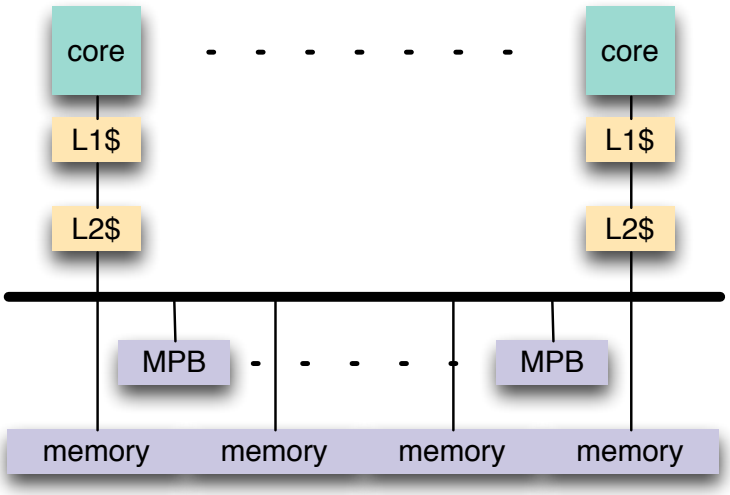
Brandenburg
University of Technology
Cottbus



10 April 2012

IN-MEMORY COMMUNICATION

EXPERIENCES WITH THE SCC

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Brandenburg University of Technology Cottbus

OUTLINE

1. Why Messaging?
2. How we use it
3. Protocols on the Intel SCC
4. Benchmarks and Experiences

MESSAGES ARE FOR COORDINATION

Traditional usage

- transfer data
- synchronize running tasks
- initiate new tasks remotely

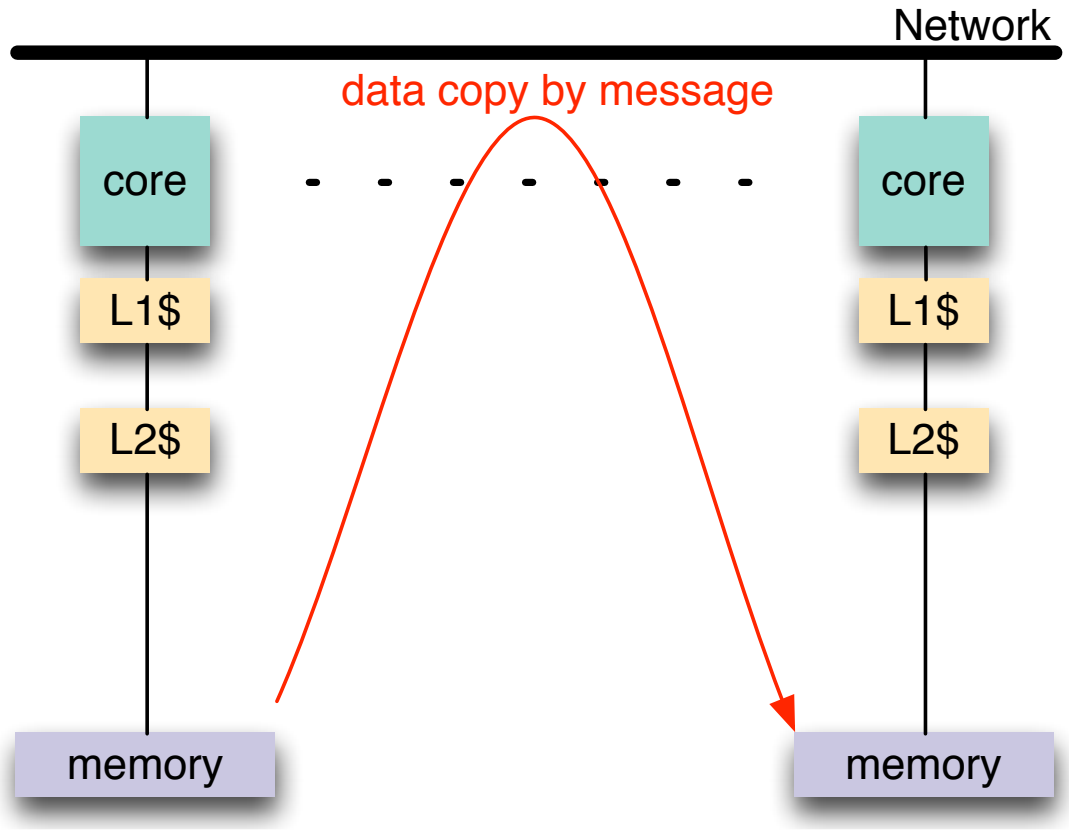
But: Many-core processors are hybrid systems

- distributed cores $\rightarrow$ message passing
- shared memory $\rightarrow$ data sharing

$\Rightarrow$ combine benefits of both
no need for data transfers, messages only for coordination

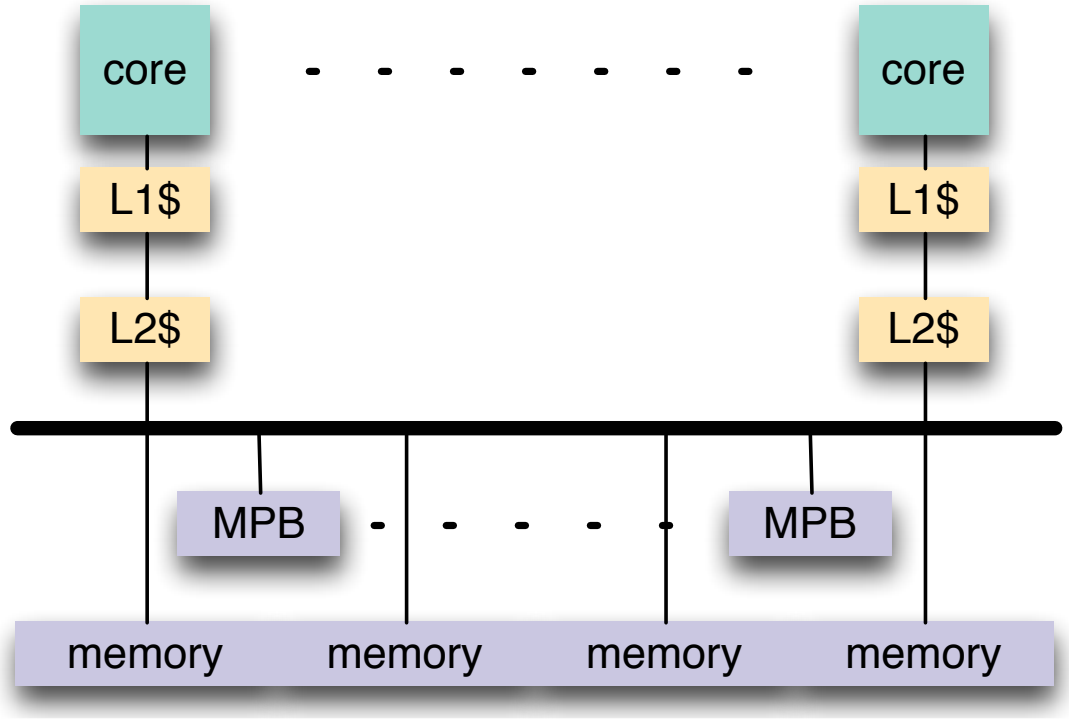
PAST: DISTRIBUTED MEMORY

Messages to copy data



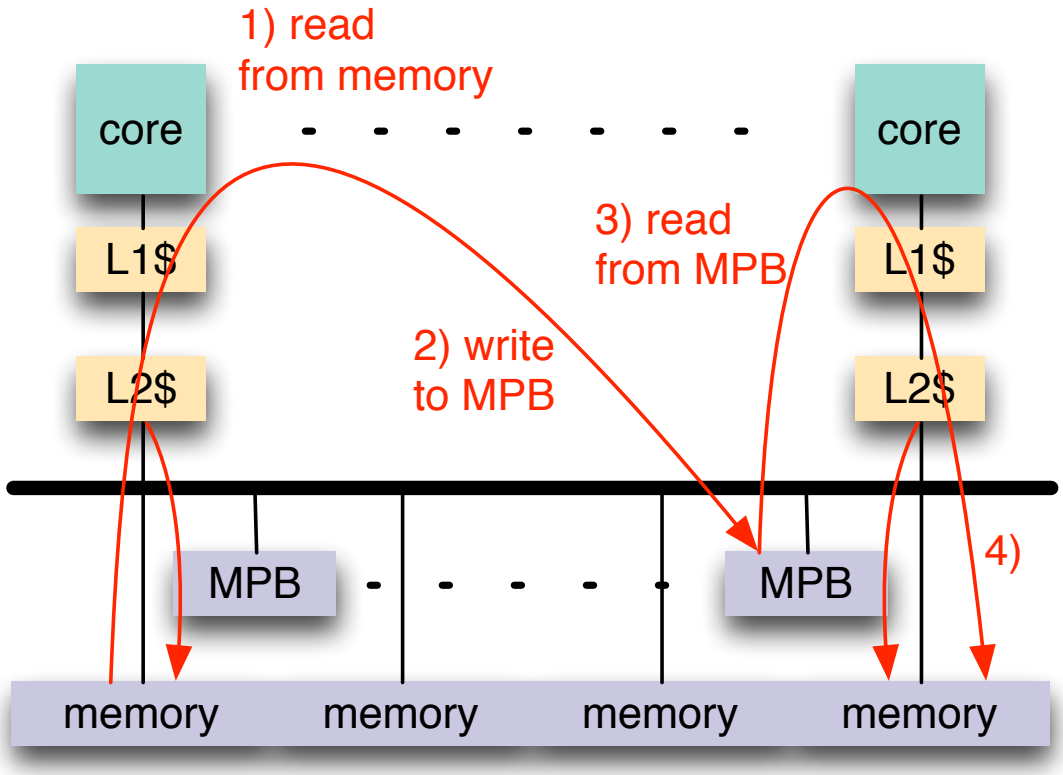
INTEL SCC: SHARED MEMORY, PRIVATE CACHES

On-Chip Network and Message Passing Buffers



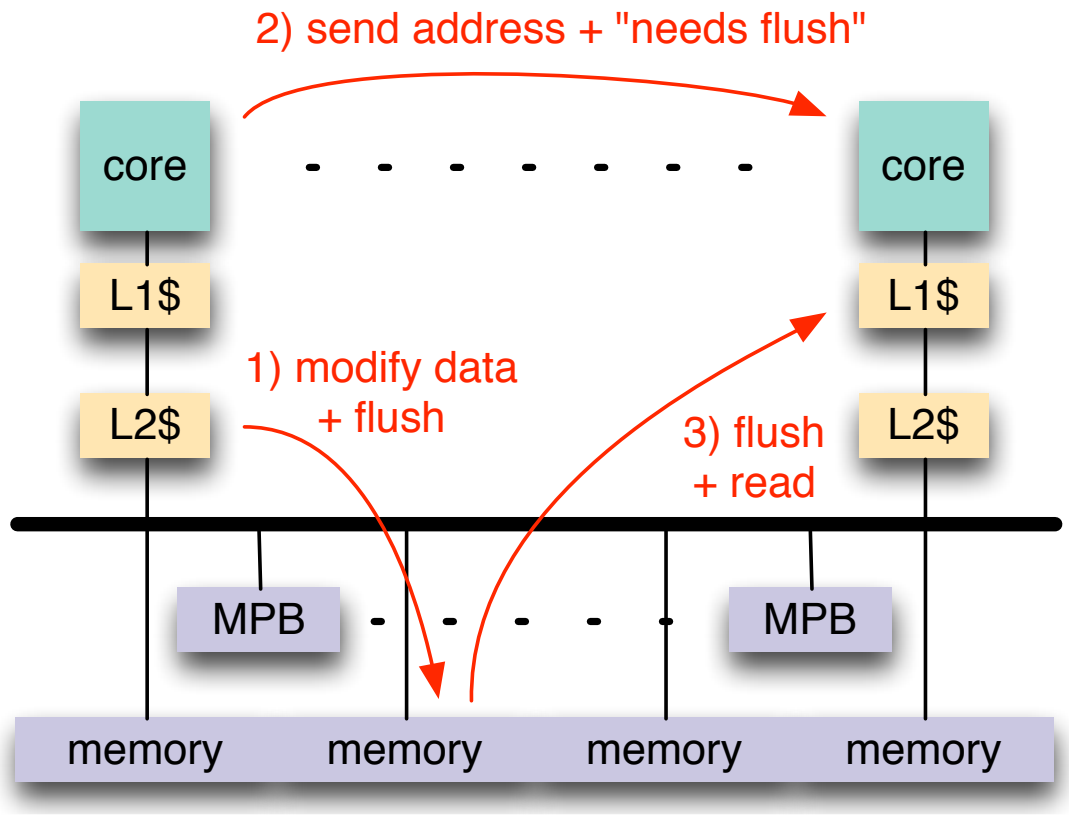
INTEL SCC: SHARED MEMORY, PRIVATE CACHES

