



SUPERMICRO AND AMD ACHIEVE OUTSTANDING LINEAR WORKLOAD SCALING FOR ORACLE DATABASE 19C

AMD Powered Supermicro A+ Servers Accelerate Oracle Database 19c Performance

Executive Summary

Supermicro, working closely in partnership with AMD, has been a part of the AMD EPYC™ processor journey since the first launch of AMD's "Zen" microarchitecture in 2017. Supermicro was one of the first server vendors to bring the 1st Gen AMD™ EPYC -processors to market with our H11 platforms. In 2019, Supermicro launched its first family of H12 generation AMD processor-powered Supermicro A+ servers optimized to deliver a new level of integration and superior performance for modern datacenters with the AMD EPYC™ 7002 Series Processors. The new A+ servers, powered by the 2nd Gen AMD EPYC 7002 series processors, deliver up to two times the performance with up to double the core count compared to 1st Gen AMD EPYC processor-based systems. With Supermicro's next-generation architecture, the A+ servers take full advantage of 2x data throughput of PCI-E 4.0 lanes that the new AMD processors provide, including the full spectrum of the latest components storage, networking, accelerators like GPUs.

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SUPERMICRO

Supermicro (Nasdaq: SMCI), the leading innovator in high-performance, high-efficiency server and storage technology is a premier provider of advanced server Building Block Solutions® for Enterprise Data Center, Cloud Computing, Artificial Intelligence, and Edge Computing Systems worldwide. Supermicro is committed to protecting the environment through its "We Keep IT Green®" initiative and provides customers with the most energy-efficient, environmentally-friendly solutions available on the market.

Supermicro's expertise and experience in optimizing systems for the AMD EPYC™ architecture has led to 27 world record system performance benchmarks at launch, in August 2019, for 2nd Gen AMD EPYC 7002 series processors. World-record performance benchmarks were set on Supermicro's new H12 A+ Servers for TPCx-IoT and TPC-DS categories. For more detailed information on AMD EPYC World Records, please see the URL (1) in the Footnotes. For TPCx-IoT, the performance of 472,200.88 IoTps was established on Supermicro's H12 TwinPro™ 2U 4-node server where faster IoT gateway data analytics are critical for the coming explosion of IoT device numbers. This server delivers the highest performance and lowest performance per dollar for a 10TB database with 64% higher QphDS throughput (Composite Query per Hour Metric) and cost savings per QphDS over the previous world record holders, see the AMD EPYC 7002 Series Processors URL(2) in Footnotes.

Supermicro offers an industry-leading portfolio of AMD EPYC based systems based on Server Building Block Solutions®. From single-socket mainstream and WIO servers to high-end Ultra server systems and multi-node systems, including BigTwin® and TwinPro®, Supermicro enables customers to build application-optimized solutions with a wide range of configuration possibilities.

AMD EPYC™ 7002 Series Processors Brings Flexibility, Performance, and Security Features

AMD EPYC 7002 Series processors offer up to 64 x86 cores per socket for high-density requirements and can dramatically increase your system performance while running a number of concurrent and complex applications. With higher frequencies than the other offerings, the AMD EPYC 7Fx2 processors are optimized for frequency sensitive and single-threaded workloads. This efficiency and speed can help you to achieve significant savings in the total cost of ownership (TCO). Based on AMD Infinity Guard, the new 2nd Gen AMD EPYC 7002 series processors also feature advanced security, including Secure Memory Encryption and Secure Encrypted Virtualization.

AMD EPYC 7Fx2 processors bring high frequencies and very high ratios of cache per core to the 2nd Gen AMD EPYC family of processors along with the large memory capacity, extreme memory bandwidth, and massive I/O, to deliver exceptional performance.

The tested configuration is shown below in Table 1. The AMD EPYC 7Fx2 processors offer high frequency that is specifically designed to optimize per-core performance for frequency sensitive workloads and core-based software licensing models.

