First Experiences with the SCC and a Comparison with Established Architectures

Stefan Lankes, Carsten Clauss

Chair for Operating Systems
RWTH Aachen University

LfBS LEHRSTUHL FÜR BETRIEBSSYSTEME
Univ.-Prof. Dr. habil. Thomas Bemmerl

RWTH AACHEN UNIVERSITY

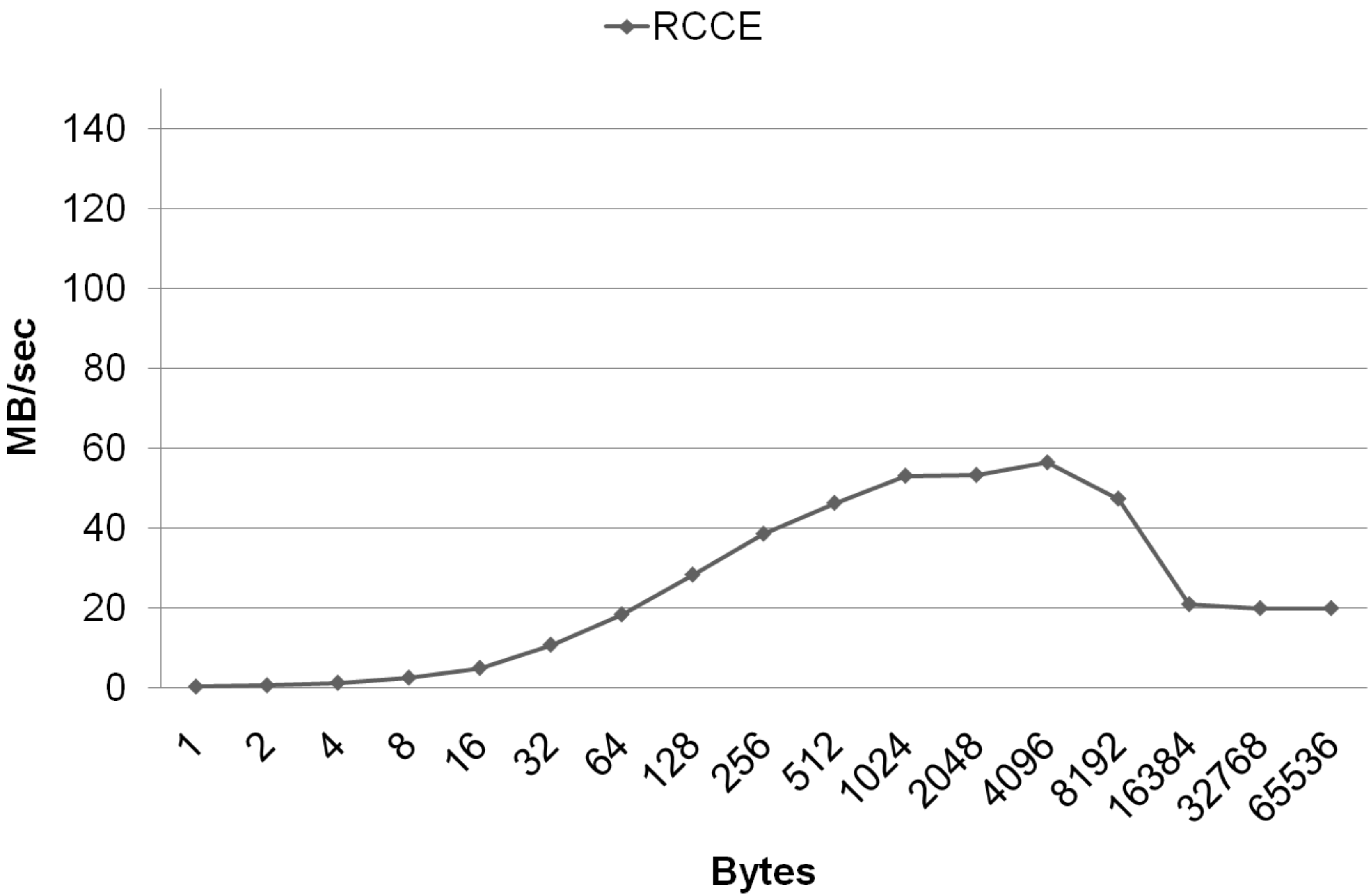
Agenda

- First RCCE and MPI benchmark results
- Cache behavior of the P54C Architecture
- Optimization of `RCCE_put` and `RCCE_get`
  - Learning from the past
- Potential of MP-MPICH
  - e.g. clustering of SCC systems
- Capability of SVM systems
  - Future project aims
- Conclusions and Outlook

Background

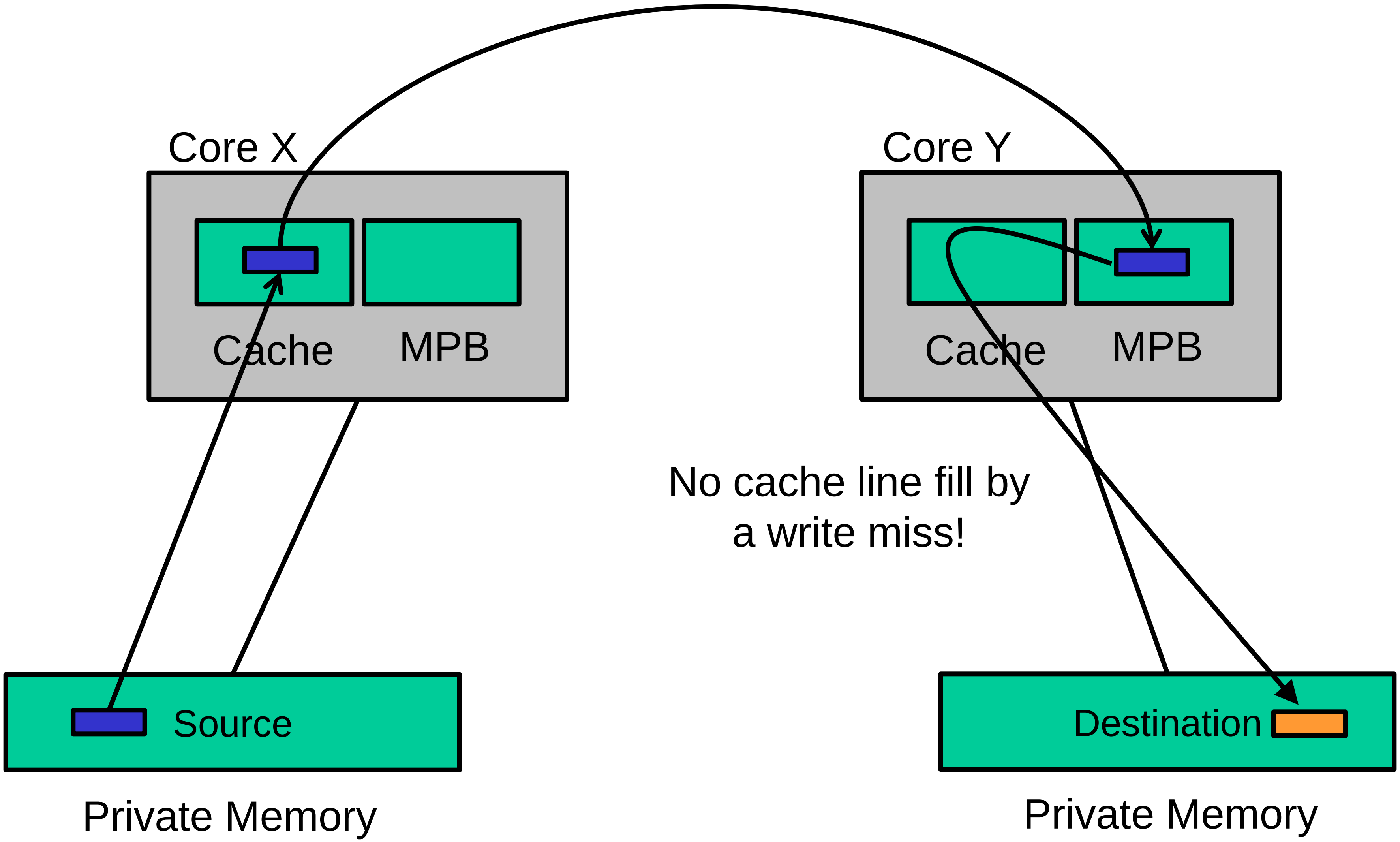
- Research topics
  - Operating Systems (of course)
  - Parallelization strategies
    - Shared Memory
    - Message Passing
  - Distributed Systems
  - Embedded and Real-Time Systems
  - …
- ➢ The Chair for Operating systems has developed an own MPI distribution
  - Based on MPICH
  - Support of different high performance interconnects (e.g. SCI)
- ➢ The “ultimate” MPI benchmark: Ping Pong
  - It is obvious to use RCCE with Message Passing Buffers
  - Enlarge RCCE example “PingPong” to send messages with variable size