Large messages push out cache contents ⇒ inefficient



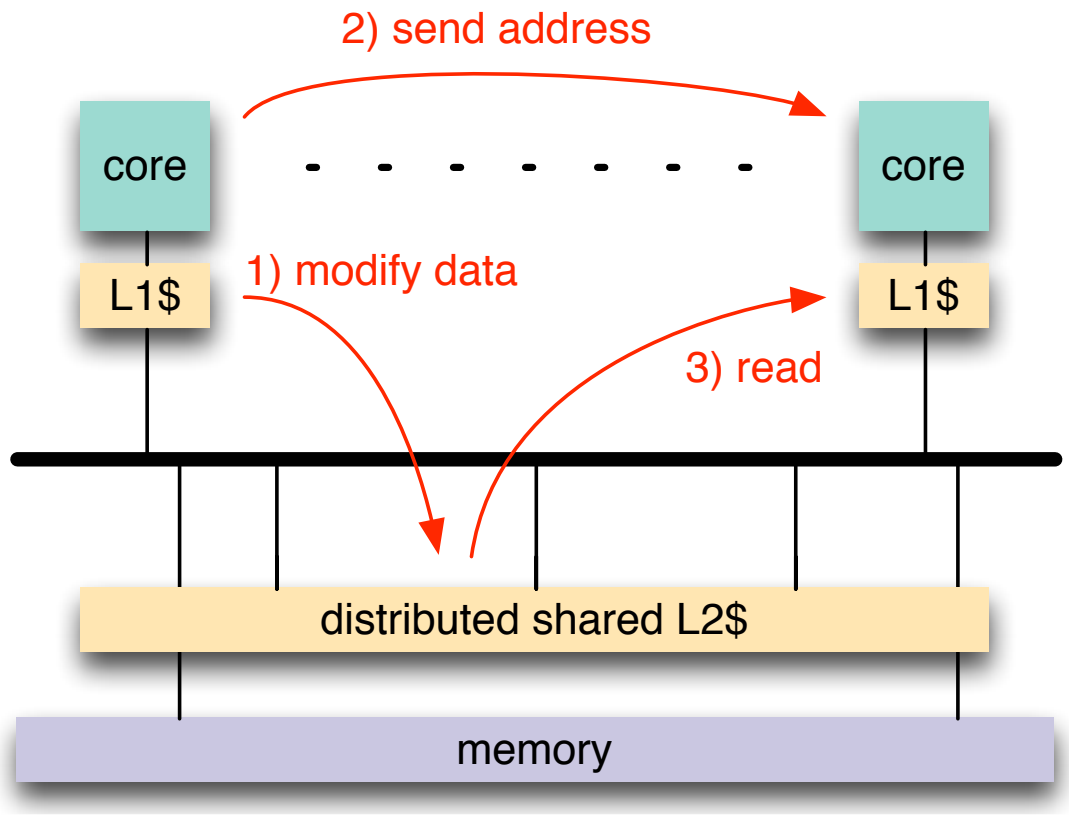
INTEL SCC: SHARED MEMORY, PRIVATE CACHES

Shared memory for data and messages



INTEL MIC: SHARED L2 CACHE

Shared L2$ for data; Messages stored in L2$



SUMMARY: MANY SMALL MESSAGES

- initiate tasks
- transfer addresses, parameters, results
- propagate consistency events
- synchronize running tasks

$\Rightarrow$ very small messages sufficient
but high number

- examples: LRPC, Barrelfish, X10, ...

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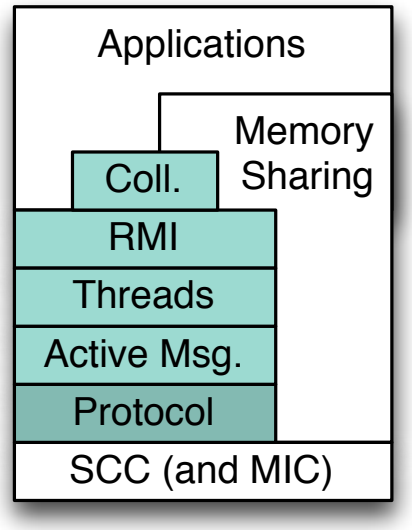
SOFTWARE STACK: TACO

- aPGAS similar to X10, but pure C++
- global object pointers, remote method calls
- collective operations on groups
- based on cooperative user-level threads and active messages



Detail: Protocol Interface

- `send(dest, msg-ptr, length)`
  asynchronous
- `probe(receive-callback)`
  receive from any source
  callback is applied on each message

SOFTWARE STACK: MEMORY-EFFICIENT SHARING

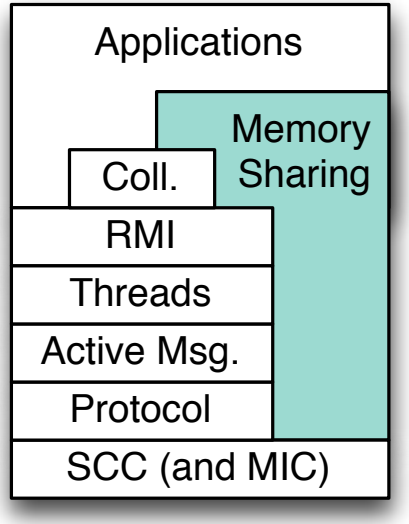
- SCC: LUT remapping, manual L2$ flushing

$\Rightarrow$ 2.5GB for shared objects

- hides coherence, replication, . . .
  using RMIs & collective operations internally

$\Rightarrow$ shared arrays, sets, graphs, . . .

- coming soon: parallel graph partitioning



Observation

protocol performance limits level of parallelism

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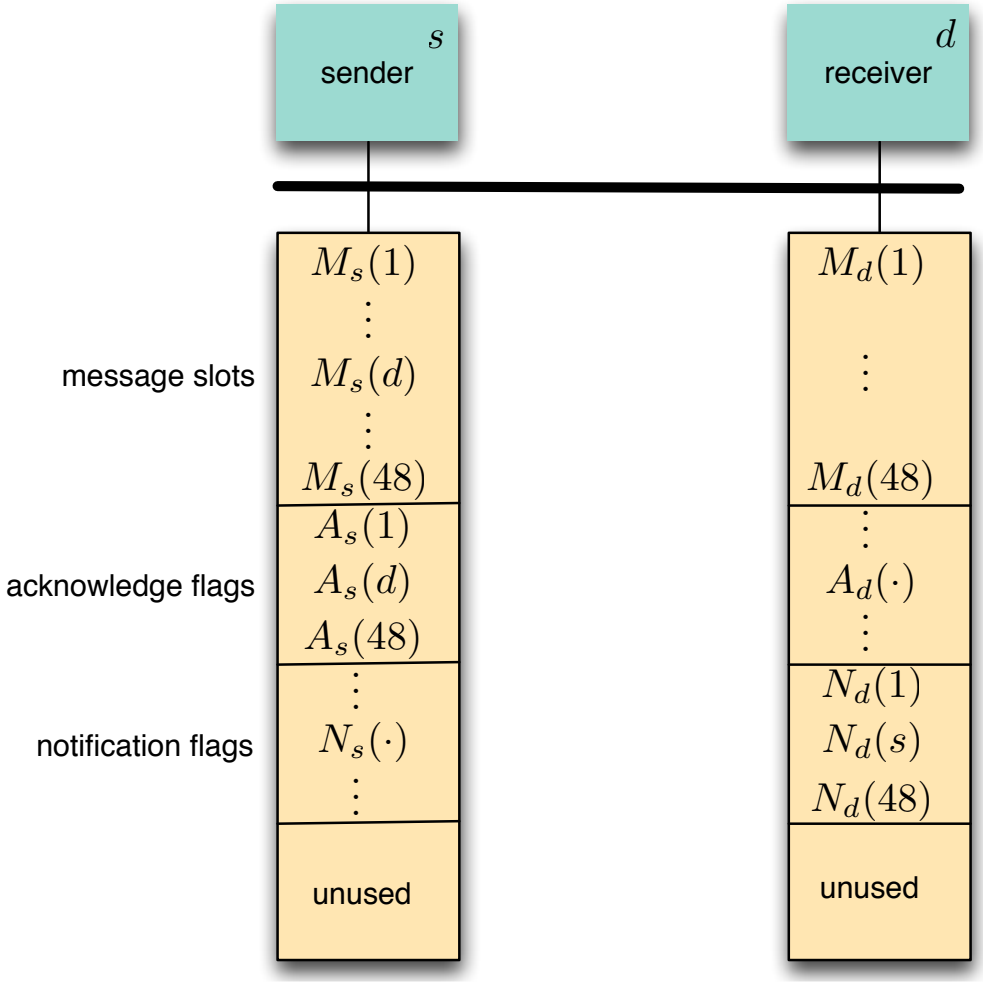
NVP: NOTIFICATION VECTOR PROTOCOL



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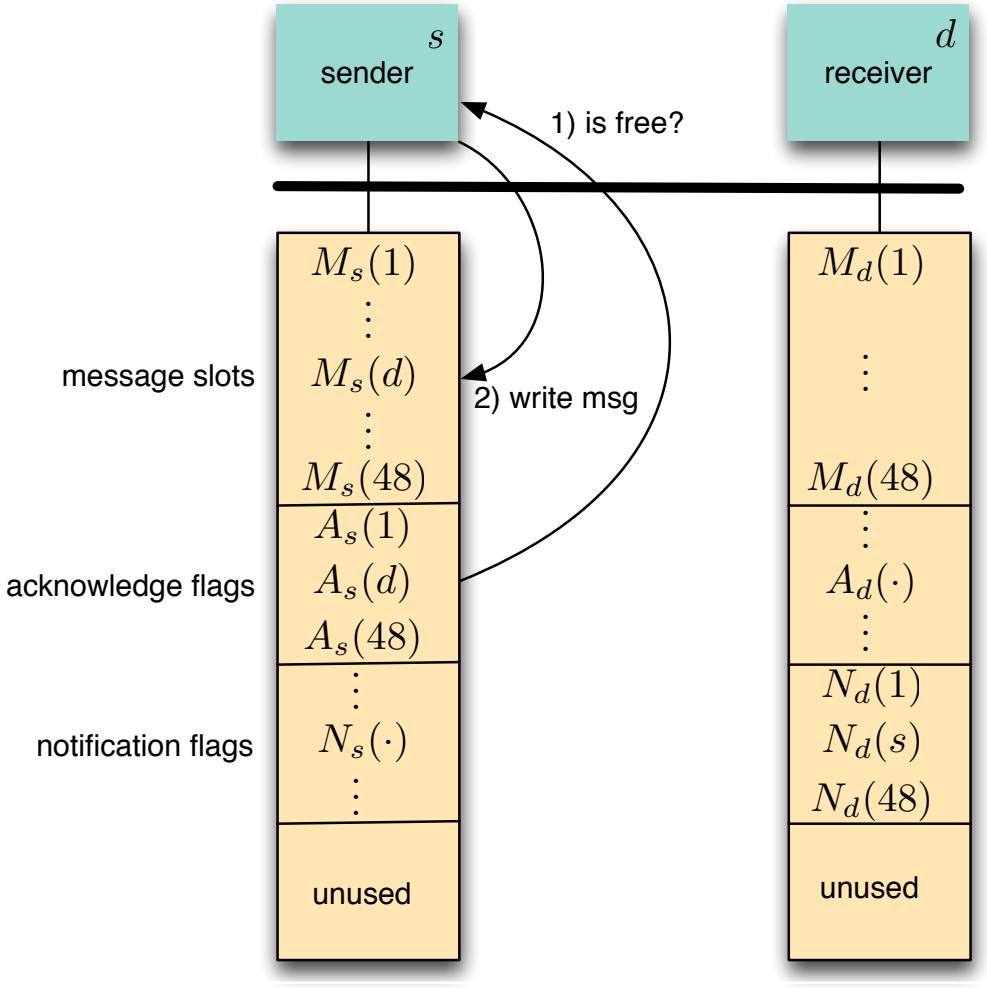