AMD EPYC 7Fx2 Processors Demonstrate Superior Performance on Transactional Processing Workloads with Oracle Database 19c

Oracle® Database delivers leading-edge innovations in relational database management systems (RDBMS) for on-premises, cloud, and hybrid workloads with exceptional performance and ease-of-use. AMD's internal test results show that AMD EPYC 7Fx2 processor-based systems deliver high performance and outstanding scaling for Online Transaction Processing (OLTP) performance with Oracle Database 19c.

Supermicro AS -1014S-WTRT server, powered by AMD EPYC 7F72

For this benchmark with Oracle Database 19c, we are using the Supermicro AS -1014S-WTRT server powered by AMD EPYC 7F52 and AMD EPYC 7F72. This system is a single socket, as shown in the table below. With AMD EPYC's core density, it is cost-effective and ideal solution for database processing and enterprise application workloads.

Server	Form Factor	System Memory	Drive Bays	Network Controllers
AS-1014S-WTRT	1U Rackmount	8 x DDR4 slots up to 3200MHZ	4 x hot swap 3.5" or 2.5" SATA3 or NVMe drives	Dual Broadcom 10G Base -TLAN ports

Table 1: Benchmarks CPU Model

Supermicro's AS -1014S-WTRT server's design philosophy was to provide a high density, single-socket server in a compact form factor (1U, 25.6" deep) that is powerful and robust enough to handle the most demanding enterprise applications while also maintaining cost efficiency. The AS -1014S-WTRT is a single socket system, in which customers may choose among AMD's 8, 16, 24, 32, and 64 cores, P variant CPU SKUs, which offer unique pricing discounts over dual socket capable AMD CPUs. We specifically selected this single-socket system for benchmarking with Oracle Database 19c because it offers a unique and strong value proposition, capable of predictable workload performance scaling. With AMD's 2nd generation cores, what used to require dual or multi-socket systems, can now be consolidated into a single scale-up server.

AS -1014S-WTRT – Oracle Database 19c



AMD EPYC 7Fx2 Processors Demonstrate Superior Performance on Transactional Processing Workloads with Oracle Database 19c

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Server	Base Frequency	Boost Frequency (up to)*	Core Processor	Memory Channels	Maximum Memory/Socket(DDR4-3200)	PCIe® Gen4 Lanes / System
AMD EPYC 7F52	3.5 GHz	3.9 GHz	16	8	4 TB	128
AMD EPYC 7F72	3.2 GHz	3.7 GHz	24	8	4 TB	128

Table 2: Figure CPU's deployed

Benchmarking with Oracle Database 19c and AMD EPYC 7Fx2 Processors

These CPUs are optimized for higher frequency as in Table 2; they excel at single-threaded workloads where core count limitation is preferred.

This workload models an order fulfillment system where the database receives requests for data, adds new data, and makes multiple changes to the data from a large number of users. The results show sustained transaction throughput and predictable scaling across 16-core and 24-core processors allowing one to right-size the compute power to the application needs and help lower total cost of ownership by only paying for cores needed to optimize core-based software licensing model costs.

AMD EPYC 7002 Series High Frequency Processors Online Transaction Processing (OLTP) Performance & Scaling On Oracle Database 19c.

