Synchronization of MPI One-Sided Communication on a Non-Cache-Coherent Many-Core System

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Steffen Christgau, Bettina Schnor

Operating Systems and Distributed Systems
Institute for Computer Science
University of Potsdam, Germany

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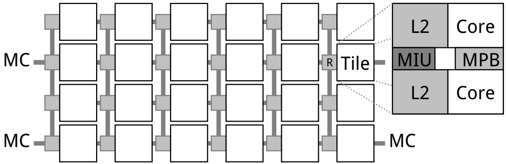

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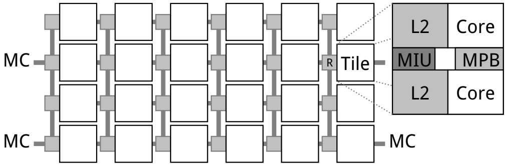
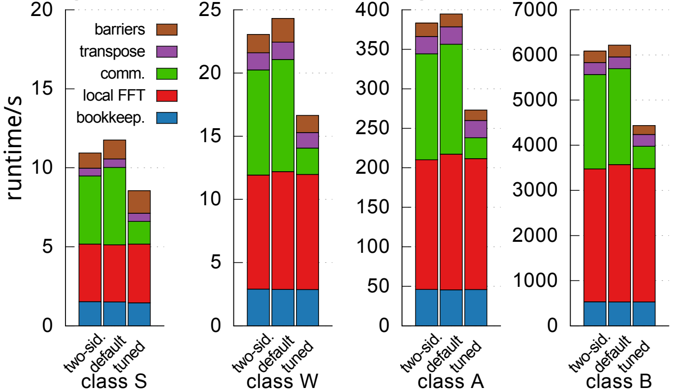


  - 48 Pentium cores with L1/2 caches, **no HW cache coherence**
  - memory subsystem allows creation of shared memory
- new approach: use shared memory on nCC CPU for **one-sided communication** and **manage cache coherence in software**

Software-Managed Cache Coherence for OSC

- previous results: reduce communication costs by factor of 4 – 5 when using OSC with software-managed cache coherence



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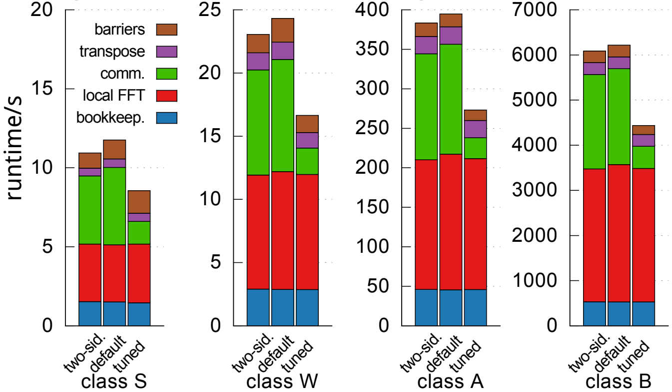

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- **today: synchronization** for one-sided communication

Agenda

Background

- MPI One-Sided Communication
- Process Synchronization
- Classification and Survey

Implementation

- Data Structures
- Algorithm

Experimental Evaluation

- Scaling
- Comparison with RCKMPI

Summary

Background: MPI Communication Styles

two-sided communication

- sender *and* receiver must know communication parameters (buffer address, data type, tag, sender/receiver)
- implicit synchronization

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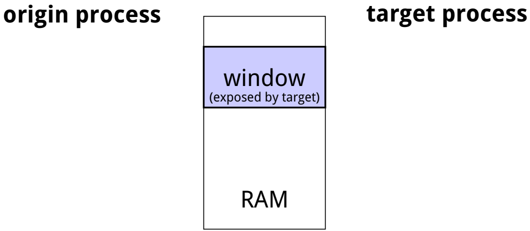

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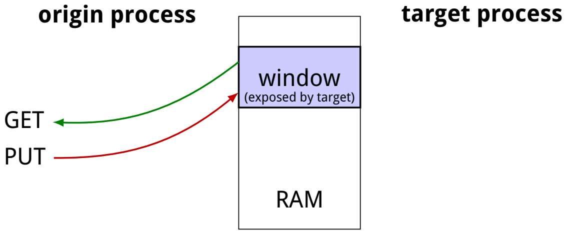

