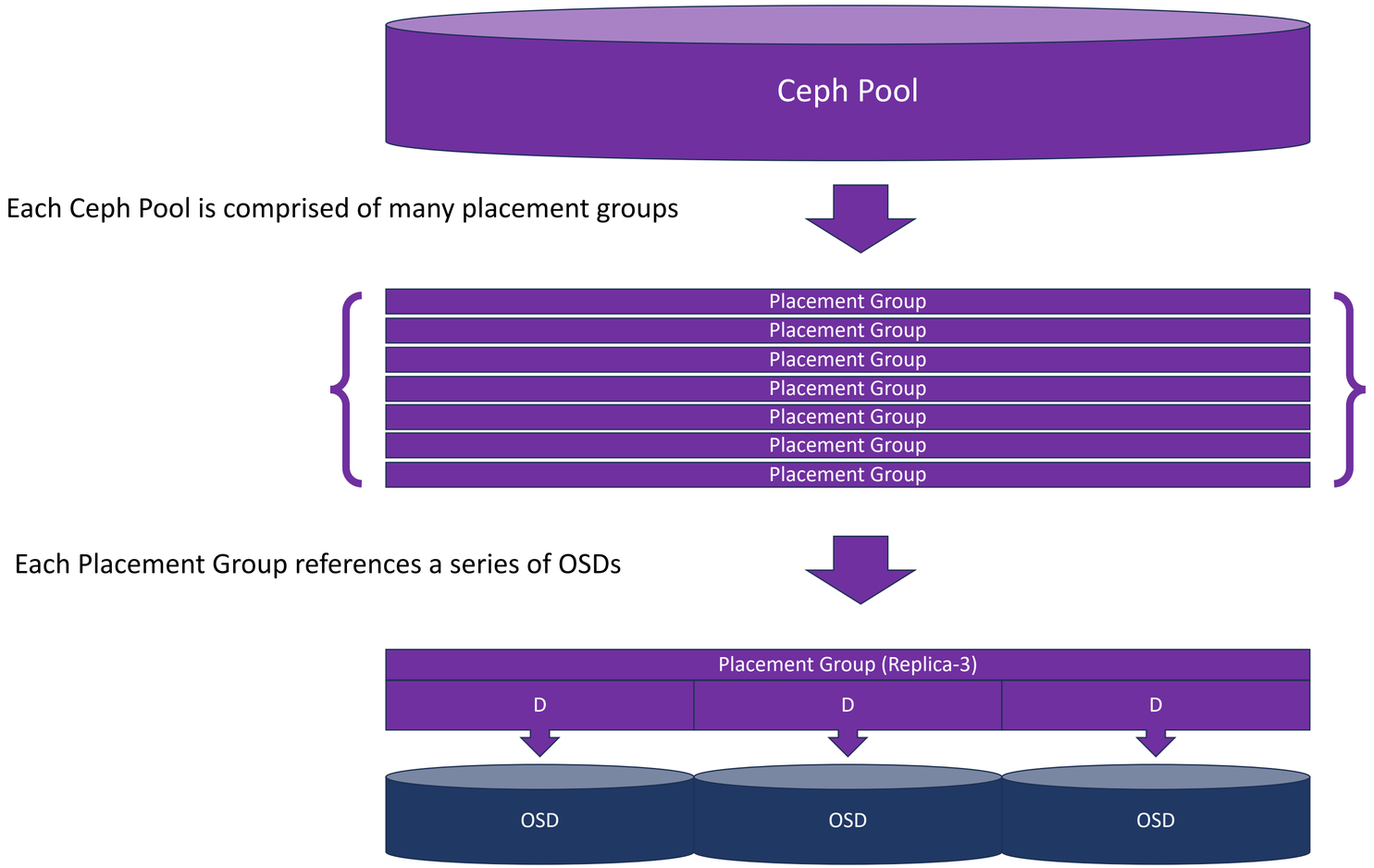
Designing Ceph Clusters: What's the Right Durability?

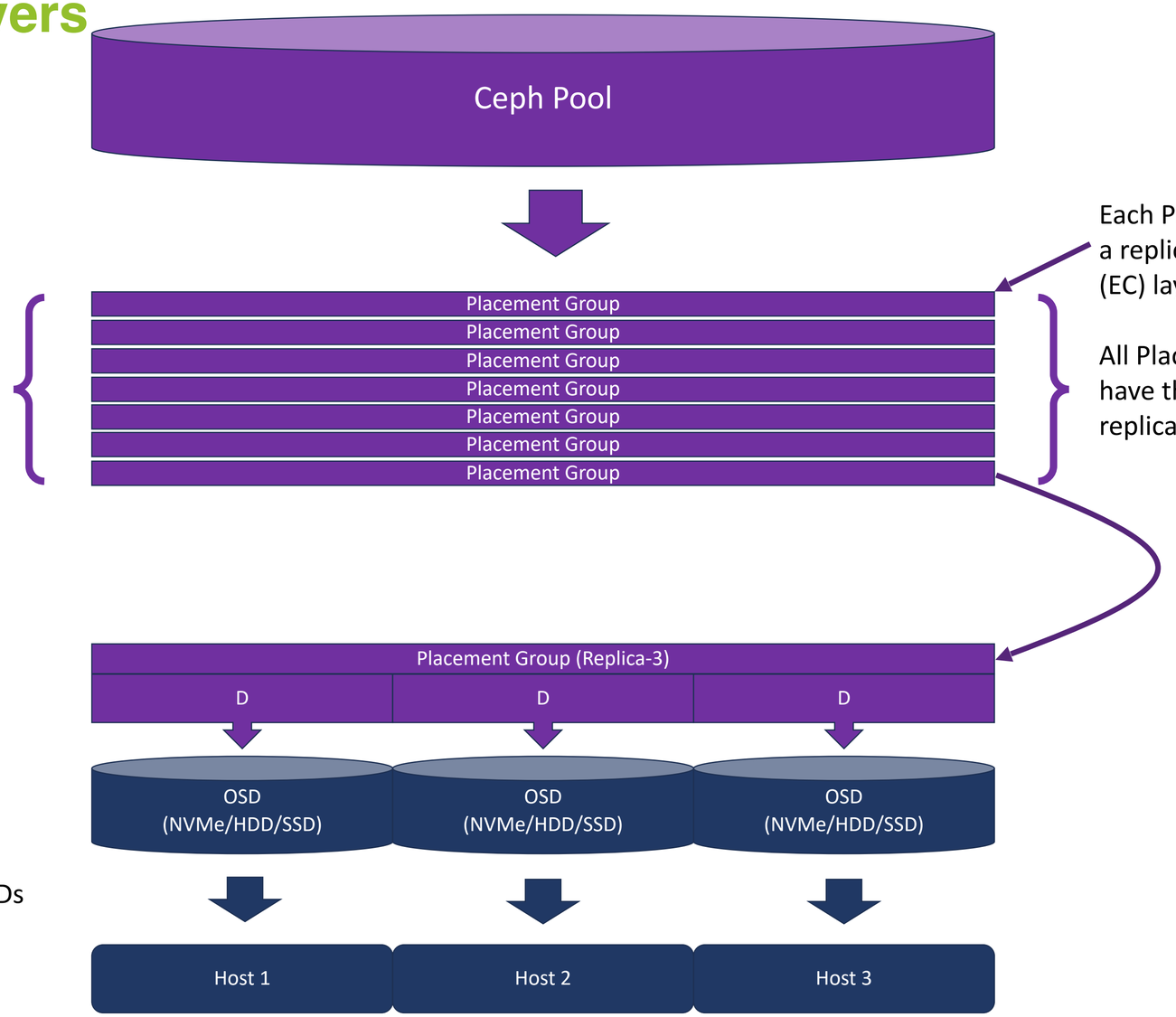
Ceph Days Seattle 2026

Steve Umbehocker, CTO/CEO, OSNexus

Understanding the Layers



Understanding the Layers



Each Placement Group can have either a replica layout or an erasure coding (EC) layout.

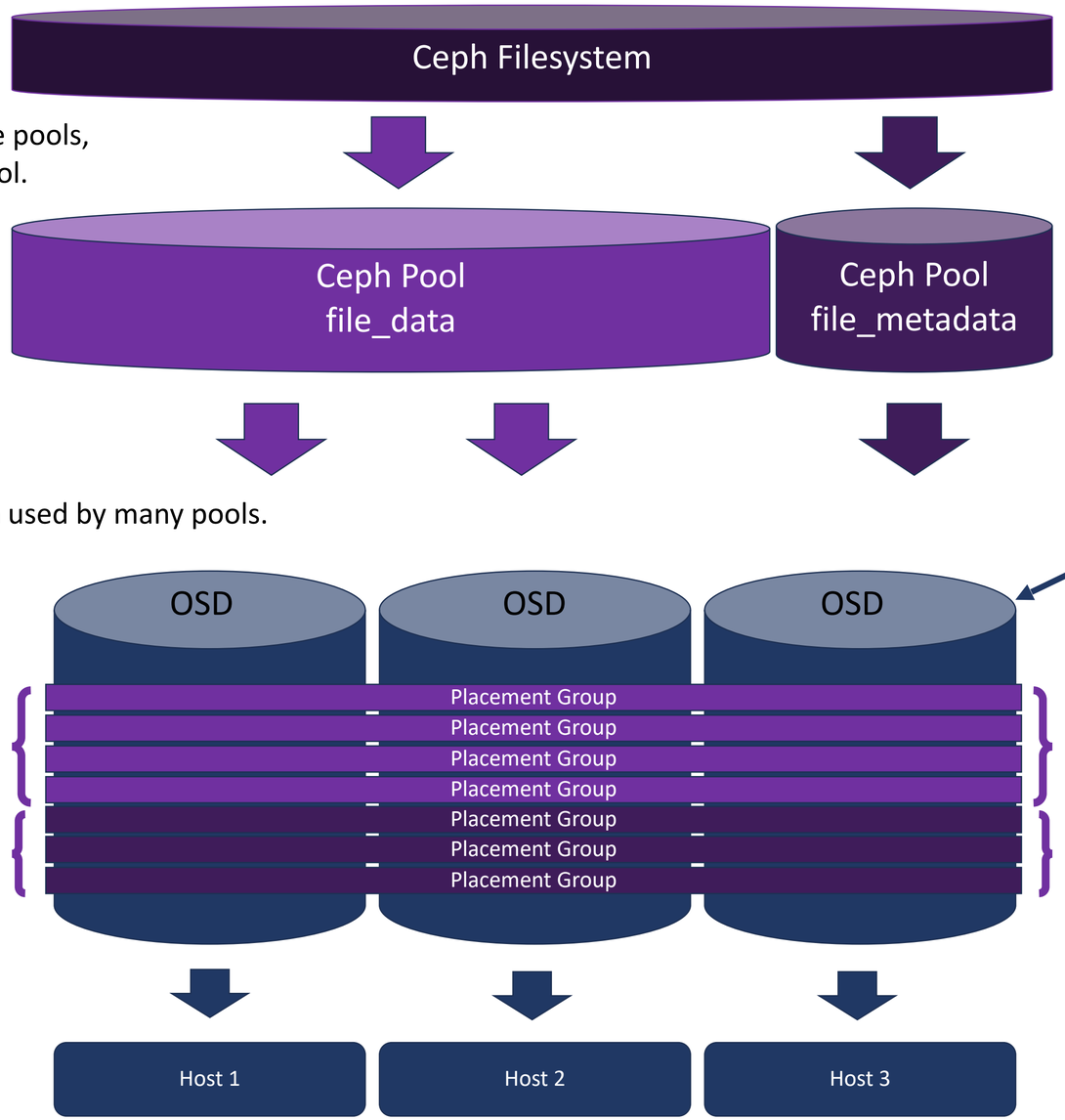
All Placement Groups for a given pool have the same layout, EC K+M or replica-N.

