Semantic Publishing Benchmark 2.0.2
Full Disclosure Report
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Preface

This is the Full Disclosure Report for the benchmark results produced by Semantic Publishing Benchmark v2.0 for GraphDB EE 10.1.0, Scale Factor 3 (256M Triples), using 3x r6id.8xlarge AWS servers in a cluster setup (another r6id.8xlarge AWS machine was used for running the benchmark).

General Terms

Test Sponsor

Test sponsor of this benchmark is Sirma AI Ad, trading as Ontotext, Bulgaria. Ontotext is a global leader in enterprise knowledge graph technology and semantic database engines. Its semantic technology is distinctive for its performance, scalability, robustness and compliance with open standards. Ontotext solutions have been applied for business critical projects in the areas of financial services (S&P), publishing (BBC, Financial Times), life sciences (Astra Zeneca), industry and infrastructure management (Johnson Controls, Siemens, Stellantis/PSA), government organizations (UK Parliament, NASA) and others. Ontotext is the developer of GraphDB semantic graph database.

1. System Description

1.1 Database System

Vendor Name	Ontotext
Database Name	GraphDB Enterprise Edition
Version No	10.1.0
Database Engine Configuration	G1 Garbage Collector with 80gb of heap memory and a few internal properties. (-XX:+UseG1GC –Xmx80g -Din-memory-literal-properties=true -Ddefault.min.distinct.threshold=100m)
Full Docker run command	docker run -d -p 7200:7200 -v /opt/temp-test-data/gdb-home:/opt/graphdb/home ontotext/graphdb:10.1.0 /opt/graphdb/dist/bin/graphdb -Dgraphdb.home=/opt/graphdb/home -XX:+UseG1GC -Xmx80g -Din-memory-literal-properties=true -Ddefault.min.distinct.threshold=100m -Dgraphdb.cluster.rpc.port=8008

Table 1: DBMS Characteristics

1.2 Database Engine Configuration

Cache Configuration	80GB Reserved memory (Java: -Xmx80g)
Transaction Isolation Level/Model	Not configurable
Reasoning Strategy/configuration	Tailormade SPB ruleset has been loaded
triple/quadruple indices	N/A
indices	GEO-SPATIAL, TEXT INDEXES (LUCENE CONNECTOR)
Optimisations	OWL:SAMEAS

Table 2: Database Engine Configuration

1.3 Platform Description

Model	AWS EC2 Instance: r6id.8xlarge
Processors	Intel Xeon Platinum 8375C, 3500 Mhz, 32 cores, L1 cache: 2560KiB, L2 cache: 40MiB, L3 cache: 54MiB
Memory	256GB, DIMM DDR4 Static column Pseudo-static Synchronous Window DRAM 3200MHz (0.3 ns)
No Disks/Type/Storage Configuration	/dev/nvme1n1= 1900GB (NVMe SSD)
Network Adapters	Elastic Network Adapter (ENA) – Amazon.com, Inc. (mtu 9001)
Operating System	Linux ip-172-31-1-44 5.15.0-1019-aws #23-Ubuntu SMP Wed Aug 17 18:33:13 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux
File System	/dev/nvme1n1 ext4 /
CPU Type & Count	Intel Xeon Platinum 8375C
No vcpu Cores	32
Memory	256GB
Total Disks Capacity	1900GB
Model	AWS EC2 Instance: r6id.8xlarge

Table 3: System Configuration

No disks	1 SSD
Storage interfaces	1 x 1900GB NVMe SSD
Storage Technologies	NVMe
RAID/HBA controller	

Table 3: No Disks/Type/Storage/Configuration

1.4 Network Infrastructure Information

Model	Elastic Network Adapter (ENA) – Amazon.com, Inc.
Network Switches	AWS
Wiring Information	AWS

Table 4: Network Infrastructure Information

2. Data Generation & Loading

2.1 Dataset Information

2.1.1 Description

Scale Factor	SF-3 256M
Data Format	Direct SPARQL endpoint insert
Data Generator Version	2.0.2 (basic-querymix-graphdb)
Time Compression ratio	N/A

