SSD Architecture Considerations for a Spectrum of Enterprise Applications

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Introduction

- Today's SSD delivers form-fit-function compatible solid-state memory replacements for hard disks

- By offering an HDD plug-in replacement, the SSD serves a massive existing infrastructure
  - Physical size and mounting
  - Host interface connectivity
  - Feature set and software compatibility

Distributed Flash Controllers Drive New SSD Topologies

- The opportunity today for SSDs in network RAID storage is to replace enterprise HDDs with high IOPS SSDs

- Advancements in distributed flash controller topologies permit the optimization of flash packaging to improve performance, power, and storage density beyond the standard SSDs in HDD form factors

HDD Storage System Alternative

- This presentation illustrates a solid state storage system alternative to HDD-based RAID storage systems
- Flash memory packaging offers better efficiency when not used in the HDD form factor
- Advanced fabric connected flash controller technology brings advantages of provisioning, reliability, performance, availability, and low cost FRU management

HDD RAID Architecture

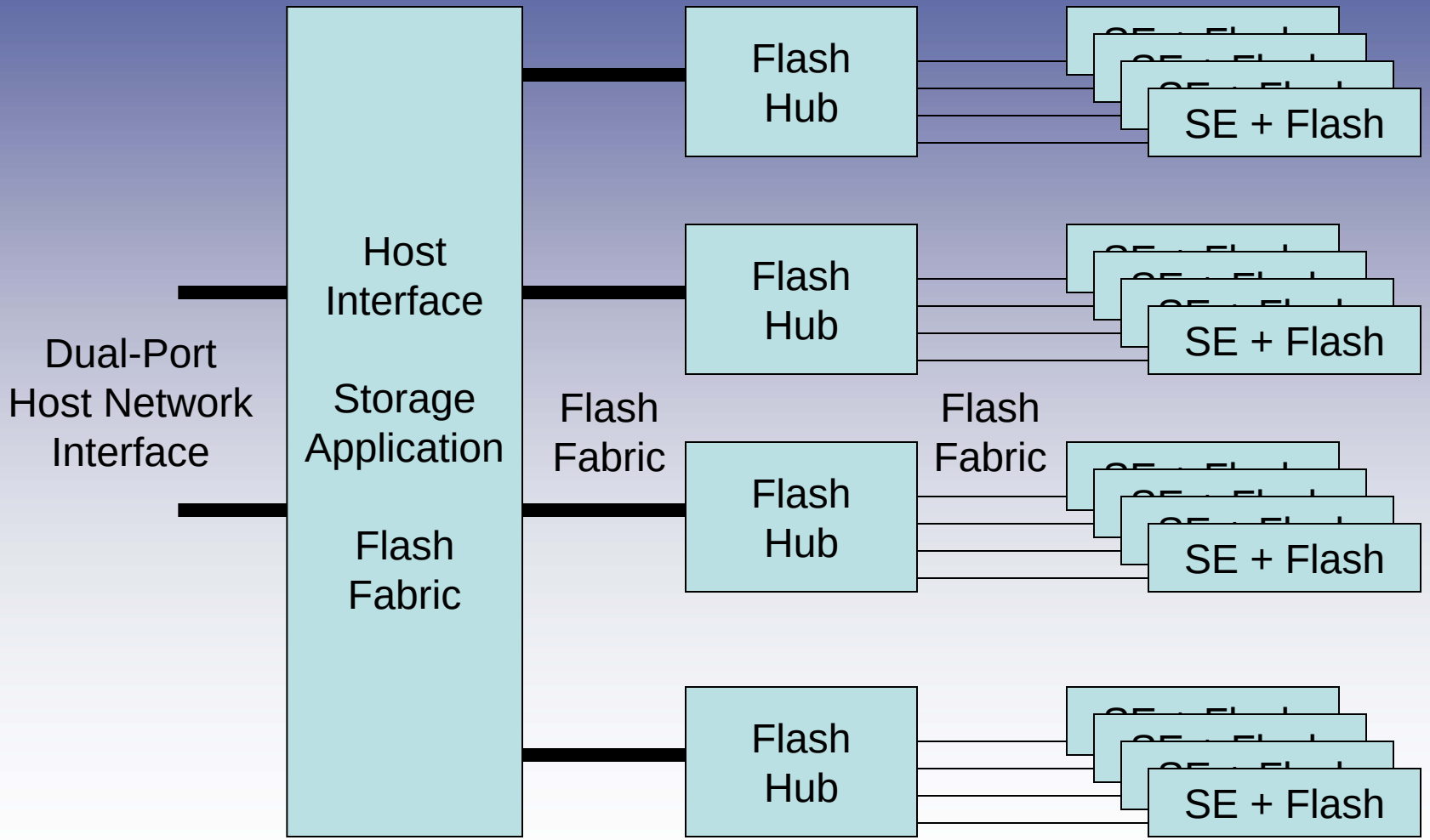
- A network storage system comprises
  - High speed network I/O to the host / network
  - Large cache memory to increase IOPS by consolidating small block transfers
  - Redundant HDD controllers, disk drives, and power supplies to ensure high system availability
  - Hot swappable media where the HDD is the FRU (Field Replaceable Unit)

