SAN Optimization for High Performance Storage with RDMA Data Transfer

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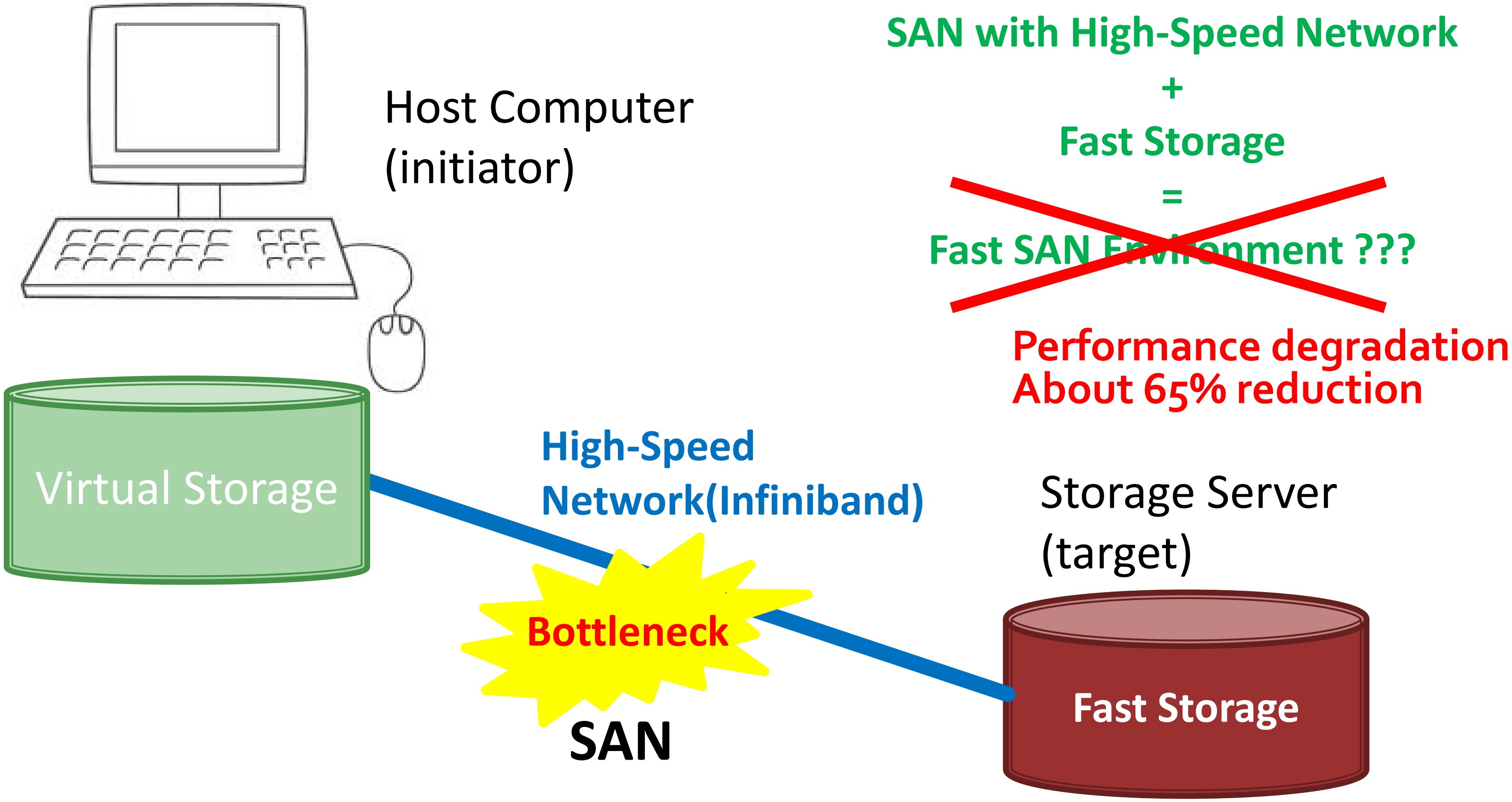
Motivation



SAN with High-Speed Network

+

Fast Storage

~~=~~

~~Fast SAN Environment ???~~

Performance degradation
About 65% reduction

Contribution

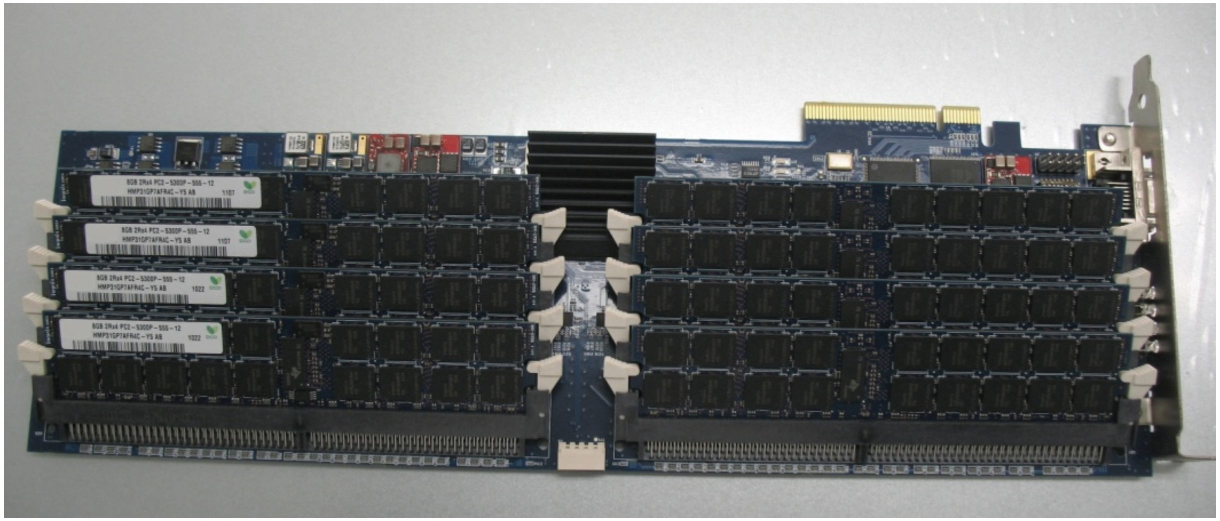
- Found performance degradation in existing SAN solution with a fast storage

- Proposed three optimizations for Fast SAN solution
  - Mitigate software overheads in SAN I/O path
  - Increase parallelism on Target side
  - Temporal merge for RDMA data transfer