Table 5: Dataset characteristics

2.1.2 External Datasets

2.1.3 Dataset Characteristics

(reference data entities size : 1155229, greatest Creative Work id : 8859807,
dbpedia locations : 268862, geonames locations : 1285124)

2.1.4 Data Generator Parameters

```
#Benchmark Threads Configuration
aggregationAgents=8
editorialAgents=2
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=30
datasetSize=232000000
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
```

```
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=true
verbose=true

#Benchmark Operational Phases
loadOntologies=true
loadReferenceDatasets=true
generateCreativeWorks=true
loadCreativeWorks=true
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=false
runBenchmark=false
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

2.2 Data Generation Times
Data generation and bulk loading went together.

Start Time (in ms)	10:00:32
End Time (in ms)	12:59:54
Generation Time	10 762 417 ms (=2h 59m 22s)

Table 6: Data Generation Times

2.3. Bulk Loading
Data generation and bulk loading went together.

Start Time (in ms)	10:00:32
End Time (in ms)	12:59:54
Generation Time	10 762 417 ms (=2h 59m 22s)

Table 7: Bulk Loading Time

2.4. Additional setup

Lucene connector time	6m38s
Create a geospatial index	7.7s

2.5. Raw results

```
Loaded 5123 files with Creative Works in 10762417 milliseconds
Warning : Possible wrong configuration for property 'scriptsPath' (test.properties)...
Generating query parameters
Analyzing existing reference knowledge in database, it may take a while...
       (reference data entities size : 1155229, greatest Creative Work id : 8859807,
dbpedia locations : 268862, geonames locations : 1285124)
............


END OF RUN, all agents shut down...

real    190m40.377s
user    21m54.144s
sys     1m41.859s
```

3. Test case: 0 read threads, 4 write threads

3.1. Benchmark Test Driver

3.1.1. Basic test driver configuration details

No of read threads	0
No of write threads	4

Table 8: Basic Test Driver Configuration Details

3.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=0
queryTimeoutSeconds=300
warmUp=true
```

3.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=0
editorialAgents=4
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

3.1.4. Raw test.properties

```
#Benchmark Threads Configuration
aggregationAgents=0
editorialAgents=4
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://54.92.203.255:7200/repositories/LDBC-SF3
endpointUpdateURL=http://54.92.203.255:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

3.1.5. Test Driver Reference Data
No modifications made.

3.2. Performance Metrics

3.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
0	23.0658

Table 9: Primary Metrics

3.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	0	2777	22139	2763

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	0 ms	0 ms	0 ms	0
Q2	0 ms	0 ms	0 ms	0
Q3	0 ms	0 ms	0 ms	0
Q4	0 ms	0 ms	0 ms	0
Q5	0 ms	0 ms	0 ms	0
Q6	0 ms	0 ms	0 ms	0
Q7	0 ms	0 ms	0 ms	0
Q8	0 ms	0 ms	0 ms	0
Q9	0 ms	0 ms	0 ms	0
Q10	0 ms	0 ms	0 ms	0
Q11	0 ms	0 ms	0 ms	0
Q12	0 ms	0 ms	0 ms	0

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	168 ms	115 ms	1051 ms	22139
Update	191 ms	155 ms	1259 ms	2777
Delete	176 ms	137 ms	1005 ms	2763

Table 12: Editorial Report

3.2.3. Raw results

```
Seconds : 1200
2022-12-06 14:40:06 (completed query mixes : 0)
        Editorial:
            4 agents

            22139 inserts (avg : 168     ms, min : 115     ms, max : 1051    ms)
            2777  updates (avg : 191     ms, min : 155     ms, max : 1259    ms)
```

```
        2763  deletes (avg : 176     ms, min : 137     ms, max : 1005    ms)

        27679 operations (22139 CW Inserts (4 errors), 2777 CW Updates (0 errors), 2763 CW
Deletions (0 errors))
        23.0658 average operations per second

