Cloud Analytics Performance Report

Actian Avalanche: Up to 20X faster and 1/3rd the cost of Amazon Redshift

MCG Global Services Benchmark Results

March 2019

Avalanche

Cloud Data Warehouse

Cloud Analytical Database Performance Testing

Product Evaluation:
Actian Avalanche and Amazon Redshift

March 2019

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Introduction

Performance is important but is only one criterion for an analytical platform selection. This is only one point-in-time check into specific performance. There are numerous other factors to consider in selection across factors of administration, integration, workload management, user interface, scalability, reliability, and numerous other criteria. It is also our experience that performance changes over time and is competitively different for different workloads. Also a performance leader can hit up against the point of diminishing returns and viable contenders can quickly close the gap.

MCG Global Services runs all of its performance tests to strict ethical standards. The results of the report are the objective results of the application of queries to the simulations described in the report. The report clearly defines the selected criteria and process used to establish the field test. The report also clearly states the data set sizes, the platforms, the queries, etc. used. The reader is left to determine for themselves how to qualify the information for their individual needs. The report does not make any claim regarding third-party certification and presents the objective results received from the application of the process to the criteria as described in the report. The report strictly measures performance and does not purport to evaluate other factors that potential customers may find relevant when making a purchase decision.

This is a sponsored report. Actian chose the competitors, the test, and the Actian configuration. MCG chose the most compatible configurations for the other tested platform. MCG ran the queries on both platforms. Choosing compatible configurations is subject to judgment. We have attempted to describe our decisions in this paper.

Although we used the TPC Benchmark™ H (TPC-H)[1] specification to derive our data and queries, this was NOT an official TPC benchmark.

In this writeup, all the information necessary is included to replicate this test. You are encouraged to compile your own representative queries, data sets, data sizes and compatible configurations and test for yourself.

[1] More can be learned about the TPC-H benchmark at http://www.tpc.org/tpch/.

Cloud Analytics Platform Offerings

Big data analytics platforms load, store, and analyze volumes of data at high speed, providing timely insights to businesses. Data-driven organizations leverage this data, for example, for advanced analysis to market new promotions, operational analytics to drive efficiency, or for predictive analytics to evaluate credit risk and detect fraud. Customers are leveraging a mix of relational analytical databases and data warehouses to gain analytic insights.

This report focuses on relational analytical databases in the cloud, because deployments are at an all-time high and poised to expand dramatically. The cloud enables enterprises to differentiate and innovate with these database systems at a much more rapid pace than was ever possible before. The cloud is a disruptive technology, offering elastic scalability vis-à-vis on-premises deployments, enabling faster server deployment and application development, and allowing less costly storage. For these reasons and others, many companies have leveraged the cloud to maintain or gain momentum as a company.

This paper specifically compares two fully-managed, cloud-based analytical databases, Actian Avalanche and Amazon Redshift, two relational analytical databases based on massively parallel processing (MPP) and columnar-based database architectures that scale and provide high-speed analytics. It should be noted while our testing measures the cloud-based performance of both offerings, Avalanche, unlike Redshift, is also available as an on-premise offering, Vector. In addition, Vector is available for developers as a free on-premise community edition, as a download with support in both the Amazon Web Services (AWS) and Azure marketplaces with single-click deployment.

Table 1. Platform Summary

	Actian Avalanche	**Amazon Redshift**
Company	Actian	Amazon
First Released	2010 (as VectorWise)	2014
Current Version	5.1	1.0.5833
SQL	Ansi-2016 Compliant	PostgreSQL 8

Test Setup

Although we used the TPC Benchmark™ H (TPC-H) specification to derive our data and queries, this was NOT an official TPC benchmark. The queries were executed using the following setup, environment, standards, and configurations.

Cluster Environments

We selected the cluster configuration based on fit-for-performance and closest price proximity.

The measure of Actian Avalanche compute power is known as Avalanche Units (AU). At the time of this writing, Avalanche is priced at $1.99 per AU per hour. This price includes both compute and cluster storage.

