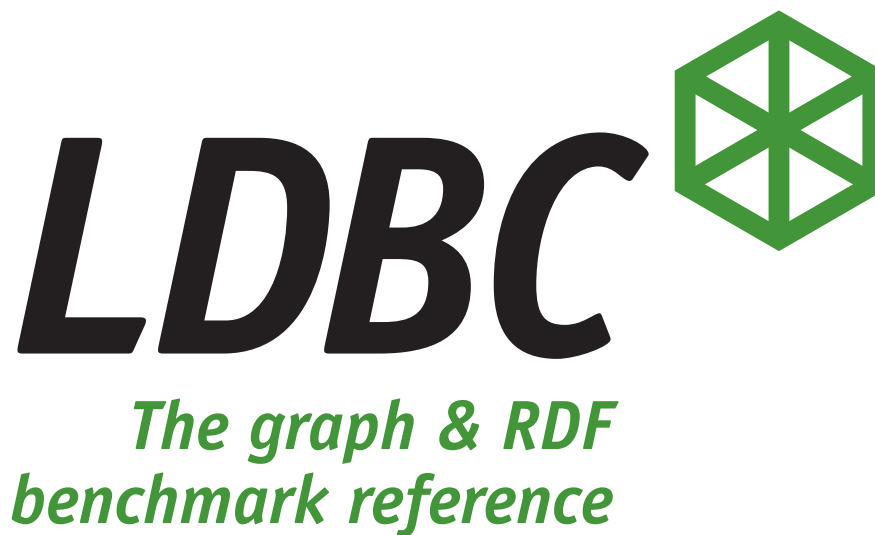




Full Disclosure Report of the LDBC Social Network Benchmark

An Implementation of the LDBC Social Network
Benchmark's Interactive Workload over Graphscope
Flex

May 28, 2025

GENERAL TERMS

Executive Summary

This document describes an implementation of the LDBC Social Network Benchmark’s Interactive workload on a graph database-like build of GraphScope Flex, a modular graph computing stack developed by Alibaba Cloud.

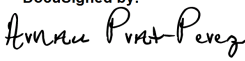
GraphScope Flex¹ is designed to accommodate the diverse and complex needs of real-world graph applications. These applications can involve a variety of graph workloads and can be deployed in different modes. In the audited benchmark runs, GraphScope Flex 0.31.3 was used to execute scale factors SF30, SF100, and SF300 in a single-instance setting (plus another instance to run the driver). The instances were deployed on the Alibaba Cloud infrastructure.

The queries were implemented declaratively using GraphScope’s Cypher implementation and compiled at runtime using their in-house compiler. The data schema follows the property graph model with indices only over vertex identifiers and neighbor sets. No additional indices or precomputed properties were used. The system under test and the driver communicate using remote HTTP.

Declaration of Audit Success

This report contains an audited LDBC benchmark run. The results have been gathered by an independent and impartial auditor who has validated the implementation of the queries, successfully run the ACID tests associated with the claimed isolation level (serializable), and verified the overall system’s configuration conformance to the description of the benchmark and its strict requirements.

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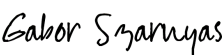
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Dr. Arnau Prat-Perez

(Auditor)

Date

Signed by:



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Dr. Gábor Szárnyas

(Head of LDBC SNB Task Force)

Date

DocuSigned by:



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6/3/2025

.....

Wenyuan Yu

(Test Sponsor Representative)

Date

¹<https://github.com/alibaba/GraphScope/tree/main/flex>

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1 SYSTEM DESCRIPTION AND PRICING SUMMARY

1.1 Details of machines driving and running the workload

1.1.1 Machine overview

The details below were obtained from Alibaba Cloud dashboard (Instance Details page). The operating system was obtained from running `uname -a` command.

Table 1.1: Machine Type and Location

Cloud provider	Alibaba Cloud
Machine region	China (Ulanqab)
Common name of the item	ecs.g8a.48xlarge
Operating system	Ubuntu 20.04.6 LTS 5.4.0-204-generic

Note that the system is configured with the following additional command, to allow for the required amount of asynchronous requests:

```
echo "fs.aio-max-nr = 2116992" » etcsysctl.conf && sysctl -p etcsysctl.conf
```

Also, for SF30, SF100 and SF300 hugepages¹ are enabled with: `echo "vm.nr_hugepages=229376" » etcsysctl.conf && sysctl -p etcsysctl.conf`

This benchmark used two `ecs.g8a.48xlarge` instances, one for the driver and one for the system under test (SUT). Both machines were assigned to the same VPC with the same subnetwork. This is shown in Figure 1.1.

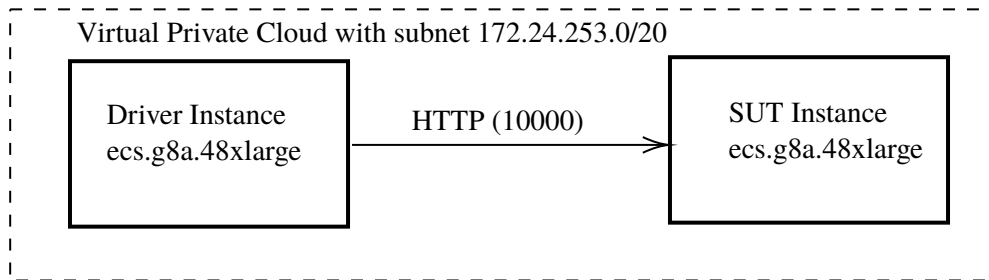


Figure 1.1: Overview of benchmark setup

1.1.2 CPU details

The details below were obtained using the command `lscpu` (Listing A.1) issued from the machine SUT and the data-sheet of the used CPU type.

Table 1.2: CPU details summary

Type	AMD EPYC 9T24 96-Core Processor
Total number	1
Cores per CPU	96
Threads per CPU core	2
CPU clock frequency	3.70 GHz
Total cache size per CPU	L1 cache: 3MiB Data + 3MiB Instruction L2 cache: 96MiB L3 cache: 384MiB

¹<https://www.kernel.org/doc/html/latest/admin-guide/mm/hugetlbpage.html>

1.1.3 Memory details

The total size of the memory installed is 768GB and the type of memory is DDR5 (according to CPU specs). We could not obtain the memory type nor the frequencies using the `sudo lshw -c memory` (Listing A.2) and other similar commands (e.g. `dmidecode`), as they were reported as ‘Unknown’.

We measured the memory read and write bandwidth with the `sysbench` tool, obtaining a read bandwidth of 1379946.65 MiB/sec Listing A.3 and write bandwidth of 312619.18 MiB/sec Listing A.4.

1.1.4 Disk and storage details

Instances have two disks installed: One 40GB NVMe ESSD device `/dev/nvme0n1` with three partitions

- `/dev/nvme0n1p1` bios boot, not mounted (1M)
- `/dev/nvme0n1p2` mounted at `/boot/efi` (fat32 - 191MB)
- `/dev/nvme0n1p3` mounted at `/` (ext4 39.8GB)

and another 4TB NVMe ESSD device `/dev/nvme1n1` mounted at `/data`. The filesystem used for this disk is `xfs`. During all the audit, only the 4TB disk was used in both instances Listing A.5.

We tested the performance of `/dev/nvme1n1` of the SUT, both for Driver Listing A.8 and Server Listing A.9 instances with the `fio` command, using 4KB blocks and a queue depth of 1 obtaining an average of 5558 and 4495 IOPS respectively.

1.1.5 Network details

The benchmark was run using two `ecs.g8a.48xlarge` instances, both deployed in the same availability zone behind a Virtual Private Cloud (VPC) configured with subnetwork `172.24.253.0/20`. Only SUT had the following ports open:

- `10000`: HTTP port used by SUT

The `ecs.g8a.48xlarge` instances use a common Ethernet adapter. This information was obtained using the `lshw -class network` command (Listing A.6). Network throughput between the two instances was measured using the `iperf` tool on port 10000 using 64 threads and the output (Listing A.7) showed an average of 64 Gbit/sec between the client and the server.

1.1.6 Machine pricing

The system pricing summary is included in the table below. The pricing of the Alibaba Cloud machine instance is the price for a 3 x 1-year reserved dedicated instance machine without upfront payment. The Graphscope Flex database software is freely available under the Apache Software License v2.0, hence its permanent license cost is 0.00 \$. The maintenance service fee guarantees 24-hour availability, 7 days a week with a 4-hour response time. The service is provided by the open-source project’s major contributors and maintainers.

Table 1.3: Pricing summary

Item	Price
ecs.g8a.48xlarge reserved instance machine in Alibaba Cloud (standard 3-year term)	408 444.48 RMB
Permanent Graphscope Flex license	0.00 RMB
Maintenance service fee (3 years)	400 000.00 RMB
Total cost of ownership	808 444.48 RMB

1.1.7 System availability

The latest software version of Graphscope Flex (version 0.31.3) was made available on March 17th, 2025. This version was deployed to the machine described in this section. Graphscope Flex is an open-source software released under the Apache Software License 2.0, the used release is available online on GitHub².

²https://github.com/alibaba/GraphScope/releases/download/v0.31.0/graphscope_flex_0.31.3_amd64.deb



2 DATASET GENERATION

2.1 General information

The data generation settings of the LDBC Datagen are described below. Datagen configuration for SF30 to SF300 are shown in Listing A.10–Listing A.12

Table 2.1: Datagen settings summary

Datagen version	v1.0.0
Output format	CsvComposite serializer
Scale factors	30, 100, and 300
Number of partitions	48

For validation, we used all validation sets from SF0.1 to SF10. Validation parameters were downloaded from LDBC GitHub¹, which are generated using the Neo4j Implementation.

Table 2.2: Datagen settings summary for Validation Datasets

Datagen version	v1.0.0
Output format	CsvComposite serializer
Scale factors	0.1, 0.3, 1, 3 and 10
Number of partitions	1

Listing 2.1: Contents of `params-sf10.ini` used for generating scale factor 10 validation set. Similar files can be used to generate the other validation datasets

```

1 ldbc.snb.datagen.generator.scaleFactor:snb.interactive.10
2 ldbc.snb.datagen.serializer.dynamicActivitySerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.
  activity.CsvCompositeDynamicActivitySerializer
3 ldbc.snb.datagen.serializer.dynamicPersonSerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.person.
  CsvCompositeDynamicPersonSerializer
4 ldbc.snb.datagen.serializer.staticSerializer:ldbc.snb.datagen.serializer.snb.csv.staticserializer.
  CsvCompositeStaticSerializer

```

2.2 Data loading and data schema

Some preprocessing is performed on the output produced by Datagen. On the one hand, `post_0_0.csv` and `comment_0_0.csv` are sorted by their creator ids. This is performed by two scripts, `reorder_post.py` and `reorder_comment.py`, respectively. `reorder_post.py` loads the `post_0_0.csv` and `post_hasCreator_person_0_0.csv` files into two tables of a Duckdb instance. Then, the two tables are joined with a left-join using `Post` and `Creator` ids. Finally, the join result is sorted by the `Creator` id and the `Post` columns are projected into a new `Post` file named `post_0_0.csv.rod`, used during the loading phase. Similarly, `comment_0_0.csv.rod` is generated in `reorder_comment.py` by processing the `Comments`.

On the other hand, two new files `post_hasCreator_person_0_0.csv.creation_date` and `comment_hasCreator_person_0_0.csv.creation_date` are created. These are obtained by joining the `creationDate` column extracted from `post_0_0.csv` and `comment_0_0.csv` with the `post_hasCreator_person_0_0.csv` and `comment_hasCreator_person_0_0.csv`, respectively. These are generated with `add_column`, a tool provided (including source code in C++).

¹https://datasets.ldbcouncil.org/interactive-v1/validation_params-interactive-v1.0.0-sf0.1-to-sf10.tar.zst

We utilize two configuration files to define the data loading process and the schema: `bulk_load.yaml` Listing A.13 and `graph.yaml` Listing A.14. The former is used to configure how data should be loaded while the later contains the schema definition.

Data loading times are shown for each scale factor in the table below (second column). Loading times are reported by the SUT, and source code was inspected to audit its correctness. After loading, the database was shut down and started again. The third column shows the times to startup from an already loaded database.

Table 2.3: Data preprocessing, loading and startup times

Scale factor	Preprocessing time (s)	Loading time (s)	Startup time (s)
30	220	44	25
100	702	338	208
300	2 314	1 429	827

3 TEST DRIVER DETAILS

The driver and implementations version used are described below as well as the amount of read and write threads used by the driver.

Table 3.1: Summary of test artifacts and main configuration parameters

Driver version	v1.2.0	https://github.com/ldbc/ldbc_snb_interactive_driver/releases/tag/v1.2.0
Implementations version	v1.0.0	https://github.com/ldbc/ldbc_snb_interactive_impls/releases/tag/1.0.0
LDBC SNB specification version	v2.2.4	https://arxiv.org/pdf/2001.02299
Driver read threads	192	
Driver write threads	96	

3.1 Driver implementation

A test driver adaptation for the SUT was provided by the test sponsor and is available as part of the supplementary package. The SUT-specific test driver class `org.ldbcouncil.snb.impls.workloads.graphscope.interactive.GraphScopeInteractiveDb` extends the class `com.ldbc.driver.Db` provided in the LDBC SNB Interactive driver package. Internally, the `GraphScopeInteractiveDb` relies on an HTTP connection to communicate with the SUT.

3.2 Benchmark configuration of driver

The following table shows, the Warmup Operation Count, Operation Count and Time Compression Ratio (TCR) for the different scale factors:

Table 3.2: Driver configuration parameters per Scale Factor

Scale factor	Warmup Operation Count	Operation Count	TCR
30	64 000 000	272 000 000	0.001
100	152 000 000	579 000 000	0.0016
300	155 400 000	591 800 000	0.0054

The complete driver configuration files for the different scale factors are shown in Listings A.15–A.17, and are also included in the attached supplementary materials.

4 PERFORMANCE METRICS

The performance metrics reported here show benchmark runs with scale factors 30, 100 and 300. In each case, the query on-time compliance is higher than the minimum required 95% ¹. The performance summary tables below highlight key performance characteristics.

Table 4.1: Summary of results for scale factor 30

Benchmark duration	Benchmark operations	Throughput	Query on-time compliance
2:00:23.894	271 979 638	37 650.00 operations second	100.00%

Table 4.2: Summary of results for scale factor 100

Benchmark duration	Benchmark operations	Throughput	Query on-time compliance
2:01:46.167	578 971 217	79 244.18 operations second	95.25%

Table 4.3: Summary of results for scale factor 300

Benchmark duration	Benchmark operations	Throughput	Query on-time compliance
2:02:30.422	591 788 249	80 510.79 operations second	95.71%

During the benchmark run, the query execution times shown in the tables below were observed using the different scale factors. Columns (except for Query and Total count) are showing duration values in microseconds (μs) precision. The notation P_i is used for the i^{th} percentile among all observed execution run times of a given query type.

¹The total number of late operations for each run in the results in the attachment is referred to as excessive_delay_count.

