RED HAT SUMMIT

BOSTON, MA
JUNE 23-26, 2015

Ceph Block Devices: A Deep Dive

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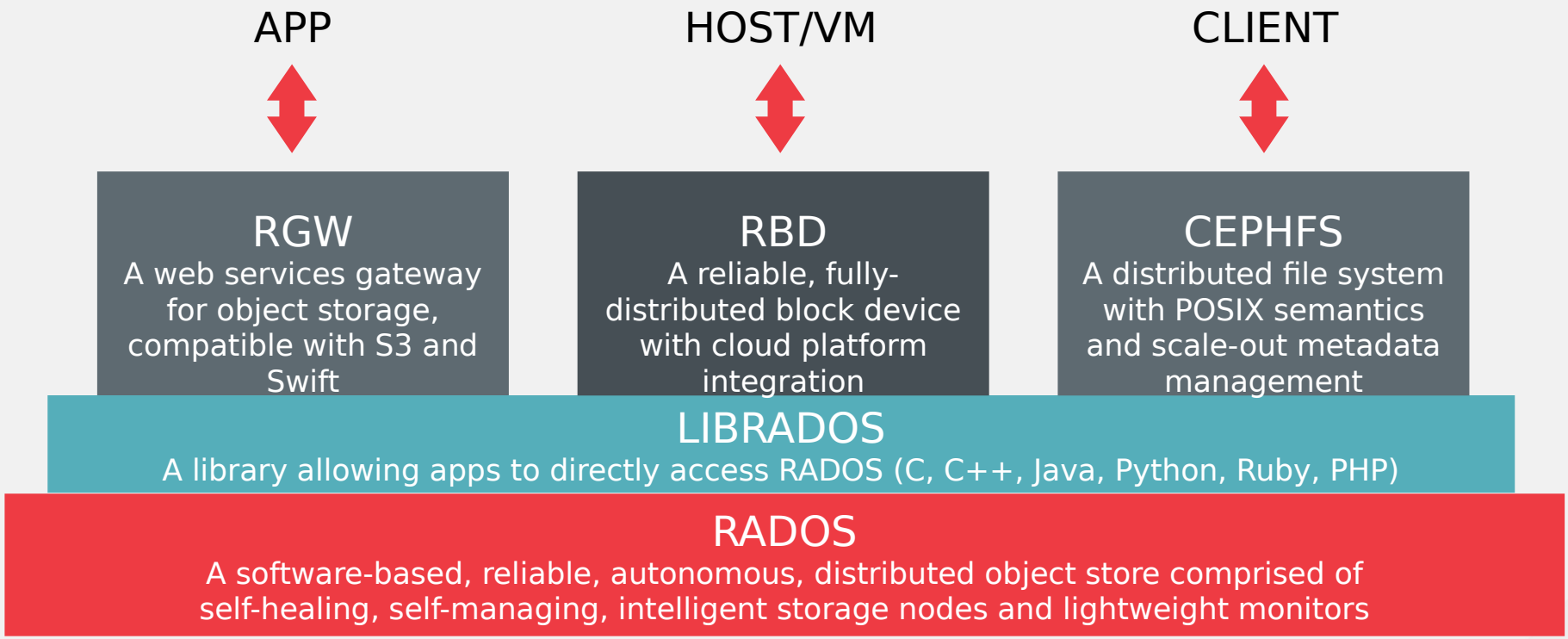
June 24, 2015

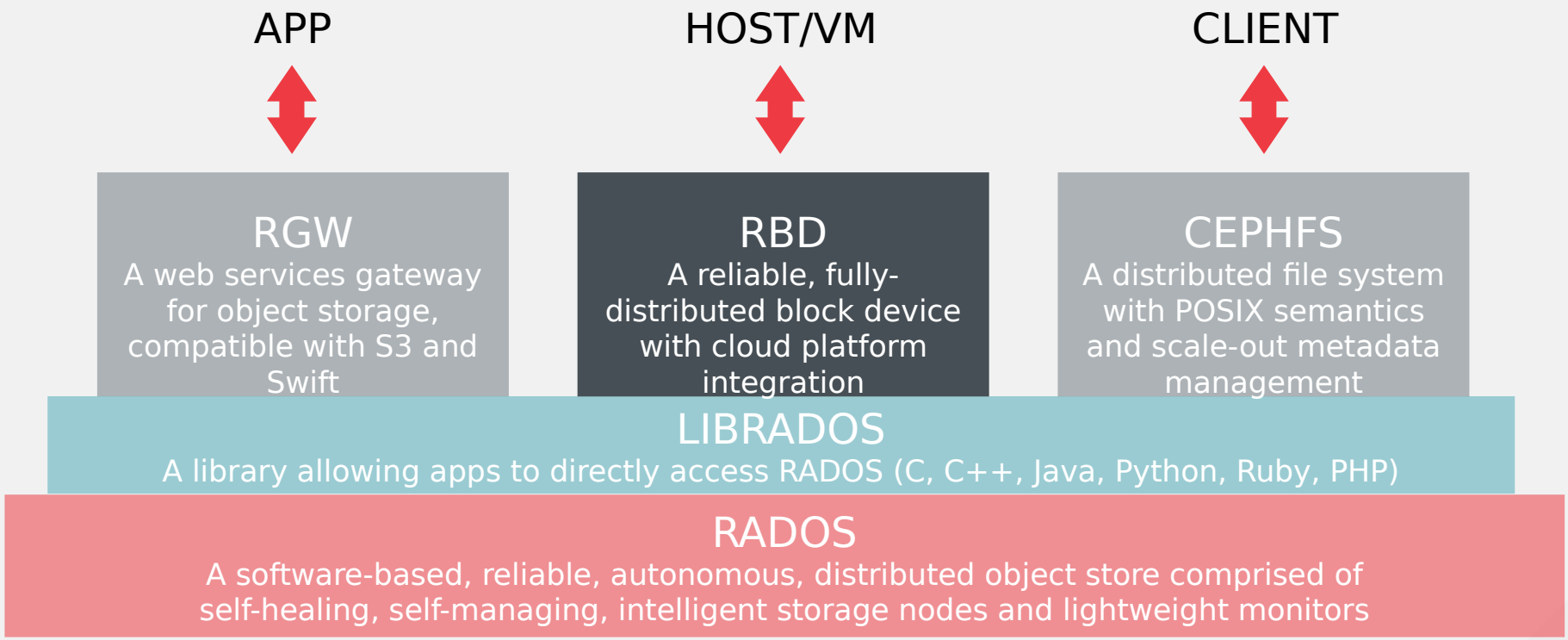
Ceph Motivating Principles

- All components must scale horizontally
- There can be no single point of failure
- The solution must be hardware agnostic
- Should use commodity hardware
- Self-manage wherever possible
- Open Source (LGPL)
- Move beyond legacy approaches
  - client/cluster instead of client/server
  - Ad hoc HA

