Flash Memory SUMMIT

Software-Defined Storage: Freeing You from Being a Storage Mastermind

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Forward-Looking Statements

During our meeting today we will make forward-looking statements.

Any statement that refers to expectations, projections or other characterizations of future events or circumstances is a forward-looking statement, including those relating to market position, market growth, product sales, industry trends, supply chain, future memory technology, production capacity, production costs, technology transitions and future products. This presentation also contains forward-looking statements attributed to third parties, which reflect their projections as of the date of issuance.

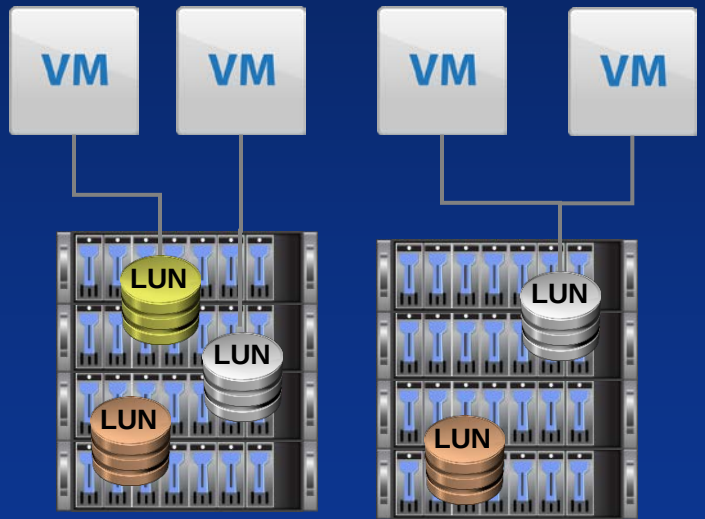
Actual results may differ materially from those expressed in these forward-looking statements due to a number of risks and uncertainties, including the factors detailed under the caption “Risk Factors” and elsewhere in the documents we file from time to time with the SEC, including our annual and quarterly reports.

We undertake no obligation to update these forward-looking statements, which speak only as of the date hereof or as of the date of issuance by a third party, as the case may be.

What is Software-Defined Storage (SDS)?

Software Defined Storage – technology that abstracts storage hardware from software to more flexibly manage storage infrastructure.

Business Benefits: Ability to quickly deploy new applications, address dynamic application and data workloads.

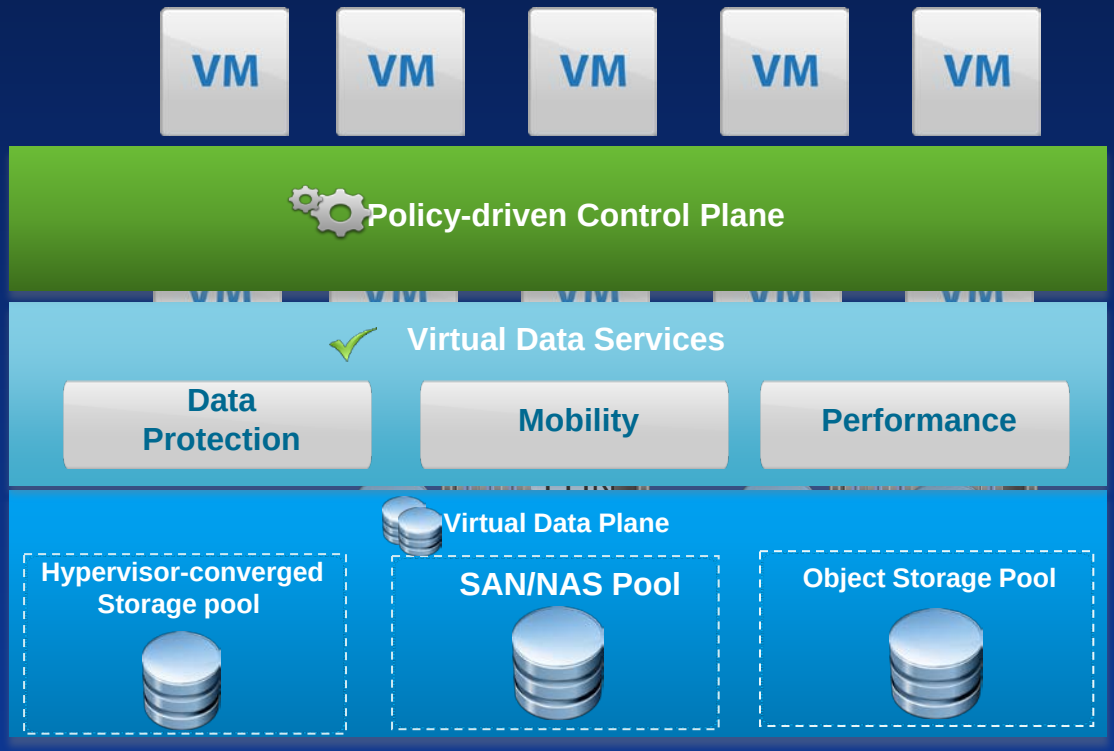


Issues Today

- Silos, discrete LUNs
- No Policies, e.g., application profiling
- Unmanageable virtual machine sprawl

Source: VMware

What is Software-Defined Storage (SDS)?