    Aggregation:
        0 agents

        0   Q1   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q2   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q3   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q4   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q5   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q6   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q7   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q8   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q9   queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q10  queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q11  queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)
        0   Q12  queries (avg : 0      ms, min : 0      ms, max : 0      ms, 0 errors)

        0 total retrieval queries (0 errors)
        0.0000 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...

real    27m45.073s
user    1m12.432s
sys     0m3.829s
```

4. Test case: 4 write threads, 8 read threads

4.1 Benchmark Test Driver

4.1.1. Basic test driver configuration details

No of read threads	8
No of write threads	4

Table 10: Basic Test Driver Configuration Details

4.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=8
queryTimeoutSeconds=300
warmUp=true
```

4.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=8
editorialAgents=4
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

4.1.4. Raw test.properties

```
#Benchmark Threads Configuration
aggregationAgents=8
editorialAgents=4
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://54.92.203.255:7200/repositories/LDBC-SF3
endpointUpdateURL=http://54.92.203.255:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

4.1.5. Test Driver Reference Data
No modifications made.

4.2. Performance Metrics

4.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
236.8183	20.5000

Table 11: Primary Metrics

4.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	284182	2777	22139	2763

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	26 ms	3 ms	230 ms	23680
Q2	3 ms	2 ms	86 ms	23682
Q3	15 ms	6 ms	977 ms	23682
Q4	7 ms	2 ms	221 ms	23682
Q5	30 ms	2 ms	576 ms	23683
Q6	41 ms	27 ms	151 ms	23681
Q7	9 ms	3 ms	102 ms	23682
Q8	30 ms	21 ms	173 ms	23684
Q9	57 ms	2 ms	323 ms	23682
Q10	32 ms	2 ms	161 ms	23680
Q11	7 ms	2 ms	538 ms	23681
Q12	7 ms	3 ms	86 ms	23683

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	190 ms	115 ms	1761 ms	19585
Update	214 ms	165 ms	1766 ms	2506
Delete	195 ms	137 ms	1734 ms	2509

Table 12: Editorial Report

4.2.3. Raw results

```
Seconds : 1200
2022-12-06 22:04:36 (completed query mixes : 23677)
        Editorial:
            4 agents

            19585 inserts (avg : 190     ms, min : 115     ms, max : 1761    ms)
            2506  updates (avg : 214     ms, min : 165     ms, max : 1766    ms)
```

```
            2509  deletes (avg : 195      ms, min : 137      ms, max : 1734     ms)


            24600 operations (19585 CW Inserts (17 errors), 2506 CW Updates (0 errors), 2509 CW
Deletions (2 errors))
            20.5000 average operations per second


      Aggregation:
            8 agents

            23680 Q1   queries (avg : 26      ms, min : 3       ms, max : 230     ms, 0 errors)
            23682 Q2   queries (avg : 3       ms, min : 2       ms, max : 86      ms, 0 errors)
            23682 Q3   queries (avg : 15      ms, min : 6       ms, max : 977     ms, 0 errors)
            23682 Q4   queries (avg : 7       ms, min : 2       ms, max : 221     ms, 0 errors)
            23683 Q5   queries (avg : 30      ms, min : 2       ms, max : 576     ms, 0 errors)
            23681 Q6   queries (avg : 41      ms, min : 27      ms, max : 151     ms, 0 errors)
            23682 Q7   queries (avg : 9       ms, min : 3       ms, max : 102     ms, 0 errors)
            23684 Q8   queries (avg : 30      ms, min : 21      ms, max : 173     ms, 0 errors)
            23682 Q9   queries (avg : 57      ms, min : 2       ms, max : 323     ms, 0 errors)
            23680 Q10  queries (avg : 32      ms, min : 2       ms, max : 161     ms, 0 errors)
            23681 Q11  queries (avg : 7       ms, min : 2       ms, max : 538     ms, 0 errors)
            23683 Q12  queries (avg : 7       ms, min : 3       ms, max : 86      ms, 0 errors)


