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DECK-SCI: High-Performance Communication and Multithreading for SCI Clusters

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Outline

- ⇒ Introduction and motivations
- ⇒ Overview of DECK-SCI
- ⇒ Key characteristics of DECK-SCI's communication protocols
- ⇒ Description and evaluation of the communication protocols
- ⇒ Concluding remarks

Introduction and motivations (1)

⇒ SCI (Scalable Coherent Interface) as a high-performance network for clusters

- ⇒ low latency (direct access to remote memory addresses)
  - communication via CPU loads and stores
- ⇒ high bandwidth

⇒ Several efforts have been made towards offering message-passing libraries for SCI clusters

- ⇒ SCIPVM
- ⇒ PVM-SCI
- ⇒ ScaMPI
- ⇒ SCI-MPICH
- ⇒ CML (Common Messaging Layer)

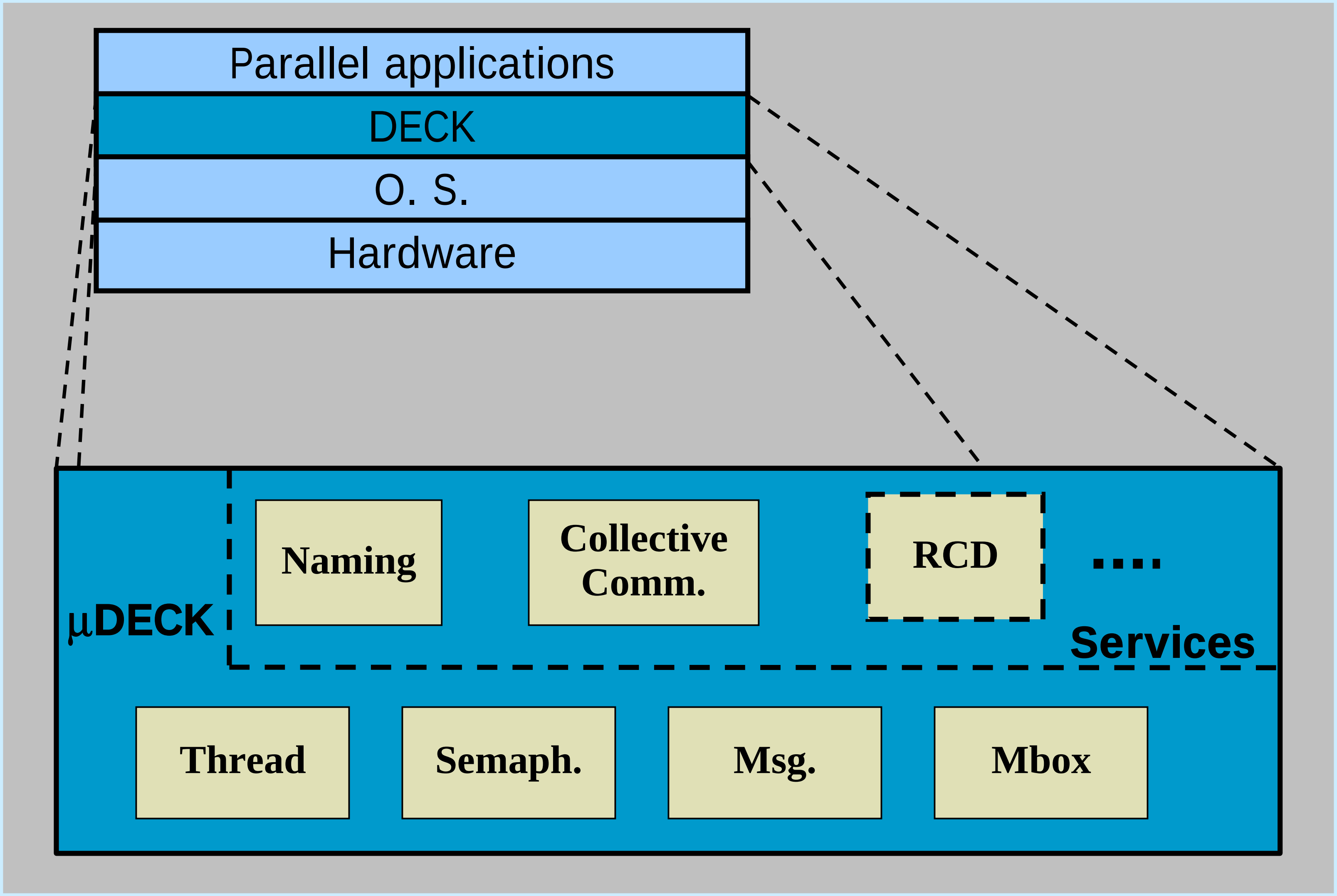
Introduction and motivations (2)

⇒ Previous implementations of DECK
  ⇒ Fast Ethernet
  ⇒ Myrinet
⇒ Main motivations for developing DECK-SCI
  ⇒ to allow the integration between Myrinet and SCI clusters
    - to support to the “MultiCluster” model
  ⇒ to devise a new library for programming SCI clusters based on
    - very efficient message-passing
    - multithreading at the API level

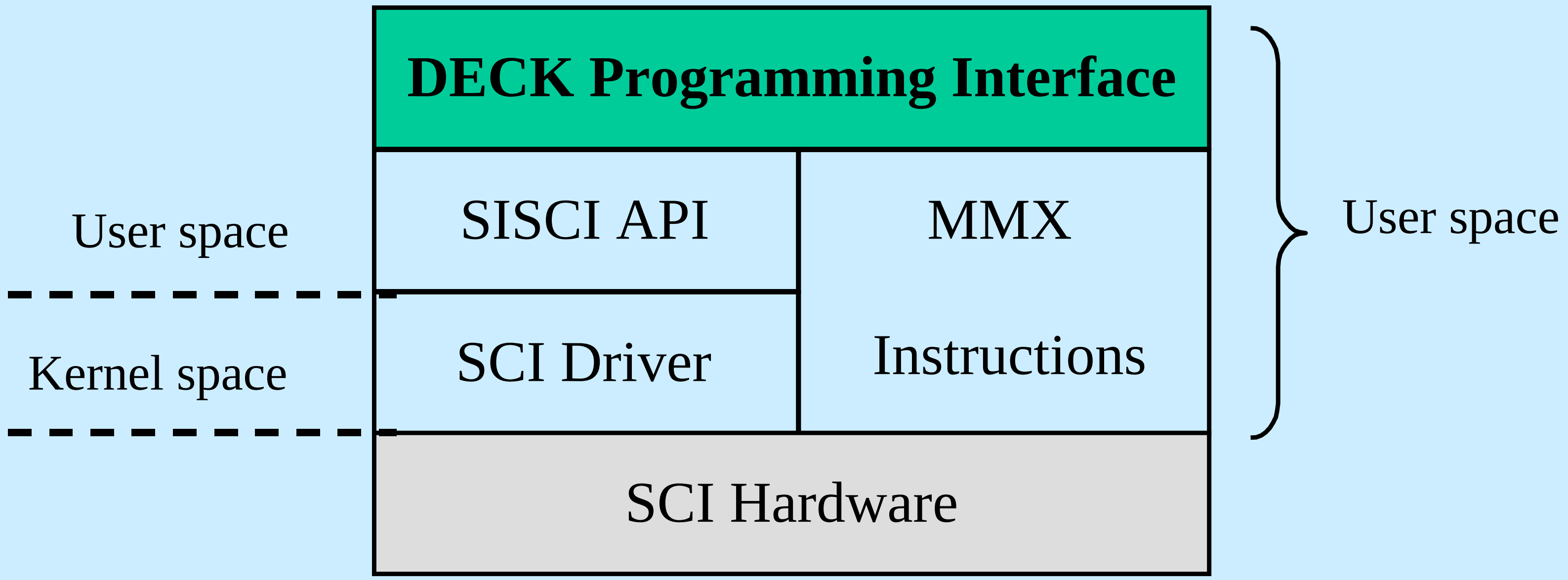
Overview of DECK (1)

