TPC Benchmark™ DS
Full Disclosure Report
for
Alibaba Cloud AnalyticDB (ADB)
(with 18 Alibaba AnalyticDB Elastic Compute Unit)
using
Alibaba Cloud AnalyticDB 3.0.11
and
Alibaba Group Enterprise Linux Server release 7.2 (Paladin)

First Edition

May 02, 2020
First Edition – May, 2020

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# Table of Contents

**Abstract**  
5

**Preface**  
11  
TPC Benchmark™ DS Overview  
11

**General Items**  
12  
0.1 Test Sponsor  
12  
0.2 Parameter Settings  
12  
0.3 Configuration Diagrams  
12

**Clause 2: Logical Database Design Related Items**  
14  
2.1 Database Definition Statements  
14  
2.2 Physical Organization  
14  
2.3 Horizontal Partitioning  
14  
2.4 Replication  
14

**Clause 3: Scaling and Database Population**  
15  
3.1 Initial Cardinality of Tables  
15  
3.2 Distribution of Tables and Logs Across Media  
15  
3.3 Mapping of Database Partitions/Replications  
16  
3.4 Implementation of RAID  
16  
3.5 DBGEN Modifications  
16  
3.6 Database Load time  
16  
3.7 Data Storage Ratio  
17  
3.8 Database Load Mechanism Details and Illustration  
17  
3.9 Qualification Database Configuration  
17

**Clause 4 and 5: Query and Data Maintenance Related Items**  
18  
4.1 Query Language  
18  
4.2 Verifying Method of Random Number Generation  
18  
4.3 Generating Values for Substitution Parameters  
18  
4.4 Query Text and Output Data from Qualification Database  
18  
4.5 Query Substitution Parameters and Seeds Used  
19  
4.6 Refresh Setting  
19  
4.7 Source Code of Refresh Functions  
19  
4.8 Staging Area  
19

**Clause 6: Data Persistence Properties Related Items**  
20

**Clause 7: Performance Metrics and Execution Rules Related Items**  
21  
7.1 System Activity  
21  
7.2 Test Steps  
21  
7.3 Timing Intervals for Each Query and Refresh Function  
21  
7.4 Throughput Test Result  
21  
7.5 Time for Each Stream  
21  
7.6 Time for Each Refresh Function  
21  
7.7 Performance Metrics  
21

**Clause 8: SUT and Driver Implementation Related Items**  
22
Clause 9: Pricing Related Items
  9.1 Hardware and Software Used
  9.2 Availability Date
  9.3 Country-Specific Pricing

Clause 11: Audit Related Items
  Auditor’s Information and Attestation Letter

Supporting Files Index

Appendix A: Provisioning Compute Services

Appendix B: Third Party Price Quotes
Abstract

This document contains the methodology and results of the TPC Benchmark™ DS (TPC-DS) test conducted in conformance with the requirements of the TPC-DS Standard Specification, Revision 2.11.0.

The test was conducted at a Scale Factor of 10000GB with 18 AnalyticDB ECU running Alibaba Cloud AnalyticDB version 3.0.11 on Alibaba Group Enterprise Linux Server release 7.2 (Paladin).

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Cluster Node</th>
<th>Database Software</th>
<th>Operation System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alibaba Cloud Computing Ltd.</td>
<td>Alibaba Cloud AnalyticDB Elastic Compute Unit</td>
<td>Alibaba Cloud AnalyticDB 3.0.11</td>
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</table>

TPC Benchmark™ DS Metrics

<table>
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<tr>
<th>Total System Cost (RMB)</th>
<th>TPC-DS Throughput (QphDS@10000GB)</th>
<th>Price/Performance (RMB/QphDS@10000GB)</th>
<th>Availability Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>¥1,126,006.68</td>
<td>14,895,566</td>
<td>¥0.08</td>
<td>As of Publication</td>
</tr>
</tbody>
</table>
## Alibaba Cloud AnalyticDB

### Full Disclosure Report

**TPC Benchmark DS**

<table>
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<tr>
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<th>TPC-DS Throughput</th>
<th>Price/Performance</th>
<th>System Availability Date</th>
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<td>14,895,566 QphDS@10000GB</td>
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<table>
<thead>
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<th>Database Manager</th>
<th>Operation System</th>
<th>Other Software</th>
<th>Cluster</th>
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<td>10,000 GB</td>
<td>Alibaba Cloud AnalyticDB 3.0.11</td>
<td>Alibaba Group Enterprise Linux Server 7.2 (Paladin)</td>
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<td>Yes</td>
</tr>
</tbody>
</table>

### Benchmarked Configuration

- **ADB instance**
  - 18 x ADB ECU.C52
  - 25GbE

### Elapsed Time

- **Load includes backup = No**
- **RAID = No**

### System Configuration:

- **Alibaba Cloud AnalyticDB Cluster**
  - Servers: 18 x ECU C52
  - Total Processors/Cores/Threads: 936 virtual cores (threads)
  - Total Memory: 6,912 GB
  - Total Storage²: 144,000 GB
  - Storage Ratio³: 14.4

### Server Configuration:

- **Per node (ECU C52)**
  - Processors/Cores/Threads: 52 virtual cores (threads)
  - Memory: 384 GB
  - Network: 25Gbps
  - Storage Device: 8,000 GB SSD (4 x 2,000 GB NVMe)

