# Host-side Filesystem Journaling for Durable Shared Storage

Andromachi Hatzieleftheriou, Stergios V. Anastasiadis

Department of Computer Science & Engineering

University of Ioannina, Greece

# Outline

Motivation

Design

Implementation

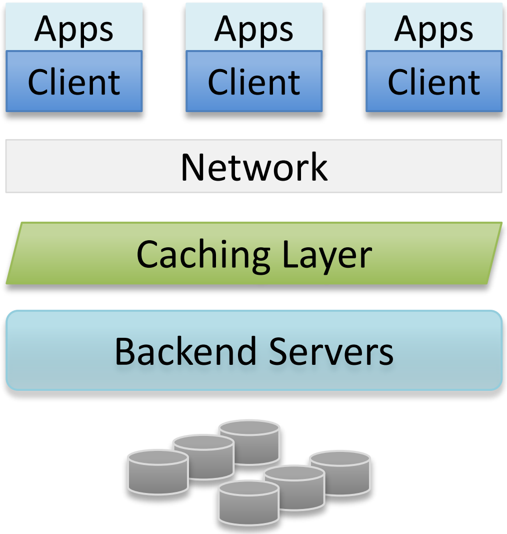
Evaluation

Conclusions

# Datacenter Storage

Multi-tier distributed systems on clusters of commodity servers and disk drives

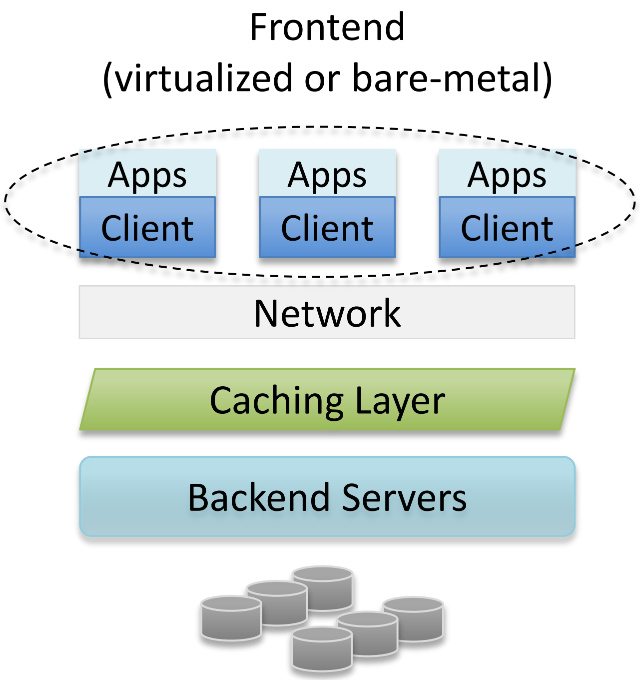
- client-side frontend
- caching layer
- backend storage



# Datacenter Storage

Multi-tier distributed systems on clusters of commodity servers and disk drives

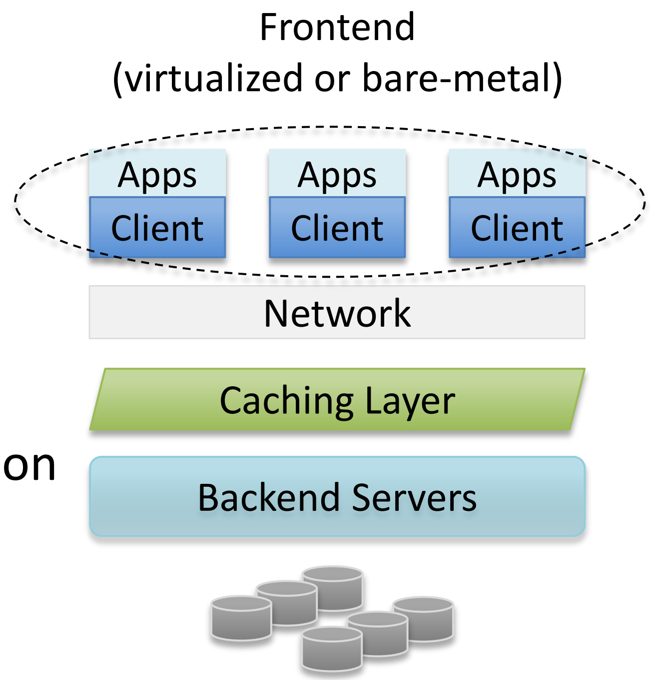
- client-side frontend
- caching layer
- backend storage