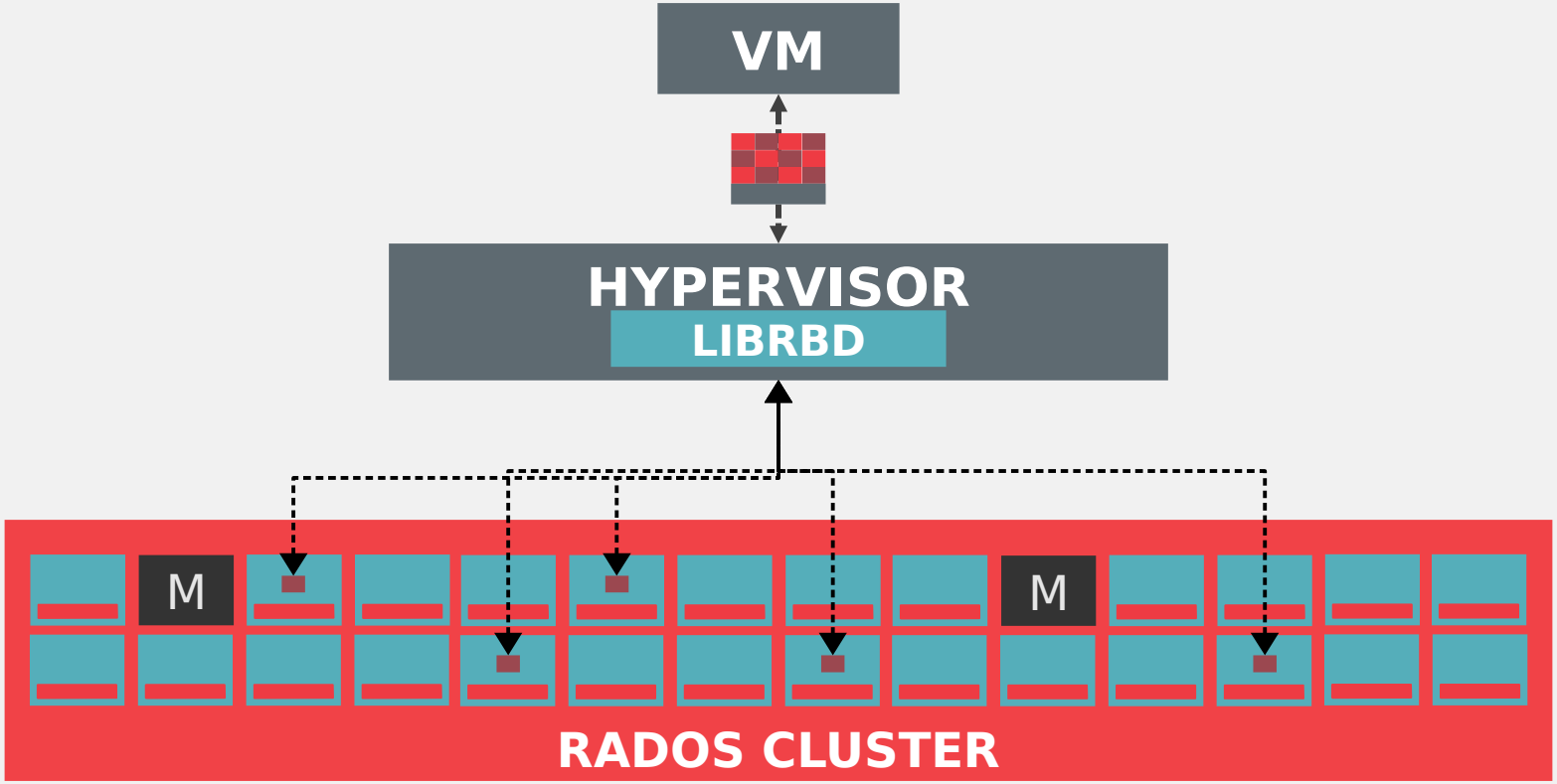
Ceph Components



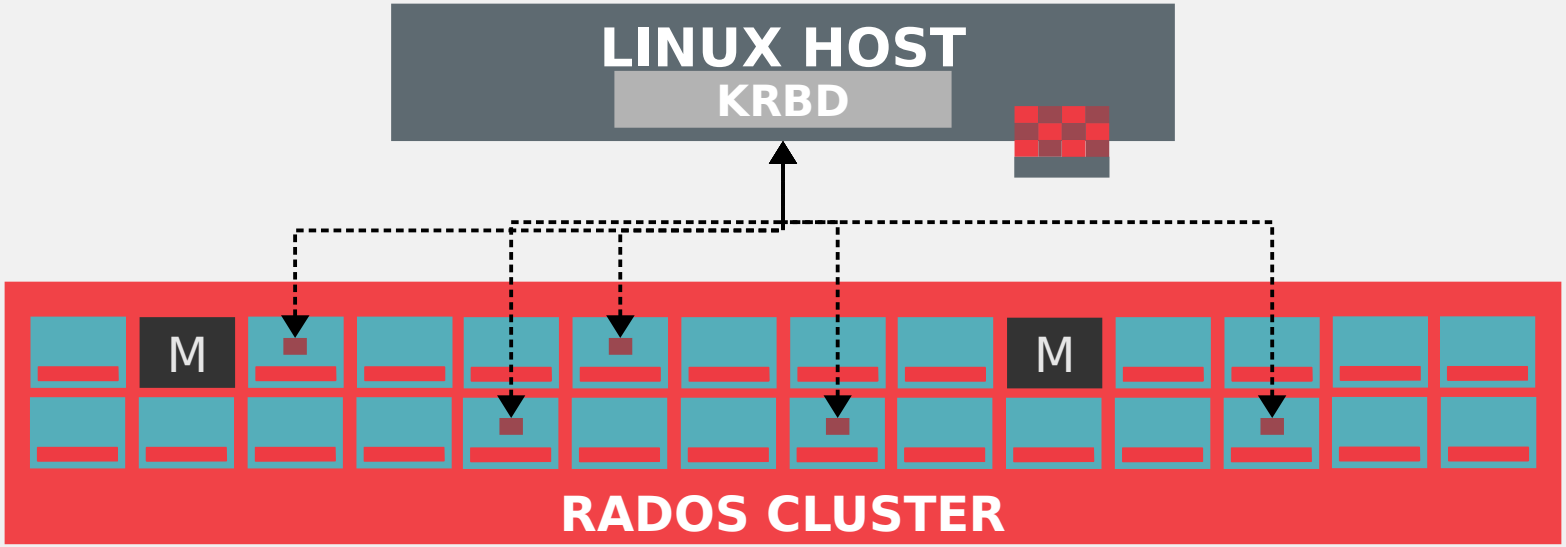
Ceph Components



Storing Virtual Disks

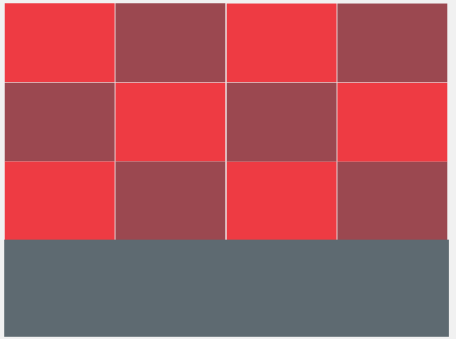


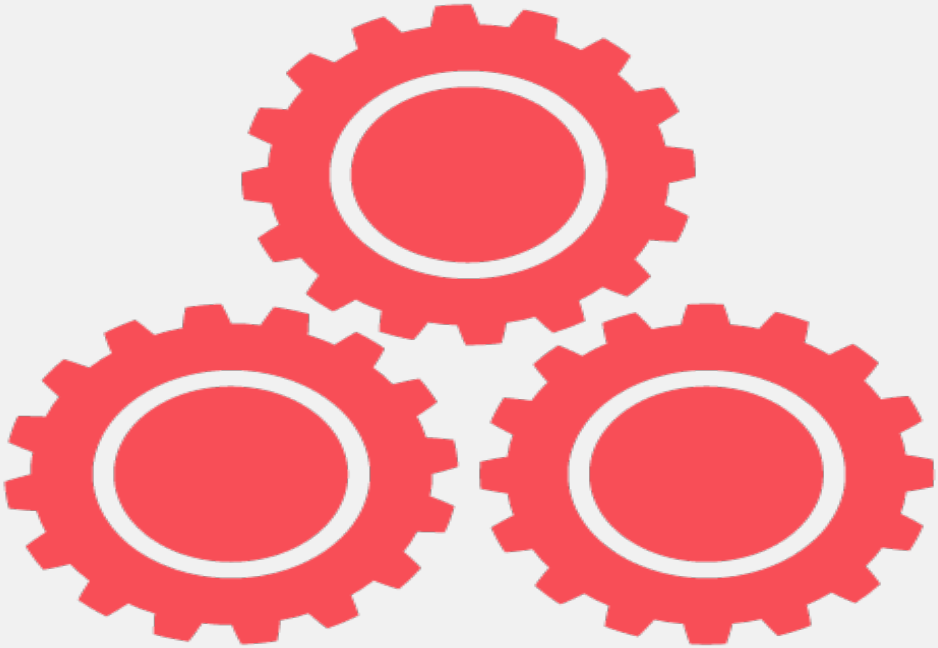
Kernel Module



RBD

- Stripe images across entire cluster (pool)
- Read-only snapshots
- Copy-on-write clones
- Broad integration
  - QEMU, libvirt
  - Linux kernel
  - iSCSI (STGT, LIO)
  - OpenStack, CloudStack, OpenNebula, Ganeti, Proxmox, oVirt
- Incremental backup (relative to snapshots)