---

¹ Dataset Size includes only raw data (i.e., no temp, index, redundant storage space, etc.).
² Total Storage = 8,000 * 18 (ECU SSD) = 144,000 GB
³ Storage Ratio = Total Storage / SF = 144,000 GB / 10,000 GB
## Alibaba Cloud AnalyticDB

**TPC-DS: 2.11.0**  
**TPC-Pricing: 2.5.0**  
**Report Date: May, 02, 2020**

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
<th>Src</th>
<th>Unit Price (RMB)</th>
<th>Qty</th>
<th>Ext. Price (RMB)</th>
<th>3-Year Maint. (RMB)</th>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>- CS2 Node Group (3 ECU nodes per group)</td>
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<td>Licence Computer and Software Services Sub-Total</td>
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<td></td>
</tr>
</tbody>
</table>

| Other Components                                  |             |         |                  |     |                  |                     |
| Lenovo Mix 210 Laptop (includes spares)           |             |         | 1,099.00         | 3   | 3,297.00         |                     |
| Other Components Sub-Total                        |             |         | 3,297.00         |     | 0.00             |                     |

1 = Alibaba Cloud, 2 = Tmail.com

| 3-Year Cost of Ownership                          |             |         | 1,126,006.68     |     |                  |                     |
| QphDs@10000GB                                    |             |         | 14,895,566       |     |                  |                     |

Audited by Francois Raab, Infosizing

RMB/QphDs@10000GB 0.08

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed components. For complete details, see the pricing sections of the TPC benchmark specifications. If you find that the stated prices are not available according to these terms, please inform at pricing@tpc.org. Thank you.
### Metrics Details:

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
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</thead>
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<tr>
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<td>Streams</td>
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<td>Second</td>
</tr>
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<td>Hour</td>
</tr>
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<td>T_power</td>
<td>1,130.2</td>
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</tr>
<tr>
<td>T_pt</td>
<td>1.2558</td>
<td>Hour</td>
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<tr>
<td>T_ttl</td>
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</tr>
<tr>
<td>T_ttl</td>
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<td>Second</td>
</tr>
<tr>
<td>T_dm1</td>
<td>284.7</td>
<td>Second</td>
</tr>
<tr>
<td>T_dm2</td>
<td>233.3</td>
<td>Second</td>
</tr>
<tr>
<td>T_tt</td>
<td>2.1428</td>
<td>Hour</td>
</tr>
<tr>
<td>T_dm</td>
<td>0.1439</td>
<td>Hour</td>
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</table>

<table>
<thead>
<tr>
<th>Load Step</th>
<th>Start</th>
<th>End</th>
<th>(sec.)</th>
<th>(hh:mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build</td>
<td>04/28/20 16:03:24.75</td>
<td>04/28/20 16:22:39.03</td>
<td>1,154.28</td>
<td>0:19:14</td>
</tr>
<tr>
<td>Audit</td>
<td>04/28/20 16:22:39.03</td>
<td>04/28/20 17:23:45.80</td>
<td>3,666.77</td>
<td>1:01:07</td>
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<tr>
<td>Finish</td>
<td>04/28/20 17:23:45.80</td>
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<td>0:00:00</td>
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<tr>
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<table>
<thead>
<tr>
<th>Test</th>
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<th>End</th>
<th>(sec.)</th>
<th>(hh:mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>04/28/20 17:35:31.31</td>
<td>04/28/20 17:54:21.51</td>
<td>1,130.20</td>
<td>0:18:50</td>
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<tr>
<td>Thruput-1</td>
<td>04/28/20 17:54:21.52</td>
<td>04/28/20 18:55:44.21</td>
<td>3,682.69</td>
<td>1:01:23</td>
</tr>
<tr>
<td>DM-1</td>
<td>04/28/20 18:55:44.22</td>
<td>04/28/20 19:00:28.91</td>
<td>284.69</td>
<td>0:04:45</td>
</tr>
<tr>
<td>Thruput-2</td>
<td>04/28/20 19:00:28.92</td>
<td>04/28/20 20:07:40.01</td>
<td>4,031.09</td>
<td>1:07:11</td>
</tr>
<tr>
<td>DM-2</td>
<td>04/28/20 20:07:40.01</td>
<td>04/28/20 20:11:33.24</td>
<td>233.23</td>
<td>0:03:53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stream</th>
<th>Start</th>
<th>End</th>
<th>(sec.)</th>
<th>(hh:mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt - 0</td>
<td>04/28/20 17:35:31.31</td>
<td>04/28/20 17:54:21.51</td>
<td>1,130.20</td>
<td>0:18:50</td>
</tr>
<tr>
<td>Tt1 - 1</td>
<td>04/28/20 17:54:21.52</td>
<td>04/28/20 18:55:44.21</td>
<td>3,682.69</td>
<td>1:01:23</td>
</tr>
<tr>
<td>Tt1 - 3</td>
<td>04/28/20 17:54:21.52</td>
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<td>3,610.25</td>
<td>1:00:10</td>
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<tr>
<td>Tt1 - 4</td>
<td>04/28/20 17:54:21.52</td>
<td>04/28/20 18:51:59.16</td>
<td>3,457.64</td>
<td>0:57:38</td>
</tr>
<tr>
<td>Tt2 - 5</td>
<td>04/28/20 19:00:28.92</td>
<td>04/28/20 20:07:40.01</td>
<td>4,031.09</td>
<td>1:07:11</td>
</tr>
<tr>
<td>Tt2 - 6</td>
<td>04/28/20 19:00:28.92</td>
<td>04/28/20 20:06:43.79</td>
<td>3,974.87</td>
<td>1:06:15</td>
</tr>
<tr>
<td>Tt2 - 7</td>
<td>04/28/20 19:00:28.92</td>
<td>04/28/20 20:07:20.53</td>
<td>4,011.61</td>
<td>1:06:52</td>
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<tr>
<td>Tt2 - 8</td>
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<td>4,007.96</td>
<td>1:06:48</td>
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<tr>
<td>DMt1 - 1</td>
<td>04/28/20 18:55:44.22</td>
<td>04/28/20 18:58:26.91</td>
<td>162.69</td>
<td>0:02:43</td>
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<tr>
<td>DMt1 - 2</td>
<td>04/28/20 18:58:26.90</td>
<td>04/28/20 19:00:28.91</td>
<td>122.01</td>
<td>0:02:02</td>
</tr>
<tr>
<td>DMt2 - 3</td>
<td>04/28/20 20:07:40.01</td>
<td>04/28/20 20:09:34.98</td>
<td>114.97</td>
<td>0:01:55</td>
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<tr>
<td>DMt2 - 4</td>
<td>04/28/20 20:09:34.98</td>
<td>04/28/20 20:11:33.24</td>
<td>118.26</td>
<td>0:01:58</td>
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</tbody>
</table>
## Timing Intervals for Queries (in Seconds)

