Improving Spark Performance with Zero-copy Buffer Management and RDMA

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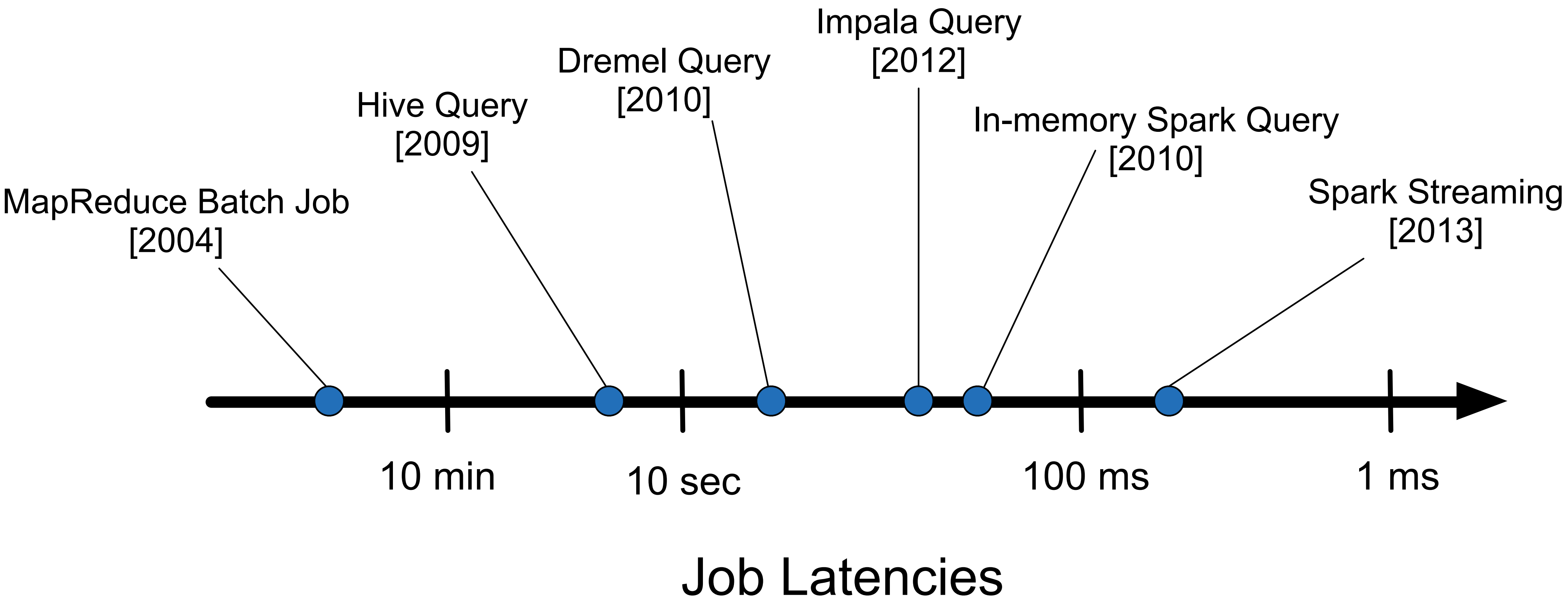
Latency matters in big data



Big Data: Not only *capable* , but also *interactively*

[Kay@SOSP13]