Ping Pong

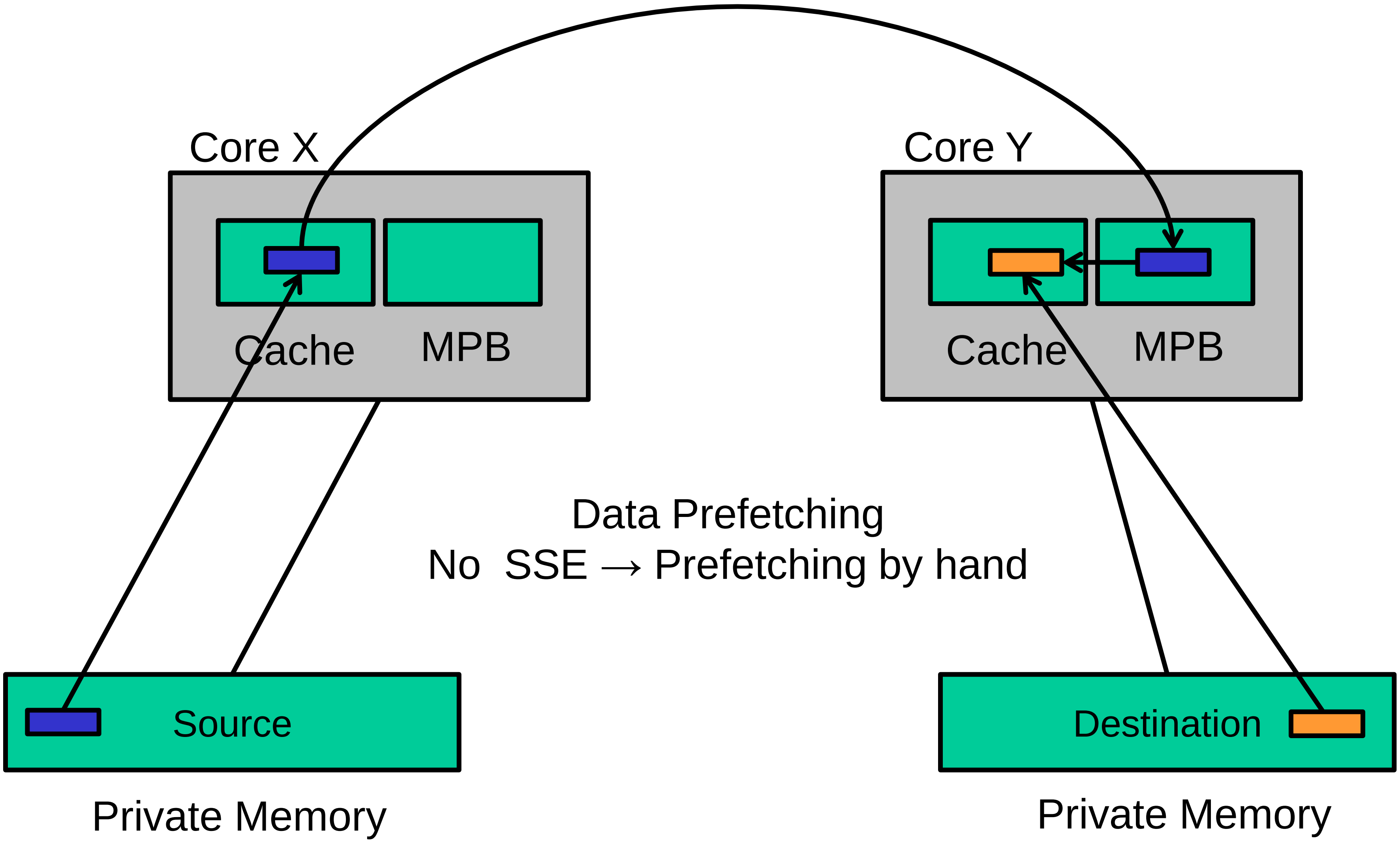


RCCE
MB/sec
140
120
100
80
60
40
20
0
1
2
4
8
16
32
64
128
256
512
1024
2048
4096
8192
16384
32768
65536
Bytes