# Datacenter Storage

## Multi-tier distributed systems on clusters of commodity servers and disk drives

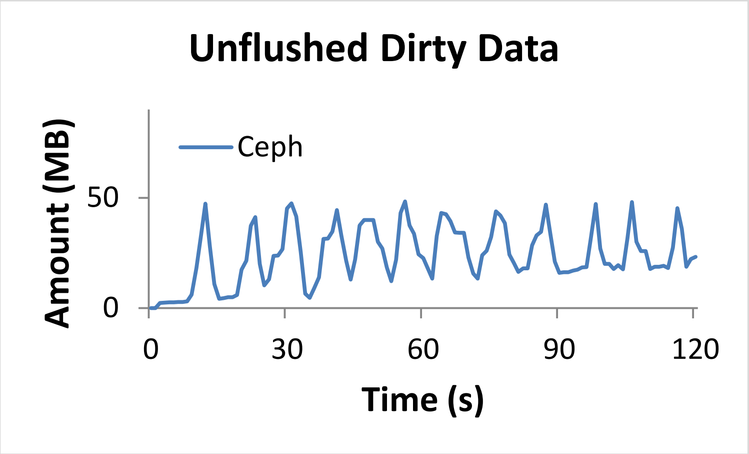
- client-side frontend
- caching layer
- backend storage




## Frontend tier: client-side

- stateless for reduced cross-layer communication
- recent updates kept in volatile memory
- lost data in case of client failure/reboot

# Representative System




## Ceph object-based scale-out file system

- client-side memory-based caching

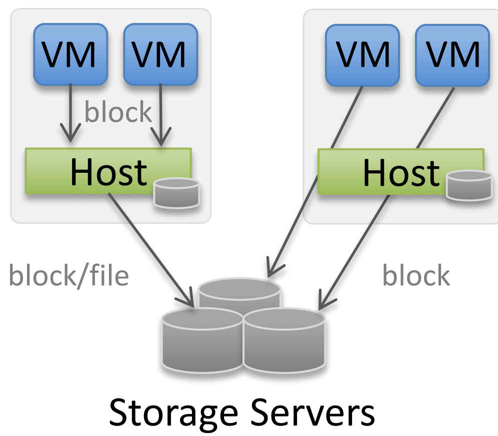
## Experiment

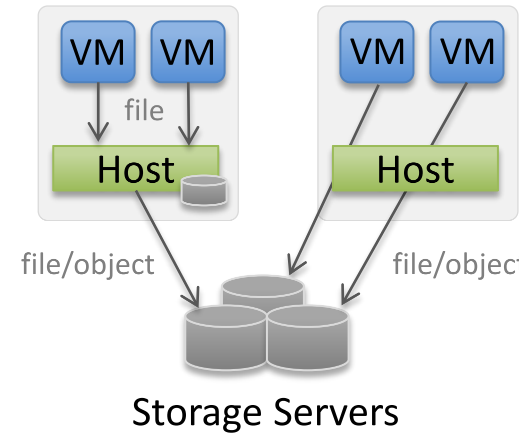
- Filebench fileserver
- writeback every 5 sec dirty data older than 30 sec (default)

## Outcome

- on average, 24.3MB of dirty data only in volatile memory over time

# Storage Interfaces




## Block-based

- ✓ virtualization flexibility
- × no sharing
- × translation overhead
- × semantic gap

## File-based

- ✓ file sharing
- ✓ improved performance
- ✓ semantics awareness
- × compatibility limitations

