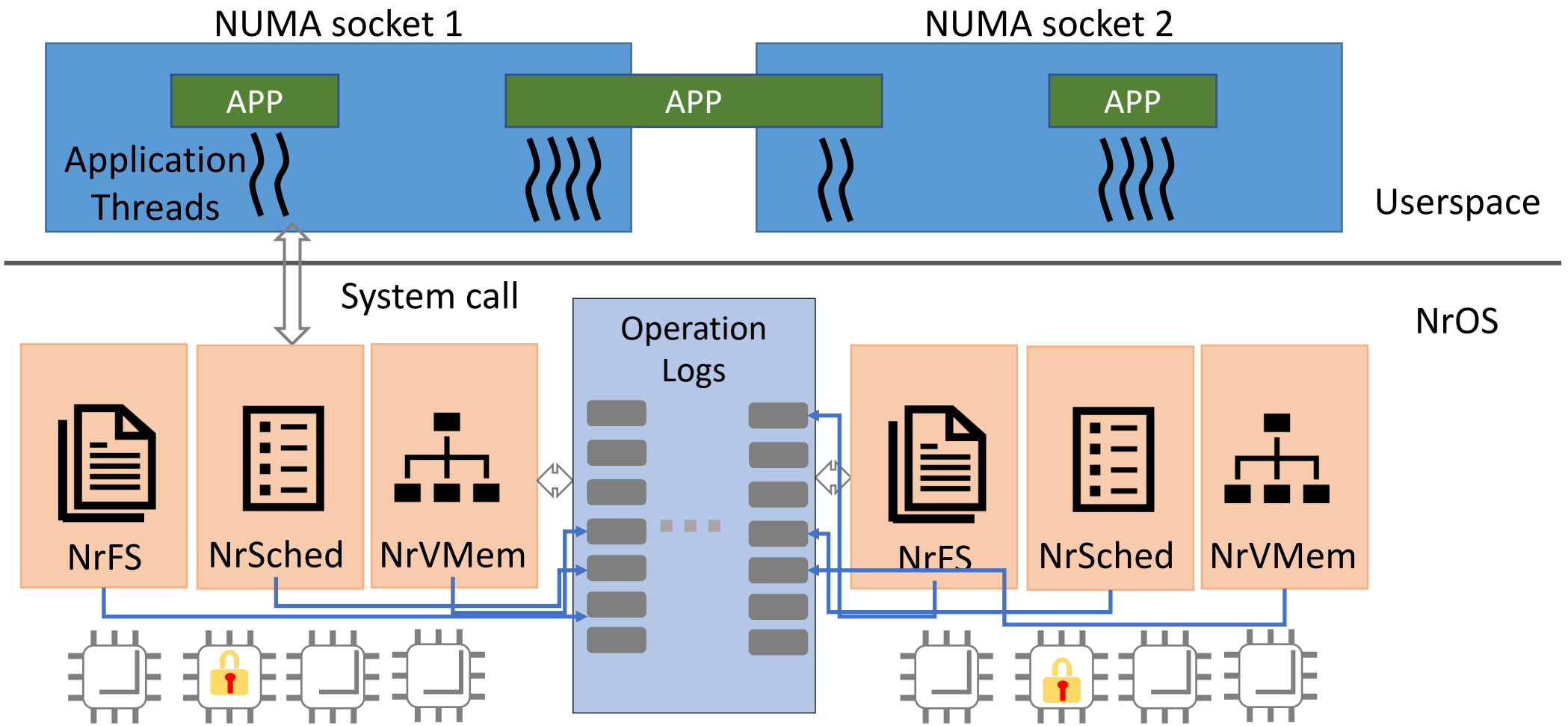

NRkernel: Key takeaways

- Simple, black-box approach (one size fits all) for concurrency
- Decomposes the problem of building scalable kernel data-structures for OS kernels
- Trade-off memory/CPU for performance: Replicate, make all reads NUMA local

https://nrkernel.systems