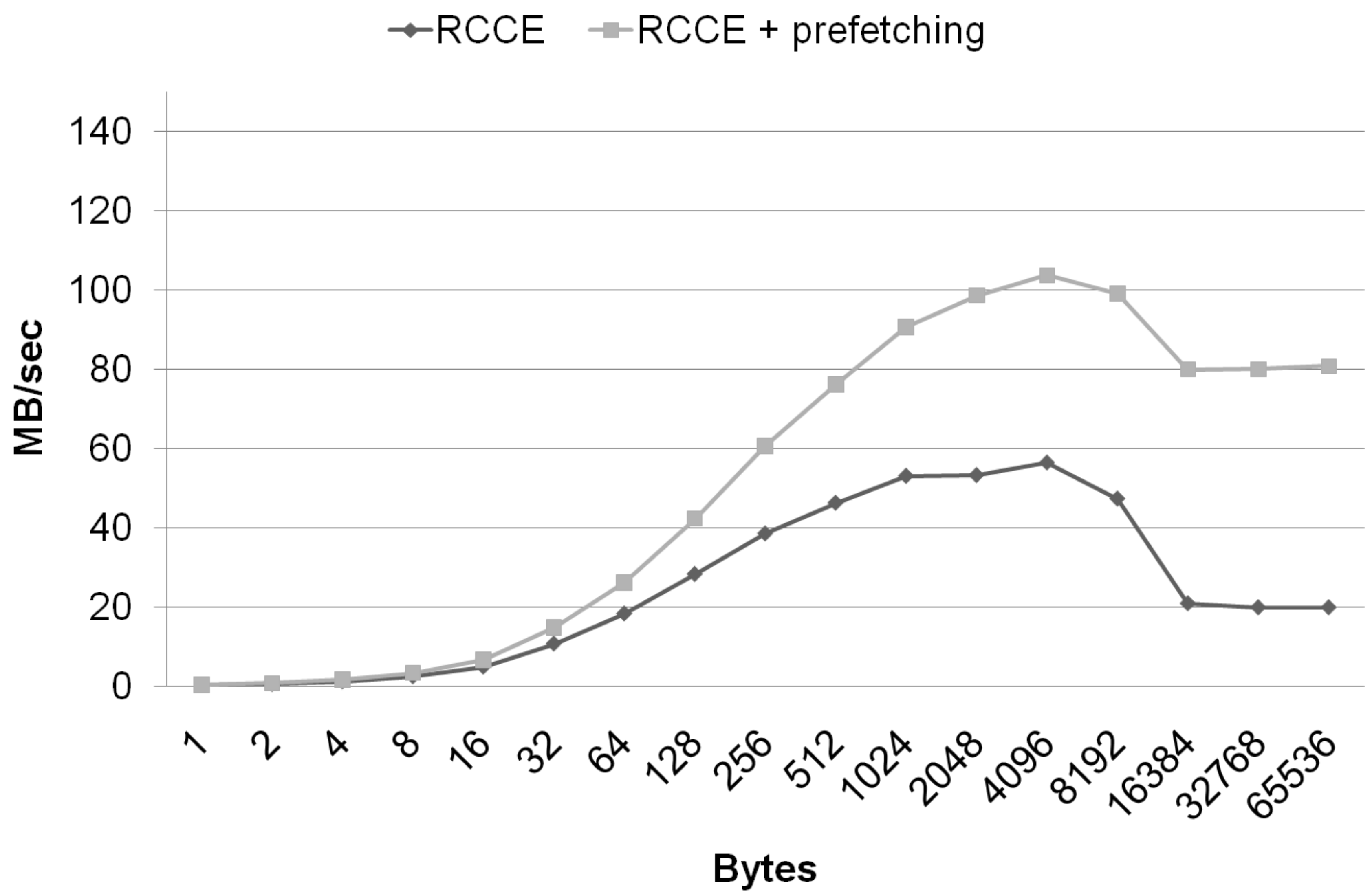
Bottleneck: Bad Cache Behaviour



Approach: Data Prefetching



Ping Pong



RCCE
RCCE + prefetching
MB/sec