Each Host has many OSDs

Understanding the Layers

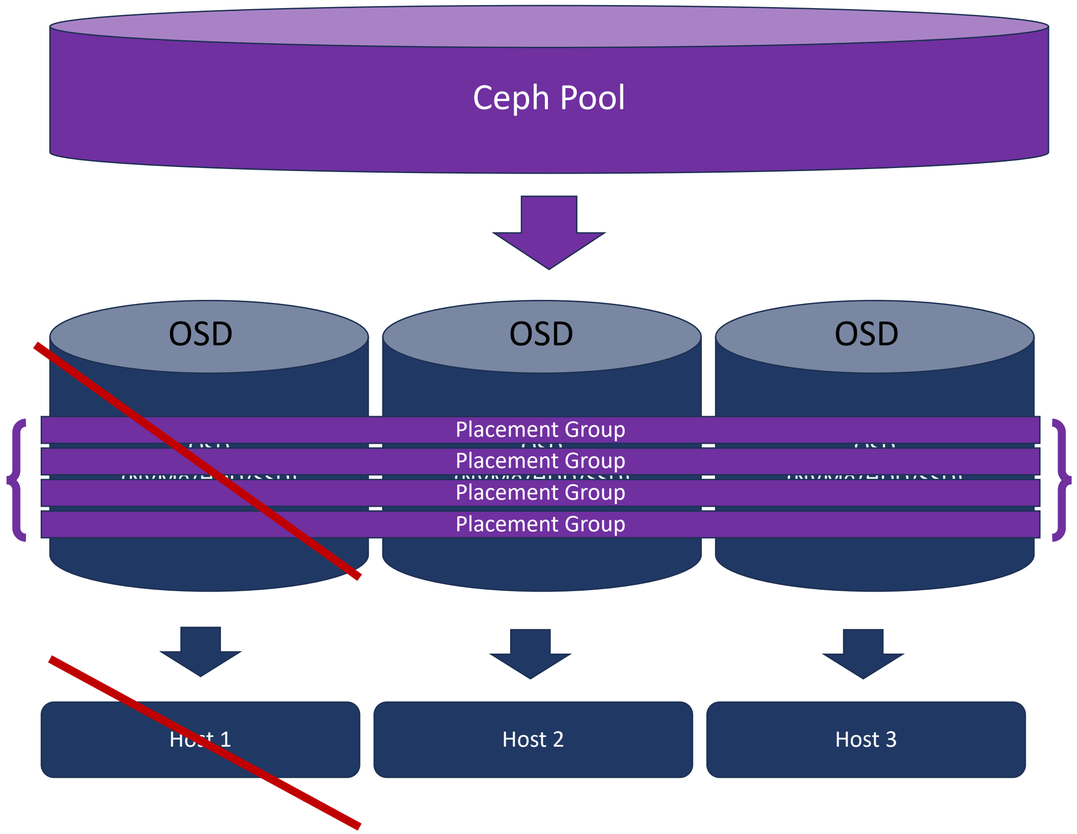
Ceph Filesystems are made up of multiple pools, at least one data pool and a metadata pool.

OSDs are a shared resource and are often used by many pools.



OSDs may be created from any media type including NVMe, SAS, NL-SAS, and SATA. Only enterprise and/or datacenter grade media should be used.

Understanding Durability



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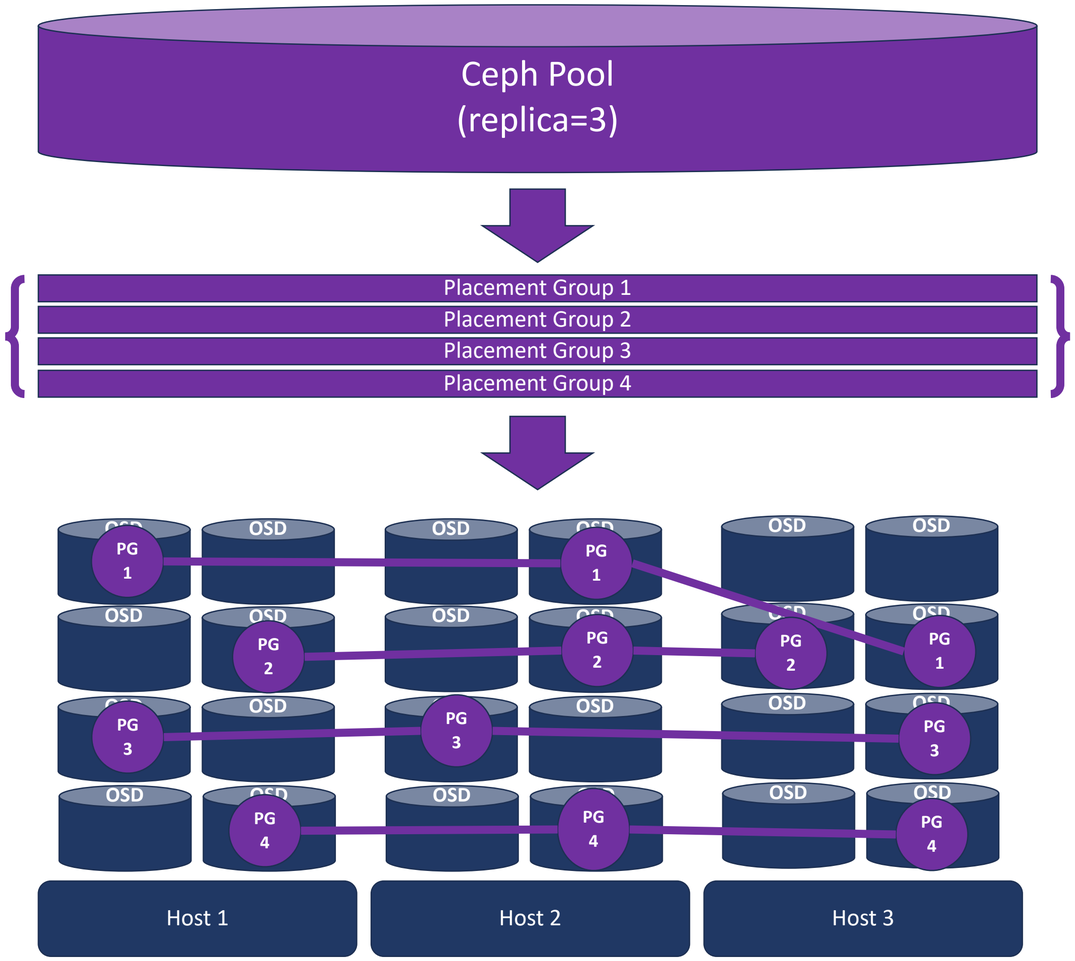

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```
ceph osd pool create <pool-name> <pg_num> <pgp_num> replicated [crush-rule-name]
