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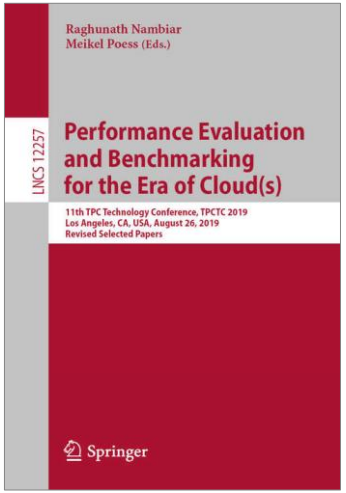
peakmarks® Benchmark Report

Oracle 19c on Ampere Altra A1

August 2023



peakmarks® presented its benchmark approach to a broader audience at the 11th TPC Technology Conference in August 2019.

Processor Comparison

	Intel Xeon 8358	Ampere Altra A1
Launch	2021	2022
Benchmark Configuration	Bare metal server	Oracle Cloud Infrastructure
Processor		
▪ Sockets	2	1
▪ Clock rate	2.6 – 3.4 GHz	3.0 GHz
▪ Cores, total	64 (bare metal)	32 (VM in OCI)
▪ Threads, total	128	32
Memory		
▪ Technology	DDR4	DDR4
▪ Clock rate	3200 MHz	3200 MHz
▪ PCI Gen	4	4
Oracle Licensing		
▪ Core factor	0.5	0.25
▪ Licensed Oracle cores	32	8

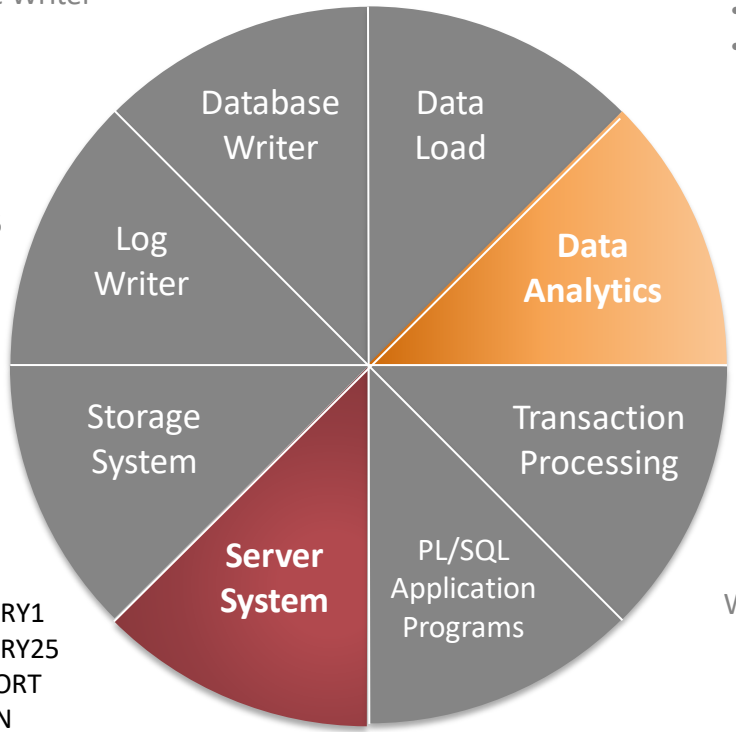
8 workload groups, over 30 workloads or micro-benchmarks

Workload for Database Writer
- DBWR-THR

Workloads for Log Writer
- LGWR-LAT1
- LGWR-LAT25
- LGWR-THR
- LGWR-LAT125

Workloads for Storage Systems
- STO-READ
- STO-RANDOM
- STO-OFFLOAD
- STO-SCATTER

Workloads for Server Systems
- SRV-MIXED
- SRV-QUERY1
- SRV-QUERY25
- SRV-REPORT
- SRV-SCAN



Workloads for Data Load
- DL-BUFFER
- DL-STREAM
- DL-DIRECT

Workloads for Data Analytics
- DA-STORAGE
- DA-ROWSTORE
- DA-OFFLOAD
- DA-COLSTORE

Workloads for Transaction Processing
- TP-MIXED1
- TP-MIXED2
- TP-REPORT
- TP-LOOKUP
- TP-LIGHT
- TP-MEDIUM
- TP-HEAVY

Workloads for PL/SQL Application Programs
- PLS-MIXED
- PLS-ADD
- PLS-BUILTIN
- PLS-FIBO
- PLS-PRIME

Abbreviations and Metrics

[MBps]	megabyte per second
[GBps]	gigabyte per second
[dbps]	database blocks per second
[rbps]	redo blocks per second
[dbpt]	database blocks per transaction
[s]	seconds
[ms]	milliseconds
[µs]	microseconds
[IOPS]	I/O operations per second

[qps]	queries per second
[rps]	rows per second
[tps]	transactions per second
[kBpt]	kilobyte per transaction
[Mops]	million operations per second
Nodes	number of cluster nodes
Jobs	number of workload processes
BuCache	Database Buffer Cache
FlCache	Database or Exadata Flash Cache

In the following reports, the key performance metrics are marked red, and the term CPU is used in the sense of the Oracle configuration parameter CPU_COUNT.

peakmarks

Stop guessing. Start measuring.