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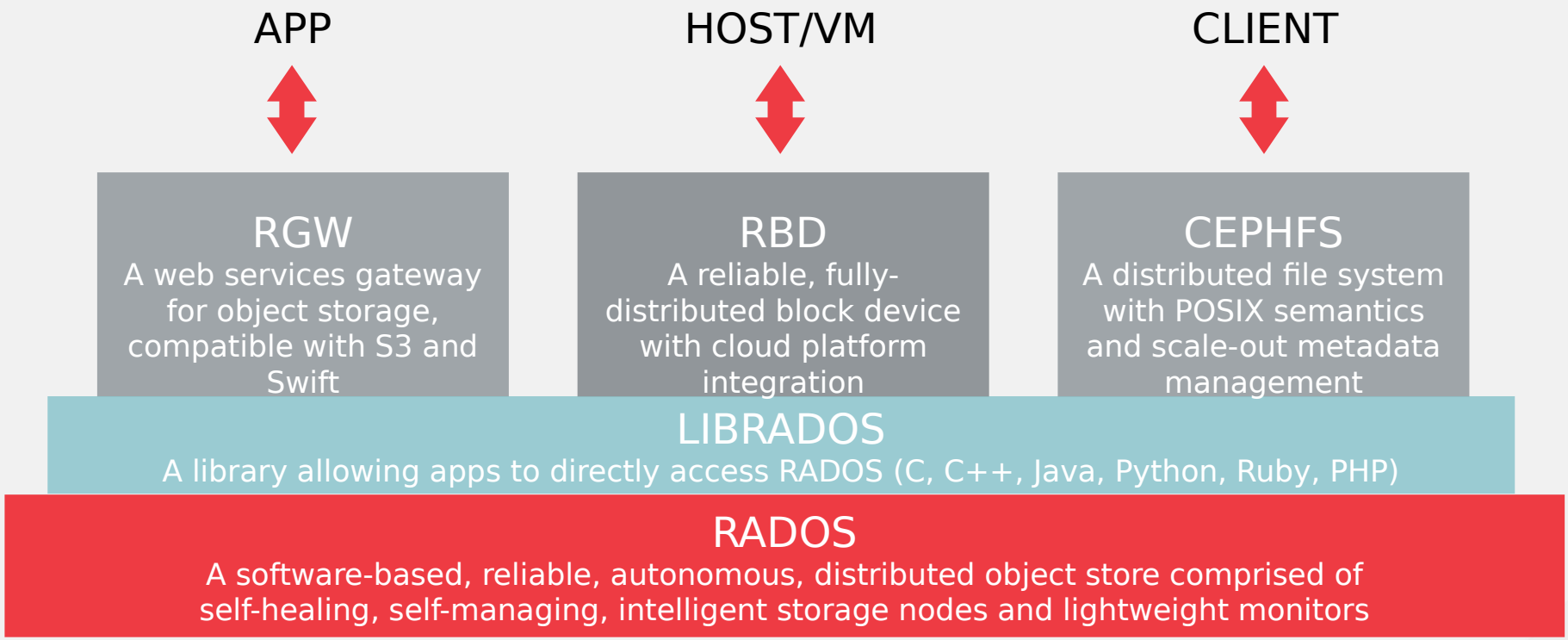
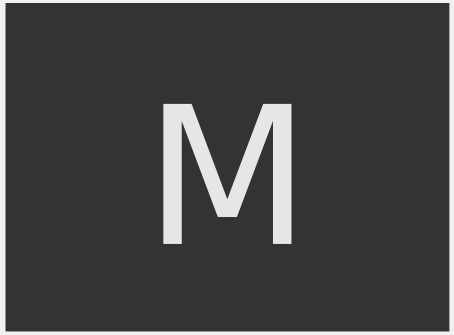


RADOS

- Flat namespace within a pool
- Rich object API
  - Bytes, attributes, key/value data
  - Partial overwrite of existing data
  - Single-object compound atomic operations
  - RADOS classes (stored procedures)
- Strong consistency (CP system)
- Infrastructure aware, dynamic topology
- Hash-based placement (CRUSH)
- Direct client to server data path

RADOS Components



OSDs:

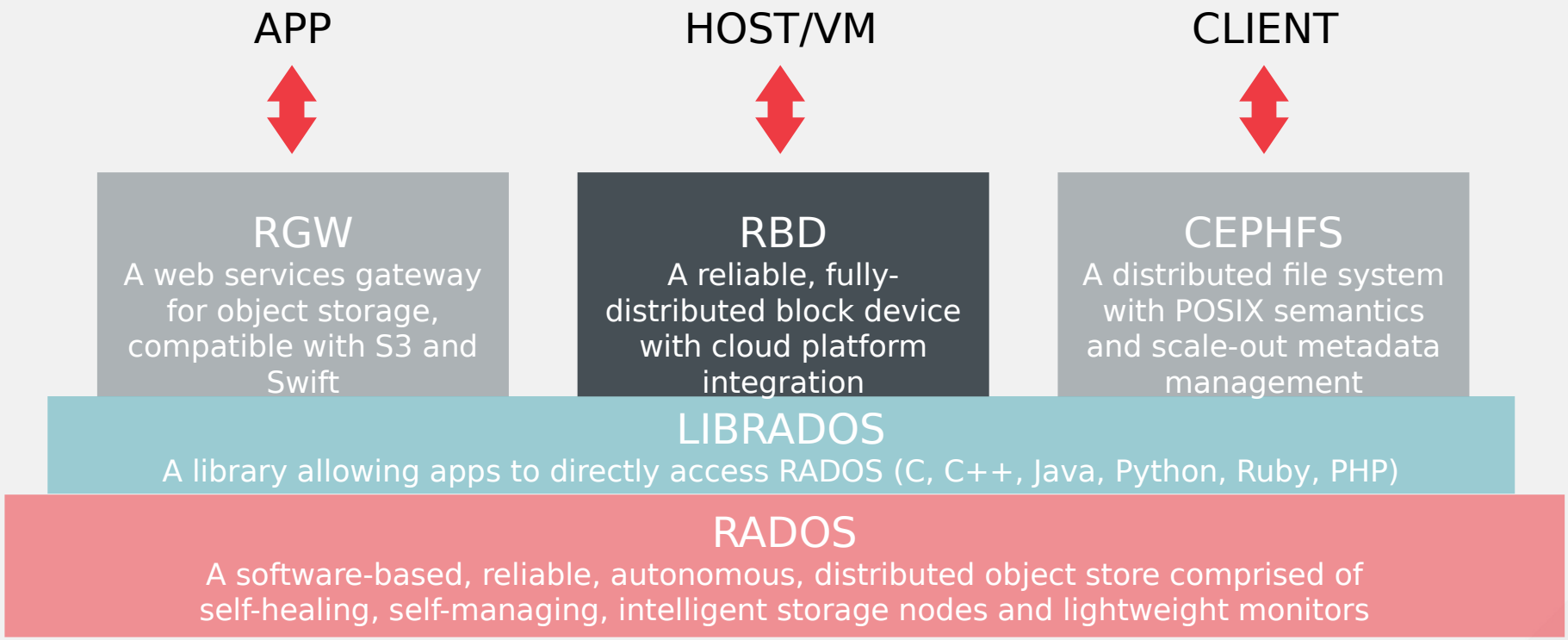
10s to 1000s in a cluster

- One per disk (or one per SSD, RAID group…)
- Serve stored objects to clients
- Intelligently peer for replication & recovery

Monitors:

- Maintain cluster membership and state
- Provide consensus for distributed decision-making
- Small, odd number (e.g., 5)
- Not part of data path

Ceph Components



Metadata

- rbd_directory
  - Maps image name to id, and vice versa
- rbd_children
  - Lists clones in a pool, indexed by parent
- rbd_id.$image_name
  - The internal id, locatable using only the user-specified image name
- rbd_header.$image_id
  - Per-image metadata

