Hyper Converged Cache For Cloud Storage

02/2017

Agenda

- **Introduction**
- Hyper Converged Cache
- Hyper Converged Cache Architecture
  - Overview
  - Design details
  - Performance overview
  - Current progress and roadmap
- Hyper Converged Cache with Optane technology
- Summary

Introduction

- Intel Cloud computing and Big Data Engineering Team
- Open source @ Spark, Hadoop, OpenStack, Ceph, NoSQL etc.
- Working with community and end customers closely
- Technology and Innovation oriented
  - Real-time, in-memory, complex analytics
  - Structure and unstructured data
  - Agility, Multi-tenancy, Scalability and elasticity
  - Bridging advanced research and real-world applications

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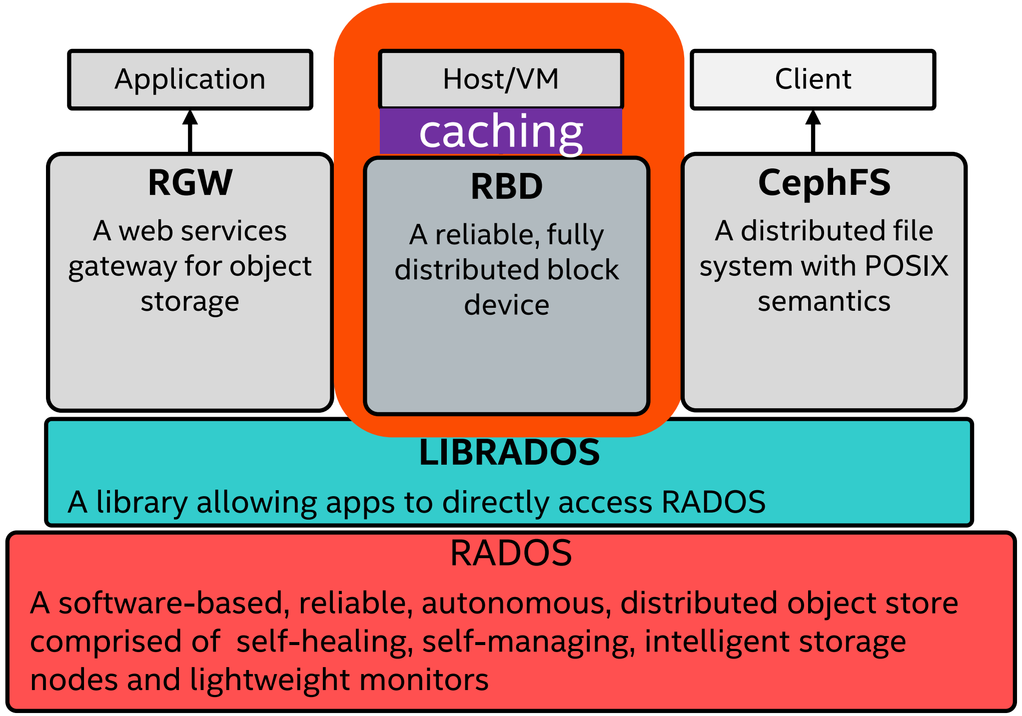
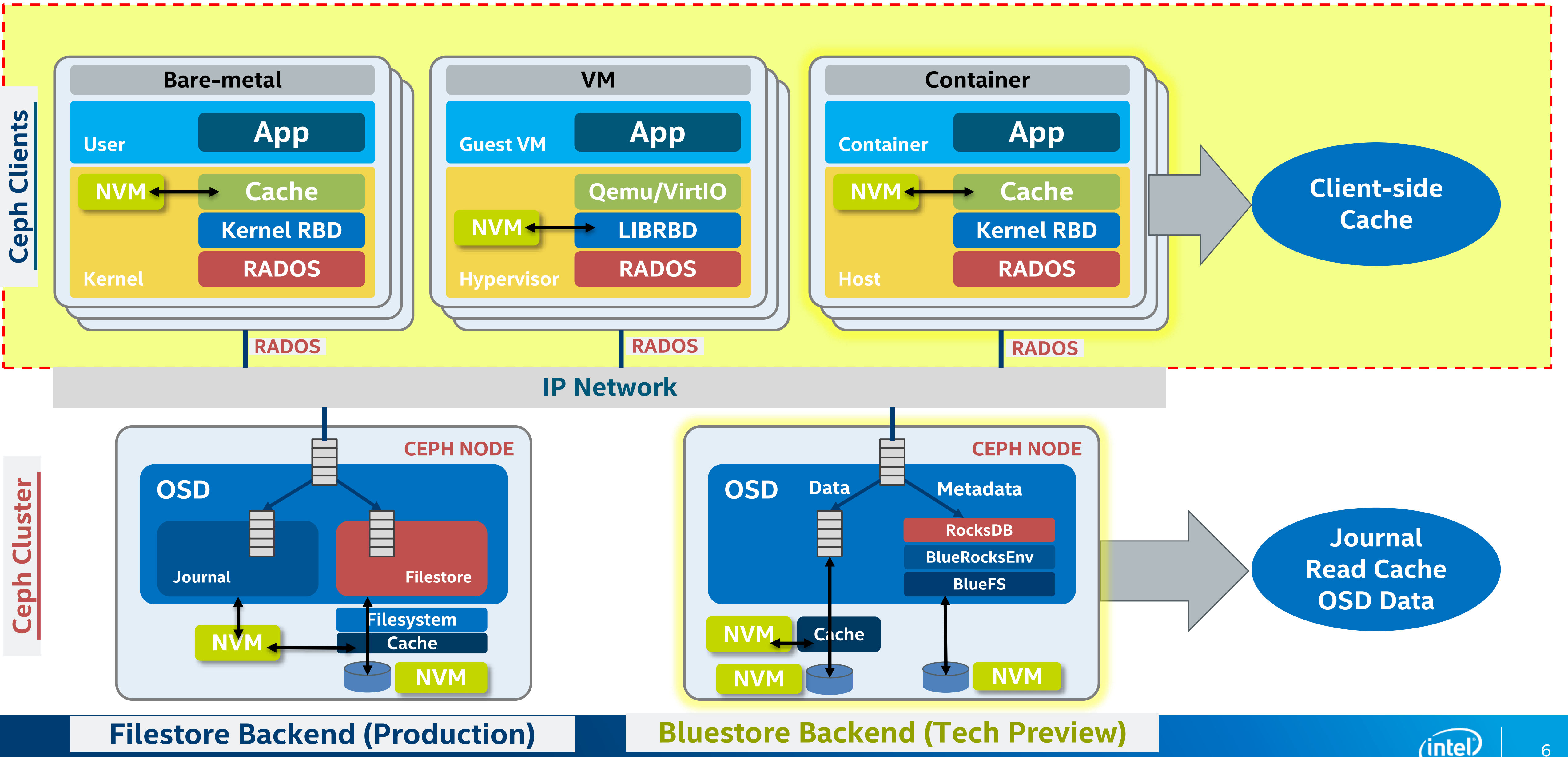
Hyper Converged Cache

- A strong demands for SSD caching in Ceph cluster
- Ceph SSD caching performance has gaps
  - Journal, Cache tiering, Flashcache/bCache not work well
- Long tail latency is big issue for workloads such as OLTP
  - Need a caching layer to reduce IO path dependency on the network

