PRISM: Rethinking the RDMA Interface for Distributed Systems

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SOSP'21

2022. 04. 12

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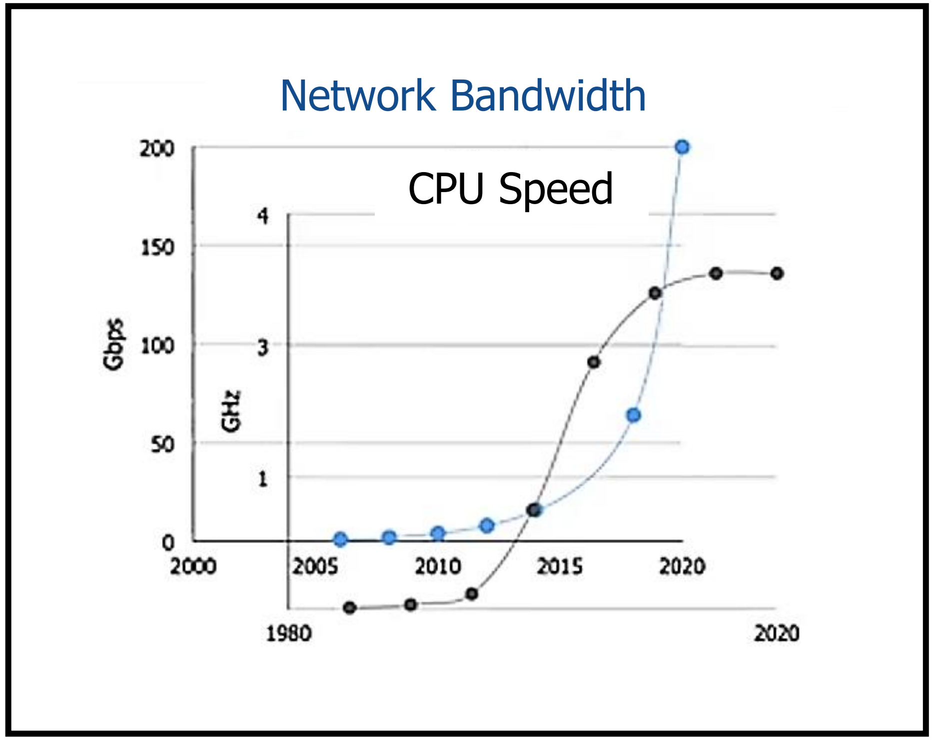
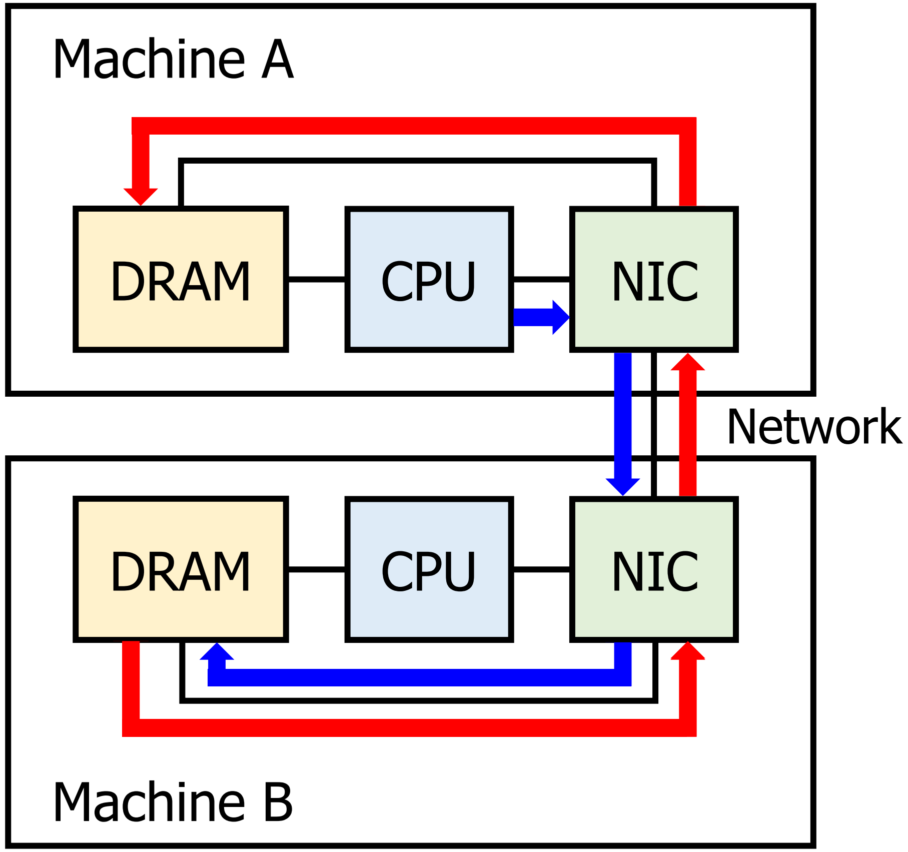
Remote Direct Memory Access (RDMA)