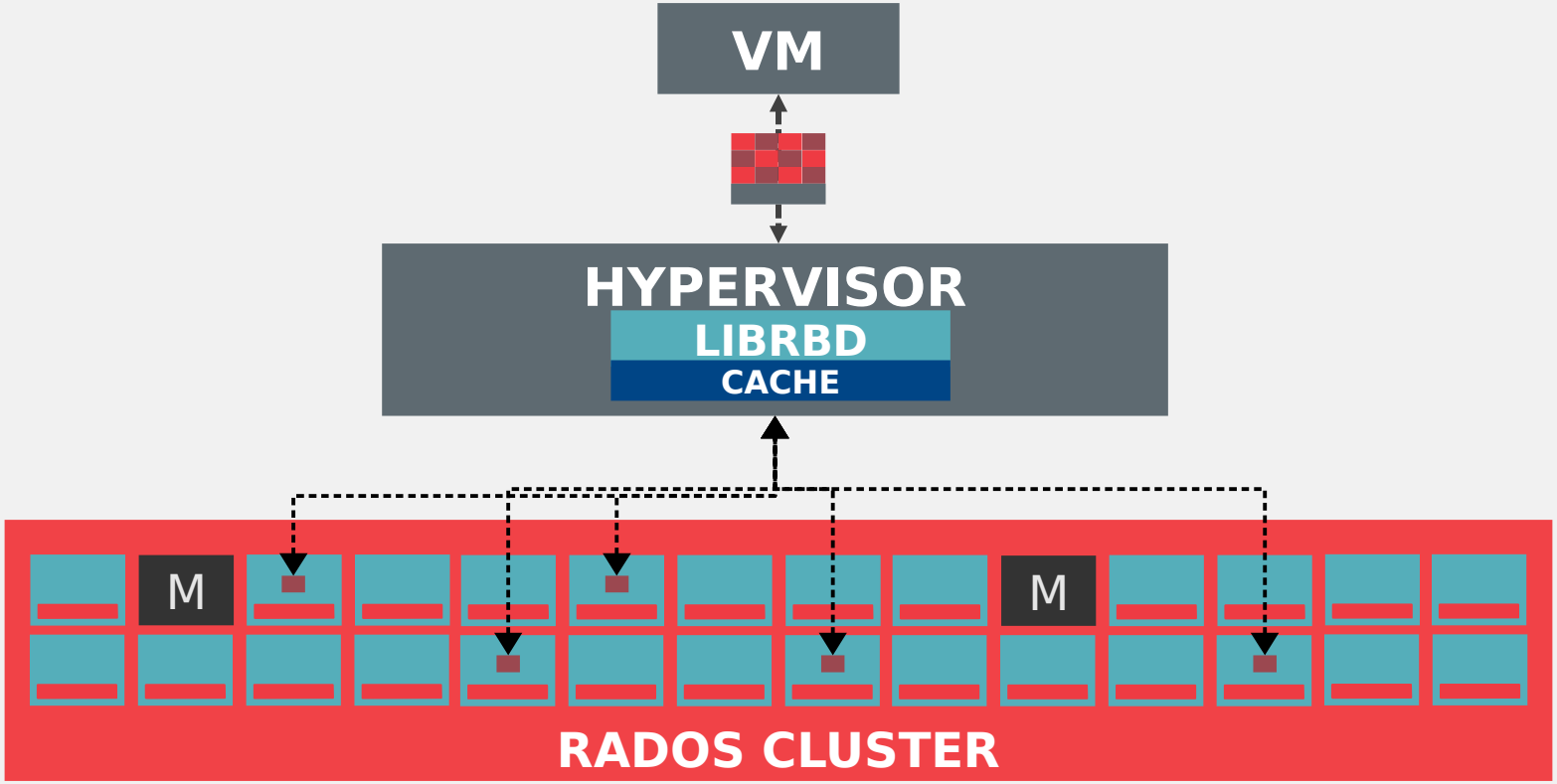
Data

- rbd_data.* objects
  - Named based on offset in image
  - Non-existent to start with
  - Plain data in each object
  - Snapshots handled by rados
  - Often sparse

Striping

- Objects are uniformly sized
  - Default is simple 4MB divisions of device
- Randomly distributed among OSDs by CRUSH
- Parallel work is spread across many spindles
- No single set of servers responsible for image
- Small objects lower OSD usage variance

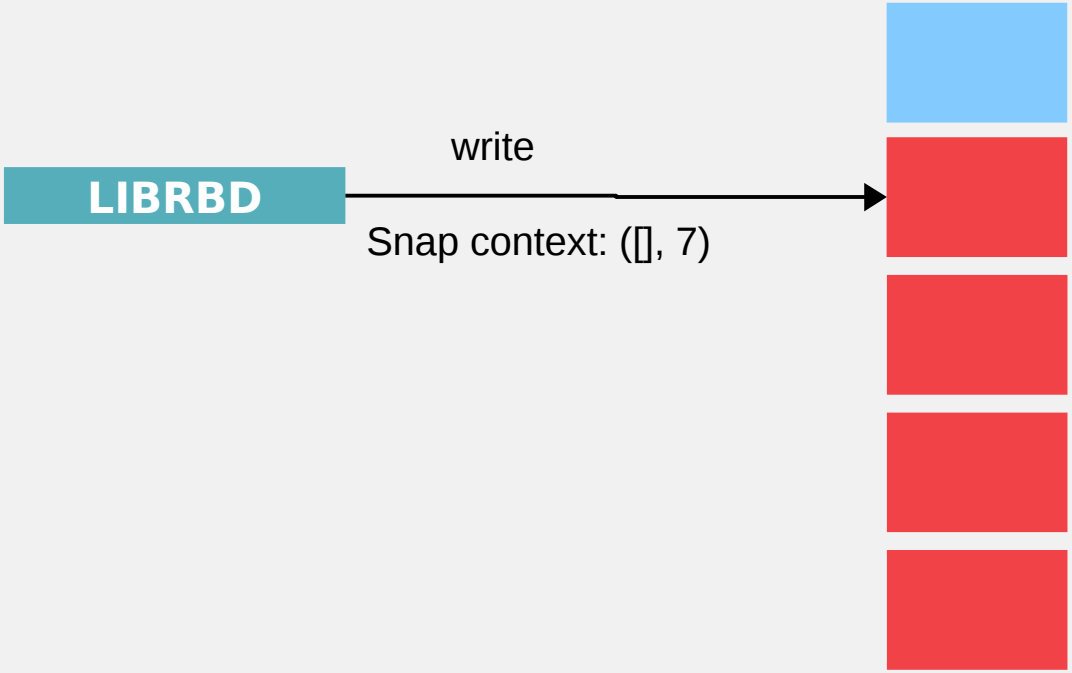
I/O



Snapshots

- Object granularity
- Snapshot context [list of snap ids, latest snap id]
  - Stored in rbd image header (self-managed)
  - Sent with every write
- Snapshot ids managed by monitors
- Deleted asynchronously
- RADOS keeps per-object overwrite stats, so diffs are easy

Snapshots



Snapshots

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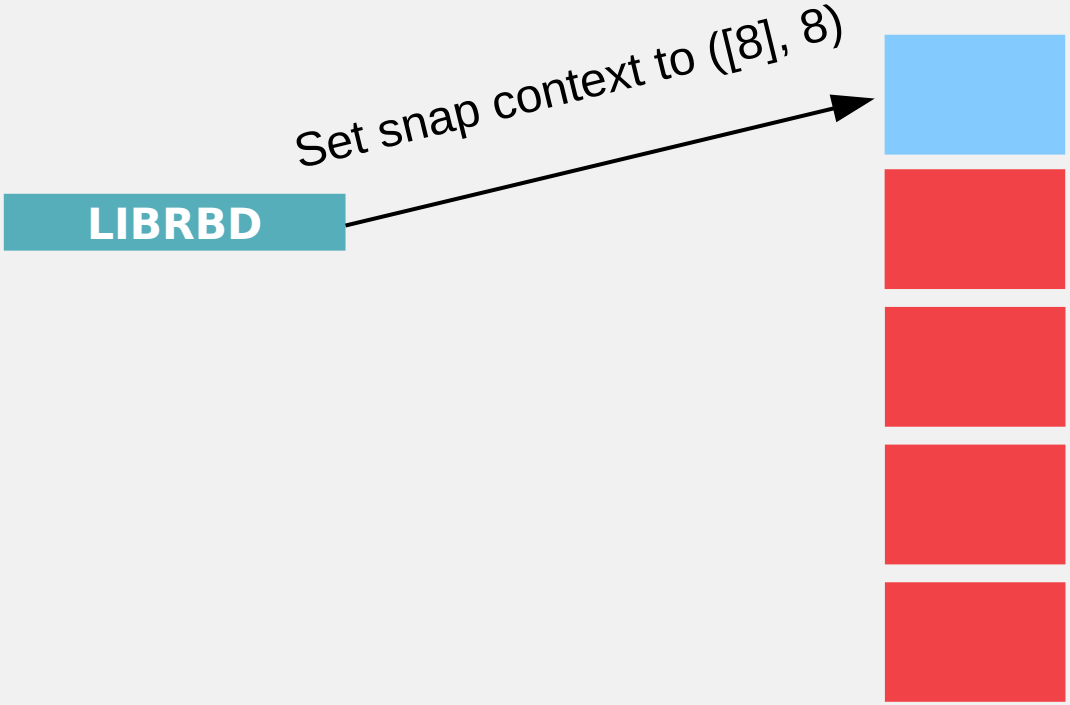

