Enterprise Storage Systems from Consumer SSDs

John Hayes
Pure Storage
The imperfect consumer SSD

- Limited ability to mix read and write operations
- No battery backup
- No multipathing
- Limited lifetime writes

- Great read performance
- High quality (simple firmware)
- Inexpensive
- Good data integrity
Pure FlashArray

Designed for 100% Flash
- Caching
- Tiering
- Disk

High-Performance Inline Data Reduction
- Inline & Global
- Deduplication & Compression
- 5-10x Reduction

Enterprise Reliability & Scalability
- Active/Active
- High Availability
- RAID-3D
- Data Integrity
- 100% Encrypted
- Online Expansion

Industry-Standard MLC Design
5-Year Warranty
Filling the consumer SSD gaps

- Write a lot at once and plan for outage
- Pack all updates into a single write
- Optimize for use not modification
- Get ready to read fast!

* Not persistent
Segments

- All data and metadata stored in **segments**
  - Segment numbers are monotonically increasing—never reused
  - Pages have segment salted checksums
- Each segment uses a different set of devices
- Segment protected by RAID
The SSD is always right

- GC
- Meta-data
- Writes (NVRAM)

- Intent Log
- Superblock
- Doublewrite
- Required reads
- Scan at startup
Consequences of lots of reads

- Only 20-100 us of CPU time is available
- Immutable segments allow lock free meta-data access
- Reading an SSD is faster than many algorithms to avoid reads including buffer caches
- Parity rebuild when a device is busy
Data Reduction

Volumes

Data

Hashes
The overhead of deduplication

- Non-cryptographic hashes in CPU (AES, CRC32C)
- Meta-data updates (including sector hashes) increase log space in proportion to compression rate.
- Garbage collecting segments without reverse references is same cost
- False positives cause more reads during flush, but they can be skipped.
Summary

- Consumer SSDs are great except for the writing
- Immutable data increases scalability
- Future reads are usually cheaper than present writes (or locks)

- You want flash right?
Thanks!

John Hayes
jhayes@purestorage.com