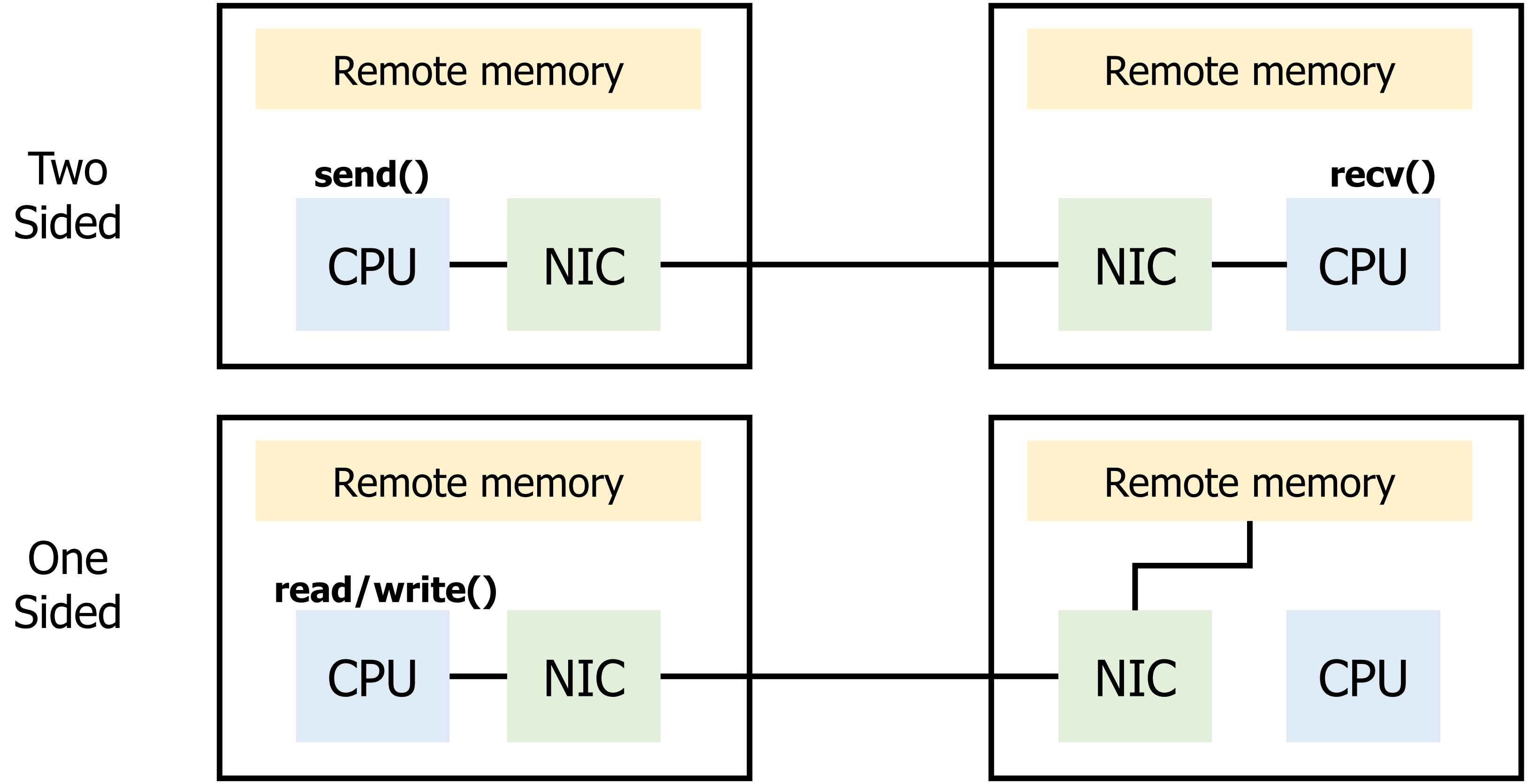
- Network bandwidth increases relative to CPU speed
- Kernel bypassing, CPU Offloading technology