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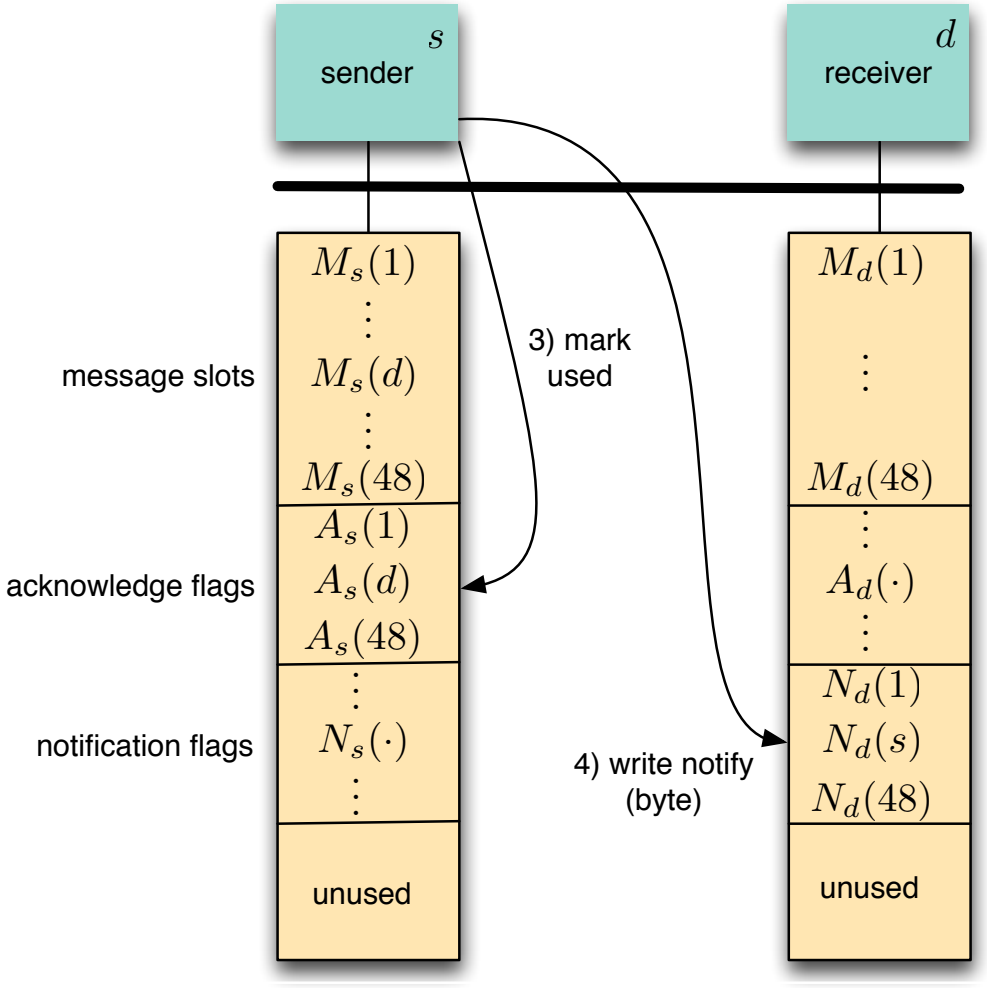

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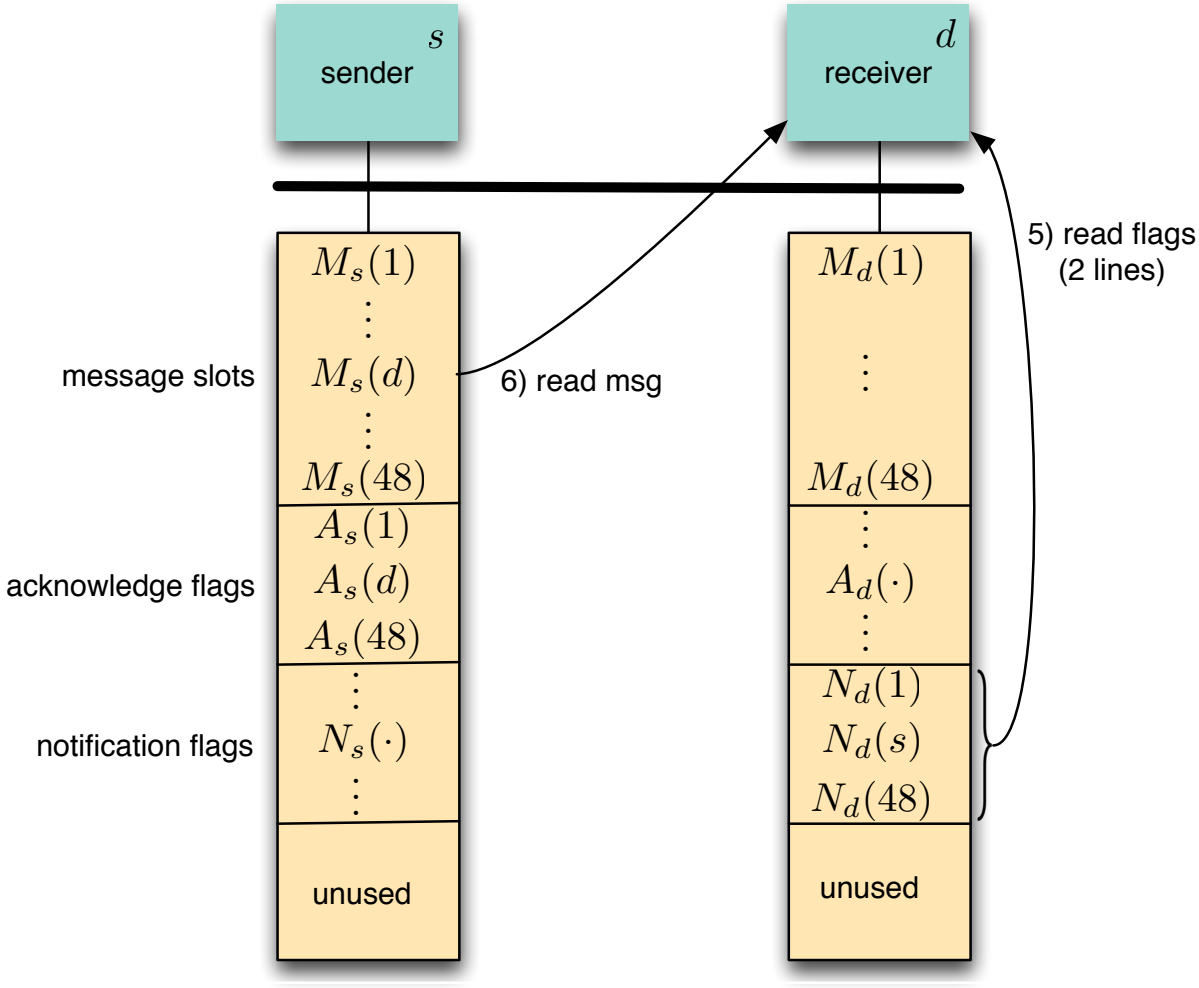

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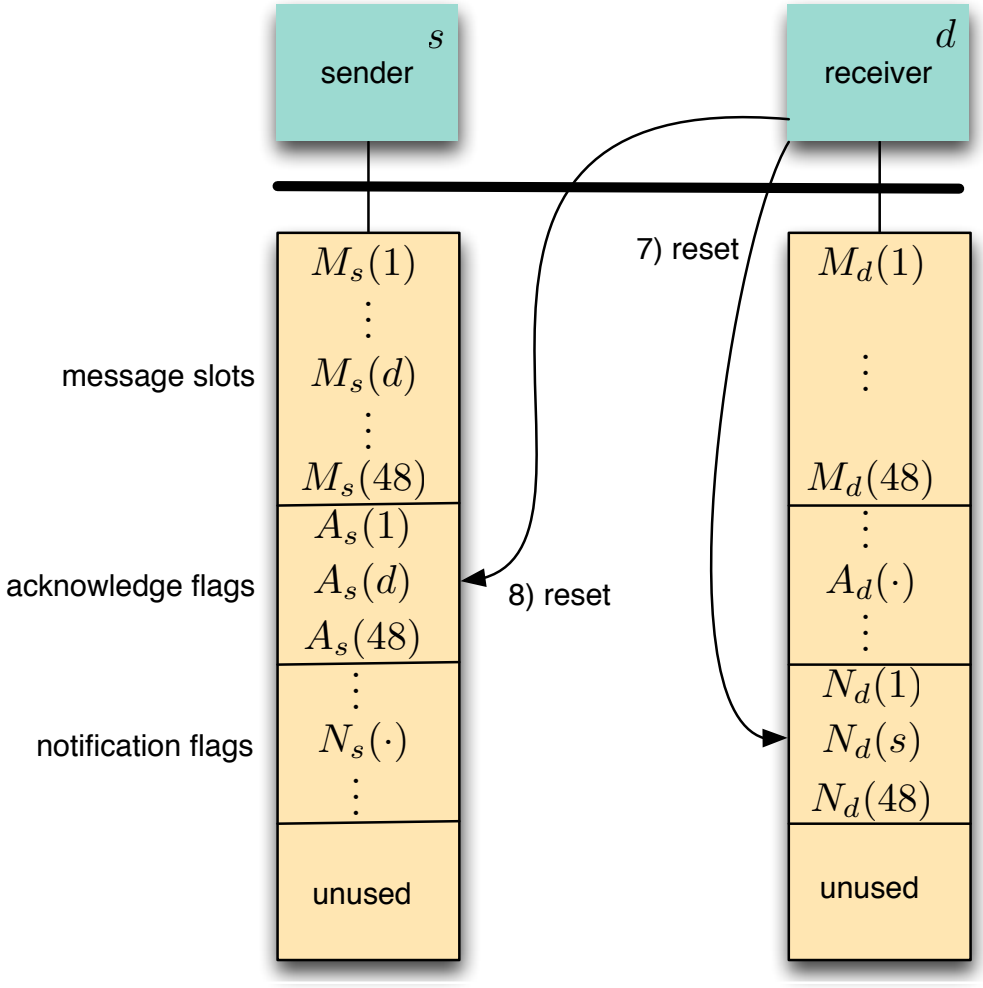

