SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

HUawei TechnoloGIES Co., LTD
Huawei OceanStor™ Dorado5000 V3

SPC-1 V3.5.0

Submission Identifier: A31010

Submitted For Review: December 5, 2017
PREAMBLE

Second Edition – February 2018

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Benchmark Specification and Glossary

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at www.storageperformance.org.

The SPC-1™ specification contains a glossary of the SPC-1™ terms used in this publication.
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AUDIT CERTIFICATION

Zhong Xu  
Huawei Technologies Co., Ltd.  
Huawei Industrial Base, Bantian,  
Longgang, Shenzhen city,  
Guangdong province, China  

December 5, 2017

I verified the SPC Benchmark 1™ (SPC-1™ Revision 3.5.0) test execution and performance results of the following Tested Storage Product:

**HUAWEI OceanStor™ Dorado5000 V3**

The results were:

<table>
<thead>
<tr>
<th>SPC-1 IOPS™</th>
<th>800,465</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Price-Performance™</td>
<td>$0.48/SPC-1 IOPS™</td>
</tr>
<tr>
<td>SPC-1 Response Time</td>
<td>0.507 ms</td>
</tr>
<tr>
<td>SPC-1 Overall Response Time</td>
<td>0.341 ms</td>
</tr>
<tr>
<td>SPC-1 ASU Capacity</td>
<td>27,058 GB</td>
</tr>
<tr>
<td>SPC-1 ASU Price</td>
<td>$13.95/GB</td>
</tr>
<tr>
<td>SPC-1 Total System Price</td>
<td>$377,376.62</td>
</tr>
</tbody>
</table>

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark.

The testing was executed using the SPC-1 Toolkit Version 3.0 Build d34fb3c. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by the Test Sponsor, stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by the Test Sponsor, and can be found at [www.storageperformance.org](http://www.storageperformance.org) under the Submission Identifier A31010.
The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository;
- The total capacity of the Application Storage Unit (ASU);
- The accuracy of the Benchmark Configuration diagram;
- The tuning parameters used to configure the Benchmark Configuration;
- The Workload Generator commands used to execute the testing;
- The validity and integrity of the test result files;
- The compliance of the results from each performance test;
- The compliance of the results from the persistence test;
- The compliance of the submitted pricing model; and
- The differences between the tested and the priced configuration, if any.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark.

The following benchmark requirements, if any, were waived according to the SPC Policies:

- None.

Respectfully Yours,

François Raab, Certified SPC Auditor
LETTER OF GOOD FAITH

Date: December 4, 2017
From: Huawei Technologies Co., Ltd.
To: Mr. Francois Raah, Certified SPC Auditor
   InfoSizing
   20 Kreg Lane
   Manitou Springs, CO 80829

Subject: SPC-1 Letter of Good Faith for the Huawei OceanStor Dorado 5000 V3

Huawei Technologies Co., Ltd. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V3.5 of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: 

Meng Guangbin
President of Storage Product Line

Date: 2017.12.01

 Huawei Industrial Base, Bantian, Longgang
 Shenzhen city
 Guangdong province
 China
 Tel: 0086-755-28780808
 http://www.huawei.com/
EXECUTIVE SUMMARY

SPC BENCHMARK 1™

EXECUTIVE SUMMARY

HUAWEI TECHNOLOGIES CO., LTD.
HUAWEI OCEANSTOR™ DORADO5000 V3

<table>
<thead>
<tr>
<th>SPC-1 IOPS™</th>
<th>800,465</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Price-Performance™</td>
<td>$471.45/SPC-1 KIOPS™</td>
</tr>
<tr>
<td>SPC-1 IOPS™ Response Time</td>
<td>0.507 ms</td>
</tr>
<tr>
<td>SPC-1 Overall Response Time</td>
<td>0.341 ms</td>
</tr>
<tr>
<td>SPC-1 ASU Capacity</td>
<td>27,058 GB</td>
</tr>
<tr>
<td>SPC-1 ASU Price</td>
<td>$13.95/GB</td>
</tr>
<tr>
<td>SPC-1 Total System Price</td>
<td>$377,376.62</td>
</tr>
</tbody>
</table>

Data Protection Level: Protected 2 (RAID 6 and full redundancy)
Physical Storage Capacity: 50,791 GB
Pricing Currency / Target Country: U.S. Dollars / USA

SPC-1 V3.5.0

SUBMISSION IDENTIFIER: A31010
SUBMITTED FOR REVIEW: DECEMBER 5, 2017
Benchmark Configuration Diagram

**Host Systems**

8 x Huawei FusionServer™ RH5885H V3

2 x QLogic dual-port QLE2562 FC HBA per FusionServer™

32 x FC connections
(4 connections per server)

**Huawei OceanStor™ Dorado5000 V3**

2 x Dorado5000 V3 Enclosures (each with)
2 x Dorado5000 V3 Active-Active Controllers (each with)

- 256GB cache
- 1 x 4-port 8Gbps Smart I/O Module
- 1 x 4*8Gbps FC port on board
- 1 x 2-port PCIe Module
- 25 x 1TB NVMe SSDs

2 x 16-port PCIe switches

**Tested Storage Configuration (TSC)**
Tested Storage Product Description

Huawei’s OceanStor™ Dorado™ V3 all-flash storage is the ideal choice for enterprises’ mission-critical business. It is the industry’s first commercial use of NVMe all-flash storage, and it delivers high-performing, reliable, and efficient storage services.

The HyperMetro gateway-free active-active solution ensures 99.9999% availability, and 3:1 data reduction guarantee reduces TCO by 50%.

The Dorado satisfies the storage requirements of databases, Virtual Desktop Infrastructure (VDI) and Virtual Server Infrastructure (VSI), smoothing the way to the all-flash era.

For more details, visit:


Priced Storage Configuration Components

<table>
<thead>
<tr>
<th>Component Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 x QLogic dual-ported QLE2562 FC HBA</td>
</tr>
<tr>
<td>2 x Dorado5000 V3 Enclosures (each with)</td>
</tr>
<tr>
<td>2 x Dorado5000 V3 Active-Active Controllers (each with)</td>
</tr>
<tr>
<td>256GB cache</td>
</tr>
<tr>
<td>1 x 4-port 8Gbps Smart I/O Module</td>
</tr>
<tr>
<td>1 x 4*8Gbps FC port on board</td>
</tr>
<tr>
<td>1 x 2-port PCIe Module</td>
</tr>
<tr>
<td>25 x 1TB NVMe SSDs</td>
</tr>
<tr>
<td>2 x 16-port PCIe 2.0 switches</td>
</tr>
</tbody>
</table>
### Storage Configuration Pricing

