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 25.1.100

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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 25.1.1xx.

Release 25.1.100 - G31365-01, April 2025

- Updated the deployed components in the Deployment Environment section. For more information, see Deployed Components section.
- Added the following new BSF Performance Benchmarking test scenario:
  - Test Scenario 9: BSF Performance Benchmarking 54K TPS traffic on a three-site Setup with traffic on one Site (25 Million Binding Sessions)
  - Test Scenario 10: BSF Performance Benchmarking 54K TPS traffic on a three-site Setup with traffic on one Site (50 Million Binding Sessions)

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 Environment (CNE) 23.3.5 and BareMetal can be used for performing benchmark tests.

Table 2-1 Observability Services

Service Name	Version
Oracle Opensearch	2.3.0
Fluentd	1.16
Oracle Opensearch Dashboard	2.3.0
Prometheus	2.44.0
Grafana	9.5.3
Jaeger	1.45.0

The following binding schema has been used for this test scenario:

```
CREATE TABLE `pcf_binding` (
  `binding_id` binary(16) NOT NULL,
  `ipv4_addr` varchar(64) DEFAULT NULL,
  `ip_domain` varchar(128) DEFAULT NULL,
  `ipv6_prefix` varchar(64) DEFAULT NULL,
  `mac_addr_48` varchar(64) DEFAULT NULL,
  `dnn` varchar(128) DEFAULT NULL,
  `supi` varchar(64) DEFAULT NULL,
  `gpsi` varchar(64) DEFAULT NULL,
  `snssai_sd` varchar(64) DEFAULT NULL,
  `snssai_sst` int DEFAULT NULL,
  `created_date_time` datetime(6) NOT NULL,
  `json_content` longblob NOT NULL,
  `last_access_timestamp` bigint unsigned DEFAULT NULL,
  `site_id` varchar(128) DEFAULT NULL,
  `audit_attempts` bigint unsigned DEFAULT NULL,
  `last_audited_date_time` datetime DEFAULT NULL,
  PRIMARY KEY (`binding_id`),
  KEY `idx_audit_datetime` (`last_audited_date_time`),
  KEY `idx_created_date_time` (`created_date_time`),
  KEY `idx_ipv4Addr` (`ipv4_addr`,`created_date_time`),
```

```
  KEY `idx_ipv6Prefix` (`ipv6_prefix`,`created_date_time`),
  KEY `idx_macAddr48` (`mac_addr_48`,`created_date_time`),
  KEY `idx_supi` (`supi`,`created_date_time`),
  KEY `idx_gpsi` (`gpsi`,`created_date_time`)
) ENGINE=ndbcluster DEFAULT CHARSET=utf8mb3;
```

Cloud Native Orchestrator

Kubernetes 1.26.x is used to manage application pods across the cluster.

cnDBTier

cnDBTier 25.1.100 is used for performing benchmark tests.

BSF Infrastructure Details

BSF infrastructure used for Benchmarking is described in this section.

Table 2-2 Hardware Details

Hardware	Details
Environment	BareMetal
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 2-3 Software Details

Applications	Version
BSF	25.1.100
ASM	1.14.6
cnDBTier	25.1.100
CNE	23.3.5

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

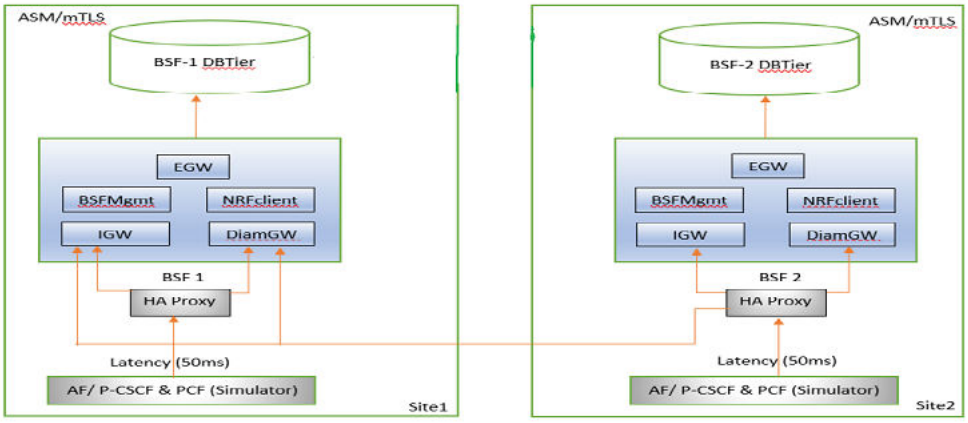
This chapters describes BSF Application related test scenarios that are validated for benchmarking BSF.

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 Scenario1: BSF Call Flow Model on Two-Site GeoRedundant (GR) setup, with 15K TPS on each site

BSF Call Flow Model: BSF Performance Benchmark for 15kTPS on a ASM enabled two-site georedundant setup. The following image represents the BSF Deployed Environment for two Sites.

Figure 3-1 Two-Site BSF Deployment



3.1.1 Test Case and Setup Details

Table 3-1 Test Case Parameters

Parameters	Values
Call Rate	30K TPS (15k TPS each BSF Instance)
Call Mix	2.1k nbsf Traffic (1.05k each site) and 27.9k Rx traffic (13.95k each site)

Table 3-1 (Cont.) Test Case Parameters

Parameters	Values
Traffic Ratio	**Nbsf TPS - 1.05k Each Site** Binding Create ratio -1 Binding Delete ratio - 1 **Rx TPS - 13.95k Each Site** Rx AAR-I ratio - 1 Other Rx messages ratio (UPDATE and STR) - 2
Active Binding Sessions	~15000000
Execution Time	11 Hours
Site Redundancy	Two-Site deployment with replication enabled

Table 3-2 Resource Footprint for BSF Microservices

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replicas
appinfo	1	1	0.5	1	2
audit-service	1	2	1	1	2
Bsf Management Service	3	4	1	4	10
cm-service	2	4	0.5	2	2
config server	2	4	0.5	2	2
Diameter Gateway	3	4	1	2	10
Egress Gateway	3	4	4	4	2
Ingress Gateway	3	4	2	4	3
nrf-client-nfmanagement	1	1	1	1	2
queryservice	1	2	1	1	2
performance	1	1	0.5	1	2

> **Note**
>
> Min Replica = Max Replica

Table 3-3 Resource Footprint for cnDBTier Microservices

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replica Count	PVC
Management node	4	4	8	10	3	ndbdisksize: 15Gi

Table 3-3 (Cont.) Resource Footprint for cnDBTier Microservices

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replica Count	PVC
Data node	10	10	96	112	10	ndbdisksize: 125Gi ndbbackupdisksize: 288Gi
mysqld	4	4	8	8	2	ndbdisksize: 50Gi
appmysqld	8	8	2	2	7	ndbdisksize: 16Gi
db-replication-service	0.2	0.2	0.5	0.5	1	ndbdisksize: 20Gi

> **Note**
>
> Min Replica = Max Replica

Table 3-4 BSF Feautures

Features Name	Feature Status(Enabled/Disabled)
Nbsf	Enabled
Rx	Enabled

3.1.2 CPU and Memory Utilization

This section lists the CPU and memory utilization for BSF and cnDBTier.

Table 3-5 BSF Microservices and their Resource Utilization - Site1 and Site2

Service	CPU-Site1	CPU - Site2	Memory - Site1	Memory - Site2
db-backup-manager-svc	0 (0%)	0 (0%)	0.03 (23.44%)	0.03 (23.44%)
db-monitor-svc	0.01 (5%)	0.01 (5%)	0.25 (50%)	0.23 (46%)
delhi-mumbai-replication-svc	0 (0%)	0 (0%)	0.42 (84%)	0.0 (0%)
init-sidecar	0 (0%)	0 (0%)	0 (0%)	0 (0%)
mysqlndbcluster	7.9 (14.11%)	7.4 (13.21%)	5.26 (37.57%)	5.07 (36.21%)
mysqlndbcluster	0.03 (0.25%)	0.03 (0.25%)	0.07 (0.23%)	0.07 (0.23%)
db-backup-executor-svc	0 (0%)	0 (0%)	0 (0%)	0 (0%)
mysqlndbcluster	8.96 (8.96%)	8.72 (8.72%)	471.79 (42.12%)	471.78 (42.12%)
init-sidecar	0 (0%)	0 (0%)	0 (0%)	0 (0%)
mysqlndbcluster	0.34 (4.25%)	0.36 (4.5%)	1.74 (10.88%)	1.76 (11%)
appinfo	0.03 (1.5%)	0.03 (1.5%)	0.44 (22%)	0.44 (22%)

Table 3-5 (Cont.) BSF Microservices and their Resource Utilization - Site1 and Site2

Service	CPU-Site1	CPU - Site2	Memory - Site1	Memory - Site2
bsf-management-service	7.58 (18.95%)	7.24 (18.1%)	12.92 (32.3%)	14.13 (35.33%)
diam-gateway	7.45 (18.63%)	7.12 (17.8%)	8.96 (44.8%)	8.95 (44.75%)
config-server	0.15 (1.88%)	0.14 (1.75%)	1.55 (38.75%)	1.64 (41%)
ocbsf-egress-gateway	0.01 (0.13%)	0.01 (0.13%)	1.32 (16.5%)	1.33 (16.63%)
ocbsf-ingress-gateway	1.49 (12.42%)	1.38 (11.5%)	6.77 (56.42%)	5.13 (42.75%)
nrf-client-nfmanagement	0.01 (0.5%)	0.01 (0.5%)	0.92 (46%)	0.79 (39.5%)
audit-service	0.01 (0.25%)	0.01 (0.25%)	0.7 (35%)	0.72 (36%)
cm-service	0.02 (0.25%)	0.01 (0.13%)	1.72 (43%)	1.66 (41.5%)
queryservice	0 (0%)	0 (0%)	0.5 (25%)	0.54 (27%)
ocbsf-performance/perf-info	0 (0%)	0.01 (0.5%)	0.14 (7%)	0.1 (5%)

Table 3-6 Observed Values of cnDBTier Services

Name	Targets
ndbappmysqld	36%/80%
ndbmgmd	0%/80%
ndbmtd	15%/80%
ndbmysqld	6%/80%
ocbsf-appinfo	1%/80%
ocbsf-bsf-management	39%/80%
ocbsf-config-server	7%/80%
ocbsf-egress-gateway	0%/80%
ocbsf-ingress-gateway	22%/80%
ocbsf-nrf-client-nfmanagement	0%/80%
ocbsf-query-service	0%/80%

3.1.3 TPS and DB Statistics

This section lists the TPS (Transactions Per Second) and DB (Database) Statistics for BSF and cnDBTier.

Table 3-7 Overall TPS Ingress/Egress TPS to/from NF

Site	Rx	nbsf	Total TPS
Site1	13.95K	1.05k	15K
Site2	13.95K	1.05k	15K

Table 3-8 DB (Database) Statisitics

DB Stats	Site1	Site2
Read Rate	5.94k	5.60k
Write Rate	11.6k	11.7k
Commit Rate	6.18k	5.85k

3.1.4 Results

Table 3-9 Latency Observations

Attributes	Average Latency (ms)
Binding Create	7.6 ms
AAR-RX-INIT	11.1 ms
AAR-RX-UPDATE	1.5 ms
RX-STR	0.7 ms

3.2 Test Scenario 2: BSF Call Flow Model Performance deployed on Single Site, with 30K TPS and ASM enabled

This test run benchmarks the performance and capacity of BSF data call model. The BSF application handles an incoming traffic of 30K TPS with replication enabled. For this setup Aspen Service Mesh (ASM) was enabled.

3.2.1 Test Case and Setup Details

Table 3-10 Test Case Parameters

Parameters	Values
Call Rate	30K TPS
Call Mix	2.1k nbsf Traffic and 27.9k Rx traffic
Traffic Ratio:	**Nbsf TPS - 2100** Binding Create ratio -1 Binding Delete ratio - 1 **Rx TPS - 27900** Rx AAR-I ratio - 1 Other Rx messages ratio (UPDATE and STR) - 2
Active User/Sessions	~15000000
Execution Time	14 Hours

Table 3-11 BSF Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replicas
appinfo	1	1	0.5	1	2
audit-service	1	2	1	1	2
Bsf Management Service	3	4	1	4	10
cm-service	2	4	0.5	2	2
config server	2	4	0.5	2	2
Diameter Gateway	3	4	1	2	10
Egress Gateway	3	4	4	4	2
Ingress Gateway	3	4	2	4	3
nrf-client-nfmanagement	1	1	1	1	2
queryservice	1	2	1	1	2
performance	1	1	0.5	1	2

Table 3-12 cnDBTier Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replica Count
Management node	4	4	8	10	3
Data node	10	10	96	112	10
mysqld	4	4	8	8	2
appmysqld	8	8	2	2	7
db-monitor-service	0.2	0.2	0.5	0.5	1
db-replication-service	0.2	0.2	0.5	0.5	1
db-backup-service	0.2	0.2	0.128	0.128	1

Table 3-13 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

3.2.2 CPU and Memory Utilization

This section lists the CPU and memory utilization for BSF and cnDBTier.