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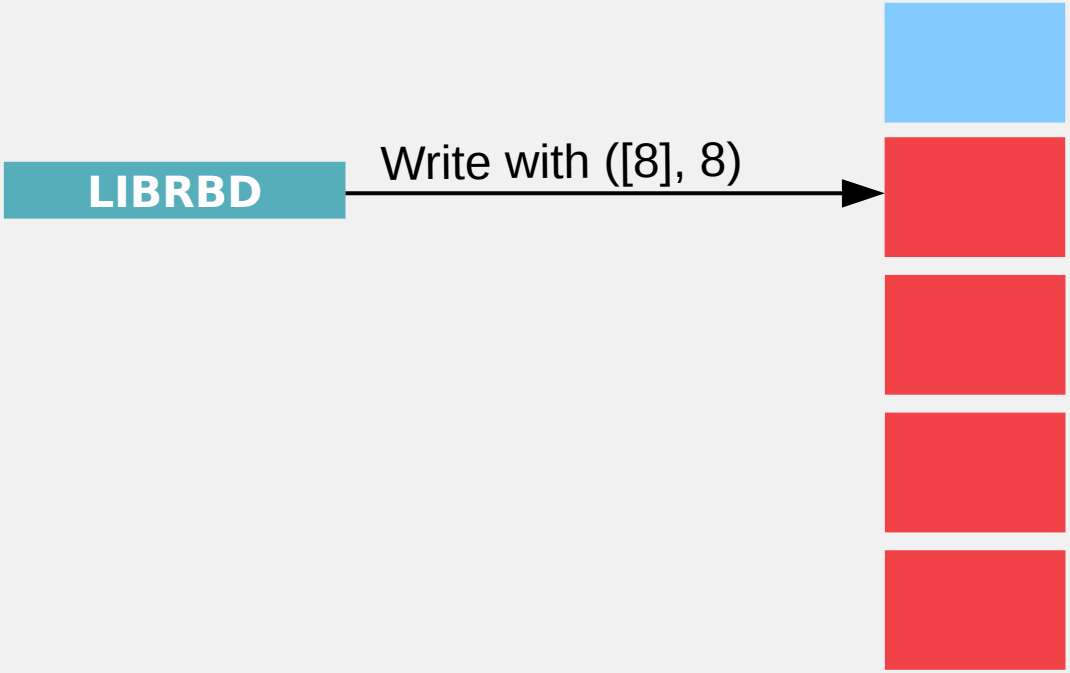

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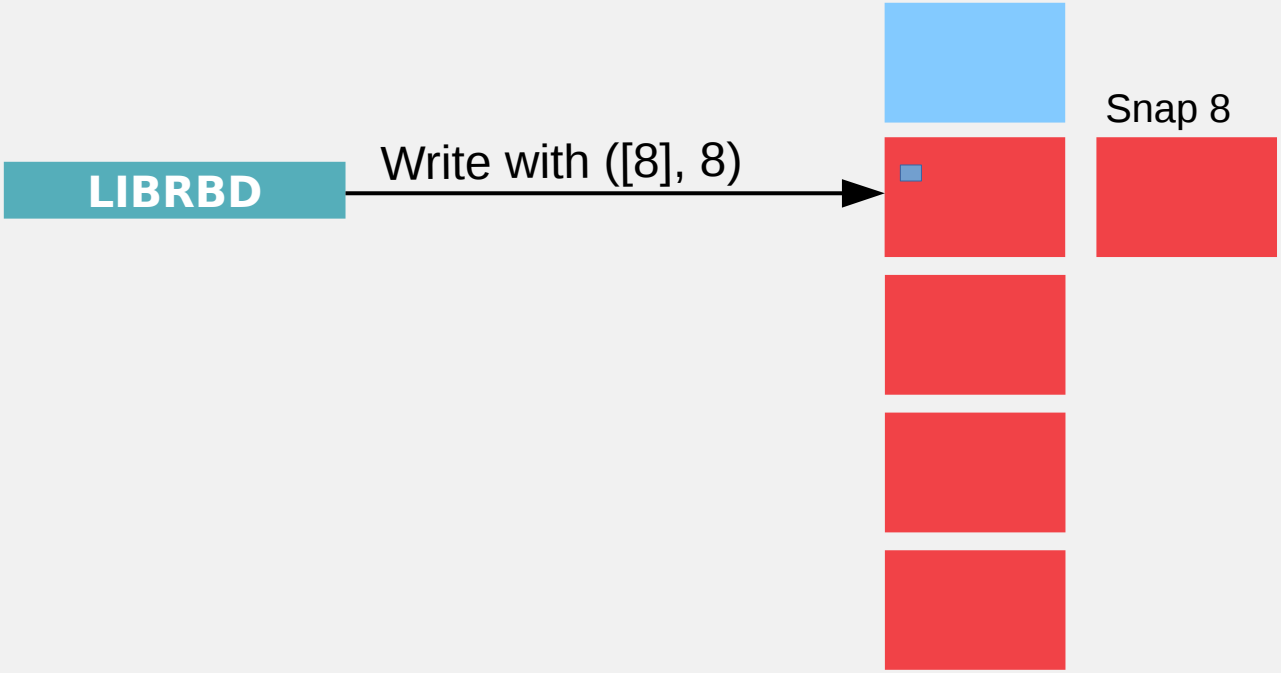
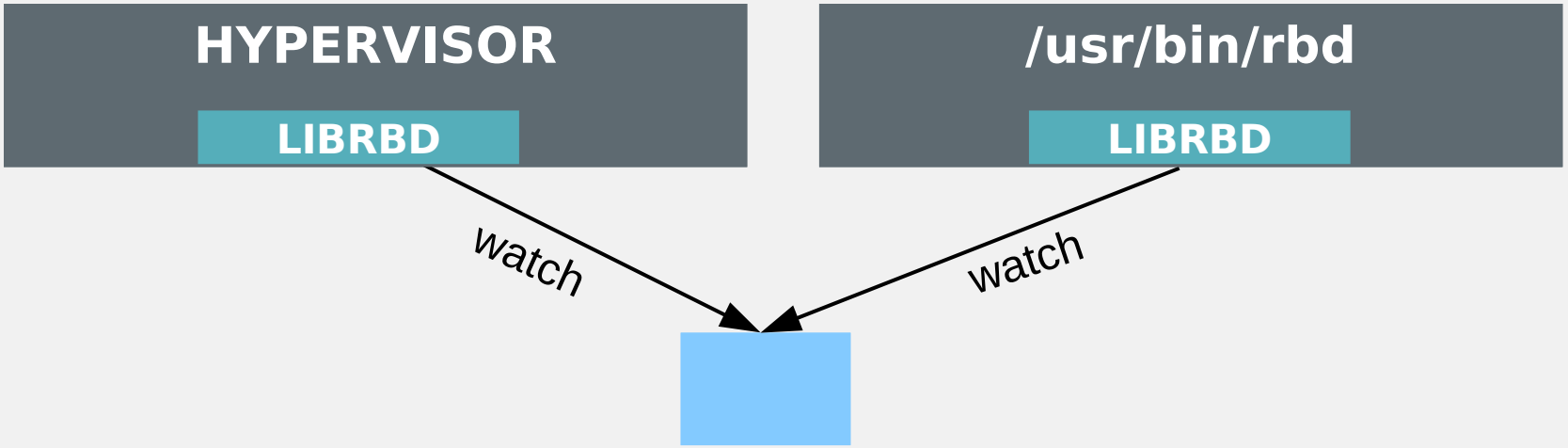


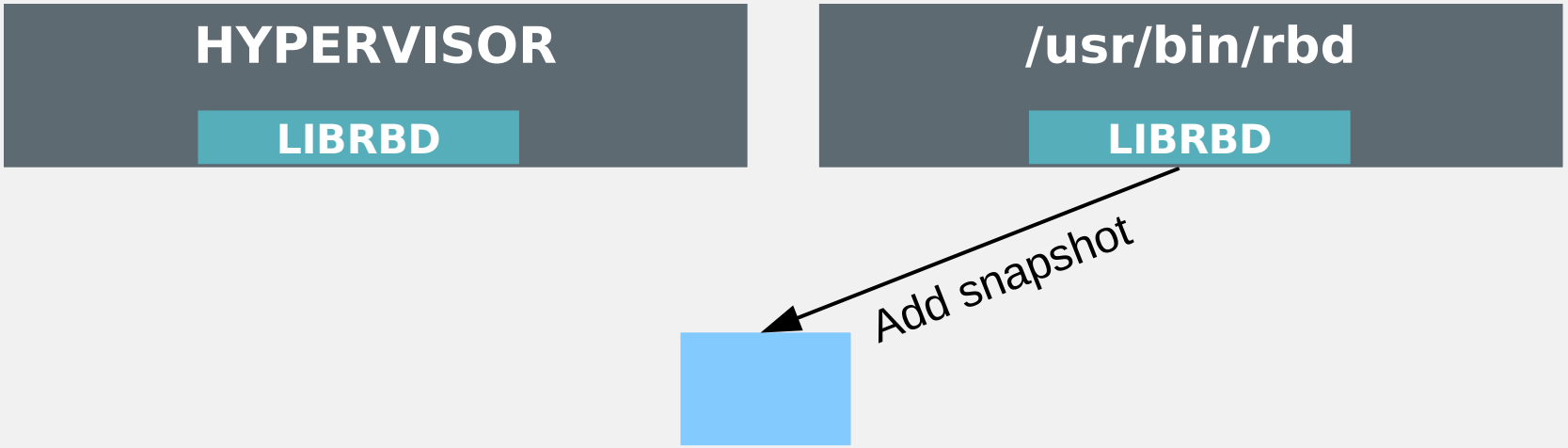
Watch/Notify

- establish stateful 'watch' on an object
  - client interest persistently registered with object
  - client keeps connection to OSD open
- send 'notify' messages to all watchers
  - notify message (and payload) sent to all watchers
  - notification (and reply payloads) on completion
- strictly time-bounded liveness check on watch
  - no notifier falsely believes we got a message

