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OpenZFS

The Best FileSystem for Every OS

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Summary & Introductions

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Covered in this presentation

What is ZFS? Why all the excitement?

What is OpenZFS? How do I Join?

What new features are in OpenZFS?

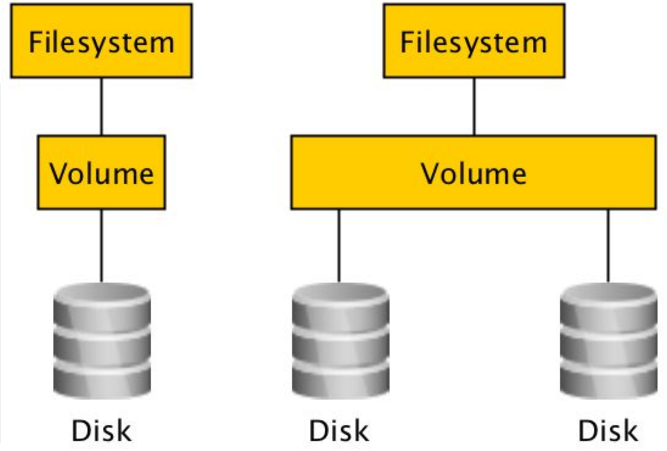
What does the future hold for OpenZFS?

What is ZFS?

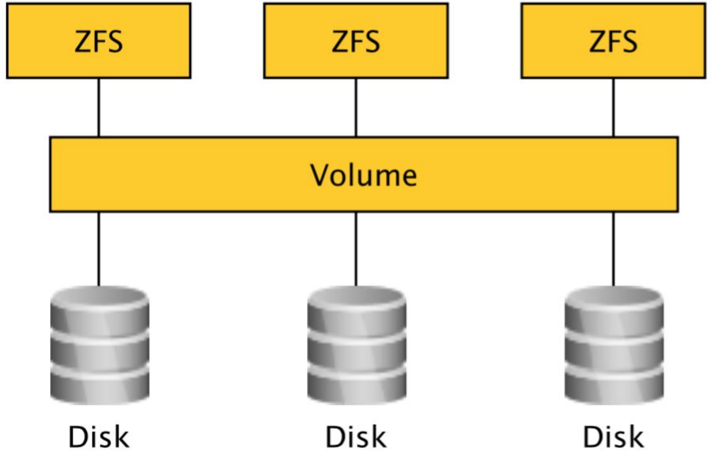
- ZFS is a filesystem with a built in volume manager (RAID)
- Space from the pool of disks is thin-provisioned to multiple filesystems or block volumes (zvols)
- All data and metadata is checksummed
- Optional transparent compression (LZ4, GZIP, soon: ZSTD)
- Copy-on-Write with snapshots and clones
- Each filesystem is tunable with properties

What Is Pooled Storage?

Regular Filesystem (Single Logical Disk)



ZFS (Many Filesystems share all space)



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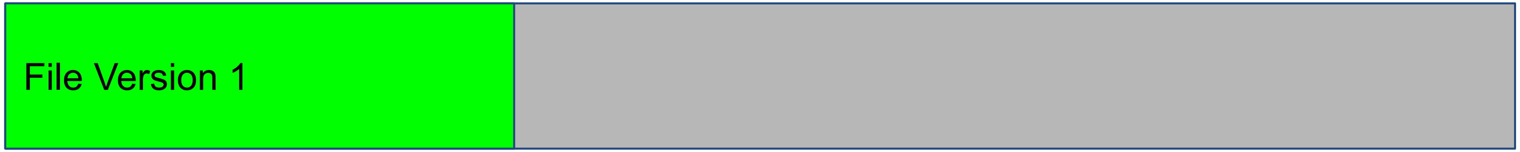
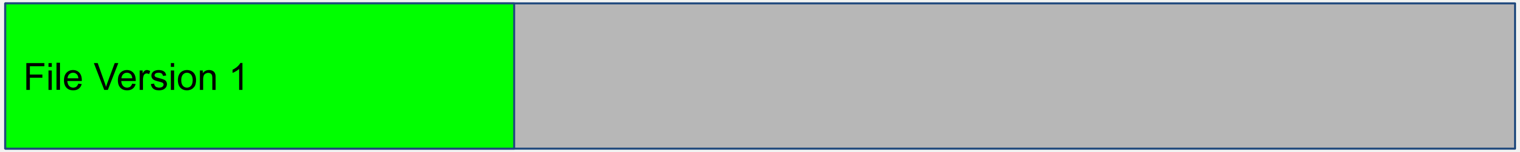
What Is Copy-on-Write?