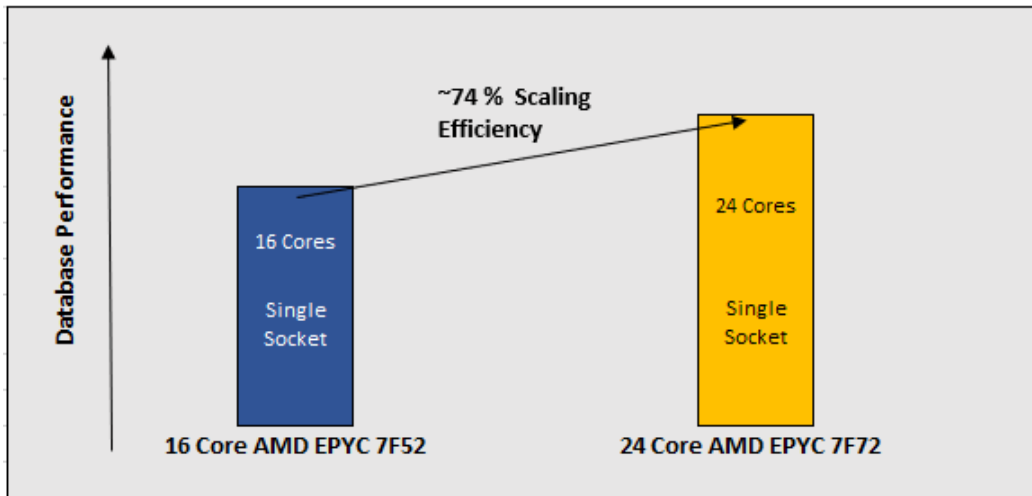


Table 3: TPC - C Benchmarks

This OLTP Workload, used for this benchmark, is derived from the TPC-C Benchmark, and as such, is not comparable to published TPC-C Benchmark results, as the OLTP workload results do not comply with the TPC-C Benchmarks in the above Table 3.

Hardware Configuration and Setup



Data Switches – SSE – C3632SR 40 GB



Management Switches – 10G Ethernet Switch SSE-X3349T



Supermicro Server – AS-1014S-WTRT – Oracle Database 19c with Oracle ASM



Benchmarking/Hammer DB – SYS - 2029U-TN24R4T

Supermicro AS -1014S-WTRT server is a 1U Rackmount Server supporting Single Socket with AMD EPYC™ 7002 Series Processors. Two different CPU models were used in this benchmark study to estimate a scaling efficiency due to the different number of cores contained.

The same tests have been applied to the same server configuration, with the only difference being the CPU, per the two options listed below in Table 2.

SuperMicro engineers executed these benchmarks with the Industry Standard HammerDB Benchmark Tool on a Supermicro AS -1014S-WTRT Server using 16-core AMD EPYC 7F52 and 24-core AMD EPYC 7F72 processors as displayed in Table 2.

The same configuration used for the TPC-C Benchmark systems has been applied to both systems.

The creation scripts for the database schema and execution scripts can be found in this document Appendix section.

The tested Oracle Database version was 19.3.0.0.0.

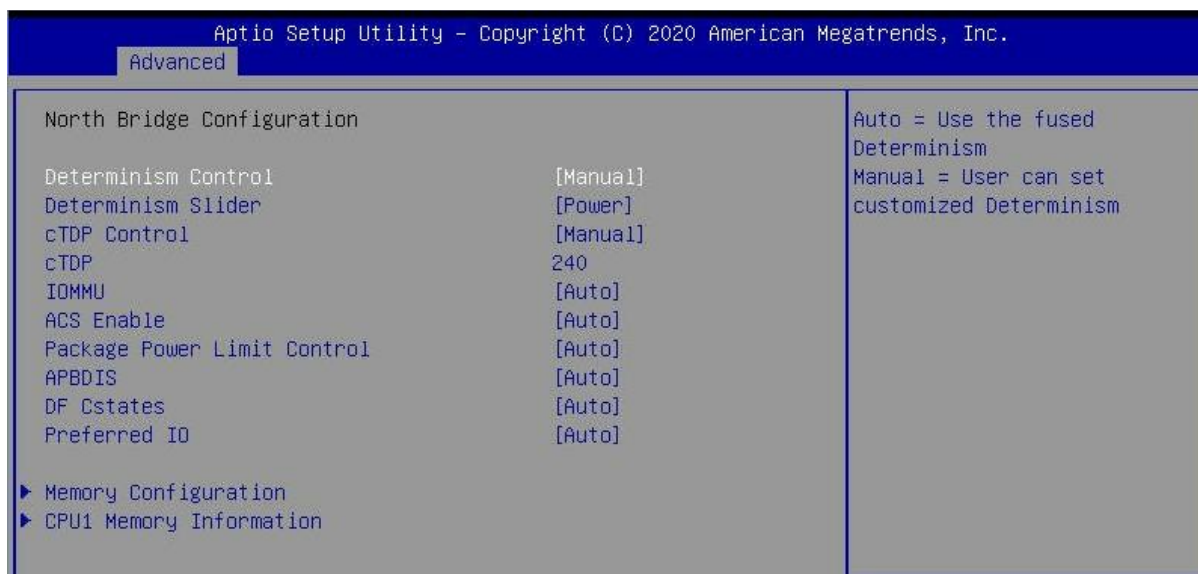
An Oracle Restart Instance was configured for the tests.