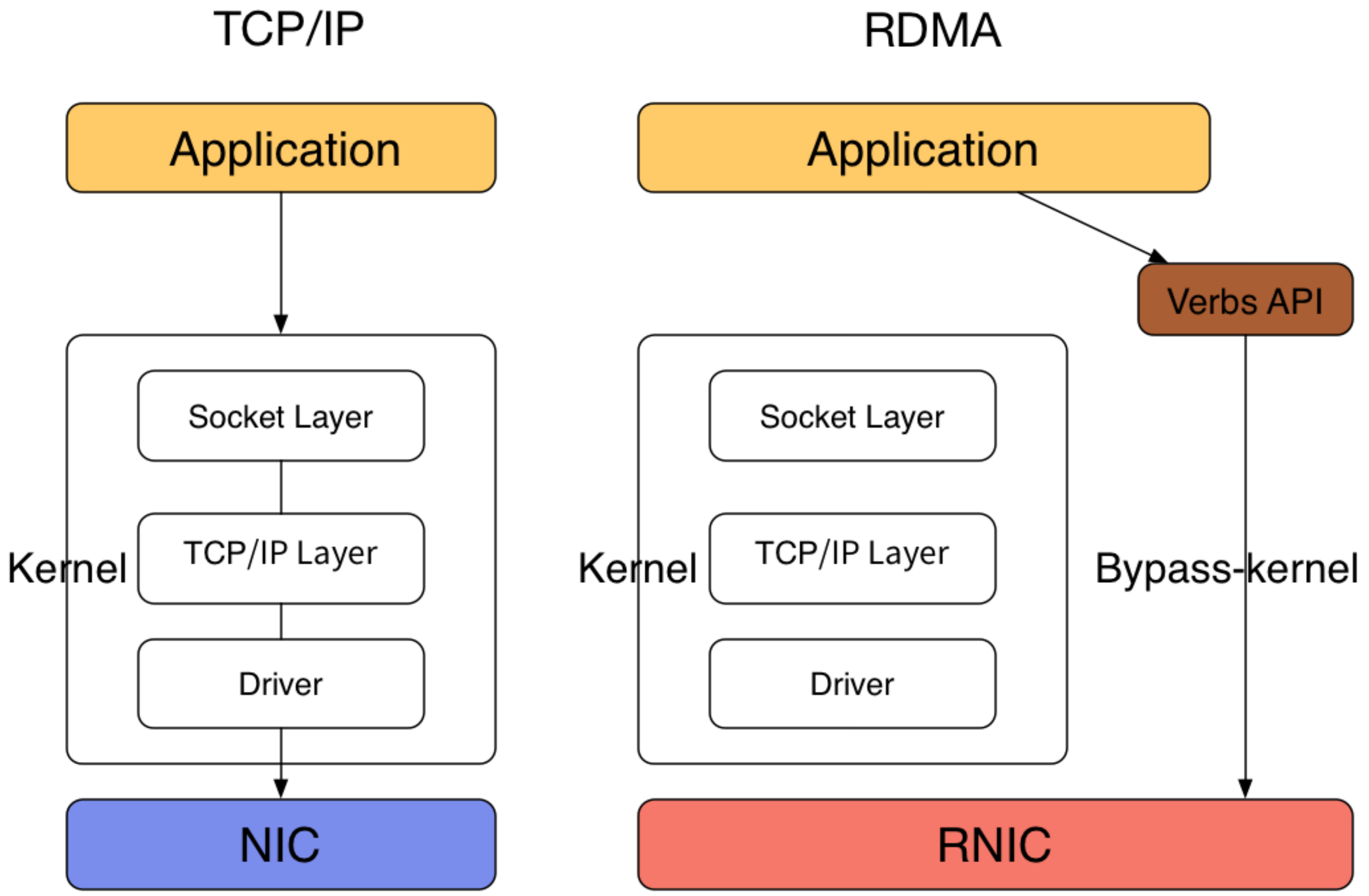
Overview of our work

- NetSpark: A reliable Spark package that takes advantage of the ***RDMA over Converged Ethernet (RoCE)*** fabric

- A combination of **memory management optimizations** for JVM-based applications to take advantage of RDMA more efficiently

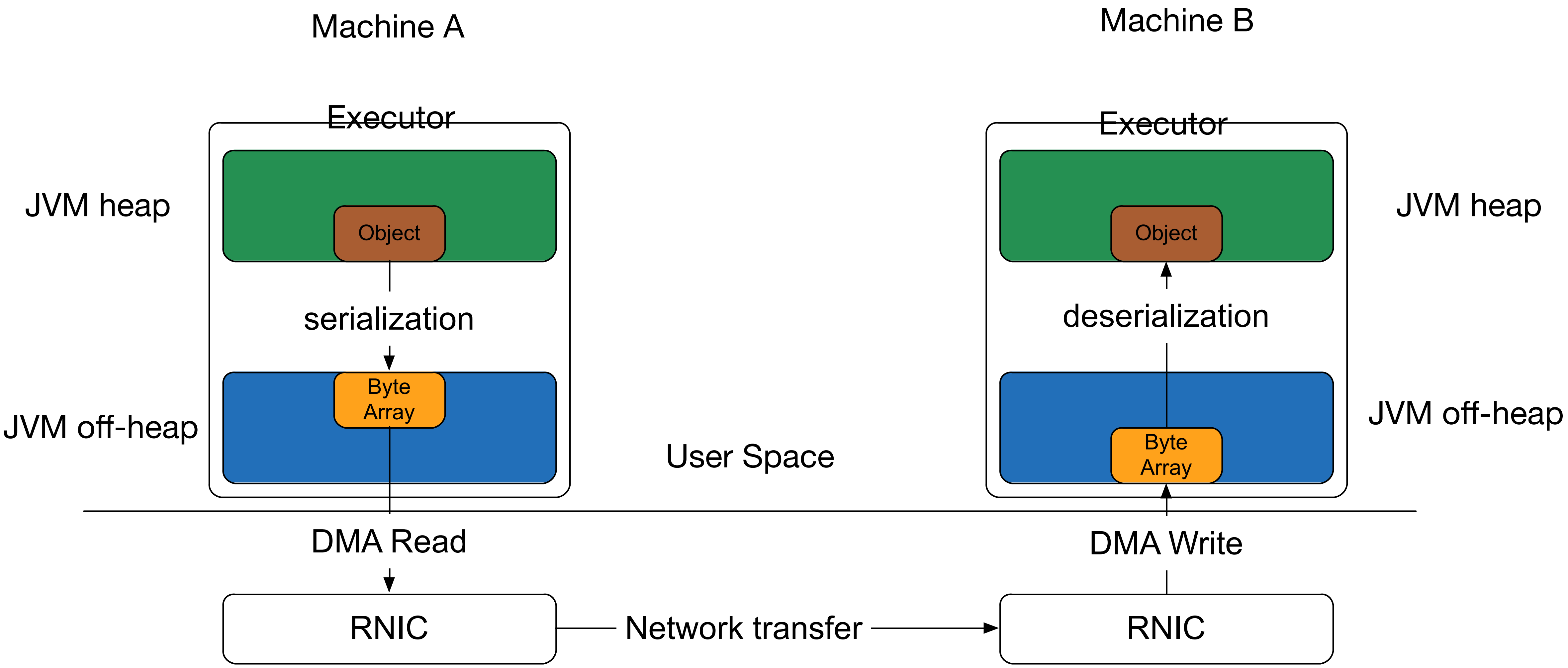
- Improving **latency-sensitive** task performance, while staying fully **compatible** with the off-the-shelf Spark