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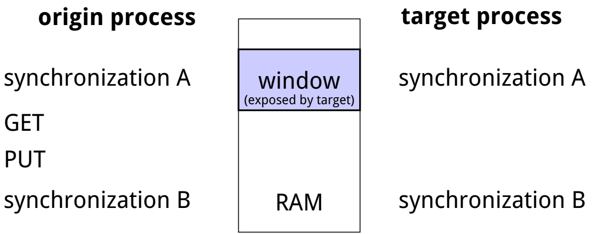

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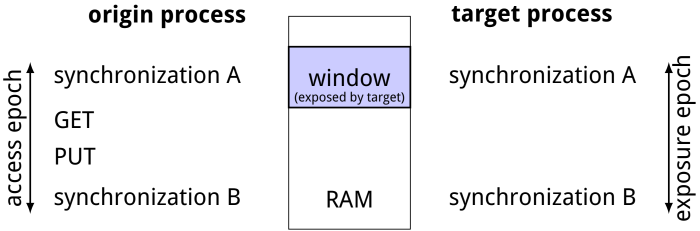

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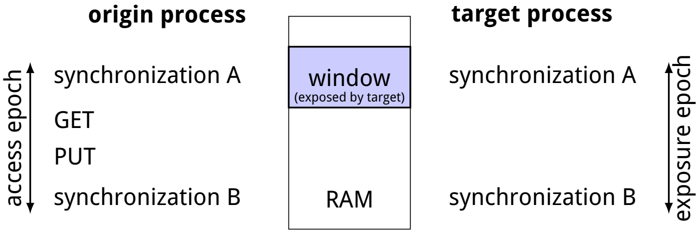
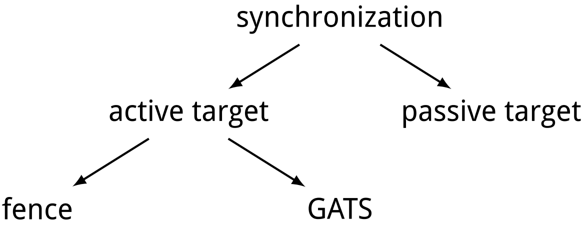
- separation of communication and synchronization



MPI Synchronization Types



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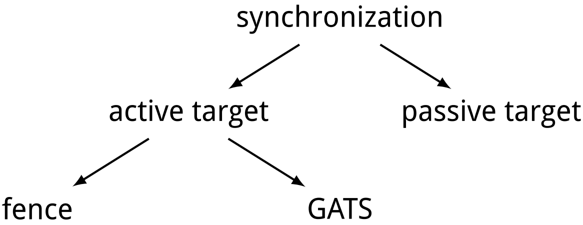

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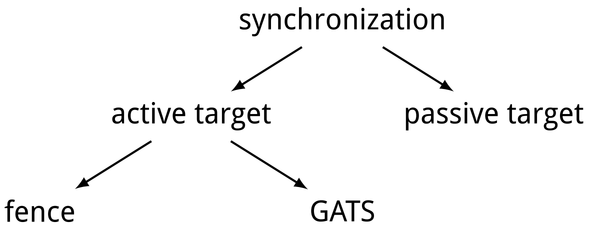

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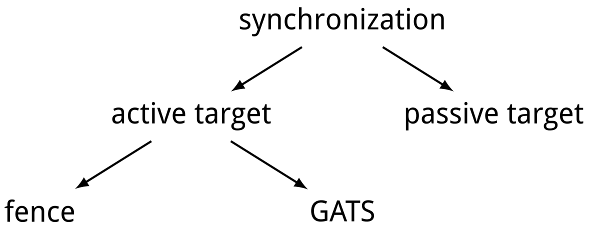

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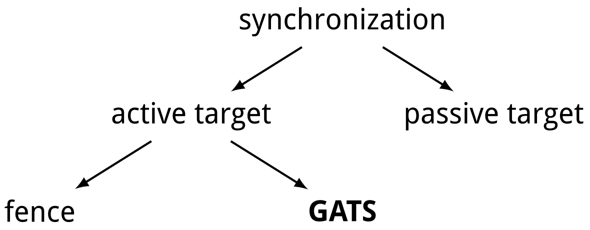