- 4 Datacenter Class 1.8T NVMe SSDs were used for Oracle storage.
- The 4 NVMe disks had been added to an Oracle ASM instance for use by Oracle Database.
 - 2 x 1.8 TB = DATA Disk Group
 - 2 x 1.8 TB = DATA Disk Group

Firmware/BIOS configuration

The Test configuration had been designed to get the most efficiency out of the Memory channels and interleaving on all 8 DIMMs, as shown in Figure 1: Firmware / Bios configuration.

- Possible NUMA Nodes / Socket configuration was set as NPS1
- SMT was enabled



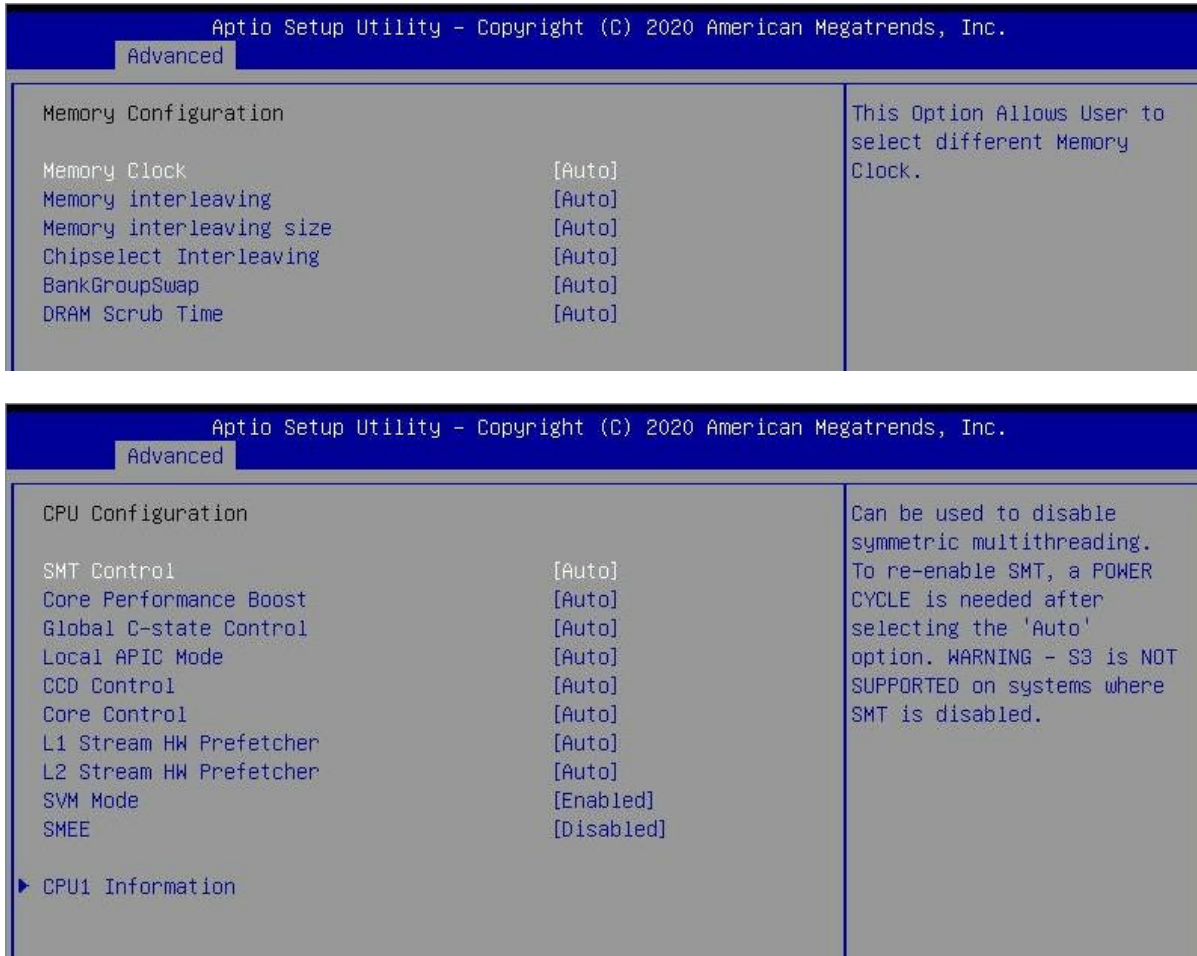


Figure 1: Firmware / Bios configuration

Hardware Linear Workload Scaling

A crucial step when building your solution is to calculate the total cost of ownership (TCO). Oracle Processor Licensing is calculated by multiplying the total number of cores on each processor by a licensing factor defined by the [Oracle Processor Core Factor Table](#). In addition to the Core license, Oracle typically charges an additional 20% for service & maintenance. With this license model, customers can reduce license costs by selecting low core count CPUs with the highest frequencies, such as the AMD EPYC 7F52 and 7F72.

Oracle Database Standard Edition licensing is based on a per-socket license model. For multi-CPU servers, such as dual and quad-socket systems, Oracle Database Standard Edition requires an individual license for each socket in the system. This makes the Supermicro AS-1014S-WTRT an ideal cost-optimized solution for small to mid-size Oracle Database deployments with linear CPU scaling.