Background:
Remote Direct Memory Access (RDMA)

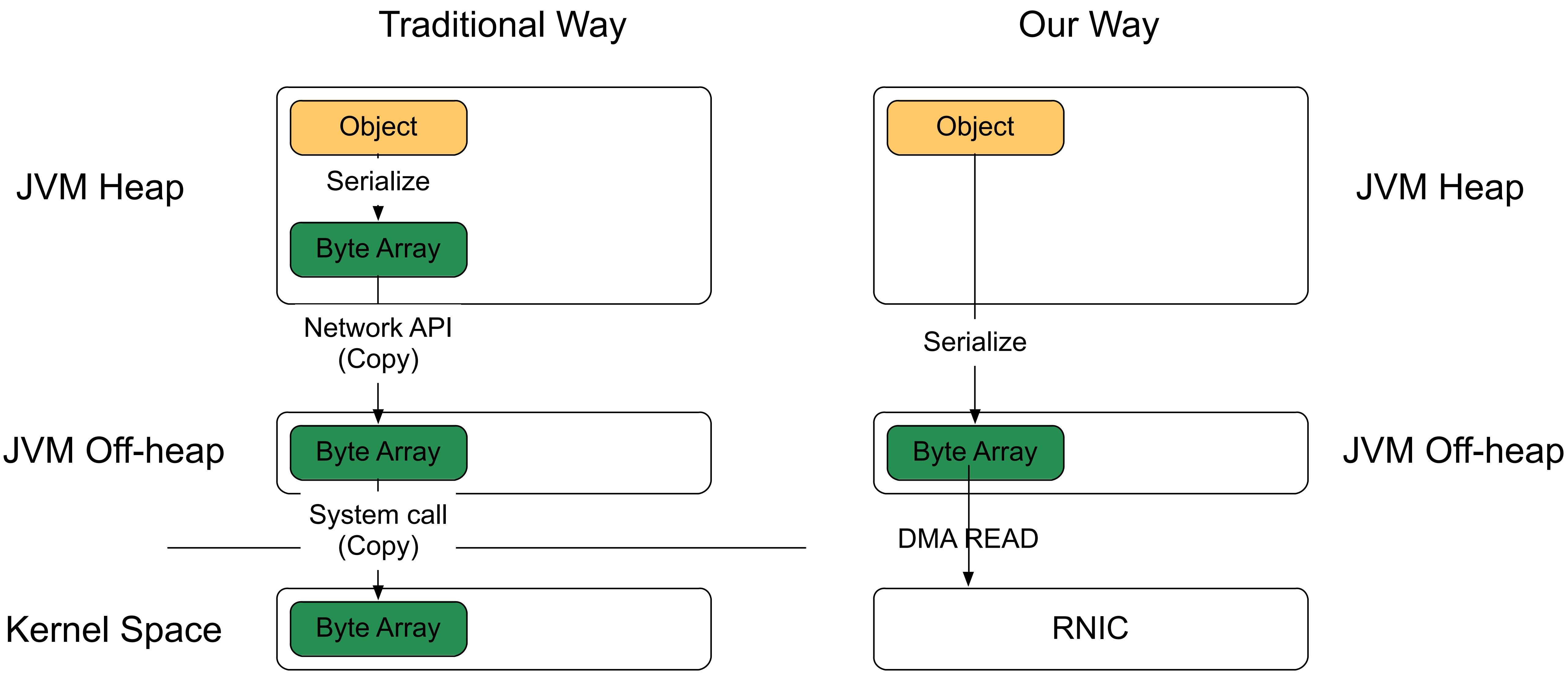


Lower CPU utilization and lower latency

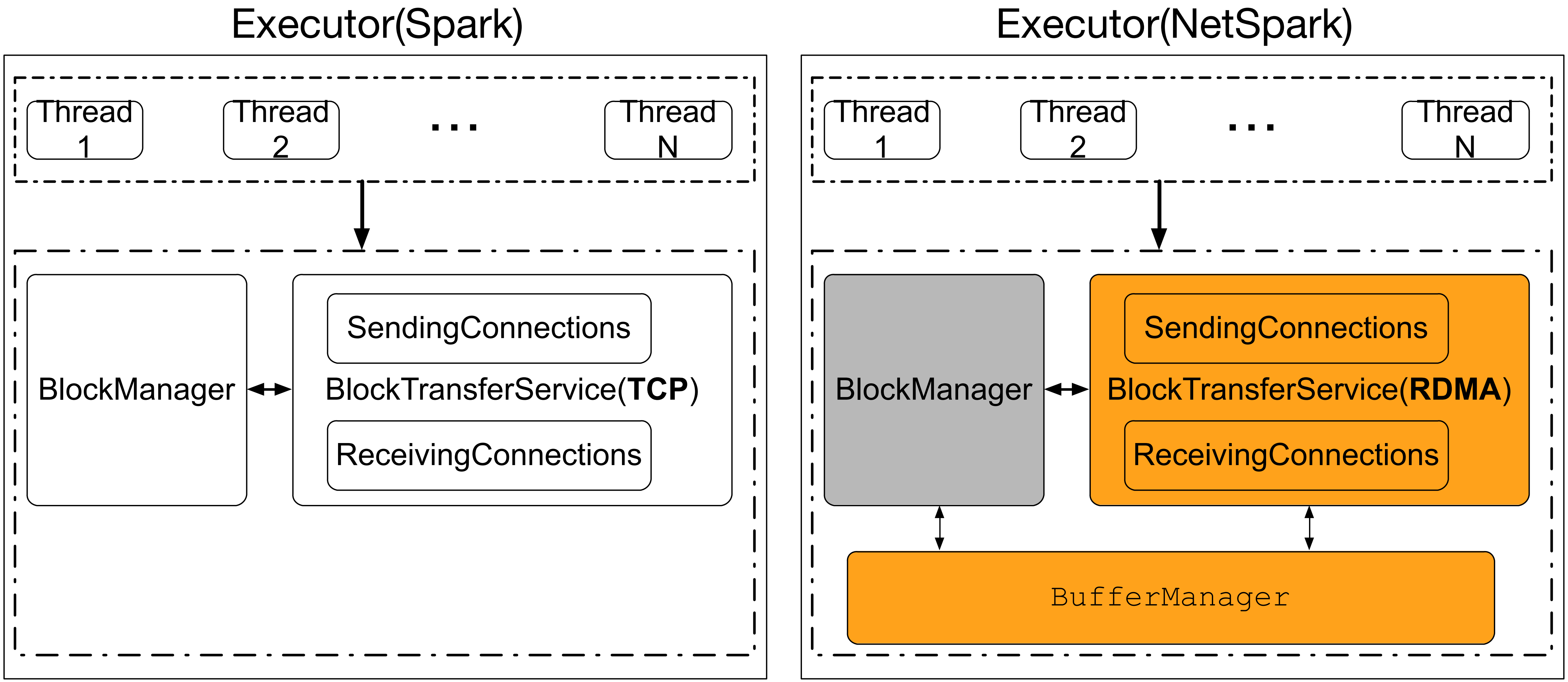
An over view of NetSpark transfer model



Zero-copy network transfer

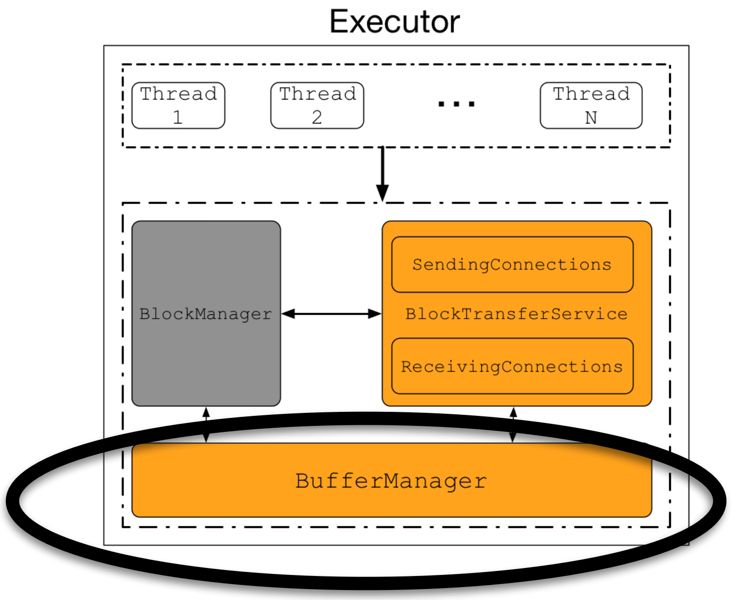


Implementation: SPARK executors



