SPC Benchmark 2/Energy™
Executive Summary

Oracle Corporation
Oracle ZFS Storage ZS3-2 Appliance
(2-node cluster)

SPC-2/E™ V1.5

Submitted for Review: June 25, 2014
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EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Oracle Corporation – http://www.oracle.com Steven Johnson – Steven.A.Johnson@oracle.com 500 Eldorado Blvd. Broomfield, CO 80021 Phone: (303) 272-9476
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Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-2 Specification revision number	V1.5
SPC-2 Workload Generator revision number	V1.2
Date Results were first used publicly	June 25, 2014
Date FDR was submitted to the SPC	June 25, 2014
Date the TSC will be available for shipment to customers	May 9, 2014
Date the TSC completed audit certification	April 25, 2014

Tested Storage Product (TSP) Description

Oracle's ZFS Storage ZS3-2 is a high-performance storage system that offers enterprise-class SAN and NAS capabilities with industry-leading Oracle Database integration, in a cost-effective high-availability configuration. The ZFS Storage ZS3-2 offers simplified set up and management combined with industry-leading storage analytics and a performance-optimized platform that uses specialized Read and Write Flash-bases SSD caching devices. The ZFS Storage ZS3-2 can scale to 512 GB Memory, 32 CPU cores, and 768 TB capacity, with up to 12.8 TB of Flash Cache in a high-availability configuration. ZFS Storage Appliances deliver additional economic value bundled data services such as file- and block-level protocols including connectivity over InfiniBand, Compression, Deduplication, Thin provisioning, DTrace Analytics, Virus Scan, Snapshots, Triple Mirror, Triple Parity RAID, Phone-home, NDMP, Clustering, etc."

SPC-2 Reported Data

SPC-2 Reported Data consists of three groups of information:

- The following SPC-2 Primary Metrics, which characterize the overall benchmark result:
  - SPC-2 MBPS™
  - SPC-2 Price Performance
  - Application Storage Unit (ASU) Capacity

- Supplemental data to the SPC-2 Primary Metrics.
  - Total Price
  - Data Protection Level

- Reported Data for each SPC Test: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand Delivery (VOD) Test.

SPC-2 MBPS™ represents the aggregate data rate, in megabytes per second, of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand (VOD).

SPC-2 Price-Performance™ is the ratio of **Total Price** to **SPC-2 MBPS™**.

ASU *(Application Storage Unit)* **Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-2 benchmark.

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page on page 10.

Data Protection Level of **Protected 2** using *Mirroring*, which configures two or more identical copies of user data.

> **Protected 2:** *The single point of failure of any **component** in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.*

Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-2 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency).*

The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

SPC-2 Reported Data *(continued)*

SPC-2 Reported Data				
Oracle ZFS Storage ZS3-2 Appliance *(2-node cluster)*				
SPC-2 MBPS™	**SPC-2 Price-Performance**	**ASU Capacity (GB)**	**Total Price**	**Data Protection Level**
16,212.66	$12.08	24,186.836	$195,915.62	Protected 2 *(Mirroring)*
The above SPC-2 MBPS™ value represents the aggregate data rate of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video On Demand (VOD)				
Currency Used:		**"Target Country":**		
U.S. dollars		USA		
SPC-2 Large File Processing (LFP) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
LFP Composite	10,810.07			$18.12
Write Only:				
1024 KiB Transfer	7,996.97	512	15.62	
256 KiB Transfer	2,144.48	1,024	2.09	
Read-Write:				
1024 KiB Transfer	12,007.56	2,048	5.86	
256 KiB Transfer	3,574.41	1,024	3.49	
Read Only:				
1024 KiB Transfer	19,686.43	256	76.90	
256 KiB Transfer	19,450.59	1,024	18.99	
The above SPC-2 Data Rate value for LFP Composite represents the aggregate performance of all three LFP Test Phases: (Write Only, Read-Write, and Read Only).				
SPC-2 Large Database Query (LDQ) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
LDQ Composite	18,953.80			$10.34
1024 KiB Transfer Size				
4 I/Os Outstanding	19,867.07	256	77.61	
1 I/O Outstanding	19,847.23	256	77.53	
64 KiB Transfer Size				
4 I/Os Outstanding	18,171.34	512	35.49	
1 I/O Outstanding	17,929.58	1,024	17.51	
The above SPC-2 Data Rate value for LDQ Composite represents the aggregate performance of the two LDQ Test Phases: (1024 KiB and 64 KiB Transfer Sizes).				
SPC-2 Video On Demand (VOD) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
	18,874.09	24,000	0.79	$10.38

SPC-2/E Reported Data

The initial temperature, recorded during the first one minute of the SPC-2/E Idle Test was 73.20F. The final temperature, recorded during the last one minute of the SPC-2/E Large Database Query (LDQ) Test was 73.20F.