Watch/Notify



Watch/Notify



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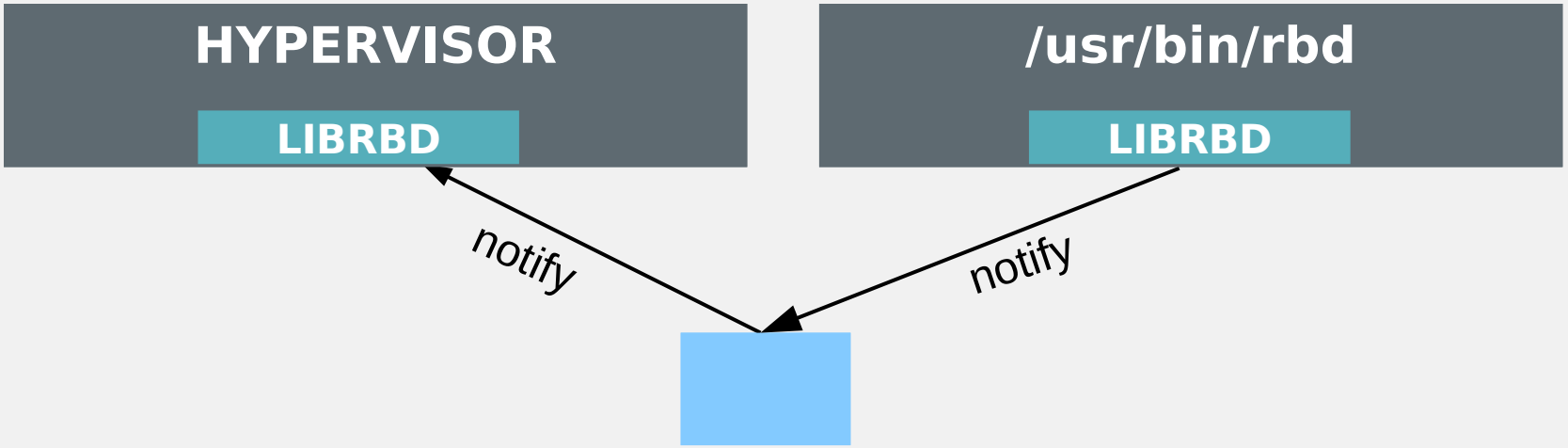

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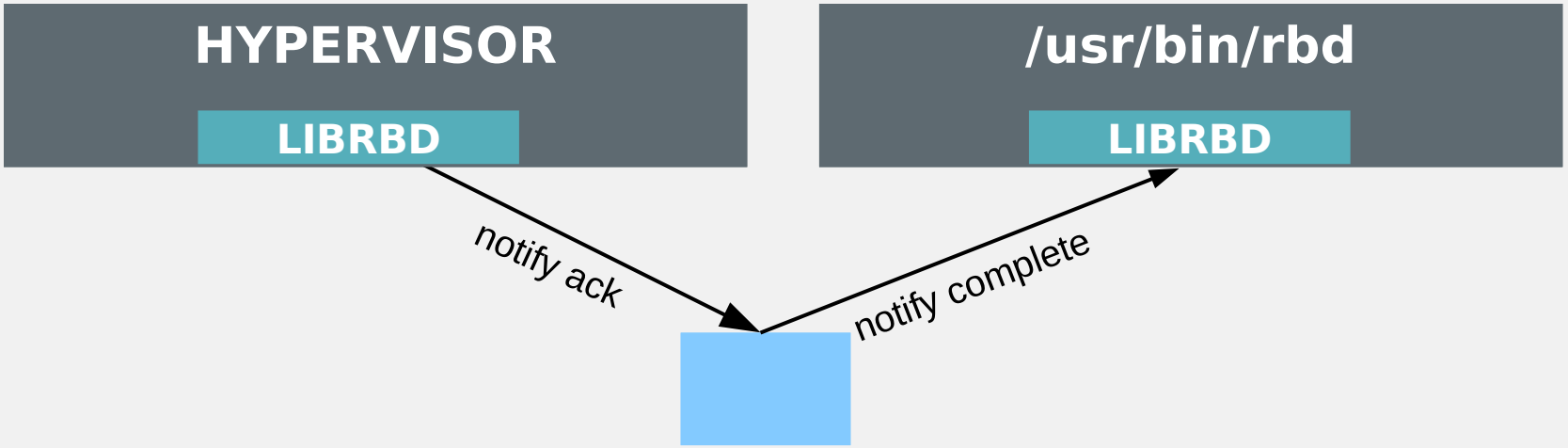

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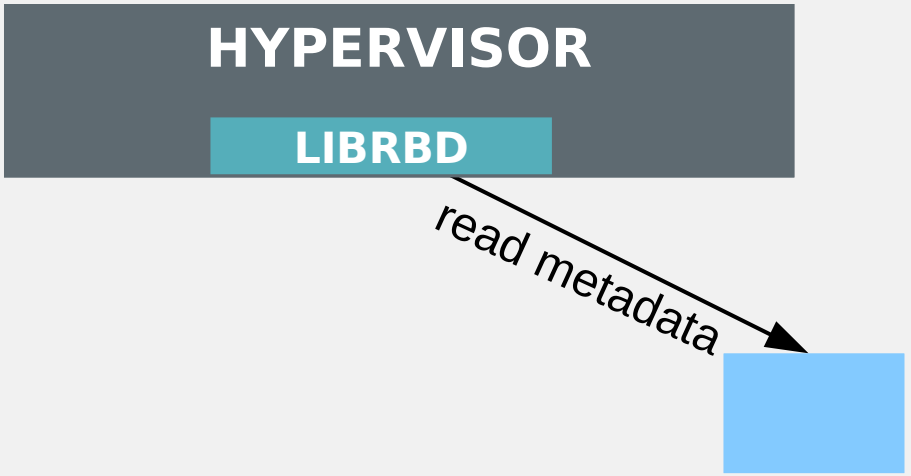
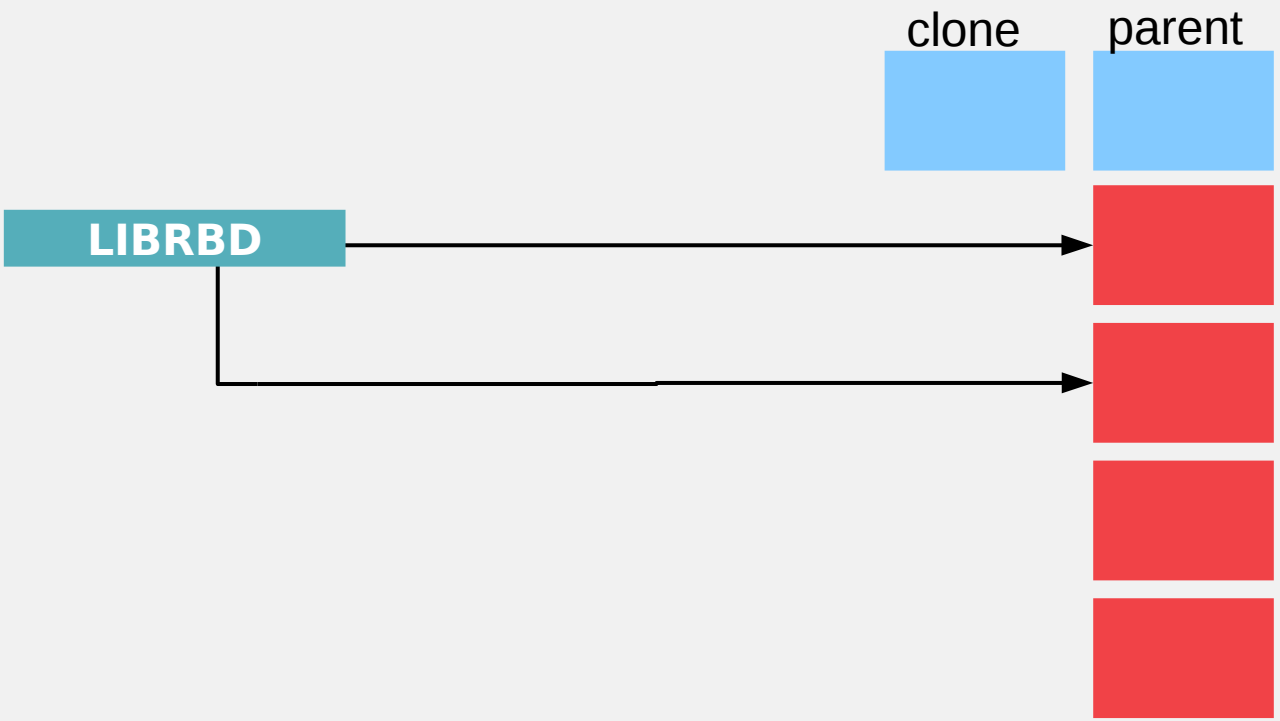


