SSDs and their Impact on IT

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Storage Portfolio Definition
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The Business Eco-System
Disk to CPU Discontinuity
Today’s CPU have become I/O starved

- Moore’s Law is outstripping disk drive rotational speed
- As a result, storage systems are hopelessly unbalanced between controller capability and storage pool performance
New Performance Bottlenecks
Larger Capacity Disks Have Made it Worse

Probability of Arm Contention has increased 6.25X
Storage Evolution...
Time for a Change?

Edison Phonograph
1880

Enterprise Hard Drive
2001
Storage Revolution
2.5” Flash Drive

New!

Capacity
- 32GB User Addressable
- 40GB SLC Server NAND
- 16MB Buffer Cache

Form Factor
- 2.5” Enterprise SFF
- 7mm thickness
- 3Gb SATA-II

Performance
- Sequential IO:
  - 250MB/sec Read
  - 150MB/sec Write
- Random IOPS:
  - 35,000/sec Read
  - 3,300/sec Write
- 2.5W Maximum

Reliability
- 2,000,000 MTBF
Why Applications Don’t Perform Waiting for DATA

• Today’s Multi-Core, Multi-Socket application server design are increasingly held back by slow storage

• When requesting data, the server spends most of it’s time waiting for storage

• Application performance remain sluggish regardless of the Server CPU horsepower

• The traditional remedy of adding more expensive DRAM may no longer suffice as data sets double every 2 years
Turbo Charged Applications
SSDs Eliminate Storage Bottlenecks

- Today’s Multi-Core, Multi-Socket application server design are now served by High Performance SSDs
- The server no longer wastes time waiting for data
- Application performance is as high as the Server CPUs horsepower
- No longer need to remedy sluggish storage performance by adding expensive DRAM
- Bottom Line: Improved end user experience, faster results & Better ROI
Why SSDs are a BIG DEAL
HDDs no longer the choice for Performance

A single Solid State Drive equals the IOPS of
100 Hard Disk Drives

30,000 IOPS = 100 Drives
Why SSDs are a BIG DEAL
Better Power/Performance Economics

A single Solid State Drive consumes less than 1/500th the power of Hard Disk Drives*

0.03kWh

1/583th Power Consumption

1.75kWh

* Assuming same random IO performance

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Why HDDs are not going away
HDDs still holds the lead in Capacity

A single Disk Drive holds 33X the capacity of SSDs

1 TByte = 33 SSDs
Optimizing for Your Working Set

HDDs are typically under utilized

190 GB = 9,100 IOPS
192 GB = 300,000 IOPS
Gain Predictable Performance
Eliminate Cache Miss Ratios Forever!

Performance Predictability

Hit and Miss Gap

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New Server Memory Hierarchy

- Pico Sec.: L1 Cache, L2 Cache, L3 Cache
- Nano Sec.: RAM
- Micro Sec.: FLASH
- Milli Sec.: Disk
Latency Comparison
Bridging the DRAM to HDD Gap

- CPU
- DRAM
- FLASH/SSD
- HDD
- TAPE

100,000 X Latency Mismatch
150 X Latency Reduction
Data Continuum

Latency Differentiated Storage Pools

- **Real Time Data**
  - Close to CPU
  - Highly Latency Sensitive

- **On Line Data**
  - Networked
  - Moderate Latency Sensitivity

- **Off-Line Data**
  - Networked
  - Low latency Sensitivity
SSD to HDD Comparison

SSD for Performance, HDD for Capacity
The Hybrid Storage Pool
Combining Performance and Capacity
The Long Tail of Data
90-90 Rule in Action

- 9 Days = 2% cached
- 27 Days = 7% cached
- 63 Days = 17% cached
Hybrid Storage Pool Economics

Right-Size Performance & Capacity

100 Enterprise HDDs

Capacity: 30TB
Performance: 30K IOPS
Cap/Op-X: $55,000 - 1.75kWh

Hybrid Storage Pool

1 SSD
30 High Capacity HDDs

Capacity: 30TB
Performance: 30K IOPS
Cap/Op-X: $6,040 - 0.392kWh

1/5th the Power
1/10th the Cost

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Reducing DRAM Dependence

ZFS’s “Waterfall Caching”

- ZFS Automatically Caches Hot Data on SSD
- Easier to meet SLAs with Predictable Performance
- Increased Power efficiency:
  - Reduced need for DRAM and high RPM HDDs

