Okeanos: Wasteless Journaling for Fast and Reliable Multistream Storage

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Outline

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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 $\rightarrow$ 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 15K RPM 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!
- 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