TPC Benchmark™ C

Full Disclosure Report

First Edition

13–Jun–2022

Using

Goldilocks v3.1 Standard Edition

on

TAEJINT&S TNS2100

First Edition: 13-Jun-2022

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Abstract

This report documents the methodology and results of the TPC Benchmark™ C (TPC-C) test conducted by TTA on the Goldilocks v3.1 Standard Edition on TAEJIN T&S TNS2100

Goldilocks v3.1 Standard Edition on TAEJIN T&S TNS2100

Company Name	System Name	Database Software	Operating System
Telecommunications Technology Association	TAEJIN T&S TNS2100	Goldilocks v3.1 Standard Edition	RedHat Enterprise Linux 7.9

TPC Benchmark™ C Metrics

Total System Cost	TPC-C Throughput	Price/Performance	Availability Date
₩ 482,989,000 (KRW)	190,443 tpmC	2,537 KRW/tpmC	Available Now

Preface

The Transaction Processing Performance Council (TPC™) is a non-profit corporation founded to define transaction processing and database benchmarks and to disseminate objective, verifiable TPC performance data to the industry. The TPC Benchmark© C is an on-line transaction processing benchmark (OLTP) developed by the TPC.

TPC Benchmark™ C Overview

TPC Benchmark™ C (TPC-C) simulates a complete computing environment where a population of users executes transactions against a database. The benchmark is centered around the principal activities (transactions) of an order-entry environment. These transactions include entering and delivering orders, recording payments, checking the status of orders, and monitoring the level of stock at the warehouses. While the benchmark portrays the activity of a wholesale supplier, TPC-C is not limited to the activity of any particular business segment, but, rather represents any industry that must manage, sell, or distribute a product or service.

TPC-C consists of a mixture of read-only and update intensive transactions that simulate the activities found in complex OLTP application environments. It does so by exercising a breadth of system components associated with such environments, which are characterized by:

- *The simultaneous execution of multiple transaction types that span a breadth of complexity*
- *On-line and deferred transaction execution modes*
- *Multiple on-line terminal sessions*
- *Moderate system and application execution time*
- *Significant disk input/output*
- *Transaction integrity (ACID properties)*
- *Non-uniform distribution of data access through primary and secondary keys*
- *Databases consisting of many tables with a wide variety of sizes, attributes, and relationships*
- *Contention of data access and update*

The performance metric reported by TPC-C is a "business throughput" measuring the number of orders processed per minute. Multiple transactions are used to simulate the business activity of processing an order, and each transaction is subject to a response time constraint. The performance metric for this benchmark is expressed in transactions-per-minute-C (tpmC). To be compliant with the TPC-C standard, all references to tpmC results must include the tpmC rate, the associated price-per-tpmC, and the availability date of the priced configuration.

TPC-C uses terminology and metrics that are similar to other benchmarks, originated by the TPC or others. Such similarity in terminology does not in any way imply that TPC-C results are comparable to other benchmarks. The only benchmark results comparable to TPC-C are other TPC-C results conformant with the same revision.

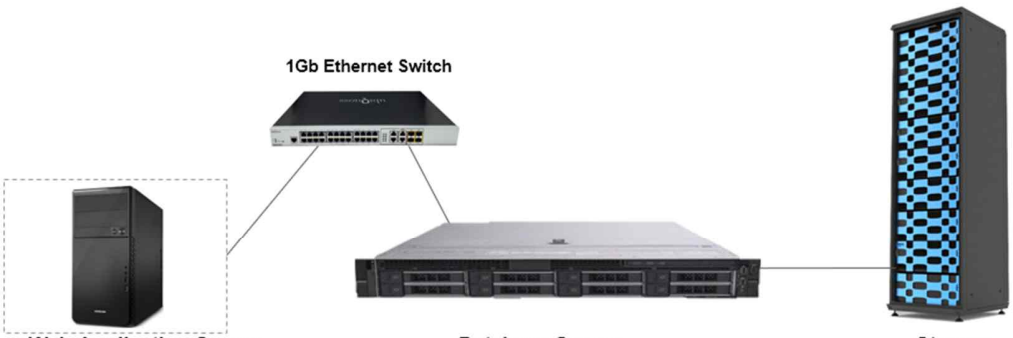
Despite the fact that this benchmark offers a rich environment that emulates many OLTP applications, this benchmark does not reflect the entire range of OLTP requirements. In addition, the extent to which a customer can achieve the results reported by a vendor is highly dependent on how closely TPC-C approximates the customer application. The relative performance of systems derived from this benchmark does not necessarily hold for other workloads or environments. Extrapolations to other environments are not recommended.

Benchmark results are highly dependent upon workload, specific application requirements, and systems design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, TPC-C should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

Further information is available at www.tpc.org

	Goldilocks v3.1 Standard Edition on TAEJIN T&S TNS2100			**TPC-C Version 5.11.0** **TPC Pricing 2.8.0** Report Date **13-Jun-2022**
Total System Cost	TPC-C Throughput	Price/Performance		Availability Date
₩ 482,989,000 (KRW)	**190,443 tpmC**	**2,537 KRW/tpmC**		**Available Now**
Server Processors/Cores/Threads	Database Manager	Operating System	Other Software	Number of Users
2/36/72	**Goldilocks v3.1 Standard Edition**	**RHEL 7.9**	**JBoss Web Server**	**150,000**

Priced Configuration (TAEJIN T&S)



3 x HANSUNG DT-S170G1IV0
- 1 x Intel(R) Core(TM) i7-10700K CPU @ 3.80GHz
- 1 x 32GB Memory
- 1 x 2TB SATA HDD
- 1 x 512GB SATA SSD
- 1 x 2-port 10G Ethernet
- 1 x 1G Ethernet

1 x TAEJIN T&S TNS-2100
- 2 x Intel(R) Xeon(R) Gold 6354 CPU @ 3.00GHz
- 8 x 128GB, 16 x 64GB (2,048GB) Memory
- 2 x 480GB SATA SSD (RAID-1, Write Through)
- 2 x 16Gb 2-Port Host Bus Adaptor
- 2 x 2-port 10G Ethernet
- 1 x 2-port 1G Ethernet
- 1 x 4-port 1G Ethernet

1 x UNIWIDE FCH2800
- 16 x 32GB (512GB) Cache Memory
- 8 x 1.6TB FMD Drive (Write Back)
- 4 x 12.8TB FMD Drive (Write Back)
- 4 x 8/16Gb 8-Port Host Bus Adaptor

System Components	**DB Server**		**WAS Server**	
	Quantity	**Description**	**Quantity**	**Description**
Processors/Cores/Threads	2/36/72	Intel(R) Xeon(R) Gold 6354 CPU @ 3.00GHz	1/8/16	Intel(R) Core(TM) i7-10700K CPU @ 3.80GHz
Memory	8/16	128 GB / 64 GB	1	32GB
Storage Controller	1 2	- LSI MegaRAID Tri-Mode SAS3516 - Broadcom / LSI MegaRAID Tri-Mode SAS3516		
Storage Device	2 8 4	480 SATA SSD (Write Through) 1.6TB FMD SSD (External, Write back) 12.8TB FMD SSD (External, Write back)	1 1	1TB SATA HDD 512GB SATA SSD
Total Storage Capacity		64.96TB		

	Goldilocks v3.1 Standard Edition on TAEJIN T&S TNS2100	TPC-C Version 5.11.0 TPC Pricing 2.8.0 Report Date 13-Jun-2022 Available Now

Description	Part Number	Source	Unit Price	Qty	Price	3-Yr. Maint. Price
Server Hardware						
DB Server – TAEJIN TNS(TNS-2100)	KR580S2	1	**52,000,000**	1	**52,000,000**	
TNS-2100, 2U, 2 소켓, 32xDIMM, 8x2.5", PSU(1+1)1400W	Model	1	(included)	1		
Intel® Xeon® Gold 6354 3.0G, 18C/36T, 39MB 캐시	CPU	1	(included)	2		
128GB DDR4 3200MHz RDIMM	RAM	1	(included)	8		
64GB DDR4 2666MHz RDIMM	RAM	1	(included)	16		
480GB SSD SATA 6Gbps 2.5"	SSD	1	(included)	2		
SAS Controller 8G Cache	RAID	1	(included)	1		
10GbE 2Port SFP+ Network Adapter(GBIC 포함)	NIC	1	(included)	2		
16G FC 2Port HBA	HBA	1	(included)	2		
3year, 24x7x4hr Onsite Support Service 1	Maintenance	1	(included)	1		
WAS Servers (per server) - DT-S170G1IV0	DT-S170G1IV0	2	1,551,000	3	**4,653,000**	
Intel® Core Processor i7-10700K, 3.8GHz	-	2	(included)	1		
DDR4 32GB, Samsung, UDIMM PC4-25600U	-	2	(included)	1		
Seagate Barracuda ST2000DM008 2 TB 3.5"	-	2	(included)	1		
HP SSD EX900 512GB	-	2	(included)	1		
2-port 10G Ethernet Controller	-	2	(included)	1		
3year, 24x7x4hr Onsite Support Service 1	Maintenance	2	792,000	3		**2,376,000**
Server Hardware Sub Total					**56,653,000**	**2,376,000**
Storage Hardware						
All Flash Storage - FCH2800	FCH2800	3	72,250,000	1	**72,250,000**	
FCH2800 Controller Device	T0001-0117-00	3	(included)	1		
Back-end Bus Adapter 12G SAS	T0001-0117-01	3	(included)	1		
16G 8-Port Host Bus Adapter	T0001-0117-02	3	(included)	4		
Cache Interconnect Adapter	T0001-0117-03	3	(included)	1		
Cache Memory DDR-3 (32GB)	T0001-0117-04	3	(included)	16		
FCH2800 Flash Disk Drive Expantion Unit	T0001-0117-05	3	(included)	1		
FCH2800 controller cpu Board	T0001-0117-06	3	(included)	1		
Rack 600x1200x2010 mm (WxDxH) 42U	T0001-0117-07	3	(included)	1		
Storage Management SW	T0001-0117-08	3	(included)	1		
UTP CAT5e Ethernet Cable 1M	61001-0001-00	3	(included)	1		
Power Cord, NICETECH, 2.5M	42119-0005-00	3	(included)	2		
1.6TB Flash Memory Disk Drive	T22601-0117-03	3	3,900,000	8	31,200,000	
12.8TB Flash Memory Disk Drive	T22601-0117-05	3	40,625,000	4	162,500,000	
3-yrs 24x7x4hrs Onsite Support Service	-	3	26,350,000	1		26,350,000

Storage Hardware Sub Total					**265,950,000**	**26,350,000**
Client/Server Software						
Red Hat Enterprise Linux Server Standard 3yrs	RH00004F3	4	4,098,000	4	16,392,000	
RHEL Server Standard Maintenance - 3yrs 24x7x4hrs	RP-CPS(OS)	4	6,000,000	4		24,000,000
Red Hat JBoss Web Server 4-Core Standard 3Year	MW00123F3	4	2,144,000	6	12,864,000	
JBoss Web Server per 4Core 3Year Maintenance	RP-CPS(WAS)	4	12,000,000	6		72,000,000
Goldilocks v3.1 Standard Edition	-	5	144,000,000	1	144,000,000	
Goldilocks v3.1 Standard Edition Technical Supports	-	5	77,000,000	3		231,000,000
Software Sub Total					**173,256,000**	**327,000,000**
Other Hardware						
UbiQuoss uSafe3010-24ps (10G, 24-port)(w/spares)	22917889	6	1,900,000	3	5,700,000	
Other Hardware Sub Total					**5,700,000**	
Discounts*						
Red Hat OS Discount					-6,792,000	-16,000,000
Red Hat JBoss Discount					-5,304,000	-36,000,000
SW Discount - Goldilocks					-100,800,000	-209,400,000
Discounts Sub Total					**-112,896,000**	**-261,400,000**
Total					**388,663,000**	**94,326,000**

Pricing Notes

1) TAEJIN T&S Inc.
2) Hansung Corporation.
3) UNIWIDE Technologies Inc.
4) Rockplace Inc.
5) Sunjesoft Inc.
6) UbiQuoss Inc.

All of the prices are based on South Korea's currency, KRW (₩, Korean Won) and excluded VAT.

* All discounts are based on Korea list prices and for similar quantities and configurations. Discounts for similarly sized configurations will be similar to those quoted here, but may vary based on the components in the configuration.