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5V3-512G-NAC-8 Dorado5000 V3(2U,Dual Ctrl,NVMe,AC:240HVDC,512GB Cache,SmartIO,16<em>8Gb FC,25</em>2.5&quot;,SPE1C0225)</td>
<td>2</td>
<td>123,590.82</td>
<td>247,181.64</td>
<td>45%</td>
<td>135,949.90</td>
</tr>
<tr>
<td>DV3-LPU5PCIE 8G PCIe Interface Board (with two NT Ports)</td>
<td>4</td>
<td>1,929.20</td>
<td>7,716.80</td>
<td>45%</td>
<td>4,244.24</td>
</tr>
<tr>
<td>D5V3-SSD-NVME-1T 1TB SSD NVMe Disk Unit (2.5&quot;)</td>
<td>50</td>
<td>4,971.40</td>
<td>248,570.00</td>
<td>45%</td>
<td>136,713.50</td>
</tr>
<tr>
<td>N8GHBA000 QLOGIC QLE2562 HBA Card, PCIe, 8Gbps DualPort, Fiber Channel Multimode LC Optic Interface, English Manual, No Drive CD</td>
<td>16</td>
<td>1,698.00</td>
<td>27,168.00</td>
<td>0%</td>
<td>27,168.00</td>
</tr>
<tr>
<td>SN2F01FCPC Patch Cord, DLC/PC, DLC/PC, Multimode, 3m A1a.2, 2mm, 42mm DLC, OM3 bending insensitive</td>
<td>32</td>
<td>19.80</td>
<td>633.60</td>
<td>0%</td>
<td>633.60</td>
</tr>
<tr>
<td>DV3-PCIESWITCH3 PCIe 3.0 Switch (AC:240HVDC, 8GB Cache, 16 Port, SWE1600P08)</td>
<td>2</td>
<td>16,218.00</td>
<td>32,436.00</td>
<td>0%</td>
<td>32,436.00</td>
</tr>
<tr>
<td>ACC-QSFP41G Quad Wire 40 Gb/s Parallel ACC for PCIe 3.0</td>
<td>8</td>
<td>1,065.30</td>
<td>8,522.40</td>
<td>0%</td>
<td>8,522.40</td>
</tr>
<tr>
<td>D5V3-LBS Basic Software (license include DeviceManager, SmartThin, SmartMigration, SmartDedupe, SmartCompression, eService, SystemReporter, UltraPath)</td>
<td>1</td>
<td>7,196.00</td>
<td>7,196.00</td>
<td>44%</td>
<td>4,029.76</td>
</tr>
</tbody>
</table>

**Hardware & Software Subtotal:** 349,697.40

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>02351GSA-88134ULF-36 Dorado5000 V3(2U,Dual Ctrl,NVMe,AC:240HVDC,512GB Cache,SmartIO,8<em>8Gb FC,25</em>2.5&quot;,SPE1C0225)-Hi-Care Onsite Premier 24x7x4H Engineer Onsite Service-36Month(s)</td>
<td>2</td>
<td>4,466.00</td>
<td>8,932.00</td>
<td>10%</td>
<td>8,002.80</td>
</tr>
<tr>
<td>02351GTY-88134ULF-36 1TB SSD NVMe Disk Unit (2.5&quot;)-Hi-Care Onsite Premier 24x7x4H Engineer Onsite Service-36Month(s)</td>
<td>50</td>
<td>216.00</td>
<td>10,800.00</td>
<td>10%</td>
<td>9,720.00</td>
</tr>
<tr>
<td>88033NAM-88134UHK-36 Basic Software License (license include DeviceManager, SmartThin, SmartMigration, SmartDedupe, SmartCompression, eService, SystemReporter)-Hi-Care Application Software Upgrade Support Service, UltraPath Software license-36Month(s)</td>
<td>1</td>
<td>1,854.00</td>
<td>1,854.00</td>
<td>30%</td>
<td>1,297.80</td>
</tr>
<tr>
<td>8812102575 OceanStor Dorado5000 V3 Installation Service - Engineering</td>
<td>1</td>
<td>9,620.68</td>
<td>9,620.68</td>
<td>10%</td>
<td>8,658.61</td>
</tr>
</tbody>
</table>

**Support & Maintenance Subtotal:** 27,679.21

**SPC-1 Total System Price:** 377,376.61

**SPC-1 KOPS™:** 800,465

**SPC-1 Price-Performance™ ($/SPC-1 KOPS™):** 471.45

**SPC-1 ASU Capacity (GB):** 27,058

**SPC-1 ASU Price ($/GB):** 13.95
**Third-Party Reseller:** Huawei Technologies Co., Ltd. only sells its products to third-party resellers who, in turn, sell those products to U.S. customers. The above reflects the pricing quoted by one of those third-party resellers. See Appendix B of the Full Disclosure Report for a copy of the third-party reseller’s quotation.

**Discount Details:** The discounts shown are based on the storage capacity purchased and are generally available.

**Warranty:** Hi-Care Premier On-Site Service include: 7x24 Technical Assistance Center Access. Access to all new software updates and Online Support. 24x7 with 4-hour On-site Hardware Replacement.

**Availability Date:** Currently available.
Response Time and Throughput Graph

Contact Information

Test Sponsor Primary Contact
Huawei Technologies Co., Ltd. – www.huawei.com
Zhong Xu – xuzhong@huawei.com

SPC Auditor
InfoSizing – www.sizing.com
Francois Raab – francois@sizing.com

Revision Information

<table>
<thead>
<tr>
<th>SPC Benchmark 1™ Revision</th>
<th>V3.5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Workload Generator Revision</td>
<td>V3.0 build d34fb3c</td>
</tr>
</tbody>
</table>

Publication Revision History
- First Edition: December 5, 2017
- Second Edition: February 15, 2018
- Updated SPC-1 Price-Performance™ metric based on SPC-1 v3.6.0 definition.
**CONFIGURATION INFORMATION**

**Benchmark Configuration and Tested Storage Configuration**

The following diagram illustrates the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC) and the Host Systems.
**Storage Network Configuration**

The Tested Storage Configuration (TSC) involved an external storage subsystem made of four Huawei OceanStor™ Dorado5000 V3 Active-Active Storage Controllers, driven by 8 host systems (Huawei FusionServer™ RH5885H V3). Each FusionServer connected one-to-one to each Dorado controller. That connection was established via two dual-port Fibre Channel HBAs on each FusionServer; and eight ports on each Dorado controller, using four on board ports and a 4-port Smart I/O Module. These Fibre Channel paths operated at 8Gbps. The four Dorado controllers were interconnected using two 16-port PCIe 3.0 Switches. Each Controller had one 8Gbps 8-lane connection to each Switch.

**Host System and Tested Storage Configuration Components**

The following table lists the components of the Host System(s) and the Tested Storage Configuration (TSC).

