Okeanos: Wasteless Journaling for Fast and Reliable Multistream Storage

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Outline

Motivation

Design

Implementation

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Conclusions

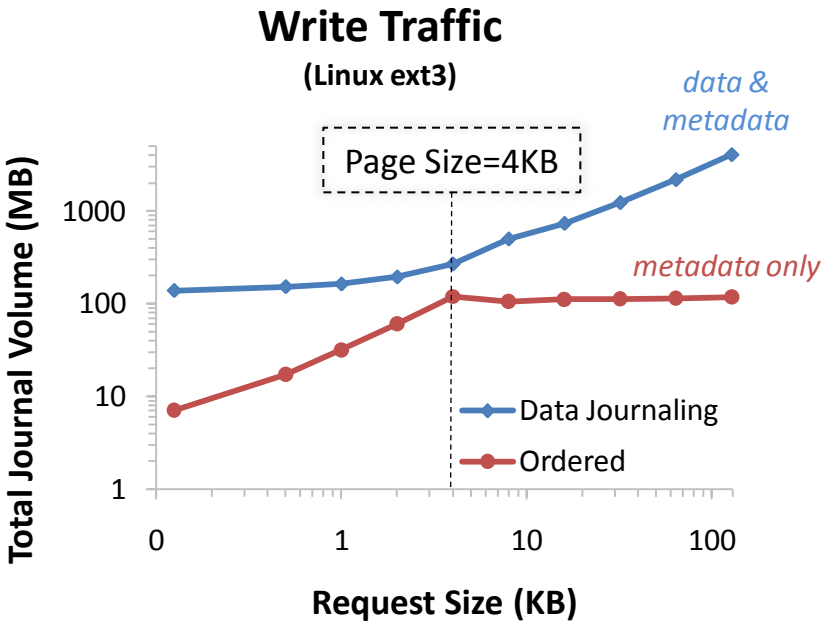
Motivation

Synchronous small writes

- critical for system and application reliability

Multistream concurrency

- effectively random I/O



In page-sized disk accesses

- async writes have good performance due to batching in memory
- sync writes result in wasteful traffic due to excessive full-page I/Os

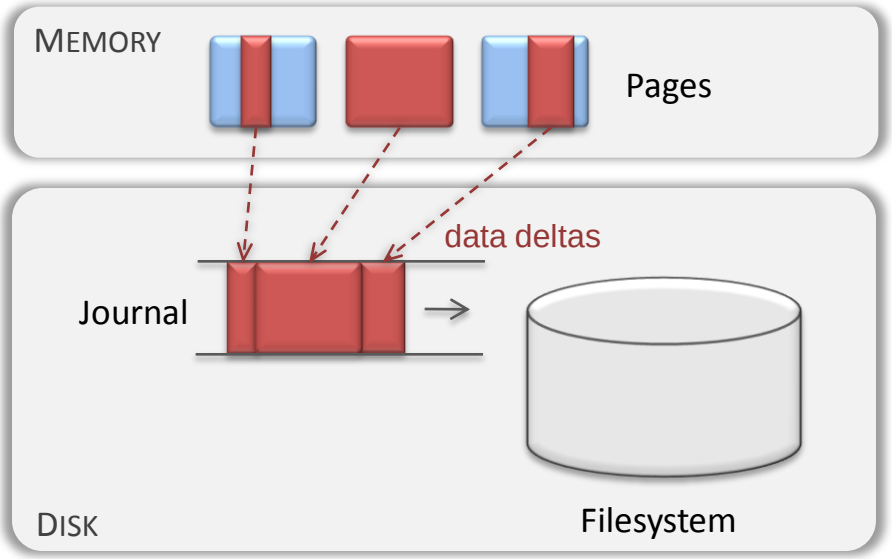
Design Goals

1. Reliable storage
   - keep data on disk
2. Inexpensive synchronous small writes
   - sequential disk throughput
3. Reduce disk bandwidth waste due to:
   - writes with high positioning overhead
   - unnecessary writes of unmodified data