RDMA provides two types of operations

- Two-sided / One-sided operations



- Less CPU Efficient
- Generalizable Interface

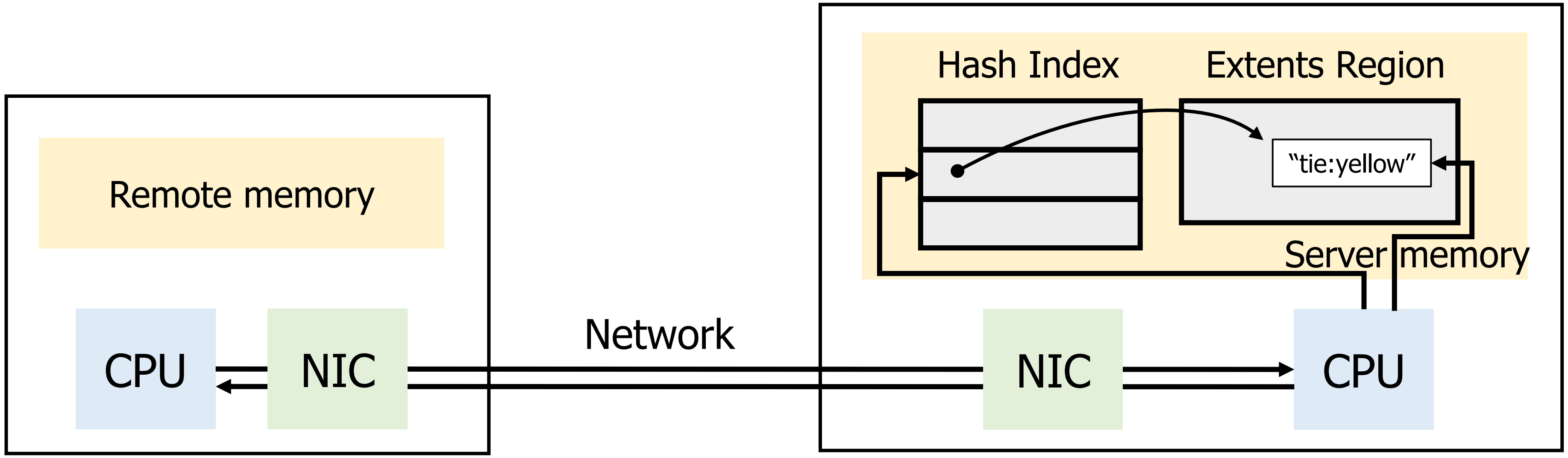
- More CPU Efficient
- Restrictive Interface

Embedded System Lab.

