Oracle® Communications

Cloud Native Core, Binding Support Function Benchmarking Guide

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Oracle Communications Cloud Native Core, Binding Support Function Benchmarking Guide, Release 25.2.200

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Contents

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Acronyms

The following table provides information about the acronyms and the terminology used in the document.

Table Acronyms and Terminologies

Acronym	Description
ASM	Aspen Service Mesh
AAR	Authorization Authentication Request
BSF	Oracle Communications Cloud Native Core, Binding Support Function
CNE	Oracle Communications Cloud Native Core, Cloud Native Environment
CPU	Central Processing Unit
DIMM	Dual In-line Memory Module
HTTP	Hypertext Transfer Protocol
MPS	Messages Per Second
NF	Network Function
NRF	Oracle Communications Cloud Native Core, Network Repository Function
PCF	Policy Control Function
P-CSCF	Proxy Call Session Control Function
PDU	Protocol Data Unit
PV	Persistent Volume
RAM	Random Access Memory
SMF	Session Management Function
STR	Session Termination Request
TPS	Transactions Per Second
vCNE	Virtual Cloud Native Environment

What’s New in this Guide

This section introduces the documentation updates for Release 25.2.2xx.

Release 25.2.200 - G54602-01, April 2026

- Removed the following old BSF Performance Benchmarking test scenarios:
  - BSF Call Flow Model on Two-Site GeoRedundant (GR) setup, with 15K TPS on each site
  - BSF Call Flow Model Performance deployed on Single Site, with 30K TPS and ASM enabled
  - BSF Call Model deployed on Three-Site GeoRedundant (GR) setup, with 35K TPS and ASM enabled
  - BSF Call Model deployed on Single Site setup, with 35K TPS traffic and ASM enabled
  - BSF Performance Benchmarking 47.7K TPS traffic on three-site Setup
  - BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on one Site
  - BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on Two Site
  - BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on three Sites
  - BSF Performance Benchmarking 54K TPS traffic on a three-site Setup with traffic on one Site (25 Million

    Binding Sessions)
  - BSF Performance Benchmarking 54K TPS traffic on a Four site Setup with traffic on one Site (Congestion Disabled)
  - BSF Performance Benchmarking 54K TPS traffic on a Four site Setup with traffic on one Site (Congestion Enabled)
- Added the following new BSF Performance Benchmarking test scenario:
  - Test Scenario: BSF Performance Benchmarking 22K TPS Traffic on a Four-site Setup with Traffic on One Site
  - Test Scenario: BSF Performance Benchmarking 63K TPS Traffic on a Three-site Setup with Traffic on One Site (with ASM)

1 Introduction

Oracle Communications Cloud Native Core, Binding Support Function (BSF) is a key component of the 5G Service Based Architecture. The Binding Support Function (BSF) allows Policy Control Function (PCF) to register, update, and remove the binding information from it, and allows Network Function (NF) consumers to discover the selected Policy Control Function.

The BSF stores the binding information for a certain PDU sessions and discovers the selected Policy Control Function according to the binding information. It also acts as diameter proxy agent or diameter redirect agent to Rx requests targeting an IP address of a UE to the selected Policy Control Function.

For any AF using Rx, such as P-CSCF, the Binding Support Function determines the selected Policy Control Function address according to the information carried by the incoming Rx requests.

The BSF provides a PDU session binding functionality, which ensures that an Application Function (AF) request for a certain PDU Session reaches the relevant PCF holding the PDU Session information.

BSF supports the following functions:

- Allows BSF users to register, discover, and remove the binding information
- Allows network function consumers to retrieve the binding information

> **Note**
>
> The performance and capacity of the BSF system may vary based on the call model, Feature/Interface configuration, and underlying CNE and hardware environment.

For more information, see *Oracle Communications Cloud Native Core, Binding Support Function User Guide*.

1.1 Purpose and Scope

This document is designed to help operators in measuring the performance and capacity of BSF application, and deployment environment setup software such as Cloud Native Environment (CNE) and cnDBTier.

It is recommended that BSF is run through a benchmark on the target cloud native infrastructure to determine the capacity and performance in the target infrastructure. This information can be used to adjust the initial deployment resources for BSF. These recommendations are just guidelines, since the actual performance of the BSF can vary significantly based on the details of the infrastructure.

1.2 References

- *Oracle Communications Cloud Native Core, Binding Support Function Installation, Upgrade, and Fault Recovery Guide*

- *Oracle Communications Cloud Native Core, Binding Support Function User Guide*
- *Oracle Communications Cloud Native Core, Cloud Native Environment Installation, Upgrade, and Fault Recovery Guide*
- *Oracle Communications Cloud Native Core, cnDBTier Installation, Upgrade, and Fault Recovery Guide*

2
Deployment Environment

This section describes the infrastructure that was used for benchmarking, Oracle Communications Cloud Native Core, Binding Support Function (BSF) deployed in cloud native platform.

2.1 Deployed Components

This section provides details about the deployed components.

Deployment Platform

Oracle Communications Cloud Native Core, Cloud Native Environment (CNE) and BareMetal are used for performing benchmark tests.

BSF Infrastructure Details

BSF infrastructure details specific to each test scenario is documented within the test scenario.

Software Details

The Software details specific to each test scenario is documented within the test scenario.

For more information about BSF Installation details, see *Oracle Communications Cloud Native Core, Binding Support Function Installation, Upgrade, and Fault Recovery Guide*.