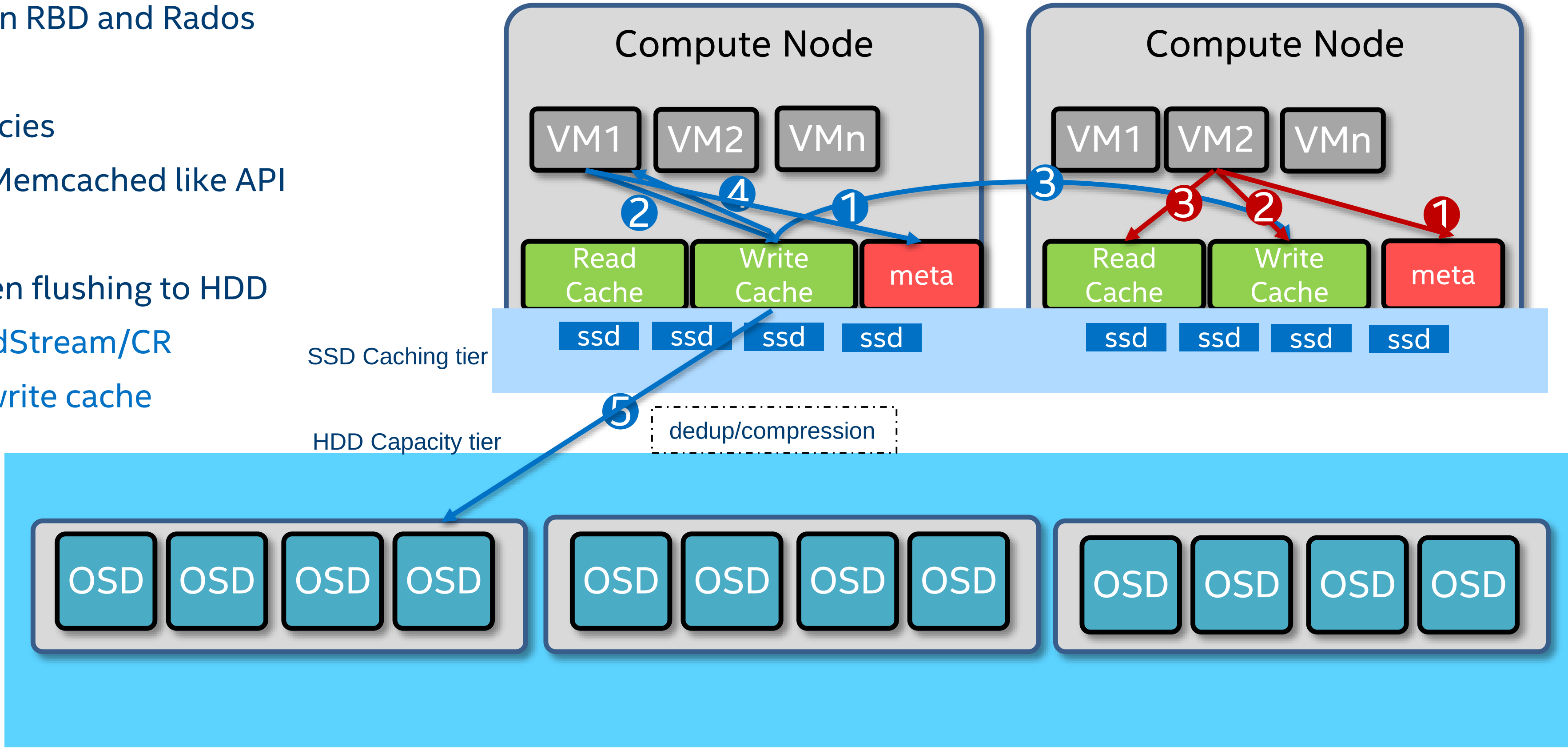


Ceph caching solutions on SSDs



Hyper Converged Cache Overview

- Client Side cache: caching on compute node
  - Local read cache and distributed write cache
  - Independent cache layer between RBD and Rados
- Extensible Framework
  - Pluggable design/cache policies
  - General caching interfaces: Memcached like API
- Data Services
  - Deduplication, Compression when flushing to HDD
- Value add feature designed for ColdStream/CR
  - Log-structure object store for write cache



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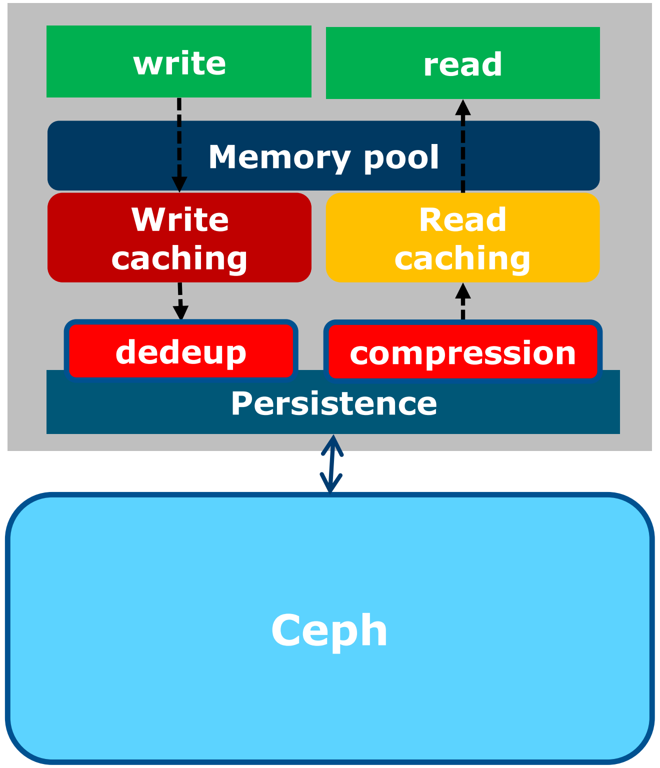
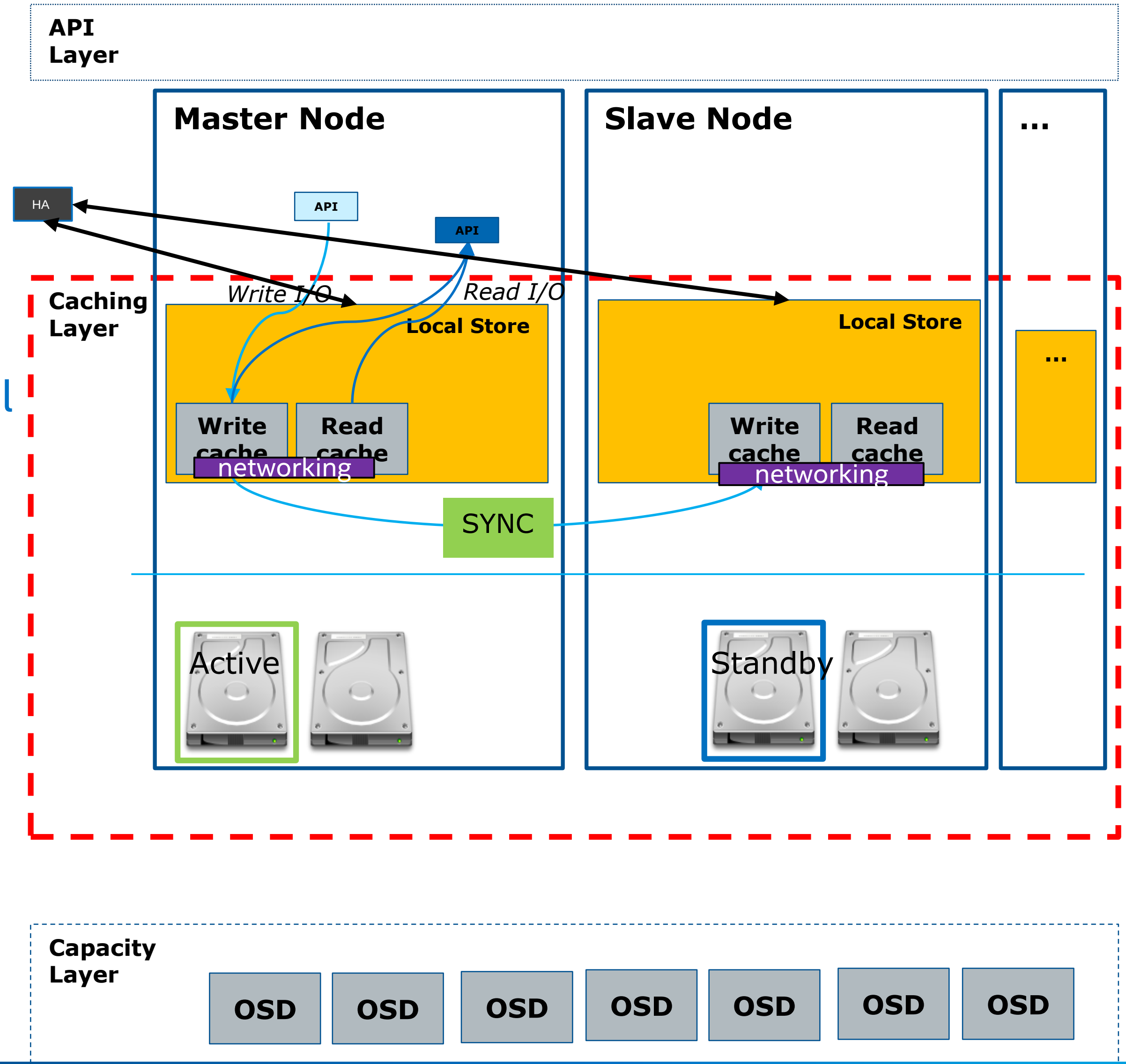
Hyper Converged Cache: General architecture