<table>
<thead>
<tr>
<th>Host Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 x Huawei FusionServer™ RH5885H V3</td>
</tr>
<tr>
<td>2 x Intel Xeon E7-4820 V2 (2.0 GHz 8-Core 16MB L3)</td>
</tr>
<tr>
<td>256GB Main Memory</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux 7.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tested Storage Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 x QLogic dual-ported QLE2562 FC HBA</td>
</tr>
<tr>
<td>2 x Dorado5000 V3 Enclosures (each with)</td>
</tr>
<tr>
<td>2 x Dorado5000 V3 Active-Active Controllers (each with)</td>
</tr>
<tr>
<td>256GB cache</td>
</tr>
<tr>
<td>1 x 4-port 8Gbps Smart I/O Module</td>
</tr>
<tr>
<td>1 x 4*8Gbps FC port on board</td>
</tr>
<tr>
<td>1 x 2-port PCIe Module</td>
</tr>
<tr>
<td>25 x 1TB NVMe SSDs</td>
</tr>
<tr>
<td>2 x 16-port PCIe 2.0 switches</td>
</tr>
</tbody>
</table>

**Differences Between Tested and Priced Storage Configurations**

There were no differences between the Tested Storage Configuration and the Priced Storage Configuration.

**Component Changes in Revised Full Disclosure Report**

The following table outlines component changes that were made in revisions to this Full Disclosure Report.

<table>
<thead>
<tr>
<th>Original Component</th>
<th>Revised Component</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>Initial submission</td>
</tr>
</tbody>
</table>
Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

All the customer tuning parameters and options that have been altered from their default values for this benchmark are included in Appendix C and in the Supporting Files (see Appendix A).

Tested Storage Configuration Creation

A detailed description of how the logical representation of the TSC was created is included in Appendix D and in the Supporting Files (see Appendix A).

Tested Storage Configuration Inventory

An inventory of the components in the TSC, as seen by the Benchmark Configuration, is included in Appendix E and in the Supporting Files (see Appendix A).

Workload Generator Storage Configuration

The SPC-1 Workload Generator storage configuration commands and parameters used to invoke the execution of the tests are included in Appendix F and in the Supporting Files (see Appendix A).

Logical Volume Capacity and ASU Mapping

The following table details the capacity of each ASU and how they are mapped to logical volumes (LV).

<table>
<thead>
<tr>
<th>LV per ASU</th>
<th>LV Capacity</th>
<th>Used per LV</th>
<th>Total per ASU</th>
<th>% ASU Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU-1</td>
<td>18</td>
<td>676.5</td>
<td>676.5</td>
<td>12,176.2</td>
</tr>
<tr>
<td>ASU-2</td>
<td>18</td>
<td>676.5</td>
<td>676.5</td>
<td>12,176.2</td>
</tr>
<tr>
<td>ASU-3</td>
<td>2</td>
<td>1,353.0</td>
<td>1,352.9</td>
<td>2,705.8</td>
</tr>
</tbody>
</table>

SPC-1 ASU Capacity 27,058.3

Physical Storage Capacity and Utilization

The following table details the Physical Capacity of the storage devices and the Physical Capacity Utilization (percentage of Total Physical Capacity used) in support of hosting the ASUs.

<table>
<thead>
<tr>
<th>Devices</th>
<th>Count</th>
<th>Physical Capacity</th>
<th>Total Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1TB NVMe SSD</td>
<td>50</td>
<td>1015.8</td>
<td>50,791.7</td>
</tr>
</tbody>
</table>

Total Physical Capacity 50,791.7

Physical Capacity Utilization 53.27%
**Data Protection**

The data protection level used for all logical volumes was **Protected 2**, which was accomplished by configuring the 50 drives into two RAID 6 storage pools of 25 drives each, and by having redundant paths to the storage pools through redundant components. The controller caches were mirrored across controllers and protected against power failures through a battery-backed flushing mechanism.
**BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs.

**Benchmark Execution Overview**

**Workload Generator Input Parameters**

The SPC-1 Workload Generator commands and input parameters for the Test Phases are presented in the Supporting Files (see Appendix A).

**Primary Metrics Test Phases**

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD_100 to RAMPD_10, RAMPU_50 to RAMPU_100, RAMP_0, REPEAT_1 and REPEAT_2.

Each Test Phase starts with a transition period followed by a Measurement Interval.

**Measurement Intervals by Test Phase Graph**

The following graph presents the average IOPS and the average Response Times measured over the Measurement Interval (MI) of each Test Phase.
Exception and Waiver

During the course of the benchmark audit, no exceptions were encountered and no benchmark requirements were waived.
SUSTAIN Test Phase

SUSTAIN – Results File

The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

SUSTAIN – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Interval</td>
<td>22-Nov-17 19:18:56</td>
<td>23-Nov-17 03:18:57</td>
<td>8:00:01</td>
</tr>
</tbody>
</table>

SUSTAIN – Throughput Graph

[Throughput Graph Image]

The graph above illustrates the throughput performance at 800,400 IOPS across different ASUs.
SUSTAIN – Response Time Graph

![Response Time Graph (SUSTAIN @ 800,400 IOPS)](image)

SUSTAIN – Data Rate Graph

![Data Rate Graph (SUSTAIN @ 800,400 IOPS)](image)
SUSTAIN – Response Time Frequency Graph

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0008</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.0003</td>
<td>0.0011</td>
<td>0.0006</td>
<td>0.0007</td>
<td>0.0002</td>
</tr>
<tr>
<td>Difference</td>
<td>0.008%</td>
<td>0.003%</td>
<td>0.001%</td>
<td>0.000%</td>
<td>0.008%</td>
<td>0.004%</td>
<td>0.003%</td>
<td>0.000%</td>
</tr>
</tbody>
</table>
RAMPD_100 Test Phase

RAMPD_100 – Results File

The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

RAMPD_100 – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Period</td>
<td>23-Nov-17 03:19:56</td>
<td>23-Nov-17 03:24:56</td>
<td>0:05:00</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>23-Nov-17 03:24:56</td>
<td>23-Nov-17 03:34:57</td>
<td>0:10:00</td>
</tr>
</tbody>
</table>

RAMPD_100 – Throughput Graph

![Throughput Graph (RAMPD_100 @ 800,400 IOPS)](image-url)
RAMPD_100 – Response Time Graph

RAMPD_100 – Data Rate Graph
RAMPD_100 – Response Time Frequency Graph

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0005</td>
<td>0.0003</td>
<td>0.0006</td>
<td>0.0004</td>
<td>0.0005</td>
<td>0.0005</td>
<td>0.0009</td>
<td>0.0002</td>
</tr>
<tr>
<td>Difference</td>
<td>0.025%</td>
<td>0.009%</td>
<td>0.022%</td>
<td>0.013%</td>
<td>0.013%</td>
<td>0.004%</td>
<td>0.008%</td>
<td>0.006%</td>
</tr>
</tbody>
</table>

RAMPD_100 – I/O Request Summary

| I/O Requests Completed in the Measurement Interval | 480,278,751 |
| I/O Requests Completed with Response Time <= 30 ms | 480,277,565 |
| I/O Requests Completed with Response Time > 30 ms | 1,186 |
Response Time Ramp Test

Response Time Ramp Test – Results File
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

Response Time Ramp Test – Phases
The Response Time Ramp Test is comprised of 11 Test Phases, including six Ramp-Down Phases (executed at 100%, 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit) and five Ramp-Up Phases (executed at 50%, 80%, 90%, 95%, and 100% of the Business Scaling Unit).