Table 3-14 BSF Services and their Resource Utilization

Microservices	Container Count	CPU	Memory
db-backup-manager-svc	1	0 (0%)	0.03 (23.44%)
db-monitor-svc	1	0.01 (5%)	0.25 (50%)
init-sidecar	7	0 (0%)	0 (0%)
mysqlndbcluster	7	7.9 (14.11%)	5.26 (37.57%)
mysqlndbcluster	3	0.03 (0.25%)	0.07 (0.23%)
db-backup-executor-svc	10	0 (0%)	0 (0%)
mysqlndbcluster	10	8.96 (8.96%)	471.79 (42.12%)
init-sidecar	2	0 (0%)	0 (0%)
mysqlndbcluster	2	0.34 (4.25%)	1.74 (10.88%)
appinfo	2	0.03 (1.5%)	0.44 (22%)
bsf-management-service	10	7.58 (18.95%)	12.92 (32.3%)
diam-gateway	10	7.45 (18.63%)	8.96 (44.8%)
config-server	2	0.15 (1.88%)	1.55 (38.75%)
ocbsf-egress-gateway	2	0.01 (0.13%)	1.32 (16.5%)
ocbsf-ingress-gateway	3	1.49 (12.42%)	6.77 (56.42%)
nrf-client-nfmanagement	2	0.01 (0.5%)	0.92 (46%)
audit-service	2	0.01 (0.25%)	0.7 (35%)
cm-service	2	0.02 (0.25%)	1.72 (43%)
queryservice	2	0 (0%)	0.5 (25%)
perf-info	2	0 (0%)	0.14 (7%)
delhi-mumbai-replication-svc	1	0 (0%)	0.42 (84%)

Table 3-15 cnDBTier Services and their Resource Utilization

Name	Targets	MinPods	MaxPods
ndbappmysqld	35%/80%	7	7
ndbmgmd	0%/80%	3	3
ndbmtd	21%/80%	10	10
ndbmysqld	5%/80%	2	2
ocbsf-appinfo	1%/80%	2	2
ocbsf-bsf-management	67%/80%	10	10
ocbsf-config-server	6%/80%	2	2
ocbsf-egress-gateway	0%/80%	2	2
ocbsf-ingress-gateway	41%/80%	3	3
ocbsf-nrf-client-nfmanagement	0%/80%	2	2
ocbsf-query-service	0%/80%	2	2

3.2.3 TPS and DB Statistics

This section lists the TPS (Transactions Per Second) and DB (Database) Statistics for BSF.

Table 3-16 TPS Statistics

Site	Rx	nbsf	Total TPS
Site1	27.9k	2.1k	30K

Table 3-17 DB(Database) Records

DB Stats	Site
Read Rate	11.1k
Write Rate	11.7k
Commit Rate	11.9k

3.2.4 Results

Table 3-18 Latency Observations

Attributes	Average Latency (ms)
Binding Create	8.1 ms
Binding Delete	8.5 ms
AAR-RX-INIT	12.2 ms
AAR-RX-UPDATE	0.8 ms
RX-STR	0.7 ms

3.3 Test Scenario 3: BSF Call Model deployed on Three-Site GeoRedundant (GR) setup, with 35K TPS and ASM enabled

This test run benchmarks the performance and capacity of BSF data call model that is deployed on a three-site georedundant setup. At each site, nbsf interface handles 1.2k TPS traffic and Rx interface handles 10.4k TPS traffic. For this setup Aspen Service Mesh (ASM) was enabled.

3.3.1 Test Case and Setup Details

Table 3-19 Test Case Parameters

Parameters	Values
Call Rate	35K TPS
Call Mix	3.6k nbsf traffic (1.2k each site) and 31.2k Rx traffic (10.4k each site)
Traffic Ratio:	**Nbsf TPS - 1.2k each Site** Binding Create ratio -1 Binding Delete ratio - 1 **Rx TPS - 10.4k each Site** Rx AAR-I ratio - 1 Other Rx messages ratio (UPDATE and STR) - 2

Table 3-19 (Cont.) Test Case Parameters

Parameters	Values
Active User/Sessions	~18.5M
Execution Time	14 Hours

Table 3-20 BSF Microservices Resource

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replicas
Appinfo	1	1	0.5	1	3
Audit Service	1	2	1	1	3
Bsf Management Service	3	4	1	4	8
CM Service	2	4	0.5	2	3
Config Service	2	4	0.5	2	3
Diameter Gateway	3	4	0.5	2	9
Egress Gateway	3	4	4	6	3
Ingress Gateway	3	4	4	6	3
Nrf Client Management	1	1	1	1	3
Query Service	1	2	1	1	3
Performance	3	4	0.5	1	3

> **Note**
>
> Min Replica = Max Replica

Table 3-21 cnDBTier Microservices Resource

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replicas
Management node	3	3	8	10	2
Data node	12	12	64	73	14
mysqld	4	4	16	16	4
appmysqld	12	12	20	20	2
db-monitor-service	0.2	0.2	0.5	0.5	1
db-replication-service	0.2	0.2	12	12	2

Table 3-21 (Cont.) cnDBTier Microservices Resource

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Replicas
db-backup-service	0.1	0.128	0.128	0.128	1

> **Note**
>
> Min Replica = Max Replica

Table 3-22 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

3.3.2 CPU and Memory Utilization

This section lists the CPU and memory utilization for BSF and cnDBTier microservices. The CPU utilization is the ratio between the (total CPU utilization against total CPU request (X)) versus (target CPU Utilization (Y) set configured for the pod).

Table 3-23 BSF Microservices CPU and Memory Utilization

Service	CPU Site1	CPU Site2	CPU Site3	Memory Site1	Memory Site2	Memory Site3
Appinfo	0.04 (1.33%)	0.04 (1.33%)	0.05 (1.67%)	0.67 (22.33%)	0.67 (22.33%)	0.67 (22.33%)
Audit Service	0.01 (0.17%)	0.01 (0.17%)	0.01 (0.17%)	0.92 (30.67%)	0.9 (30%)	0.9 (30%)
CM Service	0.02 (0.17%)	0.02 (0.17%)	0.02 (0.17%)	1.42 (23.67%)	1.29 (21.5%)	1.39 (23.17%)
Bsf Management Service	5.28 (16.5%)	5.3 (16.56%)	4.92 (15.38%)	8.34 (26.06%)	8 (25%)	7.53 (23.53%)
Diameter Gateway	5.62 (15.61%)	5.37 (14.92%)	5.39 (14.97%)	6.63 (36.83%)	6.5 (36.11%)	6.35 (35.28%)
Egress Gateway	0.01 (0.08%)	0.01 (0.08%)	0.01 (0.08%)	1.97 (16.42%)	2.04 (17%)	1.97 (16.42%)
Ingress Gateway	1.36 (11.33%)	1.49 (12.42%)	1.46 (12.17%)	4.45 (37.08%)	4.47 (37.25%)	4.66 (38.83%)
Nrf Client Management	0.01 (0.33%)	0.01 (0.33%)	0.01 (0.33%)	0.95 (31.67%)	0.95 (31.67%)	0.96 (32%)
Query Service	0 (0%)	0 (0%)	0 (0%)	0.66 (22%)	0.66 (22%)	0.66 (22%)
Perf Info	0.02 (0.67%)	0.08 (2.67%)	0.09 (3%)	0.3 (10%)	0.3 (10%)	0.3 (10%)

Table 3-24 cnDBTier Microservices CPU and Memory Utilization

Service	CPU Site1	CPU Site2	CPU Site3	Memory Site1	Memory Site2	Memory Site3
ndbappmysqld	5.46 (34.13%)	5.69 (35.56%)	5.15 (32.19%)	3.18 (79.5%)	3.12 (78%)	2.96 (74%)
ndbmtd	10.29 (7.35%)	9.34 (6.67%)	8.56 (6.11%)	662.41 (42.25%)	662.4 (42.24%)	662.38 (42.24%)
ndbmysqld	0.54 (3.38%)	0.47 (2.94%)	0.46 (2.88%)	4.35 (13.59%)	4.3 (13.44%)	4.24 (13.25%)
db-backup-manager-svc	0 (0%)	0 (0%)	0 (0%)	0.04 (31.25%)	0.04 (31.25%)	0.04 (31.25%)
db-monitor-svc	0.01 (5%)	0.01 (5%)	0.01 (5%)	0.24 (48%)	0.27 (54%)	0.24 (48%)

3.3.3 TPS and DB Statistics

This section lists the TPS (Transactions Per Second) and DB (Database) statistics for BSF.

Table 3-25 TPS Statistics

Site	Rx	nbsf	Total TPS
Site1	10.04k	1.2k	11.6k
Site2	10.04k	1.2k	11.6k
Site3	10.04k	1.2k	11.6k

Table 3-26 Database Records

DB Statistics	Site1	Site2	Site3
Read Rate	8.77k	8.77k	8.08k
Write Rate	13.4k	14.1k	13.5k
Commit Rate	9.67k	9.51k	8.79k

3.3.4 Results

Table 3-27 Latency Observations

Attributes	Average Latency (ms)
Binding Create	7.4 ms
AAR-RX-INIT	13.7 ms
AAR-RX-UPDATE	0.9 ms
RX-STR	0.9 ms

3.4 Test Scenario 4: BSF Call Model deployed on Single Site setup, with 35K TPS traffic and ASM enabled

This test run benchmarks the performance and capacity of BSF call model that is deployed on a single site setup with Aspen Service Mesh (ASM) enabled. In the setup, nbsf interface handles 3.6k TPS and Rx interface hanldes 31.2K TPS traffic respectively.

3.4.1 Test Case and Setup Details

Table 3-28 Test Case Parameters

Parameters	Values
Call Rate	35K TPS
Call Mix	3.6k nbsf and 31.2k Rx traffic
Traffic Ratio:	**Nbsf TPS - 3.6k** Binding Create ratio -1 Binding Delete ratio - 1 **Rx TPS - 31.2k** Rx AAR-I ratio - 1 Other Rx messages ratio (UPDATE and STR) - 2
Active User/Sessions	~18.5M
Execution Time	45 Hours

Table 3-29 BSF Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isitio CPU Limit	Isitio Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	1	1	0.5	1	2	2	2	2	3
Audit Service	1	2	1	1	2	2	2	2	3
BSF Management Service	3	4	1	4	2	2	2	2	10
CM Service	2	4	0.5	2	2	2	2	2	3
Config Service	2	4	0.5	2	2	2	2	2	3
Diameter Gateway	3	4	0.5	2	2	2	2	2	9
Egress Gateway	3	4	4	6	2	2	2	2	3
Ingress Gateway	3	4	4	6	2	2	2	2	3

Table 3-29 (Cont.) BSF Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isitio CPU Limit	Isitio Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Nrf Client Management	1	1	1	1	2	2	2	2	3
Query Service	1	2	1	1	2	2	2	2	3
Performance	3	4	0.5	1	2	2	2	2	3

> **Note**
>
> Min Replica = Max Replica

Table 3-30 cnDBTier Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Management node	3	3	8	10	2	2	2	2	2
Data node	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3
db-monitor-service	0.2	0.2	0.5	0.5	2	2	2	2	1
db-replication-service	0.2	0.2	12	12	2	2	2	2	2
db-backup-service	0.1	0.1	0.128	0.128	0	0	0	0	1

> **Note**
>
> Min Replica = Max Replica

Table 3-31 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

Table 3-32 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	5	Specifies the number of execution threads used by ndbmtd.
datamemory	78 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.
SERVER_XNIO_TASK_THREAD_SIZE	180	Specifies the BSF management service server thread size count.

3.4.2 CPU and Memory Utilization

This section lists the CPU and memory utilization for BSF and cnDBTier microservices. The CPU utilization is the ratio between the (total CPU utilization against total CPU request (X)) versus (target CPU Utilization (Y) configured for the pod).

Table 3-33 BSF Microservices CPU and Memory Utilization

Service	CPU	Memory
Appinfo	0.0405(1.35%)	0.736(22.9%)
Audit Service	0.0147(0.245%)	1.18(36.6%)
Bsf Management Service	16.6(41.5%)	19.3(44.9%)
CM Service	0.0364(0.303%)	2.19(34.0%)
Config Server	0.134(1.19%)	2.08(32.3%)
Diameter Gateway	14.0(38.8%)	9.01(46.6%)
Egress Gateway	0.0189(0.158%)	1.94(10.0%)
Ingress Gateway	3.61(0.158%)	7.99(41.3%)
Nrf Client Management	0.0180(0.600%)	1.26(39.2%)
Query Service	0.00911(0.152%)	0.854(26.5%)
Perf Info	0.0251(0.209%)	0.354(11.0%)

Table 3-34 cnDBTier Microservices CPU and Memory Utilization.