Performance Metrics

Table 4.4: Detailed performance benchmark results for scale factor 30 in microseconds

Query	Total count	Min.	Max.	Mean	P ₅₀	P ₉₀	P ₉₅	P ₉₉
Query1	1 780 974	4 357	471 744	8 334.64	7 896	9 743	10 755	19 772
Query10	1 251 496	6 147	407 152	15 028.21	14 410	19 115	21 277	28 875
Query11	2 315 267	242	426 432	717.48	442	623	782	10 658
Query12	1 052 394	1 409	515 968	4 598.28	4 214	6 090	6 993	15 552
Query13	2 437 123	139	401 280	635.38	325	740	856	10 330
Query14	945 007	433	617 408	23 460.38	7 986	19 746	205 216	319 632
Query2	1 251 496	615	459 120	1 910.16	1 577	2 181	2 467	13 325
Query3	436 843	3 559	364 912	7 818.53	7 465	8 729	9 719	19 046
Query4	1 286 259	1 099	406 608	2 452.76	2 024	2 584	2 976	13 773
Query5	643 130	49 352	671 200	167 623.78	163 144	233 168	246 888	270 048
Query6	146 535	300	314 992	1 878.99	1 840	3 125	3 578	12 099
Query7	964 695	150	401 856	599.72	268	447	641	10 599
Query8	5 145 038	500	413 456	1 675.91	1 178	2 462	3 004	12 080
Query9	120 587	50 808	473 984	112 087.96	109 936	135 864	142 400	155 320
ShortQuery1PersonProfile	24 825 117	88	483 952	351.76	125	176	240	6 280
ShortQuery2PersonPosts	24 825 117	99	465 232	507.31	219	418	678	12 019
ShortQuery3PersonFriends	24 825 117	95	447 792	585.35	241	778	1 435	11 894
ShortQuery4MessageContent	24 821 748	80	449 248	371.71	114	159	232	10 183
ShortQuery5MessageCreator	24 821 748	79	464 624	356.05	110	150	205	11 548
ShortQuery6MessageForum	24 821 748	85	526 528	330.40	120	163	207	10 259
ShortQuery7MessageReplies	24 821 748	98	481 616	343.96	155	236	284	6 561
Update1AddPerson	14 143	243	250 984	848.27	394	873	1 193	10 704
Update2AddPostLike	11 307 701	157	448 576	500.63	216	339	665	8 596
Update3AddCommentLike	12 121 088	158	461 232	490.87	215	328	636	8 384
Update4AddForum	253 334	178	289 408	541.23	237	428	748	9 335
Update5AddForumMembership	40 999 247	157	500 576	503.17	216	344	677	8 558
Update6AddPost	3 278 856	177	446 592	502.79	250	500	732	5 512
Update7AddComment	9 457 383	180	504 832	556.15	253	513	791	8 875
Update8AddFriendship	1 008 699	159	313 648	491.36	217	333	651	8 657

Performance Metrics

Table 4.5: Detailed performance benchmark results for scale factor 100 in microseconds

Query	Total count	Min.	Max.	Mean	P ₅₀	P ₉₀	P ₉₅	P ₉₉
Query1	3 472 159	774	1 301 696	24 541.80	23 998	31 446	34 912	43 268
Query10	2 256 903	372	1 194 048	30 987.98	30 444	39 566	42 718	50 280
Query11	4 103 461	192	1 154 304	1 420.09	855	1 296	2 378	11 525
Query12	2 051 731	181	1 067 456	9 176.34	8 594	12 346	14 001	19 934
Query13	4 751 376	180	1 084 736	1 674.27	960	2 315	3 274	11 807
Query14	1 842 371	463	1 147 840	102 182.09	14 383	368 096	423 584	520 320
Query2	2 439 896	160	715 392	3 609.48	3 038	4 362	5 339	13 672
Query3	733 952	14 539	727 840	32 803.06	32 759	38 244	40 824	49 214
Query4	2 507 671	590	1 052 096	4 348.18	3 731	5 146	6 304	14 626
Query5	1 157 387	25 530	1 160 256	401 099.04	405 504	560 064	597 664	667 040
Query6	208 010	366	644 576	4 984.70	4 567	9 639	10 857	16 556
Query7	2 375 688	170	1 047 840	933.45	387	862	1 968	10 636
Query8	18 055 229	112	1 145 792	779.45	274	473	1 323	10 531
Query9	171 302	43 636	991 104	254 343.33	256 760	318 944	338 480	381 600
ShortQuery1PersonProfile	57 897 426	95	1 100 096	570.73	178	282	611	9 847
ShortQuery2PersonPosts	57 897 426	108	802 656	863.00	380	848	1 409	10 826
ShortQuery3PersonFriends	57 897 426	104	770 848	1 107.75	452	1 916	3 300	11 267
ShortQuery4MessageContent	57 897 623	86	1 058 048	609.08	153	280	865	10 428
ShortQuery5MessageCreator	57 897 623	84	1 065 088	533.11	151	239	502	10 124
ShortQuery6MessageForum	57 897 623	91	1 188 224	554.13	172	263	501	10 228
ShortQuery7MessageReplies	57 897 623	102	1 052 096	643.44	241	459	690	10 125
Update1AddPerson	23 128	265	639 808	1 976.43	586	1 768	4 075	12 904
Update2AddPostLike	17 926 496	163	1 137 728	1 019.89	265	815	2 396	12 115
Update3AddCommentLike	24 309 064	168	1 076 288	1 017.40	265	819	2 459	12 154
Update4AddForum	405 346	194	645 312	1 066.64	299	930	2 602	12 326
Update5AddForumMembership	60 452 627	166	1 165 568	1 019.56	264	807	2 323	12 077
Update6AddPost	5 453 465	190	734 048	1 078.77	331	949	2 430	11 893
Update7AddComment	17 096 609	193	1 140 032	1 127.11	332	997	2 808	12 394
Update8AddFriendship	1 894 576	175	708 736	1 022.39	266	820	2 426	12 207

Performance Metrics

Table 4.6: Detailed performance benchmark results for scale factor 300 in microseconds

Query	Total count	Min.	Max.	Mean	P ₅₀	P ₉₀	P ₉₅	P ₉₉
Query1	3 018 969	267	1 273 536	29 015.48	28 855	36 844	39 022	46 410
Query10	1 783 937	292	1 062 784	34 648.49	34 100	45 030	48 654	57 042
Query11	3 270 551	228	1 259 904	1 575.46	1 002	1 432	2 123	11 958
Query12	1 783 937	158	1 027 648	9 345.11	8 776	13 252	15 064	20 966
Query13	4 131 222	335	1 124 096	3 226.11	2 602	4 912	5 842	13 543
Query14	1 601 902	548	1 120 384	140 099.50	20 423	364 256	408 496	508 752
Query2	2 121 438	142	723 648	3 288.32	2 822	3 962	4 576	13 465
Query3	552 769	41 706	791 776	89 971.67	90 748	103 348	109 300	122 332
Query4	2 180 366	177	742 784	4 799.78	4 225	5 506	6 315	15 120
Query5	934 443	221	1 161 152	439 602.19	449 984	596 608	628 224	679 264
Query6	135 333	371	693 728	8 357.76	7 812	17 818	19 420	23 823
Query7	2 452 912	165	713 216	865.44	364	764	1 572	10 715
Query8	26 164 402	110	1 086 208	703.77	246	419	990	10 544
Query9	111 337	143	936 672	284 193.00	288 160	354 608	370 400	403 680
ShortQuery1PersonProfile	63 062 669	95	1 094 464	546.52	172	270	561	9 990
ShortQuery2PersonPosts	63 062 669	103	1 108 800	861.78	383	848	1 381	10 825
ShortQuery3PersonFriends	63 062 669	102	1 099 008	1 146.02	494	1 892	3 375	11 363
ShortQuery4MessageContent	63 067 784	85	1 196 032	575.49	150	274	787	10 670
ShortQuery5MessageCreator	63 067 784	84	1 227 520	504.81	148	231	460	9 927
ShortQuery6MessageForum	63 067 784	88	794 112	533.94	168	254	475	10 185
ShortQuery7MessageReplies	63 067 784	104	897 088	635.23	242	461	675	10 182
Update1AddPerson	17 915	273	679 296	1 636.54	581	1 413	2 945	11 938
Update2AddPostLike	14 085 435	166	1 054 784	971.35	266	766	2 020	13 190
Update3AddCommentLike	23 529 914	170	1 429 568	967.61	266	776	2 114	13 155
Update4AddForum	306 828	192	696 096	1 028.65	301	876	2 144	13 445
Update5AddForumMembership	43 530 106	167	1 035 552	968.87	266	756	1 933	13 184
Update6AddPost	4 067 600	196	778 240	1 078.54	333	927	2 099	13 175
Update7AddComment	12 980 359	188	1 038 336	1 088.07	333	938	2 279	13 401
Update8AddFriendship	1 567 431	173	698 336	964.24	267	763	1 982	13 231

5 VALIDATION OF THE RESULTS

All scale factors from 0.1 to 10 were used for validating the correctness of the implementation over the SUT. The validation data sets were created using the SNB Interactive reference implementation over Neo4j, which can be download from the LDBC GitHub repository¹. All validation runs completed with all queries executed successfully with the expected results. A sample of the driver configuration file used for validation runs is shown in Listing A.18. Additionally, the auditor audited all query implementations, driver and configuration files.

¹https://datasets.ldbcouncil.org/interactive-v1/validation_params-interactive-v1.0.0-sf0.1-to-sf10.tar.zst

6 ACID COMPLIANCE

6.1 Transaction isolation level

The SUT supports the *serializable* isolation level, which is stricter than the *read committed* isolation level minimally required by the SNB Interactive specification.

6.2 SNB Interactive ACID test results

The ACID test implementation was reviewed to conform to the ACID test specifications, with all specified test cases implemented. The test was executed 100 times with a 100% rate of success: no atomicity or isolation tests failed. In particular, the following anomaly tests tested successfully:

- Dirty Writes (G0)
- Aborted Reads (G1A)
- Intermediate Reads (G1B)
- Circular Information Flow (G1C)
- Item-Many-Preceders (IMP)
- Predicate-Many-Preceders (PMP)
- Observed Transaction Vanishes (OTV)
- Fractured Reads (FR)
- Lost Updates (LU)
- Write Skews (WS)

6.3 Recovery and durability

Durability tests were conducted on all three audited scale factors: SF30, SF100 and SF300. After around two hours of execution time, the database process was killed with the `sudo pkill -9 rt_server` command. The following table shows the database restart times after the database server was killed.

Scale factor	Recovery startup time (s)
30	113.02
100	229.18
300	780.19

After killing and recovering from the crash, the driver log was inspected and, for each scale factor, the last 10 update operations were matched with their corresponding update queries from the dataset. Then, using the provided `rt_admin` tool, the presence of the contents on each update query was checked.

Additionally, we used the provided script `test_recovery.sh` which automatically searches for the last query instance of each type, and checks, using `rt_admin` tool, that the contents of the query are materialized in the database.

7 SUPPLEMENTARY MATERIALS

The table below shows the list of supplementary materials. These materials are made available with this full disclosure report to allow reproducibility of results. See the different README files for further instructions.

Table 7.1: Supplementary materials

File	Purpose
graphscope_audit_2025_1	Scripts used during the audit to streamline the benchmark runs
flex_ldbc_snb	Package provided by the SUT vendor. Contains instructions to install the system, tools, scripts, and driver implementation
graphscope_flex_0.31.3_amd64.deb	Binary package with the SUT database
server.tgz	Package with all the logs obtained from the server machine
driver.tgz	Package with all the logs obtained from the driver machine

Acknowledgements

8 ACKNOWLEDGEMENTS

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Appendix

A APPENDIX

A.1 CPU details

Listing A.1: Output of the `lscpu` command for one core

1	Architecture:	x86_64
2	CPU op-mode(s):	32-bit, 64-bit
3	Byte Order:	Little Endian
4	Address sizes:	52 bits physical, 57 bits virtual
5	CPU(s):	192
6	On-line CPU(s) list:	0-191
7	Thread(s) per core:	2
8	Core(s) per socket:	96
9	Socket(s):	1
10	NUMA node(s):	1
11	Vendor ID:	AuthenticAMD
12	CPU family:	25
13	Model:	17
14	Model name:	AMD EPYC 9T24 96-Core Processor
15	Stepping:	1
16	CPU MHz:	3664.462
17	BogoMIPS:	5399.99
18	Hypervisor vendor:	KVM
19	Virtualization type:	full
20	L1d cache:	3 MiB
21	L1i cache:	3 MiB
22	L2 cache:	96 MiB
23	L3 cache:	384 MiB
24	NUMA node0 CPU(s):	0-191
25	Vulnerability Gather data sampling:	Not affected
26	Vulnerability Itlb multihit:	Not affected
27	Vulnerability L1tf:	Not affected
28	Vulnerability Mds:	Not affected
29	Vulnerability Meltdown:	Not affected
30	Vulnerability Mmio stale data:	Not affected
31	Vulnerability Retbleed:	Not affected
32	Vulnerability Spec store bypass:	Vulnerable
33	Vulnerability Spectre v1:	Mitigation; usercopy/swapgs barriers and __user pointer sanitization
34	Vulnerability Spectre v2:	Mitigation; Enhanced / Automatic IBRS; STIBP disabled; RSB filling; PBRSE-
	eIBRS Not affected; BHI Not	
35		affected
36	Vulnerability Srbds:	Not affected
37	Vulnerability Tsx async abort:	Not affected
38	Flags:	fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36
	clflush mmx fxsr sse sse2 ht s	
39		yscall nx mmxext fxsr_opt pdpe1gb rdtscp lm constant_tsc rep_good nopl
	nonstop_tsc cpuid extd_apicid a	
40		perfmperv tsc_known_freq pni pclmulqdq monitor ssse3 fma cx16 pcid sse4_1
	sse4_2 x2apic movbe popcnt a	
41		es xsave avx f16c rdrand hypervisor lahf_lm cmp_legacy cr8_legacy abm sse4a
	misalignsse 3dnowprefetch	
42		osvw topoext perfctr_core perfctr_nb perfctr_llc mwaitx invpcid_single
	ibrs_enhanced vmmcall fsgsbase	
43		tsc_adjust bmi1 avx2 smep bmi2 erms invpcid avx512f avx512dq rdseed adx smap
	avx512ifma clflushopt clw	



44	b avx512cd sha_ni avx512bw avx512vl xsaveopt xsavec xgetbv1 xsaves
	avx512_bf16 clzero irperf xsaveerpt
45	r wbnoinvd arat avx512vbmi umip pku ospke avx512_vbmi2 gfni vaes vpclmulqdq
	avx512_vnni avx512_bitalg
46	avx512_vpopcntdq rdpid arch_capabilities

A.2 Memory details

Listing A.2: Output of the `lshw -c memory` command

```
1  *-memory
2      description: System Memory
3      physical id: 1000
4      size: 768GiB
5      capabilities: ecc
6      configuration: errordetection=multi-bit-ecc
7  *-bank:0
8      description: DIMM RAM
9      vendor: Alibaba Cloud
10     physical id: 0
11     slot: DIMM 0
12     size: 16GiB
13  *-bank:1
14     description: DIMM RAM
15     vendor: Alibaba Cloud
16     physical id: 1
17     slot: DIMM 1
18     size: 16GiB
19  *-bank:2
20     description: DIMM RAM
21     vendor: Alibaba Cloud
22     physical id: 2
23     slot: DIMM 2
24     size: 16GiB
25  *-bank:3
26     description: DIMM RAM
27     vendor: Alibaba Cloud
28     physical id: 3
29     slot: DIMM 3
30     size: 16GiB
31  *-bank:4
32     description: DIMM RAM
33     vendor: Alibaba Cloud
34     physical id: 4
35     slot: DIMM 4
36     size: 16GiB
37  *-bank:5
38     description: DIMM RAM
39     vendor: Alibaba Cloud
40     physical id: 5
41     slot: DIMM 5
42     size: 16GiB
43  *-bank:6
44     description: DIMM RAM
45     vendor: Alibaba Cloud
46     physical id: 6
47     slot: DIMM 6
48     size: 16GiB
49  *-bank:7
50     description: DIMM RAM
51     vendor: Alibaba Cloud
52     physical id: 7
53     slot: DIMM 7
54     size: 16GiB
```



Appendix

A.2. Memory details

```

55      *-bank:8
56          description: DIMM RAM
57          vendor: Alibaba Cloud
58          physical id: 8
59          slot: DIMM 8
60          size: 16GiB
61      *-bank:9
62          description: DIMM RAM
63          vendor: Alibaba Cloud
64          physical id: 9
65          slot: DIMM 9
66          size: 16GiB
67      *-bank:10
68          description: DIMM RAM
69          vendor: Alibaba Cloud
70          physical id: a
71          slot: DIMM 10
72          size: 16GiB
73      *-bank:11
74          description: DIMM RAM
75          vendor: Alibaba Cloud
76          physical id: b
77          slot: DIMM 11
78          size: 16GiB
79      *-bank:12
80          description: DIMM RAM
81          vendor: Alibaba Cloud
82          physical id: c
83          slot: DIMM 12
84          size: 16GiB
85      *-bank:13
86          description: DIMM RAM
87          vendor: Alibaba Cloud
88          physical id: d
89          slot: DIMM 13
90          size: 16GiB
91      *-bank:14
92          description: DIMM RAM
93          vendor: Alibaba Cloud
94          physical id: e
95          slot: DIMM 14
96          size: 16GiB
97      *-bank:15
98          description: DIMM RAM
99          vendor: Alibaba Cloud
100         physical id: f
101         slot: DIMM 15
102         size: 16GiB
103      *-bank:16
104         description: DIMM RAM
105         vendor: Alibaba Cloud
106         physical id: 10
107         slot: DIMM 16
108         size: 16GiB
109      *-bank:17
110         description: DIMM RAM
111         vendor: Alibaba Cloud
112         physical id: 11

