

EMC Performance Optimization for VMware Enabled by EMC PowerPath/VE

Applied Technology

Abstract

This white paper is an overview of the tested features and performance enhancing technologies of EMC® PowerPath®/VE 5.4. The performance and reliability of EMC PowerPath/VE are compared to the performance of VMware Native Multipathing (NMP) technology including the MRU (most recently used), fixed, and round-robin methods.

September 2009

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The performance characteristics detailed in this document are intended to give indicative performance information on a single building block. If deploying at larger scale, then further validation should be carried out to ensure that the proposed environment performs as expected.

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Part number: H6533

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Executive summary

Business case Data center managers are looking to virtualization as a means to

- reduce costs,
- increase efficiency, and
- deliver the service levels they require.

In a virtualized data center, physical server consolidation results in

- reclaiming valuable data center space,
- realizing higher use rates,
- increasing operational efficiencies, and
- improving availability of resources and applications.

As virtualized data centers expand, the physical connections between the servers and SAN storage resources become more critical.

Product solution

EMC® PowerPath®/VE can provide improved performance and reliability compared to VMware Native Multipathing (NMP). PowerPath/VE provides

- superior load balancing,
- fast path failover, and
- improved device prioritization technology.

PowerPath/VE improves your virtualized data center by

- providing predictable performance over both FC and iSCSI,
 - providing higher reliability than VMware NMP, and
 - providing failover and failback capability.
-

Key results

EMC PowerPath/VE testing showed the following results:

- PowerPath/VE provides superior load-balancing performance across multiple paths using FC or iSCSI.
 - PowerPath/VE seamlessly integrates and takes control of all device I/O, path selection, and failover without the need for additional configuration.
 - VMware NMP requires that certain configuration parameters be specified to achieve improved performance.
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Introduction

Purpose

This Applied Technology white paper demonstrates the tested features and performance enhancing technologies of EMC PowerPath/VE 5.4.

The performance and reliability of EMC PowerPath/VE are compared to the performance of VMware Native Multipathing (NMP) technology including

- MRU (most recently used)
 - Fixed
 - Round Robin
-

Audience

This white paper is intended for EMC employees, partners, and customers including IT planners, virtualization architects and administrators, and any others involved in evaluating, acquiring, managing, operating, or designing an EMC private cloud environment.

Multipath performance analysis

Introduction

To ensure maximum resource availability a data center infrastructure must

- Provide multiple physical data paths between the server and the storage resources
 - Allow path rerouting around problems such as failed components
 - Balance the traffic loads across multiple physical paths
-

Multipathing

To maintain a constant connection between a virtualized server host and its storage, a technique called *multipathing* is used.

Multipathing maintains more than one physical path for data between the host and the storage device. If any element in the SAN fails such as an adapter, switch, or cable, the virtualized server host can switch to another physical path that does not use the failed component.

The process of path switching to avoid failed components is known as *path failover*.

Load balancing

In addition to path failover, multipathing provides *load balancing*. Load balancing is the process of distributing loads across multiple physical paths to reduce or remove potential traffic bottlenecks.

Key components

Introduction

For this performance analysis test PowerPath/VE was deployed on a virtualized data center that included

- 2 ESX servers
 - CLARiiON® CX4-480
 - vSphere 4
 - Load simulation software
-

PowerPath/VE

PowerPath/VE works with VMware ESX as a Multipath Plugin (MPP) that provides path management to ESX hosts. It is installed as a kernel module on the vSphere host. It will plug in to the vSphere I/O stack framework to bring the advanced multipathing capabilities of PowerPath/VE including dynamic load balancing and automatic failover to the vSphere hosts.

CLARiiON CX4-480 FLARE® 28.10

The EMC CLARiiON CX4-480

- delivers best-in-class performance for midrange networked storage that scales seamlessly up to 471 TB of capacity
 - supports up to 256 highly available, dual-connected hosts
 - scales from 5 to 240 disks, and
 - comes pre-configured with Fibre Channel (FC) and iSCSI connectivity, allowing customers to choose the best connectivity for their specific applications.
-

vSphere 4

VMware vSphere 4 is the next logical step in IT computing, allowing customers to bring the power of cloud computing to their IT infrastructures. Building on the power of VMware Infrastructure, VMware vSphere 4 increases control over IT environments by supporting any OS, application, or hardware product.

VMware vSphere 4 is built on a proven virtualization platform to provide the foundation for internal and external clouds, using federation and standards to bridge cloud infrastructures—creating a secure, private cloud. Organizations of all sizes can achieve the full benefits of cloud computing, delivering the highest levels of application service agreements with the lowest total cost per application workload.

This EMC virtual infrastructure for Microsoft applications-data center solution delivers flexible, automatic I/O load balancing, powerful processing power, and simplified network switch management with these features introduced in VMware vSphere 4:

- **EMC PowerPath/VE path failover integration (via VMware vStorage API for Multipathing)**—As demonstrated in this solution, constantly adjusts I/O path usage and responds to changes in I/O loads from VMs.
 - **8 vCPU support**—Increases the maximum number of virtual CPUs that can be assigned to a guest VM from four to eight.
 - **VMware vNetwork Distributed Switch**—Takes the vSwitch capability one step further by extending the connections across the entire cluster.
-

Simulation software

The following load simulation software was used:

- **Microsoft Exchange 2007 Jetstress** — Jetstress simulates Exchange disk input/output (I/O) load. Specifically, Jetstress simulates the Exchange database and log file loads produced by a specific number of users.
 - **Oracle Workload ORION** — ORION generates a synthetic I/O workload, using the same I/O software stack as Oracle, to simulate the Oracle database. ORION can generate a wide range of I/O workloads.
 - **Microsoft SQLIOSim** — SQLIOSim simulates the I/O patterns of Microsoft SQL servers such as SQL Server 2005, SQL Server 2000, and SQL Server 7.0.
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Environment profile

Hardware resources

The hardware used in the performance analysis environment is listed below.

Equipment	Quantity	Configuration
EMC CLARiiON CX4-480 FLARE v.28.10	1	10 x 50 GB LUNs RAID 5 (4 paths per LUN) 1 x 1 TB LUN RAID 5 (4 paths per LUN) for VMDKs 2 x 4 Gb/s ports out per SP (2 FC, 2 iSCSI)
Dell 6850	2	Xeon Core 2 32 GB RAM QLogic HBA, dual-port, 2 Gb/s
Fibre Channel switch	1	Cisco MDS 9509 (4 Gb/s per port) Cisco Catalyst 6513 (1Gbps IP)

Virtual allocation of hardware resources

The following figure shows the virtual machine organization and allocation.



Software resources

The software used in the performance analysis environment is listed below.

Software	Version
vSphere Enterprise Plus	4.0 (build 164009)
vCenter	4.0 GA (build B162856)
PowerPath/VE	5.4 (build 257)
Microsoft Exchange 2007 JetStress	08.02.0060
Oracle Workload ORION	10.2.0.10
Microsoft SQLIOSim	1.00.069

Test design and validation

Introduction

This section outlines the test plan and implementation for the multipath performance analysis using PowerPath/VE.

Performance tests will show that EMC PowerPath/VE provides superior load-balancing, path failover, and device prioritization technology for vSphere servers.

Test plan

- Create and deploy 10 virtual machines running Windows 2008
 - During PowerPath/VE operations, the 10 VMs are on Server A
 - During NMP operations, the 10 VMs are on Server B

 - Allocate the VMs as follows:
 - 4 x Windows 2000 SQL servers
 - 3 x Exchange 2007 servers
 - 3 x Oracle ORION servers

 - Implement a storage connection using Fibre Channel
 - Install Exchange, SQL, and Oracle simulation software
 - Test system performance using default VMware Native Multipathing (NMP)
 - Test system performance using PowerPath/VE
 - Change connectivity from Fibre Channel to iSCSI
 - Test system performance using default VMware Native Multipathing (NMP)
 - Test system performance using PowerPath/VE
-

Test parameters

The PowerPath/VE performance analysis test will examine the system response to the following operations:

- Load balancing
 - Single path
 - Multipath
 - Failover and failback
 - Front-end failover
 - Back-end failover
 - VMotion changeover
 - Change host
 - Change datastore
 - Change host and datastore
-

Performance analysis tests

Single-path load-balance test

The following table outlines the steps to perform a single-path load-balancing test to compare VMware NMP to PowerPath/VE performance.

Step	Action
1	Begin I/O simulation on a VM.
2	Record performance data of the ESX server (single path) using NMP <ol style="list-style-type: none">Run ESXTOPType "d" and then "P" to type the HBA name to view paths through the HBA. Note: All the I/O rates shown in ESXTOP indicate active I/O count, not the queued I/O count.
3	Record performance data of the ESX server (single path) Utilizing PowerPath/VE <ol style="list-style-type: none">Run ESXTOPType "d" and then "P" to type the HBA name to view paths through the HBA. Note: All the I/O rates shown in ESXTOP indicate active I/O count, not the queued I/O count.

Multipath load-balance test

The following table outlines the steps to perform a multipath load-balancing test to compare VMware NMP to PowerPath/VE performance.

Step	Action
1	Begin I/O simulation on a VM.
2	Record performance data of the ESX server (multipath) using NMP <ol style="list-style-type: none">Run ESXTOPType "d" and then "P" to type the HBA name to view paths through the HBA. Note: All the I/O rates shown in ESXTOP indicate active I/O count, not the queued I/O count.
3	Install PowerPath/VE and register the PowerPath/VE license on each vSphere server.
4	Record performance data of the ESX server (multipath) using PowerPath/VE <ol style="list-style-type: none">Run ESXTOPType "d" and then "P" to type the HBA name to view paths through the HBA. Note: All the I/O rates shown in ESXTOP indicate active I/O count, not the queued I/O count.

Front-end failover test

The following table outlines the steps to perform a front-end failover test to compare VMware NMP to PowerPath/VE performance.