Response Time Ramp Test – Average Throughput Graph

![Average Throughput Graph (Response Time Ramp Test)](chart)
Response Time Ramp Test – Average Response Time Graph

Response Time Ramp Test – RAMPD 10 Response Time Graph
Repeatability Test

Repeatability Test Results File

The results file generated during the execution of the Repeatability Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

Repeatability Test Results

The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the tables below.

<table>
<thead>
<tr>
<th>Test Phase</th>
<th>100% IOPS</th>
<th>10% IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMPD</td>
<td>800,465.6</td>
<td>80,061.2</td>
</tr>
<tr>
<td>REPEAT_1</td>
<td>800,495.0</td>
<td>80,078.6</td>
</tr>
<tr>
<td>REPEAT_2</td>
<td>800,425.7</td>
<td>80,051.0</td>
</tr>
</tbody>
</table>

REPEAT_1 100 – Throughput Graph

![Throughput Graph (REPEAT_1 100 @ 800,400 IOPS)](image)
REPEAT_1_100 – Response Time Graph

![Response Time Graph](image1)

REPEAT_2_100 – Throughput Graph

![Throughput Graph](image2)
## REPEAT_2_100 – Response Time Graph

![Response Time Graph (REPEAT_2_100 @ 800,400 IOPS)](image)

### Repeatability Test – Intensity Multiplier

The following tables lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percent of difference (Difference) between Target and Measured.

#### REPEAT_1_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0005</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.0002</td>
<td>0.0008</td>
<td>0.0006</td>
<td>0.0007</td>
<td>0.0002</td>
</tr>
<tr>
<td>Difference</td>
<td>0.048%</td>
<td>0.010%</td>
<td>0.017%</td>
<td>0.013%</td>
<td>0.001%</td>
<td>0.014%</td>
<td>0.028%</td>
<td>0.005%</td>
</tr>
</tbody>
</table>

#### REPEAT_2_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0008</td>
<td>0.0003</td>
<td>0.0007</td>
<td>0.0002</td>
<td>0.0009</td>
<td>0.0005</td>
<td>0.0009</td>
<td>0.0003</td>
</tr>
<tr>
<td>Difference</td>
<td>0.049%</td>
<td>0.008%</td>
<td>0.011%</td>
<td>0.021%</td>
<td>0.022%</td>
<td>0.026%</td>
<td>0.026%</td>
<td>0.010%</td>
</tr>
</tbody>
</table>
Data Persistence Test

Data Persistence Test Result files
The results files generated during the execution of the Data Persistence Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_PERSIST_1_0_Raw_Results.xlsx
- SPC1_PERSIST_2_0_Raw_Results.xlsx

Data Persistence Test Execution
The Data Persistence Test was executed using the following sequence of steps:

- The PERSIST_1_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST_2_0 Test Phase was executed to completion.

Data Persistence Test Results

<table>
<thead>
<tr>
<th>Data Persistence Test Phase: Persist1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Logical Blocks Written</td>
<td>98,951,000</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Verified</td>
<td>52,120,082</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Overwritten</td>
<td>46,830,918</td>
</tr>
<tr>
<td>Total Number of Logical Blocks that Failed Verification</td>
<td>0</td>
</tr>
<tr>
<td>Time Duration for Writing Test Logical Blocks (sec.)</td>
<td>301</td>
</tr>
<tr>
<td>Size in Bytes of each Logical Block</td>
<td>8,192</td>
</tr>
<tr>
<td>Number of Failed I/O Requests During the Test</td>
<td>0</td>
</tr>
</tbody>
</table>

Committed Data Persistence Implementation
The persistency of committed data is implemented at two levels. At the disk level, data loss is prevented through the use of RAID 6 arrays. At the controller level, all caches are mirrored across controllers, where write requests are only completed once the local cache has been successfully mirrored in another controller’s cache. In addition, cache content is protected from a loss of power by flushing the cache content to permanent flash memory, as soon as a power loss is detected. The flushing action is powered by a battery backup located in each controller.
APPENDIX A: SUPPORTING FILES

The following table details the content of the Supporting Files provided as part of this Full Disclosure Report.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>/SPC1_RESULTS</td>
<td>Data reduction worksheets</td>
<td>root</td>
</tr>
<tr>
<td>SPC1_INIT_0_Raw_Results.xlsx</td>
<td>Raw results for INIT Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Quick_Look.xlsx</td>
<td>Quick Look Test Run Overview</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Raw_Results.xlsx</td>
<td>Raw results for Primary Metrics Test</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Summary_Results.xlsx</td>
<td>Primary Metrics Summary</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_1_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST1 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_2_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST2 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_Run_Set_Overview.xlsx</td>
<td>Run Set Overview Worksheet</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_0_Raw_Results.xlsx</td>
<td>Raw results for first VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_1_Raw_Results.xlsx</td>
<td>Raw results for second VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>/C_Tuning/aio-max-nr.sh</td>
<td>Set maximum asynchronous I/O</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>/C_Tuning/nr_requests.sh</td>
<td>Increase disk queue depth</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>/C_Tuning/scheduler.sh</td>
<td>Change the I/O scheduler</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>/D_Creation/mklun.txt</td>
<td>Create the storage environment</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>/D_Creation/mkvolume.sh</td>
<td>Create the Logical Volumes</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>/E_Inventory/shstorage.tcl</td>
<td>Captures profile of storage environment</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/E_Inventory/profile1_volume.log</td>
<td>List of logical volumes before INIT</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/E_Inventory/profile1_storage.log</td>
<td>List of storage devices before INIT</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/E_Inventory/profile2_volume.log</td>
<td>List of logical volumes after restart</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/E_Inventory/profile2_storage.log</td>
<td>List of storage devices after restart</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/F_Generator/slave_asu.asu</td>
<td>Defining LUNs hosting the ASUs</td>
<td>/F_Generator</td>
</tr>
<tr>
<td>/F_Generator/8host.HST</td>
<td>Host configuration file</td>
<td>/F_Generator</td>
</tr>
<tr>
<td>/F_Generator/full_run.sh</td>
<td>Executing all test phases</td>
<td>/F_Generator</td>
</tr>
</tbody>
</table>
## APPENDIX B: THIRD PARTY QUOTATION