- ⇒ DECK: ***Distributed and Execution Communication Kernel***
- ⇒ SPMD model + multithreading
- ⇒ Basic abstractions
  - ⇒ messages and mail boxes
    - point-to-point communication
  - ⇒ threads and semaphores

Overview of DECK (2)



Overview of DECK-SCI



Devised and implemented communication protocols

⇒ Objectives

- ⇒ to compose a communication kernel aimed at fully exploiting the high-performance capabilities of the SCI network
- ⇒ to obtain a performance near the limits of the SCI hardware
  - low latency for short messages
  - high bandwidth for large ones

⇒ Hardware platform

- ⇒ Cluster composed of four PCs equipped with dual Pentium-III (500 MHz), 256 Mbytes of RAM and SCI NICs for the PCI bus (32 bits and 33 MHz)

⇒ Three different protocols transparently chosen according to the size of the message to be sent

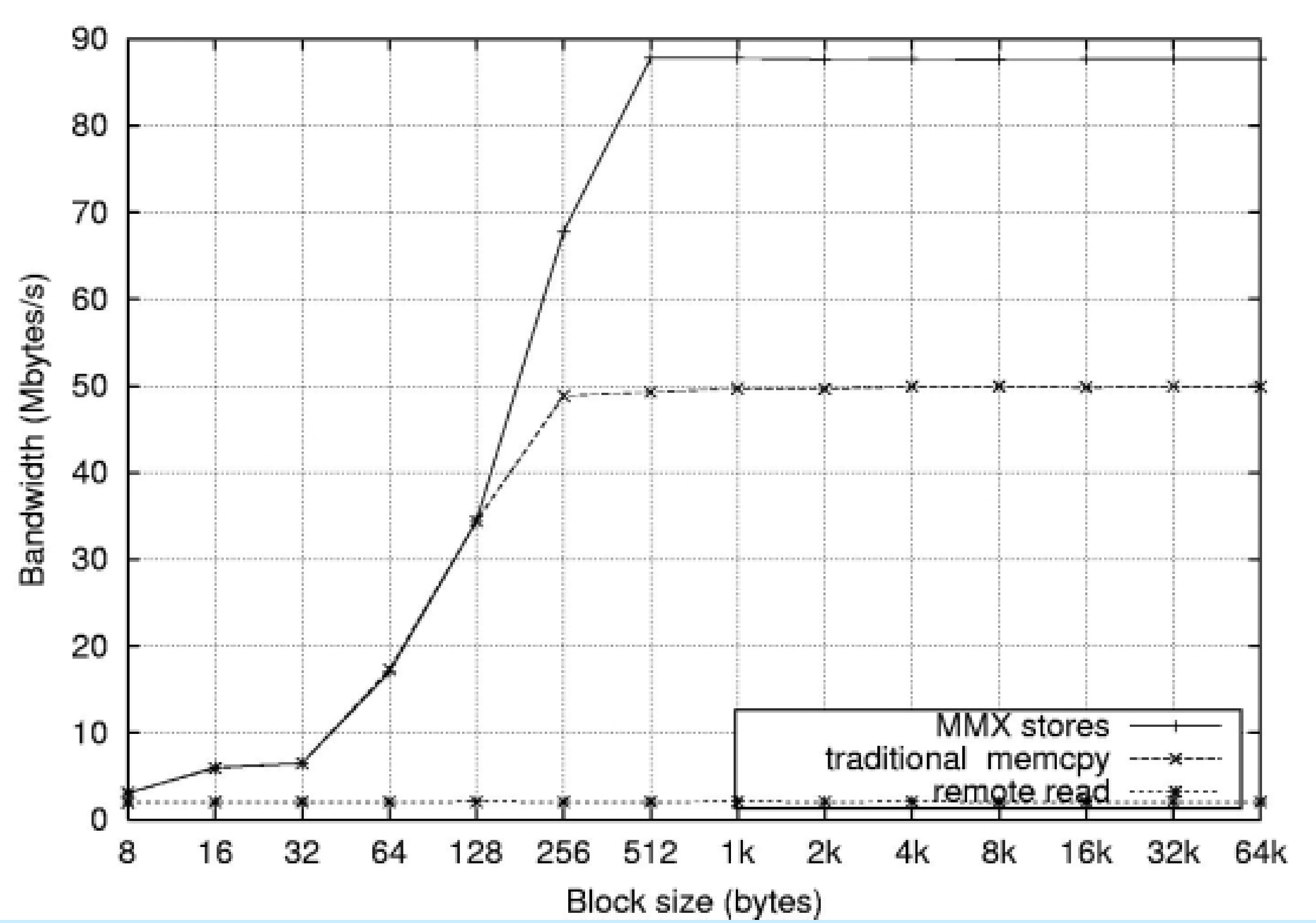
Key features of the implemented communication protocols (1)

⇒ Communication strictly accomplished by remote writes

- ⇒ **write-only protocols**

⇒ Use of MMX instructions for message transfers, in order to increase the maximum achievable bandwidth, by

- ⇒ **avoiding the traditional memcpy routine**
- ⇒ **generating a write burst on the PCI bus**



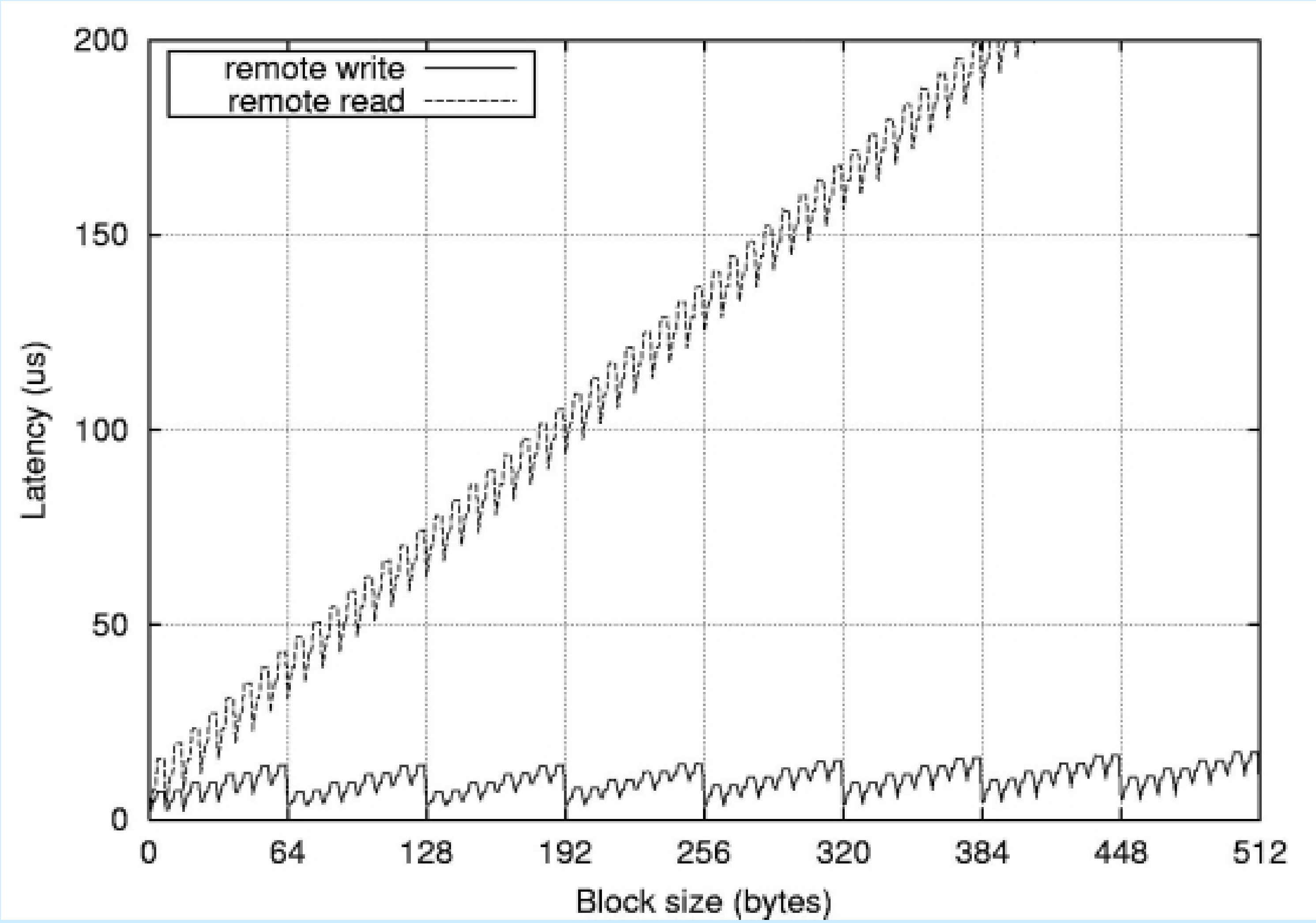
Bandwidth (Mbytes/s)
0
10
20
30
40
50
60
70
80
90
8
16
32
64
128
256
512
1k
2k
4k
8k
16k
32k
64k
Block size (bytes)
MMX stores
traditional memcpy
remote read

