Mixing Hadoop and HPC Workloads on Parallel Filesystems

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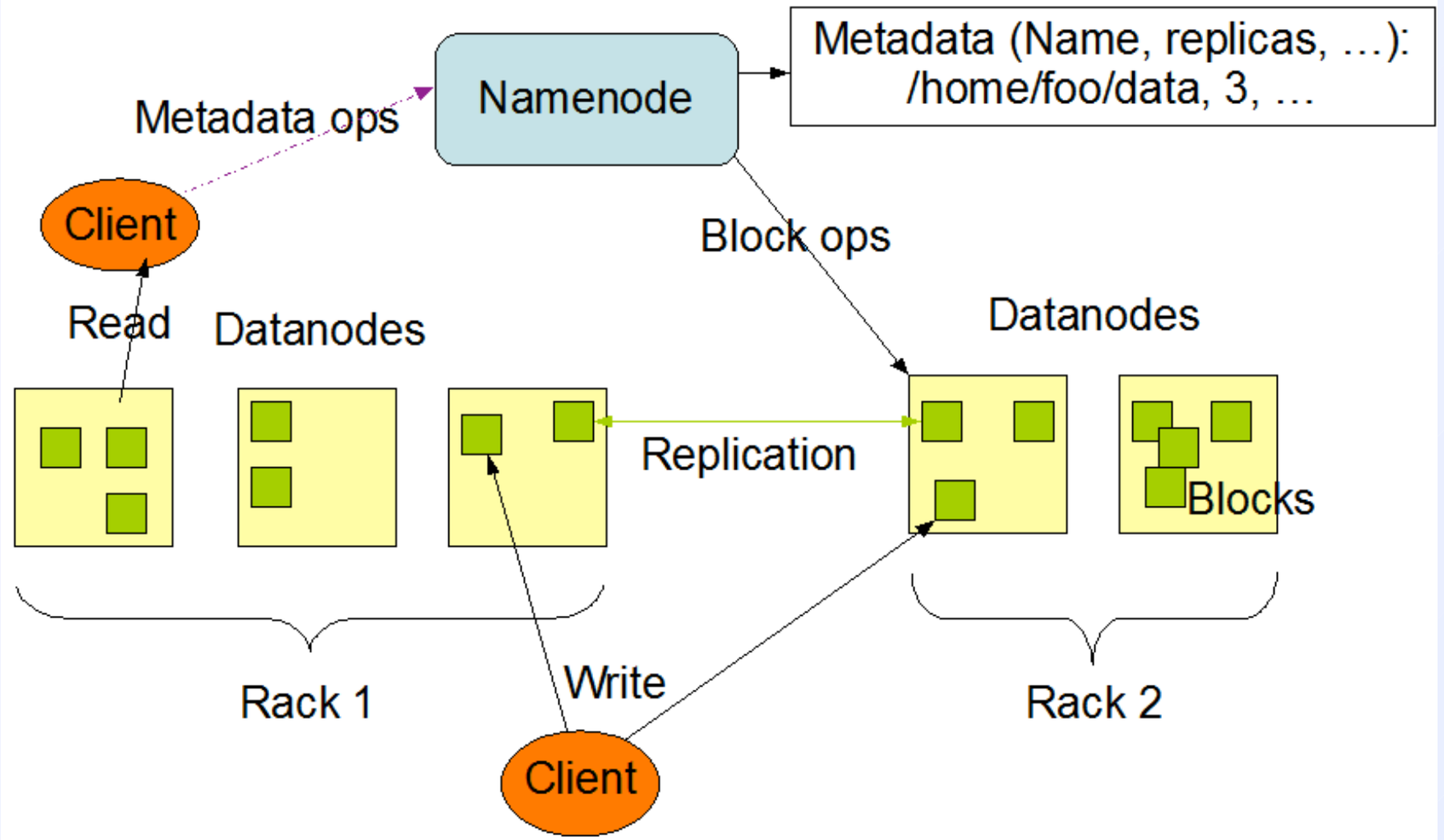
Motivation

- Strong interest in running both HPC and large-scale data mining workloads on the same infrastructure
- Hadoop-tailored filesystems (e.g. CloudStore) and high-performance computing filesystems (e.g. PVFS) are tailored to considerably different workloads
- Existing investments in HPC systems and Hadoop systems should be usable for both workloads
- Goal: Examine the performance of both types of workloads running concurrently on the same filesystem
- Goal: collect I/O traces from concurrent workload runs, for parallel filesystem simulator work

MapReduce-oriented filesystems

- Large-scale batch data processing and analysis
- Single cluster of unreliable commodity machines for both storage and computation
- Data locality is important for performance
- Examples: Google FS, Hadoop DFS, CloudStore