Service	CPU	Memory
ndbappmysqld	16.8(46.6%)	2.94(11.6%)
ndbmtd	7.66(21.3%)	5.31(90.5%)
ndbmysqld	0.818(0.835%)	0.831(7.39%)
db-backup-manager-svc	0.00353(3.53%)	3.42(54.6%)
db-monitor-svc	0.0122(6.10%)	5.48(50.6%)
replication-svc	0.0811(0.405%)	5.32(3.30%)

3.4.3 TPS and DB Statistics

This section lists the TPS (Transactions Per Second) and DB (Database) statistics for BSF.

Table 3-35 TPS Statistics

Site	Rx	nbsf	Total TPS
Site1	31.2k	3.6k	34.8k

Table 3-36 Database Records

DB Statistics	Site1
Read Rate	11.8k
Write Rate	12.9k
Commit Rate	13.0k

3.4.4 Results

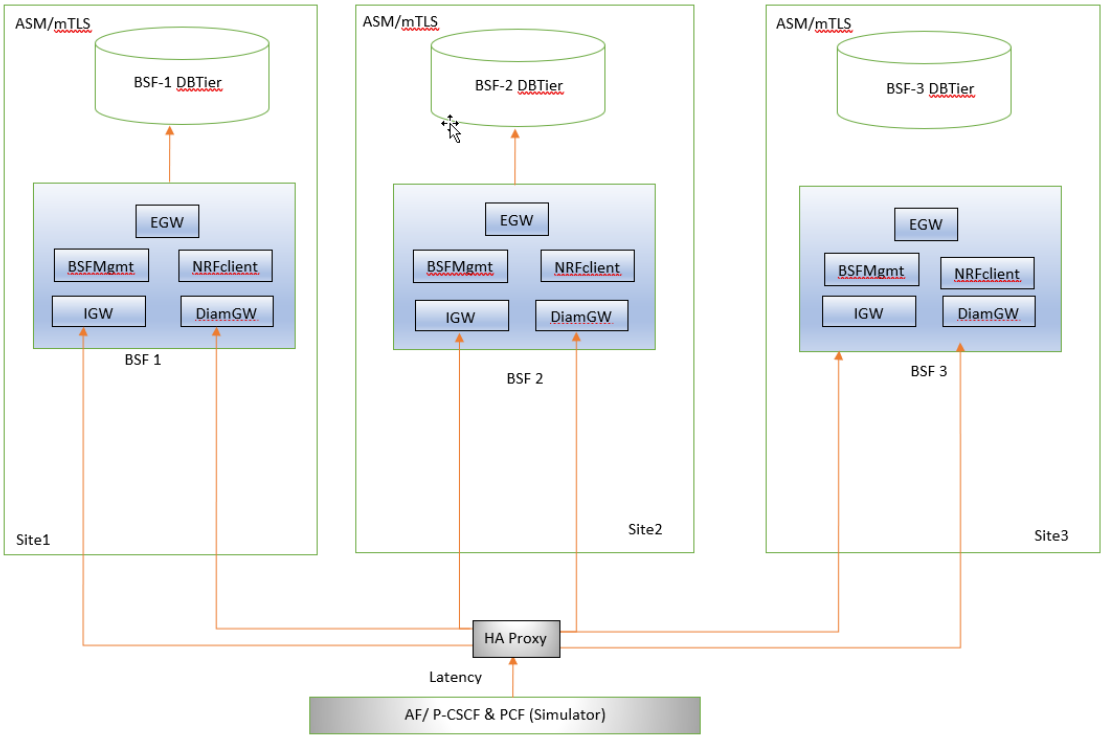
Table 3-37 Latency Observations

Attributes	Average Latency (ms)
Binding Create	7.6 ms
Binding Delete	8.9 ms
AAR-RX-INIT	13.9 ms
AAR-RX-UPDATE	0.8 ms
RX-STR	0.7 ms

3.5 Test Scenario 5: BSF Performance Benchmarking 47.7K TPS traffic on three-site Setup

BSF Call Flow Model: BSF Performance Benchmark for 47.7k TPS on a ASM enabled three-site georedundant setup. The following image represents the BSF deployment on a ASM enabled three-site georedundant setup.

Figure 3-2 Three-Site BSF Deployment



3.5.1 Test Case and Setup Details

Table 3-38 Test Case Parameters

Parameters	Values
Call Rate	47.7K TPS (Approximately, 16k TPS each site)
Call Mix	7.2k nbsf traffic (2.4K each site) and 40.5K Rx traffic (13.5K each site)
Traffic Ratio	**Nbsf TPS - 2.4K Each Site** Binding Create ratio -1 Binding Delete ratio - 1 **Rx TPS - 13.5K Each Site** Rx AAR-I ratio - 1 Other Rx messages ratio (UPDATE and STR) - 2
Active Binding Sessions	~18500000
Execution Time	58 Hours

Table 3-39 BSF Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isitio CPU Limit	Isitio Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	1	1	0.5	1	2	2	2	2	3

Table 3-39 (Cont.) BSF Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isitio CPU Limit	Isitio Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Audit Service	1	2	1	1	2	2	2	2	3
BSF Management Service	3	4	1	4	2	2	2	2	10
CM Service	2	4	0.5	2	2	2	2	2	3
Config Service	2	4	0.5	2	2	2	2	2	3
Diameter Gateway	3	4	0.5	2	2	2	2	2	9
Egress Gateway	3	4	4	6	2	2	2	2	3
Ingress Gateway	3	4	4	6	2	2	2	2	3
Nrf Client Management	1	1	1	1	2	2	2	2	3
Query Service	1	2	1	1	2	2	2	2	3
Performance	3	4	0.5	1	2	2	2	2	3

> **Note**
>
> Min Replica = Max Replica

Table 3-40 cnDBTier Microservices Resource Allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Management node	3	3	8	10	2	2	2	2	2
Data node	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

> **Note**
>
> Min Replica = Max Replica

Table 3-41 BSF Feautures

Features Name	Feature Status (Enabled/Disabled)
Nbsf	Enabled
Rx	Enabled

Table 3-42 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	5	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	78 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.
SERVER_XNIO_TASK_THREAD_SIZE	180	Specifies the BSF management service server thread size count.

3.5.2 CPU and Memory Utilization

This section lists the CPU and memory utilization for BSF and cnDBTier microservices. The CPU utilization is the ratio between the (total CPU utilization against total CPU request (X)) versus (target CPU Utilization (Y) configured for the pod).

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

Table 3-43 BSF Microservices and their Resource Utilization

Service	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory
queryservice	0.00145(0.0241%)	788(24.5%)	0.00130(0.0217%)	790(24.5%)	0.00130(0.0217%)	791(24.6%)
perf-info	0.117(0.977%)	434(13.5%)	0.117(0.973%)	4.34(13.5%)	0.116(0.967%)	447(13.9%)

Table 3-43 (Cont.) BSF Microservices and their Resource Utilization

Service	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory
nrf-client-nfmanagement	0.00457(0.152%)	1.52(47.3%)	0.00519(0.173%)	1.50(46.6%)	0.00471(0.157%)	1.50(46.7%)
ingress-gateway	1.42(11.8%)	7.06(36.5%)	1.49(12.4%)	6.95(35.9%)	1.47(12.2%)	6.40(33.1%)
egress-gateway	0.00499(0.0416%)	2.49(12.9%)	0.00446(0.0371%)	2.82(14.6%)	0.00444(0.0370%)	2.69(13.9%)
diam-gateway	5.63(15.6%)	9.66(50.0%)	5.53(15.3%)	9.57(49.5%)	5.63(15.6%)	9.41(48.7%)
config-server	0.0935(0.779%)	2.50(38.9%)	0.0910(0.759%)	2.52(39.2%)	0.0890(0.742%)	2.70(42.0%)
cm-service	0.0131(0.109%)	2.08(32.2%)	0.0133(0.111%)	2.01(31.2%)	0.0128(0.107%)	2.12(32.8%)
bsf-management-service	4.24(10.6%)	15.8(36.7%)	4.37(10.9%)	15.1(35.3%)	4.30(10.7%)	16.8(39.1%)
audit-service	0.00524(0.0874%)	1.16(36.1%)	0.00497((0.0828%)	1.17(36.4%)	0.00530(0.0883%)	1.18(36.5%)
appinfo	0.0463(1.54%)	786(24.4%)	0.0466(1.55%)	797(24.7%)	0.0473(1.58%)	791(24.6%)

The following table provides information about observed values of cnDBTier services.

Table 3-44 Observed Values of cnDBTier Services

Name	Site1 CPU	Site1 Memory	Site2 CPU	Site2 Memory	Site3 CPU	Site3 Memory
ndbappmysqld	4.86(13.5%)	17.3(26.8%)	5.23(14.5%)	17.3(26.9%)	5.20(14.4%)	17.2(26.7%)
ndbmtd	4.16(11.6%)	692(80.6%)	4.48(12.4%)	691(80.5%)	4.26(11.8%)	691(80.5%)
ndbmysqld	0.329(0.214%)	67.9(6.70%)	0.337(0.219%)	67.7(6.68%)	0.327(0.212%)	67.5(6.66%)

3.5.3 TPS and DB Statistics

This section lists the TPS (Transactions Per Second) and DB (Database) Statistics for BSF and cnDBTier.

Table 3-45 Overall TPS Ingress/Egress TPS to/from NF

Site	Rx	nbsf	Total TPS
Site1	13.5K	2.4K	15.9K
Site2	13.5K	2.4K	15.9K
Site3	13.5K	2.4K	15.9K

Table 3-46 DB (Database) Statisitics

DB Stats	Read Rate	Write Rate	Commit Rate
Site1	4.97K	20.3K	6.92K
Site2	5.02K	20.3K	6.92K
Site3	4.97K	20.3K	7.01K

3.5.4 Results

Table 3-47 Latency Observations

Attributes	Average Latency (ms)
Binding Create	5.2ms
Binding Delete	4.9ms
AAR-RX-INIT	8.48ms
AAR-RX-UPDATE	0.7ms
RX-STR	0.7ms

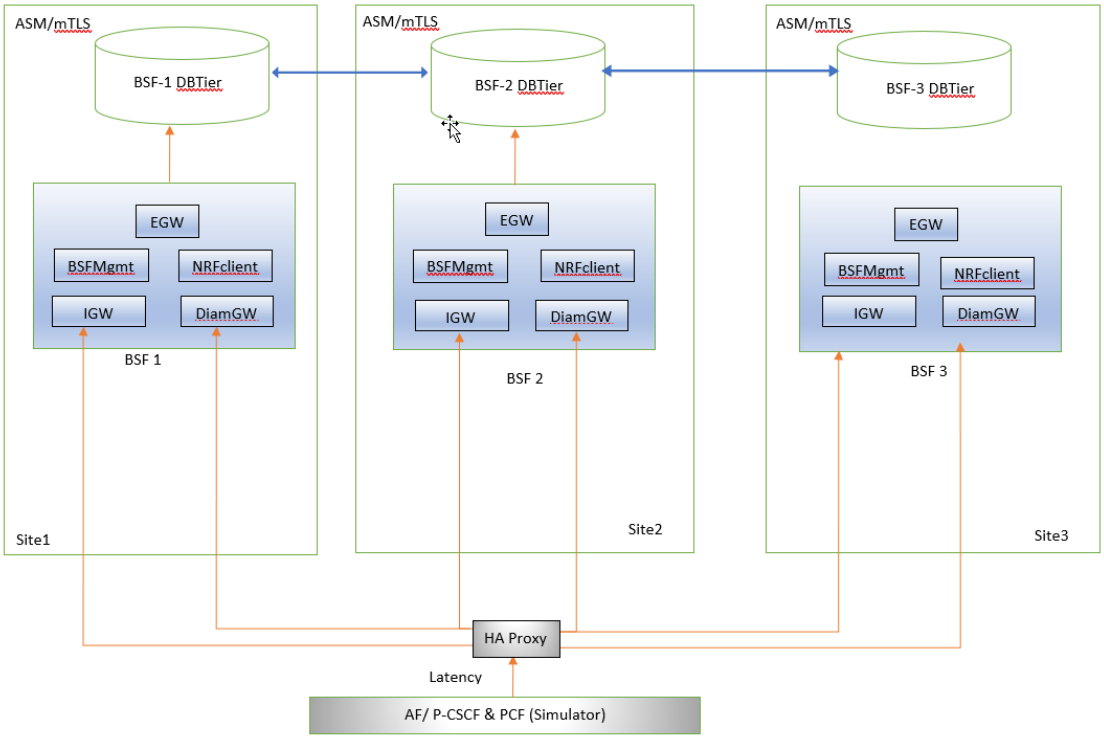
3.6 Test Scenario 6: BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on one Site

BSF Call Flow Model

BSF Performance Benchmark for 45kTPS on an ASM enabled three-site georedundant setup with traffic on one site.