<table>
<thead>
<tr>
<th>Query</th>
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<th>Stream 2</th>
<th>Stream 3</th>
<th>Stream 4</th>
<th>Stream 5</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>2</td>
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<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
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<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
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<tr>
<td>4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Notes:**
- Queries are listed in the first column, followed by the corresponding timing intervals for Stream 1 to Stream 5.
### Timing Intervals for Refresh Functions (in Seconds)

<table>
<thead>
<tr>
<th>DM Fx</th>
<th>R-Run 1</th>
<th>R-Run 2</th>
<th>R-Run 3</th>
<th>R-Run 4</th>
<th>Min</th>
<th>25%tile</th>
<th>Median</th>
<th>75%tile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF_CS</td>
<td>64.4</td>
<td>39.3</td>
<td>31.1</td>
<td>36.6</td>
<td>31.1</td>
<td>35.2</td>
<td>38.0</td>
<td>45.6</td>
<td>64.4</td>
</tr>
<tr>
<td>DF_CS</td>
<td>13.9</td>
<td>13.0</td>
<td>5.1</td>
<td>4.3</td>
<td>4.3</td>
<td>4.9</td>
<td>9.0</td>
<td>13.2</td>
<td>13.9</td>
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<tr>
<td>DF_SS</td>
<td>73.0</td>
<td>62.7</td>
<td>46.0</td>
<td>58.2</td>
<td>46.0</td>
<td>55.1</td>
<td>60.5</td>
<td>65.3</td>
<td>73.0</td>
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<td>29.9</td>
<td>19.3</td>
<td>26.9</td>
<td>19.3</td>
<td>25.0</td>
<td>28.4</td>
<td>36.3</td>
<td>55.6</td>
</tr>
<tr>
<td>LF.CR</td>
<td>30.2</td>
<td>17.5</td>
<td>18.3</td>
<td>17.1</td>
<td>17.1</td>
<td>17.4</td>
<td>17.9</td>
<td>21.3</td>
<td>30.2</td>
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<td>40.8</td>
<td>43.7</td>
<td>48.1</td>
<td>55.8</td>
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<tr>
<td>LF_J</td>
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<td>15.3</td>
<td>15.0</td>
<td>15.2</td>
<td>15.9</td>
<td>19.9</td>
<td>29.7</td>
</tr>
<tr>
<td>LF_SR</td>
<td>30.1</td>
<td>17.6</td>
<td>18.5</td>
<td>17.3</td>
<td>17.3</td>
<td>17.5</td>
<td>18.1</td>
<td>21.4</td>
<td>30.1</td>
</tr>
<tr>
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<td>42.5</td>
<td>46.6</td>
<td>52.7</td>
<td>59.6</td>
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<td>13.6</td>
<td>13.7</td>
<td>12.4</td>
<td>13.3</td>
<td>13.6</td>
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<td>29.7</td>
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<tr>
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<td>36.0</td>
<td>20.3</td>
<td>31.2</td>
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<td>20.3</td>
<td>21.5</td>
<td>26.6</td>
<td>32.4</td>
<td>36.0</td>
</tr>
</tbody>
</table>
Preface

TPC Benchmark™ DS Overview

The TPC Benchmark™ DS (TPC-DS) is a decision support benchmark that models several generally applicable aspects of a decision support system, including queries and data maintenance. The benchmark provides a representative evaluation of performance as a general-purpose decision support system.

This benchmark illustrates decision support systems that:

- Examine large volumes of data;
- Give answers to real-world business questions;
- Execute queries of various operational requirements and complexities (e.g., ad-hoc, reporting, iterative OLAP, data mining);
- Are characterized by high CPU and IO load;
- Are periodically synchronized with source OLTP databases through database maintenance functions.
- Run on “Big Data” solutions, such as RDBMS as well as Hadoop/Spark based systems.