```



Appendix

A.2. Memory details

```

113         slot: DIMM 17
114         size: 16GiB
115     *--bank:18
116         description: DIMM RAM
117         vendor: Alibaba Cloud
118         physical id: 12
119         slot: DIMM 18
120         size: 16GiB
121     *--bank:19
122         description: DIMM RAM
123         vendor: Alibaba Cloud
124         physical id: 13
125         slot: DIMM 19
126         size: 16GiB
127     *--bank:20
128         description: DIMM RAM
129         vendor: Alibaba Cloud
130         physical id: 14
131         slot: DIMM 20
132         size: 16GiB
133     *--bank:21
134         description: DIMM RAM
135         vendor: Alibaba Cloud
136         physical id: 15
137         slot: DIMM 21
138         size: 16GiB
139     *--bank:22
140         description: DIMM RAM
141         vendor: Alibaba Cloud
142         physical id: 16
143         slot: DIMM 22
144         size: 16GiB
145     *--bank:23
146         description: DIMM RAM
147         vendor: Alibaba Cloud
148         physical id: 17
149         slot: DIMM 23
150         size: 16GiB
151     *--bank:24
152         description: DIMM RAM
153         vendor: Alibaba Cloud
154         physical id: 18
155         slot: DIMM 24
156         size: 16GiB
157     *--bank:25
158         description: DIMM RAM
159         vendor: Alibaba Cloud
160         physical id: 19
161         slot: DIMM 25
162         size: 16GiB
163     *--bank:26
164         description: DIMM RAM
165         vendor: Alibaba Cloud
166         physical id: 1a
167         slot: DIMM 26
168         size: 16GiB
169     *--bank:27
170         description: DIMM RAM

```



Appendix

A.2. Memory details

```

171         vendor: Alibaba Cloud
172         physical id: 1b
173         slot: DIMM 27
174         size: 16GiB
175     *-bank:28
176         description: DIMM RAM
177         vendor: Alibaba Cloud
178         physical id: 1c
179         slot: DIMM 28
180         size: 16GiB
181     *-bank:29
182         description: DIMM RAM
183         vendor: Alibaba Cloud
184         physical id: 1d
185         slot: DIMM 29
186         size: 16GiB
187     *-bank:30
188         description: DIMM RAM
189         vendor: Alibaba Cloud
190         physical id: 1e
191         slot: DIMM 30
192         size: 16GiB
193     *-bank:31
194         description: DIMM RAM
195         vendor: Alibaba Cloud
196         physical id: 1f
197         slot: DIMM 31
198         size: 16GiB
199     *-bank:32
200         description: DIMM RAM
201         vendor: Alibaba Cloud
202         physical id: 20
203         slot: DIMM 32
204         size: 16GiB
205     *-bank:33
206         description: DIMM RAM
207         vendor: Alibaba Cloud
208         physical id: 21
209         slot: DIMM 33
210         size: 16GiB
211     *-bank:34
212         description: DIMM RAM
213         vendor: Alibaba Cloud
214         physical id: 22
215         slot: DIMM 34
216         size: 16GiB
217     *-bank:35
218         description: DIMM RAM
219         vendor: Alibaba Cloud
220         physical id: 23
221         slot: DIMM 35
222         size: 16GiB
223     *-bank:36
224         description: DIMM RAM
225         vendor: Alibaba Cloud
226         physical id: 24
227         slot: DIMM 36
228         size: 16GiB

```



Appendix

A.2. Memory details

```

229      *-bank:37
230          description: DIMM RAM
231          vendor: Alibaba Cloud
232          physical id: 25
233          slot: DIMM 37
234          size: 16GiB
235      *-bank:38
236          description: DIMM RAM
237          vendor: Alibaba Cloud
238          physical id: 26
239          slot: DIMM 38
240          size: 16GiB
241      *-bank:39
242          description: DIMM RAM
243          vendor: Alibaba Cloud
244          physical id: 27
245          slot: DIMM 39
246          size: 16GiB
247      *-bank:40
248          description: DIMM RAM
249          vendor: Alibaba Cloud
250          physical id: 28
251          slot: DIMM 40
252          size: 16GiB
253      *-bank:41
254          description: DIMM RAM
255          vendor: Alibaba Cloud
256          physical id: 29
257          slot: DIMM 41
258          size: 16GiB
259      *-bank:42
260          description: DIMM RAM
261          vendor: Alibaba Cloud
262          physical id: 2a
263          slot: DIMM 42
264          size: 16GiB
265      *-bank:43
266          description: DIMM RAM
267          vendor: Alibaba Cloud
268          physical id: 2b
269          slot: DIMM 43
270          size: 16GiB
271      *-bank:44
272          description: DIMM RAM
273          vendor: Alibaba Cloud
274          physical id: 2c
275          slot: DIMM 44
276          size: 16GiB
277      *-bank:45
278          description: DIMM RAM
279          vendor: Alibaba Cloud
280          physical id: 2d
281          slot: DIMM 45
282          size: 16GiB
283      *-bank:46
284          description: DIMM RAM
285          vendor: Alibaba Cloud
286          physical id: 2e

```



287	slot: DIMM 46
288	size: 16GiB
289	*-bank:47
290	description: DIMM RAM
291	vendor: Alibaba Cloud
292	physical id: 2f
293	slot: DIMM 47
294	size: 16GiB
295	*-firmware
296	description: BIOS
297	vendor: Alibaba Cloud ECS
298	physical id: 0
299	version: 1.0.0
300	date: 01/01/2017
301	size: 96KiB
302	capabilities: uefi virtualmachine



Listing A.3: Output of the sysbench memory read command

```
1 sysbench memory --memory-lock-size=1G --memory-total-size=16384G --memory-oper=read --threads=92 run
2 sysbench 1.0.18 (using system LuaJIT 2.1.0-beta3)
3
4 Running the test with following options:
5 Number of threads: 92
6 Initializing random number generator from current time
7
8
9 Running memory speed test with the following options:
10   block size: 1048576KiB
11   total size: 16777216MiB
12   operation: read
13   scope: global
14
15 Initializing worker threads...
16
17 Threads started!
18
19 Total operations: 13547 ( 1347.60 per second)
20
21 13872128.00 MiB transferred (1379946.65 MiB/sec)
22
23
24 General statistics:
25   total time:                10.0521s
26   total number of events:    13547
27
28 Latency (ms):
29   min:                        49.14
30   avg:                        68.08
31   max:                        264.88
32   95th percentile:          102.97
33   sum:                        922303.55
34
35 Threads fairness:
36   events (avg/stddev):       147.2500/18.42
37   execution time (avg/stddev): 10.0250/0.02b
```



Listing A.4: Output of the sysbench memory write command

```
1 sysbench memory --memory-lock-size=1G --memory-total-size=16384G --memory-oper=write --threads=92 run
2 sysbench 1.0.18 (using system LuaJIT 2.1.0-beta3)
3
4 Running the test with following options:
5 Number of threads: 92
6 Initializing random number generator from current time
7
8
9 Running memory speed test with the following options:
10   block size: 1048576KiB
11   total size: 16777216MiB
12   operation: write
13   scope: global
14
15 Initializing worker threads...
16
17 Threads started!
18
19 Total operations: 3100 ( 305.29 per second)
20
21 3174400.00 MiB transferred (312619.18 MiB/sec)
22
23
24 General statistics:
25     total time:                10.1536s
26     total number of events:    3100
27
28 Latency (ms):
29     min:                      101.88
30     avg:                      299.87
31     max:                      506.44
32     95th percentile:         369.77
33     sum:                      929601.52
34
35 Threads fairness:
36     events (avg/stddev):      33.6957/1.21
37     execution time (avg/stddev): 10.1044/0.04b
```



A.3 Disk details

Listing A.5: Output of the lsblk and parted -l command

```
1 lsblk
2 NAME      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
3 nvme0n1    259:0    0   40G  0 disk
4  -nvme0n1p1 259:1    0    1M  0 part
5  -nvme0n1p2 259:2    0  191M  0 part /boot/efi
6  -nvme0n1p3 259:3    0  39.8G  0 part /
7 nvme1n1    259:4    0   4T   0 disk /data
8
9 -----
10 sudo parted -l
11 Model: Alibaba Cloud Elastic Block Storage (nvme)
12 Disk /dev/nvme0n1: 42.9GB
13 Sector size (logical/physical): 512B/512B
14 Partition Table: gpt
15 Disk Flags:
16
17 Number  Start   End     Size    File system  Name  Flags
18  1       1049kB  2097kB  1049kB              bios_grub
19  2       2097kB  202MB   200MB    fat32         boot, esp
20  3       202MB   42.9GB  42.7GB   ext4
21
22
23 Model: Alibaba Cloud Elastic Block Storage (nvme)
24 Disk /dev/nvme1n1: 4398GB
25 Sector size (logical/physical): 512B/512B
26 Partition Table: loop
27 Disk Flags:
28
29 Number  Start  End      Size    File system  Flags
30  1       0.00B  4398GB  4398GB   xfs
```

A.4 Network details

Listing A.6: Output of the `lshw -class network` command

```

1 lshw -class network
2 *-network
3     description: Ethernet controller
4     product: Virtio network device
5     vendor: Red Hat, Inc.
6     physical id: 5
7     bus info: pci@0000:00:05.0
8     version: 00
9     width: 64 bits
10    clock: 33MHz
11    capabilities: msix bus_master cap_list
12    configuration: driver=virtio-pci latency=0
13    resources: irq:0 memory:cc402000-cc402fff memory:cc408000-cc40bfff
14 *-virtio1
15     description: Ethernet interface
16     physical id: 0
17     bus info: virtio@1
18     logical name: eth0
19     serial: 00:16:3e:07:ae:29
20     capabilities: ethernet physical
21     configuration: autonegotiation=off broadcast=yes driver=virtio_net driverversion=1.0.0 ip=172.24.253.93
        link=yes multicast=yes

```

A.5 Network performance

Some of the output has been omitted for brevity. First sum is from client to server, second sum from server to client.

Listing A.7: Output of the `iperf` command

```

1 -----
2 Client connecting to 172.24.253.92, TCP port 10000
3 TCP window size: 289 KByte (default)
4 -----
5 [ 66] local 172.24.253.93 port 47566 connected with 172.24.253.92 port 10000
6 [ 61] local 172.24.253.93 port 47512 connected with 172.24.253.92 port 10000
7 [ 64] local 172.24.253.93 port 47556 connected with 172.24.253.92 port 10000
8 [ 56] local 172.24.253.93 port 47476 connected with 172.24.253.92 port 10000
9 [  6] local 172.24.253.93 port 47034 connected with 172.24.253.92 port 10000
10 [ 65] local 172.24.253.93 port 47544 connected with 172.24.253.92 port 10000
11 [ 62] local 172.24.253.93 port 47536 connected with 172.24.253.92 port 10000
12 [ 58] local 172.24.253.93 port 47488 connected with 172.24.253.92 port 10000
13 [  3] local 172.24.253.93 port 47002 connected with 172.24.253.92 port 10000
14 [  9] local 172.24.253.93 port 47046 connected with 172.24.253.92 port 10000
15 [  7] local 172.24.253.93 port 47054 connected with 172.24.253.92 port 10000
16 [  5] local 172.24.253.93 port 47028 connected with 172.24.253.92 port 10000
17 [ 12] local 172.24.253.93 port 47074 connected with 172.24.253.92 port 10000
18 [ 10] local 172.24.253.93 port 47086 connected with 172.24.253.92 port 10000
19 [  4] local 172.24.253.93 port 47016 connected with 172.24.253.92 port 10000
20 [ 16] local 172.24.253.93 port 47082 connected with 172.24.253.92 port 10000
21 [ 11] local 172.24.253.93 port 47064 connected with 172.24.253.92 port 10000
22 [  8] local 172.24.253.93 port 47042 connected with 172.24.253.92 port 10000
23 [ 14] local 172.24.253.93 port 47102 connected with 172.24.253.92 port 10000

```



24	[15]	local	172.24.253.93	port	47122	connected with	172.24.253.92	port	10000
25	[17]	local	172.24.253.93	port	47134	connected with	172.24.253.92	port	10000
26	[19]	local	172.24.253.93	port	47142	connected with	172.24.253.92	port	10000
27	[22]	local	172.24.253.93	port	47176	connected with	172.24.253.92	port	10000
28	[18]	local	172.24.253.93	port	47148	connected with	172.24.253.92	port	10000
29	[20]	local	172.24.253.93	port	47154	connected with	172.24.253.92	port	10000
30	[21]	local	172.24.253.93	port	47166	connected with	172.24.253.92	port	10000
31	[24]	local	172.24.253.93	port	47198	connected with	172.24.253.92	port	10000
32	[26]	local	172.24.253.93	port	47216	connected with	172.24.253.92	port	10000
33	[23]	local	172.24.253.93	port	47202	connected with	172.24.253.92	port	10000
34	[27]	local	172.24.253.93	port	47222	connected with	172.24.253.92	port	10000
35	[29]	local	172.24.253.93	port	47228	connected with	172.24.253.92	port	10000
36	[28]	local	172.24.253.93	port	47236	connected with	172.24.253.92	port	10000
37	[30]	local	172.24.253.93	port	47242	connected with	172.24.253.92	port	10000
38	[31]	local	172.24.253.93	port	47244	connected with	172.24.253.92	port	10000
39	[32]	local	172.24.253.93	port	47258	connected with	172.24.253.92	port	10000
40	[33]	local	172.24.253.93	port	47262	connected with	172.24.253.92	port	10000
41	[34]	local	172.24.253.93	port	47278	connected with	172.24.253.92	port	10000
42	[35]	local	172.24.253.93	port	47292	connected with	172.24.253.92	port	10000
43	[37]	local	172.24.253.93	port	47302	connected with	172.24.253.92	port	10000
44	[38]	local	172.24.253.93	port	47330	connected with	172.24.253.92	port	10000
45	[40]	local	172.24.253.93	port	47332	connected with	172.24.253.92	port	10000
46	[36]	local	172.24.253.93	port	47314	connected with	172.24.253.92	port	10000
47	[39]	local	172.24.253.93	port	47334	connected with	172.24.253.92	port	10000
48	[42]	local	172.24.253.93	port	47346	connected with	172.24.253.92	port	10000
49	[43]	local	172.24.253.93	port	47348	connected with	172.24.253.92	port	10000
50	[45]	local	172.24.253.93	port	47364	connected with	172.24.253.92	port	10000
51	[41]	local	172.24.253.93	port	47366	connected with	172.24.253.92	port	10000
52	[44]	local	172.24.253.93	port	47374	connected with	172.24.253.92	port	10000
53	[48]	local	172.24.253.93	port	47388	connected with	172.24.253.92	port	10000
54	[46]	local	172.24.253.93	port	47386	connected with	172.24.253.92	port	10000
55	[49]	local	172.24.253.93	port	47396	connected with	172.24.253.92	port	10000
56	[47]	local	172.24.253.93	port	47412	connected with	172.24.253.92	port	10000
57	[50]	local	172.24.253.93	port	47420	connected with	172.24.253.92	port	10000
58	[51]	local	172.24.253.93	port	47428	connected with	172.24.253.92	port	10000
59	[52]	local	172.24.253.93	port	47424	connected with	172.24.253.92	port	10000
60	[53]	local	172.24.253.93	port	47438	connected with	172.24.253.92	port	10000
61	[57]	local	172.24.253.93	port	47452	connected with	172.24.253.92	port	10000
62	[60]	local	172.24.253.93	port	47504	connected with	172.24.253.92	port	10000
63	[55]	local	172.24.253.93	port	47462	connected with	172.24.253.92	port	10000
64	[63]	local	172.24.253.93	port	47528	connected with	172.24.253.92	port	10000
65	[59]	local	172.24.253.93	port	47498	connected with	172.24.253.92	port	10000
66	[54]	local	172.24.253.93	port	47448	connected with	172.24.253.92	port	10000
67	[13]	local	172.24.253.93	port	47116	connected with	172.24.253.92	port	10000
68	[25]	local	172.24.253.93	port	47188	connected with	172.24.253.92	port	10000
69	[ID]	Interval	Transfer	Bandwidth					
70	[61]	0.0- 5.0 sec	500 MBytes	840 Mbits/sec					
71	[56]	0.0- 5.0 sec	701 MBytes	1.18 Gbits/sec					
72	[6]	0.0- 5.0 sec	568 MBytes	954 Mbits/sec					
73	[62]	0.0- 5.0 sec	566 MBytes	949 Mbits/sec					
74	[3]	0.0- 5.0 sec	709 MBytes	1.19 Gbits/sec					
75	[10]	0.0- 5.0 sec	807 MBytes	1.35 Gbits/sec					
76	[14]	0.0- 5.0 sec	621 MBytes	1.04 Gbits/sec					
77	[15]	0.0- 5.0 sec	540 MBytes	906 Mbits/sec					
78	[19]	0.0- 5.0 sec	587 MBytes	984 Mbits/sec					
79	[21]	0.0- 5.0 sec	687 MBytes	1.15 Gbits/sec					
80	[26]	0.0- 5.0 sec	561 MBytes	941 Mbits/sec					
81	[29]	0.0- 5.0 sec	574 MBytes	963 Mbits/sec					



