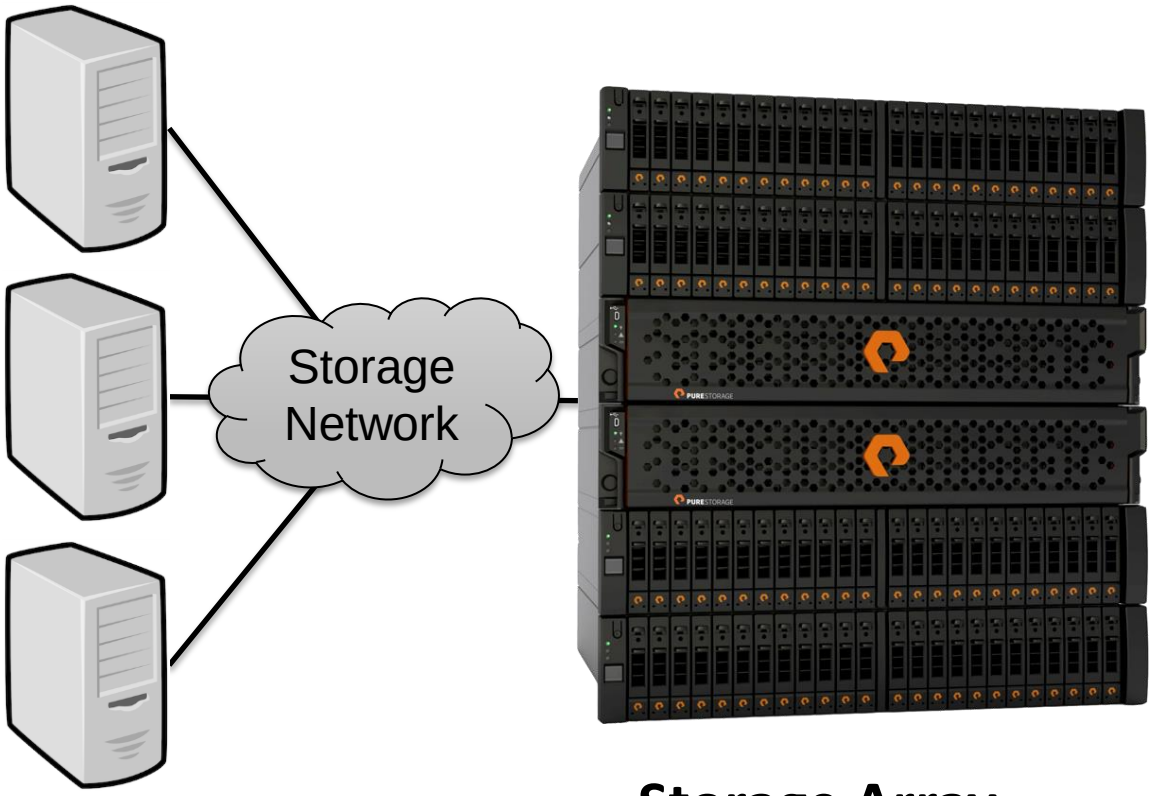
PURESTORAGE

Flash in an Enterprise Storage Array - 10x Performance for Less Than Disk

Presented by Neil Vachharajani

Enterprise Storage Arrays



Storage Array

Consolidated, manageable, and reliable

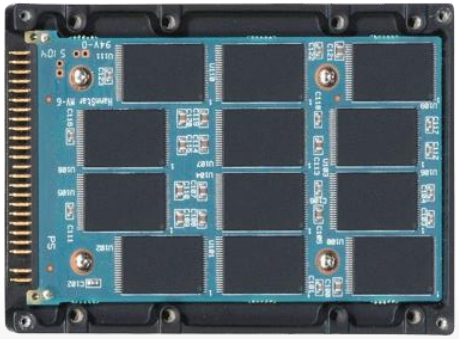
Enterprise Storage: $30B Market Built on Disk