Three year cost of ownership KRW(₩): 482,989,000

TPC-C throughput: 190,443 tpmC

Price/Performance: 2,537 ₩ / tpmC

Benchmark implementation and results independantly audited by Doug Johnson of InfoSizing (www.sizing.com)

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 pricing specifications. If you find that the stated prices are not available according to these terms, please inform the TPC at pricing@tpc.org. Thank you.

	Goldilocks v3.1 Standard Edition on TAEJIN T&S TNS2100	TPC-C Version 5.11.0 TPC Pricing 2.8.0 Report Date 13-Jun-2022 Available Now

MQTh, computed Maximum Qualified Throughput	190,443 tpmC	

Response Times (seconds)	Min	Average	90th	Max
New-Order	0.102	0.103	0.103	1.044
Payment	0.102	0.103	0.103	0.316
Order-Status	0.101	0.102	0.102	0.313
Delivery (interactive portion)	0.101	0.101	0.101	0.311
Delivery (deferred portion)	0.002	0.004	0.006	0.185
Stock-Level	0.102	0.102	0.103	0.311
Menu	0.101	0.101	0.102	0.696

Emulated Display Delay: 0.1 sec.

Transaction Mix	Percent	Number
New-Order	44.980%	79,986,284
Payment	43.011%	76,484,519
Order-Status	4.003%	7,117,494
Delivery	4.003%	7,118,825
Stock-Level	4.003%	7,119,078

Keying Times (seconds)	Min	Average	Max
New-Order	18.001	18.001	18.130
Payment	3.001	3.001	3.096
Order-Status	2.001	2.001	2.035
Delivery	2.001	2.001	2.042
Stock-Level	2.001	2.001	2.061

Think Times (seconds)	Min	Average	Max
New-Order	0.001	12.045	120.501
Payment	0.001	12.041	120.501
Order-Status	0.001	10.045	100.501
Delivery	0.001	5.029	50.301
Stock-Level	0.001	5.034	50.301

Test Duration	
Ramp-up time	65 min
Measurement Interval (MI)	420 min
Checkpoints in MI	15
Checkpoint Interval (Average / Max)	27:51 min / 27:53 min
Number of Transactions in MI (all types)	177,826,200

General Items

0.1 Application Code and Definition Statements

The application program (as defined in clause 2.1.7) must be disclosed. This includes, but is not limited to, the code implementing the five transactions and the terminal input output functions.

Appendix A contains the application source code for the transactions.

0.2 Benchmark Sponsor

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

This benchmark was sponsored by TTA, Telecommunications Technology Association. The implementation was developed and engineered in partnership with SUNJESOFT Inc. and TAEJIN T&S Inc.

0.3 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 options*
- *Recover/commit options*
- *Consistency locking options*
- *Operating system and application configuration parameters*

This requirement can be satisfied by providing a full list of all parameters.

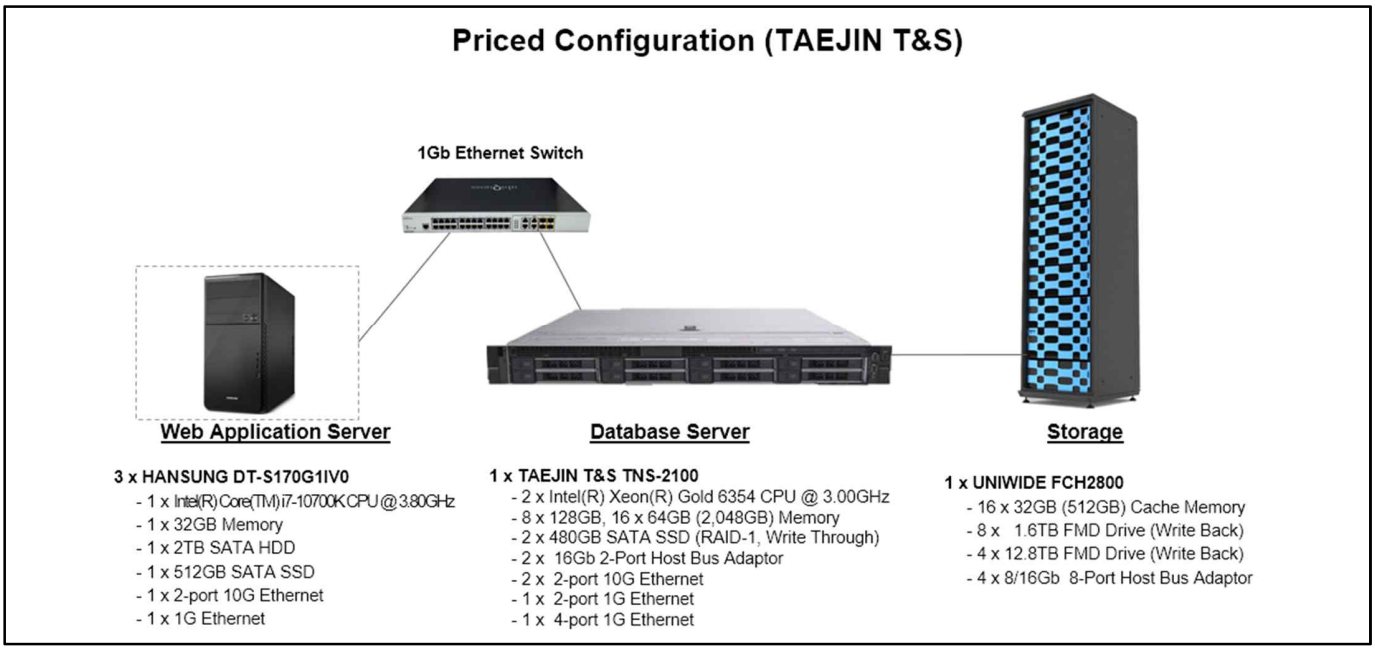
Appendix B contains the tunable parameters for the database, the operating system, and the transaction monitor.

0.4 Configuration Diagrams

Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences.

The configuration diagram for both the tested and priced system is depicted in Figure 0.1. There was no difference between the priced and tested configurations.

Figure 0.1: Benchmarked and Priced Configuration



Clause 1: Logical Database Design

1.1 Table Definitions

Listing must be provided for all table definition statements and all other statements used to set up the database.

Appendix A contains the code used to define and load the database tables.

1.2 Physical Organization of Database

The physical organization of tables and indices within the database must be disclosed.

The physical organization of the database is shown in Table 1.2.

Table 1.2: Physical Organization of the Database

Controller	Array	RAID Array	Drives	Content
MegaRAID SAS3516	Internal	RAID 1	2 x SATA 480 GB SSD	OS
Hitachi DKC810I Series	FCH2800 Array	RAID 1 (2D+2D)	4 x 1.6 TB FMD 4 x 12.8 TB FMD	Database files
Hitachi DKC810I Series	FCH2800 Array	RAID 1 (2D+2D)	4 x 1.6 TB FMD	Redo Logs

1.3 Insert and Delete Operations

It must be ascertained that insert and/or delete operations to any of the tables can occur concurrently with the TPC-C transaction mix. Furthermore, any restrictions in the SUT database implementation that precludes inserts beyond the limits defined in Clause 1.4.11 must be disclosed. This includes the maximum number of rows that can be inserted and the minimum key value for these new rows.

All insert and delete functions were verified to be fully operational during the entire benchmark.

1.4 Horizontal or Vertical Partitioning

While there are a few restrictions placed upon horizontal or vertical partitioning of tables and rows in the TPC-C benchmark, any such partitioning must be disclosed.

No horizontal or vertical partitioning was used in this benchmark.

1.5 Replication or Duplication

Replication of tables, if used, must be disclosed. Additional and/or duplicated attributes in any table must be disclosed along with a statement on the impact on performance.

No replications, duplications or additional attributes were used in this benchmark.

Clause 2: Transaction and Terminal Profiles

2.1 Random Number Generation

The method of verification for the random number generation must be described.

Random numbers were generated using ‘SysVr4 rand_r()’ call. The seed value for ‘rand_r()’ was collected and reviewed by the auditor.

2.2 Input/Output Screens

The actual layout of the terminal input/output screens must be disclosed.

All screen layouts were verified by the auditor to validate that they followed the requirements of the specifications.

2.3 Priced Terminal Feature

The method used to verify that the emulated terminals provide all the features described in Clause 2.2.2.4 must be explained. Although not specifically priced, the type and model of the terminals used for the demonstration in 8.1.3.3 must be disclosed and commercially available (including supporting software and maintenance).

The terminal attributes were manually verified by the auditor by verifying that each required feature was implemented.

2.4 Presentation Managers

Any usage of presentation managers or intelligent terminals must be explained.

Application code running on the client systems implemented the TPC-C user interface. No presentation manager software or intelligent terminal features were used. The source code for the user interface is listed in Appendix A.

2.5 Transaction Statistics

Table 2.1 lists the transaction statistics defined in Clauses 8.1.3.5 to 8.1.3.11 and observed during the Measurement Interval.

Table 2.1: Transaction Statistics

Statistic		Value
New Order	Home warehouse order lines Remote warehouse order lines Rolled back transactions Average items per order	99.001% 0.999% 1.001% 10.000
Payment	Home warehouse Remote warehouse Accessed by last name	85.001% 14.999% 59.999%
Order Status	Accessed by last name	60.011%
Delivery	Skipped transactions	0
Transaction Mix	New Order Payment Order status Delivery Stock level	44.980% 43.011% 4.003% 4.003% 4.003%

2.6 Queuing Mechanism

The queuing mechanism used to defer the execution of the Delivery transaction must be disclosed.

The queuing mechanism was implemented using ‘BlockingQueue’ provided by Java.

Clause 3: Transaction and System Properties

The results of the ACID tests must be disclosed along with a description of how the ACID requirements were met. This includes disclosing which case was followed for the execution of Isolation Test 7.

All ACID property tests were conducted according to the specification.

3.1 Atomicity

The system under test must guarantee that the database transactions are atomic; the system will either perform all individual operations on the data or will assure that no partially completed operations leave any effects on the data.

3.1.1 Atomicity of Completed Transactions

Perform the Payment transaction for a randomly selected warehouse, district, and customer (by customer number) and verify that the records in the CUSTOMER, DISTRICT, and WAREHOUSE tables have been changed appropriately.

A row was randomly selected from the CUSTOMER, DISTRICT, and WAREHOUSE tables, and the balances noted. A payment transaction was started with the same Customer, District, and Warehouse identifiers and a known amount. The payment transaction was committed and the rows were verified to contain correctly updated balances.

3.1.2 Atomicity of Aborted Transactions

Perform the Payment transaction for a randomly selected warehouse, district, and customer (by customer number) and substitute a ROLLBACK of the transaction for the COMMIT of the transaction. Verify that the records in the CUSTOMER, DISTRICT, and WAREHOUSE tables have NOT been changed.

A row was randomly selected from the CUSTOMER, DISTRICT, and WAREHOUSE tables, and the balances noted. A payment transaction was started with the same Customer, District, and Warehouse identifiers and a known amount. The payment transaction was rolled back and the rows were verified to contain the original balances.

3.2 Consistency

Consistency is the property of the application that requires any execution of a data base transaction to take the database from one consistent state to another, assuming that the data base is initially in a consistent state.

Verify that the data base is initially consistent by verifying that it meets the consistency conditions defined in Clauses 3.3.2.1 to 3.3.2.4. Describe the steps used to do this in sufficient detail so that the steps are independently repeatable.

The specification defines 12 consistency conditions, of which Consistency conditions 1 through 4 were demonstrated as follows:

1. The sum of balances (d_ytd) for all Districts within a specific Warehouse is equal to the balance (w_ytd) of that Warehouse.
2. For each District within a Warehouse, the next available Order ID (d_next_o_id) minus one is equal to the most recent Order ID [max(o_id)] for the ORDER table associated with the preceding District and Warehouse. Additionally, that same relationship exists for the most recent Order ID [max(o_id)] for the NEW-ORDER table associated with the same District and Warehouse. Those relationships can be illustrated as:

   d_next_o_id – 1 = max(o_id) = max(no_o_id)
   where (d_w_id = o_w_id = no_w_id) and (d_id = o_d_id = no_d_id)

3. For each District within a Warehouse, the value of the most recent Order ID [max(no_o_id)] minus the first Order ID [min(no_o_id)] plus one, for the NEW-ORDER table associated with the District and Warehouse, equals the number of rows in that NEW-ORDER table.
   That relationship can be illustrated as:
   max(no_o_id) – min(no_o_id) + 1 = rows in NEW-ORDER
   where (o_w_id = no_w_id) and (o_d_id = no_d_id)
4. For each District within a Warehouse, the sum of Order-Line counts [sum(o_ol_cnt)] for the Orders associated with the District equals the number of rows in the ORDER-LINE table associated with the same District.
   That relationship can be illustrated as:
   sum(o_ol_cnt) = rows in the ORDER-LINE table for the Warehouse and District

To test consistency, the following steps were executed:

1. The consistency conditions 1 through 4 were tested by running queries against the database. All queries showed that the database was in a consistent state.
2. An RTE run was executed at full load for a duration sufficient to include at least one completed checkpoint.
3. The consistency conditions 1 through 4 were tested again. All queries showed that the database was still in a consistent state.