Appendix

A.5. Network performance

82	[28]	0.0- 5.0 sec	817 MBytes	1.37 Gbits/sec
83	[30]	0.0- 5.0 sec	490 MBytes	823 Mbits/sec
84	[31]	0.0- 5.0 sec	574 MBytes	962 Mbits/sec
85	[33]	0.0- 5.0 sec	402 MBytes	674 Mbits/sec
86	[35]	0.0- 5.0 sec	820 MBytes	1.38 Gbits/sec
87	[38]	0.0- 5.0 sec	661 MBytes	1.11 Gbits/sec
88	[40]	0.0- 5.0 sec	430 MBytes	722 Mbits/sec
89	[36]	0.0- 5.0 sec	557 MBytes	935 Mbits/sec
90	[39]	0.0- 5.0 sec	709 MBytes	1.19 Gbits/sec
91	[42]	0.0- 5.0 sec	460 MBytes	772 Mbits/sec
92	[43]	0.0- 5.0 sec	754 MBytes	1.27 Gbits/sec
93	[45]	0.0- 5.0 sec	570 MBytes	956 Mbits/sec
94	[51]	0.0- 5.0 sec	433 MBytes	727 Mbits/sec
95	[53]	0.0- 5.0 sec	560 MBytes	940 Mbits/sec
96	[57]	0.0- 5.0 sec	830 MBytes	1.39 Gbits/sec
97	[13]	0.0- 5.0 sec	594 MBytes	996 Mbits/sec
98	[25]	0.0- 5.0 sec	577 MBytes	968 Mbits/sec
99	[58]	0.0- 5.0 sec	802 MBytes	1.35 Gbits/sec
100	[12]	0.0- 5.0 sec	581 MBytes	975 Mbits/sec
101	[41]	0.0- 5.0 sec	382 MBytes	641 Mbits/sec
102	[52]	0.0- 5.0 sec	625 MBytes	1.05 Gbits/sec
103	[54]	0.0- 5.0 sec	785 MBytes	1.32 Gbits/sec
104	[65]	0.0- 5.0 sec	843 MBytes	1.41 Gbits/sec
105	[32]	0.0- 5.0 sec	312 MBytes	524 Mbits/sec
106	[37]	0.0- 5.0 sec	613 MBytes	1.03 Gbits/sec
107	[24]	0.0- 5.0 sec	470 MBytes	789 Mbits/sec
108	[34]	0.0- 5.0 sec	562 MBytes	943 Mbits/sec
109	[46]	0.0- 5.0 sec	428 MBytes	717 Mbits/sec
110	[50]	0.0- 5.0 sec	609 MBytes	1.02 Gbits/sec
111	[55]	0.0- 5.0 sec	471 MBytes	790 Mbits/sec
112	[66]	0.0- 5.0 sec	660 MBytes	1.11 Gbits/sec
113	[63]	0.0- 5.0 sec	566 MBytes	949 Mbits/sec
114	[7]	0.0- 5.0 sec	688 MBytes	1.15 Gbits/sec
115	[16]	0.0- 5.0 sec	471 MBytes	790 Mbits/sec
116	[44]	0.0- 5.0 sec	414 MBytes	695 Mbits/sec
117	[49]	0.0- 5.0 sec	697 MBytes	1.17 Gbits/sec
118	[59]	0.0- 5.0 sec	452 MBytes	759 Mbits/sec
119	[64]	0.0- 5.0 sec	730 MBytes	1.22 Gbits/sec
120	[9]	0.0- 5.0 sec	715 MBytes	1.20 Gbits/sec
121	[8]	0.0- 5.0 sec	588 MBytes	986 Mbits/sec
122	[48]	0.0- 5.0 sec	492 MBytes	825 Mbits/sec
123	[20]	0.0- 5.0 sec	496 MBytes	833 Mbits/sec
124	[23]	0.0- 5.0 sec	583 MBytes	978 Mbits/sec
125	[11]	0.0- 5.0 sec	583 MBytes	979 Mbits/sec
126	[27]	0.0- 5.0 sec	732 MBytes	1.23 Gbits/sec
127	[47]	0.0- 5.0 sec	657 MBytes	1.10 Gbits/sec
128	[5]	0.0- 5.0 sec	707 MBytes	1.19 Gbits/sec
129	[4]	0.0- 5.0 sec	679 MBytes	1.14 Gbits/sec
130	[22]	0.0- 5.0 sec	642 MBytes	1.08 Gbits/sec
131	[60]	0.0- 5.0 sec	635 MBytes	1.07 Gbits/sec
132	[17]	0.0- 5.0 sec	1.01 GBytes	1.73 Gbits/sec
133	[18]	0.0- 5.0 sec	730 MBytes	1.22 Gbits/sec
134	[SUM]	0.0- 5.0 sec	38.2 GBytes	65.6 Gbits/sec
135	[56]	5.0-10.0 sec	405 MBytes	680 Mbits/sec
136	[6]	5.0-10.0 sec	624 MBytes	1.05 Gbits/sec
137	[65]	5.0-10.0 sec	820 MBytes	1.38 Gbits/sec
138	[58]	5.0-10.0 sec	840 MBytes	1.41 Gbits/sec
139	[3]	5.0-10.0 sec	698 MBytes	1.17 Gbits/sec



140	[9]	5.0-10.0 sec	790 MBytes	1.33 Gbits/sec
141	[7]	5.0-10.0 sec	440 MBytes	738 Mbits/sec
142	[12]	5.0-10.0 sec	594 MBytes	996 Mbits/sec
143	[10]	5.0-10.0 sec	769 MBytes	1.29 Gbits/sec
144	[16]	5.0-10.0 sec	811 MBytes	1.36 Gbits/sec
145	[11]	5.0-10.0 sec	515 MBytes	864 Mbits/sec
146	[19]	5.0-10.0 sec	498 MBytes	835 Mbits/sec
147	[21]	5.0-10.0 sec	680 MBytes	1.14 Gbits/sec
148	[23]	5.0-10.0 sec	472 MBytes	791 Mbits/sec
149	[27]	5.0-10.0 sec	656 MBytes	1.10 Gbits/sec
150	[31]	5.0-10.0 sec	743 MBytes	1.25 Gbits/sec
151	[32]	5.0-10.0 sec	330 MBytes	554 Mbits/sec
152	[33]	5.0-10.0 sec	908 MBytes	1.52 Gbits/sec
153	[34]	5.0-10.0 sec	500 MBytes	839 Mbits/sec
154	[35]	5.0-10.0 sec	630 MBytes	1.06 Gbits/sec
155	[38]	5.0-10.0 sec	958 MBytes	1.61 Gbits/sec
156	[36]	5.0-10.0 sec	600 MBytes	1.01 Gbits/sec
157	[41]	5.0-10.0 sec	516 MBytes	865 Mbits/sec
158	[48]	5.0-10.0 sec	455 MBytes	763 Mbits/sec
159	[49]	5.0-10.0 sec	640 MBytes	1.07 Gbits/sec
160	[50]	5.0-10.0 sec	439 MBytes	736 Mbits/sec
161	[52]	5.0-10.0 sec	728 MBytes	1.22 Gbits/sec
162	[57]	5.0-10.0 sec	577 MBytes	968 Mbits/sec
163	[55]	5.0-10.0 sec	494 MBytes	829 Mbits/sec
164	[63]	5.0-10.0 sec	489 MBytes	821 Mbits/sec
165	[54]	5.0-10.0 sec	719 MBytes	1.21 Gbits/sec
166	[13]	5.0-10.0 sec	524 MBytes	879 Mbits/sec
167	[24]	5.0-10.0 sec	485 MBytes	813 Mbits/sec
168	[45]	5.0-10.0 sec	669 MBytes	1.12 Gbits/sec
169	[44]	5.0-10.0 sec	434 MBytes	727 Mbits/sec
170	[8]	5.0-10.0 sec	492 MBytes	826 Mbits/sec
171	[28]	5.0-10.0 sec	705 MBytes	1.18 Gbits/sec
172	[53]	5.0-10.0 sec	338 MBytes	568 Mbits/sec
173	[66]	5.0-10.0 sec	472 MBytes	793 Mbits/sec
174	[64]	5.0-10.0 sec	910 MBytes	1.53 Gbits/sec
175	[22]	5.0-10.0 sec	475 MBytes	796 Mbits/sec
176	[29]	5.0-10.0 sec	588 MBytes	986 Mbits/sec
177	[40]	5.0-10.0 sec	595 MBytes	998 Mbits/sec
178	[42]	5.0-10.0 sec	506 MBytes	848 Mbits/sec
179	[60]	5.0-10.0 sec	433 MBytes	727 Mbits/sec
180	[61]	5.0-10.0 sec	675 MBytes	1.13 Gbits/sec
181	[25]	5.0-10.0 sec	823 MBytes	1.38 Gbits/sec
182	[4]	5.0-10.0 sec	630 MBytes	1.06 Gbits/sec
183	[18]	5.0-10.0 sec	679 MBytes	1.14 Gbits/sec
184	[26]	5.0-10.0 sec	801 MBytes	1.34 Gbits/sec
185	[43]	5.0-10.0 sec	601 MBytes	1.01 Gbits/sec
186	[17]	5.0-10.0 sec	713 MBytes	1.20 Gbits/sec
187	[14]	5.0-10.0 sec	540 MBytes	905 Mbits/sec
188	[15]	5.0-10.0 sec	554 MBytes	929 Mbits/sec
189	[37]	5.0-10.0 sec	660 MBytes	1.11 Gbits/sec
190	[47]	5.0-10.0 sec	579 MBytes	971 Mbits/sec
191	[51]	5.0-10.0 sec	477 MBytes	800 Mbits/sec
192	[30]	5.0-10.0 sec	408 MBytes	685 Mbits/sec
193	[39]	5.0-10.0 sec	586 MBytes	983 Mbits/sec
194	[5]	5.0-10.0 sec	753 MBytes	1.26 Gbits/sec
195	[20]	5.0-10.0 sec	547 MBytes	918 Mbits/sec
196	[62]	5.0-10.0 sec	453 MBytes	759 Mbits/sec
197	[46]	5.0-10.0 sec	321 MBytes	539 Mbits/sec



198	[59]	5.0-10.0 sec	493 MBytes	827 Mb/s
199	[SUM]	5.0-10.0 sec	37.4 GBytes	64.2 Gb/s
200	[61]	10.0-15.0 sec	513 MBytes	860 Mb/s
201	[64]	10.0-15.0 sec	825 MBytes	1.38 Gb/s
202	[56]	10.0-15.0 sec	545 MBytes	915 Mb/s
203	[6]	10.0-15.0 sec	812 MBytes	1.36 Gb/s
204	[65]	10.0-15.0 sec	782 MBytes	1.31 Gb/s
205	[62]	10.0-15.0 sec	667 MBytes	1.12 Gb/s
206	[9]	10.0-15.0 sec	809 MBytes	1.36 Gb/s
207	[7]	10.0-15.0 sec	566 MBytes	950 Mb/s
208	[16]	10.0-15.0 sec	704 MBytes	1.18 Gb/s
209	[11]	10.0-15.0 sec	770 MBytes	1.29 Gb/s
210	[8]	10.0-15.0 sec	401 MBytes	672 Mb/s
211	[18]	10.0-15.0 sec	452 MBytes	759 Mb/s
212	[20]	10.0-15.0 sec	462 MBytes	774 Mb/s
213	[21]	10.0-15.0 sec	713 MBytes	1.20 Gb/s
214	[23]	10.0-15.0 sec	410 MBytes	687 Mb/s
215	[27]	10.0-15.0 sec	767 MBytes	1.29 Gb/s
216	[29]	10.0-15.0 sec	640 MBytes	1.07 Gb/s
217	[28]	10.0-15.0 sec	840 MBytes	1.41 Gb/s
218	[33]	10.0-15.0 sec	566 MBytes	950 Mb/s
219	[34]	10.0-15.0 sec	439 MBytes	736 Mb/s
220	[42]	10.0-15.0 sec	522 MBytes	876 Mb/s
221	[45]	10.0-15.0 sec	613 MBytes	1.03 Gb/s
222	[41]	10.0-15.0 sec	649 MBytes	1.09 Gb/s
223	[49]	10.0-15.0 sec	699 MBytes	1.17 Gb/s
224	[47]	10.0-15.0 sec	498 MBytes	835 Mb/s
225	[52]	10.0-15.0 sec	678 MBytes	1.14 Gb/s
226	[55]	10.0-15.0 sec	371 MBytes	622 Mb/s
227	[54]	10.0-15.0 sec	661 MBytes	1.11 Gb/s
228	[13]	10.0-15.0 sec	572 MBytes	960 Mb/s
229	[25]	10.0-15.0 sec	638 MBytes	1.07 Gb/s
230	[24]	10.0-15.0 sec	431 MBytes	724 Mb/s
231	[30]	10.0-15.0 sec	263 MBytes	442 Mb/s
232	[35]	10.0-15.0 sec	736 MBytes	1.23 Gb/s
233	[40]	10.0-15.0 sec	652 MBytes	1.09 Gb/s
234	[51]	10.0-15.0 sec	385 MBytes	645 Mb/s
235	[66]	10.0-15.0 sec	590 MBytes	990 Mb/s
236	[58]	10.0-15.0 sec	736 MBytes	1.24 Gb/s
237	[22]	10.0-15.0 sec	540 MBytes	906 Mb/s
238	[38]	10.0-15.0 sec	566 MBytes	950 Mb/s
239	[44]	10.0-15.0 sec	488 MBytes	818 Mb/s
240	[4]	10.0-15.0 sec	624 MBytes	1.05 Gb/s
241	[10]	10.0-15.0 sec	655 MBytes	1.10 Gb/s
242	[39]	10.0-15.0 sec	608 MBytes	1.02 Gb/s
243	[48]	10.0-15.0 sec	631 MBytes	1.06 Gb/s
244	[50]	10.0-15.0 sec	429 MBytes	720 Mb/s
245	[5]	10.0-15.0 sec	459 MBytes	770 Mb/s
246	[59]	10.0-15.0 sec	572 MBytes	960 Mb/s
247	[12]	10.0-15.0 sec	691 MBytes	1.16 Gb/s
248	[37]	10.0-15.0 sec	589 MBytes	988 Mb/s
249	[46]	10.0-15.0 sec	607 MBytes	1.02 Gb/s
250	[53]	10.0-15.0 sec	410 MBytes	688 Mb/s
251	[3]	10.0-15.0 sec	545 MBytes	914 Mb/s
252	[14]	10.0-15.0 sec	559 MBytes	938 Mb/s
253	[19]	10.0-15.0 sec	534 MBytes	895 Mb/s
254	[31]	10.0-15.0 sec	636 MBytes	1.07 Gb/s
255	[57]	10.0-15.0 sec	751 MBytes	1.26 Gb/s