- **Dominated by spinning disk**
  - Capacity is plentiful
  - Performance has stagnated
  - Random I/O workloads (virtualization) – subpar performance
- **Consumer space has transitioned to Flash**
  - Drives today's smartphones, cameras, USB drives
  - Laptops and desktops come with solid-state drives (SSD)
- **Why not just put SSDs into today's disk array?**
  - Current software systems are optimized for disk
  - Flash and disk are very different
  - Need storage arrays designed to leverage flash

Flash: Opportunities and Challenges

- **Opportunities**
  - Reads: Random access and fast
  - Performance isolation
  - Virtualized data layout

- **Challenges**
  - Device longevity
  - No in place overwrites
  - Read/write performance asymmetry
  - Cost $$



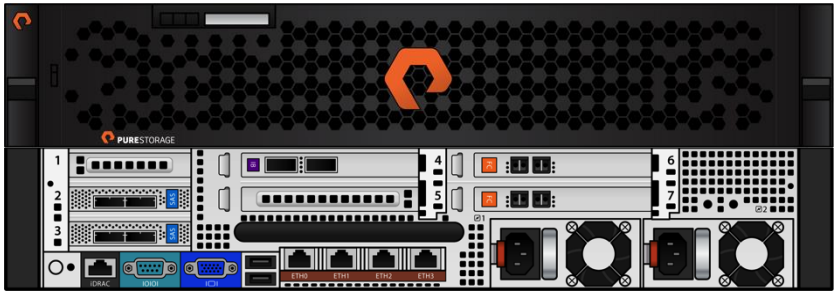
Pure Storage Architecture Principles

- **Trade raw performance for simplicity and lower cost**
  - Simplicity – prefer self-tuning system
  - Use CPU and surplus read bandwidth to reduce writes

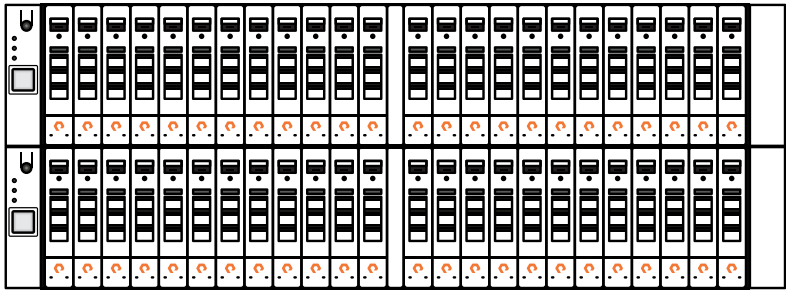
- **Don’t splurge on “enterprise” hardware**
  - Leverage cost trends in the consumer space
  - Optimize array wide, not at the individual SSD level

The Pure Storage Flash Array

FA-400 Controller



Storage Shelves



Performance*
- 400,000 **8K** IOPS
- 5 GB/s bandwidth
- <1ms average latency

Specifications
- 2x Intel “Sandy Bridge” 8-core CPUs
- 256GB DRAM
- 8Gb/s FC or 10Gb/s Ethernet
- 56Gb/s InfiniBand & 6Gb/s SAS
- 2U, 420W

SSDs
- 256 GB or 512 GB SSDs
- 100% MLC Flash

NVRAM
- Up to 2 NVRAM devices per shelf

Scale
- 20 – 100 TBs usable**
- 11 – 23 TBs raw flash (and growing!)

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* Up to. Performance depends on workload and I/O mix.
** Usable depends on actual data reduction rate, average of 5-to-1. Usable includes RAID overhead, HA, and running up to 80% full

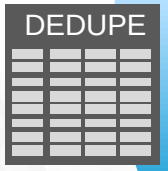
How Purity Works

Protect

- Checksum
- Copy to NV-RAM

Reduce

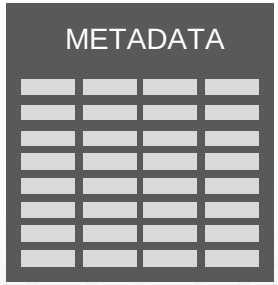
- Pattern removal
- Deduplication
- Compression