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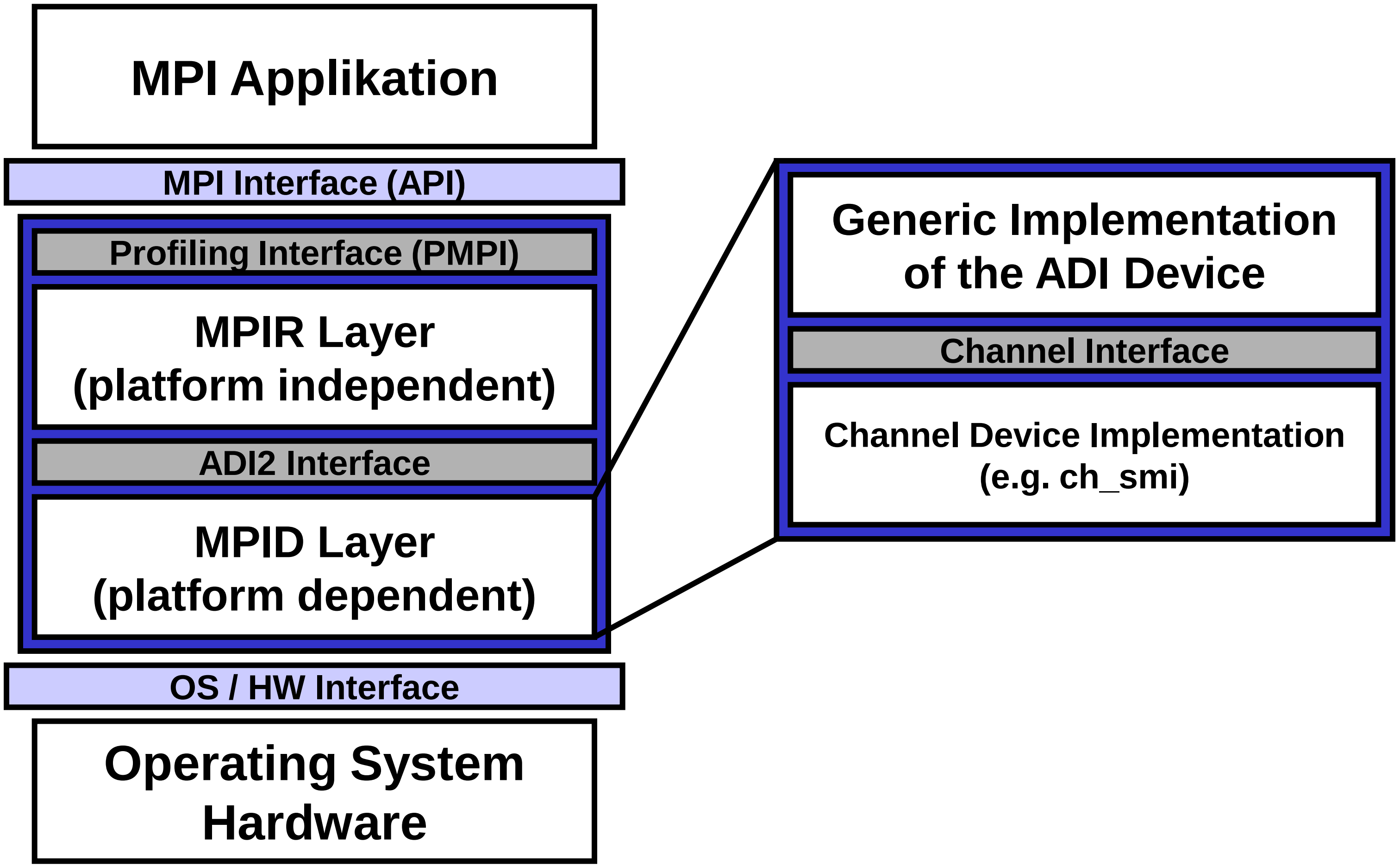
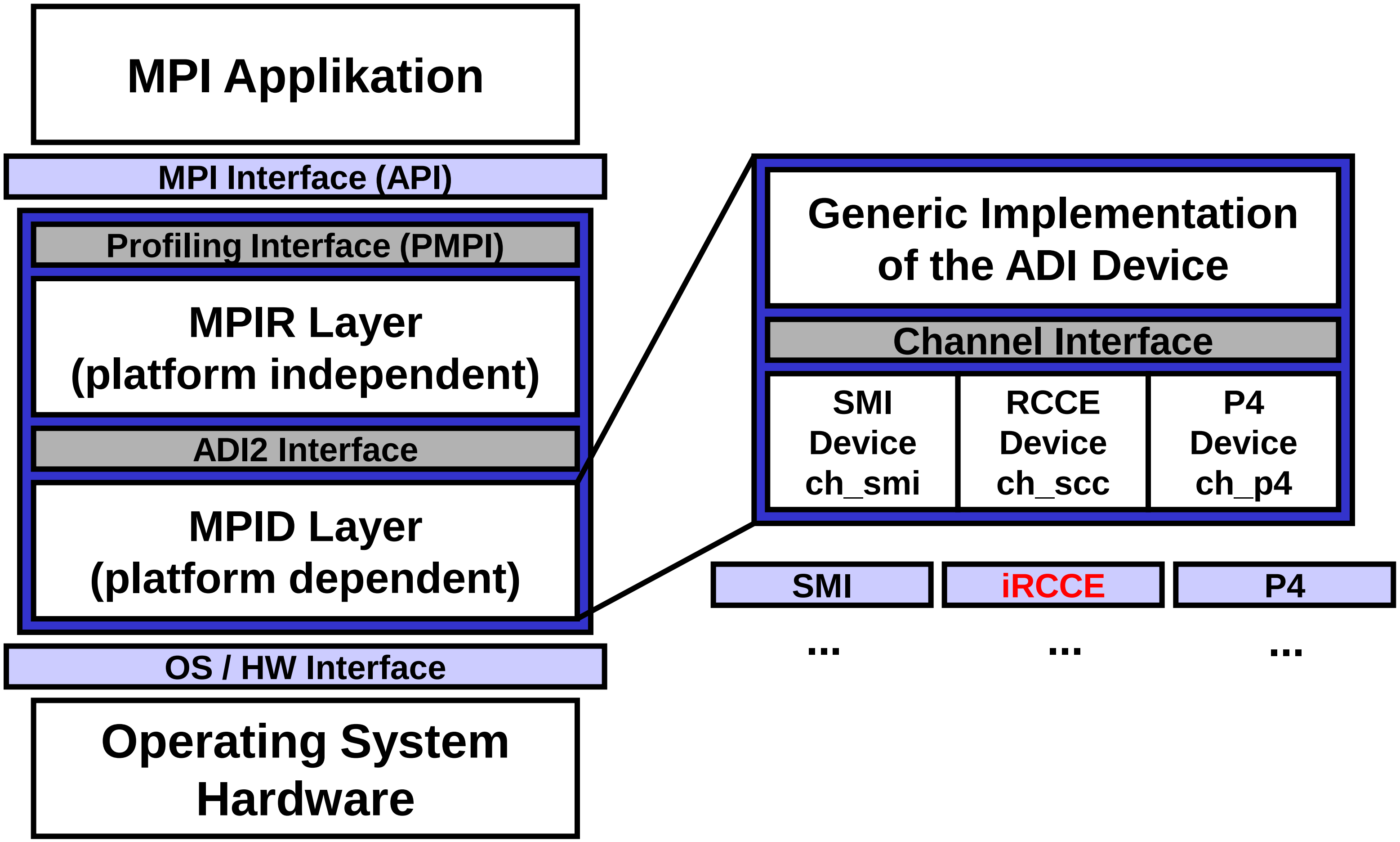
- **Layered Design of MPICH:**