Typical RAID Implementation w/ 3.5-Inch HDD

Solid State Storage Blade

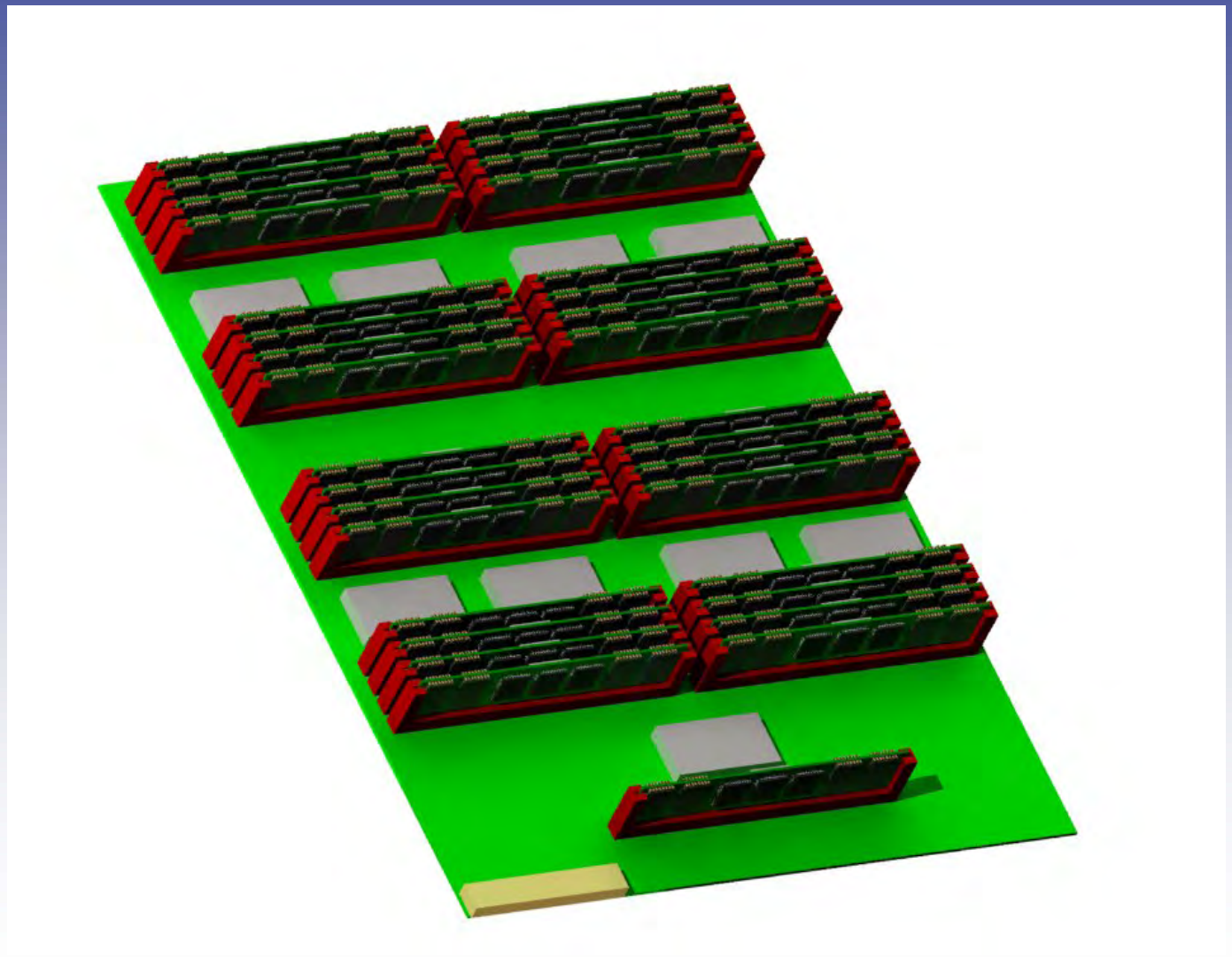
- System appropriate, high speed host front-end
  - Fibre Channel, SAS, Infiniband, PCIe
- Multiple arrays of flash DIMMs
  - The DIMM becomes the FRU interconnected through a high-speed flash fabric
- Multiple hubs on the flash fabric provide connectivity between the DIMMS and the host front-end
- System specific application configuration
  - Provisioning – Availability – Performance