3.3 Isolation

Sufficient conditions must be enabled at either the system or application level to ensure the required isolation defined above (clause 3.4.1) is obtained.

The benchmark specification defines nine tests to demonstrate the property of transaction isolation. The tests, described in Clauses 3.4.2.1 – 3.4.2.9, were all successfully executed using a series of scripts. Each included timestamps to demonstrate the concurrency of operations. The results of the queries were logged. The captured logs were verified to demonstrate the required isolation had been met.

Isolation Test 1

This test demonstrates isolation for read-write conflicts of Order-Status and New-Order transactions when the New-Order transaction is committed.

The test proceeds as follows:

1. An Order-Status transaction T0 was executed and committed for a randomly selected Customer, and the Order returned was noted.
2. A New-Order transaction T1 was started for the same Customer used in T0. T1 was stopped prior to COMMIT.
3. An Order-Status transaction T2 was started for the same Customer used in T1. T2 completed and was committed without being blocked by T1. T2 returned the same Order that T0 had returned.
4. T1 was allowed to complete and was committed.
5. An Order-Status transaction T3 was started for the same Customer used in T1. T3 returned the Order inserted by T1.

Isolation Test 2

This test demonstrates isolation for read-write conflicts of Order-Status and New-Order transactions when the New-Order transaction is rolled back.

The test proceeds as follows:

1. An Order-Status transaction T0 was executed and committed for a randomly selected Customer and the Order returned was noted.
2. A New-Order transaction T1 with an invalid item number was started for the same Customer used in T0. T1 was stopped immediately prior to ROLLBACK.
3. An Order-Status transaction T2 was started for the same Customer used in T1. T2 completed and was committed without being blocked by T1. T2 returned the same Order that T0 had returned.
4. T1 was allowed to ROLLBACK.
5. An Order-Status transaction T3 was started for the same Customer used in T1. T3 returned the same Order that T0 had returned.

Isolation Test 3

This test demonstrates isolation for write-write conflicts of two New-Order transactions when both transactions are committed.

The test proceeds as follows:

1. The D_NEXT_O_ID of a randomly selected district was retrieved.
2. A New-Order transaction T1 was started for a randomly selected customer within the District used in step 1. T1 was stopped immediately prior to COMMIT.
3. Another New-Order transaction T2 was started for the same customer used in T1. T2 waited.
4. T1 was allowed to complete. T2 completed and was committed.
5. The order number returned by T1 was the same as the D_NEXT_O_ID retrieved in step 1. The order number returned by T2 was one greater than the order number returned by T1.
6. The D_NEXT_O_ID of the same District was retrieved again. It had been incremented by two (i.e. it was one greater than the order number returned by T2).

Isolation Test 4

This test demonstrates isolation for write-write conflicts of two New-Order transactions when one transaction is rolled back.

The test proceeds as follows:

1. The D_NEXT_O_ID of a randomly selected District was retrieved.
2. A New-Order transaction T1, with an invalid item number, was started for a randomly selected customer within the district used in step 1. T1 was stopped immediately prior to ROLLBACK.
3. Another New-Order transaction T2 was started for the same customer used in T1. T2 waited.
4. T1 was allowed to roll back, and T2 completed and was committed.
5. The order number returned by T2 was the same as the D_NEXT_O_ID retrieved in step 1.
6. The D_NEXT_O_ID of the same District was retrieved again. It had been incremented by one (i.e. one greater than the order number returned by T2).

Isolation Test 5

This test demonstrates isolation for write-write conflicts of Payment and Delivery transactions when Delivery transaction is committed.

The test proceeds as follows:

1. A query was executed to find out the Customer who is to be updated by the next Delivery transaction for a randomly selected Warehouse and District.
2. The C_BALANCE of the Customer found in step 1 was retrieved.
3. A Delivery transaction T1 was started for the same Warehouse used in step 1. T1 was stopped immediately prior to COMMIT.
4. A Payment transaction T2 was started for the same Customer found in step 1. T2 waited.
5. T1 was allowed to complete. T2 completed and was committed.
6. The C_BALANCE of the Customer found in step 1 was retrieved again. The C_BALANCE reflected the results of both T1 and T2.

Isolation Test 6

This test demonstrates isolation for write-write conflicts of Payment and Delivery transactions when the Delivery transaction is rolled back.

The test proceeds as follows:

1. A query was executed to find out the Customer who is to be updated by the next delivery transaction for a randomly selected Warehouse and District.
2. The C_BALANCE of the Customer found in step 1 was retrieved.
3. A Delivery transaction T1 was started for the same Warehouse used in step 1. T1 was stopped immediately prior to COMMIT.
4. A Payment transaction T2 was started for the same customer found in step 1. T2 waited.
5. T1 was forced to execute a ROLLBACK. T2 completed and was committed. The C_BALANCE of the Customer found in step 1 was retrieved again. The C_BALANCE reflected the results of only T2.

Isolation Test 7

This test demonstrates repeatable reads for the New-Order transaction while an interactive transaction updates the prices of some items.

The test proceeds as follows:

1. The I_PRICE of two randomly selected items X and Y were retrieved.
2. A New-Order transaction T1 with a group of Items including Items X and Y was started. T1 was stopped immediately after retrieving the prices of all items. The prices of Items X and Y retrieved matched those retrieved in step 1.
3. A transaction T2 was started to increase the price of Items X and Y by 10%.
4. T2 did not stall and was committed.

5. T1 was resumed, and the prices of all Items were retrieved again within T1. The prices of Items X and Y matched those retrieved in step 1.
6. T1 was committed.
7. The prices of Items X and Y were retrieved again. The values matched the values set by T2.

The Execution followed Case D, where T3 does not stall and no transaction is rolled back. Query T4 verifies the price change made by T3.

Isolation Test 8

This test demonstrates isolation for phantom protection between New-Order and Delivery transactions.

The test proceeds as follows:

1. The NO_D_ID of all NEW_ORDER rows for a randomly selected Warehouse and District was changed to 11. The changes were committed.
2. A Delivery transaction T1 was started for the selected Warehouse.
3. T1 was stopped immediately after reading the NEW_ORDER table for the selected Warehouse and District. No qualifying row was found.
4. A New-Order transaction T2 was started for the same Warehouse and District. T2 completed and was committed without being blocked by T1.
5. T1 was resumed and the NEW_ORDER table was read again. No qualifying row was found.
6. T1 completed and was committed.
7. The NO_D_ID of all NEW_ORDER rows for the selected Warehouse and District was restored to the original value. The changes were committed.

Isolation Test 9

This test demonstrates isolation for phantom protection between New-Order and Order-Status transactions.

The test proceeds as follows:

1. An Order-Status transaction T1 was started for a randomly selected Customer.
2. T1 was stopped immediately after reading the ORDER table for the selected Customer to find the most recent Order for that Customer.
3. A New-Order transaction T2 was started for the same Customer. T2 completed and was committed without being blocked by T1.
4. T1 was resumed and the ORDER table was read again to determine the most recent Order for the same Customer. The Order found was the same as the one found in step 2.
5. T1 completed and was committed.

3.4 Durability

The tested system must guarantee durability: the ability to preserve the effects of committed transactions and ensure data base consistency after recovery from any one of the failures listed in Clause 3.5.3

- *Permanent irrecoverable failure of any single durable medium containing TPC-C database tables or recovery log data (this test includes failure of all or part of memory)*
- *Instantaneous interruption (system crash/system hang) in processing that requires system reboot to recover*
- *Failure of all or part of memory (loss of contents)*

3.4.1 Durable Media Failure

3.4.1.1 Loss of Log Media and Data Media

This test was conducted on a fully scaled database. To demonstrate recovery from a permanent failure of durable medium containing TPC-C Log Media and Data Media, the following steps were executed:

1. The total number of Orders is determined by the sum of D_NEXT_O_ID of all rows in the DISTRICT table; giving count-1.
2. The consistency is verified.
3. The RTE is started with full user load.
4. The test is allowed to run for a minimum of 5 minutes after ramp-up.
5. A first checkpoint is initiated and completed.
6. The test is allowed to run for a minimum of 2 more minutes.
7. A second checkpoint is initiated.
8. Before the second checkpoint completes, one data disk is disabled by removing it physically. Since the data disks are configured with redundancy, the transactions continued to run without interruption.
9. The test is allowed to run until the completion of the second checkpoint and for at least 5 minutes
10. A third checkpoint is initiated.
11. Before the third checkpoint completes, one log device is disabled by removing it physically. Since the log devices are configured with redundancy, the transactions continued to run without interruption.
12. The test is allowed to run until the third checkpoint has completed, but no less than 5 more minutes.
13. The RTE run is completed.
14. The consistency is verified.
15. Step 1 is repeated, giving count-2.
16. The RTE result file is used to determine the number of New-Order transactions successfully completed during the full run.
17. The difference between the count-1 and count-2 is compared with the number of New-Order transactions successfully completed during the full run. The difference indicated that no committed transactions had been lost.
18. Data from the success file is used to query the database to demonstrate that the last 500 successful New-Orders have corresponding rows in the ORDER table.

3.4.1.2 Instantaneous Loss of Storage Controller Cache

This test was executed on a fully scaled database. The following steps were executed: To demonstrate recovery from a permanent failure of a controller cache, the following steps were executed:

1. The total number of Orders is determined by the sum of D_NEXT_O_ID of all rows in the DISTRICT table; giving count-1.
2. The consistency is verified.
3. The RTE is started with full user load.
4. The test is allowed to run for a minimum of 5 minutes at full load (after ramp-up)
5. A first checkpoint is initiated and completed.
6. The test is allowed to run for a minimum of 2 more minutes.
7. A second checkpoint is initiated.
8. Before the second checkpoint completes, one of the two caches in the storage subsystem was failed (removing it from the chassis)
9. The RTE run is completed.
10. Step 1 is repeated, giving count-2.
11. The consistency is verified.
12. The RTE result file is used to determine the number of New-Order transactions successfully completed during the full run.
13. The difference between the count-1 and count-2 is compared with the number of New-Order transactions successfully completed during the full run. The difference indicated that all committed transactions had been successfully recovered.
14. Data from the success file is used to query the database to demonstrate that the last 500 successful New-Orders have corresponding rows in the ORDER table.

3.4.2 Instantaneous Interruption, Loss of Memory

As the loss of power erases the contents of memory, the instantaneous interruption and the loss of memory tests were combined into a single test. This test was executed on a fully scaled database. The following steps were executed:

1. The total number of Orders is determined by the sum of D_NEXT_O_ID of all rows in the DISTRICT table; giving count-1.
2. The consistency is verified.
3. The RTE is started with full user load.
4. The test is allowed to run for a minimum of 5 minutes at full load (after ramp-up).
5. A first checkpoint is initiated and completed.
6. The test is allowed to run for a minimum of 2 more minutes.
7. A second checkpoint is initiated.

8. Before the second checkpoint completes, the primary power to the back-end server is shut off (removing both power cords).
9. The RTE is shutdown.
10. Power is restored to the database server and the system performs an automatic recovery.
11. GOLDILOCKS is restarted and performs an automatic recovery.
12. Step 1 is repeated, giving count-2.
13. The consistency is verified.
14. The RTE result file is used to determine the number of New-Order transactions successfully completed during the full run.
15. The difference between the count-1 and count-2 is compared with the number of New-Order transactions successfully completed during the full run. The difference indicated that all committed transactions had been successfully recovered.
16. Data from the success file is used to query the database to demonstrate that the last 500 successful New-Orders have corresponding rows in the ORDER table.

Clause 4: Scaling and Database Population

4.1 Cardinality of Tables

The cardinality (e.g. number of rows) of each table, as it existed at the start of the benchmark run, must be disclosed. If the database was over-scaled and inactive rows of the WAREHOUSE table were deleted, the cardinality of the WAREHOUSE table as initially configured and the number of rows

Table 4.1 shows that number of rows for each table as they were initially populated.