```

Understanding Durability

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2. There's a brief window where the affected PGs will go into a '**peering'** state, usually just a few seconds but during this time I/O is paused.

3. After 10 minutes the OSD is marked **'out'**. This causes the degraded PGs to be remapped to use the remaining good OSDs.

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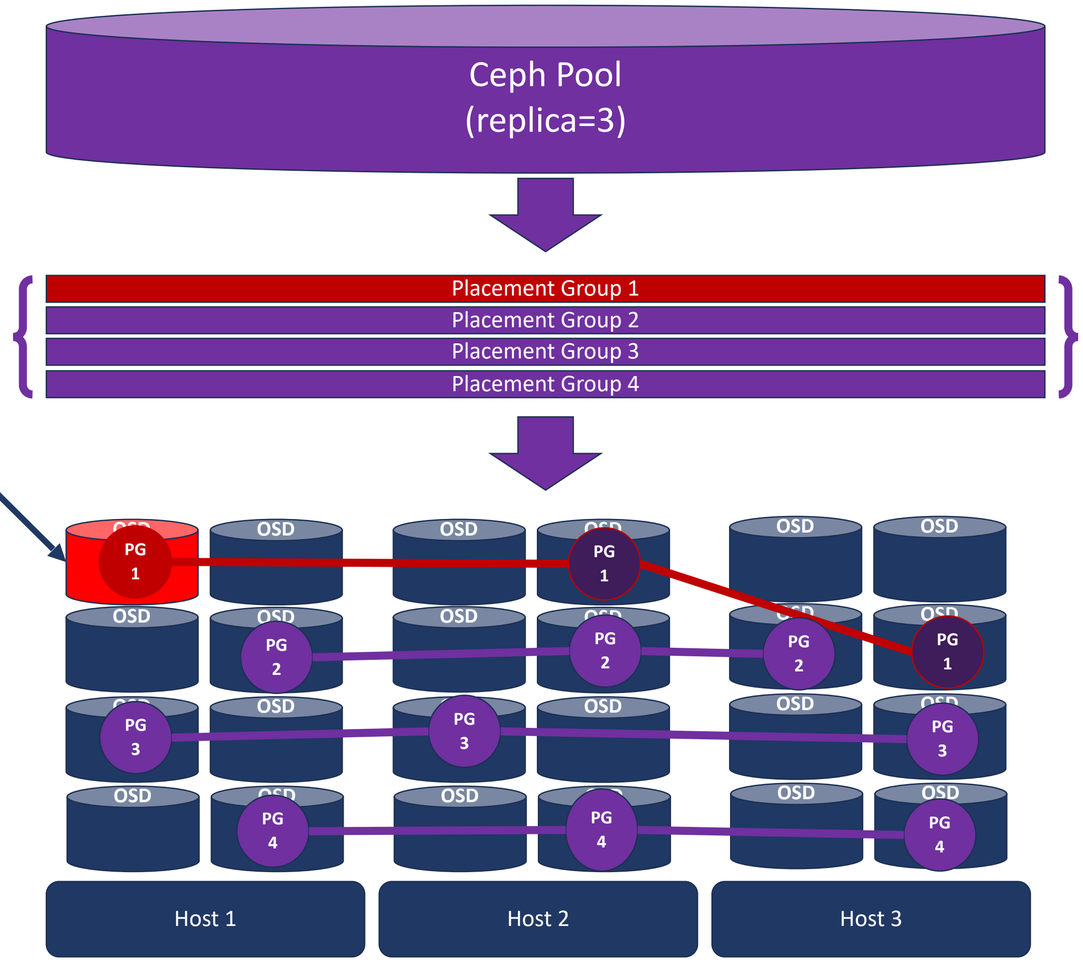

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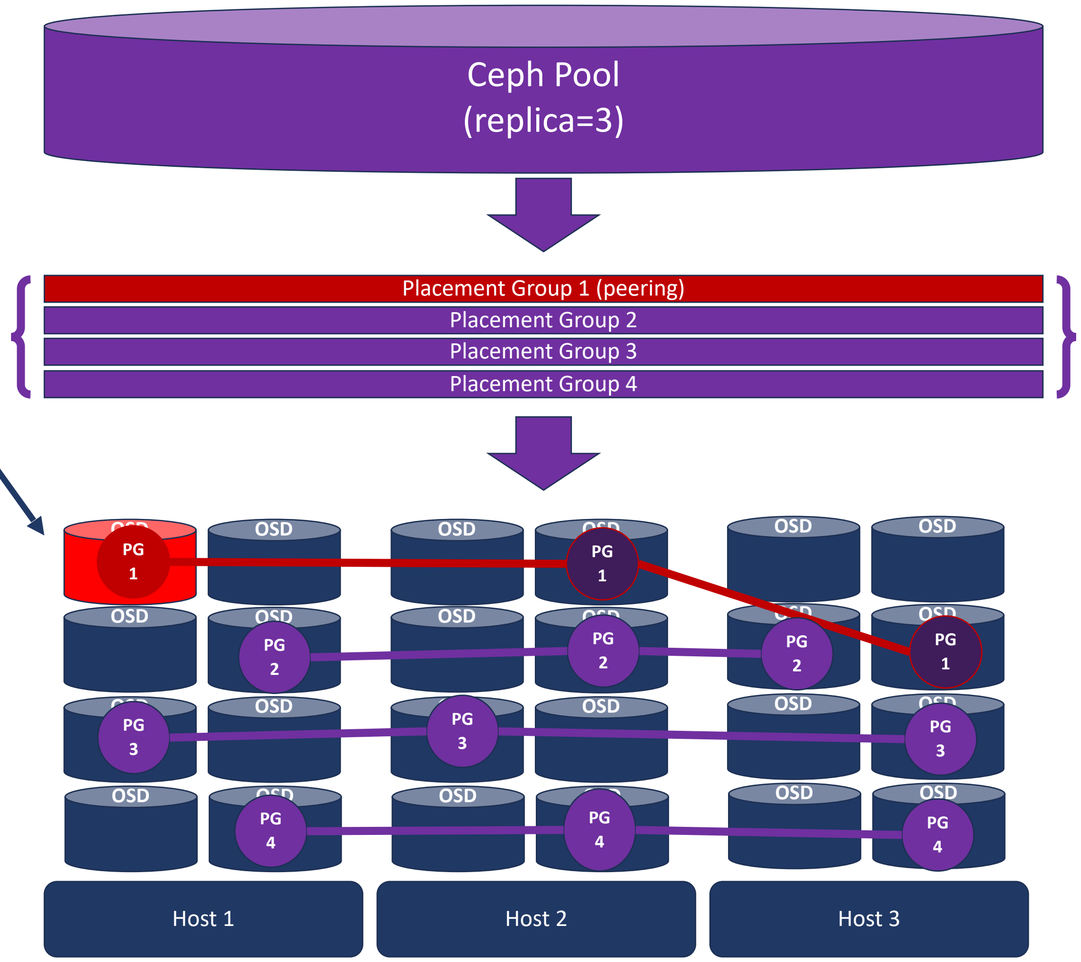