Workloads to determine the Server Performance in Database Operations

Motivation

The server performance significantly impacts the performance of all database operations.

The goal is to

- Validate the performance capabilities (speed, throughput, scalability) of server components in database operation: processors, main memory, and internal memory channels
- Determine the impact of server virtualization, multithreading, NUMA effects, and encryption on server performance
- Optimize database license and maintenance costs for server system

Notes

- Some cloud service providers do not publish their server components and configurations.
- Components and configurations of cloud services are subject to change without any prior notice.
- Customers need to know the per-core performance, significantly impacting application performance and the required Oracle licenses.
- In many cases, Oracle licensing costs far exceed infrastructure costs.

Server System Workloads

Key Performance Metrics

- SQL query throughput in queries per second [qps]
- SQL query response time in milliseconds [ms]
- Logical reads in database blocks per second [dbps]
- SQL buffer cache scan rate in megabytes per second [MBps]

Note

- All accessed data is completely stored in the database buffer cache. There are no I/O operations. All Server workloads (SRV) are CPU-bound..

Server System Workloads

Description

Workload	Measurement Unit	Action
SRV-MIXED	[qps] [ms]	Mixed queries and full table scans on cached data. This complex workload comprises the equally weighted simple workloads SRV-QUERY1, SRV-QUERY25, SRV-REPORT, and SRV-SCAN. SRV-MIXED is the most representative peakmarks workload to determine server system performance in Oracle database operation.

Notes

- All accessed data is completely stored in the database buffer cache. There are no I/O operations. All SRV workloads are CPU-bound.
- These kinds of queries are generic to all applications in all industries.

Server System Workloads

Description

Workload	Measurement Unit	Action
SRV-QUERY1	[qps] [ms]	Latency-oriented look-up query – select 1 row via index, e.g., select customer, account, product, order, invoice. This workload shows maximum query throughput and minimum response time for simple queries.
SRV-QUERY25	[qps] [ms]	Data volume-oriented look-up query – select Ø 25 rows via index, e.g., select last month's bank account bookings; select item list of order. This workload shows maximum query throughput and minimum response time for more complex queries.
SRV-REPORT	[dbps]	Online Report – select Ø 125 rows via index, e.g., select last month's cell phone call records. This workload shows maximum logical read throughput.
SRV-SCAN	[MBps]	Full table scan. Search for data without index support. This workload shows a maximum database buffer cache scan rate.

Notes

- All accessed data is completely stored in the database buffer cache. There are no I/O operations. All SRV workloads are CPU-bound.
- These kinds of queries are generic to all applications in all industries.

Server System Performance

Workload SRV-MIXED – Mixed queries and full table scans

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
3	2	SRV-MIXED	1	4	13	12	0	87	70,019	17,505	0.057	1,549,780	387,445	100.00	182
	3	SRV-MIXED	1	8	25	25	0	75	138,227	17,278	0.058	3,129,406	391,176	100.00	182
	4	SRV-MIXED	1	16	50	49	1	50	275,590	17,224	0.058	5,987,945	374,247	100.00	182
	5	SRV-MIXED	1	24	75	74	1	25	417,896	17,412	0.057	8,961,438	373,393	100.00	182
	6	SRV-MIXED	1	32	99	98	1	1	550,974	17,218	0.058	11,643,341	363,854	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
14	27	SRV-MIXED	1	4	4	3	0	96	162,648	40,662	0.025	2,821,463	705,366	100.00	301
	28	SRV-MIXED	1	32	26	25	0	74	1,109,740	34,679	0.029	17,593,398	549,794	100.00	301
	29	SRV-MIXED	1	64	51	50	0	49	2,002,292	31,286	0.032	30,099,887	470,311	100.00	301
	30	SRV-MIXED	1	96	76	75	0	24	2,244,089	23,376	0.043	34,482,989	359,198	100.00	301
	31	SRV-MIXED	1	128	99	98	0	1	2,467,971	19,281	0.052	38,356,911	299,663	100.00	301