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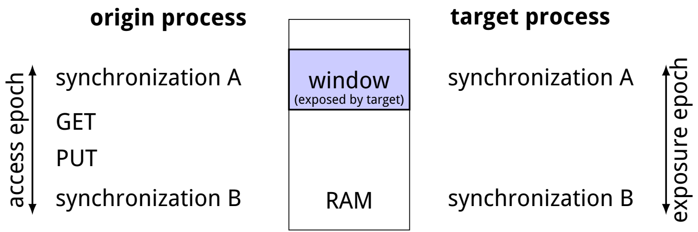

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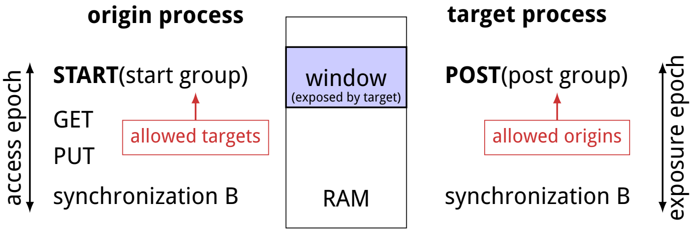

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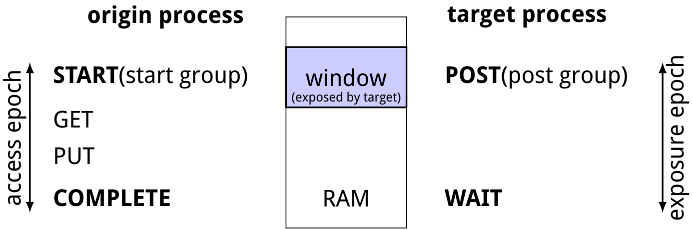


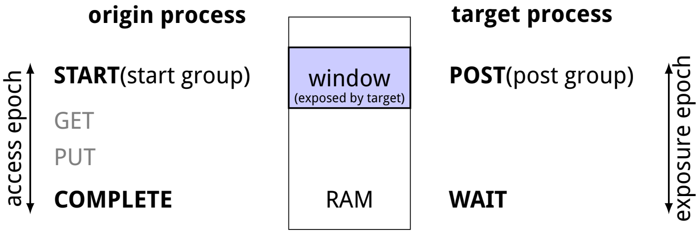
POST allow communication on own window

START open access epoch (allow communication calls)

COMPLETE finish communication and notify targets

WAIT wait for all origin notifications

Classification of Implementations



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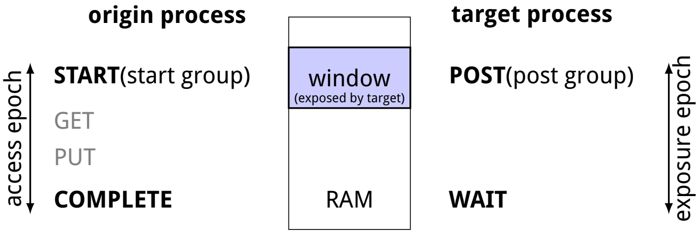

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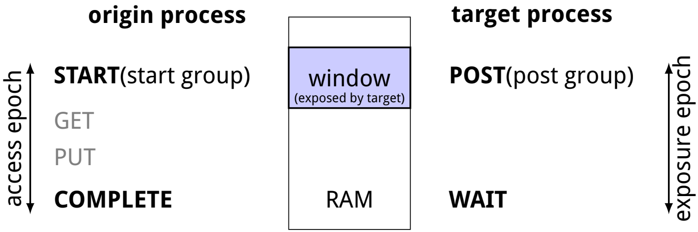

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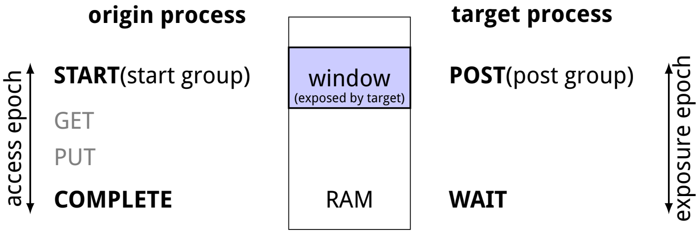