Indirect reads: One-sided vs. Two-sided

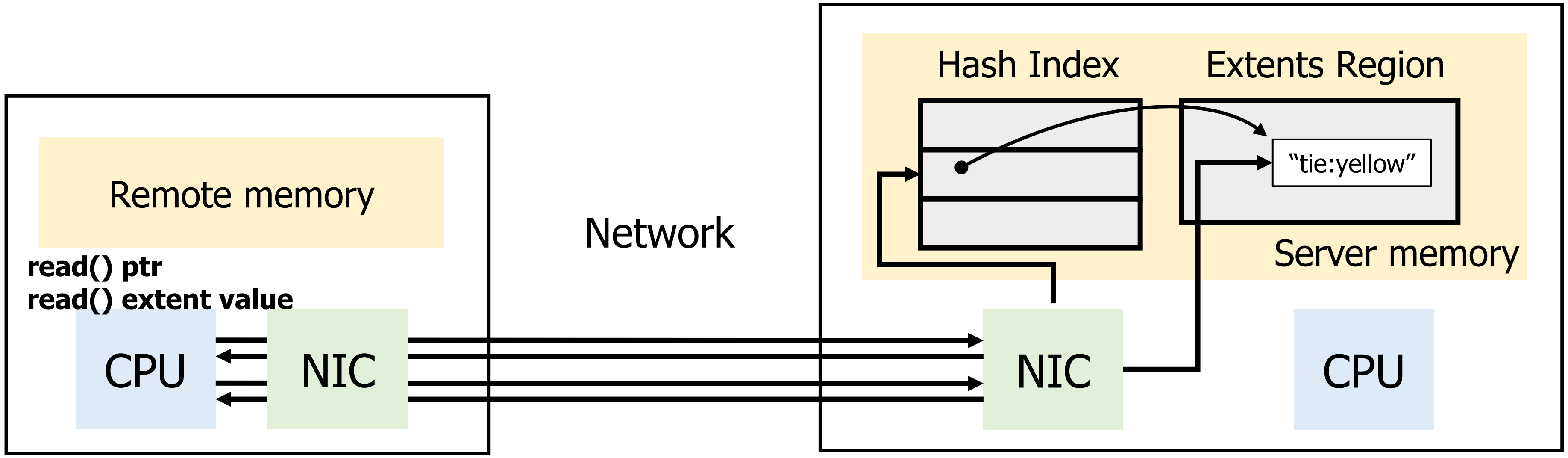
Two Sided

- **Involves CPU**
- **1 Roundtrip**



One Sided

- **No CPU involved**
- **2 Roundtrips**



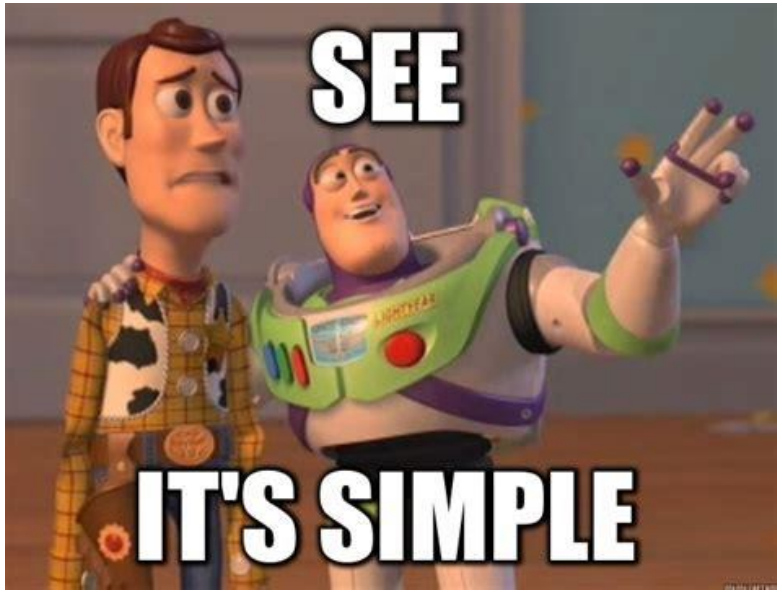
Difficulty of adapting applications to run on RDMA