3
BSF Benchmark Testing

This chapters describes BSF Application related test scenarios that are validated for benchmarking BSF.

This section describes the set-up and configurations used to benchmark BSF, and then the specific results for the benchmarks are provided for each benchmark infrastructure.

3.1 Test Scenario: BSF Performance Benchmarking 22K TPS Traffic on a Four-site Setup with Traffic on One Site

This test run benchmarks the performance and capacity of BSF call model that is deployed on a four-site setup with 22K TPS traffic on one site.

3.1.1 Testcase Setup and Details

The following table describes the test case parameters and their values:

Table 3-1 Test Case Parameters

Parameters	Values
Call Rate	22K TPS
Call Mix	14.4K nBSF + 7.8K Rx
Traffic Ratio	Binding Create ratio -1 Binding Delete ratio - 1 Rx AAR-I ratio - 1 Rx RAR ratio - 1 Rx AAR-U ratio - 1 Rx STR ratio - 1
Active Subscribers	7M subscribers and 14M sessions
Execution Time	~72 hours

BSF Infrastructure Details

BSF infrastructure used for Benchmarking is described in this section.

Table 3-2 Hardware Details

Hardware	Details
Environment	BareMetal
Server	ORACLE SERVER X9-2
Model	Intel(R) Xeon(R) Platinum 8358 CPU
Clock Speed	2.600 GHz
Total Cores	64

Table 3-2 (Cont.) Hardware Details

Hardware	Details
Memory Size	1024 GB
Type	DDR4 SDRAM
Installed DIMMs	16
Maximum DIMMs	32
Installed Memory	1024 GB

Table 3-3 Software Details

Applications	Version
BSF	25.2.200
cnDBTier	25.2.200
CNC Console	25.2.200
OSO	25.2.200
CNE	25.1.200

Table 3-4 Observability Services

Service Name	Version
Oracle Opensearch	2.15.0
Fluentd	1.17.1
Oracle Opensearch Dashboard	2.15.0
Prometheus	3.2.0
Grafana	9.5.3
Jaeger	1.65.0
Kubernetes	1.32.0

3.1.1.1 Resource Allocation

The following table describes the resource capacity allocated to the BSF microservices:

Table 3-5 BSF microservices Resource Allocation

Microservice	Replica Count (#)	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)
Appinfo	2	1	1	0.5	1
BSF Management Service	11	3	4	1	4
Alternate Route Service	2	1	2	2	4
Configuration Service	2	2	4	0.5	2
Egress Gateway	2	3	4	4	6

Table 3-5 (Cont.) BSF microservices Resource Allocation

Microservice	Replica Count (#)	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)
Ingress Gateway	9	3	4	4	6
NRF Client NF Management	2	1	1	1	1
Audit Service	2	1	2	1	1
CM Service	2	2	4	0.5	2
Query Service	2	1	2	1	1
Perfinfo	2	3	4	0.5	1
Diameter Gateway	2	3	4	0.5	2

The following table describes the resource capacity allocated to the cnDBTier microservices:

Table 3-6 cnDBTier microservices Resource Allocation

Microservices	Replica Count (#)	CPU Limit Per Pod	CPU Request Per Pod	Memory Limit Per Pod	Memory Request Per Pod
mysql-cluster-db-backup-manager-svc/db-backup-manager-svc	1	1	1	1Gi	1Gi
mysql-cluster-db-monitor-svc/db-monitor-svc	1	4	4	4Gi	4Gi
mysql-cluster-one-four-replication-svc/one-four-replication-svc	1	1	1	2Gi	1Gi
mysql-cluster-one-three-replication-svc/one-three-replication-svc	1	1	1	2Gi	1Gi
mysql-cluster-one-two-replication-svc/one-two-replication-svc	1	2	2	17Gi	17Gi
mysql-cluster-one-two-replication-svc/db-infra-monitor-svc	1	200m	200m	256Mi	256Mi
ndbappmysqld/mysqlndbcluster	6	8	8	8Gi	8Gi

Table 3-6 (Cont.) cnDBTier microservices Resource Allocation

Microservices	Replica Count (#)	CPU Limit Per Pod	CPU Request Per Pod	Memory Limit Per Pod	Memory Request Per Pod
ndbappmysqld/ db-infra-monitor-svc	6	200m	200m	256Mi	256Mi
ndbappmysqld/ init-sidecar	6	100m	100m	256Mi	256Mi
ndbmgmd/ mysqlndbcluster	2	4	4	10Gi	8Gi
ndbmgmd/db-infra-monitor-svc	2	200m	200m	256Mi	256Mi
ndbmtd/ mysqlndbcluster	6	10	10	30Gi	30Gi
ndbmtd/db-backup-executor-svc	6	100m	100m	128Mi	128Mi
ndbmtd/db-infra-monitor-svc	6	200m	200m	256Mi	256Mi
ndbmysqld/ mysqlndbcluster	6	4	4	18Gi	18Gi
ndbmysqld/init-sidecar	6	100m	100m	256Mi	256Mi
ndbmysqld/db-infra-monitor-svc	6	200m	200m	256Mi	256Mi

The following table describes the interfaces that were either enabled or disabled for this run:

Table 3-7 BSF Features

Feature Name	Feature Status
Audit	Enabled
Overload	Enabled
Congestion	Enabled
dnssrv	Enabled
Controlled Shutdown	Enabled
NF Scoring	Enabled
Congestion	Enabled

3.1.2 Results

CPU and Memory Utilization

The following table describes the benchmarking number as per the system maximum capacity utilization for BSF microservices.