Amazon Redshift has four configuration options—large and 8xlarge classes for both dense compute or dense storage architecture. For our performance testing, we used the lowest hourly rate we found for Redshift's 8xlarge class—which was a dc2.8xlarge instance type was $4.80 per node[2]. Redshift also has reserved instance pricing, which can be substantially cheaper than on-demand pricing. However, reserved instance pricing can only be procured with 1 or 3-year commitments and is cheapest when paid in full upfront. Long commitments are out of scope for this field test, so we chose the lowest on-demand rate.

Our performance testing included two different cluster environments:

- Actian Avalanche 32 Avalanche Units (AU)
- Amazon Redshift dc2.8xlarge 16 nodes (with 32 CPUs 244GB RAM each)

Test Data

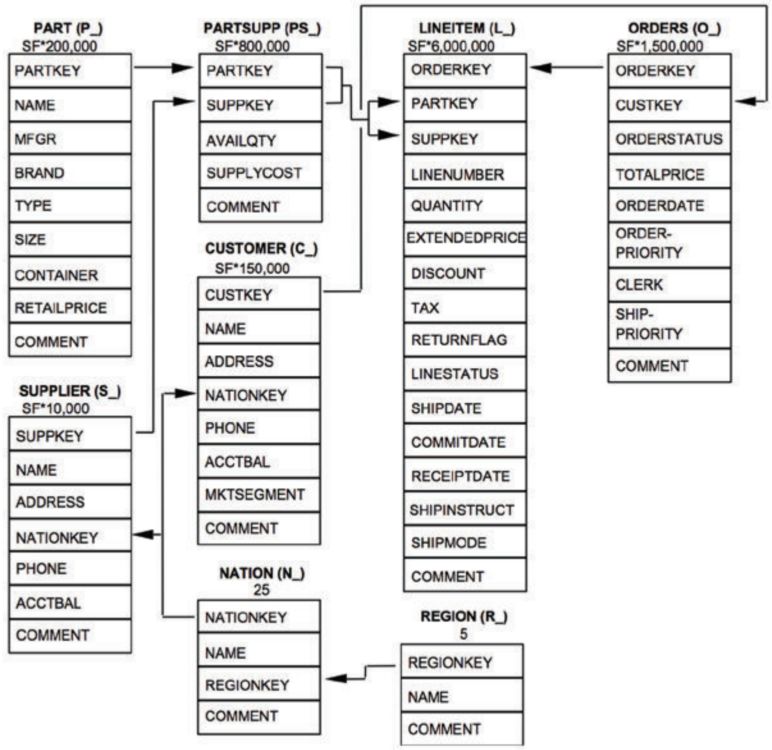
The data sets used in the performance tests were derived directly from the TPC-H.

From tpc.org: "The TPC-H is a decision support benchmark. It consists of a suite of business-oriented ad-hoc queries and concurrent data modifications. The queries and the data populating the database have been chosen to have broad industry-wide relevance. This benchmark illustrates decision support systems that examine large volumes of data, execute queries with a high degree of complexity, and give answers to critical business questions."

To show the data model, the following diagram was taken from page 13 of the TPC-H Revision 2.17.3 specification document.

[2] Amazon Redshift pricing was found at https://aws.amazon.com/redshift/pricing/.

Figure 1. TPC-H Data Model



To give an idea of the data volumes used in our performance testing, the following table gives row counts of the database when loaded with 10TB of data:

Table 2. Table Row Count @ 10TB

Table	10TB Row Count
Customer	1,500,000,000
Line Item	59,999,994,267
Nation	25
Region	5
Orders	15,000,000,000
Part	2,000,000,000
Supplier	100,000,000
PartSupp	8,000,000,000

Data Loading and Additional Setup

For the selected platforms, we created the test tables according to above schema, loaded the data into both clusters, and performed some additional configuration according to the recommended best practices of each platform.

When creating the test tables, we specified some partitioning/distribution schemes for both Avalanche and Redshift. For Avalanche, we partitioned the larger tables on key fields. On Redshift, partitioning is called distribution, but it is essentially the same effect. Both are specified in the data definition language (DDL), i.e., the CREATE TABLE statements, of both platforms. Both horizontally distribute the data, so that rows that share the same partition/distribution key value will be stored on the same node of the cluster. This is critical to performance in clustered environments, because when the database engine creates hash tables for join and aggregation operations, if the rows for one group is spread over different nodes, the DBMS must consolidate all the group's data into a single node's memory for processing. This is horribly inefficient. Even though this test was NOT an official TPC Benchmark™ H, the partitioning/distribution of data would be allowed under section 1.5.4 of the specification document.