## Object-based

- ✓ scalability

# The Problem of Block-based Caching

## Strengths

Performance
- improved throughput
- reduced latency

Efficiency
- reduced server & network load

## Weaknesses

Functionality
- no file sharing

Overhead
- translation overhead
- metadata persistence

Consistency
- semantic gap
- ordering of requests
- grouping of operations

# Key Insight

## Improve

- the durability of the memory-based cache at the client of shared storage systems

## Gain

- performance
- efficiency

# Design Goals

## Interface

- POSIX-like file-based interface

## Sharing

- native file-sharing support within and across hosts

## Durability

- recent updates survive client reboots

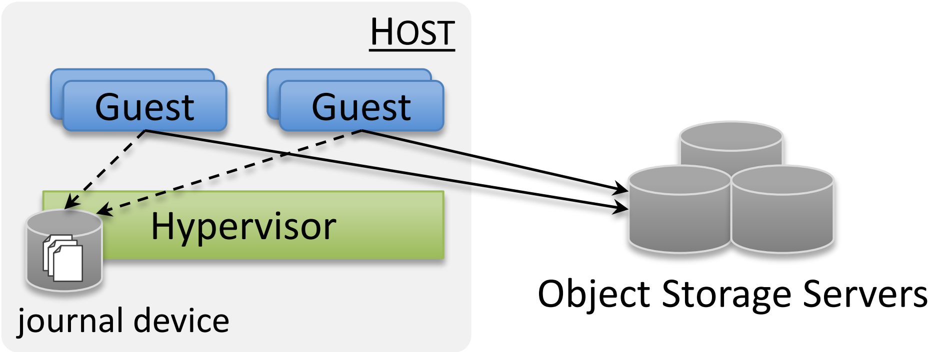
## Performance

- sequential disk throughput for writes

## Scalability

- scale-out backend servers

# The Arion System Architecture



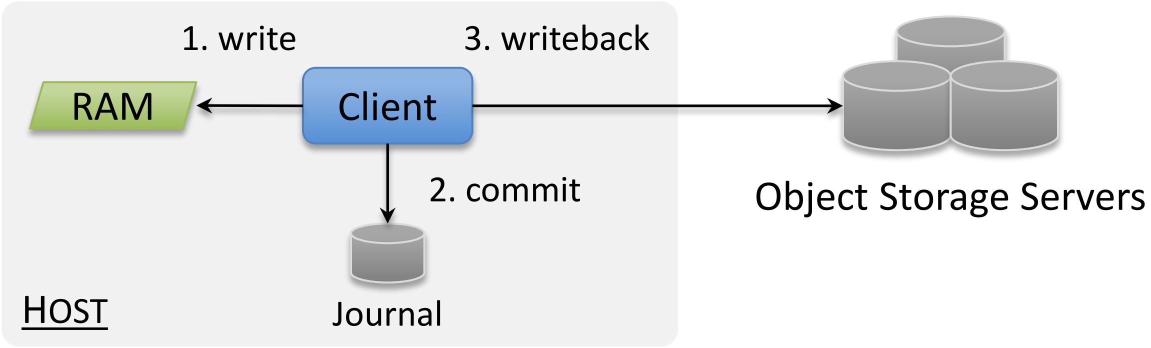

## Distributed filesystem

- object-based
- multiple data & metadata servers
- virtualized <u>or</u> bare-metal client
- multiple backend replicas

## Local journal at the client-side

- heterogeneous replication
- reliable directly attached storage
- log both data and corresponding metadata
- one journal per client

# Journaling and Writeback




## Local journal device attached to client at mount-time

## Commit

- synchronously transfer data updates from memory to journal
- periodically or explicit flush request

## Writeback

- occasionally copy data blocks from memory to filesystem servers
- periodically, under memory or journal space pressure