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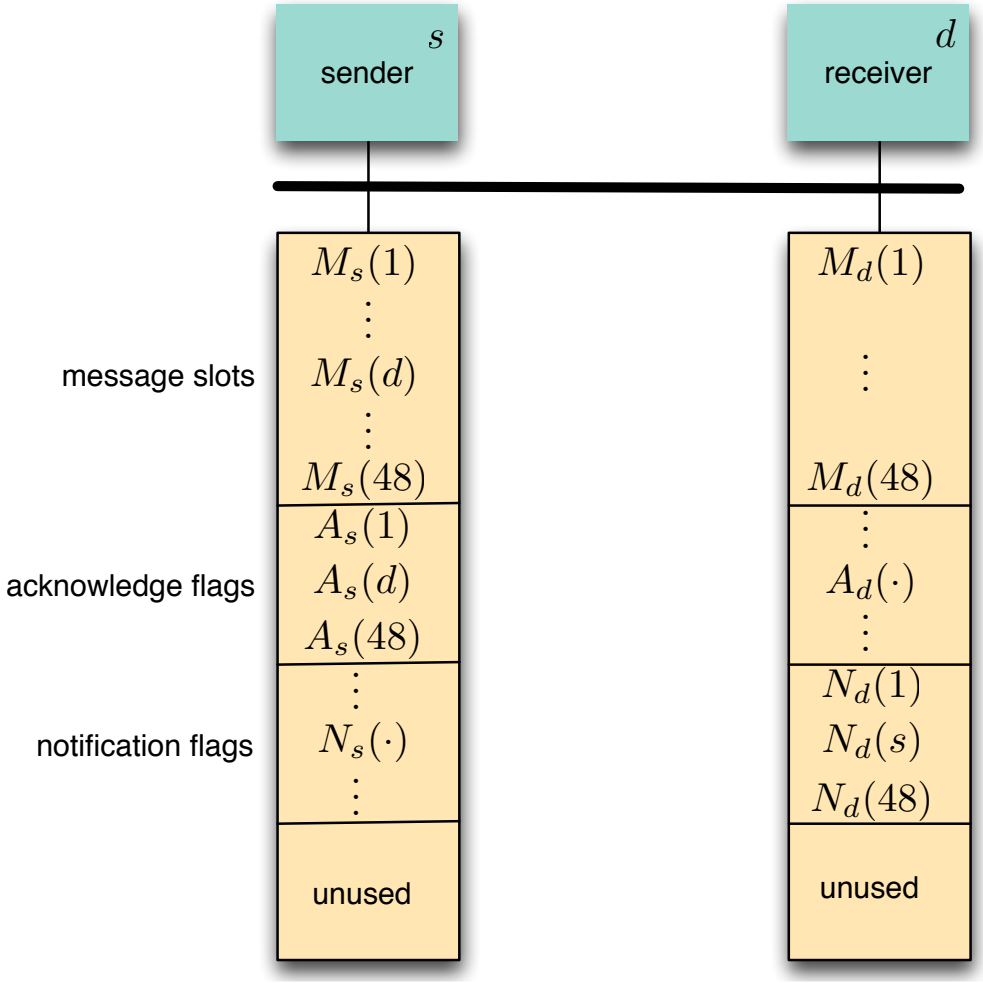
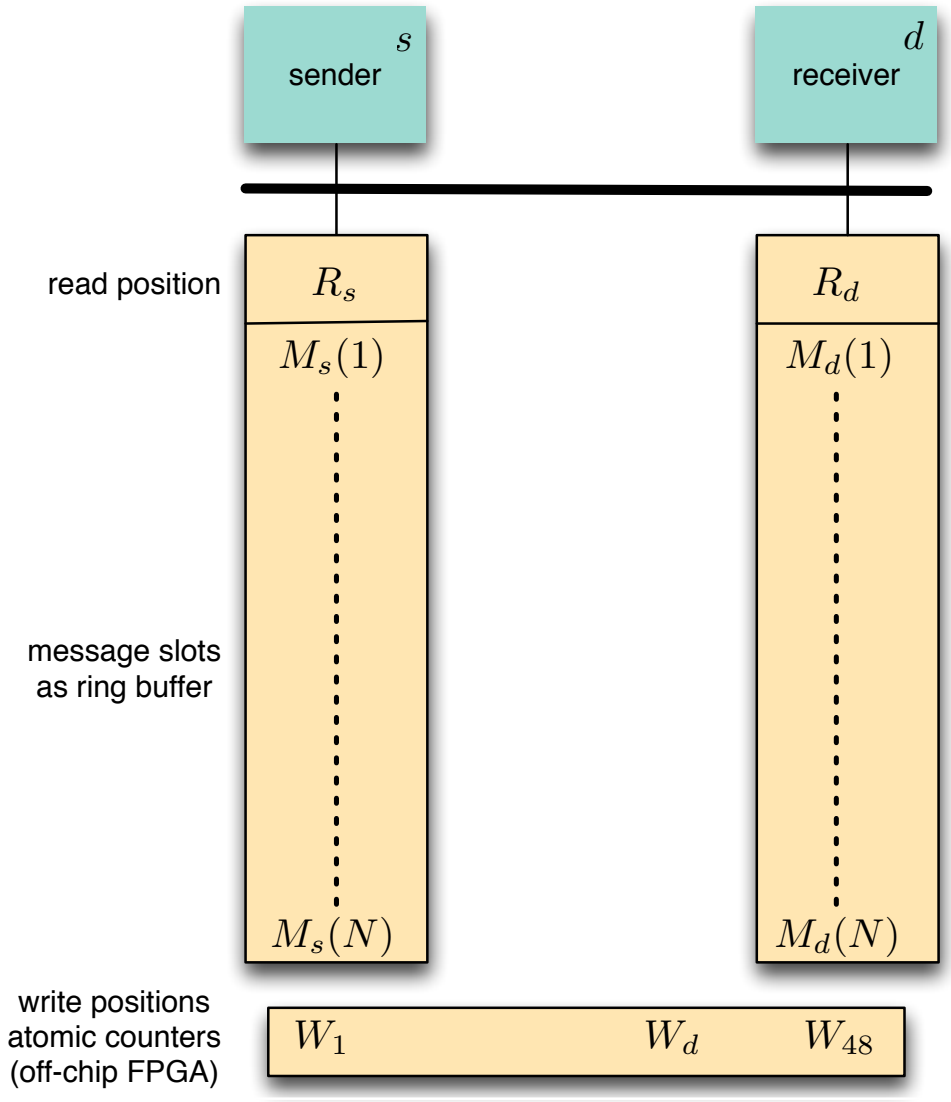


SRBP: SYNCHRONIZED RINGBUFFER PROTOCOL



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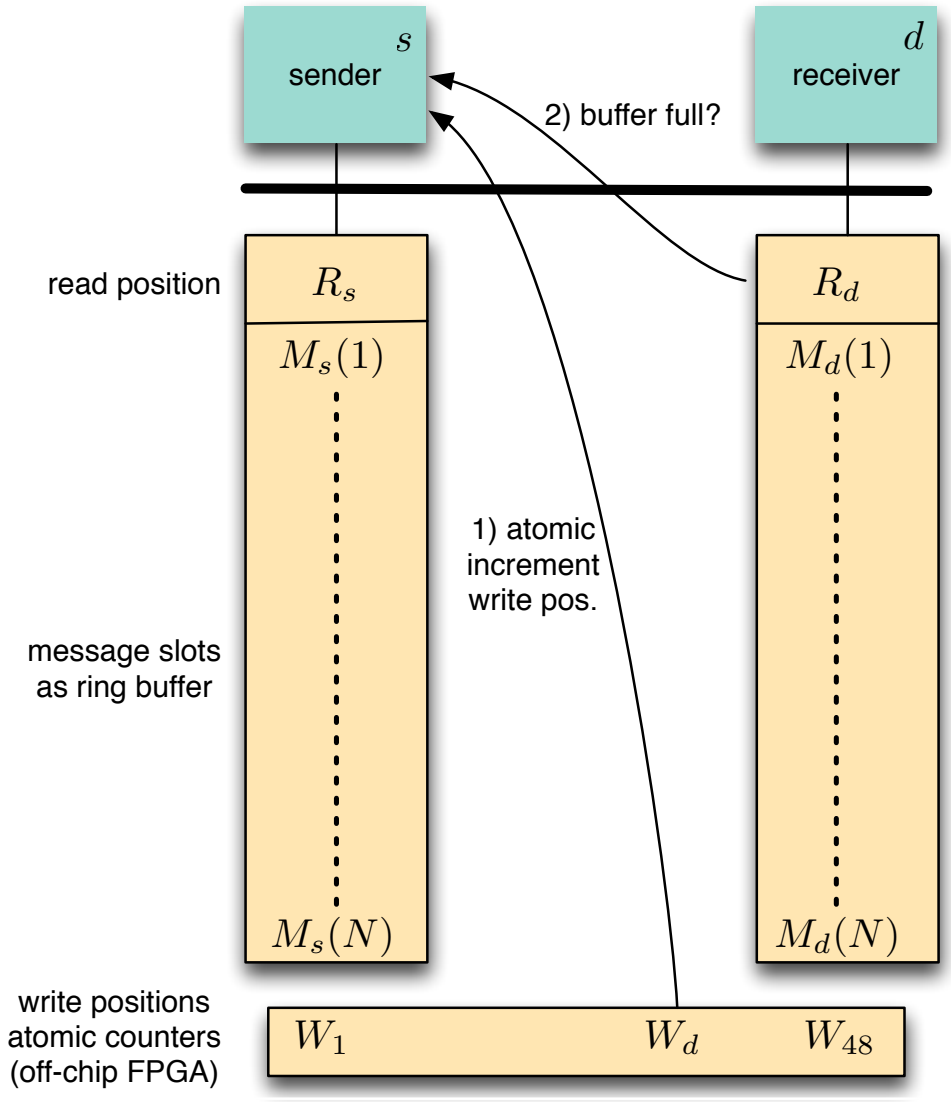

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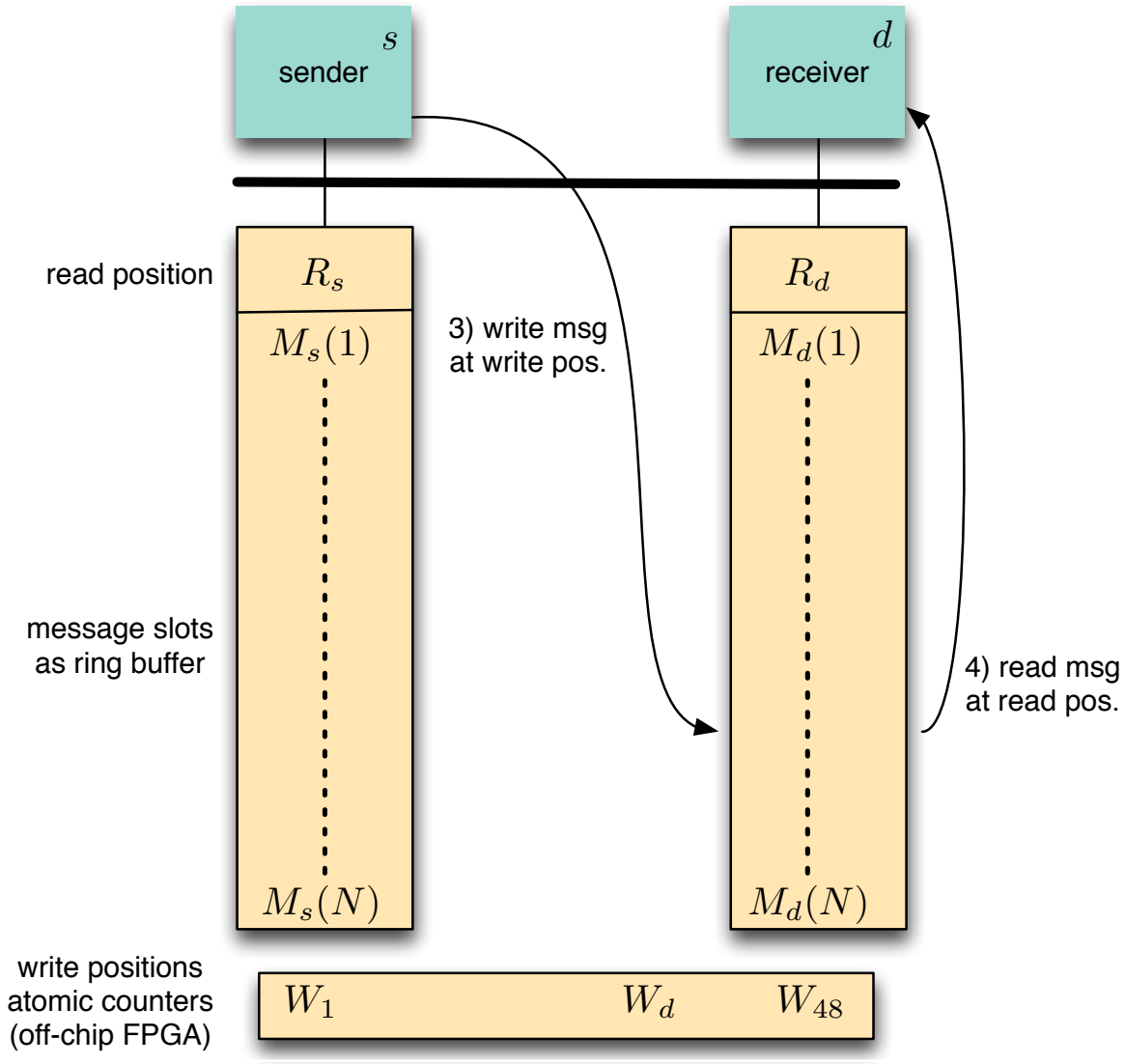