Key features of the implemented communication protocols (2)

⇒ Exploitation of the PCI-SCI adapter's stream buffers

⇒ eight stream buffers with 64 bytes

- pipeline with eight stages



remote write
remote read
Latency (us)
200
150
100
50
0
0
64
128
192
256
320
384
448
512
Block size (bytes)

Key features of the implemented communication protocols (3)

- ⇒ Polling-based message passing
  - ⇒ **avoid interrupts for signaling the arrival of a message**
- ⇒ Thread-awareness and thread safety

“Protocol 1”: short messages

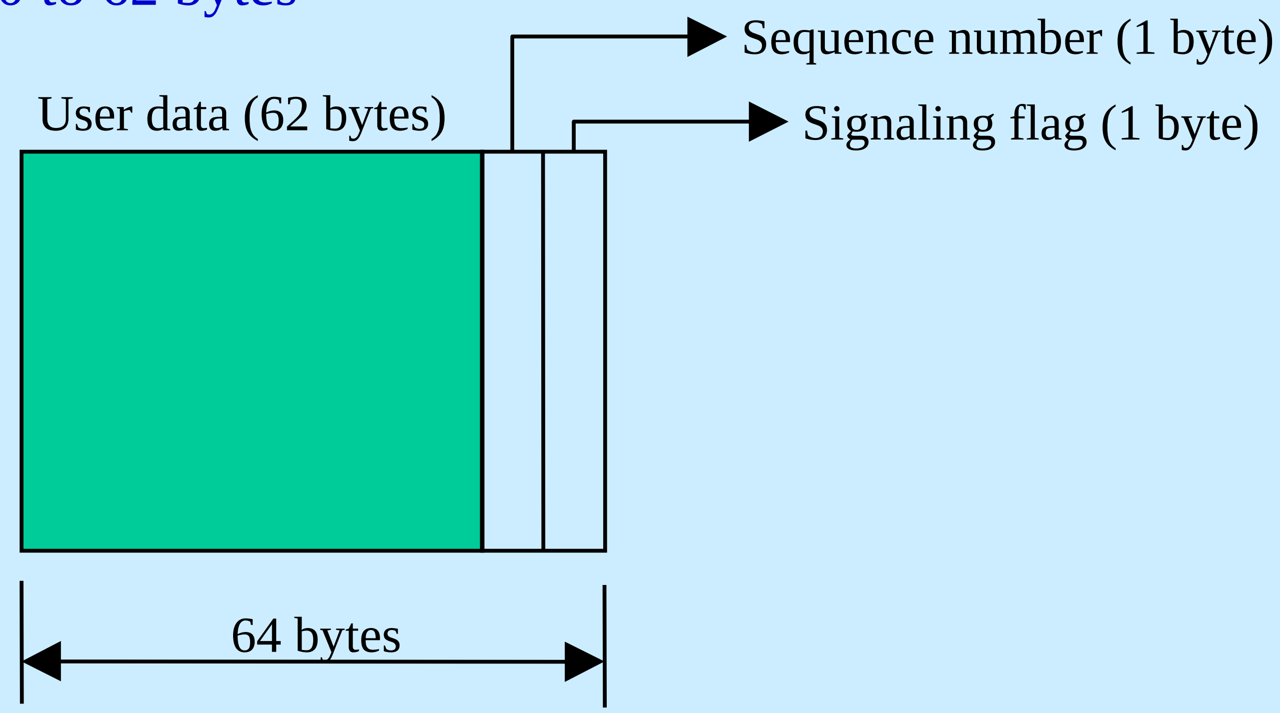
⇒ Objective: very low-latency for short messages