- Implemented the new SAN solution as a prototype

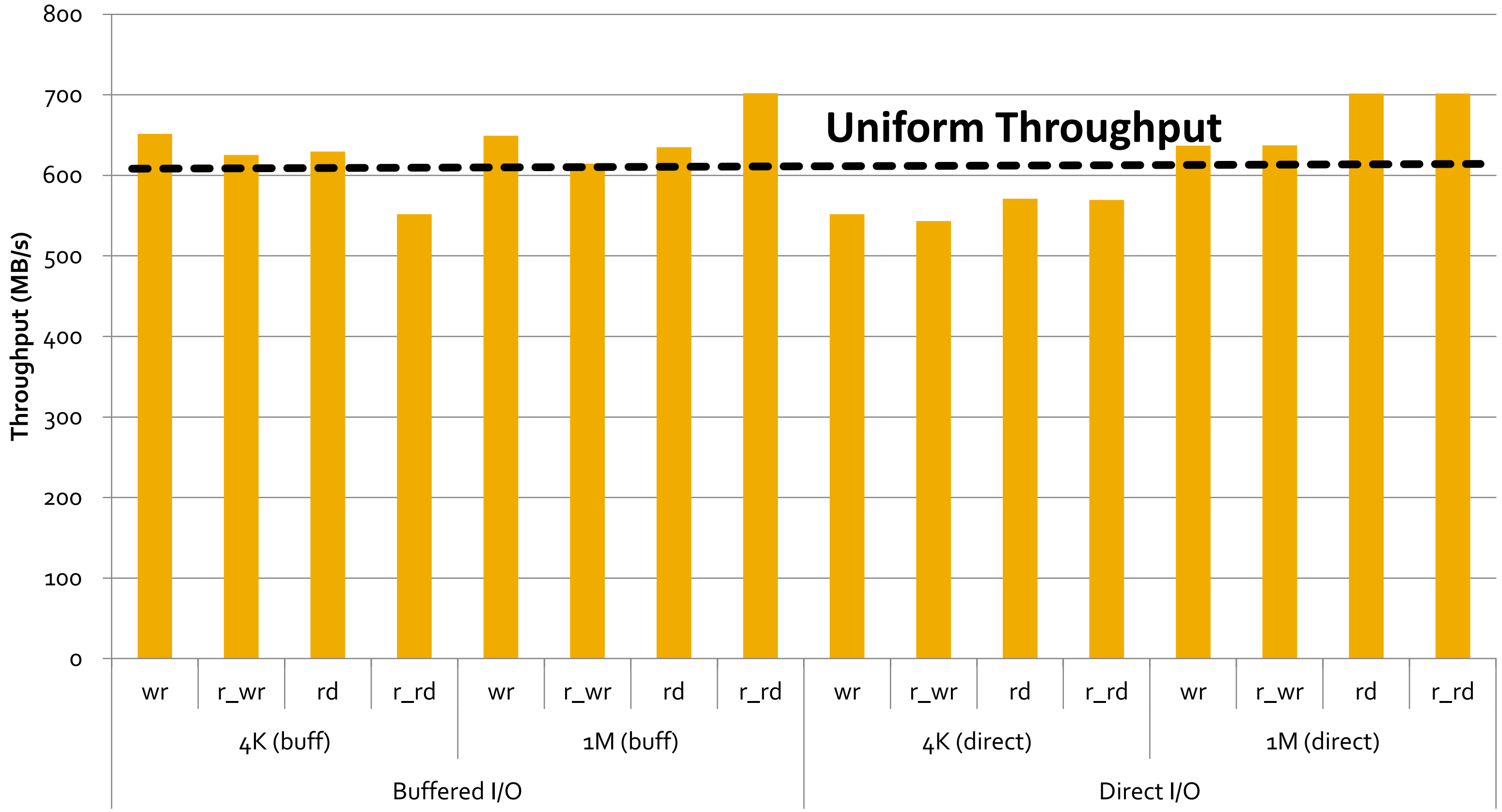
Fast Storage

- DRAM-SSD (provided by TAEJIN Infotech)
  - 7 usecs for reading/writing a 4KB page
  - Peak device throughput: 700 MB/s
  - DDR2 64 GB, PCI-Express type



DRAM SSD Performance Test

- FIO micro benchmark, 16 threads



SCST

- Generic SCSI Target Subsystem for Linux
    - Open Program for implementing SAN environment
    - Support Ethernet, FC, Infiniband and so on.
    - Use SRP(SCSI RDMA Protocol) for Infiniband

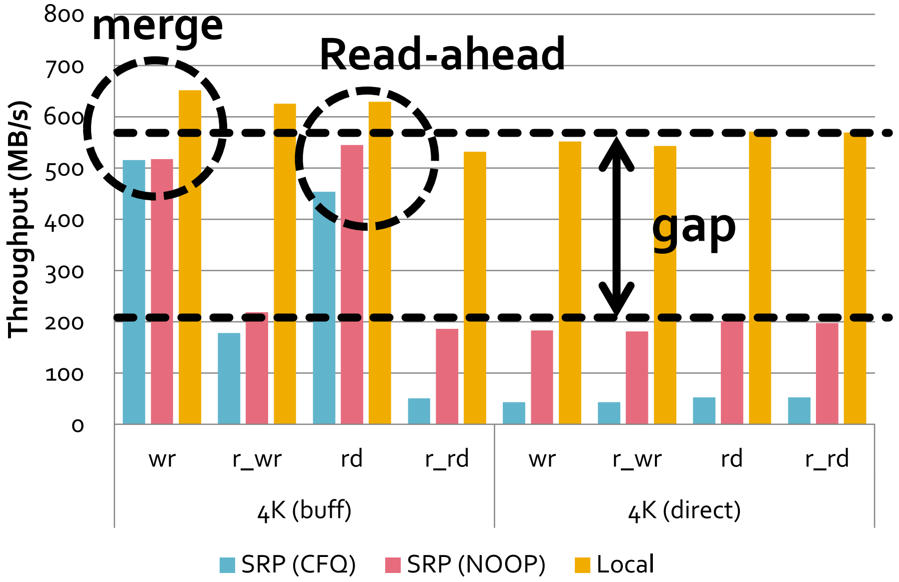
Evaluation Environment

SPEC	TARGET	INITATOR
CPU	Intel Xeon E5630 (8 core)	Intel Xeon E5630 (8 core)
Memory	16GB	8GB
INFINIBAND CARD	MHQH19B-XTC 1port (40Gb/s)	MHQH19B-XTC 1port (40Gb/s)