A benchmark result measures query response time in single user mode, query throughput in multi user mode and data maintenance performance for a given hardware, operating system, and data processing system configuration under a controlled, complex, multi-user decision support workload.

The purpose of TPC benchmarks is to provide relevant, objective performance data to industry users. To achieve that purpose, TPC benchmark specifications require benchmark tests be implemented with systems, products, technologies and pricing that:

a) Are generally available to users;
b) Are relevant to the market segment that the individual TPC benchmark models or represents (e.g., TPC-DS models and represents complex, high data volume, decision support environments);
c) Would plausibly be implemented by a significant number of users in the market segment modeled or represented by the benchmark.

In keeping with these requirements, the TPC-DS database must be implemented using commercially available data processing software, and its queries must be executed via SQL interface. The use of new systems, products, technologies (hardware or software) and pricing is encouraged so long as they meet the requirements above. Specifically prohibited are benchmark systems, products, technologies or pricing (hereafter referred to as "implementations") whose primary purpose is performance optimization of TPC benchmark results without any corresponding applicability to real-world applications and environments. In other words, all "benchmark special" implementations, which improve benchmark results but not real-world performance or pricing, are prohibited.

TPC benchmark results are expected to be accurate representations of system performance. Therefore, there are specific guidelines that are expected to be followed when measuring those results. The approach or methodology to be used in the measurements are either explicitly described in the specification or left to the discretion of the test sponsor.

When not described in the specification, the methodologies and approaches used must meet the following requirements:

- The approach is an accepted engineering practice or standard;
- The approach does not enhance the result;
- Equipment used in measuring the results is calibrated according to established quality standards;
- Fidelity and candor is maintained in reporting any anomalies in the results, even if not specified in the benchmark requirements.

Further information is available at http://www.tpc.org/
General Items

0.1 Test Sponsor

A statement identifying the benchmark sponsor(s) and other participating companies must be provided.

This benchmark was sponsored by Alibaba Cloud Computing Ltd.

0.2 Parameter Settings

Settings must be provided for all customer-tunable parameters and options which have been changed from the defaults found in actual products, including by not limited to:

- Database Tuning Options
- Optimizer/Query execution options
- Query processing tool/language configuration parameters
- Recovery/commit options
- Consistency/locking options
- Operating system and configuration parameters
- Configuration parameters and options for any other software component incorporated into the pricing structure
- Compiler optimization options

This requirement can be satisfied by providing a full list of all parameters and options, as long as all those which have been modified from their default values have been clearly identified and these parameters and options are only set once.

Default ADB configuration parameters and options are used.

0.3 Configuration Diagrams

Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences. This includes, but is not limited to:

- Number and type of processors
- Size of allocated memory, and any specific mapping/partitioning of memory unique to the test. Number and type of disk units (and controllers, if applicable).
- Number of channels or bus connections to disk units, including their protocol type.
- Number of LAN (e.g. Ethernet) Connections, including routers, workstations, terminals, etc., that were physically used in the test or are incorporated into the pricing structure.
- Type and the run-time execution location of software components (e.g., DBMS, query processing tools/languages, middle-ware components, software drivers, etc.).
Measured Configuration

The measured configuration consisted of 18 ECUs:

ECU details (18 ECUs):
- ECU Instance Type: C52
- Processors: 52 virtual cores (threads)
- Memory: 384 GB
- Storage:
  - 8,000 GB SSD Local Disk (data disk)
- Network:
  - Bandwidth (Gbit/s): 25.0

AnalyticDB System Components Configuration

<table>
<thead>
<tr>
<th>ECU</th>
<th>Coordinator</th>
<th>Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Coordinator</td>
<td>Worker</td>
</tr>
<tr>
<td>1-18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Priced Configuration

There are no differences between the priced and measured configurations.
Clause 2: Logical Database Design Related Items

2.1 Database Definition Statements

Listings must be provided for the DDL scripts and must include all table definition statements and all other statements used to set up the test and qualification databases.

The Supporting File Archive contains the table definitions and all other statements used to set up the test and qualification databases.

2.2 Physical Organization

The physical organization of tables and indices within the test and qualification databases must be disclosed. If the column ordering of any table is different from that specified in Clause 2.3 or 2.4, it must be noted.

Horizontal partitioning is used as described in 2.3.

2.3 Horizontal Partitioning

If any directives to DDLs are used to horizontally partition tables and rows in the test and qualification databases, these directives, DDLs, and other details necessary to replicate the partitioning behavior must be disclosed.

All tables are partitioned. The partition columns for the tables are:
call_center: cc_call_center_sk
catalog_page: cp_catalog_page_sk
customer: c_customer_sk
customer_address: ca_address_sk
customer_demographics: cd_demo_sk
date_dim: d_date_sk
household_demographics: hd_demo_sk
income_band: ib_income_band_sk
item: i_item_sk
promotion: p_promo_sk
reason: r_reason_sk
ship_mode: sm_ship_mode_sk
store: s_store_sk
time_dim: t_time_sk
warehouse: w_warehouse_sk
web_page: wp_web_page_sk
web_site: web_site_sk
catalog_sales: cs_item_sk, cs_sold_date_sk
catalog_returns: cr_item_sk, cr_returned_date_sk
inventory: inv_item_sk, inv_date_sk
store_returns: sr_item_sk, sr_returned_date_sk
store_sales: ss_item_sk, ss_sold_date_sk
web_returns: wr_item_sk, wr_returned_date_sk
web_sales: ws_item_sk, ws_sold_date_sk

2.4 Replication

Any replication of physical objects must be disclosed and must conform to the requirements of Clause 2.5.3.