APPENDIX A – Oracle Linux Configuration

The recommended way to configure Oracle Linux for Oracle Database is by installing the Oracle Preinstallation RPM. The procedure can be found in Oracle’s “Database Installation Guide for Linux.”, see the following regarding Oracle Database 19c.

- <https://docs.oracle.com/en/database/oracle/oracle-database/19/ladbi/overview-of-oracle-linux-configuration-with-oracle-rpms.html#GUID-693599D4-BD32-4E6A-9689-FA7D1CD75653>
- Install Oracle Linux 7.6 with UEK 4 (4.14.35.1902.0.18)
- Register your Linux distribution through Oracle’s Unbreakable Linux Network (ULN) and download and configure the yum repository for your system using the Oracle Linux yum server for your Oracle Linux release.
- Install the Oracle Preinstallation RPM with the RPM for your Oracle Grid Infrastructure and Oracle Database releases and update your Linux release.
- Make sure that after the Oracle binaries are extracted to ORACLE_HOME and after executing root.sh, you have the following entries in your/etc/sysctl.conf file. Please add the vm.nr Hugepages at the end of /etc/sysctl.conf based on your available DRAM, In our test case, the total DRAM was 512 GB, and we allowed the Hugepages size to occupy around 460GB. Please refer to Oracle Tuning SGA with Hugepages in the link below (Chapter A.7)
- See <https://docs.oracle.com/en/database/oracle/oracle-database/19/unxar/administering-oracle-database-on-linux.html#GUID-76C03D99-6025-41F2-8BE3-F6DCDB1DCEE0>