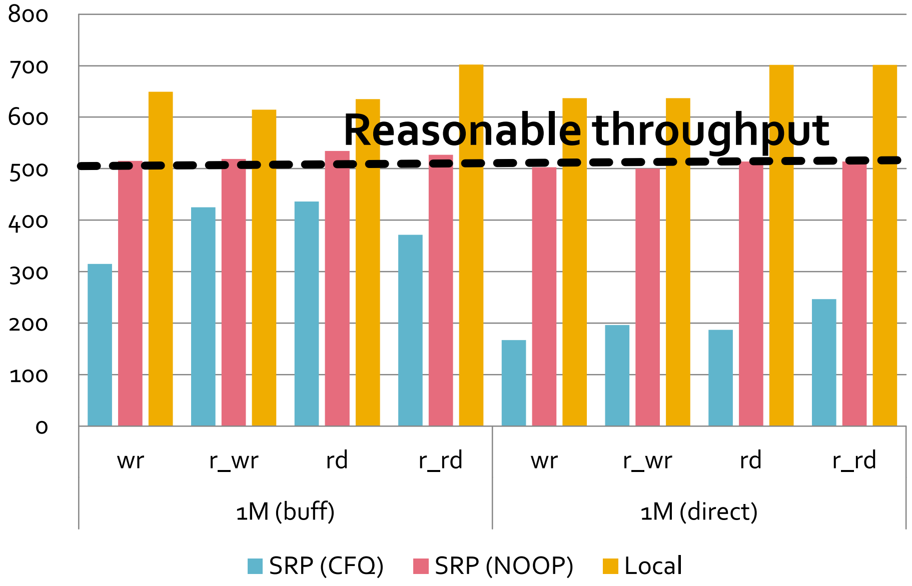
- Device :DRAM SSD(64GB)
- Workload size : 16 thread x 3GB (48GB)
- Request size : 4K/1M
- I/O type: Buffered/Direct, Sequential/Random, Read/Write
- Benchmark Tool : FIO micro benchmark

Evaluation (SCST)