Step	Action
1	Begin I/O simulation on a VM.
2	<p>Fibre Channel: Disable any of the HBA ports through the switch fabric</p> <ol style="list-style-type: none">Wait for the path failure on the disabled HBA (check the system log for the path failure message)I/Os should still flow through the other HBA's active paths <p>iSCSI: Disable any of the NIC ports through the Ethernet switch</p> <ol style="list-style-type: none">Wait for the path failure on the disabled NIC (check the system log for the path failure message)I/Os should still flow through the other NIC active paths
3	Install PowerPath/VE and register the PowerPath/VE license on each vSphere server.
4	<p>Enable the port through the switch</p> <ol style="list-style-type: none">Wait for the paths to be restored <p>Note: Automatic restoration of the paths can take up to 5 minutes. Within this time frame the paths should come back and I/O should start in those restored paths (check the system log).</p> <ol style="list-style-type: none">Alternatively, (when supported) the "powermt restore" command can be used to manually invoke the restore action. <p>Note: On CLARiiON systems there should not be any unnecessary trespass to the volume if the current LUN owner is alive and connected.</p>

Back-end failover test

The following table outlines the steps to perform a back-end failover test to compare VMware NMP to PowerPath/VE performance.

Step	Action
1	Begin I/O simulation on a VM.
2	Disable any of the array ports through the fabric switch (Fibre Channel) or Ethernet switch (iSCSI) <ol style="list-style-type: none">Wait for the path failure on the disabled target (check the system log for the path failure message)I/Os should still flow through the other active paths Note: On CLARiiON systems you may see trespass when the current LUN owner is disabled, and I/O will flow on the trespassed paths.
3	Install PowerPath/VE and register the PowerPath/VE license on each vSphere server.
4	Enable the array port through the switch <ol style="list-style-type: none">Wait for the paths to restored Note: Automatic restoration of the paths can take up to 5 minutes. Within this time frame the paths should be come back and I/O should start in those restored paths. <ol style="list-style-type: none">Alternatively, (when supported) the "powermt restore" command can be used to manually invoke the restore action. Note: On CLARiiON systems you should see failback of the LUN when a Current LUN owner connection is restored (check the system log).

VMotion change host test

The following table outlines the steps to perform a VMotion change host test to compare VMware NMP to PowerPath/VE performance.

Step	Action
1	Power ON the VMs and migrate using the "Change Host" option.
2	Begin I/O simulation on a VM, without enabling PowerPath/VE (this test case can be performed with or without I/O from the VM).
3	Select the destination ESX.
4	Select the resource pool.
5	Select the priority.
6	Finish the migration.

Result: The VM should be migrated successfully (with or without I/O). If I/O was present, the I/O should not fail.

VMware Native Multipathing performance results

Introduction

This section describes the performance results of the test conditions when executed using the VMware VMkernel multipathing plug-in and the default VMware Native Multipathing (NMP).

The NMP is an extensible module that manages subplug-ins. There are two types of NMP subplug-ins:

- Storage Array Type Plug-ins (SATPs), and
- Path Selection Plug-ins (PSPs).

SATPs and PSPs can be built in and provided by VMware, or can be provided by a third party.

Device configuration

The device configuration is shown in the following figure. Note that by default, VMware NMP will be the owner of all devices if there are no third-party Multipath Plug-ins (MPPs) such as EMC PowerPath/VE installed.

10.241.15.110 VMware ESX, 4.0.0, 164009

Getting Started Summary Virtual Machines Performance Configuration Tasks & Events Alarms Permissions Maps Storage Views

Hardware

- Processors
- Memory
- Storage
- Networking
- Storage Adapters
- Network Adapters
- Advanced Settings

Storage Adapters Refresh Rescan...

Device	Type	WWN
82801EB/ER (ICH5/ICH5R) IDE Controller		
vmhba5	Block SCSI	
vmhba32	Block SCSI	
LP10000 2Gb Fibre Channel Host Adapter		
vmhba1	Fibre Channel	20:00:00:00:c9:55:2a:f0 10:00:00:00:c9:55:2a:f0
vmhba4	Fibre Channel	20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		

Details

vmhba4

Model: LP10000 2Gb Fibre Channel Host Adapter

WWN: 20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3

Targets: 4 Devices: 11 Paths: 44

View: Devices Paths

Identifier	Runtime Name	LUN	Type	Transport	Capacity	Owner
<(naa.... naa.600601605710220050d...	vmhba1:C0:T0:L0	0	disk	Fibre Channel	1.05 TB	NMP
<(naa.... naa.60060160571022004e4...	vmhba1:C0:T0:L6	6	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.60060160571022004f4c...	vmhba1:C0:T0:L7	7	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200504...	vmhba1:C0:T0:L8	8	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200514...	vmhba1:C0:T0:L9	9	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200524...	vmhba1:C0:T0:L10	10	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200534...	vmhba1:C0:T0:L11	11	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200544...	vmhba1:C0:T0:L12	12	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200554...	vmhba1:C0:T0:L13	13	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.6006016057102200564...	vmhba1:C0:T0:L14	14	disk	Fibre Channel	50.00 GB	NMP
<(naa.... naa.60060160571022001c5...	vmhba1:C0:T0:L16	16	disk	Fibre Channel	50.00 GB	NMP

The following figure showed that each LUN has four paths. There are two active and two standby paths. However, because VMware NMP is the owner of all devices, only one active path is used for I/O.

The screenshot shows the VMware vSphere Configuration console for a host named 10.241.15.110 VMware ESX, 4.0.0, 164009. The 'Storage Adapters' section is expanded, showing a list of adapters. The 'LP10000 2Gb Fibre Channel Host Adapter' (vmhba4) is selected, and its details are shown below. The 'Paths' view is active, displaying a table of paths for each LUN.

Storage Adapters

Device	Type	WWN
82801EB/ER (ICH5/ICH5R) IDE Controller		
vmhba5	Block SCSI	
vmhba32	Block SCSI	
LP10000 2Gb Fibre Channel Host Adapter		
vmhba1	Fibre Channel	20:00:00:00:c9:55:2a:f0 10:00:00:00:c9:55:2a:f0
vmhba4	Fibre Channel	20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		

Details

vmhba4
 Model: LP10000 2Gb Fibre Channel Host Adapter
 WWN: 20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3
 Targets: 4 Devices: 11 Paths: 44

View: Devices | Paths

Runtime Name	Target	LUN	Status
vmhba4:CO:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active
vmhba4:CO:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Active (I/O)
vmhba4:CO:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	Stand by
vmhba4:CO:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	Stand by
vmhba4:CO:T2:L6	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	6	Active
vmhba4:CO:T3:L6	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	6	Active (I/O)
vmhba4:CO:T0:L6	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	6	Stand by
vmhba4:CO:T1:L6	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	6	Stand by
vmhba4:CO:T2:L7	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	7	Active
vmhba4:CO:T3:L7	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	7	Active (I/O)
vmhba4:CO:T0:L7	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	7	Stand by
vmhba4:CO:T1:L7	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	7	Stand by
vmhba4:CO:T2:L8	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	8	Active
vmhba4:CO:T3:L8	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	8	Active (I/O)
vmhba4:CO:T0:L8	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	8	Stand by
vmhba4:CO:T1:L8	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	8	Stand by
vmhba4:CO:T2:L9	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	9	Active
vmhba4:CO:T3:L9	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	9	Active (I/O)
vmhba4:CO:T0:L9	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	9	Stand by
vmhba4:CO:T1:L9	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	9	Stand by
vmhba4:CO:T2:L10	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	10	Active
vmhba4:CO:T3:L10	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	10	Active (I/O)
vmhba4:CO:T0:L10	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	10	Stand by

VMware NMP policy does round-robin across multiple active paths based on usage. There is only one active I/O path at a given time and it sends down a certain number of I/Os before switching to another active path. The default path switching is based on "number of IOs" and the default value for that is 1,000. That value can be changed with the following command:

```
esxcli nmp device setpolicy --device <device UID> --psp VMW_PSP_RR
esxcli nmp roundrobin setconfig --device <device UID> --iops 1 --type iops
```

The results after changing the IOPS value to 1 are shown in the following figure:

PORT-ID	USED-BY	TEAM-PNIC	SNAME	PKT/s	MB/s	PKT/s	MB/s	DRP%	ADDR%
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	15.77	0.03	10.68	0.01	0.00	0.00
16777219	4096/vmnic8	vmnic8	vSwitch0	14.24	0.02	7.63	0.00	0.00	0.00
16777220	4248/VM151_CK_LUN13	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777221	4257/VM152_CK_LUN14	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777222	4284/VM153_CK_LUN16	vmnic8	vSwitch0	1.02	0.00	1.02	0.00	0.00	0.00
16777223	4302/VM171	vmnic8	vSwitch0	0.51	0.00	0.51	0.00	0.00	0.00
16777224	4314/Windows2008R2-7	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777225	4333/Windows2008-VM1	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777226	4351/Windows7FC7137	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777238	6654/VM145_CK_LUN8	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777239	6673/VM146_CK_LUN9	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777240	6684/VM147_CK_LUN10	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777241	6701/VM149_CK_LUN12	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777242	6717/VM148_CK_LUN11	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777243	6741/VM160	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777244	6765/VM162	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777245	6780/VM164	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk0	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331652	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331654	vmk2	vmnic4	vSwitch2	10752.34	208.89	16187.03	40.25	0.00	0.00
67109865	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
67109866	vmnic5	-	vSwitch3	11037.54	191.78	21437.58	44.37	0.00	0.00
67109867	vmk1	vmnic5	vSwitch3	11040.59	191.05	15294.08	41.42	0.00	0.00