Table 3-8 BSF Microservices and their Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
Appinfo	1.95%	27.78%	1.60%	27.64%	1.60%	26.76%	1.40%	27.64%
BSF Management Service	19.97%	57.34%	0.05%	39.23%	0.05%	38.55%	0.07%	44.36%
Alternate Route Service	0.10%	17.19%	0.10%	17.04%	0.10%	17.36%	0.10%	16.99%
Configuration Service	0.50%	36.45%	0.30%	30.37%	0.33%	23.78%	0.27%	24.27%
Egress Gateway	0.07%	15.59%	0.07%	13.56%	0.10%	14.57%	0.10%	15.56%
Ingress Gateway	28.43%	50.70%	0.33%	16.08%	0.22%	16.37%	0.30%	16.06%
NRF Client NF Management	0.30%	45.90%	0.30%	43.75%	0.30%	46.00%	0.30%	45.70%
Audit Service	0.43%	52.25%	0.10%	40.92%	0.10%	40.14%	0.10%	42.48%
CM Service	0.20%	62.50%	0.12%	45.90%	0.12%	53.47%	0.12%	43.70%

The following table provides information about cnDBTier resource utilization:

Table 3-9 cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-db-backup-manager-svc/db-backup-manager-svc	0.40%	8.40%	0.10%	9.18%	0.20%	9.57%	0.10%	8.79%
mysql-cluster-db-monitor-svc/db-monitor-svc	1.68%	21.26%	0.07%	19.04%	0.70%	19.04%	0.38%	19.63%

Table 3-9 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-four-one-replication-svc/four-one-replication-svc	-	-	-	-	-	-	0.30%	1.76%
mysql-cluster-four-one-replication-svc/db-infra-monitor-svc	-	-	-	-	-	-	0.50%	20.31%
mysql-cluster-four-three-replication-svc/four-three-replication-svc	-	-	-	-	-	-	0.50%	12.99%
mysql-cluster-four-two-replication-svc/four-two-replication-svc	-	-	-	-	-	-	0.50%	13.38%
ndbappmysqld/mysqlndbcluster	12.72%	51.45%	0.16%	48.17%	0.25%	48.02%	0.18%	48.42%
ndbappmysqld/db-infra-monitor-svc	0.58%	21.88%	0.83%	21.48%	0.58%	21.61%	0.75%	21.74%
ndbappmysqld/init-sidecar	2.00%	0.39%	2.00%	0.39%	2.00%	0.39%	2.00%	0.39%
ndbmgmd/mysqlndbcluster	0.11%	0.31%	0.11%	0.33%	0.11%	0.35%	0.12%	0.31%
ndbmgmd/db-infra-monitor-svc	0.50%	20.12%	0.50%	20.90%	0.50%	20.12%	0.50%	19.73%

Table 3-9 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
ndbmtd/mysqlndbcluster	11.69%	90.80%	3.28%	88.25%	3.81%	88.29%	2.85%	88.31%
ndbmtd/db-backup-executor-svc	1.00%	46.61%	1.00%	46.74%	1.00%	46.09%	1.00%	46.09%
ndbmtd/db-infra-monitor-svc	3.67%	21.09%	3.33%	21.03%	2.50%	20.96%	5.58%	21.03%
ndbmysqld/mysqlndbcluster	2.46%	23.48%	0.62%	20.86%	0.62%	20.87%	0.60%	20.86%
ndbmysqld/init-sidecar	2.00%	0.59%	2.00%	0.59%	2.00%	0.59%	2.00%	0.65%
ndbmysqld/db-infra-monitor-svc	1.17%	26.30%	1.08%	27.60%	1.08%	28.06%	1.25%	25.98%
mysql-cluster-two-four-replication-svc/two-four-replication-svc	-	-	0.50%	13.43%	-	-	-	-
mysql-cluster-two-one-replication-svc/two-one-replication-svc	-	-	0.30%	1.74%	-	-	-	-
mysql-cluster-two-one-replication-svc/db-infra-monitor-svc	-	-	0.50%	21.09%	-	-	-	-

Table 3-9 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-two-three-replication-svc/two-three-replication-svc	-	-	0.50%	13.28%	-	-	-	-
mysql-cluster-three-four-replication-svc/three-four-replication-svc	-	-	-	-	0.50%	13.48%	-	-
mysql-cluster-three-one-replication-svc/three-one-replication-svc	-	-	-	-	0.25%	1.73%	-	-
mysql-cluster-three-one-replication-svc/db-infra-monitor-svc	-	-	-	-	0.50%	20.31%	-	-
mysql-cluster-three-two-replication-svc/three-two-replication-svc	-	-	-	-	0.40%	13.48%	-	-
mysql-cluster-one-four-replication-svc/one-four-replication-svc	0.40%	13.18%	-	-	-	-	-	-

Table 3-9 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-one-three-replication-svc/one-three-replication-svc	0.50%	13.33%	-	-	-	-	-	-
mysql-cluster-one-two-replication-svc/one-two-replication-svc	0.30%	1.73%	-	-	-	-	-	-
mysql-cluster-one-two-replication-svc/db-infra-monitor-svc	0.50%	19.53%	-	-	-	-	-	-

Table 3-10 Read, Write, and Commit Operations for cnDBTier Services

Sites	Read Operations per Second	Write Operations per Second	Commit Operations per Second
Site1	1.24K	3.01K	3.02K
Site2	0.01K	3.00K	0.28K
Site3	0.01K	3.00K	0.28K
Site4	0.01K	3.00K	0.28K

3.1.2.1 Latency

The below table summarizes the average per-pod latency percentiles (50th and 99th) for microservice requests, indicating how fast or slow the requests are at different levels.