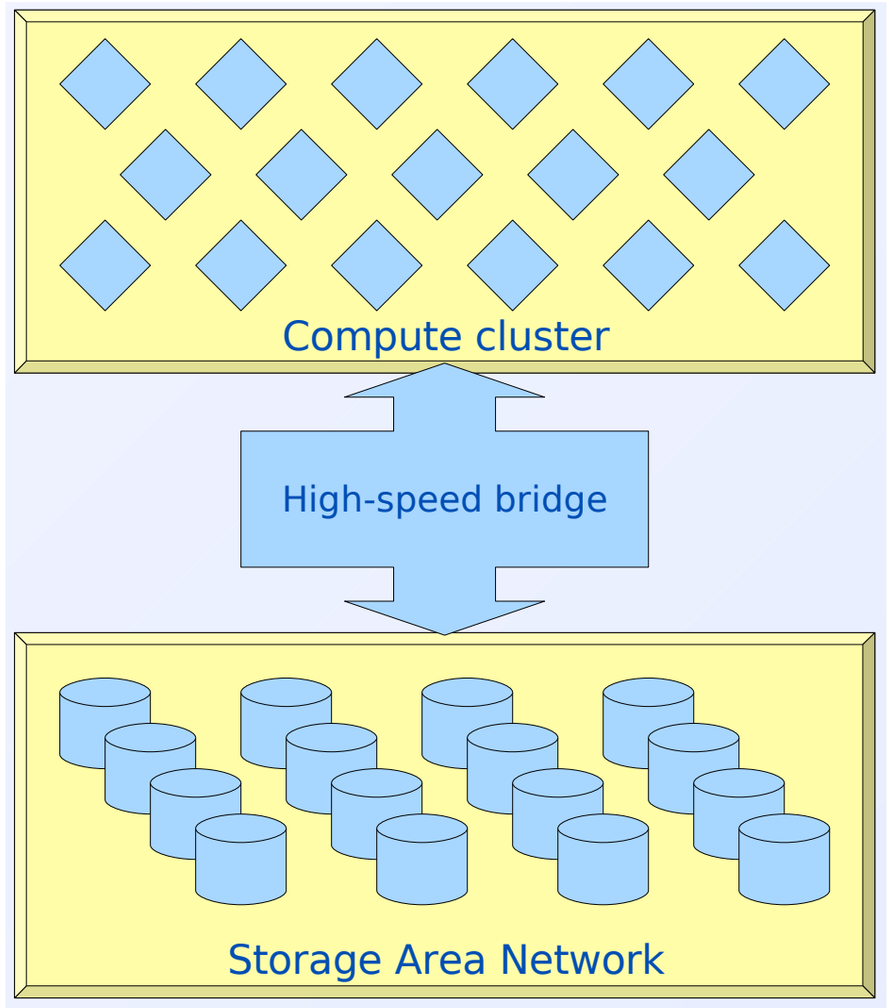
Hadoop DFS architecture



http://hadoop.apache.org

High-Performance Computing filesystems

- High-throughput, low-latency workloads
- Architecture: separate compute and storage clusters, high-speed bridge between them
- Typical workload: simulation checkpointing
- Examples: PVFS, Lustre, PanFS, Ceph



Running each workload on the non-native filesystem

- Two-sided problem: running HPC workloads on a Hadoop filesystem, and Hadoop workloads on an HPC filesystem
- Different interfaces:
  - HPC workloads need a POSIX-like interface and shared writes
  - Hadoop is write-once-read-many
- Different data layout policies

Running HPC workloads on a Hadoop filesystem

- Chosen filesystem: CloudStore
  - Downside of Hadoop's HDFS: no support for shared writes (needed for HPC N-1 workloads)
  - Cloudstore has HDFS-like architecture, and shared write support