I/O traffic performance

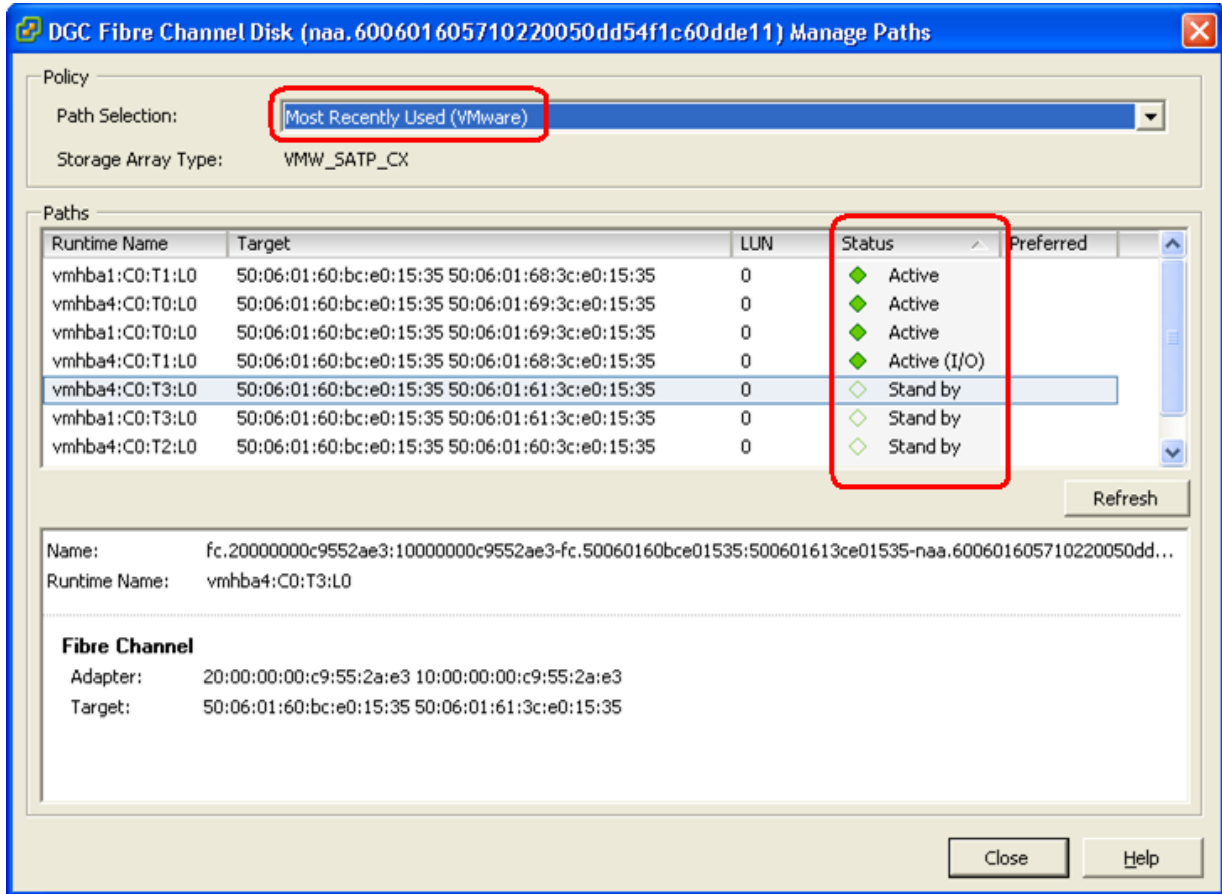
When there are four Windows 2008 VMs running SQLIOstress, three Windows 2008 VMs running JetStress 2007, and three Windows 2003 VMs running Oracle ORION, there are about 11,000 I/Os at one time. As illustrated from the ESXTOP utility, all these I/Os come through only one path, vmhba4, to access the CLARiON LUNs.

ADAPTR	CID	TID	LID	NCHNS	NTGTS	NLUNS	CHDS/s	READS/s	WRITES/s	MBREAD/s	MBWRIT/s	DAVG/cmd	KAVG/c
vmhba0	-	-	-	1	1	1	0.80	0.00	0.80	0.00	0.00	0.09	0.
vmhba1	-	-	-	1	4	44	0.00	0.00	0.00	0.00	0.00	0.00	0.
vmhba2	-	-	-	1	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.
vmhba3	-	-	-	1	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.
vmhba32	-	-	-	2	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.
vmhba4	-	-	-	1	4	44	11114.02	4460.18	6652.23	2.636	39.86	1.65	0.
vmhba5	-	-	-	2	1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.

Path selection profiles

VMware NMP supports three PSPs by default. The following three figures show the Path Selection as Most Recently Used (MRU), Round Robin (RR), and Fixed.

Most Recently Used



Round Robin

Policy

Path Selection: Round Robin (VMware)

Storage Array Type: VMW_SATP_CX

Paths

Runtime Name	Target	LUN	Status	Preferred
vmhba4:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Active (I/O)	
vmhba1:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Active (I/O)	
vmhba4:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active (I/O)	
vmhba1:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active (I/O)	
vmhba4:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	Stand by	
vmhba1:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	Stand by	
vmhba4:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	Stand by	

Refresh

Name: fc.20000000c9552ae3:10000000c9552ae3-fc.50060160bce01535:500601613ce01535-naa.600601605710220050dd...

Runtime Name: vmhba4:C0:T3:L0

Fibre Channel

Adapter: 20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3

Target: 50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35

Close Help

Fixed

Policy

Path Selection: Fixed (VMware)

Storage Array Type: VMW_SATP_CX

Paths

Runtime Name	Target	LUN	Status	Preferred
vmhba1:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	◆ Active	
vmhba4:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	◆ Active	
vmhba1:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	◆ Active	
vmhba4:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	◆ Active (I/O)	
vmhba4:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	◇ Stand by	
vmhba1:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	◇ Stand by	
vmhba4:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	◇ Stand by	

Refresh

Name: fc.20000000c9552ae3:10000000c9552ae3-fc.50060160bce01535:500601683ce01535-naa.600601605710220050dd...

Runtime Name: vmhba4:C0:T1:L0

Fibre Channel

Adapter: 20:00:00:00:c9:55:2a:e3 10:00:00:00:c9:55:2a:e3

Target: 50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35

Close Help

I/O results for path selection profiles

The following three figures show the I/O performance in the three different Path Selections.

Most Recently Used

```

root@6850A:~#
10:59:01am up 14 days 10 min, 183 worlds; CPU load average: 0.42, 0.45, 0.25
ADAPTR  CID  TID  LID  NCHNS  NTGTS  NLUNS  CMDs/s  READS/s  WRITES/s  MBREAD/s  MBWRTN/s  DAVG/cmd  KAVG/cmd  GAVG/cmd  QAVG/cmd
vmhba0  -   -   -    1    1    1    1.41    0.00    1.41    0.00    0.01    0.09    0.01    0.10    0.00
vmhba1  -   -   -    1    4   44   1612.01  1605.99  6.02    2.87    0.03    0.11    0.01    0.12    0.00
vmhba2  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba3  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba32 -   -   -    2    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba4  -   -   -    1    4   44   8228.10  5859.58  2368.53  18.92    9.82    0.27    0.00    0.27    0.00
vmhba5  -   -   -    2    1    1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
  
```

Round Robin

```

root@6850A:~#
1:53:05pm up 13 days 3:05, 190 worlds; CPU load average: 0.62, 0.53, 0.61
ADAPTR  CID  TID  LID  NCHNS  NTGTS  NLUNS  CMDs/s  READS/s  WRITES/s  MBREAD/s  MBWRTN/s  DAVG/cmd  KAVG/cmd  GAVG/cmd  QAVG/cmd
vmhba0  -   -   -    1    1    1   16.24    0.00   16.04    0.00    0.94    0.17    0.01    0.17    0.00
vmhba1  -   -   -    1    4   44   2091.43  813.80  1259.63  5.31    8.16    0.52    0.01    0.53    0.00
vmhba2  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba3  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba32 -   -   -    2    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba4  -   -   -    1    4   44   7321.28  5991.23  1310.89  19.85   11.21    1.56    0.01    1.57    0.00
vmhba5  -   -   -    2    1    1    0.20    0.00    0.00    0.00    0.00    3.24    0.01    3.25    0.00
  
```

Fixed

```

root@6850A:~#
10:55:09am up 14 days 7 min, 183 worlds; CPU load average: 0.44, 0.24, 0.17
ADAPTR  CID  TID  LID  NCHNS  NTGTS  NLUNS  CMDs/s  READS/s  WRITES/s  MBREAD/s  MBWRTN/s  DAVG/cmd  KAVG/cmd  GAVG/cmd  QAVG/cmd
vmhba0  -   -   -    1    1    1    1.61    0.00    1.61    0.00    0.01    0.10    0.01    0.11    0.00
vmhba1  -   -   -    1    4   44   2862.43  1492.95  1369.48  8.39    5.68    0.41    0.00    0.41    0.00
vmhba2  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba3  -   -   -    1    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba32 -   -   -    2    0    0    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
vmhba4  -   -   -    1    4   44   5522.48  4301.57  1220.90  14.15    5.05    0.28    0.00    0.28    0.00
vmhba5  -   -   -    2    1    1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
  
```

Fibre Channel performance results

Introduction

This section describes the performance test results when multipathing is handled by PowerPath/VE and connectivity is established using Fibre Channel.

PowerPath/VE works with VMware ESX as a Multipath Plug-in (MPP) that provides path management to ESX hosts. It is installed as a kernel module on the vSphere host. It will plug in to the vSphere I/O stack framework to bring the advanced multipathing capabilities of PowerPath/VE, including dynamic load balancing and automatic failover, to the vSphere hosts.

Device configuration

After PowerPath/VE is installed on a vSphere host, it claims all storage devices on which it is supported. The figure below shows that PowerPath/VE is the owner of devices on a CLARiiON CX4-480.

The screenshot shows the VMware ESX configuration interface for Storage Adapters. It lists two Fibre Channel host adapters: vmhba1 and vmhba4. Below, the details for vmhba4 are shown, including its model and WWN. A table lists storage devices connected to vmhba4, with the 'Owner' column consistently showing 'PowerPath'.