The test data was stored in parquet format in an AWS Simple Storage Service (S3) bucket. For Actian Avalanche, we loaded data by creating an EXTERNAL TABLE directly to our test data. Then we used INSERT to load the data from the external table into the test tables we created for the benchmark. For Redshift, we used the COPY command to load the data directly from the same S3 bucket. The same generated source data was used for both platforms.

Once the data was loaded, statistics were gathered for both platforms. For Avalanche, the CREATE STATS command was used for each table. For Redshift, the ANALYZE command was issued for each table. This operation is also allowed by the TPC-H specification in section 5.2.8.

Additionally for both platforms, we created primary and foreign key constraints for the test tables with ALTER TABLE commands. There is a slight difference in the implementation of this for each platform. In Redshift, the constraints are accepted, but not enforced by the DBMS. They are used only for query planning to improve performance. For Avalanche, the constraints are enforced—meaning an error is thrown if a constraint is violated. Avalanche also uses the constraints to assist with query execution planning. The constraints used complied with the TPC-H specification section 1.4.2.

Finally on Avalanche, we created explicit indexes. According to Actian documentation, indexing is not always required for good performance. However, they recommend indexing for large tables with highly selective queries. Indexes are allowed by TPC-H specification section 1.5.7. However, Redshift does not use indexes. According to Amazon's website, "Amazon Redshift doesn't require the creation and maintenance of indexes: every column is almost its own index, with just the right structure for the data being stored."

The following table summarizes the additional setup we did to the test data prior to executing the performance queries.

Table 3. Additional Setup

	Partition/Distribution		Constraints		Indexes	
Table	**Avalanche**	**Redshift**	**Avalanche**	**Redshift**	**Avalanche**	**Redshift**
Customer	c_custkey	c_custkey	PK c_custkey FK n_nationkey	PK c_custkey FK n_nationkey	c_custkey	N/A
Line Item	l_orderkey	l_orderkey	FK o_orderkey FK ps_partkey FK ps_suppkey FK p_partkey FK s_suppkey	FK o_orderkey FK ps_partkey FK ps_suppkey FK p_partkey FK s_suppkey	l_orderkey	N/A
Nation	none	none	PK n_nationkey FK r_regionkey	PK n_nationkey FK r_regionkey	n_regionkey	N/A
Region	none	none	PK r_regionkey	PK r_regionkey	r_regionkey	N/A
Orders	o_orderkey	o_orderkey	PK o_orderkey FK c_custkey	PK o_orderkey FK c_custkey	o_orderdate	N/A
Part	p_partkey	p_partkey	PK p_partkey	PK p_partkey	p_partkey	N/A
Supplier	none	none	PK s_suppkey FK n_nationkey	PK s_suppkey FK n_nationkey	s_nationkey	N/A
PartSupp	ps_partkey	ps_partkey	PK ps_partkey PK ps_suppkey FK p_partkey FK s_suppkey	PK ps_partkey PK ps_suppkey FK p_partkey FK s_suppkey	ps_partkey	N/A

Queries

We sought to replicate the TPC-H Benchmark queries modified only by syntax differences required by the platforms. The TPC's benchmark is a fair representation of enterprise query needs. The queries used for the derived tests were compliant with the standards set out by the TPC-H specification and included only minor query modifications as set out by section 2.2.3 of the TPC-H specification document. For example, minor query modifications included vendor-specific syntax for date expressions. Also, in the specification, queries 2, 3, 10, 18 and 21 require row limits and, thus, vendor specific syntax was used (e.g., TOP, FIRST, LIMIT, and so forth) as allowed by section 2.1.2.9 of the TPC-H specification.

Our testing included all 22 queries of the TPC-H specification, which are described by the table below.