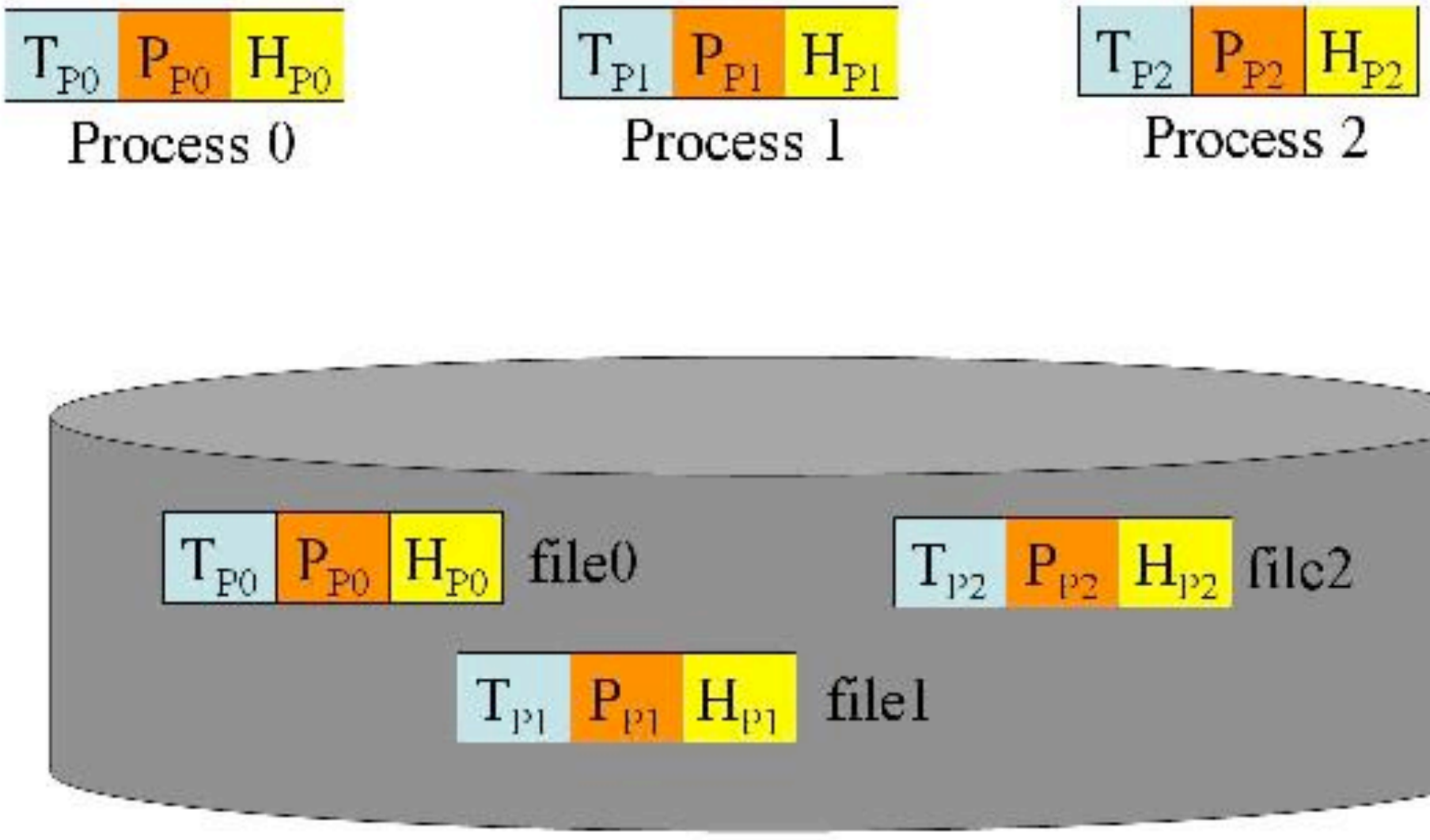
Running Hadoop workloads on an HPC filesystem

- Chosen HPC filesystem: PVFS
  - PVFS is open-source and easy to configure
  - Tantisiriroj et al. at CMU have created a shim to run Hadoop on PVFS
  - Shim also adds prefetching, buffering, exposes data layout