- Building a hyper-converged cache solutions for the cloud
  - Started with Ceph*
  - Block cache, object cache, file cache
  - Replication architecture
- Extensible Framework
  - Pluggable design/cache policies
  - Support third-party caching software
- Advanced data services:
  - Compression, deduplication, QOS
- Value added feature for future SCM device



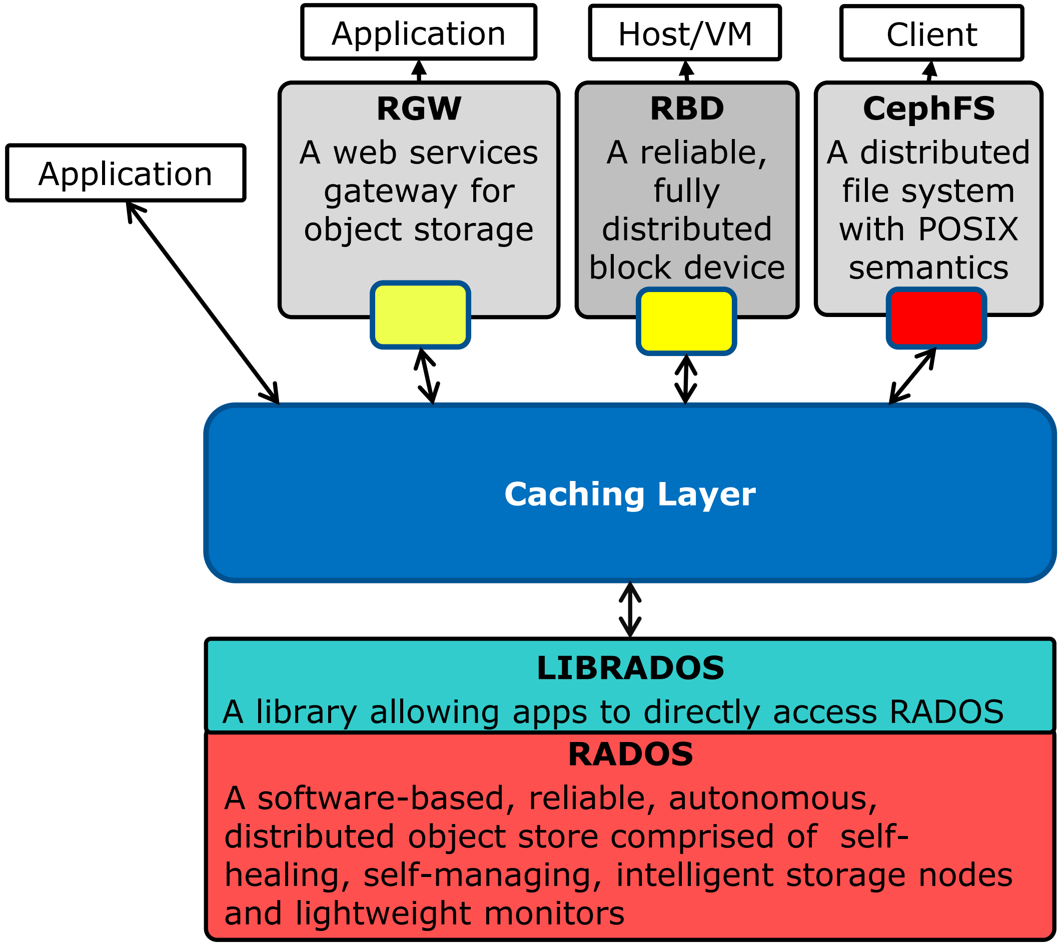
Hyper Converged Cache: Design details

- Generic interfaces:
  - **RBD**, RGW and Cephfs
- Master/Slave architecture:
  - Two hosts are required in order to provide physical redundancy
- Advanced service: dedup, compression, QoS, optimized with caching semantics



Hyper Converged Cache: API layer

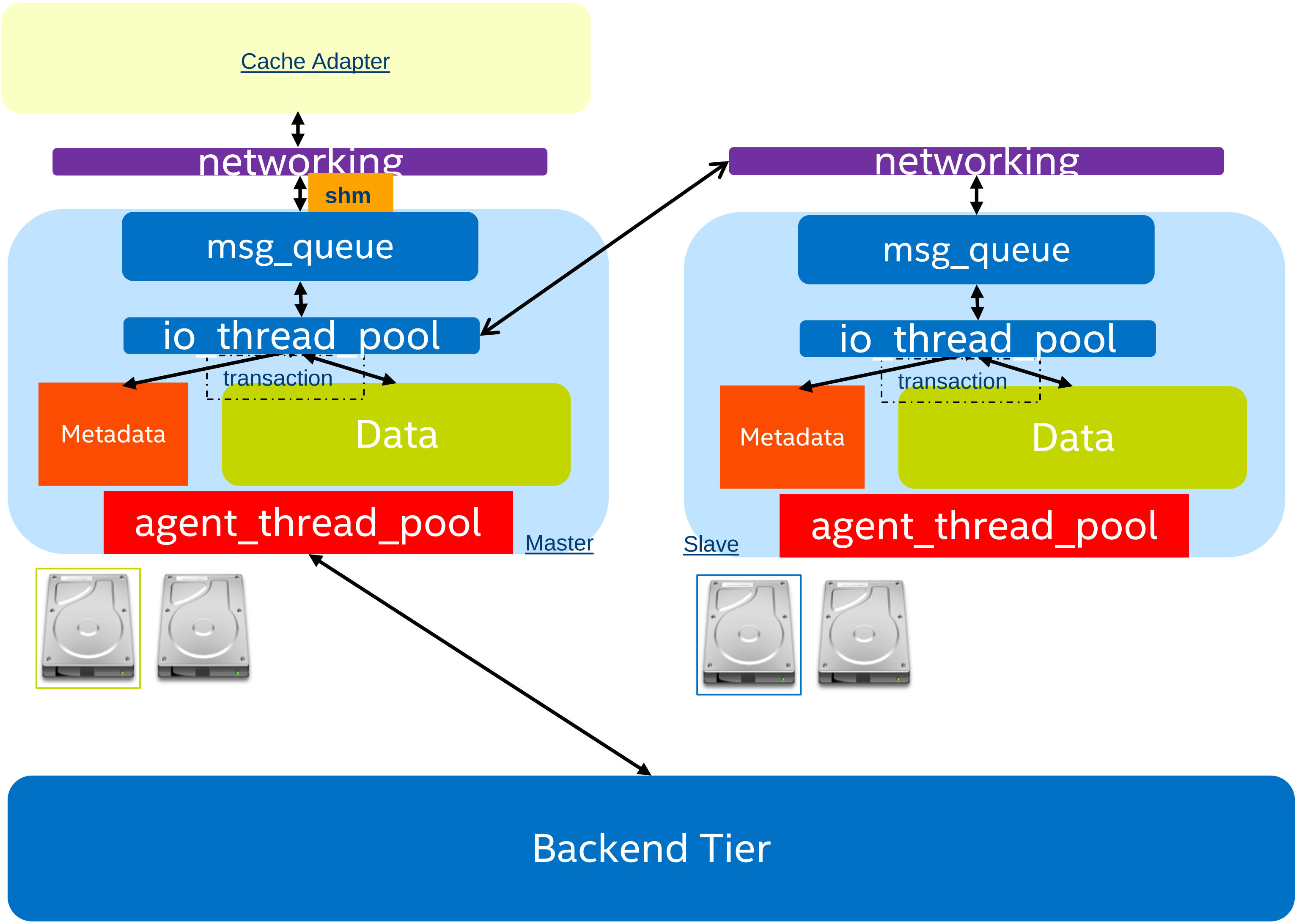
- **RBD**:
  - Hooks on librbd
  - caching for small writes
- **RGW**:
  - Caching over http
  - For metadata and small data
- **CephFS**:
  - Extend POSIX API
  - Caching for metadata and small writes