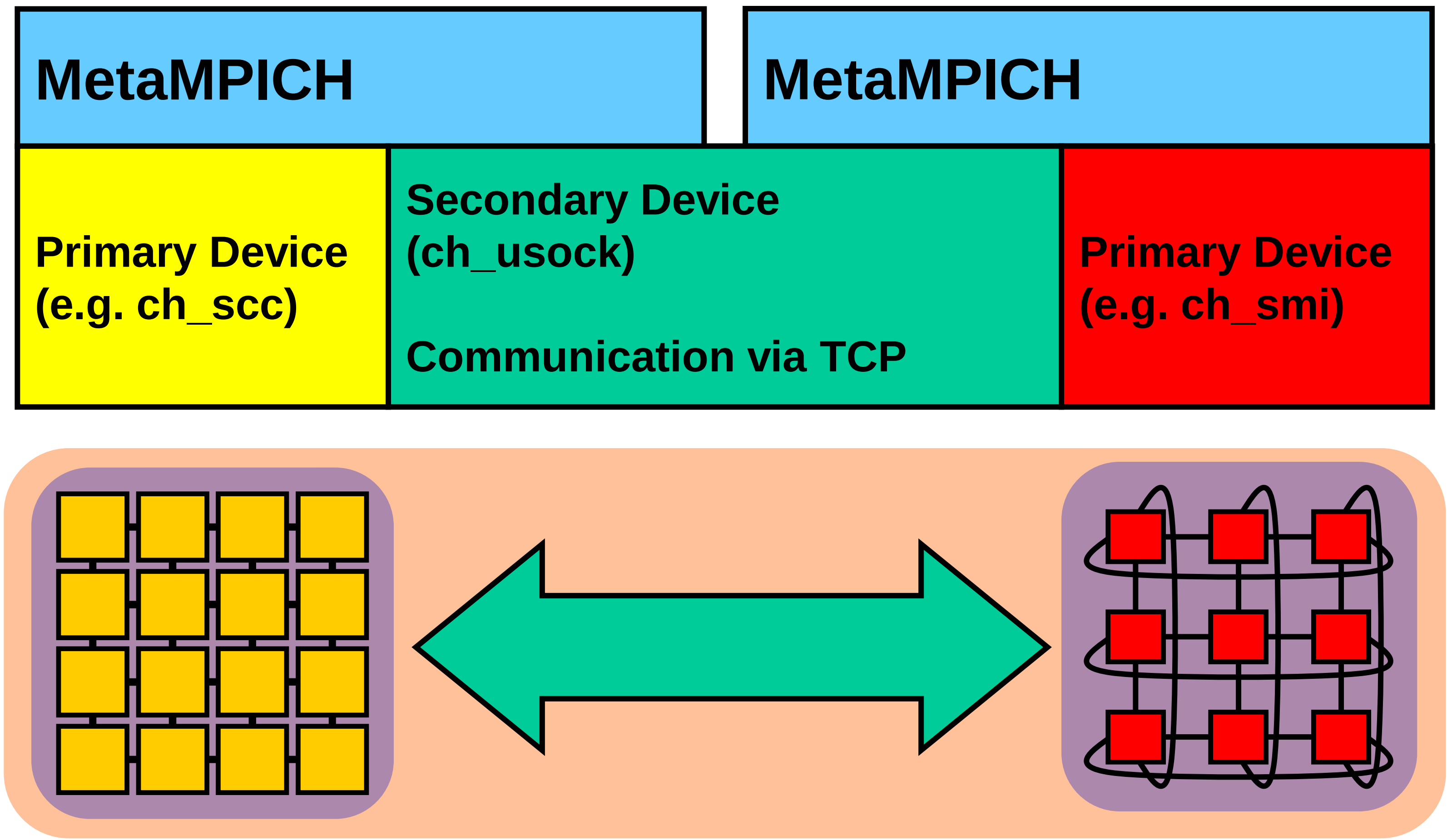
Metacomputing / Grid-enabled MPI

- **Multi-Device Support → *MetaMPICH***

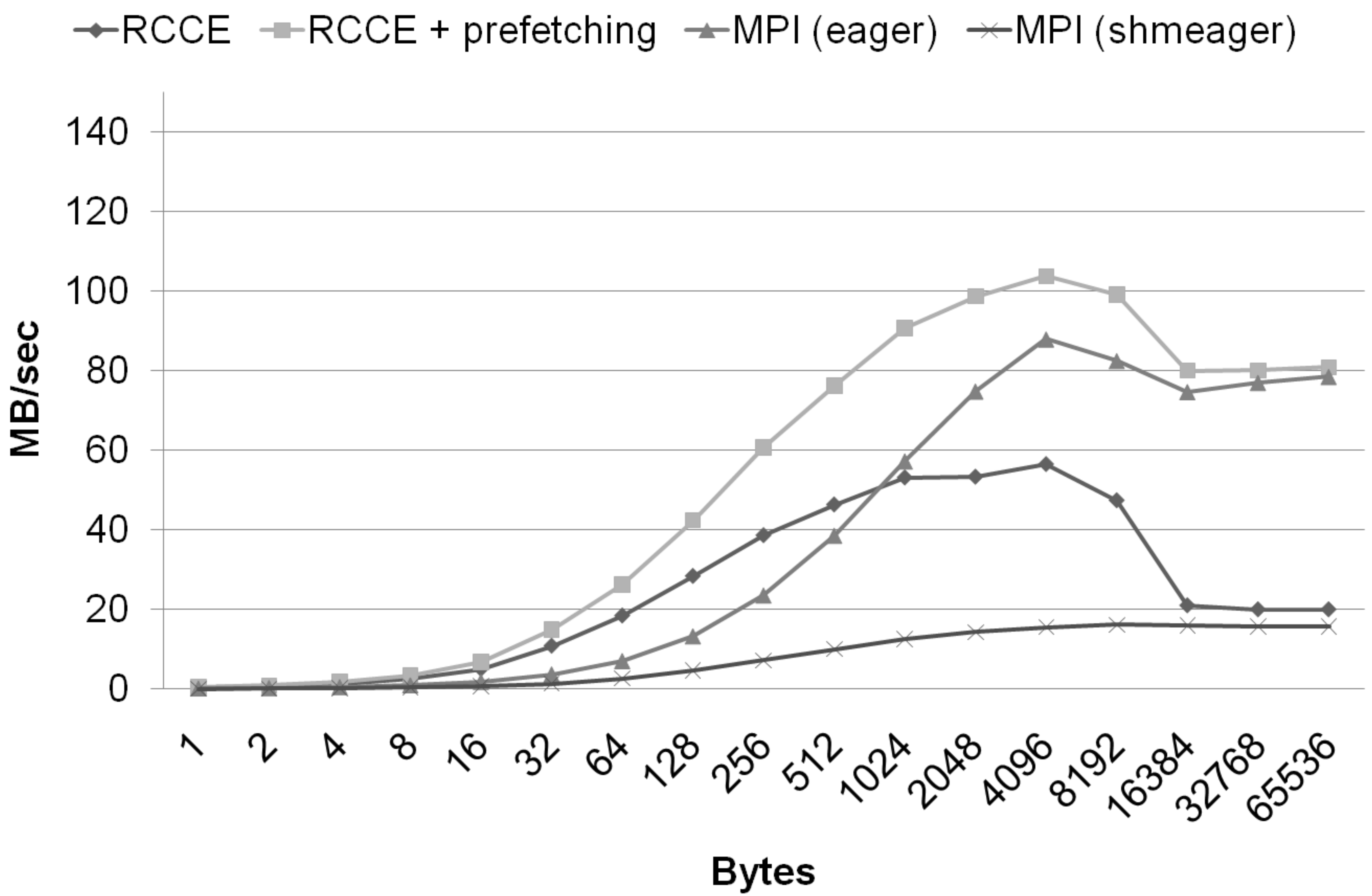


Metacomputing / Grid-enabled MPI

- **The Secondary Device → *ch_usock***



Ping Pong



RCCE
RCCE + prefetching
MPI (eager)
MPI (shmeager)
MB/sec
140
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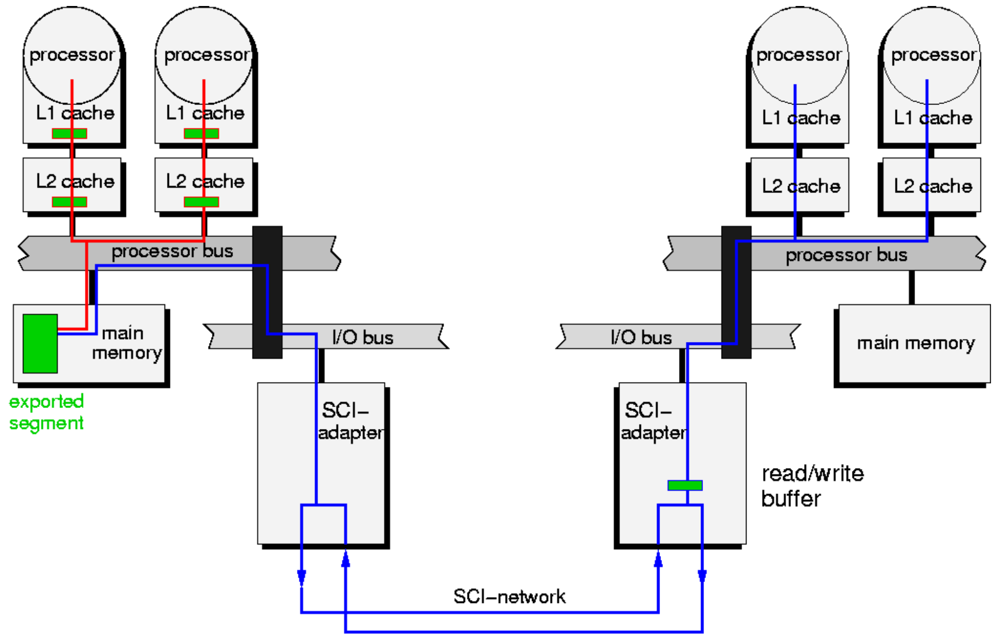