Table 3-11 Average Current Percentile Latency Observations (in milliseconds)

Services	50th Percentile (ms)	99th Percentile (ms)
Ingress Gateway	2	19
Egress Gateway	1	2
Diameter Gateway	<1	<1

3.2 Test Scenario: BSF Performance Benchmarking 54K TPS traffic on a Three-site Setup with Traffic on One Site (with ASM)

This test run benchmarks the capacity and performance of BSF call model that is deployed on a three-site setup with 54K TPS traffic on one site and ASM is enabled.

3.2.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-12 Testcase Parameters

Parameters	Values
Call Rate	54K TPS
Call Mix	4.5k nbsf Traffic and 50k Rx traffic
Traffic Ratio	Binding Create ratio -1 Binding Delete ratio - 1 Rx AAR-I ratio - 1 Rx RAR ratio - 1 Rx AAR-U ratio - 1 Rx STR ratio - 1
Active Binding Sessions	~50000000
Execution Time	~15 Hours

BSF Infrastructure Details

BSF infrastructure used for Benchmarking is described in this section.

Table 3-13 Hardware Details

Hardware	Details
Environment	Bare Metal
Server	ORACLE SERVER X9-2
Model	Intel(R) Xeon(R) Platinum 8358
Clock Speed	2.60 GHz
Total Cores	64
Memory Size	64 GB
Type	DIMM DDR4 Synchronous Registered(Buffered) 3200 MHz (0.3 ns)
Installed DIMMs	16
Maximum DIMMs	32
Installed Memory	1024 GB

Table 3-14 Software Details

Application	Version
BSF	25.1.100
cnDBTier	25.1.100
CNC Console	25.1.100
ASM	1.14.6
CNE	23.3.5

Table 3-15 Observability Services

Service Name	Version
Fluentd OpenSearch	1.16
Grafana	9.5.3
Jaeger	1.45.0
Oracle Opensearch	2.3.0
Oracle Opensearch Dashboard	2.3.0
Prometheus	2.44.0
Kubernetes	1.26.x

3.2.1.1 Resource Allocation

The following table describes the resource capacity allocated to the BSF microservices:

Table 3-16 BSF microservices Resource Allocation

Service Name	Replica Count (#)	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Istio CPU Request	Istio CPU Limit	Istio Memory Request (Gi)	Istio Memory Limit (Gi)
Appinfo	3	2	2	1	1	2	2	2	2
Audit Service	3	2	2	1	1	2	2	2	2
BSF Management Service	9	4	4	1	4	2	2	2	2
CM Service	3	4	4	1	2	2	2	2	2
Config Service	3	4	4	1	2	2	2	2	2
Diameter Gateway	8	4	4	2	2	2	2	2	2
Egress Gateway	3	4	4	4	6	2	2	2	2
Ingress Gateway	3	4	4	4	6	2	2	2	2

Table 3-16 (Cont.) BSF microservices Resource Allocation

Service Name	Replica Count (#)	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Istio CPU Request	Istio CPU Limit	Istio Memory Request (Gi)	Istio Memory Limit (Gi)
Nrf Client Management	2	1	1	1	1	2	2	2	2
Query Service	3	2	2	1	1	2	2	2	2
Performance	3	4	4	1	1	2	2	2	2

The following table describes the resource capacity allocated to the cnDBTier microservices:

Table 3-17 cnDBTier Services Resource Allocation

Microservice Name	Replica Count (#)	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Istio CPU Request	Istio CPU Limit	Istio Memory Request (Gi)	Istio Memory Limit (Gi)
ndbmgmd	2	3	3	10	10	2	2	2	2
ndbmtd	8	12	12	100	100	5	5	2	2
mysqld	4	4	4	16	16	4	4	4	4
appmysqld	3	12	12	20	20	5	5	6	6
db-monitor-service	1	0.2	0.2	0.5	0.5	2	2	2	2
db-replication-service	2	0.2	0.2	12	12	2	2	2	2
db-backup-service	1	0.1	0.1	0.128	0.128	0	0	0	0

3.2.2 Results

CPU and Memory Utilization

The following table describes the benchmarking number as per the system maximum capacity utilization for BSF Microservices.