Table 4. Query Descriptions

Q#	Description	Sum	Sub-query	Joins*	Min/ Max	Avg	Count	Top/ Limit
1	Pricing Summary Report	✓				✓	✓	
2	Minimum Cost Supplier		✓	5	✓			✓

3	Shipping Priority	✓		3				✓
4	Order Priority Checking		✓	2			✓	
5	Local Supplier Volume	✓		6				
6	Forecasting Revenue Change	✓						
7	Volume Shipping	✓	✓	6				
8	National Market Share	✓	✓	8				
9	Product Type Profit Measure	✓	✓	6				
10	Returned Item Reporting	✓		4				✓
11	Important Stock Identification	✓	✓	3				
12	Shipping Modes and Order Priority	✓		2				
13	Customer Distribution		✓	2			✓	
14	Promotion Effect	✓		2				
15	Top Supplier		✓	2	✓			
16	Parts/Supplier Relationship		✓	2			✓	
17	Small Quantity Order Revenue	✓	✓	2		✓		
18	Large Volume Customer	✓	✓	3				✓
19	Discounted Revenue	✓		2				
20	Potential Part Promotion	✓	✓	3				
21	Suppliers Who Kept Orders Waiting		✓	4			✓	✓
22	Global Sales Opportunity	✓	✓	2		✓	✓	

**Given as the number of tables involved in joins. Both implicit and explicit joins are counted.*

Test Results

There are some important distinctions of the performance testing described here within and the TPC-H. These include:

Data and Schema

- The schema and data used were from the TPC-H.

Single-User Power Runs

- Three power runs were completed. Each of the 22 queries was executed three times in order (1, 2, 3,…) against each vendor cloud platform, and the fastest of the three times was used as the performance metric.
- For this workload, the primary metric used was the best execution times for each query. These best times were then added together to gain the total aggregate execution time for the entire workload.

Single-User Power Runs with Continuous Updates

- Three power runs were repeated—this time with continuous updates happening at the same time. The update methodology was derived from the TPC-H specification document, section 2.5, which refers to continuous updates as "refresh functions." During the tests, the following operations were performed:
  - Begin loop
    - Insert a new row into the ORDERS table
    - Insert a random number (between 1 and 7) of new rows into the LINEITEM table
    - Delete an old row from the ORDERS table
    - Delete the rows (between 1 and 7) from the LINEITEM table which correspond to the deleted order
  - End loop and repeat continuously
- Each of the 22 queries was executed three times in order (1, 2, 3,…) against each vendor cloud platform while continuous updates were also being processed, and the fastest of the three times was used as the performance metric.
- For this workload, the primary metric used was the best execution times for each query. These best times were then added together to gain the total aggregate execution time for the entire workload.

20-User Power Runs

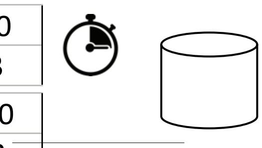
- Three power runs were also completed simulating 20 concurrent users. For these tests, 20 identical query requests (threads) of the 22 queries were simultaneously submitted. This differs from the throughput (multi-stream) runs defined by the TPC-H. The diagram below represents this test.
- For the concurrency simulation workload, the primary metric used was the average execution time across all 20 users for each query. The best average of the three runs was taken.

20-User Power Runs with Continuous Updates

- The 20-User Power Runs test was repeated with the continuous updates running simultaneously.
- The same continuous update methodology was used as described in the Single-User Power Runs with Continuous Updates section above.
- Once again, the primary metric used was the average execution time across all 20 users for each query. The best average of the three runs was taken.

Table 5. Concurrent User Simulation

Thread	1	2	3	4	5	6	7	8	9	10
Query	3	3	3	3	3	3	3	3	3	3
Thread	11	12	13	14	15	16	17	18	19	20
Query	3	3	3	3	3	3	3	3	3	3



This section analyzes the results from the tests described earlier using these methods.

Single-User Power Runs

The following chart shows the aggregate total performance of the best times for each platform. As you can see, Actian Avalanche was 81% faster that Amazon Redshift when considering the entire workload.

Figure 6. Single-User Power Runs Aggregate Results

[Chart]

The following table shows the full set of individual query times (in seconds) for both Actian Avalanche and Amazon Redshift.