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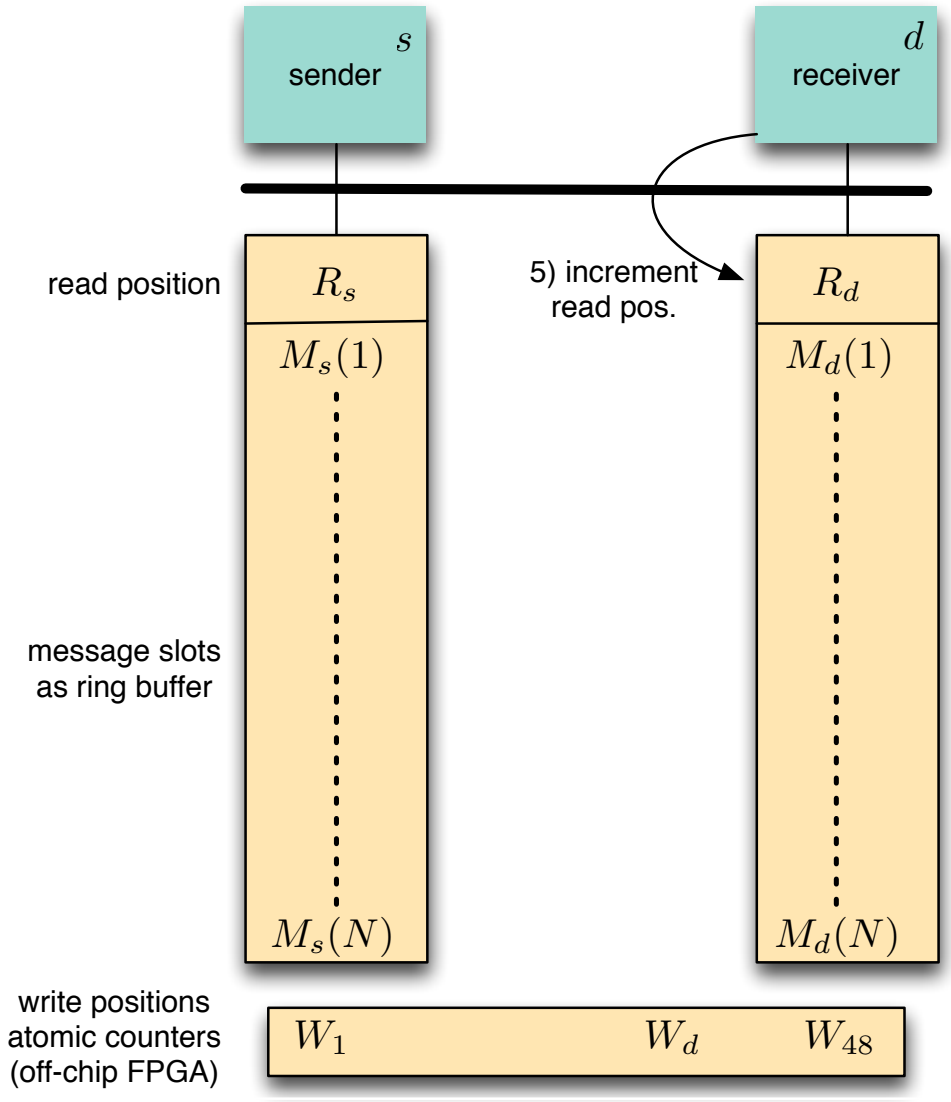

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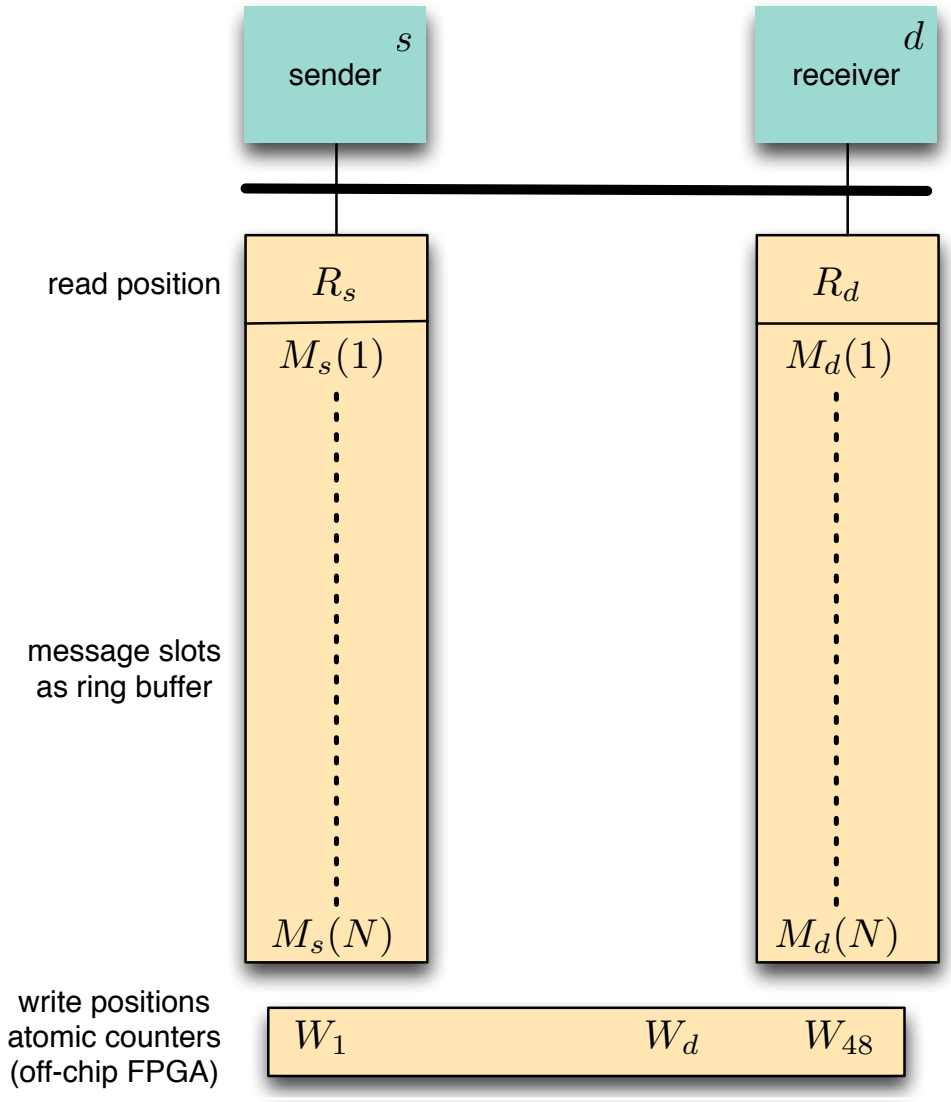

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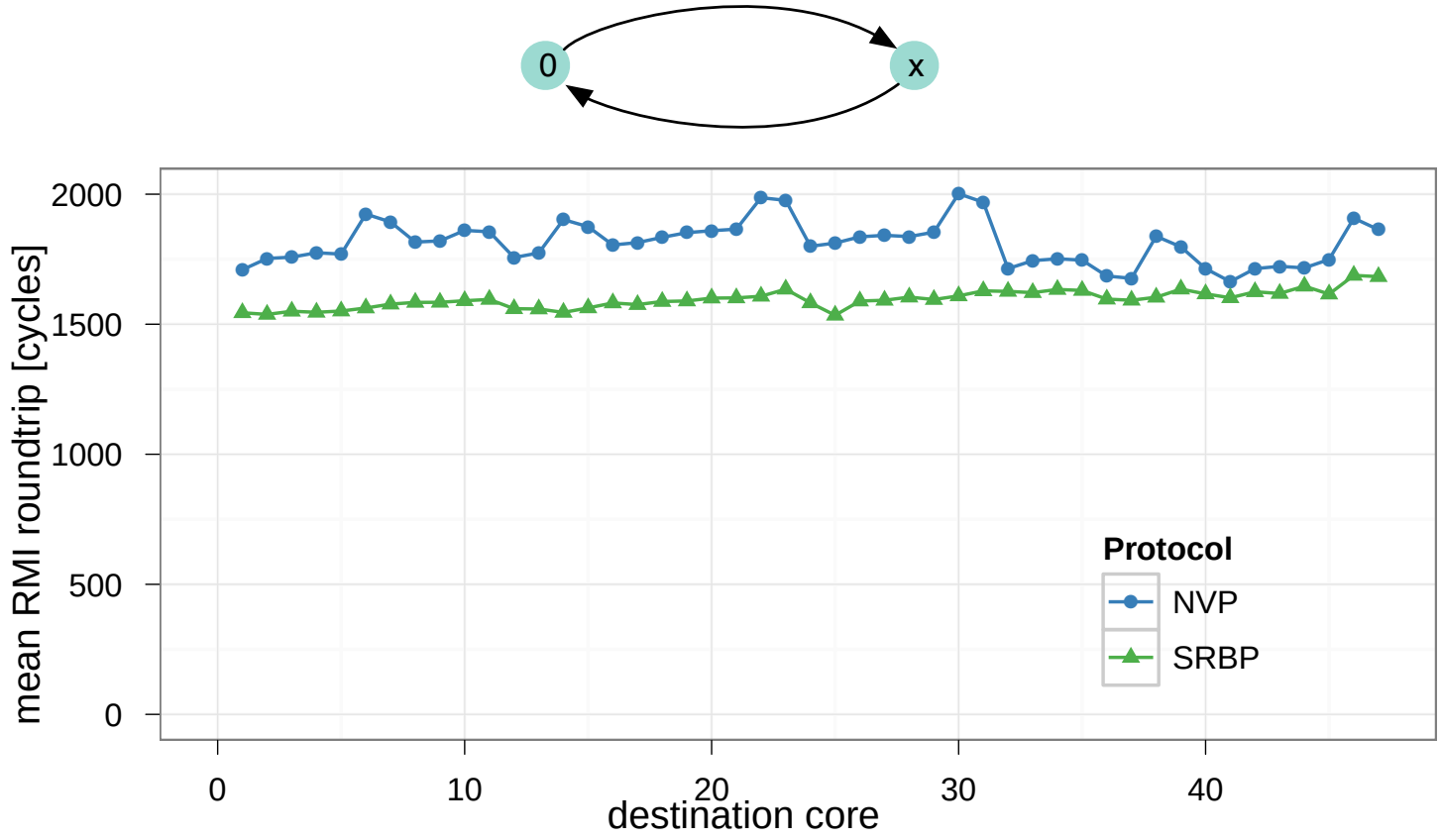
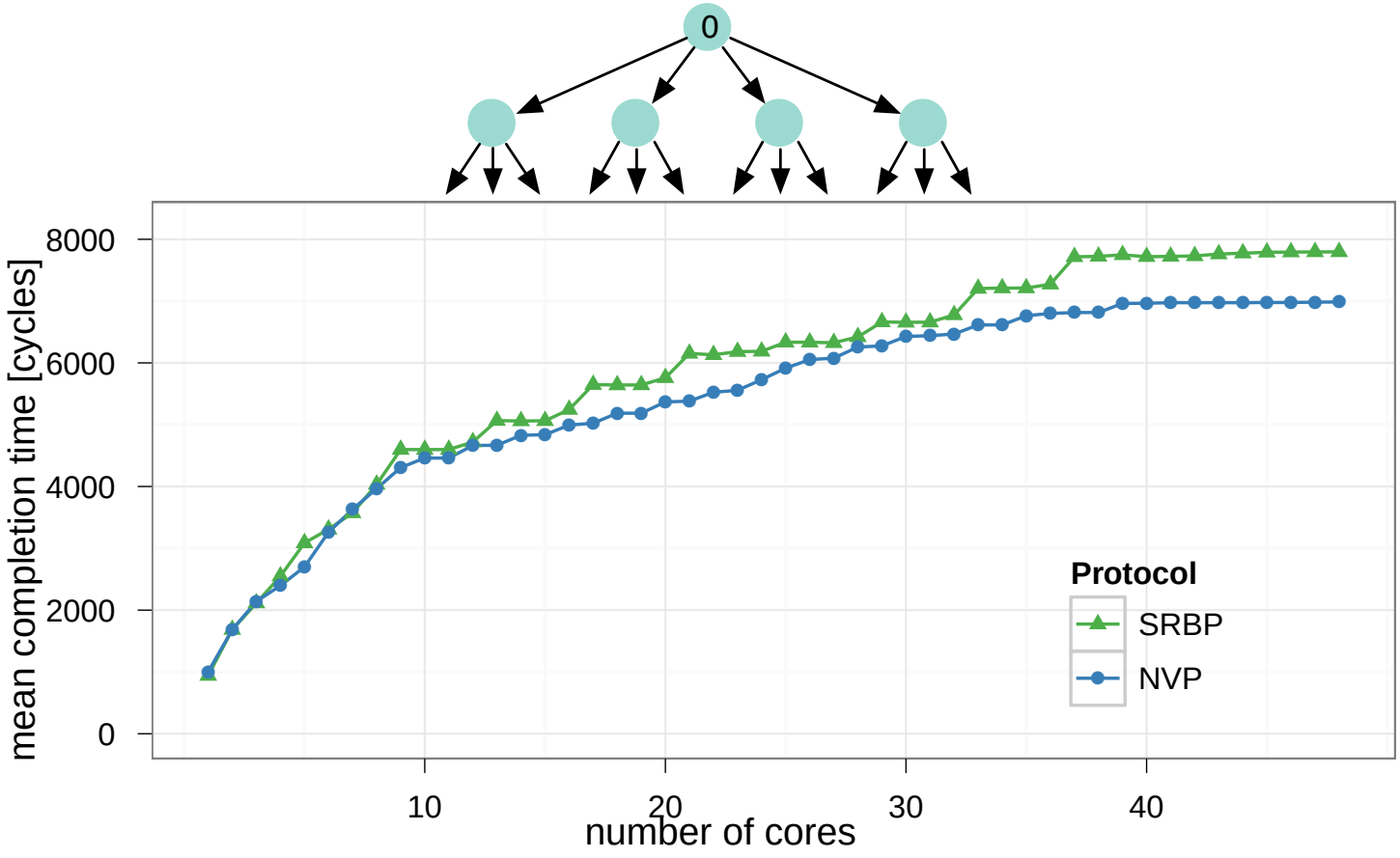
ROUNDTRIPS: <2000 CYCLES