Power Environment
Average RMS Voltage: 208.64   Average Power Factor: 0.940

	Usage Profile			Nominal			
	Hours of Use per Day			Power	Traffic	Ratio	Heat
	Heavy	Moderate	Idle	watts	MBPS	MBPS/w	BTU/hr
Low Daily Usage:	0	8	16	2850.91	5122.12	1.80	9,727.58
Medium Daily Usage:	4	14	6	3063.23	11797.08	3.85	10,452.04
High Daily Usage:	18	6	0	3209.69	16591.74	5.17	10,951.77
	Composite Metrics:			3,041.27	11,170.32	3.67	

Annual Energy Use, kWh: 26,641.57
Energy Cost, $/kWh: $ 0.12   Annual Energy Cost, $: $ 3,196.99

HEAVY SPC-2 Workload: 3,219.55W at a data rate of 17,000.30 MB/s.

MODERATE SPC-2 Workload: 3,180.10W at a data rate of 15,366.36 MB/s.

IDLE SPC-2 Workload: 2,686.31W at data rate of zero (0).

The above usage profile describes conditions in environments that respectively impose light *(Low Daily Usage)*, moderate *(Medium Daily Usage)*, and extensive *(High Daily Usage)* demands on the Tested Storage Configuration (TSC). The data in this profile represents the combined results of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ) and Video on Demand Delivery (VOD).

The detailed SPC-2/E Reported Data and associated charts for each workload, including the Idle Test, are available in this document, via the hyperlinks listed below:

- The SPC-2/E Idle Test chart
- SPC-2/E Large File Processing (LFP) Reported Data table and associated charts
- SPC-2/E Large Database Query (LDQ) Reported Data table and associated charts
- SPC-2/E Video on Demand Delivery (VOD) Reported Data table and associated charts

The definitions, listed below, for the remaining items in the above SPC-2/E Reported Data table, are identical for the SPC-2/E Reported Data tables for each of the three individual SPC-2 workloads: LFP, LDQ and VOD.

AVERAGE RMS VOLTAGE: The average supply voltage applied to the Tested Storage Product (TSP) as measured during the Measurement Intervals of the SPC-2 Tests.

AVERAGE POWER FACTOR: The ratio of average real power, in watts, to the average apparent power, in volt-amps flowing into the Tested Storage Product (TSP) during the Measurement Intervals of the SPC-2 Tests.

NOMINAL POWER, W: The average power consumption over the course of a day *(24 hours)*, taking into account hourly load variations.

NOMINAL TRAFFIC, MBPS: The average data rate over the course of a day *(24 hours)*, taking into account hourly load variations.

NOMINAL MBPS/W: The overall efficiency with which the reported data rate can be supported, reflected by the ratio of **NOMINAL TRAFFIC** versus the **NOMINAL POWER**.

NOMINAL HEAT, BTU/HR: The average amount of heat required to be dissipated over the course of a day *(24 hours)*, taking into account hourly load variations. *(1 watt = 3.412 BTU/hr)*

COMPOSITE METRICS: The aggregated **NOMINAL POWER**, **NOMINAL TRAFFIC**, and **NOMINAL MBPS/W** for all three environments: **LOW**, **MEDIUM**, and **HIGH DAILY USAGE**.