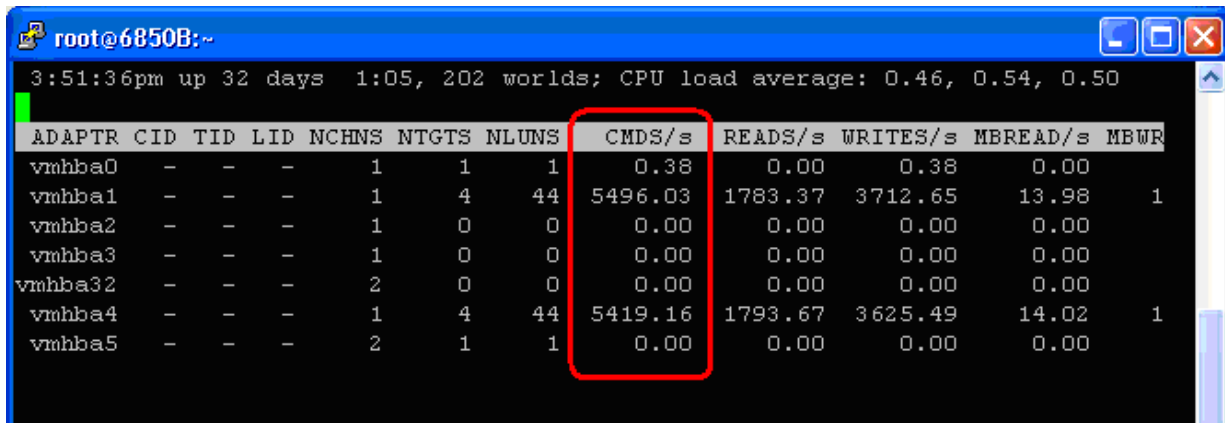
Device	Type	WWN
82801EB/ER (ICH5/ICH5R) IDE Controller		
vmhba5	Block SCSI	
vmhba32	Block SCSI	
LP10000 2Gb Fibre Channel Host Adapter		
vmhba1	Fibre Channel	20:00:00:00:c9:55:2d:0c 10:00:00:00:c9:55:2d:0c
vmhba4	Fibre Channel	20:00:00:00:c9:55:2a:a5 10:00:00:00:c9:55:2a:a5
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		

Identifier	Runtime Name	LUN	Type	Transport	Capacity	Owner
(naa.... naa.60060160571022004e4...	vmhba1:CO:T0:L0	0	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.60060160571022004f4c...	vmhba1:CO:T0:L1	1	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200504...	vmhba1:CO:T0:L2	2	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220054d...	vmhba1:CO:T0:L3	3	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220055d...	vmhba1:CO:T0:L4	4	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220056d...	vmhba1:CO:T0:L5	5	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220057d...	vmhba1:CO:T0:L6	6	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200514...	vmhba1:CO:T0:L7	7	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200524...	vmhba1:CO:T0:L8	8	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200534...	vmhba1:CO:T0:L9	9	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220058d...	vmhba1:CO:T0:L10	10	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200544...	vmhba1:CO:T0:L11	11	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200554...	vmhba1:CO:T0:L12	12	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.6006016057102200564...	vmhba1:CO:T0:L13	13	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.60060160571022001c5...	vmhba1:CO:T0:L15	15	disk	Fibre Channel	50.00 GB	PowerPath
(naa.... naa.600601605710220050d...	vmhba1:CO:T0:L20	20	disk	Fibre Channel	1.05 TB	PowerPath

PowerPath/VE dynamic load balancing

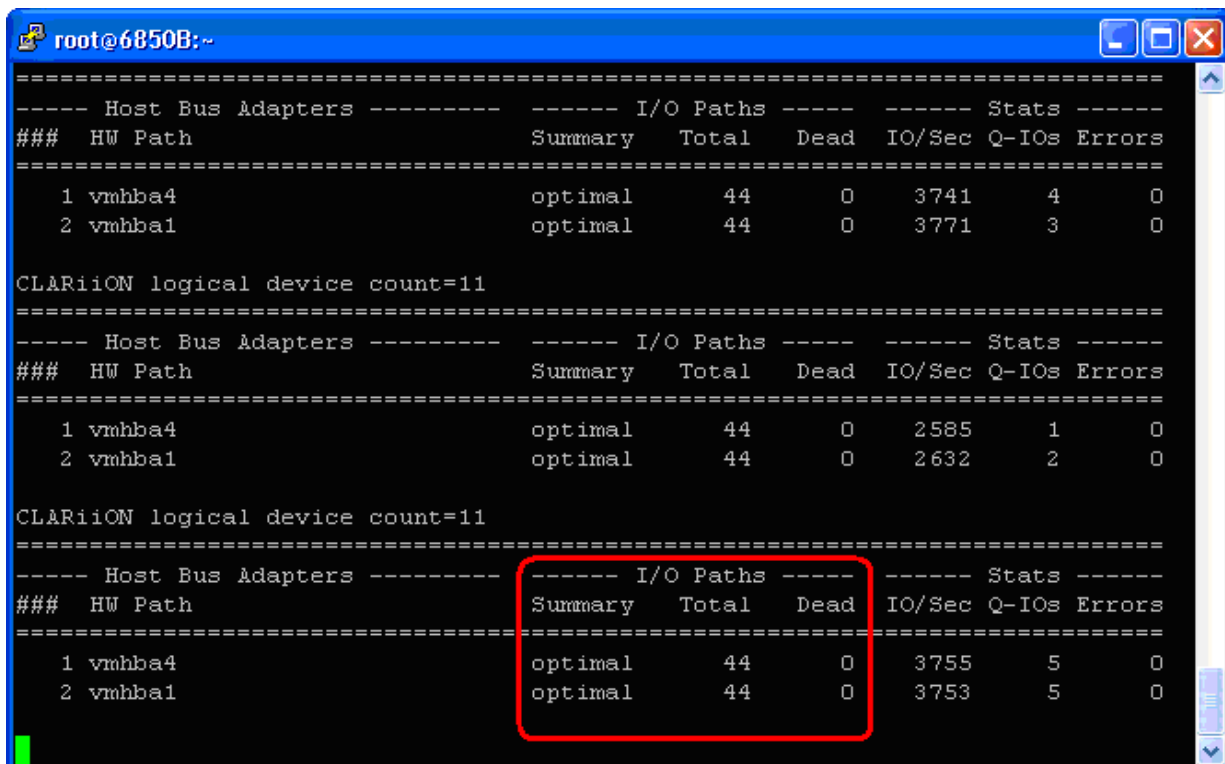
PowerPath/VE is designed to use all paths at all times. PowerPath/VE distributes I/O requests to logical devices across all available paths, rather than requiring a single path to bear the entire I/O requests.

The figure below shows ESXTOP output. I/O requests on both vmhba1 and vmhba4 are well balanced.



```
root@6850B:~
3:51:36pm up 32 days 1:05, 202 worlds; CPU load average: 0.46, 0.54, 0.50
ADAPTR CID TID LID NCHNS NTGTS NLUNS CMDS/s READS/s WRITES/s MBREAD/s MBWR
vmhba0 - - - 1 1 1 0.38 0.00 0.38 0.00
vmhba1 - - - 1 4 44 5496.03 1783.37 3712.65 13.98 1
vmhba2 - - - 1 0 0 0.00 0.00 0.00 0.00
vmhba3 - - - 1 0 0 0.00 0.00 0.00 0.00
vmhba32 - - - 2 0 0 0.00 0.00 0.00 0.00
vmhba4 - - - 1 4 44 5419.16 1793.67 3625.49 14.02 1
vmhba5 - - - 2 1 1 0.00 0.00 0.00 0.00
```

PowerPath/VE also provides a command line tool for path management. The figure below shows each device has two optimal paths to handle I/O requests. As noticed earlier, it also showed the I/O requests are balanced between two paths.



```
root@6850B:~
----- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
-----
1 vmhba4 optimal 44 0 3741 4 0
2 vmhba1 optimal 44 0 3771 3 0

CLARiON logical device count=11
----- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
-----
1 vmhba4 optimal 44 0 2585 1 0
2 vmhba1 optimal 44 0 2632 2 0

CLARiON logical device count=11
----- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
-----
1 vmhba4 optimal 44 0 3755 5 0
2 vmhba1 optimal 44 0 3753 5 0
```


The following two figures show the path status and LUN status.

Path Status

The screenshot shows the VMware ESX configuration interface for storage adapters. The left sidebar contains 'Hardware' and 'Software' sections. The main area is titled 'Storage Adapters' and includes a table of adapters and a 'Details' section for the selected 'vmhba1' adapter. Below the details is a 'View' section with 'Devices' and 'Paths' tabs. The 'Paths' tab is active, displaying a table of storage paths with columns for Runtime Name, Target, LUN, and Status.