- SRBP >200 cycles faster than NVP
- distance has only little impact (10%)

COLLECTIVE OPERATIONS: LOGARITHMIC GROWTH



- constant overhead per core, interleaves with other tasks
- SRBP slower than NVP (counter congestion)

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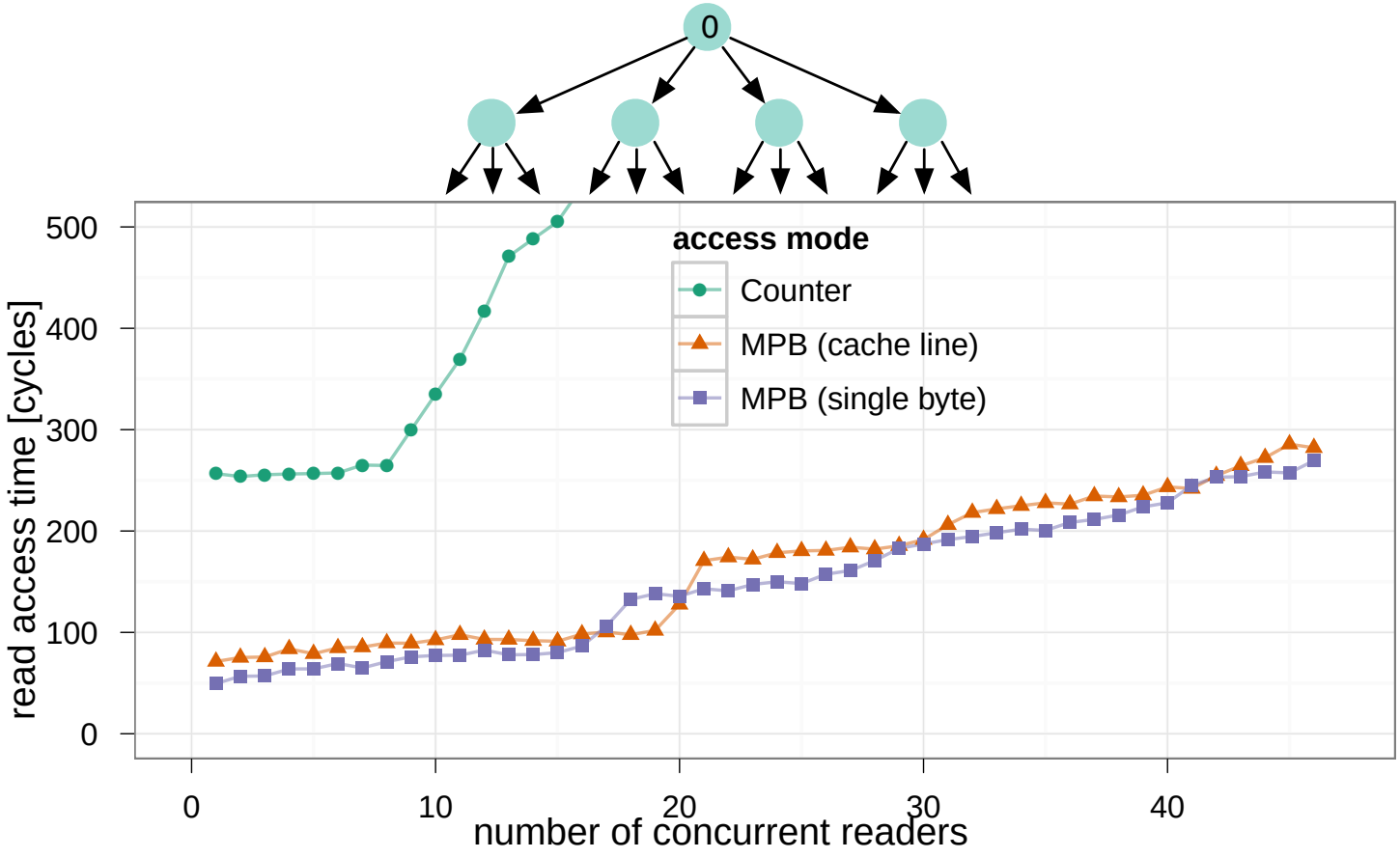

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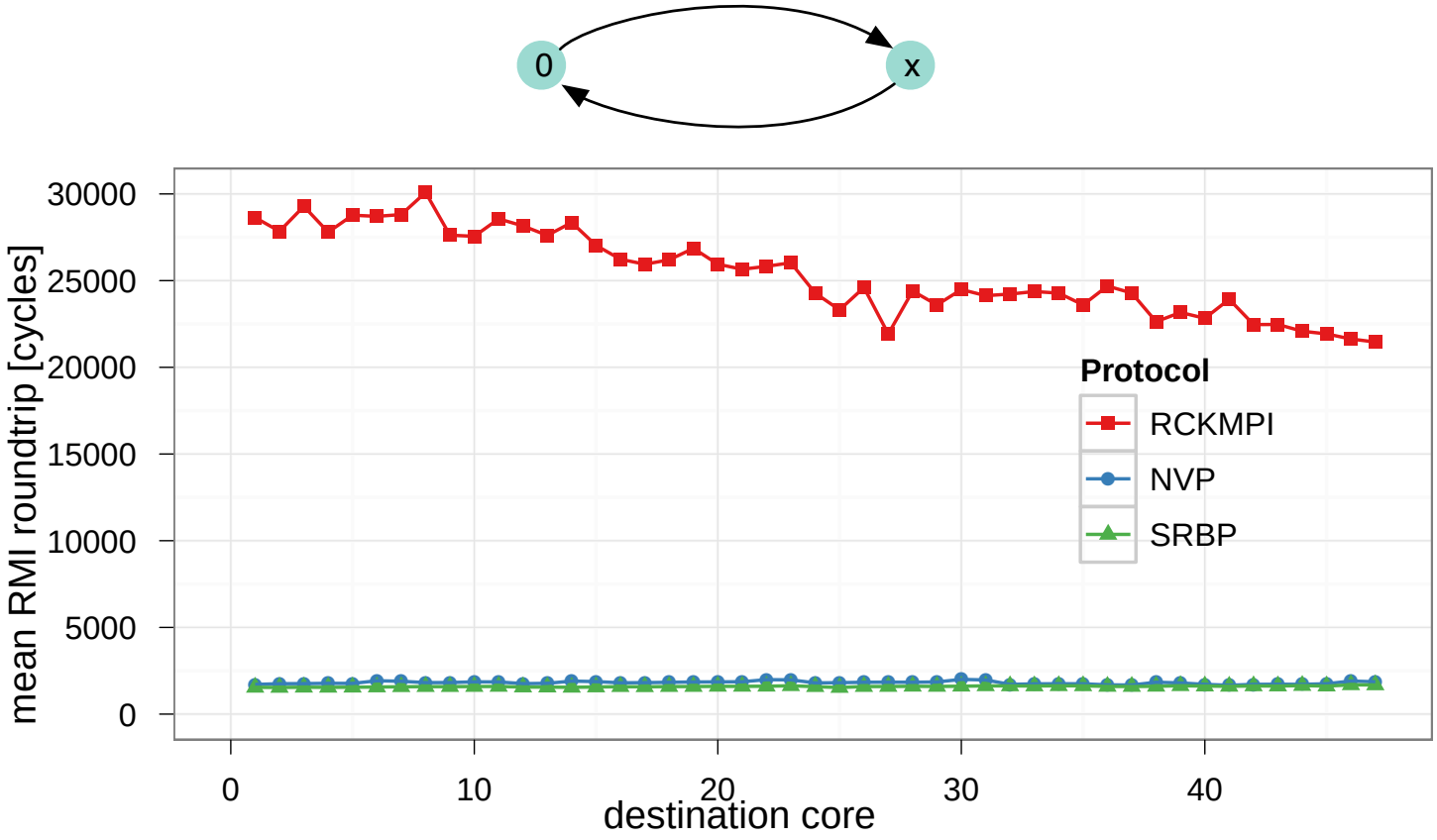
ROUNDTRIPS: 15X FASTER THAN RCKMPI



- MPI: supports large messages, tags, source-dest matching, . . .
- NVP/SRBP: offloading 15x smaller workloads still efficient

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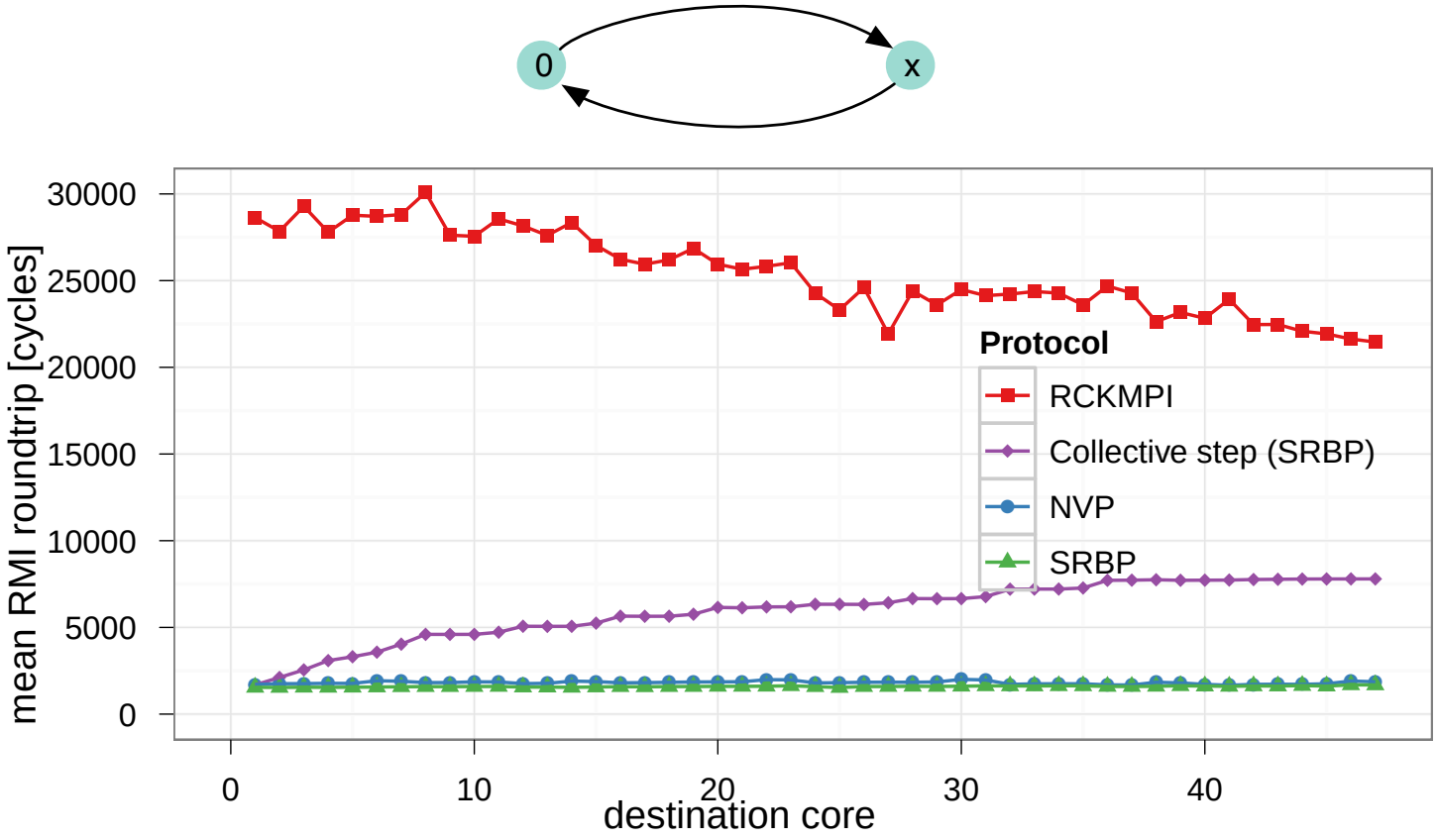