Workload SRV-QUERY1 – Simple look-up query, max throughput, low response time

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
2	7	SRV-QUERY1	1	1	3	3	0	97	48,967	48,967	0.020	195,925	195,925	99.96	182
	8	SRV-QUERY1	1	8	25	25	1	75	397,111	49,639	0.020	1,585,004	198,126	100.00	181
	9	SRV-QUERY1	1	16	50	49	1	50	820,023	51,251	0.019	3,260,363	203,773	100.00	182
	10	SRV-QUERY1	1	24	74	73	1	26	1,222,703	50,946	0.020	4,847,338	201,972	100.00	182
	11	SRV-QUERY1	1	32	99	97	1	1	1,573,047	49,158	0.020	6,218,803	194,338	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
14	7	SRV-QUERY1	1	1	1	1	0	99	126,902	126,902	0.008	460,106	460,106	100.00	300
	8	SRV-QUERY1	1	32	26	25	0	74	3,368,485	105,265	0.009	10,171,543	317,861	100.00	301
	9	SRV-QUERY1	1	64	51	50	0	49	5,652,614	88,322	0.011	16,986,701	265,417	100.00	301
	10	SRV-QUERY1	1	96	76	75	0	24	6,098,959	63,531	0.016	18,283,906	190,457	100.00	301
	11	SRV-QUERY1	1	128	97	96	1	3	6,303,748	49,248	0.020	18,863,574	147,372	100.00	301

Workload SRV-QUERY25 – More complex query, max throughput, low response time

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
2	12	SRV-QUERY25	1	1	4	3	0	96	14,701	14,701	0.068	412,298	412,298	99.98	180
	13	SRV-QUERY25	1	8	25	25	0	75	115,926	14,491	0.069	3,231,557	403,945	100.00	182
	14	SRV-QUERY25	1	16	50	49	1	50	239,289	14,956	0.067	6,624,101	414,006	100.00	182
	15	SRV-QUERY25	1	24	75	73	1	25	354,158	14,757	0.067	9,741,144	405,881	100.00	182
	16	SRV-QUERY25	1	32	99	97	1	1	471,008	14,719	0.068	12,863,100	401,972	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
14	12	SRV-QUERY25	1	1	1	1	0	99	36,798	36,798	0.027	1,072,999	1,072,999	99.98	301
	13	SRV-QUERY25	1	32	25	25	0	75	830,549	25,955	0.038	22,449,732	701,554	100.00	301
	14	SRV-QUERY25	1	64	51	50	0	49	1,475,883	23,061	0.043	39,673,583	619,900	100.00	301
	15	SRV-QUERY25	1	96	76	75	0	24	1,687,416	17,577	0.057	45,340,544	472,297	100.00	301
	16	SRV-QUERY25	1	128	98	97	0	2	1,849,399	14,448	0.069	49,682,958	388,148	100.00	301

Workload SRV-REPORT – Online Report, max throughput of Logical Reads

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
2	2	SRV-REPORT	1	1	3	3	0	97	4,622	4,622	0.216	591,133	591,133	100.00	180
	3	SRV-REPORT	1	8	25	25	0	75	33,031	4,129	0.241	4,194,732	524,342	100.00	182
	4	SRV-REPORT	1	16	50	49	1	50	64,990	4,062	0.245	8,181,421	511,339	100.00	182
	5	SRV-REPORT	1	24	75	74	1	25	97,247	4,052	0.246	12,139,095	505,796	100.00	182
	6	SRV-REPORT	1	32	99	98	1	1	126,934	3,967	0.250	15,707,636	490,864	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Queries total [qps]	Queries per cpu [qps]	Response time [ms]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
14	17	SRV-REPORT	1	1	1	1	0	99	9,447	9,447	0.106	1,274,085	1,274,085	99.98	301
	18	SRV-REPORT	1	32	26	25	0	74	209,855	6,558	0.152	26,515,043	828,595	100.00	301
	19	SRV-REPORT	1	64	51	50	0	49	368,199	5,753	0.174	46,222,534	722,227	100.00	301
	20	SRV-REPORT	1	96	76	75	0	24	419,855	4,373	0.228	52,677,112	548,720	100.00	301
	21	SRV-REPORT	1	128	99	98	0	1	469,143	3,665	0.273	58,864,456	459,879	100.00	301

Workload SRV-SCAN – Scan-Rate in Oracle Buffer Cache

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Scan rate total [MBps]	Scan rate per cpu [MBps]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
2	17	SRV-SCAN	1	1	3	3	0	97	3,410	3,410	437,061	437,061	100.00	182
	18	SRV-SCAN	1	8	25	25	0	75	25,621	3,203	3,263,565	407,946	100.00	182
	19	SRV-SCAN	1	16	50	50	0	50	48,835	3,052	6,180,475	386,280	100.00	182
	20	SRV-SCAN	1	24	75	74	0	25	68,826	2,868	8,593,115	358,046	100.00	182
	21	SRV-SCAN	1	32	99	99	0	1	85,433	2,670	10,534,476	329,202	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Scan rate total [MBps]	Scan rate per cpu [MBps]	Log reads total [dbps]	Log reads per cpu [dbps]	BuCache read [%]	Elapsed time [s]
14	22	SRV-SCAN	1	1	1	1	0	99	4,298	4,298	550,096	550,096	100.00	300
	23	SRV-SCAN	1	32	26	25	0	74	89,935	2,810	11,511,621	359,738	100.00	301
	24	SRV-SCAN	1	64	51	50	0	49	143,916	2,249	18,421,249	287,832	100.00	301
	25	SRV-SCAN	1	96	76	75	0	24	164,124	1,710	21,007,822	218,831	100.00	301
	26	SRV-SCAN	1	128	99	98	1	1	168,839	1,319	21,611,373	168,839	100.00	301

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Swiss precision in timing.