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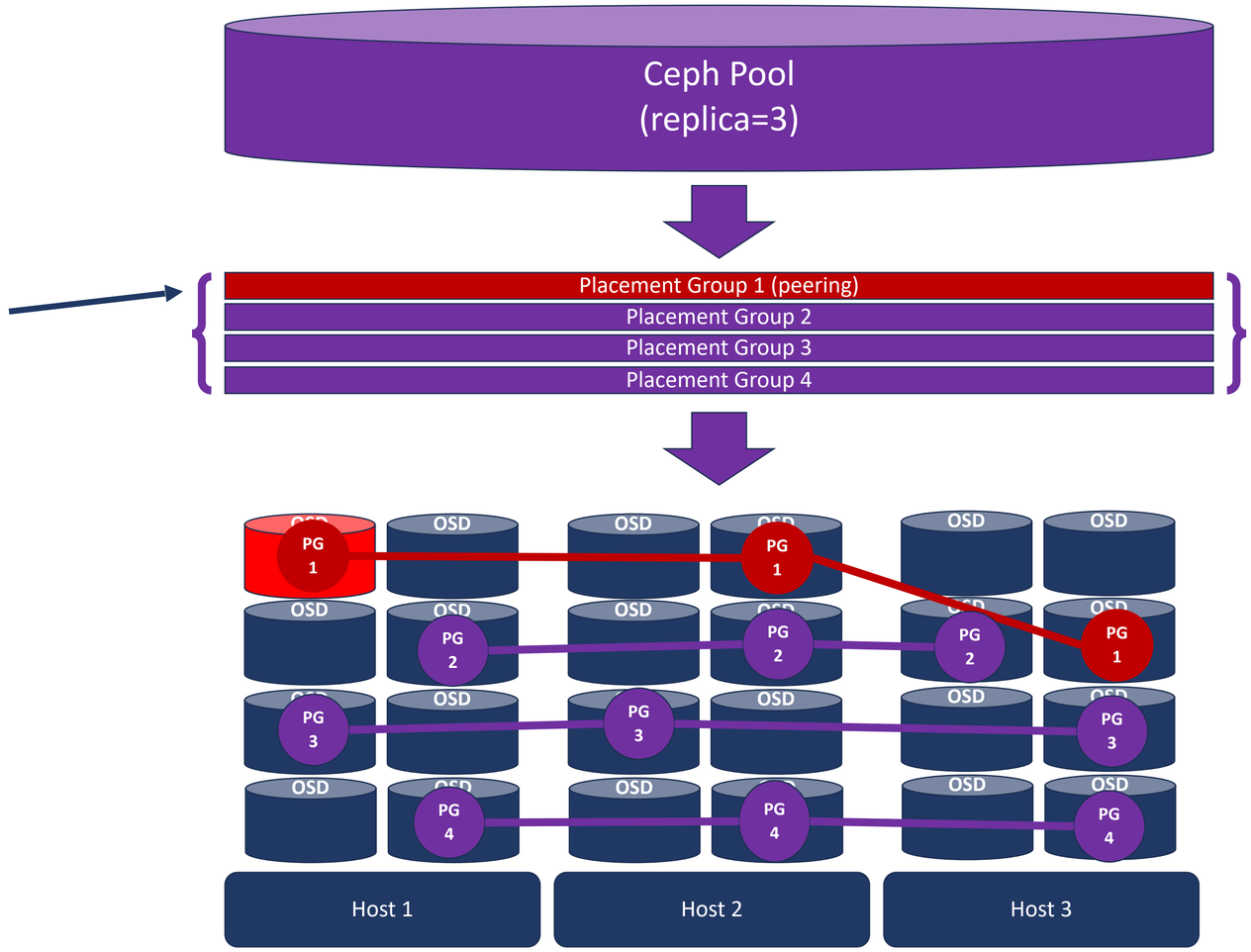

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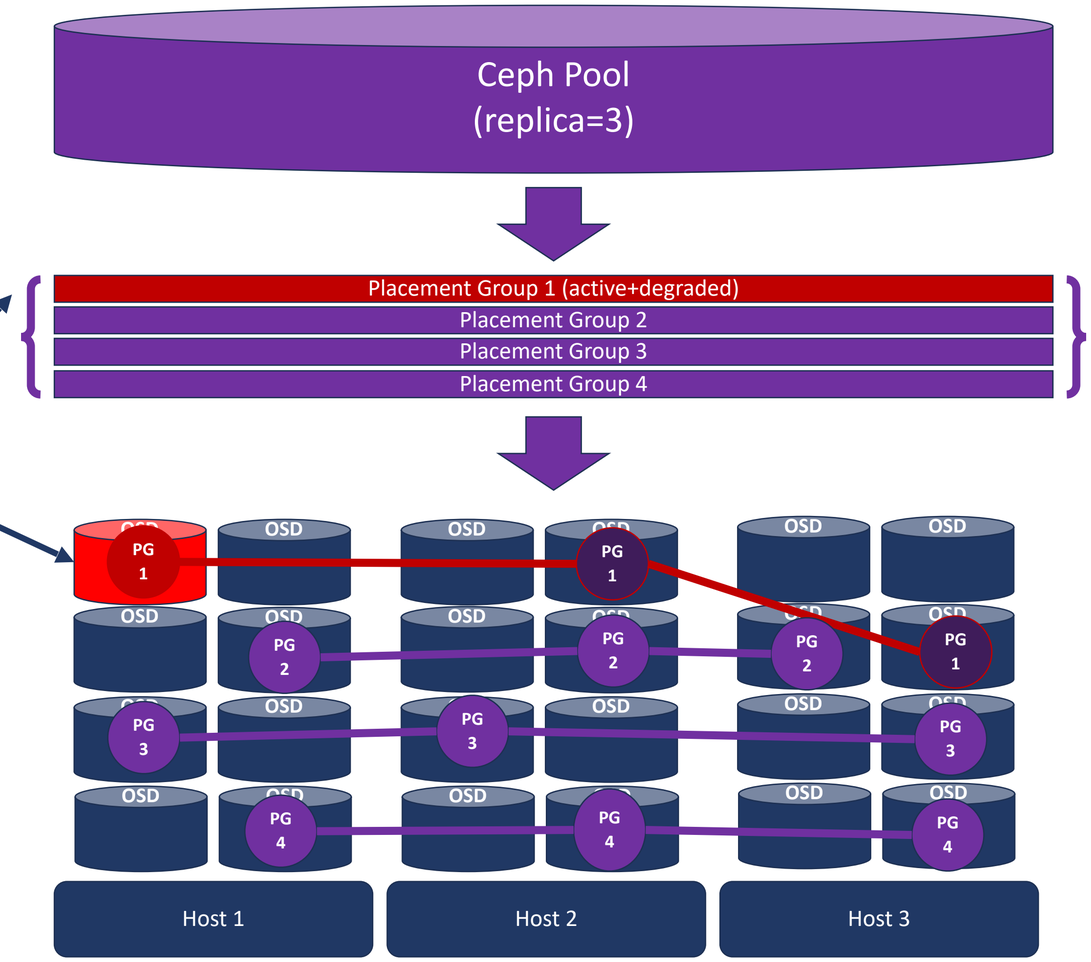

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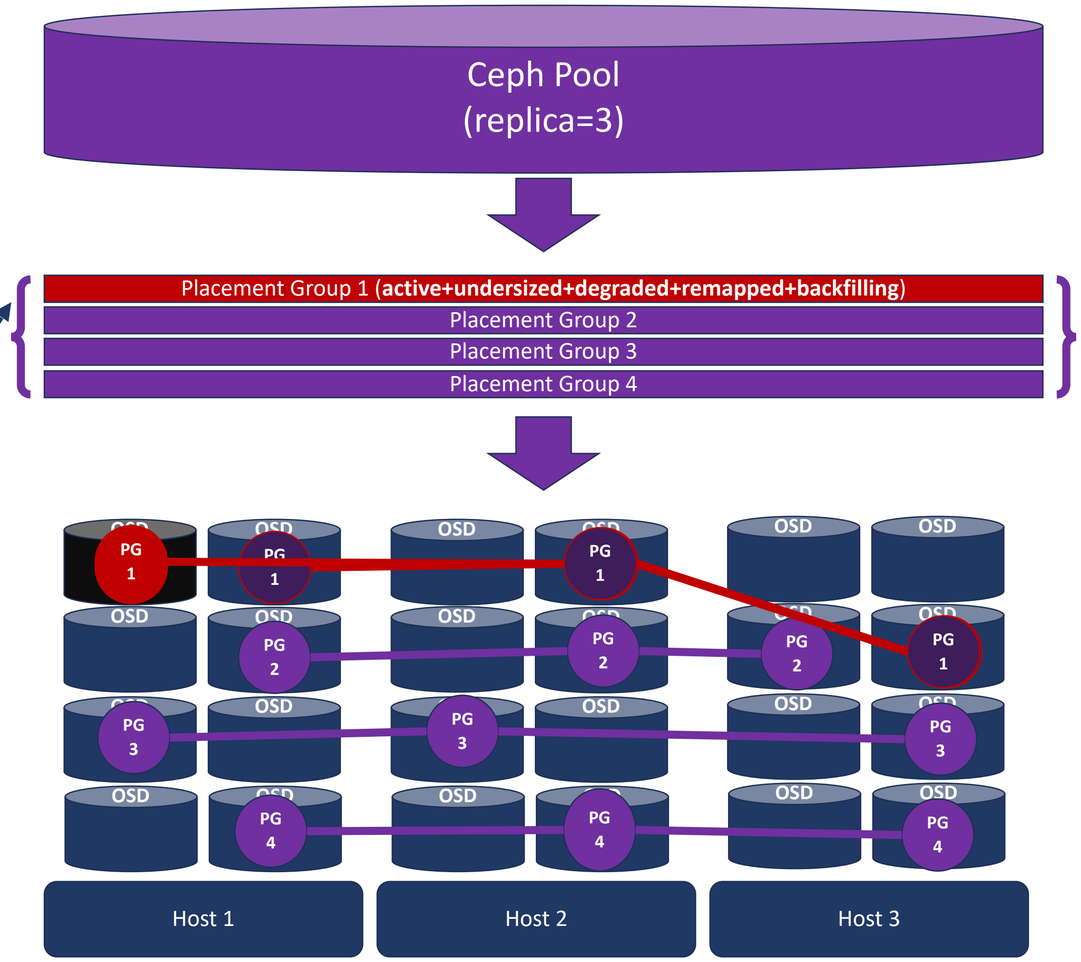

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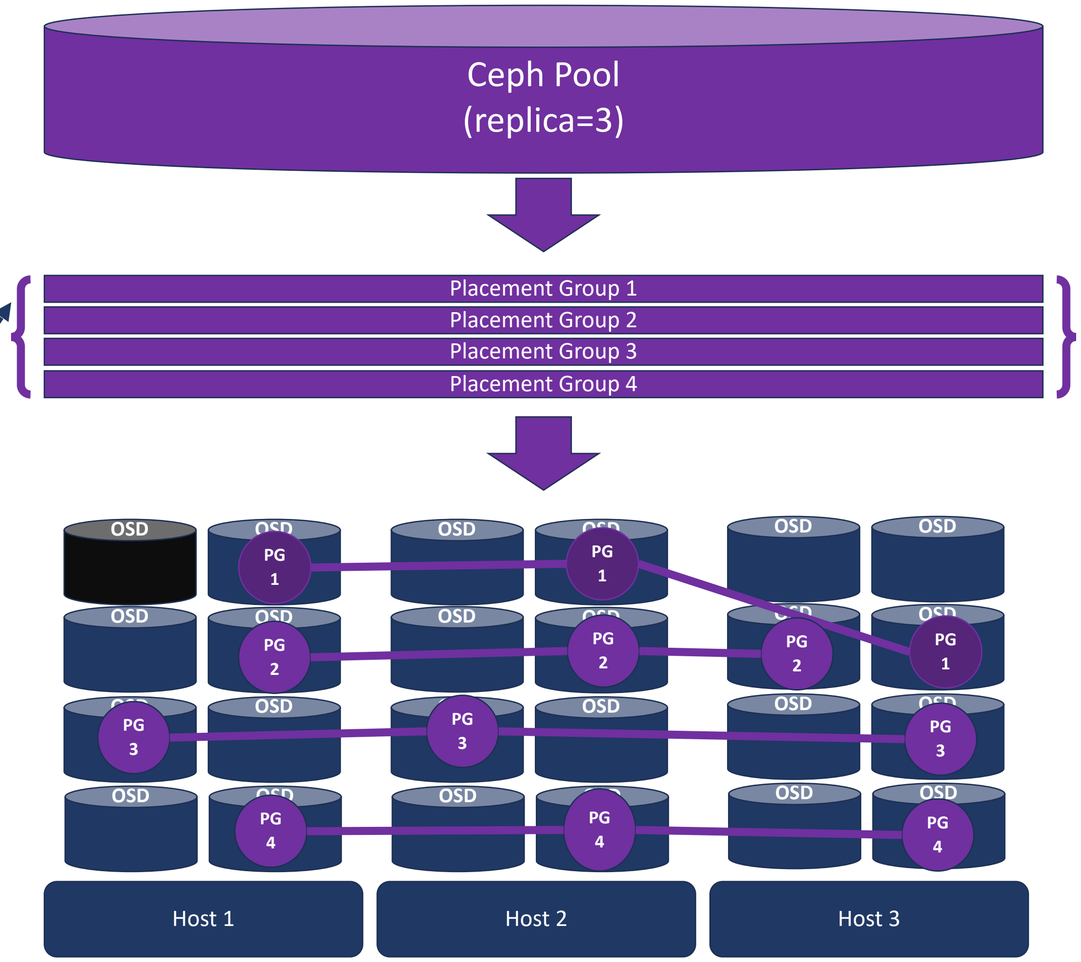
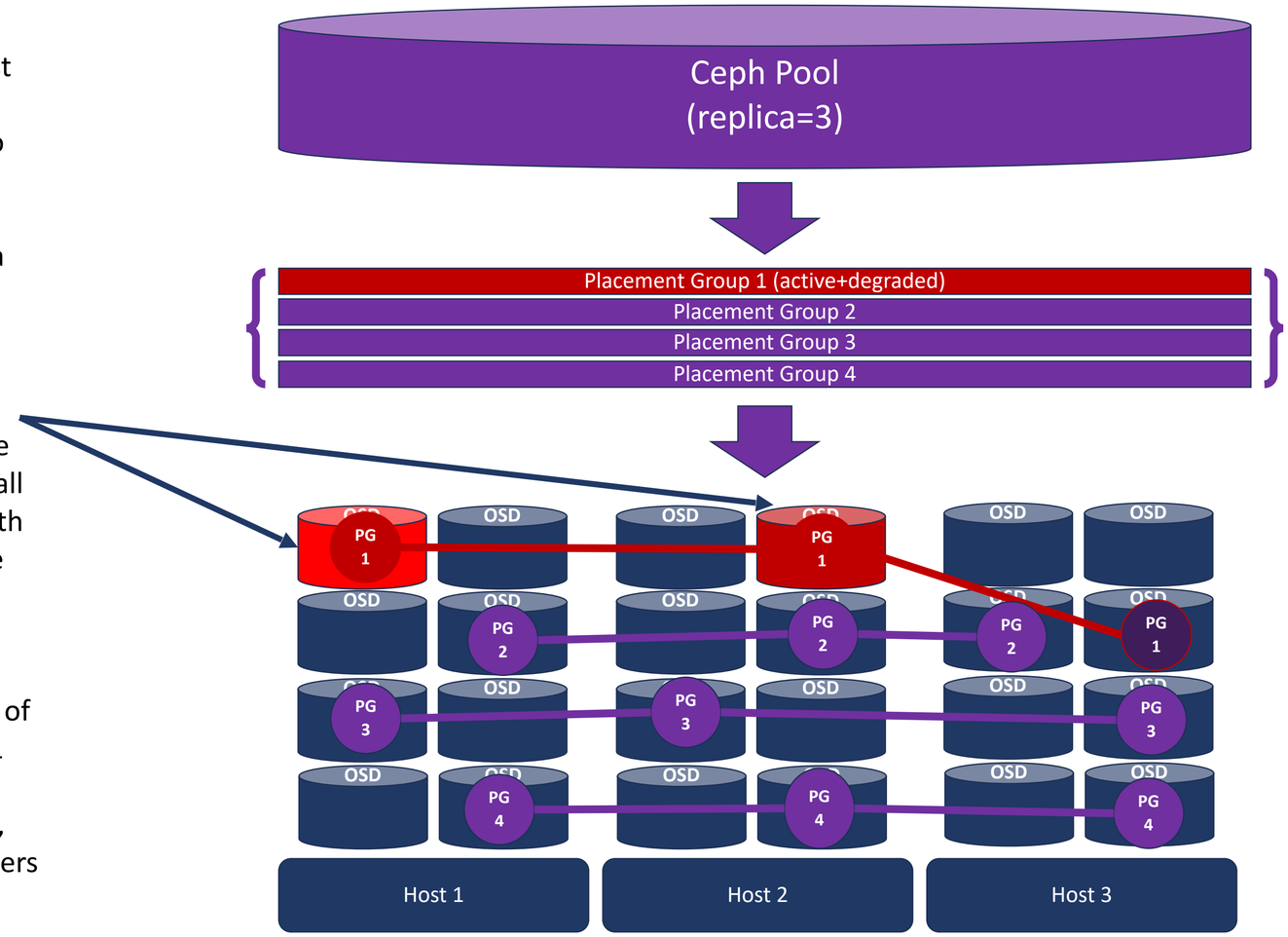


Understanding Durability

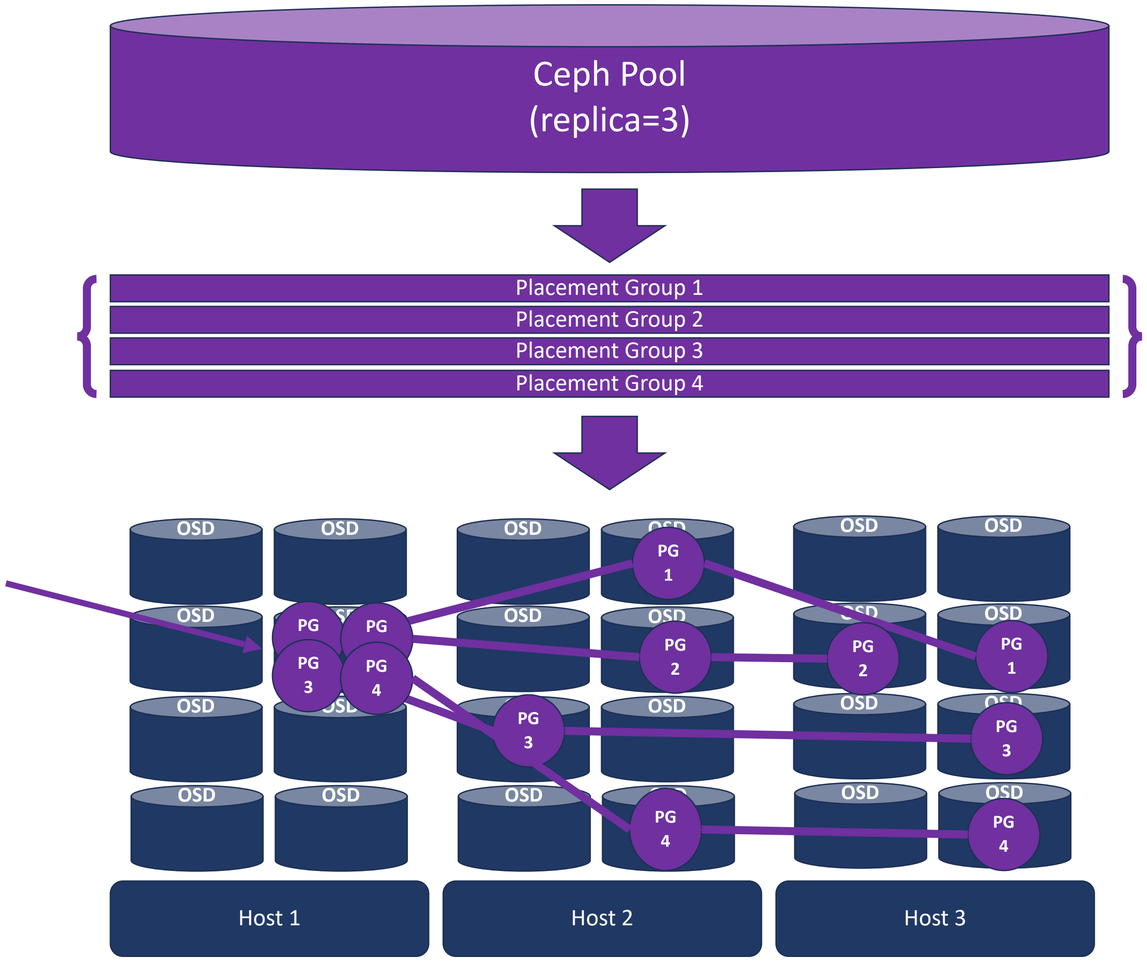
1. In this example two OSDs have failed. A first OSD and then a second OSD within the window where the cluster was backfilling to recover from the first OSD failure.