The following image represents the BSF deployment on an ASM enabled three-site georedundant setup:

Figure 3-3 ASM enabled three-site georedundant setup



3.6.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-48 Testcase Parameters

Parameters	Values
Call Rate	45K TPS
Call Mix	Approximately, 3.6k nbsf traffic and 41.4k Rx traffic on one site
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	~25000000
Execution Time	~7 Hours

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

Table 3-49 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	1	1	1	1	2	2	2	2	4
Audit Service	2	2	1	1	2	2	2	2	4
BSF Management Service	4	4	4	4	2	2	2	2	9
CM Service	4	4	2	2	2	2	2	2	4
Config Service	4	4	2	2	2	2	2	2	4
Diameter Gateway	4	4	2	2	2	2	2	2	10
Egress Gateway	4	4	6	6	2	2	2	2	4
Ingress Gateway	4	4	6	6	2	2	2	2	4
Nrf Client Management	1	1	1	1	2	2	2	2	4
Query Service	2	2	1	1	2	2	2	2	4
Performance	4	4	1	1	2	2	2	2	4

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

Table 3-50 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
Management node	3	3	10	10	2	2	2	2	2
Data node	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-51 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-52 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	5	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	78 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.6.2 CPU and Memory Utilization

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

Table 3-53 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	14.2(35.5%)	9.38 Bil(43.7%)	3.11(15.5%)	1.96 Bil(9.13%)	-	-	-	-	-	-	-	-
Perfinfo	0.148(0.924%)	591 Mil(13.7%)	0.317(3.96%)	756 Mil(8.81%)	-	-	-	-	-	-	-	-
Appinfo	0.105(2.63%)	2.12 Bil(49.4%)	0.293(3.66%)	1.35 Bil(15.7%)	-	-	-	-	-	-	-	-

Table 3-53 (Cont.) 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
cm-service	0.0201(0.126%)	2.80 Bil(32.6%)	0.327((4.08%)	779 Nil(9.06%)	-	-	-	-	-	-	-	-
Config-server	0.0940(0.588%)	3.22 Bil((37.5%)	0.368((4.60%)	758 Mil(8.82%)	-	-	-	-	-	-	-	-
bsf-management-service	12.0(33.3%)	25.4 Bil(65.8%)	9.00(50.0%)	1.87 Bil(9.67%)	-	-	-	-	-	-	-	-
egress-gateway	0.00893(0.0558%)	3.22 Bil(12.5%)	0.280(3.50%)	762 Mil(8.87%)	-	-	-	-	-	-	-	-
ingress-gateway	2.81(17.6%)	7.83 Bil(30.4%)	2.08(26.0%)	832 Mil(9.68%)	-	-	-	-	-	-	-	-
nrf-client-nfmanagement	0.0106(0.265%)	1.95 Bil(45.5%)	0.299(3.74%)	769 Mil(8.96%)	-	-	-	-	-	-	-	-
audit-service	0.0539(0.673%)	1.70 Bil((39.6%)	0.294(3.68%)	779 Mil(9.07%)	-	-	-	-	-	-	-	-
query service	0.00163(0.0204%)	1.06 Bil(24.8%)	0.277(3.47%)	748 Mil(8.71%)	-	-	-	-	-	-	-	-

The following table provides information about observed values of cnDBTier services.

Table 3-54 Observed Values of cnDBTier Services

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	13.8 (38.3%)	41.1 Bil (63.8%)	6.47 (40.5%)	786 Mil (4.08%)	-	-	-	-	-	-	-	-
ndbmtd	7.85 (21.8%)	73.3 Bil (85.3%)	8.94 (54.9%)	1.78 Bil (9.30%)	-	-	-	-	-	-	-	-

Table 3-54 (Cont.) Observed Values of cnDBTier Services

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
ndbmysqld	0.366 (0.238 %)	68.7 Bil (6.78 %)	0.503 (0.286 %)	769 Mil (1.33 %)	-	-	-	-	-	-	-	-

3.6.3 TPS and DB Statistics

Table 3-55 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	45K	41.4K	3.6K
Site 2	-	-	-
Site 3	-	-	-

Observed values of cnDBTier Record counts:

Table 3-56 Database Records

DB Statistics	Read	Write	Commit
Site1	12.9K	14K	14.2K
Site2	-	-	-
Site3	-	-	-

3.6.4 Results

Table 3-57 Results

Attributes	Average Latency (ms)
Binding Create	7.3
Binding Delete	6.55
AAR-RX-INIT	8.4
RX-RAR	0.81
AAR-RX-UPDATE	1.07
RX-STR	0.77

Table 3-58 Average NF Latency

NF	50th Percentile (Site 1)	99th Percentile (Site 1)
Ingress Gateway	6.05 ms	16.2 ms
Egress Gateway	1.03 ms	1.15 ms

Table 3-58 (Cont.) Average NF Latency

NF	50th Percentile (Site 1)	99th Percentile (Site 1)
Diameter Gateway	-	0.368 ms

3.7 Test Scenario 7: BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on Two Site

BSF Call Flow Model: BSF Performance Benchmark for 45kTPS on an ASM enabled three-site georedundant setup with traffic on two sites

3.7.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-59 Testcase Parameters

Parameters	Values
Call Rate	45K TPS
Call Mix	3.6k nbsf**(**1.8K on each each site**)** traffic and 41.4k (20.7K each site) Rx traffic on a ASM enabled Setup.
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	~25000000
Execution Time	~17 Hours

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

Table 3-60 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	1	1	1	1	2	2	2	2	4
Audit Service	2	2	1	1	2	2	2	2	4
BSF Management Service	4	4	4	4	2	2	2	2	9
CM Service	4	4	2	2	2	2	2	2	4

Table 3-60 (Cont.) BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Config Service	4	4	2	2	2	2	2	2	4
Diameter Gateway	4	4	2	2	2	2	2	2	10
Egress Gateway	4	4	6	6	2	2	2	2	4
Ingress Gateway	4	4	6	6	2	2	2	2	4
Nrf Client Management	1	1	1	1	2	2	2	2	4
Query Service	2	2	1	1	2	2	2	2	4
Performance	4	4	1	1	2	2	2	2	4

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

Table 3-61 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
Management node	3	3	10	10	2	2	2	2	2
Data node	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-62 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-63 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	5	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	78 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.7.2 CPU and Memory Utilization

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

Table 3-64 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	7.74 (19.3 %)	7.85 Bil (36.5 %)	1.11 (5.54 %)	1.86 Bil (8.66 %)	8.42 (21.0 %)	7.94 Bil (37.0 %)	1.35 (6.44 %)	1.84 Bil (8.55 %)	-	-	-	-
Perfinfo	0.166 (1.04 %)	5.79 Mil (13.5 %)	0.0246 (0.307 %)	710 Mil (8.27 %)	0.167 (1.04 %)	579 Mil (13.5 %)	0.0264 (0.265 %)	713 Mil (8.30 %)	-	-	-	-
Appinfo	0.0951 (2.38 %)	1.07 Bil (24.9 %)	0.0186 (0.232 %)	728 Mil (8.48 %)	0.107 (2.66 %)	1.06 Bil (24.7 %)	0.0191 (0.143 %)	726 Mil (8.45 %)	-	-	-	-
cm-service	0.0222 (0.139 %)	2.82 Bil (32.8 %)	0.0233 (0.291 %)	742 Mil (8.64 %)	0.0161 (0.100 %)	2.77 Bil (32.3 %)	0.0223 (0.211 %)	722 Mil (8.40 %)	-	-	-	-
Config-server	0.0940 (0.588 %)	3.61 Bil (42.0 %)	0.0953 (1.19 %)	737 Mil (8.58 %)	0.0891 (0.557 %)	3.44 Bil (40.0 %)	0.0885 (1.00 %)	730 Mil (8.49 %)	-	-	-	-

Table 3-64 (Cont.) 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
bsf-management-service	5.54 (15.4 %)	25.4 Bil (65.7 %)	3.74 (20.8 %)	1.73 Bil (8.97 %)	6.43 (17.9 %)	25.8 Bil (66.7 %)	4.38 (23.6 %)	1.71 Bil (8.85 %)	-	-	-	-
egress-gateway	0.0163 (0.102 %)	3.23 Bil (12.5 %)	0.00980 (0.122 %)	719 Mil (8.37 %)	0.0134 (0.0839%)	3.07 Bil (11.9 %)	0.0110 (0.0644%)	712 Mil (8.39 %)	-	-	-	-
ingress-gateway	1.37 (8.55 %)	9.65 Bil (37.4 %)	0.859 (10.7 %)	964 Mil (11.2 %)	1.45 (9.05 %)	9.40 Bil (36.5 %)	0.890 (9.87 %)	850 Mil (9.90 %)	-	-	-	-
nrf-client-nfmanagement	0.00892 (0.223 %)	1.96 Bil (45.6 %)	0.0151 (0.188 %)	748 Mil (8.71 %)	0.00871 (0.218 %)	1.96 Bil (45.6 %)	0.0157 (0.119 %)	727 Mil (8.46 %)	-	-	-	-
audit-service	0.0105 (0.131 %)	1.80 Bil (42.0 %)	0.0121 (0.151 %)	754 Mil (8.77 %)	0.0103 (0.129 %)	1.73 Bil (40.2 %)	0.0139 (0.949 %)	715 Mil (8.33 %)	-	-	-	-
query service	0.00303 (0.0379%)	1.06 Bil (24.8 %)	0.0105 (0.132)	725 Mil (8.44 %)	0.00240 (0.0300%)	1.04 Bil (24.1 %)	0.0114 (0.788 %)	715 Mil (8.32 %)	-	-	-	-

The following table provides information about observed values of cnDBTier services.

Table 3-65 Observed Values of cnDBTier Services

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	6.27 (16.4 %)	38.8 Bil	3.03 (20.2 %)	770 Mil (3.94 %)	7.58 (21.1 %)	38.8 Bil (60.3 %)	3.56 (23.7 %)	774 Mil (4.01 %)	-	-	-	-
ndbmtd	5.00 (12.9 %)	750 Bil	4.62 (30.8 %)	1.75 Bil (8.93 %)	5.44 (15.1 %)	748 Bil (87.1 %)	5.07 (33.8 %)	1.75 Bil (9.05 %)	-	-	-	-
ndbmysqld	0.628 (0.190 %)	68.7 Bil	0.202 (0.270 %)	747 Mil (1.23 %)	0.305 (0.198 %)	68.7 Bil (6.78 %)	0.192 (0.256 %)	755 Mil (1.30 %)	-	-	-	-

3.7.3 TPS and DB Statistics

Table 3-66 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	22.5k	20.7k	1.8k
Site2	22.5k	20.7k	1.8k
Site 3	-	-	-

Observed values of cnDBTier Record counts:

Table 3-67 Database Records

DB Statistics	Read	Write	Commit
Site1	6.25k	14k	6.59k
Site2	7.38k	14.1k	7.84k
Site3	-	-	-

3.7.4 Results

Table 3-68 Results

Attributes	Average Latency (ms)
Binding Create	5.85
Binding Delete	5.17
AAR-RX-INIT	6.73
RX-RAR	0.51
AAR-RX-UPDATE	0.57
RX-STR	0.49

Table 3-69 Average NF Latency

NF	50th Percentile (Site 1)	99th Percentile (Site 1)	50th Percentile (Site 2)	99th Percentile (Site 2)
Ingress Gateway	4.97 ms	7.93 ms	5.21 ms	9.20 ms
Egress Gateway	1.39 ms	1.54 ms	1.95 ms	2.09 ms
Diameter Gateway	-	0.0639 ms	-	0.0866 ms

3.8 Test Scenario 8: BSF Performance Benchmarking 45K TPS traffic on a three-site Setup with traffic on three Sites

BSF Call Flow Model: BSF Performance Benchmark for 45kTPS on an ASM enabled three-site georedundant setup with traffic on three sites.

