Ceph
Successes and challenges with open source distributed storage

Carlos Maltzahn, standing in for Sage Weil

DOMA Workshop, 11/16/17

Baskin Engineering UC SANTA CRUZ

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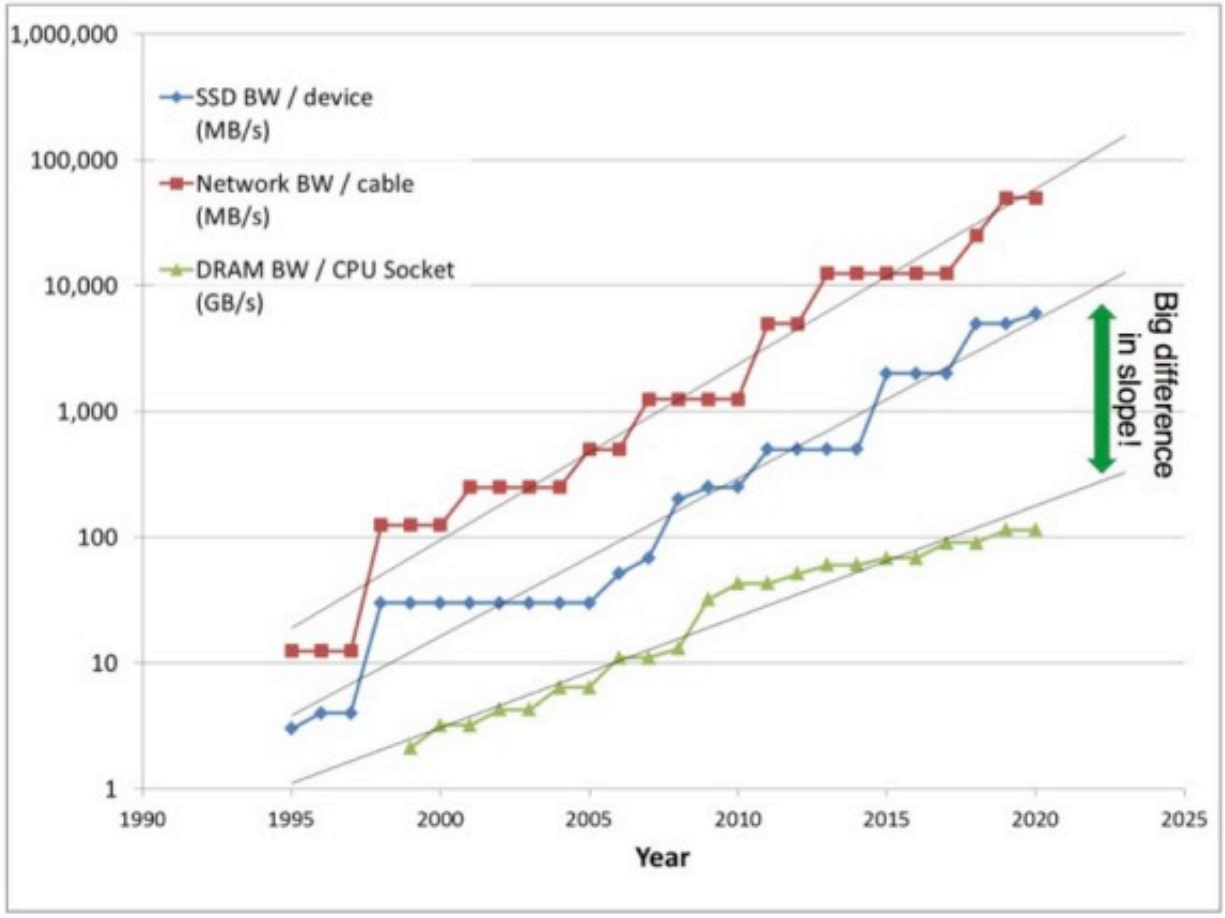
Purpose of this talk

- Share important challenges
- Look forward (a little bit)
- Collect feedback

Network, Storage, & DRAM trends

Log scale

- Use DRAM Bandwidth as a proxy for CPU throughput
- Reasonable approximation for DMA and poor cache performance workloads (e.g. Storage)