Table 3-18 BSF Microservices and their Resource Utilization

Service	Site1 CPU	Site1 Memory	Site1 Istio CPU	Site1 Istio Memory	Site2 CPU	Site2 Memory	Site2 Istio CPU	Site2 Istio Memory	Site3 CPU	Site3 Memory	Site3 Istio CPU	Site3 Istio Memory
diam-gateway	14.7 (45.9 %)	9.13 (53.2 %)	2.76 (17.2 %)	3.19 (18.6 %)	0.196 (0.615 %)	7.29 (42.4 %)	0.037 (0.23 0 %)	2.90 (16.9 %)	0.191 (0.597 %)	7.01 (40 %)	0.036 (0.224 %)	2.85 (16.6 %)
Perfinfo	0.114 (0.952 %)	0.439 (13.6 %)	0.013 (0.209 %)	0.914 (14.2 %)	0.112 (0.940 %)	0.395 (12.2 %)	0.012 (0.198 %)	0.932 (14.5 %)	0.112 (0.976 %)	0.395 (12.3 %)	0.013 (0.211 %)	0.962 (14.9 %)
Appinfo	0.049 (0.821 %)	0.814 (25.3 %)	0.009 (0.145 %)	0.925 (14.4 %)	0.055 (0.891 %)	0.803 (24.9 %)	0.008 (0.134 %)	0.926 (14.4 %)	0.057 (0.953 %)	0.799 (24.8 %)	0.008 (0.133 %)	0.930 (14.4 %)
cm-service	0.013 (0.113 %)	1.99 (30.9 %)	0.017 (0.284 %)	1.02 (15.9 %)	0.139 (0.115 %)	2.01 (3.11 %)	0.015 (0.255 %)	1.04 (16.2 %)	0.014 (0.114 %)	2.01 (31.3 %)	0.015 (0.25 %)	1.04 (16.1 %)
Config-server	0.102 (0.85 %)	2.47 (38.2 %)	0.086 (1.45 %)	1.00 (15.6 %)	0.091 (0.755 %)	2.56 (39.7 %)	0.084 (1.40 %)	1.04 (16.1 %)	0.089 (0.723 %)	2.61 (40.6 %)	0.081 (1.35 %)	1.02 (15.9 %)
bsf-management-service	13.1 (36.3 %)	26.9 (69.6 %)	7.83 (43.5 %)	3.84 (19.8 %)	0.012 (0.033 %)	15.1 (39.0 %)	0.050 (0.280 %)	3.32 (17.2 %)	0.012 (0.085 %)	15.5 (40.0 %)	0.046 (0.253 %)	3.35 (17.3 %)
egress-gateway	0.006 (0.05 %)	2.71 (14 %)	0.011 (0.188 %)	1.07 (16.7 %)	0.005 (0.046 %)	2.16 (11.2 %)	0.012 (0.202 %)	1.08 (16.7 %)	0.006 (0.04 %)	2.14 (11.1 %)	0.009 36 (0.156 %)	1.07 (16.5 %)
ingress-gateway	3.35 (27.9 %)	8.37 (43.3 %)	2.17 (36.1 %)	1.65 (25.6 %)	0.034 (0.285 %)	4.19 (21.7 %)	0.017 (0.286 %)	1.08 (16.8 %)	0.033 (0.271 %)	4.18 (21.6 %)	0.015 (0.249 %)	1.09 (17.0 %)
nrf-client-nfmanagement	0.005 (0.27 %)	1.05 (49 %)	0.006 (0.142 %)	0.653 (15.2 %)	0.006 (0.279 %)	1.02 (47.7 %)	0.007 (0.173 %)	0.656 (15.3 %)	0.006 (0.286 %)	1.02 (47.7 %)	0.006 (0.142 %)	0.654 (15.2 %)
audit-service	0.008 (0.132 %)	1.62 (50.3 %)	0.007 (0.110 %)	0.933 (14.5 %)	0.003 (0.054 %)	1.46 (46.4 %)	0.006 (0.102 %)	0.942 (14.6 %)	0.003 (0.054 %)	1.49 (46.4 %)	0.008 (0.131 %)	0.940 (14.6 %)
queryservice	0.001 (0.023 %)	0.745 (23.1 %)	0.006 (0.097 %)	0.921 (14.3 %)	0.002 (0.034 %)	0.810 (25.2 %)	0.006 (0.102 %)	0.923 (14.3 %)	0.002 (0.027 %)	0.798 (24.8 %)	0.006 (0.107 %)	0.926 (14.4 %)

The following table provides information about cnDBTier resource utilization:

Table 3-19 cnDBTier Resource Utilization

Name	Site1 CPU	Site1 Memory	Site1 Istio CPU	Site1 Istio Memory	Site2 CPU	Site2 Memory	Site2 Istio CPU	Site2 Istio Memory	Site3 CPU	Site3 Memory	Site3 Istio CPU	Site3 Istio Memory
ndbappmysqld	17.6 (73.2 %)	14.3 (29.6 %)	5.54 (61.6 %)	1.19 (18.4 %)	0.141 (0.391 %)	8.22 (12.8 %)	0.131 (0.872 %)	1.19 (6.14 %)	0.139 (0.387 %)	8.19 (12.7 %)	0.132 (0.881 %)	1.18 (6.09 %)
ndbmtd	17.7 (73.9 %)	439 (79.9 %)	14.0 (156 %)	2.90 (45.1 %)	5.65 (15.7 %)	786 (91.5 %)	1.09 (7.27 %)	2.97 (15.3 %)	5.85 (16.2 %)	786 (91.4 %)	1.32 (8.80 %)	2.94 (15.2 %)
ndbmysqld	0.527 (0.371 %)	68.7 (9.98 %)	0.31 (0.530 %)	1.24 (3.40 %)	0.416 (0.270 %)	13.3 (1.31 %)	0.310 (0.414 %)	1.48 (2.55 %)	0.410 (0.267 %)	7.03 (0.694 %)	0.310 (0.414 %)	1.49 (2.57 %)

Table 3-20 cnDBTier Read, Write and Commit Operations

Sites	Read Operations per Second	Write Operations per Second	Commit Operations per Second
Site1	9.05K	6.08K	2.13K
Site2	-	-	-
Site3	-	-	-

3.3 Test Scenario: BSF Performance Benchmarking 63K TPS Traffic on a Three-site Setup with Traffic on One Site (with ASM)

This test run benchmarks the performance and capacity of BSF call model that is deployed on a three-site setup with 63K TPS traffic on one site and ASM is enabled.