This is your disk:

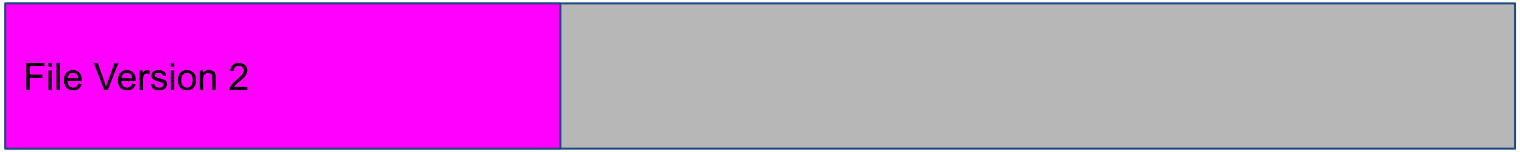

File Version 1

This is your disk on ZFS:

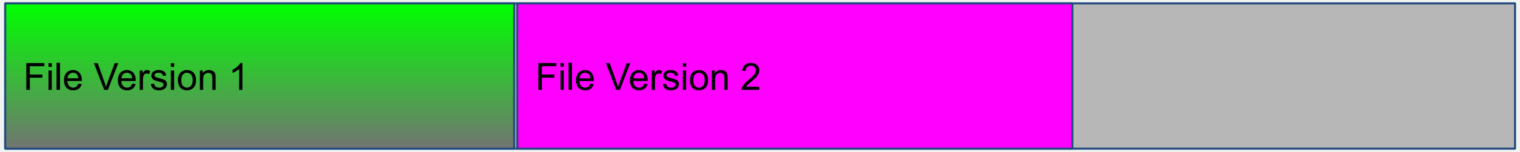

File Version 1

What Is Copy-on-Write?

This is your disk:

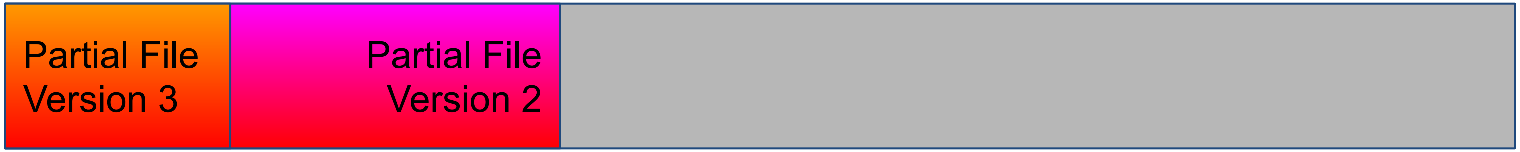


This is your disk on ZFS:

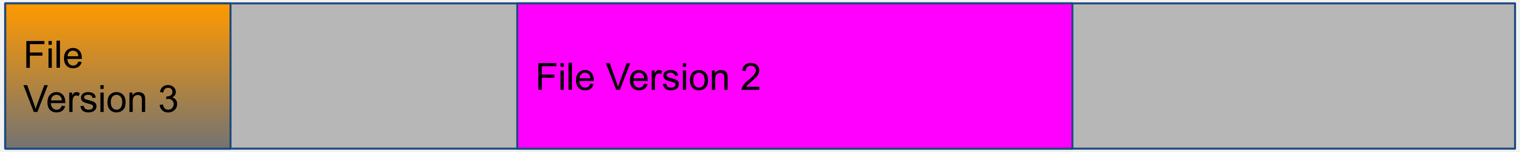


What Is Copy-on-Write?

This is your disk when the power fails:

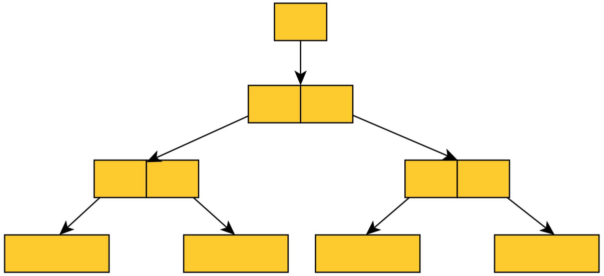


This is your disk on ZFS:

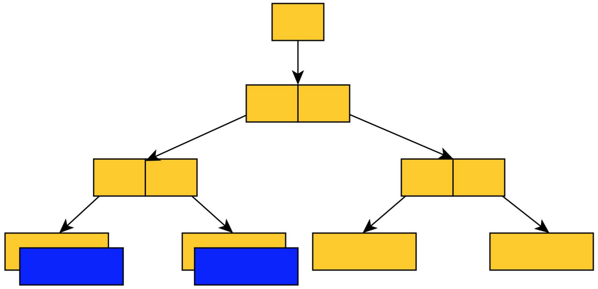


Transaction Updates

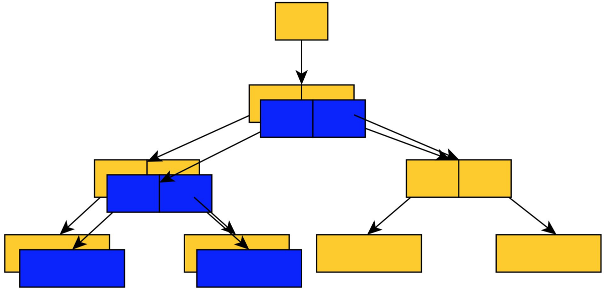
1. Consistent filesystem state



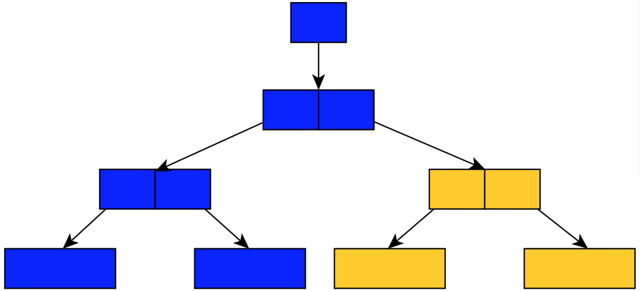
2. Modify a file



3. Update Metadata



4. Write the uberblock (commit)



Why All The Excitement?

- Copy-on-Write means snapshots are consistent and instant
- Blocks used in snapshot(s) kept when overwritten/deleted
- Snapshots allow access to filesystem at point-in-time
- No performance impact on reads/writes
- Take no additional space until blocks change
- Makes your storage ransomware-resistant
- Clones allow you to “fork” a filesystem

The Evolution of ZFS

- ZFS was originally developed at Sun Microsystems starting in 2001, and open sourced under the CDDL license in 2005
- Oracle bought Sun in 2010, and close sourced further work
- illumos, a fork of the last open source version of Solaris became the new upstream for work on ZFS
- ZFS was ported to many platforms, including FreeBSD in 2007 and Linux in 2008. The OpenZFS project was founded to coordinate development across platforms.

OpenZFS

- The original plan for OpenZFS was a single common repository where the OS independent code would live and be tested
- Each OS would sync with this repo and add their own glue
- However, the effort required to maintain a repo that would not be directly used by any of the consumers was not viable
- The “repo of record” became a fork of illumos
- FreeBSD tracked very closely
- Linux spent a great deal of effort getting caught up

Platforms

- OpenZFS is now available on almost every platform
  - illumos (OmniOS, OpenIndiana, SmartOS, DilOS, Tribblix)
  - FreeBSD (FreeNAS, XigmaNAS, TrueOS, pfSense, etc)
  - Linux (ZFS-on-Linux, Ubuntu, Gentoo, OviOS)
  - Mac OS X (ZFS-on-OSX, GreenBytes/ZEVO, Akitio, MacZFS)
  - Windows (https://openzfsonwindows.org/)
  - NetBSD
  - OSv

Divergence

- Each different platform’s version of ZFS started to diverge
- OpenZFS replaced the old “pool version number” with “Feature Flags”, since features would land in different orders
- Bugs were fixed in one repo and not necessarily upstreamed or communicated to other platform’s could apply the same fix
- Each camp did their development within their own community, and other communities might not be aware of duplicate efforts, etc.

