Testing SSD's vs. HDD's

The Same – But Different

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Anthony Lavia

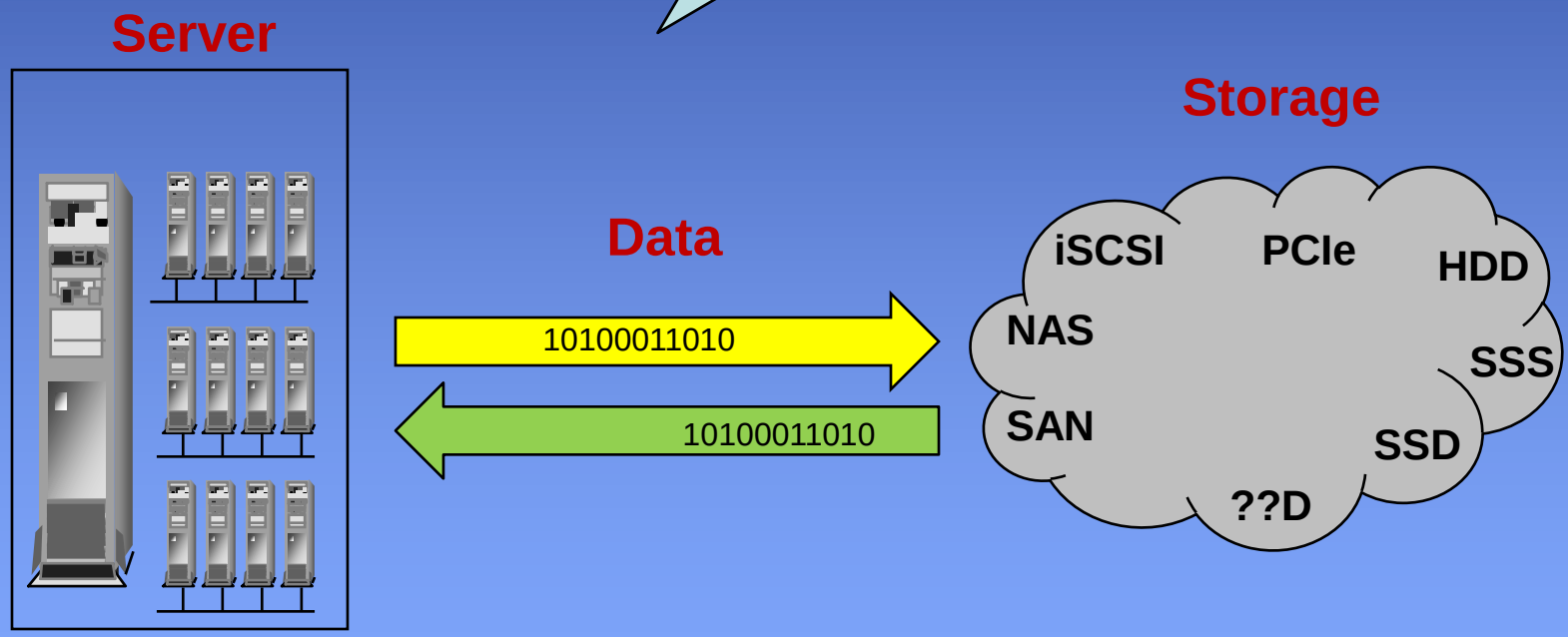
President & CEO

Introduction

- HDD vs. SSD
- Is SSD technology disruptive?
- Customer Expectations
- Factors Affecting Customer Expectations
- Test Methodologies / Examples
- New Metrics
- Summary

HDD vs. SSD

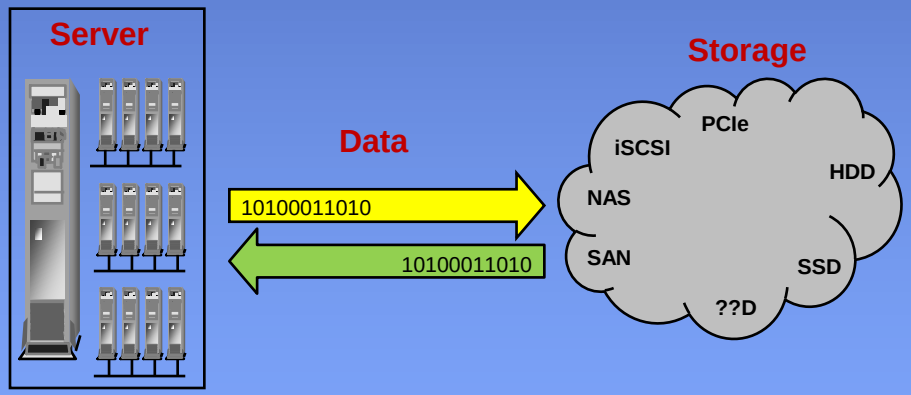
“The same……”