Reseller: Noviant

<table>
<thead>
<tr>
<th>No.</th>
<th>Model</th>
<th>Description</th>
<th>Qty</th>
<th>Unit Price (USD)</th>
<th>Ext Price (USD)</th>
<th>Disc. (off)</th>
<th>Disc. Price (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Phase</td>
<td>1.1 Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1</td>
<td>OceanStor Dorado 5600 V3 Main Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2</td>
<td>Controller Enclosure</td>
<td>DVS-51225-NAC-8</td>
<td>2</td>
<td>123,580.82</td>
<td>247,161.64</td>
<td>45.00%</td>
<td>135,949.90</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Expanding Interface Module</td>
<td>DVS-LP8P-PCIE</td>
<td>4</td>
<td>1,626.20</td>
<td>7,718.80</td>
<td>45.00%</td>
<td>4,264.24</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Disk Components</td>
<td>DVS-33D-NVME-1T</td>
<td>1</td>
<td>4,647.20</td>
<td>24,870.00</td>
<td>45.00%</td>
<td>13,671.00</td>
</tr>
<tr>
<td>1.1.4</td>
<td>HBA</td>
<td>NSHBA000</td>
<td>16</td>
<td>1,644.00</td>
<td>26,304.00</td>
<td>0.00%</td>
<td>26,304.00</td>
</tr>
<tr>
<td>1.1.5</td>
<td>Accessory</td>
<td>SNIPPC</td>
<td>32</td>
<td>29.00</td>
<td>936.00</td>
<td>0.00%</td>
<td>936.00</td>
</tr>
<tr>
<td>1.1.5</td>
<td>DVS-PCIE SWITCH</td>
<td>32</td>
<td>10,216.00</td>
<td>32,692.80</td>
<td>0.00%</td>
<td>32,692.80</td>
<td></td>
</tr>
<tr>
<td>1.1.6</td>
<td>Software</td>
<td>G80-8044-2503-650</td>
<td>1</td>
<td>7,180.00</td>
<td>7,180.00</td>
<td>44.00%</td>
<td>4,029.76</td>
</tr>
<tr>
<td></td>
<td>Total of Product</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>353,037.40</td>
</tr>
<tr>
<td>1.1.7</td>
<td>Maintenance Support Service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.7</td>
<td>DVS-51225-NAC-8</td>
<td>DVS-53000 V3U Dual Ctrl NVMe</td>
<td>2</td>
<td>6,944.00</td>
<td>13,888.00</td>
<td>10.00%</td>
<td>12,500.00</td>
</tr>
<tr>
<td>1.1.7</td>
<td>DVS-33D-NVME-1T</td>
<td>H-Care Onsite Premier 24x7x4 Engineer Onsite Service-36Month(s)</td>
<td>1</td>
<td>2,160.00</td>
<td>10,800.00</td>
<td>0.00%</td>
<td>7,200.00</td>
</tr>
<tr>
<td>1.1.7</td>
<td>DVS-LB5</td>
<td>G80-8044-2503-650</td>
<td>1</td>
<td>1,054.00</td>
<td>1,054.00</td>
<td>0.00%</td>
<td>1,054.00</td>
</tr>
<tr>
<td>1.1.7</td>
<td>OceanStor Dorado 5600 V3 Installation Service - Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.7</td>
<td>G812105375</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total of Service (2 Years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27,879.26</td>
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<tr>
<td></td>
<td>Total Price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>380,916.66</td>
</tr>
</tbody>
</table>

Notes:
- H-Care Premier On-Site Service includes: 7*24 Technical Assistance Center Access, Access to all new software updates and Online Support, 24/7/4 Hours Onsite Hardware Replacement
Payment Terms:

Comments:

Noviant is an Authorized Value Added Reseller (VAR) of networking products. Products sold by NF are factory new unless otherwise specified. All new products sold by NF carry its own Original Equipment Manufacturer’s (OEM) Limited Warranty and software licenses. This Quote is valid for 90 days. Prices and availability is subject to change without notice. Installation and configuration costs are not included in the quoted pricing unless specified. A 20% Restocking Fee applies to all cancelled orders and/or returned products. Special Orders are non-refundable. Buyer is responsible for payment of all applicable taxes and freight charges. Issuance of customer PO against this Quote constitutes acceptance of Noviant Sales Terms conditions.

I agree to these terms and conditions.

Authorized Signature: ___________________________  Print Name: ___________________________  Date: ____________

Authorized Signature: ___________________________  Print Name: ___________________________  Date: ____________

Noviant: ___________________________  Print Name: ___________________________  Date: ____________
APPENDIX C: TUNING PARAMETERS AND OPTIONS

The following scripts, listed below, were used to set tuning parameters and options:

- `aio-max-nr.sh` to set the maximum asynchronous I/O
- `nr_requests.sh` to change the I/O scheduler
- `scheduler.sh` to increase the disk queue depth

The scripts described above are included in the Supporting Files (see Appendix A) and listed below.

**aio-max-nr.sh**

```bash
echo 1048576 > /proc/sys/fs/aio-max-nr
```

**nr_requests.sh**

```bash
echo 1024 > /sys/block/sdb/queue.nr_requests
echo 1024 > /sys/block/sdc/queue.nr_requests
echo 1024 > /sys/block/sdd/queue.nr_requests
echo 1024 > /sys/block/sde/queue.nr_requests
echo 1024 > /sys/block/sdf/queue.nr_requests
echo 1024 > /sys/block/sdg/queue.nr_requests
echo 1024 > /sys/block/sdh/queue.nr_requests
echo 1024 > /sys/block/sdi/queue.nr_requests
echo 1024 > /sys/block/sdj/queue.nr_requests
echo 1024 > /sys/block/sdk/queue.nr_requests
echo 1024 > /sys/block/sdl/queue.nr_requests
echo 1024 > /sys/block/sdm/queue.nr_requests
echo 1024 > /sys/block/sdn/queue.nr_requests
echo 1024 > /sys/block/sdo/queue.nr_requests
echo 1024 > /sys/block/sdp/queue.nr_requests
echo 1024 > /sys/block/sdq/queue.nr_requests
echo 1024 > /sys/block/sdr/queue.nr_requests
echo 1024 > /sys/block/sds/queue.nr_requests
echo 1024 > /sys/block/sdt/queue.nr_requests
echo 1024 > /sys/block/sdu/queue.nr_requests
echo 1024 > /sys/block/sdv/queue.nr_requests
echo 1024 > /sys/block/sdx/queue.nr_requests
echo 1024 > /sys/block/sdy/queue.nr_requests
```