- Common policy-based automation and orchestration
- Third-party services integration
- Abstraction and pooling
- Infrastructure integration
- New storage tiers based on a pool of shared storage resources

Source: VMware

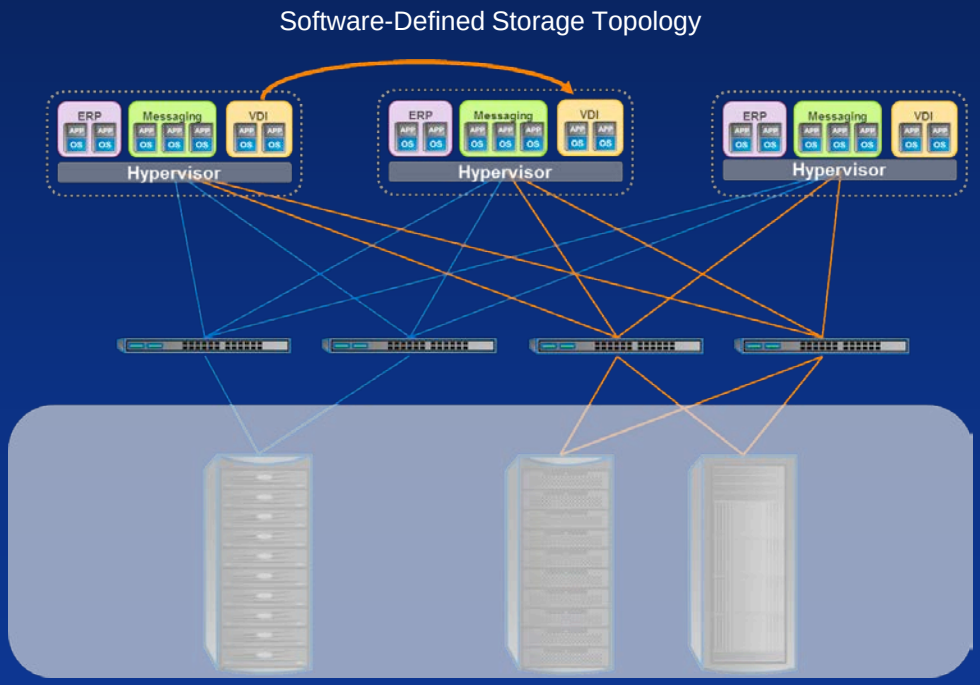
Nexus of Enablement

- Only just now enabled by advances in *industry standard* **multi-core** processors *(no longer expensive FPGAs, ASICs or proprietary CPUs)*
- Affordability of SSDs to be included pervasively in the architecture

Why use Software-Defined Storage (SDS)?

To help explain Software-Defined Storage, we should understand the strengths and limitations of the two predominant storage architectures from the past 20-30 years:

SAN – Storage Area Networks
NAS – Network Attached Storage



Graphic source: http://sniaesfblog.org/wp-content/uploads/2013/08/VirtualizationChanges.png

Why use Software-Defined Storage (SDS)?

STORAGE AREA NETWORK (SAN)

- High-Performance Proprietary Scale-Up architectures
  - Originally designed to assure high availability of data on failure-prone Hard Disk Drives
- Ideal for mission-critical enterprise applications
  - OLTP, ERP, CRM (e.g., SAP and Oracle)
- High Degree of Operational Complexity
  - Dedicated Storage Admins
  - Heavy configuration, e.g., RAID levels
  - Tier 1 scalable to a few hundred TB's per silo (backup and disaster recovery limits storage capacity)

NETWORK ATTACHED STORAGE (NAS)

- Proprietary Storage Tiers, Scale-Up & Scale-Out
- Ideal for file sharing, unstructured data repositories
- Semi-complex operations
  - Tier 1 scale-up to ~500TB per namespace (backup and disaster recovery limits storage capacity), up to 20PB per namespace on scale-out
  - Tiering, data stored for audits, regulatory compliance, and E-Discovery
  - Network traffic affects performance
  - RAID overhead or file striping with erasure coding to protect against mechanical HDD failure

