SUSE® Storage

Sizing and Performance for Ceph

Lars Marowsky-Brée
Distinguished Engineer
lmb@suse.com

We adapt. You succeed.

What is Ceph?

From 10,000 Meters

- Open Source Storage Distributed solution
- Most popular choice of distributed storage for openStack[1]
- Lots of goodies
  - Distributed Object Storage
  - Redundancy
  - Efficient Scale-Out
  - Can be built on commodity hardware
  - Lower operational cost

[1] *http://www.openstack.org/blog/2013/11/openstack-user-survey-statistics-november-2013/*

From 1,000 Meters

- Three interfaces rolled into one
  - Object Access (like Amazon S3)
  - Block Access
  - (Distributed File System)
- Sitting on top of a Storage Cluster
  - Self Healing
  - Self Managed
  - No Bottlenecks

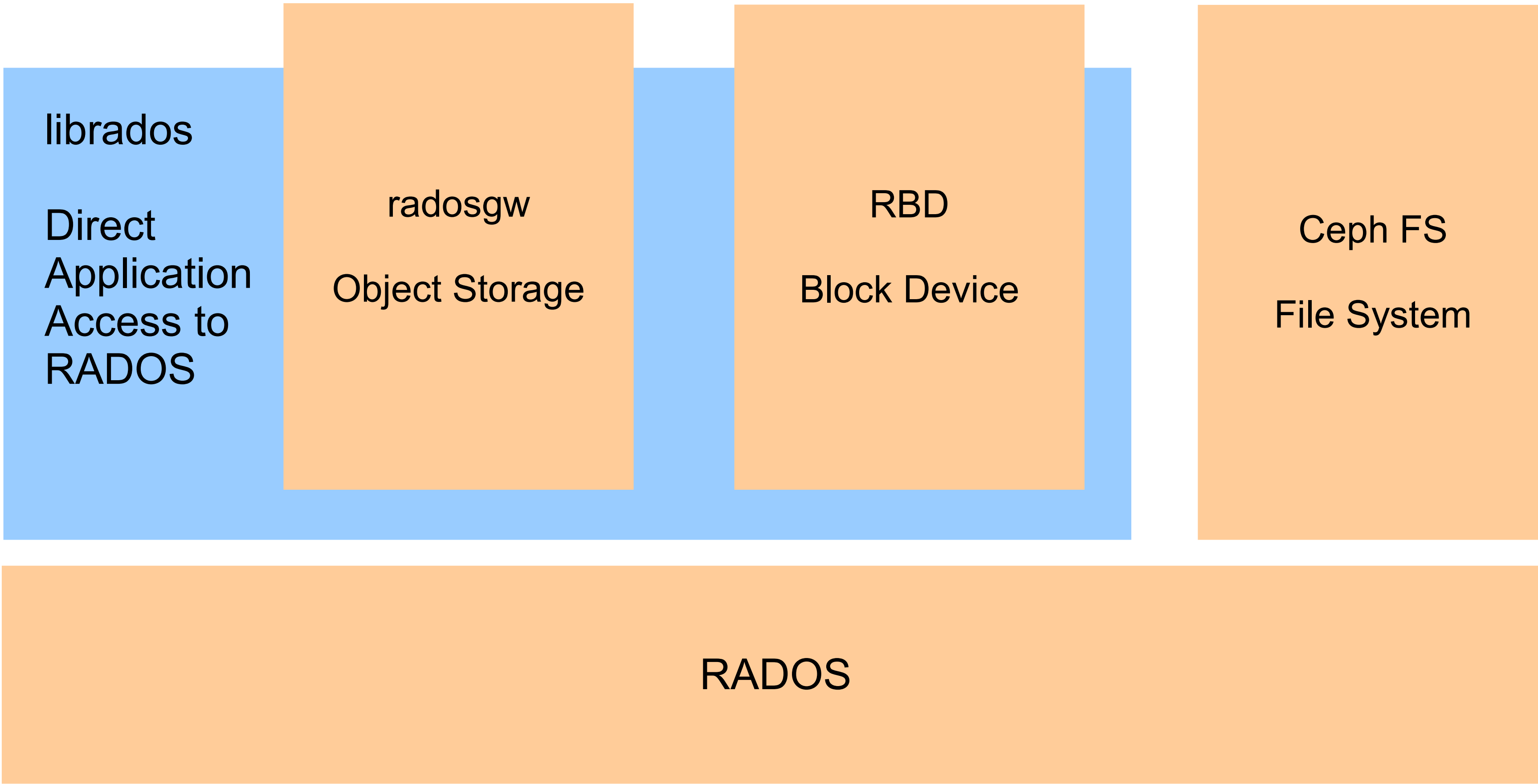
From 1,000 Meters

Unified Data Handling for 3 Purposes

Object Storage (Like Amazon S3)	Block Device	File System
•RESTful Interface •S3 and SWIFT APIs	•Block devices •Up to 16 EiB •Thin Provisioning •Snapshots	•POSIX Compliant •Separate Data and Metadata •For use e.g. with Hadoop

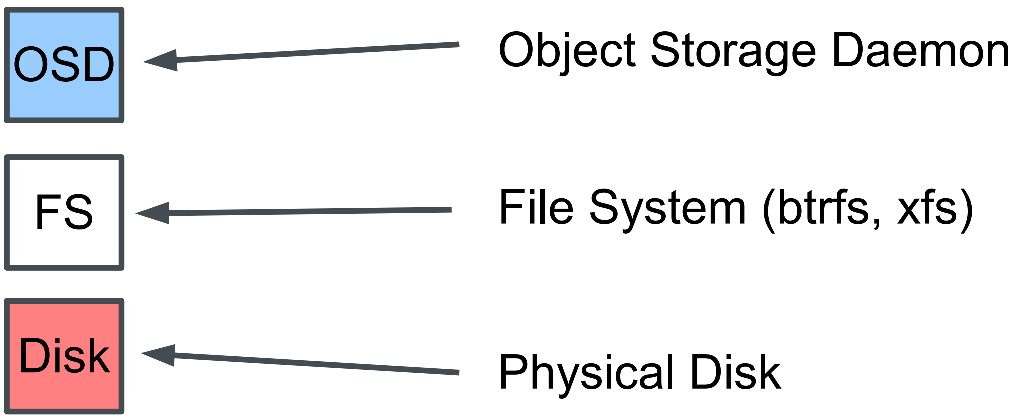
Autonomous, Redundant Storage Cluster

Component Names



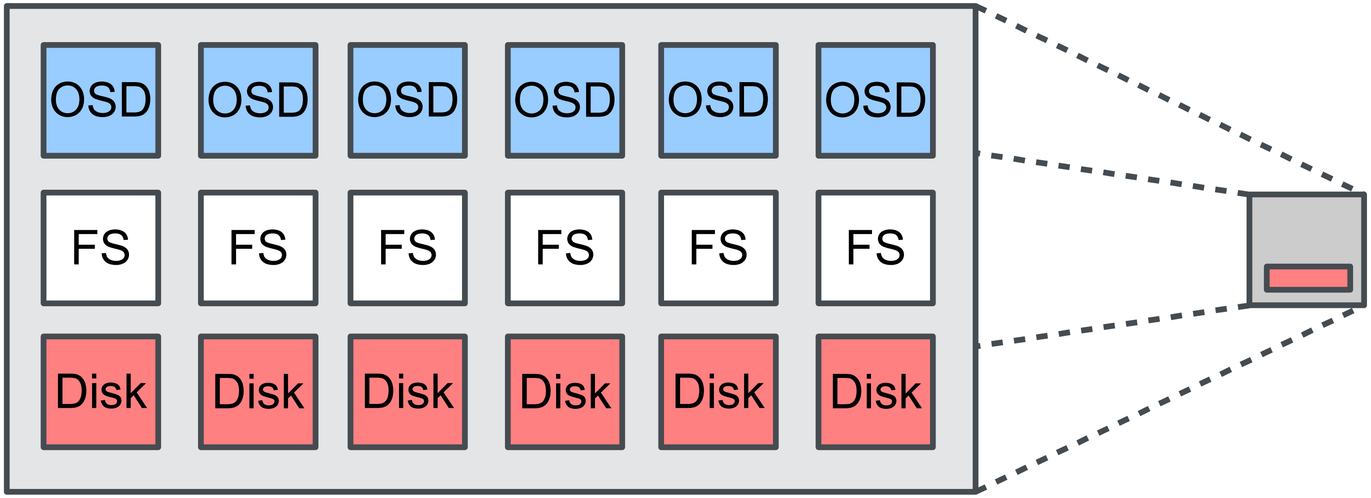
How Does Ceph Work?