Solid State Storage Blade



Flash Memory SUMMIT

Solid State Storage Blade



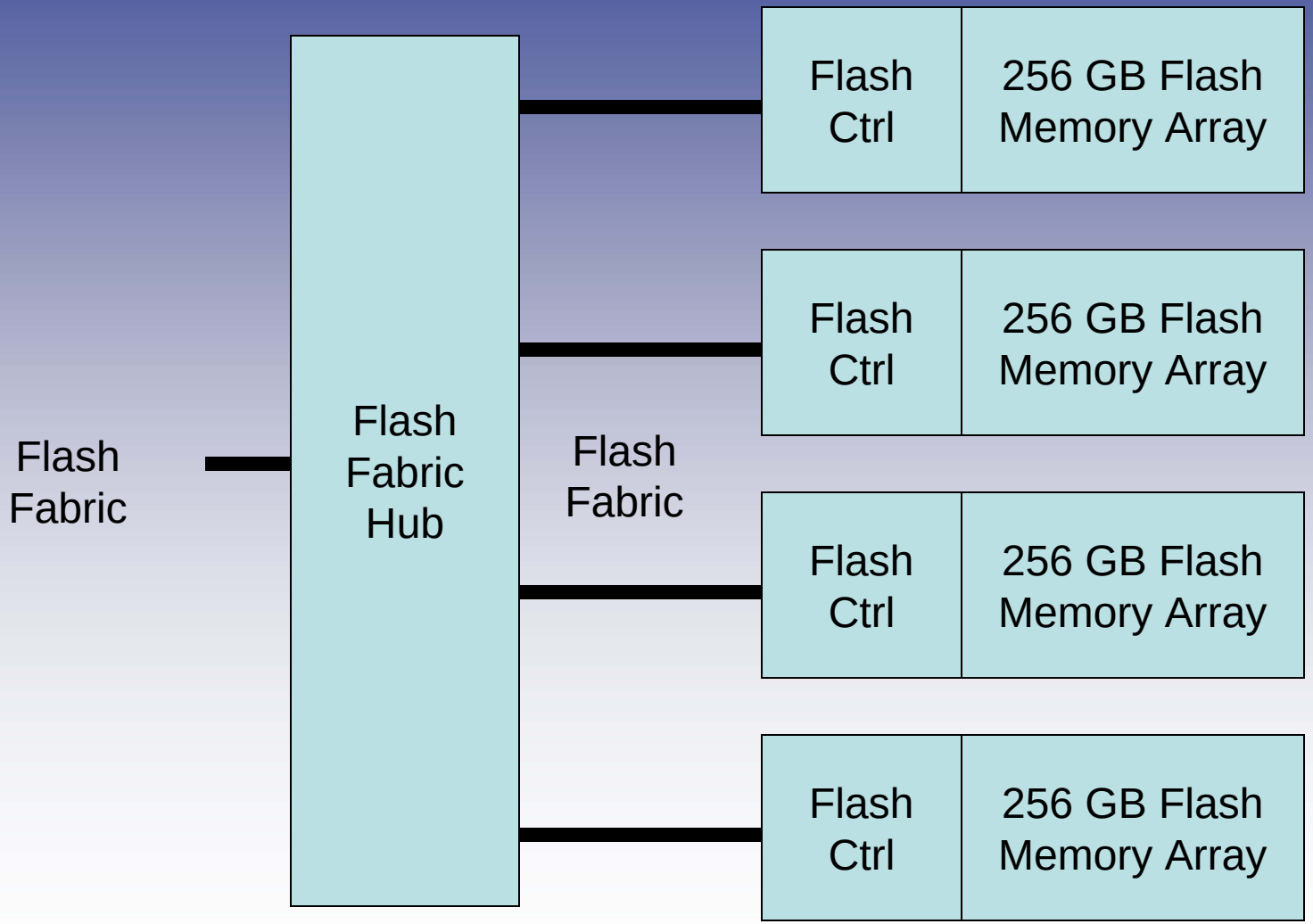
DIMM Packaging Simplifies FRU and User Experience

- This SSD topology takes advantage of high volume and low manufacturing costs of DIMM packaging
- Configurable for redundancy (RAID) and hot swapping, the DIMM is field replaceable without system power down
- The user (not the SSD manufacturer) determines overall capacity through the population and density of DIMMs

Flash Fabric

- High Speed Serial Single or Multiple Lane
  - Typical serial similar to SATA and PCIe
- Simplified Fabric Complexity Relative to
  - PCIe, SATA, SAS, IP
- Low Latency
  - Optimize IOPS and Reduce Bottlenecks
- Packets Optimized for Logical Flash Pages
  - Enforce Flash Media Efficiencies

Four DIMM Array – 1 TeraByte



DIMM Characteristics

- 256 GByte Capacity
- 2 Watts
- 25 K / 20 K / ~20 K IOPS
  - 4 KByte random Read / Write / 2R:1W
- 300 MB/s / 200 MB/s
  - 128 KByte sequential Read / Write
- 78 IOPS per GByte 2R:1W
  - 20 K / 256
- 128 GBytes per Watt
  - 256 GBytes / 2