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summary of conducted source code survey

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- **MVAPICH/shared memory: trigger-only + shared memory**
  - proposed by POTLURI ET AL., 2011
  - two bit vectors per process, one bit per process
  - POST: set process' bit in origin vectors / START: do nothing
  - check for synchronization (poll vector) in communication calls
  - COMPLETE: set process' bit in target vectors / WAIT: poll vector

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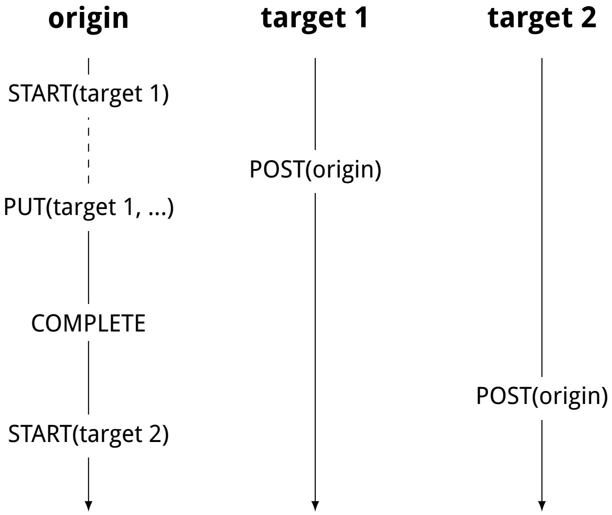

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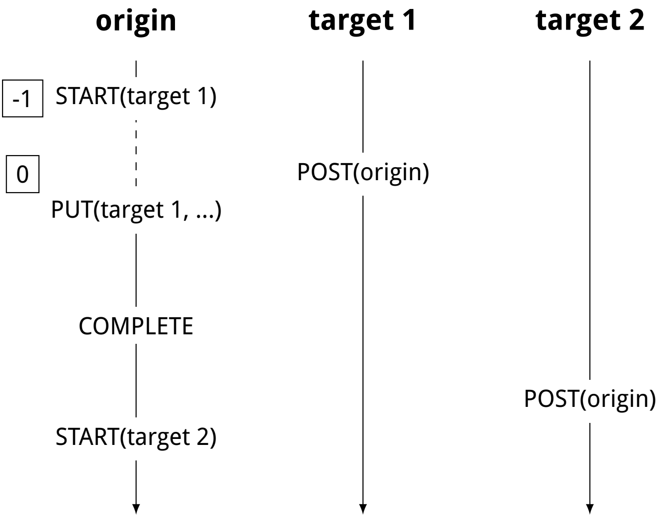

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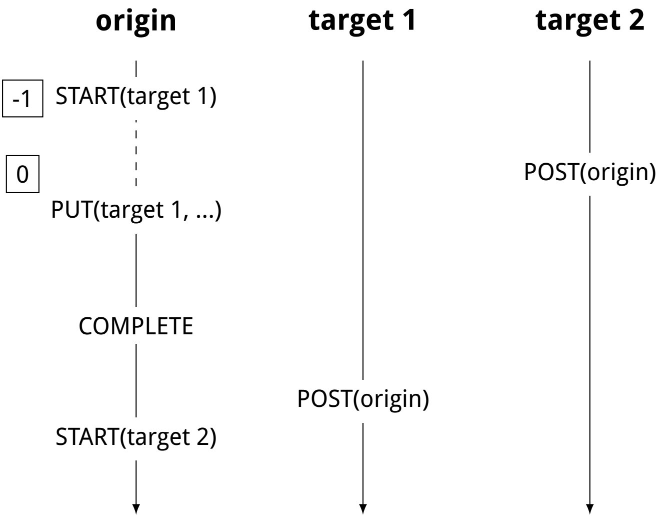

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  - increment and poll operations
  - error-prone (**bug**), fixed after report $\rightarrow$ now MVAPICH-like

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→ large variety of implementations

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SCOSCo: Implementation on the SCC