            284182 total retrieval queries (0 errors)
            236.8183 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...


real    27m48.434s
user    21m57.153s
sys     1m7.230s
```

5. Test case: 16 read threads, 0 write threads

5.1 Benchmark Test Driver

5.1.1. Basic test driver configuration details

No of read threads	16
No of write threads	0

Table 12: Basic Test Driver Configuration Details

5.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=16
queryTimeoutSeconds=300
warmUp=true
```

5.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=16
editorialAgents=0
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

5.1.4. Raw test.properties

```
#Benchmark Threads Configuration
aggregationAgents=16
editorialAgents=0
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://54.92.203.255:7200/repositories/LDBC-SF3
endpointUpdateURL=http://54.92.203.255:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

5.1.5. Test Driver Reference Data
No modifications made.

5.2. Performance Metrics

5.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
466.7958	0.0000

Table 13: Primary Metrics

5.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	560155	0	0	0

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	27 ms	2 ms	300 ms	46678
Q2	3 ms	2 ms	47 ms	46678
Q3	14 ms	5 ms	1155 ms	46680
Q4	6 ms	1 ms	231 ms	46678
Q5	30 ms	2 ms	536 ms	46679
Q6	43 ms	27 ms	109 ms	46679
Q7	8 ms	2 ms	68 ms	46682
Q8	31 ms	22 ms	198 ms	46681
Q9	61 ms	2 ms	334 ms	46680
Q10	33 ms	1 ms	140 ms	46679
Q11	7 ms	2 ms	1389 ms	46680
Q12	6 ms	2 ms	71 ms	46681

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	0 ms	0 ms	0 ms	0
Update	0 ms	0 ms	0 ms	0
Delete	0 ms	0 ms	0 ms	0

Table 12: Editorial Report

5.2.3. Raw results

```
Seconds : 1200
2022-12-06 15:43:35 (completed query mixes : 46674)
        Editorial:
            0 agents

            0    inserts (avg : 0      ms, min : 0      ms, max : 0        ms)
            0    updates (avg : 0      ms, min : 0      ms, max : 0        ms)
```

```
        0       deletes (avg : 0        ms, min : 0        ms, max : 0        ms)

        0 operations (0 CW Inserts (0 errors), 0 CW Updates (0 errors), 0 CW Deletions (0 errors))
        0.0000 average operations per second

    Aggregation:
        16 agents

        46678 Q1   queries (avg : 27    ms, min : 2      ms, max : 300    ms, 0 errors)
        46678 Q2   queries (avg : 3     ms, min : 2      ms, max : 47     ms, 0 errors)
        46680 Q3   queries (avg : 14    ms, min : 5      ms, max : 1155   ms, 0 errors)
        46678 Q4   queries (avg : 6     ms, min : 1      ms, max : 231    ms, 0 errors)
        46679 Q5   queries (avg : 30    ms, min : 2      ms, max : 536    ms, 0 errors)
        46679 Q6   queries (avg : 43    ms, min : 27     ms, max : 109    ms, 0 errors)
        46682 Q7   queries (avg : 8     ms, min : 2      ms, max : 68     ms, 0 errors)
        46681 Q8   queries (avg : 31    ms, min : 22     ms, max : 198    ms, 0 errors)
        46680 Q9   queries (avg : 61    ms, min : 2      ms, max : 334    ms, 0 errors)
        46679 Q10  queries (avg : 33    ms, min : 1      ms, max : 140    ms, 0 errors)
        46680 Q11  queries (avg : 7     ms, min : 2      ms, max : 1389   ms, 0 errors)
        46681 Q12  queries (avg : 6     ms, min : 2      ms, max : 71     ms, 0 errors)

        560155 total retrieval queries (0 errors)
        466.7958 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...