RDMA buffer management

- RDMA require a fixed physical memory address
  - for Java: off-heap
- Significant allocate/de-allocate cost
- Need to register to RDMA
  - High overhead



Simple solution: Pre-allocate RDMA buffer space to avoid allocation / register overhead

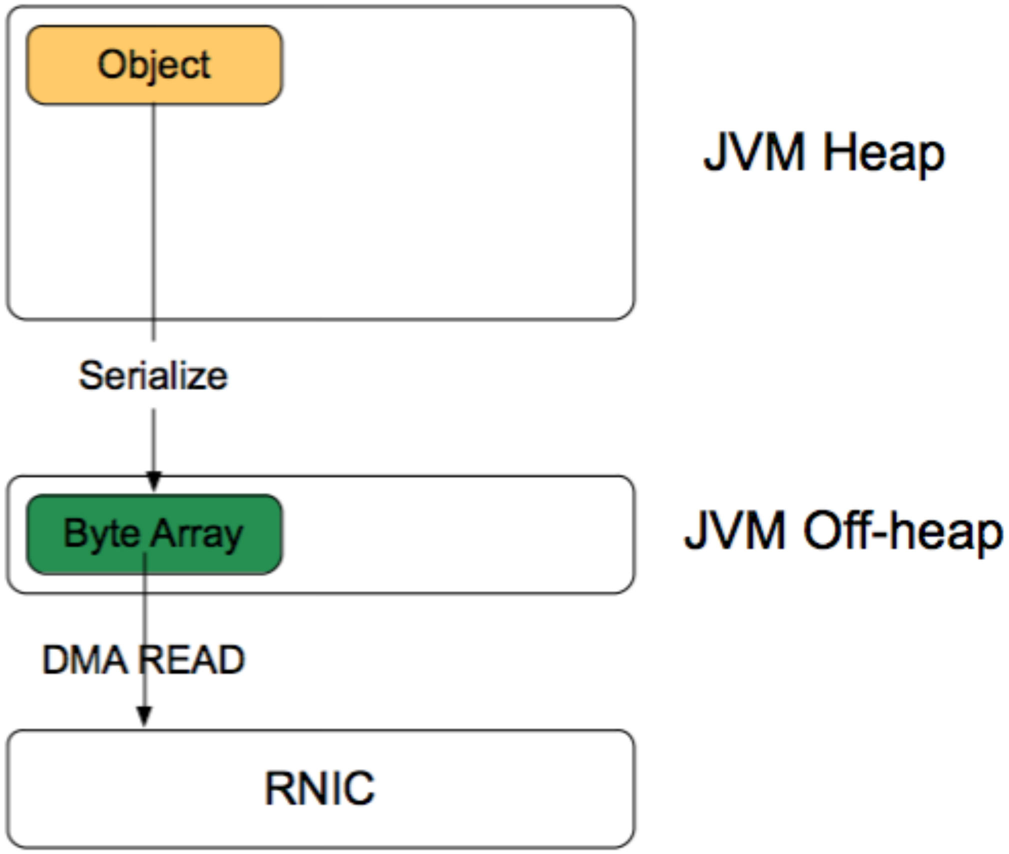
RDMA Buffer Management (cont’d)