echo 1024 > /sys/block/sdam/queue.nr_requests
echo 1024 > /sys/block/sdan/queue.nr_requests
echo 1024 > /sys/block/sdao/queue.nr_requests
echo 1024 > /sys/block/sdap/queue.nr_requests
echo 1024 > /sys/block/sdaq/queue.nr_requests
echo 1024 > /sys/block/sdar/queue.nr_requests
echo 1024 > /sys/block/sdas/queue.nr_requests
echo 1024 > /sys/block/sdat/queue.nr_requests
echo 1024 > /sys/block/sdau/queue.nr_requests
echo 1024 > /sys/block/sdav/queue.nr_requests
echo 1024 > /sys/block/sdaw/queue.nr_requests
echo 1024 > /sys/block/sday/queue.nr_requests
echo 1024 > /sys/block/sdaz/queue.nr_requests
echo 1024 > /sys/block/sdba/queue.nr_requests
echo 1024 > /sys/block/sdbb/queue.nr_requests
echo 1024 > /sys/block/sdbc/queue.nr_requests
echo 1024 > /sys/block/sdbd/queue.nr_requests
echo 1024 > /sys/block/sdbe/queue.nr_requests
echo 1024 > /sys/block/sdbf/queue.nr_requests
echo 1024 > /sys/block/sdbg/queue.nr_requests
echo 1024 > /sys/block/sdbh/queue.nr_requests
echo 1024 > /sys/block/sdbi/queue.nr_requests
echo 1024 > /sys/block/sdbj/queue.nr_requests
echo 1024 > /sys/block/sdbk/queue.nr_requests
echo 1024 > /sys/block/sdbl/queue.nr_requests
echo 1024 > /sys/block/sdbm/queue.nr_requests
echo 1024 > /sys/block/sdbn/queue.nr_requests
echo 1024 > /sys/block/sdbo/queue.nr_requests
echo 1024 > /sys/block/sdbp/queue.nr_requests
echo 1024 > /sys/block/sdbq/queue.nr_requests
echo 1024 > /sys/block/sdbr/queue.nr_requests
echo 1024 > /sys/block/sdbs/queue.nr_requests
echo 1024 > /sys/block/sdbt/queue.nr_requests
echo 1024 > /sys/block/sdbu/queue.nr_requests
echo 1024 > /sys/block/sdbv/queue.nr_requests
echo 1024 > /sys/block/sdbw/queue.nr_requests
echo 1024 > /sys/block/sdbx/queue.nr_requests
echo 1024 > /sys/block/sdby/queue.nr_requests
echo 1024 > /sys/block/sdbz/queue.nr_requests
echo 1024 > /sys/block/sdca/queue.nr_requests
echo 1024 > /sys/block/sdcb/queue.nr_requests
echo 1024 > /sys/block/sdcc/queue.nr_requests
echo 1024 > /sys/block/sdcd/queue.nr_requests
echo 1024 > /sys/block/sdce/queue.nr_requests
echo 1024 > /sys/block/sdcf/queue.nr_requests
echo 1024 > /sys/block/sdch/queue.nr_requests
echo 1024 > /sys/block/sdci/queue.nr_requests
echo 1024 > /sys/block/sdck/queue.nr_requests
echo 1024 > /sys/block/sdcj/queue.nr_requests
echo 1024 > /sys/block/sdcl/queue.nr_requests
echo 1024 > /sys/block/sdcm/queue.nr_requests
echo 1024 > /sys/block/sdcn/queue.nr_requests
echo 1024 > /sys/block/sdco/queue.nr_requests
echo 1024 > /sys/block/sdcp/queue.nr_requests
echo 1024 > /sys/block/sdcq/queue.nr_requests
echo 1024 > /sys/block/sdcr/queue.nr_requests
echo 1024 > /sys/block/sdcc/queue.nr_requests
echo 1024 > /sys/block/sdcs/queue.nr_requests
echo 1024 > /sys/block/sdct/queue.nr_requests
echo 1024 > /sys/block/sdcu/queue.nr_requests
echo 1024 > /sys/block/sdcv/queue/nr_requests
echo 1024 > /sys/block/sdcw/queue/nr_requests
echo 1024 > /sys/block/sdcx/queue/nr_requests
echo 1024 > /sys/block/sdcy/queue/nr_requests
echo 1024 > /sys/block/sdcz/queue/nr_requests
echo 1024 > /sys/block/sdda/queue/nr_requests

* scheduler.sh *

#!/bin/bash

echo noop > /sys/block/sdb/queue/scheduler
echo noop > /sys/block/sdc/queue/scheduler
echo noop > /sys/block/sdd/queue/scheduler
echo noop > /sys/block/sde/queue/scheduler
echo noop > /sys/block/sdf/queue/scheduler
echo noop > /sys/block/sdg/queue/scheduler
echo noop > /sys/block/sdh/queue/scheduler
echo noop > /sys/block/sdi/queue/scheduler
echo noop > /sys/block/sdj/queue/scheduler
echo noop > /sys/block/sdk/queue/scheduler
echo noop > /sys/block/sdl/queue/scheduler
echo noop > /sys/block/sdm/queue/scheduler
echo noop > /sys/block/sdn/queue/scheduler
echo noop > /sys/block/sdo/queue/scheduler
echo noop > /sys/block/sdp/queue/scheduler
echo noop > /sys/block/sdq/queue/scheduler
APPENDIX D: STORAGE CONFIGURATION CREATION

Environment
First, the CLI commands from the following command file are copied and pasted into the Dorado5000 V3 CLI window. These commands are executed on one of the Host Systems.

- mklun.txt

Next, the following shell script is executed on one of the Host Systems.

- mkvolume.sh

The command files described above are included in the Supporting Files (see Appendix A) and listed below.

Following are the detailed steps involved in creating the storage configuration:

Step 1 - Create Disk Domains, Storage Pools, LUNs
The mklun.txt command file, listed below, includes all the CLI commands to perform the following actions:

- Create 2 disk domains
- Create 2 storage pools
- Create 16 LUNs
- Create one LUN group
- Add the 16 LUNs to the LUN group

Step 2 - Create Mapping View, Host Group and Host
The mklun.txt command file, listed below, includes all the CLI commands to perform the following actions:

- Create 1 mapping view
- Create 1 host group
- Create 8 hosts
- Add the 8 hosts to the host group
- Add the host group and the LUN group to the mapping view
- Add the Fibre Channel ports to the hosts

Step 3 - Create Volumes on the Master Host System
The mkvolume.sh script, listed below, is executed on the Master Host System to perform the following actions:

- Create 16 physical volumes
- Create 1 volume group
- Create 38 logical volumes (18 for ASU-1, 18 for ASU-2 and 2 for ASU-3)
Storage Configuration Creation

```xml
mklun.txt

create disk_domain name=dd0 disk_list=all controller_enclosure_list=CTE0
disk_domain_id=0
create disk_domain name=dd1 disk_list=all controller_enclosure_list=CTE1
disk_domain_id=1
create storage_pool name=pool0 capacity=15554GB disk_domain_id=0 raid_level=RAID6
pool_id=0
create storage_pool name=pool1 capacity=15554GB disk_domain_id=1 raid_level=RAID6
pool_id=1
create lun name=lun1 pool_id=0 capacity=1944GB owner_controller=0A lun_id=1
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun2 pool_id=0 capacity=1944GB owner_controller=0B lun_id=2
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun3 pool_id=1 capacity=1944GB owner_controller=1A lun_id=3
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun4 pool_id=1 capacity=1944GB owner_controller=1B lun_id=4
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun5 pool_id=0 capacity=1944GB owner_controller=0A lun_id=5
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun6 pool_id=0 capacity=1944GB owner_controller=0B lun_id=6
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun7 pool_id=1 capacity=1944GB owner_controller=1A lun_id=7
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun8 pool_id=1 capacity=1944GB owner_controller=1B lun_id=8
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun9 pool_id=0 capacity=1944GB owner_controller=0A lun_id=9
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun10 pool_id=0 capacity=1944GB owner_controller=0B lun_id=10
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun11 pool_id=1 capacity=1944GB owner_controller=1A lun_id=11
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun12 pool_id=1 capacity=1944GB owner_controller=1B lun_id=12
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun13 pool_id=0 capacity=1944GB owner_controller=0A lun_id=13
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun14 pool_id=0 capacity=1944GB owner_controller=0B lun_id=14
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun15 pool_id=1 capacity=1944GB owner_controller=1A lun_id=15
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun name=lun16 pool_id=1 capacity=1944GB owner_controller=1B lun_id=16
lun_type=thin compression_enabled=yes dedup_enabled=no
create lun_group name=lg lun_group_id=1
add lun_group lun lun_group_id=1 lun_id_list=1-16
create mapping_view name=mv mapping_view_id=1
create host_group name=hg host_group_id=1
create host name=h1 operating_system=Linux host_id=1
create host name=h2 operating_system=Linux host_id=2
create host name=h3 operating_system=Linux host_id=3
create host name=h4 operating_system=Linux host_id=4
create host name=h5 operating_system=Linux host_id=5
create host name=h6 operating_system=Linux host_id=6
create host name=h7 operating_system=Linux host_id=7
create host name=h8 operating_system=Linux host_id=8
add host_group host host_group_id=1 host_id_list=1,2,3,4,5,6,7,8
add mapping_view host_group mapping_view_id=1 host_group_id=1
add mapping_view lun_group mapping_view_id=1 lun_group_id=1
add host initiator host host_id=1 initiator_type=FC wwn=21000024ff756e88
add host initiator host host_id=1 initiator_type=FC wwn=21000024ff756e89
add host initiator host host_id=1 initiator_type=FC wwn=21000024ff53330c
add host initiator host host_id=1 initiator_type=FC wwn=21000024ff53330d
```
add host initiator host_id=2 initiator_type=FC wwn=21000024ff543b14
add host initiator host_id=2 initiator_type=FC wwn=21000024ff543b15
add host initiator host_id=2 initiator_type=FC wwn=21000024ff4380b6
add host initiator host_id=2 initiator_type=FC wwn=21000024ff4380b7
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4c3001
add host initiator host_id=3 initiator_type=FC wwn=21000024ff5332b4
add host initiator host_id=3 initiator_type=FC wwn=21000024ff5332b5
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4c3000
add host initiator host_id=4 initiator_type=FC wwn=21000024ff533872
add host initiator host_id=4 initiator_type=FC wwn=21000024ff54527c
add host initiator host_id=4 initiator_type=FC wwn=21000024ff54527d
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5332b4
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5332d4
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5332d5
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4b826a
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4b826b
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4c300c
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4c300d
add host initiator host_id=7 initiator_type=FC wwn=21000024ff3c6b6b
add host initiator host_id=7 initiator_type=FC wwn=21000024ff3c6b69
add host initiator host_id=7 initiator_type=FC wwn=21000024ff540bba
add host initiator host_id=7 initiator_type=FC wwn=21000024ff540bbb
add host initiator host_id=8 initiator_type=FC wwn=21000024ff53b6f2
add host initiator host_id=8 initiator_type=FC wwn=21000024ff53b6f3
add host initiator host_id=8 initiator_type=FC wwn=21000024ff5333c6
add host initiator host_id=8 initiator_type=FC wwn=21000024ff5333c7

mkvolume.sh

pvcreate /dev/sdb
pvcreate /dev/sdc
pvcreate /dev/sdd
pvcreate /dev/sde
pvcreate /dev/sdf
pvcreate /dev/sdg
pvcreate /dev/sdh
pvcreate /dev/sdi
pvcreate /dev/sdj
pvcreate /dev/sdk
pvcreate /dev/sdl
pvcreate /dev/sdm
pvcreate /dev/sdn
pvcreate /dev/sdo
pvcreate /dev/sdp
pvcreate /dev/sdq

vgcreate vg1 /dev/sdb /dev/sdc /dev/sdd /dev/sde /dev/sdf /dev/sdg /dev/sdh /dev/sdi /dev/sdj /dev/sdk /dev/sdl /dev/sdm /dev/sdn /dev/sdo /dev/sdp /dev/sdq

lvcreate -n asu101 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu102 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu103 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu104 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu105 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu106 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu107 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu108 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu109 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu110 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu111 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu112 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu113 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu114 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu115 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu116 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu117 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu118 -i 16 -I 512 -C y -L 630g vg1

lvcreate -n asu201 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu202 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu203 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu204 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu205 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu206 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu207 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu208 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu209 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu210 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu211 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu212 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu213 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu214 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu215 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu216 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu217 -i 16 -I 512 -C y -L 630g vg1
lvcreate -n asu218 -i 16 -I 512 -C y -L 630g vg1

lvcreate -n asu301 -i 16 -I 512 -C y -L 1260g vg1
lvcreate -n asu302 -i 16 -I 512 -C y -L 1260g vg1
APPENDIX E: CONFIGURATION INVENTORY

An inventory of the Tested Storage Configuration was collected before and after the test execution. The test execution script invokes **shstorage.tcl** to collect the inventory profile of the storage configuration. The following log file are generated and are included in the Supporting Files (see Appendix A):

- **profile1_volume.log** List of configured volumes before the INIT Phase.
- **profile1_storage.log** List of configured storage before the INIT Phase.
- **Profile2_volume.log** List of configured volumes after TSC restart.
- **Profile2_storage.log** List of configured storage after TSC restart.

The above script is included in the Supporting Files (see Appendix A) and listed below.

```bash
#!/usr/bin/tclsh

package require Expect
set stor 8.46.177.230
set stor_user admin
set stor_pswd Admin@storage1

proc cmd {str} {
    append str "\r"
    send "\r"
    expect ">
    send $str
    expect {
        -re "More" {
            send " ";
            exp_continue
        }
        -re ">" {
            send "\r"
        }
    }
    set expect_out(buffer) " "
}

spawn ssh $stor_user@$stor
set timeout 60
expect {
    "assword" {
        send "$stor_pswd\r"
    }
    "yes/no" {
        send "yes\r"
        expect "assword";
        send "$stor_pswd\r"
    }
} expect ">

set ddcount 2
```
set poolcount 2
set luncount 16
set mapcount 1

cmd "change user_mode current_mode user_mode=developer"
cmd "show system general"
cmd "show controller general"
sleep 3
send "\003"
cmd "show fan"
cmd "show power_supply"
cmd "change cli capacity_mode=precise"

cmd "show disk_domain general"
for {set i 0} { $i < $ddcount } { incr i } {
    cmd "show disk_domain general disk_domain_id=$i"
sleep 1
    send " "
    send "\r"
    send "\003"
}