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general idea for SCC:

- bit vectors and counters for synchronization
- allocation in shared memory, but on nCC system
- software-managed cache coherence (if required)

Data Structures

match vector = bit vector

- for synchronization at epoch start:
- one vector per process, placed in shared memory
- dedicated to origin processes
- k-th bit set $\Rightarrow$ target process with ID/rank k synchronized

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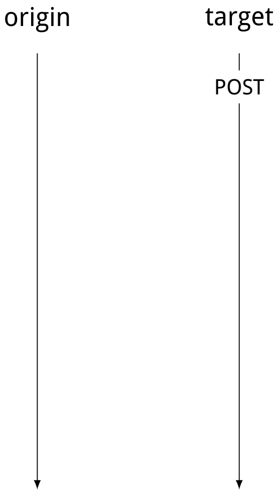
completion counter (CC)

- for synchronization at epoch end
- one integer per process in shared memory
- placed at well-known offset behind match vector
- dedicated to target processes
- $CC == 0 \Rightarrow$ all origins have completed

Synchronization: Epoch Start

POST(post_group)



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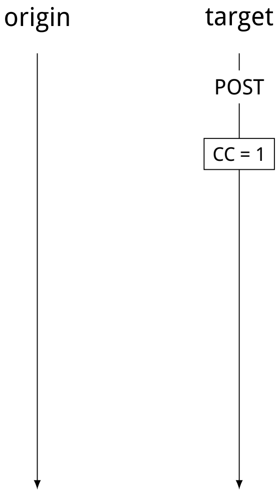

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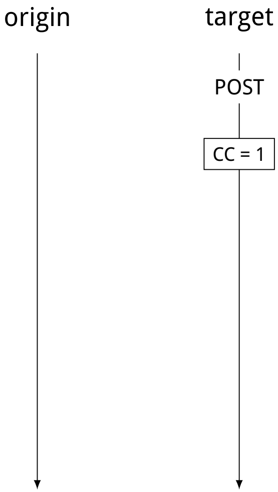

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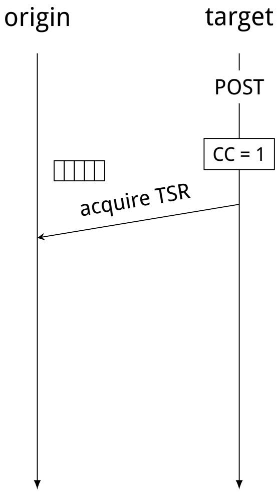

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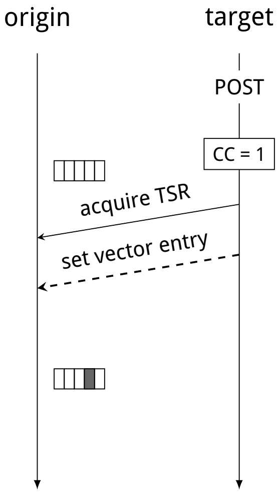

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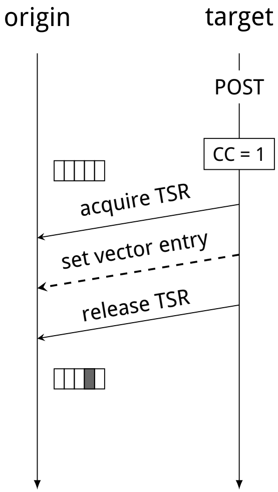

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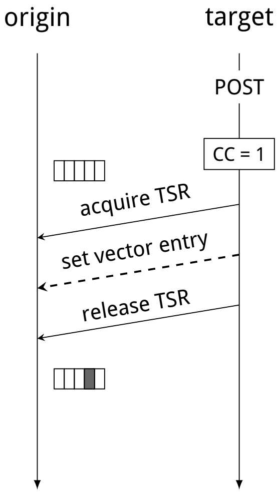

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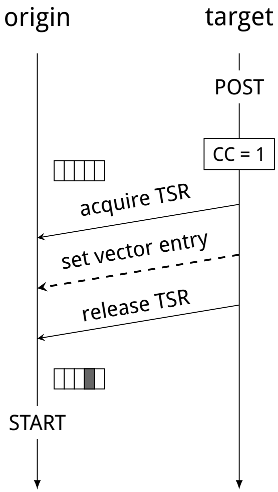