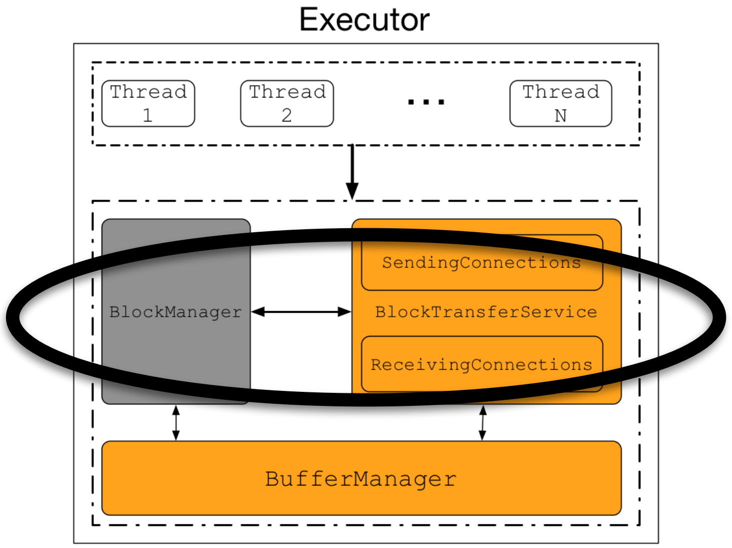
- A small number of large-enough fixed-size off-heap buffers
  - Like the Linux kernel buffer, but @ user space
- But … need to copy from heap to off-heap

Serializing directly into the off-heap RDMA buffer

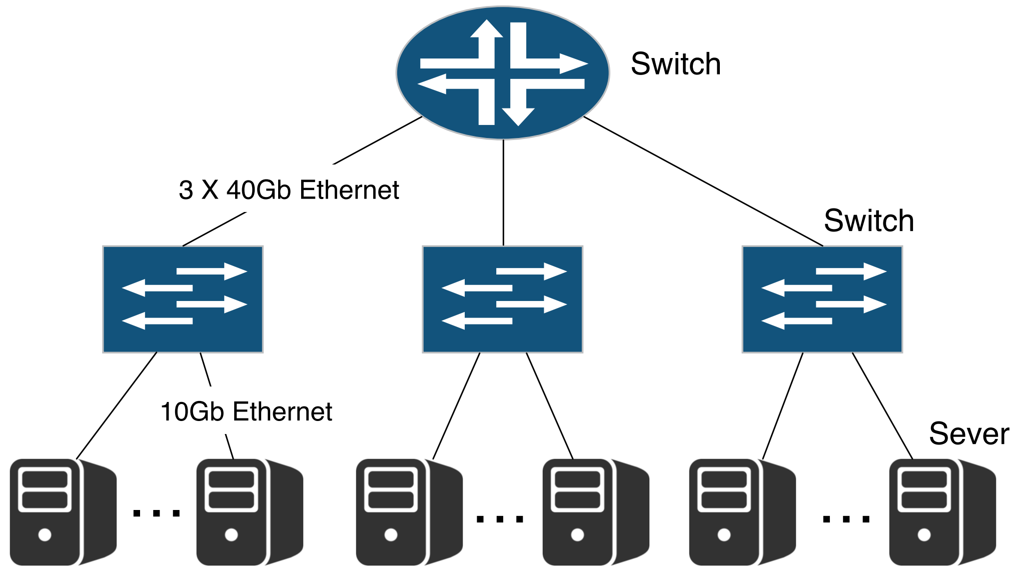
- Rewrite Java InputStream and OutputStream to take advantage of the new buffer manager

- Details in the paper





Evaluation: Testbed



Network topology of our testbed

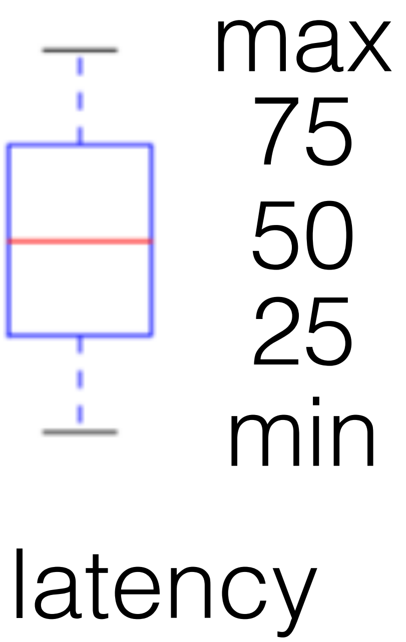
1. 3 switches, 34 servers
2. RoCE, 10GE
3. Using priority flow control for RDMA to avoid packets loss