## Written-back and invalidated pages removed from journal

# Consistency

Shared file access with tokens

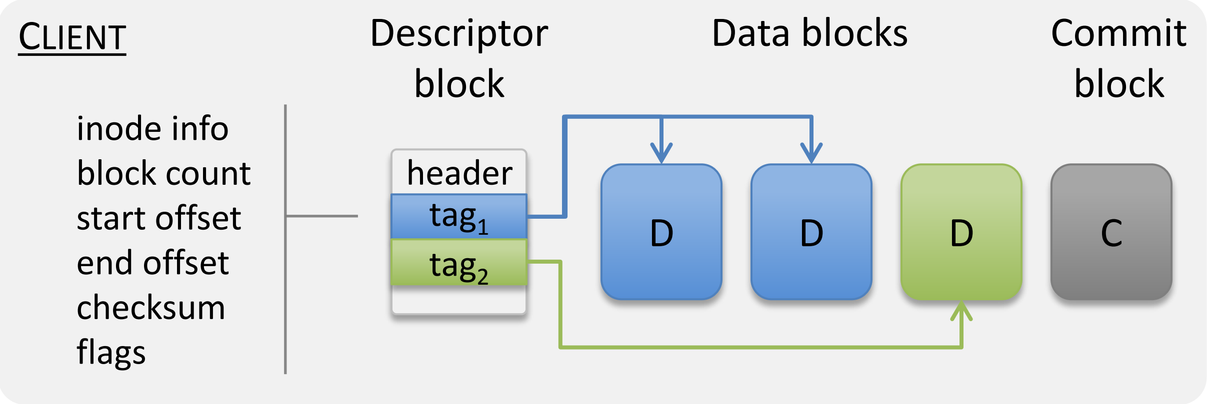
Normal operation - conflicting writes from different clients

- checkpoint pending writes
- invalidate related journal entries
- revoke write token

Failure - client reconnection or reboot after a crash

- acquire required tokens
- replay file updates only if journaled metadata is newer than metadata fetched from the server

# Implementation




## Prototype implementation

- CephFS kernel-level client (Linux kernel v3.6.6)
- Linux JBD2

## During commit

- include metadata attributes in the journal tags of the descriptor block

## During recovery

- compare journaled metadata attributes with those newly fetched from MDS
- replay writes only for files not accessed after the transaction commit

# Experiments

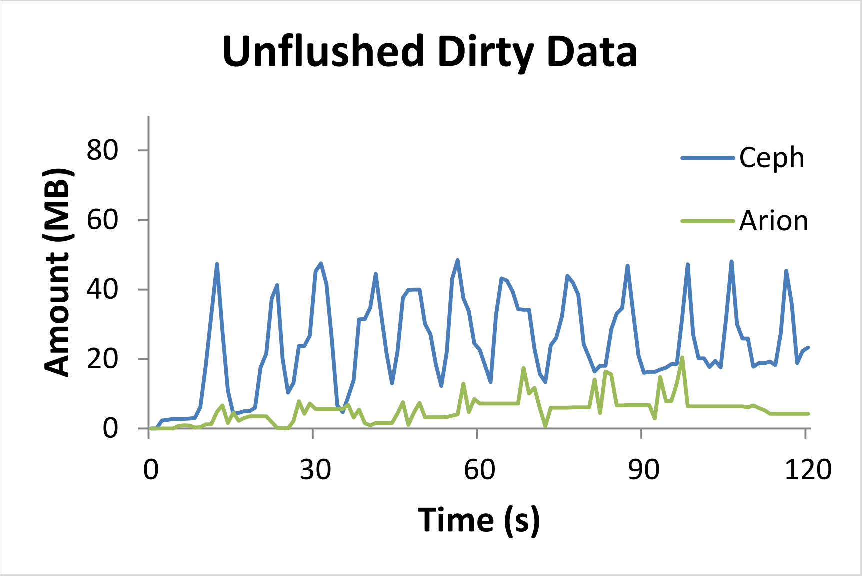
## Experimentation Environment:

- Backend Servers - Ceph v0.80.1 (3 OSDs, 1 MON, 1 MDS)
  - 3GB RAM, 2 x 300GB 15KRPM SAS disks, 2 x quad-core x86-64 2.66GHz
  - separate OSD journal device
  - replication factor 3
- Virtualized client
  - 2GB RAM, 2 x VCPUs
  - journal size 2GB, commit interval 1s
- Host - XEN v4.2.0
  - 2 x 300GB 15KRPM SAS disks (RAID0), 2 x quad-core x86-64 2.66GHz