Table 7. Single-User Power Runs Individual Results

Query	Avalanche	Redshift	Query	Avalanche	Redshift
1	10.860	21.069	**12**	1.461	22.072
2	1.887	5.404	**13**	64.949	34.084
3	12.926	36.087	**14**	4.001	11.316
4	0.483	28.290	**15**	7.278	12.319
5	14.868	17.531	**16**	13.653	6.790
6	0.815	6.083	**17**	7.773	17.890
7	10.764	21.874	**18**	5.423	35.897
8	5.482	15.457	**19**	10.825	29.995
9	75.416	66.257	**20**	8.128	17.210

10	6.421	18.795	**21**	15.916	36.046
11	53.464	163.726	**22**	16.663	8.184
			TOTAL	**349.456**	**632.376**

Single-User Power Runs with Continuous Updates

The following chart shows the aggregate total performance of the best times for each platform. As you can see, Actian Avalanche was 41% faster that Amazon Redshift with continuous updates running when considering the entire workload.

Figure 8. Single-User Power Runs with Continuous Updates Aggregate Results

[Chart]

Table 9. Single-User Power Runs with Continuous Updates Individual Results

Query	Avalanche	Redshift	Query	Avalanche	Redshift
1	11.745	27.189	**12**	1.807	25.961
2	2.467	8.902	**13**	104.672	35.788
3	19.615	37.218	**14**	4.387	11.604
4	0.559	32.803	**15**	8.042	12.497
5	15.364	21.100	**16**	19.209	6.920
6	1.148	7.088	**17**	13.257	20.652
7	16.710	23.368	**18**	6.360	40.906
8	9.833	17.499	**19**	35.076	34.240
9	112.832	72.634	**20**	8.703	18.056
10	6.948	21.124	**21**	18.674	42.883
11	54.090	167.665	**22**	20.282	8.257
			TOTAL	**419.780**	**694.354**

20-User Power Runs

The following chart shows the aggregate total performance of the best times for each platform. As you can see, Actian Avalanche was 2.8 times faster that Amazon Redshift when considering the entire workload.

Figure 10. 20-User Power Runs Aggregate Results

[Chart]

The following table shows the full set of individual query times (in seconds) for both Actian Avalanche and Amazon Redshift.

Table 11. 20-User Power Runs Individual Results

Query	Avalanche	Redshift	Query	Avalanche	Redshift
1	56.590	249.773	12	13.359	196.907
2	11.686	34.241	13	171.445	416.636
3	114.076	211.547	14	23.844	68.421
4	5.067	231.166	15	54.163	144.301
5	45.903	127.747	16	45.611	59.638
6	9.789	44.889	17	101.095	188.722
7	122.635	178.005	18	51.928	363.911
8	42.558	126.440	19	112.273	237.823
9	444.855	512.191	20	86.118	105.567
10	67.424	146.589	21	73.385	484.466
11	198.757	1,171.499	22	60.323	75.383
			TOTAL	1,912.884	5,375.863

20-User Power Runs with Continuous Updates

The following chart shows the aggregate total performance of the best times for each platform. As you can see, Actian Avalanche was 2.4 times faster that Amazon Redshift with continuous updates running when considering the entire workload.

Figure 12. 20-User Power Runs with Continuous Updates Aggregate Results

[Chart]

Table 13. 20-User Power Runs with Continuous Updates Individual Results

Query	Avalanche	Redshift	Query	Avalanche	Redshift
1	63.723	288.657	12	49.183	225.171
2	16.426	36.976	13	214.240	451.462
3	116.265	233.143	14	24.038	75.491
4	6.216	281.559	15	57.202	153.519
5	51.208	146.603	16	45.703	65.352
6	17.770	49.971	17	179.984	249.974
7	162.977	194.416	18	62.609	396.375
8	197.684	134.077	19	216.760	284.229
9	497.868	570.587	20	92.129	113.709

10	82.188	167.401	**21**	79.090	532.886
11	218.573	1,294.389	**22**	62.785	79.769
			TOTAL	**2,514.621**	**6,025.716**

Price Per Performance

The price-performance metric is dollars per query-hour ($/query-hour). This is defined as the normalized cost of running our performance testing workloads on each of the cloud platforms. It was calculated by multiplying the best on-demand rate (expressed in dollars) offered by the cloud platform vendor (at the time of testing) times the number of computation nodes used in the cluster and by dividing this amount by the aggregate total of the best execution times for each query (expressed in hours).