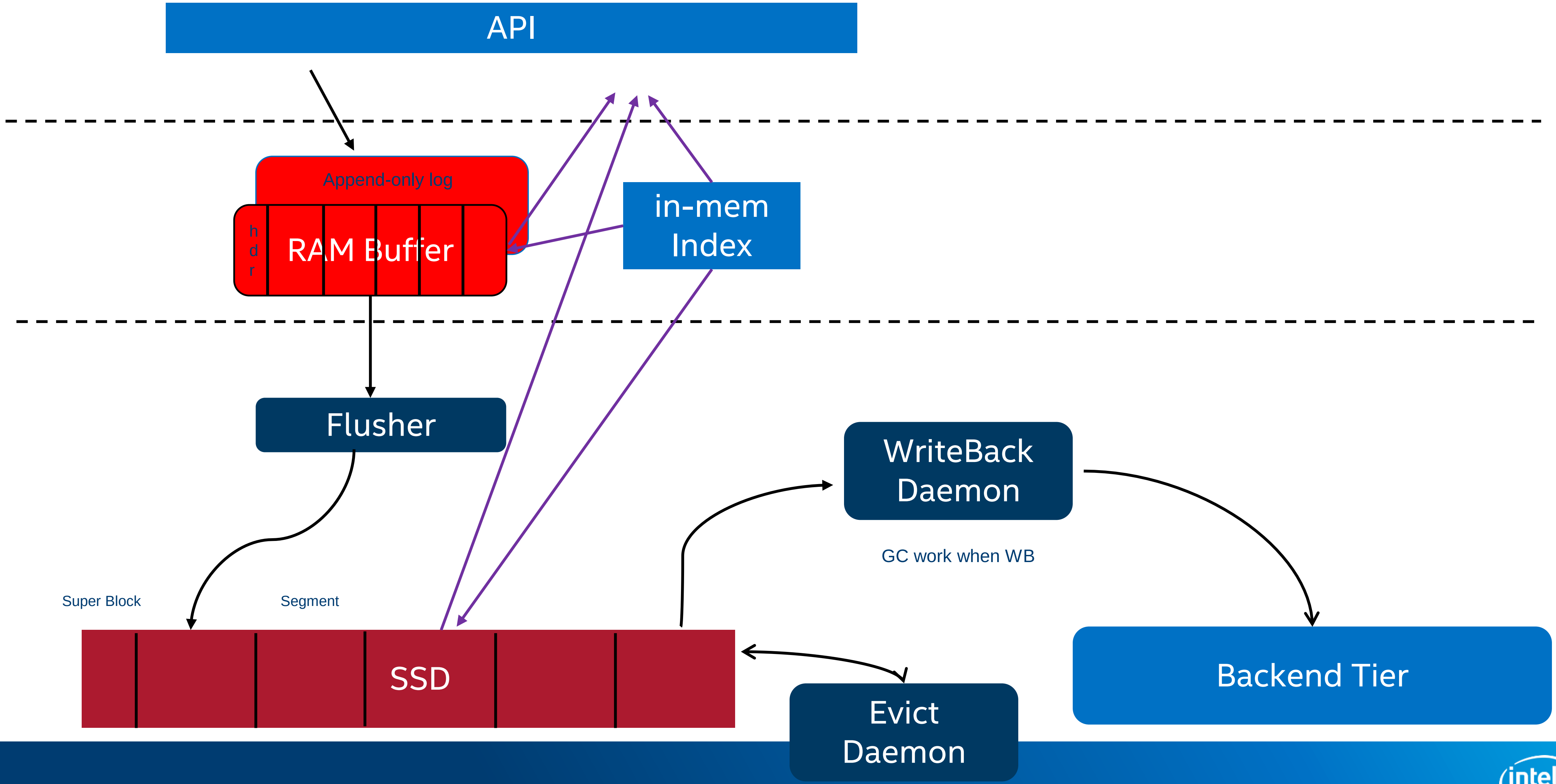
Hyper Converged Cache: Master/Slave replication

Master/Slave architecture:

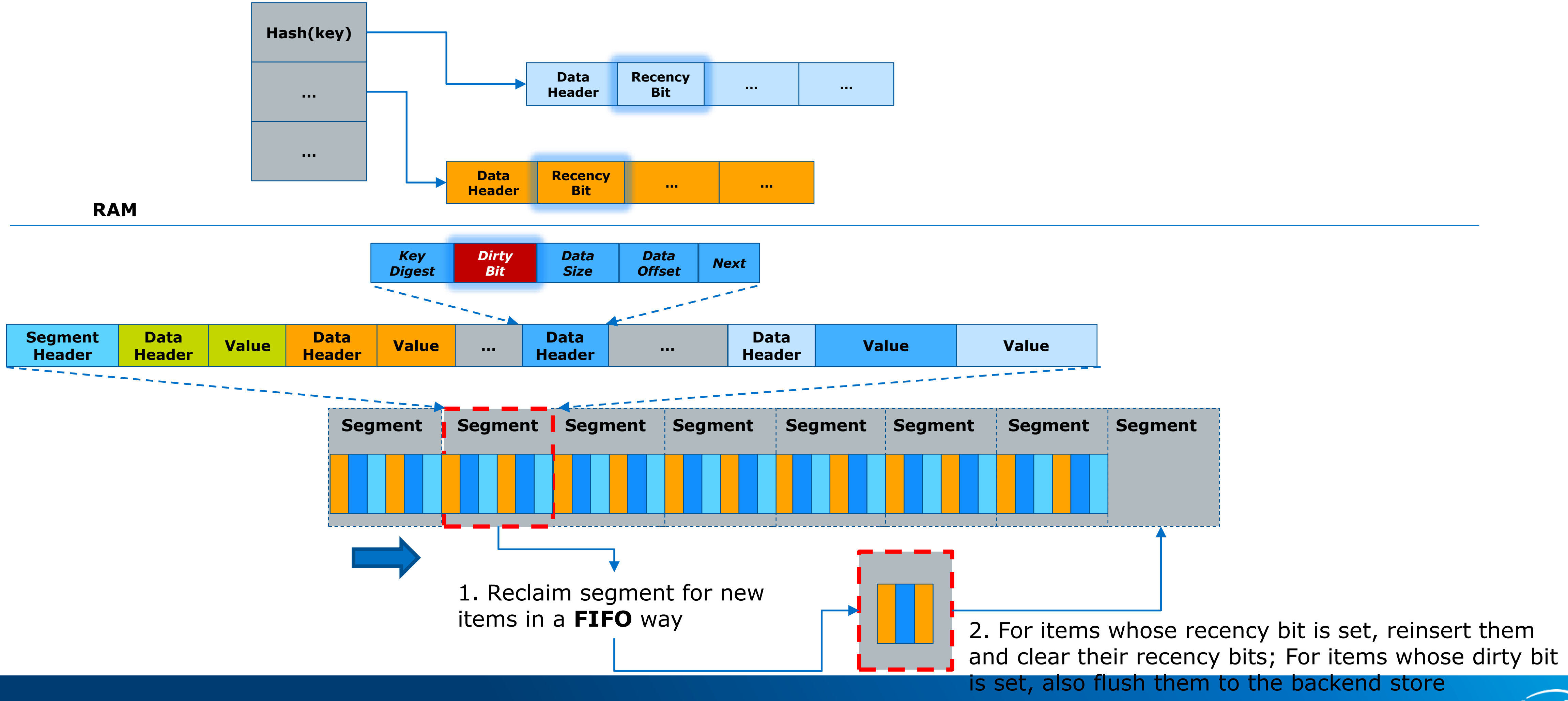
- Each host will have two process
  - Master: accept local read/writes and replicates to slave
  - Slave: accept replication writes
- Configurable master/slave pair
  - Specified in static configuration file(dynamic configuration will be in HA service later)
- Adapter sends read to master only
- Adapter sends write to master, then master replicates to slave
  - Local messaging will use shared memory
  - Client ACK on two writes finish