Storage Adapters Table:

Device	Type	WWN
82801EB/ER (ICH5/ICH5R) IDE Controller		
vmhba5	Block SCSI	
vmhba32	Block SCSI	
LP10000 2Gb Fibre Channel Host Adapter		
vmhba1	Fibre Channel	20:00:00:00:c9:55:2d:0c 10:00:00:00:c9:55:2d:0c
vmhba4	Fibre Channel	20:00:00:00:c9:55:2a:a5 10:00:00:00:c9:55:2a:a5
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		

Details for vmhba1:

Model: LP10000 2Gb Fibre Channel Host Adapter
 WWN: 20:00:00:00:c9:55:2d:0c 10:00:00:00:c9:55:2d:0c
 Targets: 4 Devices: 11 Paths: 44

View: Paths

Runtime Name	Target	LUN	Status
vmhba1:CO:T0:L1	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	1	Active
vmhba1:CO:T3:L2	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	2	Active
vmhba1:CO:T2:L2	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	2	Active
vmhba1:CO:T1:L2	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	2	Active
vmhba1:CO:T0:L2	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	2	Active
vmhba1:CO:T3:L7	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	7	Active
vmhba1:CO:T2:L7	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	7	Active
vmhba1:CO:T1:L7	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	7	Active
vmhba1:CO:T0:L7	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	7	Active
vmhba1:CO:T3:L8	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	8	Active
vmhba1:CO:T2:L8	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	8	Active
vmhba1:CO:T1:L8	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	8	Active
vmhba1:CO:T0:L8	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	8	Active
vmhba1:CO:T3:L9	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	9	Active
vmhba1:CO:T2:L9	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	9	Active
vmhba1:CO:T1:L9	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	9	Active
vmhba1:CO:T0:L9	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	9	Active
vmhba1:CO:T2:L11	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	11	Active
vmhba1:CO:T3:L11	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	11	Active
vmhba1:CO:T0:L11	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	11	Active
vmhba1:CO:T1:L11	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	11	Active
vmhba1:CO:T2:L12	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	12	Active
vmhba1:CO:T3:L12	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	12	Active

LUN Status

The screenshot shows a window titled "DGC Fibre Channel Disk (naa.60060160571022004e4c1b38355cde11) Manage Paths". The window is divided into several sections:

- Policy:** Includes a "Path Selection" dropdown menu and a "Storage Array Type" field set to "---".
- Paths:** A table listing active paths with columns for Runtime Name, Target, LUN, and Status.
- Refresh:** A button to refresh the path information.
- Details:** Fields for Name and Runtime Name.
- Fibre Channel:** Details for the adapter and target.
- Buttons:** "Close" and "Help" buttons at the bottom right.

Runtime Name	Target	LUN	Status
vmhba4:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	Active
vmhba4:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Active
vmhba4:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	Active
vmhba4:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active
vmhba1:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35	0	Active
vmhba1:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active
vmhba1:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:60:3c:e0:15:35	0	Active

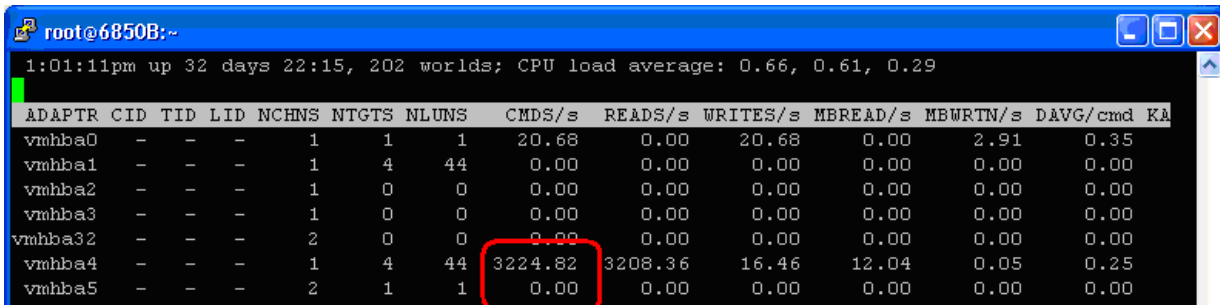
Name: fc.20000000c9552aa5:10000000c9552aa5-fc.50060160bce01535:500601613ce01535-naa.60060160571022004e4c1b38355cde11
Runtime Name: vmhba4:C0:T1:L0

Fibre Channel
Adapter: 20:00:00:00:c9:55:2a:a5 10:00:00:00:c9:55:2a:a5
Target: 50:06:01:60:bc:e0:15:35 50:06:01:61:3c:e0:15:35

Front-end failover results

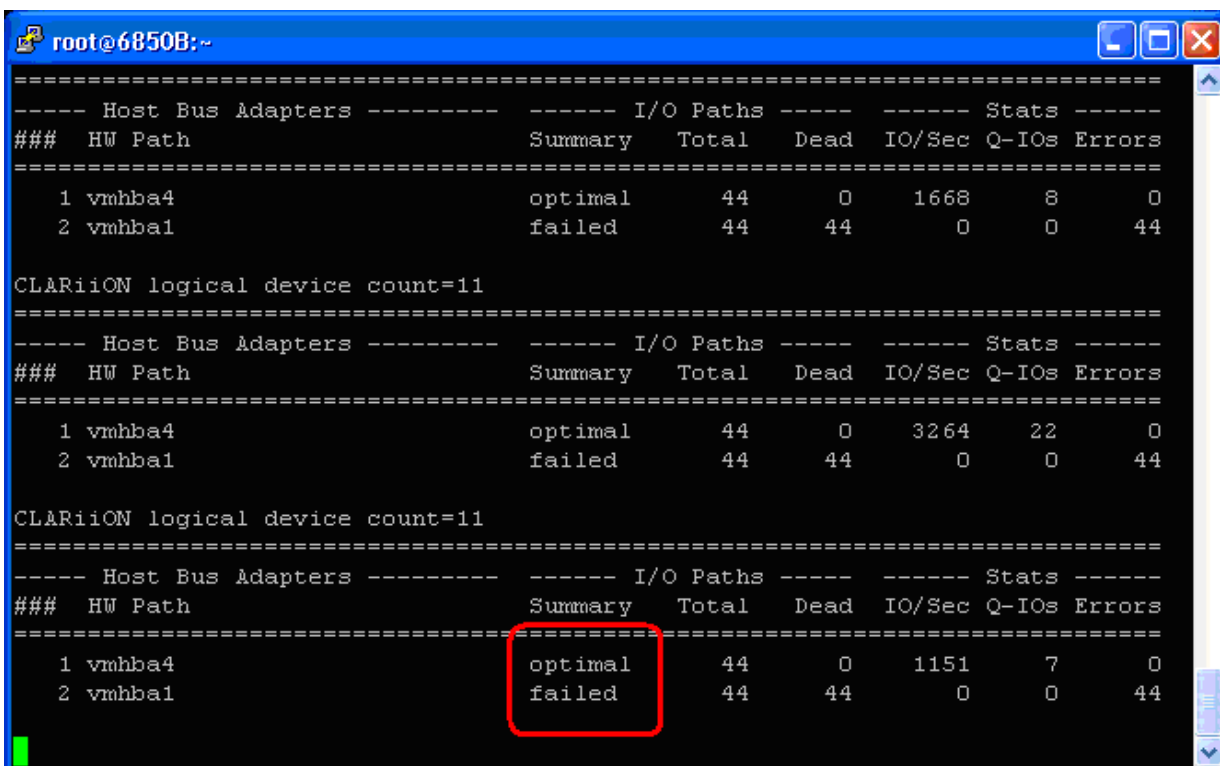
In this test, we simulate the path failure on the front end by disabling the HBA port on a Fibre Channel switch.

In the following figure, ESXTOP shows that only one path handles I/O requests.



```
root@6850B:~
1:01:11pm up 32 days 22:15, 202 worlds; CPU load average: 0.66, 0.61, 0.29
ADAPTR CID TID LID NCHNS NTGTS NLUNS  CMD/s  READS/s  WRITES/s  MBREAD/s  MBWRTN/s  DAVG/cmd  KA
vmhba0 - - - 1 1 1 20.68 0.00 20.68 0.00 2.91 0.35
vmhba1 - - - 1 4 44 0.00 0.00 0.00 0.00 0.00 0.00
vmhba2 - - - 1 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba3 - - - 1 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba32 - - - 2 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba4 - - - 1 4 44 3224.82 3208.36 16.46 12.04 0.05 0.25
vmhba5 - - - 2 1 1 0.00 0.00 0.00 0.00 0.00 0.00
```

In the following figure, the powermt utility shows only one path is optimal and the other path is failed.



```
root@6850B:~
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
1 vmhba4 optimal 44 0 1668 8 0
2 vmhba1 failed 44 44 0 0 44

CLARiiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
1 vmhba4 optimal 44 0 3264 22 0
2 vmhba1 failed 44 44 0 0 44

CLARiiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
1 vmhba4 optimal 44 0 1151 7 0
2 vmhba1 failed 44 44 0 0 44
```

In the following figure, vCenter also shows one path is dead.

The screenshot shows the vCenter interface for a storage adapter. The main table lists the adapter and its paths:

Device	Type	WWN
82801EB/ER (ICH5/ICH5R) IDE Controller		
vmhba5	Block SCSI	
vmhba32	Block SCSI	
LP10000 2Gb Fibre Channel Host Adapter		
vmhba1	Fibre Channel	20:00:00:00:c9:55:2d:0c 10:00:00:00:c9:55:2d:0c
vmhba4	Fibre Channel	20:00:00:00:c9:55:2a:a5 10:00:00:00:c9:55:2a:a5
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		

The details for **vmhba1** are shown below:

Model: LP10000 2Gb Fibre Channel Host Adapter
 WWN: 20:00:00:00:c9:55:2d:0c
 Targets: 4 Devices: 11 Paths: 44

The 'View' section shows a table of paths with their status:

Runtime Name	Target	LUN	Status
vmhba1:C0:T3:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Active
vmhba1:C0:T2:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Dead
vmhba1:C0:T1:L0	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	0	Active
vmhba1:C0:T0:L0	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	0	Dead
vmhba1:C0:T3:L1	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	1	Active
vmhba1:C0:T2:L1	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	1	Dead
vmhba1:C0:T1:L1	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	1	Active
vmhba1:C0:T0:L1	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	1	Dead
vmhba1:C0:T3:L2	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	2	Active
vmhba1:C0:T2:L2	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	2	Dead
vmhba1:C0:T1:L2	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	2	Active
vmhba1:C0:T0:L2	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	2	Dead
vmhba1:C0:T3:L7	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	7	Active
vmhba1:C0:T2:L7	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	7	Dead
vmhba1:C0:T1:L7	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	7	Active
vmhba1:C0:T0:L7	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	7	Dead
vmhba1:C0:T3:L8	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	8	Active
vmhba1:C0:T2:L8	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	8	Dead
vmhba1:C0:T1:L8	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	8	Active
vmhba1:C0:T0:L8	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	8	Dead
vmhba1:C0:T3:L9	50:06:01:60:bc:e0:15:35 50:06:01:68:3c:e0:15:35	9	Active
vmhba1:C0:T2:L9	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	9	Dead
vmhba1:C0:T1:L9	50:06:01:60:bc:e0:15:35 50:06:01:69:3c:e0:15:35	9	Active

After enabling the port on the Fibre Channel switch, the failed path will be automatically restored on a path test or bus rescan within a maximum 360 seconds. Issuing a manual “powermt restore” will restore the failed path immediately.