3.8.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-70 Testcase Parameters

Parameters	Values
Call Rate	45K TPS
Call Mix	Approximately, 3.6k nbsf traffic and 41.4k 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	~25000000
Execution Time	~40 Hours

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

Table 3-71 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	1	1	1	1	2	2	2	2	4
Audit Service	2	2	1	1	2	2	2	2	4
BSF Management Service	4	4	4	4	2	2	2	2	9
CM Service	4	4	2	2	2	2	2	2	4
Config Service	4	4	2	2	2	2	2	2	4
Diameter Gateway	4	4	2	2	2	2	2	2	10
Egress Gateway	4	4	6	6	2	2	2	2	4
Ingress Gateway	4	4	6	6	2	2	2	2	4
Nrf Client Management	1	1	1	1	2	2	2	2	4
Query Service	2	2	1	1	2	2	2	2	4

Table 3-71 (Cont.) BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Performance	4	4	1	1	2	2	2	2	4

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

Table 3-72 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
Management node	3	3	10	10	2	2	2	2	2
Data node	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-73 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-74 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	5	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	78 GB	Specifes the cnDBTier ndb data memory capacity configuration.
cnDBTier App node (ndbappmysqld) istio side car parameter (proxy.istio.io/config)	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.

Table 3-74 (Cont.) Configuring Helm Parameters

cnDBTier Parameter	Value	Description
cnDBTier Data node (ndbmtd) istio side car parameter (proxy.istio.io/config)	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.8.2 CPU and Memory Utilization

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

Table 3-75 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	5.88 (14.7 %)	8.73 Bil (40.6 %)	0.973 (4.87 %)	2.14 Bil (9.97 %)	5.58 (14.0 %)	8.38 Bil (37.5 %)	0.883 (4.42 %)	2.01 Bil (9.36 %)	5.73 (14.3 %)	8.44 Bil (39.3 %)	0.952 (4.76 %)	1.95 Bil (9.09 %)
Perfinfo	0.174 (1.09 %)	608 Mil (14.2 %)	0.0302 (0.377 %)	745 Mil (8.67 %)	0.172 (1.07 %)	579 Mil (13.5 %)	0.0353 (0.441 %)	757 Mil (8.81 %)	0.168 (1.05 %)	567 Mil (13.2 %)	0.0330 (0.413 %)	749 Mil (8.72 %)
Appinfo	0.107 (2.67 %)	1.07 Bil (24.9 %)	0.0257 (0.322 %)	745 Mil (8.67 %)	0.119 (2.98 %)	1.06 Bil (24.7 %)	0.0238 (0.298 %)	754 Mil (8.78 %)	0.104 (2.60 %)	1.07 Bil (24.8 %)	0.0251 (0.314 %)	756 Mil (8.80 %)
cm-service	0.0204 (0.128 %)	2.85 Bil (33.2 %)	0.0325 (0.406 %)	776 Mil (9.03 %)	0.0183 (0.114 %)	2.78 Bil (32.3 %)	0.0313 (0.392 %)	748 Mil (8.70 %)	0.0199 (0.125 %)	2.92 Bil (34.0 %)	0.0313 ((0.391%)	755 Mil (8.79 %)
config-server	0.107 (0.670 %)	3.70 Bil (43.1 %)	0.105 (1.31 %)	760 Mil (8.85 %)	0.102 (0.635 %)	3.54 Bil (41.3 %)	0.101 (1.26 %)	751 Mil (8.75 %)	0.0988 (0.617 %)	3.46 Bil (40.3 %)	0.103 (1.29 %)	777 Mil (9.04 %)
bsf-management-service	4.37 (12.1 %)	28.5 Bil (73.8 %)	2.95 (16.4 %)	1.96 Bil (10.1 %)	4.20 (11.7 %)	26.7 Bil (69.0 %)	2.77 (15.4 %)	1.85 Bil (9.57 %)	4.28 (11.9 %)	25.3 Bil (65.5 %)	2.81 (15.6 %)	1.85 Bil (9.57 %)
egress-gateway	0.0118 (0.0737%)	3.30 Bil (12.8 %)	0.0204 (0.255 %)	743 Mil (8.65 %)	0.00856 (0.0535%)	3.14 Bil (12.2 %)	0.0170 (0.213 %)	746 Mil (8.69 %)	0.0107 (0.0668%)	3.38 Bil (13.1 %)	0.0183 (0.229 %)	741 Mil (8.63 %)

Table 3-75 (Cont.) 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
ingress-gateway	1.03 (6.46 %)	10.3 Bil (40.1 %)	0.626 (7.82 %)	1.23 Bil (14.3 %)	1.11 (6.92 %)	9.71 Bil (37.7 %)	0.662 (8.27 %)	973 Mil (11.3 %)	0.994 (6.21 %)	6.98 Bil (27.1 %)	0.636 (7.95 %)	865 Mil (10.1 %)
nrf-client-nfmanagement	0.0161 (0.403 %)	1.97 Bil (45.9 %)	0.0212 (0.265 %)	764 Mil (8.90 %)	0.0157 (0.391 %)	1.97 Bil (45.8 %)	0.0242 (0.302 %)	754 Mil (8.78 %)	0.0139 ((0.348%)	1.97 Bil (46.0 %)	0.0215 (0.269 %)	766 Mil (8.92 %)
audit-service	0.0499 (0.624 %)	1.88 Bil (43.7 %)	0.0358 (0.448 %)	774 Mil (9.01 %)	0.0541 (0.676 %)	1.89 Bil (43.9 %)	0.0446 (0.558 %)	751 Mil (8.75 %)	0.0180 (0.225 %)	1.85 Bil (43.1 %)	0.0194 (0.243 %)	741 Mil (8.62 %)
query service	0.00297 (0.0371%)	1.06 Bil (24.8 %)	0.0183 (0.228 %)	745 Mil (8.67 %)	0.00260 (0.0325%)	1.04 Bil (24.1 %)	0.0196 (0.245 %)	740 Mil (8.61 %)	0.00262 (0.0327%)	1.05 Bil (24.5 %)	0.0179 (0.223 %)	738 Mil (8.59 %)

The following table provides information about observed values of cnDBTier services.

Table 3-76 Observed Values of cnDBTier Services

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	4.93 (13.7 %)	59.9 Bil (93.0 %)	2.45 (16.3 %)	791 Mil (4.09 %)	14.8 (41.2 %)	60.2 Bil (85.6 %)	2.34 (15.6 %)	789 Mil (4.08 %)	4.89 (13.6 %)	47.5 Bil (75.3 %)	2.45 (16.4 %)	786 Mil (4.06 %)
ndbmtd	4.88 (13.6 %)	770 Bil (89.7 %)	4.10 (27.3 %)	1.81 Bil (9.38 %)	4.98 (13.7 %)	770 Bil (89.7 %)	3.94 (26.3 %)	1.80 Bil (9.31 %)	4.98 (13.8 %)	742 Bil (86.8 %)	4.09 (27.3 %)	1.85 Bil (9.59 %)
ndbmysqld	0.338 (0.220 %)	68.7 (6.78 %)	0.206 (0.274 %)	776 Mil (1.34 %)	0.320 (0.208 %)	68.7 Bil (6.61 %)	0.209 (0.278 %)	786 Mil (1.36 %)	0.369 (0.240 %)	39.8 Bil (5.14 %)	0.209 (0.279 %)	770 Mil (1.33 %)

3.8.3 TPS and DB Statistics

Table 3-77 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	15k	13.8k	1.2k
Site2	15k	13.8k	1.2k
Site3	15k	13.8k	1.2k

Observed values of cnDBTier Record counts:

Table 3-78 Database Records

DB Statistics	Read	Write	Commit
Site1	4.86k	14k	4.96k
Site2	4.66k	14.1k	4.76k
Site3	4.74k	14k	4.92k

3.8.4 Results

Table 3-79 Results

Attributes	Average Latency (ms)
Binding Create	6.6
Binding Delete	5.8
AAR-RX-INIT	7.57
RX-RAR	0.57
AAR-RX-UPDATE	0.63
RX-STR	0.58

Table 3-80 Average NF Latency

NF	50th Percentile (Site 1)	99th Percentile (Site 1)	50th Percentile (Site 2)	99th Percentile (Site 2)	50th Percentile (Site 3)	99th Percentile (Site 3)
Ingress Gateway	5.35 ms	11.7 ms	5.34 ms	18.5 ms	5.50 ms	10.2 ms
Egress Gateway	1.40 ms	1.53 ms	1.85 ms	1.99 ms	0.855 ms	1.15 ms
Diameter Gateway	-	0.126 ms	-	0.116 ms	-	0.346 ms

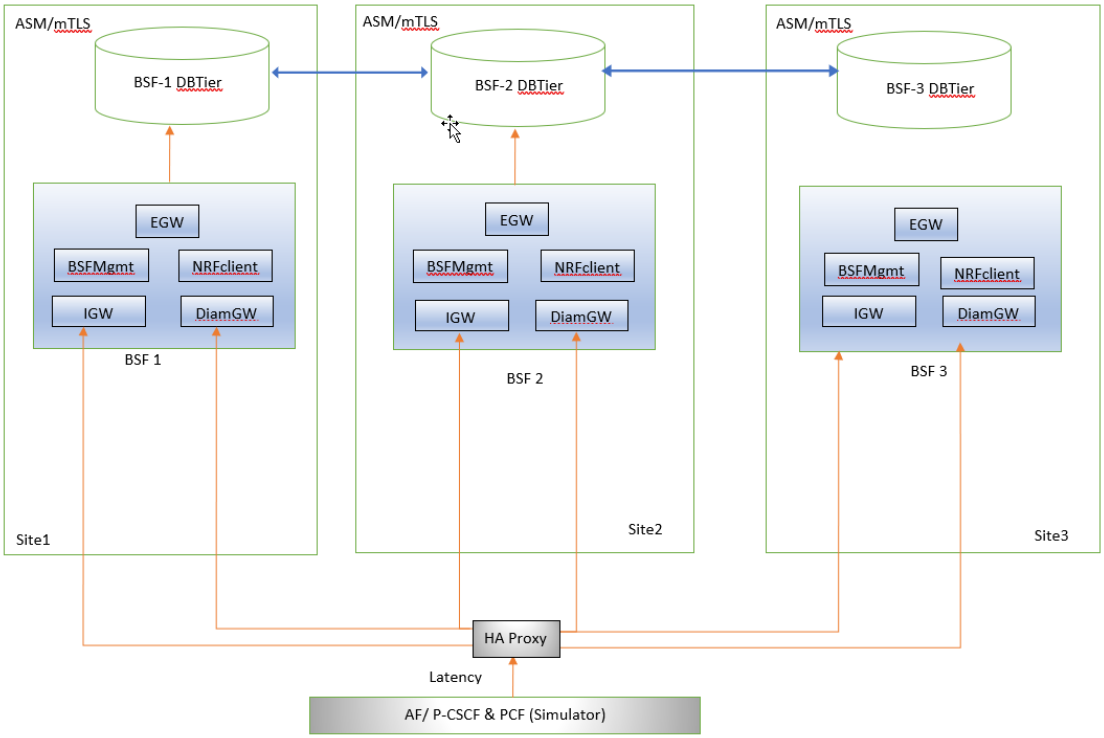
3.9 Test Scenario 9: BSF Performance Benchmarking 54K TPS traffic on a three-site Setup with traffic on one Site (25 Million Binding Sessions)

BSF Call Flow Model

BSF Performance Benchmark for 54K TPS on an ASM enabled three-site georedundant setup with traffic on one site.