- Applications are limited to the current RDMA read/write interface

Extend the RDMA interface

PRISM's API design principles

- Generality
- Minimal interface complexity
- Minimal implementation complexity



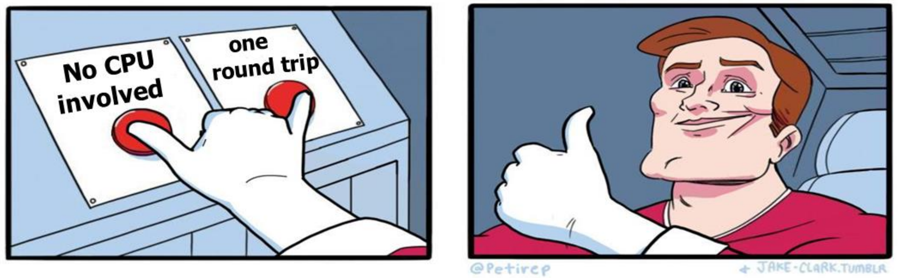
PRISM Primitives

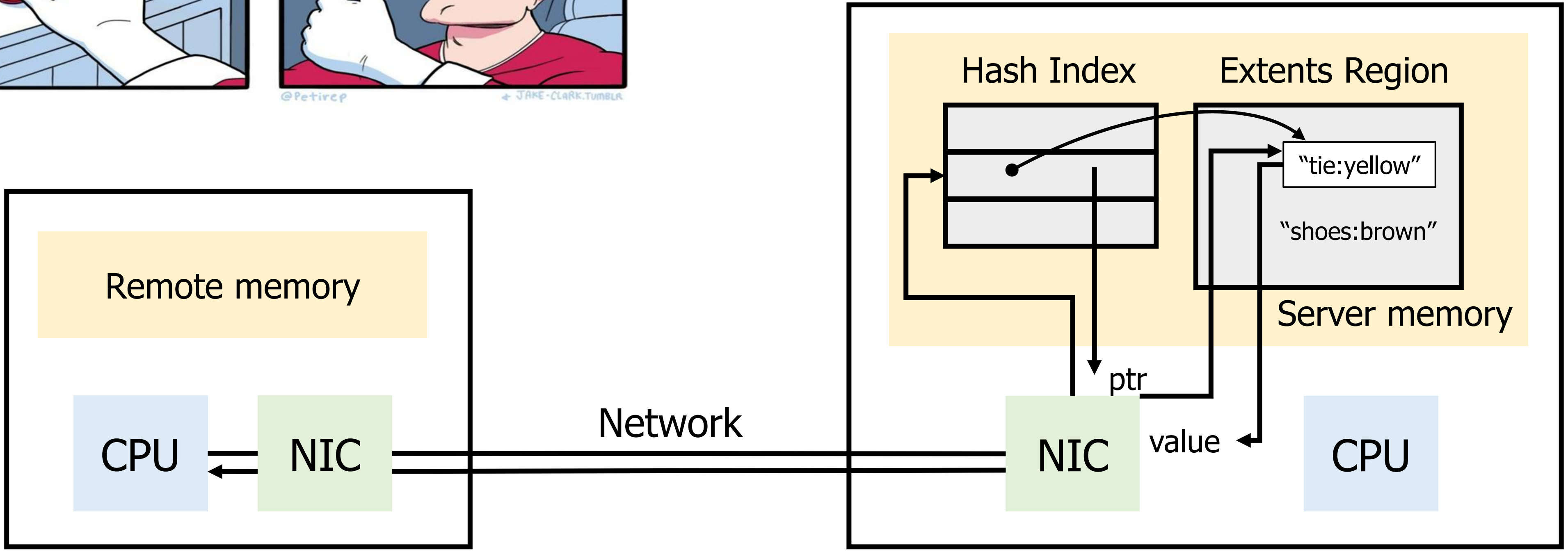
- Indirect, Enhanced CAS, Allocation, Operation Chaining

Indirect Reads/Writes	The target address specified by the operation can instead be interpreted as a pointer to the actual target
Enhanced Compare And Swap	Extends RDMA CAS to provide support for arithmetic comparisons (>, <) during the compare phase
Allocation	Allows memory allocation on the data-plane from a pre-registered pool of memory
Operation chaining	Allows for the execution of a chain of other PRISM primitives at the NIC