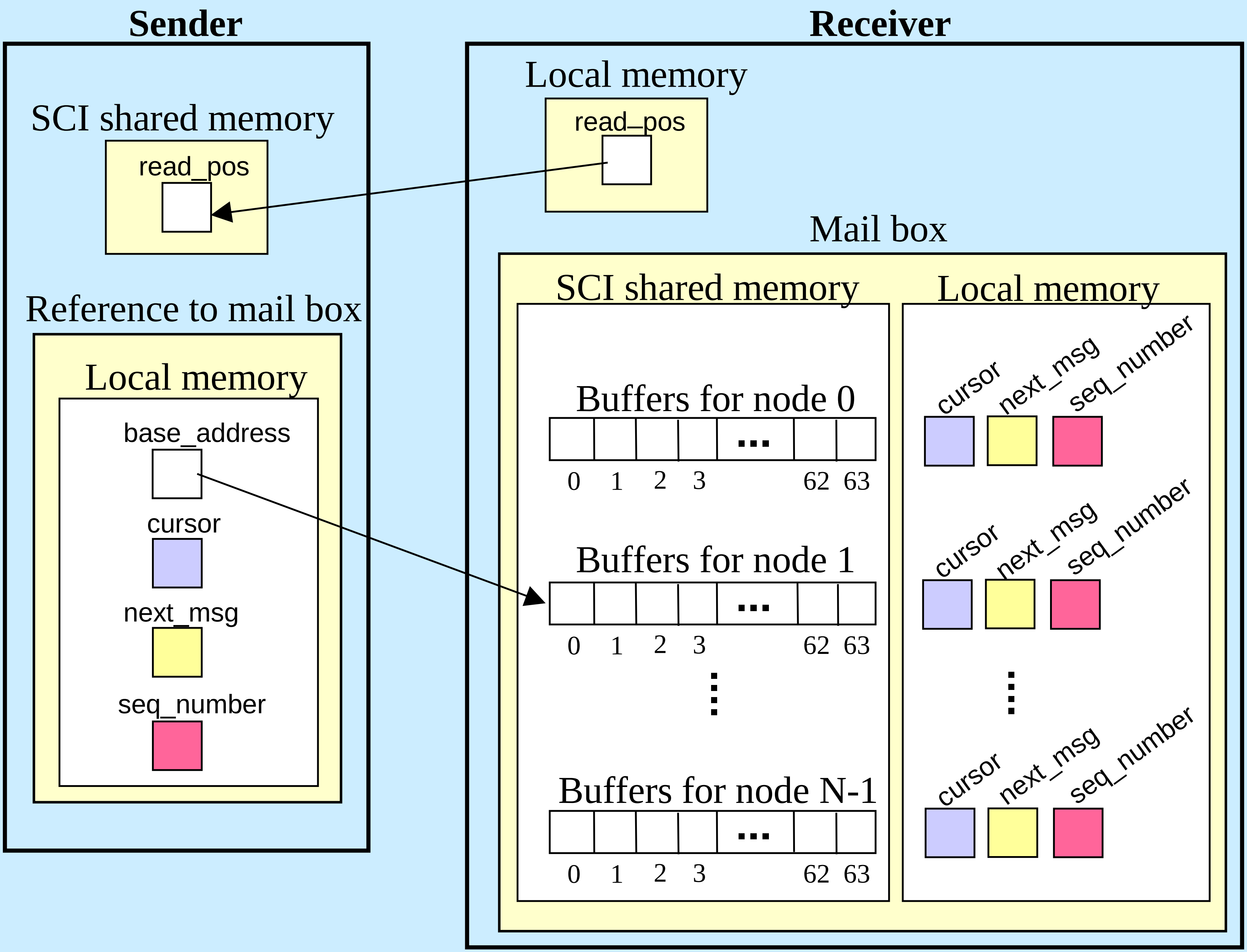
⇒ **minimal overhead**

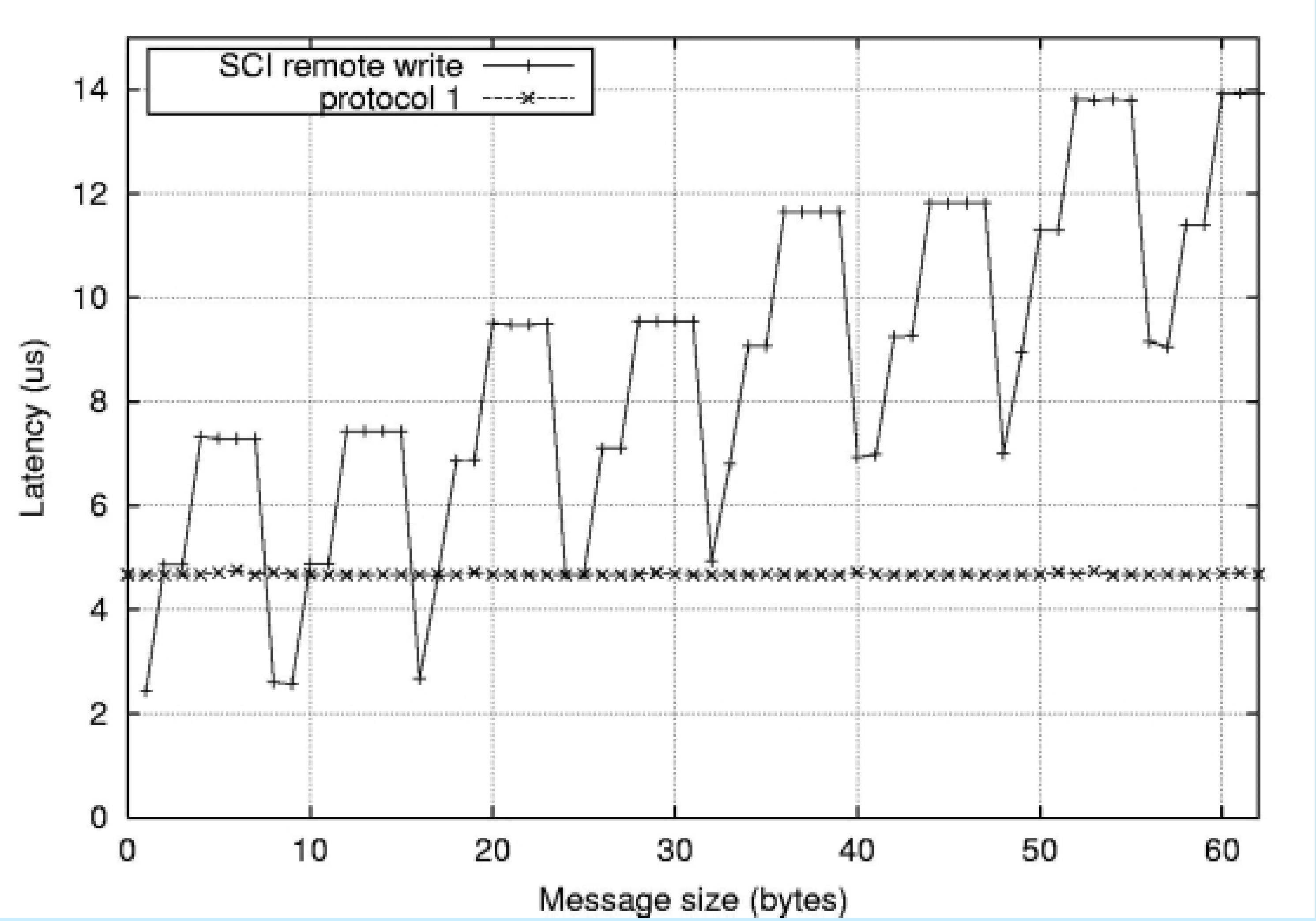
⇒ **signaling and communication using a single SCI packet**

⇒ Specialized in exchanging short messages

⇒ 0 to 62 bytes




Sender
SCI shared memory
read_pos
Reference to mail box
Local memory
base_address
cursor
next_msg
seq_number
Receiver
Local memory
read_pos
Mail box
SCI shared memory
Buffers for node 0
0 1 2 3 ... 62 63
Buffers for node 1
0 1 2 3 ... 62 63
Buffers for node N-1
0 1 2 3 ... 62 63
Local memory
cursor
next_msg
seq_number