3.3.1 Test Case and Setup Details

Table 3-21 Test Case Parameters

Parameters	Values
Call Rate	63K TPS
Call Mix	8.43K nbsf traffic and 54.7K Rx traffic
Traffic Ratio	Binding Create ratio -1 Binding Delete ratio - 1 Binding Get ratio (Discovery) - 0.15 Rx AAR-I ratio - 1 Rx RAR ratio - 1 Rx AAR-U ratio - 1 Rx STR ratio - 1
Active Subscribers	32M

Table 3-21 (Cont.) Test Case Parameters

Parameters	Values
Execution Time	~72 hours

BSF Infrastructure Details

BSF infrastructure used for Benchmarking is described in this section.

Table 3-22 Hardware Details

Hardware	Details
Environment	BareMetal
Server	ORACLE SERVER X9-2
Model	Intel(R) Xeon(R) Platinum 8358 CPU
Clock Speed	2.600 GHz
Total Cores	64
Memory Size	1024 GB
Type	DDR4 SDRAM
Installed DIMMs	16
Maximum DIMMs	32
Installed Memory	1024 GB

Table 3-23 Software Details

Applications	Version
BSF	25.2.200
cnDBTier	25.2.200
CNC Console	25.2.200
OSO	25.2.200-rc2
ASM	1.14.6-am9
CNE	23.3.4

Table 3-24 Observability Services

Service Name	Version
Oracle Opensearch	2.3.0
Fluentd	1.9.4
Oracle Opensearch Dashboard	2.3.0
Prometheus	2.44.0
Grafana	9.1.7
Jaeger	1.45.0
Kubernetes	1.26.x

3.3.1.1 Resource Allocation

The following table describes the resource capacity allocated to the BSF microservices:

Table 3-25 BSF Microservices Resource Allocation

Service Name	Replica Count (#)	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Istio CPU Request	Istio CPU Limit	Istio Memory Request (Gi)	Istio Memory Limit (Gi)
Appinfo	3	2	2	1	1	2	2	2	2
BSF Management Service	14	4	4	1	4	2	2	2	2
Alternate Route Service	3	2	2	2	4	2	2	2	2
Configuration Service	3	4	4	1	2	2	2	2	2
Egress Gateway	3	4	4	4	6	2	2	2	2
Ingress Gateway	7	4	4	4	6	2	2	2	2
NRF Client NF Management	3	1	1	1	1	2	2	2	2
Audit Service	3	2	2	1	1	2	2	2	2
CM Service	3	4	4	1	2	2	2	2	2
Query Service	3	2	2	1	1	2	2	2	2
Perfinfo	3	4	4	1	1	2	2	2	2
Diameter Gateway	15	4	4	1	2	2	2	2	2

The following table describes the resource capacity allocated to the cnDBTier microservices:

Table 3-26 cnDBTier Microservices Resource Allocation

Microservices	Replica Count (#)	CPU Limit Per Pod	CPU Request Per Pod	Memory Limit Per Pod	Memory Request Per Pod
mysql-cluster-db-backup-manager-svc/db-backup-manager-svc	1	100m	100m	128Mi	128Mi
mysql-cluster-db-monitor-svc/istio-proxy	1	5	5	5Gi	5Gi

Table 3-26 (Cont.) cnDBTier Microservices Resource Allocation

Microservices	Replica Count (#)	CPU Limit Per Pod	CPU Request Per Pod	Memory Limit Per Pod	Memory Request Per Pod
mysql-cluster-db-monitor-svc/db-monitor-svc	1	4	4	4Gi	4Gi
mysql-cluster-one-four-replication-svc/istio-proxy	1	5	5	5Gi	5Gi
mysql-cluster-one-four-replication-svc/one-four-replication-svc	1	2	2	12Gi	12Gi
mysql-cluster-one-three-replication-svc/istio-proxy	1	5	5	5Gi	5Gi
mysql-cluster-one-three-replication-svc/one-three-replication-svc	1	2	2	12Gi	12Gi
mysql-cluster-one-two-replication-svc/istio-proxy	1	2	2	2Gi	2Gi
mysql-cluster-one-two-replication-svc/one-two-replication-svc	1	2	2	12Gi	12Gi
mysql-cluster-one-two-replication-svc/db-infra-monitor-svc	1	200m	200m	256Mi	256Mi
ndbappmysqld/istio-proxy	9	5	5	5Gi	5Gi
ndbappmysqld/mysqlndbcluster	9	8	8	15Gi	15Gi
ndbappmysqld/db-infra-monitor-svc	9	200m	200m	256Mi	256Mi
ndbappmysqld/init-sidecar	9	100m	100m	256Mi	256Mi
ndbmgmd/istio-proxy	2	1	1	2Gi	2Gi
ndbmgmd/mysqlndbcluster	2	3	3	10Gi	10Gi

Table 3-26 (Cont.) cnDBTier Microservices Resource Allocation

Microservices	Replica Count (#)	CPU Limit Per Pod	CPU Request Per Pod	Memory Limit Per Pod	Memory Request Per Pod
ndbmgmd/db-infra-monitor-svc	2	200m	200m	256Mi	256Mi
ndbmtd/istio-proxy	12	5	5	5Gi	5Gi
ndbmtd/mysqlndbcluster	12	12	12	64Gi	64Gi
ndbmtd/db-backup-executor-svc	12	100m	100m	128Mi	128Mi
ndbmtd/db-infra-monitor-svc	12	200m	200m	256Mi	256Mi
ndbmysqld/istio-proxy	6	5	5	5Gi	5Gi
ndbmysqld/mysqlndbcluster	6	4	4	16Gi	16Gi
ndbmysqld/init-sidecar	6	100m	100m	256Mi	256Mi
ndbmysqld/db-infra-monitor-svc	6	200m	200m	256Mi	256Mi