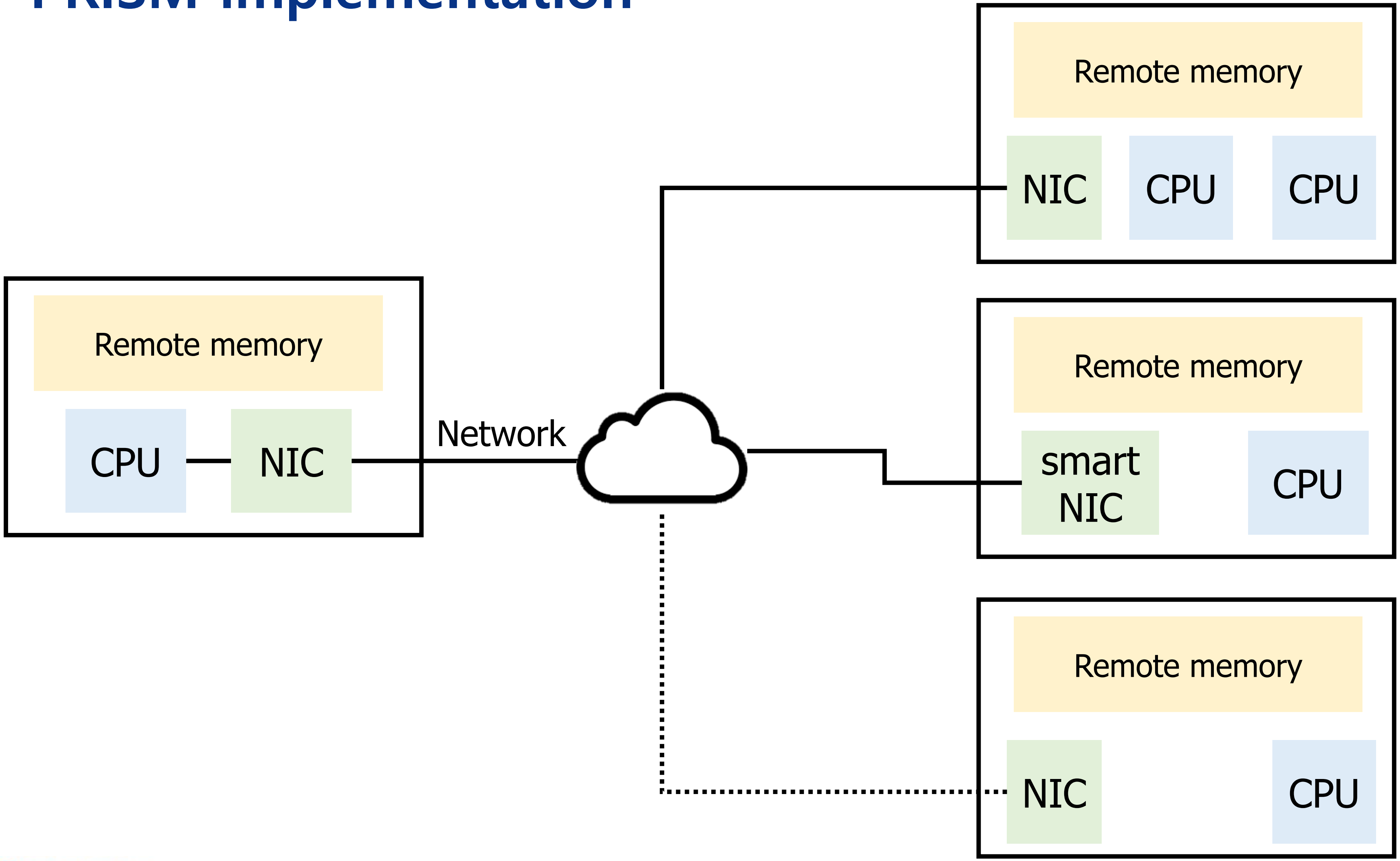
Indirect Reads with PRISM

- No CPU involved
- 1 Network Roundtrip





PRISM implementation



Snap inspired Software RDMA Prototype

Mellanox BlueField-1 SmartNIC Prototype

PRISM API could be added to a NIC ASIC

Applications designed with PRISM

- **PRISM-KV**: a Key-Value Store that implements both read and write operations using the One Sided PRISM API
- **PRISM-RS**: a replicated storage system that implements the ABD quorum replication protocol
- **PRISM-TX**: a transactional storage system that implements a timestamp-based optimistic concurrency control protocol using PRISM's primitives.

- **PRISM-KV: Key-Value Storage**

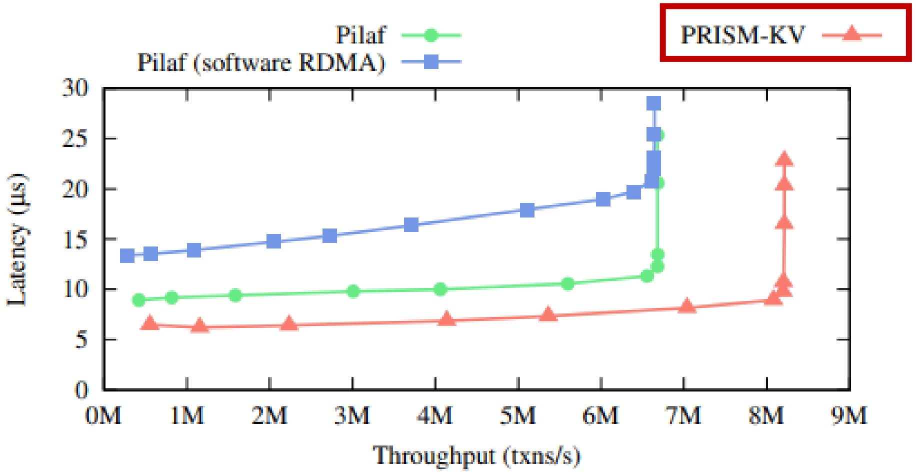


Figure 3. Throughput versus average latency comparison for PRISM-KV and Pilaf, 100% reads, uniform distribution.