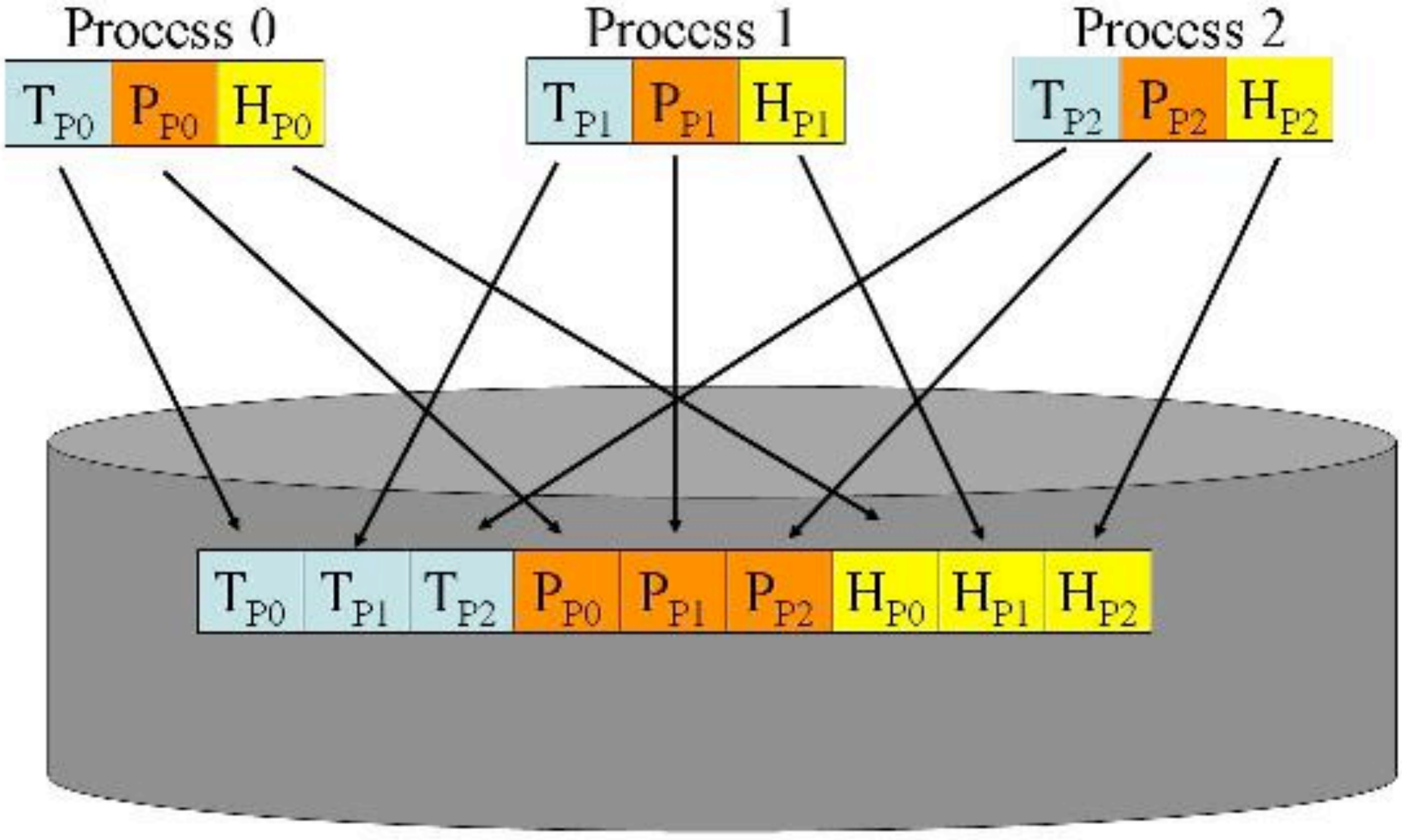
The two concurrent workloads

- IOR checkpointing workload
  - writes large amounts of data to disk from many clients
    - N-1 and N-N write patterns
- Hadoop MapReduce HTTP attack classifier (TFIDF)
  - Using a pre-generated attack model, classify HTTP headers as normal traffic or attack traffic