Evaluation: Experiment Setup

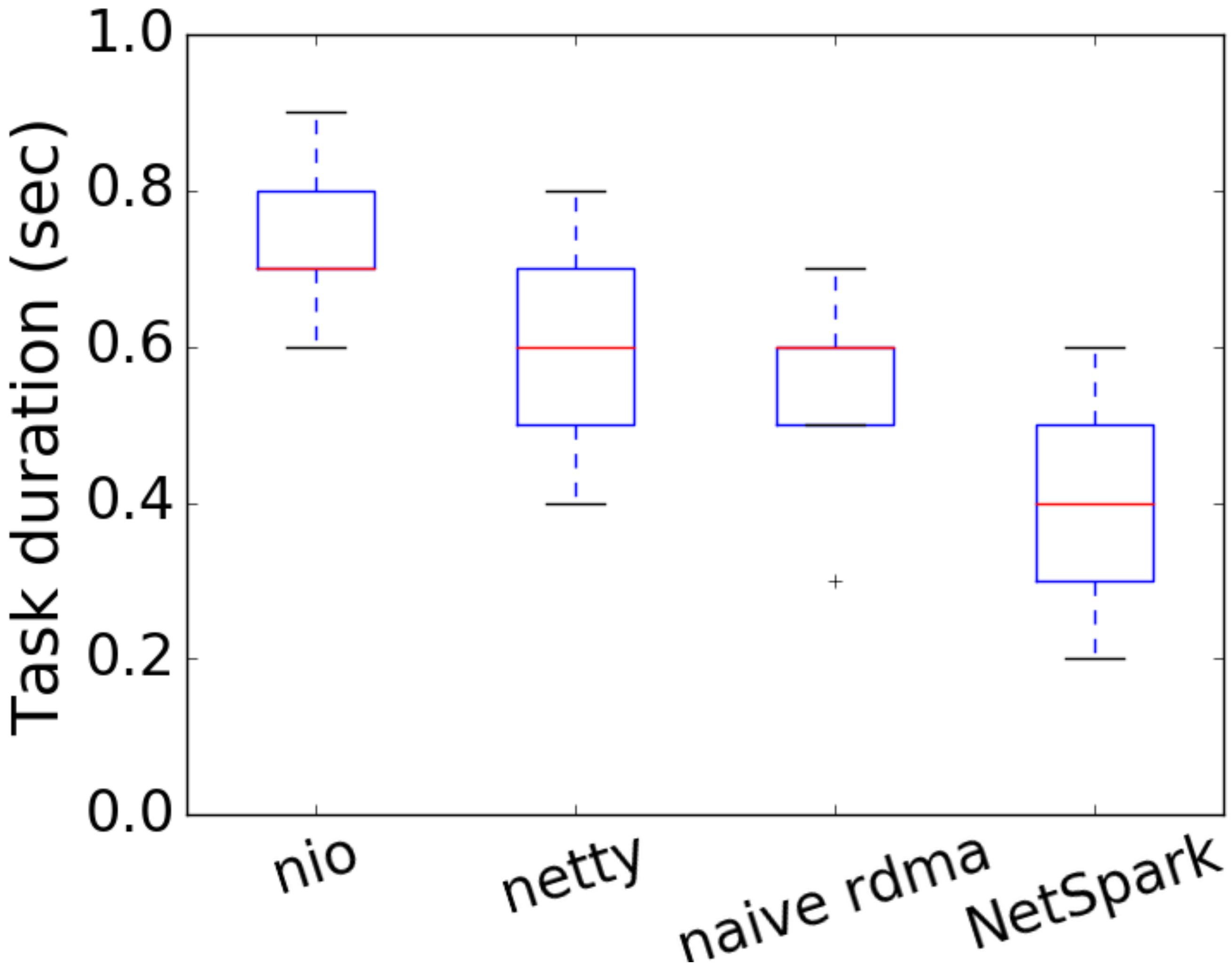
Compared four different executor implementation

1. Java NIO
2. Netty
3. Naive RDMA
4. NetSpark

(Spark version: 1.5.0)