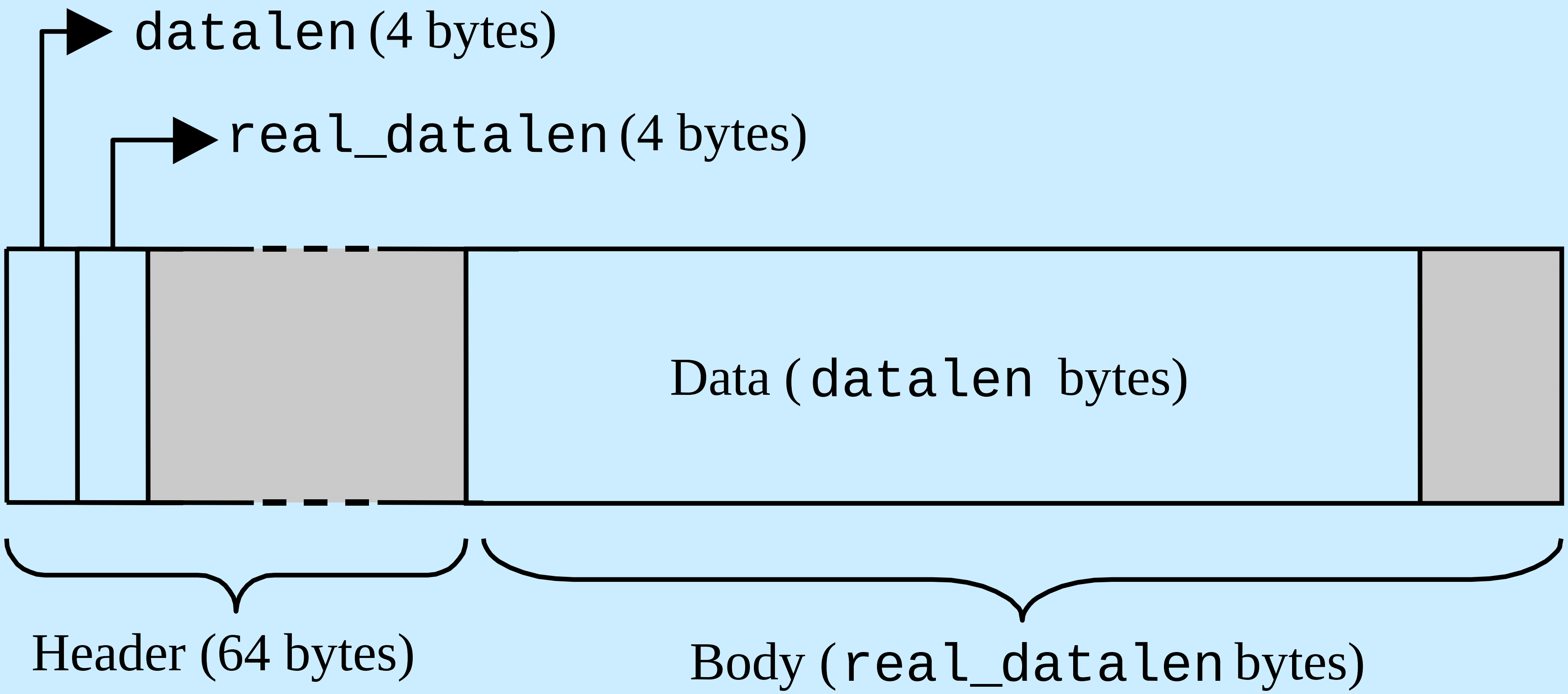


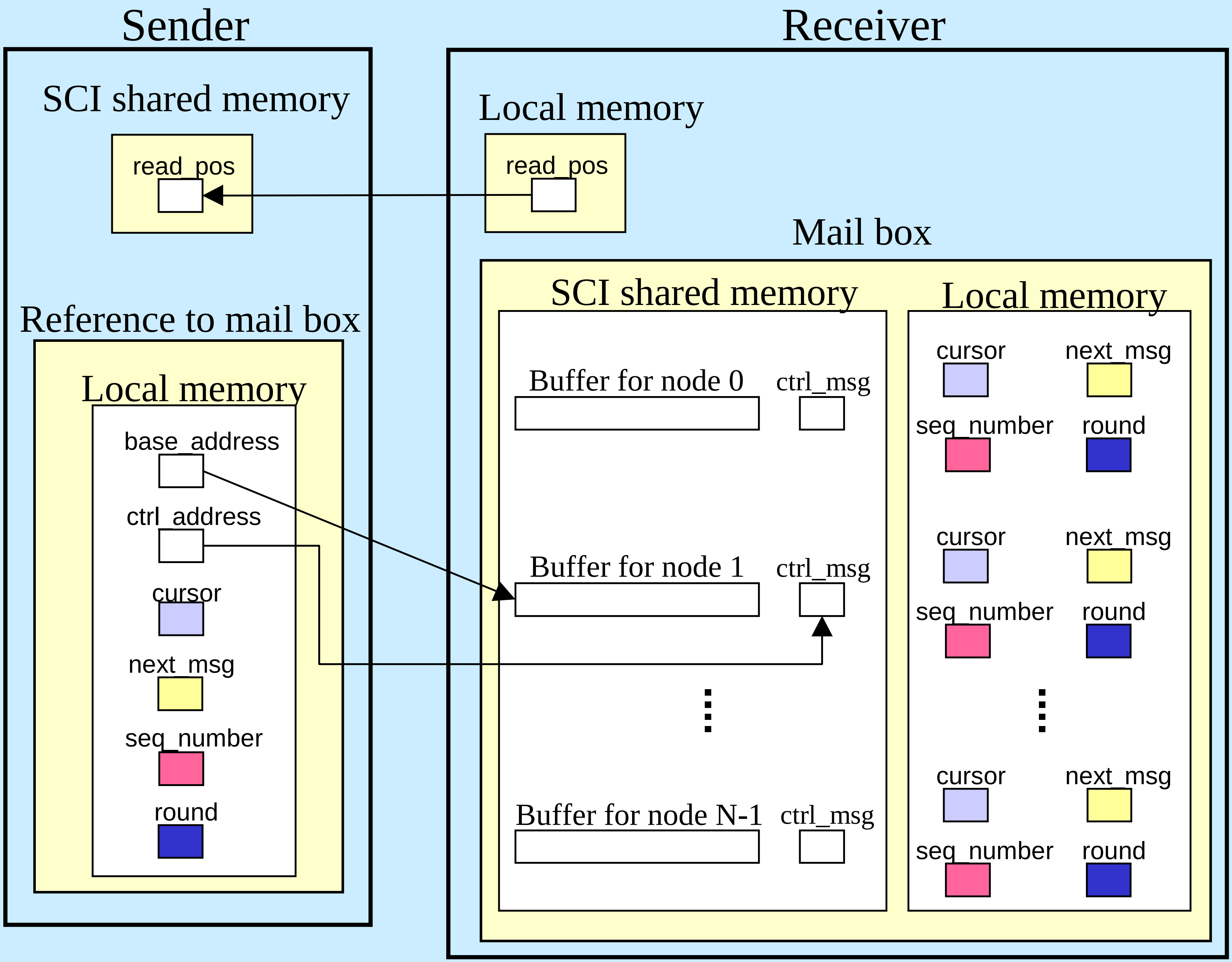
SCI remote write
protocol 1
Latency (us)
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60
Message size (bytes)

“Protocol 2”: general-purpose

⇒ It handles messages greater than 62 bytes

⇒ Signaling with an additional SCI packet




Sender
SCI shared memory
read_pos
Reference to mail box
Local memory
base_address
ctrl_address
cursor
next_msg
seq_number
round
Receiver
Local memory
read_pos
Mail box
SCI shared memory
Buffer for node 0
ctrl_msg
Buffer for node 1
ctrl_msg
Buffer for node N-1
ctrl_msg
Local memory
cursor
next_msg
seq_number
round
cursor
next_msg
seq_number
round
cursor
next_msg
seq_number
round

“Protocol 3”: zero-copy mechanism (1)

⇒ Objective

  ⇒ to get as much as possible from the SCI network, boosting the bandwidth near the limits imposed by the SCI hardware