Table 4.1: Number of Rows for Server

Table	Cardinality
Warehouse	15,000
District	150,000
Customer	450,000,000
History	450,000,000
Order	450,000,000
New Order	135,000,000
Order Line	4,499,034,427
Stock	1,500,000,000
Item	100,000
Unused Warehouses	0

4.2 Database Implementation

A statement must be provided that describes: The data model implemented by DBMS used (e.g. relational, network, hierarchical). The database interfaces (e.g. embedded, call level) and access language (e.g. SQL, DL/1, COBOL read/write used to implement the TPC-C transaction. If more than one interface/access language is used to implement TPC-C, each interface/access language must be described and a list of which interface/access language is used with which transaction type must be disclosed.

Goldilocks v3.1 is an in-memory DBMS, implementing the relational model.

The transactions are implemented in SQL via JDBC calls to the database engine.

All application code and procedures are listed in Appendix A.

4.3 Distribution of Database Files

The distribution of tables and logs across all media must be explicitly depicted for tested and priced systems.

The database files are stored on a set of four 1.6TB disks configured as RAID1(2+2). The database log files are stored on four 1.6TB disks and four 12.8TB disks configured as RAID1(2+2).

Table 4.3: Database file locations

Name	Location	Description
system_XXX.dbf	/data/db/db1	System tables and dictionary
tpcc_data_XX.dbf	/data/db/db1 /data/db/db2 /data/db/db3 /data/db/db4 /data/db/db5	Database data files
redo_X_X.log	/wal	Database log files

The distribution of tables and logs across storage media is shown in Table 1.2.

4.4 60-Day Space

Details of the 60-day space computations along with proof that the database is configured to sustain 8 hours of growth for the dynamic tables (Order, Order-Line, and History) must be disclosed.

A test run of over 8 hours was executed to demonstrate that the configuration is capable of sustaining 8 hours of growth at the reported throughput. The computation of the 60-day storage requirements is shown in Table 4.4.

Table 4.4: 60-Day Space Calculations

Base Unit (KBytes)	1
tpmC	190,443.533

Table	Rows	Data	Index	Initial Population	5% Growth	8-Hour Growth	Required Runtime Space
WAREHOUSE	15,000	120,936	408	121,344	6,067	0	127,411
DISTRICT	150,000	19,096	6,256	25,352	1,268	0	26,620
CUSTOMER	450,000,000	289,764,536	37,169,768	326,934,304	16,346,715	0	343,281,019
NEW_ORDER	135,000,000	8,535,344	4,801,448	13,336,792	666,840	0	14,003,632
ITEM	100,000	10,808	2,736	13,544	677	0	14,221
STOCK	1,500,000,000	553,338,152	49,482,672	602,820,824	30,141,041	0	632,961,865
HISTORY	450,000,000	37,451,584	0	37,451,584	0	7,607,906	45,059,490
ORDERS	450,000,000	28,758,776	34,270,184	63,028,960	0	5,842,051	68,871,011
ORDER_LINE	4,499,034,427	425,262,408	177,075,232	602,337,640	0	86,387,707	688,725,347
Total		1,343,261,640	302,808,704	1,646,070,344	47,162,608	99,837,664	1,793,070,616

60-Day Requirements	
Dynamic-Space	491,472,768
Free-Space	2,671,976
Static-Space	1,154,597,576
Daily-Growth	99,837,664
Daily-Spread	0
60-Day Space	7,144,857,436

Memory Requirements	
Final Allocation	1,824,694,456
Non-Growing 5%	47,162,608
1-Day Memory	1,871,857,064

Storage Requirements	
Total Disk Space	8,602,247,544
Log space used	262,144,000
60-Day Space	7,144,857,436
Remaining Space	1,195,246,108

TABLE_NAME	Record Count	TOTAL(KBYTE)	USED(KBYTE)
WAREHOUSE	15,000	121,008	120,936
WAREHOUSE_PK_IDX		17,288	408
DISTRICT	150,000	19,096	19,096
DISTRICT_PK_IDX		81,272	6,256
CUSTOMER	450,000,000	289,764,680	289,764,536
CUSTOMER_PK_IDX		16,179,000	16,011,736
CUSTOMER_IDX_W_ID_D_ID_LAST		21,329,992	21,158,032
NEW_ORDER	135,000,000	8,535,456	8,535,344
NEW_ORDER_PK_IDX		4,950,528	4,801,448
ORDERS	450,000,000	28,758,872	28,758,776
ORDERS_PK_IDX		16,172,544	16,011,672
ORDERS_IDX2		18,418,960	18,258,512
ORDER_LINE	4,499,034,427	425,340,912	425,262,408
ORDER_LINE_PK_IDX		178,577,288	177,075,232
ITEM	100,000	10,840	10,808
ITEM_PK_IDX		19,096	2,736
STOCK	1,500,000,000	553,338,360	553,338,152
STOCK_PK_IDX		49,655,160	49,482,672
HISTORY	450,000,000	37,451,968	37,451,584
Total Before 8-hour run		1,648,742,320	1,646,070,344

TABLE_NAME	Record Count	TOTAL(KBYTE)	USED(KBYTE)
WAREHOUSE	15,000	121,008	120,936
WAREHOUSE_PK_IDX		17,288	408
DISTRICT	150,000	19,096	19,096
DISTRICT_PK_IDX		81,272	6,256
CUSTOMER	450,000,000	289,765,456	289,765,400
CUSTOMER_PK_IDX		16,179,000	16,011,736
CUSTOMER_IDX_W_ID_D_ID_LAST		21,329,992	21,158,032
NEW_ORDER	144,360,937	10,753,752	10,753,272
NEW_ORDER_PK_IDX		7,776,680	7,776,160
ORDERS	541,799,097	34,553,064	34,551,552
ORDERS_PK_IDX		21,955,640	21,955,448
ORDERS_IDX2		26,320,248	26,320,040
ORDER_LINE	5,417,008,694	509,088,072	509,039,680
ORDER_LINE_PK_IDX		238,559,968	238,559,824
ITEM	100,000	10,840	10,808
ITEM_PK_IDX		19,096	2,736
STOCK	1,500,000,000	553,338,360	553,338,152
STOCK_PK_IDX		49,655,160	49,482,672
HISTORY	538,616,290	45,150,464	45,150,344
Total After 8-hour run		1,824,694,456	1,824,022,552

Clause 5: Performance Metrics

5.1 TPC Benchmark C Metrics

The TPC-C Metrics are reported in the front of this report as part of the executive summary.

5.2 Response Times

Ninetieth percentile, maximum and average response times must be reported for all transaction types as well as for the menu response time.

During the performance run transactions are submitted by the RTE in accordance with the required mix, Keying Times and Think Times of the benchmark Specification. Transactions are submitted by emulated users via HTTP. All timings are recorded by the RTE. The response time is measured from the submission of the transaction until the last byte of response is received by the RTE.

The details of the response times are reported in the front of this report as part of the Executive Summary.

5.3 Keying and Think Times

The minimum, the average, and the maximum keying and think times must be reported for each transaction type.

The details of the keying and think times are reported in the front of this report as part of the Executive Summary.

5.4 Distribution and Performance Curves

5.4.1 Response Time frequency distribution curves

Response Time frequency distribution curves must be reported for each transaction type.

Figure 5.4.1.1 shows the Response Time frequency distribution curves for the New-Order transaction.

Figure 5.4.1.2 shows the Response Time frequency distribution curves for the Payment transaction.

Figure 5.4.1.3 shows the Response Time frequency distribution curves for the Order-Status transaction.

Figure 5.4.1.4 shows the Response Time frequency distribution curves for the interactive portion of the Delivery transaction.

Figure 5.4.1.5 shows the Response Time frequency distribution curves for the Stock-Level transaction.