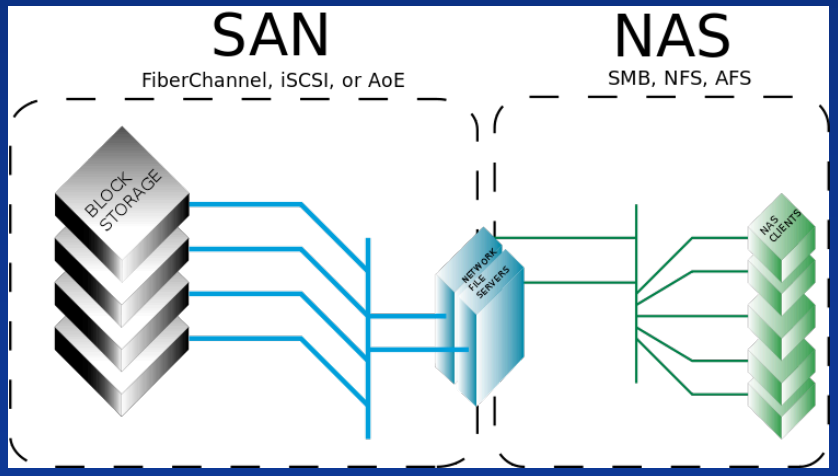
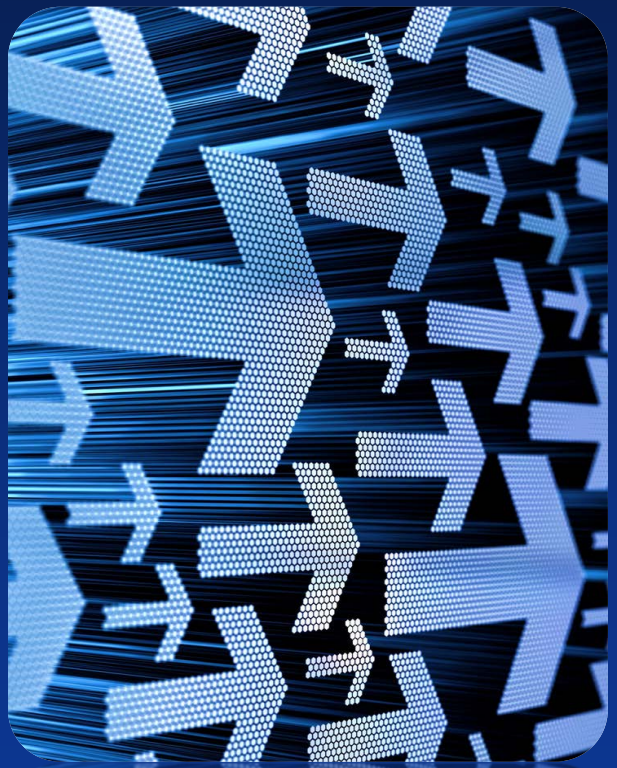


Image source:http://upload.wikimedia.org/wikipedia/commons/thumb/0/05/SANvsNAS.svg/750px-SANvsNAS.svg.png

Why use Software-Defined Storage?

Moving forward…

- Will SAN and NAS be the platforms to carry the demand for storage capacity?
- What are the main drivers that will cause a shift in storage design and architectures, and thus a direction away from SAN and NAS?



What are the Customer Pain Points to Address?

Avoid hardware vendor lock-in

- Reduce dependency of relatively high costs of proprietary SAN and NAS in favor of SDS running on commodity hardware
- Better utilization with incumbent SAN and NAS investments through federation and virtualization solutions which incorporate SDS
- Better alignment of the value of data to relative storage costs infrastructure (e.g. transactional data on mission-critical SAN, archival data on inexpensive object storage hardware)

What are the Customer Pain Points to Address?

Reduction in OPEX

- Increased storage capacity needed, but without adding additional storage admins
  - Multi-petabyte SAN and NAS would need numerous storage admins to manage the 300TB-600TB storage silos
- Existing Backup and Disaster Recovery processes become an inhibitor when attempting to protect ~500TB data sets

Why use Software-Defined Storage?

Desire to leverage Big Data Analytics

- Only 12%[1] of corporate data is used for analytics, according to Forrester; tremendous upside to leverage all data for business decision making
- Companies wish to act on their data analysis to make better decisions
- Big Data Analytics may grow to many petabytes, even exabytes, thus exceeding the capabilities of traditional SANs and NAS;
- Hadoop file system (HDFS) is a prime example of SDS on commodity hardware

1 - The Forrester WaveTM: Big Data Hadoop Solutions, Q1 2014 by Mike Gualtieri and Noel Yuhanna, February 27, 2014

What are Customer Pain Points?

"Mobile First" (BYOD) Corporate Initiatives

- Improve efficiency of workforce through the use of mobile corporate apps
- BYOD means outside the corporate firewall, with employees in the field or outside the office
- Traditional SAN and NAS solutions are cost prohibitive when data sets grow beyond a petabyte
- SAN and NAS chatty protocols don't work for Internet-based/mobile data traffic
  - SAN and NAS storage protocols need a constant network connection to work
  - Internet protocols connect "on demand"

Why use Software-Defined Storage?

Certainly, Big Data, Mobility, and Virtualization are possible on HDDs, so what value does flash storage provide?