cat /etc/sysctl.conf

```

# sysctl settings are defined through files in
# /usr/lib/sysctl.d/, /run/sysctl.d/, and /etc/sysctl.d/.
#
# Vendors settings live in /usr/lib/sysctl.d/.
# To override a whole file, create a new file with the same in
# /etc/sysctl.d/ and put new settings there. To override
# only specific settings, add a file with a lexically later
# name in /etc/sysctl.d/ and put new settings there.
#
# For more information, see sysctl.conf(5) and sysctl.d(5).

# oracle-database-preinstall-19c setting for fs.file-max is 6815744
fs.file-max = 6815744
# oracle-database-preinstall-19c setting for kernel.sem is '250 32000 100 128'
kernel.sem = 250 32000 100 128
# oracle-database-preinstall-19c setting for kernel.shmmni is 4096
kernel.shmmni = 4096
# oracle-database-preinstall-19c setting for kernel.shmall is 1073741824 on x86_64
kernel.shmall = 173741824
# oracle-database-preinstall-19c setting for kernel.shmmax is 4398046511104 on
x86_64
kernel.shmmax = 4398046511104
# oracle-database-preinstall-19c setting for kernel.panic_on_oops is 1 per Orabug
19212317
kernel.panic_on_oops = 1
# oracle-database-preinstall-19c setting for net.core.rmem_default is 262144
net.core.rmem_default = 262144
# oracle-database-preinstall-19c setting for net.core.rmem_max is 4194304
net.core.rmem_max = 4194304
# oracle-database-preinstall-19c setting for net.core.wmem_default is 262144
net.core.wmem_default = 262144
# oracle-database-preinstall-19c setting for net.core.wmem_max is 1048576
net.core.wmem_max = 1048576
# oracle-database-preinstall-19c setting for net.ipv4.conf.all.rp_filter is 2
net.ipv4.conf.all.rp_filter = 2
# oracle-database-preinstall-19c setting for net.ipv4.conf.default.rp_filter is 2
net.ipv4.conf.default.rp_filter = 2
# oracle-database-preinstall-19c setting for fs.aio-max-nr is 1048576
fs.aio-max-nr = 1048576
# oracle-database-preinstall-19c setting for net.ipv4.ip_local_port_range is 9000 65500
net.ipv4.ip_local_port_range = 9000 65500

vm.nr_hugepages=236000 ( reduce it to memory available ) NR huge pages x 2MB /
1024 = 460 GB (In our test case our DRAM capacity used was 512 GB)

```

APPENDIX B – Oracle Database 19c Configuration

- Oracle Database is tuned for this Benchmark using the profile parameters below:

\$ cat /u01/app/oracle/product/19.0.0/dbhome_1/dbs/initROMETPCC.ora

```

ROMETPCC.__data_transfer_cache_size=0
# ROMETPCC.__db_cache_size=142807662592
ROMETPCC.__db_cache_size=285615325184
ROMETPCC.__inmemory_ext_roarea=0
ROMETPCC.__inmemory_ext_rwarea=0
ROMETPCC.__java_pool_size=1073741824
ROMETPCC.__large_pool_size=1073741824
ROMETPCC.__oracle_base='/u01/app/oracle'#ORACLE_BASE set from environment
ROMETPCC.__pga_aggregate_target=54223962112
# ROMETPCC.__sga_target=162671886336
ROMETPCC.__sga_target=406679715840
# ROMETPCC.__shared_io_pool_size=536870912
ROMETPCC.__shared_io_pool_size=0
# ROMETPCC.__shared_pool_size=17716740096
ROMETPCC.__shared_pool_size=51539607552
ROMETPCC.__streams_pool_size=0
ROMETPCC.__unified_pga_pool_size=0
*.audit_file_dest='/u01/app/oracle/admin/ROMETPCC/adump'
*.audit_trail='db'
*.compatible='19.0.0'
*.control_files='+REDO/ROMETPCC/CONTROLFILE/current.258.1045714053','+REDO/ROMETPC
C/CONTROLFILE/current.257.1045714053','+REDO/ROMETPCC/CONTROLFILE/current.256.1045
714053'
*.db_block_size=8192
*.db_create_file_dest='+DATA'
*.db_create_online_log_dest_1='+REDO'
*.db_create_online_log_dest_2='+REDO'
*.db_create_online_log_dest_3='+REDO'
*.db_domain='supermicro.com'
*.db_name='ROMETPCC'
*.diagnostic_dest='/u01/app/oracle'
*.dispatchers='{PROTOCOL=TCP} (SERVICE=ROMETPCCXDB)'
*.local_listener='LISTENER_ROMETPCC'
*.nls_language='AMERICAN'
*.nls_territory='AMERICA'
*.open_cursors=300
*.pga_aggregate_target=51585m
*.processes=2560
*.remote_login_passwordfile='EXCLUSIVE'
*.sga_target=154755m
*.undo_tablespace='UNDOTBS1'