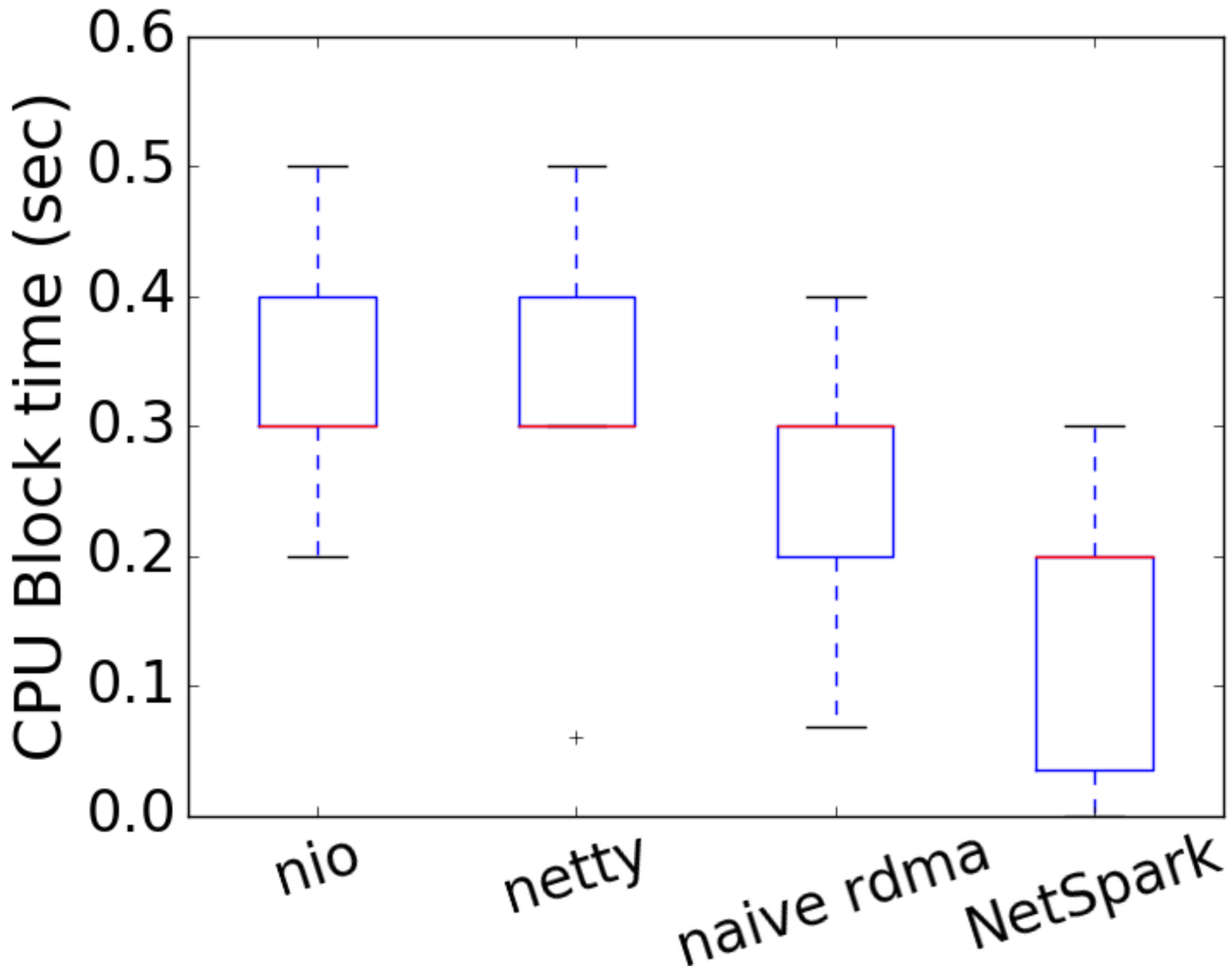
Group-by performance on small dataset



- Spark example
- 2.5GB data shuffled

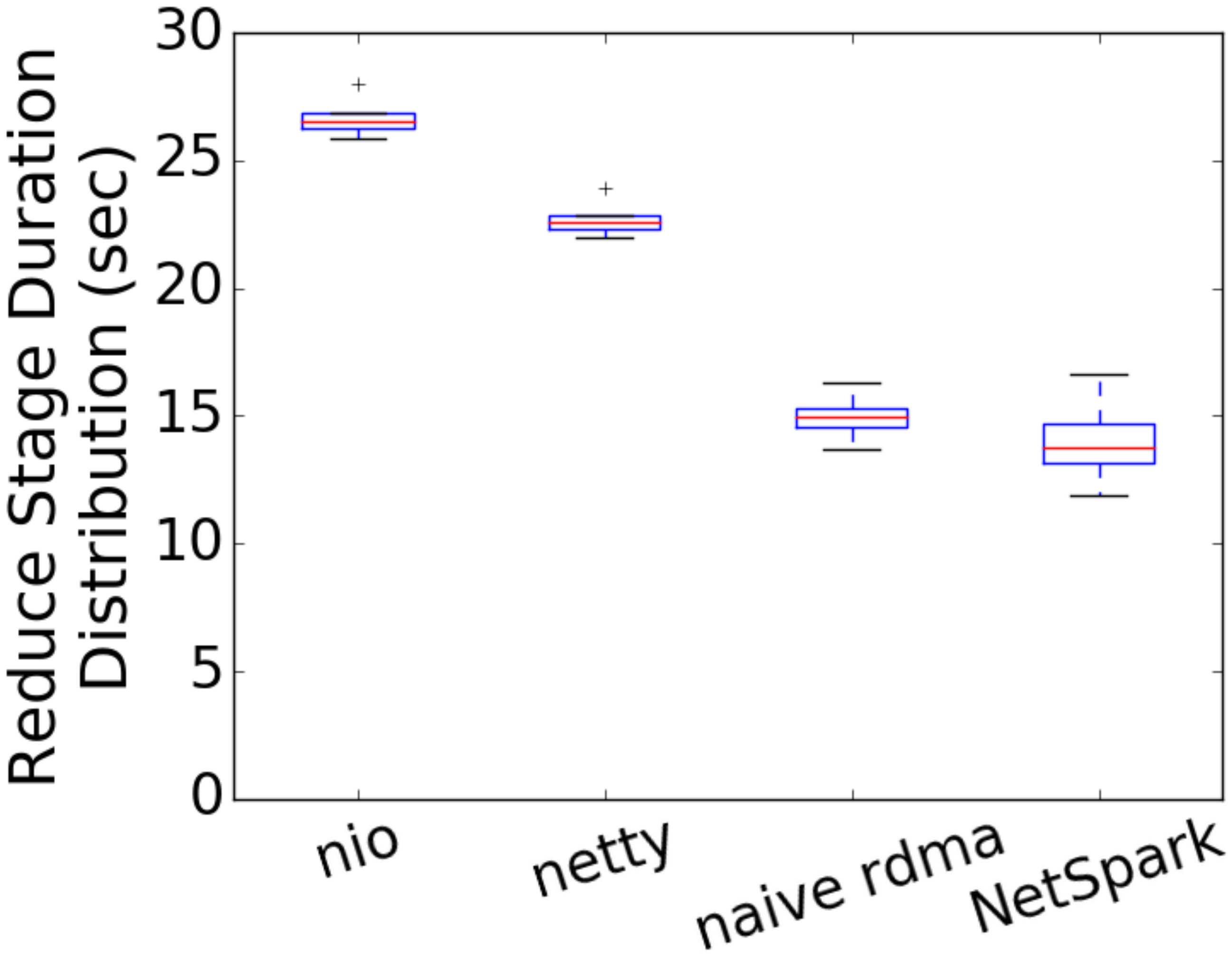
About 17% improvement over the naive RDMA

