A Better Storage Solution

Presented by: Richard Goss
The Problem with Hard Disks

- Processors have increased in speed by orders of magnitude over the years.
- But spinning hard disk drives (HDD) have not.
- This difference has created a substantial performance gap between how fast processors demand data and how quickly HDD responds.
- HDD speed lags behind processors because it is constrained by physical components.
What is the alternative

Solid State Disk

- Flash
- RAM
- Combination: RAM & Flash
Why Solid State Disks?

- 1956 RAMAC
  - Performance Comparison the first hard disk drive (HDD)
  - 5 MB storage
  - 1,200 RPM
- 2007 Cheetah Drive
  - 400GB storage
  - 15,000 RPM

- From 1956 to 2007:
  - 12.5 times increase in RPM
  - 80,000 times increase in capacity

Little change in HDD performance over the years!
- Processors have increased in speed by orders of magnitude over the years.

1956: IBM 305 RAMAC Computer with Disk Drive
Solid-State Drive Technology

- NAND flash: non-volatile memory used for data storage
- Flash management enables:
  - Disk emulation
  - Extended endurance
  - High reliability
SSD: A Better Solution

Instead of rotating disks, solid state disks (SSD) use RAM and Flash chips. SSD:

- Dramatically lowers response time (latency)
- Offers extremely high inputs / outputs / second (IOPS)
- Uses less power and less space

The future of data storage
No decline in performance over time

SanDisk SSD SATA 5000 2.5"
Read measurement

Seagate ST910021AS
Read measurement

H2BENCHW 3.6 results
Comparison on average results

Max 67MB/s

Average 36MB/s

Min 25MB/s

Performance decreases as the media fills up with data
SSD V Rotating Drive

SanDisk SSD
Read Performance Starts High and Stays High

HDD
Read Performance Starts Low, Spikes Even Lower, and Degrades Over Time

In fact, during extreme impact testing the surrounding notebook hardware breaks before the [SSD] drive”

Dell press release, April 24, 2007
SSD (Flash) Key Benefits

- **Primary Benefits:**
  - Reliability and Endurance
- **Performance**
  - Power consumption
- **Secondary Benefits:**
  - Resistance to shock and vibration
  - Low acoustics
  - Wide temperature range
SSD (Flash) Benefits: Reliability & Endurance

- No failures from moving mechanical parts
- Higher MTTF resulting in lower failure rates
  - 2M hours vs. 500K hours
    - 4X more than 7200RPM HDD
    - 2X more than 15K RPM HDD
- Enhanced Endurance:
  - Write 100GB/day on 32GB SSD and the SSD will last more than 10 years*
- Highly durable:
  - Operating shock 1500G vs. 300G
  - Operating vibration 16.3 gRMS 10-2000 Hz
Performance Comparison: Flash drives

- **Seq. Read**: 59 MB/s (HDD5400), 54 MB/s (HDD7200), 200 MB/s (SSD 7000 MLC)
- **Rnd. Read**: 4.5 MB/s (HDD5400), 6.3 MB/s (HDD7200), 200 MB/s (SSD 7000 MLC)
- **Seq. Write**: 59 MB/s (HDD5400), 60 MB/s (HDD7200), 140 MB/s (SSD 7000 MLC)
- **Rnd. Write**: 3.8 MB/s (HDD5400), 4.1 MB/s (HDD7200), 23 MB/s (SSD 7000 MLC)
Performance Matrix: Flash Drive

- Seq. Read 64KB: HDD5400 59, HDD7200 54, SSD 7000 MLC 0.4
- Rnd. Read 4KB: HDD5400 0.5, HDD7200 1.6, SSD 7000 MLC 0.3
- Seq. Write 64KB: HDD5400 60, HDD7200 59, SSD 7000 MLC 140
- Rnd. Write 4KB: HDD5400 140, HDD7200 0.3, SSD 7000 MLC 0.3
Power Consumption (Green)

Power consumption:
- Active (R/W operation) – 1.0W
- Idle – 0.4W

Power & heat:
- Power efficiency required to reduce electricity cost and expensive fans in a multi-disk system
NAND Flash in PCs

H-HDD System

Embedded System Cache

Removable System Cache

SSD, the HDD-less Solution
The Worldwide Marketing Manager for IBM Blade Center, said:

“IBM is the first major blade vendor to deliver enterprise-class solid state storage in blade servers, helping clients balance datacenter cost, complexity, reliability and manageability.

SSD’s uses up to 87 percent less power than a conventional hard disk drive and runs with no moving parts, eliminating a common point of disk failure and making the HS21 XM blade solution even more reliable.”
Ram Disk Applications

- Write intensive databases
- Databases that need the highest possible performance
- Must maintain low latency during peak operating periods
- Transaction heavy applications (OLTP, messaging, etc).
Response Times

- A high end hard disk array can easily supply 5,000 IOPS with a 5 ms response time.
- If 25 users are causing actions that result in 5,000 I/Os to complete, then at 5 ms response time each user will wait on the storage for 25 seconds.
- If that same workload is put on storage with a response time of 0.5 ms, then each user only waits 2.5 seconds!
How does HDD try to solve performance issues?

- Massive arrays of disks

- This only ensures that access time (latency) doesn’t rise above 5 - 8 ms and that parallel operations can be handled (so 1,000 people can all wait on the data).

- Can Solve: IO per second (IOPS) problems; bandwidth problems
The Latency Problem: I Have an I/O Bottleneck, Now What?

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<tr>
<th>Data Access Patterns</th>
<th>Add Processors</th>
<th>Add RAM</th>
<th>Add Spindles</th>
<th>Monolithic RAID</th>
<th>Solid State Disk</th>
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Storage Pyramid

- SSD
- DDR Solid State Disk
- Cached Flash
- Flash RAID
- Cached RAID
- RAID

Performance
Have you used a SSD today

- Conducted a financial trade
- Shopped online
- Used pre-paid wireless
- Played an online game
- Used an ATM
- Sent a TEXT message
- Placed an online bet
- Booked a cruise
Thank You