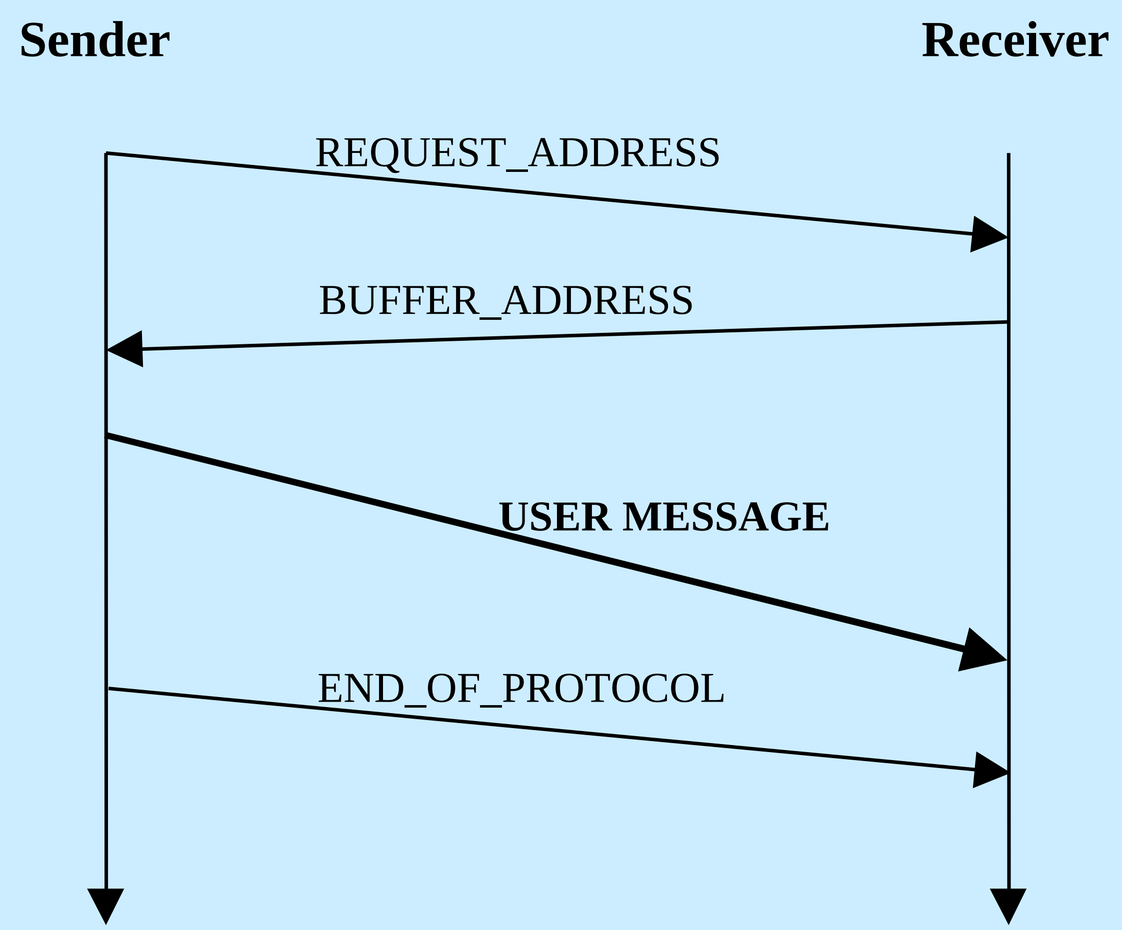
⇒ Messages are directly sent to the user buffer, without additional data movement into local memory

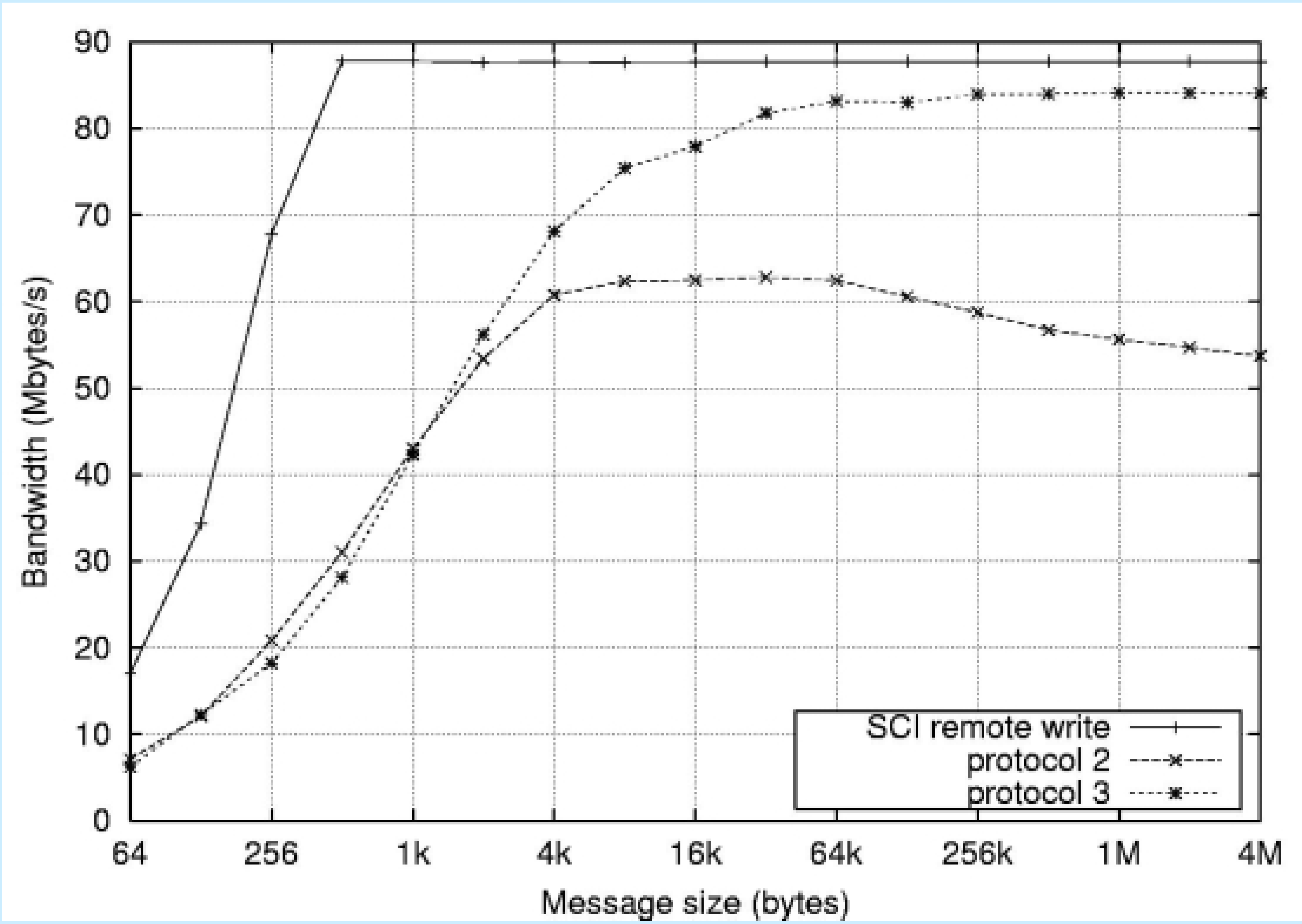
⇒ Handshaking between sender and receiver