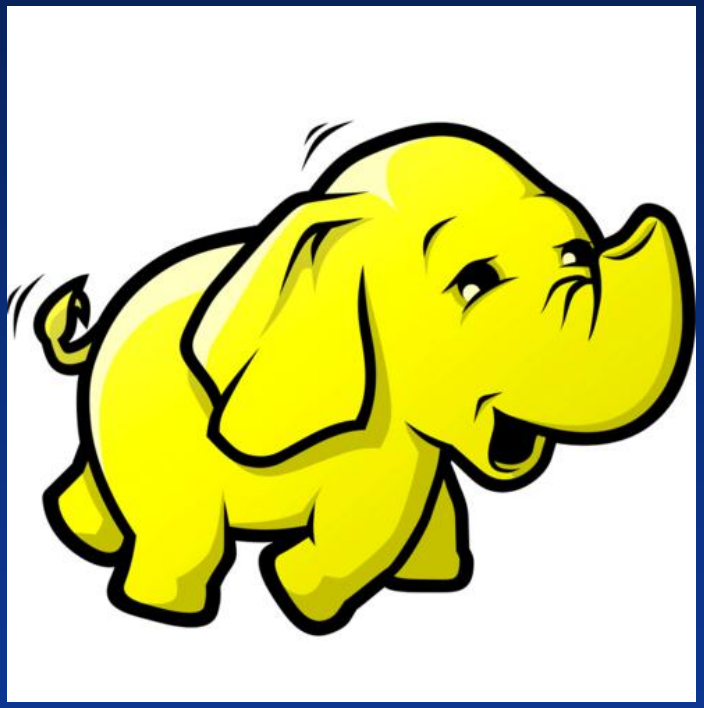
How SSDs Enable SDS

Flash SSD instead of HDD example

Hadoop Big Data Analytics Uses HDFS as SDS

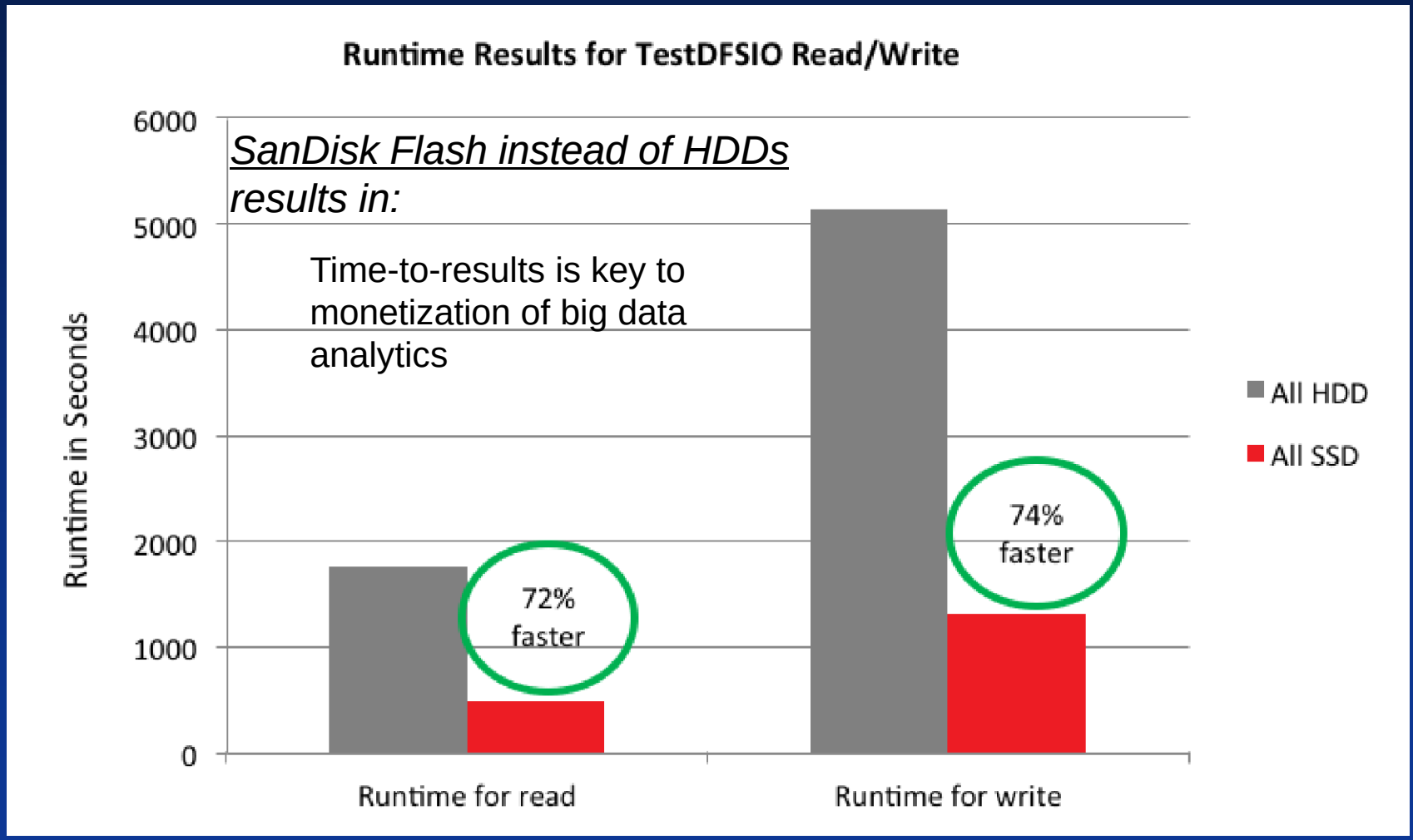
Hadoop Distributed File System (HDFS) is an open-source framework to store and process large data sets on commodity clusters