The following image represents the BSF deployment on an ASM enabled three-site georedundant setup:

Figure 3-4 ASM enabled three-site georedundant setup



3.9.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-81 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	~25000000
Execution Time	~84 Hours

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

Table 3-82 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	2	2	1	1	2	2	2	2	3
Audit Service	2	2	1	1	2	2	2	2	3
BSF Management Service	4	4	1	4	2	2	2	2	9
CM Service	4	4	1	2	2	2	2	2	3
Config Service	4	4	1	2	2	2	2	2	3
Diameter Gateway	4	4	2	2	2	2	2	2	8
Egress Gateway	4	4	4	6	2	2	2	2	3
Ingress Gateway	4	4	4	6	2	2	2	2	3
Nrf Client Management	1	1	1	1	2	2	2	2	2
Query Service	2	2	1	1	2	2	2	2	3
Performance	4	4	1	1	2	2	2	2	3

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

Table 3-83 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
ndbmgmd	3	3	10	10	2	2	2	2	2
ndbmtd	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-84 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-85 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	11	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	37 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.9.2 CPU and Memory Utilization

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

Table 3-86 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	15.666 (48.96 %)	8.421 (52.63 %)	3.058 (19.11 %)	2.431 (15.19 %)	0.124 (0.39 %)	5.824 (36.40 %)	0.033 (0.21 %)	2.325 (14.53 %)	0.119 (0.37 %)	5.782 (36.14 %)	0.034 (0.21 %)	2.298 (14.36 %)
Perfinfo	0.130 (1.08 %)	0.400 (13.35 %)	0.012 (0.20 %)	0.749 (12.48 %)	0.126 (1.05 %)	0.399 (13.31 %)	0.012 (0.20 %)	0.737 (12.29 %)	0.111 (0.92 %)	0.404 (13.48 %)	0.011 (0.18 %)	0.746 (12.43 %)
Appinfo	0.055 (0.92 %)	0.758 (25.26 %)	0.010 (0.17 %)	0.741 (12.35 %)	0.054 (0.90 %)	0.749 (24.97 %)	0.012 (0.20 %)	0.732 (12.21 %)	0.054 (0.90 %)	0.749 (24.97 %)	0.010 (0.17 %)	0.741 (12.35 %)

Table 3-86 (Cont.) 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
cm-service	0.018 (0.15 %)	2.175 (36.25 %)	0.017 (0.28 %)	0.830 (13.83 %)	0.016 (0.13 %)	2.037 (33.95 %)	0.017 (0.28 %)	0.793 (13.22 %)	0.015 (0.12 %)	2.148 (35.81 %)	0.017 (0.28 %)	0.796 (13.26 %)
Config-server	0.110 (0.92 %)	2.527 (42.12 %)	0.093 (1.55 %)	0.831 (13.85 %)	0.100 (0.83 %)	2.410 (40.17 %)	0.082 (1.37 %)-	0.805 (13.41 %)	0.089 (0.74 %)	2.488 (41.47 %)	0.077 (1.28 %)	0.794 (13.23 %)
bsf-management-service	13.006 (36.13 %)	22.446 (62.35 %)	7.737 (42.98 %)	4.297 (23.87 %)	0.019 (0.05 %)	14.439 (40.11 %)	0.052 (0.29 %)	2.616 (14.53 %)	0.018 (0.05 %)	15.061 (41.83 %)	0.040 (0.22 %)	2.666 (14.81 %)
egress-gateway	0.008 (0.07 %)	2.375 (13.19 %)	0.010 (0.17 %)	0.894 (14.89 %)	0.006 (0.05 %)	2.271 (12.61 %)	0.013 (0.22 %)	0.846 (14.10 %)	0.007 (0.06 %)	2.413 (13.41 %)	0.011 (0.18 %)	0.856 (14.27 %)
ingress-gateway	3.271 (27.26 %)	9.154 (50.86 %)	2.084 (34.73 %)	3.658 (60.97 %)	0.034 (0.28 %)	2.626 (14.59 %)	0.012 (0.20 %)	0.846 (14.10 %)	0.027 (0.23 %)	2.633 (14.63 %)	0.012 (0.20 %)	0.850 (14.16 %)
nrf-client-nfmanagement	0.006 (0.30 %)	0.982 (49.12 %)	0.007 (0.18 %)	0.532 (13.31 %)	0.007 (0.35 %)	0.959 (47.95 %)	0.006 (0.15 %)	0.534 (13.35 %)	0.007 (0.35 %)	0.964 (48.19 %)	0.007 (0.18 %)	0.531 (13.28 %)
audit-service	0.004 (0.07 %)	1.069 (35.64 %)	0.025 (0.42 %)	0.741 (12.35 %)	0.005 (0.08 %)	1.081 (36.04 %)	0.008 (0.13 %)	0.733 (12.22 %)	0.003 (0.05 %)	1.073 (35.77 %)	0.008 (0.13 %)	0.735 (12.26 %)
query service	0.003 (0.05 %)	0.703 (23.44 %)	0.007 (0.12 %)	0.746 (12.43 %)	0.003 (0.05 %)	0.706 (23.54 %)	0.008 (0.13 %)	0.743 (12.39 %)	0.008 (0.13 %)	0.737 (12.29 %)	0.015 (0.12 %)	2.148 (35.81 %)

The following table provides information about observed values of cnDBTier services.

Table 3-87 Observed Values of cnDBTier Services

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	17.699 (73.75 %)	14.835 (32.97 %)	5.412 (60.13 %)	1.071 (17.85 %)	0.153 (0.64 %)	12.697 (28.22 %)	0.137 (1.52 %)	1.031 (17.19 %)	0.132 (0.55 %)	12.756 (28.35 %)	0.133 (1.48 %)	1.074 (17.90 %)
ndbmtd	17.231 (17.95 %)	325.102 (63.50 %)	14.501 (36.25 %)	2.490 (15.56 %)	5.671 (5.91 %)	323.887 (63.26 %)	1.745 (4.36 %)	2.434 (15.21 %)	6.554 (6.83 %)	323.833 (63.25 %)	1.640 (4.10 %)	2.412 (15.08 %)

Table 3-87 (Cont.) Observed Values of cnDBTier Services

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
ndbmysqld	0.526 (3.29 %)	16.396 (25.62 %)	0.328 (4.10 %)	1.074 (13.43 %)	0.405 (2.53 %)	15.003 (23.44 %)	0.280 (3.50 %)	1.048 (13.10 %)	0.365 (2.28 %)	14.976 (23.40 %)	0.290 (3.62 %)	1.064 (13.31 %)

3.9.3 TPS and DB Statistics

Table 3-88 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	54K	50K	4.5K
Site 2	-	-	-
Site 3	-	-	-

Observed values of cnDBTier Record counts:

Table 3-89 Database Records

DB Statistics	Read	Write	Commit
Site1	9.05K	6.10K	2.14K
Site2	-	-	-
Site3	-	-	-

3.9.4 Results

Table 3-90 Results

Attributes	Average Latency (ms)
Binding Create	16.1
Binding Delete	18.2
AAR-RX-INIT	16.9
RX-RAR	0.7
AAR-RX-UPDATE	0.6
RX-STR	0.4

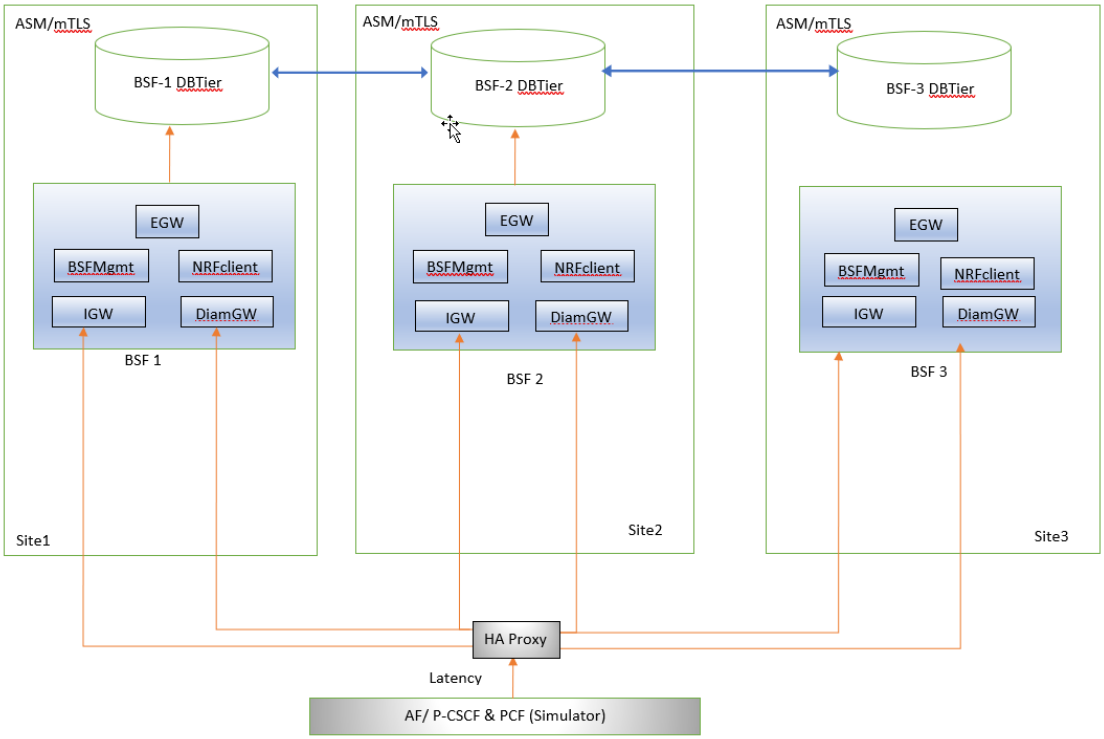
3.10 Test Scenario 10: BSF Performance Benchmarking 54K TPS traffic on a three-site Setup with traffic on one Site (50 Million Binding Sessions)

BSF Call Flow Model

BSF Performance Benchmark for 54K TPS on an ASM enabled three-site georedundant setup with traffic on one site.

The following image represents the BSF deployment on an ASM enabled three-site georedundant setup:

Figure 3-5 ASM enabled three-site georedundant setup



3.10.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-91 Testcase Parameters

Parameters	Values
Call Rate	54K TPS
Call Mix	4.5k nbsf Traffic and 50k Rx traffic

Table 3-91 (Cont.) Testcase Parameters

Parameters	Values
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

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

Table 3-92 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	2	2	1	1	2	2	2	2	3
Audit Service	2	2	1	1	2	2	2	2	3
BSF Management Service	4	4	1	4	2	2	2	2	9
CM Service	4	4	1	2	2	2	2	2	3
Config Service	4	4	1	2	2	2	2	2	3
Diameter Gateway	4	4	2	2	2	2	2	2	8
Egress Gateway	4	4	4	6	2	2	2	2	3
Ingress Gateway	4	4	4	6	2	2	2	2	3
Nrf Client Management	1	1	1	1	2	2	2	2	2
Query Service	2	2	1	1	2	2	2	2	3
Performance	4	4	1	1	2	2	2	2	3

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

Table 3-93 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
ndbmgmd	3	3	10	10	2	2	2	2	2
ndbmtd	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-94 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-95 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	11	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	37 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.10.2 CPU and Memory Utilization

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

Table 3-96 BSF Microservices and their Resource Utilization

Service	Site1 CPU	Site1 Memory	Site1 Istio CPU	Site1 Istio Memory	Site2 CPU	Site2 Istio 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 %)	0.0368 (0.230 %)	2.90 (16.9 %)	0.191 (0.597 %)	7.01 (40 %)	0.0358 (0.224 %)	2.85 (16.6 %)
Perfinfo	0.114 (0.952 %)	0.439 (13.6 %)	0.0125 (0.209 %)	0.914 (14.2 %)	0.112 (0.940 %)	0.395 (12.2 %)	0.0119 (0.198 %)	0.932 (14.5 %)	0.112 (0.976 %)	0.395 (12.3 %)	0.0127 (0.211 %)	0.962 (14.9 %)
Appinfo	0.0492 (0.821 %)	0.814 (25.3 %)	0.00868 (0.145 %)	0.925 (14.4 %)	0.055 (0.891 %)	0.803 (24.9 %)	0.00806 (0.134 %)	0.926 (14.4 %)	0.0574 (0.953 %)	0.799 (24.8 %)	0.008 (0.133 %)	0.930 (14.4 %)
cm-service	0.013 (0.113 %)	1.99 (30.9 %)	0.0170 (0.284 %)	1.02 (15.9 %)	0.139 (0.115 %)	2.01 (3.11 %)	0.0153 (0.255 %)	1.04 (16.2 %)	0.0136 (0.114 %)	2.01 (31.3 %)	0.015 (0.25 %)	1.04 (16.1 %)
Config-server	0.102 (0.85 %)	2.47 (38.2 %)	0.0869 (1.45 %)	1.00 (15.6 %)	0.0914 (0.755 %)	2.56 (39.7 %)	0.0842 (1.40 %)	1.04 (16.1 %)	0.0890 (0.723 %)	2.61 (40.6 %)	0.0811 (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 %)	0.0117 (0.0328 %)	15.1 (39.0 %)	0.0505 (0.280 %)	3.32 (17.2 %)	0.0116 (0.0849 %)	15.5 (40.0 %)	0.0455 (0.253 %)	3.35 (17.3 %)
egress-gateway	0.006 (0.05 %)	2.71 (14 %)	0.0113 (0.188 %)	1.07 (16.7 %)	0.00545 (0.0455 %)	2.16 (11.2 %)	0.0121 (0.202 %)	1.08 (16.7 %)	0.00573 (0.0478 %)	2.14 (11.1 %)	0.00936 (0.156 %)	1.07 (16.5 %)
ingress-gateway	3.35 (27.9 %)	8.37 (43.3 %)	2.17 (36.1 %)	1.65 (25.6 %)	0.0343 (0.285 %)	4.19 (21.7 %)	0.0172 (0.286 %)	1.08 (16.8 %)	0.0325 (0.271 %)	4.18 (21.6 %)	0.0150 (0.249 %)	1.09 (17.0 %)
nrf-client-nfmanagement	0.00540 (0.27 %)	1.05 (49 %)	0.00568 (0.142 %)	0.653 (15.2 %)	0.00558 (0.279 %)	1.02 (47.7 %)	0.00691 (0.173 %)	0.656 (15.3 %)	0.00571 (0.286 %)	1.02 (47.7 %)	0.00569 (0.142 %)	0.654 (15.2 %)
audit-service	0.00789 (0.132 %)	1.62 (50.3 %)	0.00661 (0.110 %)	0.933 (14.5 %)	0.00323 (0.0536 %)	1.46 (46.4 %)	0.00614 (0.102 %)	0.942 (14.6 %)	0.00325(0.0541 %)	1.49 (46.4 %)	0.00787 (0.131 %)	0.940 (14.6 %)
query service	0.00140 (0.0233 %)	0.745 (23.1 %)	0.00580 (0.0967 %)	0.921 (14.3 %)	0.00204 (0.0335 %)	0.810 (25.2 %)	0.00613 (0.102 %)	0.923 (14.3 %)	0.00163 (0.0273 %)	0.798 (24.8 %)	0.00644 (0.107 %)	0.926 (14.4 %)

The following table provides information about observed values of cnDBTier services.