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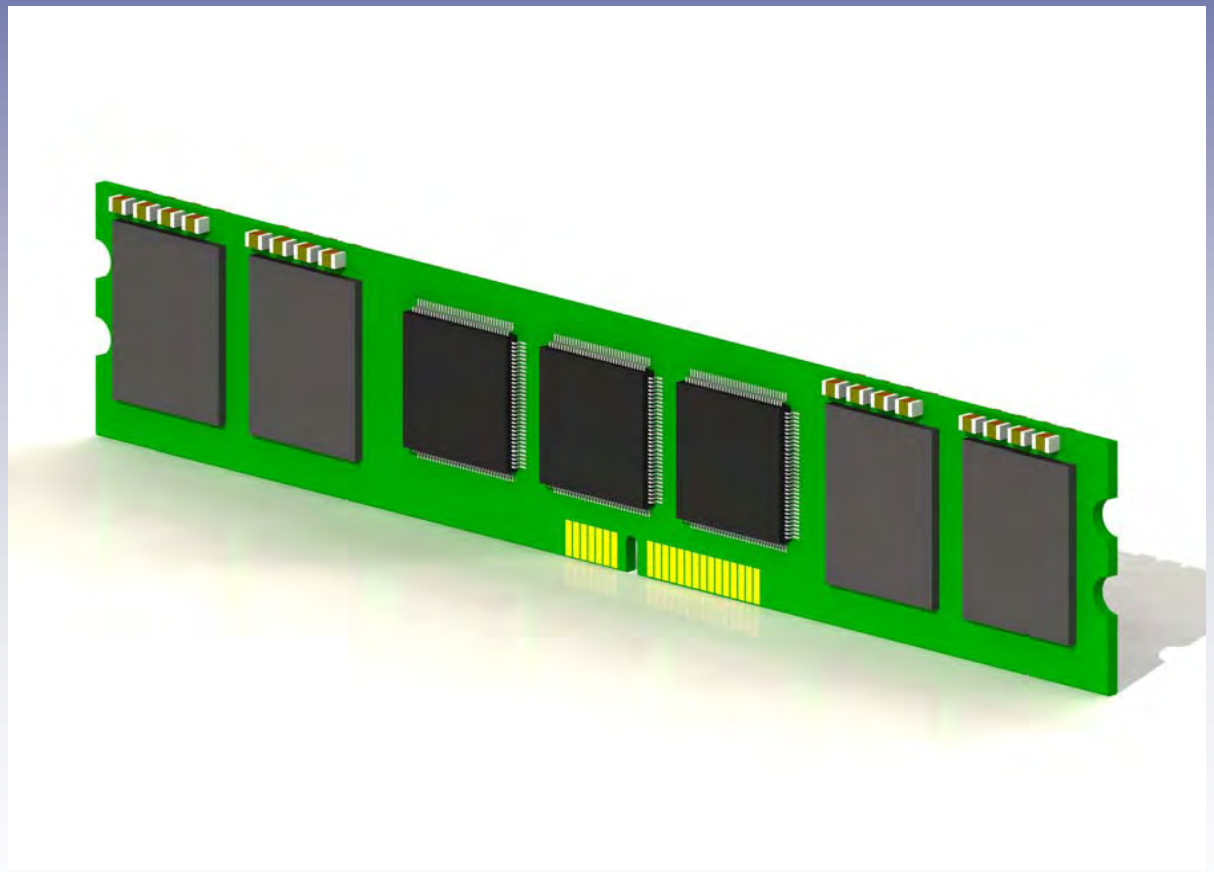
DIMM Storage Element



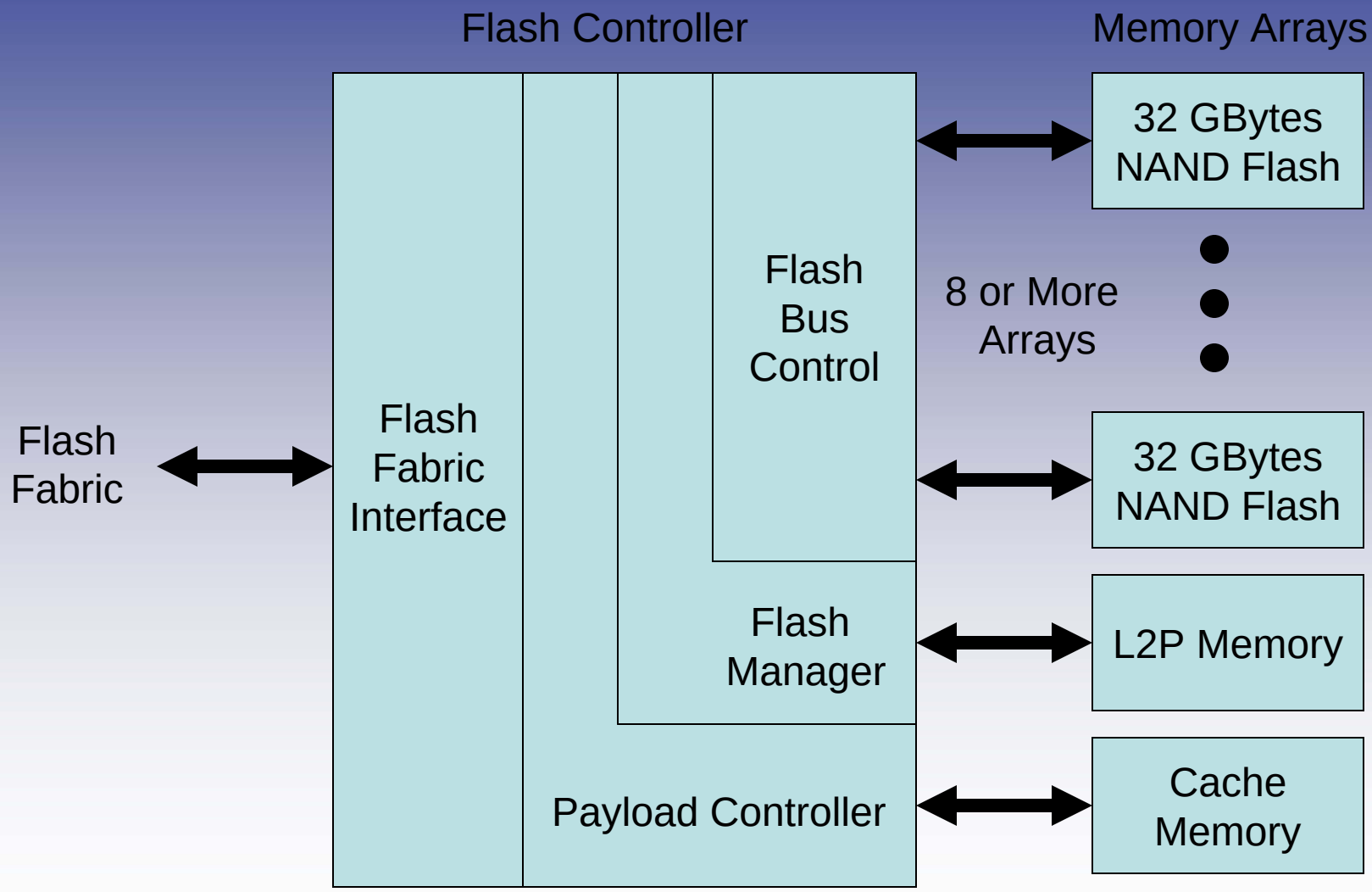
Distributed Flash Controllers Using High Speed Fabric