- I/O Scheduler policy
  - CFQ -> NOOP



Small Size



Large Size

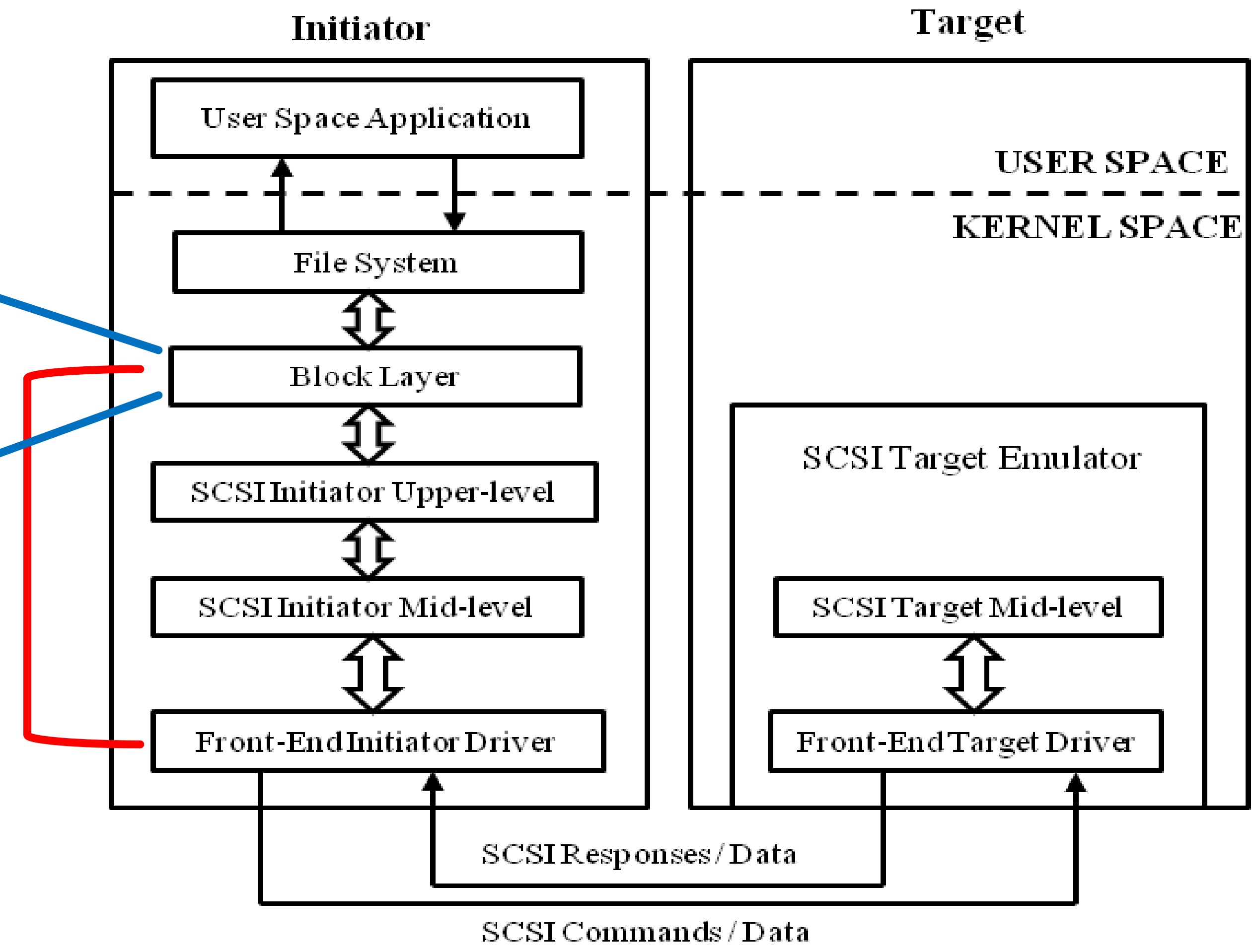
Traditional SAN I/O Path in the Linux

Elevator for request merge

Plug-Unplug mechanism

Cause some delays

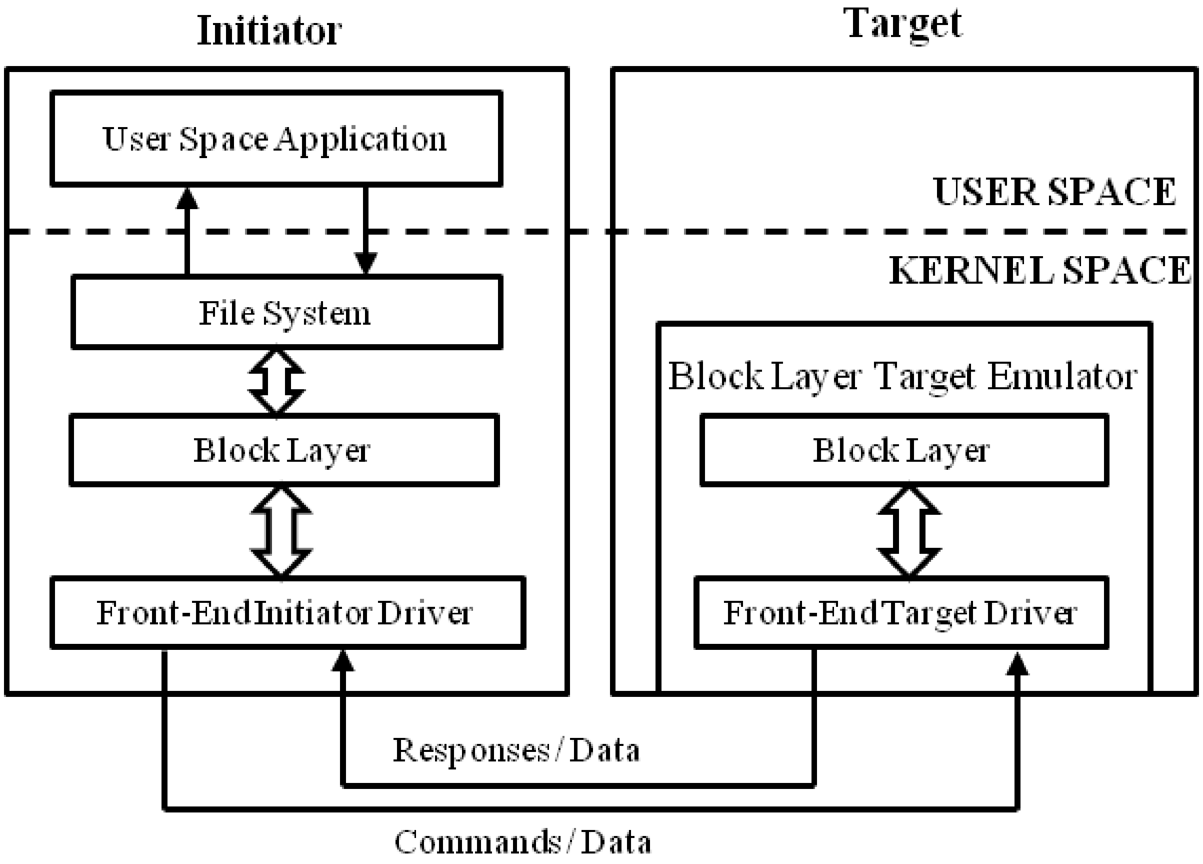
Too long



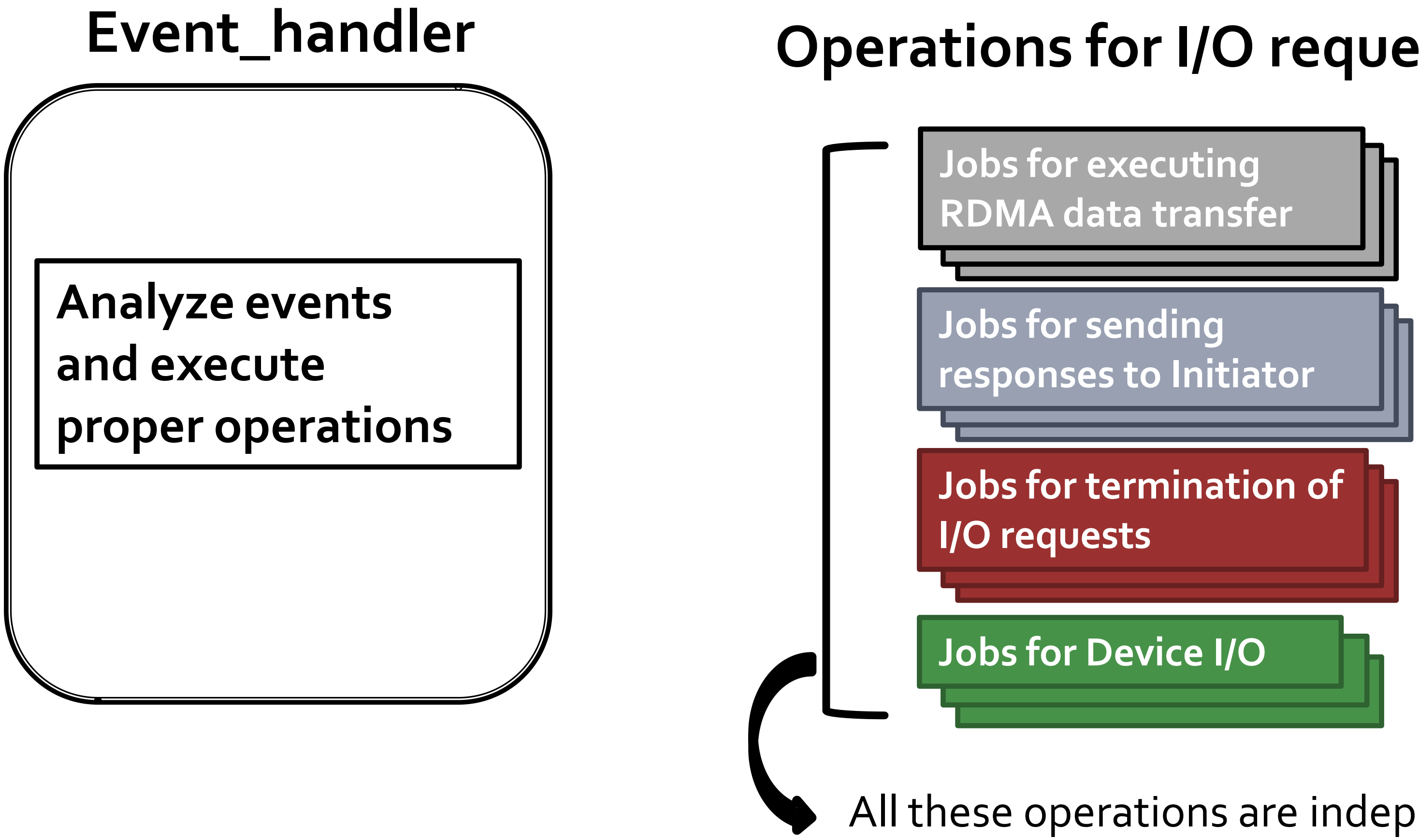
Optimization 1

- Remove software overheads in I/O path
  - Bypass SCSI layer
  - Discard existing I/O scheduler
    - Remove elevator merge and plug-unplug
    - Maintain wait-queue based on *bio* structure
    - Very simple & fast I/O scheduler
- BRP(Block RDMA Protocol)
  - Commands are also based on *bio* structure, not scsi command