ANNUAL ENERGY USE, KWH: An estimate of the average energy use across the three environments over the course of a year and computed as (**NOMINAL POWER** * 24 *0.365).
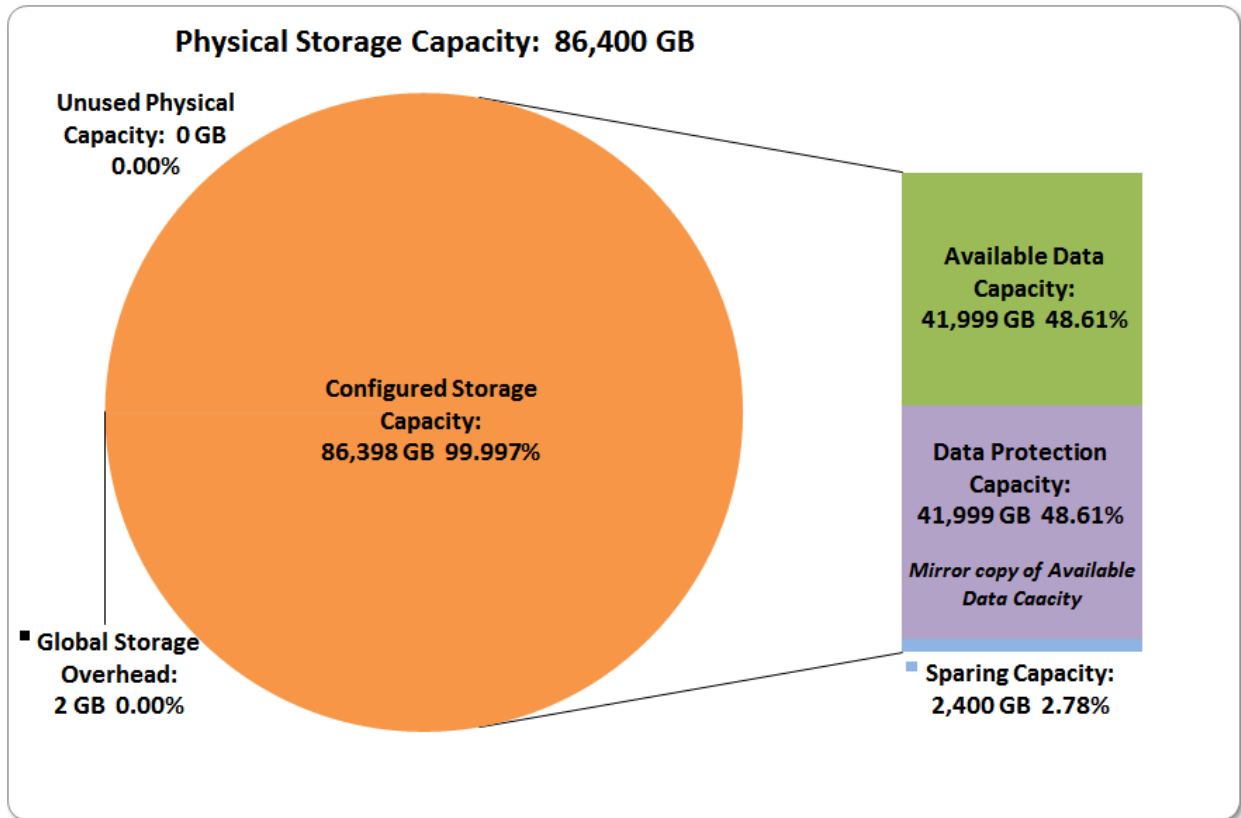
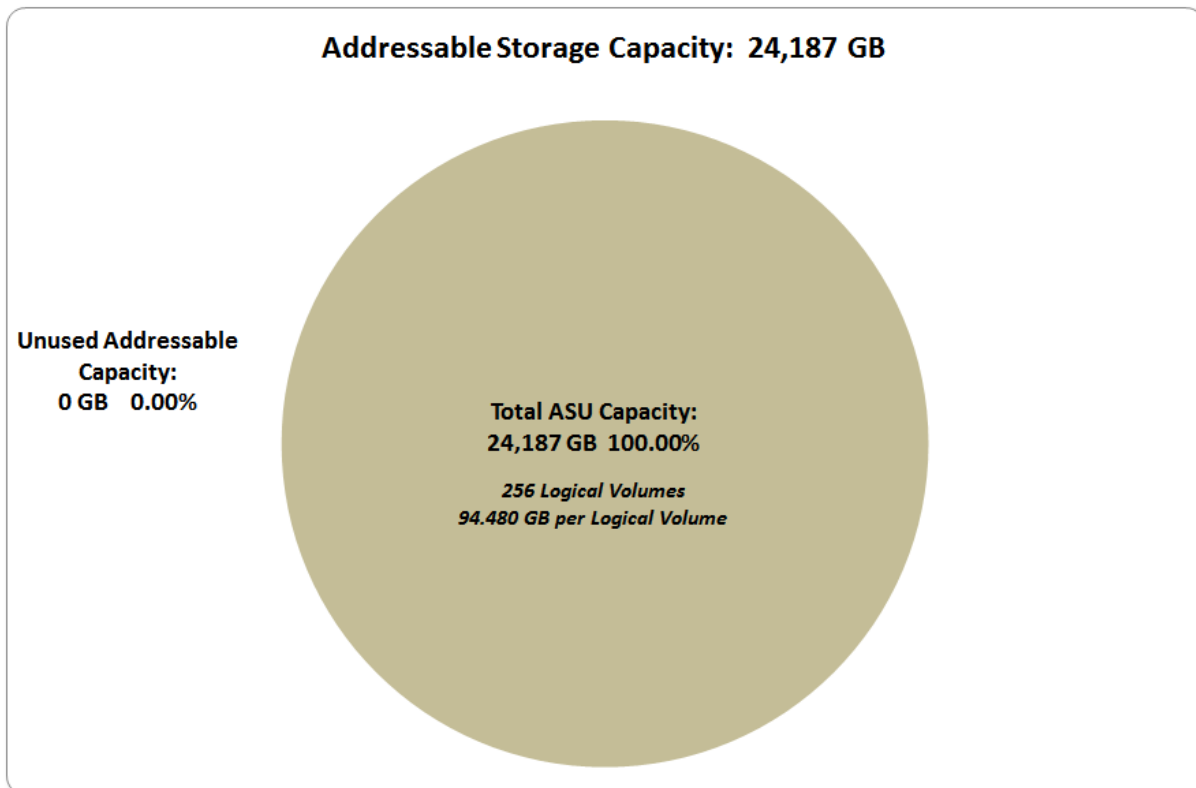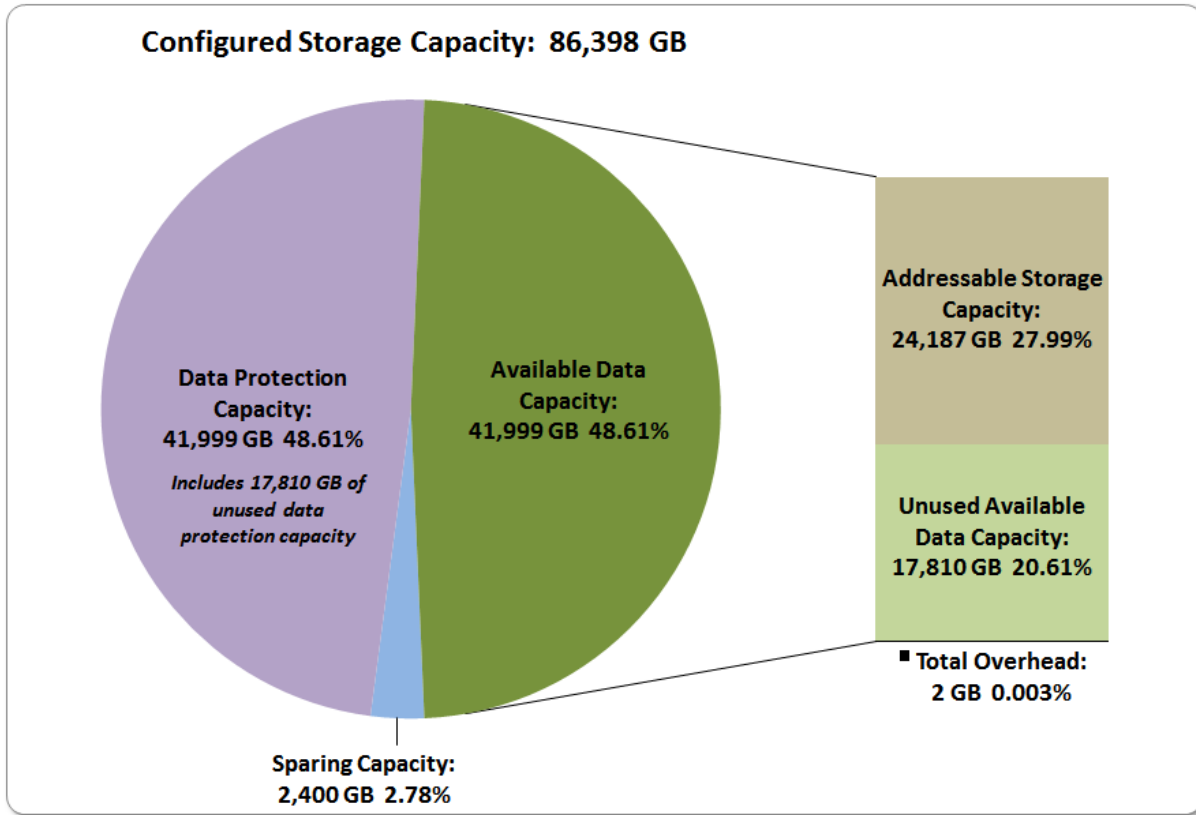**ENERGY COST, $/KWH**: A standardized energy cost per kilowatt hour.