- Communication over the Fabric
  - High speed single or multi-lane
  - Optimized command set for low power and low latency
- Each Controller Manages Arrays of Flash
  - Appears as a group of logical pages to the fabric
  - Translation to host logical blocks performed at the Application Layer through a Logical Unit Manager

Flash Controller

- Basic Flash Controller Responsibilities
  - Interface I/O supporting all of the external connectivity, features and protocols
  - Logical block to physical memory translation mapping and management
  - Flash channel management with error detection, error correction, wear leveling, defect management, and the flash physical interface

DIMM Storage FRU

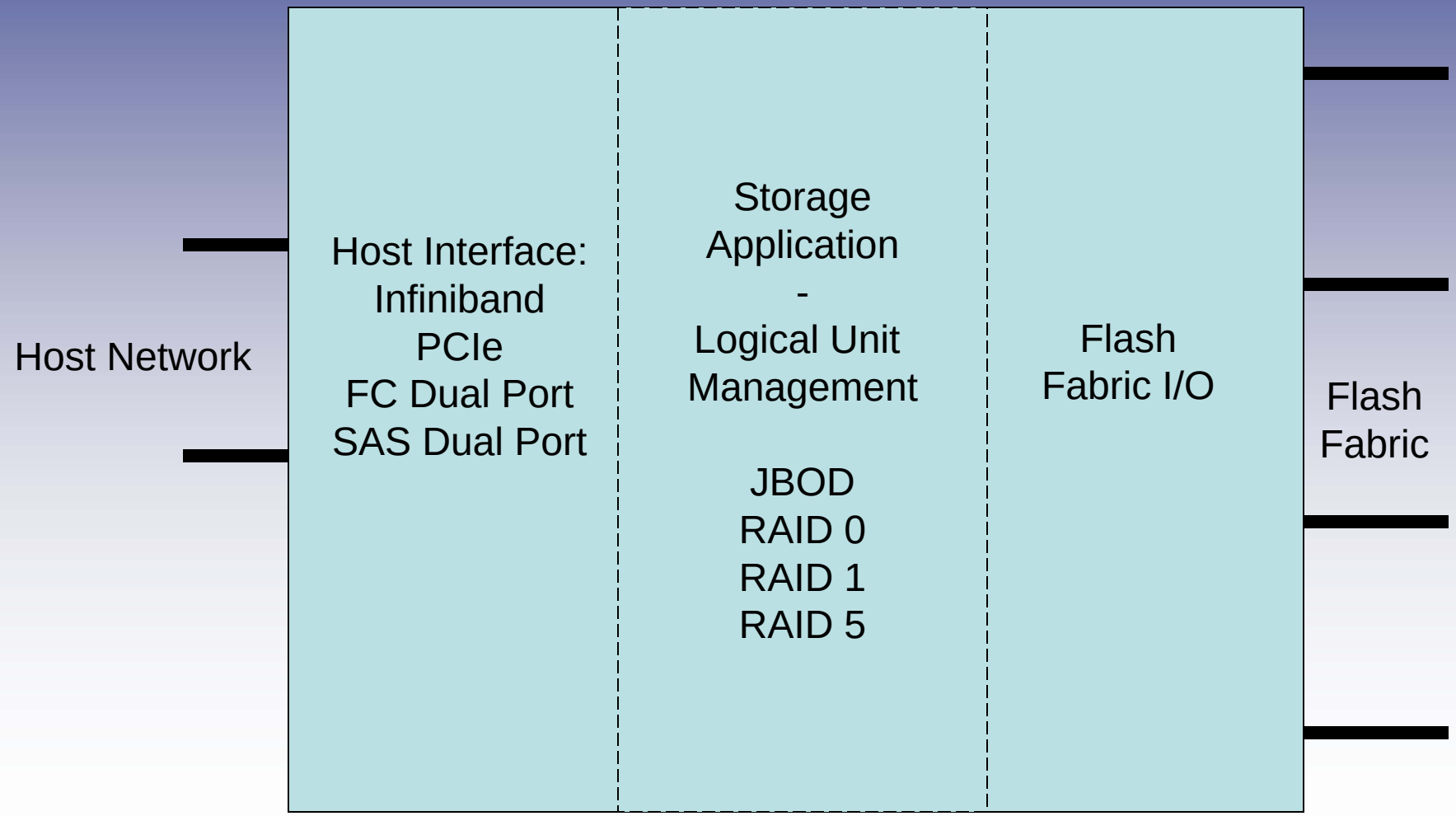


Storage Application Logical Unit Management

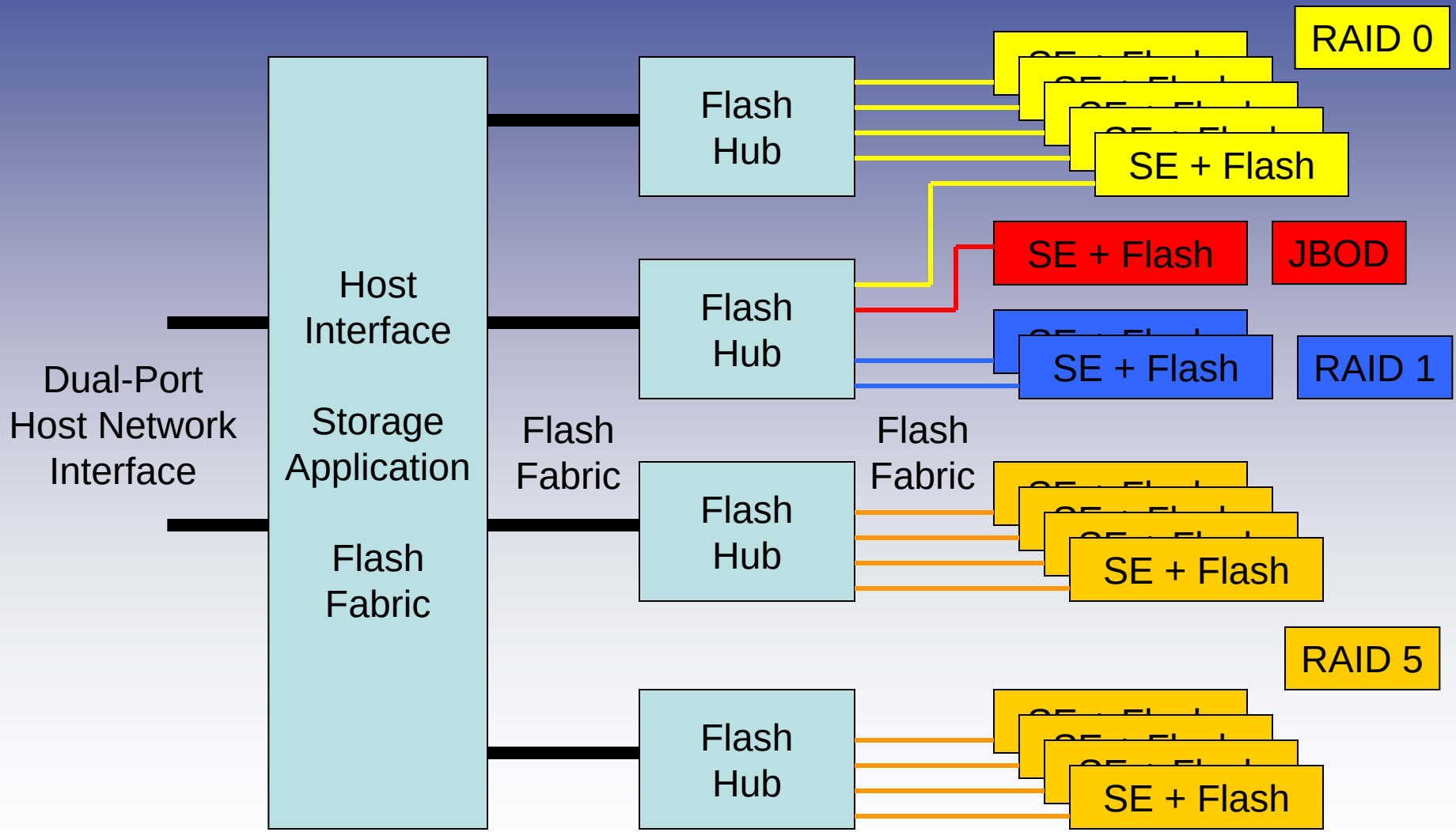
- JBOD
  - Individual Disks with no Redundancy
- RAID 0
  - Striped Disks with no Redundancy
- RAID 1
  - Mirrored Disks with Redundancy
- RAID 5
  - 3 or More Disks with Redundancy