real    27m48.943s
user    39m41.797s
sys     2m26.175s
```

6. Test case: 32 read threads, 0 write threads

6.1. Benchmark Test Driver

6.1.1. Basic test driver configuration details

No of read threads	32
No of write threads	0

Table 14: Basic Test Driver Configuration Details

6.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=32
queryTimeoutSeconds=300
warmUp=true
```

6.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=32
editorialAgents=0
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

6.1.4. Raw test.properties

```
#Benchmark Threads Configuration
aggregationAgents=32
editorialAgents=0
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://54.92.203.255:7200/repositories/LDBC-SF3
endpointUpdateURL=http://54.92.203.255:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

6.1.5. Test Driver Reference Data
No modifications made.

6.2. Performance Metrics

6.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
754.5850	0.0000

Table 15: Primary Metrics

6.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	905502	0	0	0

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	32 ms	3 ms	502 ms	75460
Q2	4 ms	2 ms	87 ms	75461
Q3	18 ms	5 ms	1796 ms	75461
Q4	8 ms	2 ms	507 ms	75457
Q5	36 ms	2 ms	774 ms	75458
Q6	49 ms	28 ms	156 ms	75457
Q7	10 ms	3 ms	93 ms	75461
Q8	36 ms	24 ms	302 ms	75458
Q9	80 ms	2 ms	649 ms	75454
Q10	44 ms	2 ms	207 ms	75459
Q11	11 ms	2 ms	1981 ms	75457
Q12	8 ms	3 ms	82 ms	75459

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	0 ms	0 ms	0 ms	0
Update	0 ms	0 ms	0 ms	0
Delete	0 ms	0 ms	0 ms	0

Table 12: Editorial Report

6.2.3. Raw results

```
Seconds : 1200
2022-12-06 20:26:42 (completed query mixes : 75442)
        Editorial:
            0 agents

            0     inserts (avg : 0      ms, min : 0      ms, max : 0        ms)
            0     updates (avg : 0      ms, min : 0      ms, max : 0        ms)
```

```
          0      deletes (avg : 0       ms, min : 0       ms, max : 0        ms)

          0 operations (0 CW Inserts (0 errors), 0 CW Updates (0 errors), 0 CW Deletions (0 errors))
          0.0000 average operations per second

      Aggregation:
          32 agents

          75460 Q1   queries (avg : 32      ms, min : 3       ms, max : 502     ms, 0 errors)
          75461 Q2   queries (avg : 4       ms, min : 2       ms, max : 87      ms, 0 errors)
          75461 Q3   queries (avg : 18      ms, min : 5       ms, max : 1796    ms, 0 errors)
          75457 Q4   queries (avg : 8       ms, min : 2       ms, max : 507     ms, 0 errors)
          75458 Q5   queries (avg : 36      ms, min : 2       ms, max : 774     ms, 0 errors)
          75457 Q6   queries (avg : 49      ms, min : 28      ms, max : 156     ms, 0 errors)
          75461 Q7   queries (avg : 10      ms, min : 3       ms, max : 93      ms, 0 errors)
          75458 Q8   queries (avg : 36      ms, min : 24      ms, max : 302     ms, 0 errors)
          75454 Q9   queries (avg : 80      ms, min : 2       ms, max : 649     ms, 0 errors)
          75459 Q10  queries (avg : 44      ms, min : 2       ms, max : 207     ms, 0 errors)
          75457 Q11  queries (avg : 11      ms, min : 2       ms, max : 1981    ms, 0 errors)
          75459 Q12  queries (avg : 8       ms, min : 3       ms, max : 82      ms, 0 errors)

          905502 total retrieval queries (0 errors)
          754.5850 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...


real    27m55.090s
user    72m7.702s
sys     4m37.553s
```

7. Test case: 64 read threads, 0 write threads

7.1. Benchmark Test Driver

7.1.1. Basic test driver configuration details

No of read threads	64
No of write threads	0

Table 16: Basic Test Driver Configuration Details

7.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=64
queryTimeoutSeconds=300
warmUp=true
```

7.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=64
editorialAgents=0
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