  ⇒ synchronous protocol

  ⇒ there is no need of flow control

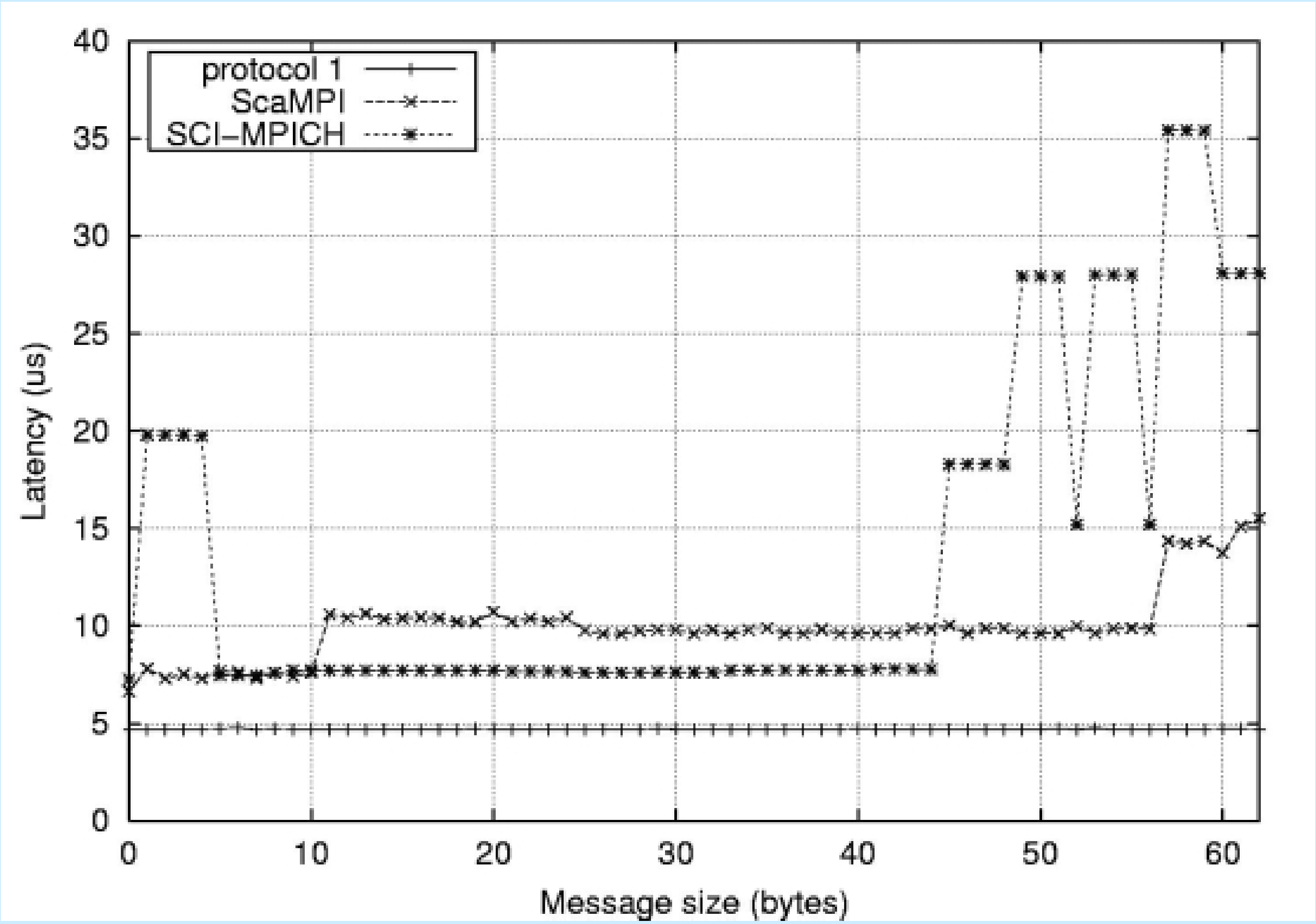
“Protocol 3”: zero-copy mechanism (2)



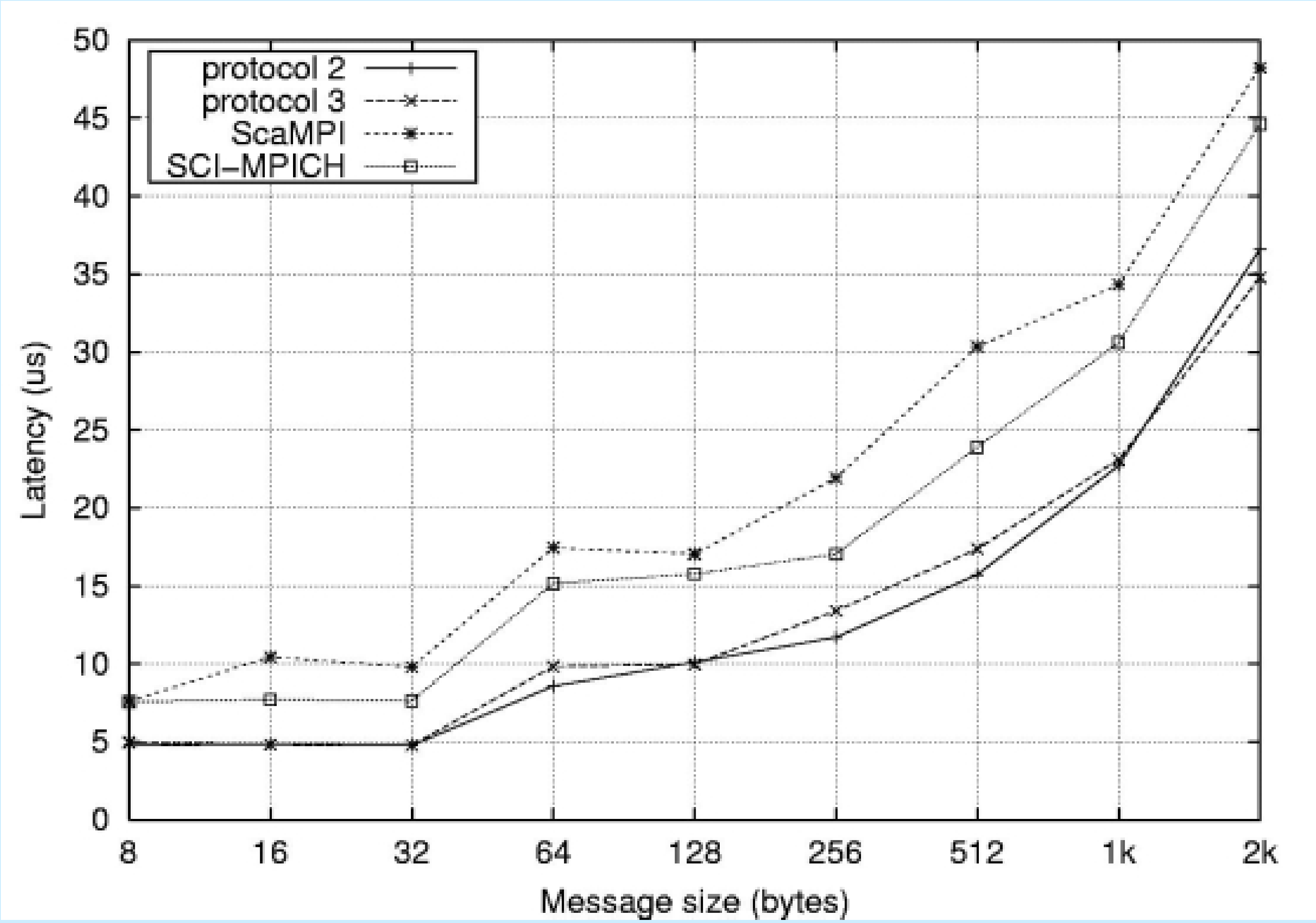


90
80
70
60
50
40
30
20
10
0
Bandwidth (Mbytes/s)
64
256
1k
4k
16k
64k
256k
1M
4M
Message size (bytes)
SCI remote write
protocol 2
protocol 3