## Workloads

- Filebench fileserver & mail server
- Flexible I/O Tester

# Filebench Fileserver

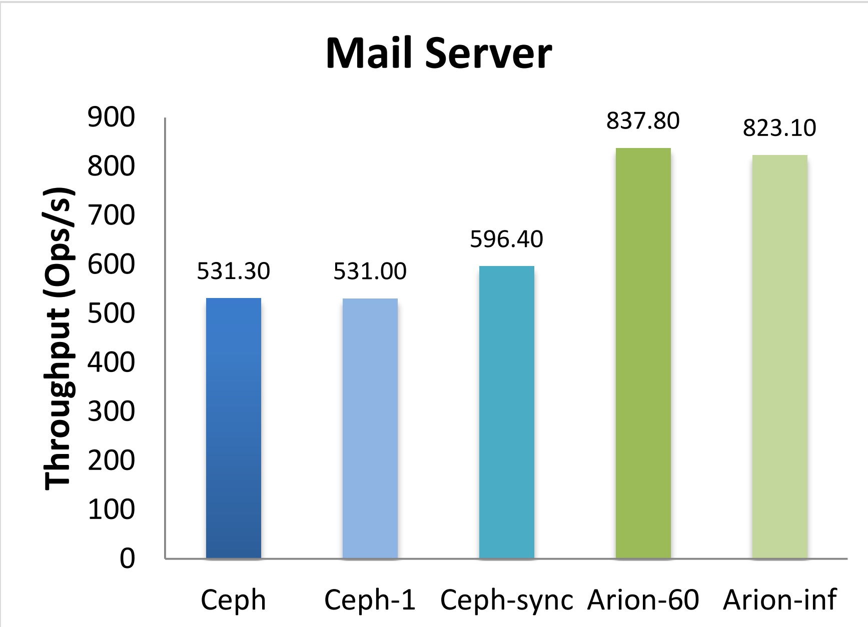


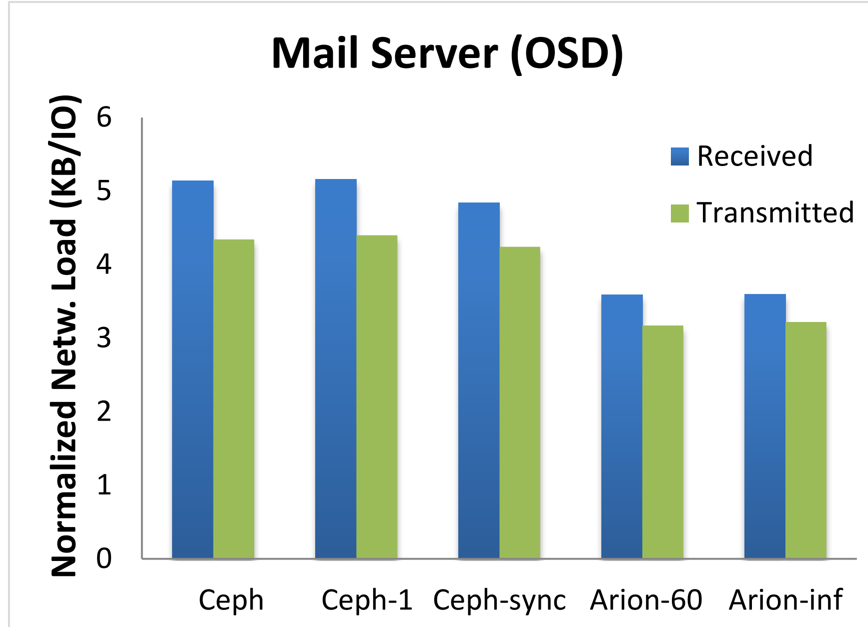

Arion flushes dirty data to local journal every second

Reduced amount of vulnerable data in memory

- from 24.3MB to 5.4MB over time