The following table describes the features that were either enabled or disabled for this run:

Table 3-27 BSF Features

Feature Name	Feature Status
Audit	Enabled
Overload	Enabled
dnssrv	Enabled
Controlled Shutdown	Enabled
NF Scoring	Enabled
SBI Routing	Enabled

3.3.2 Results

CPU and Memory Utilization

The following table describes the benchmarking number as per the system maximum capacity utilization for BSF microservices.

Table 3-28 BSF Microservices and their Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
Appinfo Istio	0.17%	15.54%	0.15%	15.66%	0.17%	15.67%	0.15%	15.56%
Appinfo	1.07%	28.12%	1.02%	27.41%	1.07%	27.60%	1.05%	27.73%
BSF Management Service Istio	32.46%	19.55%	0.61%	18.61%	0.49%	18.36%	0.30%	18.09%
BSF Management Service	27.72%	57.52%	0.29%	29.99%	0.27%	27.82%	0.06%	44.49%
Alternate Route Service Istio	0.12%	16.86%	0.15%	17.11%	0.15%	16.42%	0.17%	16.62%
Alternate Route Service	0.10%	17.17%	0.10%	17.10%	0.10%	14.94%	0.10%	14.53%
Configuration Service Istio	2.40%	17.37%	2.30%	17.74%	2.23%	17.07%	2.37%	16.93%
Configuration Service	0.99%	37.79%	0.92%	37.14%	0.92%	35.11%	1.01%	36.02%
Egress Service Istio	0.87%	17.95%	0.55%	17.87%	0.58%	17.81%	0.17%	17.63%
Egress Gateway	0.70%	15.36%	1.82%	14.73%	1.89%	15.08%	0.06%	13.34%
Ingress Gateway Istio	28.91%	23.73%	0.28%	19.63%	0.25%	21.91%	0.21%	17.42%
Ingress Gateway	21.32%	39.88%	0.25%	38.49%	0.28%	31.97%	0.23%	16.66%
NRF Client NF Management Istio	0.17%	16.59%	0.15%	16.46%	0.17%	17.01%	0.15%	16.39%
NRF Client NF Management	0.23%	45.64%	0.20%	41.34%	0.23%	41.63%	0.23%	43.62%
Audit Service Istio	0.45%	16.02%	0.47%	15.79%	0.50%	16.19%	0.20%	15.89%
Audit Service	0.28%	49.12%	0.27%	47.88%	0.25%	48.96%	0.10%	37.76%

Table 3-28 (Cont.) BSF Microservices and their Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
CM Service Istio	0.38%	17.43%	0.42%	17.46%	0.37%	17.81%	0.38%	17.22%
CM Service	0.17%	50.28%	0.16%	46.27%	0.15%	46.09%	0.18%	53.35%
Query Service Istio	0.13%	15.40%	0.12%	15.82%	0.13%	15.74%	0.12%	15.66%
Query Service	0.05%	33.98%	0.05%	34.15%	0.05%	34.08%	0.05%	34.47%
Perfinfo Istio	0.27%	15.51%	0.25%	15.71%	0.25%	15.62%	0.23%	15.48%
Perfinfo	1.03%	14.03%	0.92%	13.64%	0.98%	13.67%	0.99%	13.77%
Diameter Gateway Istio	24.13%	18.62%	0.43%	18.15%	0.44%	18.11%	0.58%	17.98%
Diameter Gateway	27.71%	58.13%	0.35%	36.18%	0.35%	37.76%	0.30%	27.73%

The following table provides information about cnDBTier resource utilization:

Table 3-29 cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-db-backup-manager-svc/db-backup-manager-svc	1.00%	79.69%	1.00%	92.19%	1.00%	79.69%	1.00%	81.25%
mysql-cluster-db-monitor-svc/istio-proxy	0.06%	6.46%	0.08%	6.17%	0.08%	6.60%	0.08%	6.27%
mysql-cluster-db-monitor-svc/db-monitor-svc	0.10%	25.39%	0.10%	19.46%	0.12%	19.82%	0.95%	21.56%

Table 3-29 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-one-four-replication-svc/istio-proxy	0.08%	6.31%	-	-	-	-	-	-
mysql-cluster-one-four-replication-svc/one-four-replication-svc	0.30%	2.64%	-	-	-	-	-	-
mysql-cluster-one-three-replication-svc/istio-proxy	0.06%	6.23%	-	-	-	-	-	-
mysql-cluster-one-three-replication-svc/one-three-replication-svc	0.30%	2.40%	-	-	-	-	-	-
mysql-cluster-one-two-replication-svc/istio-proxy	0.15%	15.82%	-	-	-	-	-	-
mysql-cluster-one-two-replication-svc/one-two-replication-svc	0.30%	8.37%	-	-	-	-	-	-
mysql-cluster-one-two-replication-svc/db-infra-monitor-svc	0.50%	20.31%	-	-	-	-	-	-
ndbappmysqld/istio-proxy	20.28%	7.98%	0.58%	8.04%	0.59%	7.99%	0.49%	8.13%