HDFS was originally architected for HDDs



Hadoop Big Data Analytics Uses HDFS as SDS

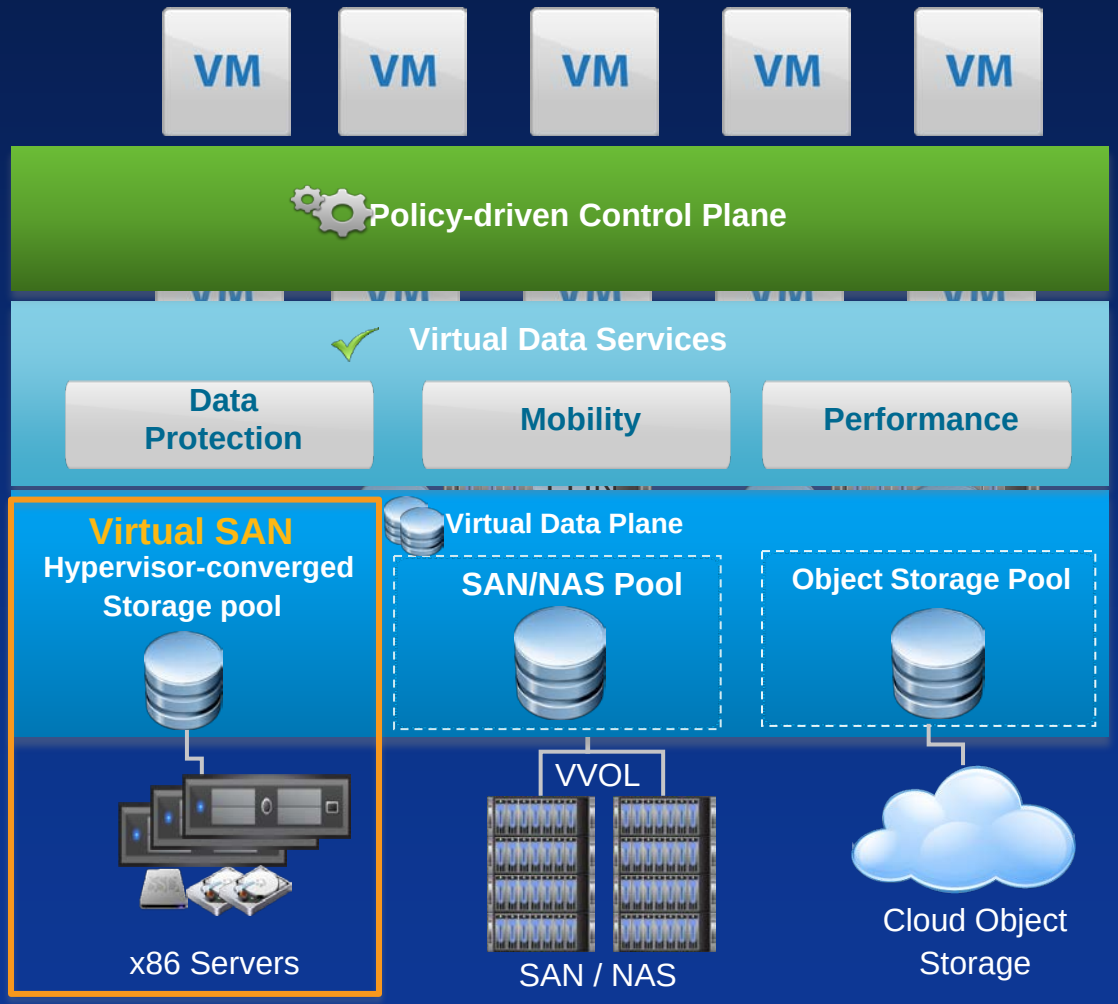
SanDisk Benchmark Results



How SSDs Enable SDS

A Flash-Cache Example

How SSDs enable SDS



VMware vSAN is a new software-defined storage tier for VMware vSphere. Virtual SAN creates a flash-optimized, highly resilient shared datastore designed for virtual environments.

Source: VMware

How SSDs Enable SDS

In VMware Virtual SAN, ALL read and write operations always go directly to a flash SSD tier

Flash-based devices serve two purposes in Virtual SAN

1. Non-volatile Write Buffer (30%)
   - Writes are acknowledged when they enter prepare stage on SSD
   - Reduces latency for writes
2. Read Cache (70%)
   - Cache hits reduces read latency
   - Cache miss – retrieve data from HDD

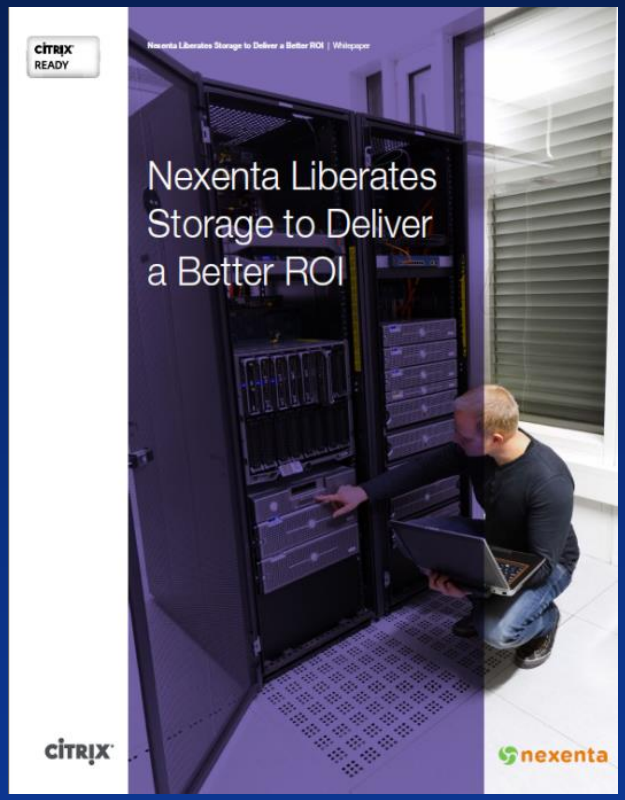
Thus, SSDs are central to the operation of VSAN