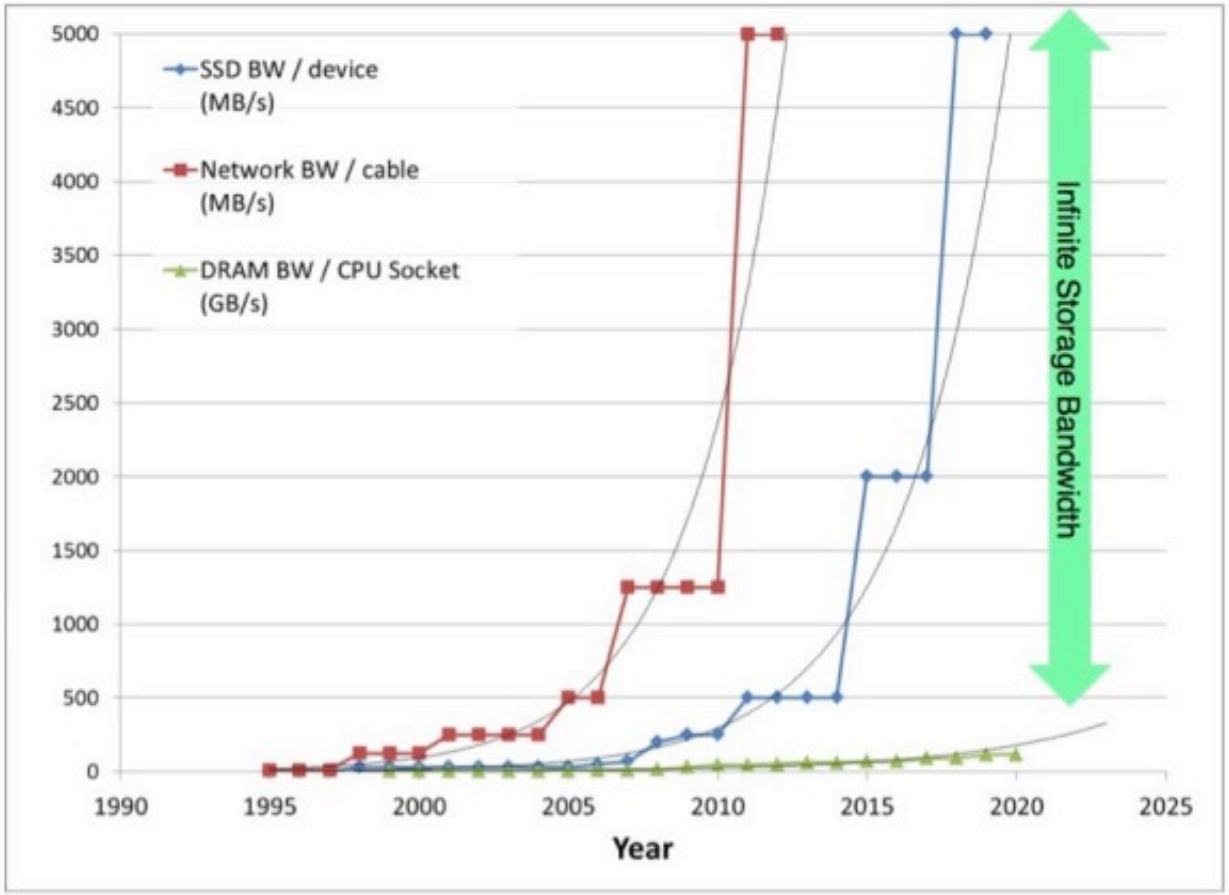


Credit: [SanDisk Data Center Tech Blog: CPU Bandwidth – The Worrisome 2020 Trend](#) 3/23/16

Network, Storage, & DRAM trends

Linear scale

- Same data as last slide, but for the Log-impaired
- Storage Bandwidth is not literally infinite
- But the ***ratio*** of Network and Storage to CPU throughput is widening very quickly