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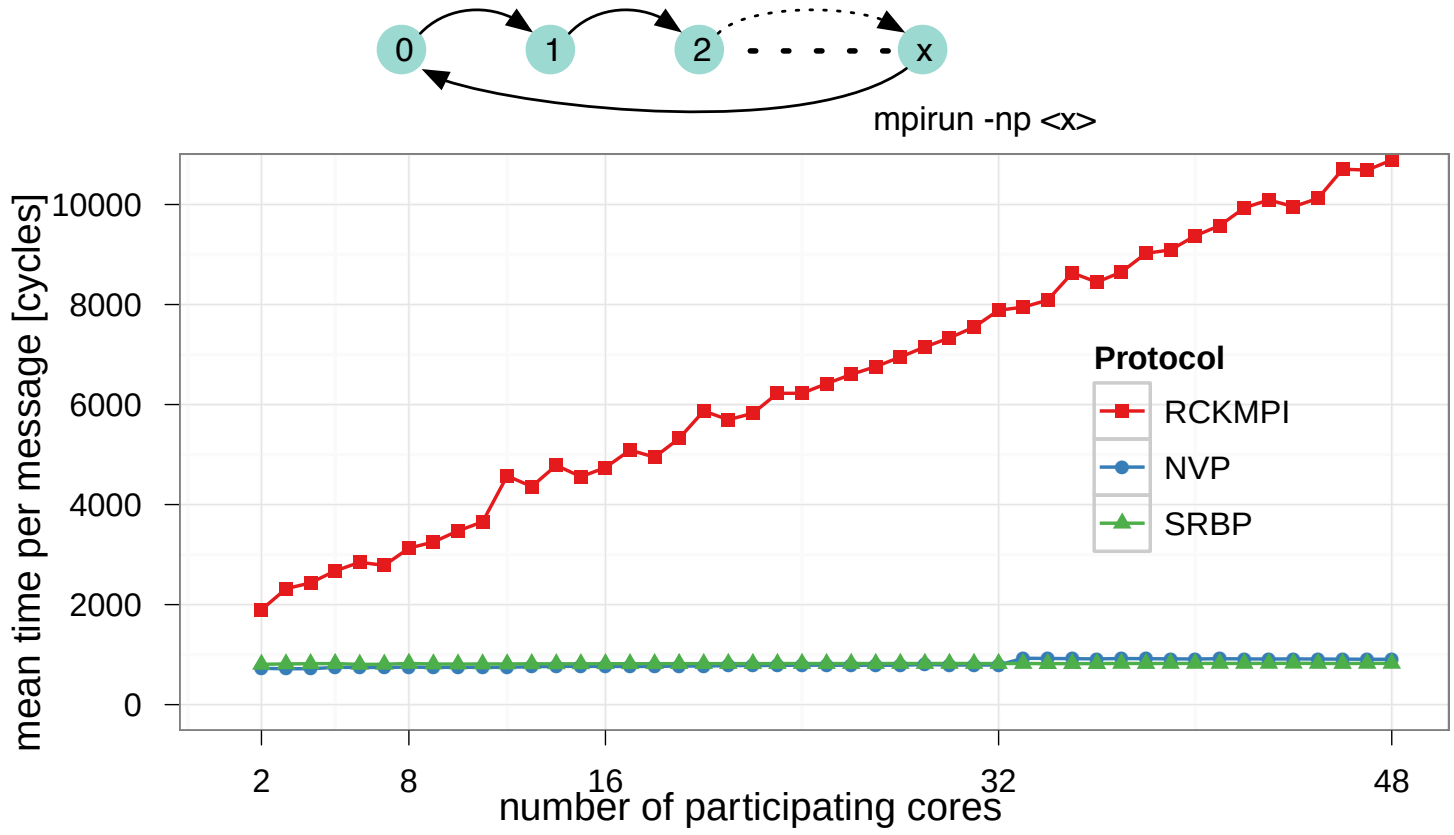
MAIN COST FACTOR: POLLING OVERHEAD

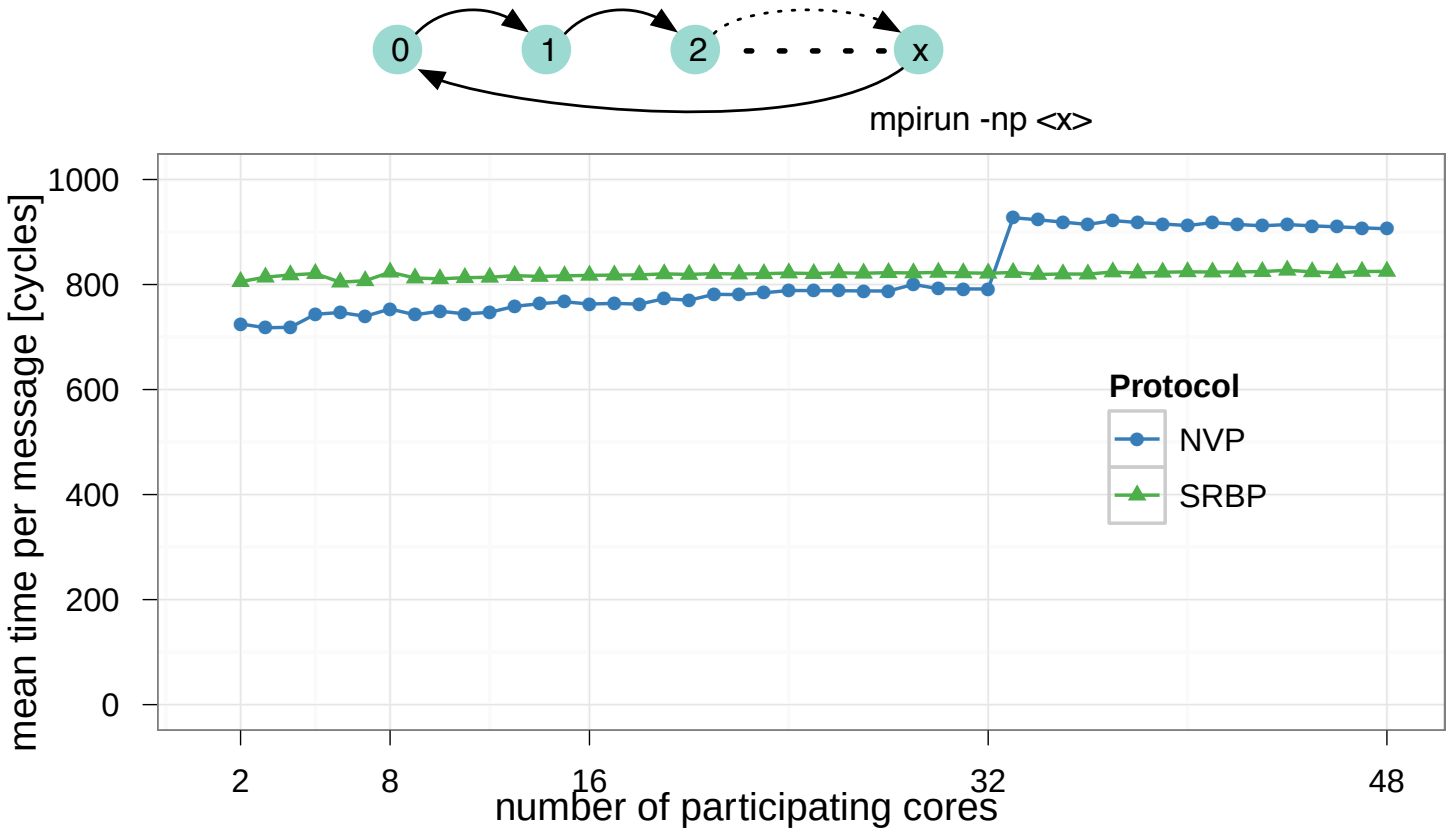


RCKMPI: polling one line per core, takes 200 cycles

NVP: polling one line per 32 cores

SRBP: polling on single word

MAIN COST FACTOR: POLLING OVERHEAD



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CONCLUSION: EFFICIENCY THROUGH SPECIALIZATION

- many-cores are hybrid systems

$\Rightarrow$ combine shared memory and message passing

- just small & simple messages

$\Rightarrow$ simpler & faster protocols, more parallelism

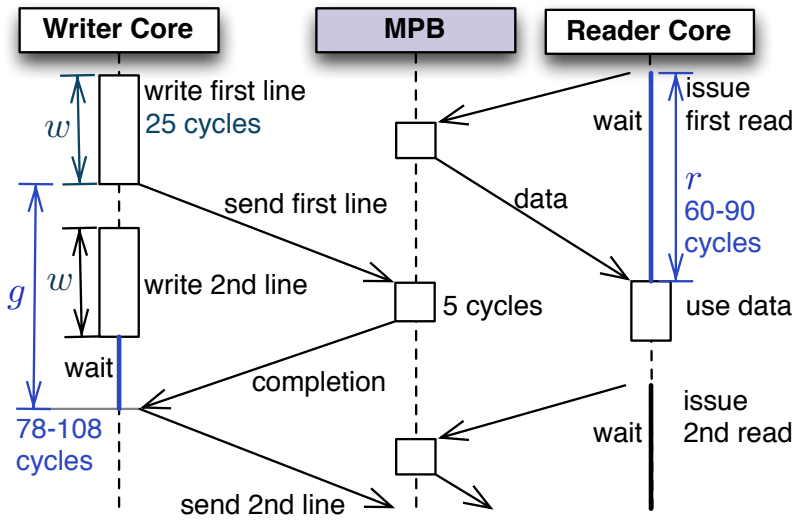
- analysis $\rightsquigarrow$ 70% overhead by notification and probe