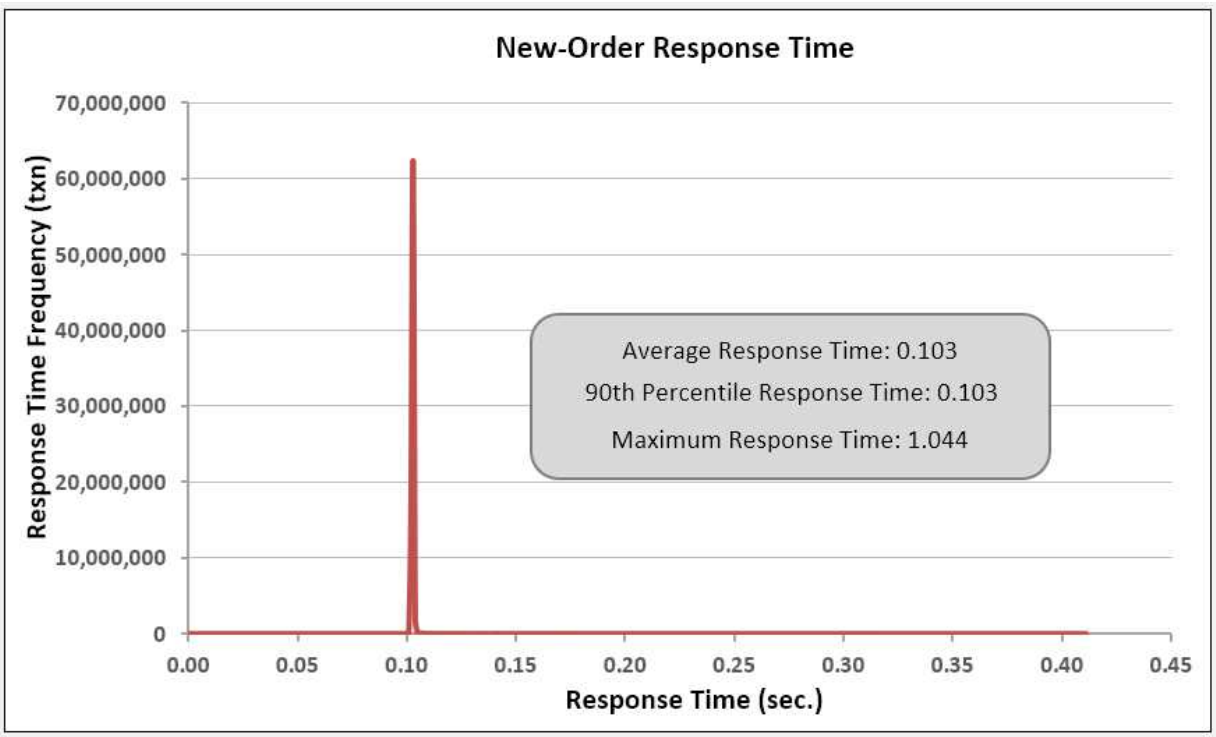


Figure 5.4.1.1: New-Order RT Frequency Distribution

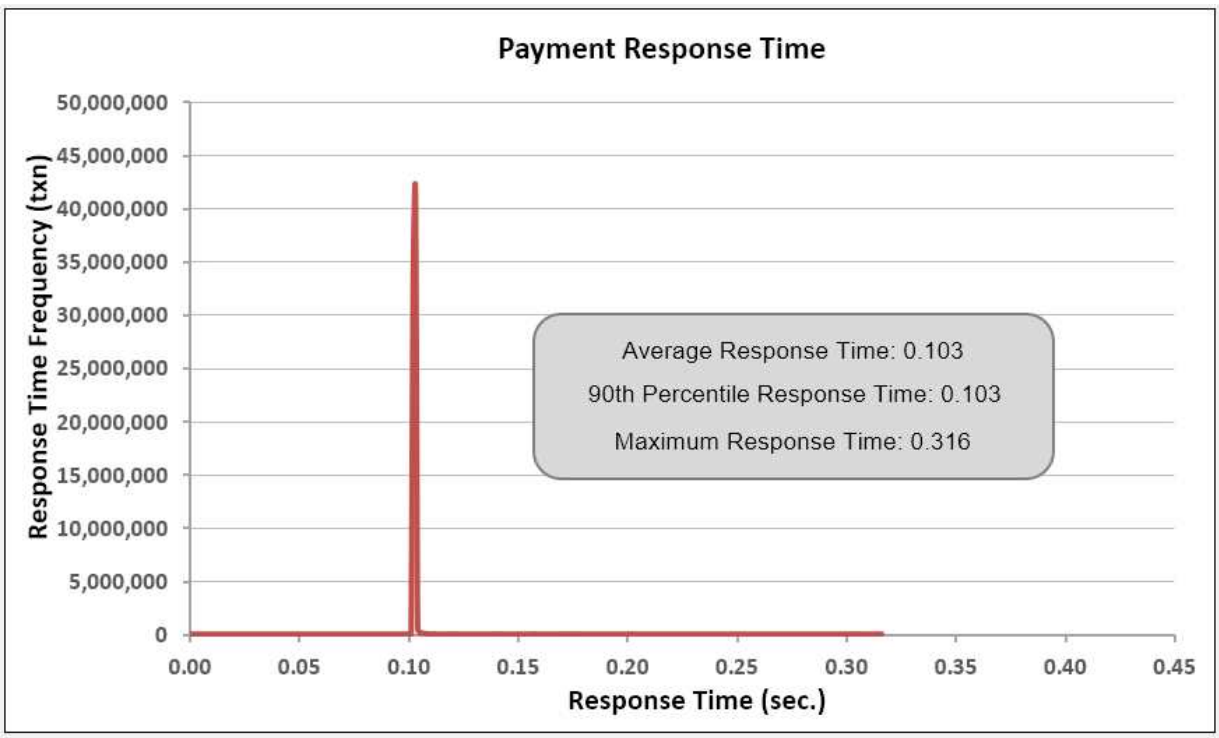


Figure 5.4.1.2: Payment RT Frequency Distribution

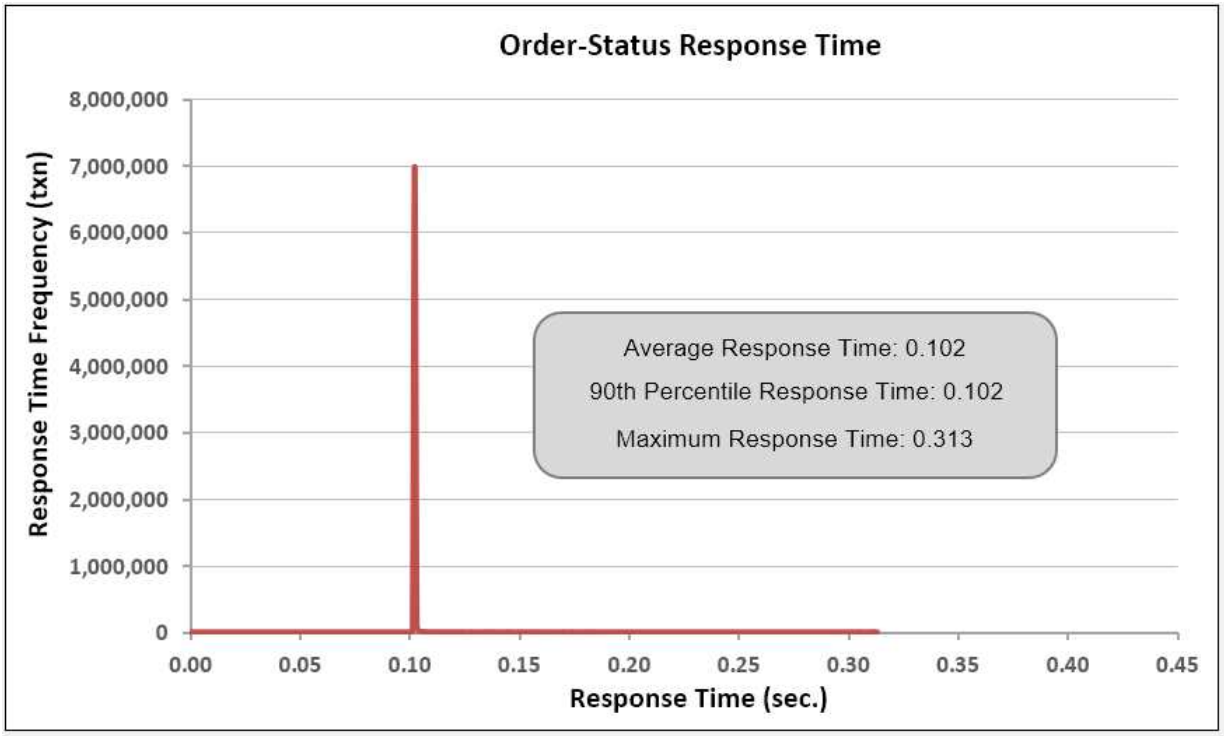


Figure 5.4.1.3: Order-Status RT Frequency Distribution

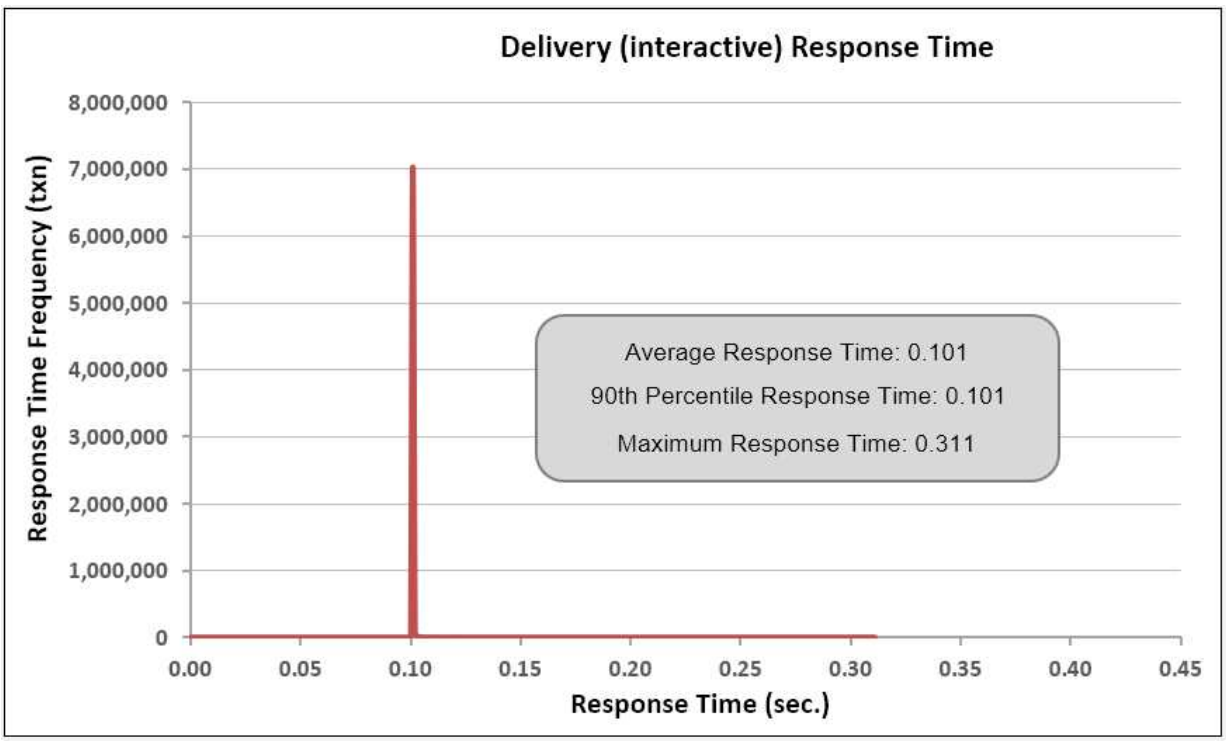


Figure 5.4.1.4: Delivery (Interactive) RT Frequency Distribution

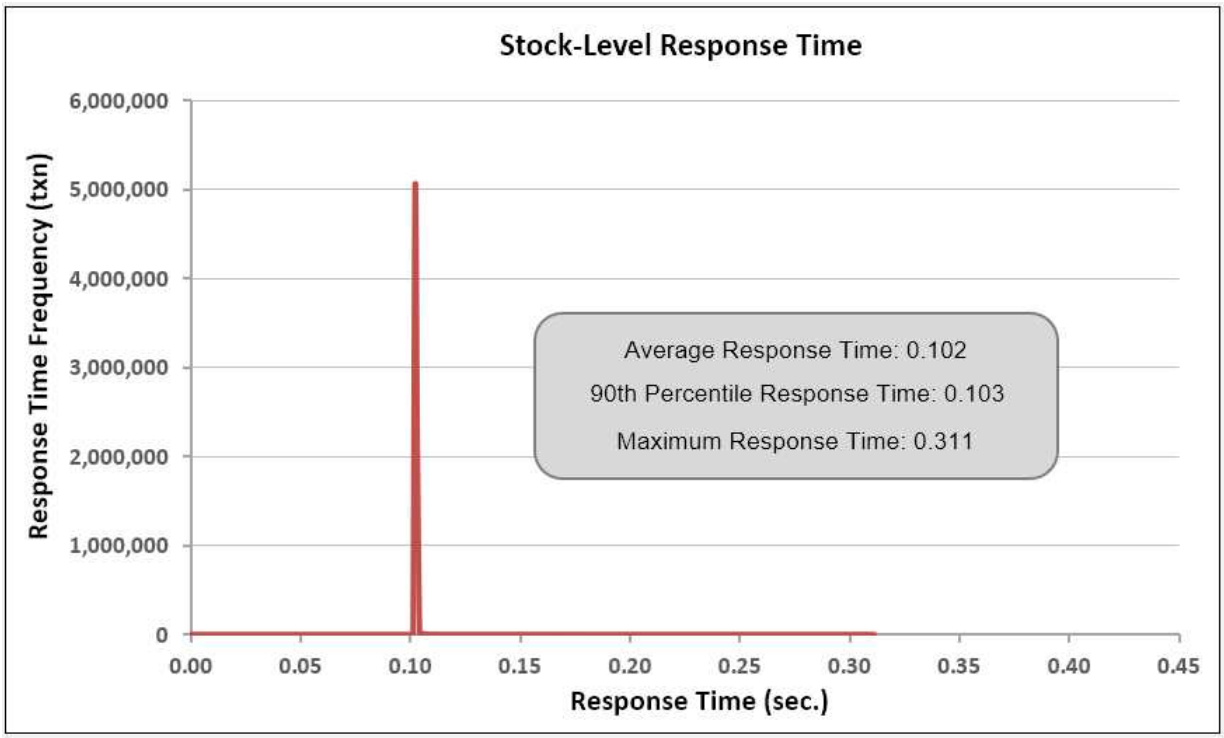


Figure 5.4.1.5: Stock-Level RT Frequency Distribution

5.4.2 Response Time versus throughput

The performance curve for response times versus throughput must be reported for the New-Order transaction.

Figure 5.4.2 shows the Response Time versus throughput curves for the New-Order transaction.

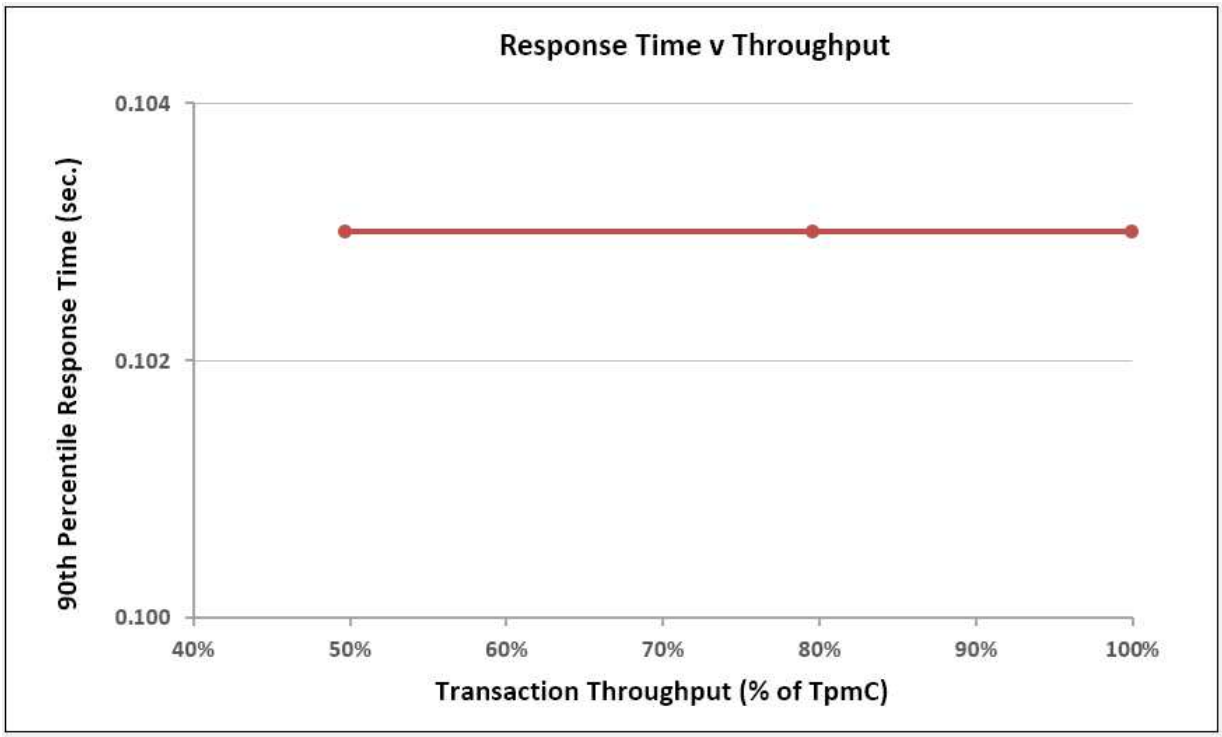


Figure 5.4.2: New-Order RT versus Throughput

5.4.3 Think Time frequency distribution

Think Time frequency distribution curves (see Clause 5.6.3) must be reported for the New-Order transaction.