If you contiguously ran all 22 of these queries to completion of the set, the cost at an hourly basis is indicated in the chart below. As you can see, Actian Avalanche completed these queries with 2.2 times more cost effectiveness than Amazon Redshift.

Figure 14. Single-User Price-Performance @ 10TB ($ per Query per Hour)

[Chart]

The following table details the breakdown of the price-performance calculation.

Table 15. Single-User Price-Performance @ 10TB Breakdown

	Avalanche	Redshift
Instance Class	Standard	dc2.8xlarge
Node Count	32 AU	16 nodes
Compute ($/node/hour)	$1.99	$4.80
Total Compute ($/hour)	$63.68	$76.80
Total Execution Time (seconds)	349	632
Concurrent Users	1	1
Price-Performance ($/query-hour)	**$6.18**	**$13.49**

If you ran all 22 of these queries to completion of the set using our method to simulate 20 concurrent users and added up the average completion time of each query, the cost at an hourly basis is indicated in the chart below. As you can see, Actian Avalanche completed these queries with 3.4 times more cost effectiveness than Amazon Redshift.

Figure 16. 20-User Price-Performance @ 10TB ($ per Query per Hour)

[Chart]

The following table details the breakdown of the price-performance calculation.

Table 17. 20-User Price-Performance @ 10TB Breakdown

	Avalanche	Redshift
Instance Class	Standard	dc2.8xlarge
Node Count	32 AU	16 nodes
Compute ($/node/hour)	$1.99	$4.80
Total Compute ($/hour)	$63.68	$76.80
Total Execution Time (seconds)	1,913	5,376
Concurrent Users	20	20
Price-Performance ($/query-hour)	**$1.69**	**$5.73**

Conclusion

Cloud analytical databases are a way for enterprises to avoid large capital expenditures, provision quickly, and provide performance at scale for advanced analytic queries. Relational databases with analytic capabilities continue to support the advanced analytic workloads of the organization with performance, scale, and concurrency. For our performance testing, which contains a representative set of corporate-complex queries derived from the well-known TPC Benchmark™ H (TPC-H)[3] standard, Actian Avalanche outperformed Amazon Redshift.

Overall, the performance testing results were insightful in revealing query execution performance and some of the differentiators for the tested platforms. Actian Avalanche query response times on the 10TB performance tests were 81% faster than Redshift. When 20 concurrent users were simulated, Avalanche was 2.8 times faster.

In terms of price per performance, Actian Avalanche ran the performance test queries 2.2 times cheaper than Redshift in terms of cost per query per hour. When 20 concurrent users were simulated, Avalanche was 3.4 times cheaper.

These performance results are most likely explained by the technology underlying Vector. The basic architecture of Actian Avalanche is the Actian patented X100 engine, which utilizes a concept known as "vectorized query execution" where processing of data is done in chunks of cache-fitting vectors. Vector performs “single instruction, multiple data” processes by leveraging the same operation on multiple data simultaneously and exploiting the parallelism capabilities of modern hardware. It reduces overhead found in conventional "one-row-at-a-time processing" found in other platforms. Additionally, the compressed column-oriented format uses a scan-optimized buffer manager.

Overall, Actian Avalanche is an excellent choice for data-driven companies needing high performance and a scalable, fully-managed analytical database in the cloud—at a reasonable cost.

[3] This was NOT an official TPC Benchmark™ H (TPC-H) benchmark. More can be learned about the TPC-H benchmark at http://www.tpc.org/tpch/.

About McKnight Consulting Group

About MCG

Learn more at http://www.mcknightcg.com/.

About Actian

Actian, the hybrid data management, analytics and integration company, delivers data as a competitive advantage to thousands of customers worldwide. Through the deployment of innovative hybrid data technologies and solutions Actian ensures that business critical systems can transact and integrate at their very best – on premise, in the cloud or both. Thousands of forward-thinking organizations around the globe trust Actian to help them solve the toughest data challenges to transform how they run their businesses, today and in the future.

To learn more about Actian Avalanche, visit www.actian.com/avalanche