# Filebench Mail Server



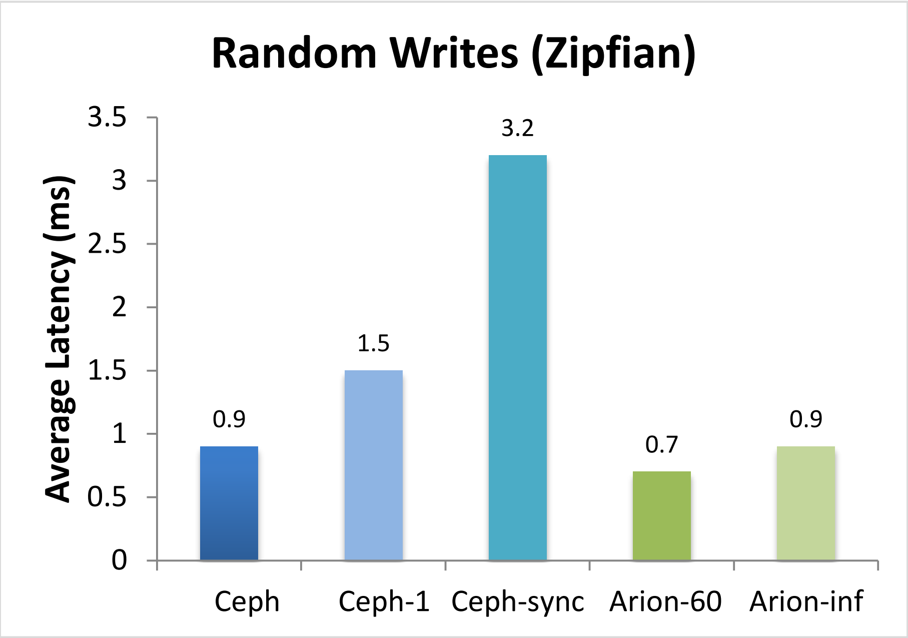

Varying writeback and expiration intervals

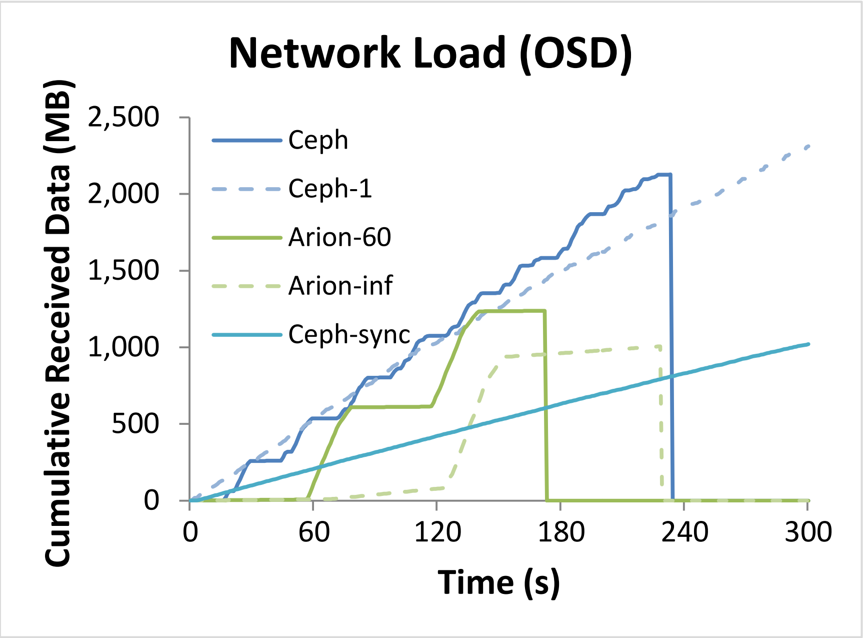
Arion achieves up to 58% higher operation throughput than Ceph

OSD network traffic normalized by the number of completed operations

- 30% reduction of the received network load
- 27% reduction of the transmitted network load