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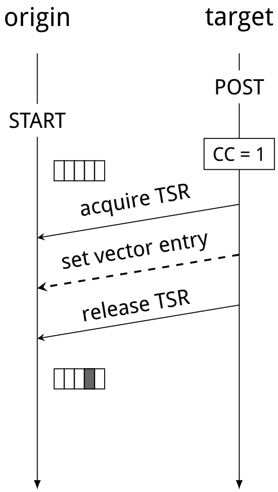
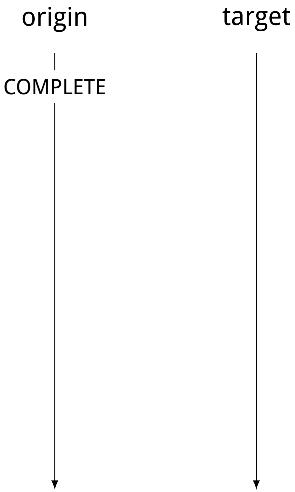


Synchronization: Epoch End

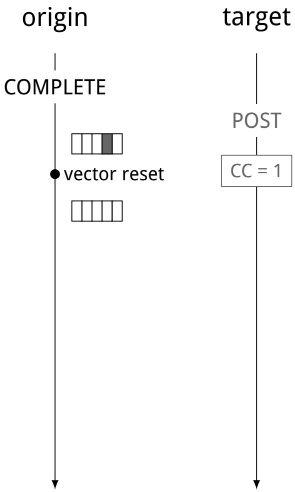
COMPLETE



Synchronization: Epoch End

COMPLETE

- wait for all (remaining) targets
- reset match vector entries



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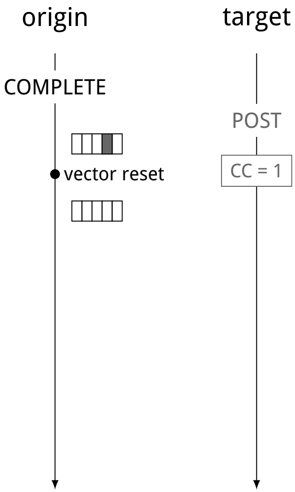

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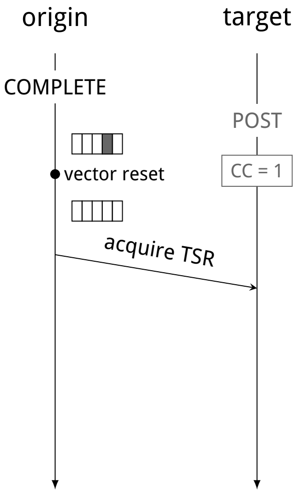

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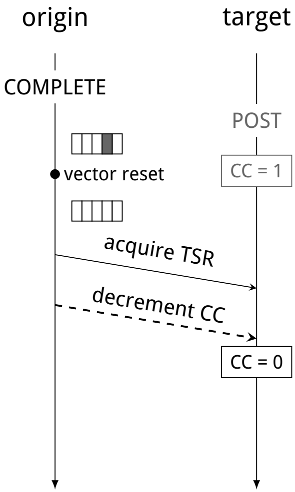

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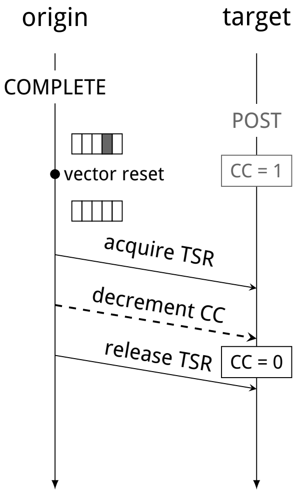

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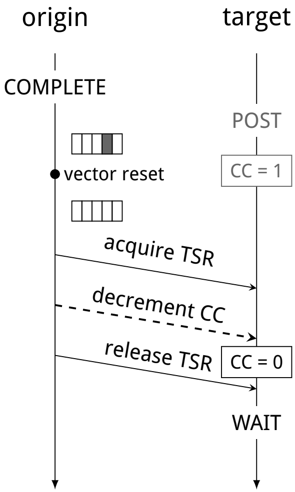
- **poll CC uncached** until zero
  - caching would prevent progression