Figure 5.4.3 shows the Think Time frequency distribution curves for the New-Order transaction.

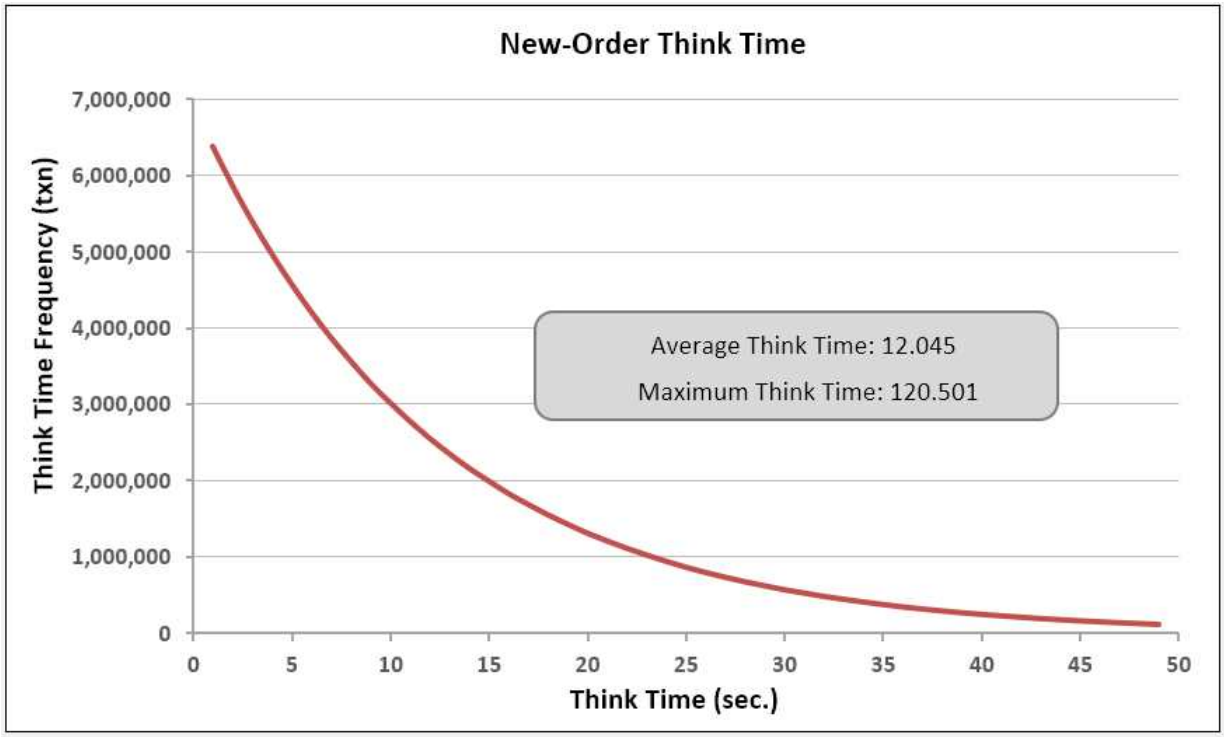


Figure 5.4.3: New-Order Think Time Frequency Distribution

5.4.4 Throughput versus elapsed time

A graph of throughput versus elapsed time must be reported for the New-Order transaction.

Figure 5.4.4 shows the throughput versus elapsed time for the New-Order transaction. The start and end of the Measurement Interval is included on the figure.

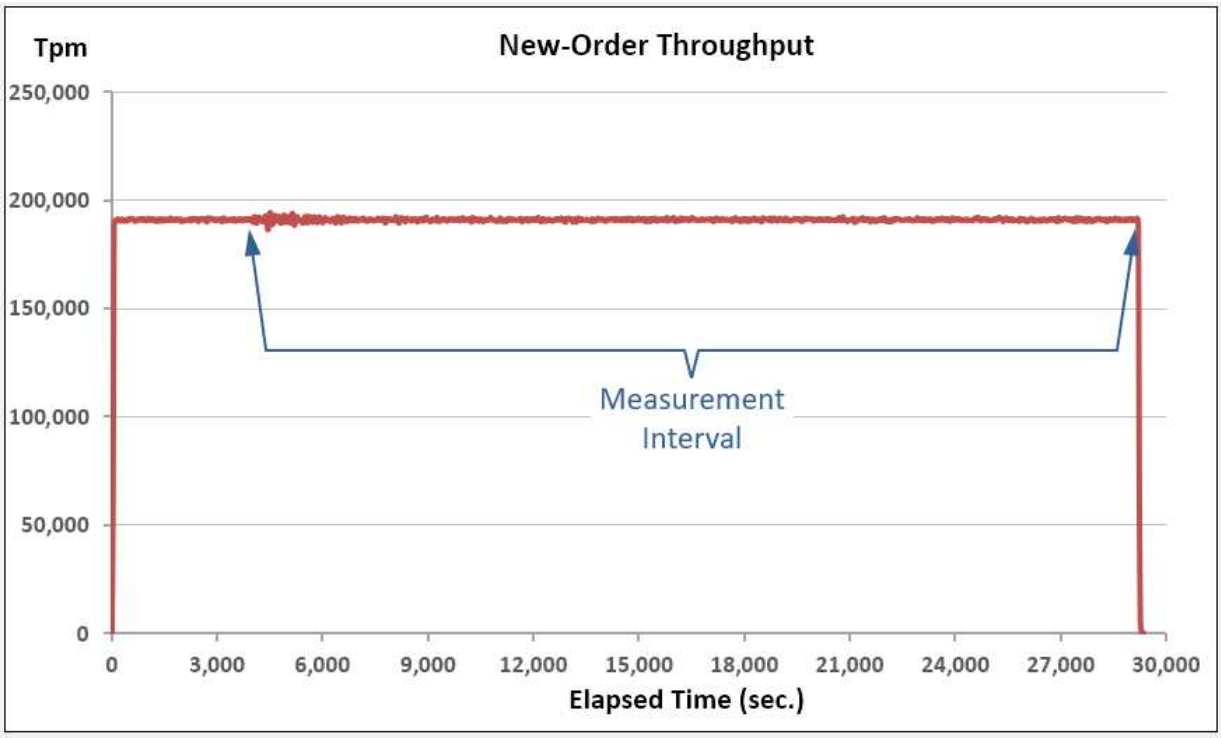


Figure 5.4.4: New-Order Throughput versus Elapsed Time

5.5 Steady State Determination

The method used to determine that the SUT had reached a steady state prior to commencing the measurement interval must be disclosed.

Steady state was determined using real time monitor utilities from the RTE. Steady state was further confirmed by a visual analysis of the throughput graph.

5.6 Work Performed During Steady State

A description of how the work normally performed during a sustained test (for example checkpointing, writing redo/undo log records, etc.) actually occurred during the measurement interval must be reported.

During the test, Goldilocks satisfied all of the ACID properties required by the benchmark specification. Committed transactions write a Redo record in the transaction log, to be used in case of system failure. The Redo records are used for roll-forward recovery during a re-start following a failure. This prevents the system from losing any committed transactions. Checkpoints periodically occurred about every 27.85 min. and are completed in about 17.28 min.

5.7 Measurement Period Duration

A statement of the duration of the measurement interval for the reported Maximum Qualified Throughput (tpmC) must be included.

The duration of the reported measured interval was 7 hours (7hr = 420min = 25,200sec).

5.8 Transaction Statistics

The percentage of the total mix for each transaction type must be disclosed. The percentage of New-Order transactions rolled back as a result of invalid item number must be disclosed. The average number of order-lines entered per New-Order transaction must be disclosed. The percentage of remote order lines per New-Order transaction must be disclosed. The percentage of remote Payment transactions must be disclosed. The percentage of customer selections by customer last name in the Payment and Order-Status transactions must be disclosed. The percentage of skipped Delivery transactions must be disclosed.

The details of the transaction statistics are reported in the front of this report as part of the Executive Summary.

5.9 Checkpoints

The number of checkpoints in the Measurement Interval, the time in seconds from the start of the Measurement Interval to the first checkpoint, and the Checkpoint Interval must be disclosed.

Two full checkpoints occurred before the Measurement Interval. 15 full checkpoints occurred during the Measurement Interval. The checkpoints' start and end times and durations during the Measurement Interval are listed in table 5.6.

Table 5.6: Checkpoints

Event	Event time	Execution time	Interval
Measurement Interval Begin	2022-04-20 14:29:44	-	-
Checkpoint3 Begin	2022-04-20 14:38:09		00:27:51
Checkpoint3 End	2022-04-20 14:55:25	00:17:16	
Checkpoint4 Begin	2022-04-20 15:05:58		00:27:49
Checkpoint4 End	2022-04-20 15:23:14	00:17:16	
Checkpoint5 Begin	2022-04-20 15:33:50		00:27:52
Checkpoint5 End	2022-04-20 15:51:04	00:17:14	
Checkpoint6 Begin	2022-04-20 16:01:40		00:27:50
Checkpoint6 End	2022-04-20 16:18:55	00:17:15	
Checkpoint7 Begin	2022-04-20 16:29:31		00:27:51
Checkpoint7 End	2022-04-20 16:46:47	00:17:16	
Checkpoint8 Begin	2022-04-20 16:57:22		00:27:51
Checkpoint8 End	2022-04-20 17:14:38	00:17:16	
Checkpoint9 Begin	2022-04-20 17:25:13		00:27:51
Checkpoint9 End	2022-04-20 17:42:31	00:17:18	
Checkpoint10 Begin	2022-04-20 17:53:05		00:27:52
Checkpoint10 End	2022-04-20 18:10:22	00:17:17	
Checkpoint11 Begin	2022-04-20 18:20:56		00:27:51
Checkpoint11 End	2022-04-20 18:38:12	00:17:16	
Checkpoint12 Begin	2022-04-20 18:48:47		00:27:51
Checkpoint12 End	2022-04-20 19:06:05	00:17:18	
Checkpoint13 Begin	2022-04-20 19:16:37		00:27:50
Checkpoint13 End	2022-04-20 19:33:52	00:17:15	
Checkpoint14 Begin	2022-04-20 19:44:29		00:27:52
Checkpoint14 End	2022-04-20 20:01:47	00:17:18	
Checkpoint15 Begin	2022-04-20 20:12:20		00:27:51
Checkpoint15 End	2022-04-20 20:29:33	00:17:13	
Checkpoint16 Begin	2022-04-20 20:40:13		00:27:53
Checkpoint16 End	2022-04-20 20:57:32	00:17:19	
Checkpoint17 Begin	2022-04-20 21:08:06		00:27:53
Checkpoint17 End	2022-04-20 21:25:26	00:17:20	
Measurement Interval End	2022-04-20 21:33:17	-	-

Clause 6: SUT, Driver and Communication

6.1 Remote Terminal Emulator (RTE)

If the RTE is commercially available, then its inputs must be specified. Otherwise, a description must be supplied of what inputs (e.g., scripts) to the RTE had been used.

The RTE software used was internally developed. The RTE simulated web users. It generated random input data based on the benchmark requirements and recorded response times and other statistics for each transaction cycle.

6.2 Emulated Components

It must be demonstrated that the functionality and performance of the components being emulated in the Driver System are equivalent to the priced system. The results of the test described in Clause 6.6.3.4 must be disclosed.

No components were emulated by the driver system.

6.3 Functional Diagrams

A complete functional diagram of both the benchmark configuration and the configuration of the proposed (target) system must be disclosed. A detailed list of all hardware and software functionality being performed on the Driver System and its interface to the SUT must be disclosed.

The diagram in Figure 0.1 shows the tested and priced benchmark configurations.

6.4 Networks

The network configuration of both the tested services and proposed (target) services which are being represented and a thorough explanation of exactly which parts of the proposed configuration are being replaced with the Driver System must be disclosed.