# Flexible IO Tester

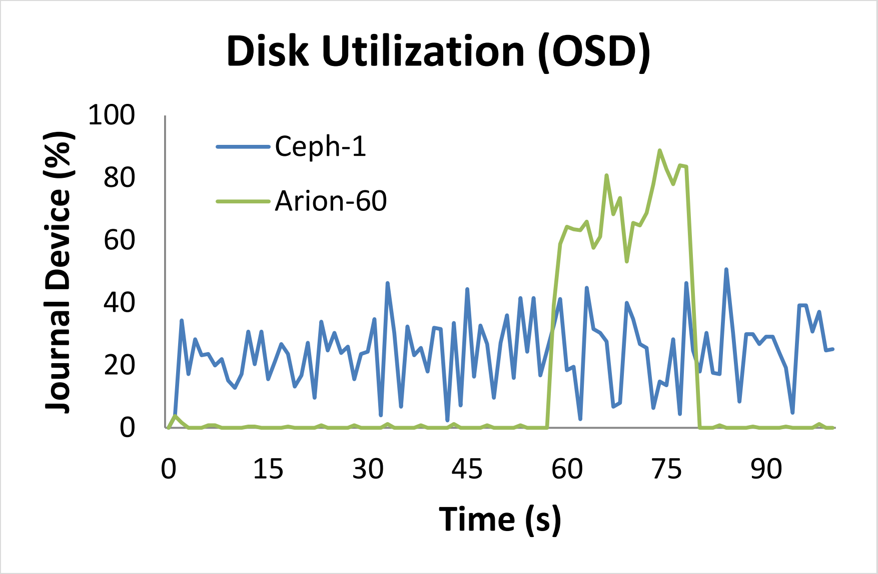


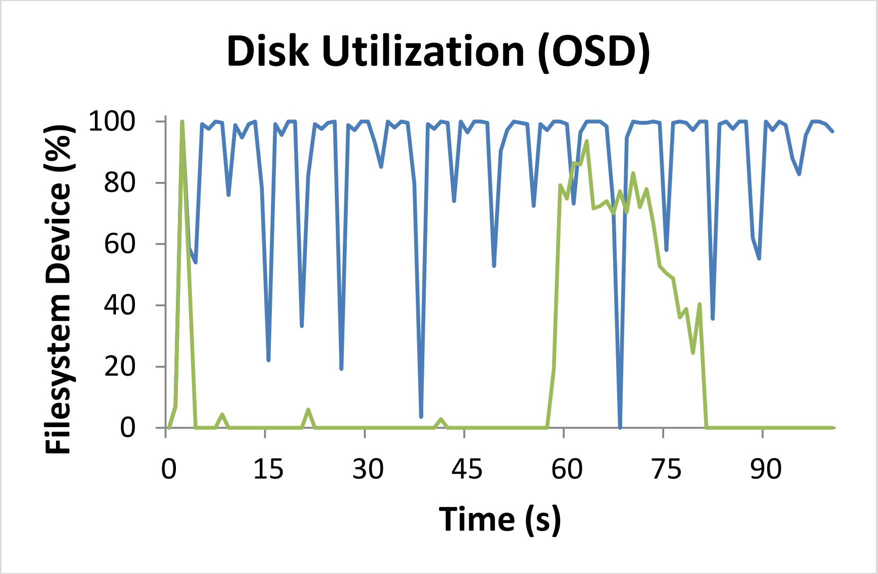




Arion-60 achieves 22% reduced write latency

Received OSD network traffic reduced by 42%

# Flexible IO Tester




## Reduced disk utilization at the servers

- filesystem device utilization reduced by 82%

# Conclusions & Future Work

Durable shared storage through host-side journal integration at the client of a distributed filesystem

Tunable control over

- amount of dirty pages staged at the host
- time period for dirty pages to reach the backend servers

Benefits

- improved durability of frontend memory caching
- increased performance
- resource efficiency (network & disk)

Future work

- further experimentation
- extend host-based journaling to support disk-based caching