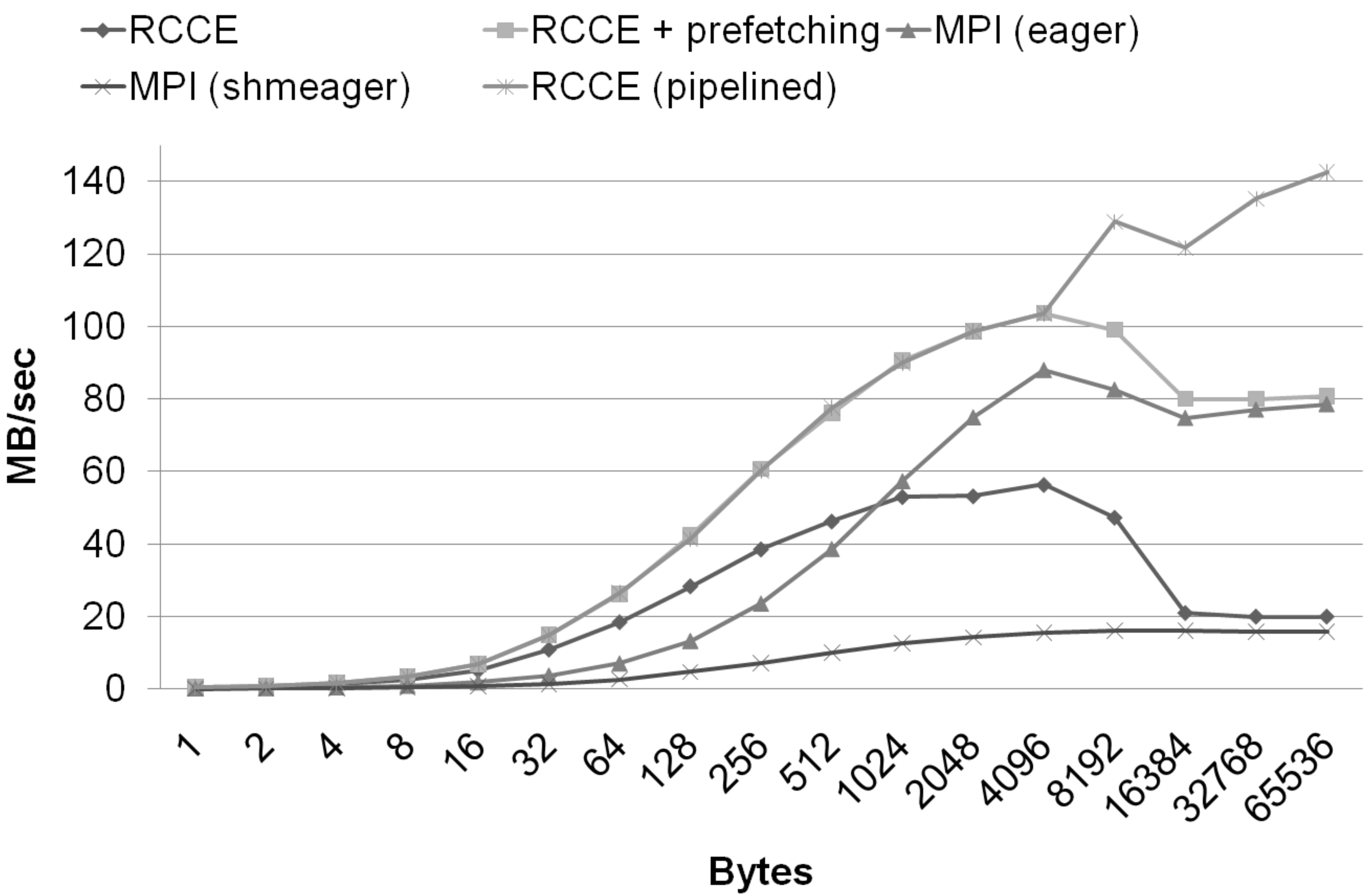
Pipelining on Shared Memory Architectures

- Most SCI adapters used PCI (express) as I/O bus
  - ➢ Cache coherence not supported
  - ➢ Only local segments are cache able
  - ➢ On SCC, the cache is on all shared regions disabled



- Classic optimization technique: Pipelining

Ping Pong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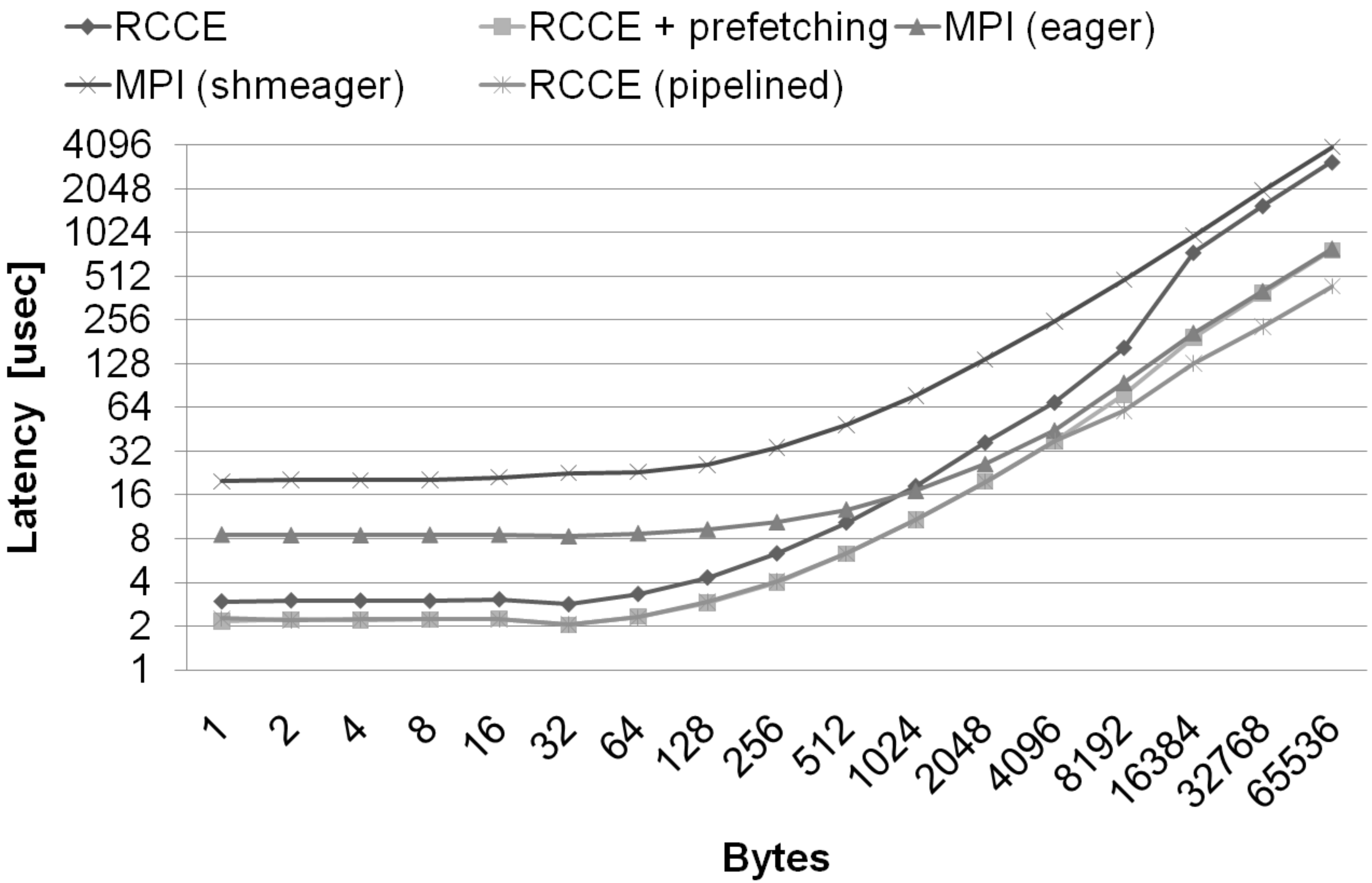
Ping Pong