7.1.4. Raw test.properties
```
#Benchmark Threads Configuration
aggregationAgents=64
editorialAgents=0
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3)
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

7.1.5. Test Driver Reference Data
No modifications made.

7.2. Performance Metrics

7.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
985.6333	0.0000

Table 17: Primary Metrics

7.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	1182760	0	0	0

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	56 ms	4 ms	841 ms	98567
Q2	9 ms	3 ms	134 ms	98565
Q3	30 ms	7 ms	2969 ms	98561
Q4	16 ms	3 ms	628 ms	98563
Q5	65 ms	3 ms	896 ms	98560
Q6	87 ms	32 ms	342 ms	98562
Q7	47 ms	5 ms	209 ms	98563
Q8	79 ms	41 ms	472 ms	98563
Q9	138 ms	4 ms	1647 ms	98561
Q10	60 ms	2 ms	259 ms	98572
Q11	21 ms	3 ms	2616 ms	98563
Q12	19 ms	3 ms	153 ms	98560

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	0 ms	0 ms	0 ms	0
Update	0 ms	0 ms	0 ms	0
Delete	0 ms	0 ms	0 ms	0

Table 12: Editorial Report

7.2.3. Raw results

```
Seconds : 1200
2022-12-06 21:10:26 (completed query mixes : 98535)
        Editorial:
            0 agents

            0    inserts (avg : 0     ms, min : 0      ms, max : 0       ms)
            0    updates (avg : 0     ms, min : 0      ms, max : 0       ms)
```

```
         0    deletes (avg : 0       ms, min : 0       ms, max : 0       ms)

         0 operations (0 CW Inserts (0 errors), 0 CW Updates (0 errors), 0 CW Deletions (0 errors))
         0.0000 average operations per second

     Aggregation:
         64 agents

         98567 Q1   queries (avg : 56    ms, min : 4    ms, max : 841    ms, 0 errors)
         98565 Q2   queries (avg : 9     ms, min : 3    ms, max : 134    ms, 0 errors)
         98561 Q3   queries (avg : 30    ms, min : 7    ms, max : 2969   ms, 0 errors)
         98563 Q4   queries (avg : 16    ms, min : 3    ms, max : 628    ms, 0 errors)
         98560 Q5   queries (avg : 65    ms, min : 3    ms, max : 896    ms, 0 errors)
         98562 Q6   queries (avg : 87    ms, min : 32   ms, max : 342    ms, 0 errors)
         98563 Q7   queries (avg : 47    ms, min : 5    ms, max : 209    ms, 0 errors)
         98563 Q8   queries (avg : 79    ms, min : 41   ms, max : 472    ms, 0 errors)
         98561 Q9   queries (avg : 138   ms, min : 4    ms, max : 1647   ms, 0 errors)
         98572 Q10  queries (avg : 60    ms, min : 2    ms, max : 259    ms, 0 errors)
         98563 Q11  queries (avg : 21    ms, min : 3    ms, max : 2616   ms, 0 errors)
         98560 Q12  queries (avg : 19    ms, min : 3    ms, max : 153    ms, 0 errors)

         1182760 total retrieval queries (0 errors)
         985.6333 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...

real    28m28.048s
user    88m31.510s
sys     6m54.519s
```

8. Test case: 64 read threads, 4 write threads

8.1. Benchmark Test Driver

8.1.1. Basic test driver configuration details

No of read threads	64
No of write threads	4

Table 18: Basic Test Driver Configuration Details

8.1.2. Configuration Parameters for Driver Warmup

```
warmupPeriodSeconds=400
aggregationAgents=64
queryTimeoutSeconds=300
warmUp=true
```

8.1.3. Configuration Parameters for Driver Execution

```
aggregationAgents=64
editorialAgents=4
benchmarkRunPeriodSeconds=1200
queryTimeoutSeconds=300
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://52.91.73.231:7200/repositories/LDBC-SF3
endpointUpdateURL=http://52.91.73.231:7200/repositories/LDBC-SF3/statements
queriesPath=./data/sparql
runBenchmark=true
```

8.1.4. Raw test.properties
```
#Benchmark Threads Configuration
aggregationAgents=64
editorialAgents=4
dataGeneratorWorkers=4