Why do we have an improvement?



- CPU block time
- Measurements from SPARK log
- Following *Kay@NSDI15*

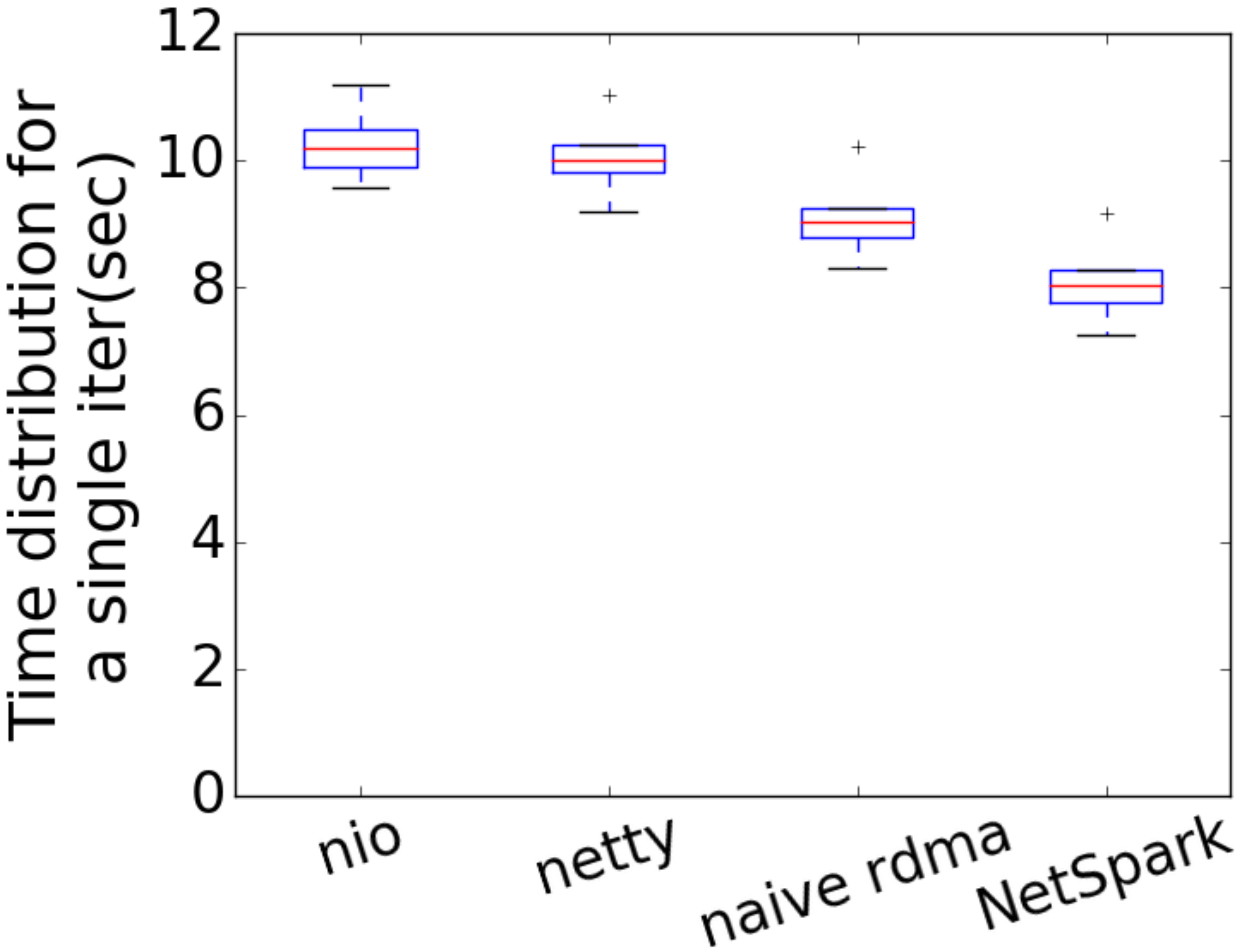
Group by on larger data - entire reduce stage



A larger dataset about 107.3GB for shuffle

~40% faster over Netty

PageRank on a large graph



Twitter Graph Dataset
[Kwak@www2010]

41million nodes

1.5 billion edges

20% faster than Netty

10% faster than naive
RDMA

Conclusion

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