cmd "show storage_pool general"
sleep 1
send " "
send "\r"
send "\003"
for {set i 0} { $i < $poolcount } { incr i } {
    cmd "show storage_pool general pool_id=$i"
    sleep 1
    send " "
    send "\r"
    send "\003"
}

for {set i 1} { $i <= $luncount } { incr i } {
    cmd "show lun general lun_id=$i"
sleep 1
    send " "
    send "\r"
    send "\003"
}

sleep 1
send " "
send "\r"
send "\003"
cmd "show disk general"
send "G"
sleep 4
send "\r"
send "\003"
set expect_out(buffer) " "

for {set a 0} { $a <= 24 } { incr a } {
    cmd "show disk general disk_id=CTE0.$a"
    send " "
    send "\r"
send "\003"
}
for {set a 0} { $a <= 24 } { incr a } {
        cmd "show disk general disk_id=CTE1.$a"
        send " "
        send "\r"
        send "\003"
    }

    cmd "change cli capacity_mode=automatic"
    cmd "show mapping_view general"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show mapping_view general mapping_view_id=1"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show mapping_view lun_group mapping_view_id=1"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show mapping_view host_group mapping_view_id=1"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show lun_group lun lun_group_id=1"
    cmd "show host_group host host_group_id=1"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show host general host_id=1"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show host general host_id=2"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show host general host_id=3"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show host general host_id=4"
    sleep 1
    send " "
    send "\r"
    send "\003"
    cmd "show host general host_id=5"
    sleep 1
    send " "
    send "\r"
    send "\003"
APPENDIX E
Configuration Inventory

```bash
cmd "show host general host_id=6"
sleep 1
send " "
send "\r"
send "\003"
cmd "show host general host_id=7"
sleep 1
send " "
send "\r"
send "\003"
cmd "show host general host_id=8"
sleep 1
send " "
send "\r"
send "\003"
cmd "show initiator host_id=1"
sleep 2
send "\r"
cmd "show initiator host_id=2"
sleep 2
send "\r"
cmd "show initiator host_id=3"
sleep 2
send "\r"
cmd "show initiator host_id=4"
sleep 2
send "\r"
cmd "show initiator host_id=5"
sleep 2
send "\r"
cmd "show initiator host_id=6"
sleep 2
send "\r"
cmd "show initiator host_id=7"
sleep 2
send "\r"
cmd "show initiator host_id=8"
sleep 2
send "\r"
cmd "show enclosure"
sleep 2
send "\003"
cmd "show port general physical_type=FC"
sleep 2
send "\003"
cmd "show port general physical_type=SAS"
sleep 2
send "\003"
cmd "show port general"
send "G"
sleep 5
send "\r"
set expect_out(buffer) " "
sleep 5
cmd "show system general"
send "\003"
cmd "show system general"
send "exit\r"
expect ">
send "exit\r"
expect "(y/n):"
```
```bash
send "y\r"
sleep 5
send "exit\r"
expect "closed"
```
APPENDIX F: WORKLOAD GENERATOR

The host parameters for the SPC-1 workload generator were defined using the script `8host.HST`. The ASUs accessed by the SPC-1 workload generator are defined using the script `slave_asu.asu`. The phases of the benchmark are executed using the script `full_run.sh`. The script pauses at the end of the PERSIST_1 test phase. Once the TSC has been restarted, the PERSIST_2 test phase is executed by pressing ENTER from the console where the script has been invoked.

The above script is included in the Supporting Files (see Appendix A) and listed below.

**8host.HST**

```
PORT=1962
LOGIN=root
CONFIG=/root/SPCv302
WEIGHT=1
STORAGE=slave_asu.asu
EXEC=spc1
-- Host Entries
HOST=8.46.177.224
HOST=8.46.177.223
HOST=8.46.177.222
HOST=8.46.177.221
HOST=8.46.177.121
HOST=8.46.177.120
HOST=8.46.177.126
HOST=8.46.177.220
```

**slave_asu.asu**

```
ASU=1
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu101
DEVICE=/dev/vg1/asu102
DEVICE=/dev/vg1/asu103
DEVICE=/dev/vg1/asu104
DEVICE=/dev/vg1/asu105
DEVICE=/dev/vg1/asu106
DEVICE=/dev/vg1/asu107
DEVICE=/dev/vg1/asu108
DEVICE=/dev/vg1/asu109
DEVICE=/dev/vg1/asu110
DEVICE=/dev/vg1/asu111
DEVICE=/dev/vg1/asu112
DEVICE=/dev/vg1/asu113
DEVICE=/dev/vg1/asu114
DEVICE=/dev/vg1/asu115
DEVICE=/dev/vg1/asu116
```
DEVICE=/dev/vg1/asu117
DEVICE=/dev/vg1/asu118

--
ASU=2
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu201
DEVICE=/dev/vg1/asu202
DEVICE=/dev/vg1/asu203
DEVICE=/dev/vg1/asu204
DEVICE=/dev/vg1/asu205
DEVICE=/dev/vg1/asu206
DEVICE=/dev/vg1/asu207
DEVICE=/dev/vg1/asu208
DEVICE=/dev/vg1/asu209
DEVICE=/dev/vg1/asu210
DEVICE=/dev/vg1/asu211
DEVICE=/dev/vg1/asu212
DEVICE=/dev/vg1/asu213
DEVICE=/dev/vg1/asu214
DEVICE=/dev/vg1/asu215
DEVICE=/dev/vg1/asu216
DEVICE=/dev/vg1/asu217
DEVICE=/dev/vg1/asu218

--
ASU=3
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu301
DEVICE=/dev/vg1/asu302

```
full_run.sh
```

```bash
#!/bin/sh
expect shstorage.tcl > profile1_storage.log
date > profile1_volume.log
lvdisplay >> profile1_volume.log
date >> profile1_volume.log
date >> profile1_volume.log

spc1 -run SPC1_INIT -iops 45000 -storage slave_asu.asu -output
~/newtool/spc1_INIT_45k_iops -master 8host.HST
spc1 -run SPC1_VERIFY -iops 100 -storage slave_asu.asu -output
~/newtool/spc1_VERIFY1_100_iops
spc1 -run SPC1_METRICS -iops 800000 -storage slave_asu.asu -output
~/newtool/spc1_METRICS_800k_iops -master 8host.HST
spc1 -run SPC1_VERIFY -iops 100 -storage slave_asu.asu -output
~/newtool/spc1_VERIFY2_100_iops
spc1 -run SPC1_PERSIST_1 -iops 200000 -storage slave_asu.asu -output
~/newtool/spc1_PERSIST_200k_iops -master 8host.HST

echo "Power cycle TSC, then Enter to continue"
read

expect shstorage.tcl > profile2_storage.log
date > profile2_volume.log
lvdisplay >> profile2_volume.log
date >> profile2_volume.log
date >> profile2_volume.log

spc1 -run SPC1_PERSIST_2 -iops 200000 -storage slave_asu.asu -output
~/newtool/spc1_PERSIST_200k_iops -master 8host.HST