The bandwidth of the networks used in the tested/priced configuration must be disclosed.

The diagram in Figure 0.1 shows the network configuration between the components of the tested configuration. The RTE and the SUT are connected through a 1Gbps switch.

The network bandwidths are listed in Figure 0.1.

6.5 Operator Intervention

If the configuration requires operator intervention (see Clause 6.6.6), the mechanism and the frequency of this intervention must be disclosed.

No operator intervention is required to sustain eight hours at the reported throughput.

Clause 7: Pricing

7.1 Hardware and Software Pricing

A detailed list of hardware and software used in the priced system must be reported. Each separately orderable item must have vendor part number, description, and release/revision level, and either general availability status or committed delivery date. If package-pricing is used, vendor part number of the package and a description uniquely identifying each of the components of the package must be disclosed. Pricing source and effective date(s) of price(s) must also be reported.

The details of the hardware and software are reported in the front of this report as part of the Executive Summary.

7.2 Three Year Price

The total 3-year price of the entire configuration must be reported, including: hardware, software, and maintenance charges. Separate component pricing is recommended. The basis of all discounts used must be disclosed.

The pricing details for this TPC-C result are reported in the front of this report as part of the Executive Summary.

7.3 Availability Dates

The committed delivery date for general availability (availability date) of products used in the price calculations must be reported. When the priced system includes products with different availability dates, the reported availability date for the priced system must be the date at which all components are committed to be available.

All components of the priced system are available as of the date of this publication.

Clause 8: Reporting

8.1 Full Disclosure Report

A Full Disclosure report is required in order for results to be considered compliant with the TPC-C benchmark specification

This document constitute the Full Disclosure Report for the TPC-C benchmark result describes within.

Clause 9: Auditor Attestation

9.1 Auditor Information

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 who to contact in order to obtain further information regarding the audit process.

This benchmark was audited by:

InfoSizing

Doug Johnson

63 Lourdes Drive

Leominster, MA, 01453 USA
Phone: +1 (978) 343-6562

www.sizing.com

9.2 Attestation Letter

The auditor's attestation letter is included in the following pages.

InfoSizing
The Right Metric For Sizing IT

TPC
Certified Auditor

Sejin Hwang
Senior Research Engineer
Telecommunications Technology Association (TTA)
Bundang-ro 47, Bundang-gu, Seongnam-city
Gyeonggi-do, 13591, Republic of Korea

June 16, 2022

I verified the TPC Benchmark™ C v5.11.0 performance of the following configuration:

Platform:	TAEJIN T&S TNS2100
Operating System:	Red Hat Enterprise Linux 7.9
Database Manager:	Goldilocks v3.1 Standard Edition

The results were:

Performance Metric	**190,443 tpmC**
Number of Users	150,000

Server	**TAEJIN T&S TNS2100**		
CPUs	2x Intel® Xeon® Gold 6354 (3.00 GHz, 18-core, 39 MB Cache)		
Memory	2,048 GB		
Storage	***Qty***	***Size***	***Type***
	2	480 GB	SATA SSD
	8	1.6 TB	FMD SSD (External)
	4	12.8 TB	FMD SSD (External)

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 transactions were correctly implemented
- The database records were the proper size
- The database was properly scaled and populated
- The ACID properties were met
- Input data was generated according to the specified percentages
- The transaction cycle times included the required keying and think times
- The reported response times were correctly measured
- At least 90% of all delivery transactions met the 80 Second completion time limit

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

- All 90% response times were under the specified maximums
- The measurement interval was representative of steady state conditions
- The reported measurement interval was over 120 minutes
- Checkpoint intervals were under 30 minutes
- The 60-day storage requirement was correctly computed
- The system pricing was verified for major components and maintenance

Additional Audit Notes:

None.

Respectfully Yours,

Doug Johnson, Certified TPC Auditor

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Appendix A: Source Code

The source code and scripts used to implement the benchmark is provided as a soft appendix. This soft appendix includes the following files:

```
\ACID
    \ACID\include
    \ACID\src
    \ACID\include\acid.h
    \ACID\src\atom.c
    \ACID\src\compare.c
    \ACID\src\consist.c
    \ACID\src\Delivery.c
    \ACID\src\isol1.c
    \ACID\src\isol2.c
    \ACID\src\isol3.c
    \ACID\src\isol4.c
    \ACID\src\isol5.c
    \ACID\src\isol6.c
    \ACID\src\isol7.c
    \ACID\src\isol8.c
    \ACID\src\isol9.c
    \ACID\src\Makefile
    \ACID\src\NewOrder.c
    \ACID\src\OrderStatus.c
    \ACID\src\Payment.c
    \ACID\src\support.c
\bin
    \bin\load.sh
\html
    \html\DeliveryInput.html
    \html\MainMenu.html
    \html\NewOrderInput.html
    \html\OrderStatusInput.html
    \html\PaymentInput.html
    \html\StockLevelInput.html
\include
    \include\spt_proc.h
    \include\support.h
\java
    \java\Common.java
    \java\Delivery.java
    \java\NewOrder.java
    \java\OrderStatus.java
    \java\Payment.java
    \java\StockLevel.java
\scripts
    \scripts\analyze_system.sql
    \scripts\analyze_table.sql
    \scripts\analyze_table_district.sql
    \scripts\analyze_table_item.sql
    \scripts\analyze_table_new_order.sql
    \scripts\analyze_table_orders.sql
    \scripts\analyze_table_order_line.sql
```

```
    \scripts\analyze_table_stock.sql
    \scripts\analyze_table_warehouse.sql
    \scripts\audit.sql
    \scripts\checkpoint.py
    \scripts\count.sql
    \scripts\create_audit_table.sql
    \scripts\create_index.sql
    \scripts\create_procedure.sql
    \scripts\create_table.sql
    \scripts\create_tablespace.sql
    \scripts\dbcheck.sql
    \scripts\dbtables.sql
    \scripts\runcheck.sql
    \scripts\sys
         \scripts\sys\be
             \scripts\sys\be\part_info.sh
             \scripts\sys\be\reboot_info.sh
             \scripts\sys\be\sw_info.sh
             \scripts\sys\be\sys_info.sh
\src
    \src\free_space.c
    \src\load.c
    \src\load_new.c
    \src\Makefile
    \src\support.c
```

Appendix B: Tunable Parameters

goldilocks.properties.conf

```
TRANSACTION_COMMIT_WRITE_MODE = 1
TRANSACTION_TABLE_SIZE = 1024
UNDO_RELATION_COUNT = 1024
LOG_BUFFER_SIZE = 3G
LOG_FILE_SIZE = 50G
LOG_GROUP_COUNT = 5
PENDING_LOG_BUFFER_COUNT = 8
SPIN_COUNT = 1
BUSY_WAIT_COUNT = 1000
SYSTEM_TABLESPACE_DIR = '/data/db/db1'
SYSTEM_MEMORY_UNDO_TABLESPACE_SIZE = 16G
SYSTEM_MEMORY_TEMP_TABLESPACE_SIZE = 1G
SHARED_MEMORY_STATIC_SIZE = 4G
PARALLEL_IO_FACTOR = 5
PARALLEL_IO_GROUP_1 = '/data/db/db1'
LOG_DIR = '/wal'
CLIENT_MAX_COUNT = 1024
PROCESS_MAX_COUNT = 1024
PARALLEL_LOAD_FACTOR = 16
SHARED_SESSION = NO
CONTROL_FILE_COUNT = 2
CONTROL_FILE_0 = '/wal/control_0.ctl'
CONTROL_FILE_1 = '/wal/control_1.ctl'
```

limit.conf

```
# /etc/security/limits.conf
#
#This file sets the resource limits for the users logged in via PAM.
#It does not affect resource limits of the system services.
#
#Also note that configuration files in /etc/security/limits.d
directory,
#which are read in alphabetical order, override the settings in this
#file in case the domain is the same or more specific.
#That means for example that setting a limit for wildcard domain
here
#can be overriden with a wildcard setting in a config file in the
#subdirectory, but a user specific setting here can be overriden
only
#with a user specific setting in the subdirectory.
#
#Each line describes a limit for a user in the form:
#
#<domain>        <type>  <item>  <value>
#
tpcc soft nofile 65535
tpcc hard nofile 65535
tpcc soft nproc 65535
tpcc hard nproc 65535



# End of file
```

server.xml

```
<?xml version='1.0' encoding='utf-8'?>
<Context>

    <WatchedResource>WEB-INF/web.xml</WatchedResource>



<Resource
    name='jdbc/goldilocks'
    auth='Container'
    type='javax.sql.DataSource'
    driverClassName='sunje.goldilocks.jdbc.GoldilocksDriver'
    url='jdbc:goldilocks://10.100.250.156:22581/test'
    username='test'
    password='test'
    maxActive='10'
    maxIdle='10'
    maxWait='-1'
/>

</Context>
```

Sysctl_fe.conf

```
<?xml version='1.0' encoding='utf-8'?>
<Server port="8005" shutdown="SHUTDOWN">
  <Listener
className="org.apache.catalina.startup.VersionLoggerListener" />
  <!-- Security listener. Documentation at
/docs/config/listeners.html
  <Listener
className="org.apache.catalina.security.SecurityListener" />
  -->
  <!--APR library loader. Documentation at /docs/apr.html -->
  <!--Initialize Jasper prior to webapps are loaded. Documentation
at /docs/jasper-howto.html -->
  <Listener className="org.apache.catalina.core.JasperListener" />
  <!-- Prevent memory leaks due to use of particular java/javax
APIs-->
  <Listener
className="org.apache.catalina.core.JreMemoryLeakPreventionListener"
/>
  <Listener
className="org.apache.catalina.mbeans.GlobalResourcesLifecycleListen
er" />
  <Listener
className="org.apache.catalina.core.ThreadLocalLeakPreventionListene
r" />

  <GlobalNamingResources>
    <Resource name="UserDatabase" auth="Container"
              type="org.apache.catalina.UserDatabase"
              description="User database that can be updated and
saved"

factory="org.apache.catalina.users.MemoryUserDatabaseFactory"
              pathname="conf/tomcat-users.xml" />
  </GlobalNamingResources>

  <Service name="Catalina">



                        <Connector port="8080"

acceptCount="150000"

maxConnections="141000"

connectionTimeout="20000000"

maxThreads="1024"

maxKeepAliveRequests="-1" keepAliveTimeout="-1"

protocol="org.apache.coyote.http11.Http11NioProtocol"
redirectPort="8443"
                        />


    <Connector port="8009" protocol="AJP/1.3" redirectPort="8443" />


    <Engine name="Catalina" defaultHost="localhost">


      <Realm className="org.apache.catalina.realm.LockOutRealm">
        <Realm
className="org.apache.catalina.realm.UserDatabaseRealm"
               resourceName="UserDatabase"/>
      </Realm>

      <Host name="localhost"  appBase="webapps"
            unpackWARs="true" autoDeploy="true">



      </Host>
    </Engine>
  </Service>
</Server>
```

Appendix C: Price Quotations

DB Server

TAEJIN T&S

견 적 서

건 명	한국정보통신기술협회(TTA)	상 호	㈜태진티엔에스
수 신	황세진 선임연구원님	대표이사	조 병 영 (직인생략)
참 조	TPC-C 시험인증 관련 건	주 소	서울시특별시 구로구 디지털로 306, 707호
연 락 처		연 락 처	Tel. 82-70-7703-9880 | Fax. 82-2-2082-1566

납 기 일 자	협의 및 납품	견 적 번 호	영업본부-20220523-01
무 상 보 증	납품 및 검수 완료일로부터, 3년(24시간 x 7일)	견 적 일 자	2022년 5월 23일
결 제 조 건	검수 후, 즉시 현금결제	견 적 유 효	견적일로 부터 90일(3개월)
납 품 장 소	지정장소	담 당 자	김 진 과장 | 010-5286-7275 | jk@tjtns.co.kr
견 적 금 액	**₩ 52,000,000- (부가세별도)**	**일금 오천이백만원 (부가세포함)**	

※ 견적 요청에 감사드리며, 귀사의 일익번창을 기원합니다. (단위 : 원)

구 분	상 세 사 양	수 량	비 고
x86 서버	**TNS-2100**	**1**	
모델명	TNS-2100, 2U, 2소켓, 32xDIMM, 8x2.5", PSU(1+1)1400W	1	
CPU	Intel® Xeon® Gold 6354 3.0G, 18C/36T, 39MB 캐시	2	총 36코어, 3.0G
RAM	128GB DDR4 3200MHz RDIMM	8	총합 2,048GB
RAM	64GB DDR4 2666MHz RDIMM	16	
SSD	480GB SSD SATA 6Gbps 2.5"	2	
RAID	SAS Controller 8G Cache	1	
NIC	10GbE 2Port SFP+ Network Adapter(GBIC 포함)	2	총 4포트
HBA	16G FC 2Port HBA	2	총 4포트
공급가 합계(부가세 별도)			**52,000,000**

※ 상기 견적은 해당 건에 한하며, 타 사례의 근거가 될 수 없습니다.