For a Moment, Zooming to Atom Level



- OSDs serve storage objects to clients
- Peer to perform replication and recovery

Put Several of These in One Node

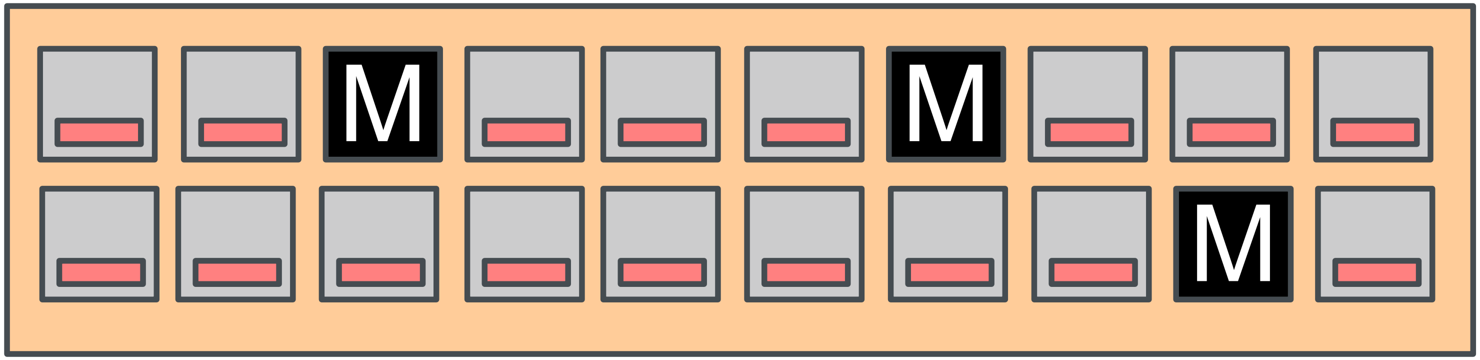


Mix In a Few Monitor Nodes

M

- Monitors are the brain cells of the cluster
  - Cluster Membership
  - Consensus for Distributed Decision Making
- Do not serve stored objects to clients

Voilà, a Small RADOS Cluster



Several Ingredients

- Basic Idea
  - Coarse grained partitioning of storage supports policy based mapping (don't put all copies of my data in one rack)
  - Topology map and Rules allow clients to “compute” the exact location of any storage object
- Three conceptual components
  - Pools
  - Placement groups
  - CRUSH: deterministic decentralized placement algorithm

Pools

- A pool is a logical container for storage objects
- A pool has a set of parameters
  - a name
  - a numerical ID (internal to RADOS)
  - number of replicas OR erasure encoding settings
  - number of placement groups
  - placement rule set
  - owner
- Pools support certain operations
  - create/remove/read/write entire objects
  - snapshot of the entire pool