N-to-N example



N-to-1 strided example



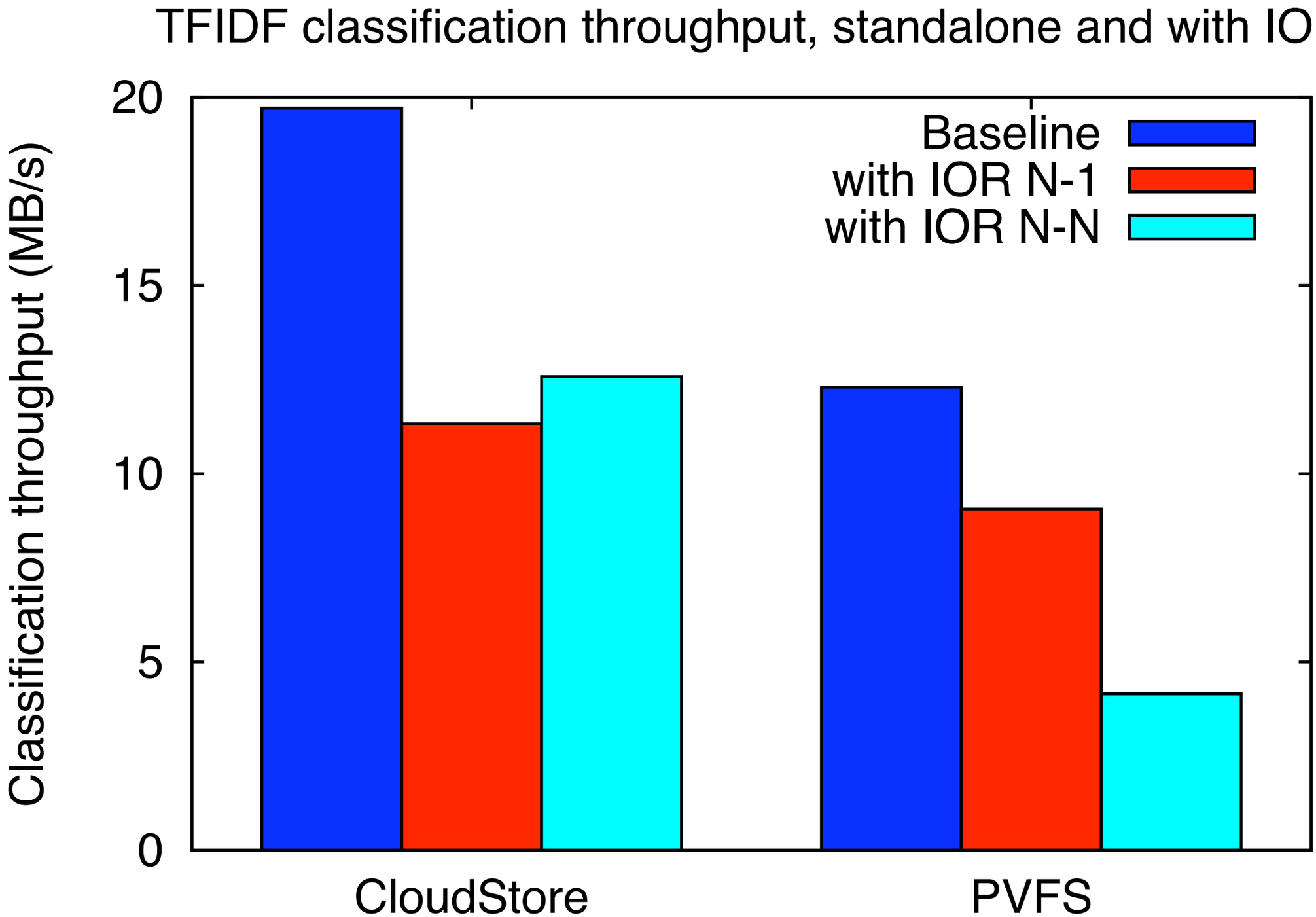
Experimental Setup

- System: 19 nodes, 2-core 2.4 GHz Xeon, 120 GB disks
- IOR baseline: N-1 strided workload, 64 MB chunks
- IOR baseline: N-N workload, 64 MB chunks
- TFIDF baseline: classify 7.2 GB of HTTP headers
- Mixed workloads:
  - IOR N-1 and TFIDF, IOR N-N and TFIDF
  - Checkpoint size adjusted to make IOR and TFIDF take the same amount of time