RCCE
RCCE + prefetching
MPI (eager)
MPI (shmeager)
RCCE (pipelined)
Latency [usec]
4096
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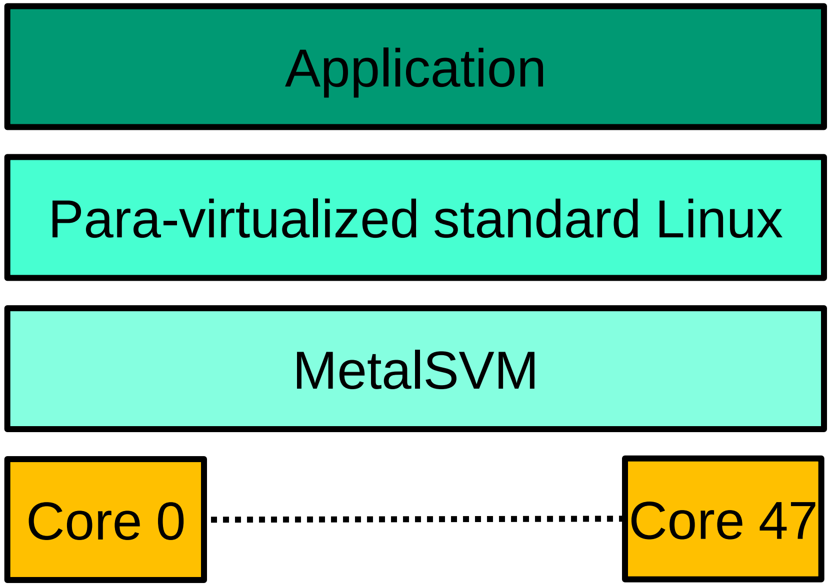
Parallelization Strategies

- Two basic strategies
  - Communication via Message Passing
    - Code restructuring
    - It's difficult to use, because we learnt sequential programming (C, C++, Java)
    - Scales very well (→ MPI, URPC, Barrelfish)
  - Communication via Shared Memory
    - The first contact is easier. Feels like sequential programming.
    - However, it is much more complex (False Sharing, Races, Deadlocks, NUMA) .
    - Incremental parallelization
    - Scales mostly good…

Benefits of Shared Memory Parallelization

- Algorithms with a dynamic data structure and access pattern are easier to parallelize.
  - Adaptive PDE solvers
    - e.g. Structured Adaptive Mesh Refinements PDE solver
    - Not ideal for NUMA architectures
    - Using of Affinity-On-Next-Touch to redistribute pages
  - Airline flight scheduling module
    - Part of Lufthansa Systems' decision support system
    - Searching for a flight between A and B with N connections
    - Consideration of departure- and arrival-time, capacity, costs,…
    - More complex as the *Shortest Path Problem*
    - Using of double-linked lists
- **Aim:** A scalable Shared Virtual Memory (SVM) system on the top of SCC

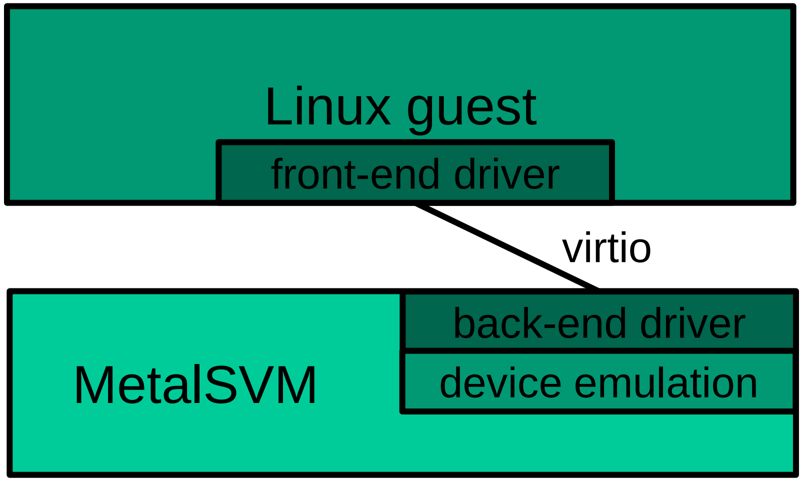
MetalSVM: A Virtual NUMA Architecture on SCC



- MetalSVM will be a small hypervisor, which uses paravirtualization techniques to run Linux on SCC.
- The integrated SVM system gives the Linux kernel a transparent (and cacheable) view of the memory.

- Linux defines a clear interface between the paravirtualized kernel and its hypervisor.
- MetalSVM uses this interface to paravirtualize Linux.
- For instance, the spinlock interface could be used to synchronize Linux threads over the MPB.