2. If there are not enough OSDs remaining in a PG **(min_size param)** the pool will stop. min_size is a pool level param and it should always be set by default so that there's remaining durability. For a replica=3 pool with three copies of the data that means we want a minimum of replica=2 for all PGs at all times, so we'd set min_size=2 (default). With two copies of the data if one copy is bad we can detect that via a checksum and still continue and recover.

3. In this example we've lost two (2) OSDs out of three. With only one OSD remaining in PG1 we're not meeting the min_size=2 requirement. The PG will stop accepting IO, writes will hang until one of the OSDs recovers or the min_size is reduced to 1.



Understanding Durability – Teamwork!



More realistic example showing the multiple PGs per OSD. By our calculation for this cluster there would be **64** PGs per OSD but we're showing just 4x PGs for clarity.

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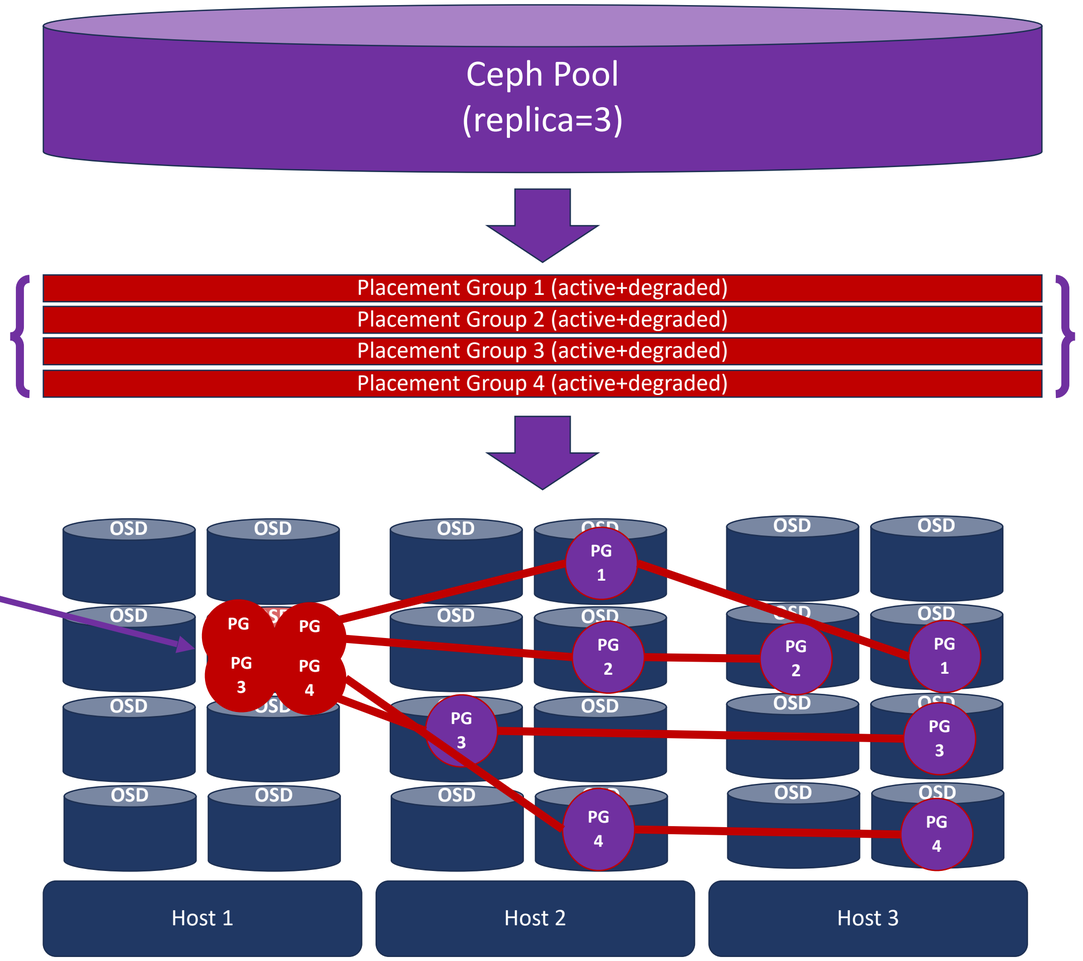

When an OSD fails, many PGs are affected but many OSDs come to the rescue.

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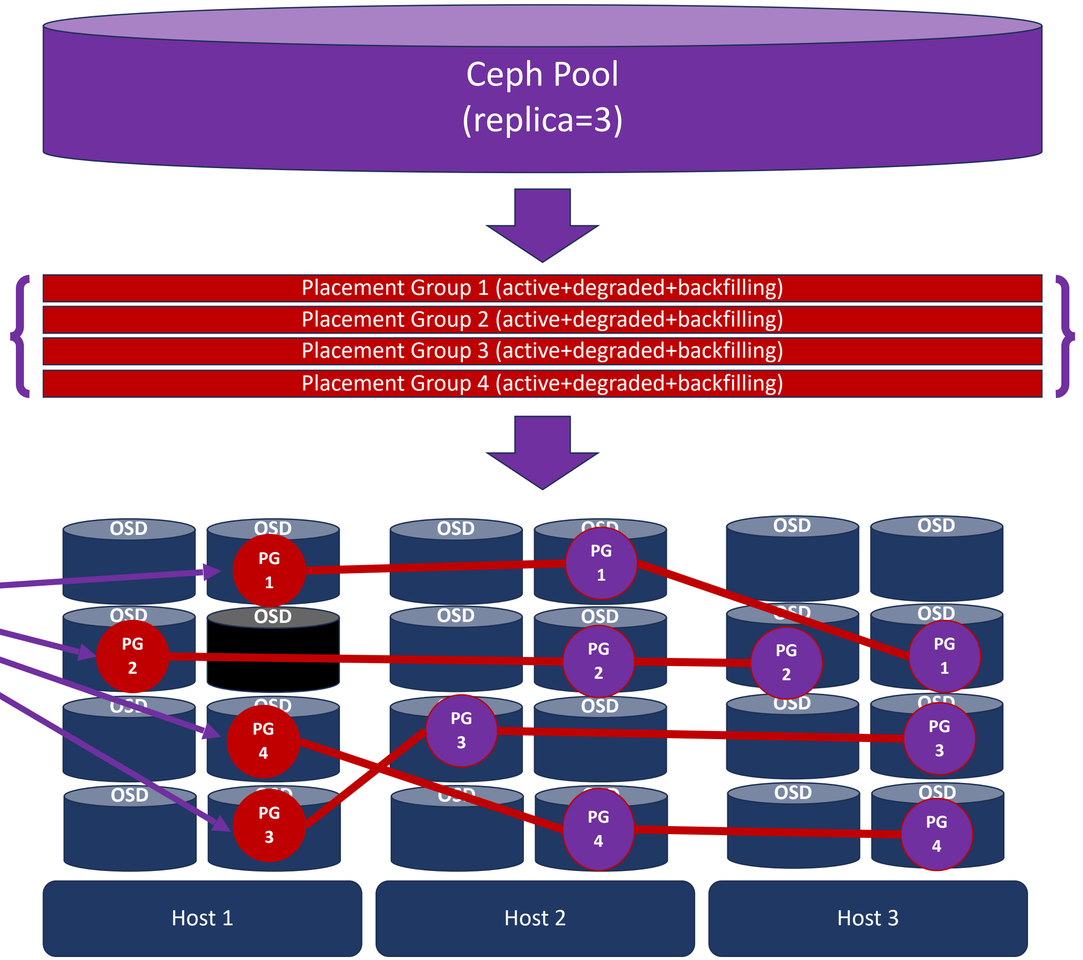

PGs on the effected OSD have been remapped to many other OSDs with the help of many OSDs on other nodes. Each PG is responsible for 1/64th of the data on a given OSD so backfilling it's data to other OSDs goes quickly and the process can be highly parallelized unlike traditional RAID.

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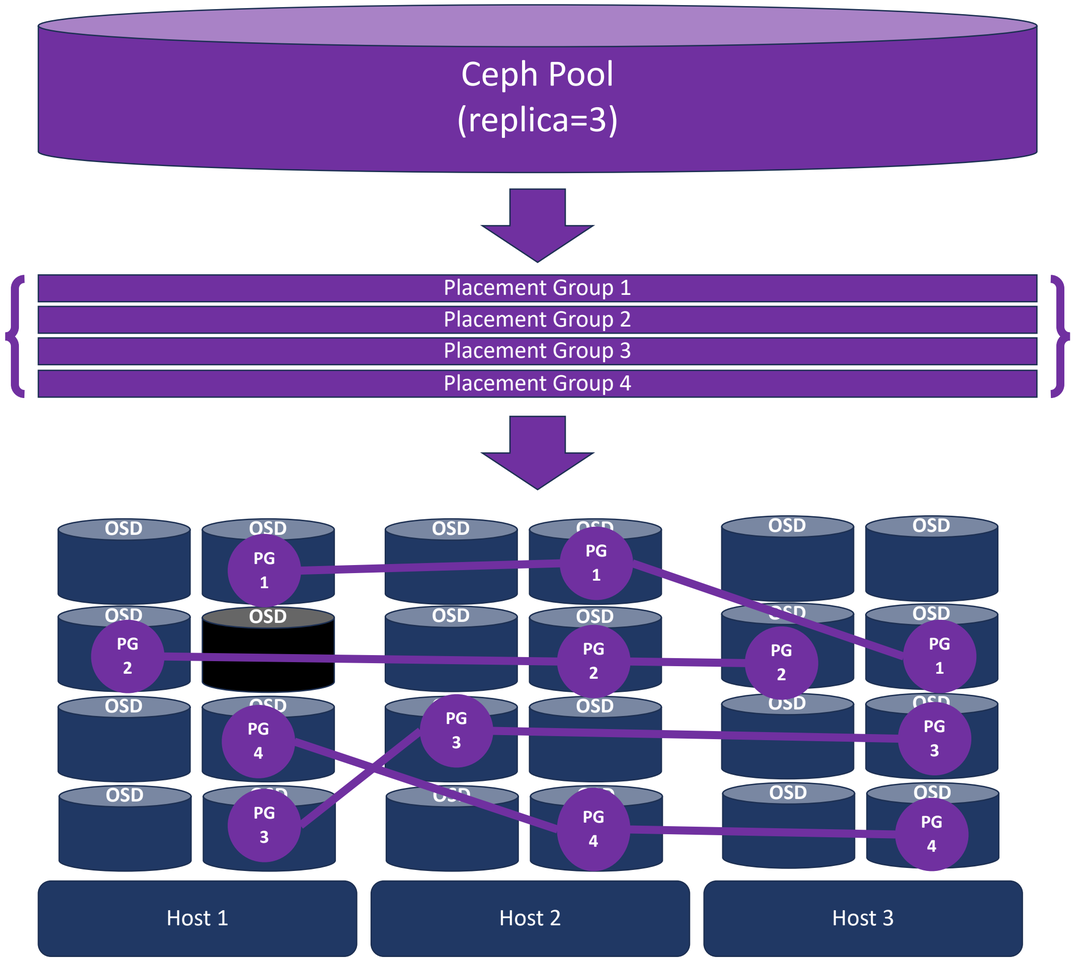

