ZFS

The Next Word...

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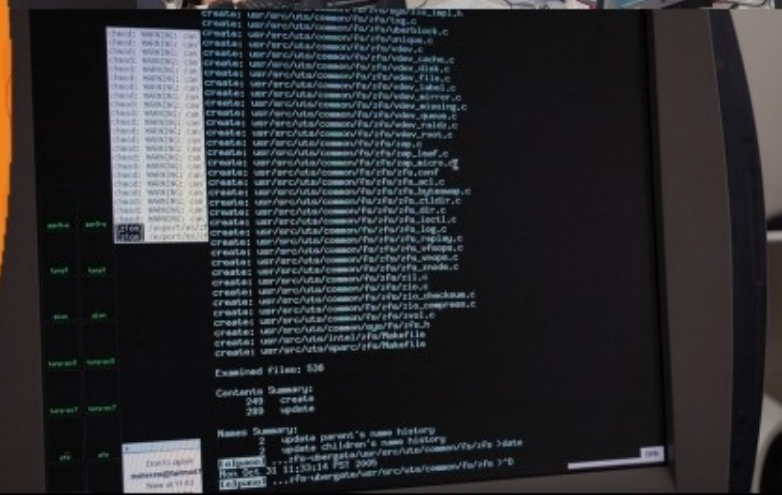
www.opensolaris.org/os/community/zfs



What's in the pipeline?

- Performance
- User quotas
- Pool recovery
- Triple-parity RAID-Z
- De-dup
- Encryption
- BP rewrite (huh?) & device removal
- Shadow migration
- Random cool features

Performance

- Hybrid storage pools
- New block allocator
- Raw scrub
- Parallel device open
- Zero-copy I/O
- Scrub prefetch
- Native iSCSI
- Sync mode
- Just-in-time decompression

ZFS Hybrid Storage Pools

- Separate log devices for fast synchronous writes
  - Enterprise-grade SLC flash SSD
    - Cheaper than NVRAM
    - A few GB is plenty
    - Easily clustered over standard SAS fabric
- Cache devices for fast random reads
  - Cheap, consumer-grade MLC flash
    - L2ARC: an eviction cache for the L1ARC (DRAM)
    - As much as necessary to hold working set
    - It's just a cache – failures are OK, no need to cluster
    - Everything is checksummed – no risk of silent errors
- Low-power, high-capacity disks for primary storage

ZFS Hybrid Pool Example

- 4 Xeon 7350 Processors (16 cores)
- 32GB FB DDR2 ECC DRAM
- OpenSolaris with ZFS

Configuration A:

(7) 146GB 10,000 RPM SAS Drives

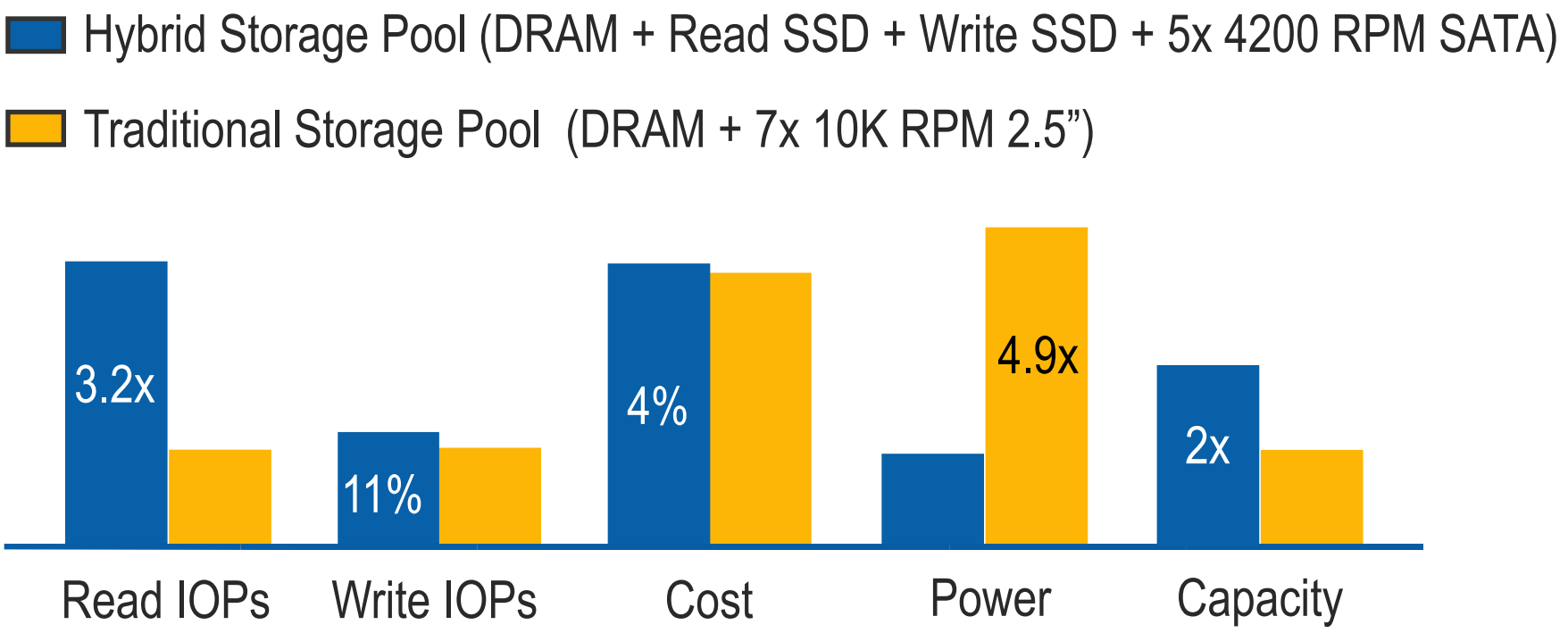
Configuration B:

(1) 32G SSD Log Device

(1) 80G SSD Cache Device

(5) 400GB 4200 RPM SATA Drives

ZFS Hybrid Pool Performance



- If NVRAM were used, hybrid wins on cost, too
- For large configs (50T - 1PB+) cost is entirely amortized

User Quotas

- For enterprise customers
  - Finer grained answer to “where did my space go”
- For education customers
  - Many users, want quota per user
  - One fs / user is too many (unfortunately)
- User & group quotas with “deferred enforcement”
  - User may go over quota for several seconds (one transaction group) before system notices that they are over quota and returns EDQUOT
- Supports both SMB SIDs and POSIX UIDs/GIDs

User Quota Interface

- New properties
  - userused@<user> groupused@<group>
  - userquota@<user> groupquota@<group>
  - “zfs get” / “zfs set” like other properties
  - <user> or <group> specified as:
    - Numeric POSIX ID (`125829`)
    - POSIX name (`ahrens`)
    - Numeric SID (`S-1-123-456-789`)
    - SID name (`matthew.ahrens@sun`)
- New subcommands: “zfs userspace” and “zfs groupspace”
  - Display table, one line per user or group, e.g.:

```
TYPE        NAME          USED  QUOTA
POSIX User  ahrens         14M     1G
POSIX User  lling         258M   none
POSIX Group staff        3.75G    32T
SMB User    marks@sun     103M     5G
```

Pool Recovery: The Problem

- ZFS pool integrity depends on explicit write ordering
  - > Some cheap disks and USB bridges silently ignore it!
- Result: uberblock written before data it points to
  - > Power loss can lead to complete pool failure