Storage Front-End

Host I/O – Application Layer – Flash I/O



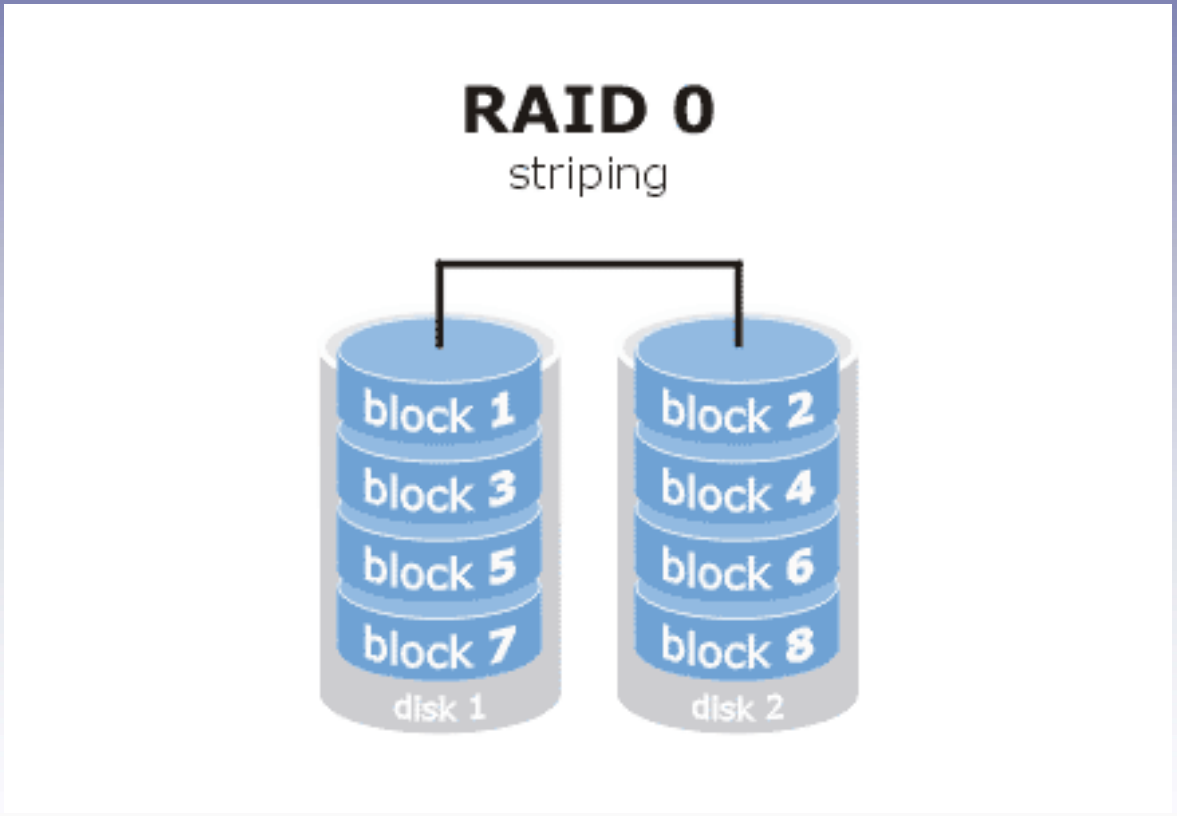
Application Configured Solid State Storage Blade



JBOD on a Single DIM

- 256 GByte Capacity
- ~20 K IOPS Random 2R:1W 4 KB
- >200 MBps Sequential (Fabric Saturated)
- High Availability
  - No Redundancy
- 128 GBytes per Watt
  - 256 GBytes / 2 W
- 78 IOPS per GB
  - 20 K / 256 GBytes
- 10,000 IOPS per Watt
  - 20 K / 2 W

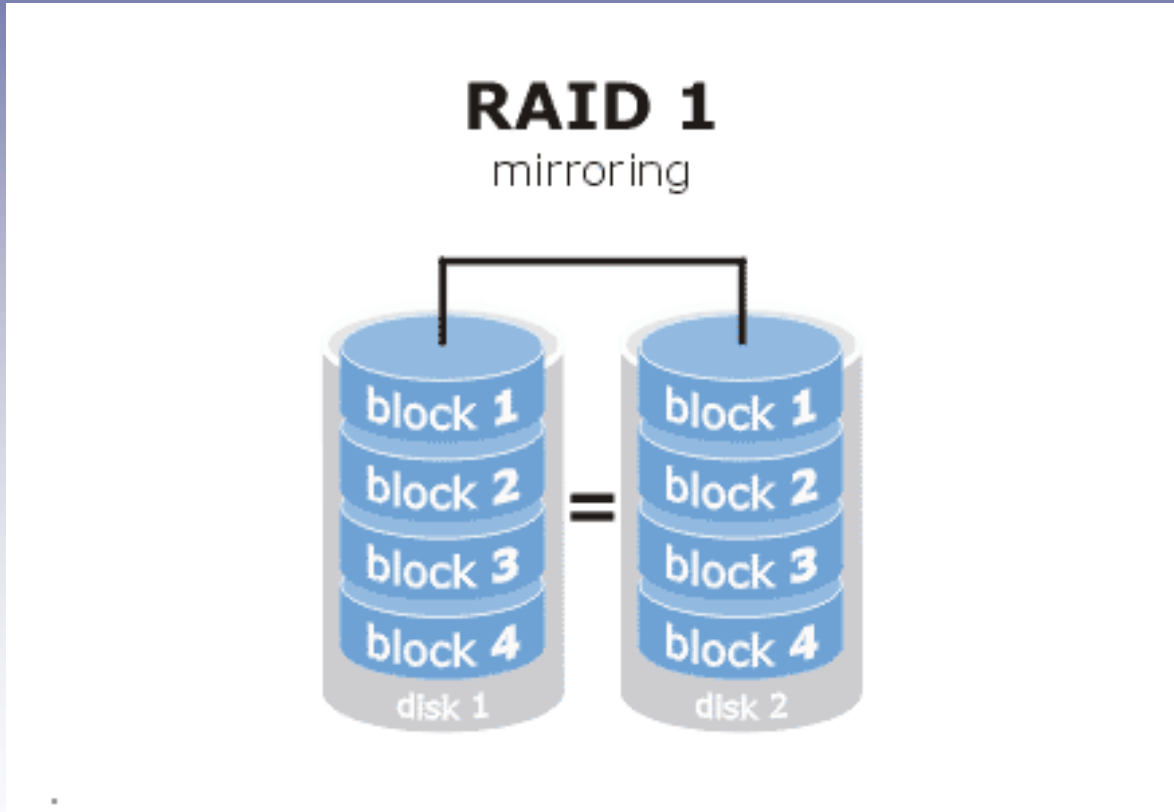
RAID 0 Example



RAID 0 Across Five DIMS

- 1.25 TeraByte Capacity
- ~100 K IOPS Random 2R:1W 4 KB
- >800 MBps Sequential
- High Availability
  - No Redundancy
- 125 GBytes per Watt
  - 1,250 GB / 10 W
- 80 IOPS per GB
  - 100 K / 1,250 GB
- 10,000 IOPS per Watt
  - 100 K / 10 W