ANNUAL ENERGY COST: An estimate of the annual energy use across the three environments over the course of a year and computed as (**ANNUAL ENERGY USE** * **ENERGY COST**).

Storage Capacities and Relationships

The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.

Physical Storage Capacity: 86,400 GB

Unused Physical
Capacity: 0 GB
0.00%

Configured Storage
Capacity:
86,398 GB 99.997%

Available Data
Capacity:
41,999 GB 48.61%

Data Protection
Capacity:
41,999 GB 48.61%

*Mirror copy of Available
Data Caacity*

Global Storage
Overhead:
2 GB 0.00%

Sparing Capacity:
2,400 GB 2.78%

Configured Storage Capacity: 86,398 GB

Data Protection Capacity:
41,999 GB 48.61%

Includes 17,810 GB of unused data protection capacity

Available Data Capacity:
41,999 GB 48.61%

Addressable Storage Capacity:
24,187 GB 27.99%

Unused Available Data Capacity:
17,810 GB 20.61%

■ **Total Overhead:**
2 GB 0.003%

Sparing Capacity:
2,400 GB 2.78%

Addressable Storage Capacity: 24,187 GB

Unused Addressable Capacity:
0 GB 0.00%

Total ASU Capacity:
24,187 GB 100.00%

256 Logical Volumes
94.480 GB per Logical Volume

Total Unused Storage Capacity Ratio and Detail

Physical Storage Capacity: 86,400 GB

Unused Physical Capacity: 0 GB

Physical Storage Capacity Used: 50,781 GB 58.77%

Total Unused Storage Capacity: 35,619 GB 41.23%

Unused Configured Capacity: 35,619 GB

includes 17,810 GB of Unused Data Protection Capacity

Unused Addressable Capacity: 0 GB

SPC-2 Storage Capacity Utilization	
Application Utilization	27.99%
Protected Application Utilization	55.99%
Unused Storage Ratio	41.23%

Application Utilization: Total ASU Capacity *(24,186.836 GB)* divided by Physical Storage Capacity *(86,400.000 GB)*.

Protected Application Utilization: Total ASU Capacity *(24,186.836 GB)* plus total Data Protection Capacity *(41,998.805 GB)* minus unused Data Protection Capacity 17,809.549 *(GB)* divided by Physical Storage Capacity *(86,400.000 GB)*.

Unused Storage Ratio: Total Unused Capacity *(35,619.098 GB)* divided by Physical Storage Capacity *(86,400.000 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 28-29 in the Full Disclosure Report.