#Benchmark Configuration Parameters
warmupPeriodSeconds=400
benchmarkRunPeriodSeconds=1200
datasetSize=232000000 # (SF3
generatedTriplesPerFile=50000
queryTimeoutSeconds=300
querySubstitutionParameters=100000
benchmarkByQueryMixRuns=0
minUpdateRateThresholdOps=0.0
minUpdateRateThresholdReachTimePercent=0
maxUpdateRateThresholdOps=0.0
endpointURL=http://54.92.203.255:7200/repositories/LDBC-SF3
endpointUpdateURL=http://54.92.203.255:7200/repositories/LDBC-SF3/statements
#endpointURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10
```

```
#endpointUpdateURL=http://localhost:8080/openrdf-sesame/repositories/ldbc10/statements
ontologiesPath=./data/ontologies
referenceDatasetsPath=./data/datasets
creativeWorksPath=./generated
queriesPath=./data/sparql
validationPath=./data/validation
definitionsPath=./definitions.properties
scriptsPath= *** full path to /data/scripts ***
enableCompressionOnGeneratedData=false
creativeWorksInfo=dataset.info
generateCreativeWorksFormat=n-quads
currentRateReportPeriodSeconds=0
saveDetailedQueryLogs=false
verbose=true

#Benchmark Operational Phases
loadOntologies=false
loadReferenceDatasets=false
generateCreativeWorks=false
loadCreativeWorks=false
generateQuerySubstitutionParameters=true
validateQueryResults=false
warmUp=true
runBenchmark=true
runBenchmarkOnlineReplicationAndBackup=false
checkConformance=false
```

8.1.5. Test Driver Reference Data
No modifications made.

8.2. Performance Metrics

8.2.1. SPB Primary Metrics

Retrieval Query Rate (queries/second)	Update Rate (Operations per second)
1121.7633	9.5292

Table 19: Primary Metrics

8.2.2. Query Execution Report

Duration of Bulk Load	No of retrieval queries	No of update queries	No of insert queries	No of delete queries
10 762 417 ms	1346116	1113	9154	1168

Table 10: Query Execution Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Q1	44 ms	2 ms	1436 ms	112177
Q2	6 ms	2 ms	764 ms	112173
Q3	24 ms	6 ms	4804 ms	112182
Q4	11 ms	2 ms	1009 ms	112177
Q5	45 ms	2 ms	1218 ms	112181
Q6	55 ms	27 ms	883 ms	112173
Q7	15 ms	3 ms	910 ms	112167
Q8	44 ms	23 ms	943 ms	112173
Q9	135 ms	2 ms	2296 ms	112176
Q10	54 ms	2 ms	994 ms	112180
Q11	15 ms	2 ms	3278 ms	112176
Q12	12 ms	3 ms	895 ms	112181

Table 11: Aggregation Report

Query	Arithmetic Mean of Execution Time	Minimum Execution Time	Maximum Execution Time	Count of Executions
Insert	408 ms	155 ms	3416 ms	9154
Update	477 ms	188 ms	3389 ms	1113
Delete	419 ms	178 ms	3267 ms	1168

Table 12: Editorial Report

8.2.3. Raw results

```
Seconds : 1200
2022-12-22 01:30:55 (completed query mixes : 112146)
        Editorial:
                4 agents

                9154  inserts (avg : 408     ms, min : 155     ms, max : 3416    ms)
                1113  updates (avg : 477     ms, min : 188     ms, max : 3389    ms)
```

```
            1168  deletes (avg : 419      ms, min : 178     ms, max : 3267    ms)


            11435 operations (9154 CW Inserts (25 errors), 1113 CW Updates (0 errors), 1168 CW
Deletions (2 errors))
            9.5292 average operations per second