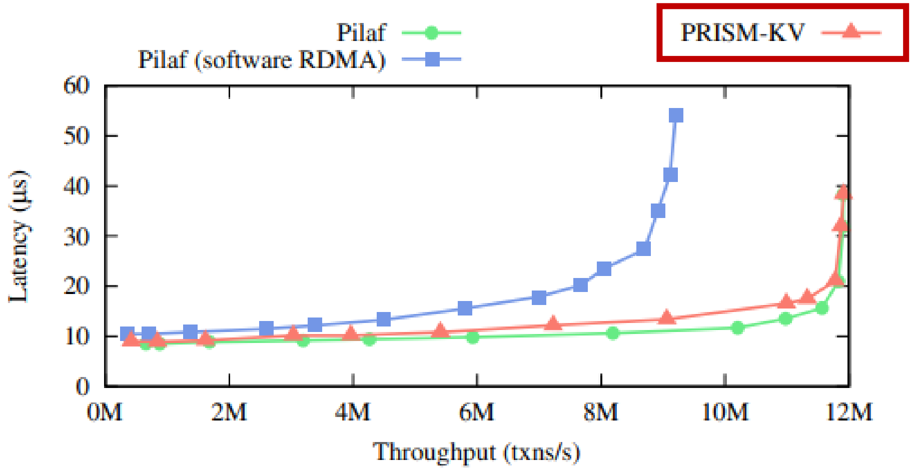


Figure 4. Throughput versus average latency for PRISM-KV and Pilaf, 50% reads, uniform distribution.

- **Latency difference is about 2X**
- **22% higher read throughput**

matches RDMA-enabled Pilaf for 50/50 mixed workload

- **PRISM-RS: Replicated Block Store**

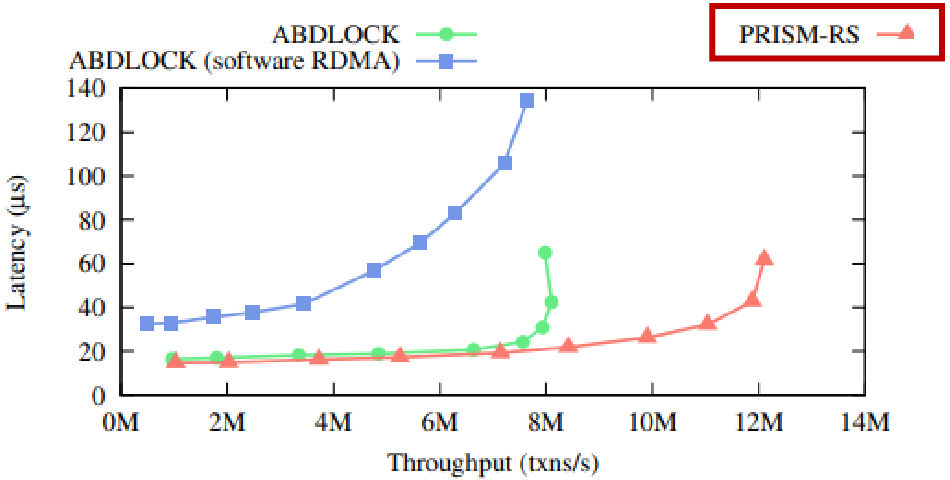


Figure 6. Throughput-latency comparison between PRISM-RS and the two variants of lock-based ABD.

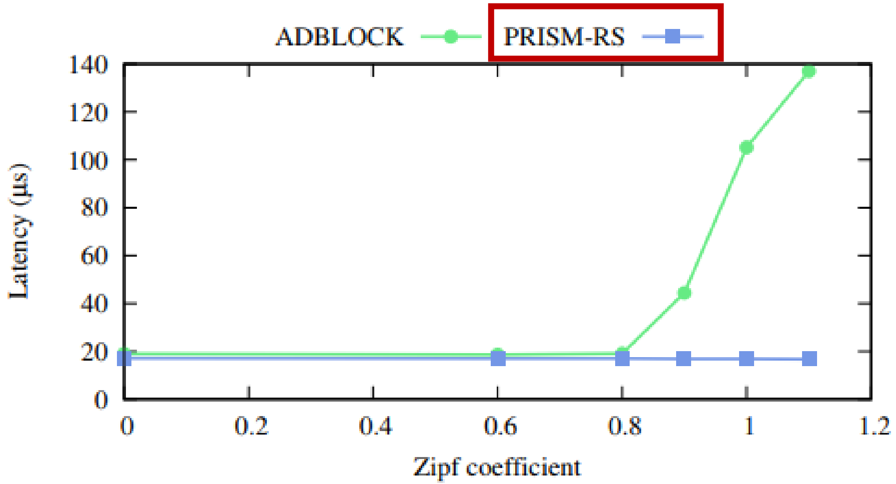


Figure 7. Latency comparison between PRISM-RS and ABD-LOCK for various degrees of contention.