OpenZFS Developers Summit

- The new OpenZFS project organized a conference in November 2013 to have developers from the various platforms share their work and future ideas and find solutions
- Included a platform panel (Linux, Mac OS, IllumOS, FreeBSD) and vendor lightning talks
- Attended by over 30 developers, since grown to over 100
- Now includes a hackathon to work on prototypes while experts are in the room for advice / design discussions

Leadership Meeting

- At the OpenZFS Developer Summit 2018 a discussion between the various platform leaders lead to the formation of a monthly video conference to discuss ongoing issues
- Meeting once a month instead of once a year provides more information exchange and faster response times
- Goal is to keep the platforms better in-sync and compatible
- Open to anyone. Live streamed and recorded to Youtube

Outcomes

- The leadership meetings have been very successful
- OpenZFS is working to standardize the command line interface where it has diverged across platforms
- New features are discussed during the design phase and platform specific issues are resolved early, with better results
- More effort into effective naming of tunables (ashift is an internal implementation detail, the user tunable should be called sectorsize and be expressed in bytes)

Deprecation Policy

- Creation of a deprecation policy. After 18 years it is time to remove a feature from ZFS: Deduplicated send (replication)
- Feature is not related to pool dedup, rarely used, complicated
- This will require building a utility to convert old replication streams so they can be received by future versions of ZFS
- Also slated for removal: dedupditto. Designed to write a 2nd copy of a block if it is deduped more than 100 times. Turns out it has never worked properly, not checked/fixed on scrub

Cross Platform Compatibility

- Improved user interface for pool creation. Specify `compatible=openzfs-2019` or `compatible=freebsd-12`
- Enable only those feature flags compatible selected platforms
- The OpenZFS-YYYY macro will refer to what is available across all platforms as of January of that year
- Still identifying what best options are for other values
- Need to suppress the commended upgrade in `zpool status`

Compression Conundrum

- Another feature is slated for removal: the ability to disable the Compressed ARC feature. Interferes with updating compression algorithms and increases code complexity
- I am working on adding ZStandard compression of ZFS
  - ZStandard is under very active development, we do not want to be frozen to an older version for compatibility
  - Need to support upgrading compression algorithms
  - No guarantee same data will compress to same hash

Features: All Platforms

- sequential scrub/resilver
- zpool scrub pause/resume
- device removal
- zpool checkpoint
- zpool initialize
- spacemap encoding v2
- Channel programs
- large dnode

Features: Some Platforms

- Encryption (incl. raw send/recv)
- multi-import protection (MMP)
- special devices for metadata (allocation classes)
- parallel ZFS mount
- zpool sync
- TRIM (new way)
- resilver restart
- xattr=sa

Features: Coming Soon

- fast clone deletion
- spacemap log
- remove dedupditto
- redacted send/recv
- ZSTD compression
- per-vdev properties
- Enable compression by default

Features: Future

- RAID-Z Expansion
- DRAID
- Persistent L2ARC
- Adaptive Compression (compress more when not busy)
- Smart Compression (file based heuristic)
- Platform specific ShareNFS property handling

Features: Wish List

- Improved dedup (dedup log)
- Offline Dedup
- File Cloning
- Per-dataset throttling/QoS (IOPS and BPS)
- SMR Support (Shingled Disks)
- Clustered Features
- Continuous Replication

The Linux 5.x Scare

- With the release of Linux kernel 5.0 it was announced that some kernel functions that OpenZFS was using were being removed in favour of newer GPL-only symbols
- This broke compilation of OpenZFS and scared a lot of people
- The functions that were removed were to do with SSE/SIMD
- Were used to Vectorize (speed up) Checksumming
- ZFS-on-Linux simply reverted to standard checksumming

The Linux 5.x Scare

- Greg Kroah-Hartman followed up on the mailing list with:
  - "Sorry, no, we do not keep symbols exported for no in-kernel users."
  - "my tolerance for ZFS is pretty non-existant."
- Longtime Linux kernel developer Christoph Hellwig also suggested users switch to FreeBSD instead if they care about ZFS.

Get Involved

- The OpenZFS community is very active and very welcoming
- Watch some of the past “OpenZFS Leadership Meeting” conference calls on youtube to see for yourself
- The “repo of record” is transitioning to the ZFS-on-Linux repo as it has the most active development and the most code that still needs to be pulled into other platforms
- Github Issues and Pull requests
- Mailing Lists (Topic Box) for discussions

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QUESTIONS

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klarasystems.com

More Resources

- Want to know more about ZFS?
  - “FreeBSD Mastery: ZFS” & “FreeBSD Mastery: Advanced ZFS”
  - Not just for FreeBSD, DRM-Free ebooks ZFSBook.com
  - https://www.FreeBSD.org/handbook/zfs.html
- BSDNow.tv - Weekly video podcast on BSD & ZFS
- @allanjude on twitter