Optimization 1



Operations on Target side



Event_handler

Analyze events and execute proper operations

Operations for I/O request

Jobs for executing RDMA data transfer

Jobs for sending responses to Initiator

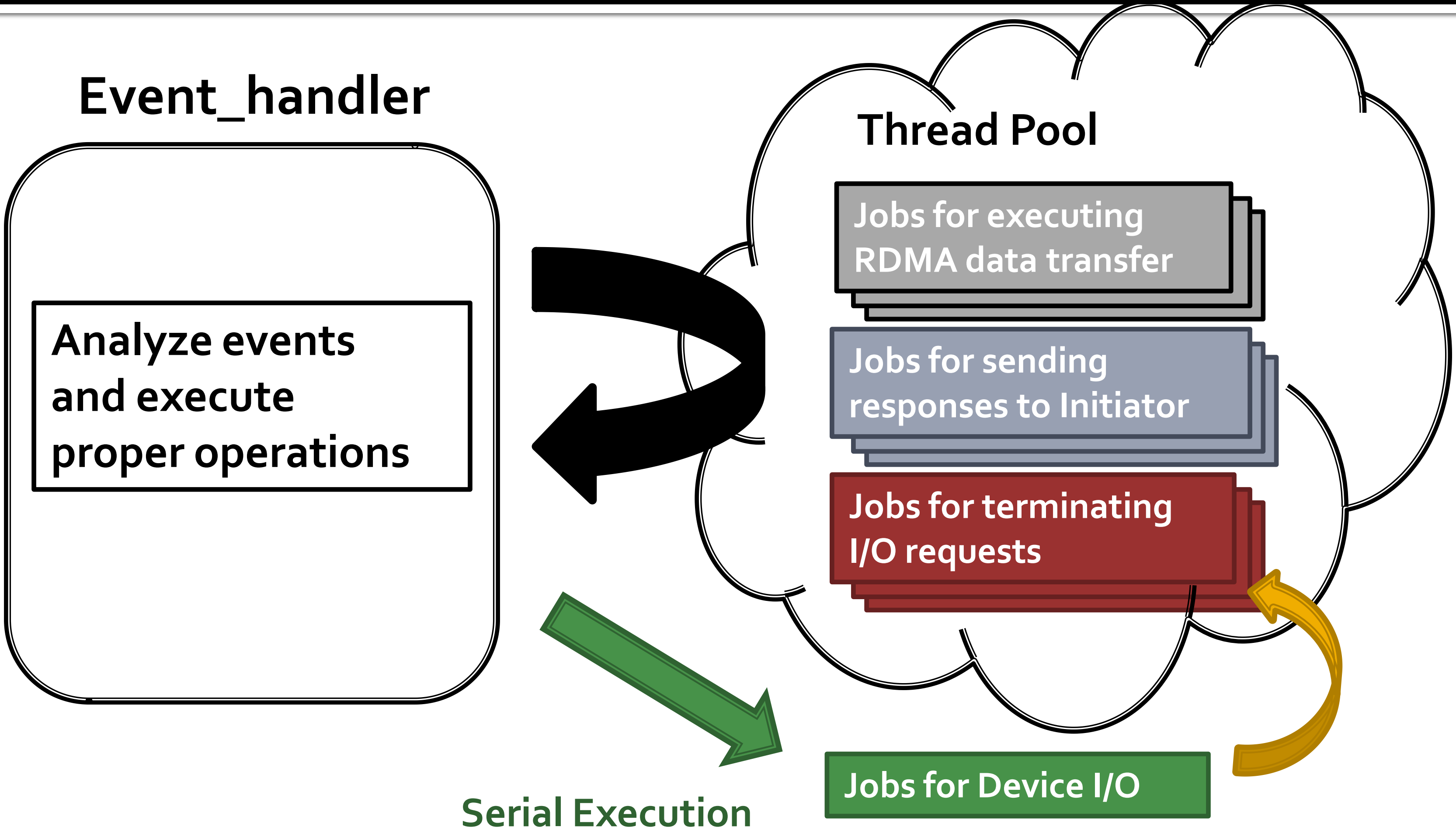
Jobs for termination of I/O requests

Jobs for Device I/O

All these operations are independent each other

can be processed in parallel

Operations on Target side



Event_handler

Analyze events and execute proper operations

Thread Pool

Jobs for executing RDMA data transfer

Jobs for sending responses to Initiator

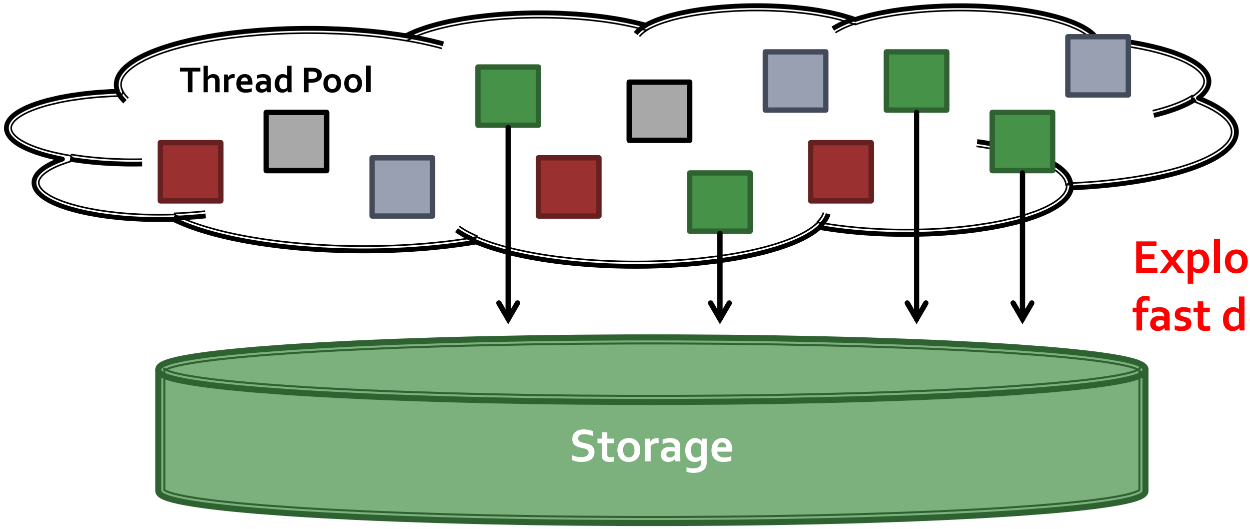
Jobs for terminating I/O requests

Jobs for Device I/O

Serial Execution

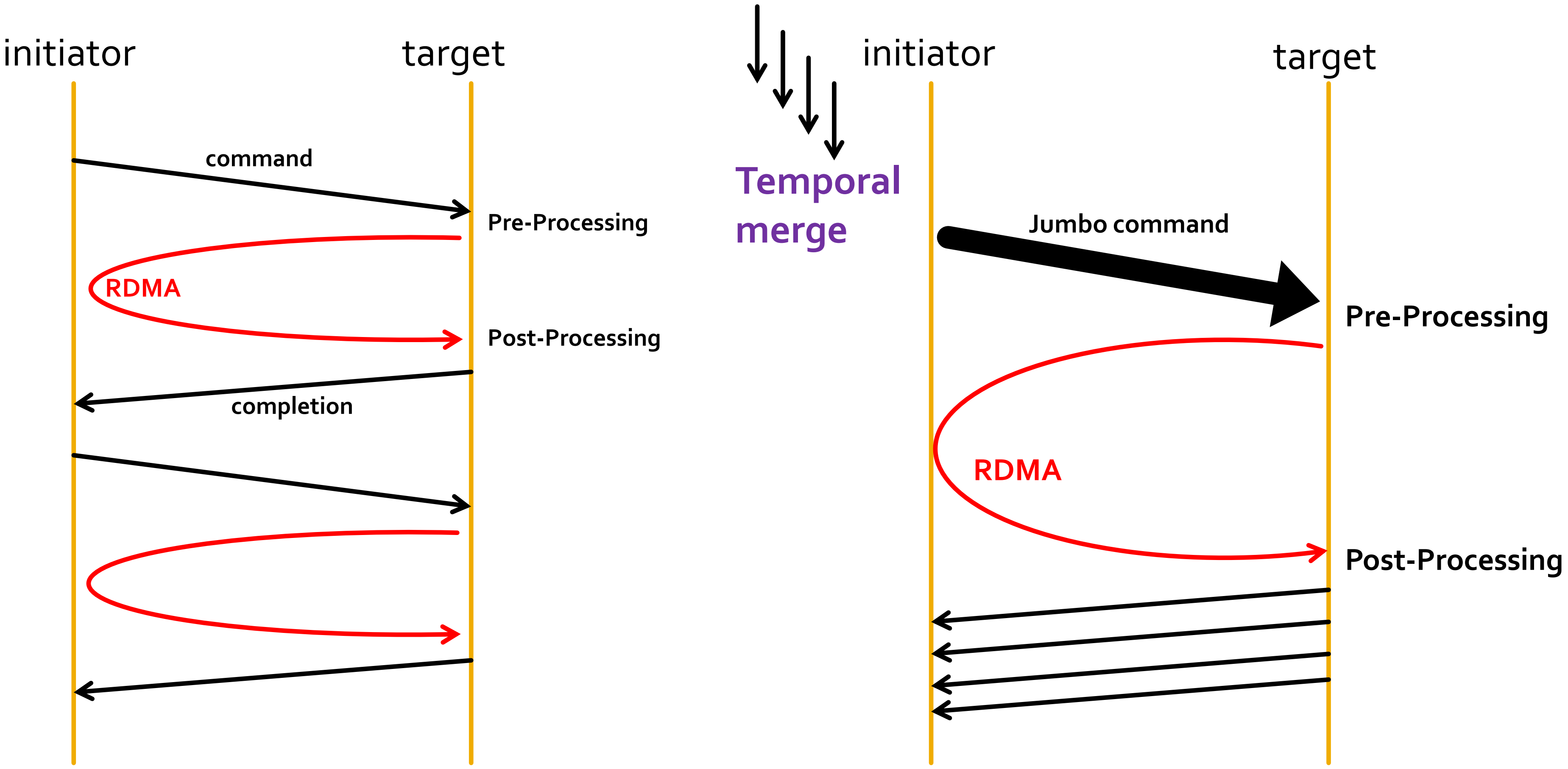
Optimization 2

- Increase Parallelism on the Target side
  - All the procedures for I/O requests are processed in thread-pool
    - Induce Multiple device I/O



Exploit high bandwidth of fast device

RDMA Data Transfer



initiator

target

command

Pre-Processing

RDMA

Post-Processing

completion

Temporal merge

initiator

target

Jumbo command

Pre-Processing

RDMA

Post-Processing

Optimization 3

- RDMA data transfer with temporal merge
  - Merge small sized data regardless of its spatial continuance
  - Enabled at the only intensive-I/O situation

Evaluation

- BRP-1
  - Remove software overhead in I/O path
- BRP-2
  - BRP-1 + Increase Parallelism
- BRP-3
  - BRP2 + Temporal Merge at the intensive I/O situation
  - Just BRP means BRP-3

