Virtual SAN Architecture Deep Dive

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• Pricing and packaging for any new technologies or features discussed or presented have not been determined.
Virtual SAN: Product goals

1. Targeted customer: **vSphere admin**
2. Compelling Total Cost of Ownership (TCO)
   - CAPEX: capacity, performance
   - OPEX: ease of management
3. The Software-Defined Storage for VMware
   - Strong integration with all VMware products and features
What is Virtual SAN?

• Software-based storage built in ESXi
• Aggregates local Flash and HDDs
• Shared datastore for VM consumption
• Converged compute + storage
• Distributed architecture, no single point of failure
• Deeply integrated with VMware stack
Virtual SAN Scale Out
Virtual SAN Scale Up
Single Virtual SAN datastore scalability

Cluster: 3 - 32 nodes; up to 5 SSDs, 35 HDDs per host

Capacity: 4.4 Petabytes

Performance: 2M IOPS – 100% reads

640K IOPS – 70% reads
Virtual SAN Is Highly Resilient Against Hardware Failures

- **Simple** to set resiliency goals via policy
- Enforced **per VM** and **per vmdk**
- **Zero data loss** in case of disk, network or host failures
- **High availability** even during network partitions
- Automatic, distributed **data reconstruction** after failures
- Interoperable with vSphere HA and Maintenance Mode
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Virtual SAN (VSAN) is NOT a Virtual Storage Appliance (VSA)

- Virtual SAN is fully integrated with vSphere (ESXi & vCenter)
- Drivers embedded in ESXi 5.5 contain the Virtual SAN smarts
- Kernel modules: most efficient I/O path
  - Minimal consumption of CPU and memory
  - Specialized I/O scheduling
  - Minimal network hops, just one storage and network stack
- Eliminate unnecessary management complexity (appliances)
Simple cluster configuration & management

One click away!!!

- Virtual SAN configured in **Automatic mode**, all empty local disks are claimed by Virtual SAN for the creation of the distributed vsanDatastore.
- Virtual SAN configured in **Manual mode**, the administrator must manually select disks to add the distributed vsanDatastore by creating Disk Groups.
Simplified Provisioning For Applications

**Legacy**

5. Consume from pre-allocated bin
4. Select appropriate bin
3. Expose pre-allocated bins
2. Pre-allocate static bins
1. Pre-define storage configurations

- Overprovisioning (better safe than sorry!)
- Wasted resources, wasted time
- Frequent Data Migrations

**VSAN**

1. Define storage policy
2. Apply policy at VM creation

Resource and data services are automatically provisioned and maintained

- No overprovisioning
- Less resources, less time
- Easy to change
# Virtual SAN Storage Policies

<table>
<thead>
<tr>
<th>Storage Policy</th>
<th>Use Case</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object space reservation</td>
<td>Capacity</td>
<td>Default 0 Max 100%</td>
</tr>
<tr>
<td>Number of failures to tolerate (RAID 1 – Mirror)</td>
<td>Availability</td>
<td>Default 1 Max 3</td>
</tr>
<tr>
<td>Number of disk stripes per object (RAID 0 – Stripe)</td>
<td>Performance</td>
<td>Default 1 Max 12</td>
</tr>
<tr>
<td>Flash read cache reservation</td>
<td>Performance</td>
<td>Default 0 Max 100%</td>
</tr>
<tr>
<td>Force provisioning</td>
<td></td>
<td>Disabled</td>
</tr>
</tbody>
</table>
How To Deploy A Virtual SAN Cluster

**Software + Hardware**

**Component Based**

Choose individual components …

*Any* Server on vSphere Hardware Compatibility List

SSD or PCIe

SAS/NL-SAS/ SATA HDDs

HBA/RAID Controller

…using the VMware Virtual SAN Compatibility Guide (VCG) *(1)*

**Virtual SAN Ready Node**

40 OEM validated server configurations ready for Virtual SAN deployment *(2)*

**VMware EVO:RAIL**

Hyper-Converged Infrastructure

A Hyper-Converged Infrastructure Appliance (HCIA) for the SDDC

Each EVO:RAIL HCIA is pre-built on a qualified and optimized 2U/4 Node server platform.

Sold via a single SKU by qualified EVO:RAIL partners *(3)*

**Maximum Flexibility**  
**Maximum Ease of Use**

Note: 1) Components must be chosen from Virtual SAN HCL, using any other components is unsupported – see Virtual SAN VMware Compatibility Guide Page

2) VMware continues to update/ add list of the available Ready Nodes, please refer to Virtual SAN VMware Compatibility Guide Page for latest list

3) EVO:RAIL availability in 2H 2014. Exact dates will vary depending on the specific EVO:RAIL partner
VSAN Hardware
**Virtual SAN Disk Groups**

- Virtual SAN organizes storage devices in **disk groups**
- A host may have up to **5 disk groups**
- A disk group is composed of **1 flash device and 1-7 magnetic disks**
- Compelling cost model:
  - **HDD** – **Cheap capacity**: persist data, redundancy for resiliency
  - **Flash** – **Cheap IOPS**: read caching and write buffering
Flash Devices

All writes and the vast majority of reads are served by flash storage

1. Write-back Buffer (30%)
   - Writes acknowledged as soon as they are persisted on flash (on all replicas)

2. Read Cache (70%)
   - Active data set always in flash, hot data replace cold data
   - Cache miss – read data from HDD and put in cache

A performance tier tuned for virtualized workloads

- High IOPS, low $/IOPS
- Low, predictable latency

Achieved with modest capacity: ~10% of HDD
Magnetic Disks (HDD)

Capacity tier: low $/GB, work best for sequential access
  Asynchronously retire data from Write Buffer in flash
  Occasionally read data to populate Read Cache in flash