No physical object was replicated.
Clause 3: Scaling and Database Population

3.1 Initial Cardinality of Tables

The cardinality (e.g., the number of rows) of each table of the test database, as it existed at the completion of the database load (see Clause 7.1.2) must be disclosed.

Table 3.1 lists the cardinality of each table as they existed upon completion of the build.

<table>
<thead>
<tr>
<th>Table Name</th>
<th>Row Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>call_center</td>
<td>54</td>
</tr>
<tr>
<td>catalog_page</td>
<td>40,000</td>
</tr>
<tr>
<td>catalog_returns</td>
<td>1,440,033,112</td>
</tr>
<tr>
<td>catalog_sales</td>
<td>14,399,964,710</td>
</tr>
<tr>
<td>customer</td>
<td>65,000,000</td>
</tr>
<tr>
<td>customer_address</td>
<td>32,500,000</td>
</tr>
<tr>
<td>customer_demographics</td>
<td>1,920,800</td>
</tr>
<tr>
<td>date_dim</td>
<td>73,049</td>
</tr>
<tr>
<td>household_demographics</td>
<td>7,200</td>
</tr>
<tr>
<td>income_band</td>
<td>20</td>
</tr>
<tr>
<td>inventory</td>
<td>1,311,525,000</td>
</tr>
<tr>
<td>item</td>
<td>402,000</td>
</tr>
<tr>
<td>promotion</td>
<td>2,000</td>
</tr>
<tr>
<td>reason</td>
<td>70</td>
</tr>
<tr>
<td>ship_mode</td>
<td>20</td>
</tr>
<tr>
<td>store</td>
<td>1,500</td>
</tr>
<tr>
<td>store_returns</td>
<td>2,879,889,326</td>
</tr>
<tr>
<td>store_sales</td>
<td>28,800,122,710</td>
</tr>
<tr>
<td>time_dim</td>
<td>86,400</td>
</tr>
<tr>
<td>warehouse</td>
<td>25</td>
</tr>
<tr>
<td>web_page</td>
<td>4,002</td>
</tr>
<tr>
<td>web_returns</td>
<td>720,020,485</td>
</tr>
<tr>
<td>web_sales</td>
<td>7,199,963,324</td>
</tr>
<tr>
<td>web_site</td>
<td>78</td>
</tr>
</tbody>
</table>

3.2 Distribution of Tables and Logs Across Media

The distribution of tables and logs across all media must be explicitly described using a format similar to that shown in the following example for both the tested and priced systems.
### Table 3.2 Distribution of Tables and Logs

<table>
<thead>
<tr>
<th>Server Node</th>
<th>Disk Type</th>
<th>Disk drive</th>
<th>Description of Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinator (1-2)</td>
<td>Local SSD Disk</td>
<td>/dev/nvme0n1</td>
<td>event log and transaction log</td>
</tr>
<tr>
<td>worker (1-18)</td>
<td>Local SSD Disk</td>
<td>/dev/nvme[0-3]n1</td>
<td>event log, temp files, cache of table data</td>
</tr>
</tbody>
</table>

All the base Tables were stored on local storage.

Table size on local storage:
- `store_sales`: 3996GB
- `catalog_sales`: 3024GB
- `web_sales`: 1512GB
- `store_returns`: 342GB
- `catalog_returns`: 234GB
- `web_returns`: 104.4GB
- `inventory`: 28.8GB
- `customer`: 8576MB
- `customer_address`: 3510MB
- `customer_demographics`: 79MB
- `item`: 110MB
- `time_dim`: 4.8MB
- `catalog_page`: 5.4MB
- `date_dim`: 9.9MB
- `household_demographics`: 156KB
- `call_center`: 24KB
- `promotion`: 252KB
- `web_site`: 28KB
- `web_page`: 392KB
- `store`: 396KB
- `income_band`: 8KB
- `reason`: 8KB
- `ship_mode`: 8KB
- `warehouse`: 8KB

### 3.3 Mapping of Database Partitions/Replications

*The mapping of database partitions/replications must be explicitly described.*

Neither database partitions nor replications were mapped to specific devices.

### 3.4 Implementation of RAID

*Implementations may use some form of RAID. The RAID level used must be disclosed for each device. If RAID is used in an implementation, the logical intent of its use must be disclosed.*

For each ECU node, a logical volume is created on four PCIe NVMe drives and all data is stored in this logical volume.

### 3.5 DBGEN Modifications

*The version number (i.e., the major revision number, the minor revision number, and third tier number) of dsdgen must be disclosed. Any modifications to the dsdgen source code (see Appendix B:) must be disclosed. In the event that a program other than dsdgen was used to populate the database, it must be disclosed in its entirety.*

Dsdgen version v2.11.0rc2 was used. No changes were made to the dsdgen tool.

### 3.6 Database Load time

*The database load time for the test database (see Clause 7.4.3.7) must be disclosed.*

The database load time was 1154.3 seconds.
3.7 Data Storage Ratio

The data storage ratio must be disclosed. It is computed by dividing the total data storage of the priced configuration (expressed in GB) by \( SF \) corresponding to the scale factor chosen for the test database as defined in Clause 3.1. The ratio must be reported to the nearest 1/100th, rounded up. For example, a system configured with 96 disks of 2.1 GB capacity for a 100GB test database has a data storage ratio of 2.02.