Proposed approach:

- batch random small writes in memory
- journal data updates at subpage granularity

Wasteless Journaling



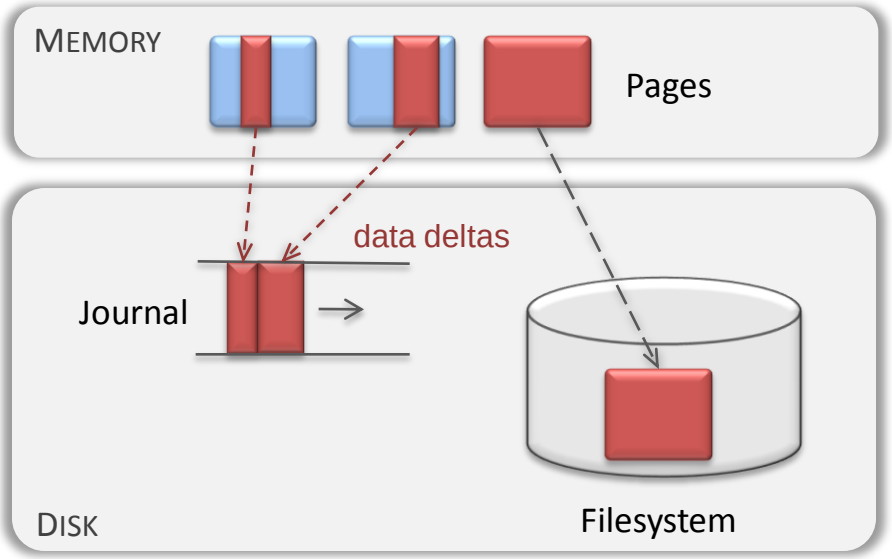
Idea:

1. Synchronously transfer data deltas from memory to journal
2. Occasionally move data blocks from memory to final location

Still wasteful!

- large writes → disk traffic duplication

Selective Journaling



Definition:

- write threshold differentiates requests by size

Idea:

1. Transfer large requests to final location without journaling of data
2. Treat small requests according to wasteless journaling

Consistency

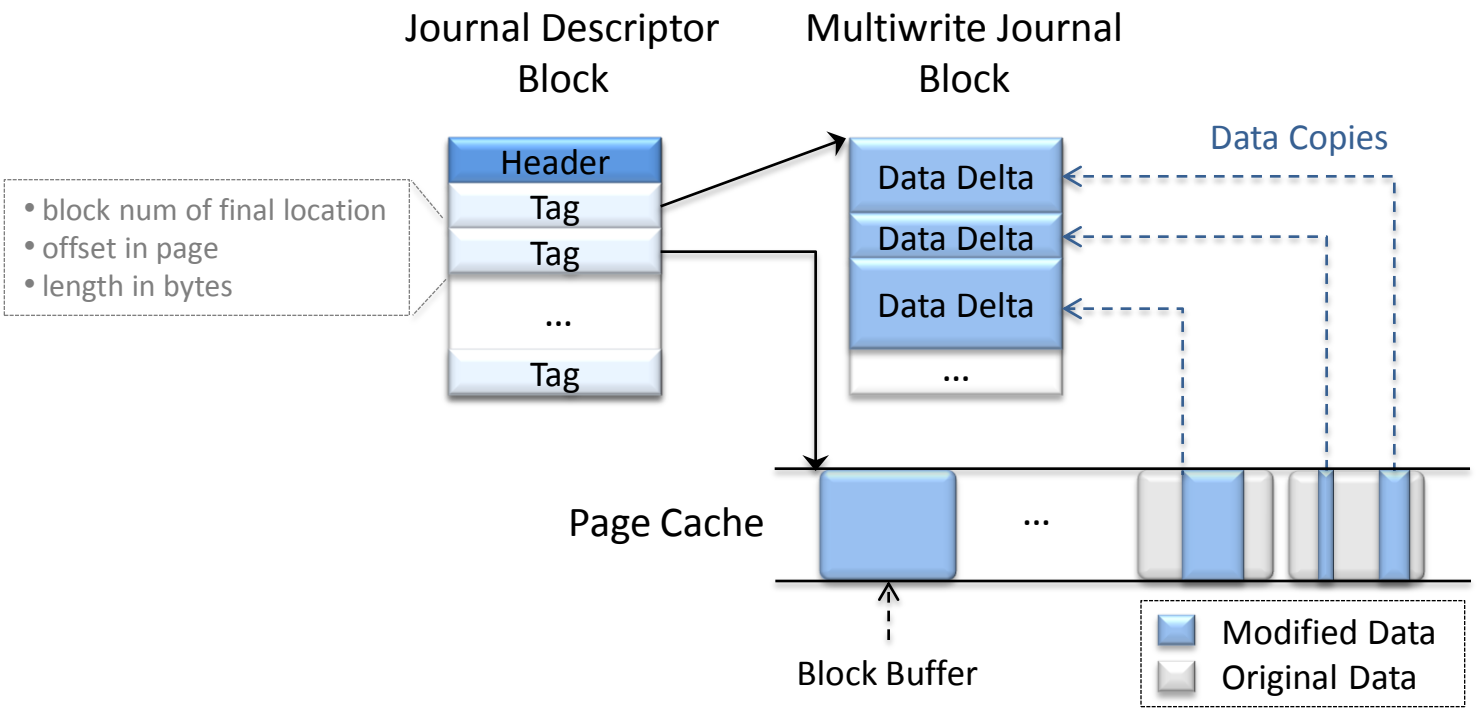
Wasteless Journaling:

- atomic updates of both data and metadata

Selective Journaling:

- data updates either journaled or not depending on request size
- consistency at least as strict as default ext3 journaling mode (ordered)

Prototype Implementation



Multiwrite journal block

- accumulates multiple subpage data updates

During recovery

- apply data deltas to corresponding final disk blocks

Experiments

Implemented in Linux kernel 2.6.18 ext3

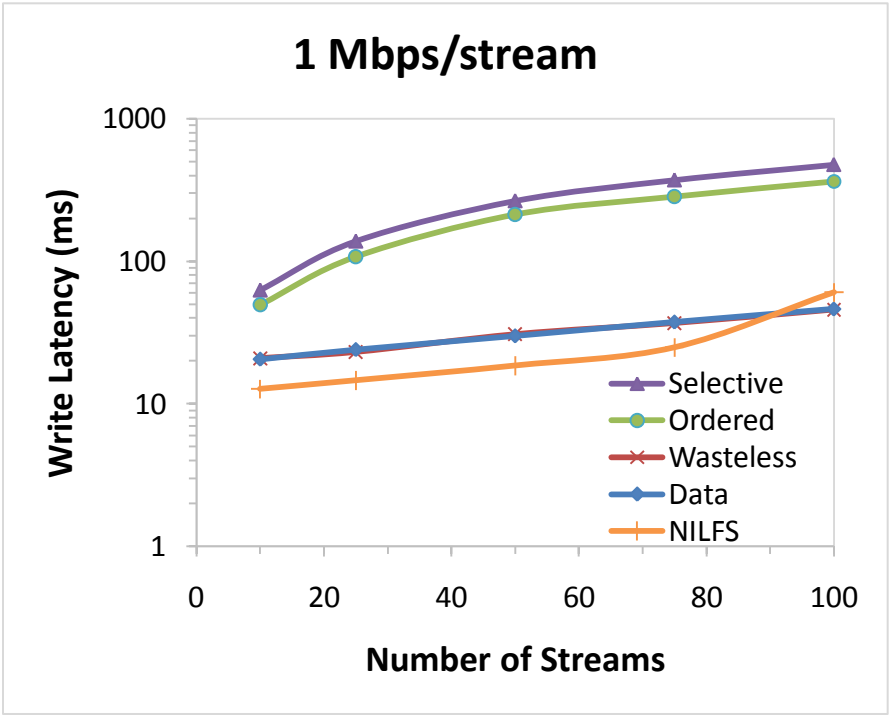
Experimentation Environment:

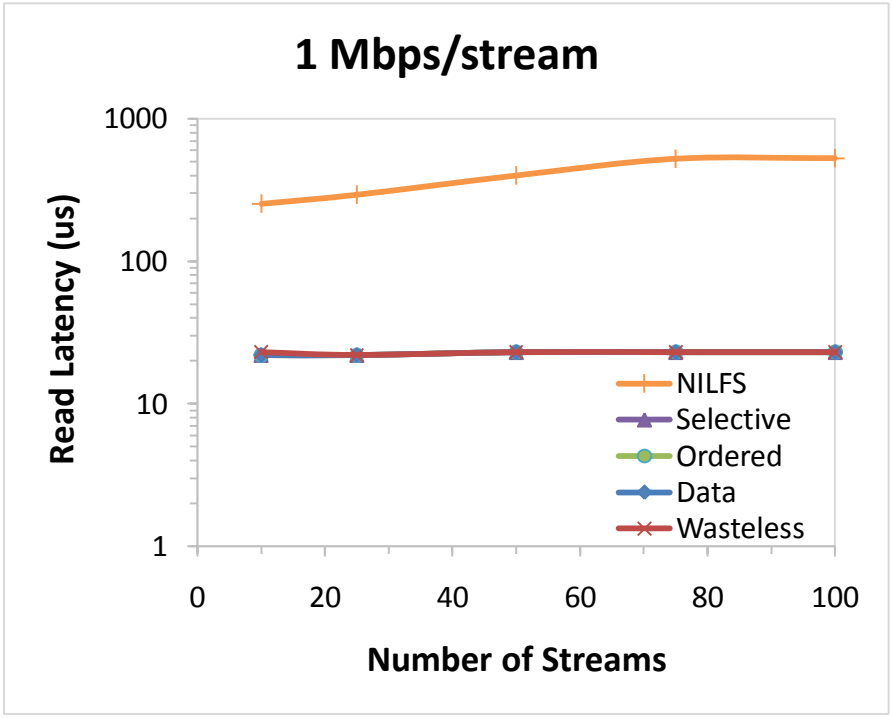
- x86-based servers
- quad-core 2.66GHz processor
- 3GB RAM
- Seagate Cheetah SAS 300GB 15KRPM disks

Workloads:

- Microbenchmarks
- Postmark
- MPIO-IO over PVFS2

Latency

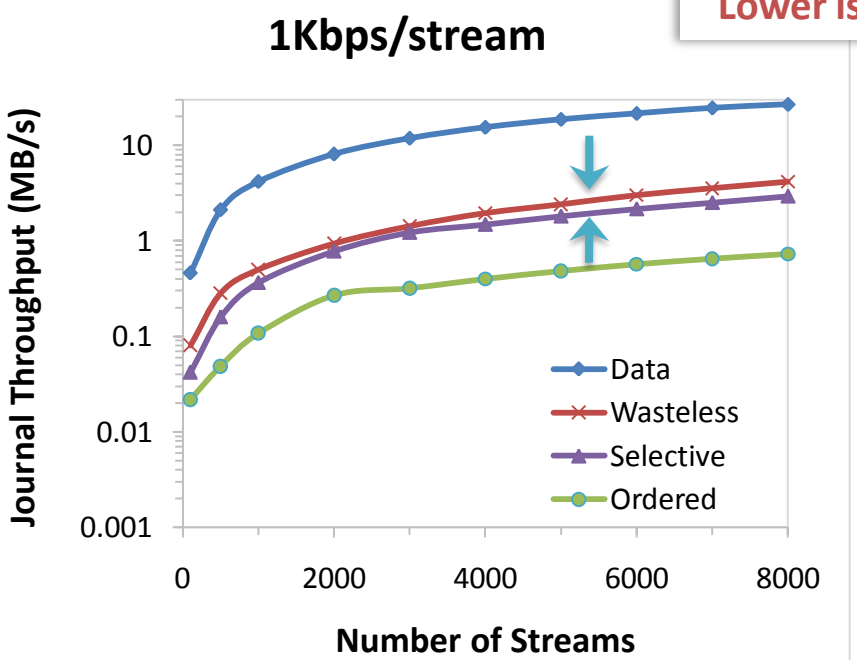


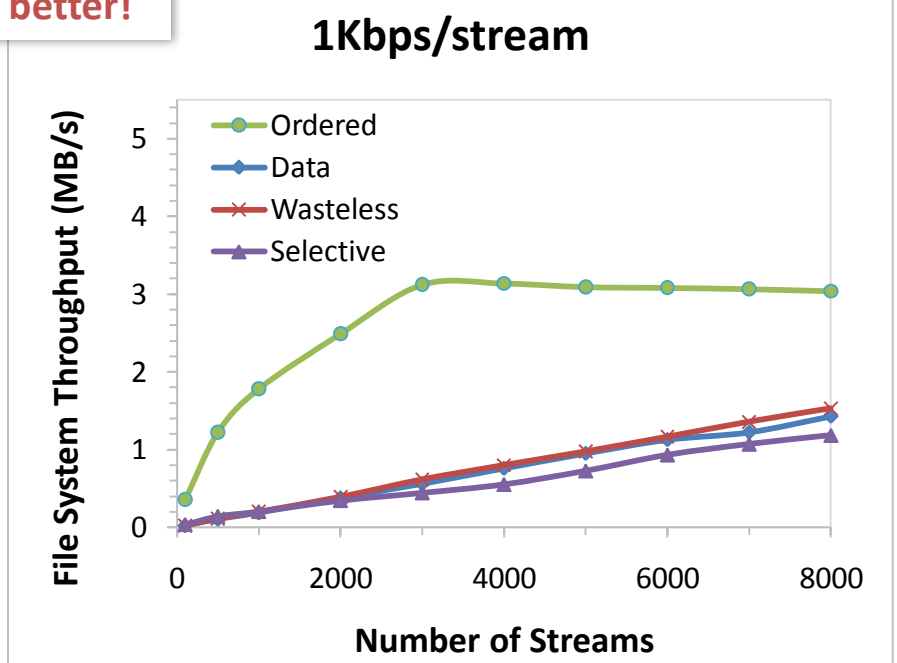


- Data & wasteless achieve substantially lower write latency
  - similar to NILFS (stable Linux port of LFS)
- NILFS read latency significantly higher due to poor storage locality!

Disk Traffic

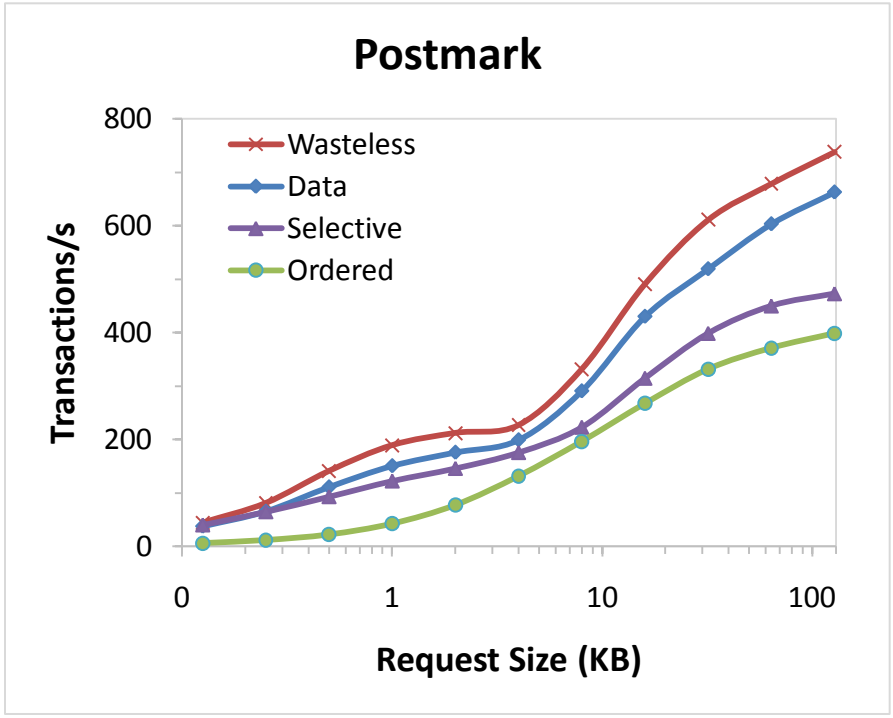
Lower is better!