※ 확장 및 이설, 타 기종으로의 교체 등의 지원 및 정기점검은 포함 되어 있지 않습니다.

WAS Server

IT 하드웨어(서버/스토리지/PC) 제조 및 판매, 망연계 및 보안솔루션, 가상화솔루션, IT컨설팅 및 유지보수 전문

유 지 보 수 견 적 서

관리 NO : UWT-22-0603-005

TTA 서병준 연구원님

UNIWIDE Technologies, Inc
서울특별시 구로구 디지털로 273
에이스하이엔드타워 1차 1404호
대표이사 : 우 홍 문 (인)
대표전화 : 070-7306-0500
팩스번호 : 02-866-0037

견적일자 2022-06-08
유 효 기 간 : 견적서 발행 후 2주
결 제 조 건 : 현금
지 급 조 건 : 계산서 발행 후 30일

	내 용		수량	단가	합계	구매 가격
구매가격	HANSUNG	DT-S170G1fV0	3	1,551,000	4,653,000	4,653,000
	CPU	Intel Core Processor i7-10700K, 3.8Ghz				
	MEMORY	UDIMM PC4-256000U				
	HDD	ST2000DM008 2TB 3.5				
	SDD	SSD EX900 512GB				
	NIC	2 Port 10G Ethernet Controller			per month	per year
	내 용		**수량**	**단가**	**월 보수료**	**년 유지보수료**
유지보수 가격	HANSUNG	DT-S170G1fV0	3	22,000	66,000	792,000
	3years, 24X7X4hrs Onsite Support Service					
					sum	
				3년 유지보수+ 납품가		7,029,000
합 계					**DC 적용**	**7,029,000**

* 유지보수 조건

1) 전화 지원,현장 대응지원, **PART 교체후 회수 조건 (비 회수시 별도 비용청구)**

2) 소모성 부품 및 스토리지 battery 유상 처리

3) 유지보수 대상장비의 H/W에 한함 (계약 체결전 장애에 대해서는 별도 비용 청구 및 유지보수 제외)

4) 기타 유지보수 범위에 포함되지 않는 기술지원 유상

ex) 계약기간 전 발생한 장애,상주,정전대기,성능분석,기기이설,시스템구성변경 등

5) PART 지원 조건 (기술지원 요청 시 유상 처리 기준)
* 업무시간 내에만 지원(토요일, 국/공휴일 제외)(업무 시간외는 별도 협의필요)

본견적서로 발주를 진행하고 싶으시다면 명판 및 직인을 날인하시어 팩스&메일로 송부하여 주시기 바랍니다.

명판	직인

* 상기 와 같이 견적 합니다.
* 우리은행 :1005-101-400697 (예금주 : 유니와이드테크놀러지) , 세금 계산서 : aasle@uniwide.co.kr
* 담당자 : 기술팀장 박성진 (070-7306-0545 , 010-2676-2181,jinhan42@uniwide.co.kr)

Storage

UNIWIDE Technologies

Quotation

견 적 일 자: UWT22 - Cloudbiz -0526
수 신: 한국정보통신기술협회
납 품 일 자: 고객 요청 시,
견적유효기간: 견적 후 7일
결 제 조 건: 납품 후 즉시 현금
무상유지보수: 3 년
기 타:

UNIWIDE Technologies, Inc.
서울시 구로구 디지털로26길5, 1404호
(에이스하이엔드타
대표이사 : 우 종
TEL : 070-7306-05
FAX : 02-866-0037

기술연구소
견적책임자 : 클라우드팀 / 황윤식 팀장
전 화 번 호 : 070-7306-0515
휴 대 전 화 : 010-5133-3254
이 메 일 : yshwang@uniwide.co.kr

공 급 금 액: **292,300,000** 원(부가세 별도

모 델: FCH2800

PART NUMBER	제품명	수량	도입수량	공급단가	공급합가
FCH2800	**All Flash Storage - FCH2800**	1			
T0001-0117-00	FCH2800 Controller Device	1			
T0001-0117-01	Back-end Bus Adapter 12G SAS	1			
T0001-0117-02	16G 8-Port Host Bus Adapter	4			
T0001-0117-03	Cache Interconnect Adapter	1			
T0001-0117-04	Cache Memory DDR-3 (32GB)	16			
T0001-0117-05	FCH2800 Flash Disk Drive Expantion Unit	1	1	72,250,000	₩72,250,000
T0001-0117-06	FCH2800 controller cpu Board	1			
T0001-0117-07	Rack 600x1200x2010 mm (WxDxH) 42U	1			
T0001-0117-08	Storage Management SW	1			
61001-0001-00	UTP CAT5e Ethernet Cable 1M	1			
42119-0005-00	Power Cord, NICETECH, 2.5M	2			
T22601-0117-03	1.6TB Flash Memory Disk Drive	1	8	3,900,000	₩31,200,000
T22601-0117-05	12.8TB Flash Memory Disk Drive	1	4	40,625,000	₩162,500,000
	3-yrs 24x7x4hrs Onsite Support Service	1	1	26,350,000	₩26,350,000
	제 안 가				**₩292,300,000**
	부 가 세				**₩29,230,000**
	부 가 세 포 함 가				**₩321,530,000**

본견적서를 발주를 진행하고 싶으시다면 명판 및 직인을 날인하시어 팩스를 송부하여 주시기 바랍니다.

명판	직인

RHEL/JWS

rockPLACE
(주)락플레이스 www.rockplace.co.kr

㈜락플레이스
135-120 서울시 강남구 신사동 634-10 윤당빌딩 3층 Tel.02)6251.7788 Fax.02)6251.6677

rockPLACE, Inc.
3F, Yundang bldg, 634-10, Shinsa-dong, Gangnam-gu,Seoul, Korea Tel : 822-6251-7788 Fax: 822-6251-6677

견 적 서

REF No.	: 2021RP11-2903	TERMS AND CONDITION	
DATE	: 2021. 11. 29.		
COMPANY	: TTA	납 기	: 발주후 4주이내
ATTN	: 최기한 선임연구원님 귀하 TEL : 031-780-9256	유지보수	: 납품일로부터 1년
Email	: kihanc@tta.or.kr	결제조건	: 익월말 현금
FROM	: ㈜락플레이스 이왕모 과장 TEL : 010-9116-4680	유효기간	: 견적일로부터 4개월
Email	: wmlee@rockplace.co.kr		

下記와 같이 見積합니다.

㈜ 락플레이스
대표이사 서 동 식

ITEM DESCRIPTION (VAT 별도, 단위 : 원)

Part No.	Description	수량	소비자가	공급단가	공급합계
OS	Red Hat Enterprise Linux Operating System Platform				
RH00004F3	Red Hat Enterprise Linux Server, Standard (Physical or Virtual Nodes) 3Year support : Easy ISOs: OS, Source, Documentation ISO Images 가상화 Guest OS : 2guests Red Hat Network 서비스 : 3년 Phone,email Support : 09:00 ~ 17:00 Scope of Coverage : Standard Maximum Memory Support: Unlimited	4	4,098,000	2,400,000	9,600,000
연간기술지원	연간 방문 기술지원 (옵션)				
RP-CPS(OS)	rockPLACE Support Carepack - Linux Standard (3년) per Server 3 Year, 24x7, 4hr response 이메일, 전화, 원격지원, 현장지원 서비스 On Site Support - Total 연간 10회 Support (아래 지원내역에 준함) - Installation & Startup Service Included - Problem tracking/Emergency assistance - Update, Patch 작업 지원 - 서비스, 시스템 환경, 네트워크 환경 설정 변경 지원 - 인수 시험, 성능 시험, 비상 복구 훈련 지원	4	6,000,000	2,000,000	8,000,000
소 계 금 액					17,600,000

Part No.	Description	수량	소비자가	공급단가	공급합계
WEB	Red Hat JBoss Web Server				
MW00123F3	Red Hat JBoss Web Server, 4-Core Standard 3Year - 전화/팩 지원 : 월-금, 9 a.m. - 5 p.m. 4시간내 응답 - unlimited incidents.	6	2,144,000	1,260,000	7,560,000
연간기술지원	연간 방문 기술지원 (옵션)				
RP-CPS(WAS)	rockPLACE Support Carepack - JBoss Standard (3년) per 4Core 3 Year, 24x7, 4hr response 이메일, 전화, 원격지원, 현장지원 서비스 On Site Support - Total 10회 Support (아래 지원내역에 준함) - Installation & Startup Service Included - Problem tracking/Emergency assistance - Update, Patch 작업 지원 - 서비스, 시스템 환경, 네트워크 환경 설정 변경 지원 - 인수 시험, 성능 시험, 비상 복구 훈련 지원	6	12,000,000	6,000,000	36,000,000
소 계 금 액					43,560,000

합 계	61,160,000
부가세	6,116,000
합 계(부가세포함)	67,276,000

Remarks

1. Red Hat 제품은 년간 Subscription 제품이며, 기간이 만료되실 경우 Renewal을 하셔야합니다.
2. 발주 시에는 반드시 고객정보(엔드유져명, 담당자, 연락처, Email)가 있어야 합니다.
3. OnSite 방문지원이 필요하실 경우에는 케어팩을 구매하셔야 합니다.

Network Switch

상품상세정보

확대보기 수량 : 대

네트워크스위치

업체명 : 주식회사엔에스지[중소기업] 계약자/공급자 정보조회
계약방법 : 다수공급자계약
규격명 : 네트워크스위치, 유비쿼스, uSafe3010-24T, 24port (공급)
가격 : 1,900,000 원 다량납품할인율 확인 → Price
단위 : 대
원산지 : 대한민국
주요부품1[원산지] : Firmware[대한민국]
주요부품2[원산지] : Main Board[대한민국]
제조사 : (주)유비쿼스
납품장소 : 수요기관 지정장소
인도조건 : 현장설치도
공급지역 : 전지역
부가세여부 : 부가가치세포함
계약기간 : 2017/08/24 ~ 2022/08/23
납품기한 : 60일 (납품요구일로부터)
조달수수료여부 : 조달수수료 별도 조달수수료 안내·계산
첨부파일 : 2018/02/01_00176118204-(계약예규)물품구매(제조)계약일반조건(기재부예규제328호20161230).hwp
2018/02/02_00176118204-다수공급자계약특수조건(조달청공고2017-73호,2017.7.14).hwp
2018/02/03_00176118204-물품구매계약품질관리특수조건(2017.8.28.).hwp
2018/02/04_00176118204-엔에스지_규격서(2017.08).zip
대분류 : 09 - 전자/정보/통신/영상
중분류 : 07 - 음향장비 및 신호장치
물품분류번호 : 43222612
세부품명번호 : 4322261201
물품식별번호 : 22917889
계약번호 : 00176118204-9
징수구분 : 후징수

DBMS

견 적 서

TTA 貴中

Title : TPC-C Performance&Quality Authentication

▣ 수 신 : 황세진 선임연구원님 (010-5110-4883, hsejin314@tta.or.kr)
▣ 견적일자 : 2022년 05월 20일
▣ 유효기간 : 견적일로부터 1개월

대표이사 : 김 기 완 (
주 소 : 서울시 영등포구 당산로171
금강펜테리움IT타워 604호
영업대표 : 사업본부 김수호 부장
전화번호 : 010-4734-4646
e-mail :shkim@sunjesoft.com

※ Goldilocks Standard Edition for LINUX 1식

(단위 : 원)

No.	Description	Unit Price	Q'ty	Total Price	Offer Price	비 고
[72Core]						
1	Goldilocks Ver 3.1 DBMS Standard Edition	144,000,000	1 Set(s)	144,000,000	43,200,000	
	- Query Processes Module					
	- Storage Management Module					
소 계 (부가세 별도)				144,000,000	**43,200,000**	
2	DBMS Implementaion & Supports	77,000,000	3 Set(s)	231,000,000	21,600,000	
소 계 (부가세 별도)				231,000,000	**21,600,000**	
합 계 (부가세 별도)				375,000,000	**64,800,000**	

총 합 계 (부가세 별도)	**64,800,000**	

* Remarks
- For Technical supports, it indicates 24 x 7 x 4 hours of support