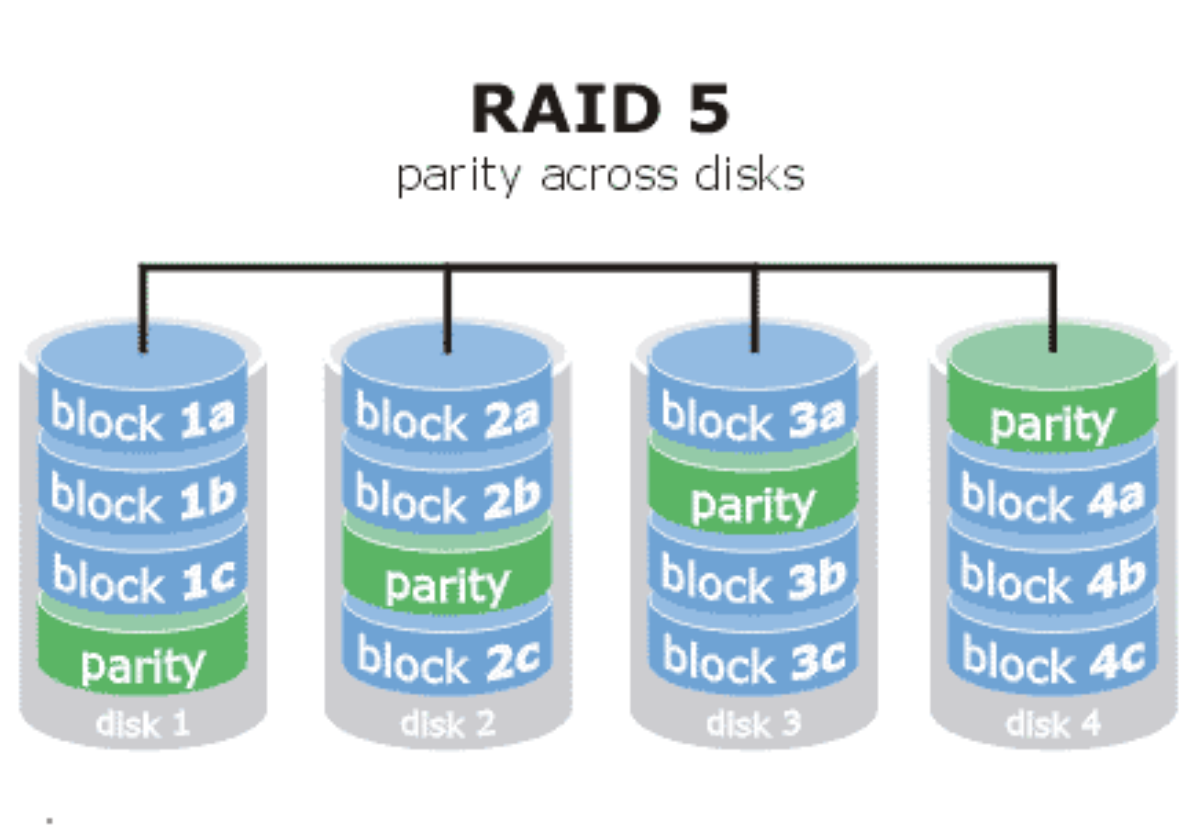
RAID 1 Example



RAID 1 Across Two DIMS

- 256 GByte Capacity
- ~33 K IOPS Random 2R:1W 4 KB
- >400 / 200 MBps R/W Sequential
- High Availability
  - One DIMM per DIMM Pair Redundancy
- 64 GBytes per Watt
  - 256 GB / 4 W
- 129 IOPS per GByte
  - 33 K / 256 GB
- 8,250 IOPS per Watt
  - 33 K / 4 W

RAID 5 Example



RAID 5 Across Eight DIMS

- 1.75 TeraByte Capacity
- ~140 K IOPS Random 2R:1W 4 KB
- >800 MBps Sequential
- High Availability
  - One DIMM Redundancy
- 109 GBytes per Watt
  - 1,750 GB / 16 W
- 80 IOPS per GB
  - 140 K / 1,750 GB
- 8,750 IOPS per Watt
  - 140 K / 16 W

Storage Application Performance Variations

	IOPS	MBps	GB / W	IOPS / G	IOPS / W
JBOD	20K	300R / 200W	128	78	10,000
RAID 0	100K	>800	125	80	10,000
RAID 1	33K	400R / 200W	64	129	8,250
RAID 5	140K	>800	109	80	8,750

Wrap Up

There are many storage applications with a corresponding number of SSD solutions ranging from 1.8” HDD replacements to PCIe plug-in cards.

This discussion represents one perspective among the many solid state storage solutions.

SMART is currently developing Fabric Attached flash controllers. Our first products based on this technology will be available in Q1 of 2010.

Thank You!