The data storage ratio is \( \frac{144,000}{10,000} = 14.4 \)

Total Storage Capacity (Local node) = 18 (ECU) * 8,000GB = 144,000 GB

3.8 Database Load Mechanism Details and Illustration

The details of the database load must be disclosed, including a block diagram illustrating the overall process. Disclosure of the load procedure includes all steps, scripts, input and configuration files required to completely reproduce the test and qualification databases.

The database was built as shown in Figure 3.8. All of the related source code and scripts are included in the Supporting Files.

![Figure 3.8: Block Diagram of database build process](image)

The final database load time is calculated as (load end time – load start time – duration of validation scripts).

3.9 Qualification Database Configuration

Any differences between the configuration of the qualification database and the test database must be disclosed.

The qualification database was built using the same scripts as the test database with the following exceptions:

- The Scale factor is adjusted to 1 GB

All of the related source code and scripts are included in the Supporting Files.
Clause 4 and 5: Query and Data Maintenance Related Items

4.1 Query Language

The query language used to implement the queries must be identified.

SQL was the query language used to implement the queries.

4.2 Verifying Method of Random Number Generation

The method of verification for the random number generation must be described unless the supplied dsdgen and dsqgen were used.

TPC-supplied dsdgen version 2.11.0rc2 and dsqgen version 2.11.0rc2 were used.

4.3 Generating Values for Substitution Parameters

The method used to generate values for substitution parameters must be disclosed. The version number (i.e., the major revision number, the minor revision number, and third tier number) of dsqgen must be disclosed.

TPC supplied dsqgen version 2.11.0rc2 was used to generate the substitution parameters, as follows:

```
/dsqgen \
  -directory $modified_tpl_dir \
  -input $modified_tpl_dir/templates.lst \
  -scale ${sf} \
  -streams 9 \
  -output_dir $output_dir \
  -dialect adb \
  -rngseed $SEED
```

4.4 Query Text and Output Data from Qualification Database

The executable query text used for query validation must be disclosed along with the corresponding output data generated during the execution of the query text against the qualification database. If minor modifications have been applied to any functional query definitions or approved variants in order to obtain executable query text, these modifications must be disclosed and justified. The justification for a particular minor query modification can apply collectively to all queries for which it has been used. The output data for the power and Throughput Tests must be made available electronically upon request.

Supporting Files Archive contains the actual query text and query output. Following are the modifications to the query.

The following MQM are used:

- Use vendor-specific syntax of date expressions. (MQM f.1)
  - Q5
  - Q12
  - Q16
  - Q20
  - Q21
  - Q32
  - Q37
  - Q40
  - Q72
  - Q77
4.5 Query Substitution Parameters and Seeds Used

All the query substitution parameters used during the performance test must be disclosed in tabular format, along with the seeds used to generate these parameters.

The Supporting Files Archive contains the query substitution parameters and seed used in the test.

4.6 Refresh Setting

All query and refresh session initialization parameters, settings and commands must be disclosed.

The Supporting Files Archive contains the query and scripts, along with initialization parameters and settings.

4.7 Source Code of Refresh Functions

The details of how the data maintenance functions were implemented must be disclosed (including source code of any non-commercial program used).

The Supporting Files Archive contains the source code implementing the refresh functions.

4.8 Staging Area

Any object created in the staging area (see Clause 5.1.8 for definition and usage restrictions) used to implement the data maintenance functions must be disclosed. Also, any disk storage used for the staging area must be priced, and any mapping or virtualization of disk storage must be disclosed.

Loading refreshing data from external tables
Clause 6: Data Persistence Properties Related Items

The results of the data accessibility tests must be disclosed along with a description of how the data accessibility requirements were met.

The data accessibility test was performed by failing the local storage of one ADB ECU. This failure was induced during the execution of the first data maintenance test.

The logical volume on each ECU is made of 4 PCIe NVMe. The storage failure was simulated by removing access to 1 of the PCIe NVMe.

The Supporting Files Archive contains the logs of status before and after the storage failures.
Clause 7: Performance Metrics and Execution Rules
Related Items

7.1 System Activity

Any system activity on the SUT that takes place between the conclusion of the load test and the beginning of the performance test must be fully disclosed including listings of scripts or command logs.

The only activity between the end of the load test and the beginning of the performance test was the generation of the executable query text.

7.2 Test Steps

The details of the steps followed to implement the performance test must be disclosed.

The Supporting Files Archive contains the scripts and logs.

7.3 Timing Intervals for Each Query and Refresh Function

The timing intervals defined in Clause 7 must be disclosed.

See the Executive Summary at the beginning of this report.

7.4 Throughput Test Result

For each Throughput Test, the minimum, the 25th percentile, the median, the 75th percentile, and the maximum times for each query shall be reported.

See the Executive Summary at the beginning of this report.

7.5 Time for Each Stream

The start time and finish time for each query stream must be reported.

See the Executive Summary at the beginning of this report.

7.6 Time for Each Refresh Function

The start time and finish time for each data maintenance function in the refresh run must be reported for the Throughput Tests.

See the Executive Summary at the beginning of this report.