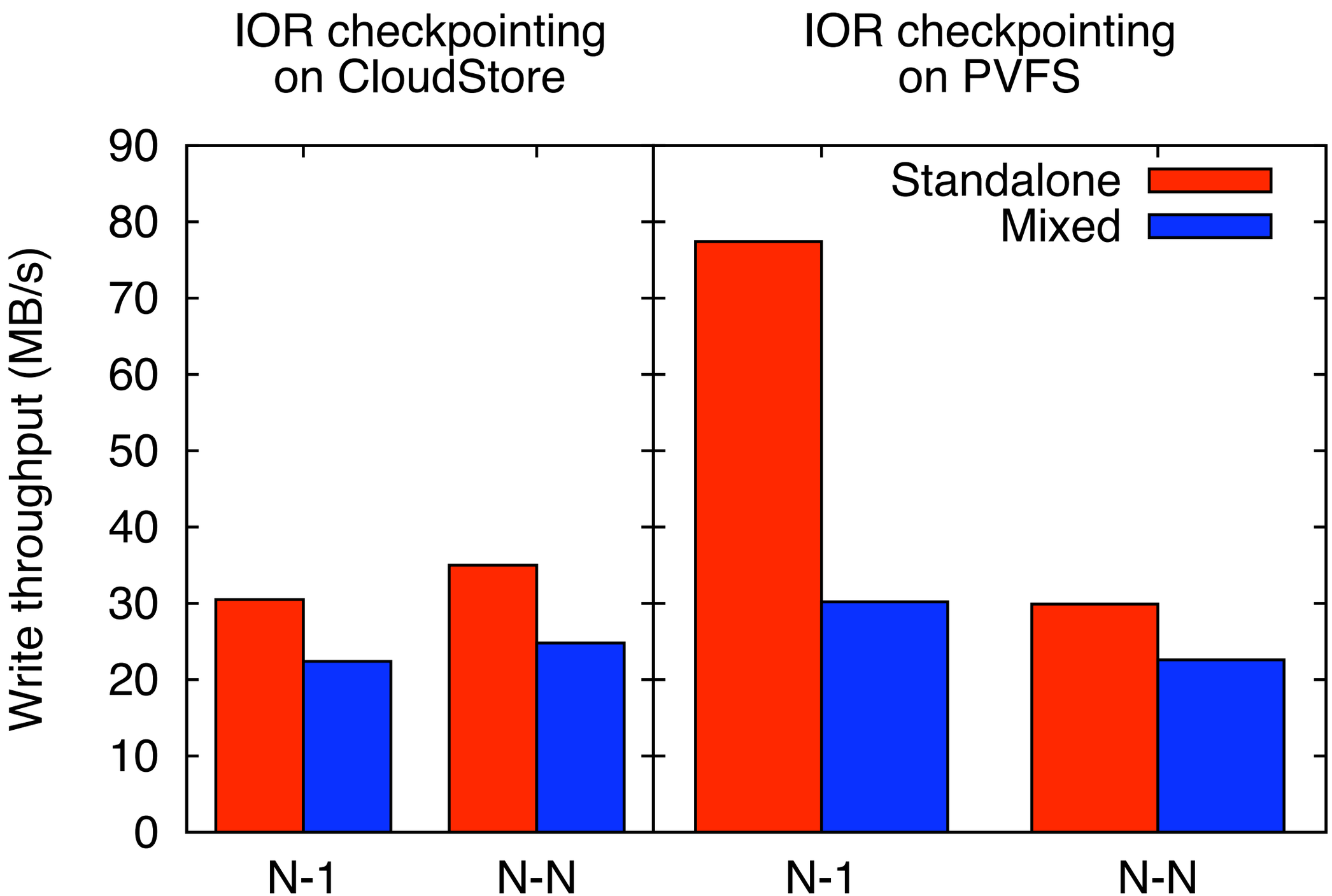
Performance metrics

- Throughputs are not comparable between workloads
- Per-workload throughput: measure how much each job is slowed down by the mixed workload
- Runtime: compare the runtime of the mixed workload with the runtime of the same jobs run sequentially