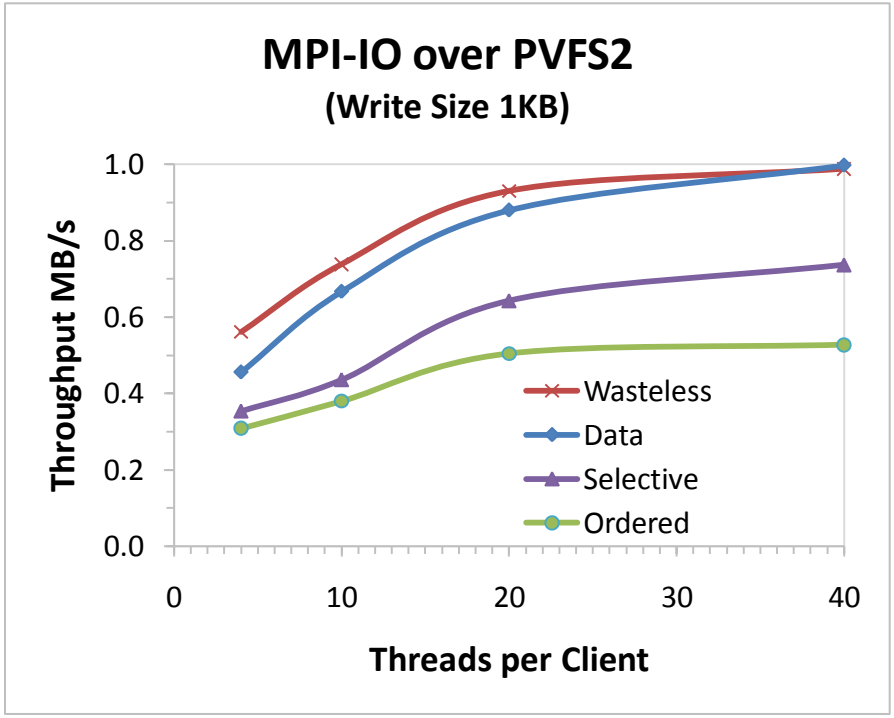




- Data journaling expensive in terms of journal traffic
- Ordered journaling incurs increased filesystem traffic
- Wasteless & selective substantially reduce journal and filesystem traffic

Application-Level Workloads





- Small files workload
  - wasteless increases transaction throughput
- Parallel I/O workload
  - 13 clients, 1 PVFS2 data server, 1 PVFS2 metadata server (15 machines)
  - wasteless doubles the throughput of parallel application checkpointing

Conclusions & Future Work

Key concept:

- apply subpage journaling of data updates to ensure reliability

Wasteless Journaling

- merges subpage writes into page-sized journal blocks

Selective Journaling

- journals only updates below a write threshold

Performance benefits demonstrated over ext3:

- reduced write latency
- improved transaction throughput
- avoided bandwidth waste

Future Work

- extent for virtualization environments and flash memory systems