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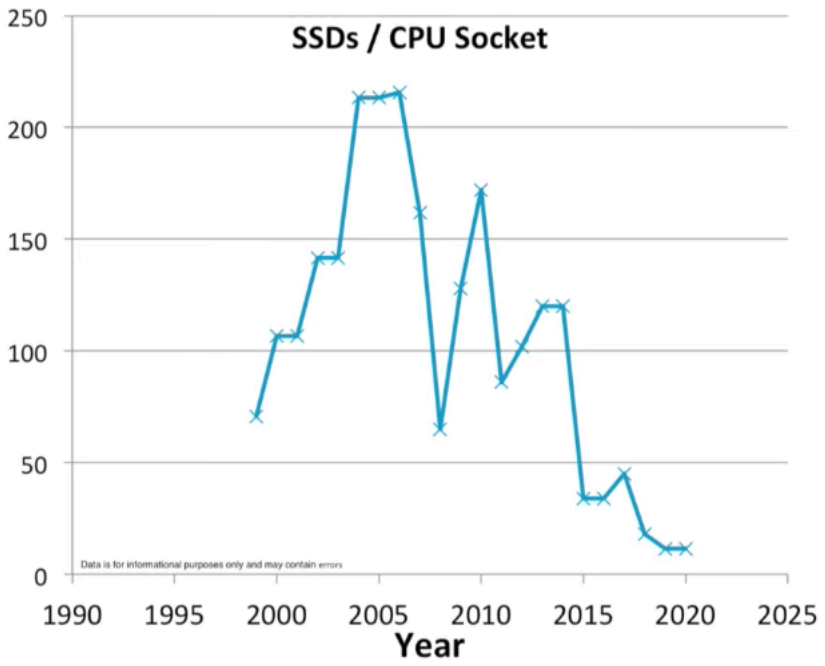
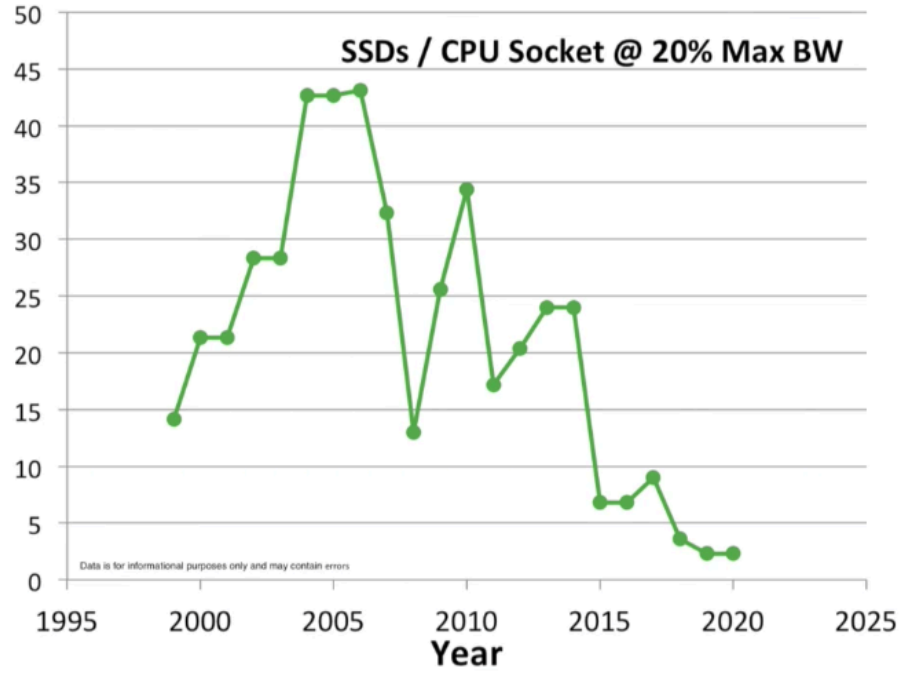
The CPU/DRAM Bottleneck

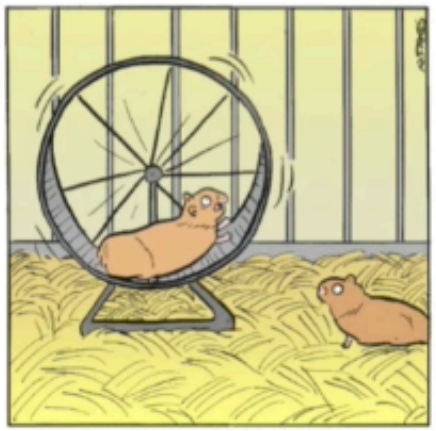




Credit: SanDisk Data Center Tech Blog: CPU Bandwidth – The Worrisome 2020 Trend 3/23/16