Back-end failover results

We simulate the back-end failure by disabling CLARiiON SP ports on the Fibre Channel switch. When one port on each SP is disabled, both paths went into degraded mode, as shown in the following figure.

```

root@6850B:~
=====
---- Host Bus Adapters ----- I/O Paths ---- Stats ----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
  1 vmhba4 degraded 44 22 3480 3 22
  2 vmhba1 degraded 44 22 3609 4 22

CLARiiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ---- Stats ----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
  1 vmhba4 degraded 44 22 3473 5 22
  2 vmhba1 degraded 44 22 3346 5 22

CLARiiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ---- Stats ----
### HW Path Summary Total Dead IO/Sec Q-IOs Errors
=====
  1 vmhba4 degraded 44 22 2640 5 22
  2 vmhba1 degraded 44 22 2751 6 22
  
```

The following figure shows that only one SP port has active I/O requests.

```

root@6850B:~
1:09:03pm up 32 days 22:23, 203 worlds; CPU load average: 0.81, 0.55, 0.55
ADAPTR CID TID LID NCHNS NTGTS NLUNS CMDS/s READS/s WRITES/s MBREAD/s MBWRTN/s DAVG/cmd KA
vmhba0 - - - 1 1 1 0.76 0.00 0.76 0.00 0.01 0.11
vmhba1 - - - 1 4 44 2872.28 2395.06 474.93 11.23 8.13 1.46
vmhba2 - - - 1 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba3 - - - 1 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba32 - - - 2 0 0 0.00 0.00 0.00 0.00 0.00 0.00
vmhba4 - - - 1 4 44 2857.59 2350.43 504.88 11.05 7.04 1.45
vmhba5 - - - 2 1 1 0.00 0.00 0.00 0.00 0.00 0.00
  
```

After the SP ports were enabled again, both paths are back to the optimal mode as shown in the following two figures.

```

root@6850B:~
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path                      Summary    Total    Dead  IO/Sec  Q-IOs  Errors
=====
  1 vmhba4                        optimal    44      0     2964    8      0
  2 vmhba1                        optimal    44      0     3115    6      0

CLARiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path                      Summary    Total    Dead  IO/Sec  Q-IOs  Errors
=====
  1 vmhba4                        optimal    44      0     3469    4      0
  2 vmhba1                        optimal    44      0     3479    4      0

CLARiON logical device count=11
=====
---- Host Bus Adapters ----- I/O Paths ----- Stats -----
### HW Path                      Summary    Total    Dead  IO/Sec  Q-IOs  Errors
=====
  1 vmhba4                        optimal    44      0     2955    3      0
  2 vmhba1                        optimal    44      0     2796    2      0

```

```

root@6850B:~
1:11:30pm up 32 days 22:25, 202 worlds; CPU load average: 0.75, 0.74, 0.63
=====
ADAPTR  CID  TID  LID  NCHNS  NTGTS  NLUNS  CMDS/s  READS/s  WRITES/s  MBREAD/s  MBWRTN/s  DAVG/cmd  KA
-----  -   -   -   -      -      -      -      -      -      -      -      -      -
vmhba0  -   -   -   1      1      1      1.61    0.00     1.61     0.00     0.00     0.02     0.10
vmhba1  -   -   -   1      4      44     4817.36 1838.88  2978.48  8.57     16.25    1.46
vmhba2  -   -   -   1      0      0      0.00    0.00     0.00     0.00     0.00     0.00     0.00
vmhba3  -   -   -   1      0      0      0.00    0.00     0.00     0.00     0.00     0.00     0.00
vmhba32 -   -   -   2      0      0      0.00    0.00     0.00     0.00     0.00     0.00     0.00
vmhba4  -   -   -   1      4      44     4704.53 1873.62  2830.91  8.78     14.88    1.48
vmhba5  -   -   -   2      1      1      0.00    0.00     0.00     0.00     0.00     0.00     0.00

```

iSCSI performance results

Introduction

This section describes the performance test results when multipathing is handled by PowerPath/VE and connectivity is established using iSCSI.

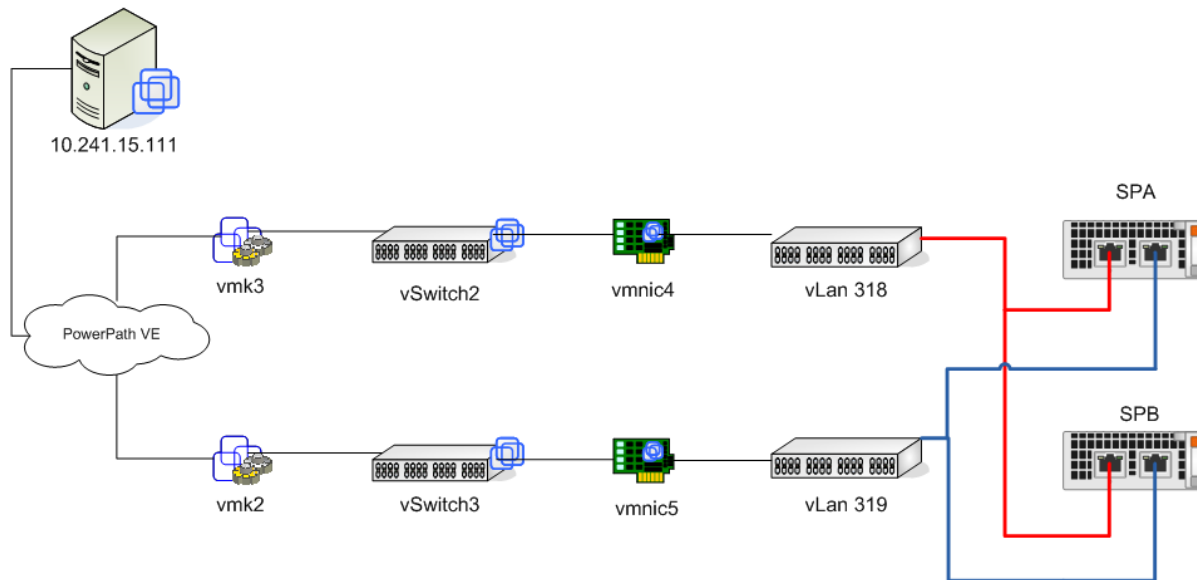
PowerPath/VE works with VMware ESX as a Multipath Plug-in (MPP) that provides path management to ESX hosts. It is installed as a kernel module on the vSphere host. It will plug in to the vSphere I/O stack framework to bring the advanced multipathing capabilities of PowerPath/VE, including dynamic load balancing and automatic failover, to the vSphere hosts.

Environment configuration

Performance tests conducted for iSCSI included 10 virtual machines. They are as follows

- 3 Oracle Simulators (using ORION software)
- 4 SQL Simulators (using SQL Iostress)
- 3 Exchange Simulators (using Jetstress)

The following illustration shows the test environment configuration.



Single-path load-balancing results

The following figure shows a screenshot of the PowerPath/VE host with only one path.

```

root@6850B:~
10:40:24am up 7 days 21:09, 211 worlds; CPU load average: 0.23, 0.15, 0.14

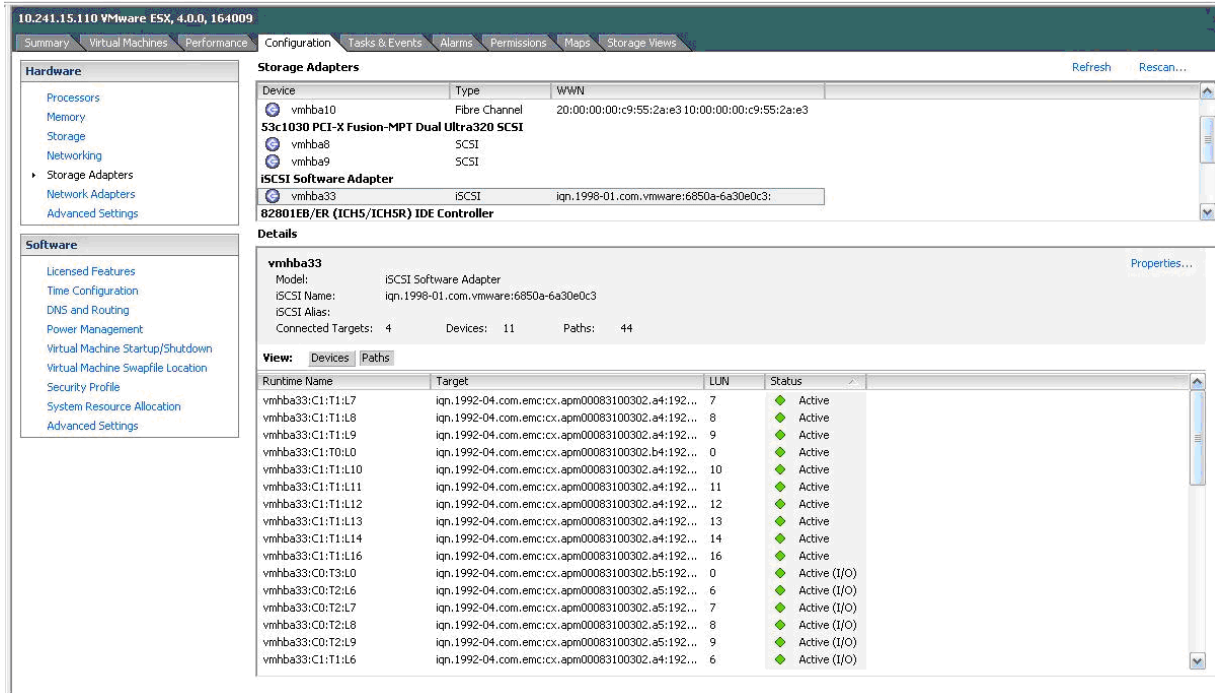
```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRFTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	148.30	0.81	111.58	0.06	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777220	4096:vswwf0	vmnic8	vSwitch0	148.30	0.81	9.54	0.00	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777236	6271:VM160	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777243	6450:VM101_CX_LUN6	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777244	6786:VM103_CX_LUN7	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	fallback	vSwitch2	0.95	0.00	0.00	0.00	0.00	0.00
50331655	vmnic4	-	vSwitch2	0.95	0.00	0.00	0.00	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	10100.84	596.90	31846.52	67.28	0.00	0.00
83886090	vmnic5	-	vSwitch3	10100.36	596.81	40291.79	71.50	0.00	0.00