Workloads to determine the Data Analytics Performance

Motivation

In general, data analytics operations cause full table scans. The performance of full table scan operation depends on the location of data in the storage hierarchy (storage, memory) and the technology used to boost scan performance (smart scan for the data location storage system, in-memory column store for the data location memory).

The goal is to

- Optimize data scan throughput
- Validate the impact of several factors on data analytics performance
  - Smart scan offload technology
  - In-memory column store technology
- Optimize Oracle license and maintenance costs

Key Performance Metrics

- SQL data scan rate in megabyte per second [MBps] or rows per second [rps]

Data Analytics Workloads

Description

Workload	Measurement Unit	Action
DA-STORAGE	[MBps] [rps]	Simple aggregate after full table scan, using conventional storage.
DA-OFFLOAD	[MBps] [rps]	Simple aggregate after full table scan, using smart-scan offload technology.
DA-ROWSTORE	[MBps] [rps]	Simple aggregate after full table scan, using row-store.
DA-COLSTORE	[MBps] [rps]	Simple aggregate after full table scan, using column-store.

Note

- These analytic workloads are generic to all applications in all industries.

Data Analytics Performance

Workload DA-ROWSTORE – Data scan using buffer cache row store

Ampere Altra A1
32c, 32t, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	DOP	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	CPU iow [%]	Scan rate total [rps]	Scan rate total [MBps]	FlCache read [%]	BuCache read [%]	Elapsed time [s]
4	1	DA-ROWSTORE	1	1	1	3	3	0	97	0	11,640,683	3,516	0.00	100.00	180
	2	DA-ROWSTORE	1	8	1	25	25	0	75	0	84,455,021	25,508	0.00	100.00	182
	3	DA-ROWSTORE	1	16	1	50	50	0	50	0	161,212,678	48,691	0.00	100.00	181
	4	DA-ROWSTORE	1	24	1	75	74	0	25	0	226,474,766	68,402	0.00	100.00	182
	5	DA-ROWSTORE	1	32	1	99	99	0	1	0	282,846,522	85,429	0.00	100.00	182

Intel Xeon 8358
2s, 64c, 128t, Launch 2021
Licensed Oracle Cores: 32

Run	Test	Workload	Nodes	Jobs	DOP	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	CPU iow [%]	Scan rate total [rps]	Scan rate total [MBps]	FlCache read [%]	BuCache read [%]	Elapsed time [s]
10	469	DA-ROWSTORE	2	2	1	3	2	1	97	0	15,013,408	4,535	0.00	100.00	182
	470	DA-ROWSTORE	2	36	1	26	25	0	74	0	252,940,482	76,420	0.00	100.00	183
	471	DA-ROWSTORE	2	72	1	51	50	1	49	0	436,468,828	131,863	0.00	100.00	183
	472	DA-ROWSTORE	2	108	1	76	75	1	24	0	499,437,021	150,883	0.00	100.00	183
	473	DA-ROWSTORE	2	144	1	97	96	1	3	0	518,029,114	156,496	0.00	100.00	183

Workload DA-COLSTORE – Data scan using column store

Ampere Altra A1
32c, 32f, Launch 2022
Licensed Oracle Cores: 8

Run	Test	Workload	Nodes	Jobs	DOP	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	CPU iow [%]	Scan rate total [rps]	Scan rate total [MBps]	FlCache read [%]	BuCache read [%]	Elapsed time [s]
4	6	DA-COLSTORE	1	1	1	3	3	0	97	0	2,857,569,742	910,025	0.00	100.00	181
	7	DA-COLSTORE	1	8	1	25	25	0	75	0	20,092,145,123	6,398,904	0.00	100.00	182
	8	DA-COLSTORE	1	16	1	50	49	1	50	0	36,221,467,587	11,536,106	0.00	100.00	181
	9	DA-COLSTORE	1	24	1	75	74	1	25	0	52,822,677,226	16,823,559	0.00	100.00	182
	10	DA-COLSTORE	1	32	1	100	98	1	0	0	70,196,452,198	22,356,905	0.00	100.00	182

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Simple. Representative. Fast.