1. Our cluster is now back to 100% full health without a hot-spare.
2. Recovery was many times faster than it would take to return to full health using traditional RAID with a hot-spare.

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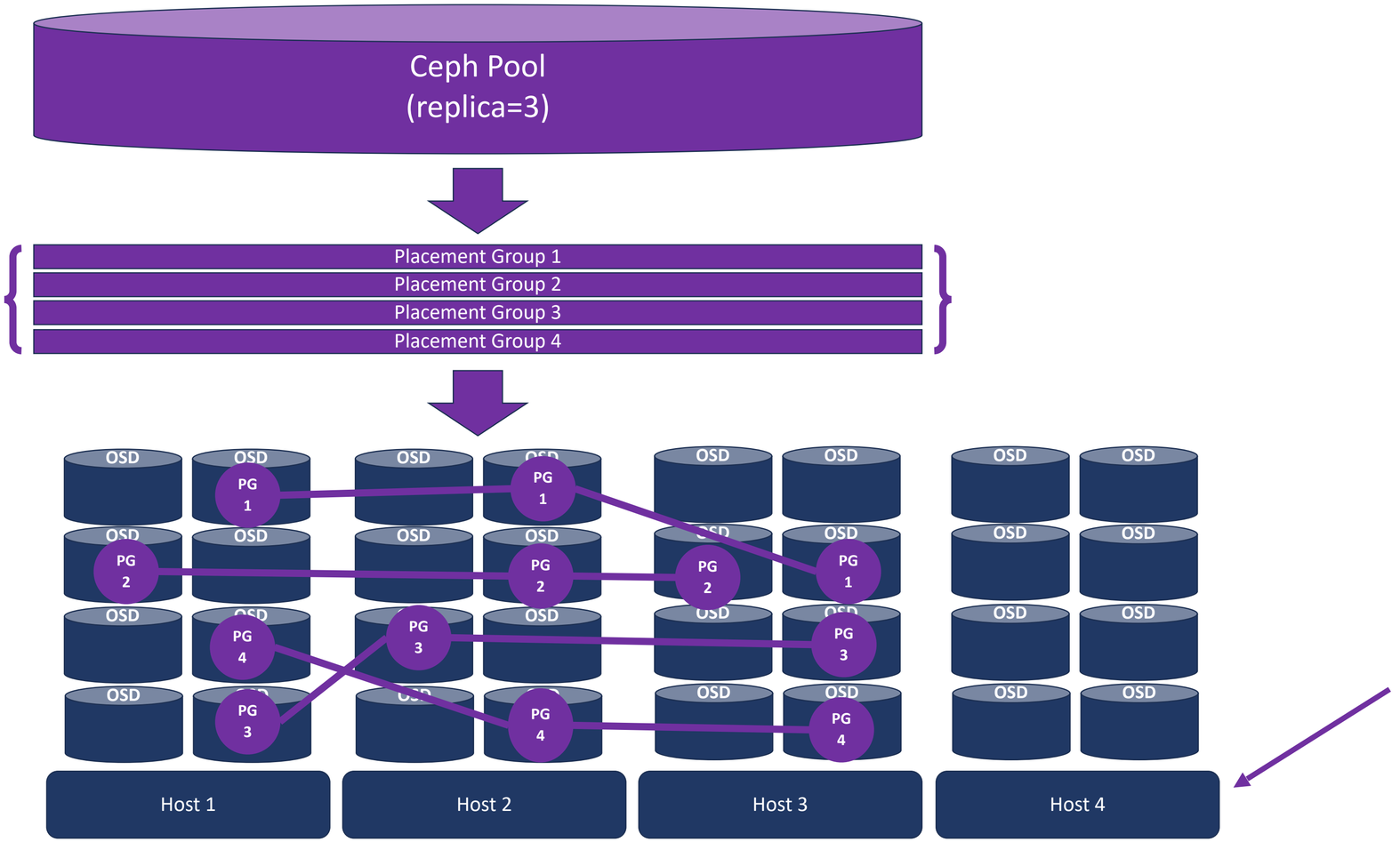
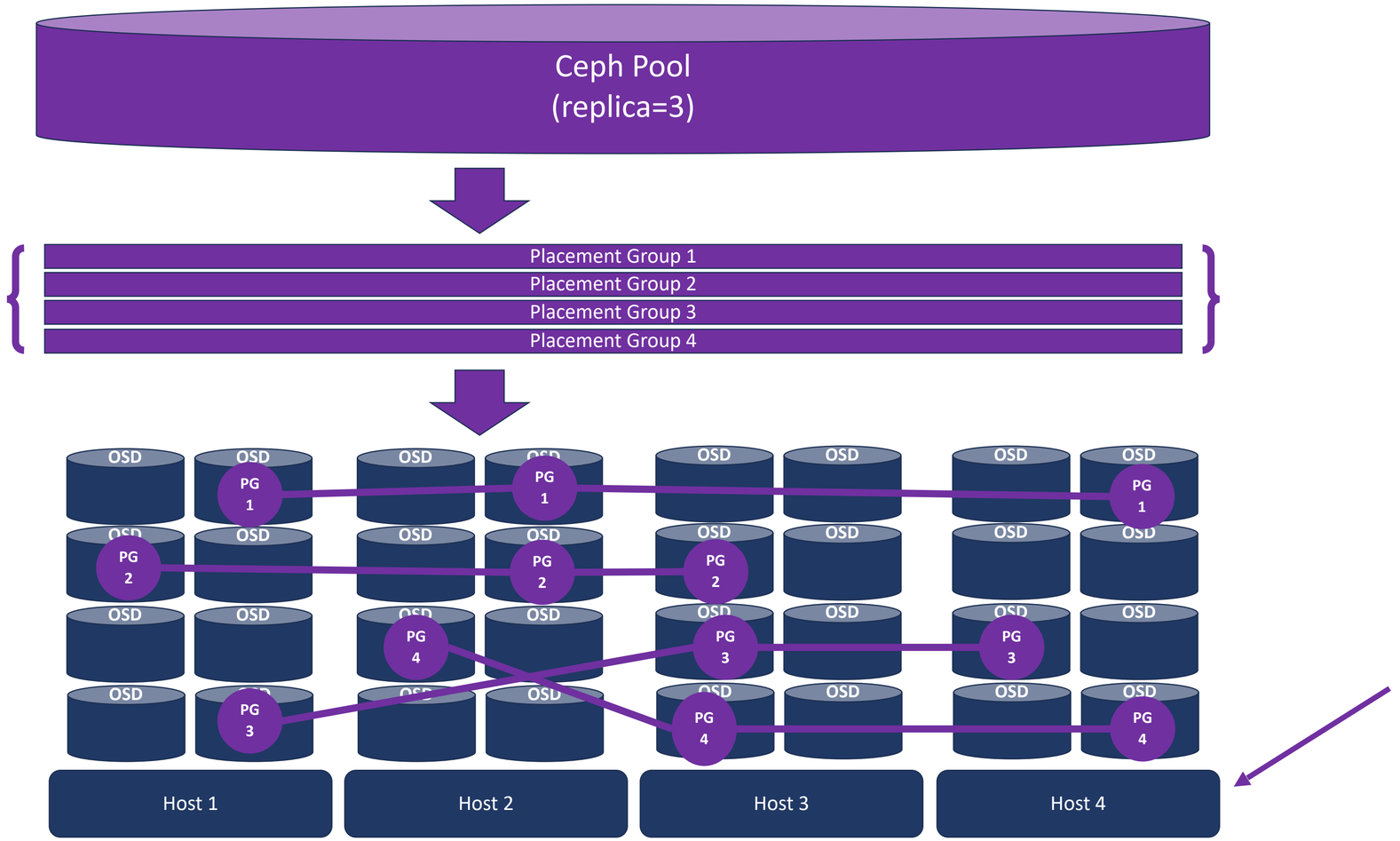


Adding a host with more OSDs give the PGs more space to spread out into. This is done via remapping the PGs but without them becoming degraded.

Understanding Durability



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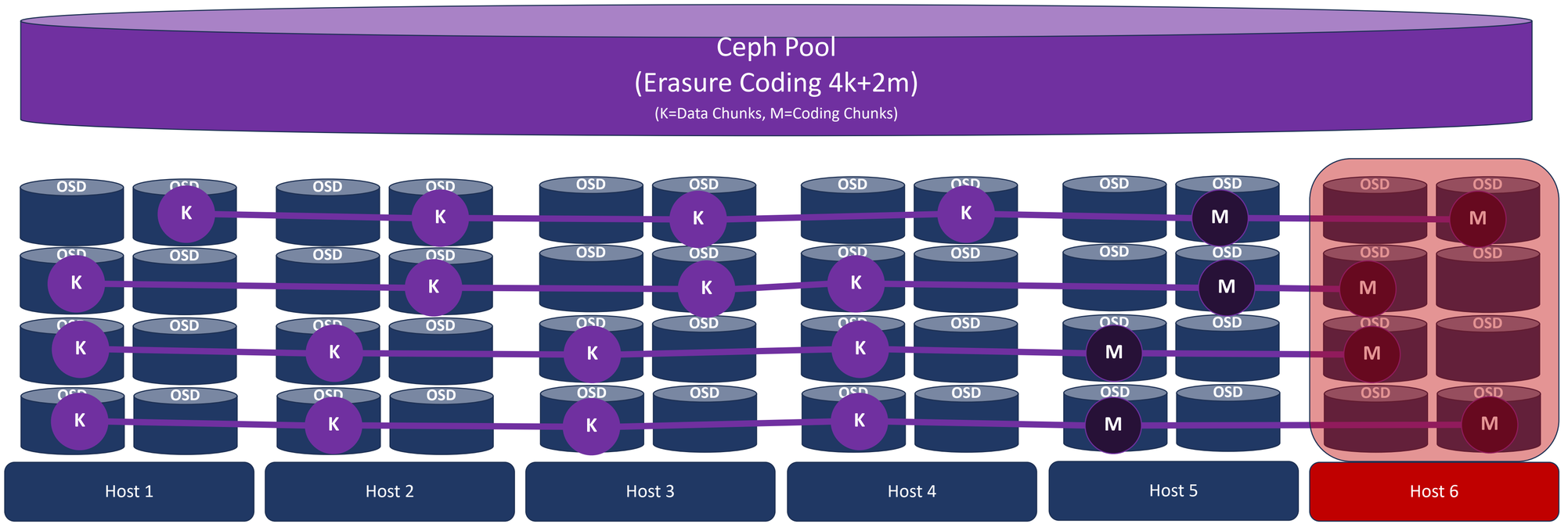
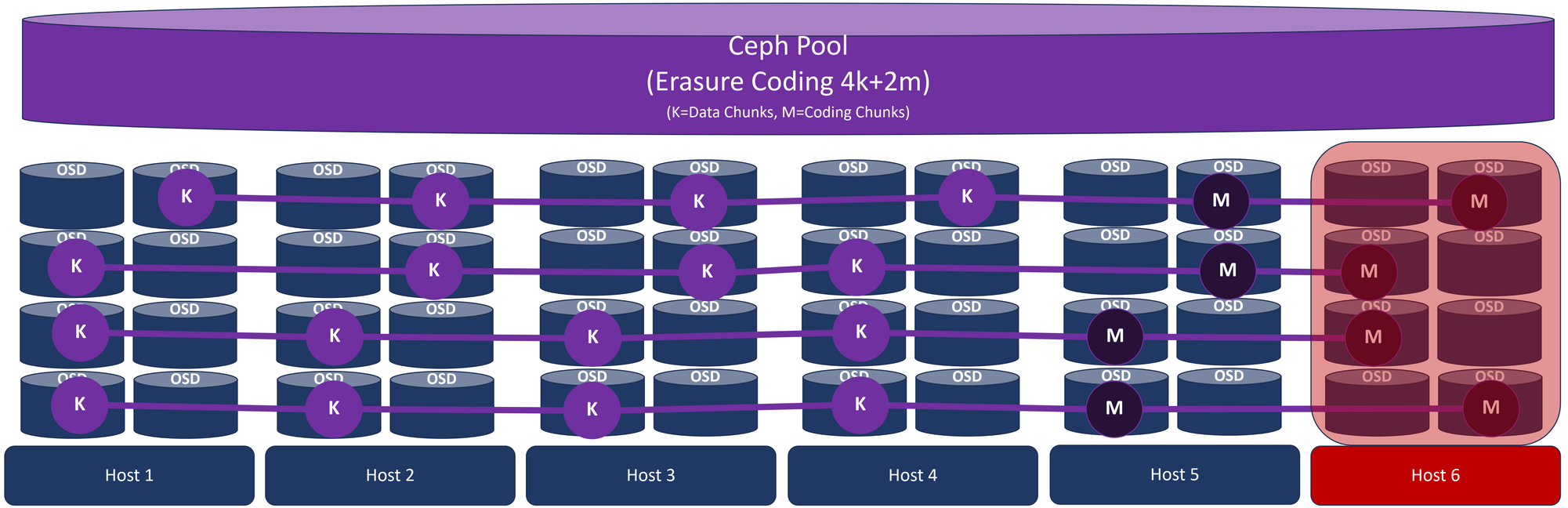


With EC pools we need a min_size set to K+1 to ensure we always have a coding block available to recover from.