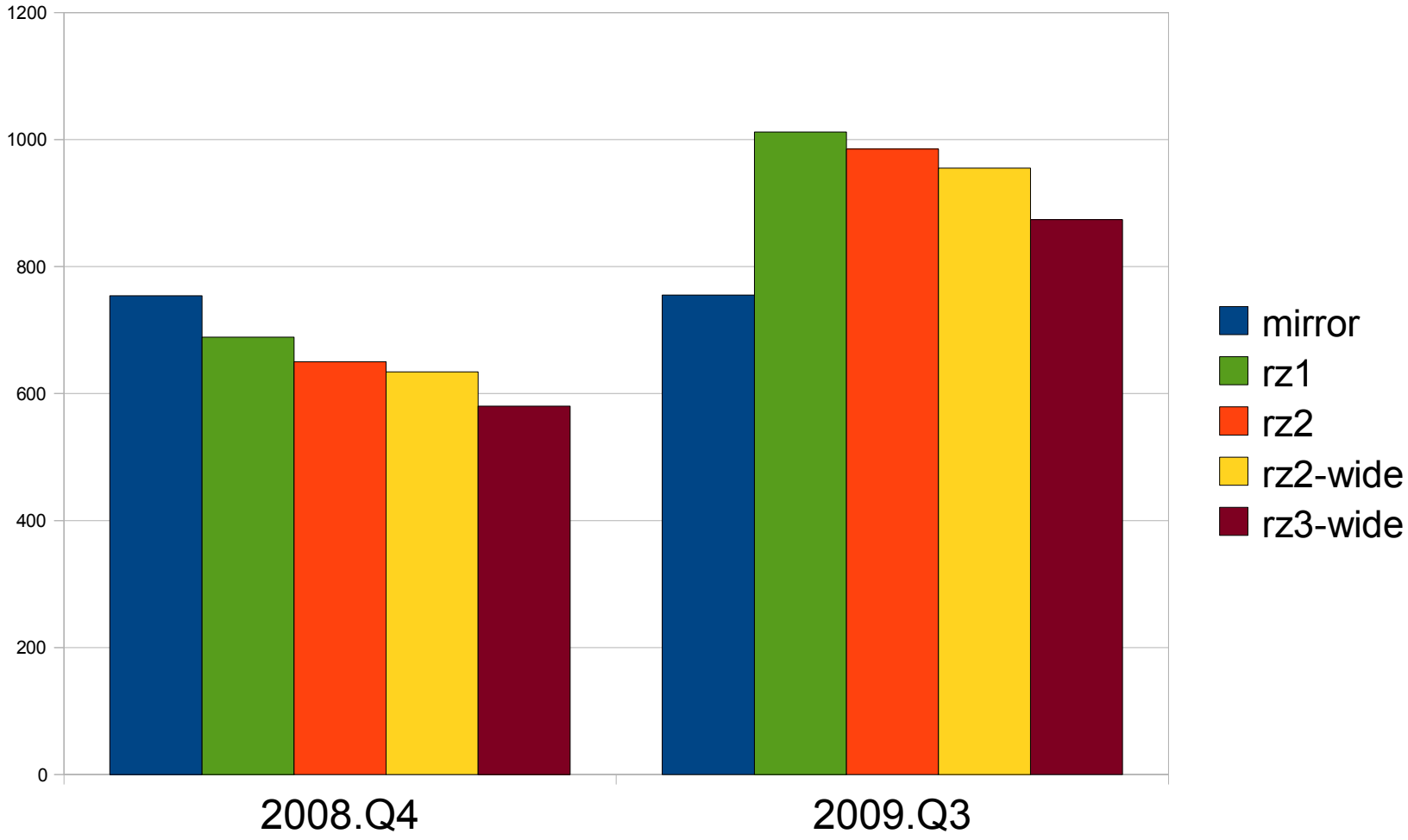
Pool Recovery: The Solution

- Recover pool even if devices ignore write barriers
  - Check integrity of recent transaction groups at pool open
  - If damaged, rollback to earlier uberblock
  - Rollback made reliable by deferred block reallocation
- Status
  - Working code; finalizing user experience

Triple-Parity RAID-Z (RAIDZ3)

- Survives three-disk failure
  - Or, more likely: two-disk failure plus occasional bad reads
- Enables bigger, faster, high-BER disks
  - 30-40% of the bits on modern hard disks are ECC
  - With different zone recording tables, we could have:
    - 30-40% higher capacity
    - 30-40% higher bandwitdh
    - Much more frequent errors, detected and corrected by ZFS
- Status
  - Integrated into OpenSolaris
  - Write-side “mind the gap” performance improvement