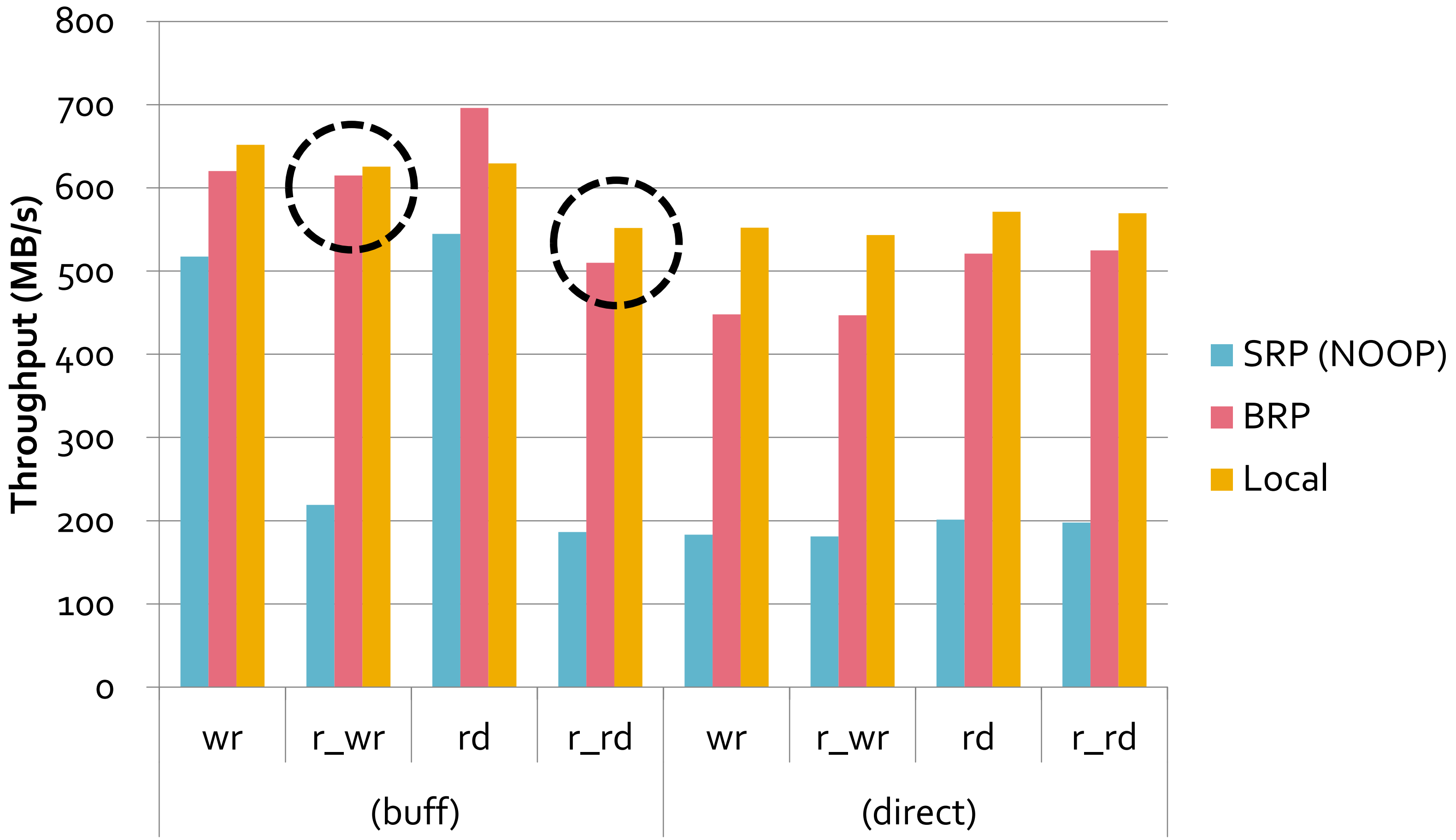
Evaluation

- Latency comparison
  - Direct I/O, 4KB
  - dd test

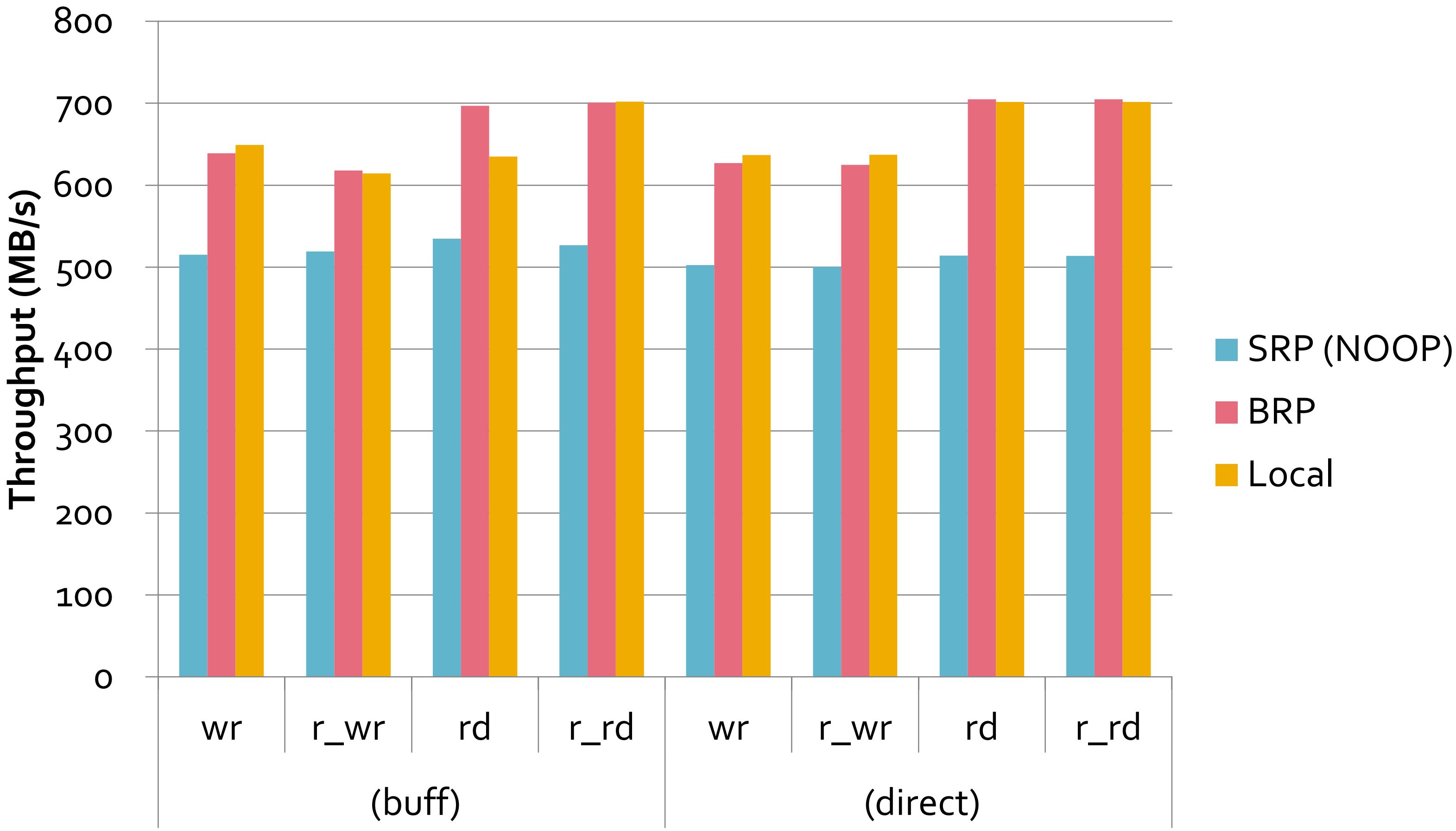
I/O Type	SRP(usec)	BRP(usec)	Latency Reduction
Read	63 (51)	43 (31)	-31.7 (-39.2) %
Write	75 (62)	54 (41)	-28 (-33.8)%

( ) : the value excepting device I/O latency
read-12usec, write-13usec

Evaluation (small size: 4KB)