HDD vs. SSD

"…….but different"

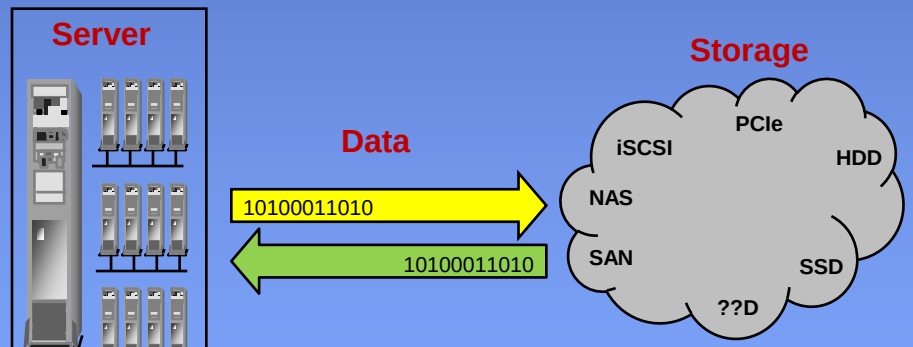
	HDD	SSD
Media	Rotational Media	NAND Flash
IOPS	100 - 300	40,000 - 150,000
Latency	5.5 msec	0.015 msec
MTBF	300K - 1M hrs	1.5M - 3M hrs
Shock	200 - 400 G's	1,500 G's



Is SSD technology disruptive?

"……disruptive"

	HDD	SSD
Storage utilization	20 - 30 %	Near 100%
IT efficiencies	maintenance	
Data virtualization	less effective	
Server/Storage performance gap	wide gap	



HDD vs. SSD

- **Major Performance Factors**

HDD	SSD
Read /Write ratio	Read /Write ratio
Random vs. Sequential	Random vs. Sequential
Block size	Block size
Rotational speed	SLC vs. MLC
Seek time	Controller / NAND Mgmt
Bandwidth MB/S	Bandwidth MB/S
IOPS	IOPS
Power Consumption	Power Consumption

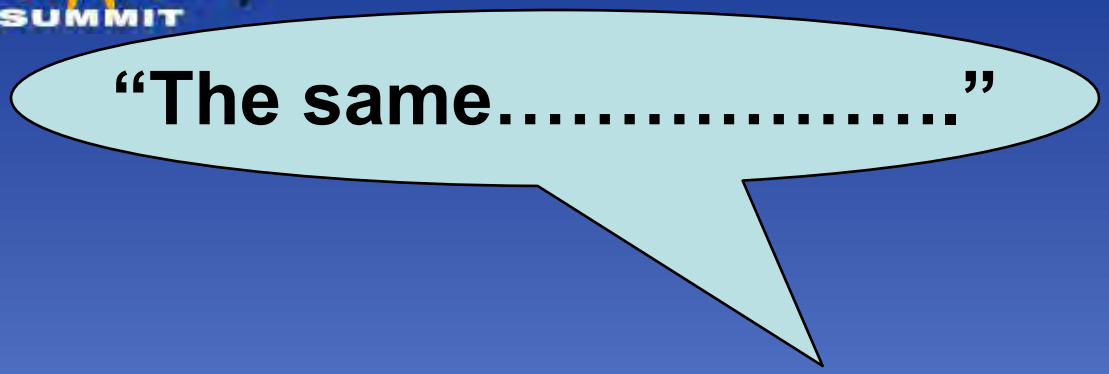
HDD vs. SSD

- **Performance Comparison**

	HDD 3.5" 15K RPM	HDD 2.5" 15K RPM	SSD 2.5"
Capacity	300GB	146GB	64GB
Read	100 MB/s	130 MB/s	300 MB/s
IOPS	700	580	6900
Price	~ $600	~ $500	~ $800
Watts	15 W	8.3 W	1.5 W

Source: Various Vendor Websites & Storage Review. Pricing based on information from Various Websites.