Store

- Create RAID-3D segments
- Flush writes via flash scheduler

Write



Read

Optimize

Validate & Serve

- Validate checksums

Multi-Path Read

- Read from fastest path via scheduler
- Decompress

Flash Management

- Global wear leveling & refresh
- Global deletion management
- Integrity checking

Flash Memory

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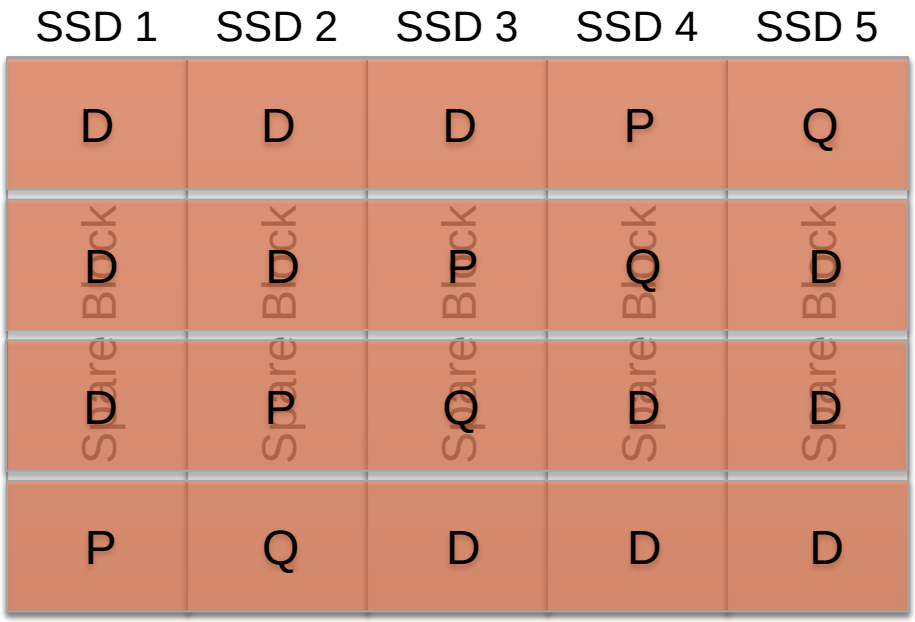
Caring For Your Flash: Writing in Log Structure



- **Aligning to SSD Geometry**
  - Spare blocks encompass one or more SSD erase blocks
  - Writes encompass one or more SSD pages
- **Contiguous sectors not contiguous on flash**
  - Flash has great random read performance

FlashCare™: Optimizing Flash Globally

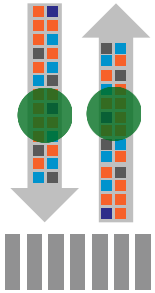
100% Virtualized Wide-Dispersed Data Layout

- No performance hot spots
- Evenly wears flash
- Bonus: no hot spares!

Flash Geometry-Aligned Writes

- Aligns with erase block boundaries
- Minimizes data movement “work” by SSD controller

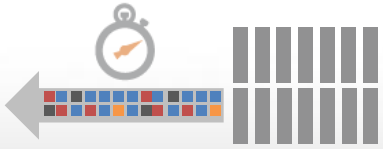
Non-Blocking Reads & Writes



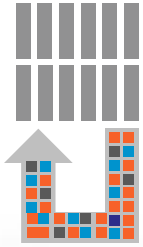
- Micro-schedules each SSD
- Isolates reads and writes to a SSD
- Re-issues IO to alternate location if SLA exceeded

Deep Write Pipelining

- Manage volatile SSD caches
- SW tolerates flush latency
- Optimized to leverage SSD bandwidth



Continuous Background Optimization



- Handles garbage collection and wear management globally
- Periodically refreshes flash cells for longer retention
- Verifies data integrity

Flash Personality Layer

- Understands ideal IO fingerprint of each SSD
- Allows for mixing multiple generations of flash in one system

Conclusions

- **Data reduction in the field**

  - Makes flash affordable for all

- **Enterprise system from commodity components**
  - Non-disruptive everything
    - From software updates to hardware upgrades
  - With the Purity OS, components have proven extremely reliable
  - High performance - < 1 ms latency typical