Priced Storage Configuration Pricing

| Part Number	Description	Quantity	US List	Total List	Discount	Net Price
7103829	Oracle ZFS Storage ZS3-2: controller, includes SAS2 PCIE 16 port HBA	2	$17,097.00	$34,194.00	40.00%	$20,516.40
7102984	One 16 GB DDR3-1600 registered DIMM (for factory installation)	32	$302.00	$9,664.00	20.00%	$7,731.20
7103790	SAS PCIE 6Gbs 16 port (for factory installation)	2	$1,167.00	$2,334.00	40.00%	$1,400.40
7104928	Cable: 3 meters, mini SAS to mini SAS HD (for factory installation)	8	$186.00	$1,488.00	40.00%	$892.80
7101673	Sun Storage 16Gbs FC PCIe HBA, dual port, Qlogic	6	$1,696.00	$10,176.00	40.00%	$6,105.60
7101675	Sun Storage 2x16Gbs FC optics, SR, Qlogic	6	$960.00	$5,760.00	40.00%	$3,456.00
SR-JUMP-1MC13	Power cord: Sun Rack 2 jumper, 1 meter, C14RA plug, C13 connector, 13 A (for factory installation)	4	$29.00	$116.00	40.00%	$69.60
7103910	Oracle Storage Drive Enclosure DE2-24P: base chassis (for factory installation)	12	$4,071.00	$48,852.00	40.00%	$29,311.20
7103911	One 300 GB 10000 rpm 2.5 inch SAS-2 HDD with evo bracket (for factory installation)	288	$345.00	$99,360.00	40.00%	$59,616.00
SR-JUMP-1MC13	Power cord: Sun Rack 2 jumper, 1 meter, C14RA plug, C13 connector, 13 A (for factory installation)	24	$29.00	$696.00	40.00%	$417.60
SR-1242-N	Sun Rack II, 42U, 1200mm depth, 600mm width, empty shipping only (do not install product inside the rack while it is on this pallet)	1	$2,149.00	$2,149.00	20.00%	$1,719.20
SR-10K-L630-N	Sun Rack II 10kVA PDU, Single Phase, 48 Supplied Amps Max, NEMA L6-30P on 4m captive cords, Data Center Two 30A NEMA L6-30R (30A breakers), 42 C13 and 6 C19 Outlets in 6 Groups, Current Metering.	1	$900.00	$900.00	20.00%	$720.00
SR-JUMPKIT-N	Jumper Cable Start Up Kit: qty 10 of 1 meter C13 plugs + qty 10 of 2 meter C13 plugs + qty 2 1 meter C19 plugs + Qty 2 2meter C19 plugs	1	$198.00	$198.00	20.00%	$158.40
7101674	Sun Storage 16Gbs FC PCIe HBA, dual port, Qlogic	6	$2,035.00	$12,210.00	40.00%	$7,326.00
7101676	Sun Storage 2x16Gbs FC optics, SR, Qlogic	6	$1,152.00	$6,912.00	40.00%	$4,147.20
X9732A-Z-N	2M LC to LC FC Optical Cable RoHS-6 compliant	12	$65.00	$780.00	40.00%	$468.00
	Oracle Premium Support for Systems: 1-Year 7/24, 2 hour response time.	3		$84,884.04		$51,860.02
	TOTALS			**$320,673.04**		**$195,915.62**

The following pricing includes the following:

- Acknowledgement of new and existing hardware and/or software problems within four hours.

- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration component.

Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

The TSC was configured with two PDUs to better distribute the measurement demand on the Yokogawa power meter. The Priced Storage was configured with a single PDU, which is sufficient to power the both the TSC and Priced Storage Configuration. The use of one PDU in the TSC would have no impact on the reported performance.

Priced Storage Configuration Diagram
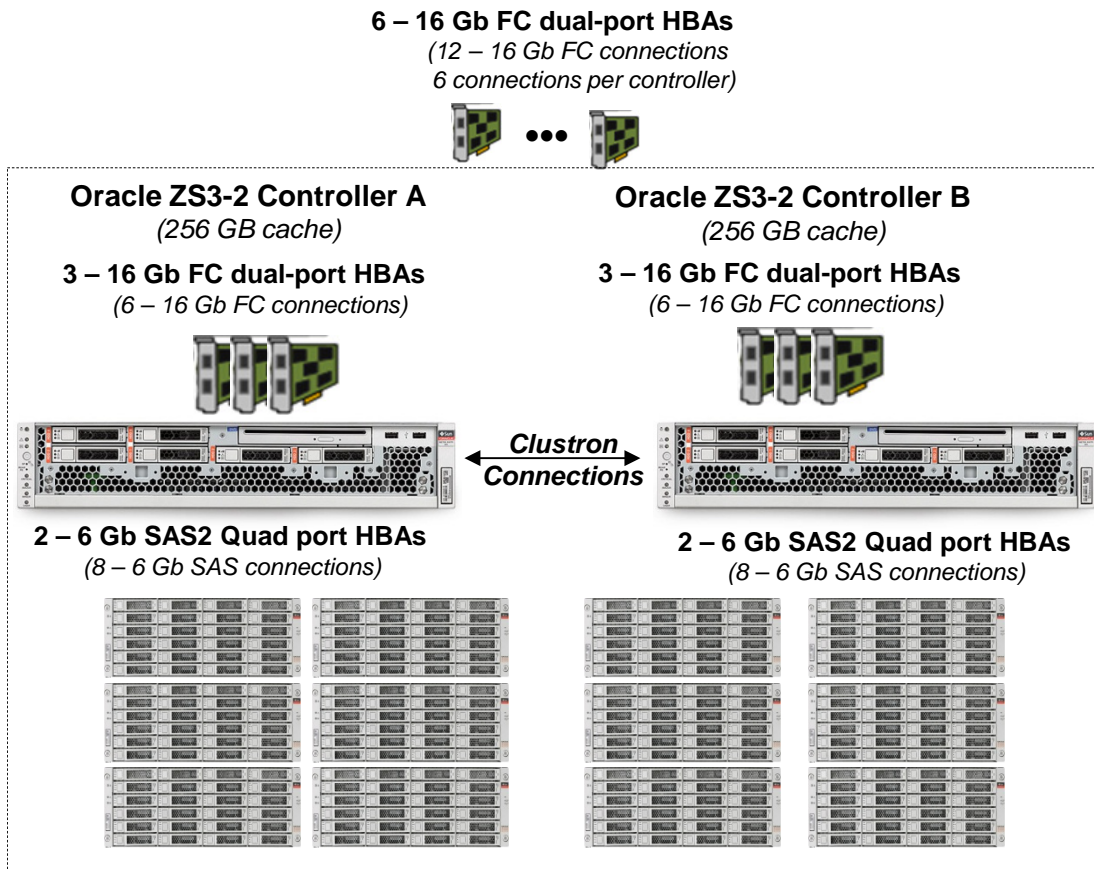
6 – 16 Gb FC dual-port HBAs
(12 – 16 Gb FC connections
6 connections per controller)