     Aggregation:
            64 agents


            112177 Q1   queries (avg : 44      ms, min : 2      ms, max : 1436   ms, 2 errors)
            112173 Q2   queries (avg : 6       ms, min : 2      ms, max : 764    ms, 1 errors)
            112182 Q3   queries (avg : 24      ms, min : 6      ms, max : 4804   ms, 0 errors)
            112177 Q4   queries (avg : 11      ms, min : 2      ms, max : 1009   ms, 0 errors)
            112181 Q5   queries (avg : 45      ms, min : 2      ms, max : 1218   ms, 2 errors)
            112173 Q6   queries (avg : 55      ms, min : 27     ms, max : 883    ms, 0 errors)
            112167 Q7   queries (avg : 15      ms, min : 3      ms, max : 910    ms, 0 errors)
            112173 Q8   queries (avg : 44      ms, min : 23     ms, max : 943    ms, 0 errors)
            112176 Q9   queries (avg : 135     ms, min : 2      ms, max : 2296   ms, 0 errors)
            112180 Q10  queries (avg : 54      ms, min : 2      ms, max : 994    ms, 0 errors)
            112176 Q11  queries (avg : 15      ms, min : 2      ms, max : 3278   ms, 0 errors)
            112181 Q12  queries (avg : 12      ms, min : 3      ms, max : 895    ms, 0 errors)


            1346116 total retrieval queries (5 errors)
            1121.7633 average queries per second


Stopping the benchmark...
END OF RUN, all agents shut down...


real    28m0.610s
user    112m14.105s
sys     9m1.418s
```

9. Recovery

Execution Duration	N/A
Time to Recover	N/A

Table 14: Recovery

10. Pricing Summary

See https://calculator.aws/#/createCalculator/EC2 for the current details on the r6id.8xlarge machine(s). Tables 18-22 describe pricing information for three years of usage. Using the same three r6id.8xlarge Amazon machines, costing a fixed $82,422.36 for all scenarios for three years (3x $763.17 per month, standard saving plan, no upfront). The license cost is variable based on the number of cores used, not the number of cores available. Each core costs $2500 per year. The maintenance cost is $0 since this is already covered in the license cost. The number of cores required for a license is calculated as follows:

`CPU_cores_license = number_of_read_threads + (number_of_machines * number_of_write_threads)`

This is because the writing threads are not distributed through the cluster, but the reading threads are.

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 12 CPU CORES) (EE)	$90,000
0X	MAINTENANCE	$0
TOTAL		$172,422

Table 20 Pricing information: 0 read threads, 4 write threads

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 16 CPU CORES) (EE)	$120,000
0X	MAINTENANCE	$0
TOTAL		$202,422

Table 21 Pricing information: 16 read threads, 0 write threads

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 32 CPU CORES) (EE)	$240,000
0X	MAINTENANCE	$0
TOTAL		$322,422

Table 22 Pricing information: 32 read threads, 0 write threads

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 64 CPU CORES) (EE)	$480,000
0X	MAINTENANCE	$0
TOTAL		$562,422

Table 23 Pricing information: 64 read threads, 0 write threads

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 20 CPU CORES) (EE)	$150,000
0X	MAINTENANCE	$0
TOTAL		$232,422

Table 24 Pricing information: 8 read threads, 4 write threads

	Item	Price
3X	AMAZON R6ID.8XLARGE	$82,422.36
1X	GRAPHDB LICENSE (FOR 76 CPU CORES) (EE)	$570,000
0X	MAINTENANCE	$0
TOTAL		$652,422

Table 25 Pricing information: 64 read threads, 4 write threads

11. Attachment's CheckList

CLAUSE 1	RDF Database load scripts if any
CLAUSE 2	RDF Database configuration of more details are available
CLAUSE 3	Operating System and Hardware Settings
CLAUSE 4	Benchmark test driver configuration and any modified query templates and (or) ontologies / reference datasets
CLAUSE 5	All of the log files generated by the benchmark driver

Table 26: Checklist