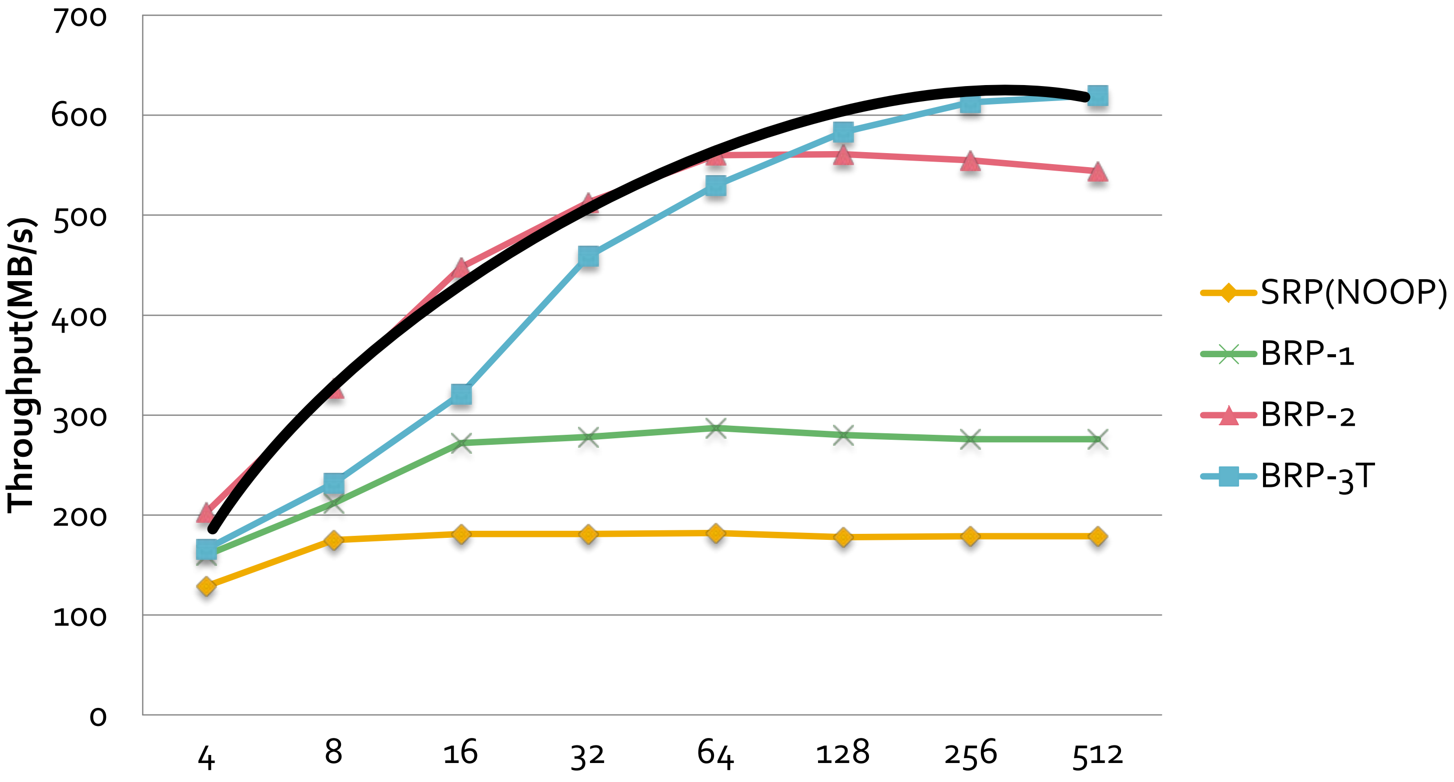


Evaluation (large size: 1MB)



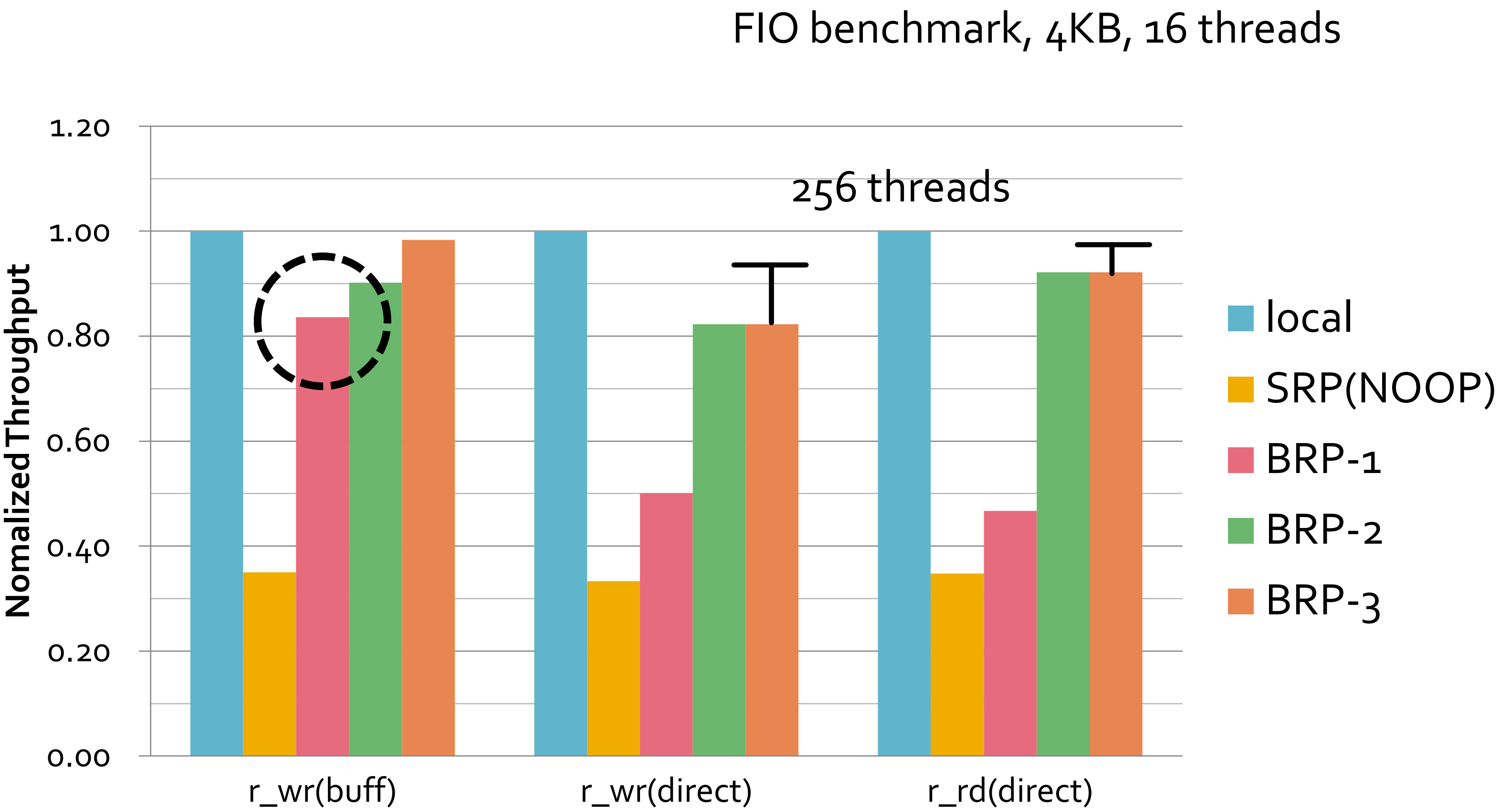
Evaluation

FIO benchmark, random write, 4KB, direct I/O,



BRP-3T: always executes temporal merge

Evaluation


FIO benchmark, 4KB, 16 threads
256 threads
Nomalized Throughput
1.20
1.00
0.80
0.60
0.40
0.20
0.00
r_wr(buff)
r_wr(direct)
r_rd(direct)
local
SRP(NOOP)
BRP-1
BRP-2
BRP-3

Conclusion

- SAN with high performance storage
- Propose new SAN solution
  - Remove Software overheads in I/O path
  - Increase parallelism on the Target side
  - Temporal merge for RDMA data transfer
- Implement the optimized SAN as a prototype

Thank you !

QnA?