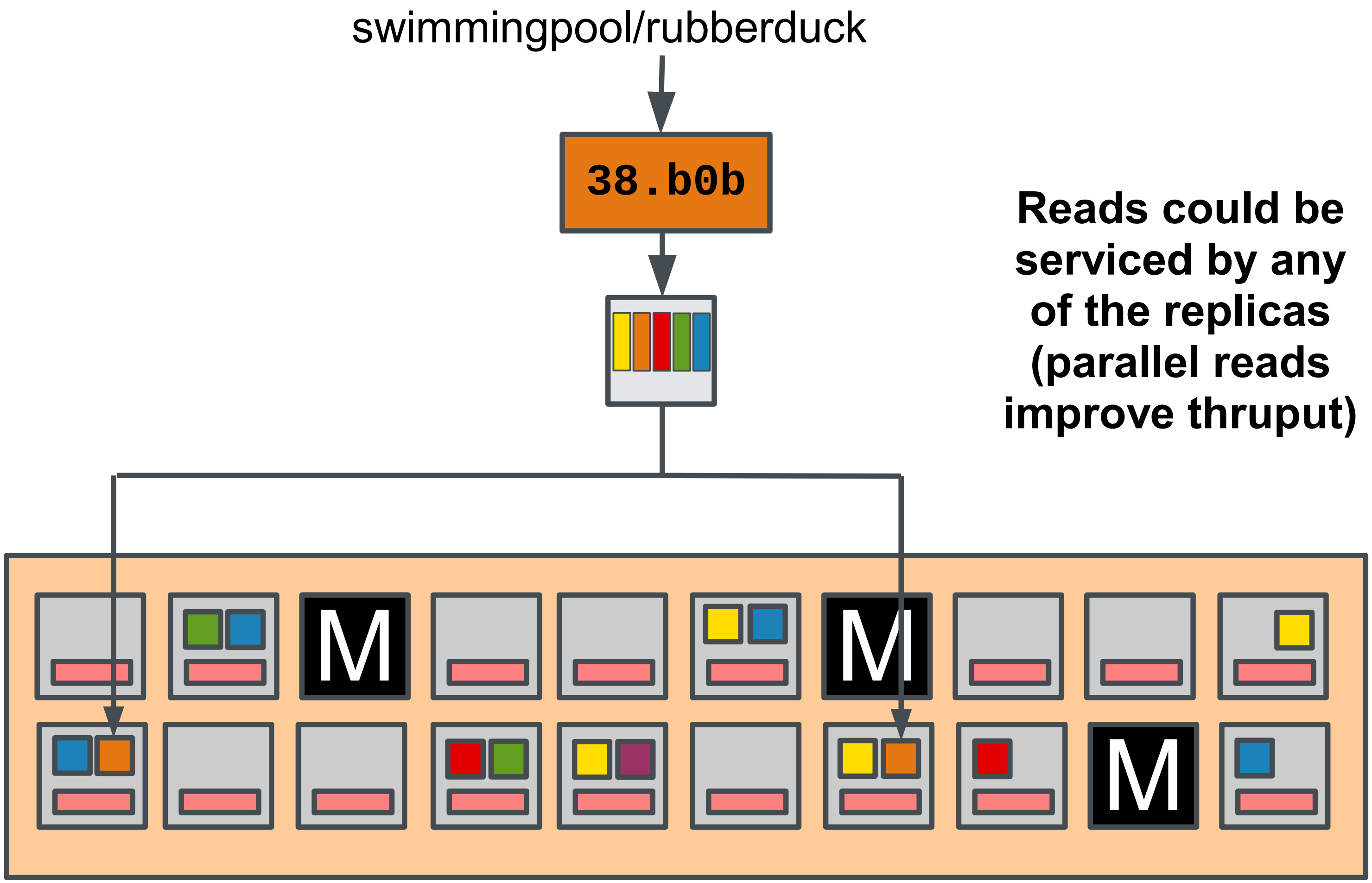
Placement Groups

- Placement groups help balance data across OSDs
- Consider a pool named “swimmingpool”
  - with a pool ID of 38 and 8192 placement groups (PGs)
- Consider object “rubberduck” in “swimmingpool”
  - hash(“rubberduck”) % 8192 = 0xb0b
  - The resulting PG is 38.b0b
- One PG typically spans several OSDs
  - for balancing
  - for replication
- One OSD typically serves many PGs