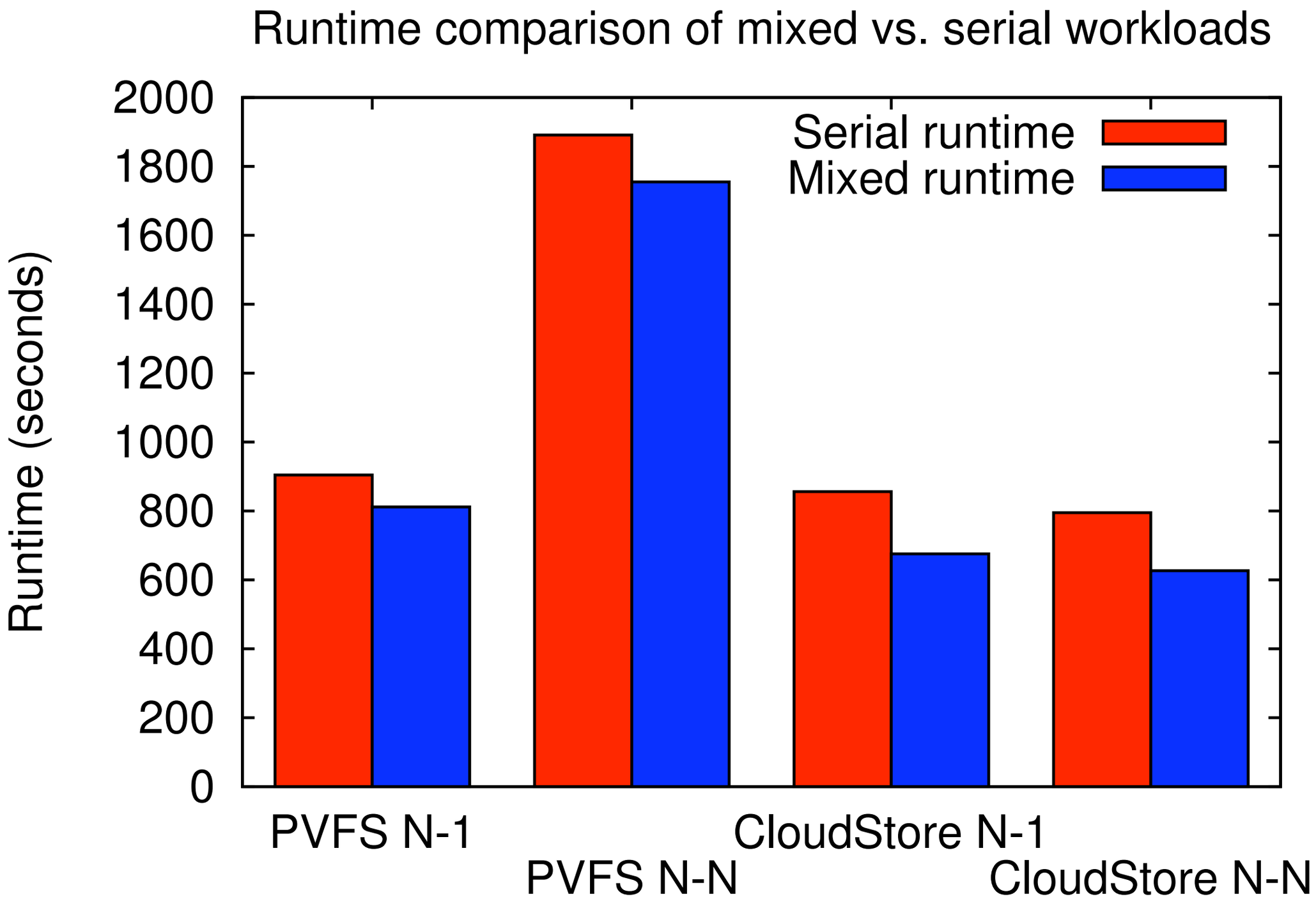
Hadoop performance results



IOR performance results



Runtime results

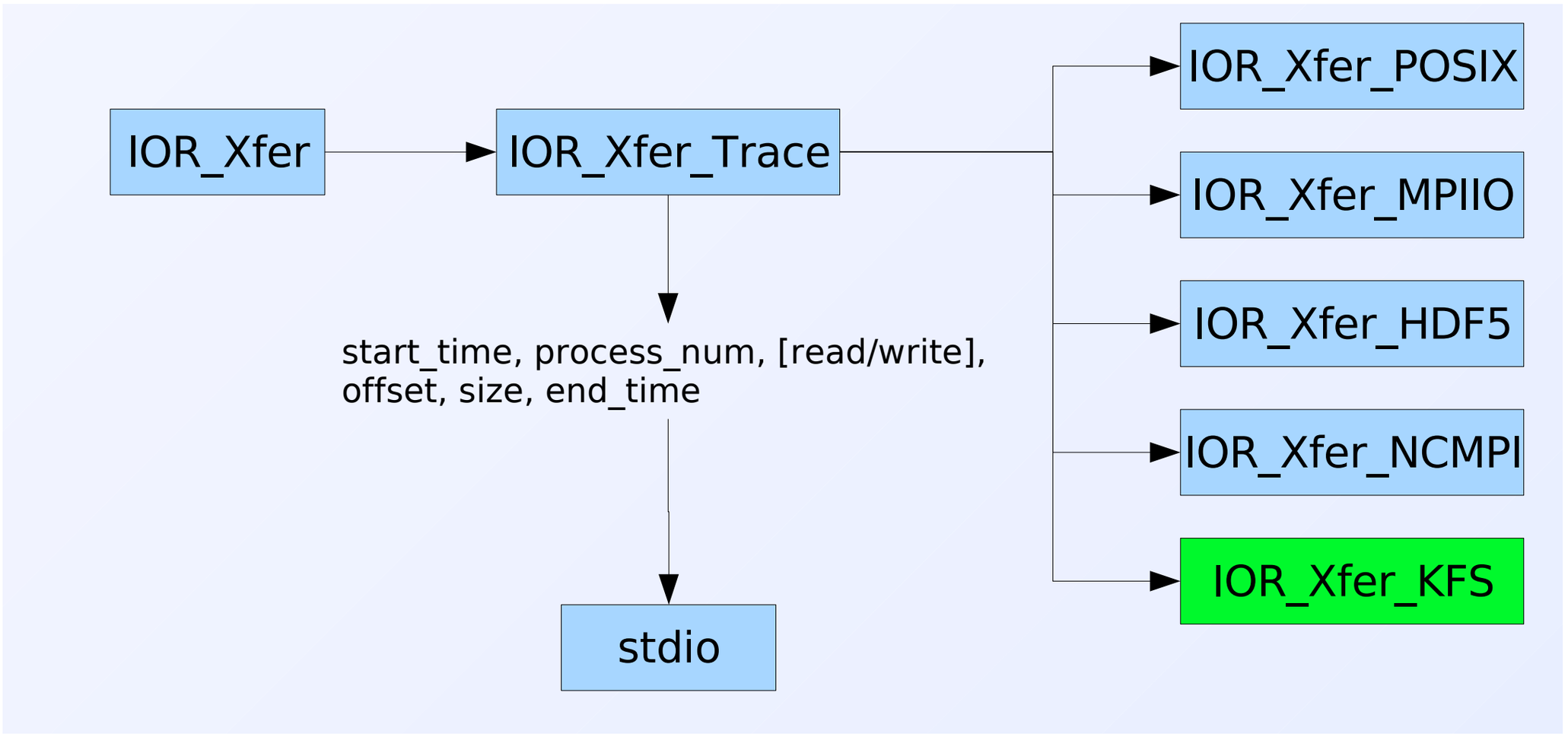


Tracing infrastructure

- We gather traces to use for our parallel filesystem simulator
- Existing tracing mechanisms (e.g. strace, Pianola, Darshan) don't work well with Java or CloudStore
- Solution: our own tracing mechanisms for IOR and Hadoop