Customer Expectations



“NAND Component” vs. “Sub-System” ???

Customers are purchasing a Sub-System…They are concerned with:

- *The Controller / Interface*
- *Power Management*
- *Drive Life*
- *Etc., Etc., Etc.*

“……but different”

- Examples of HDD Tests
  - 1000 HDD’s for 1000 Hours (6 Weeks)
  - Contact Start / Stop Tests (50K Cycles or
  - Hot / Wet & Cold / Dry Environmental
  - Track Dwell / Off Track Erasure
  - Storage Corrosion Test
  - Zone Performance Test
  - Etc., Etc,, Etc.

Key Factors Affecting Expectations

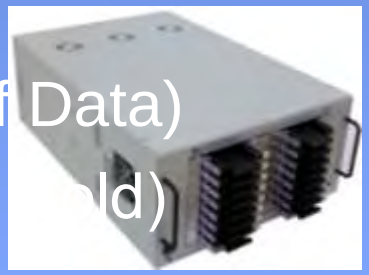
...of the SSD Subsystem…and the NAND Flash Device.

- Subsystem
  - NAND Management
    - Wear Leveling
    - Error Management (Not ECC, just NAND errors)
    - ECC
  - Power Management
  - Controller I/F (SAS, SATA, PCIe, etc.)
- NAND
  - Cycling
  - Disturb (Program or Erase)
  - Data Retention

How To Test for these Factors

“The same……”

- Just as with HDD’s there are a number of methods to influence the previously mentioned factors:
  - Duty Cycle (Volume of Data)
  - Temperature (Hot…and Cold)
  - Voltage



Wear Leveling

“……but different”

“I have heard that SSD’s have a limited life…how long will they last?” *Typical Customer*

- Example Test - Wear Leveling (SSD)
  - Objectives
    - Validate an even distribution of erase counts across the drive media.
    - Identify Long Term Reliability of “NAND Components”
  - Test
    - Random write and verify over entire drive 20% of test time.
    - Heavily exercise 10 % of the DUT 80% of test time
    - Each exercise period pick a new randomly chosen area to heavily exercise.

Uncontrolled Power Event (Shutdown)

"……but different"

"HDD's have inertia…
SSD's do not…"

- Write Shutoff (Splicer)
  - Objectives
    - Identify problem of incomplete write operation during a power failure.
    - Ensure no data loss
  - Test
    - Simulate condition by turning off the power in a middle of a write.
    - SSD must successfully complete finish writing the sector even. though power was removed in the middle of the write operation.
    - Restart SSD and check data at the exact sector of failure.
    - Ensure No Data is disturbed in other areas of Device.

New testing metrics proposals

- **Virtual RPM (vRPM)**
  - Proposal by Sandisk
  - Calculated measurement
  - Determines virtual RPM of HDD needed to achieve equal performance of SSD
- **New method of testing endurance**
  - Proposal by Sandisk
  - Long-term Data Endurance (LDE) using TBW
  - TBW (TeraBytesWritten) determines life expectancy of SSD based on workload scenarios
- **Write Amplification**
  - Proposal by Intel
  - Measure resulting actual data written vs. host data
  - If writing 4KB of host data results in 128KB of actual flash block size
    - Write amplification is a factor of 32 times
  - Testing with Write Amplification factor of 1. Block size = data written to flash
  - Improves endurance limits

Summary

- As customers become more knowledgeable on SSD's they are better at defining expectations for their markets
- New SSD Testing methodology is evolving
- Need to differentiate NAND (component) vs. SSD (Sub-System) Reliability
- Need to better understand the differences SLC vs. MLC (Reliability & Performance)
- Need to distinguish testing type by Application (Enterprise vs. Consumer)

	Enterprise	Consumer
IOPS need	Very High	Medium
Read bandwidth	Very High	Medium
Write bandwidth	High	Low
Reliability	Very High	Medium
Price tolerance	Medium/High	Low/Medium
$/IOPS	Very Low	Low
Capacity (GB)	Medium/High	Low

In addition to existing HDD Test Requirements, the industry will require establishment of new common testing methodologies to ensure reliability and it will be critical to leverage the knowledge learned from the HDD World.

Thank You