RAID-Z Write Throughput Results



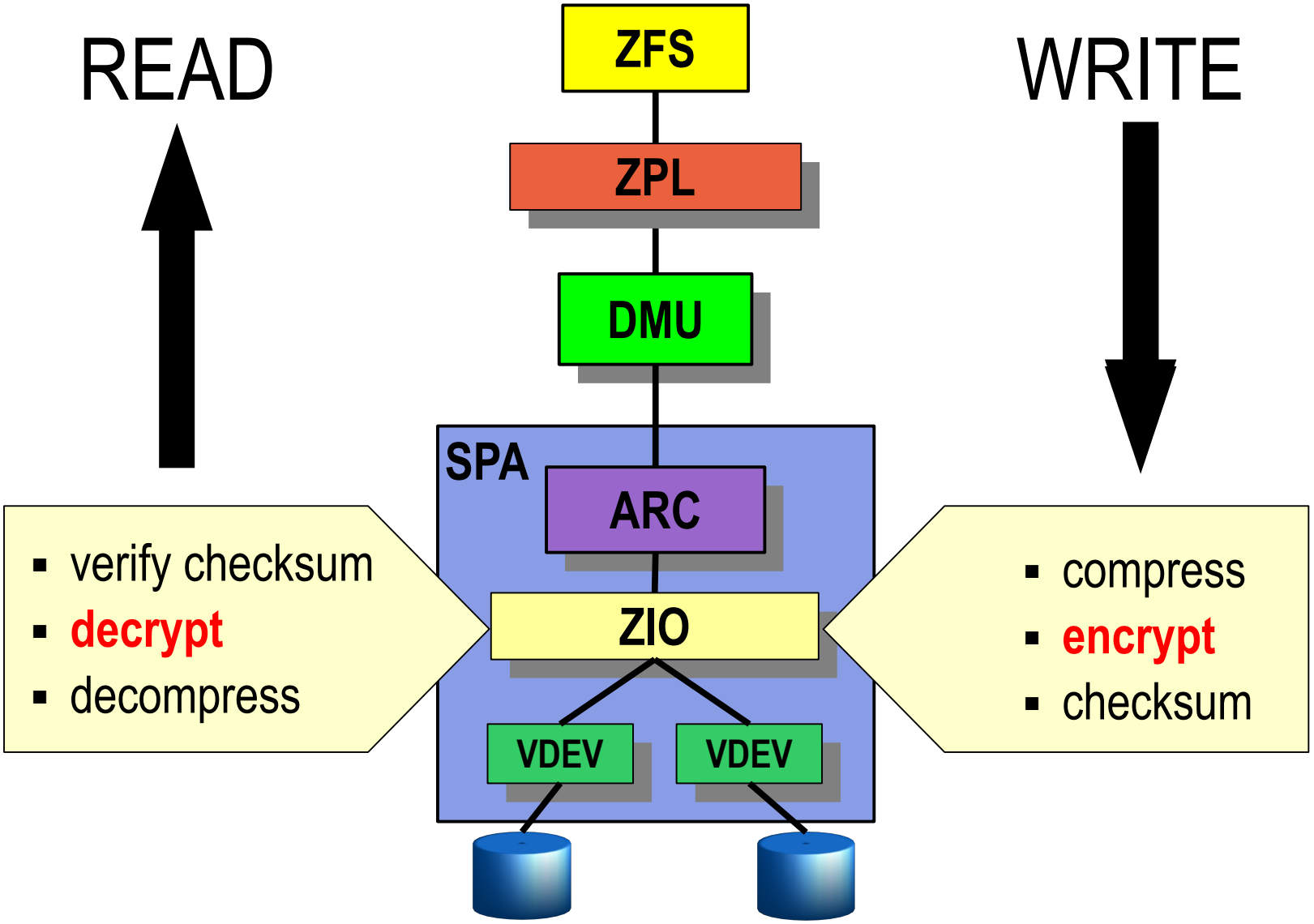
Preliminary throughput data

Note throughput was also much more consistent

Dedup

- Only store one copy of identical data blocks
  - Three parts: on-disk, in-core, over-the-wire
- Key applications
  - Virtualization
  - Backup servers
  - Build environments
- Behaves like you'd expect
  - Transactional
  - Plays well with other ZFS features
  - No special hardware
  - Unlimited scale

ZFS Encryption



ZFS Encryption: Design Goals

- Encrypt all data and ZPL metadata (name, owner, etc)
  - All data on zvols can be encrypted
- Allow for secure delete
- Must not require special hardware
  - But should be able to take advantage of it
- Don't break Copy-On-Write semantics
- Integrate with existing ZFS admin model
- Support mix of ciphertext and cleartext datasets

ZFS Encryption: Key Management

- Dataset encryption requires two different types of keys
  - A user specified key called the “wrapping” key
  - A randomly generated dataset key wrapped by the user specified key
- This model simplifies such tasks as secure deletion
  - Get rid of the wrapping key and the data is deleted
- The wrapped key can also change without changing the user specified wrapping key

ZFS Encryption: Administration

- Dataset encryption can only be enabled at create time
  - Specify keysource and encryption algorithm
  - Enables SHA-256 checksum automatically
- Keysource indicates location of the wrapping key
- Two encryption algorithms supported initially
  - AES-128-CCM
  - AES-256-CCM (default when enabled)

```
# zfs create -o encryption=on -o keysource=passphrase,prompt tank/fs
```

BP Rewrite

- Move blocks and update all pointers atomically
  - Foundational ZFS technology
  - Enables device removal, on-line defrag, recompress, etc.
- Rocket science
  - Subtle, racy, hard to debug – and has to be perfect
- Status
  - Now: code works on quiescent pool
  - Soon: work with concurrent read/write activity
  - Finally: configuration changes, out-of-space issues

Shadow Migration

- Migrate data from third-party NAS
  - Minimal downtime, usable immediately
  - VFS/vnode interposer: new share faults in data from old
- Status
  - Done: basic functionality, background migration, analytics
  - To do: hard links, progress monitoring, error management
  - Initial version NFS-only

Random Cool Features

- Dynamic LUN expansion
- Snapshot holds
- Access-based enumeration
- Multi-mount protection
- Slog offline (and figured out most of slog removal)

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