Table 3-29 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
ndbappmysqld/mysqlndbcluster	25.57%	27.51%	0.39%	26.59%	0.42%	26.87%	0.32%	25.72%
ndbappmysqld/db-infra-monitor-svc	0.78%	21.79%	0.89%	21.70%	0.67%	21.61%	0.67%	21.57%
ndbappmysqld/init-sidecar	2.00%	0.39%	2.00%	0.39%	2.00%	0.39%	2.00%	0.43%
ndbmgmd/istio-proxy	0.65%	15.53%	0.60%	15.70%	0.60%	15.82%	0.70%	15.21%
ndbmgmd/mysqlndbcluster	0.17%	20.37%	0.18%	20.37%	0.18%	20.38%	0.18%	20.37%
ndbmgmd/db-infra-monitor-svc	0.50%	20.51%	0.50%	20.31%	0.50%	20.51%	0.50%	20.70%
ndbmtd/istio-proxy	45.52%	7.67%	3.12%	7.48%	3.87%	7.63%	2.97%	7.57%
ndbmtd/mysqlndbcluster	30.56%	86.37%	5.83%	85.80%	6.84%	85.80%	6.40%	85.84%
ndbmtd/db-backup-executor-svc	2.83%	57.29%	1.00%	48.11%	1.00%	46.81%	1.00%	46.61%
ndbmtd/db-infra-monitor-svc	3.12%	20.90%	2.21%	21.06%	2.17%	21.03%	2.08%	21.03%
ndbmysqld/istio-proxy	2.34%	7.76%	1.52%	7.76%	1.54%	7.67%	1.47%	7.65%
ndbmysqld/mysqlndbcluster	4.08%	26.73%	2.25%	24.21%	2.38%	23.84%	2.40%	23.54%
ndbmysqld/init-sidecar	2.00%	0.98%	2.00%	0.65%	2.00%	0.78%	2.00%	0.72%
ndbmysqld/db-infra-monitor-svc	1.17%	25.00%	1.08%	23.96%	0.83%	23.31%	0.83%	24.09%

Table 3-29 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-four-one-replication-svc/istio-proxy	-	-	-	-	-	-	0.15%	15.58%
mysql-cluster-four-one-replication-svc/four-one-replication-svc	-	-	-	-	-	-	0.30%	2.76%
mysql-cluster-four-one-replication-svc/db-infra-monitor-svc	-	-	-	-	-	-	0.50%	20.31%
mysql-cluster-four-three-replication-svc/istio-proxy	-	-	-	-	-	-	0.06%	6.19%
mysql-cluster-three-four-replication-svc/istio-proxy	-	-	-	-	0.06%	6.31%	-	-
mysql-cluster-four-three-replication-svc/four-three-replication-svc	-	-	-	-	-	-	0.25%	2.32%
mysql-cluster-four-two-replication-svc/istio-proxy	-	-	-	-	-	-	0.08%	6.23%

Table 3-29 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-three-four-replication-svc/three-four-replication-svc	-	-	-	-	0.30%	2.32%	-	-
mysql-cluster-three-one-replication-svc/istio-proxy	-	-	-	-	0.15%	15.38%	-	-
mysql-cluster-three-one-replication-svc/three-one-replication-svc	-	-	-	-	0.20%	2.43%	-	-
mysql-cluster-three-one-replication-svc/db-infra-monitor-svc	-	-	-	-	0.50%	19.53%	-	-
mysql-cluster-three-two-replication-svc/istio-proxy	-	-	-	-	0.08%	6.48%	-	-
mysql-cluster-three-two-replication-svc/three-two-replication-svc	-	-	-	-	0.30%	2.67%	-	-
mysql-cluster-four-two-replication-svc/four-two-replication-svc	-	-	-	-	-	-	0.30%	2.38%

Table 3-29 (Cont.) cnDBTier Resource Utilization

Microservices	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory	Site4 CPU	Site4 Memory
mysql-cluster-two-four-replication-svc/istio-proxy	-	-	0.06%	6.33%	-	-	-	-
mysql-cluster-two-four-replication-svc/two-four-replication-svc	-	-	0.25%	2.34%	-	-	-	-
mysql-cluster-two-one-replication-svc/istio-proxy	-	-	0.15%	16.26%	-	-	-	-
mysql-cluster-two-one-replication-svc/two-one-replication-svc	-	-	0.30%	2.51%	-	-	-	-
mysql-cluster-two-one-replication-svc/db-infra-monitor-svc	-	-	0.50%	19.53%	-	-	-	-
mysql-cluster-two-three-replication-svc/istio-proxy	-	-	0.06%	6.27%	-	-	-	-
mysql-cluster-two-three-replication-svc/two-three-replication-svc	-	-	0.25%	2.47%	-	-	-	-

Table 3-30 Read, Write, and Commit Operations for cnDBTier Services

Sites	Read Operations per Second	Write Operations per Second	Commit Operations per Second
Site1	7.298K	5.254K	1.934K
Site2	2.387K	7.244K	0.037K
Site3	1.834K	5.569K	0.059K

3.3.2.1 Latency

The below table summarizes the average per-pod latency percentiles (50th and 99th) for microservice requests, indicating how fast or slow the requests are at different levels.

Table 3-31 Average Current Percentile Latency Observations (in milliseconds)

Services	50th Percentile (ms)	99th Percentile (ms)	
Ingress Gateway	0.007	0.015	
Egress Gateway	0.001	0.002	
Diameter Gateway	<1	<1	