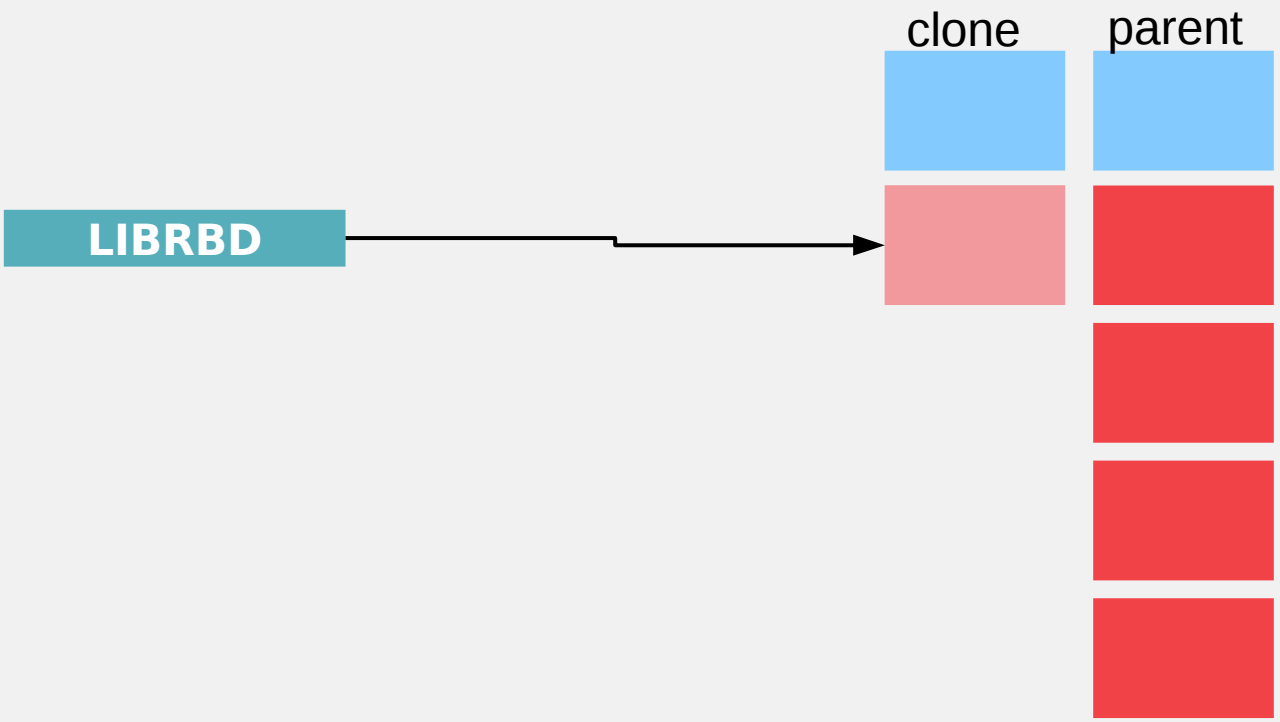
Clones

- Copy-on-write (and optionally read, in Hammer)
- Object granularity
- Independent settings
  - striping, feature bits, object size can differ
  - can be in different pools
- Clones are based on protected snapshots
  - 'protected' means they can't be deleted
- Can be flattened
  - Copy all data from parent
  - Remove parent relationship