- **2µs faster than ABD-LOCK**
- **~4million more ops/sec**

Dramatic benefits where there is contention on popular keys

- **PRISM-TX: Distributed Transactions**

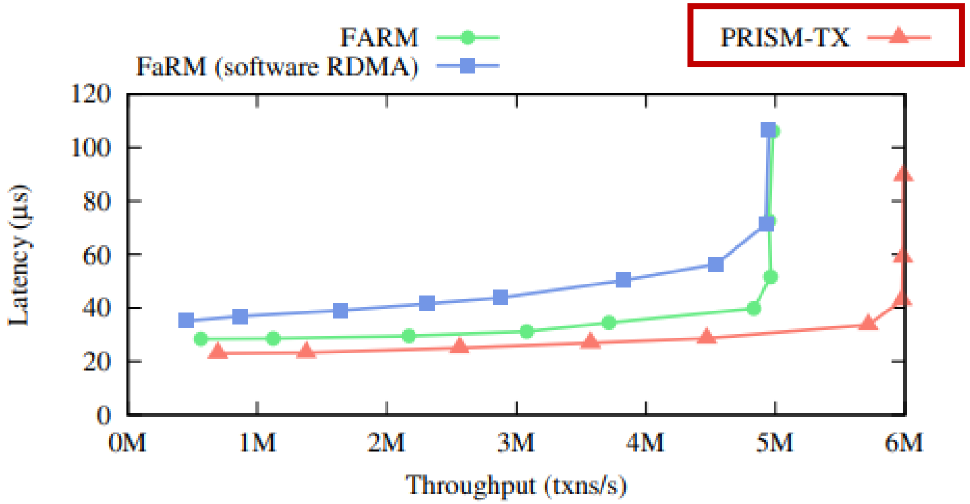


Figure 9. Throughput-latency comparison between PRISM-TX and FaRM for YCSB-T workload with low contention.

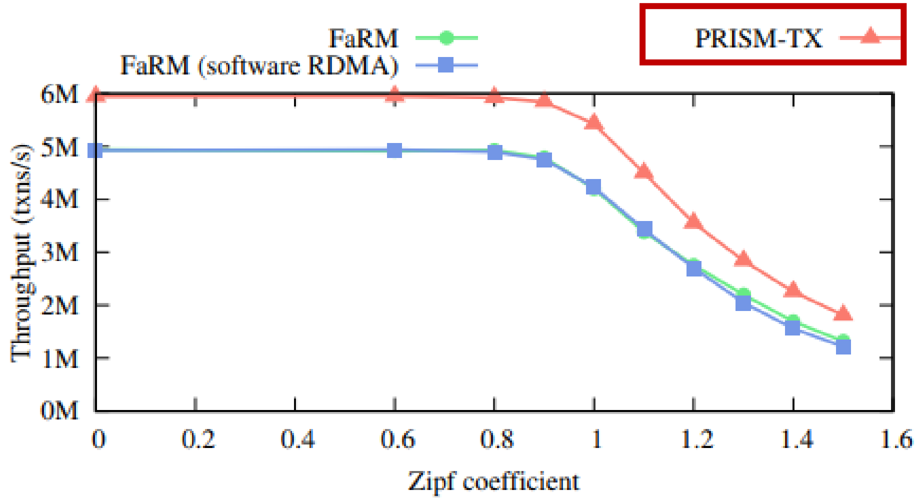


Figure 10. Peak throughput comparison between PRISM-TX and FaRM for YCSB-T workload with varying contention.

- **5.5µs faster than FaRM**
- **1 million more txns/s**

Maintains performance benefit under high contention

PRISM

- The current RDMA Interface isn't expressive enough to benefit most distributed systems applications

- PRISM proposes a set of generic primitives that extend the RDMA API

  : Indirect, enhanced CAS, allocation, operation chanining

- Demonstrate the PRISM API's benefits by designing 3 new applications

  : PRISM-KV, PRISM-RS, PRISM-TX

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Thank You!

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