Table 3-97 Observed Values of cnDBTier Services

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 %)

3.10.3 TPS and DB Statistics

Table 3-98 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	54K	50K	4.5K
Site 2	-	-	-
Site 3	-	-	-

Observed values of cnDBTier Record counts:

Table 3-99 Database Records

DB Statistics	Read	Write	Commit
Site1	9.05K	6.08K	2.13K
Site2	-	-	-
Site3	-	-	-

3.10.4 Results

Table 3-100 Results

Attributes	Average Latency (ms)
Binding Create	11.2
Binding Delete	12.8
AAR-RX-INIT	18.2
RX-RAR	0.6
AAR-RX-UPDATE	0.5
RX-STR	0.4

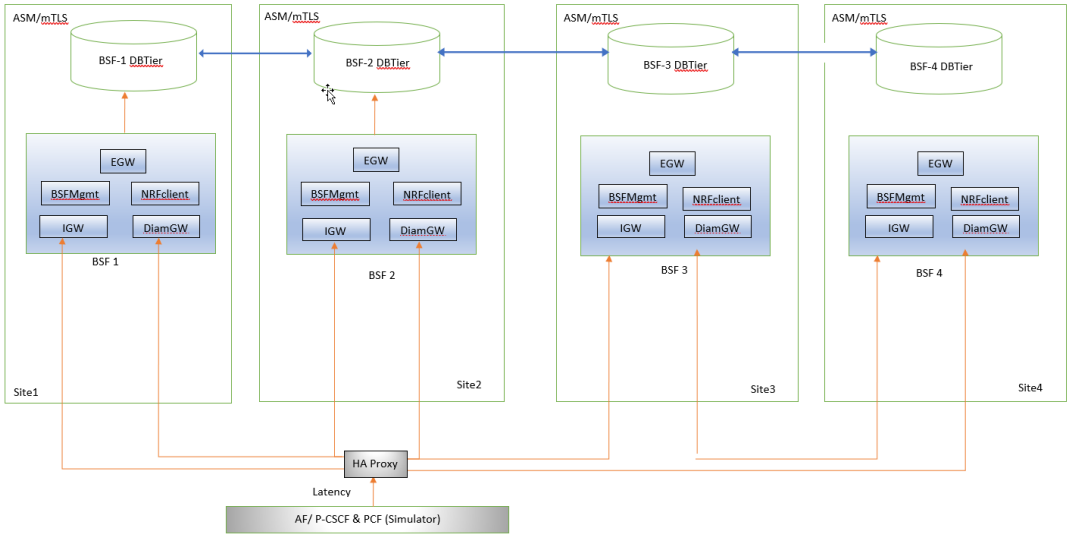
3.11 BSF Performance Benchmarking 54K TPS traffic on a Four-site Setup with traffic on one Site (Congestion Disabled)

BSF Call Flow Model

BSF Performance Benchmark for 54K TPS on an ASM enabled four-site georedundant setup with traffic on one site.

The following image represents the BSF deployment on an ASM enabled four-site georedundant setup:

Figure 3-6 ASM Enabled Four-site Georedundant Setup



3.11.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-101 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	~72 Hours

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

Table 3-102 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	2	2	1	1	2	2	2	2	3
Audit Service	2	2	1	1	2	2	2	2	3
BSF Management Service	4	4	1	4	2	2	2	2	9
CM Service	4	4	1	2	2	2	2	2	3
Config Service	4	4	1	2	2	2	2	2	3
Diameter Gateway	4	4	2	2	2	2	2	2	8
Egress Gateway	4	4	4	6	2	2	2	2	3
Ingress Gateway	4	4	4	6	2	2	2	2	3
Nrf Client Management	1	1	1	1	2	2	2	2	2
Query Service	2	2	1	1	2	2	2	2	3
Performance	4	4	1	1	2	2	2	2	3

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

Table 3-103 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
ndbmgmd	3	3	10	10	2	2	2	2	2
ndbmtd	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-104 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-105 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	11	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	37 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.11.2 CPU and Memory Utilization

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

BSF Microservices and their Resource Utilization

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

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
diam-gateway	16.036 (50.11%)	10.645 (66.53%)	6.384 (39.90%)	2.750 (17.19%)	0.075 (0.47%)	3.136 (39.20%)	0.024 (0.30%)	1.155 (14.44%)	0.061 (0.38%)	2.508 (31.35%)	0.022 (0.27%)	1.136 (14.20%)	0.059 (0.37%)	2.328 (29.10%)	0.042 (0.53%)	1.191 (14.89%)

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
Perfinfo	0.115 (0.96%)	0.412 (13.74%)	0.012 (0.20%)	0.846 (14.10%)	0.083 (1.04%)	0.272 (13.62%)	0.009 (0.22%)	0.492 (12.30%)	0.013 (0.22%)	0.732 (12.21%)	0.002 (0.05%)	0.621 (31.05%)	0.002 (0.05%)	0.620 (31.01%)	0.005 (0.12%)	0.490 (12.26%)
Appinfo	0.056 (0.93%)	0.763 (25.42%)	0.011 (0.18%)	0.820 (13.67%)	0.038 (0.95%)	0.497 (24.85%)	0.007 (0.18%)	0.512 (12.79%)	0.034 (0.85%)	0.507 (25.34%)	0.007 (0.18%)	0.487 (12.18%)	0.028 (0.70%)	0.508 (25.39%)	0.007 (0.18%)	0.490 (12.26%)
cm-service	0.020 (0.17%)	2.216 (36.93%)	0.018 (0.30%)	0.888 (14.79%)	0.011 (0.14%)	1.257 (31.42%)	0.012 (0.30%)	0.547 (13.67%)	0.012 (0.10%)	1.860 (31.01%)	0.014 (0.23%)	0.814 (13.57%)	0.010 (0.12%)	1.399 (34.99%)	0.015 (0.38%)	0.564 (14.11%)
Config-server	0.115 (0.96%)	2.527 (42.12%)	0.085 (1.42%)	0.899 (14.99%)	0.056 (0.70%)	1.508 (37.70%)	0.045 (1.12%)	0.544 (13.60%)	0.047 (0.59%)	1.493 (37.33%)	0.037 (0.92%)	0.536 (13.40%)	0.053 (0.66%)	1.583 (39.58%)	0.047 (1.18%)	0.553 (13.82%)
bsf-management-service	13.145 (36.51%)	23.284 (64.68%)	7.855 (43.64%)	3.112 (17.29%)	0.093 (0.58%)	4.022 (25.14%)	0.056 (0.70%)	1.182 (14.77%)	0.007 (0.04%)	4.583 (28.64%)	0.016 (0.20%)	1.174 (14.67%)	0.008 (0.05%)	3.684 (23.02%)	0.022 (0.27%)	1.189 (14.87%)
egress-gateway	0.095 (0.79%)	2.789 (15.49%)	0.039 (0.65%)	0.990 (16.50%)	0.085 (1.06%)	1.696 (14.14%)	0.031 (0.78%)	0.581 (14.53%)	0.006 (0.07%)	1.762 (14.68%)	0.008 (0.20%)	0.573 (14.33%)	['0.006 (0.07%)	1.861 (15.51%)	0.009 (0.22%)	0.589 (14.72%)
ingress-gateway	3.301 (27.51%)	6.412 (35.62%)	2.006 (33.43%)	1.103 (18.38%)	0.026 (0.33%)	1.909 (15.91%)	0.010 (0.25%)	0.571 (14.28%)	0.023 (0.29%)	1.875 (15.62%)	0.012 (0.30%)	0.562 (14.04%)	['0.028 (0.35%)	1.904 (15.87%)	0.016 (0.40%)	0.571 (14.28%)
nrf-client-nfmanagement	0.006 (0.30%)	1.006 (50.29%)	0.007 (0.18%)	0.684 (17.09%)	0.007 (0.35%)	0.985 (49.27%)	0.007 (0.18%)	0.526 (13.16%)	0.007 (0.35%)	0.994 (49.71%)	0.006 (0.15%)	0.532 (13.31%)	['0.006 (0.30%)	['0.973 (48.63%)	0.006 (0.15%)	['0.533 (13.33%)
audit-service	0.024 (0.40%)	1.235 (41.18%)	0.025 (0.42%)	0.854 (14.23%)	0.020 (0.50%)	0.862 (43.12%)	0.025 (0.62%)	0.508 (12.70%)	0.004 (0.10%)	0.729 (36.43%)	0.007 (0.18%)	0.496 (12.40%)	['0.004 (0.10%)	['0.711 (35.55%)	['0.008 (0.20%)	['0.490 (12.26%)

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
queryservice	0.003 (0.05%)	0.923 (30.76%)	0.007 (0.12%)	0.819 (13.66%)	0.002 (0.05%)	0.615 (30.76%)	0.005 (0.12%)	0.498 (12.45%)	0.002 (0.05%)	0.621 (31.05%)	0.006 (0.15%)	0.493 (12.33%)	['0.002 (0.05%)	0.620 (31.01%)	0.005 (0.12%)	0.490 (12.26%)

Observed Values of cnDBTier Services

The following table provides information about observed values of cnDBTier services.

Service	Site 1 CPU	Site 1 Memory	Site 1 IstioCPU	Site 1 IstioMemory	Site 2 CPU	Site 2 Memory	Site 2 IstioCPU	Site 2 IstioMemory	Site 3 CPU	Site 3 Memory	Site 3 IstioCPU	Site 3 IstioMemory	Site 4 CPU	Site 4 Memory	Site 4 IstioCPU	Site 4 IstioMemory
ndbappmysqld	17.826 (74.28%)	14.117 (31.37%)')]	6.909 (76.77%	1.322 (22.04%)	0.152 (0.63%)	12.361 (27.47%)	0.110 (1.22%)	1.293 (21.55%)	0.110 (1.22%)	1.293 (21.55%)	0.083 (0.92%)	1.249 (20.82%)	0.093 (0.39%)	11.559 (25.69%)	0.081 (0.90%)	1.237 (20.62%)
ndbmtd	17.960 (18.71%)	324.243 (63.33%)	16.106 (40.27%)	3.091 (19.32%)	7.353 (7.66%)	324.522 (63.38%)	1.617 (4.04%)	3.116 (19.48%)	7.636 (7.95%)']	324.854 (63.45%)	1.695 (4.24%)	3.123 (19.52%)	7.305 (7.61%)	324.876 (63.45%)	1.599 (4.00%)	3.191 (19.95%)
ndbmysqld	0.818 (3.41%)	24.810 (25.84%)	0.513 (4.28%)	1.938 (16.15%)	0.487 (2.03%)	22.604 (23.55%)	['0.383 (3.19%)	1.972 (16.43%)	0.466 (1.94%)	22.377 (23.31%)	0.407 (3.39%)	1.916 (15.97%)	0.467 (1.95%)	22.298 (23.23%)	0.400 (3.33%)	1.938 (16.15%)

3.11.3 TPS and DB Statistics

Table 3-106 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	54K	50K	4.5K
Site 2	-	-	-
Site 3	-	-	-
Site 4	-	-	-

Observed values of cnDBTier Record counts:

Table 3-107 Database Records

DB Statistics	Read	Write	Commit
Site1	9.05K	6.25K	2.25K
Site2	-	-	-
Site3	-	-	-
Site4	-	-	-

Replication Delay

Observed values of latency on replication channels:

DB Statistics	Latency Min (Seconds)	Latency Max (Seconds)
Site1	0	0
Site2	0	1
Site3	0	1
Site4	0	1

3.11.4 Results

Table 3-108 Results

Attributes	Average Latency (ms)
Binding Create	8.3
Binding Delete	8.1
AAR-RX-INIT	10.4
RX-RAR	0.9
AAR-RX-UPDATE	0.5
RX-STR	0.5