How SSDs Enable SDS

Metadata SSD-HDD Hybrid Example

Nexenta Hybrid SSD-HDD solution

- Virtual Desktop Infrastructure – Hybrid HDDs and SSDs
- SanDisk enables latency-sensitive metadata lookup I/O write operations
- IOPS-intensive SAN performance, but not on proprietary hardware; commodity hardware
  - Ability to meet end-user experience expectations for VDI at a price point that 1/8th the traditional SAN costs
    - $10-$15 per seat; norm is ~$100 per seat on SAN-based solutions
  - Leverages DIY industry standard gear, including SanDisk SSDs



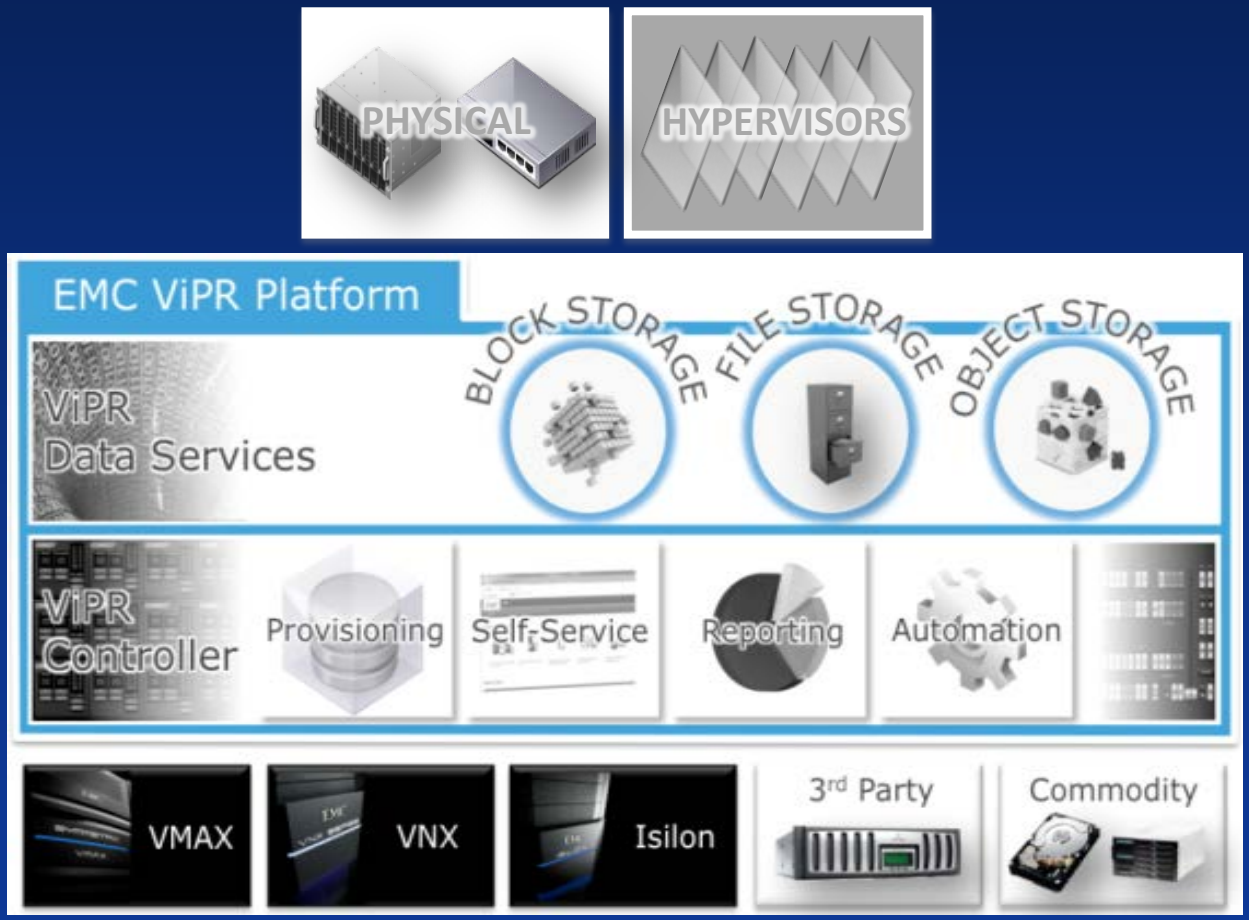
http://www.citrix.com/cms/ready/files/1713/9826/9812/CR_VDI_Whitepaper_Nexenta.pdf

How SSDs Enable SDS

A Federated Example with an Incumbent SAN Vendor

EMC ViPR Software-Defined Storage

Integrated with VMware, also supports other environments



Who are the major players in SDS?