Device Emulation

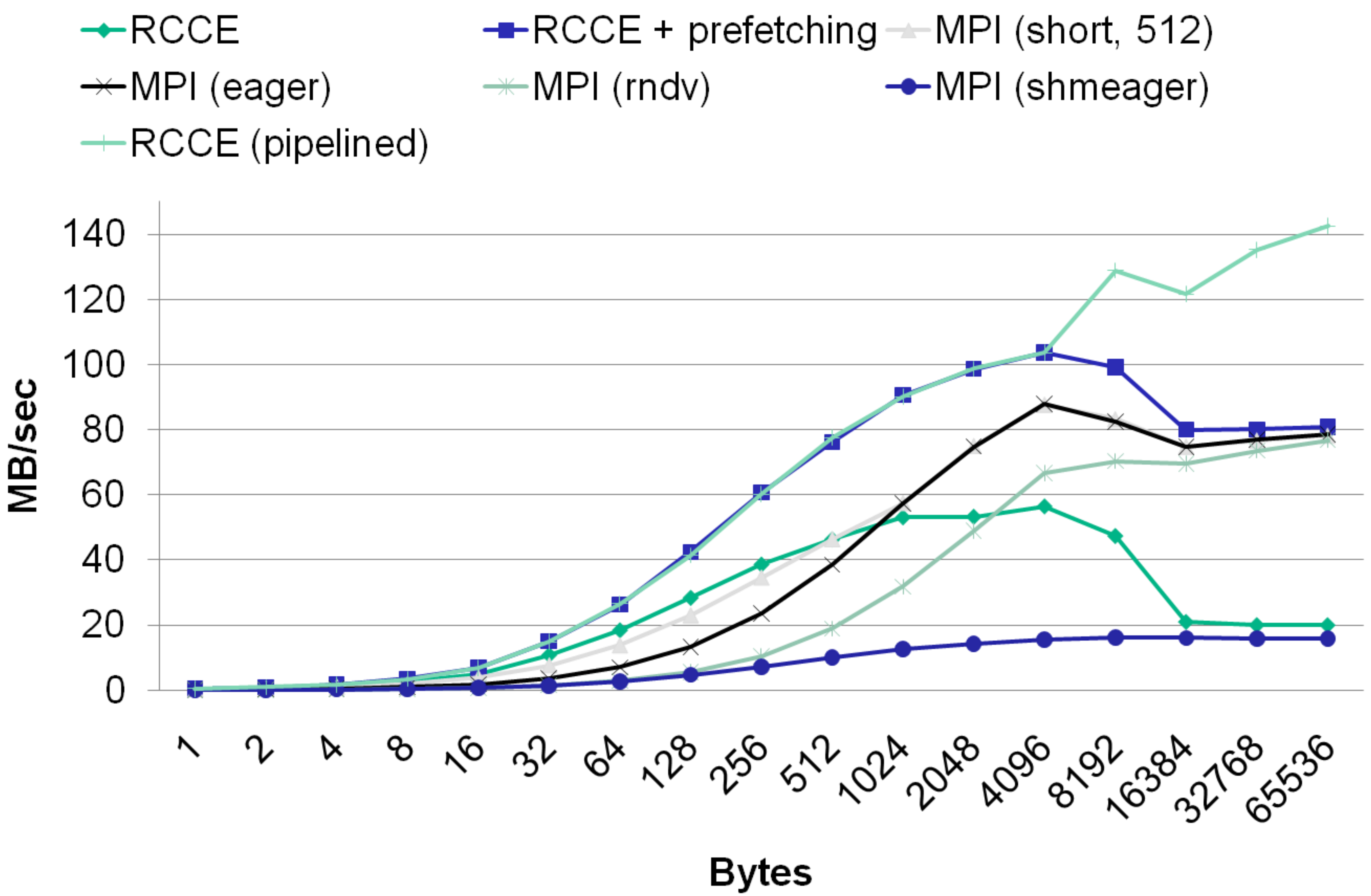


- Linux provides already an I/O virtualization framework called `Virtio`.
- `Virtio` provides a common front end for e.g network and block devices.
- This increases the reusability of code across different hypervisors (Xen, KVM, lguest).
- MetalSVM will support this framework to minimize the changes to Linux kernel.
- The smooth integration of a new device into Linux could be realized by developing a specific device emulation layer for MetalSVM.

Conclusions and Outlook

- Established techniques could be used to increase the performance
- The cache behavior of P54C could be “nicer”.
  - More influences will be preferable
- Clustering of SCC via MP-MPICH already possible
- The SCC is an ideal architecture to build a scalable SVM systems
  - Fast collective operations

Ping Pong



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MPI (rndv)
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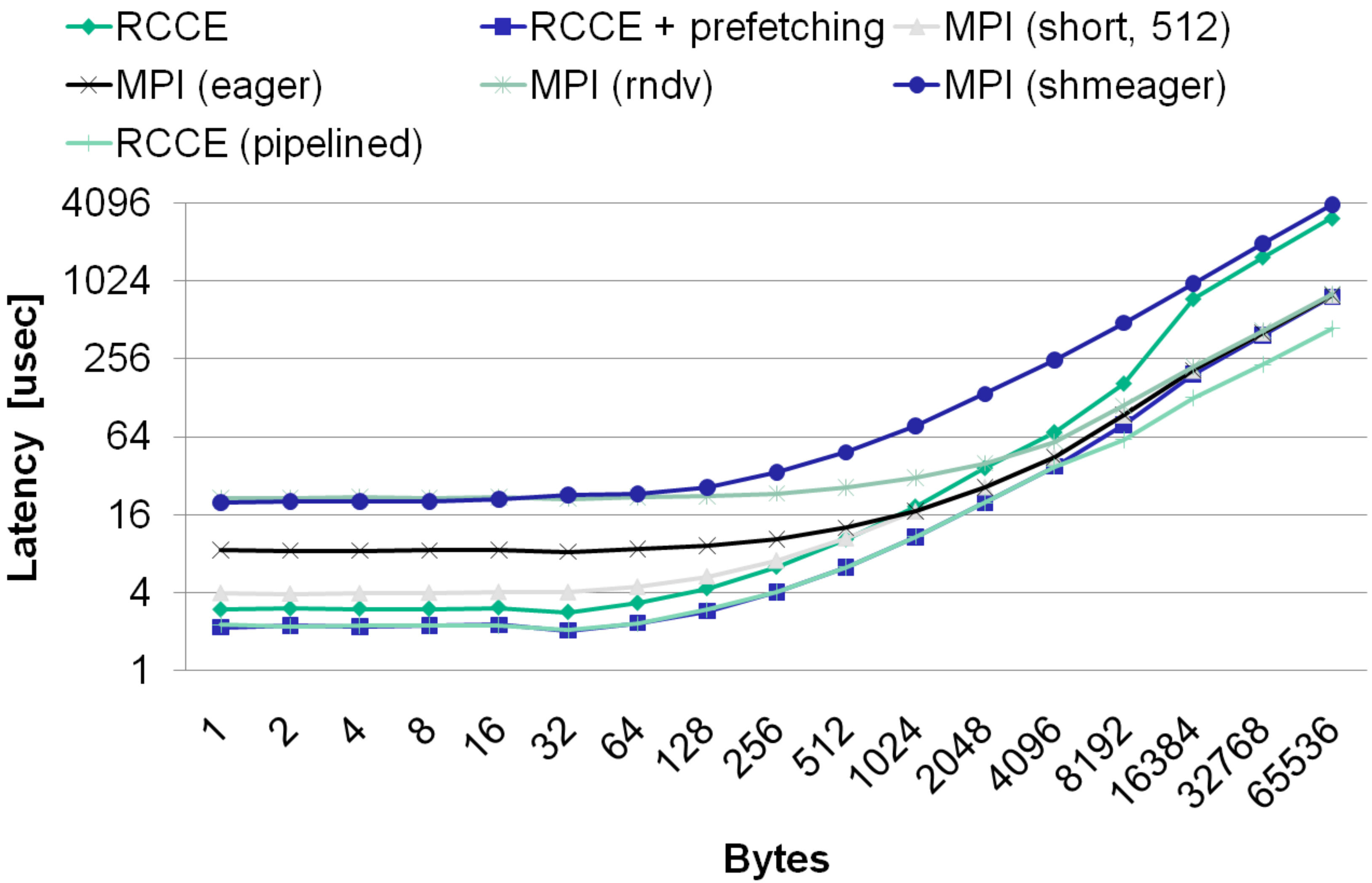
Ping Pong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