Number and type of spindles still matter for performance when…
  Very large data set does not fit in flash Read Cache
  High sustained write workload needs to be destaged from flash to HDD

SAS/NL-SAS/SATA HDDs supported
  Different configurations per capacity vs. performance requirements
Storage Controllers

SAS/SATA Storage Controllers
  Pass-through or “RAID0” mode supported

Performance using RAID0 mode is controller dependent
  Check with your vendor for SSD performance behind a RAID-controller
  Management headaches for “volume” creation

Storage Controller Queue Depth matters
  Higher storage controller queue depth will increase performance

Validate number of drives supported for each controller
Virtual SAN Network

- **New** Virtual SAN traffic VMkernel interface.
  - Dedicated for Virtual SAN *intra-cluster* communication and data replication.
- Supports both Standard and Distributes vSwitches
  - Leverage NIOC for QoS in shared scenarios
- NIC teaming – used for availability and not for bandwidth aggregation.
- **Layer 2** Multicast must be enabled on physical switches.
  - Much easier to manage and implement than Layer 3 Multicast
Data storage
Object and Components Layout

```
/vmfs/volumes/vsanDatastore/foo/
```

foo.vmx, .log, etc

The VM Home directory object is formatted with VMFS to allow a VM’s configuration files to be stored on it. Mounted under the root dir vsanDatastore

availability policy reflected on number of replicas

Performance policy may include a stripe width per replica

Object “components” may reside in different disks and/or hosts

Virtual SAN Storage Objects
Advantages of objects

- A storage platform **designed for SPBM**
  - Per VM, per VMDK level of service
  - Application gets exactly what it needs

- Higher **availability**
  - Per object quorum

- Better **scalability**
  - Per VM locking, no issues as #VMs grows
  - No global namespace transactions
Deep breath...
Anatomy of a Write

VM running on host **H1**

H1 is **owner** of virtual disk object

Number Of Failures To Tolerate = 1

Object has 2 **replicas** on H1 and H2

1. Guest OS **issues** write op to virtual disk

2. Owner **clones** write op

3. **In parallel**: sends "**prepare**" op to H1 (locally) and H2

4. H1, H2 **persist** op to Flash (log)

5. H1, H2 **ACK** prepare op to owner

6. Owner waits for ACK from both ‘prepares’ and **completes** I/O

7. Later, owner **commits** batch of writes
Destaging Writes from Flash to HDD

- **Data from committed writes** accumulate on Flash (Write Buffer)
  - From different VMs / virtual disks

- **Elevator algorithm** flushes written data to HDD asynchronously
  - Physically **proximal** batches of data per HDD for improved performance
  - **Conservative**: overwrites are good; conserve HDD I/O
  - **HDD write buffers** are flushed, before discarding writes from SSD
1. **Guest OS issues** a read on virtual disk

2. **Owner chooses** replica to read from
   - **Load balance** across replicas
   - Not necessarily local replica (if one)
   - A block always read from same replica; data cached on at most 1 SSD; **maximize effectiveness**

3. At chosen replica (H2): read data from SSD **Read Cache**, if there

4. Otherwise, read from HDD and place data in SSD **Read Cache**
   - Replace ‘cold’ data

5. Return data to owner

6. Complete read and return data to VM
Virtual SAN Caching Algorithms

- VSAN exploits temporal and spatial locality for caching
- **Persistent cache** by the replica (Flash)
  - Not by the client! Why?
- Improved **flash utilization** in cluster
- **Avoid data migration** with VM migration
  - DRS: 10s of migrations per day
- **No latency penalty**
  - Network latencies: 5 – 50 usec (10GbE)
  - Flash latencies with real load: ~1 msec
- VSAN supports **in-memory local cache**
  - Memory: very low latency
  - View Accelerator (CBRC)
Fault tolerance
Magnetic Disk Failure: Instant mirror copy

- **Degraded** - All impacted components on the failed HDD instantaneously re-created on other disks, disk groups, or hosts.
Flash Device Failure: Instant mirror copy

- **Degraded** – Entire disk group failure. Higher reconstruction impact. All impacted components on the disk group instantaneously re-created on other disks, disk groups, or hosts.
Host Failure: 60 Minute Delay

- **Absent** – Host failed or disconnected. Highest reconstruction impact. Wait to ensure not transient failure. Default delay of 60 min. After that, start reconstructing objects and components onto other disk, disk groups, or hosts.
Virtual SAN 1 host isolated – HA restart

Isolated host: esxi-01

RAID-1: vmdk

VSAN network

vSphere HA restarts VM
Virtual SAN partition – With HA restart

Partition 1: esxi-01 esxi-02
Partition 2: esxi-03 esxi-04

vsan network

vSphere HA restarts VM in Partition 2, it owns > 50% of components!

raid-1

vmdk

witness

HA restart
3 Maintenance mode options:

- Ensure accessibility
- Full data migration
- No data migration
Virtual SAN Monitoring and Troubleshooting

• vSphere UI

• Command line tools

• Ruby vSphere Console

• VSAN Observer
Virtual SAN Key Benefits

Radically Simple
- Enabled/configured in two clicks
- Policy-based management
- Self-tuning and elastic
- Deep integration with VMware stack
- VM-centric tools for monitoring & troubleshooting

High Performance
- Flash acceleration
- Up to 2M IOPS from 32 nodes
- Low, predictable latencies
- Minimal CPU, RAM consumption
- Matches the VDI density of all flash array

Lower TCO
- Eliminates large upfront investments (CAPEX)
- Grow-as-you-go (OPEX)
- Flexible choice of industry standard hardware
- Does not require specialized skills
Thank You
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