ESTABLISHED VENDORS

BLOCK/SAN

- DataCore (SANsymphony-V)
- IBM (SAN Volume Controller)
- FalconStor (IPStor)
- Dell Fluid Cache

FILE-BASED FOR NAS

- Nexenta
- GlusterFS (RedHat)
- IBM GPFS
- Dell FluidFS NAS

MAJOR VENDOR HETEROGENEOUS SDS

- EMC ViPR, TwinStrata
- NetApp ONTAP
- HP StoreVirtual
- Hitachi Virtual Storage Platform

EMERGING VENDORS

HYPER-CONVERGED

- Nutanix
- Scale Computing
- SimpliVity
- Pivot3
- Atlantis

OBJECT-BASED

- Cleversafe (dsNET)
- Amplidata (AmpliStor)
- EMC (Atmos)
- Caringo (CAStor)
- Hitachi Content Platform
- OpenStack Swift

MAJOR VENDOR SDS

- VMware vSAN
- Microsoft (Storage Spaces)
- Red Hat (Storage Server)

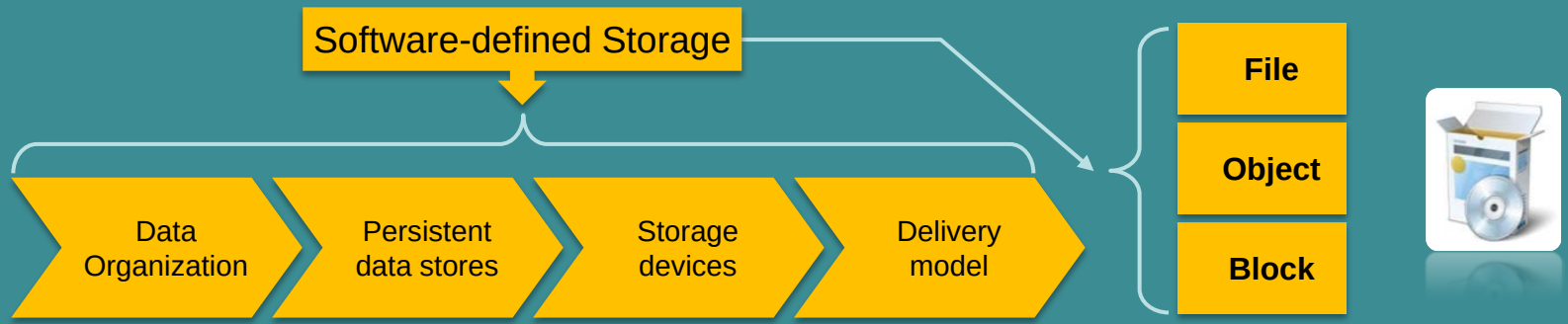
SSD Adoption

SanDisk

What is the Adoption Trend of SDS?

According to IDC:

By 2015, commercial software-defined storage revenue will cross $1.8 billion



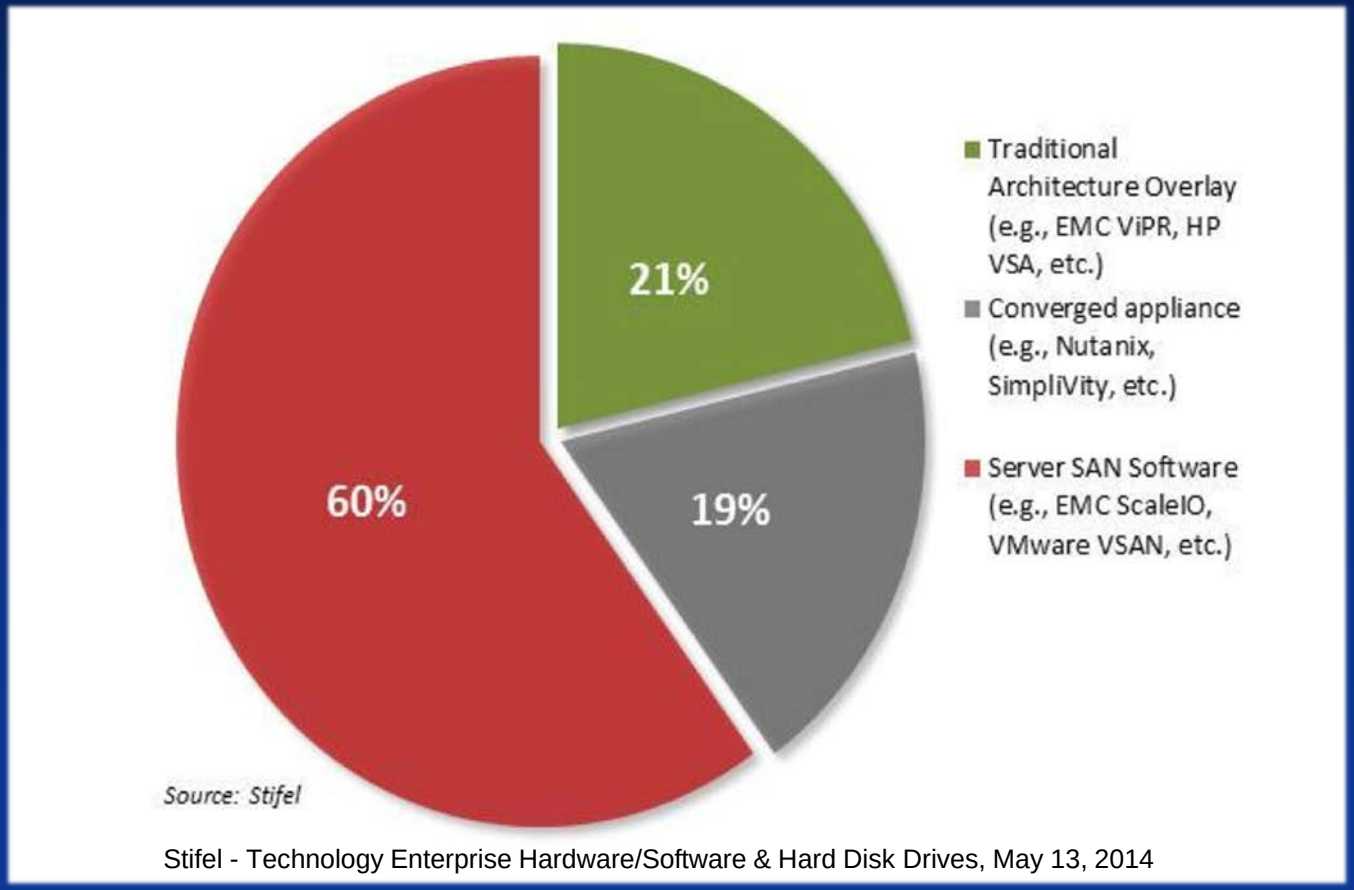
IDC notes:

- Hyper-converged will be the fastest growing segment, followed by scale-out file/object storage solutions
- Software-defined storage will drive server-based storage

Source: IDC Storage Predictions 2014

What is the Adoption Trend of SDS?

Stifel – Interview research: Of the potential software-defined storage delivery models, what do you view as the most attractive for your environment?



Stifel - Technology Enterprise Hardware/Software & Hard Disk Drives, May 13, 2014

In Conclusion

- Software-Defined Storage addresses shortcomings of SAN and NAS
  - SDS may be cost and performance-optimized for specific types of workloads (e.g. VDI)
  - Ease of petabyte-scale data management by one or few storage admins
- Many different approaches to SDS: vendor-specific hardware to open source
- SanDisk continues to work closely with both proprietary and open source SDS providers to give you the confidence that whichever route you choose, there is quality SSDs certified to run your business critical solutions

Thank You!

Keep up to date with me for the latest technology trends and news at

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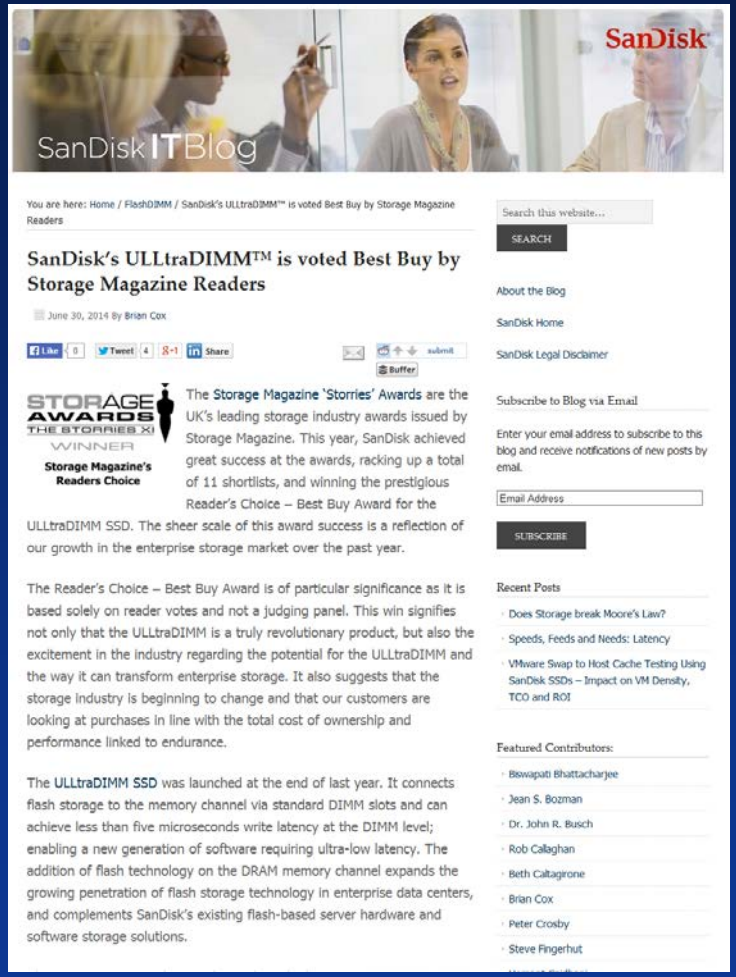

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