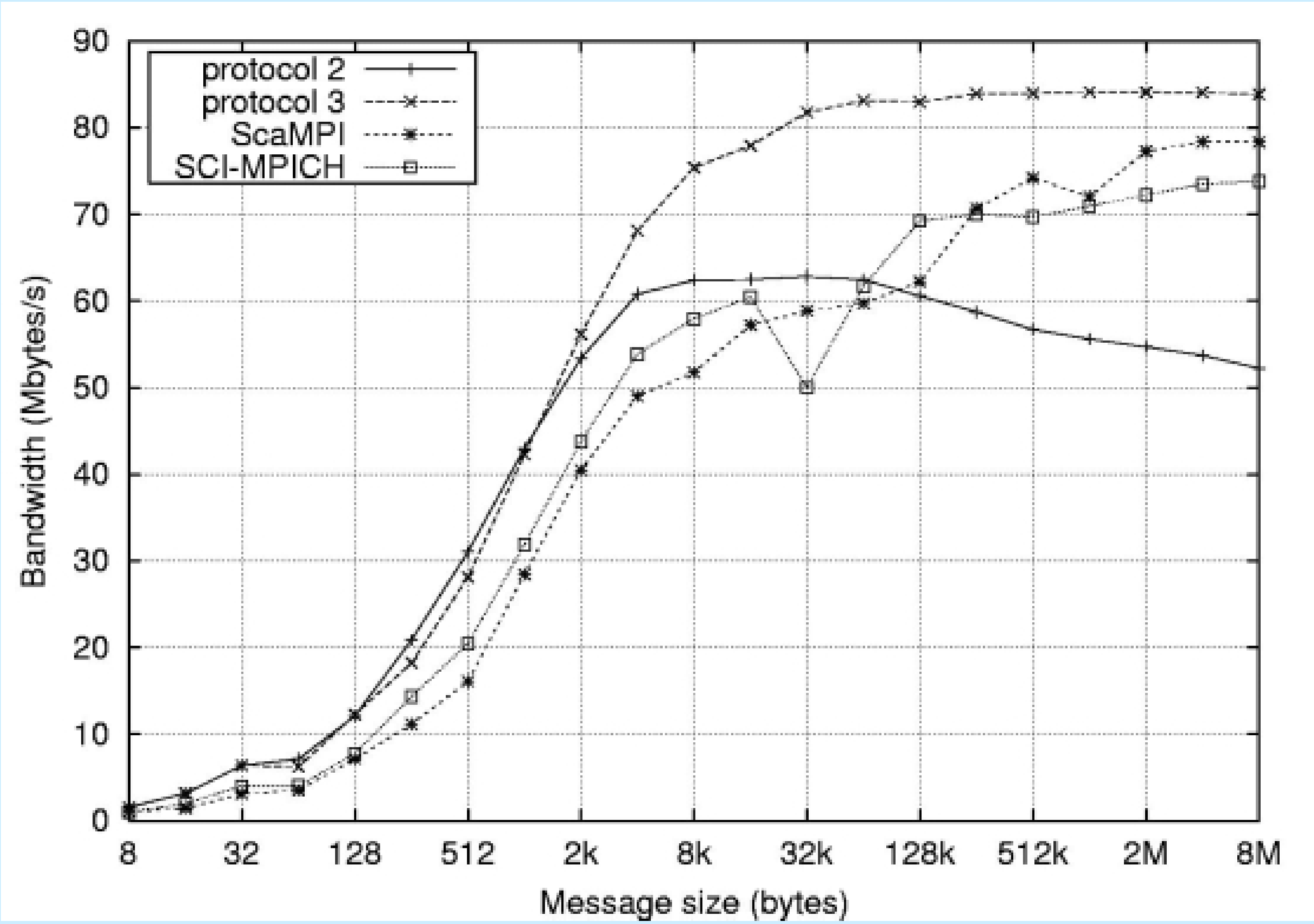
DECK-SCI, SCI-MPICH and ScaMPI (1)



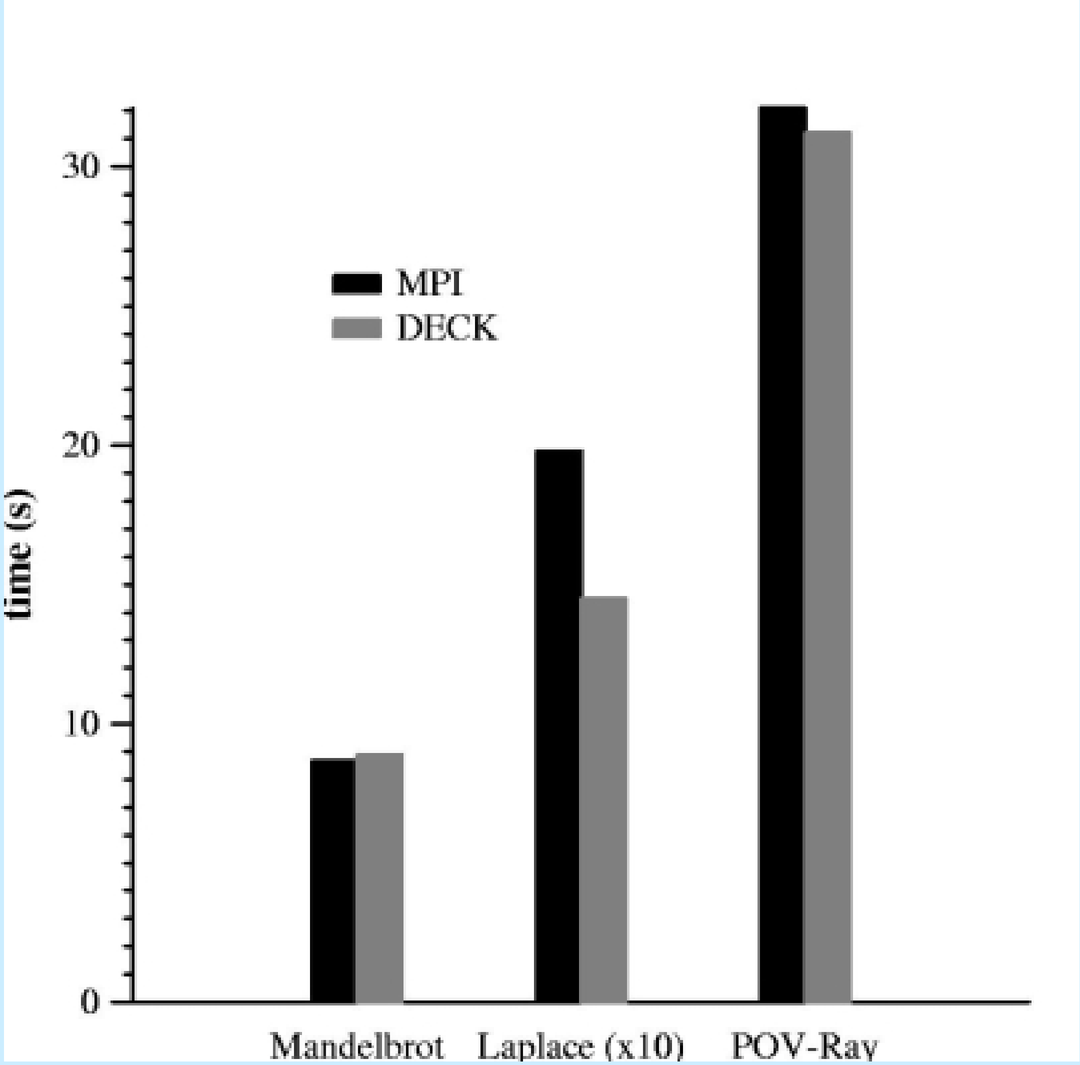
DECK-SCI, SCI-MPICH and ScaMPI (2)



DECK-SCI, SCI-MPICH and ScaMPI (3)



DECK-SCI and ScaMPI



Concluding remarks (1)

Library	Maximum bandwidth	Use of the maximum SCI bandwidth
DECK-SCI	84.12 Mbytes/s	95.9 %
ScaMPI	78.35 Mbytes/s	89.3 %
SCI-MPICH	73.80 Mbytes/s	84.1 %

Library	Minimal latency
DECK-SCI	4.66 µs
ScaMPI	6.63 µs
SCI-MPICH	7.26 µs

Concluding remarks (2)

⇒ Gains obtained with raw communication

- ⇒ maximum bandwidth
  - gain of 7,36% compared to ScaMPI
  - gain of 13,98% compared to SCI-MPICH
- ⇒ minimal latency
  - reduction of 29,71% compared to ScaMPI
  - reduction of 35,81% compared to SCI-MPICH

Concluding remarks (3)

- ⇒ Results with applications show that DECK-SCI performs at least as well as ScaMPI
- ⇒ Another alternative for SCI programming
  - ⇒ integration of communication and multithreading

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