$\Rightarrow$ great potential for power savings by better HW support

OUTLINE

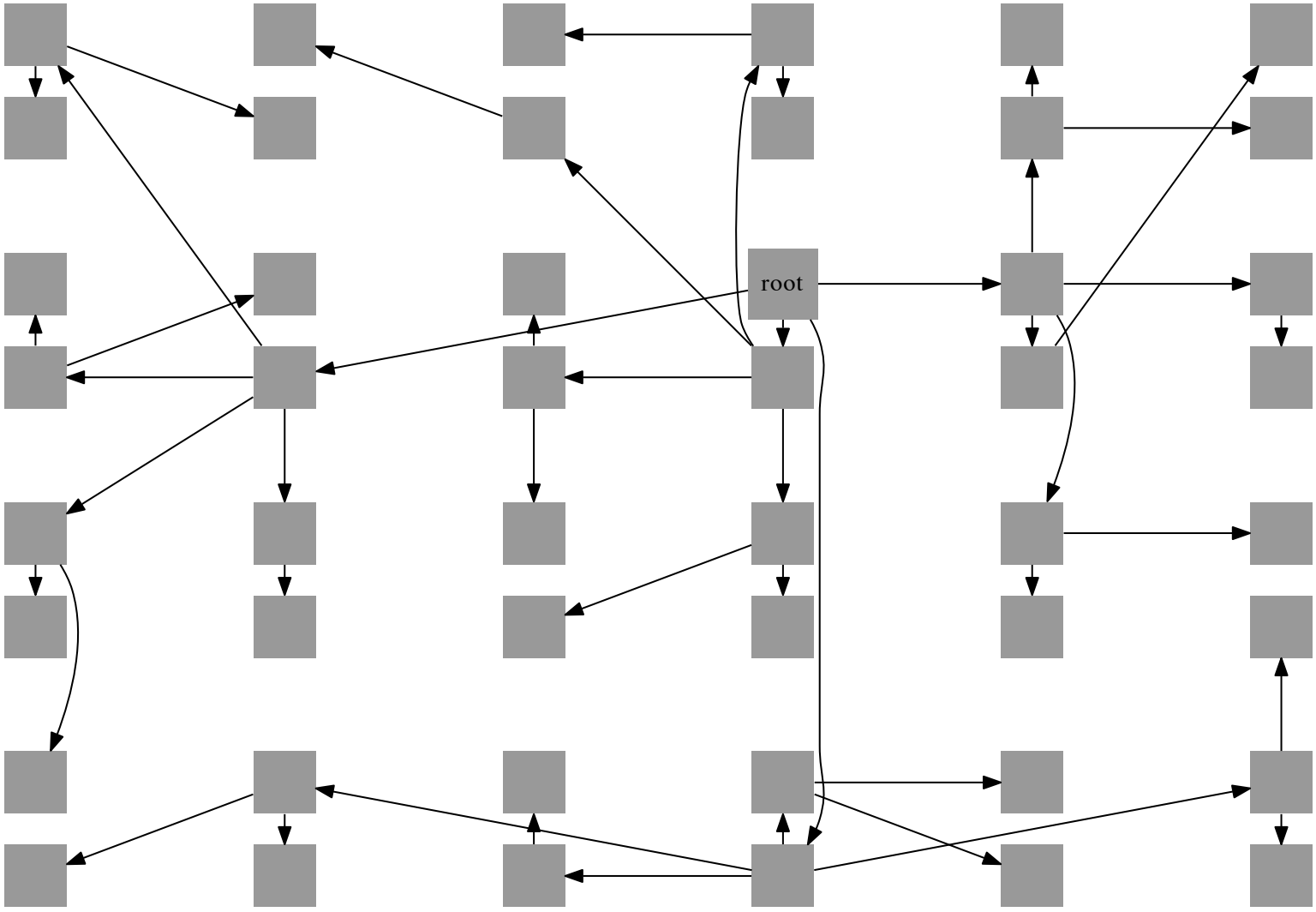
5. Appendix

WGR COST MODEL

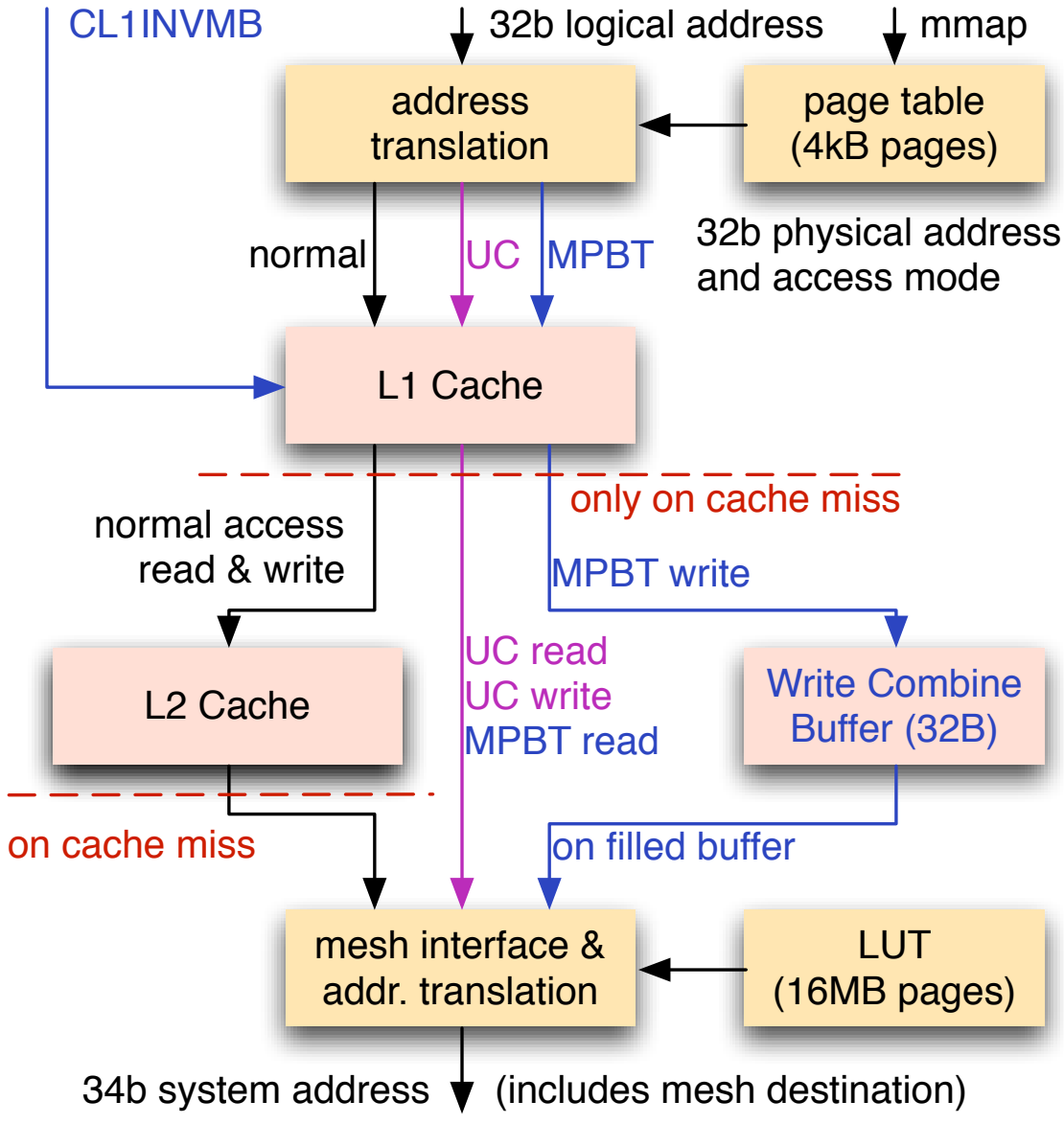


	UC	bypass	MPBT	bypass
w	5	5	25	25
g	51–84	17	78–108	39
r	54–87	19	60–90	21

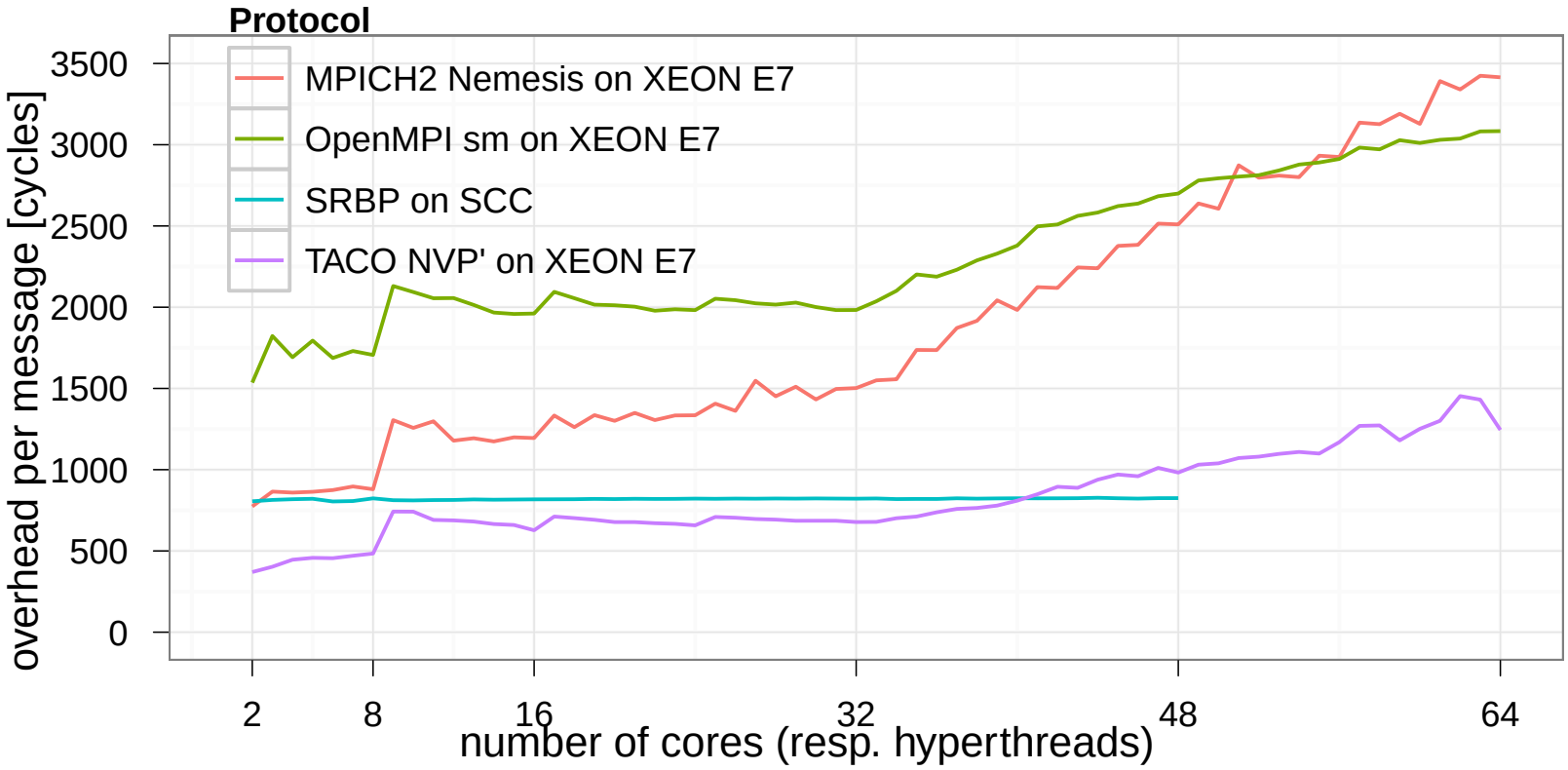
COLLECTIVE OPERATIONS



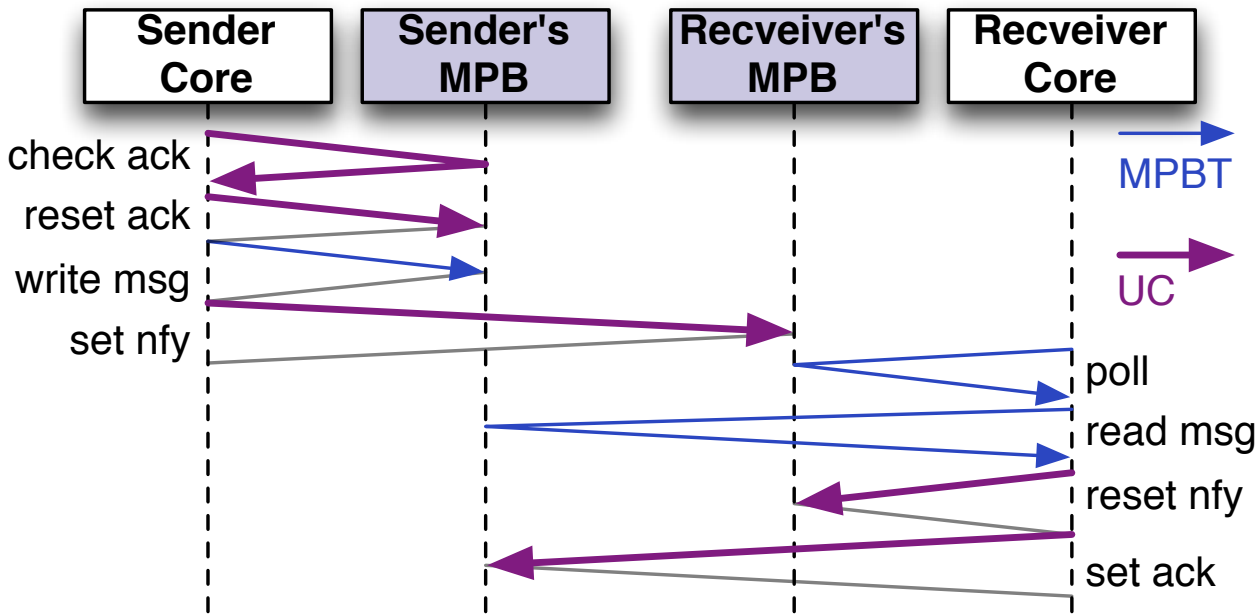
SCC ADDRESS TRANSLATION



PROTOCOL SCALABILITY ON XEON E7



PROTOCOLS: NVP



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