7.7 Performance Metrics

The computed performance metric, related numerical quantities and the price/performance metric must be reported.

\[ \text{QphDS@10000GB} = 14,895,566 \]

See the Executive Summary at the beginning of this report for more detail.
Clause 8: SUT and Driver Implementation Related Items

8.1 Driver

A detailed textual description of how the driver performs its functions, how its various components interact and any product functionalities or environmental settings on which it relies must be provided. All related source code, scripts and configuration files must be disclosed. The information provided should be sufficient for an independent reconstruction of the driver.

The Mysql compatible ADB client was used to submit the queries. It connects to the ADB instance via JDBC. The command is: mysql -h${host} –P${port} -Dtpcds10000 -A -c

The ADB instance accepts SQL queries from the ADB clients and processes the queries. All queries are compiled on the ADB Coordinator node and then dispatched to the ADB worker nodes as distributed tasks. When the tasks finish, their result is collected by the Coordinator which sends the query output to the ADB client.

The Supporting Files Archive contains all the command, scripts and logs.

8.2 Implementation Specific Layer (ISL)

If an implementation specific layer is used, then a detailed description of how it performs its functions, how its various components interact and any product functionalities or environmental settings on which it relies must be provided. All related source code, scripts and configuration files must be disclosed. The information provided should be sufficient for an independent reconstruction of the implementation specific layer.

No Implementation Specific Layer was used.

8.3 Profile-Directed Optimization

If profile-directed optimization as described in Clause 7.2.10 is used, such use must be disclosed. In particular, the procedure and any scripts used to perform the optimization must be disclosed.

Profile-directed optimization was not used.
Clause 9: Pricing Related Items

9.1 Hardware and Software Used

A detailed list of hardware and software used in the priced system must be reported. The rules for pricing are included in the current revision of the TPC Pricing Specification located on the TPC website (http://www.tpc.org).

A detailed list of all licensed services, hardware and software, is provided in the Executive Summary of this report.

9.2 Availability Date

The System Availability Date (see Clause 7.6.5) must be the single availability date reported on the first page of the executive summary. The full disclosure report must report Availability Dates individually for at least each of the categories for which a pricing subtotal must be. All Availability Dates required to be reported must be disclosed to a precision of 1 day, but the precise format is left to the test sponsor.

The total system is available as of the date of this report.

9.3 Country-Specific Pricing

Additional Clause 7 related items may be included in the full disclosure report for each country specific priced configuration.

The configuration is priced in RMB for the China market.
Clause 11: Audit Related Items

Auditor’s Information and Attestation Letter

The auditor’s agency name, address, phone number, and attestation letter with a brief audit summary report indicating compliance must be included in the full disclosure report. A statement should be included specifying whom to contact in order to obtain further information regarding the audit process.

This benchmark was audited by: Francois Raab, of InfoSizing.

Benchmark sponsor: Liang Lin
Alibaba Cloud Intelligence Business Group
969 West Wen Yi Road
Yu Hang District, Hangzhou
Zhejiang, China

May 2, 2020 (revised May 17, 2020)

I verified the TPCBenchmark™DS(2.11.0) performance of the following configuration:

Platform: Alibaba Cloud AnalyticDB (ADB)
on Alibaba Cloud Elastic Compute Unit (ECU)

Operating System: Alibaba Group Enterprise Linux Server 7.2 (Paladin)
Database Manager: Alibaba Cloud AnalyticDB 3.0.11

The results were:

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Load Time</td>
<td>14,895,566 QphDS@10000GB</td>
</tr>
<tr>
<td>Servers</td>
<td>Alibaba Cloud Elastic Compute Unit (ECU)</td>
</tr>
<tr>
<td>CPUs</td>
<td>52 x Virtual Cores (threads)</td>
</tr>
<tr>
<td>Memory</td>
<td>384 GB</td>
</tr>
<tr>
<td>Storage</td>
<td>4 x 2,000 GB</td>
</tr>
</tbody>
</table>

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

The following verification items were given special attention:

- The database records were defined with the proper layout and size
- The database population was generated using Ddgen
- The database was properly scaled to 10,000GB and populated accordingly
- The database load time was correctly measured and reported
The query templates were produced using approved minor query modifications and query variants

- The query input variables were generated by Dsogen
- The execution of the queries against the qualification database produced compliant output
- The tests were driven and sequenced according to the requirements
- The throughput tests involved 4 query streams
- The execution times for queries and data maintenance functions were correctly measured and reported
- The data accessibility test was performed and verified
- The system pricing was verified for major components and maintenance
- The major pages from the FDR were verified for accuracy

Additional Audit Notes:

In the course of the benchmark execution and the independent audit process, a number of issues were raised with the benchmark maintenance subcommittee. These issues were resolved, sometimes resulting in changes to the benchmark specification. While this result was audited against version 2.11.0 of the benchmark, it also takes advantage of some pending changes that are intended for release in the next version of the benchmark.