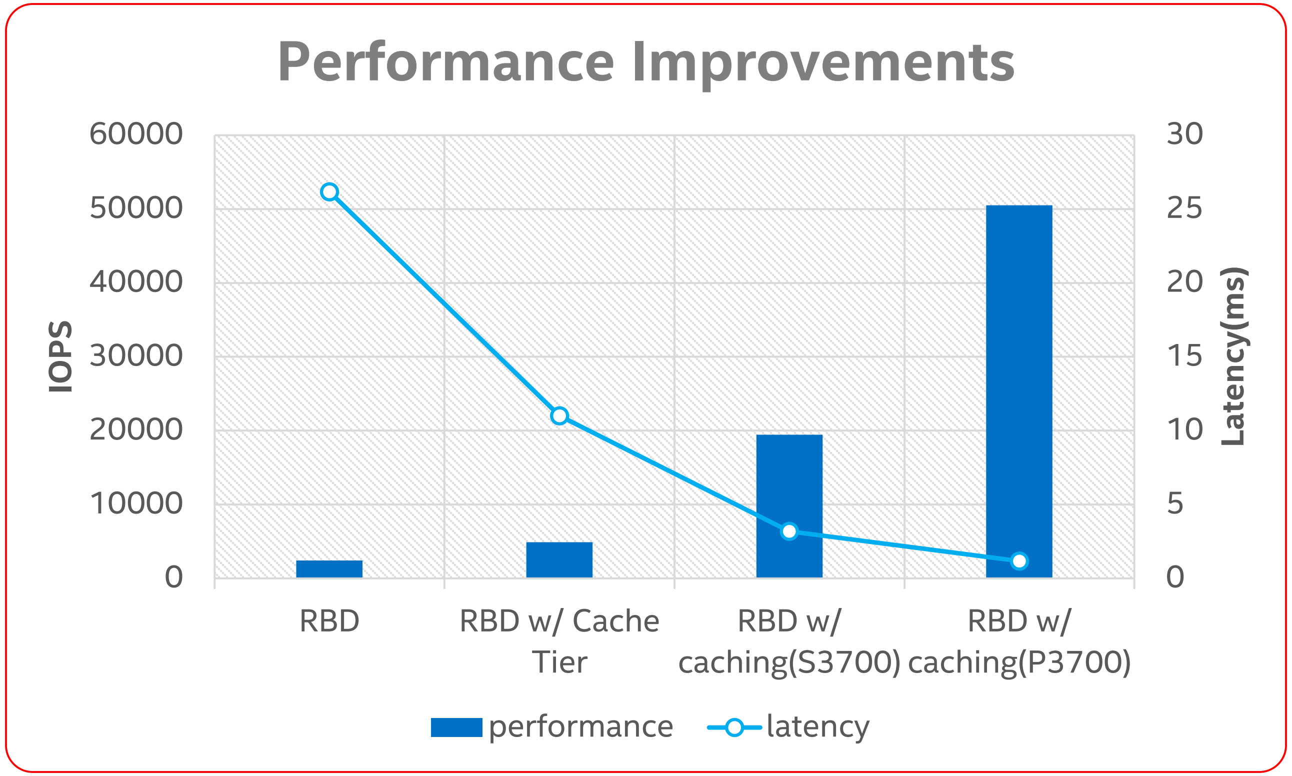
Hyper Converged Cache: Storage backend



Hyper Converged Cache: Storage backend With Caching Semantic

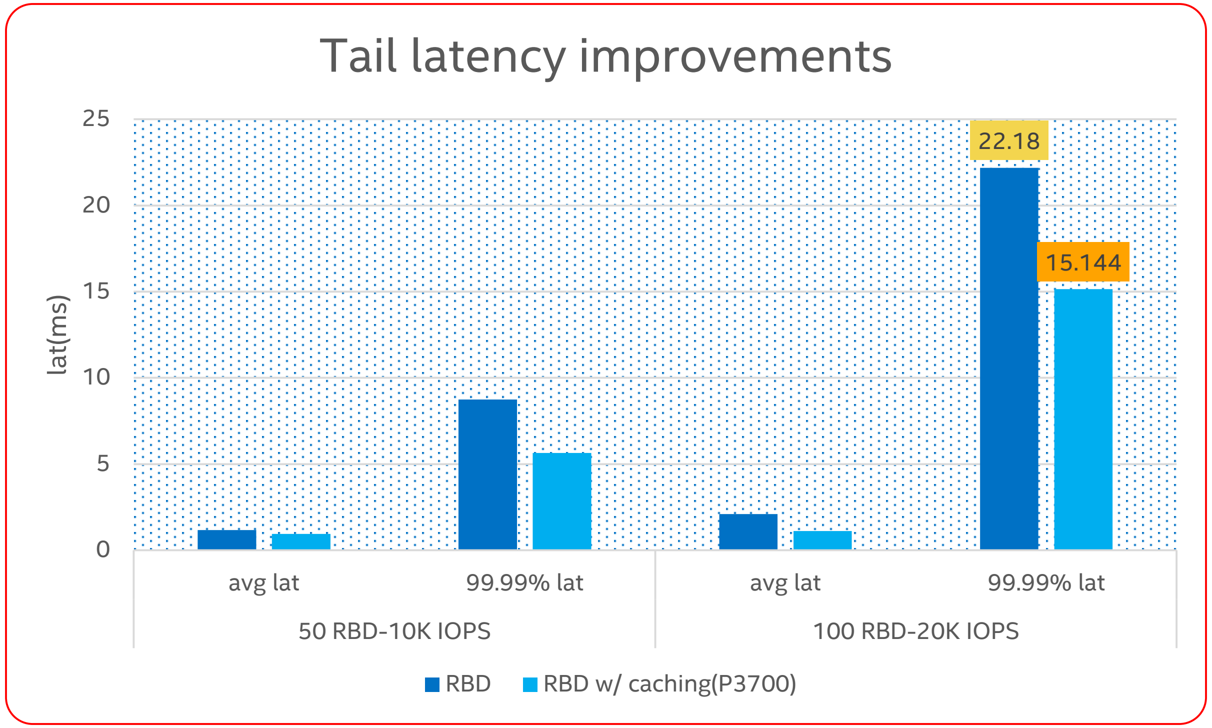


Hyper Converged Cache: Performance



- Hyper converged cache is able to provide ~7x performance improvements w/ zipf 4k randwrite, the latency also decreased ~92%.
  - With NVMe disk caching, the performance improved like 20x.
- Comparing with cache tier, the performance improved ~5x, the code path is much simpler.

Hyper Converged Cache: Tail Latency



- With SSD caching, hyper converged cache is able to reduce **~30%** tail latency under specified load.
  - Much easier to control and meet QOS/SLA requirements.

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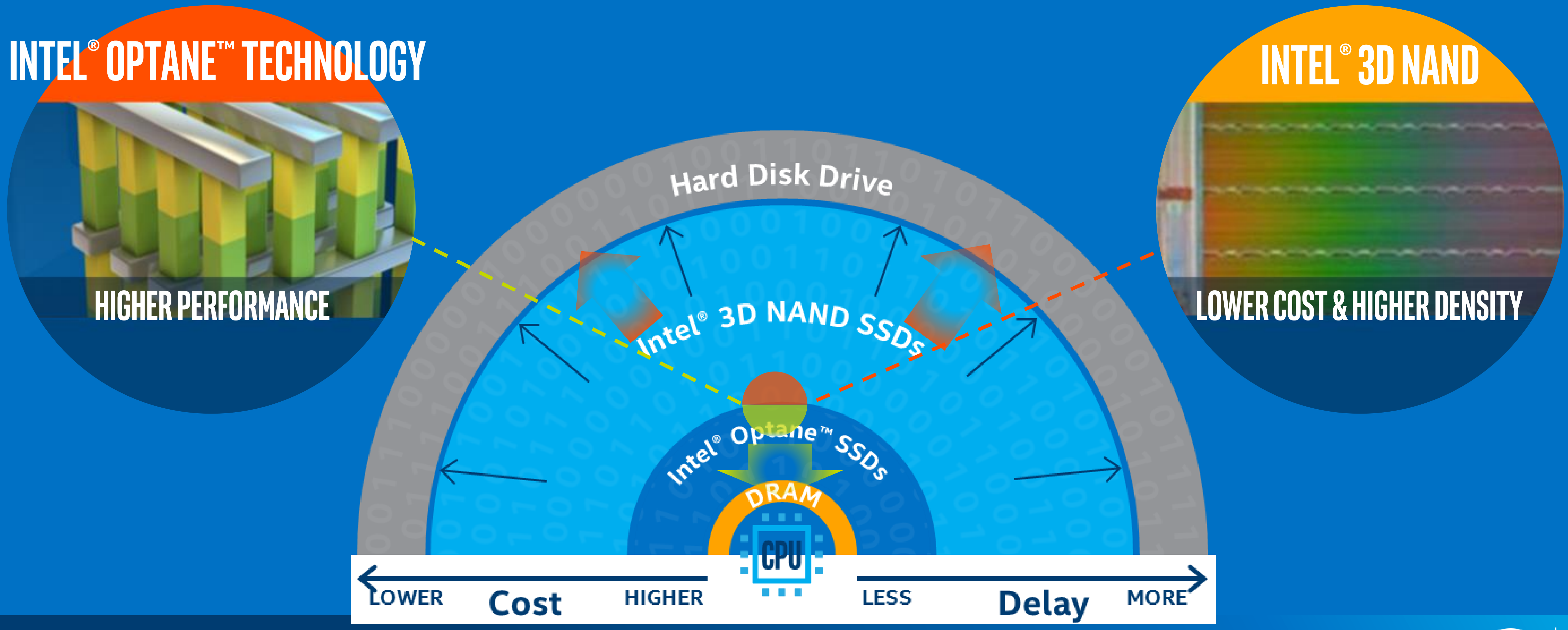
Upstream status and Roadmap

- Upstream BluePrint: **CRASH-CONSISTENT ORDERED WRITE-BACK CACHING EXTENSION**
  - A new librbd read cache to support **LBA-based** caching with DRAM/*non-volatile* storage backends
  - An **ordered write-back** cache that maintains checkpoints internally (or is structured as a data journal), such that writes that get flushed back to the cluster are always **crash consistent**. Even if one were to lose the client cache entirely, the disk image is still holding a valid file system that looks like it is just a little bit stale [1]. Should have durability characteristics similar to async replication if done right.
  - External **caching plug-in** interface – kernel and usermode
- Internal POC code done 80%. Will open source the project soon.

Intel investment: Two technologies



INTEL® OPTANE™ TECHNOLOGY

Size and Latency Specification Comparison

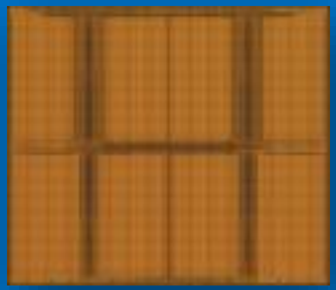
HDD
Latency: ~10 MillionX
Size of Data: ~10,000X

MEMORY

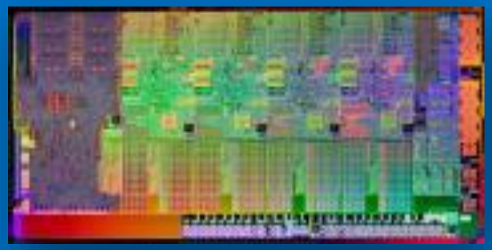
NAND SSD
Latency: ~100,000X
Size of Data: ~1,000X