256	[17]	10.0-15.0 sec	906 MBytes	1.52 Gbits/sec
257	[26]	10.0-15.0 sec	703 MBytes	1.18 Gbits/sec
258	[32]	10.0-15.0 sec	596 MBytes	1.00 Gbits/sec
259	[36]	10.0-15.0 sec	524 MBytes	878 Mbits/sec
260	[15]	10.0-15.0 sec	372 MBytes	625 Mbits/sec
261	[43]	10.0-15.0 sec	584 MBytes	980 Mbits/sec
262	[60]	10.0-15.0 sec	614 MBytes	1.03 Gbits/sec
263	[63]	10.0-15.0 sec	677 MBytes	1.14 Gbits/sec
264	[SUM]	10.0-15.0 sec	37.3 GBytes	64.2 Gbits/sec
265	[66]	15.0-20.0 sec	503 MBytes	844 Mbits/sec
266	[61]	15.0-20.0 sec	579 MBytes	972 Mbits/sec
267	[64]	15.0-20.0 sec	692 MBytes	1.16 Gbits/sec
268	[62]	15.0-20.0 sec	769 MBytes	1.29 Gbits/sec
269	[58]	15.0-20.0 sec	822 MBytes	1.38 Gbits/sec
270	[7]	15.0-20.0 sec	685 MBytes	1.15 Gbits/sec
271	[12]	15.0-20.0 sec	659 MBytes	1.10 Gbits/sec
272	[10]	15.0-20.0 sec	693 MBytes	1.16 Gbits/sec
273	[16]	15.0-20.0 sec	710 MBytes	1.19 Gbits/sec
274	[11]	15.0-20.0 sec	710 MBytes	1.19 Gbits/sec
275	[14]	15.0-20.0 sec	559 MBytes	938 Mbits/sec
276	[15]	15.0-20.0 sec	608 MBytes	1.02 Gbits/sec
277	[22]	15.0-20.0 sec	534 MBytes	896 Mbits/sec
278	[20]	15.0-20.0 sec	676 MBytes	1.13 Gbits/sec
279	[26]	15.0-20.0 sec	449 MBytes	754 Mbits/sec
280	[29]	15.0-20.0 sec	598 MBytes	1.00 Gbits/sec
281	[33]	15.0-20.0 sec	532 MBytes	892 Mbits/sec
282	[40]	15.0-20.0 sec	726 MBytes	1.22 Gbits/sec
283	[39]	15.0-20.0 sec	608 MBytes	1.02 Gbits/sec
284	[43]	15.0-20.0 sec	653 MBytes	1.10 Gbits/sec
285	[45]	15.0-20.0 sec	784 MBytes	1.32 Gbits/sec
286	[41]	15.0-20.0 sec	470 MBytes	788 Mbits/sec
287	[44]	15.0-20.0 sec	487 MBytes	817 Mbits/sec
288	[49]	15.0-20.0 sec	747 MBytes	1.25 Gbits/sec
289	[47]	15.0-20.0 sec	633 MBytes	1.06 Gbits/sec
290	[52]	15.0-20.0 sec	777 MBytes	1.30 Gbits/sec
291	[54]	15.0-20.0 sec	471 MBytes	790 Mbits/sec
292	[13]	15.0-20.0 sec	800 MBytes	1.34 Gbits/sec
293	[25]	15.0-20.0 sec	596 MBytes	1000 Mbits/sec
294	[46]	15.0-20.0 sec	542 MBytes	910 Mbits/sec
295	[50]	15.0-20.0 sec	451 MBytes	756 Mbits/sec
296	[65]	15.0-20.0 sec	836 MBytes	1.40 Gbits/sec
297	[8]	15.0-20.0 sec	516 MBytes	866 Mbits/sec
298	[18]	15.0-20.0 sec	566 MBytes	950 Mbits/sec
299	[24]	15.0-20.0 sec	354 MBytes	595 Mbits/sec
300	[42]	15.0-20.0 sec	303 MBytes	509 Mbits/sec
301	[32]	15.0-20.0 sec	322 MBytes	541 Mbits/sec
302	[37]	15.0-20.0 sec	611 MBytes	1.02 Gbits/sec
303	[63]	15.0-20.0 sec	645 MBytes	1.08 Gbits/sec
304	[35]	15.0-20.0 sec	675 MBytes	1.13 Gbits/sec
305	[36]	15.0-20.0 sec	445 MBytes	747 Mbits/sec
306	[51]	15.0-20.0 sec	501 MBytes	840 Mbits/sec
307	[53]	15.0-20.0 sec	431 MBytes	723 Mbits/sec
308	[17]	15.0-20.0 sec	773 MBytes	1.30 Gbits/sec
309	[34]	15.0-20.0 sec	532 MBytes	893 Mbits/sec
310	[4]	15.0-20.0 sec	631 MBytes	1.06 Gbits/sec
311	[19]	15.0-20.0 sec	371 MBytes	622 Mbits/sec
312	[21]	15.0-20.0 sec	686 MBytes	1.15 Gbits/sec
313	[38]	15.0-20.0 sec	652 MBytes	1.09 Gbits/sec



Appendix

A.5. Network performance

314	[59]	15.0-20.0 sec	624 MBytes	1.05 Gbits/sec
315	[60]	15.0-20.0 sec	477 MBytes	800 Mbits/sec
316	[56]	15.0-20.0 sec	494 MBytes	828 Mbits/sec
317	[55]	15.0-20.0 sec	516 MBytes	866 Mbits/sec
318	[6]	15.0-20.0 sec	667 MBytes	1.12 Gbits/sec
319	[5]	15.0-20.0 sec	478 MBytes	801 Mbits/sec
320	[23]	15.0-20.0 sec	522 MBytes	876 Mbits/sec
321	[48]	15.0-20.0 sec	602 MBytes	1.01 Gbits/sec
322	[30]	15.0-20.0 sec	640 MBytes	1.07 Gbits/sec
323	[9]	15.0-20.0 sec	729 MBytes	1.22 Gbits/sec
324	[57]	15.0-20.0 sec	676 MBytes	1.13 Gbits/sec
325	[3]	15.0-20.0 sec	659 MBytes	1.11 Gbits/sec
326	[27]	15.0-20.0 sec	617 MBytes	1.04 Gbits/sec
327	[28]	15.0-20.0 sec	766 MBytes	1.28 Gbits/sec
328	[31]	15.0-20.0 sec	409 MBytes	686 Mbits/sec
329	[SUM]	15.0-20.0 sec	37.4 GBytes	64.2 Gbits/sec
330	[61]	20.0-25.0 sec	485 MBytes	813 Mbits/sec
331	[64]	20.0-25.0 sec	996 MBytes	1.67 Gbits/sec
332	[58]	20.0-25.0 sec	732 MBytes	1.23 Gbits/sec
333	[3]	20.0-25.0 sec	722 MBytes	1.21 Gbits/sec
334	[5]	20.0-25.0 sec	628 MBytes	1.05 Gbits/sec
335	[4]	20.0-25.0 sec	708 MBytes	1.19 Gbits/sec
336	[15]	20.0-25.0 sec	642 MBytes	1.08 Gbits/sec
337	[17]	20.0-25.0 sec	902 MBytes	1.51 Gbits/sec
338	[19]	20.0-25.0 sec	442 MBytes	741 Mbits/sec
339	[22]	20.0-25.0 sec	530 MBytes	890 Mbits/sec
340	[20]	20.0-25.0 sec	534 MBytes	896 Mbits/sec
341	[26]	20.0-25.0 sec	342 MBytes	575 Mbits/sec
342	[29]	20.0-25.0 sec	637 MBytes	1.07 Gbits/sec
343	[30]	20.0-25.0 sec	524 MBytes	880 Mbits/sec
344	[32]	20.0-25.0 sec	586 MBytes	984 Mbits/sec
345	[35]	20.0-25.0 sec	676 MBytes	1.13 Gbits/sec
346	[39]	20.0-25.0 sec	714 MBytes	1.20 Gbits/sec
347	[45]	20.0-25.0 sec	645 MBytes	1.08 Gbits/sec
348	[41]	20.0-25.0 sec	559 MBytes	938 Mbits/sec
349	[44]	20.0-25.0 sec	554 MBytes	929 Mbits/sec
350	[46]	20.0-25.0 sec	464 MBytes	778 Mbits/sec
351	[57]	20.0-25.0 sec	578 MBytes	970 Mbits/sec
352	[59]	20.0-25.0 sec	567 MBytes	951 Mbits/sec
353	[54]	20.0-25.0 sec	606 MBytes	1.02 Gbits/sec
354	[65]	20.0-25.0 sec	739 MBytes	1.24 Gbits/sec
355	[7]	20.0-25.0 sec	570 MBytes	957 Mbits/sec
356	[10]	20.0-25.0 sec	524 MBytes	880 Mbits/sec
357	[40]	20.0-25.0 sec	531 MBytes	890 Mbits/sec
358	[55]	20.0-25.0 sec	335 MBytes	563 Mbits/sec
359	[63]	20.0-25.0 sec	451 MBytes	756 Mbits/sec
360	[24]	20.0-25.0 sec	532 MBytes	892 Mbits/sec
361	[37]	20.0-25.0 sec	744 MBytes	1.25 Gbits/sec
362	[8]	20.0-25.0 sec	624 MBytes	1.05 Gbits/sec
363	[31]	20.0-25.0 sec	660 MBytes	1.11 Gbits/sec
364	[43]	20.0-25.0 sec	792 MBytes	1.33 Gbits/sec
365	[13]	20.0-25.0 sec	495 MBytes	830 Mbits/sec
366	[25]	20.0-25.0 sec	670 MBytes	1.12 Gbits/sec
367	[66]	20.0-25.0 sec	544 MBytes	913 Mbits/sec
368	[6]	20.0-25.0 sec	777 MBytes	1.30 Gbits/sec
369	[28]	20.0-25.0 sec	740 MBytes	1.24 Gbits/sec
370	[33]	20.0-25.0 sec	681 MBytes	1.14 Gbits/sec
371	[34]	20.0-25.0 sec	486 MBytes	815 Mbits/sec



Appendix

A.5. Network performance

372	[38]	20.0-25.0 sec	532 MBytes	893 Mb/s
373	[52]	20.0-25.0 sec	517 MBytes	867 Mb/s
374	[62]	20.0-25.0 sec	505 MBytes	848 Mb/s
375	[11]	20.0-25.0 sec	560 MBytes	940 Mb/s
376	[23]	20.0-25.0 sec	625 MBytes	1.05 Gb/s
377	[36]	20.0-25.0 sec	588 MBytes	987 Mb/s
378	[48]	20.0-25.0 sec	628 MBytes	1.05 Gb/s
379	[47]	20.0-25.0 sec	388 MBytes	651 Mb/s
380	[27]	20.0-25.0 sec	574 MBytes	963 Mb/s
381	[60]	20.0-25.0 sec	663 MBytes	1.11 Gb/s
382	[12]	20.0-25.0 sec	692 MBytes	1.16 Gb/s
383	[56]	20.0-25.0 sec	402 MBytes	674 Mb/s
384	[9]	20.0-25.0 sec	522 MBytes	876 Mb/s
385	[18]	20.0-25.0 sec	392 MBytes	657 Mb/s
386	[42]	20.0-25.0 sec	679 MBytes	1.14 Gb/s
387	[50]	20.0-25.0 sec	368 MBytes	618 Mb/s
388	[51]	20.0-25.0 sec	373 MBytes	626 Mb/s
389	[53]	20.0-25.0 sec	508 MBytes	853 Mb/s
390	[16]	20.0-25.0 sec	817 MBytes	1.37 Gb/s
391	[49]	20.0-25.0 sec	801 MBytes	1.34 Gb/s
392	[21]	20.0-25.0 sec	751 MBytes	1.26 Gb/s
393	[14]	20.0-25.0 sec	688 MBytes	1.16 Gb/s
394	[SUM]	20.0-25.0 sec	37.3 GBytes	64.2 Gb/s
395	[61]	25.0-30.0 sec	711 MBytes	1.19 Gb/s
396	[61]	0.0-30.0 sec	3.38 GBytes	968 Mb/s
397	[64]	25.0-30.0 sec	753 MBytes	1.26 Gb/s
398	[64]	0.0-30.0 sec	4.79 GBytes	1.37 Gb/s
399	[65]	25.0-30.0 sec	843 MBytes	1.41 Gb/s
400	[65]	0.0-30.0 sec	4.75 GBytes	1.36 Gb/s
401	[62]	25.0-30.0 sec	434 MBytes	727 Mb/s
402	[62]	0.0-30.0 sec	3.31 GBytes	948 Mb/s
403	[9]	25.0-30.0 sec	489 MBytes	820 Mb/s
404	[9]	0.0-30.0 sec	3.96 GBytes	1.13 Gb/s
405	[12]	25.0-30.0 sec	652 MBytes	1.09 Gb/s
406	[12]	0.0-30.0 sec	3.78 GBytes	1.08 Gb/s
407	[10]	25.0-30.0 sec	753 MBytes	1.26 Gb/s
408	[10]	0.0-30.0 sec	4.10 GBytes	1.17 Gb/s
409	[4]	25.0-30.0 sec	816 MBytes	1.37 Gb/s
410	[4]	0.0-30.0 sec	3.99 GBytes	1.14 Gb/s
411	[17]	25.0-30.0 sec	822 MBytes	1.38 Gb/s
412	[17]	0.0-30.0 sec	5.03 GBytes	1.44 Gb/s
413	[19]	25.0-30.0 sec	829 MBytes	1.39 Gb/s
414	[19]	0.0-30.0 sec	3.18 GBytes	911 Mb/s
415	[22]	25.0-30.0 sec	549 MBytes	920 Mb/s
416	[22]	0.0-30.0 sec	3.19 GBytes	914 Mb/s
417	[21]	25.0-30.0 sec	748 MBytes	1.26 Gb/s
418	[21]	0.0-30.0 sec	4.16 GBytes	1.19 Gb/s
419	[26]	25.0-30.0 sec	644 MBytes	1.08 Gb/s
420	[26]	0.0-30.0 sec	3.42 GBytes	979 Mb/s
421	[27]	25.0-30.0 sec	527 MBytes	885 Mb/s
422	[27]	0.0-30.0 sec	3.78 GBytes	1.08 Gb/s
423	[29]	25.0-30.0 sec	681 MBytes	1.14 Gb/s
424	[29]	0.0-30.0 sec	3.63 GBytes	1.04 Gb/s
425	[31]	25.0-30.0 sec	610 MBytes	1.02 Gb/s
426	[31]	0.0-30.0 sec	3.55 GBytes	1.01 Gb/s
427	[32]	25.0-30.0 sec	404 MBytes	678 Mb/s
428	[32]	0.0-30.0 sec	2.49 GBytes	713 Mb/s
429	[34]	25.0-30.0 sec	442 MBytes	742 Mb/s



430	[34]	0.0-30.0 sec	2.89 GBytes	828 Mb/s
431	[35]	25.0-30.0 sec	660 MBytes	1.11 Gb/s
432	[35]	0.0-30.0 sec	4.10 GBytes	1.17 Gb/s
433	[38]	25.0-30.0 sec	730 MBytes	1.23 Gb/s
434	[38]	0.0-30.0 sec	4.00 GBytes	1.15 Gb/s
435	[42]	25.0-30.0 sec	476 MBytes	798 Mb/s
436	[42]	0.0-30.0 sec	2.88 GBytes	823 Mb/s
437	[41]	25.0-30.0 sec	481 MBytes	807 Mb/s
438	[41]	0.0-30.0 sec	2.98 GBytes	855 Mb/s
439	[44]	25.0-30.0 sec	516 MBytes	866 Mb/s
440	[44]	0.0-30.0 sec	2.82 GBytes	808 Mb/s
441	[46]	25.0-30.0 sec	473 MBytes	794 Mb/s
442	[46]	0.0-30.0 sec	2.77 GBytes	793 Mb/s
443	[49]	25.0-30.0 sec	642 MBytes	1.08 Gb/s
444	[49]	0.0-30.0 sec	4.13 GBytes	1.18 Gb/s
445	[47]	25.0-30.0 sec	594 MBytes	997 Mb/s
446	[47]	0.0-30.0 sec	3.27 GBytes	936 Mb/s
447	[60]	25.0-30.0 sec	570 MBytes	957 Mb/s
448	[60]	0.0-30.0 sec	3.31 GBytes	949 Mb/s
449	[59]	25.0-30.0 sec	677 MBytes	1.14 Gb/s
450	[59]	0.0-30.0 sec	3.31 GBytes	947 Mb/s
451	[54]	25.0-30.0 sec	713 MBytes	1.20 Gb/s
452	[54]	0.0-30.0 sec	3.86 GBytes	1.11 Gb/s
453	[13]	25.0-30.0 sec	616 MBytes	1.03 Gb/s
454	[13]	0.0-30.0 sec	3.52 GBytes	1.01 Gb/s
455	[3]	25.0-30.0 sec	579 MBytes	971 Mb/s
456	[3]	0.0-30.0 sec	3.82 GBytes	1.09 Gb/s
457	[7]	25.0-30.0 sec	647 MBytes	1.08 Gb/s
458	[7]	0.0-30.0 sec	3.51 GBytes	1.00 Gb/s
459	[16]	25.0-30.0 sec	493 MBytes	826 Mb/s
460	[16]	0.0-30.0 sec	3.91 GBytes	1.12 Gb/s
461	[11]	25.0-30.0 sec	578 MBytes	970 Mb/s
462	[11]	0.0-30.0 sec	3.63 GBytes	1.04 Gb/s
463	[23]	25.0-30.0 sec	682 MBytes	1.14 Gb/s
464	[23]	0.0-30.0 sec	3.22 GBytes	920 Mb/s
465	[28]	25.0-30.0 sec	531 MBytes	891 Mb/s
466	[28]	0.0-30.0 sec	4.30 GBytes	1.23 Gb/s
467	[37]	25.0-30.0 sec	726 MBytes	1.22 Gb/s
468	[37]	0.0-30.0 sec	3.85 GBytes	1.10 Gb/s
469	[40]	25.0-30.0 sec	528 MBytes	887 Mb/s
470	[40]	0.0-30.0 sec	3.38 GBytes	967 Mb/s
471	[36]	25.0-30.0 sec	634 MBytes	1.06 Gb/s
472	[36]	0.0-30.0 sec	3.27 GBytes	935 Mb/s
473	[43]	25.0-30.0 sec	665 MBytes	1.12 Gb/s
474	[43]	0.0-30.0 sec	3.95 GBytes	1.13 Gb/s
475	[57]	25.0-30.0 sec	754 MBytes	1.26 Gb/s
476	[57]	0.0-30.1 sec	4.07 GBytes	1.16 Gb/s
477	[25]	25.0-30.0 sec	490 MBytes	823 Mb/s
478	[25]	0.0-30.0 sec	3.71 GBytes	1.06 Gb/s
479	[58]	25.0-30.0 sec	645 MBytes	1.08 Gb/s
480	[58]	0.0-30.1 sec	4.47 GBytes	1.28 Gb/s
481	[45]	25.0-30.0 sec	563 MBytes	945 Mb/s
482	[45]	0.0-30.1 sec	3.75 GBytes	1.07 Gb/s
483	[6]	25.0-30.0 sec	614 MBytes	1.03 Gb/s
484	[6]	0.0-30.1 sec	3.97 GBytes	1.13 Gb/s
485	[39]	25.0-30.0 sec	491 MBytes	823 Mb/s
486	[39]	0.0-30.1 sec	3.63 GBytes	1.04 Gb/s
487	[52]	25.0-30.0 sec	769 MBytes	1.29 Gb/s