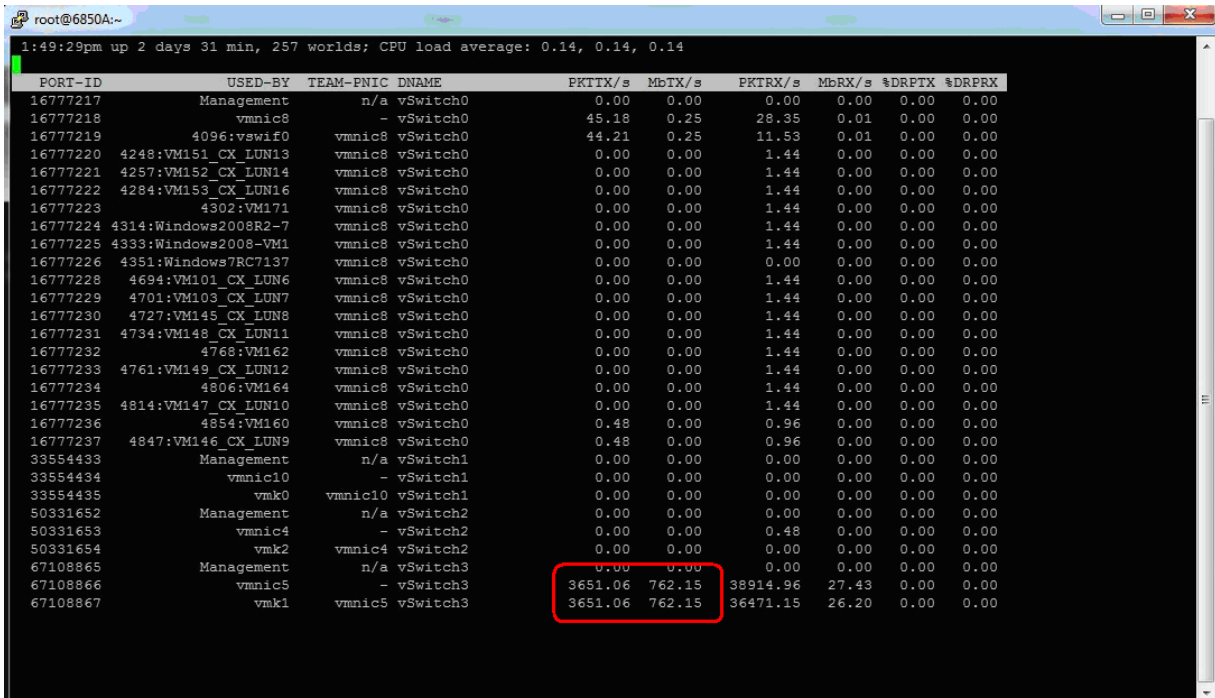
Multipath load-balancing results The following two figures show VMware NMP ownership and Path Status.

The screenshot shows the VMware ESX Storage Adapters configuration. The 'Storage Adapters' section lists several adapters, with 'vmhba33' selected. The 'Details' section for 'vmhba33' shows it is an iSCSI Software Adapter with 4 connected targets, 11 devices, and 44 paths. Below this, a table lists the storage paths with columns for Name, Runtime Name, LUN, Type, Transport, Capacity, and Owner.

Name	Runtime Name	LUN	Type	Transport	Capacity	Owner
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	10	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	11	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	12	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	13	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	14	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L...	16	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L0	0	disk	iSCSI	1.05 TB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L6	6	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L7	7	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L8	8	disk	iSCSI	50.00 GB	NMP
DGC Fibre Channel Disk (naa.6006...	vmhba33:CO:T2:L9	9	disk	iSCSI	50.00 GB	NMP



The following figure is an ESXTOP screen showing the performance data for NMP (notice no load balancing).



The following two figures show PowerPath/VE ownership and path status.

10.241.15.111 VMware ESX, 4.0.0, 164009

Configuration | Tasks & Events | Alarms | Permissions | Maps | Storage Views

Storage Adapters Refresh Rescan...

Device	Type	WWN
vmhba10	Fibre Channel	20:00:00:00:c9:55:2a:a5
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		
vmhba8	SCSI	
vmhba9	SCSI	
iSCSI Software Adapter		
vmhba33	iSCSI	iqn.1998-01.com.vmware:6850B-75881c69
82801EB/ER (ICH5/ICH5R) IDE Controller		

Details Properties...

vmhba33

Model: iSCSI Software Adapter
 iSCSI Name: iqn.1998-01.com.vmware:6850B-75881c69
 iSCSI Alias:
 Connected Targets: 4 Devices: 11 Paths: 44

View: Devices Paths

Name	Runtime Name	LUN	Type	Transport	Capacity	Owner
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L11	11	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L20	20	disk	iSCSI	1.05 TB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L12	12	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L13	13	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L15	15	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L0	0	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L1	1	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L2	2	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L7	7	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L8	8	disk	iSCSI	50.00 GB	PowerPath
DGC Fibre Channel Disk (naa.6006...	vmhba33:C0:T3:L9	9	disk	iSCSI	50.00 GB	PowerPath

10.241.15.111 VMware ESX, 4.0.0, 164009

Configuration | Tasks & Events | Alarms | Permissions | Maps | Storage Views

Storage Adapters Refresh Rescan...

Device	Type	WWN
vmhba10	Fibre Channel	20:00:00:00:c9:55:2a:a5
53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI		
vmhba8	SCSI	
vmhba9	SCSI	
iSCSI Software Adapter		
vmhba33	iSCSI	iqn.1998-01.com.vmware:6850B-75881c69
82801EB/ER (ICH5/ICH5R) IDE Controller		

Details Properties...

vmhba33

Model: iSCSI Software Adapter
 iSCSI Name: iqn.1998-01.com.vmware:6850B-75881c69
 iSCSI Alias:
 Connected Targets: 4 Devices: 11 Paths: 44

View: Devices Paths

Runtime Name	Target	LUN	Status
vmhba33:C0:T3:L11	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	11	Active
vmhba33:C3:T1:L20	iqn.1992-04.com.emc.cx.apm00083100302.b4:192...	20	Active
vmhba33:C0:T3:L12	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	12	Active
vmhba33:C0:T3:L13	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	13	Active
vmhba33:C0:T3:L15	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	15	Active
vmhba33:C2:T2:L20	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	20	Active
vmhba33:C0:T3:L0	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	0	Active
vmhba33:C0:T3:L1	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	1	Active
vmhba33:C0:T3:L2	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	2	Active
vmhba33:C0:T3:L7	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	7	Active
vmhba33:C0:T3:L8	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	8	Active
vmhba33:C0:T3:L9	iqn.1992-04.com.emc.cx.apm00083100302.b5:192...	9	Active
vmhba33:C2:T2:L0	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	0	Active
vmhba33:C2:T2:L1	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	1	Active
vmhba33:C2:T2:L2	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	2	Active
vmhba33:C2:T2:L7	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	7	Active
vmhba33:C2:T2:L8	iqn.1992-04.com.emc.cx.apm00083100302.a5:192...	8	Active

The following figure is an ESXTOP screen showing the I/O with PowerPath/VE enabled. Note that the load is evenly distributed across VMkernel NICs and physical NICs.

1:42:32pm up 7 days 11 min, 211 worlds; CPU load average: 0.17, 0.14, 0.15

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbIX/s	PKTRX/s	MbRX/s	‡DRPTX	‡DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	102.52	0.49	61.04	0.04	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777220	4096:vswwif0	vmnic8	vSwitch0	103.00	0.49	8.11	0.00	0.00	0.00
16777222	4313:VM160	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777223	4311:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777224	4375:VM103_CX_LUN7	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777226	4379:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777227	4415:VM162	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777228	4434:VM164	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777229	4393:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777230	4394:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777231	5583:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777232	5634:VM101_CX_LUN6	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	3477.10	381.21	18863.68	31.60	0.00	0.00
50331655	vmnic4	-	vSwitch2	3477.57	381.21	25033.00	34.60	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	3816.13	383.30	18533.23	28.27	0.00	0.00
83886090	vmnic5	-	vSwitch3	3815.65	383.22	24058.34	30.93	0.00	0.00

Front-end failover results The following figure shows the I/O before the simulated front-end path failure.