Intel® Optane™ Technology
Latency: ~100X
Size of Data: ~1,000X

DRAM
Latency: ~10X
Size of Data: ~100X



SRAM
Latency: 1X
Size of Data: 1X

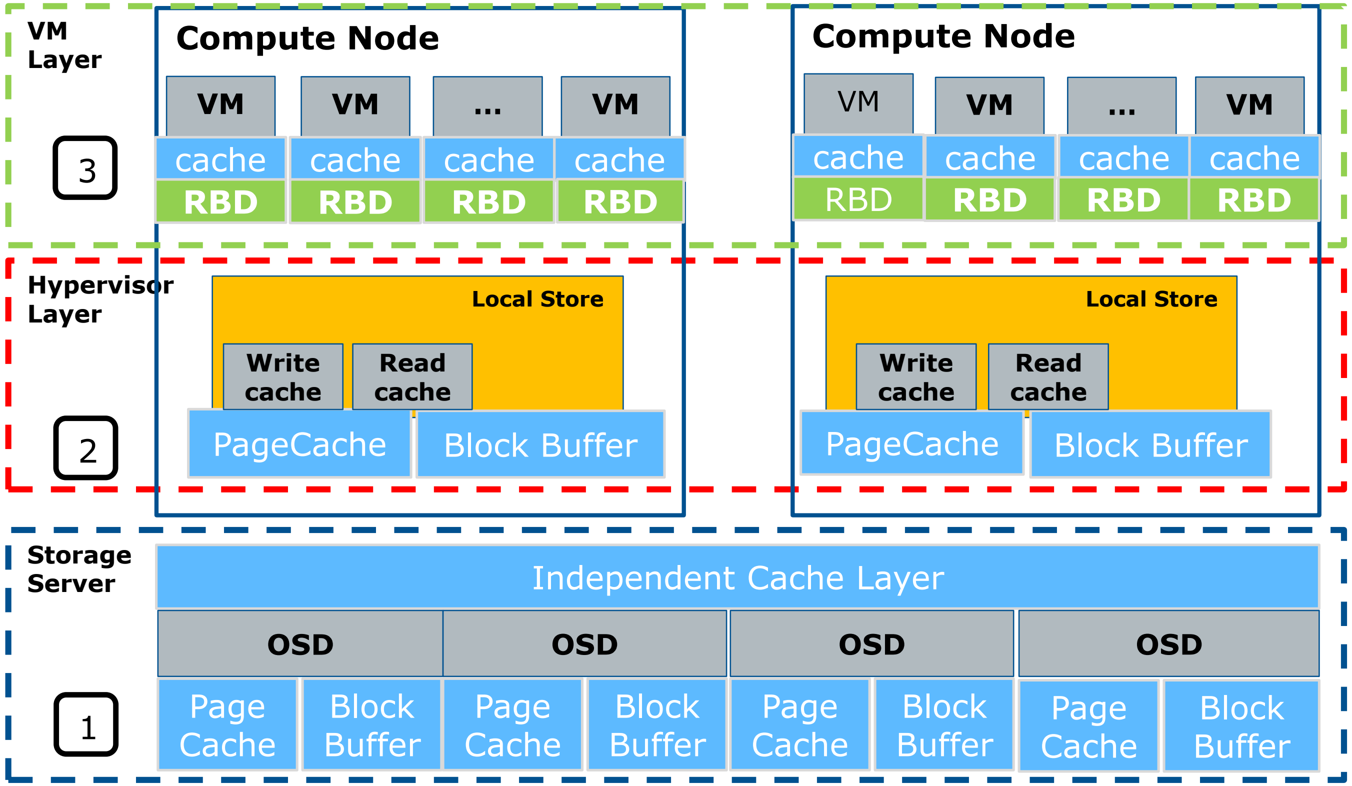


STORAGE

Technology claims are based on comparisons of latency, density and write cycling metrics amongst memory technologies recorded on published specifications of in-market memory products against internal Intel specifications.

Lower latency is faster

Hyper Converged Cache: caching on Optane?



1. Using Intel® Optane™ device as block buffer cache device.
2. Using Intel® Optane™ device as page caching device.
3. Using 3D XPointTM device as OS L2 memory?

Summary

- With client-side SSD caching, RBD randwrite improved ~5x, the latency also decreased ~92%.
- With client-side SSD caching, the long tail latency could be improved a lot.
- With the emerging new media like Optane, the caching benefit will be more higher
- Next step:
  - Finish the coding work(80% done) and open source the project
  - Tests on objects and filesystem

Q&A

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Test and System Configurations: See Back up for details.

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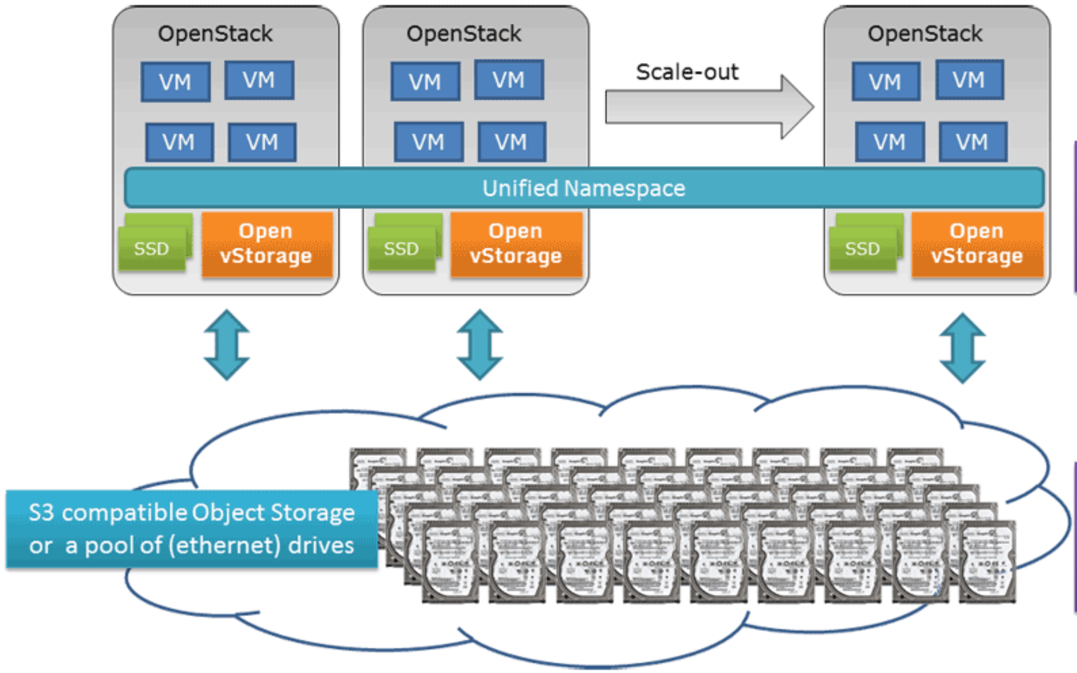
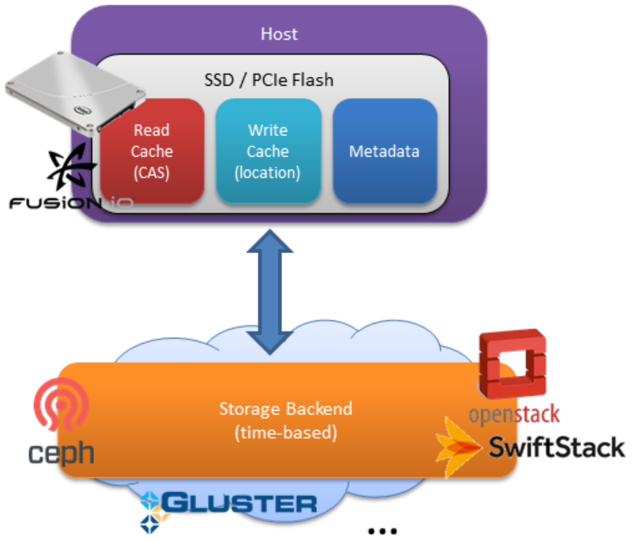
BACKUP