1 X DRAM

10-20 X SSD

1000’s X HDD
ZFS Turbo Charges Applications

The Hybrid Storage Pool

- ZFS Dynamically:
  - Writes new data to a very fast SSD pool as write cache (ZIL)
  - Determines data access patterns and stores frequently accessed data in the SSD based read cache (L2ARC)
  - Bundles IO into sequential lazy writes for more efficient use of low cost mechanical disks
Even SANs are out of Steam
Example on how Moore’s Law races on…

1000 Servers Need 200M IOPS!

- High-end SAN storage systems support 1000+ server connections but cannot keep up with modern CPUs need for performance

- Modern Servers can process data 200+ times faster than SAN storage systems ability to deliver data
Where to Deploy SSDs?
Storage or Server?

- **320 IOPS**
  - Avg. Latency: 3,125 μs

- **319 IOPS**
  - Avg. Latency: 20 μs

**1 IOPS Lost**

**SAN**

**10μS**

**50,000 IOPS**

**16,667 IOPS Lost**

**33,333 IOPS**
Different FLASH Implementations

SSD
- Application
- O/S
- Mem
- I/O
- PCIe
- HBA
- SAS/SATA
- Cntr
- FLASH
- FLASH
- FLASH

Today

PCle
- Application
- O/S
- Mem
- I/O
- PCIe
- Cntr
- FLASH
- FLASH
- FLASH

Today

Memory
- Application
- O/S
- Mem
- Cntr
- FLASH
- FLASH
- FLASH

2012
Sun Server Attached SSD
Delivering the Highest Performance

- High performance 15K HDDs are replaced with 100X higher performance SSDs
- HDDs now only play a High Capacity role

Arrays and JBODs
Enterprise Class SSD (Intel)
Servers

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Modern server designs require very high IO and while mechanical HDDs are great for capacity, they are hopelessly falling behind in IO performance.
Turbo Charging Servers
Server Attached SSD for Performance

- Replacing HDDs with Server Attached SSDs restores the balance between the CPU’s need for data and the performance delivery capability of the storage subsystem.
ZFS Turbo Charges Applications

Distributed Hybrid Storage Pool

- Server integrated SSDs act as a high performance data cache to existing SAN or NAS storage making the application impervious to SAN/NAS storage latency.
Distributed Hybrid Storage Pool

ZFS Caches Hot Data on Server SSDs

- Frequently accessed data is automatically cached closest to the CPU for maximum performance.
- Less frequently accessed data can now be stored centrally for lowest cost storage capacity.

High Performance ZFS

iSCSI or FC

High Capacity
The Sun X6250 Blade
Same design as X4150

**Step One**
- Remove HDDs, and
- Insert SDDs

**Step Two**
- Move cable from SAS to SATA connector for best performance
- Repeat for all 4 drives slots
- Power now reduced by 40 watts!
Scale Performance

4 SSDs/Blade, 40 SSDs/chassis

- Repeat for all 10 blades
- Power now reduced by 400 watts!

Step Three

Step Four

- Fill a rack with 4 chassis
- Enjoy 8M IOPS per rack
- Enjoy 1,6 kWh reduction per rack
Open Flash
Sun SSD FLASH module

Capacity
- 24 GB User Addressable
- 32 GB SLC Server NAND (RAW)
- 64 MB DRAM Buffer Cache

Form Factor
- miniDIMM
- 3mm thickness
- 3Gb SATA-II

Performance
- Sequential IO:
  - 250MB/sec Read
  - 150MB/sec Write
- Random IOPS:
  - 20,000/sec Read
  - 7,000/sec Write
- 2W Maximum

Reliability
- 7 x 24 x 3 years (100% Write Duty)
- 2,000,000 hours MTBF
Sun Open Flash Modules enables tightly Server Integrated SSDs

Server options completely without mechanical HDDs are now a reality.
The Caching Server acts as a “caching gate-way” to existing SAN or NAS storage.

Frequently accessed data is retained in high performance SSD based storage pools.
Turbo Charging Networked Storage

High I/O Open Storage Caching Server

- Frequently used Data is Cashed on a High Performance Open Storage Caching Server
- Dormant Data is moved automatically by ZFS to centralized high capacity/low cost networked storage
FISHWorks

Appliance Instantiation of Open Storage

- Accessible via WEB-browser
- Easy to Configure & Diagnose

- Extremely granular Analytics via D-Trace and Fully Integrated Software and Hardware (FISH)
Thank You!

SSDs, HSPs and Unified Systems

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