With a 4K+2M pool (K=4, M=2) this means we need a min_size of 5 (K = 4 + 1 coding block = 5 min_size).
With a 8K+3M pool (K=8, M=3) this means we need a min_size of 9 (K = 8 + 1 coding block = 9 min_size).
With a 16K+4M pool (K=16, M=4) this means we need a min_size of 17 (K = 16 + 1 coding block = 17 min_size).

Trivia time, is it safe?



Yes! With 4K+2M we need to maintain K+1 (5) and with one host offline we've 5 out of 6 chunks.

ceph config set mon mon_osd_down_out_subtree_limit **host**

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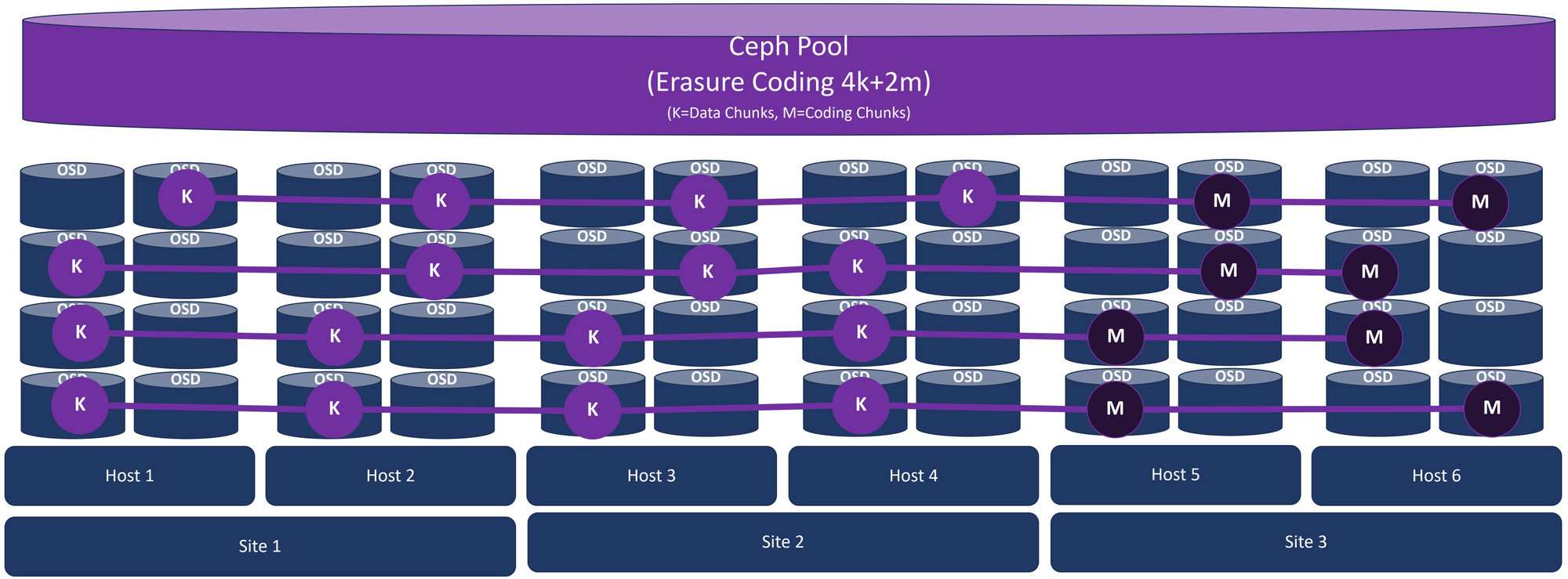

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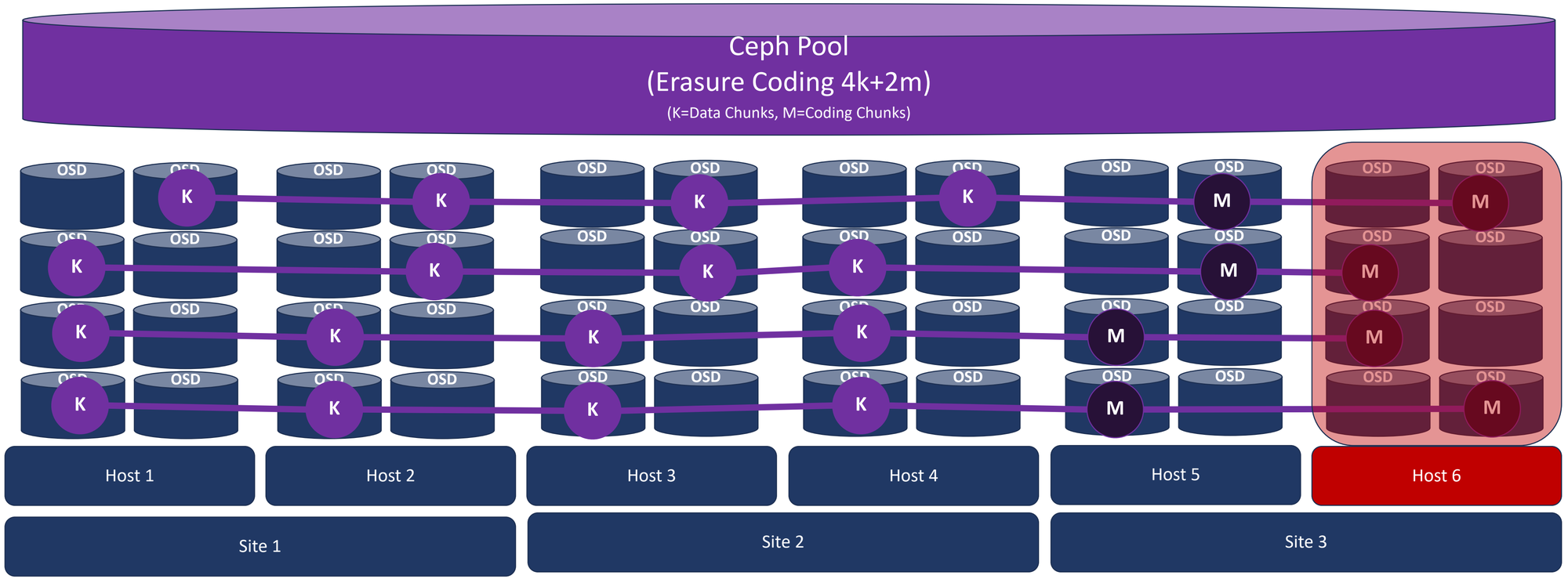

Looks safe, but not safe! Yes with 4K+2M we maintain K+1 (5) and with one host offline but this is multi-site!

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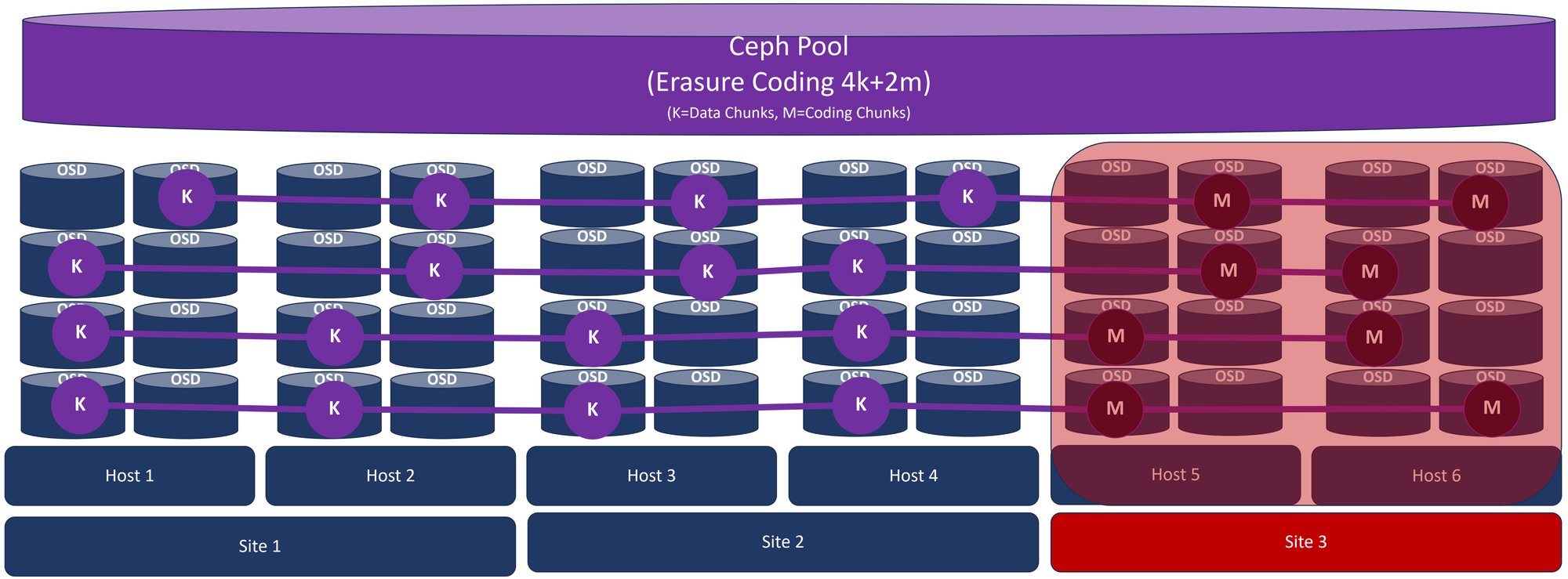

Not Safe! With a site outage we lose two hosts at once and we'll no longer have K+1 chunks available per PG.