Effects Of The CPU/DRAM Bottleneck

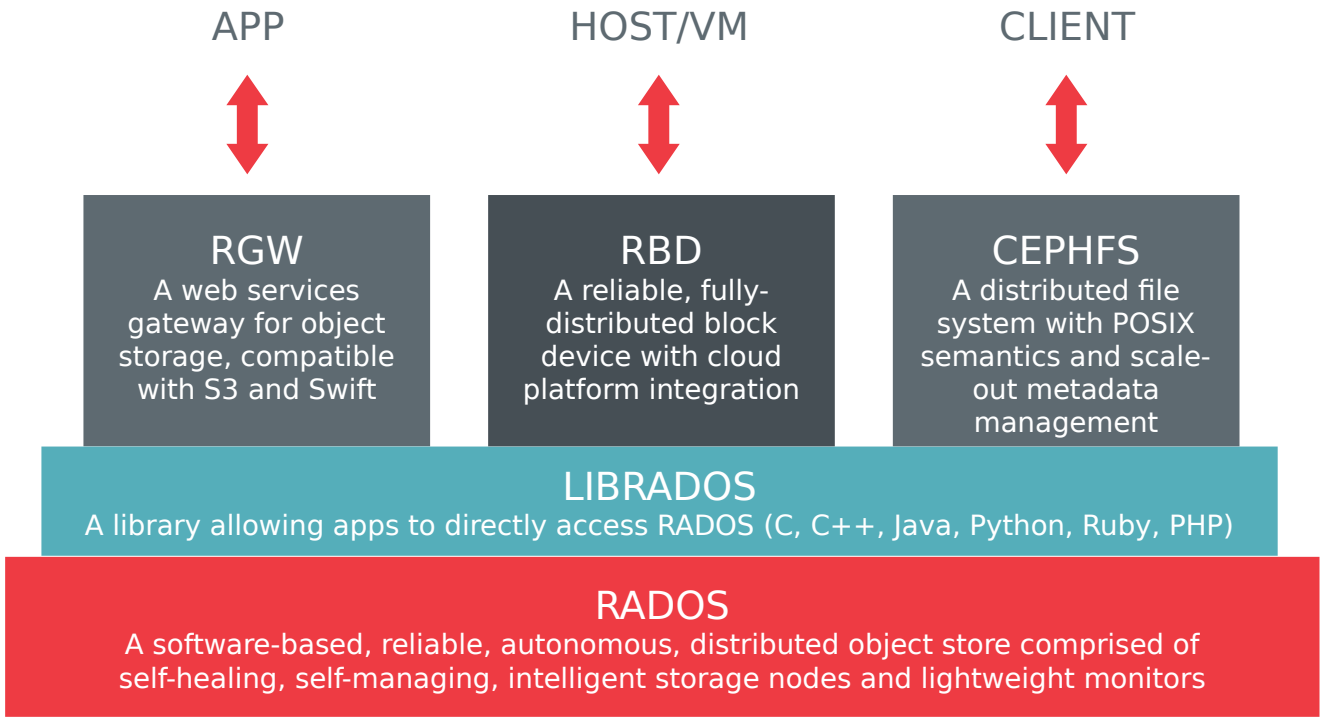
- Storage Cost = Media + Access + Management
- Shared nothing architecture conflates access and management
- Storage costs will become dominated by Management cost
- Storage costs become CPU/DRAM costs



"Sometimes I just feel like I'm not getting anywhere."

Credit: Allen Samuels at OpenStack Summit Austin, 4/2716:
The Consequences of Infinite Storage Bandwidth

ARCHITECTURAL COMPONENTS



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Challenges

- Current Architecture works great for multiple interfaces and directly-attached HDDs (aka spinners)
- Challenges
  - Storage devices are getting too fast
  - OSD peering too expensive for fabric-connected storage devices
  - Control of tail latency
  - Global name space scalability
    - frequent reason why people switch from files to objects