488	[52]	0.0-30.1 sec	4.00 GBytes	1.14 Gbits/sec
489	[55]	25.0-30.0 sec	425 MBytes	713 Mbits/sec
490	[55]	0.0-30.1 sec	2.55 GBytes	728 Mbits/sec
491	[8]	25.0-30.0 sec	534 MBytes	897 Mbits/sec
492	[8]	0.0-30.1 sec	3.08 GBytes	879 Mbits/sec
493	[14]	25.0-30.0 sec	385 MBytes	646 Mbits/sec
494	[14]	0.0-30.1 sec	3.27 GBytes	934 Mbits/sec
495	[20]	25.0-30.0 sec	516 MBytes	865 Mbits/sec
496	[20]	0.0-30.1 sec	3.16 GBytes	900 Mbits/sec
497	[24]	25.0-30.0 sec	488 MBytes	818 Mbits/sec
498	[24]	0.0-30.1 sec	2.70 GBytes	768 Mbits/sec
499	[51]	25.0-30.0 sec	423 MBytes	710 Mbits/sec
500	[51]	0.0-30.1 sec	2.53 GBytes	722 Mbits/sec
501	[63]	25.0-30.0 sec	539 MBytes	905 Mbits/sec
502	[63]	0.0-30.1 sec	3.29 GBytes	938 Mbits/sec
503	[66]	25.0-30.0 sec	774 MBytes	1.30 Gbits/sec
504	[66]	0.0-30.2 sec	3.46 GBytes	986 Mbits/sec
505	[18]	25.0-30.0 sec	543 MBytes	912 Mbits/sec
506	[18]	0.0-30.1 sec	3.28 GBytes	936 Mbits/sec
507	[30]	25.0-30.0 sec	320 MBytes	538 Mbits/sec
508	[30]	0.0-30.1 sec	2.58 GBytes	737 Mbits/sec
509	[56]	25.0-30.0 sec	470 MBytes	788 Mbits/sec
510	[56]	0.0-30.2 sec	2.95 GBytes	839 Mbits/sec
511	[33]	25.0-30.0 sec	727 MBytes	1.22 Gbits/sec
512	[33]	0.0-30.2 sec	3.73 GBytes	1.06 Gbits/sec
513	[48]	25.0-30.0 sec	649 MBytes	1.09 Gbits/sec
514	[48]	0.0-30.2 sec	3.38 GBytes	961 Mbits/sec
515	[50]	25.0-30.0 sec	406 MBytes	681 Mbits/sec
516	[50]	0.0-30.2 sec	2.64 GBytes	751 Mbits/sec
517	[5]	25.0-30.0 sec	670 MBytes	1.12 Gbits/sec
518	[5]	0.0-30.2 sec	3.61 GBytes	1.03 Gbits/sec
519	[15]	25.0-30.0 sec	636 MBytes	1.07 Gbits/sec
520	[15]	0.0-30.2 sec	3.27 GBytes	932 Mbits/sec
521	[53]	25.0-30.0 sec	492 MBytes	826 Mbits/sec
522	[SUM]	25.0-30.0 sec	37.3 GBytes	64.2 Gbits/sec
523	[53]	0.0-30.2 sec	2.68 GBytes	762 Mbits/sec
524	[SUM]	0.0-30.2 sec	225 GBytes	64.0 Gbits/sec



A.6 IO performance

Listing A.8: Output of the `fio` command in the Driver instance

```

1 fio --rw=write --ioenginesync --fdatasync=1 --direct=1 --directory=io-test-data --size=2g --bs=4k --name=iotest
2 iotest: (g=0): rw=write, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B, ioengine=sync, iodepth=1
3 fio-3.16
4 Starting 1 process
5 iotest: Laying out IO file (1 file / 2048MiB)
6 Jobs: 1 (f=1): [W(1)][100.0%][w=21.7MiB/s][w=5558 IOPS][eta 00m:00s]
7 iotest: (groupid=0, jobs=1): err= 0: pid=294592: Sat Mar 29 19:16:59 2025
8   write: IOPS=5142, BW=20.1MiB/s (21.1MB/s)(2048MiB/101953msec); 0 zone resets
9     clat (usec): min=70, max=11253, avg=90.78, stdev=77.15
10    lat (usec): min=70, max=11253, avg=90.82, stdev=77.15
11    clat percentiles (usec):
12      | 1.00th=[ 76], 5.00th=[ 78], 10.00th=[ 78], 20.00th=[ 80],
13      | 30.00th=[ 81], 40.00th=[ 82], 50.00th=[ 83], 60.00th=[ 84],
14      | 70.00th=[ 85], 80.00th=[ 87], 90.00th=[ 94], 95.00th=[ 111],
15      | 99.00th=[ 269], 99.50th=[ 412], 99.90th=[ 1012], 99.95th=[ 1483],
16      | 99.99th=[ 3425]
17   bw ( KiB/s): min= 6008, max=23232, per=99.97%, avg=20562.84, stdev=1860.11, samples=203
18   iops        : min= 1502, max= 5808, avg=5140.71, stdev=465.03, samples=203
19   lat (usec)   : 100=93.15%, 250=5.72%, 500=0.77%, 750=0.19%, 1000=0.06%
20   lat (msec)   : 2=0.07%, 4=0.02%, 10=0.01%, 20=0.01%
21   fsync/fdatasync/sync_file_range:
22     sync (usec): min=74, max=11488, avg=103.27, stdev=92.68
23     sync percentiles (usec):
24       | 1.00th=[ 81], 5.00th=[ 84], 10.00th=[ 86], 20.00th=[ 88],
25       | 30.00th=[ 89], 40.00th=[ 91], 50.00th=[ 92], 60.00th=[ 95],
26       | 70.00th=[ 98], 80.00th=[ 101], 90.00th=[ 108], 95.00th=[ 124],
27       | 99.00th=[ 338], 99.50th=[ 515], 99.90th=[ 1254], 99.95th=[ 1942],
28       | 99.99th=[ 3621]
29   cpu         : usr=0.60%, sys=4.26%, ctx=1572864, majf=0, minf=14
30   IO depths    : 1=200.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
31     submit     : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
32     complete   : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
33     issued rwts: total=0,524288,0,0 short=524287,0,0,0 dropped=0,0,0,0
34     latency    : target=0, window=0, percentile=100.00%, depth=1
35
36 Run status group 0 (all jobs):
37   WRITE: bw=20.1MiB/s (21.1MB/s), 20.1MiB/s-20.1MiB/s (21.1MB/s-21.1MB/s), io=2048MiB (2147MB), run=101953-101953
38         msec
39
40 Disk stats (read/write):
41   nvme1n1: ios=0/1047980, merge=0/4, ticks=0/94529, in_queue=240, util=99.94%=

```



Listing A.9: Output of the `fio` command in the Server instance

```

1 fio --rw=write --ioengine=sync --fdatasync=1 --direct=1 --directory=io-test-data --size=2g --bs=4k --name=iotest
2 iotest: (g=0): rw=write, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B, ioengine=sync, iodepth=1
3 fio-3.16
4 Starting 1 process
5 iotest: Laying out IO file (1 file / 2048MiB)
6 Jobs: 1 (f=1): [W(1)][100.0%][w=17.6MiB/s][w=4495 IOPS][eta 00m:00s]
7 iotest: (groupid=0, jobs=1): err= 0: pid=1898071: Sat Mar 29 19:17:33 2025
8   write: IOPS=4636, BW=18.1MiB/s (18.0MB/s)(2048MiB/113081msec); 0 zone resets
9     clat (usec): min=69, max=5534, avg=91.36, stdev=85.61
10    lat (usec): min=69, max=5535, avg=91.40, stdev=85.61
11   clat percentiles (usec):
12     | 1.00th=[ 75], 5.00th=[ 76], 10.00th=[ 77], 20.00th=[ 79],
13     | 30.00th=[ 80], 40.00th=[ 80], 50.00th=[ 82], 60.00th=[ 83],
14     | 70.00th=[ 84], 80.00th=[ 87], 90.00th=[ 93], 95.00th=[ 110],
15     | 99.00th=[ 322], 99.50th=[ 506], 99.90th=[ 1237], 99.95th=[ 1762],
16     | 99.99th=[ 3294]
17   bw ( KiB/s): min= 9632, max=20208, per=100.00%, avg=18545.28, stdev=1135.63, samples=226
18   iops        : min= 2408, max= 5052, avg=4636.32, stdev=283.91, samples=226
19   lat (usec)   : 100=93.20%, 250=5.39%, 500=0.90%, 750=0.27%, 1000=0.10%
20   lat (msec)   : 2=0.11%, 4=0.03%, 10=0.01%
21   fsync/fdatasync/sync_file_range:
22     sync (usec): min=79, max=5652, avg=123.92, stdev=86.94
23     sync percentiles (usec):
24       | 1.00th=[ 84], 5.00th=[ 86], 10.00th=[ 87], 20.00th=[ 88],
25       | 30.00th=[ 89], 40.00th=[ 91], 50.00th=[ 92], 60.00th=[ 95],
26       | 70.00th=[ 105], 80.00th=[ 147], 90.00th=[ 217], 95.00th=[ 265],
27       | 99.00th=[ 383], 99.50th=[ 490], 99.90th=[ 947], 99.95th=[ 1385],
28       | 99.99th=[ 2835]
29   cpu          : usr=0.49%, sys=3.94%, ctx=1572864, majf=0, minf=14
30   IO depths    : 1=200.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
31   submit      : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
32   complete    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
33   issued rwts: total=0,524288,0,0 short=524287,0,0,0 dropped=0,0,0,0
34   latency     : target=0, window=0, percentile=100.00%, depth=1
35
36 Run status group 0 (all jobs):
37   WRITE: bw=18.1MiB/s (18.0MB/s), 18.1MiB/s-18.1MiB/s (18.0MB/s-18.0MB/s), io=2048MiB (2147MB), run=113081-113081
38   msec
39
40 Disk stats (read/write):
41   nvme1n1: ios=0/1047075, merge=0/4, ticks=0/105112, in_queue=144, util=99.95%

```

A.7 Datagen configuration

Listing A.10: Contents of params-sf30.ini used for scale factor 30

```

1 ldbc.snb.datagen.generator.scaleFactor:snb.interactive.30
2 ldbc.snb.datagen.serializer.numUpdatePartitions:48
3
4 ldbc.snb.datagen.serializer.dynamicActivitySerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.
  activity.CsvCompositeDynamicActivitySerializer
5 ldbc.snb.datagen.serializer.dynamicPersonSerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.person.
  CsvCompositeDynamicPersonSerializer
6 ldbc.snb.datagen.serializer.staticSerializer:ldbc.snb.datagen.serializer.snb.csv.staticserializer.
  CsvCompositeStaticSerializer

```

Listing A.11: Contents of params-sf100.ini used for scale factor 100

```

1 ldbc.snb.datagen.generator.scaleFactor:snb.interactive.100
2 ldbc.snb.datagen.serializer.numUpdatePartitions:48
3
4 ldbc.snb.datagen.serializer.dynamicActivitySerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.
  activity.CsvCompositeDynamicActivitySerializer
5 ldbc.snb.datagen.serializer.dynamicPersonSerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.person.
  CsvCompositeDynamicPersonSerializer
6 ldbc.snb.datagen.serializer.staticSerializer:ldbc.snb.datagen.serializer.snb.csv.staticserializer.
  CsvCompositeStaticSerializer

```

Listing A.12: Contents of params-sf300.ini used for scale factor 300

```

1 ldbc.snb.datagen.generator.scaleFactor:snb.interactive.300
2 ldbc.snb.datagen.serializer.numUpdatePartitions:48
3
4 ldbc.snb.datagen.serializer.dynamicActivitySerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.
  activity.CsvCompositeDynamicActivitySerializer
5 ldbc.snb.datagen.serializer.dynamicPersonSerializer:ldbc.snb.datagen.serializer.snb.csv.dynamicserializer.person.
  CsvCompositeDynamicPersonSerializer
6 ldbc.snb.datagen.serializer.staticSerializer:ldbc.snb.datagen.serializer.snb.csv.staticserializer.
  CsvCompositeStaticSerializer

```

A.8 Load configuration

Listing A.13: Contents of bulkload.yaml describing how to import the dataset

```

1 graph: ldbc_snb
2 loading_config:
3   data_source:
4     scheme: file
5     location: {PATH_TO_DATASET}
6   import_option: init # append, overwrite, only init is supported now
7   format:
8     type: csv
9   metadata:
10     delimiter: "|" # other loading configuration places here
11 vertex_mappings:
12   - type_name: PLACE
13     inputs:
14       - static/place_0_0.csv

```



```

15 - type_name: PERSON
16   inputs:
17     - dynamic/person_0_0.csv
18 - type_name: COMMENT
19   inputs:
20     - dynamic/comment_0_0.csv.rod
21 - type_name: POST
22   inputs:
23     - dynamic/post_0_0.csv.rod
24 - type_name: FORUM
25   inputs:
26     - dynamic/forum_0_0.csv
27 - type_name: ORGANISATION
28   inputs:
29     - static/organisation_0_0.csv
30 - type_name: TAGCLASS
31   inputs:
32     - static/tagclass_0_0.csv
33 - type_name: TAG
34   inputs:
35     - static/tag_0_0.csv
36 edge_mappings:
37   - type_triplet:
38     edge: HASCREATOR
39     source_vertex: COMMENT
40     destination_vertex: PERSON
41     inputs:
42       - dynamic/comment_hasCreator_person_0_0.csv.creation_date
43     source_vertex_mappings:
44       - column:
45         index: 0
46         name: id
47     destination_vertex_mappings:
48       - column:
49         index: 1
50         name: id
51     column_mappings:
52       - column:
53         index: 2
54         name: creationDate
55         property: creationDate
56   - type_triplet:
57     edge: HASCREATOR
58     source_vertex: POST
59     destination_vertex: PERSON
60     inputs:
61       - dynamic/post_hasCreator_person_0_0.csv.creation_date
62     source_vertex_mappings:
63       - column:
64         index: 0
65         name: id
66     destination_vertex_mappings:
67       - column:
68         index: 1
69         name: id
70     column_mappings:
71       - column:
72         index: 2