Respectfully Yours,

François Raab, TPC Certified Auditor
## Supporting Files Index

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
<th>Archive File Pathname</th>
</tr>
</thead>
</table>
| Clause 3 | Database create and load scripts, SQL scripts for validation and log files | SupportingFiles/Clauses/3/init.sh  
|          |                                                                             | SupportingFiles/Clauses/3/load.sh  
|          |                                                                             | SupportingFiles/Clauses/3/sqls/count_tables.sql  
|          |                                                                             | SupportingFiles/Clauses/3/sqls/desc_tables.sql  
|          |                                                                             | SupportingFiles/Clauses/3/sqls/Validate_Data.sql  
|          |                                                                             | SupportingFiles/Clauses/3/sqls/Check_Insert.sql  
|          |                                                                             | SupportingFiles/Clauses/3/sqls/Check_RI.sql  
|          |                                                                             | SupportingFiles/Clauses/3/logs/  
|          | Scripts for collecting statistics                                           | SupportingFiles/Clauses/3/analyze_tables.sh  
|          | Tools for data generation                                                   | SupportingFiles/Clauses/3/datagen.sh  
| Clause 4 | The script to execute qualification test and log file                       | SupportingFiles/Clauses/4/run_qualification_test.sh  
|          |                                                                             | SupportingFiles/Clauses/4/logs/qualification_test.log  
|          | SQL for qualification queries                                               | SupportingFiles/Clauses/4/queries/  
|          | Query patches                                                               | SupportingFiles/Clauses/4/patches  
|          | Output from executing qualification queries                                  | SupportingFiles/Clauses/4/output/  
| Clause 5 | Data maintenance execution scripts and logs files for each stream [s]       | SupportingFiles/Clauses/5/mt.sh  
|          |                                                                             | SupportingFiles/Clauses/5/run_refresh.sh  
|          |                                                                             | SupportingFiles/Clauses/5/logs/run_refresh_[s].log  
|          |                                                                             | SupportingFiles/Clauses/5/logs/mt_[s].log  
|          | SQL scripts for DM functions for stream [s]                                 | SupportingFiles/Clauses/5/mtsql_[s]/  
|          | Output from executing DM functions                                          | SupportingFiles/Clauses/5/outputs/  
|          | Raw data files for maintenance                                              | SupportingFiles/Clauses/5/data  
|          | MT function and data verification scripts, sqls, outputs and logs            | SupportingFiles/Clauses/5/run_verify_mt.sh  
|          |                                                                             | SupportingFiles/Clauses/5/mt_verify/run_verify_mt.log  
|          |                                                                             | SupportingFiles/Clauses/5/mt_verify/sqls/  
|          |                                                                             | SupportingFiles/Clauses/5/mt_verify/*_out  
| Clause 6 | Data accessibility test scripts, logs and output files                      | SupportingFiles/Clauses/6/data_access_test.sh  
|          |                                                                             | SupportingFiles/Clauses/6/logs/data_access_test.log  
|          |                                                                             | SupportingFiles/Clauses/6/output/worker_disk_remove.out  
|          |                                                                             | SupportingFiles/Clauses/6/output/worker_disk_status_fail.out  
|          |                                                                             | SupportingFiles/Clauses/6/output/worker_disk_status_good.out  

Alibaba Cloud AnalyticDB  
Full Disclosure Report  
TPC Benchmark DS
<table>
<thead>
<tr>
<th>Clause 7</th>
<th>Performance test scripts and logs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/pt.sh</td>
</tr>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/tt.sh</td>
</tr>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/run_stream.sh</td>
</tr>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/logs/pt.log</td>
</tr>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/logs/tt_[r].log</td>
</tr>
<tr>
<td></td>
<td>SupportingFiles/Clause_7/logs/stream_[s]_timing.log</td>
</tr>
<tr>
<td>Query text for query [q] in stream [s]</td>
<td>SupportingFiles/Clause_7/stream_[s]/queries/query_[q].sql</td>
</tr>
<tr>
<td>Output of query [q] in stream [s]</td>
<td>SupportingFiles/Clause_7/stream_[s]/output/query_[q].out</td>
</tr>
</tbody>
</table>
Appendix A: Provisioning Compute Services

Purchase Page for provisioning the 6 node groups (18 ECU) Alibaba Cloud AnalyticDB with 3-Year Subscription

Original page in Chinese
English version (Chrome translated)
Appendix B: Third Party Price Quotes

Lenovo MIX 210 tablet (Chinese version)

Lenovo MIX 210 tablet (Chrome translated English version)
### Lenovo / Lenovo MIX 320/310 quad-core tablet PC 2-in-1

**notebook 10.1-inch Win10 learning office entertainment pc light and thin portable laptop**

- **price**: ¥1099.00
- **weight**: Shanghai to Hangzhou on city streets 3h / Express: 0.00

**Monthly sales**: 4  |  **Cumulative evaluation**: 29  |  **Total Points**: 109

<table>
<thead>
<tr>
<th>Color Classification</th>
<th>Type</th>
<th>Package</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>MIX 320 HD / 25 / 32GB</td>
<td>MIX 320 HD / 25 / 32GB</td>
<td>¥1099.00</td>
</tr>
<tr>
<td>MIX 320 HD / 32GB</td>
<td>MIX 320 HD / 4G / 64GB</td>
<td>MIX 320 HD / 4G / 128GB</td>
<td>¥1099.00</td>
</tr>
</tbody>
</table>

#### Quantity
- 1

**Service**
- Accidental warranty for two years: ¥66.00
- One-year extended warranty: ¥59.80
- Two-year comprehensive warranty: ¥100.00
- Digital service on-site installation and commissioning: ¥109.00

**Flower Stage**
- The product can enjoy up to 3 installments of interest-free:
  - ¥366.33 x1 period (including handling fee)
  - ¥191.40 x2 period (including handling fee)

**Buy now**