Storage devices are getting too fast

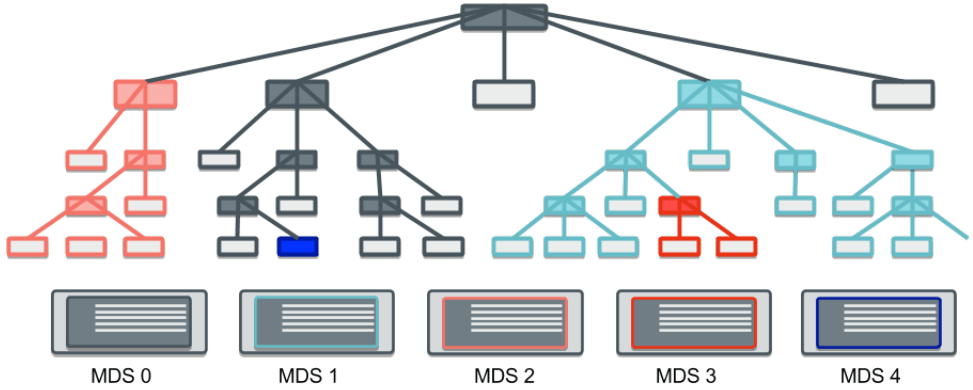
- NVMe is too fast
  - Migrating OSD critical path from thread-based to *futures*-based
  - Probably going to use Seastar library (seastar-project.org)
  - Most code doesn't have to change, e.g. peering and consistency code
  - Will greatly reduce the CPU cost for all storage
  - Will take at least a year
- Fabric-based storage devices (NVMeoF)
  - OSD to OSD replication causes too much overhead
  - Planning a new pool type where one OSD manages all replica
  - Fabrics might be too expensive, especially if already CPU-limited
  - New device interfaces might make OSD to OSD replication affordable again
    - For example, NVMe key/value interface standardization effort

Challenges

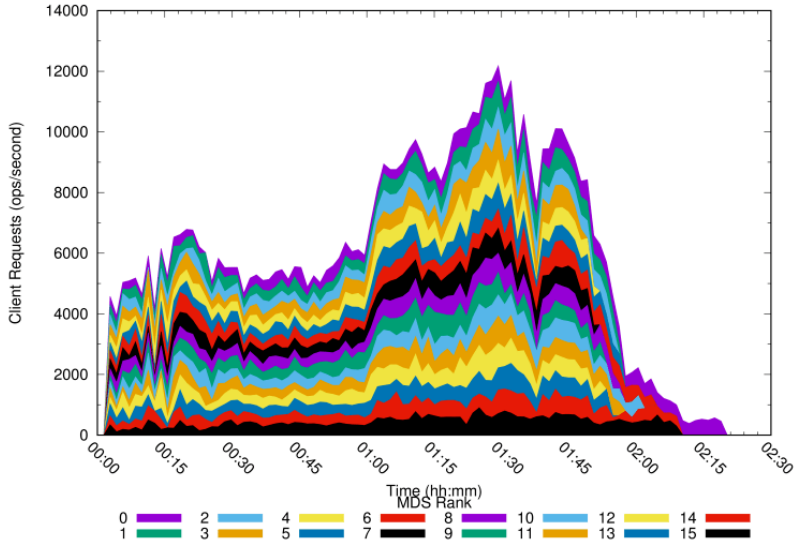
- Tail latency control
  - Planning a new pool type for quorum-based consistency
  - Different writers to different replica in parallel with eventual consistency
  - Strong consistency: read all replica and resolve conflicts
  - Weak consistency: read one replica only
- Files vs objects
  - Objects are considered to be more scalable than files
  - Most file systems have *one* name server: that doesn’t scale
  - Many file system workloads with > 50% metadata operations
  - Luminous release introduces multiple active metadata servers