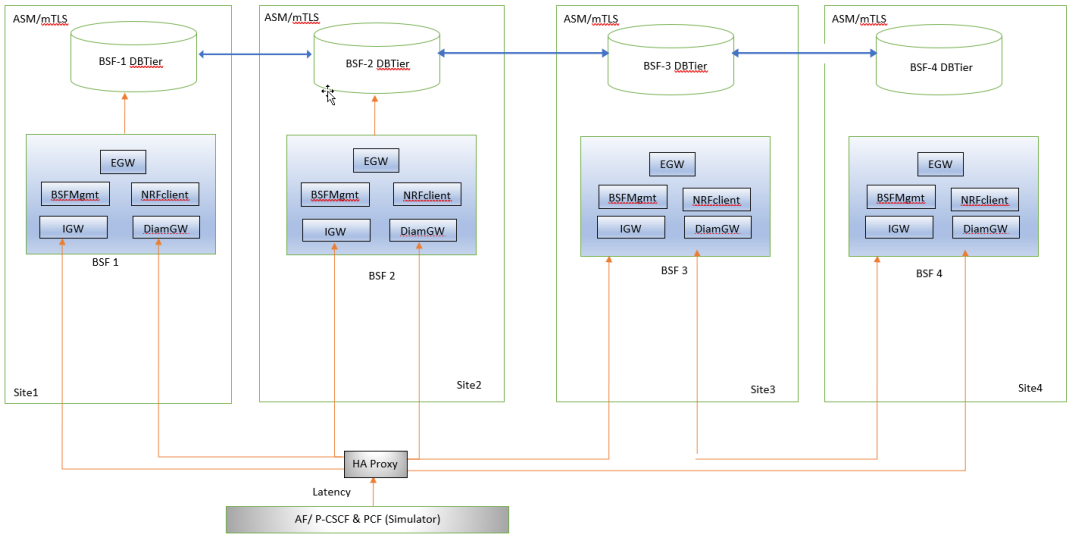
3.12 BSF Performance Benchmarking 54K TPS traffic on a Four-site Setup with traffic on one Site (Congestion Enabled)

BSF Call Flow Model

BSF Performance Benchmark for 54K TPS on an ASM enabled four-site georedundant setup with traffic on one site.

The following image represents the BSF deployment on an ASM enabled four-site georedundant setup:

Figure 3-7 ASM Enabled Four-site Georedundant Setup



3.12.1 Test Case and Setup Details

The following table describes the testcase parameters and their values:

Table 3-109 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	~12 Hours

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

Table 3-110 BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
Appinfo	2	2	1	1	2	2	2	2	3
Audit Service	2	2	1	1	2	2	2	2	3

Table 3-110 (Cont.) BSF microservices Resource allocation

Service Name	CPU Request Per Pod	CPU Limit Per Pod	Memory Request Per Pod	Memory Limit Per Pod	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replicas
BSF Management Service	4	4	1	4	2	2	2	2	9
CM Service	4	4	1	2	2	2	2	2	3
Config Service	4	4	1	2	2	2	2	2	3
Diameter Gateway	4	4	2	2	2	2	2	2	8
Egress Gateway	4	4	4	6	2	2	2	2	3
Ingress Gateway	4	4	4	6	2	2	2	2	3
Nrf Client Management	1	1	1	1	2	2	2	2	2
Query Service	2	2	1	1	2	2	2	2	3
Performance	4	4	1	1	2	2	2	2	3

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

Table 3-111 cnDBTier services resource allocation

Microservice Name	CPU Request per Pod	CPU Limit Per Pod	Memory Request per Pod (Gi)	Memory Limit Per Pod (Gi)	Isito CPU Request	Isito CPU Limit	Isito Memory Request (Gi)	Isito Memory Limit (Gi)	Replica Count
ndbmgmd	3	3	10	10	2	2	2	2	2
ndbmtd	12	12	100	100	5	5	2	2	8
mysqld	4	4	16	16	4	4	4	4	4
appmysqld	12	12	20	20	5	5	6	6	3

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

Table 3-112 BSF Features

Features Name	Feature Status
Nbsf	Enabled
Rx	Enabled

The following cnDBTier and Policy helm parameters configured for this run:

Table 3-113 Configuring Helm Parameters

cnDBTier Parameter	Value	Description
MaxNoOfExecutionThreads	11	Specifies the number of execution threads used by ndbmtd.
MaxNoOfConcurrentScans	495	Specifies the maximum number of scans executing concurrently on ndbmtd.
datamemory	37 GB	Specifes the cnDBTier ndb data memory capacity configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier App node (ndbappmysqld) istio side car configuration.
proxy.istio.io/config	'{concurrency: 8}'	Specifies the cnDBTier Data node (ndbmtd) istio side car configuration.
BSF Parameter		
proxy.istio.io/config	'{concurrency: 4}'	Specifies the BSF management service istio side car configuration.

3.12.2 CPU and Memory Utilization

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

BSF Microservices and their Resource Utilization

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

Table 3-114 BSF Microservices and their Resource Utilization

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
diam-gateway	16.405 (51.27%)	9.913 (61.96%)	6.686 (41.79%)	2.468 (15.42%)	0.074 (0.46%)	3.385 (42.31%)	0.056 (0.70%)	1.168 (14.60%)	0.061 (0.38%)	2.771 (34.64%)	0.024 (0.30%)	1.157 (14.47%)	0.058 (0.36%)	2.665 (33.31%)	0.028 (0.35%)	1.227 (15.33%)
Perfinfo	0.113 (0.94%)	0.416 (13.87%)	0.013 (0.22%)	0.851 (14.18%)	0.086 (1.07%)	0.273 (13.67%)	0.009 (0.22%)	0.500 (12.50%)	0.106 (0.88%)	0.400 (13.35%)	0.012 (0.20%)	0.737 (12.29%)	0.071 (0.89%)	0.271 (13.57%)	0.010 (0.25%)	0.532 (13.31%)

Table 3-114 (Cont.) BSF Microservices and their Resource Utilization

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
Appinfo	0.052 (0.87%)	0.764 (25.46%)	0.012 (0.20%)	0.818 (13.64%)	0.030 (0.75%)	0.497 (24.85%)	0.007 (0.18%)	0.503 (12.57%)	0.032 (0.80%)	0.507 (25.34%)	0.006 (0.15%)	0.499 (12.48%)	0.031 (0.78%)	0.510 (25.49%)	0.007 (0.18%)	0.505 (12.62%)
cm-service	0.018 (0.15%)	2.307 (38.44%)	0.019 (0.32%)	0.893 (14.88%)	0.011 (0.14%)	1.282 (32.06%)	0.011 (0.27%)	0.551 (13.77%)	0.013 (0.11%)	1.897 (31.62%)	0.015 (0.25%)	0.809 (13.48%)	0.017 (0.43%)	0.564 (14.11%)	0.004 (0.10%)	0.721 (36.04%)
Config-server	0.119 (0.99%)	2.448 (40.80%)	0.087 (1.45%)	0.892 (14.86%)	0.064 (0.80%)	1.514 (37.84%)	0.050 (1.25%)	0.552 (13.79%)	0.047 (0.59%)	1.801 (45.02%)	0.038 (0.95%)	0.549 (13.72%)	0.049 (0.61%)	1.827 (45.68%)	0.045 (1.12%)	0.570 (14.26%)
bsf-management-service	13.320 (37.00%)	22.150 (61.53%)	7.895 (43.86%)	3.896 (21.64%)	0.094 (0.59%)	4.045 (25.28%)	0.063 (0.79%)	1.185 (14.81%)	0.007 (0.04%)	7.717 (48.23%)	0.018 (0.22%)	1.194 (14.93%)	0.008 (0.05%)	7.717 (48.23%)	0.022 (0.27%)	1.206 (15.08%)
egress-gateway	0.092 (0.77%)	2.934 (16.30%)	0.039 (0.65%)	0.963 (16.05%)	0.084 (1.05%)	1.923 (16.02%)	0.033 (0.83%)	0.590 (14.75%)	0.006 (0.15%)	0.583 (14.58%)	0.047 (0.59%)	1.801 (45.02%)	0.012 (0.30%)	0.583 (14.58%)	0.049 (0.61%)	1.827 (45.68%)
ingress-gateway	3.281 (27.34%)	9.870 (54.83%)	2.022 (33.70%)	1.447 (24.12%)	0.027 (0.34%)	1.932 (16.10%)	0.015 (0.38%)	0.577 (14.43%)	0.022 (0.27%)	1.888 (15.73%)	0.010 (0.25%)	0.573 (14.33%)	0.012 (0.30%)	0.584 (14.60%)	0.006 (0.07%)	1.872 (15.60%)
nrf-client-nfmanagement	0.007 (0.35%)	1.013 (50.63%)	0.006 (0.15%)	0.686 (17.14%)	0.006 (0.30%)	0.998 (49.90%)	0.007 (0.18%)	0.530 (13.26%)	0.006 (0.15%)	0.535 (13.38%)	0.022 (0.27%)	1.888 (15.73%)	0.022 (0.27%)	1.923 (16.02%)	0.012 (0.30%)	0.584 (14.60%)
audit-service	0.023 (0.38%)	1.254 (41.80%)	0.023 (0.38%)	0.851 (14.18%)	0.019 (0.47%)	0.872 (43.60%)	0.022 (0.55%)	0.513 (12.82%)	0.004 (0.10%)	0.735 (36.77%)	0.007 (0.18%)	0.506 (12.65%)	0.004 (0.10%)	0.721 (36.04%)	0.006 (0.15%)	0.505 (12.62%)

Table 3-114 (Cont.) BSF Microservices and their Resource Utilization

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
queryservice	0.003 (0.05%)	0.931 (31.02%)	0.008 (0.13%)	0.809 (13.48%)	0.002 (0.05%)	0.623 (31.15%)	0.004 (0.10%)	0.502 (12.55%)	0.002 (0.05%)	0.615 (30.76%)	0.005 (0.12%)	0.490 (12.26%)	0.005 (0.12%)	0.499 (12.48%)	0.011 (0.14%)	1.462 (36.55%)

Observed Values of cnDBTier Services

The following table provides information about observed values of cnDBTier services.

Table 3-115 Observed Values of cnDBTier Services

Service	Site 1 CPU	Site 1 Memory	Site 1 Istio CPU	Site 1 Istio Memory	Site 2 CPU	Site 2 Memory	Site 2 Istio CPU	Site 2 Istio Memory	Site 3 CPU	Site 3 Memory	Site 3 Istio CPU	Site 3 Istio Memory	Site 4 CPU	Site 4 Memory	Site 4 Istio CPU	Site 4 Istio Memory
ndbappmysqld	18.292 (76.22%)	'14.170 (31.49%)	6.909 (76.77%)	1.316 (21.94%)	0.162 (0.67%)	12.379 (27.51%)	0.117 (1.30%)	1.255 (20.91%)	0.098 (0.41%)	12.281 (27.29%)	0.090 (1.00%)	1.246 (20.77%)	0.093 (0.39%)	11.750 (26.11%)	0.102 (1.13%)	1.252 (20.87%)
ndbmtd	19.268 (20.07%)	324.049 (63.29%)	16.136 (40.34%)	3.081 (19.26%)	6.304 (6.57%)	324.378 (63.36%)	1.622 (4.06%)	3.139 (19.62%)	7.216 (7.52%)	324.667 (63.41%)	1.684 (4.21%)	3.124 (19.53%)	6.931 (7.22%)	321.891 (62.87%)	1.627 (4.07%)	3.175 (19.84%)
ndbmysqld	0.815 (3.40%)	24.730 (25.76%)	0.512 (4.27%)	1.944 (16.20%)	0.486 (2.02%)	22.572 (23.51%)	0.381 (3.18%)	1.978 (16.48%)	0.465 (1.94%)	22.442 (23.38%)	0.408 (3.40%)	1.912 (15.93%)	0.456 (1.90%)	22.481 (23.42%)	0.403 (3.36%)	1.928 (16.06%)

3.12.3 TPS and DB Statistics

Table 3-116 Overall TPS Ingress & Egress TPS to/from NF

Site	Total TPS	Rx	Nbsf
Site1	54K	50K	4.5K
Site 2	-	-	-
Site 3	-	-	-
Site 4	-	-	-

Observed values of cnDBTier Record counts:

Table 3-117 Database Records

DB Statistics	Read	Write	Commit
Site1	8.63K	6.212K	2.3K
Site2	-	-	-
Site3	-	-	-
Site4	-	-	-

Replication Delay

Observed values of latency on replication channels:

DB Statistics	Latency Min (Seconds)	Latency Max (Seconds)
Site1	0	0
Site2	0	1
Site3	0	0
Site4	0	1

3.12.4 Results

Table 3-118 Results

Attributes	Average Latency (ms)
Binding Create	8.2
Binding Delete	8.0
AAR-RX-INIT	10.8
RX-RAR	0.9
AAR-RX-UPDATE	0.5
RX-STR	0.5