Oracle ZS3-2 Controller A
(256 GB cache)

3 – 16 Gb FC dual-port HBAs
(6 – 16 Gb FC connections)

Oracle ZS3-2 Controller B
(256 GB cache)

3 – 16 Gb FC dual-port HBAs
(6 – 16 Gb FC connections)

Clustron Connections

2 – 6 Gb SAS2 Quad port HBAs
(8 – 6 Gb SAS connections)

2 – 6 Gb SAS2 Quad port HBAs
(8 – 6 Gb SAS connections)

Oracle ZFS Storage ZS3-2 Appliance *(2-node cluster)*

2 – Oracle ZFS ZS3-2 controllers *(cluster configuration)*
(256 GB cache per controller, 512 GB total)

6 – 16 Gb FC dual-port HBAs *(3 HBAs per controller)*
(6 – 16 Gb FC connections per controller, 12 total, 12 used)

4 – 6 Gb SAS 16 port HBAs *(2 HBAs per controller)*
(32 – 6 Gb logical SAS connections per controller, 64 total, 64 used)

12 – Sun disk shelf base *(2 SAS I/O modules per base)*

288 – 300 GB 10K RPM 2.5" SAS-2 Disk Drives

1 – Sun Rack II 42U

2 – Sun Rack II 10kVA PDUs

Priced Storage Configuration Components

Priced Storage Configuration
6 – Sun Storage 16 Gbps FC PCIe dual-port HBAs with   12 – Sun Storage 16 Gbps FC optics
Oracle ZFS Storage ZS3-2 Appliance *(2-node cluster)*
2 – Oracle ZFS ZS3-2 controllers *(cluster configuration)*   256 GB cache/memory per controller *(512 GB total)*

6 – Sun Storage 16 Gbps FC PCIe dual-port HBAs with
          12 – Sun Storage 16 Gbps FC optics
         (3 FC HBAs and 6 FC optics per controller)

6 – 16 Gb FC front-end connections per controller   *(12 – 16 Gb FC front-end connections total, 12 used)*
2 – SAS PCIe 6 Gb 16 port adapters   *(1 adapter included with each controller)*

4 physical SAS connections per adapter
      4 logical SAS connections per physical connection
     16 logical SAS connections per adapter
      8 physical SAS connections per controller
    (32 total logical connections, 32 used)

2 – SAS PCIe 6 Gb 16 port adapters
    (1 additional adapter per controller)
      4 physical SAS connections per adapter
      4 logical SAS connections per physical connection
     16 logical SAS connections per adapter
      8 physical SAS connections per controller
    (32 total logical connections, 32 connections used)

12 – Sun disk shelf base each with 2 SAS I/O modules,   2 AC PSUs and 2 cooling fans
288 – 300 GB 10K RPM 2.5" SAS-2 disk drives
1 – Sun Rack II, 42U
1 – Sun Rack II 10kVA PDU, single phase,   48 supported amps max