Global Name Spaces

- Multiple active name servers
  - first proposed by Sage Weil at SC04

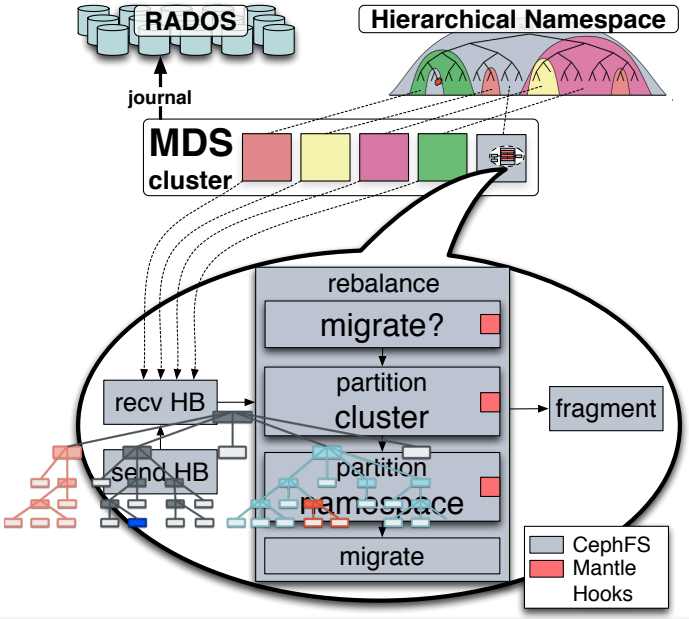


- Challenges
  - Load balancing
  - Consistency
  - Logical names vs physical names (e.g., mapping files to objects)

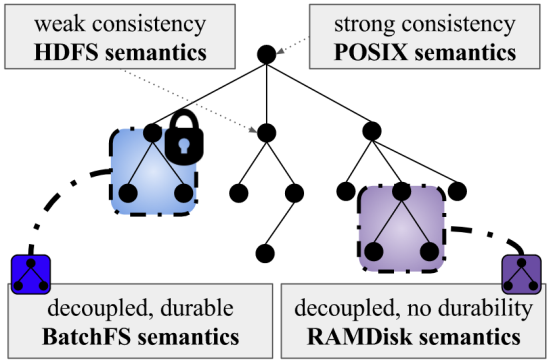


Credit: http://ceph.com/community/new-luminous-multiple-active-metadata-servers-cephfs/

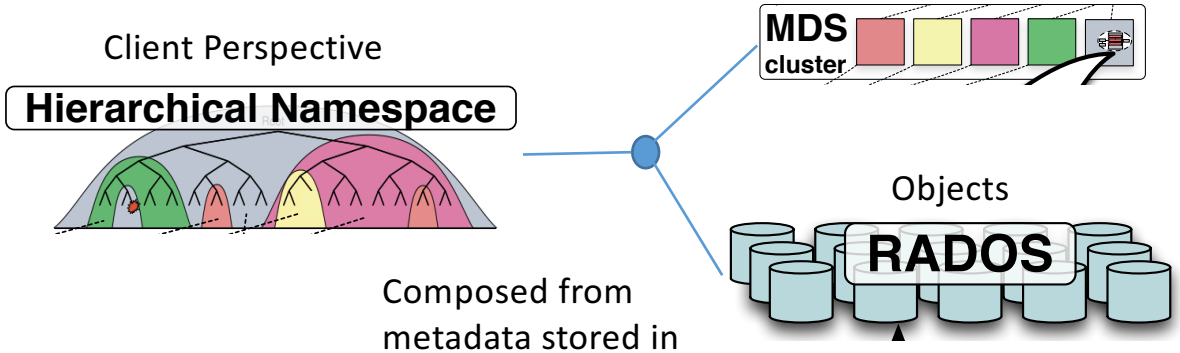
Global Name Spaces



Michael Sevilla, Noah Watkins, Carlos Maltzahn, Ike Nassi, Scott Brandt, Sage Weil, Greg Farnum, and Sam Fineberg, "Mantle: A programmable metadata load balancer for the ceph file system," SC '15, November 2015.



Michael A. Sevilla, Ivo Jimenez, Noah Watkins, Jeff LeFevre, Peter Alvaro, Shel Finkelstein, Carlos Maltzahn, Patrick Donnelley, "Cudele: An API and Framework for Programmable Consistency and Durability in a Global Namespace," submitted for publication.



Summary

- Data management CPU overhead will dominate cost of storage
- Ceph data path will get a lot shorter, check out seastar-project.org
- Tail latency control via quorum-based consistency (new pool type)
- Global name space scalability via
  - Subtree-specific load balancing policies
  - Subtree-specific consistency semantics that can be dynamically changed
  - Decoupling logical names from physical metadata management
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Ceph Pools

- Grouping of objects into sets that differ by the following
  - Resilience (number of replicas or erasure code parameters)
  - Placement groups
  - CRUSH rules
  - Snapshots
  - Ownership
  - Future object management alternatives (see below)