```

```

73         name: creationDate
74         property: creationDate
75     - type_triplet:
76         edge: HASTAG
77         source_vertex: POST
78         destination_vertex: TAG
79         inputs:
80             - dynamic/post_hasTag_tag_0_0.csv
81         source_vertex_mappings:
82             - column:
83                 index: 0
84                 name: id
85         destination_vertex_mappings:
86             - column:
87                 index: 1
88                 name: id
89     - type_triplet:
90         edge: REPLYOF
91         source_vertex: COMMENT
92         destination_vertex: COMMENT
93         inputs:
94             - dynamic/comment_replyOf_comment_0_0.csv
95         source_vertex_mappings:
96             - column:
97                 index: 0
98                 name: id
99         destination_vertex_mappings:
100             - column:
101                 index: 1
102                 name: id
103     - type_triplet:
104         edge: REPLYOF
105         source_vertex: COMMENT
106         destination_vertex: POST
107         inputs:
108             - dynamic/comment_replyOf_post_0_0.csv
109         source_vertex_mappings:
110             - column:
111                 index: 0
112                 name: id
113         destination_vertex_mappings:
114             - column:
115                 index: 1
116                 name: id
117     - type_triplet:
118         edge: CONTAINEROF
119         source_vertex: FORUM
120         destination_vertex: POST
121         inputs:
122             - dynamic/forum_containerOf_post_0_0.csv
123         source_vertex_mappings:
124             - column:
125                 index: 0
126                 name: id
127         destination_vertex_mappings:
128             - column:
129                 index: 1
130                 name: id

```



```

131 - type_triplet:
132     edge: HASMEMBER
133     source_vertex: FORUM
134     destination_vertex: PERSON
135     inputs:
136     - dynamic/forum_hasMember_person_0_0.csv
137     source_vertex_mappings:
138     - column:
139         index: 0
140         name: id
141     destination_vertex_mappings:
142     - column:
143         index: 1
144         name: id
145 - type_triplet:
146     edge: HASMODERATOR
147     source_vertex: FORUM
148     destination_vertex: PERSON
149     inputs:
150     - dynamic/forum_hasModerator_person_0_0.csv
151     source_vertex_mappings:
152     - column:
153         index: 0
154         name: id
155     destination_vertex_mappings:
156     - column:
157         index: 1
158         name: id
159 - type_triplet:
160     edge: HASINTEREST
161     source_vertex: PERSON
162     destination_vertex: TAG
163     inputs:
164     - dynamic/person_hasInterest_tag_0_0.csv
165     source_vertex_mappings:
166     - column:
167         index: 0
168         name: id
169     destination_vertex_mappings:
170     - column:
171         index: 1
172         name: id
173 - type_triplet:
174     edge: ISLOCATEDIN
175     source_vertex: COMMENT
176     destination_vertex: PLACE
177     inputs:
178     - dynamic/comment_isLocatedIn_place_0_0.csv
179     source_vertex_mappings:
180     - column:
181         index: 0
182         name: id
183     destination_vertex_mappings:
184     - column:
185         index: 1
186         name: id
187 - type_triplet:
188     edge: ISLOCATEDIN

```



```

189     source_vertex: PERSON
190     destination_vertex: PLACE
191     inputs:
192     - dynamic/person_isLocatedIn_place_0_0.csv
193     source_vertex_mappings:
194     - column:
195         index: 0
196         name: id
197     destination_vertex_mappings:
198     - column:
199         index: 1
200         name: id
201 - type_triplet:
202     edge: ISLOCATEDIN
203     source_vertex: POST
204     destination_vertex: PLACE
205     inputs:
206     - dynamic/post_isLocatedIn_place_0_0.csv
207     source_vertex_mappings:
208     - column:
209         index: 0
210         name: id
211     destination_vertex_mappings:
212     - column:
213         index: 1
214         name: id
215 - type_triplet:
216     edge: ISLOCATEDIN
217     source_vertex: ORGANISATION
218     destination_vertex: PLACE
219     inputs:
220     - static/organisation_isLocatedIn_place_0_0.csv
221     source_vertex_mappings:
222     - column:
223         index: 0
224         name: id
225     destination_vertex_mappings:
226     - column:
227         index: 1
228         name: id
229 - type_triplet:
230     edge: KNOWS
231     source_vertex: PERSON
232     destination_vertex: PERSON
233     inputs:
234     - dynamic/person_knows_person_0_0.csv
235     source_vertex_mappings:
236     - column:
237         index: 0
238         name: id
239     destination_vertex_mappings:
240     - column:
241         index: 1
242         name: id
243 - type_triplet:
244     edge: LIKES
245     source_vertex: PERSON
246     destination_vertex: COMMENT

```



```

247   inputs:
248     - dynamic/person_likes_comment_0_0.csv
249   source_vertex_mappings:
250     - column:
251         index: 0
252         name: id
253   destination_vertex_mappings:
254     - column:
255         index: 1
256         name: id
257   column_mappings:
258     - column:
259         index: 2
260         name: creationDate
261         property: creationDate
262 - type_triplet:
263     edge: LIKES
264     source_vertex: PERSON
265     destination_vertex: POST
266   inputs:
267     - dynamic/person_likes_post_0_0.csv
268   source_vertex_mappings:
269     - column:
270         index: 0
271         name: id
272   destination_vertex_mappings:
273     - column:
274         index: 1
275         name: id
276   column_mappings:
277     - column:
278         index: 2
279         name: creationDate
280         property: creationDate
281 - type_triplet:
282     edge: WORKAT
283     source_vertex: PERSON
284     destination_vertex: ORGANISATION
285   inputs:
286     - dynamic/person_workAt_organisation_0_0.csv
287   source_vertex_mappings:
288     - column:
289         index: 0
290         name: id
291   destination_vertex_mappings:
292     - column:
293         index: 1
294         name: id
295   column_mappings:
296     - column:
297         index: 2
298         name: workFrom
299         property: workFrom
300 - type_triplet:
301     edge: ISPARTOF
302     source_vertex: PLACE
303     destination_vertex: PLACE
304   inputs:

```



```

305     - static/place_isPartOf_place_0_0.csv
306   source_vertex_mappings:
307     - column:
308       index: 0
309       name: id
310   destination_vertex_mappings:
311     - column:
312       index: 1
313       name: id
314 - type_triplet:
315   edge: HASTYPE
316   source_vertex: TAG
317   destination_vertex: TAGCLASS
318   inputs:
319     - static/tag_hasType_tagclass_0_0.csv
320   source_vertex_mappings:
321     - column:
322       index: 0
323       name: id
324   destination_vertex_mappings:
325     - column:
326       index: 1
327       name: id
328 - type_triplet:
329   edge: ISSUBCLASSOF
330   source_vertex: TAGCLASS
331   destination_vertex: TAGCLASS
332   inputs:
333     - static/tagclass_isSubclassOf_tagclass_0_0.csv
334   source_vertex_mappings:
335     - column:
336       index: 0
337       name: id
338   destination_vertex_mappings:
339     - column:
340       index: 1
341       name: id
342 - type_triplet:
343   edge: STUDYAT
344   source_vertex: PERSON
345   destination_vertex: ORGANISATION
346   inputs:
347     - dynamic/person_studyAt_organisation_0_0.csv
348   source_vertex_mappings:
349     - column:
350       index: 0
351       name: id
352   destination_vertex_mappings:
353     - column:
354       index: 1
355       name: id
356   column_mappings:
357     - column:
358       index: 2
359       name: classYear
360       property: classYear

```


Listing A.14: Contents of graph.yaml1 describing the data schema

```

1 name: ldhc_snb
2 store_type: mutable_csr
3 schema:
4   vertex_types:
5     - type_id: 0
6       type_name: PLACE
7       properties:
8         - property_id: 0
9           property_name: id
10          property_type:
11            primitive_type: DT_SIGNED_INT64
12        - property_id: 1
13          property_name: name
14          property_type:
15            string:
16              var_char:
17                max_length: 256
18        - property_id: 2
19          property_name: url
20          property_type:
21            string:
22              var_char:
23                max_length: 256
24        - property_id: 3
25          property_name: type
26          property_type:
27            string:
28              var_char:
29                max_length: 32
30   primary_keys:
31     - id
32   - type_id: 1
33     type_name: PERSON
34     properties:
35       - property_id: 0
36         property_name: id
37         property_type:
38           primitive_type: DT_SIGNED_INT64
39       - property_id: 1
40         property_name: firstName
41         property_type:
42           string:
43             var_char:
44               max_length: 80
45       - property_id: 2
46         property_name: lastName
47         property_type:
48           string:
49             var_char:
50               max_length: 80
51       - property_id: 3
52         property_name: gender
53         property_type:
54           string:
55             var_char:
56               max_length: 80

```



```

57     - property_id: 4
58       property_name: birthday
59       property_type:
60         temporal:
61           date32:
62     - property_id: 5
63       property_name: creationDate
64       property_type:
65         temporal:
66           timestamp:
67     - property_id: 6
68       property_name: locationIP
69       property_type:
70         string:
71         var_char:
72           max_length: 80
73     - property_id: 7
74       property_name: browserUsed
75       property_type:
76         string:
77         var_char:
78           max_length: 80
79     - property_id: 8
80       property_name: language
81       property_type:
82         string:
83         var_char:
84           max_length: 256
85     - property_id: 9
86       property_name: email
87       property_type:
88         string:
89         var_char:
90           max_length: 2144
91     primary_keys:
92       - id
93   - type_id: 2
94     type_name: COMMENT
95     properties:
96       - property_id: 0
97         property_name: id
98         property_type:
99           primitive_type: DT_SIGNED_INT64
100     - property_id: 1
101       property_name: creationDate
102       property_type:
103         temporal:
104           timestamp:
105     - property_id: 2
106       property_name: locationIP
107       property_type:
108         string:
109         var_char:
110           max_length: 80
111     - property_id: 3
112       property_name: browserUsed
113       property_type:
114         string:

```



```

115         var_char:
116             max_length: 80
117     - property_id: 4
118       property_name: content
119       property_type:
120         string:
121           var_char:
122             max_length: 2144
123     - property_id: 5
124       property_name: length
125       property_type:
126         primitive_type: DT_SIGNED_INT32
127   primary_keys:
128     - id
129 - type_id: 3
130   type_name: POST
131   properties:
132     - property_id: 0
133       property_name: id
134       property_type:
135         primitive_type: DT_SIGNED_INT64
136     - property_id: 1
137       property_name: imageFile
138       property_type:
139         string:
140           var_char:
141             max_length: 80
142     - property_id: 2
143       property_name: creationDate
144       property_type:
145         temporal:
146           timestamp:
147     - property_id: 3
148       property_name: locationIP
149       property_type:
150         string:
151           var_char:
152             max_length: 80
153     - property_id: 4
154       property_name: browserUsed
155       property_type:
156         string:
157           var_char:
158             max_length: 80
159     - property_id: 5
160       property_name: language
161       property_type:
162         string:
163           var_char:
164             max_length: 80
165     - property_id: 6
166       property_name: content
167       property_type:
168         string:
169           var_char:
170             max_length: 2144
171     - property_id: 7
172       property_name: length

```



```

173         property_type:
174             primitive_type: DT_SIGNED_INT32
175     primary_keys:
176         - id
177 - type_id: 4
178   type_name: FORUM
179   properties:
180       - property_id: 0
181         property_name: id
182         property_type:
183             primitive_type: DT_SIGNED_INT64
184       - property_id: 1
185         property_name: title
186         property_type:
187             string:
188                 var_char:
189                     max_length: 256
190       - property_id: 2
191         property_name: creationDate
192         property_type:
193             temporal:
194                 timestamp:
195     primary_keys:
196         - id
197 - type_id: 5
198   type_name: ORGANISATION
199   properties:
200       - property_id: 0
201         property_name: id
202         property_type:
203             primitive_type: DT_SIGNED_INT64
204       - property_id: 1
205         property_name: type
206         property_type:
207             string:
208                 var_char:
209                     max_length: 32
210       - property_id: 2
211         property_name: name
212         property_type:
213             string:
214                 var_char:
215                     max_length: 256
216       - property_id: 3
217         property_name: url
218         property_type:
219             string:
220                 var_char:
221                     max_length: 256
222     primary_keys:
223         - id
224 - type_id: 6
225   type_name: TAGCLASS
226   properties:
227       - property_id: 0
228         property_name: id
229         property_type:
230             primitive_type: DT_SIGNED_INT64

```



```

231     - property_id: 1
232       property_name: name
233       property_type:
234         string:
235         var_char:
236           max_length: 256
237     - property_id: 2
238       property_name: url
239       property_type:
240         string:
241         var_char:
242           max_length: 256
243     primary_keys:
244       - id
245   - type_id: 7
246     type_name: TAG
247     properties:
248       - property_id: 0
249         property_name: id
250         property_type:
251           primitive_type: DT_SIGNED_INT64
252       - property_id: 1
253         property_name: name
254         property_type:
255           string:
256           var_char:
257             max_length: 256
258       - property_id: 2
259         property_name: url
260         property_type:
261           string:
262           var_char:
263             max_length: 256
264     primary_keys:
265       - id
266   edge_types:
267     - type_id: 0
268       type_name: HASCREATOR
269       vertex_type_pair_relations:
270         - source_vertex: COMMENT
271           destination_vertex: PERSON
272           relation: MANY_TO_MANY
273           x_csr_params:
274             sort_on_compaction: TRUE
275         - source_vertex: POST
276           destination_vertex: PERSON
277           relation: MANY_TO_MANY
278           x_csr_params:
279             sort_on_compaction: TRUE
280     properties:
281       - property_id: 0
282         property_name: creationDate
283         property_type:
284           temporal:
285             timestamp:
286     - type_id: 1
287       type_name: HASTAG
288       vertex_type_pair_relations:

```



```

289     - source_vertex: POST
290       destination_vertex: TAG
291       relation: MANY_TO_MANY
292     - source_vertex: FORUM
293       destination_vertex: TAG
294       relation: MANY_TO_MANY
295     - source_vertex: COMMENT
296       destination_vertex: TAG
297       relation: MANY_TO_MANY
298   - type_id: 2
299     type_name: REPLYOF
300     vertex_type_pair_relations:
301       - source_vertex: COMMENT
302         destination_vertex: COMMENT
303         relation: MANY_TO_MANY
304       - source_vertex: COMMENT
305         destination_vertex: POST
306         relation: MANY_TO_MANY
307   - type_id: 3
308     type_name: CONTAINEROF
309     vertex_type_pair_relations:
310       - source_vertex: FORUM
311         destination_vertex: POST
312         relation: MANY_TO_MANY
313   - type_id: 4
314     type_name: HASMEMBER
315     vertex_type_pair_relations:
316       - source_vertex: FORUM
317         destination_vertex: PERSON
318         relation: MANY_TO_MANY
319     x_csr_params:
320       sort_on_compaction: TRUE
321     properties:
322       - property_id: 0
323         property_name: joinDate
324         property_type:
325           temporal:
326             timestamp:
327   - type_id: 5
328     type_name: HASMODERATOR
329     vertex_type_pair_relations:
330       - source_vertex: FORUM
331         destination_vertex: PERSON
332         relation: MANY_TO_MANY
333   - type_id: 6
334     type_name: HASINTEREST
335     vertex_type_pair_relations:
336       - source_vertex: PERSON
337         destination_vertex: TAG
338         relation: MANY_TO_MANY
339   - type_id: 7
340     type_name: ISLOCATEDIN
341     vertex_type_pair_relations:
342       - source_vertex: COMMENT
343         destination_vertex: PLACE
344         relation: MANY_TO_MANY
345       - source_vertex: PERSON
346         destination_vertex: PLACE

```



```

347         relation: MANY_TO_MANY
348     - source_vertex: POST
349         destination_vertex: PLACE
350         relation: MANY_TO_MANY
351     - source_vertex: ORGANISATION
352         destination_vertex: PLACE
353         relation: MANY_TO_MANY
354 - type_id: 8
355     type_name: KNOWS
356     vertex_type_pair_relations:
357     - source_vertex: PERSON
358         destination_vertex: PERSON
359         relation: MANY_TO_MANY
360     properties:
361     - property_id: 0
362         property_name: creationDate
363         property_type:
364             temporal:
365                 timestamp:
366 - type_id: 9
367     type_name: LIKES
368     vertex_type_pair_relations:
369     - source_vertex: PERSON
370         destination_vertex: COMMENT
371         relation: MANY_TO_MANY
372     - source_vertex: PERSON
373         destination_vertex: POST
374         relation: MANY_TO_MANY
375     properties:
376     - property_id: 0
377         property_name: creationDate
378         property_type:
379             temporal:
380                 timestamp:
381 - type_id: 10
382     type_name: WORKAT
383     vertex_type_pair_relations:
384     - source_vertex: PERSON
385         destination_vertex: ORGANISATION
386         relation: MANY_TO_MANY
387     properties:
388     - property_id: 0
389         property_name: workFrom
390         property_type:
391             primitive_type: DT_SIGNED_INT32
392 - type_id: 11
393     type_name: ISPARTOF
394     vertex_type_pair_relations:
395     - source_vertex: PLACE
396         destination_vertex: PLACE
397         relation: MANY_TO_MANY
398 - type_id: 12
399     type_name: HASTYPE
400     vertex_type_pair_relations:
401     - source_vertex: TAG
402         destination_vertex: TAGCLASS
403         relation: MANY_TO_MANY
404 - type_id: 13