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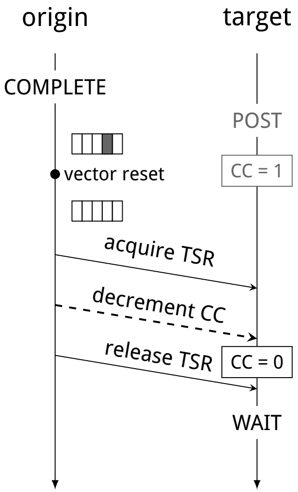
WAIT

- **poll CC uncached** until zero
  - caching would prevent progression



Summary: No caching and no coherence needed!

Microbenchmark

- existing MPI benchmark suites, e.g. OSU: no dedicated synchronization benchmark $\rightarrow$ create own one
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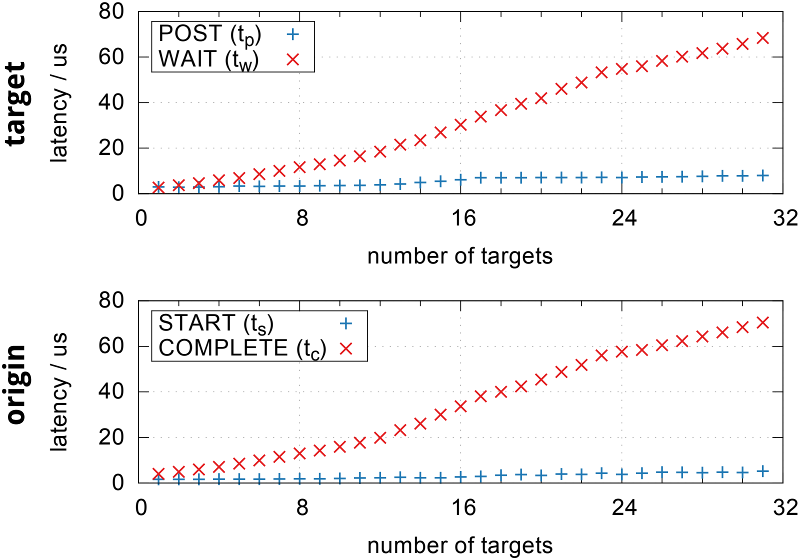
- n processes $=$ 1 origin + $(n-1)$ targets
- Pseudocode:

for $i = 0 \ldots 1000$ **do**
  if proc is origin **then**
    $\textsc{time}(\textsc{Start}(G_s = \{1 \ldots n-1\}))$
    $\textsc{time}(\textsc{Complete})$
  else
    $\textsc{time}(\textsc{Post}(G_p = \{0\}))$
    $\textsc{time}(\textsc{Wait})$
  end if
end for

Scaling

Increasing Number of Targets



Comparison with RCKMPI

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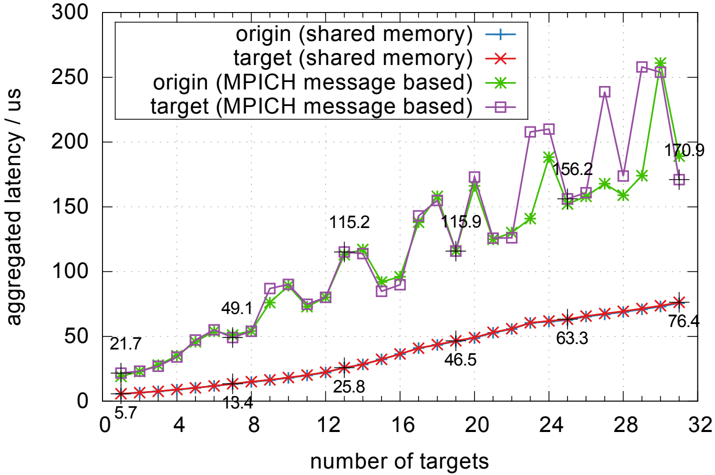

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Thanks for your attention!

time for questions and suggestions…