CRUSH

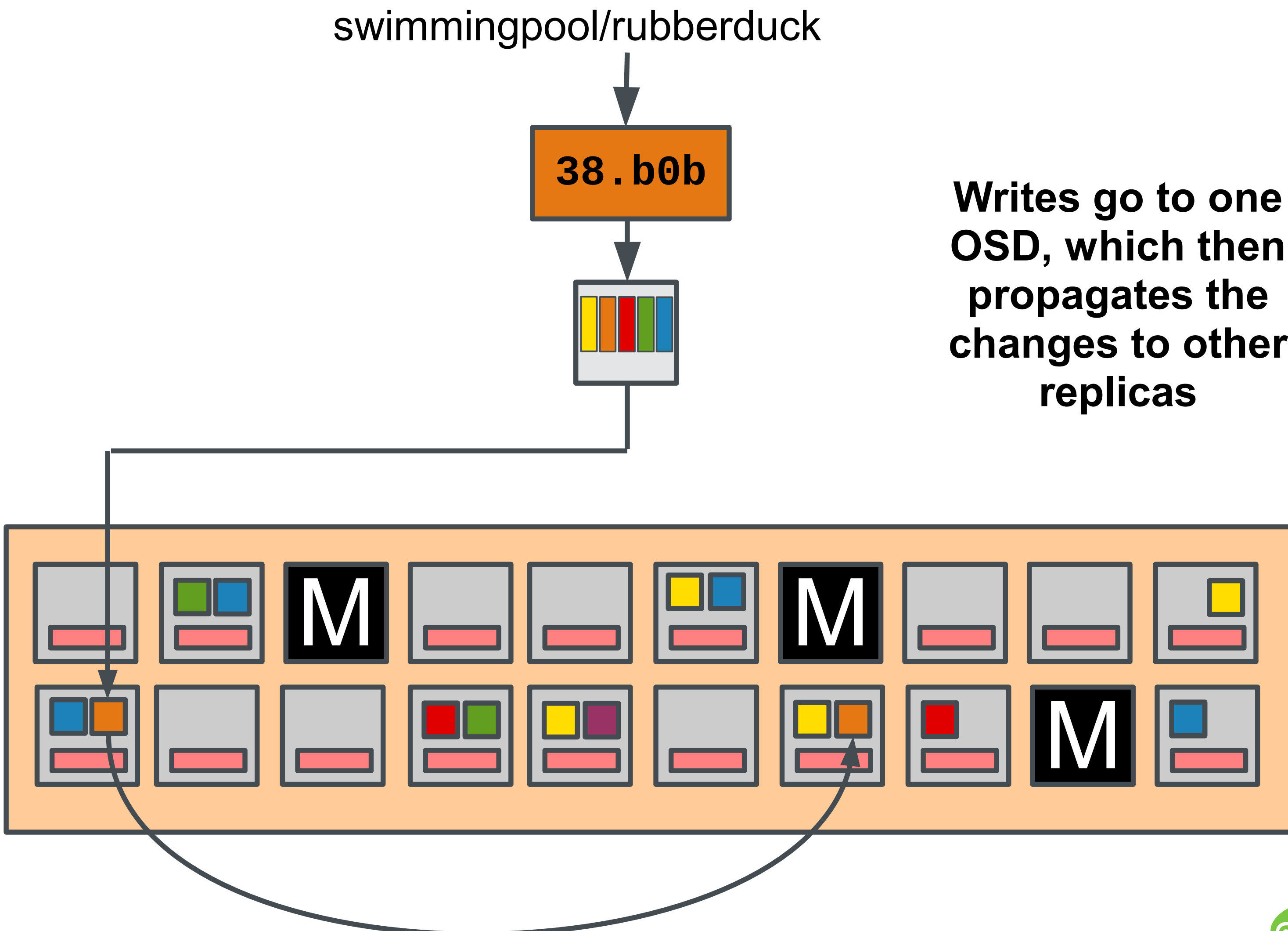
- CRUSH uses a map of all OSDs in your cluster
  - includes physical topology, like row, rack, host
  - includes rules describing which OSDs to consider for what type of pool/PG
- This map is maintained by the monitor nodes
  - Monitor nodes use standard cluster algorithms for consensus building, etc

CRUSH in Action: Reading



Reads could be serviced by any of the replicas (parallel reads improve thruput)

CRUSH in Action: Writing



Writes go to one OSD, which then propagates the changes to other replicas

Software Defined Storage

Legacy Storage Arrays

- Limits:
  - Tightly controlled environment
  - Limited scalability
  - Few options
    - Only certain approved drives
    - Constrained number of disk slots
    - Few memory variations
    - Only very few networking choices
    - Typically fixed controller and CPU
- Benefits:
  - Reasonably easy to understand
  - Long-term experience and “gut instincts”
  - Somewhat deterministic behavior and pricing

Software Defined Storage (SDS)

- Limits:
  - ?

- Benefits:
  - Infinite scalability
  - Infinite adaptability
  - Infinite choices
  - Infinite flexibility
  - ... right.