```

Additional Parameters ##### (Please check and add all these parameters on the database)

```
*.db_16k_cache_size=0G
*.db_block_checking='FALSE'
*.db_block_checksum='FALSE'
*.db_block_size=8192
*.DB_CACHE_ADVICE='ON'
*.db_create_file_dest='+DATA'
*.db_file_multiblock_read_count=16
*.db_writer_processes=16
*.disk_asynch_io=TRUE
*.dml_locks=16384
*.fast_start_mttr_target=0
*.filesystemio_options='setall'
*.inmemory_size=48g
*.lock_sga=TRUE
*.log_buffer=16G
*.log_checkpoint_interval=262144
*.log_checkpoint_timeout=900
*.log_checkpoints_to_alert=TRUE
*.nls_language='AMERICAN'
*.nls_territory='AMERICA'
*.open_cursors=16384
*.parallel_max_servers=0
*.parallel_min_servers=0
*.parallel_servers_target=1792
*.plsql_code_type='NATIVE'
*.plsql_optimize_level=2
*.processes=2048
*.query_rewrite_enabled='FALSE'
*.remote_login_passwordfile='EXCLUSIVE'
*.replication_dependency_tracking=FALSE
*.result_cache_max_size=32G
*.statistics_level='TYPICAL'
*.timed_statistics=TRUE
*.trace_enabled=FALSE
*.transactions_per_rollback_segment=1
*.undo_management='AUTO'
*.undo_retention=2
*._undo_autotune='FALSE'
*.use_large_pages='ONLY'
```

Preparing Benchmark Database

Benchmark Database Creation

Benchmark database has been created using the SQL Scripts below

Tablespace creation

```
-- Oracle OMF with ASM BASED
CREATE BIGFILE TABLESPACE TPCC_800 DATAFILE SIZE 300G AUTOEXTEND ON NEXT 10G
BLOCKSIZE 8K
EXTENT MANAGEMENT LOCAL AUTOALLOCATE
SEGMENT SPACE MANAGEMENT AUTO;

CREATE BIGFILE TABLESPACE TPCC_800_OL DATAFILE SIZE 500G AUTOEXTEND ON NEXT 10G
BLOCKSIZE 8K
EXTENT MANAGEMENT LOCAL AUTOALLOCATE
SEGMENT SPACE MANAGEMENT AUTO;
```

Temporary Tablespace creation

```
CREATE TEMPORARY TABLESPACE TPCCTEMP TEMPFIL '+DATA' size 30G AUTOEXTEND ON
NEXT 10M MAXSIZE UNLIMITED EXTENT MANAGEMENT LOCAL UNIFORM SIZE 10M;

-- ALTER TABLESPACE TEMP ADD TEMPFIL '+DATA' SIZE 20G AUTOEXTEND ON NEXT 1G
MAXSIZE 32767M;
```

Create Users and grants

```
CREATE USER tpcc800 IDENTIFIED BY tpcc800 DEFAULT TABLESPACE TPCC_800 TEMPORARY
TABLESPACE TPCCTEMP;

grant create session to tpcc800;

grant connect, resource to tpcc800;

GRANT CONNECT, RESOURCE, DBA to tpcc800;

GRANT UNLIMITED TABLESPACE TO tpcc800;
```

APPENDIX C – Configuration Validation for HammerDB

Preparing Benchmark Client

a. Install Oracle Database 19c client on Oracle Linux

Install Oracle client software on the client machine and configure as per the below instructions

<https://www.hammerdb.com/docs/ch04s02.html#d0e699>

Install Oracle Database 19c client software on the client machine and configure as per the below instructions