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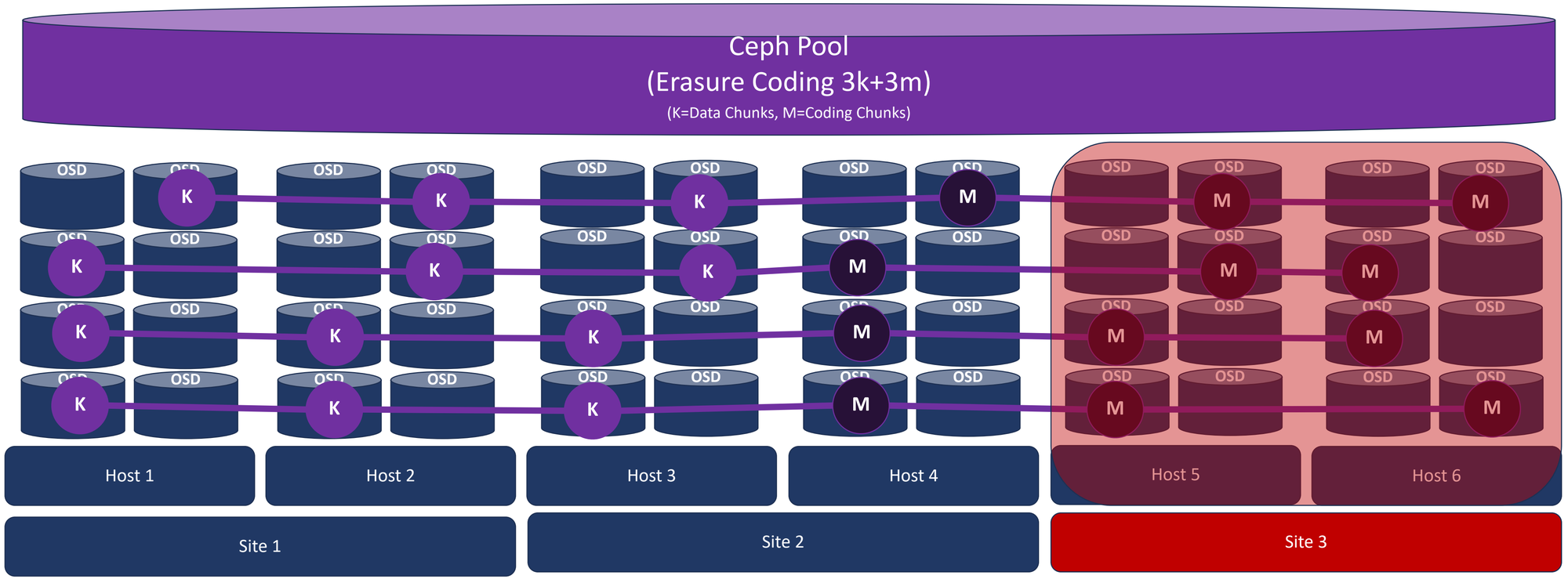
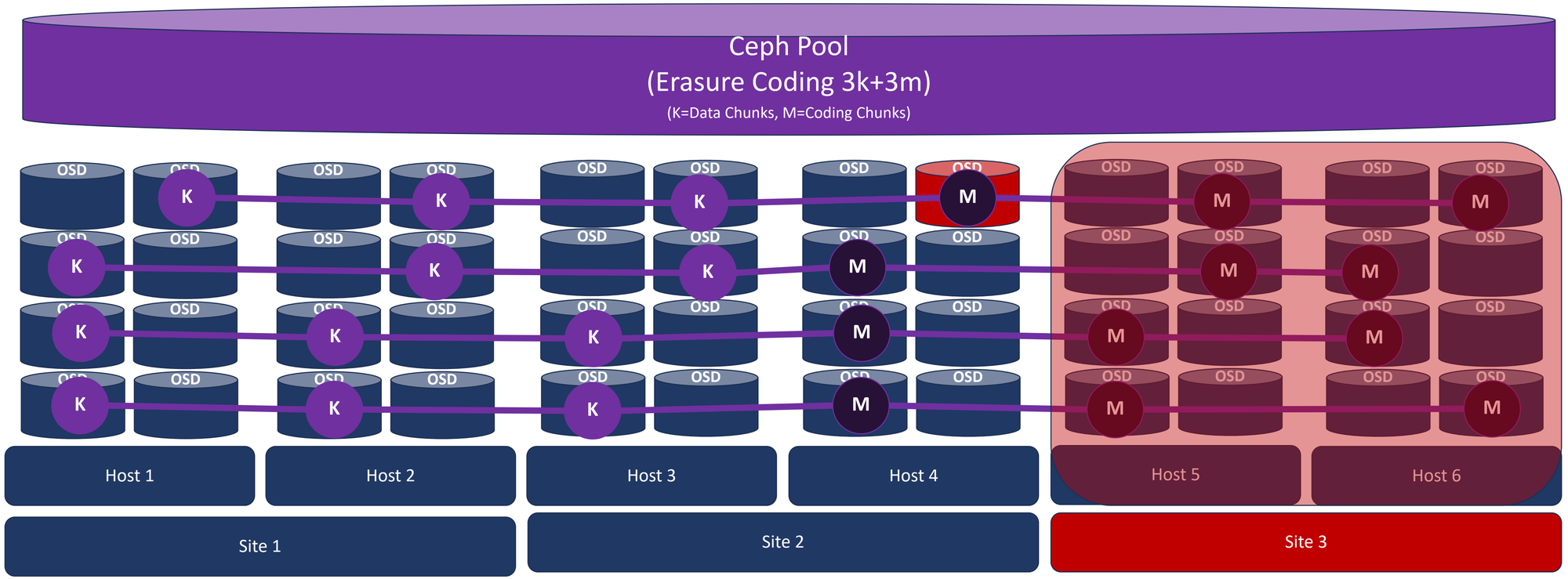


We've now changed our design to use EC 3K+3M so our K+1 is now 4. Is it safe?

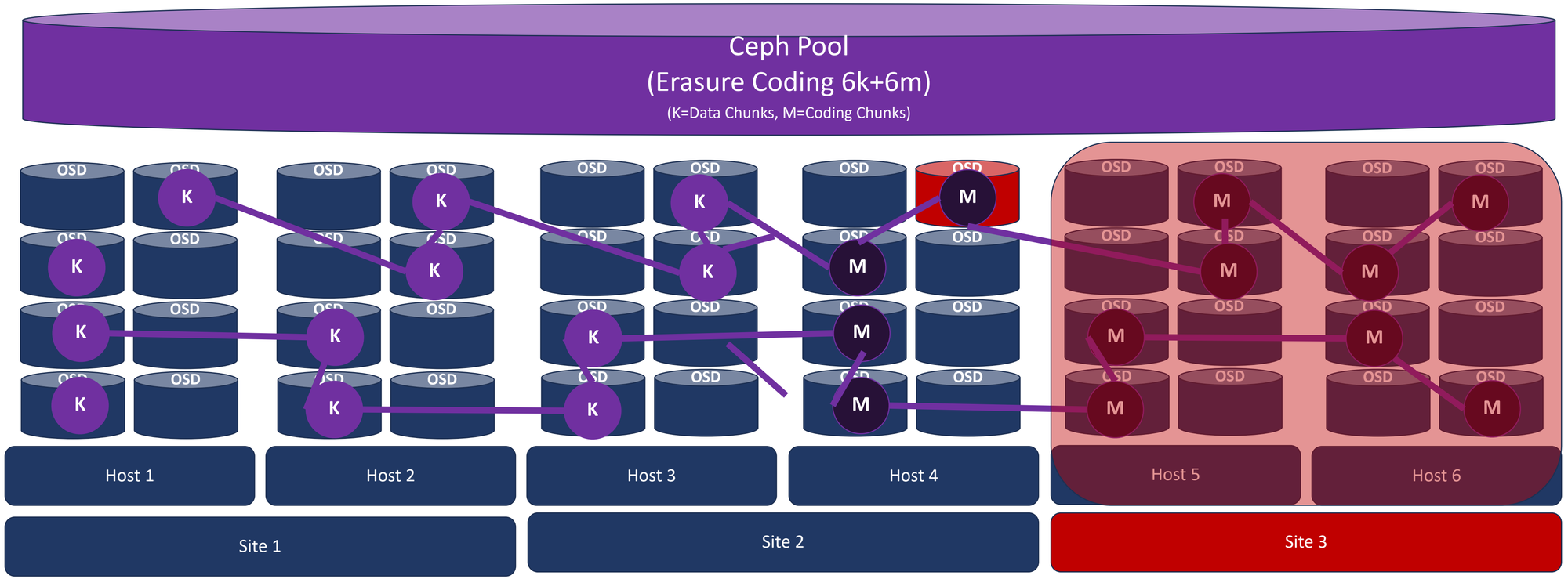
Yes! With 3K+3M we need to maintain K+1 (4) and with one site offline we've 4 out of 6 chunks.

Trivia time, is it safe?



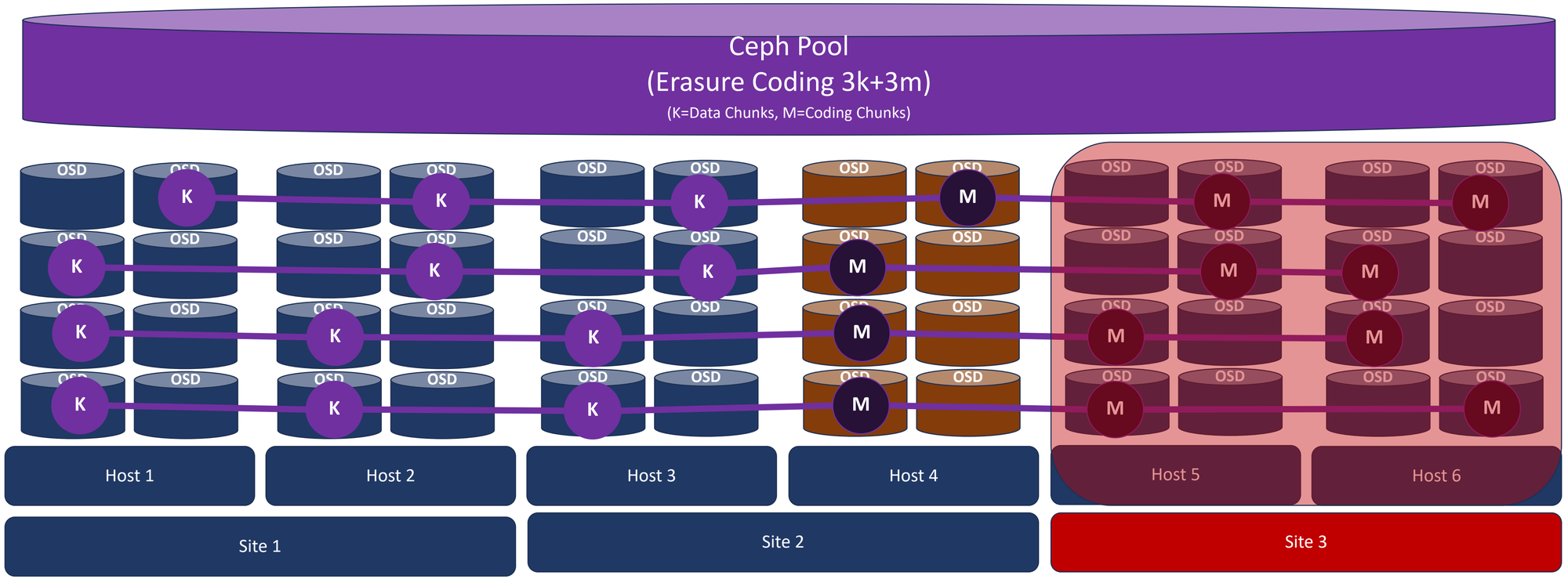
What happens if we have an OSD fail in another site just before or after a site outage?

Trivia time, is it safe?



Doubling the PG length from 3K+3M to 6K+6M retains our 50% usable and gives us an additional coding block remaining after a combination site outage and device failure.

Double-Layer Durability



Having storage virtualization be it hardware or software RAID underneath the OSDs makes sense at large scale and in certain multi-site scenarios. With the OSDs produced from fault-tolerant block devices from an underlying SAN (eg. Seagate EP) or NVMe RAID stack (eg. Xinnor, Graid Tech) the entire cluster is insulated from individual device failures. This typically comes at a cost of 12% to 20% overhead but localizes the rebuilds, eliminates the WAN load due to media failures, and can reduce CPU and RAM costs.

Q&A

Solution Design Review: sdr@osnexus.com
Design Utilities: https://osnexus.com/ceph-designer