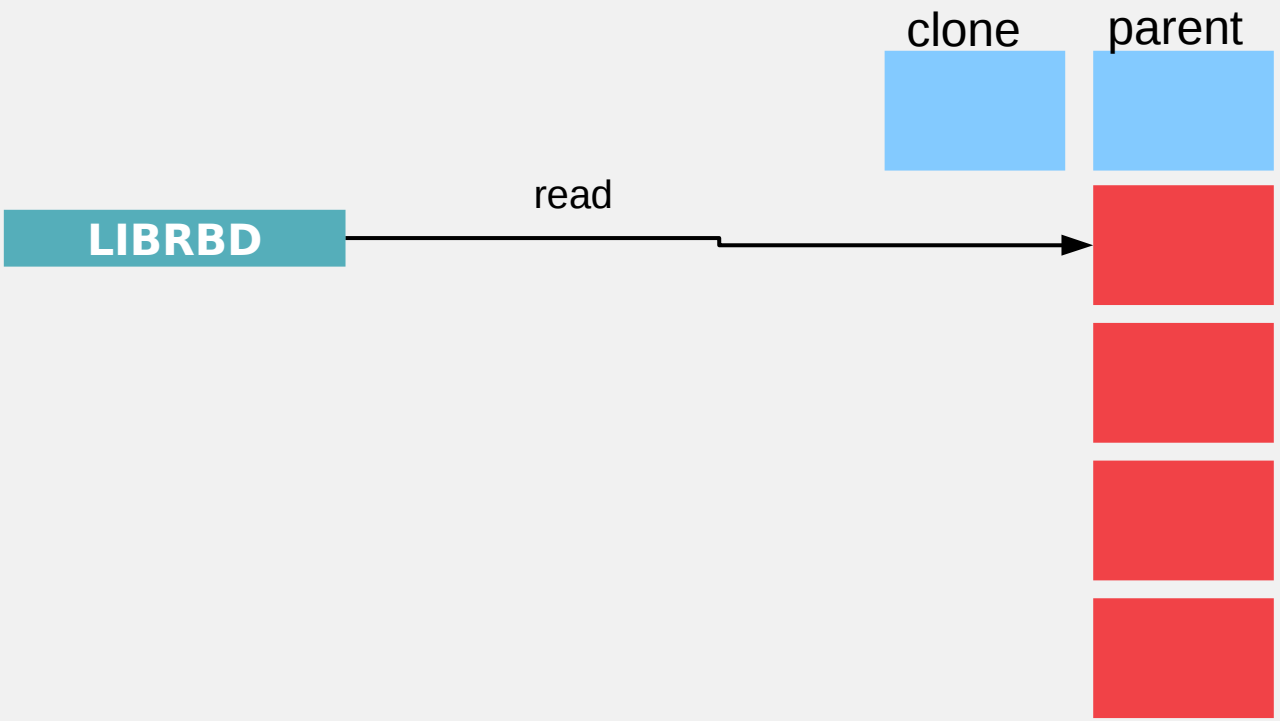
Clones - read



Clones - write



Clones - write



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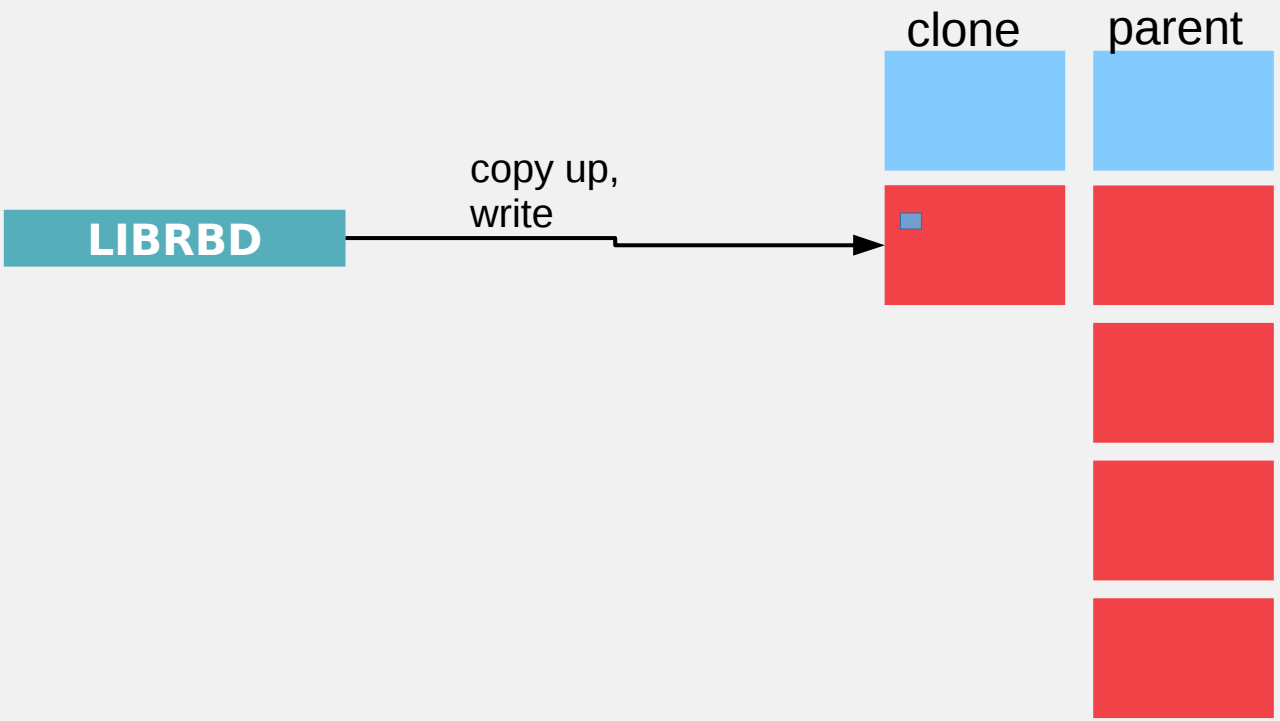
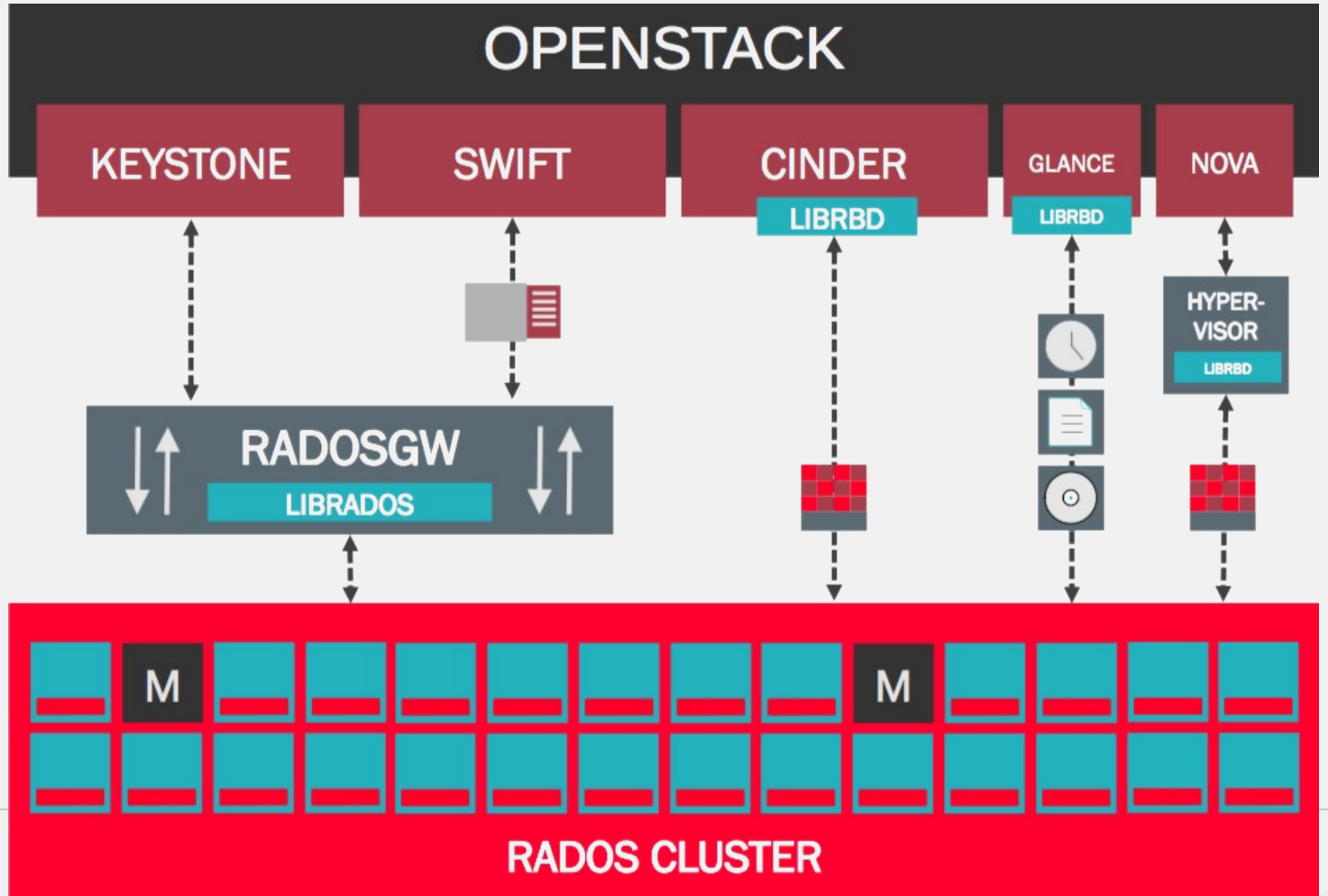


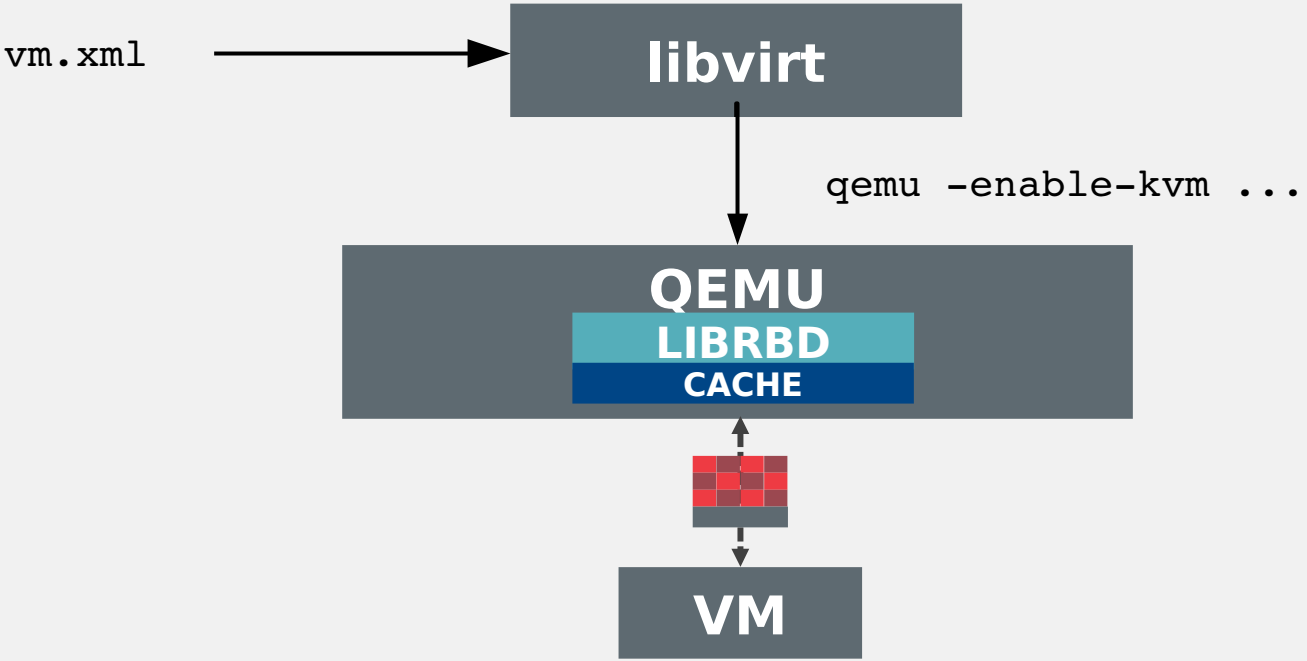
Ceph and OpenStack



Virtualized Setup

- Secret key stored by libvirt
- XML defining VM fed in, includes
  - Monitor addresses
  - Client name
  - QEMU block device cache setting
    - Writeback recommended
  - Bus on which to attach block device
    - virtio-blk/virtio-scsi recommended
    - Ide ok for legacy systems
  - Discard options (ide/scsi only), I/O throttling if desired

Virtualized Setup



Kernel RBD

- `rbd map` sets everything up
- `/etc/ceph/rbdmap` is like `/etc/fstab`
- udev adds handy symlinks:
  - `/dev/rbd/$pool/$image[@snap]`
- striping v2 and later feature bits not supported yet
- Can be used to back LIO, NFS, SMB, etc.
- No specialized cache, page cache used by filesystem on top

What's new in Hammer

- Copy-on-read
- Librbd cache enabled in safe mode by default
- Readahead during boot
- Lttng tracepoints
- Allocation hints
- Cache hints
- Exclusive locking (off by default for now)
- Object map (off by default for now)

Infernalis

- Easier space tracking (rbd du)
- Faster differential backups
- Per-image metadata
  - Can persist rbd options
- RBD journaling
- Enabling new features on the fly

Future Work

- Kernel client catch up
- RBD mirroring
- Consistency groups
- QoS for rados (policy at rbd level)
- Active/Active iSCSI
- Performance improvements
  - Newstore osd backend
  - Improved cache tiering
  - Finer-grained caching
  - Many more

Questions?

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