Properties of a SDS System

- Throughput
- Latency
- IOPS

- Availability
- Reliability

- Capacity
- Density

- **Cost**

Architecting a SDS system

- These goals often conflict:
  - Availability versus Density
  - IOPS versus Density
  - Everything versus Cost
- Many hardware options
- Software topology offers many configuration choices
- There is no one size fits all

Setup Choices

Networking (Public and Private)

- Ethernet (1, 10, 40 GbE)
  - Reasonably inexpensive (except for 40 GbE)
  - Can easily be bonded for availability
  - Use jumbo frames
- Infiniband
  - High bandwidth
  - Low latency
  - Typically more expensive
  - No support for RDMA yet in Ceph, need to use IPoIB

Network

- Choose the fastest network you can afford
- Switches should be low latency with fully meshed backplane
- Separate public and cluster network
- Cluster network should typically be twice the public bandwidth
  - Incoming writes are replicated over the cluster network
  - Re-balancing and re-mirroring take utilize the cluster network

Different Access Modes

- radosgw:
  - An additional gateway in front of your RADOS cluster
  - Little impact on throughput, but it does affect latency

- User-space RADOS access:
  - More feature rich than in-kernel rbd.ko module
  - Typically provides higher performance

Storage Node

- CPU
  - Number and speed of cores
- Memory
- Storage controller
  - Bandwidth, performance, cache size
- SSDs for OSD journal
  - SSD to HDD ratio
- HDDs
  - Count, capacity, performance

Adding More Nodes

- Capacity increases
- Total throughput increases
- IOPS increase
- Redundancy increases
- Latency unchanged
- Eventually: network topology limitations
- Temporary impact during re-balancing

Adding More Disks to a Node

- Capacity increases
- Redundancy increases
- Throughput might increase
- IOPS might increase
- Internal node bandwidth is consumed
- Higher CPU and memory load
- Cache contention
- Latency unchanged

OSD File System

- btrfs
  - Typically better write throughput performance
  - Higher CPU utilization
  - Feature rich
    - Compression, checksums, copy on write
  - The choice for the future!

- XFS
  - Good all around choice
  - Very mature for data partitions
  - Typically lower CPU utilization
  - The choice for today!

Impact of Caches

- Cache on the client side
  - Typically, biggest impact on performance
  - Does not help with write performance
- Server OS cache
  - Low impact: reads have already been cached on the client
  - Still, helps with readahead
- Caching controller, battery backed:
  - Significant impact for writes

Impact of SSD Journals

- SSD journals accelerate bursts and random write IO
- For sustained writes that overflow the journal, performance degrades to HDD levels
- SSDs help very little with read performance
- SSDs are very costly
  - ... and consume storage slots -> lower density
- A large battery-backed cache on the storage controller is highly recommended if not using SSD journals

Hard Disk Parameters

- Capacity matters
  - Often, highest density is not most cost effective
- On-disk cache matters less
- Reliability advantage of Enterprise drives typically marginal compared to cost
  - Buy more drives instead
- RPM:
  - Increase IOPS & throughput
  - Increases power consumption
  - 15k drives quite expensive still

Impact of Redundancy Choices

- Replication:
  - n number of exact, full-size copies
  - Potentially increased read performance due to striping
  - Increased cluster network utilization for writes
  - Rebuilds can leverage multiple sources
  - Significant capacity impact

- Erasure coding:
  - Data split into k parts plus m redundancy codes
  - Better space efficiency
  - Higher CPU overhead
  - Significant CPU and cluster network impact, especially during rebuild
  - Cannot directly be used to with block devices (see next slide)

Cache Tiering

- Multi-tier storage architecture:
  - Pool acts as a transparent write-back overlay for another
    - e.g., SSD 3-way replication over HDDs with erasure coding
  - Can flush either on relative or absolute dirty levels, or age
  - Additional configuration complexity and requires workload-specific tuning
  - Also available: read-only mode (no write acceleration)
  - Some downsides (no snapshots)
- A good way to combine the advantages of replication and erasure coding

Conclusion

Questions and Answers?

Thank you.

We adapt. You succeed.

We adapt. You succeed.

Corporate Headquarters
Maxfeldstrasse 5
90409 Nuremberg
Germany

+49 911 740 53 0 (Worldwide)
www.suse.com

Join us on:
www.opensuse.org