10:36:50am up 7 days 21:05, 212 worlds; CPU load average: 0.23, 0.15, 0.14

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbIX/s	PKTRX/s	MbRX/s	‡DRPTX	‡DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	178.68	0.98	141.76	0.10	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777220	4096:vswwif0	vmnic8	vSwitch0	177.69	0.98	18.70	0.03	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777236	6271:VM160	vmnic8	vSwitch0	0.49	0.00	0.49	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777243	6450:VM101_CX_LUN6	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777244	6786:VM103_CX_LUN7	vmnic8	vSwitch0	0.49	0.00	0.49	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	2431.56	402.63	19411.15	38.78	0.00	0.00
50331655	vmnic4	-	vSwitch2	2431.56	402.40	24214.71	41.08	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	3264.40	352.35	17208.96	40.35	0.00	0.00
83886090	vmnic5	-	vSwitch3	3264.40	352.35	22132.14	42.72	0.00	0.00

The following figure shows the I/O after the simulated front-end path failure. Data moved to a single VMkernel NIC within 5-10 seconds (2-second delay at least on ESXTOP, most likely instantly).

```

root@6850B:~
10:40:24am up 7 days 21:09, 211 worlds; CPU load average: 0.23, 0.15, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218		vmnic8	- vSwitch0	148.30	0.81	111.58	0.06	0.00	0.00
16777219		vmk0	vmnic8 vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777220	4096:vswwif0	vmnic8	vSwitch0	148.30	0.81	9.54	0.00	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777236	6271:VM160	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777243	6450:VM101_CX_LUN6	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
16777244	6786:VM103_CX_LUN7	vmnic8	vSwitch0	0.00	0.00	1.91	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434		vmnic10	- vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435		vmk1	vmnic10 vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653		vmk3	fallback vSwitch2	0.95	0.00	0.00	0.00	0.00	0.00
50331655		vmnic4	- vSwitch2	0.95	0.00	0.00	0.00	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089		vmk2	vmnic5 vSwitch3	10100.84	\$96.90	31846.52	67.28	0.00	0.00
83886090		vmnic5	- vSwitch3	10100.36	\$96.81	40291.79	71.50	0.00	0.00

Back-end failover results

The following figure shows the PowerPath/VE host before any back-end ports were shut down to simulate a back-end failure.

```

root@6850B:~
11:57:06am up 7 days 22:26, 199 worlds; CPU load average: 0.23, 0.15, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	86.63	0.36	54.64	0.05	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777220	4096:vsrif0	vmnic8	vSwitch0	86.63	0.36	20.67	0.03	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
16777245	6915:VM160	vmnic8	vSwitch0	0.00	0.00	0.98	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	2464.54	324.07	15899.66	35.37	0.00	0.00
50331655	vmnic4	-	vSwitch2	2464.54	324.07	19956.53	37.33	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	2191.85	300.61	14685.85	31.83	0.00	0.00
83886090	vmnic5	-	vSwitch3	2191.85	300.61	18549.77	33.69	0.00	0.00

The following figure shows that after failing one port on SPB (vLAN 318) the I/O is mostly load balanced, though not as ideal as with an even number of paths.

```

root@6850B:~
12:02:11pm up 7 days 22:31, 199 worlds; CPU load average: 0.23, 0.15, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	74.86	0.36	46.25	0.03	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777220	4096:vsrif0	vmnic8	vSwitch0	74.86	0.36	7.15	0.00	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
16777245	6915:VM160	vmnic8	vSwitch0	0.00	0.00	0.48	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	5453.59	228.87	13467.79	22.48	0.00	0.00
50331655	vmnic4	-	vSwitch2	5454.54	228.90	17534.73	24.48	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	6611.82	238.31	15406.13	106.17	0.00	0.00
83886090	vmnic5	-	vSwitch3	6611.35	237.83	25450.23	111.21	0.00	0.00

The following figure shows the I/O after SPB vlan 318 port has been re-enabled (10-20 seconds). It load balanced perfectly.

```

root@68508:~
12:05:27pm up 7 days 22:34, 199 worlds; CPU load average: 0.23, 0.15, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	61.51	0.35	41.01	0.04	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777220	4096:vswwf0	vmnic8	vSwitch0	61.51	0.35	11.44	0.02	0.00	0.00
16777235	6259:VM164	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777237	6317:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777238	6310:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777239	6351:VM162	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777240	6347:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777241	6393:VM146_CX_LUN9	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777242	6400:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
16777245	6915:VM160	vmnic8	vSwitch0	0.00	0.00	0.95	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	2160.55	82.21	5122.66	25.97	0.00	0.00
50331655	vmnic4	-	vSwitch2	2163.41	82.33	7122.04	26.96	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	2239.23	81.83	5157.95	25.95	0.00	0.00
83886090	vmnic5	-	vSwitch3	2239.70	81.83	7172.58	26.95	0.00	0.00

VMotion change host results

The following figure shows Host 2 (NMP enabled) before the VMs migrated from the PowerPath/VE ESX host.

```

root@6850A:~
1:43:59pm up 2 days 25 min, 183 worlds; CPU load average: 0.14, 0.14, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbIX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	10.74	0.02	8.79	0.00	0.00	0.00
16777219	4096:vswwf0	vmnic8	vSwitch0	10.74	0.02	8.30	0.00	0.00	0.00
16777220	4248:VM151_CX_LUN13	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777221	4257:VM152_CX_LUN14	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777222	4284:VM153_CX_LUN16	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777223	4302:VM171	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777224	4314:Windows2008R2-7	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777225	4333:Windows2008-VM1	vmnic8	vSwitch0	0.00	0.00	1.46	0.00	0.00	0.00
16777226	4351:Windows7RC7137	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk0	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331652	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmnic4	-	vSwitch2	0.00	0.00	0.49	0.00	0.00	0.00
50331654	vmk2	vmnic4	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
67108865	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
67108866	vmnic5	-	vSwitch3	6.35	0.03	6.35	0.00	0.00	0.00
67108867	vmk1	vmnic5	vSwitch3	6.35	0.03	5.86	0.00	0.00	0.00

The following figure shows Host 2 after the VMs are migrated.

```

root@6850A:~
1:49:29pm up 2 days 31 min, 257 worlds; CPU load average: 0.14, 0.14, 0.14

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	45.18	0.25	28.35	0.01	0.00	0.00
16777219	4096:vswif0	vmnic8	vSwitch0	44.21	0.25	11.53	0.01	0.00	0.00
16777220	4248:VM151_CX_LUN13	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777221	4257:VM152_CX_LUN14	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777222	4284:VM153_CX_LUN16	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777223	4302:VM171	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777224	4314:Windows2008R2-7	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777225	4333:Windows2008-VM1	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777226	4351:Windows7RC7137	vmnic8	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777228	4694:VM101_CX_LUN6	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777229	4701:VM103_CX_LUN7	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777230	4727:VM145_CX_LUN8	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777231	4734:VM148_CX_LUN11	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777232	4768:VM162	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777233	4761:VM149_CX_LUN12	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777234	4806:VM164	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777235	4814:VM147_CX_LUN10	vmnic8	vSwitch0	0.00	0.00	1.44	0.00	0.00	0.00
16777236	4854:VM160	vmnic8	vSwitch0	0.48	0.00	0.96	0.00	0.00	0.00
16777237	4847:VM146_CX_LUN9	vmnic8	vSwitch0	0.48	0.00	0.96	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk0	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331652	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmnic4	-	vSwitch2	0.00	0.00	0.48	0.00	0.00	0.00
50331654	vmk2	vmnic4	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
67108865	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
67108866	vmnic5	-	vSwitch3	3651.06	762.15	38914.96	27.43	0.00	0.00
67108867	vmk1	vmnic5	vSwitch3	3651.06	762.15	36471.15	26.20	0.00	0.00

The following figure shows Host 1 (PowerPath/VE enabled) after all the VMs have been migrated off.

```

root@6850B:~
1:50:19pm up 7 days 19 min, 139 worlds; CPU load average: 0.01, 0.36, 0.47

```

PORT-ID	USED-BY	TEAM-PNIC	DNAME	PKTIX/s	MbTX/s	PKTRX/s	MbRX/s	%DRPTX	%DRPRX
16777217	Management	n/a	vSwitch0	0.00	0.00	0.00	0.00	0.00	0.00
16777218	vmnic8	-	vSwitch0	13.29	0.02	11.81	0.01	0.00	0.00
16777219	vmk0	vmnic8	vSwitch0	0.00	0.00	1.48	0.00	0.00	0.00
16777220	4096:vswif0	vmnic8	vSwitch0	13.29	0.02	7.88	0.00	0.00	0.00
33554433	Management	n/a	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554434	vmnic10	-	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
33554435	vmk1	vmnic10	vSwitch1	0.00	0.00	0.00	0.00	0.00	0.00
50331649	Management	n/a	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331653	vmk3	vmnic4	vSwitch2	0.00	0.00	0.00	0.00	0.00	0.00
50331655	vmnic4	-	vSwitch2	0.00	0.00	0.49	0.00	0.00	0.00
67108865	Management	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108866	120	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108867	121	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108868	122	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108869	123	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108870	124	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108871	125	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
67108872	126	-	DvsPortset-0	0.00	0.00	0.00	0.00	0.00	0.00
83886087	Management	n/a	vSwitch3	0.00	0.00	0.00	0.00	0.00	0.00
83886089	vmk2	vmnic5	vSwitch3	0.49	0.00	0.00	0.00	0.00	0.00
83886090	vmnic5	-	vSwitch3	0.49	0.00	0.49	0.00	0.00	0.00

Conclusion

Summary

Performance tests show that EMC PowerPath/VE provides improved performance and reliability over VMware Native Multipathing (NMP).

For vSphere servers, using PowerPath/VE provides

- superior load balancing,
 - fast path failover, and
 - improved device prioritization technology.
-

Findings

The following results were determined using the stated test plan and methodology:

- PowerPath/VE provides superior load-balancing performance across multiple paths using FC or iSCSI.
 - PowerPath/VE seamlessly integrates and takes control of all device I/O, path selection, and failover without the need for additional configuration.
 - VMware NMP requires that certain configuration parameters be specified to achieve improved performance.
-

Benefits

PowerPath/VE improves your virtualized data center by

- Providing predictable performance over both FC and iSCSI
 - Providing higher reliability than VMware NMP
 - Providing failover and failback capability
-

Next steps

EMC can help accelerate assessment, design, implementation, and management while lowering the implementation risks and cost of creating a virtualized data center.

To learn more about this and other solutions contact an EMC representative or visit www.emc.com.