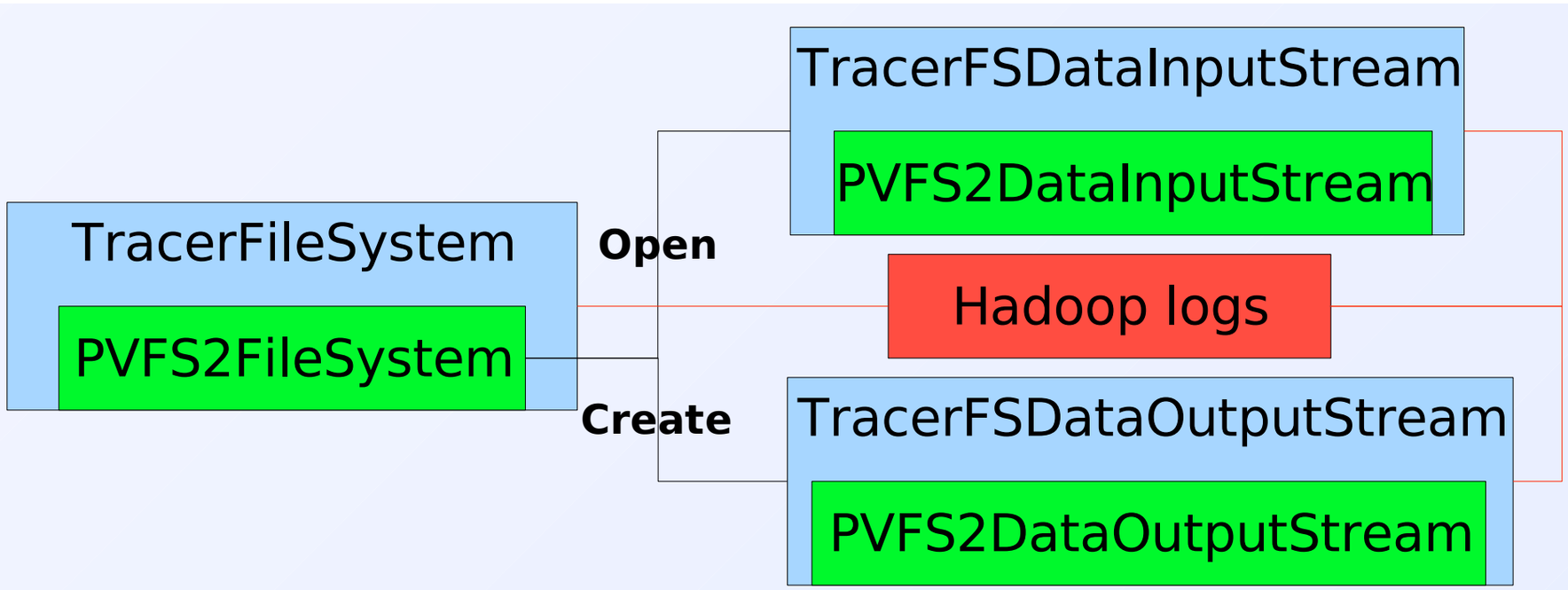
Tracing IOR workloads

- Trace shim intercepts I/O calls, sends to stdio



Tracing Hadoop

- Tracing shim wraps filesystem interfaces, sends I/O calls to Hadoop logs



Format: filename, pid, start_time, end_time, operation(param, ...) = result <elapsed ms>

Tracing overhead

- Trace data goes to NFS-mounted share (no disk overhead)
- Small Hadoop reads caused huge tracing overhead
  - Solution: record traces behind read-ahead buffers
- Overhead (throughput slowdown):
  - IOR checkpointing: 1%
  - TFIDF Hadoop: 5%
  - Mixed workloads: 10%

Conclusions

- Each mixed workload component is noticeably slowed, but...
- If only total runtime matters, the mixed workloads are faster
- PVFS shows different slowdowns for N-N vs. N-1 workloads
- Tracing infrastructure: buffering required for small I/O tracing
- Future work:
  - Run experiments at a larger scale
  - Use experimental results to improve parallel filesystem simulator
  - Investigate scheduling strategies for mixed workloads

Questions?

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