<https://www.hammerdb.com/docs/ch01s06.html#d0e382>

HammerDB In Linux user's .bashrc , include the following line:
export LD_LIBRARY_PATH= \$ORACLE_HOME/lib:\$LD_LIBRARY_PATH

b. Install HammerDB on *HammerDB* Linux user

The Installation instructions for HammerDB can be found on HammerDB website :

“Section 5 , Installing and Starting HammerDB on Linux”

<https://www.hammerdb.com/docs/ch01s05.html>

Install HammerDB on the Local Test System (**LTS**) from: <https://www.hammerdb.com/docs/ch01s05.html>

c. Benchmark Schema TPCC800 Data Creation

Benchmark database had been created using HammerDB CLI (command line interface). Commands used for schema creation are as below

```
Login as 'hammerdb' Linux user
$ pwd
/hammerdb/HammerDB-3.1
$ ./hammerdbcli
HammerDB CLI v3.1
Copyright (C) 2003-2018 Steve Shaw
Type "help" for a list of commands
The xml is well-formed, applying configuration
hammerdb>

dbset db ora
dbset bm TPC-C
diset connection system_password <OraclePassword/User SYSTEM>
diset connection instance rometpcc
diset tpcc tpcc_user tpcc800
diset tpcc tpcc_pass tpcc800
diset tpcc tpcc_def_temp TPCCTEMP
diset tpcc count_ware 256
diset tpcc num_vu 20
diset tpcc tpcc_def_tab tpcc_800
diset tpcc tpcc_ol_tab tpcc_800_ol
diset tpcc partition true
diset tpcc hash_clusters true
print dict
buildschema
```

Executing Benchmark runs

Here is a sample script for HammerDB benchmark run with 256 Warehouses and 100 Virtual users.

```
Login as 'hammerdb' Linux user
$ pwd
/hammerdb/HammerDB-3.1
$ ./hammerdbcli
HammerDB CLI v3.1
Copyright (C) 2003-2018 Steve Shaw
Type "help" for a list of commands
The xml is well-formed, applying configuration
hammerdb>

dbset db ora
diset tpcc ora_driver timed
dbset bm TPC-C
print bm
diset connection system_password <OraclePassword for SYSTEM user>
diset connection instance rometpcc
diset tpcc tpcc_user tpcc800
diset tpcc tpcc_pass tpcc800
diset tpcc count_ware 256
diset tpcc tpcc_def_tab tpcc_800
diset tpcc tpcc_ol_tab tpcc_800_ol
diset tpcc checkpoint true
diset tpcc rampup 3
diset tpcc duration 10
loadscript
vuset vu 100
vuset showoutput 1
vuset logtotemp 1
vuset unique 1
vucreate
print dict
print vuconf
print script
vurun
```

Conclusion

Oracle Database Standard Edition licensing is based on a per-socket license model. For multi-CPU servers, such as dual and quad-socket systems, Oracle Database Standard Edition requires an individual license for each socket in the system. This makes the Supermicro AS-1014S-WTRT an ideal cost-optimized solution for small to mid-size Oracle Database deployments with linear CPU scaling.

Footnotes

Performance measured with Oracle Database 19c on Oracle Linux 7.6 with UEK 4 (4.14.35.1902.0.18) using HammerDB version 22. Max boost for AMD EPYC processors is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems.

1. AMD EPYC™ World Records: : [AMD EPYC™ Processor World Records | AMD](#)
2. AMD EPYC™ 7002 series Processors: [EPYC-7002-TPC-DS-10TB-World-Record.pdf](#)

*Max Boost reference: Max boost for AMD EPYC processors is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems.

About Super Micro Computer, Inc.

Supermicro (Nasdaq: SMCI), the leading innovator in high-performance, high-efficiency server and storage technology is a premier provider of advanced Server Building Block Solutions® for Enterprise Data Center, Cloud Computing, Artificial Intelligence, and Edge Computing Systems worldwide. Supermicro is committed to protecting the environment through its “We Keep IT Green®” initiative and provides customers with the most energy-efficient, environmentally-friendly solutions available on the market.

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