Open vStorage



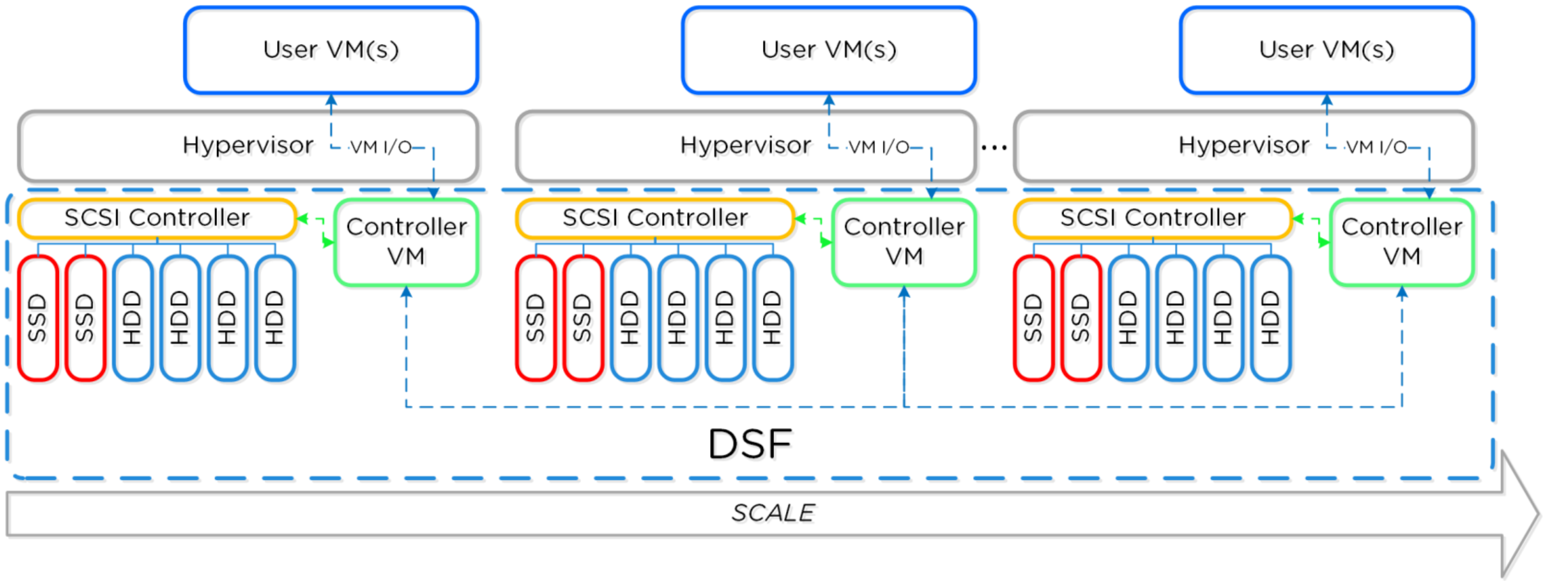
Tier 1 - Location Based
- Read/Write cache on SSD
- Block based storage
- Thin provisioning
- VM Centric
- Distributed Transaction Log

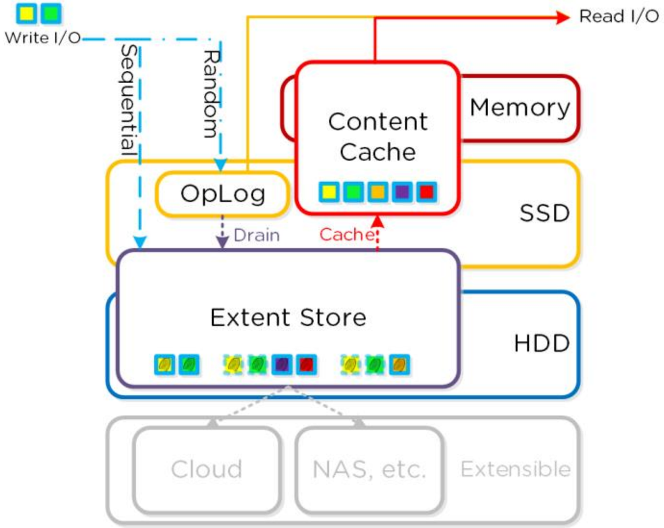
Tier 2 -Time Based
- Zero Copy Snapshot
- Zero Copy Cloning
- Continuous data protection
- Redundant storage
- Scale-out



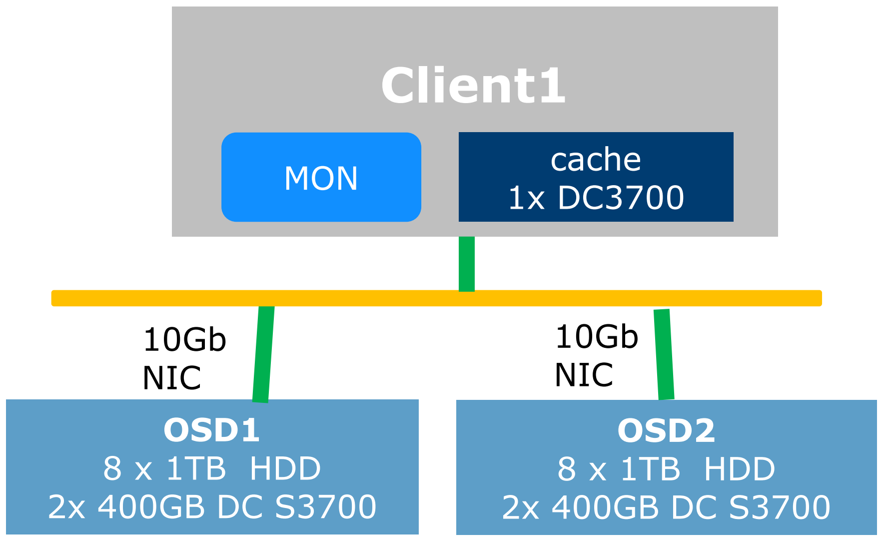
Turning Object Storage into block storage for Virtual Machine Storage

Nutanix


User VM(s)
User VM(s)
User VM(s)
Hypervisor
VM I/O
Hypervisor
VM I/O
...
Hypervisor
VM I/O
SCSI Controller
Controller VM
SCSI Controller
Controller VM
SCSI Controller
Controller VM
SSD
SSD
HDD
HDD
HDD
HDD
DSF
SCALE


Write I/O
Read I/O
Sequential
Random
Content Cache
Memory
OpLog
SSD
Drain
Cache
Extent Store
HDD
Cloud
NAS, etc.
Extensible

H/W Configuration



Client Cluster	
CPU	Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.80GHz
Memory	96 GB
NIC	10Gb
Disks	1 HDD for OS 400G SSD for cache
Ceph Cluster	
CPU	OSD: Intel(R) Xeon(R) CPU E31280 @ 3.50GHz
Memory	32 GB
NIC	10GbE
Disks	2 x 400 GB SSD (Journal) 8 x 1TB HDD (Storage)

2 hosts Ceph cluster each host has 8 x 1TB HDD as OSDs and 2x Intel® DC S3700 SSD journal

1 Client with 1x 400GB Intel® DC S3700 SSD as cache device

S/W Configuration

- Ceph* version : 10.2.2 (Jewel)
- Replica size : 2
  - Data pool : 16 OSDs. 2 SSDs for journal, 8 OSDs on each node
  - OSD Size : 1TB * 8
  - Journal Size : 40G * 8
  - Cache: 1 x 400G Intel® DC S3700
  - FIO volume size: 10G
- Cetune test benchmark
  - fio + librbd

Cetune: https://github.com/01org/cetune

Testing Configuration

Test cases:

- Operation: 4K random write with fio (zipf=1.2)

Detail case:

- Cache size < volume size (w/ zipf)
  - w/o flush & evict: cache size 10G.
  - w/ flush w/o evict: cache size 10G.
  - w/ flush & evict: cache size 10G.
- Hot data = volume size * zipf1.2(5%), runtime = 4 hours

Caching Parameters:

- object_size=4096
- cache_flush_queue_depth=256
- cache_ratio_max=0.7
- cache_ratio_health=0.5
- cache_dirty_ratio_min=0.1
- cache_dirty_ratio_max=0.95
- cache_flush_interval=3
- cache_evict_interval=5
- Runtime: Base: 200s ramp up, 14400s run
- DataStoreDev=/dev/sde
- cache_total_size=10G
- cacheservice_threads_num=128
- agent_threads_num=32