```



```
405     type_name: ISSUBCLASSOF
406     vertex_type_pair_relations:
407         - source_vertex: TAGCLASS
408           destination_vertex: TAGCLASS
409           relation: MANY_TO_MANY
410 - type_id: 14
411   type_name: STUDYAT
412   vertex_type_pair_relations:
413       - source_vertex: PERSON
414         destination_vertex: ORGANISATION
415         relation: MANY_TO_MANY
416   properties:
417       - property_id: 0
418         property_name: classYear
419         property_type:
420             primitive_type: DT_SIGNED_INT32
```


A.9 Benchmark configuration

Listing A.15: Contents of benchmark-sf30.properties used for scale factor 30

```

1 url={SERVER}
2
3 printQueryNames=false
4 printQueryStrings=false
5 printQueryResults=false
6
7 status=1
8 thread_count=192
9 name=LDBC-SNB
10 mode=execute_benchmark
11 results_log=true
12 status=1
13 time_unit=MICROSECONDS
14 time_compression_ratio=0.001
15 peer_identifiers=
16 workload_statistics=false
17 spinner_wait_duration=1
18 help=false
19 ignore_scheduled_start_times=false
20
21 workload=org.ldbcouncil.snb.driver.workloads.interactive.LdbcSnbInteractiveWorkload
22 db=org.ldbcouncil.snb.impls.workloads.graphscope.interactive.GraphScopeInteractiveDb
23
24
25 queryDir={FLEX_SNB_FOLDER}/queries/
26 ldbc.snb.interactive.updates_dir={UPDATE_STREAMS}
27 ldbc.snb.interactive.parameters_dir={SUBSTITUTION_PARAMS}
28 ldbc.snb.interactive.short_read_dissipation=0.2
29 # Supported scale factors are 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000
30 ldbc.snb.interactive.scale_factor=30
31 operation_count=272000000
32 warmup=64000000
33
34 ldbc.snb.interactive.LdbcQuery1_enable=true
35 ldbc.snb.interactive.LdbcQuery2_enable=true
36 ldbc.snb.interactive.LdbcQuery3_enable=true
37 ldbc.snb.interactive.LdbcQuery4_enable=true
38 ldbc.snb.interactive.LdbcQuery5_enable=true
39 ldbc.snb.interactive.LdbcQuery6_enable=true
40 ldbc.snb.interactive.LdbcQuery7_enable=true
41 ldbc.snb.interactive.LdbcQuery8_enable=true
42 ldbc.snb.interactive.LdbcQuery9_enable=true
43 ldbc.snb.interactive.LdbcQuery10_enable=true
44 ldbc.snb.interactive.LdbcQuery11_enable=true
45 ldbc.snb.interactive.LdbcQuery12_enable=true
46 ldbc.snb.interactive.LdbcQuery13_enable=true
47 ldbc.snb.interactive.LdbcQuery14_enable=true
48
49 ldbc.snb.interactive.LdbcShortQuery1PersonProfile_enable=true
50 ldbc.snb.interactive.LdbcShortQuery2PersonPosts_enable=true
51 ldbc.snb.interactive.LdbcShortQuery3PersonFriends_enable=true
52 ldbc.snb.interactive.LdbcShortQuery4MessageContent_enable=true
53 ldbc.snb.interactive.LdbcShortQuery5MessageCreator_enable=true
54 ldbc.snb.interactive.LdbcShortQuery6MessageForum_enable=true

```



```
55 | ldcb.snb.interactive.LdbcShortQuery7MessageReplies_enable=true
56 |
57 | ldcb.snb.interactive.LdbcUpdate1AddPerson_enable=true
58 | ldcb.snb.interactive.LdbcUpdate2AddPostLike_enable=true
59 | ldcb.snb.interactive.LdbcUpdate3AddCommentLike_enable=true
60 | ldcb.snb.interactive.LdbcUpdate4AddForum_enable=true
61 | ldcb.snb.interactive.LdbcUpdate5AddForumMembership_enable=true
62 | ldcb.snb.interactive.LdbcUpdate6AddPost_enable=true
63 | ldcb.snb.interactive.LdbcUpdate7AddComment_enable=true
64 | ldcb.snb.interactive.LdbcUpdate8AddFriendship_enable=true
```

Listing A.16: Contents of `benchmark-sf100.properties` used for scale factor 100

```

1 url={SERVER}
2
3 printQueryNames=false
4 printQueryStrings=false
5 printQueryResults=false
6
7 status=1
8 thread_count=192
9 name=LDBC-SNB
10 mode=execute_benchmark
11 results_log=true
12 time_unit=MICROSECONDS
13 time_compression_ratio=0.0016
14 peer_identifiers=
15 workload_statistics=false
16 spinner_wait_duration=1
17 help=false
18 ignore_scheduled_start_times=false
19
20 workload=org.ldbcouncil.snb.driver.workloads.interactive.LdbcSnbInteractiveWorkload
21 db=org.ldbcouncil.snb.impls.workloads.graphscope.interactive.GraphScopeInteractiveDb
22
23
24 queryDir={FLEX_SNB_FOLDER}/queries/
25 ldbc.snb.interactive.updates_dir={UPDATE_STREAMS}
26 ldbc.snb.interactive.parameters_dir={SUBSTITUTION_PARAMS}
27 ldbc.snb.interactive.short_read_dissipation=0.2
28 # Supported scale factors are 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000
29 ldbc.snb.interactive.scale_factor=100
30 operation_count=579000000
31 warmup=152000000
32
33 ldbc.snb.interactive.LdbcQuery1_enable=true
34 ldbc.snb.interactive.LdbcQuery2_enable=true
35 ldbc.snb.interactive.LdbcQuery3_enable=true
36 ldbc.snb.interactive.LdbcQuery4_enable=true
37 ldbc.snb.interactive.LdbcQuery5_enable=true
38 ldbc.snb.interactive.LdbcQuery6_enable=true
39 ldbc.snb.interactive.LdbcQuery7_enable=true
40 ldbc.snb.interactive.LdbcQuery8_enable=true
41 ldbc.snb.interactive.LdbcQuery9_enable=true
42 ldbc.snb.interactive.LdbcQuery10_enable=true
43 ldbc.snb.interactive.LdbcQuery11_enable=true
44 ldbc.snb.interactive.LdbcQuery12_enable=true
45 ldbc.snb.interactive.LdbcQuery13_enable=true
46 ldbc.snb.interactive.LdbcQuery14_enable=true
47
48 ldbc.snb.interactive.LdbcShortQuery1PersonProfile_enable=true
49 ldbc.snb.interactive.LdbcShortQuery2PersonPosts_enable=true
50 ldbc.snb.interactive.LdbcShortQuery3PersonFriends_enable=true
51 ldbc.snb.interactive.LdbcShortQuery4MessageContent_enable=true
52 ldbc.snb.interactive.LdbcShortQuery5MessageCreator_enable=true
53 ldbc.snb.interactive.LdbcShortQuery6MessageForum_enable=true
54 ldbc.snb.interactive.LdbcShortQuery7MessageReplies_enable=true
55
56 ldbc.snb.interactive.LdbcUpdate1AddPerson_enable=true

```



```
57 | ldc.snb.interactive.LdbcUpdate2AddPostLike_enable=true
58 | ldc.snb.interactive.LdbcUpdate3AddCommentLike_enable=true
59 | ldc.snb.interactive.LdbcUpdate4AddForum_enable=true
60 | ldc.snb.interactive.LdbcUpdate5AddForumMembership_enable=true
61 | ldc.snb.interactive.LdbcUpdate6AddPost_enable=true
62 | ldc.snb.interactive.LdbcUpdate7AddComment_enable=true
63 | ldc.snb.interactive.LdbcUpdate8AddFriendship_enable=true
```

Listing A.17: Contents of `benchmark-sf300.properties` used for scale factor 300

```

1 url={SERVER}
2
3 printQueryNames=false
4 printQueryStrings=false
5 printQueryResults=false
6
7 status=1
8 thread_count=192
9 name=LDBC-SNB
10 mode=execute_benchmark
11 results_log=true
12 time_unit=MICROSECONDS
13 time_compression_ratio=0.0054
14
15 peer_identifiers=
16 workload_statistics=false
17 spinner_wait_duration=1
18 help=false
19 ignore_scheduled_start_times=false
20
21
22 workload=org.ldbcouncil.snb.driver.workloads.interactive.LdbcSnbInteractiveWorkload
23 db=org.ldbcouncil.snb.impls.workloads.graphscope.interactive.GraphScopeInteractiveDb
24
25 queryDir={FLEX_SNB_FOLDER}/queries/
26 ldbc.snb.interactive.updates_dir={UPDATE_STREAMS}
27 ldbc.snb.interactive.parameters_dir={SUBSTITUTION_PARAMS}
28 ldbc.snb.interactive.short_read_dissipation=0.2
29 # Supported scale factors are 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000
30 ldbc.snb.interactive.scale_factor=300
31 operation_count=591800000
32 warmup=155400000
33
34 ldbc.snb.interactive.LdbcQuery1_enable=true
35 ldbc.snb.interactive.LdbcQuery2_enable=true
36 ldbc.snb.interactive.LdbcQuery3_enable=true
37 ldbc.snb.interactive.LdbcQuery4_enable=true
38 ldbc.snb.interactive.LdbcQuery5_enable=true
39 ldbc.snb.interactive.LdbcQuery6_enable=true
40 ldbc.snb.interactive.LdbcQuery7_enable=true
41 ldbc.snb.interactive.LdbcQuery8_enable=true
42 ldbc.snb.interactive.LdbcQuery9_enable=true
43 ldbc.snb.interactive.LdbcQuery10_enable=true
44 ldbc.snb.interactive.LdbcQuery11_enable=true
45 ldbc.snb.interactive.LdbcQuery12_enable=true
46 ldbc.snb.interactive.LdbcQuery13_enable=true
47 ldbc.snb.interactive.LdbcQuery14_enable=true
48
49 ldbc.snb.interactive.LdbcShortQuery1PersonProfile_enable=true
50 ldbc.snb.interactive.LdbcShortQuery2PersonPosts_enable=true
51 ldbc.snb.interactive.LdbcShortQuery3PersonFriends_enable=true
52 ldbc.snb.interactive.LdbcShortQuery4MessageContent_enable=true
53 ldbc.snb.interactive.LdbcShortQuery5MessageCreator_enable=true
54 ldbc.snb.interactive.LdbcShortQuery6MessageForum_enable=true
55 ldbc.snb.interactive.LdbcShortQuery7MessageReplies_enable=true
56

```



```
57 |
58 | ldbc.snb.interactive.LdbcUpdate1AddPerson_enable=true
59 | ldbc.snb.interactive.LdbcUpdate2AddPostLike_enable=true
60 | ldbc.snb.interactive.LdbcUpdate3AddCommentLike_enable=true
61 | ldbc.snb.interactive.LdbcUpdate4AddForum_enable=true
62 | ldbc.snb.interactive.LdbcUpdate5AddForumMembership_enable=true
63 | ldbc.snb.interactive.LdbcUpdate6AddPost_enable=true
64 | ldbc.snb.interactive.LdbcUpdate7AddComment_enable=true
65 | ldbc.snb.interactive.LdbcUpdate8AddFriendship_enable=true
```

A.10 Validation configuration

Listing A.18: The contents of `validate.properties`

```

1 url={SERVER}
2 readTimeout=5000000
3 connectTimeout=5000000
4 connectPoolMaxIdle=10
5 keepAliveDuration=5000
6 maxRequestsPerHost=180
7 maxRequests=180
8
9 printQueryNames=false
10 printQueryStrings=false
11 printQueryResults=false
12
13 status=1
14 thread_count=1
15 mode=validate_database
16 name=LDBC-SNB
17 results_log=false
18 time_unit=MILLISECONDS
19 time_compression_ratio=0.001
20 peer_identifiers=
21 workload_statistics=false
22 spinner_wait_duration=0
23 help=false
24 ignore_scheduled_start_times=true
25
26 workload=org.ldbcouncil.snb.driver.workloads.interactive.LdbcSnbInteractiveWorkload
27 db=org.ldbcouncil.snb.impls.workloads.graphscope.interactive.GraphScopeInteractiveDb
28
29 operation_count=10000
30
31 queryDir={FLEX_SNB_FOLDER}/queries/
32 validate_database={VALIDATION_PARAMS}
33 ldbc.snb.interactive.parameters_dir={SUBSTITUTION_PARAMS}
34 # Supported scale factors are 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000
35 ldbc.snb.interactive.scale_factor=0.1
36 ldbc.snb.interactive.short_read_dissipation=0.2
37
38 ldbc.snb.interactive.LdbcQuery1_freq=1
39 ldbc.snb.interactive.LdbcQuery2_freq=1
40 ldbc.snb.interactive.LdbcQuery3_freq=1
41 ldbc.snb.interactive.LdbcQuery4_freq=1
42 ldbc.snb.interactive.LdbcQuery5_freq=1
43 ldbc.snb.interactive.LdbcQuery6_freq=1
44 ldbc.snb.interactive.LdbcQuery7_freq=1
45 ldbc.snb.interactive.LdbcQuery8_freq=1
46 ldbc.snb.interactive.LdbcQuery9_freq=1
47 ldbc.snb.interactive.LdbcQuery10_freq=1
48 ldbc.snb.interactive.LdbcQuery11_freq=1
49 ldbc.snb.interactive.LdbcQuery12_freq=1
50 ldbc.snb.interactive.LdbcQuery13_freq=1
51 ldbc.snb.interactive.LdbcQuery14_freq=1
52
53 ldbc.snb.interactive.LdbcQuery1_enable=true
54 ldbc.snb.interactive.LdbcQuery2_enable=true

```



```
55 ldbc.snb.interactive.LdbcQuery3_enable=true
56 ldbc.snb.interactive.LdbcQuery4_enable=true
57 ldbc.snb.interactive.LdbcQuery5_enable=true
58 ldbc.snb.interactive.LdbcQuery6_enable=true
59 ldbc.snb.interactive.LdbcQuery7_enable=true
60 ldbc.snb.interactive.LdbcQuery8_enable=true
61 ldbc.snb.interactive.LdbcQuery9_enable=true
62 ldbc.snb.interactive.LdbcQuery10_enable=true
63 ldbc.snb.interactive.LdbcQuery11_enable=true
64 ldbc.snb.interactive.LdbcQuery12_enable=true
65 ldbc.snb.interactive.LdbcQuery13_enable=true
66 ldbc.snb.interactive.LdbcQuery14_enable=true
67
68 ldbc.snb.interactive.LdbcShortQuery1PersonProfile_enable=true
69 ldbc.snb.interactive.LdbcShortQuery2PersonPosts_enable=true
70 ldbc.snb.interactive.LdbcShortQuery3PersonFriends_enable=true
71 ldbc.snb.interactive.LdbcShortQuery4MessageContent_enable=true
72 ldbc.snb.interactive.LdbcShortQuery5MessageCreator_enable=true
73 ldbc.snb.interactive.LdbcShortQuery6MessageForum_enable=true
74 ldbc.snb.interactive.LdbcShortQuery7MessageReplies_enable=true
75
76 ldbc.snb.interactive.LdbcUpdate1AddPerson_enable=true
77 ldbc.snb.interactive.LdbcUpdate2AddPostLike_enable=true
78 ldbc.snb.interactive.LdbcUpdate3AddCommentLike_enable=true
79 ldbc.snb.interactive.LdbcUpdate4AddForum_enable=true
80 ldbc.snb.interactive.LdbcUpdate5AddForumMembership_enable=true
81 ldbc.snb.interactive.LdbcUpdate6AddPost_enable=true
82 ldbc.snb.interactive.LdbcUpdate7AddComment_enable=true
83 ldbc.snb.interactive.LdbcUpdate8AddFriendship_enable=true
```